US Army Corps of Engineers
Memphis District

FLOOD CONTROL
MISSISSIPPI RIVER & TRIBUTARIES
ST. FRANCIS BASIN PROJECT

JUSTIFICATION REPORT REPAIR OF MARKED TREE SIPHON

APRIL 1983

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DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
668 CLIFFORD DAVIS FEDERAL BUILDING
MEMPHIS, TENNESSEE 38103

Reply to
Attention of:

LMMCO-O

14 April 1983

SUBJECT: Marked Tree Siphon Justification Report

Commander, Lower Mississippi Valley Division
ATTN: LMVCO-O

1. Reference: Paragraph 5, 3rd Ind, 23 Nov 81, (MD 15 Feb 80).

2. Above reference directs that a report be made which would evaluate costs and benefits for repairs to the structure.

3. The inclosed report shows costs and quantified benefits. Other benefits which would require excessive time and cost to evaluate are discussed as unquantified. Paragraph X-02 contains my recommendations.

JOHN F. HATCH, JR.
Colonel, Corps of Engineers
Commanding

PERTINENT DATA

Justification Report - Repair of Marked Tree Siphon, Memphis District
CE: Siphon transfers water from St. Francis Lake to St. Francis River, 7.22 river miles above the Marked Tree Gage.

Authority for Siphon: A feature of the St. Francis Basin, flood control and major drainage, Mississippi River and Tributaries, FC Act of 1928, amended 1936.

Authority for Report: LMVCO-O (MD 15 Feb 80) 3rd Ind., Subject: Remedial Repairs to Marked Tree Siphon, LMVD, 23 Nov 81; paragraph 5 directs a report on plan of operation and economic justification of repairs.

Problem: The siphon was completed in 1939. Recent inspection shows imminence of functional failure. The flared inlet and outlet portions of all three tubes have deteriorated severely because of cavitation, abrasion and corrosion. The starting system needs serious repairs. The original justifying purpose of the siphon as an aid to navigation no longer exists. All future beneficial effects of continuing operation of the siphon by repair as maintenance are here evaluated in comparison with repair costs. The purpose of this report is to determine whether the siphon should be repaired or abandoned.

Estimated First Cost of Repair: All first costs are Federal. With contingencies, E&D, S&A, the total (Jul 82) is $552,000 for repair of three barrels, and $190,000 for repair of only one barrel.

Project Economics: Analysis was made using 2 1/2% interest as in the original authorization and also using the current rate of 7 7/8%. Annual charges include annual equivalents of first costs and major replacements and cost of operation and minor maintenance. Quantified annual benefits are: Channel Maintenance Reduction $11,242, Irrigation $0, Flood Control $9,100, General Recreation $64, and Sport Fishing $8,648. There was derived an annual loss to Commercial Fisheries of $6,810; this amount was added to annual charges of repair. Unquantified benefits are: Irrigation, Water Quality, Gate Maintenance, Emergency Operations, and Aesthetics. The life of the repaired siphon is estimated as 50 years.

Total Annual Charges (Jul 82) versus Total Annual Benefits:

Full Renewal: Repair of Three Barrels	2 1/2% Federal, Non-Federal		7 7/8% Federal, Non-Federal	
Annual Charges	$27,078	$7,000	$52,031	$7,000
	$34,078		$59,031	
Annual Benefits	$29,054		$29,054	
Benefit-Cost Ratio, B/C	0.85		0.49	
Excess Benefits, B-C	$-5,024		$-29,977	

Total Annual Charges (Jul 82) versus Total Annual Benefits:

Minimum Renewal: Repair of Only One Barrel	2 1/2% Federal	2 1/2% Non-Federal	7 7/8% Federal	7 7/8% Non-Federal
Annual Charges	$14,313	$7,000	$22,864	$7,000
	$21,313		$29,864	
Annual Benefits	$29,054		$29,054	
Benefit-Cost Ratio, B/C	1.36		0.97	
Excess Benefits, B-C	$ 7,741		$ -810	

Other Agencies: Drainage District 7 of Poinsett County, Arkansas, provided agricultural data. U. S. Fish and Wildlife Service and Arkansas Game and Fish Commission were consulted on environmental questions. Soil Conservation Service and the Arkansas Agricultural Extension Service were consulted in irrigation analysis.

JUSTIFICATION REPORT

REPAIR OF MARKED TREE SIPHON

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SECTION I - GENERAL

I-01. AUTHORIZATION AND PURPOSE OF REPORT

Based on Inspection Report No. 3, Marked Tree Siphon, Marked Tree, Arkansas, 28 September 1976, and Inspection Report No. 4, Marked Tree Siphon, Marked Tree, Arkansas, the District Engineer, Memphis, sent a letter on 15 February 1980 to Division Engineer, Lower Mississippi Valley, subject: "Remedial Repairs to Marked Tree Siphon". In paragraph 8, the District Engineer requested approval to accomplish the needed repairs. The 3rd Ind, 23 Nov 81, in paragraphs 2 and 5 directed the submission to Commander, Lower Mississippi Valley Division, of a report which will evaluate the costs and benefits for repairs to the structure. This report responds to that directive.

I-02. HISTORICAL BACKGROUND (REFER TO PLATE I-1: AREAS AFFECTED BY SIPHON)

I-02 - a. War Department Permit to Close St. Francis River.

In 1923 Drainage District 7 of Poinsett County, Arkansas, requested from the War Department their permission to extend southwestward a levee constructed by others on the left, or southeast, side of the Right Hand Chute of Little River. The proposed levee would close the St. Francis River about 9 miles above Marked Tree, then continue westward and southward to protect the city of Marked Tree against St. Francis River floods. At that time there was steamboat navigation on the St. Francis River from its mouth to Wappapello, Missouri. All bridges were then movable or otherwise navigable. Since the proposed levee would be in fact a dam across the navigable river, the War Department Permit of 1924 required a navigation lock and a controlled structure for lowflow augmentation in the river downstream. The Permit specified that all flows up to 2600 cfs would be sent down the existing river, and that no flow would be allowed down the new bypass floodway when the lake would be below 210.25 mgl. Thus navigation capability was to be preserved both in St. Francis Lake and in St. Francis River downstream.

I-02 - b. Local Compliance with Permit Requirements.

By September 1926, Drainage District 7 of Poinsett had completed a navigation lock and a "sluiceway". This structure was a slide-gated box culvert, with 4 barrels 8' x 6' x 200', which had a capacity of 1108.68 $H^{\frac{1}{2}}$, and would pass the specified 2600 cfs when the head difference was 5.5 feet. In the period 1936-1938, due to poor foundation, outlet scour, and severe underseepage, this culvert was

irreparably damaged; no remnants are now visible. In response to statements of incapability by Drainage District 7 of Poinsett, the U. S. Army Corps of Engineers was authorized to restore the lost lowflow augmentation capacity. Foundation exploration indicated a replacement culvert to be unfeasible. A siphon was designed, with 3 steel barrels of 9' diameter x 228', started by an electric vacuum pump in one hour for the first barrel. It has a capacity of 1486.14 $H\frac{1}{2}$, and will pass the specified 2600 cfs when the head difference is 3.06 feet. In June 1939 the siphon was completed and turned over to Drainage District 7 of Poinsett for operation and maintenance. They have operated the siphon since that time.

I-02 - c. Operational Constraints.

There has never been a formal plan of operation as an agreement between Drainage District 7 of Poinsett and the U. S. Army Corps of Engineers. But certain criteria have been accepted as the general plan of operation. Downstream agricultural flooding begins when the tailwater elevation at Lower Lock Gage is higher than 208.6, though other kinds of damage do not occur until a higher stage is reached. The siphon is not operated at a higher Lower Lock reading than 208.6. A Review Report on the St. Francis River in Drainage District 7 of Poinsett County, Arkansas dated 2 June 1965, published as Senate Document 57/89/1, and adopted by the Flood Control Act of 27 October 1965, dealt in part with control gates in Oak Donnick Floodway to prevent the water level in St. Francis Lake from falling below 210.0 NGVD. In this report and in the subsequent General Design Memorandum 108, approved 3 September 1969, the justifying benefit of these control gates was the preservation of fish and wildlife assets within the Lake, as evaluated by the U. S. Fish and Wildlife Service. The authorizing act provides for the operation of the gates and the siphon to maintain St. Francis Lake at a minimum elevation of 210 feet. In December 1977 a Memorandum of Understanding was signed by Drainage District 7 of Poinsett and by the Arkansas Game and Fish Commission, which contained the additional provision that the gates and siphon can, by specific agreement in each case, be used to drop the Lake below 210 for a few hours prior to the arrival of a known upstream flood. This Memorandum of Understanding is in effect an agreed plan of operation, though the agreement is not with the United States. The lowering of water level in anticipation of an imminent flood can be done by the gates alone, but not as fast as with the addition of siphon withdrawal.

I-03. PRESENT PROBLEM.

The siphon has been in operation for forty-three years. Due to the length of usage and absence of any major rehabilitation efforts, portions of the project have deteriorated extensively. The major problems that now exist are:

a. The timber piling and wale system that serve as a trash barrier has deteriorated to the point that it is almost nonexistent. Only a few, isolated timbers are visible above the water.

b. The siphon pipes have rusted extensively both inside and outside. Pitting of the metal is visible in some areas. The plugs inserted in the holes which contained pressure valves used during an earlier study are leaking. The extreme ends of the pipe that are frequently submerged during periods of high water have rusted to the point that holes are visible through the metal.

c. The mechanical and electrical equipment used to prime the siphon pipes is unreliable and in varying degrees of inoperability. Some of the equipment will not operate at all while other parts must be altered to get them to work.

d. The electrical wires leading into the operating house are too low and have exposed wires.

I-04. PROPOSED WORK.

In order to restore the siphon to a dependable level of operation, the following remedial actions must be performed:

a. For the full renewal of the project to its original condition, a new trashrack should be constructed to halt the influx of trash, driftwood, and debris. However, the trashrack has been essentially non-existent for about half the life of the project. The entrance lips of the flared inlets are at elevation 203.3 NGVD, and experience has shown that no floating trash is ingested when the lake headwater is not lowered below 210.0 NGVD. That floating trash which does collect in the forebay has been easily removed by a winch-truck at the toe of the levee. Therefore, both renewal plans, construction of a new trashrack was eliminated.

b. The siphon pipes need to be blast-cleaned and painted with a rust inhibiting paint both inside and outside. For the minimum renewal plan, only one pipe would be repaired.

c. The mechanical and electrical equipment should be repaired or replaced as necessary.

d. The electrical wiring leading to the operating house should be replaced and relocated by the local power company.

SECTION II - NEEDS FOR SIPHON OPERATION

II-01. NAVIGATION.

The siphon was justified for lowflow augmentation to enable fulltime navigation as discussed in paragraph I-01 a. The only navigation now on the St. Francis River is by trailer-launched small boats. Huxtable Pumping Plant blocks access from the Mississippi River. Bridges are no longer navigable. They have become immovable through disuse or maintenance modifications. Replacements and bridges at new locations have not been designed for navigation. The Marked Tree Lock has been filled with earth. The original justifying navigational need no longer exists.

II-02. CHANNEL MAINTENANCE REDUCTION.

Since the St. Francis River is a flood control channel it is designated for periodic Federal maintenance when it shows the need. In the Review Report mentioned in paragraph I-02-c, the effect of the proposed Lake control gates in preserving headwater for the operation of the siphon was discussed. A benefit of the siphon's operation was considered to be reduction of the cost of maintenance, since lowflow augmentation would reduce willow growth in the bottom and would leave less bank exposed for willows and other flow-retarding vegetation.

II-03. IRRIGATION.

In 1964 an intensive survey of irrigation was made in the zone between the siphon and Huxtable Pumping Plant. Among the 31 sites analyzed, only 2 users transported riverwater more than ½ mile from the river. Elsewhere, groundwater was stored in diked reservoirs by co-op groups and water companies or was pumped directly into flumes by single owners or small groups. A quadmap strip has been prepared to show the whole extent of the lower river, which is divided into 9 reaches between major tributaries and other significant points. An envelop-line ½ mile from the river was drawn throughout, and the potential river-irrigable acreage was derived by reaches. Each 1964 withdrawal site was plotted. With few exceptions, the pumps were mounted on small barges with industrial gasoline or diesel engines. Distribution was usually by small ditches or flumes, though some spray sets near the river were noted. Table II-03 below shows 1964 data. River water use for irrigation has continued, as discussed in paragraph V-01-6.

TABLE II-03 RIVERWATER IRRIGATION 1964

RIVER MILE	LOCATION	REACH	SITE NO.	PUMP GPM	CAPACITY CFS	IRRIGATED ACRES	IRRIGABLE ACRES
132.67	SIPHON	EXIT					
132.17		1	1	1-2500	6	200	
130.70		1	2	2-800	4	400	
REACH	TOTAL	1			10 cfs	600 Ac	1,401 Ac
130.25	ENTR. LHCLR						
	6.0 Abv on LR		A	1-2500	6	300 Ac	
128.00		2	3	1-2500	6	400	
124.45		2	4	1-2500	6	100	
123.20		2	5	1-2500	6	400	
123.00		2	6	1-1400	3	100	
REACH	TOTAL	2			21 cfs	1,000 Ac	6,227 Ac
121.60	ENTR. D47+D1						
107.00		3	7	3-1500	10	145	
104.00		3	8	1-1700	4	80	
86.33		3	9	1-1500	3	37	
85.20		3	10	1-1400	3	116	
82.45		3	11	1-1200	3	60	
80.40		3	12	1-600	1	40	
REACH	TOTAL	3			24 cfs	478 Ac	26,734 Ac
79.44	ENTR. TYRONZA R.						
76.80		4	13	1-1200	3	27	
76.10		4	14	1-1400	3	40	
71.05		4	15	2-2000	9	170	
70.20		4	16	1-2000	4	60	
67.55		4	17	1-2000	4	50	
66.10		4	18	1-2000	4	40	
0.7 Abv 65.80		4	19	2-2000	9	300	
3.3 Abv 65.80		4	20	1-1200	3	200	
REACH TOTAL		4			39 cfs	887 Ac	10,188 Ac
65.80	HD. GRASSY LAKE C.O.						
62.90		5	21	1-2000	4	80	
REACH TOTAL		5			4 cfs	80 Ac	2,921 Ac
61.00	FT. GRASSY LAKE C.O.						
60.90		6	22	2-2000	9	220	
(B and C in Fldwy)							
60.40		6	D	1-2500	6	300	
59.80		6	E	1-2500	6	300	
REACH TOTAL					21 cfs	820 Ac	4,284 Ac
54.00	HD. ROUND POND C.O.						
REACH TOTAL		7			0 cfs	0 Ac	6,296 Ac

TABLE II-03 RIVERWATER IRRIGATION 1964 (CONT'D)

RIVER MILE	LOCATION	REACH	SITE NO.	PUMP GPM	CAPACITY CFS	IRRIGATED ACRES	IRRIGABLE ACRES
44.80	FT. ROUND POND C.O.						
8.4 Abv. 44.80		8	FU	1-2500	6	300	
40.65		8	GU	1-2500	6	300	
3.2 Abv. 38.90		8	FL	1-2500	6	300	
2.4 Abv. 38.90		8	GL	1-2500	6	300	
REACH TOTAL		8			24 cfs	1,200 Ac	7,573 Ac
38.25	ENTR. BLACKFISH BAYOU						
29.10		9	H	1-2500	6	300	
28.00		9	I	1-2500	6	300	
REACH TOTAL		9			12 cfs	600 Ac	15,612 Ac
14.80	HUXTABLE PUMPING PLANT						
TOTALS, SIPHON TO HUXTABLE, 1964					161 cfs	5,965 Ac	81,236 Ac

II-04. FLOOD CONTROL.

The topographic map "Marked Tree" shows clearly that "St. Francis Lake" does not resemble the usual concept of a lake. At various times in the last few centuries, earthquakes have caused subsidence along existing streams in the former Gulf Embayment. In such manner the "St. Francis Sunk Lands" were created along the St. Francis River. A strip from 1/4 to 1/2 mile wide and about 12 miles long subsided enough that it was almost constantly flooded, with lesser "sunken strips" to the northeastward. When local organizations, and later the Federal Government, were confining St. Francis floods within a leveed floodway, an area was inclosed that came to be called St. Francis Lake. The approximate dimensions of this inclosure are: 12 miles long, 2 1/2 miles wide at the south end, 4 1/2 miles wide at the Poinsett-Craighead County line, and less than 1 mile wide at the north end, where the St. Francis Floodway enters. The Big Lake Floodway enters from the northeast near the south end of the Lake. Flood flows through the Lake go southwestward through the Oak Donnick portion of the St. Francis Floodway. Most of the inclosure is still in woodland, but in the southeast and east portions the land is enough higher that it has been cleared and farmed for many years. In 12 tracts there are 5,974 acres of cropland under 9 ownerships. This cleared land varies in elevation from 213 NGVD to 223 NGVD. Although most years flood water reaches the levees during the winter, there is a rather short cropseason during which the basic Lake level of 210 NGVD may not be exceeded enough to cause prohibitive losses. The siphon operation delays a cropseason rise and reduces its crest elevation by an average of 0.3 foot. The use of the siphon reduce losses to "lake farming." This benefit is quantified in detail in Section V-01-c.

II-05. SPORT FISHING.

The vacation sport fishing expedition will prefer more renowned locations, such as Mallard Lake, Greers Ferry, and the White River Reservoirs, but there is a considerable sport fishing short-term usage in the St. Francis River and in the Floodway. Comparison of physical facts in Section IV shows that the River has the greater value. More flow and depth should be better for sport fishing in either stream. Repair of the siphon would benefit this use of the River, while abandoment would benefit this use of the Floodway. These effects are quantified and compared in Section V-01-d(2) and (4). Impractical to quantify is the value to rural children of very brief fishing visits. Many more rural residences are within quick walking distance of the River than there are near the Floodway channel. So repair of the siphon, to maintain the already superior value of the River, would seem to have some special and recreational value to those pre-adults who could not be called true sport fishermen.

II-06. GENERAL RECREATION.

There is some general recreational use of the River and the Floodway, principally by adjacent residents. Swimming and water-ski boating are not prevalent, since water quality is less than ideal, though not truly dangerous. Pleasure-boating and nature-watching are enhanced by more flow and depth of water, and many more residences are adjacent to the River than to the Floodway channel. The River is probably more aesthetically pleasing for nonconsumptive use than the Floodway. Indications are that more people would be better served if the River's flow is augmented by the repaired siphon than would be if abandonment augmented the Floodway's flow. Quantification and comparison of this factor are in Section V-01-d(1) and (4).

II-07. COMMERCIAL FISHERIES.

Commercial fishing by trot-lines, gill-nets, and various forms of fish-traps is done on both the River and the Floodway. There is a considerable and unquantified licensed harvesting for home consumption by single families or informal partnerships, usually close to their residences on the River. Without data over any considerable period, there are some harvest estimates for full-time commercial fishermen. Reference is made again to Section IV. Although the River would seem to have a greater productive capacity than the Floodway, the sample harvest information mentioned indicates that the harvest is several times greater in the Floodway. There are detailed discussions of this phenomenon in Section VIII-03. Quantification of the conflicting effects in the River and the Floodway of siphon repair or abandonment is found in Section V-01-d(3) and (4).

II-08. WATER QUALITY.

The Review Report mentioned in paragraph I-02-c, published as Senate Document 57/89/1, contained as Appendix D a Water Resources Study by the U. S. Public Health Service. This study developed data on the 95% exceedence lowflow in the St. Francis River at the Marked Tree Gage, without siphon operation. At that time untreated sewage was being discharged at Lepanto into Left Hand Chute of Little River and at Marked Tree into LHCLR and into the St. Francis River. Under those conditions the Public Health Service Study stated that lowflow at the Marked Tree Gage showed adequate dilution of sewage without augmentation by the siphon. At present, the effluent from the Lepanto lagoon treatment system still enters LHCLR, and Marked Tree sewage is carried to a lagoon treatment system within the St. Francis Floodway: thus it has no effect on the river. These improved conditions make it clear that siphon flow is not needed for sewage dilution. In addition to the former sewage pollution, water quality has been degraded by several kinds of agricultural chemicals. The St. Francis River at Marked Tree receives runoff from almost entirely cropland below Manila and below Blytheville. Further downstream, major tributaries are Ditches 47 and 1, Tyronza River, and Blackfish Bayou, draining similar areas. The river from the siphon to Huxtable Pumping Plant has probably a uniform level of agrichemical contamination throughout. The water at the foot of St. Francis Lake also originates as agricultural runoff. Flows from the east side from Wappapello to Crowleys Ridge are joined in the Floodway from the Ridge to St. Francis Lake by five sleeved-entrance tributaries: Varney River, Big Slough, Locust and Eight-Mile Creeks, Thompson's Creek, and Cockle Burr Slough. However, there is a difference in final effect. Contaminated water in the river and its tributaries collects and flows steadily. But equally contaminated water in the floodway and the lake overflows the old meandering, and in places choked, original river channel, and is frequently overbank between the levees. Though some of the floodway is farmed, there are several reaches where the slowing and filtering effects remove some of the contaminants that have been adsorbed by suspended solids. In the major drainage area above Big Lake, runoff is equally contaminated, and with better interior channels the Big Lake Floodway causes only minor decontamination. In summary, water available to siphon transfer is less contaminated than that in the river, though any adequate quantification would require excessive time and money, since many variables influence the result. But it is clear that siphon operation does make some water quality improvement in the river downstream.

II-09. GATE MAINTENANCE.

The St. Francis Lake control gates in Oak Donnick Floodway will at times need maintenance. The two gate-chambers have entrance and exit stoplogs. For some maintenance operations, if the flow can be handled by one side, the other can be dewatered without a problem. But maintenance adjacent to the structure could require diversion of all flow. In some circumstances the siphon could perform this diversion, without causing damage along the river downstream. Thus, siphon operability could provide an advantage under some conditions.

II-10. EMERGENCY OPERATIONS.

In that part of the Floodway below St. Francis Bay, where siltation of the channel continues to be serious, channel maintenance by silt removal was badly needed, was authorized, and was begun. The work was halted by the discovery of the presence of an endangered species. It is not now foreseen when, if ever, this remedial channel restoration can be resumed. The resulting reduction in Floodway capacity has already raised the flowline of the project design flood enough to seriously reduce the Floodway levee freeboard, thus reducing the degree of protection of the eastward protected area. It can occur that a combination of severe storms could produce upstream indications which would enable predictions of an approaching crest which would overtop and crevasse some part of the vulnerable levee reach. Under these conditions, some relief to the critical reach could be provided by operation of the siphons. If, before the Floodway crest arrived, all three siphon barrels were started there would be a diversion of flow from the Floodway, amounting to several thousand cfs. It is also recognized that, with storms of such postulated severity as to produce a Floodway flow of this magnitude, the interior drainage system of the River and its tributaries would be unable to prevent overbank flooding in much of the protected area, and Huxtable Pumping Plant would already be operating at full capacity. Partial relief of the Floodway by siphon diversion would add to the Huxtable load and would increase the existing interior flooding along the River. But the increase in interior damage would be far less than that caused by a major crevasse. This concept resembles the use of a controllable spillway, and its use would only be by command decision to prevent a predicted certain disaster. Repair of the siphon will retain flood fight capability that would be an essential emergency relief.

II-11. AESTHETIC EFFECTS

In PERTINENT CORRESPONDENCE, a letter of 2 November 1982 from Drainage District 7 of Poinsett County, Arkansas, refers to the concern of Marked Tree residents that the siphon should remain available for maintaining low water flow in the River. On 23 June 1982 in an informal conference with DD7 on the beginning of this study, they provided data of value.

The Board was told that no public meeting was planned for this study, due to its constraints in time and money. It has become apparent that the general public in the area has been slow to learn of the possibility of losing the siphon's operation, but since the time of the letter mentioned above there have been more oral statements to Board members and employees by many residents of the affected area, both rural and urban. Those who do not use the water for fishing, irrigation, or any other specific purpose say simply that the River looks better with more water in it; some refer to the faster current resulting from deeper water. These attitudes are more pronounced among those to whom the River is visible from their residences. Aesthetics relates to the enjoyment of beauty, and beauty may be only

the opinion of the observer. But for a large number of residents along the River, it is their opinion that in dry periods the River is more beautiful when lowflow is augmented by the siphon. For these people, there is a real aesthetic effect of value in preserving operability of the siphon.

II-12. HISTORICAL SIGNIFICANCE.

In paragraph III-02, SIPHON DISCHARGE CAPACITY, the outstanding hydraulic efficiency of 97.1% and the refinements producing it are discussed in detail. Such high efficiency may possibly be found in the automatic regulating siphon spillways cast in place in some high concrete dam. But for any siphon over an earth embankment, of the size and capacity of these barrels if such exist, this refinement of design has produced an efficiency which is believed unique. The structure is a credit to the U. S. Army Engineers of the Division and District Offices who designed and constructed it, and adds to the total knowledge of the profession of hydraulic engineering. Though this value is unquantifiable and intangible, it is presented for consideration in justification of repair.

SECTION III - HYDROLOGY AND HYDRAULICS

III-01. LOWFLOW DISCHARGE COMPUTATIONS

The original justification for the siphon, as a replacement for the destroyed "sluiceway", was lowflow augmentation for downstream navigation. This need no longer exists. At the present time consideration is being given to the need for lowflow augmentation for other purposes. The period 15 July - 15 August is the time of maximum withdrawal of pumped-out irrigation water from the river downstream. The month of October is historically the time of minimum lowflow in the interior river system. Thus there is needed for these two seasonal periods an estimation of lowflow, without siphon augmentation, in the river between the siphon and Huxtable Pumping Plant.

III-01-a. General Process.

Reference is made to "Review Report, St. Francis River, Drainage District 7 of Poinsett County, Arkansas", later published as SD 57/89/1. Appendix D contains a Water Resources Study by the U. S. Public Health Service, which presents an analysis of 95% exceedence lowflows in the St. Francis River at the Marked Tree gage. In Table VI-2, values are given in acre-feet per month. These are converted to monthly average lowflow in cubic feet per second. At the time of that study, the drainage area above the Marked Tree gage was 495.40 square miles. It is accepted that lowflow is only groundwater return, without stormflow crest timings, and is thus related directly to the drainage area. For the drainage area at any point of interest in this system, lowflow can be derived as: $Q = CM$. From data in the cited study, the values of C were derived for the two seasons of interest. Cumulative values of M were derived for all points of interest. Dividing the river into 9 reaches, determined by entrances of major tributaries and other factors, the lowflows at the head and foot of each reach were computed.

III-01-b. Lowflow Supply for Irrigation.

For the maximum withdrawal period, 15 July - 15 August, lowflows without siphon augmentation were computed. The value of C for this period having been determined, lowflows at the head and foot of each reach were computed as $Q = 0.4350\ M$. These values are used in the consideration of irrigation riverwater needs.

III-01-c. Minimum Lowflow Conditions.

In consideration of environmental values in the downstream river, the minimum month of October was believed significant in regard to flows without siphon augmentation. The value of C for this month having been determined, lowflows at the head and foot of each reach were computed as $Q = 0.1673\ M$. These values are used in the environmental analysis of fisheries and other biological needs in the downstream river, being without siphon augmentation.

III-02. SIPHON DISCHARGE CAPACITY

The refinements of design and construction of the 3 identical siphon barrels resulted in an outstanding hydraulic efficiency. All joints were butt-welded, with the inside seam beads ground smooth. The main barrel is round with a 9' diameter. The outlet end, slanting down at about 45 degrees, is 35' long and flares horizontally to a flow area at the exit which is 2 times the flow area of the round barrel. The outlet flare angle is 5.7 degrees, or 1' in 10'. The inlet end, slanting at about 48 degrees, flares in a length of 23' to an inlet flow area which also is 2 times the flow area of the round barrel. The bends connecting the ends to the barrel have about a 25 foot centerline radius. In the original design the entrance, exit, bend and friction losses were so estimated as to rate each barrel at: $Q = 0.814\ A\ (2gH)^{\frac{1}{2}}$. In repeated discharge measurements the actual barrel rating was established beyond question as: $Q = 0.971\ A\ (2gH)^{\frac{1}{2}}$. It became clearly evident that the refinements had been justified. Entrance lip loss is minimal, convergence is without turbulence, bend loss is very small, friction loss is almost as low as glass, and non-turbulent expansion in the long-tapered outlet effectively reduces exit velocity by one-half. Since the actual measured discharge is 97.1% of the theoretical no-loss discharge for the same head differential, it is operating with only a 2.9% loss of total energy. This 97.1% efficiency was not thought to have been achievable under conditions other than those of laboratory models. Each barrel actually does discharge $495.38\ H^{\frac{1}{2}}$ cfs.

III-03. HISTORICAL HYDROGRAPHS, ST. FRANCIS LAKE

Stage hydrographs at the Upper Lock gage, for with-siphon and without siphon conditions, were provided for the economic evaluation of damages associated with the period 1976 to present. This period was selected because of the inconsistencies of lake operation prior to 1976 resulting from continual changes (mostly erosive in nature) in the drainage system. Actual daily discharges for this period were calculated from stage data and number of siphons operating. From the resulting discharge hydrograph the difference in stage for the without-siphon condition was derived from an estimated stage-volume relationship above the gage. The maximum difference between with and without-siphon conditions was estimated to be 0.3 feet.

When the siphon is operated, the flow in the St. Francis River is increased by a variable amount. When the siphon is not operated, all outflow from St. Francis Lake goes down the Floodway. Thus, repair of the siphon will keep the capability of River flow augmentation, and abandonment of the siphon will remove that capability. Since the environmental values of the two stream segments are related to the flow available during lowflow periods, in SECTION V-01-d several values are compared with relation to the future repair or abandonment of the siphon. These values must be considered in relation to a comparison of the physical characteristics of the two stream segments.

The River is defined as that portion of the St. Francis River which begins at the outlet of the siphon, River mile 132.67, and extends to the entrance of the Huxtable Pumping Plant, River mile 14.80. There are two cutoff artificial channel segments, Grassy Lake and Round Pond. The remainder of the River is highly meandered and has the usual pools and crossings of such natural streams.

The Floodway is confined by levees and Crowleys Ridge to retain overbank floods, but the Floodway channels have relatively high capacity. More than two-thirds of the Floodway channel is artificial, but there are three segments of natural channel below St. Francis Bay. The Floodway here considered begins at the foot of St. Francis Lake (SLSF RR), Floodway mile 73.50, and extends to the entrance of L'Anguille River, Floodway mile 5.50.

PARAMETERS	FLOODWAY	COMPARISON	RIVER
Channel Length	68.00 miles	x 173% =	117.87 miles
Natural Stream	20.80 miles	x 499% =	103.87 miles
Percent Natural	31%		88%
Channelized Parts	47.20 miles	x 30% =	14.00 miles
Percent Channelized	69%		12%
Lowflow Water Surface			
Siphon Abandoned	2,225 acres	x 142%	3,150 acres
Siphon Repaired	2,210 acres	x 149%	3,293 acres
Access Road Approaches	35	x 383% =	134
Riverbank Roads, Public	15.8 miles	x 396% =	62.5 miles

The presence of the Huxtable Pumping Plant has two effects on the comparative values of the two waterways. Access from the Mississippi River for migratory replenishment of fish is unimpeded in the Floodway, while historically Huxtable gate closure has blocked migratory access to the River about 6 1/2% of the time. The elevation of the entrance weir at Huxtable provides a lowflow conservation pool averaging 15 feet deep and extending upstream about 18 miles; there is no lowflow conservation pool in the Floodway below the gates at the foot of St. Francis Lake.

Detailed HEP or HES comparative analyses are considered beyond the scope of this report.

SECTION V - BENEFIT EVALUATION

V-01 QUANTIFIED VALUES

V-01-a. Channel Maintenance Reduction.

As stated in paragraph II-02, operation of the siphon reduces the cost of channel maintenance by leaving less bank exposed for vegetative growth. In the 1964 Review Report mentioned in paragraph I-02-c the benefit of reduced maintenance cost was estimated as $2,000 per year. In the 1967 GDM 108, Oak Donnick Floodway, a new computation of this annual benefit gave a value of $2,500. No reduction is cost for twenty-year silt cleanouts was quantified. Continued channel maintenance experience now provides a better basis for estimating the four-year brushkill cost parameter as dollars/mile/foot of depth (of exposed bank). Various observations by local interests and others indicate that, in lowflow periods, the rise in water level when the siphon is started is about 4 feet in the reach above Marked Tree. This rise is diminished by the effect of downstream tributaries to about 1 foot at Huxtable Pumping Plant. In the 117.87 miles of River, the averaged effect of starting the siphon is a rise of about 2.5 feet. Current factors for brushkill cost in a channel having the average depth and side slopes of this portion of the River show the cost for both sides to be $161.78/mile/foot of depth (of exposed bank). Reduction of depth of exposed bank being 2.5 feet, the benefit of repairing the siphon rather than abandoning it is thus computed as $47,673 every fourth year, or an average annual equivalent value of $11,242, using 2½% interest and a 50-year repaired life.

V-01-b. Irrigation.

As discussed in paragraph II-03, a detailed field investigation of the use of River water for irrigation between the Siphon and Huxtable Pumping Plant was made in 1964, producing the data shown in Table II-03. These data have been revised to current conditions, based on interviews with Arkansas Extension Service County Agents and Soil Conservation Service Conservationists in the counties of interest, and other information from employees of Drainage District 7 of Poinsett. A consensus of the opinion of the informants was used to construct a change from 1964 to 1984 (beginning of the 50-year project life of the repaired siphon), with regard to the zone generally adjacent to the River, and considering their observations of trends. There is a decrease in the number of direct pump-out plants in use, whether barge-mounted or topbank with adjustable suction. There is an increase in well-pumps very near the River. All consider this as the use of River water, since the well lift will be only about 5 feet more than a lift from the River water surface; groundwater level in these close wells varies with the River's variation and not with rainfall. It is thus accepted that well-pump withdrawal from the River-maintained adjacent aquifer is an equivalent to River pump-out withdrawal, but with equipment less costly to install, operate, and maintain. It appears that, within the River-water supply zone, there is about a 28% increase in irrigated acres, and a change in cropping pattern from about 16% rice to about 26% rice. It is said that rice averages 2.5 feet of irrigation water per season compared with about 1.0 foot of irrigation water for various combinations of other crops. Resolution of the indicated factors shows an increase of 43% of former River irrigation water, and the above-stated 28% increase of River-irrigation acres. These increases produce the data shown in Table V-01-b(1), 1984 conditions. Projection increase factors found in "Lower Mississippi River Comprehensive Study, 1974, Appendix H: Irrigation" for WRPA 2 and LRA 131 "Delta" have been adjusted as influenced by opinions of the above-described informants. It is believed reasonable to predict for the interval 1984 to 2034 (50-year life of repaired siphon) an increase of 49% of 1984 River irrigation water, and an increase of 42% of 1984 acreage irrigated from the River. These increases produce the data shown in Table V-01-b(2), 2034 conditions. In this table, for the 9 reach subdivisions, the 95% exceedence lowflow for July-August without siphon augmentation is shown, derived as stated in paragraph III-01-b. It is seen in the three columns at the right of the table that in all reaches there is an adequate surplus of River lowflow without siphon augmentation, after the predicted 50-year growth. Although another unquantified siphon effect on irrigation power consumption is discussed in paragraph V-02-a, it cannot here be shown that siphon augmentation is needed for the predictable use of River water for irrigation. Major changes in world demand for rice could create such a need, but any attempt to quantify the magnitude and timing of such changes would be conjectural. No siphon repair benefit for irrigation is quantified.

TABLE V-01-b(1) 1984 CONDITIONS
PROJECTED IRRIGATED ACREAGE AND RESIDUAL FLOWS

RIVER MILE	LOCATION	REACH	PROJECTED IRRIGATED	POTENTIAL IRRIGABLE	ADDED RIVER Q cfs	PUMPED OUT Q cfs	RESIDUAL RIVER Q cfs
132.67	SIPHON EXIT				+ 63		63
		1	768 Ac	1,401 Ac	+ 6	-14	55
130.25	ENTR. LHCLR		384		+ 74	- 9	120
		2	1,280	6,227	+ 3	-30	93
121.60	ENTR. D47+D1				+ 20		113
		3	612	26,734	+ 31	-34	110
79.44	ENTR. TYRONZA R.				+284		394
		4	1,135	10,188	+ 20	-56	358
65.80	HD. GRASSY LAKE C.O.						358
		5	102	2,921	+ 4	- 6	356
61.00	FT. GRASSY LAKE C.O.						356
		6	1,050	4,284	+ 8	-30	334
54.00	HD. ROUND POND C.O.						334
		7	0	6,296	+ 19	- 0	353
44.80	FT. ROUND POND C.O.						353
		8	1,536	7,573	+ 5	-34	324
38.25	ENTR. BLACKFISH BAYOU				+274		598
		9	768	15,612	+ 65	-17	646
14.80	HUXTABLE PUMPING PLANT						646
PROJECTED 1984			7,635 Ac(9%)	81,236 Ac	+876(26%)	-230	646

TABLE V-01-b(2) 2034 CONDITIONS
PROJECTED IRRIGATED ACREAGE AND RESIDUAL FLOWS

RIVER MILE	LOCATION	REACH	PROJECTED IRRIGATED	POTENTIAL IRRIGABLE	ADDED RIVER Q cfs	PUMPED OUT Q cfs	RESIDUAL RIVER Q cfs
132.67	SIPHON EXIT				+ 63		63
		1	1,090 Ac	1,401 Ac	+ 6	-21	48
130.25	ENTR. LHCLR		545		+ 74	-13	109
		2	1,818	6,227	+ 3	-45	67
121.60	ENTR. D47+D1				+ 20		87
		3	869	26,734	+ 31	-51	67
79.44	ENTR. TYRONZA R.				+284		251
		4	1,612	10,188	+ 20	-84	371
65.80	HD. GRASSY LAKE C.O.						287
		5	145	2,921	+ 4	- 9	282
61.00	FT. GRASSY LAKE C.O.						282
		6	1,491	4,284	+ 8	-45	245
54.00	HD. ROUND POND C.O.						245
		7	0	6,296	+ 19	- 0	264
44.80	FT. ROUND POND C.O.						264
		8	2,181	7,573	+ 5	-51	218
38.25	ENTR. BLACKFISH BAYOU				+274		492
		9	1,091	15,612	+ 65	-25	532
14.80	HUXTABLE PUMPING PLANT						532
PROJECTED 2034			10,842 Ac(13%)	81,236 Ac	+876(39%)	-344	532

V-01-c. Flood Control (see paragraph II-04)

Lake Farming, Crop Loss Reduction, General Procedure

Without and with project expected annual crop damages within St. Francis Lake were estimated as arithmetic averages of calculated crop losses for the two conditions over the period from February 1976 through July 1982. This approach was taken since the period of record was relatively short (although it probably covers the range of operation of the siphon considering the constraints on its use imposed by the elevation of the receiving waters) and the fact that even with siphon, farmers vary their planting dates to accommodate weather conditions and accept the resultant yields. This period was judged to be the only representative record of hydrologic conditions since the Oak Donnick flood control gates were not functional prior to that period. Crop losses were calculated through the use of the computer program, "Computerized Agricultural Crop Flood Damage Assessment System" (CACFDAS) developed by Mississippi State University for the Vicksburg District and subsequently revised for the Lower Mississippi Valley Division. Crop inundation reduction benefits are quantified as the difference between without and with project damages. The CACFDAS program estimates crop losses over a historic or simulated period of record through the integration of data contained in three input files:

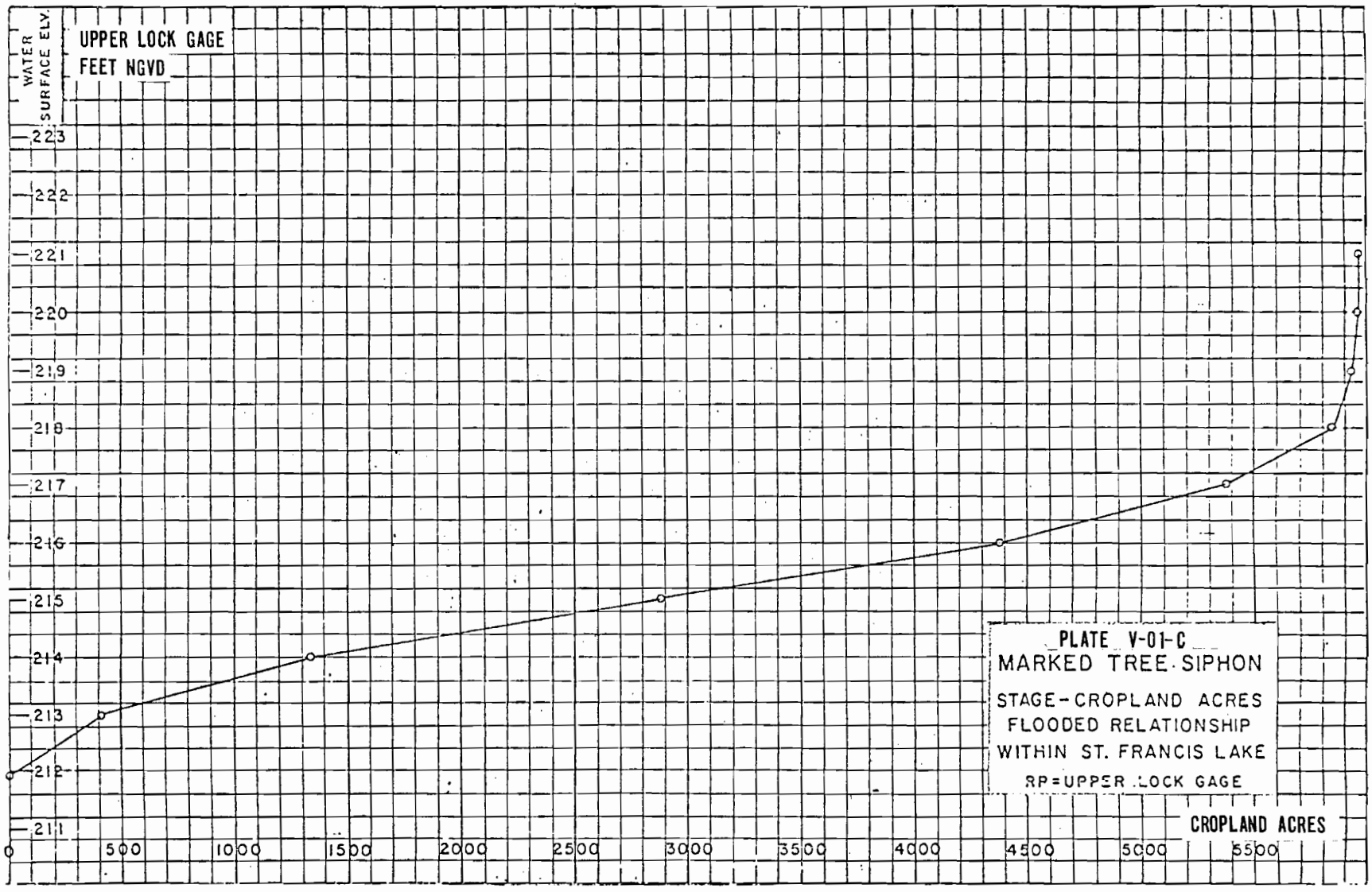
(1) A daily cropland acres flooded history for the period of record;

(2) Crop budget information containing the cost of production operations for each crop, dates the operations are performed, and the critical duration of flooding during each operation which will cause damages; and

(3) Crop control information which contains expected net and gross return values for each crop, crop substitution patterns, and critical dates for replanting of flood damaged crops.

Daily Cropland Acres Flooded History

A daily cropland acres flooded record was developed for both without and with project conditions by integrating a stage-cropland acre flooded relationship for St. Francis Lake with daily stage-hydrographs for the period February 1976 through July 1982. The common reference point for each relationship is the Upper Lock gage located on the northeast wingwall of the siphon inlet. Cropland locations in St. Francis Lake were determined by 1977 aerial photos of the region, reaffirmed by field inspection. Ground elevations within these areas were ascertained from topographic maps and survey information which was available from a prior study. A relationship between ground elevation and cropland acres flooded was developed by planimetering cropland acres flooded over the ground elevations between 210.0 feet and 223.0 feet in one foot increments. This relationship was adjusted


WATER SURFACE ELV.
UPPER LOCK GAGE
FEET NGVD
223
222
221
220
219
218
217
216
215
214
213
212
211
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
CROPLAND ACRES
PLATE V-01-C
MARKED TREE SIPHON
STAGE - CROPLAND ACRES
FLOODED RELATIONSHIP
WITHIN ST. FRANCIS LAKE
RP = UPPER LOCK GAGE

to account for differences in water surface elevations at the various crop fields and the water surface elevation at the Upper Lock gage. Collation and summation of this adjusted data yielded the stage-cropland acres flooded relationship presented on Plate V-01-c.

Stage-hydrograph information for repaired siphon conditions was taken from daily Upper Lock gage readings for the period February 1976 through July 1982. The abandoned siphon stage-hydrograph was derived by calculating the discharge through the siphon for each day of this period, translating this discharge to a water elevation differential through a rating curve for St. Francis Lake, and adding the resulting differential to the repaired siphon gage reading for the corresponding day.

The stage-cropland acres flooded relationships were integrated with the stage-hydrographs through their common variable to yield a daily acres of cropland flooded record for abandoned and repaired siphon conditions, which was disaggregated by year and used as input to the CACFDAS program.

Crop Budgets

Crop budgets were developed by modifying generalized Arkansas crop budgets as published by the Arkansas Crop and Livestock Reporting Service by field observation of production practices in St. Francis Lake. These adjusted crop budgets were further modified and results calibrated using historic information on planting dates, yields, and historic damages provided by lake farmers. Two sets of crop budgets were developed for St. Francis Lake for each year of the period of record, one for cropland experiencing flooding from water elevations above 217.0 feet on the Upper Lock gage and one for cropland experiencing flooding from water elevations of 217.0 and below. These two areas were judged to be sufficiently different in cropping patterns and flooding problems to warrant the distinction. Croplands subject to flooding at 217.0 feet or below on the Upper Lock gage are planted exclusively in soybeans while croplands subject to flooding from elevations above 217.0 feet have a small percentage of milo and cotton in addition to the soybeans. No double cropping takes place in either zone nor is there any projected land use change over the period of analysis. There were no projected differences in farming practices or cropping patterns between abandoned and repaired siphon conditions.

Crop Control Information

Information on gross and net revenue values for crops in the study area are based upon current normalized prices provided by the U.S. Water Resources Council for Fiscal Year 1982 adjusted to constant 1981 dollars. Benefit estimates based upon unadjusted current normalized prices are also presented in the paragraphs on sensitivity contained

in Section VII. Expected net returns are dependent upon yields which have varied over the period of analysis, largely as a result of delayed planting dates. The presence of the siphon does not affect these planting dates to any appreciable extent and there are thus, no differences in yields between abandoned and repaired siphon conditions. Since there was a considerable difference in planting dates over the period of record (ranging from the end of May to the end of July), separate crop control information was developed for each year of this period. Information gleaned from St. Francis Lake farmers, historic gage readings, and rainfall data were employed in the development of the crop control input.

Crop Damages

Crop damages for both abandoned and repaired siphon conditions were estimated through the CACFDAS program and resultant damage estimates for with siphon conditions for each year from 1976 through July 1982 (which corresponds to the actual field conditions for this period) were compared with actual losses, yield reductions, and replants for the corresponding year as provided by St. Francis Lake farmers. The inputs to the CACFDAS were changed in some instances to calibrate crop damage loss estimates generated by CACFDAS to the actual losses. A major St. Francis Lake farmer provided the bulk of the information necessary for alteration of input data. Having thus calibrated the program, abandoned siphon damage estimates were obtained from CACFDAS by combining crop budget and crop control information for repaired siphon conditions with the stage-cropland acres flooded history simulated for abandoned siphon conditions.

Results

As stated earlier, farmers in St. Francis Lake adjust the timing of their farming operations to the flooding situations they are experiencing or that they anticipate. In following these practices, they often experience reduced yields (and, therefore, reduced net returns), but seldom a complete crop loss. Over the period from February 1976 to July 1982, there were only two situations in which flooding per se caused crop losses: (1) a fall flood during the lay-by season in 1977[1/], and (2) an early spring flood during 1981 which necessitated a replant with the accompanying increased production costs and reduced yields. Computer simulation for repaired siphon conditions estimated the total net losses from these two floods to be $294,200. When abandoned siphon stage-cropland acres flooded data was run with the same crop budgets and crop control inputs, the resulting

1/ Although this loss could not be substantiated through phone interviews with St. Francis Lake farmers, the time of year and water elevations would seem to indicate that losses should have occurred.

outputs also revealed damages only for the years 1977 and 1981. Total damages estimated under abandoned siphon conditions for 1977 and 1981 equaled $339,200. Total flood damage reduction benefits for this six and one half year period therefore are estimated to be $45,000 yielding an average annual benefit of $6,900. This estimate is taken to be the expected annual value of flood inundation reduction benefits for project base year 1984. The 2034 expected annual value was estimated by indexing this 1984 value by a factor derived from the historical trend of the Productivity Index for the Delta States published by the Economic Research Service, USDA (Economic Indicators of the Farm Sector: Productivity and Efficiency Statistics, 1979, Statistical Bulletin No. 65, Table 68, page 89). A linear regression was performed on the data presented in this table which yielded the following equation:

$y = -3540.6601 + 1.8520906X$, where
X = year; and
Y = productivity index number relating units of output to units of input.

This regression equation was employed to estimate productivity index numbers for 1984 and 2034, from which an index factor was calculated. The index factor for 2034 using a 1984 base is 1.6916 and, thus, 2034, inundation reduction benefits are estimated at $11,700.

A benefit stream over the period of analysis was constructed by assuming a linear growth rate of benefits. This stream was discounted to the beginning of 1984 and amortized over 50 years at 2.5% to yield an average annual equivalent value of $9,100.

V-01-d. Aquatic-Based Values.

Derivation of Input Parameters

Repair of the siphon will continue the present capability of River lowflow augmentation, while abandonment would send all lake outflows down the Floodway at all times. Estimates of the average six-month non-flooding-period flows are 3500 cfs down the River, including 500 cfs siphon augmentation, and 3500 cfs down the Floodway. Abandonment of the siphon would reduce the River flow to 3000 cfs and would increase the Floodway flow to 4000 cfs. For quantifying the environmental effects of the changes, user-man-days-per-acre quantities were estimated for the "no-cost" abandoned condition, then modified by a change factor derived as one-half the percent of flow change, to get comparable quantities for the repaired condition. Selection of values per man-day enabled derivation of values per acre. The acreages being known, the resulting annual values of sportfishing and general aquatic recreation were compared for abandoned and repaired conditions in the River and in the Floodway. Commercial fishing values were obtained by a different procedure described in paragraph V-01-d(3). Table V-01-d(4) shows the application of the process discussed above. Water surface area acres were estimated by a generalization of available cross-sections of the River and Floodway channels. With the siphon operating, surface area of the River was estimated as 3293 acres and of the Floodway as 2210 acres. With the siphon abandoned, the depth of flow in the 117.87 miles of 1:2 side-slope River channel would be decreased by 2.5 feet, decreasing the surface area by 143 acres, leaving 3150 acres. With the siphon abandoned, the depth of flow in the 68 miles of 1:½ side-slope Floodway channel would be increased by 1.85 feet, increasing the surface area by 15 acres, total area 2225 acres. These values are shown in Section IV. Man-day analysis discussion follows.

Man-Day Analysis

A man-day analysis was conducted to determine the potential impact that abandonment of the siphon would have on both the consumptive and nonconsumptive recreational value of the affected Basin area. The water surface acreages were computed for both conditions for the Oak Donnick Floodway and the St. Francis River. Man-day values were derived from a comparison of values for similar riverine systems in Arkansas, from correspondence and discussions with the Arkansas Game and Fish Commission, and from historical data provided by the U. S. Fish and Wildlife Service.

Monetary values were assigned to the man-day usage in compliance with the guidance set forth in Principles and Standards for Water and Related Land Resource Planning, as amended in 1981. These two values were multiplied together to give the existing dollar value per acre for a particular recreational resource type.

Impacts associated with the repairs to the Marked Tree Siphon for the purposes of man-day analysis were divided into those impacts to the floodway and to the St. Francis River.

Under repaired siphon conditions, the average annual flow in the St. Francis River will be approximately 3,500 cfs--the Oak Donnick Floodway has an average annual flow of 3,500 cfs. With siphon abandonment, the river would lose about 500 cfs which would be diverted to the floodway as shown in table below:

	Abandoned Siphon	Repaired Siphon
River	3,000	3,500
Floodway	4,000	3,500

Low flow conditions in both the floodway and river are considered to be the most critical or stressful time of the year for aquatic resources. It is estimated that there is a six month interval when low flow conditions can occur in the river, and thus when the siphon could be in operation. There is sufficient rainfall during the other six months to provide for enough flow in the river to deactivate the siphon. In assessing the impacts of alternatives to both channels (floodway and river), two factors were considered: the estimated time when the siphon would be in operation and induced difference in flows with or without siphon operations. Since water surface acreage for the alternatives will remain almost the same for the river and for the floodway, the changes in water flow instead of water surface acreage were taken into account when deriving man-day usage values. For example, with siphon abandoned, the average annual flow in the river would be reduced by about 16.7 percent. Conversely, flows in the floodway would be increased 12.5 percent since low flows would be diverted to floodway during 6 months of the year. Working from this premise, the changes in the man-day use per acre were considered to be directly proportional to the percent changes in flow.

Table V-01-d(4) presents the man-day values expected to occur with both alternatives. Siphon repair or abandonment is estimated to be completed during FY 83. Environmental impacts are anticipated to occur immediately and no change in the level of recreation activity is projected over the period of analysis. Therefore, the expected annual benefit values calculated here are constant over the time period of analysis and are numerically the same as their annual equivalent values.

With siphon operation, it is assumed that low flow releases in the river would occur only during three months of the year. In these three months there would be a 6.25 percent change in flow for the Oak Donnick Floodway. Therefore, the St. Francis River would show an 8.30 percent increase (or one-half of the percentage difference in flow) in sport fishing and an 8.30 percent increase in general outdoor recreation and commercial fishing. However, there would be a 6.25 percent decrease in all activities for the Oak Donnick Floodway. For siphon repair, there would be a net annual benefit of $16,371 for the river and a net loss of $14,469 for the floodway.

V-01-d(1). General Outdoor Recreation for Floodway and St. Francis River

Nonconsumptive outdoor recreational activities such as boating, swimming, and hiking are limited in the St. Francis River Basin due to the lack of facilities to accommodate them and less than ideal water quality in both the Floodway and the St. Francis River for water contact sports.

The human usage rate (annual man-days per acre) of the land and water varies according to the type of activity, quality of the habitat and location and accessibility of an area. For the purpose of this study, a man-day is achieved by a recreationist making a trip for the purpose of engaging in an activity. The usage rates (man-day usage) for nonconsumptive outdoor recreational activities were derived from available data bases. General recreation man-day usage for repaired siphon conditions is predicated on 560 trips per year on 3,293 acres (1,332 ha) or .17 man-days/acre for the St. Francis River. For the Floodway, general recreation man-day usage for repaired siphon conditions is predicated on 287 trips per year on 2,210 (894 ha) or .13 man-days/acre. Set values for each type of general recreation are derived subjectively from Water Resources Council's Principles and Standards (1981). General outdoor recreation (swimming and recreational boating) are valued at $1.80 for the Floodway and $2.00 for the St. Francis River. A lower monetary value for the general recreation was assigned to the floodway because access to its water is limited due to a lack of roads and the large extent of private land in the floodway. Table V-01-d(4) shows values in the river and in the floodway for repaired siphon and for abandoned siphon.

V-01-d(2). Sport Fishing in the River

That portion of the St. Francis River below the Marked Tree Siphon has remained mostly unchannelized, but existing streambank vegetation has suffered from the encroachment of agricultural practices. The "greenway" adjacent to the river varies considerably along its route due to the relief of the land and the subsequent floodplain with adjacent wetland areas. Species which contribute to sport fishing include catfish, black bass, white bass, bluegill, crappie and bream. With the siphon abandoned, water surface area in the River would decrease from 3293 acres to 3150 acres.

Values for the angler-day usage were derived from discussions with the Arkansas Game and Fish Commission and several documents on river basins with features similar to the St. Francis River. Sport fishing man-day usage under abandoned siphon conditions is projected on 3,150 acres (1,274 ha) to be 21,767 trips per year or 6.91 man-days per acre. The monetary value assigned to a man-day of sport fishing is $4.10, utilizing the highest value possible for generalized fishing activities per Principles and Standards (1982). Therefore, multiplying the abandoned siphon fishing man-days by this dollar value and 143 acres less surface gives an abandoned siphon total sport fishing recreational value of $89,240. Summary of man-day and monetary values for sport fisheries is shown on Table V-01-d(4). With repaired siphon, the value would increase to $100,996, a gain of $11,756.

Sport Fishing in the Floodway

While the extent of sport fishing supplied in the Oak Donnick Floodway varies seasonally, its waters do provide recreational experiences. Due to past channelization within the Oak Donnick Floodway, siltation and lack of aquatic faunal habitat have placed some limitations on the existing commercial fishery resource. Currently, sport fishing has slacked off within the floodway due to a lack of aquatic habitat commensurate with the degree and frequency of channelization and follow up maintenance. However, Arkansas Game and Fish fisheries biologists have reiterated that currently, commercial fishing is still a profitable occupation in the floodway. Under repaired siphon conditions, 2,210 surface acres (894 ha) of fishery habitat are present within the floodway below the Marked Tree Siphon. With the abandonment of the Marked Tree Siphon, the water acreage within the Floodway would increase by only 15 acres due to the almost vertical side slopes of the banks in much of the channelization sections. However, water depth could increase by as much as 1 to 2 feet and flow by as much as 16.7 percent. There would also be an increase in aquatic habitat, dependent on seasonal rainfall.

Values of the angler-day analysis were derived from discussions with the Arkansas Game and Fish Commission and several approved documents on river basins with similar features. Sport fishing man-day usage with the siphon repaired is predicated on 10,144 trips per year on 2,210 acres (894 ha) or 4.59 man-days/acre. It is felt that this is a realistic figure since other water projects in the delta area of Arkansas with better access have 30 percent higher usage. The monetary value assigned to a man-day of sport fishing is $4.10, utilizing the highest value possible for generalized fishing activities according to Principles and Standards (1973), as amended in 1981. Therefore, multiplying the abandoned siphon fishing man-days by this dollar value gives a abandoned siphon total sport fishing recreational value of $44,700. The difference between $44,700 (the abandoned siphon annual equivalent value) and $41,592 (repaired annual equivalent value) shows an expected net annual fishing loss of $3,108 as shown in Table V-01-d(4), derived in the floodway from repair of the siphon.

V-01-d(3) Commercial Fishery in the Floodway

The total number of regular (full-time) commercial fishermen licensed to sell their catch from fishing in the Floodway is around 25. These fishermen derived most of their annual income from fishing. The number of casual (or part-time) fishermen who license a small amount of commercial tackle and use the catch for personal use or to supplement their income through trade to non-commercial outlets, is estimated at approximately 7 times the full-time commercial or approximately 175. This information has been generated through data from commercial fishery industry surveys for Arkansas.

Commercial fish harvest data is not available for the Oak Donnick Floodway. An estimated but very generalized dollar value for the annual commercial fish harvest for the Floodway was extrapolated from commercial fishery industry surveys for other river systems in the State of Arkansas, other documents on river basins with similar features and discussions with the Arkansas Game and Fish Commission. A total annual commercial catch in the Oak Donnick Floodway with abandoned siphon was estimated at 385,110 pounds at .47 cents a pound, with a value of $181,002. The bulk of the commercial harvest will be made up of principally buffalo (Ictiobus bubalus), channel catfish (Ictalurus punctatus), carp (Cyprinus carpio), and freshwater drum (Aplodinotus grunniens). Repair of the siphon with its resultant reduction of flow to the floodway will result in an estimated catch of 361,040 pounds with a value of $169,689, a decrease of $11,313.

Freshwater shell fishing also occurs in the Floodway; however, the amount of mussels removed from the Floodway system is unknown.

Additional information on recruitment and spawning data related to the increased commercial fishery in the floodway is outlined in Section VIII under paragraph titled, Commercial Fishery Productivity.

V-01-d(4). Commercial Fishery in the River

The number of individuals engaged in full-time commercial fishing in the St. Francis River below Marked Tree Siphon to above Huxtable Pumping Station is believed to be not more than 10. This number represents the number of regular or full-time commercial fishermen. Figures for casual or part-time fishermen were estimated and are similar to the floodway or approximately 7 times the full-time commercial fishermen.

By using data from surveys for commercial fish harvests for other river systems in Arkansas and discussions with the Arkansas Game and Fish Commission, the annual commercial fish harvest from the St. Francis River with abandoned siphon was roughly estimated at 115,426 pounds at .47 cents a pound with a value of $54,250. Channel catfish, buffalo and some carp and drum make up the commercial fish harvest. Repair of the siphon is estimated to increase the harvest to 125,006 pounds with a value of $58,753, a gain of $4,503.

Values on total mussel harvest are unavailable for the river, as in the floodway, but freshwater shell fishing still constitutes an important economic resource base in the area.

V-01-d(5). Summary Table of Aquatic-Based Values

The following summary table shows the computation of changes in values in the River and in the Floodway. Compared to the values with siphon abandoned, the net results, for the whole system, of siphon repair are:

General Outdoor Recreation	$ 64	Gain
Sport Fishing	$8,648	Gain
Commercial Fisheries	$6,810	Loss
Total Environmental Effect	$1,902	Gain

TABLE V-01-d(4)

Alternatives - Marked Tree Siphon - Summary of Man-Day Values

Study Area and Activity	Alternative	Man-Day Per Acre	Value Per Man-Day	Value Per Acre	Acres	Activity Dollar Value	Change in $ Value from Abandoned Condition
St. Francis River - General Outdoor Recreation	1. Abandon	.16	$2.00	$ .32	3,150	$ 1,008	$ 0
	2. Repair	.17	$2.00	$ .34	3,293	$ 1,120	$+ 112
St. Francis River - Sport Fishing	1. Abandon	6.91	$4.10	$28.33	3,150	$ 89,240	$ 0
	2. Repair	7.48	$4.10	$30.67	3,293	$100,996	$+11,756
St. Francis River - Commercial Fishing	1. Abandon					$ 54,250	$ 0
	2. Repair					$ 58,753	$+ 4,503
Oak Donnick Floodway - General Outdoor Recreation	1. Abandon	.14	$1.80	$ .25	2,225	$ 556	$ 0
	2. Repair	.13	$1.80	$ .23	2,210	$ 508	$- 48
Oak Donnick Floodway - Sport Fishing	1. Abandon	4.90	$4.10	$20.09	2,225	$ 44,700	$ 0
	2. Repair	4.59	$4.10	$18.82	2,210	$ 41,592	$- 3,108
Oak Donnick Floodway - Commercial Fishing	1. Abandon					$181,002	$ 0
	2. Repair					$169,689	$-11,313

Total Annual Values	St. Francis River	Change from Abandoned	Oak Donnick Floodway	Change from Abandoned
Abandon Siphon	$144,498	$ 0	$226,258	$ 0
Repair Siphon	$160,869	$+16,371	$211,789	$-14,469

Net Environmental Effect of Siphon Repair: $+1,902

V-02 UNQUANTIFIED VALUES

V-02-a. Irrigation

There is connected with irrigation an unquantified benefit from the repaired siphon in lowflow augmentation during the irrigation season. River water must be lifted from 15 to 25 feet, depending on the site. In tables V-01-b(1) and V-01-b(2) predicted capacities are from 230 cfs in 1984 to 344 cfs in 2034. The difference in power consumption is predicted on an estimated averaged difference of 2.5 feet in water surface elevation resulting from repair or abandonment of the siphon. It is beyond the scope of this report to accumulate the highly variable data such as energy requirements per year, installation efficiencies, and actual operating practices, so no attempt is now made to quantify the average annual saving in energy costs resulting from the higher river surface with siphon operation. There is clearly a real benefit, which would become more important with rising costs of fuel and electric energy.

V-02-b. Water Quality

Discussion in paragraph II-08 shows that sewage dilution in the River does not require siphon operation, but that agrichemical pollution in the River is reduced by the siphon in that it introduces water which is partly decontaminated by Upper Floodway and Lake action. Urban water supply does not use River water, and there is no known use as potable water by rural residents. But there is a real, though unquantified, reduction of pollution which has value in any water-contact use of the River.

V-02-c. Gate Maintenance

Refer to paragraph II-09. In planning the St. Francis Lake Control Gates in Oak Donnick Floodway, no structural major maintenance was anticipated. However, some work of that nature has already been done, without making a diversion channel; the siphon helped control flows. Should the need for future work of a different nature arise, the siphon could again make a diversion channel unrequired. Excavating a diversion around the east side of the structure would be relatively simple. Stabilizing the refilled diversion against Floodway overbank flows would be very expensive. If only one such event occurred in the next fifty years, the diversion cost could easily approach the cost of repairing the siphon. Estimation of the year of occurrence and determination of construction costs are beyond the scope of this report for quantification. But the diversion potential of the siphon for one or more unanticipated events should be preserved.

V-02-d. Emergency Operations

As stated in paragraph II-10, use of all three siphon barrels to reduce major flows in the Floodway would increase damage along the River to some extent, but in no way comparable to the disastrous damage caused by a major levee crevasse. The cost of retention of this relief capability by siphon repair is relatively small compared to the probable cost of such a catastrophe. Evaluation in terms of average annual equivalent benefit would be made on a probability basis, after estimating the value of damage caused by a levee failure. A flood which would overtop the vulnerable part of the levee can be assigned a certain recurrence interval in years, and the corresponding probability of occurrence in any year. If the diverted flow of the siphon is added to the flow of the crevassing flood, this larger flow is that of a flood of longer recurrence interval in years, and a lesser probability of occurrence in any year. Thus the siphon has the capability of increasing the degree of protection provided to the lower basin by the Floodway. If the difference between the "abandoned" probability factor and "repaired" probability factor is multiplied by the cost of levee failure damage, the resulting damage-prevented benefit should greatly exceed any predictable deficiency in excess benefits. Quantification of this analysis is considered beyond the scope of this report. A more important factor is that, unlike a deliberate crevasse with evacuation warnings, the postulated levee failure could very quickly flood low points in escape routes before rural residents could reach safety. This real danger to human life is not quantifiable.

V-02-e. Aesthetics

Operation of the siphon will add to the flow in the old St. Francis River channel thereby increasing the water surface elevation and area. This decreases the frequency of exposed bars/mud flats occurrence and decreases the vegetation growth below banks, in the channel. It would also increase fish population and waterfowl useage.

The old river channel will be more aesthetically pleasing as related wildlife (waterfowl) will be more abundant, the bottom will be exposed less frequently and the amount of dead in-bank vegetation which results from control by herbicide application would be decreased.

V-02-f. Flowage Easement Impacts.

In the design of the leveed Floodway below the Cross-Poinsett County line, the capability of diversion into the old River during a major flood had always been considered in determining the flowline from which flowage easements were derived. The earliest study referred to the gated culverts; in later design the siphons had replaced the culverts. Since the west side of the Lower Floodway is confined by the sloping land rising to the foot of Crowleys Ridge, there is a large acreage involved in flowage. Easements were obtained on 48,500 acres in 417 tracts, and 20,000 acres are still without easements.

Easements that have been obtained were based on 2600 cfs flow being diverted by the siphons down the old River during the design flood. Landowners involved are especially alert regarding any action which changes Floodway flows. For example, there was concern over the minor increase in Floodway drainage area caused by the diversion of Upper Buffalo Creek through Cockle Burr Slough Inlet. The time and cost of the hydraulic, appraisal, and acquisition studies needed to evaluate the impact of eliminating the capability of diverting 2600 cfs down the old River if the siphons are not repaired has not been evaluated. The benefit derived from avoiding the flowage claims by complete maintenance of the siphon is now unquantified. However, it is estimated that the total cost of handling these flowage easement adjustments plus the added payments to affected landowners would be more than the total first cost of full siphon repair of all three barrels.

V-03. HISTORICAL SIGNIFICANCE

The unique engineering aspects of the siphon have been described in paragraphs II-12 and III-02. For forty-three years this structure has augmented lowflow in the River downstream and has reduced crop losses on farms within the Lake. Though navigation needs no longer exist, other benefits of continuing the operability by repair are listed in Section V above. No approach has been made to any Historical Society, but far less worthy structures have been designated as having historical significance justifying preservation.

V-04. SUMMARY OF BENEFITS

INTRODUCTION

This portion of the report presents a summary of the total quantified benefits associated with repair of the Marked Tree Siphon as well as the overall framework in which they were calculated. Methodologies and calculation procedures are presented in Section V-01 of this report. Benefits in each category were estimated on the basis of the difference between flood related damages and water use potential projected under abandoned siphon conditions and those conditions projected to exist if the siphon is repaired.

There was no projected land use change between without and with siphon conditions or between existing and future time periods.

The period of amortization is 50 years. The common reference date for calculation of the present worth of all benefit and cost estimates is the beginning of 1984, the earliest point at which primary direct flood damage reduction benefits begin to accrue. The period over which primary direct flood benefits accrue is from the beginning of 1984 to the beginning of 2034. Values of present and future benefits are transposed into comparable units by referencing all estimates to a common point in time through standard discounting techniques and an appropriate interest rate. An interest rate of 2.50 per cent is the project interest rate applicable for the St. Francis Basin as a whole.

Average annual equivalent benefits at the current interest rate, 7.875%, are displayed in the sensitivity paragraphs located at the end of Section VII-02. Benefits and benefit-cost ratios are also shown for two sets of prices, current WRC prices and WRC prices modified to reflect constant price levels.

All monetized benefits are expressed in the latest available or approved price levels which are stated within the write-up of each category.

Benefit categories quantified in this report include Navigation Benefits, Reduced Channel Maintenance Benefits, Irrigation Benefits, Agricultural Inundation Reduction Benefits and Recreation Benefits.

V-04-a. Navigation Benefits

As indicated in paragraph II-01, there is no commercial navigation on the St. Francis River at this time nor is any projected over the period of analysis. Therefore, no benefits exist in this category.

V-04-b. Channel Maintenance Reduction

The need for lowflow augmentation to reduce channel maintenance costs is described in paragraph II-02 and is quantified in paragraph V-01-a. The average annual equivalent value is there shown as $11,242.

V-04-c. Irrigation Benefits

The analysis of availability of irrigation water and projections of irrigation needs presented in paragraph V-01-b of this report indicated that there will be an adequate supply of water over the projection period even without the low flow augmentation provided by the Siphon. There are, thus, no benefits attributable to this category.

V-04-d. Flood Control (Lake Farming Crop Loss Reduction)

Paragraph II-04 describes St. Francis Lake and the farming therein. Section V-01-c derives in detail the benefit of crop loss reduction by use of the siphon. The future benefit of continuing operation of the repaired siphon is shown to have an average annual equivalent value of $9,100.

V-04-e. General Recreation

General recreation associated with the affected waterways is discussed in paragraph V-01-d(1). As shown in the Summary Table V-01-d(4), recreation in the Floodway decreases in value from $556 to $508 with siphon repair, a loss of $48; recreation in the River increases in value from $1,008 to $1,120 with siphon repair, a gain of $112. The net benefit to general recreation from siphon repair is $64.

V-04-f. Sport Fishing

Sport fishing in the affected waterways is discussed in paragraph II-05 and is quantified in paragraph V-01-d(2). As shown in the Summary Table V-01-d(4), sport fishing in the Floodway decreases in values from $44,700 to $39,868 with siphon repair, a loss of $4,832; sport fishing in the River increases in value from $89,240 to $99,086 with siphon repair, a gain of $9,846. The net benefit to sport fishing from siphon repair is $5,014.

V-04-g. Commercial Fisheries

Commercial fishing is discussed in paragraph II-07 and the fishery values are quantified in paragraph V-01-d(3). As shown in the Summary Table V-01-d(4), commercial fishery value in the Floodway decreases from $181,002 to $169,689 with siphon repair, a loss of $11,313; commercial fishery value in the River increases from $54,250 to $58,753, a gain of $4,503. The net loss to future commercial fishing from siphon repair is $6,810. This annual loss is added to the total average annual equivalent costs, as stated in paragraph VI-04.

TABLE V-04
SUMMARY OF AVERAGE ANNUAL EQUIVALENT BENEFITS

Navigation Benefits	$ 0	
Channel Maintenance Reduction	11,242	
Irrigation	0	
Flood Control	9,100	1/
General Recreation	64	
Sport Fishing	8,648	
Total Benefits	$29,054	

1/ Benefits with use of unadjusted WRC prices would be $7,650. Total benefits would be $27,604.

SECTION VI - FIRST COSTS AND ANNUAL CHARGES

VI-01 FIRST COSTS OF REPAIR WORK

The repair work necessary for continued operation of the siphon is described in paragraph I-04. The cost estimates below are based on mid-1982 unit prices.

TABLE VI-01-a. REPAIR OF THREE BARRELS

Mechanical Job	
Equipment	$ 31,800
Remove and replace siphon pipe ends	331,780
Labor for blast cleaning and painting pipes	22,260
Supplies for repairing pipes	4,240
Miscellaneous material and labor	12,720
Electrical Job	6,800
Net Costs	$ 409,600
Contingencies 10% ±	41,400
Total Costs of Work	$ 451,000
E&D	50,000
S&A	51,000
TOTAL FIRST COST (Jul 82)	$ 552,000

TABLE VI-01-b. REPAIR OF ONLY ONE BARREL

Mechanical Job	
Equipment	$ 10,600
Remove and replace siphon pipe ends	110,590
Labor for blast cleaning and painting pipe	7,420
Supplies for repairing pipe	1,410
Miscellaneous material and labor	4,240
Electrical Job	6,800
Net Costs	$ 141,060
Contingencies 10% ±	14,100
Total Costs of Work	$ 155,170
E&D	17,240
S&A	17,590
TOTAL FIRST COST (Jul 82)	$ 190,000

VI-02 ANNUAL CHARGES OF REPAIR WORK

TABLE VI-02-a. REPAIR OF THREE BARRELS

Total First Cost	$552,000	$552,000
Amortization Factor, 2 1/2%	0.03526	
Amortization Factor, 7 7/8%		0.08057
Average Annual Equivalent Value	$ 19,464	$ 44,475

TABLE VI-02-b. REPAIR OF ONLY ONE BARREL

Total First Cost	$190,000	$190,000
Amortization Factor, 2 1/2%	0.03526	
Amortization Factor, 7 7/8%		0.08057
Average Annual Equivalent Value	$ 6,699	$ 15,308

VI-03 ANNUAL OPERATION AND MAINTENANCE

VI-03-a. Operation and Minor Maintenance

Estimated Non-Federal Annual Cost	$7,000

VI-03-b. Major Replacements

Major Replacement Costs are Estimated as:

Electrical	
In 5th year	2,000
In 10th year	3,000
In 20th year	5,000
In 30th year	5,000
In 40th year	5,000
Mechanical	
In 5th year	2,000
In 10th year	3,000
In 20th year	5,000
In 30th year	5,000
In 40th year	5,000

TABLE VI-03-b - AVERAGE ANNUAL EQUIVALENT COSTS, REPLACEMENTS

Year	Cost	Present Value Factor		Present Values of Costs	
		2½%	7 7/8%	2½%	7 7/8%
5	$ 4,000	0.88385	.68454	3,525	2,738
10	6,000	0.78120	.46859	4,687	2,812
20	10,000	0.61027	.21958	6,103	2,196
30	10,000	0.47674	.10289	4,767	1,029
40	10,000	0.37243	.04821	3,724	482
		Total Present Value		$22,816	$ 9,257
		Amortization Factor		0.03526	0.08057
	Average Annual Equivalent Value			$ 804	$ 746

VI-04 COMMERCIAL FISHING LOSSES

Commercial fishing in the River and in the Floodway is discussed in paragraph II-07. Changes in commercial fishery values in both streams, as affected by repair or abandonment of the siphon, are quantified in paragraph V-01-d(3). As stated in paragraph V-04-g, the net loss to commercial fisheries caused by repair of the siphon is included as an item in paragraph VI-05, TOTAL ANNUAL CHARGES.

VI-05 TOTAL ANNUAL CHARGES (Jul 82)

TABLE VI-05-a. Repair of Three Barrels

Average Annual Equivalent Costs	2 1/2%		7 7/8%	
	Federal	Non-Federal	Federal	Non-Federal
First Costs of Repairs	$19,464		$44,475	
Annual O&M		$7,000		$7,000
Major Replacements	804		746	
Commercial Fishery Loss	6,810		6,810	
TOTALS	$27,078	$7,000	$52,031	$7,000
	$34,078		$59,031	

TABLE VI-05-b. Repair of Only One Barrel

Average Annual Equivalent Costs	2 1/2%		7 7/8%	
	Federal	Non-Federal	Federal	Non-Federal
First Costs of Repairs	$ 6,699		$15,308	
Annual O&M		$7,000		$7,000
Major Replacements	804		746	
Commercial Fishery Loss	6,810		6,810	
TOTALS	$14,313	$7,000	$22,864	$7,000
	$21,313		$29,864	

SECTION VII - ECONOMIC JUSTIFICATION

VII-01 SENSITIVITY ANALYSIS CONSIDERATIONS

VII-01(a). Sensitivity Principles

Economic justification of the siphon repair is contingent upon the sensitivity of benefit and cost estimates to the assumptions, hypotheses, and variables used in the analysis. The sensitivity of economic conclusions to changes in these parameters is one measure of the certainty or uncertainty that one may attach to the conclusions.

The various benefit categories discussed here have significantly different contributions to the total benefits computed for each alternative. Tables VII-02-a and VII-02-b present the relative proportion of benefits contributed by each benefit category for the recommended plan. Obviously the sensitivities of those categories having the higher proportional contribution to the total are relatively more important.

VII-01(b). Interest Rates

Restoration of Marked Tree Siphon was analyzed using an interest rate of 2.50 per cent, the project interest rate for the St. Francis Basin as authorized. This is felt the appropriate rate to use in analyzing the repair of individual structures of this authorized project. For repair of three barrels the benefit-cost ratio is 0.85 and for only one barrel, 1.36. Tables VII-02(a thru d) present summariess of the benefit-cost analysis for Marked Tree Siphon restoration at the authorized and current interest rates.

VII-01(c). Project Life

This analysis was conducted using a project life of 50 years, the approximate useful life of the Siphon. The St. Francis Basin as a whole however has a project life of 100 years. The use of a project life of 50 years as opposed to 100 years will have no effect since the benefits and costs were compared in terms of average annual values and the fact that salvage values have no significant impact on the analysis.

VII-01(d). Adjustments to WRC Current Normalized Agricultural Prices

As stated in the paragraphs on agricultural inundation reduction benefits, current normalized agricultural prices as computed by the Water Resources Council have been adjusted for constant 1981 price levels. The value of one bushel of soybeans based upon these adjusted

prices is equal to $8.36 whereas unadjusted WRC Current Normalized Prices would value this same bushel of soybeans at $7.09. If agricultural inundation reduction benefits were based upon unadjusted WRC Current Normalized Prices, the estimated benefit presented in Section V-04-d would reduce from $9,100 to $7,650. This would result in a decrease in the benefit-cost ratio from 0.85 to 0.81, for repair of three barrels, and from 1.36 to 1.30, for repair of only one barrel.

TABLE VII-02-a. Marked Tree Siphon, Repair of Three Barrels
Comparison of Average Annual Equivalent Benefits and Costs

Project Life = 50 Years
Project Interest Rate = 2.50%

Costs

Item	Amount
First Costs	$19,464
Annual Operation and Maintenance	$ 7,000
Replacements	$ 804
Commercial Fishing Losses	$ 6,810
Total	$34,078

Benefits

Category	Unadjusted WRC Prices Amount	Percent Of Total	Adjusted WRC Prices Amount	Percent Of Total
Navigation	$ 0	(0)	$ 0	(0)
Reduced Channel Maintenance	$11,242	(41)	$ 11,242	(39)
Irrigation	$ 0	(0)	$ 0	(0)
Sport Fishing	$ 8,648	(31)	$ 8,648	(30)
General Recreation	$ 64	(0)	$ 64	(0)
Crop Benefits	$ 7,650	(28)	$ 9,100	(31)
Total	$27,604	(100)	$ 29,054	(100)

Benefit/Cost Ratio:

(a) Unadjusted WRC Prices 0.81
(b) Adjusted WRC Prices 0.85
(c) Adjusted B-C $ -5,024

TABLE VII-02-b. Marked Tree Siphon, Repair of Only One Barrel
Comparison of Average Annual Equivalent Benefits and Costs

Project Life = 50 Years
Project Interest Rate = 2.50%

Costs

Item	Amount
First Costs	$ 6,699
Annual Operation and Maintenance	$ 7,000
Replacements	$ 804
Commercial Fishing Losses	$ 6,810
Total	$21,313

Benefits

Category	Unadjusted WRC Prices Amount	Percent Of Total	Adjusted WRC Prices Amount	Percent Of Total
Navigation	$ 0	(0)	$ 0	(0)
Reduced Channel Maintenance	$11,242	(41)	$ 11,242	(39)
Irrigation	$ 0	(0)	$ 0	(0)
Sport Fishing	$ 8,648	(31)	$ 8,648	(30)
General Recreation	$ 64	(0)	$ 64	(0)
Crop Benefits	$ 7,650	(28)	$ 9,100	(31)
Total	$27,604	(100)	$ 29,054	(100)

Benefit/Cost Ratio:

(a) Unadjusted WRC Prices 1.30
(b) Adjusted WRC Prices 1.36
(c) Adjusted B-C $7,741

TABLE VII-02-c. Marked Tree Siphon, Repair of Three Barrels
Comparison of Average Annual Equivalent Benefits and Costs

Project Life = 50 Years
Current Interest Rate = 7.875%

Costs

Item	Amount
First Costs	$44,475
Annual Operation and Maintenance	$ 7,000
Replacements	$ 746
Commercial Fishing Losses	$ 6,810
Total	$59,031

Benefits

Category	Unadjusted WRC Prices Amount	Percent Of Total	Adjusted WRC Prices Amount	Percent Of Total
Navigation	$ 0	(0)	$ 0	(0)
Reduced Channel Maintenance	$11,242	(41)	$ 11,242	(39)
Irrigation	$ 0	(0)	$ 0	(0)
Sport Fishing	$ 8,648	(31)	$ 8,648	(30)
General Recreation	$ 64	(0)	$ 64	(0)
Crop Benefits	$ 7,650	(28)	$ 9,100	(31)
Total	$27,604	(100)	$ 29,054	(100)

Benefit/Cost Ratio:

(a) Unadjusted WRC Prices 0.47
(b) Adjusted WRC Prices 0.49

TABLE VII-02-d. Marked Tree Siphon, Repair of Only One Barrel
Comparison of Average Annual Equivalent Benefits and Costs

Project Life = 50 Years
Current Interest Rate = 7.875%

Costs

Item	Amount
First Costs	$15,308
Annual Operation and Maintenance	$ 7,000
Replacements	$ 746
Commercial Fishing Losses	$ 6,810
Total	$29,864

Benefits

Category	Unadjusted WRC Prices Amount	Percent Of Total	Adjusted WRC Prices Amount	Percent Of Total
Navigation	$ 0	(0)	$ 0	(0)
Reduced Channel Maintenance	$11,242	(41)	$ 11,242	(39)
Irrigation	$ 0	(0)	$ 0	(0)
Sport Fishing	$ 6,810	(31)	$ 6,810	(30)
General Recreation	$ 64	(0)	$ 64	(0)
Crop Benefits	$ 7,650	(28)	$ 9,100	(31)
Total	$27,604	(100)	$ 29,054	(100)

Benefit/Cost Ratio:

(a) Unadjusted WRC Prices 0.92
(b) Adjusted WRC Prices 0.97

VIII-01 AQUATIC HABITAT

The water surface acreage of the St. Francis Floodway is approximately 2,210 acres under normal flow conditions. If the Siphon is abandoned, all low flow water would be in the Oak Donnick Floodway. The added low flow would only increase the water surface to 2225 acres in the floodway due to its steep, eroded banks and deeply cut channels, and the lack of low-lying areas. However, low flows in the floodway would be increased by a depth of about 2 feet. The increased water depth in the floodway would benefit fish by providing additional volume within the aquatic habitat.

Increased flows in the floodway could beneficially affect the endangered fat pocketbook pearly mussel Proptera = (Potamilus) capax. The only known live population of P. capax in the St. Francis Basin was found in a ten mile reach of the St. Francis River from Madison, Arkansas to the upstream area of Clark's Corner Cutoff, approximately 45 miles south of the foot of St. Francis Lake. P. capax is primarily considered a large river species. It has been collected in a variety of habitat types from sand to mud substrates, in moderate to slow flowing streams, and at depths of only a few inches to 8 feet or more. Inundating presently exposed sand bars in the floodway channel during low flows could provide additional aquatic habitat or substrate for mussel utilization and its host species. Very little is known about the mussel's life history, its required host species and other habitat requirements.

The Fish and Wildlife Service, Atlanta Regional Office, by letter of 5 May 1981, stated that the repair of the Marked Tree Siphon would not likely jeopardize the continued existence of the fat pocketbook pearly mussel. However, the additional water afforded to the floodway as a result of siphon abandonment would not affect water quality and would probably have a stabilizing effect on the mussel's environs during normal low water periods in the system, since all waters entering the lake would then pass through the floodway.

The average annual surface acreage of the St. Francis River under study is approximately 3,293 acres. Without further detailed hydrologic studies, the water surface during low flow stages without the siphon operating is estimated as 3150 acres. However, without the additional water discharge through the siphon, the low water stages of the river would be decreased by about 2.5 feet. This decrease in water volume and depth would provide less habitat for fish, mussel and benthic organism utilization.

With siphon operation releases, increased flows during periods of low flow would provide an increase in habitat for adult fish; it is uncertain how much habitat improvement would be afforded to fry and

juveniles, which normally inhabit shallow waters with moderate currents.

Siphon abandonment would reduce water in the riverbed directly below the siphon. This reach of the river channel would not be dewatered, since it receives backwaters from a ditch located about 200 yards below the siphon, plus the river is fed by tributaries downstream. Reduced flows would have an adverse impact on aquatic habitat, particularly in the upper reaches of the study area where the river would receive no water from lake and river system. Incoming waters from tributaries provide only a small flow in the river, especially during a very dry season. Aquatic habitat just below the siphon would be most affected since this area provides good fishing opportunities and good quality habitat for fish by affording a food source from the Lake through siphon releases. The availability of aquatic habitat for adult fish utilization and macroinvertebrate productivity would be reduced throughout the study area.

VIII-02 VEGETATION

Siphon abandonment would reduce low flows and water depths in the river downstream throughout the study area. The exposed banks would become colonized by vegetation such as the water tolerant willows which would restrict flow, and fallen trees would tend to clog the waterway. Encroachment of vegetation would be particularly evident in the upper reaches of the study area just below the siphon and the downstream portions where incoming waters from tributaries are not that substantial. However, the flushing effect of high water flows during spring would probably hinder the growth of vegetation on the river banks and main channel for the middle and lower reaches of the study area.

VIII-03 COMMERCIAL FISHERY PRODUCTIVITY

The larger commercial fish harvest in the floodway is attributed to two primary factors. The first one is habitat suitability for the commercial fish species. In a natural stream where a greater diversity of habitat types occurs, there will be several different species occupying those specific habitats best suited for survival. These areas will be somewhat randomly distributed over the length of the river resulting in an overall population with a larger number of species but with few individuals in each species. This situation produces a high diversity.

In a channelized river, practically all of the diverse aquatic habitats have been eliminated in favor of a broad, straighted channel with more uniform depths and widths. Those species requiring various types of cover substrate and associated food chain will be eliminated from the system. These affected fish species would be replaced by species that are adapted to the open, muddy channel bottoms with little environmental heterogeneity. A channelized waterway would

result in a lower diversity with fewer species in the fish community but with many individuals in each species.

The productivity should also be lower than natural sections as studies in the literature have indicated. Therefore, based on the above, it is logical to presume that there would be fewer numbers of commercial fish species inhabiting the floodway. However, the number of commercial fish seller licenses for the floodway versus the river does not reflect the findings in the literature. More commercial fishing appears to occur in the floodway. This would indicate that something in the habitat of the floodway is suitable to commercial fish species production.

The second factor contributing to a larger commercial fish population in the Oak Donnick Floodway is the higher recruitment potential there than in the St. Francis River. The Arkansas Game and Fish Commission states that recruitment of fish into a population locally occurs largely from overbank flooding in the floodway which replenishes adjacent lacustrine habitats, thus providing suitable habitat for commercial fish spawning and egg and young fish development. Other recruitment of fish probably occur from outside the existing population from fish immigration into the Floodway from the backwaters of the L'Anguille and Mississippi Rivers. Local recruitment of young of the year and recruitment of adult fish from outside sources replace the fish that are harvested, thus providing a good renewable resource. The river, however, does not have the recruitment potential of the floodway. Recruitment of commercial fish takes place from young of the year classes already in the river and from tributary ditches. Little recruitment comes from above the siphon or from below the Huxtable Pumping Plant. In essence, the lower St. Francis River is blocked at both ends and few fish can migrate into the river system from St. Francis Lake and the backwaters of the Mississippi River. Further discussion of the extent of blockage caused by the Huxtable Pumping Plant can be found in Section IV.

Additionally, the river is not subjected to the periodic overbank flooding which occurs in the floodway. This overbank flooding replenishes adjacent wet areas needed for successful spawning activities of rough or commercial fish species in the floodway.

The St. Francis River has more water area and has more diverse, natural habitat than the floodway. However, because of the habitat suitability and higher recruitment potential for rough fish in the floodway, the commercial fish population appears to be larger there than in the river. This larger population attracts and supports more commercial fishermen as shown by the numbers of commercial licenses to sell their catch for both waterways. It should be noted that commercial fishing is a profit-oriented activity, and fishermen will set nets where they can make the most money for the least expense in time and money regardless of the accessibility of the area or the total length of one stream versus another.

SECTION IX - PLAN OF OPERATION

If the recommendation to repair is approved, a formal plan of operation will be prepared and presented to Drainage District 7 of Poinsett. Their formal acceptance will be requested in consideration of Federal work required for repairs, and will be required before the preparation of contract plans and specifications. This Plan of Operation will contain the following statements. The siphon will not be operated while St. Francis River water is higher than 208.6 NGVD on the Lower Lock Gage. The siphon will not normally be operated while St. Francis Lake water is lower than 210.0 NGVD on the Upper Lock Gage. But during the crop season, May to December, when upstream data shows the approach of a damaging flood, the Lake may be temporarily lowered below 210.0 NGVD. This operational exception will be used only with the concurrence of the Arkansas Game and Fish Commission in each specific case.

SECTION X - DISCUSSION AND RECOMMENDATION

X-01 DISCUSSION

In Section II there are twelve needs described which are or were affected by the operation of the siphon. The needs for navigation and sewage dilution no longer exist. In Section V - BENEFIT EVALUATION, those benefits which have been quantified are computed in V-01, and summarized in V-04. The values discussed in V-02 could be quantified by extensive and costly study beyond the scope of this report. Total annual charges in paragraph VI-05 include as a repair cost the net value of an increased commercial fishery that is believed would be the result of siphon abandonment, though conditions have been the same as with the future repaired siphon. Not a loss of an existing asset, this is actually a predicted value increase that will be foregone by the siphon repair.

Based on 50-year life and 2.50 percent interest rate, to repair only one barrel will produce a B/C ratio of 1.36 and excess annual benefits of $7,741. All of the quantified benefits can be obtained with only one operable barrel. So can irrigation power savings, water quality improvement, aesthetics, and historical significance.

With the same life and interest rate, to repair all three barrels will produce a B/C ratio of 0.85, with annual costs $5,024 greater than benefits quantified.

But there are other benefits produced by the availability of all three repaired barrels that have clear value. They could be quantified only at a great increase of time and cost, and such quantification is considered to be beyond the scope of this report. It is believed that when quantified these benefits would be much greater than those now quantified.

The flexibility provided by three operable barrels may be of considerable importance if the unpredictable use of flow diversion during gate repair should arise in 50 years. A diversion channel east of the gate structure could prove very difficult to restabilize. But this problem involves only money. Paragraphs II-09 and V-02-c discuss but do not quantify.

As discussed in paragraph V-02-f in more detail, the reduction of siphon diversion capability could produce a very costly renegotiation of present flowage easements in the Lower Floodway.

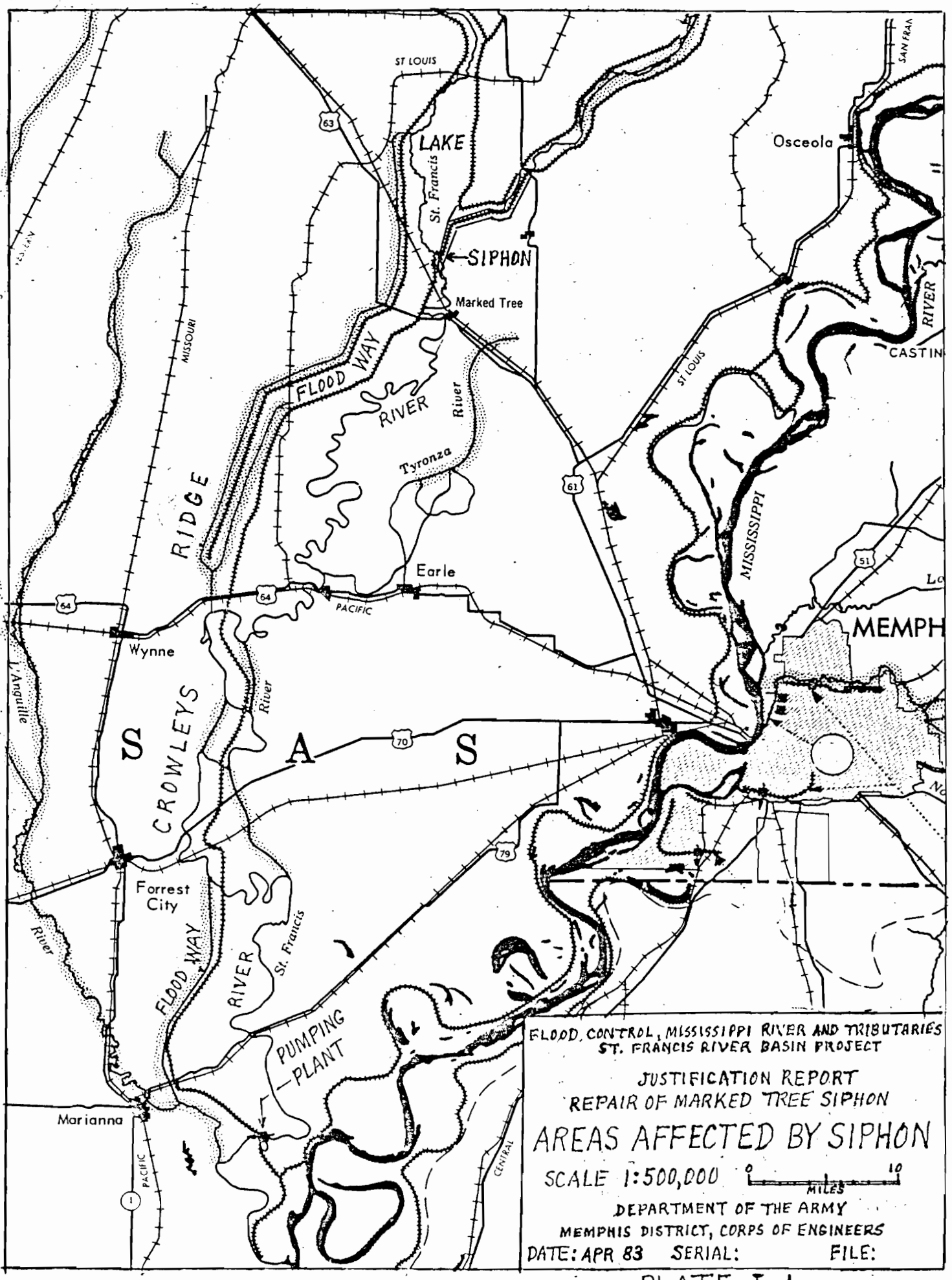
Of much greater importance in the matter of repairing all three barrels is the possible use of the siphon as an emergency operations diversion relief for the St. Francis Floodway. This use is discussed in detail in paragraphs II-10 and V-02-d. In addition to increasing the degree of protection against a major flood which could cause millions of dollars in damages, there is a human life factor involved. A major crevasse could trap several families under adverse conditions of weather, darkness, and communications which could prevent

helicopter rescue. The value of any appreciable increase in the degree of protection against loss of life may be unquantifiable and the probability of the described event may be impossible to evaluate. But the need for operability of all three barrels may outweigh the quantified B/C ratio of 0.85 in this consideration.

X-02 RECOMMENDATION

After full consideration of both quantified and unquantified benefits, I recommend that the siphon be repaired as outlined in Table VI-01-a, repair of three barrels.

JOHN F. HATCH, JR.
Colonel, Corps of Engineers
District Engineer



FLOOD CONTROL, MISSISSIPPI RIVER AND TRIBUTARIES
ST. FRANCIS RIVER BASIN PROJECT

JUSTIFICATION REPORT
REPAIR OF MARKED TREE SIPHON

AREAS AFFECTED BY SIPHON

SCALE 1:500,000 0 10 MILES

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS

DATE: APR 83 SERIAL: FILE:

PLATE I-1

DRAINAGE DISTRICT NUMBER SEVEN
POINSETT COUNTY
MARKED TREE, ARKANSAS 72365

November 2, 1982

Colonel John H. Hatch
Department of the Army
Memphis District Corps of Engineers
668 Clifford Davis Federal Building
Memphis,Tennessee 38103

Dear Colonel Hatch;

The Commissioners of Drainage District Number Seven of Poinsett County Arkansas, are aware of the study being made for repairing the siphons on the St. Francis River at Marked Tree. We are very anxious that the study being conducted take in consideration the importance of running the siphons, in order to maintain low water flow on the St. Francis River. It is extremely important to the city of Marked Tree, with a population of approximately four thousand.

Also, would like to call attention to the Corps, to the fact that water management is extremely important to the wildlife habitat. Without the siphons running, there would be times that there would be too much water, in the floodway, for the survival of wildlife (deer, turkey, etc.) Also, not generally known, too much water in the floodway is bad for duck hunting.

The Commissioners strongly urge you to give serious consideration to all the facts regarding the maintenance and repair of these siphons.

Very truly yours,

Dan F. Portis

Dan F. Portis
Chairman

DFP/bjs