US Army Corps
of Engineers
Memphis District

FLOOD CONTROL
MISSISSIPPI RIVER & TRIBUTARIES
ST. FRANCIS BASIN PROJECT

JUSTIFICATION REPORT REPAIR OF MARKED TREE SIPHON

NOVEMBER 1985

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 85) is $604,000 for repair of three barrels, and $208,000 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 8-5/8%. Annual charges include annual equivalents of first costs and major replacements and cost of operation and minor maintenance. The following quantified average annual equivalent benefits are based on the recommended full repair of three barrels, a 50-year repaired life, and the project authorized interest rate of 2-1/2%: Channel Maintenance Cost Reduction, $38,790; Sport Fishing, $6,963; Flood Control, St. Francis Lake, $8,200; Flood Control, Straight Slough Area, $66,600; Crevasse Prevention Benefits, $33,870. Unquantified Benefits of Repair are: General River Recreation, Commercial Fishing, Aesthetic Effects, Historical Significance, Lake Control Gate Repairs, Avoidance of Flowage Damage Claims, and Rural Domestic Water Supply.

Total Annual Charges (Jul 85) versus Total Annual Benefits:

Full Renewal: Repair of Three Barrels	2-1/2% Federal, Non-Federal		8-5/8% Federal, Non-Federal	
Annual Charges	$22,101	$ 7,000	$53,668	$ 7,000
	$29,101		$60,668	
Annual Benefits	$154,423		$149,573	
Benefit-Cost Ratio, B/C	5.31		2.47	
Excess Benefits, B-C	$125,322		$88,905	

Total Annual Charges (Jul 85) versus Total Annual Benefits:

Minimum Renewal: Repair of Only One Barrel	2-1/2% Federal, Non-Federal	8-5/8% Federal, Non-Federal
Annual Charges	$ 8,138 + $ 7,000 = $15,138	$18,958 + $ 7,000 = $25,958
Annual Benefits	$105,759	$101,594
Benefit-Cost Ratio, B/C	6.99	3.91
Excess Benefits, B-C	$90,621	$75,636

Economic analyses above are based on existing channel conditions in the Floodway below Riverfront. Benefits from use of siphon withdrawal to prevent a crevasse are reduced by possible future channel maintenance in that reach. In Appendix B the effect of this possible future increase in Floodway conveyance is analyzed.

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.

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REPAIR OF MARKED TREE SIPHON
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FLOOD CONTROL, MISSISSIPPI RIVER AND TRIBUTARIES
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JUSTIFICATION REPORT
REPAIR OF MARKED TREE SIPHON

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 November 1981, in paragraphs 2 and 5 directed the preparation and submission of a report which would evaluate the costs and benefits for repairs to the structure. This report responds to that directive.

I-02. HISTORICAL BACKGROUND (REFER TO PLATE II-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 was below 210.25 Mean Gulf Level. 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 County 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 $H^{1}/2$, and would pass the specified 2600 cfs when the head difference was 5.5 feet. In the period 1936-1938, due to poor foundation conditions, 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, 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 $H^{1}/2$, 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 County 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 and the U.S. Army Corps of Engineers, but certain criteria have been accepted as the general plan of operation. In clarification of elevation references, the following changes have resulted from extensive geodetic surveys. Before Federal involvement, each levee or drainage district had its own datum. Federal work first was referenced to Mean Gulf Level (mgl). Later the datum Mean Sea Level (msl) was established in this area, with small differences from mgl at some locations. The present elevation reference is to the National Geodetic Vertical Datum (NGVD) which has the same elevation as the former msl. Downstream agricultural flooding begins when the tailwater elevation at Lower Lock Gage is higher than 208.5 NGVD, 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 208.5 NGVD. 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 msl. 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 County and by the Arkansas Game and Fish Commission, which contained the additional provision that the gates and the 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. Since the Huxtable Pumping Plant began operation it has become clear that a formal Plan of Operation is needed, to include control of future siphon operation which would affect the operation of the Pumping Plant.

I-03. PRESENT PROBLEM.

The siphon has been in operation for forty-six 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 served 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 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, and must be replaced.

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 then 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, in both renewal plans, construction of a new trashrack was eliminated.

b. The siphon pipes need to be blasted-cleaned and painted with a rust inhibiting paint both inside and outside. For the minimum renewal plan, only one pipe would be repaired. For full renewal all three pipes 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 VI contains a cost estimate as of July 1985 for this work.

SECTION II
PHYSICAL FACTS, RIVER AND FLOODWAY

This report investigates the justification for repair of the Marked Tree Siphon by considering the effects of transferring flows from the Floodway to the River; the transfer rate of flow varies because of variable external conditions, as explained in SECTION IIIA. The condition of the siphon is such that without repair it will become inoperable. With repair it may be operated strictly in accordance with the constraints detailed in SECTION IX, Plan of Operation. for evaluation of environmental and other effects of permissible siphon operation, the physical facts about the two waterways are here compared.

The Floodway confines overbank flows by levees and Crowleys Ridge (below Floodway Mile 59.5) but has a channel of considerable capacity for flows which are bankfull or less. As shown in the table following, almost three-fourths of the Floodway channel is artificial, but there are three segments of natural channel below St. Francis Bay - Straight Slough entrance. The Floodway channel here being considered begins at the outlet of the St. Francis Lake (Oak Donnick) Control Gates, Floodway Mile 84.94, and extends to the junction with the St. Francis River channel below Huxtable Pumping Plant, Floodway Mile 11.55.

The River begins at the outlet of the Marked Tree Siphon, River Mile 132.67, and extends to the entrance at the Huxtable Pumping Plant, River Mile 14.8. There are two cutoffs by artificial channels, being 12% of the total length. The natural stream shows the typical alluvial valley pattern of wide meandering and has the usual deep pools on the outside of bends and somewhat wider shallow crossings between bend pools. Almost all of the natural stream has very good shade from banktop trees.

There are watercourses connected to these two main channels and thus affected by changes in water surface elevations at their junctions. On those which are tributaries and add inflow at their junctions, the distance upstream on each tributary to the point where the change in the tributary would be trivial, has been estimated. On the old bendways, which have only minor local runoff outflows, the depths and water surface acres will be affected by changes in main channel conditions, and their lengths have been noted. Both sport and commercial fishing are observed on these bendways, and they have significance as off-channel breeding areas, not being as subject to bank erosion and siltation as are the tributary streams. Since this report is still not of unlimited scope, and much physical information would be needed, quantification of siphon lowflow effects on these lateral watercourses has not been made. But they are presented here, and can be readily located on pertinent quadrangle maps, for comparative consideration of the two main channels.

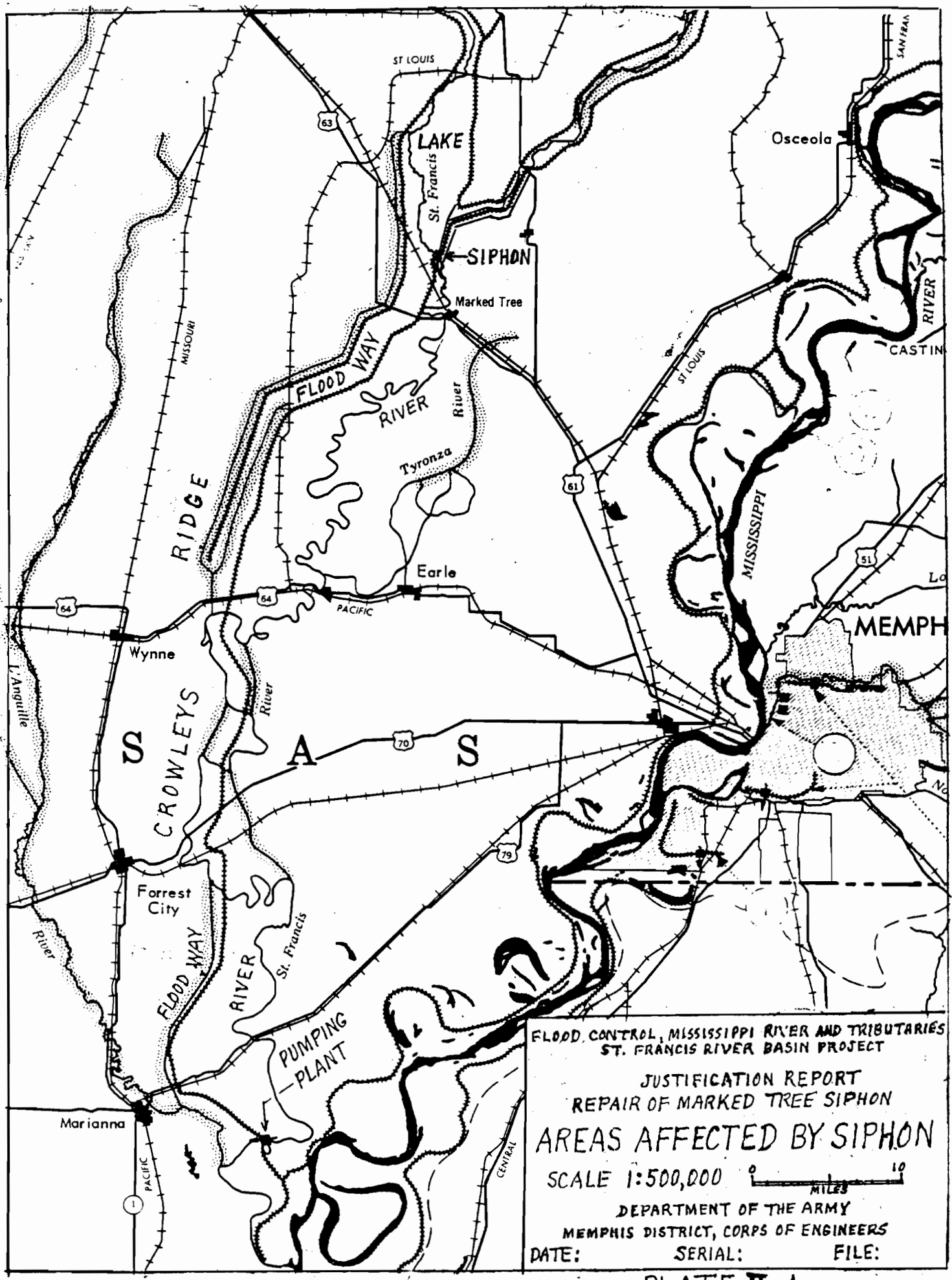
Connected to the Floodway there are two tributary streams and no old bendways. Considered as having affectable value are: the lower 2.2 miles of L'Anguille river, entering at Floodway Mile 17.5, and the lower 4.6 miles of St. Francis Bay, entering at Floodway Mile 59.5.

Tributary to the River there are five streams, with affected portions as shown: the lower 5.8 miles of Blackfish Bayou, entering at River Mile 38.23; the lower 7.3 miles of Tryronza River, entering at River Mile 79.44; the lower 3.0 miles of Ditch 1, entering at River Mile 121.60; the lower 6.9 miles of Left Hand Chute of Little River, entering at River Mile 130.25; and the lower 6.0 miles of Rivervale Outlet Ditch, entering at River Mile 132.67. There are eight old bendways connected to the River; parts of each are of fishery value affected by main channel changes, as listed: 1.1 miles of Raft Bayou, from River Mile 23.40; 2.2 miles of North Alligator Bayou, from River Mile 28.10; 5.9 miles of Cow Bayou, from River Mile 29.70 (Cody Bridge); 4.0 miles of "Old River," from River Mile 38.90; 9.9 miles of "Old River," from River Mile 44.80 (foot of Round Pond Cutoff); 2.0 miles of Fishers Lake, from River Mile 52.70; 1.4 miles of "Old River," from River Mile 54.00 (head of Round Pond Cutoff); and 3.4 miles of "Old River," from River Mile 65.80 (head of Grassy Lake Cutoff).

Channel Lengths	Floodway	River
Total Length, Main Channel	73.39 miles	117.87 miles
Artificial channel Length	52.59 miles	14.00 miles
Natural Stream Length	20.80 miles	103.87 miles
Percent Natural	28%	88%
Number of Tributaries	2	5
Affected Miles in Tributaries	6.8 miles	29.0 miles
Number of Old Bendways	0	8
Affected Bendway Miles	0	29.90 miles
Accessibility		
Access Road approaches, Public	35	134
Public Roads Along Channel Bank	15.8 miles	62.5 miles
Lowflow Water Surface Area, July, 50% Exceedence		
With Siphon Off	2138 acres	3551 acres
With Siphon On	2121 acres	4043 acres
Percentage Change	1%	14%

Access from the Mississippi River for migratory replenishment of fish population is unimpeded in the Floodway. At River Mile 14.80, the Huxtable Pumping Plant gate closure has blocked migratory access to the River about 6% of the time since the plant became operational.

The elevation of the entrance weir at Huxtable creates a permanent lowflow conservation pool averaging 15 feet deep and extending upstream about 18 miles. The only conservation pool in the Floodway is St. Francis Lake, access to which is barred by the St. Francis Lake (Oak Donnick) Control Gates, which have no provision for fish passage except when fully open during flood flows.


ST LOUIS
63
LAKE
St. Francis
SIPHON
Marked Tree
Osceola
MISSOURI
FLOOD WAY
RIVER
River
Tyronza
RIDGE
61
ST LOUIS
MISSISSIPPI
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CASTIN
64
Earle
PACIFIC
MEMPH
51
Wynne
L'Anguille
River
CROWLEYS
S A S
70
79
Forrest City
FLOOD WAY
RIVER
St. Francis
River
PUMPING PLANT
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JUSTIFICATION REPORT
REPAIR OF MARKED TREE SIPHON
AREAS AFFECTED BY SIPHON
SCALE 1:500,000
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MILES
DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
DATE:
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PLATE II-1

SECTION III - NEEDS FOR SIPHON OPERATION

III-01. NAVIGATION.

The siphon was constructed 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.

III-02. CHANNEL MAINTENANCE COST 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 on the St. Francis River in Drainage District 7 of Poinsett County, Arkansas, 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. This benefit is quantified in paragraph V-01.

III-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 1/2 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 lower river, which is divided into 9 reaches between major tributaries and other significant points. An envelop line 1/2 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 III-03 below shows 1964 data. River water use for irrigation has continued, as discussed in paragraph V-02.

TABLE III-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 III-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

III-04. FLOOD CONTROL, ST. FRANCIS LAKE

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 enclosed that came to be called St. Francis Lake. The approximate dimensions of this enclosure 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 enclosure 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 reduces losses to "lake farming." This benefit is quantified in detail in paragraph V-03.

III-05. FLOOD CONTROL, STRAIGHT SLOUGH AREA.

As shown in APPENDIX A, during the period of record in which the Huxtable Pumping Plant has been operable, the siphon has been operated 58.2% of the total days in the period. The siphon was operating 9.4% of

the total days while the Huxtable Plant was pumping; for an added 1% of the total days, tailwater elevation was above 208.5 NGVD and the Huxtable Plant was not pumping. Neither of the above conditions will occur in the future under the agreed Plan of Operation stated in SECTION IX, except in a declared flood-fighting emergency. During 47.8% of the total period studied, the siphon operation reduced stages in the Floodway without violating the stated restraints. The resulting flood control benefit in the Straight Slough Area will continue in the future on an average annual equivalent basis, and is quantified in paragraph V-04.

III-06. SPORT FISHING

It is shown in SECTION IVA that use of the siphon for lowflow augmentation in the River produces increases in hydraulic quantities, such as depth and water surface area. The biological opinion is that these increases would not greatly increase the numbers or poundage of the several species of sport fish population. However, sport fishermen activity shows a definite increase with increases in lowflow depth and width. In connected old bendways as well as on the main River, and immediately below the siphon, people fish from banks, bridges, and boats, though seldom coming from far distant places. As shown in SECTION II, access is good. Sport fishing does receive benefits from siphon operation. These benefits are evaluated in paragraph V-04 and analyzed in detail in SECTION VIII.

III-07. GENERAL RECREATION

Both the River and the Floodway are locally considered less than ideal for swimming, though some swimmers have been observed. Water-skiing and boat-racing are almost unknown. There is some use of the River in a generally aesthetic sense, for bird-watching, picnics, and hot-weather low-speed boating. Recreational use in lowflow periods enhanced by siphon lowflow augmentation, so there is a benefit from siphon availability. The benefit is small and has not been quantified.

III-08. COMMERCIAL FISHING

There is currently commercial fishing in the Floodway and in the River and its bendways. Referring to the hydraulic quantity differences caused by siphon lowflow augmentation, as shown in SECTION IV-A, the biological opinion is that these increases do not significantly increase the numbers or poundage of the several species of commercial fish population. Unrecorded interviews with part-time commercial fishermen indicate much more interest and activity when lowflow is augmented by the siphon. However, there is no reliable data on annual harvest poundage under past conditions of siphon operability and no basis for estimating the reduction in harvest that would occur if the siphon were to be permanently inoperable; therefore, this siphon benefit is not quantified. There have been in past lowflow periods requests by commercial fishermen that DD7 operate the siphon to give enough depth to justify placing and servicing commercial fishing equipment. They consider that a siphon benefit exists for them.

III-09. WATER QUALITY.

The 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 Lake control gates in Oak Donnick Floodway to maintain a minimum level of water in the Lake at 210.0 NGVD. The Lake had been threatened by erosion channels which had progressively lowered the minimum water level to 204.0 NGVD. Further lowering would have prevented the operation of the Marked Tree Siphon. Investigation of needs for continuing the operability of the siphon included the need for dilution of sewage pollution in the River during lowflow periods. Appendix D of this Review Report was a Water Resources Study by the Public Health Service, Region VII, the title being in part: "Study of Potential Need for . . . Streamflow Regulation for Control of Water Quality Below the Marked Tree Siphon," February 1963. Parts of that study are in SECTION IIIA of this report. At that time untreated sewage was being discharged into Left Hand Chute of Little River at Lepanto and at Marked Tree into LHCLR and into the St. Francis River. That study developed data on the 95% exceedence lowflow at the Marked Tree gage, without siphon operation. The conclusion then was that lowflow augmentation by the siphon was not needed for dilution of sewage pollution. Since that time, Lepanto uses lagoon treatment discharging into LHCLR, and Marked Tree has a lagoon treatment system inside the Floodway below U.S. 63. With these treatments there is still less need for the siphon in regard to sewage. The water in the St. Francis River and in the St. Francis Floodway is also affected by agrichemicals, including fertilizers, defoliants, and pesticides. Not all of these chemicals are biodegradable. The runoff from cropland contains some chemicals in solution and others which have been adsorbed by particles of transported silt. Where flows are spread and decelerated by passing through wide areas of vegetated wetland, some of the silt becomes sediment. While adsorbed chemicals will thus contaminate the benthos, they are removed from the running water. The River, from the siphon to Huxtable Pumping Plant, receives runoff through five major tributaries from 2013 square miles, almost all of which is cropland. The Floodway, from Lake Wappapello to Mile 11.55, receives runoff through nine entrances from 8400 square miles, most of which is cropland. Some of the land is farmed inside the St. Francis and Big Lake Floodways and St. Francis Lake, but all of Big Lake Refuge and Hunting Area, most of St. Francis Lake, and some reaches of the St. Francis Floodway above Lake City, are still vegetated wetlands. These wetlands qualitatively reduce agrichemical pollution. So the operating siphon transfers some slightly decontaminated water from the Floodway into the River, where no decontaminating influences exist. This benefit to the River by continuing the operability of the siphon is rational and real, although there is no attempt to quantify it. A protracted series of samplings and analyses would be needed to establish any differences in kind or severity of agrichemical pollution.

III-10. GATE MAINTENANCE.

In the General Design Memorandum 108, "Oak Donnick Floodway," cost estimate for the St. Francis Lake Control Gates showed annual charges for operation and maintenance and for major replacements during the projected 100-year life of the project. The values of these annual charges are such that it is clear that no serious major problem was anticipated by OCE (approved in 6th Ind., 3 Sep 69) nor by MRC (satisfied in 9th Ind., 27 Feb 70). However, due principally to automatic controls malfunctions, very soon severely threatening scour had occurred just below the structure. The gates were still manually operable, so an initial Lake drawdown by open gates and heavy siphon withdrawal was followed by closed gates with the siphon then delaying Lake rise. A massive restoration of the scourhole was thus enabled. Minor maintenance within a gate chamber can be done by closing one side with stoplogs and using the other side as a bypass. But some major problems involving the whole structure or an immediately adjacent area are possible in the remainder of the 100-year project feature life. It is not considered feasible to predict the exact nature of a major problem nor the year in which it would occur, but its possibility cannot be denied. If the siphon is not kept operable in all three barrels, then some other bypass means would have to be provided. During the earlier development of the referenced GDM, as submitted in November 1967, it was proposed to install two "bascule" structures, one each in Ditches 60 and 61. It was stressed that the two ditches must not be closed for gate construction during the same period, since each must act in turn as the bypass for the other. Simultaneous or overlapping gate construction closures would require a temporary third channel as the bypass. It was emphasized that the restabilization of the backfilled bypass ditch, after completion of both gates required its closure, would be extremely difficult and prohibitively costly. Simultaneous or overlapping construction of Ditch 60 gate and Ditch 61 gate offered no advantage commensurate with the risks involved in a costly third channel temporary bypass. With the siphon abandoned, an event requiring some form of bypass is possible. For cost estimation, the same quantities are assumed for alternate bypass sites, one on the east side of Dam 10 in Ditch 61 and the other on the east side of the control gate structure in Ditch 60. The bypass channel depth would be 15', bottom width 50', side slopes 1:2, and length 2400'. After completion of the repair work at the gate, the bypass channel would be backfilled with its original spoil, compacted. The finished surface will be 110' wide, 12-inch cover of 15% soil cement. At both ends, where the temporary channel left and returned to existing ditches, the toe, slope, and top bank would be covered with a 2' layer of 14" riprap, 70' long and 200' wide. A cost table follows, which shows that this unpredictable but quite possible bypass need without a repaired siphon would cost as much as full repair of the siphon, shown in SECTION VI. Due to event unpredictability, the siphon-bypass benefit is presented as unquantified.

COST ESTIMATE - BYPASS CHANNEL

Cost Acct.		Quantity			Unit Cost	First Cost
01	LANDS AND DAMAGES					
	ROW, Channel and Temporary Spoil, Woodland	15.43	Ac	@	$800	$12,344
	Easement, Temporary Access Road, 14,000', Cropland	16	Ac	@	$300	4,800
	Improvements					0
	Subtotal					$17,144
	Contingencies 25% +					4,356
	Land Costs					$21,500
	Acquisition Costs, 3 Tracts					3,500
01	LANDS AND DAMAGES					$25,000
09	CHANNELS AND CANALS					
	Clearing and Grubbing, 12.21 Ac	19	Sta.	@	$600	$ 11,400
	Excavation	106,667	CY	@	$0.75	80,000
	Backfill, Compacted	106,667	CY	@	$2	213,334
	Soil Cement, Surface, 1'X110'X 2400', 9778 CY:					
	Cement, 15%, 1 barrel/CY Mix	9,778	Barrels	@	$12	117,336
	Mix and Place	29,333	Sq.Yd.	@	$1.50	44,000
	Riprap, both ends, 14" stone, 2' layer (1037 CY)	1,556	Tons	@	$18	28,008
	Filter Material	650	Tons	@	$16	10,400
	Net Costs					$504,478
	Contingencies 25% +					125,522
	Gross Construction Costs					$630,000
	E&D					22,500
	S&A					39,500
09	CHANNELS AND CANALS					$692,000
	TOTAL FIRST COSTS					$717,000

III-11. 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, the fat pocketbook pearly mussel, (Proptera (=Potamilus) Capax). The 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. A combination of severe storms could produce upstream flooding, with an approaching crest which would crevasse part of the vulnerable levee reach. Under these conditions, 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 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. Relief of the Floodway danger by siphon diversion would add to the Huxtable load and would increase the existing interior flooding along the River. However, 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 certain disaster. The probability of severe dollar damage and the hazard to human life can be reduced by the siphon. Repair of the siphon will retain flood fight capability that could be an essential emergency relief. Hydrologic and economic details are shown in paragraph V-05 and in Appendix B.

III-12. AESTHETIC EFFECTS

In Appendix C, 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.

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, and the covering of sand bars. 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, though it is not quantifiable.

III-13. HISTORICAL SIGNIFICANCE.

In paragraph IV-01, 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 or 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. For forty-six years this structure has augmented lowflow in the River and has reduced crop losses on farms within the Lake and Floodway. On several occasions visiting groups of hydraulic engineers from river basins such as the Danube and the Rhine have been shown by MRC the various flood control and navigation features of the Lower Mississippi Valley. The non-Federal Rivervale "inverted siphon" Culvert has been of interest because of its unusual dimensions and high capacity ($Q=2365H^{1/2}$), and the Federal Marked Tree Siphon has been of greater interest because of its unique efficiency. There have allegedly been some statements that this structure was already known in their country and permission to photograph it was requested. With justifiable pride (possibly chauvinistic) the tour guides have shown the visitors this unique structure designed by our engineers of an earlier generation. The siphon still has historical and technical value. Though this value is unquantifiable and intangible, it is presented for consideration in justification of repair. See paragraph VIII 3e concerning recommendation for the National Register of Historic Places.

III-14. FLOWAGE EASEMENTS.

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. The elimination of siphon outflow capability could result in current easements being declared invalid and new easements being required. The benefit derived from avoiding the flowage claims by complete maintenance of the siphon is real, but has not been quantified.

SECTION IV - HYDROLOGY AND HYDRAULICS, GENERAL

IV-01. 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: $Q = 0.814A\sqrt{2gH}$. In repeated discharge measurements the actual barrel rating was established beyond question as: $Q = 0.971A\sqrt{2gH}$. 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 $495.38\sqrt{H}$ cfs.

IV-02. HISTORICAL HYDROGRAPHS, ST. FRANCIS LAKE.

Stage hydrographs at the Upper Lock gage, on the northeast wingwall of the siphon inlet basin, for with-siphon and without-siphon conditions, were provided for the 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 gage data and number of barrels 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 at the approximate center of the affected cropland.

SECTION IVA - HYDROLOGY AND HYDRAULICS, LOWFLOWS

IVA-01. PRINCIPLES OF LOWFLOW COMPUTATION.

For the peak floodflows of runoff from rainstorms, present hydrologic methods involve frequency analysis of rainfall, unit hydrographs considering subwatershed characteristics and loss factors, and routing runoff hydrographs through a drainage system. But in several countries in the past, usable approximations of peak storm flows were obtained by the use of exponential formulas. The usual format was: $Q = CM^X + B$, in which Q was the peak flow in cfs, M was the drainage area in square miles at each point of interest, X was an exponent less than 1.000, and B was a constant to account for the high cfs/square mile in the first square mile of a hilly watershed (in flat land B was usually zero). The coefficient C depended on watershed location and characteristics and the storm frequency of interest. In Baxter's work on Cypress Creek in southeast Arkansas, he found the exponent X to be 0.833; in other topography X has varied from 0.500 to 0.950. But X has always been less than 1.000, because the arrival of tributary peaks at a junction is rarely simultaneous and thus the peak flows are not additive.

Lowflow is not storm runoff with peaks; it is a relatively steady flow from groundwater return and sometimes from swamp-storage outflow. Thus at junctions lowflows are directly additive, so the exponent of the drainage area must always be 1.000. Therefore, lowflow is computed as: $Q = CM$, in which Q is lowflow in cfs, M is the drainage area in square miles. C is a coefficient derived from lowflow observations, and we have: $C = Q/M$. It has a value influenced by watershed and drainage system characteristics and by climate. From analysis of observations for a specific watershed, values of C may be derived for various lowflow exceedence frequency percentages and seasons. Since the characteristics of the watersheds of interest in the present study are reasonably uniform, the values of C derived in paragraphs IVA-02 and IVA-03 are used throughout the two systems.

Table IVA-01 shows the cumulative drainage areas in square miles above and below each junction and at key gages in the River and in the Floodway.

TABLE IVA-01
CUMULATIVE DRAINAGE AREAS IN RIVER AND FLOODWAY

Point Identification	Stream Mile	Square Miles Tributary	Square Miles Intervening	Cumulative Sq. Mi.
(St. Francis River)				0
				137
Entr. Rivervale O.D.	132.67	137		
			14	
				151
Entr. LHCLR	130.25	174		
				325
			9	
Marked Tree Gage	125.45			334
			2	
				336
Ditches 47 and 1	121.60	46		
				382
			71	
				453
Entr. Tyronza R.	79.44	653		
				1106
			1	
Parkin Gage	78.00			1107
			45	
Head Grassy Lake Cutoff	65.80			1152
			71	
Foot Round Pond Cutoff	44.80			1223
			11	
				1234
Entr. Blackfish Bayou	38.25	630		
				1864
			149	
(St. Francis River)				2013
Huxtable Pumping Plant	14.80			
(St. Francis Floodway)				
Upper Lock Gage	85.4			4643.47
			7.71	
US 63 Gage, SFF	82.6			4651.18
			35.75	
				4686.93
Entr. Straight Slough	59.5	415.84		
				5102.77
			4.24	
Riverfront Gage	58.0			5107.01
			142.30	
				5249.31
Entr. L'Anguille R.	17.5	942.33		
				6191.64
			10.67	
				6202.31
Entr. SFR below Huxtable	11.55	2013		

IIIA-02. DERIVATION OF LOWFLOW COEFFICIENTS.

References below are to: "Water Resources Study, Marked Tree siphon," February 1963, Region VII, Public Health Service, U.S. Dept. H.E.W., republished as Appendix D, SD 57/89/1, 2 June 1965, Review Report on the St. Francis River Basin in Drainage District 7, Poinsett County, Arkansas. Basic data are derived from Figure 2, "Annual Discharge Frequency," and from Table VI-02, "Annual Low flow Distribution by Months, at the Marked Tree River Gage, Without Siphon Flows," when the drainage area above that gage was 495.40 square miles. Pertinent pages from that report are bound at the end of this SECTION. Flows in acre-feet per time period are converted into average flows for the time period in cfs, from which the lowflow coefficients are derived.

TABLE IVA-02
LOWFLOWS AT MARKED TREE GAGE, WITHOUT SIPHON; M = 495.40

Time Period	Exceedence Percent	Total Lowflow In Period Acre-Feet	Average Flow, CFS Q	Q/M=C Coefficient C
Annual	95%	200,000	276	0.557
	50%	440,000	608	1.227
July	95%	15,000	244	0.493
	50%	33,000	537	1.084
August	95%	11,000	179	0.361
	50%	24,200	394	0.795
September	95%	7,000	118	0.238
	50%	15,400	259	0.523
October	95%	5,000	81	0.164
	50%	11,000	179	0.361

IVA-03. LOWFLOWS WITHOUT SIPHON, IN RIVER AND FLOODWAY.

The drainage area above the Marked Tree River Gage was 495.40 square miles during the period studied by the Public Health Service, but has been reduced to 333.81 square miles by the diversion of Upper Buffalo Creek through Cockle Burr Slough into the Floodway. The land drained is suffficiently homogeneous that the same coefficients, C = CFS/Square Mile, are continued for the River. Drainage areas are now: Foot of Rivervale Outlet Ditch, M = 137; Marked Tree River Gage, M = 334; Parkin River Gage, M = 1107.

TABLE IVA-03
RIVER LOWFLOWS, WITHOUT SIPHON

Time Period	Exceedence Percent	Q/M = C	Foot R.O.D. Q	Marked Tree River Gage Q	Parkin River Gage Q
July	95%	0.493	68	165	546
	50%	1.084	149	362	1200
August	95%	0.361	49	121	400
	50%	0.795	109	266	880
September	95%	0.238	33	79	263
	50%	0.523	72	175	579
October	95%	0.164	22	55	182
	50%	0.361	49	121	400

In the Floodway, here considered as the reach from the St. Francis Lake Control Gates, Mile 84.94, to the St. Francis River Outlet from Huxtable, Mile 11.55, the reservoir storage attenuation effects of Lake Wappapello, Big Lake, St. Francis Lake, and the leveed floodway storage, all reduce overbank peak flood flows. But the relatively steady non-cresting lowflows are not so directly affected. Below Lake Wappapello, through eight inlets the St. Francis Floodway above St. Francis Lake receives inflows, and below Hornersville the Little River Floodway receives inflows through two inlets as well as the very complex Little River agricultural drainage system outflow from above Hornersville. Except for the 1310 square miles above Wappapello Dam, lowflow in the Floodway is received from the same kind of intensely farmed agricultural land that contributes lowflow to the St. Francis River between the Siphon and the Huxtable Pumping Plant. The drainage area above the Marked Tree Floodway Gage at US 63 was 4489.59 square miles during the period studied by the Public Health Service but has been increased to 4651.18 square miles by the Upper Buffalo Creek diversion. The Public Health Service study stated that the average annual discharge in the Floodway was 4260 cfs from 4489.59 square miles and in the River was 1670 cfs from 495.40 square miles. With present drainage areas, these flows would be in the Floodway 4740 cfs and in the River 1190 cfs. After consideration of the regulation of flow from the hills above Wappapello Dam and the lowflow reductions in the wooded lower lakes and Floodway from evaporation, transpiration, and percolation, it is reasonable that the lowflow coefficients should be reduced. By empirically changing the various River coefficients in Table IVA-03 to 60% of their values for use in Table IVA-04 as Floodway coefficients, results are obtained which are compatible with the referenced study. Floodway drainage areas are now: Upper Lock Gage, 4643.47; Marked Tree Floodway Gage at US 63, 4651.18; Riverfront Gage, 5107.01.

TABLE IVA-04
FLOODWAY LOWFLOWS, WITHOUT SIPHON

Time Period	Exceedence Percent	Q/M = C	Upper Lock Q	Marked Tree US 63 Q	Riverfront Gage Q
July	95%	0.296	1374	1377	1512
	50%	0.650	3018	3023	3320
August	95%	0.217	1008	1009	1108
	50%	0.477	2215	2219	2436
September	95%	0.143	664	665	730
	50%	0.314	1458	1460	1604
October	95%	0.098	455	456	500
	50%	0.317	1008	1009	1108

IVA-04. LAKE SUPPLY AVAILABILITY FOR SIPHON AUGMENTATION OF RIVER LOWFLOW.

Flow of a siphon barrel is entirely a function of the difference in elevation between headwater and tailwater. It is either "off" or "on," and the flow cannot be regulated as can that which passes through a structure with movable gates. On Plate IVA-01, "Lowflow Augmentation by Siphon," at the end of this SECTION, there are 3 curves of flow versus elevation. Marked: "Rating-Total Combined Q," the first curve shows the water surface elevations (WSEL) of flows in the St. Francis River departing from the mouth of Rivervale Outlet Ditch (R.O.D.) and combined with the outflow of a siphon barrel. These WSEL are essentially the tailwater elevations of the siphon. The second curve, marked: "Siphon Part of Combined Q," shows a siphon headwater of 210.0; by the accepted Plan of Operation the Lake must not be lowered below 210.0. The siphon tailwater is on the first curve, so the siphon flow is subject to "tailwater control." The third (dashed) curve, marked: "R.O.D. Part of Combined Q," shows the R.O.D. flow contributing to the tailwater elevation. The use of these curves is to determine the Q value of siphon flow when headwater is kept at 210.0 and R.O.D. flow changes. It is noted that, for Lake supply inflows of lowflow period magnitude, the St. Francis Lake Control Gates will pass excess water and preserve the headwater elevation of 210.0. For any Rivervale Outlet Ditch flow, find the WSEL on the "R.O.D. Part" curve, then read the siphon flow for that tailwater elevation on the "Siphon Part" curve for that tailwater, and read the departing augmented flow at that elevation on the "Rating-Total Combined" curve.

In the following tables containing flows for different months and exceedence percentages, the entry "N.A." means that the siphon transfer is not available. With headwater at 210.0 and the R.O.D. flow entering at that time, the siphon flow is determined; if that transfer flow is greater than the inflow to the Upper Lock area of the Lake, the headwater will fall below 210.0; since this violates the accepted Plan of Operation, the siphon must remain "off;" it is "N.A."

In Table IVA-05 below, Column 1 contains inflows to Upper Lock area, from Table IVA-04. Column 2 has flows entering the tailwater area from Rivervale Outlet Ditch. Column 3 shows tailwater WSEL from Plate IVA-1. Columns 4 and 5 compute siphon Q from the resulting Head differential. Column 6 shows remaining Lake flow for disposal by the Gate in the Floodway; it is Column 1 minus Column 5; if it is negative, the siphon will be "off," and only R.O.D. flow will be departing. Column 7 is Column 2 plus Column 5, or Column 2 alone if siphon is "off." Columns 8 ad 9 show the result of computations.

TABLE IVA-05
SIPHON TRANSFER AVAILABLE

Month	Exceed. Percent	1 Lake UL Q	2 R.O.D. Q	3 R.O.D. Part, WSEL	4 "Siphon On" H	5 "Siphon On" Q	6 Excess UL Q	7 Total SFR Q	8 210 Lake ?	9 Add To River Q
July	95%	1374	68	204.52	5.48	1160	214	1228	Yes	1160
	50%	3018	149	204.74	5.26	1136	1882	1285	Yes	1136
August	95%	1008	49	204.47	5.53	1165	-157	49	No	N.A.
	50%	2215	109	204.63	5.37	1148	1067	1257	Yes	1148
September	95%	664	33	204.43	5.57	1169	-505	33	No	N.A.
	50%	1458	72	204.53	5.47	1159	299	1231	Yes	1159
October	95%	455	22	204.40	5.60	1172	-717	22	No	N.A.
	50%	1008	49	204.47	5.53	1165	-157	49	No	N.A.

By a further application of the methods outlined in Paragraphs IVA-02 and IVA-03, using data from the described Public Health Service report, lowflow coefficients for the Floodway were derived for a series of "Exceedence Frequencies in Percent" for the four months of principal interest. Siphon availability as related to lowflows into the Lake would be exceeded as follows:

July, C 0.296, Q 1374, exceedence 95%
August, C 0.237, Q 1100, exceedence 90%
September, C 0.245, Q 1136; exceedence 70%
October, C 0.242, Q 1126, exceedence 42%

It thus appears that the siphon could be unavailable in July for 5 years out of 100 years, in August for 10 years out of 100 years, in September for 30 years out of 100 years, and in October for 58 years out of 100 years. Unavailability would not persist through the whole month, but could occur for a brief period with the probabilities shown. This transference of lowflow coefficients is believed to be too conservative, in view of the frequently recorded one-barrel siphon flow in October while the Upper Lock Gage was at 211.0 or 212.0. However, it is not believed that the value of greater accuracy in this availability data warrants a complete historical frequency analysis of inflows into St. Francis Lake.

IVA-05. FLOW AND DEPTH CHANGES IN RIVER AND FLOODWAY.

There are four Rating Curve Plates at the end of this SECTION: Plate IVA-2, Marked Tree (US 63B) Gage, River Mile 125.45; Plate IVA-3, Parkin (US 74) Gage, River Mile 78.0; Plate IVA-4, Marked Tree (US 63) Gage, Floodway Mile 82.6; Plate IVA-5, Riverfront (US 64) Gage, Floodway Mile 58.0.

In the following Table IVA-06, siphon transfer flows are added to the "siphon-off" flows at Marked Tree River Gage and at Parkin River Gage (see Table IVA-03) to give "siphon-on " flows. From the rating Curve Plates IVA-2 and IVA-3, WSEL and depths are then derived for both conditions.

TABLE IVA-06
FLOW AND WATER DEPTH CHANGES IN RIVER

Month and Exceed. Percent		Add To River Q	River Changes					
			Siphon Off			Siphon On		
			Q	WSEL	Depth	Q	WSEL	Depth
			MARKED TREE RIVER GAGE - BOTTOM 193.4					
July	95%	1160	165	194.8	1.4	1325	201.2	7.8
	50%	1136	362	196.1	2.7	1498	201.8	8.4
August	95%	N.A.	121	194.4	1.0	NO CHANGE		1.0
	50%	1148	266	195.5	2.1	1414	201.5	8.1
September	95%	N.A.	79	194.1	0.7	NO CHANGE		0.7
	50%	1159	175	194.8	1.4	1334	201.2	7.8
October	95%	N.A.	55	193.9	0.5	NO CHANGE		0.5
	50%	N.A.	121	194.4	1.0	NO CHANGE		1.0
			PARKIN RIVER GAGE - BOTTOM 175.8					
July	95%	1160	546	178.0	2.2	1706	180.8	5.0
	50%	1136	1200	179.6	3.8	2336	182.3	6.5
August	95%	N.A.	400	177.7	1.9	NO CHANGE		1.9
	50%	1148	880	178.9	3.1	2028	181.5	5.7
September	95%	N.A.	263	177.3	1.5	NO CHANGE		1.5
	50%	1159	579	178.1	2.8	1738	180.9	5.1
October	95%	N.A.	182	177.0	1.2	NO CHANGE		1.2
	50%	N.A.	400	177.7	1.9	NO CHANGE		1.9

In the following Table IVA-07, siphon transfer flows are subtracted from the "siphon-off' flows at Marked Tree Floodway Gage and at Riverfront Floodway Gage (see Table IVA-04) to give "siphon-on" flows. From the Rating Curve Plates IVA-4 and IVA-5, WSEL and depths are then derived for both conditions.

TABLE IVA-07
FLOW AND WATER DEPTH CHANGES IN FLOODWAY

Month and Exceed. Percent		Reduce Floodway Q	Floodway Changes					
			Siphon Off			Siphon On		
			Q	WSEL	Depth	Q	WSEL	Depth
			MARKED TREE FLOODWAY GAGE - BOTTOM 194.0					
July	95%	1160	1377	198.6	4.6	217	196.0	2.0
	50%	1136	3023	200.8	6.8	1887	199.3	5.3
August	95%	N.A.	1009	198.0	4.0	NO CHANGE		4.0
	50%	1148	2219	199.8	5.8	1071	198.1	4.1
September	95%	N.A.	665	197.3	3.3	NO CHANGE		3.3
	50%	1159	1460	198.7	4.7	301	196.4	2.4
October	95%	N.A.	456	196.8	2.8	NO CHANGE		2.8
	50%	N.A.	1009	198.0	4.0	NO CHANGE		4.0
			RIVERFRONT FLOODWAY GAGE - BOTTOM 175.3					
July	95%	1160	1512	181.5	6.2	352	177.3	2.0
	50%	1136	3320	185.1	9.8	2184	183.1	7.8
August	95%	N.A.	1108	180.4	5.1	NO CHANGE		5.1
	50%	1148	2436	183.6	8.3	1288	180.9	5.6
September	95%	N.A.	730	179.1	3.8	NO CHANGE		3.8
	50%	1159	1604	181.8	6.5	445	177.8	2.5
October	95%	N.A.	500	178.1	2.8	NO CHANGE		2.8
	50%	N.A.	1108	180.4	5.1	NO CHANGE		5.1

IVA-06. WATER SURFACE AREA CHANGES IN RIVER AND FLOODWAY.

After reviewing several hundred channel sections of the River and the Floodway, four typical sections were derived, as shown on Plates IVA-6 and IVA-7 at the end of this SECTION. Recognizing that the natural River channel has steeper outside banks and flatter inside banks at its meander curves, two typical equivalent trapezoidal sections are shown on Plate IVA-6. The Upper River is 54.67 miles long, from Mile 132.67 at the mouth of Rivervale Outlet Ditch to Mile 78.00 at the Parkin Gage. For this reach the average of the depths at Marked Tree Gage and at Parkin Gage is converted to an average water surface width (WSW) by the formula: WSW = 9.5 X Ave. Depth + 185: For the Upper River the water surface area in acres (WSAc) is computed as: WSAc = 0.1212 X WSW X 54.67 miles. The Lower River is 63.2 miles long, from Mile 78.00 at the Parkin Gage to Mile 14.8 at Huxtable Pumping Plant. For this reach the depth at Parkin Gage is converted to an average WSW by the formula:

WSW = 11 X Depth + 235: For the Lower River: WSAc = 0.1212 X WSW X 63.2 miles. Adding produces WSAc for the whole River.

Plate IVA-7 shows upper and lower typical sections for the Floodway channel. Although these artificial channels were built as trapezoidal, toe erosion and bank caving in most areas has produced almost vertical banks and considerably wider bottoms, as shown on these sections. The Upper floodway is 26.94 miles long, from Mile 84.94 at the St. Francis Control Gate to Mile 58.00 at the Riverfront Gage. For this reach the average of the depths at US 63 Floodway Gage and at Riverfront Gage is converted to an average WSW by the formula: WSW = Ave. Depth + 190'. (If the depth were greater than 12', WSW = 6 X Ave. Depth + 130'.) For the Upper Floodway, WSAc = WSW X 0.1212 X 26.94 miles. The Lower Floodway is 46.45 miles long, from Mile 58.00 at Riverfront Gage to Mile 11.55 at the entrance of St. Francis River below Huxtable Pumping Plant. For this reach the depth at Riverfront Gage is converted to an average WSW by the formula: WSW = Depth + 255. (If the depth were greater than 15', WSW = 6 X Depth + 180'.) For the Lower Floodway, WSAc = WSW X 0.1212 X 46.45 miles. Adding produces WSAc for the whole Floodway.

For July, August, September, and October, for lowflows of 95% and of 50% exceedence, for these eight cases water surface acres with "siphon off" and with "siphon on" must be computed for River and for Floodway, to show changes in surface acres. The following Table IVA-08 is for one of the eight cases, as a sample. The other seven parts are similar and are on file. Computations are as described above. All depths are those developed in Tables IVA-06 and IVA-07.

TABLE IVA-08 (ONE OF EIGHT PARTS)
JULY, 50% EXCEEDENCE PERCENTAGE

SIPHON CHANGES IN WATER SURFACE ACRES, RIVER AND FLOODWAY

RIVER

Siphon OFF Or ON	Marked Tree Gage D'	Parkin Gage D'	Ave D'	Upper River 54.67 Miles Ave WSW	WSAc	Parkin Gage D'	Lower River 63.2 Miles Ave WSW	WSAc	Total WSAc
OFF	2.7	3.8	3.25	215.9	1430.6	3.8	276.8	2120.2	3550.8
ON	8.4	6.5	7.45	255.8	1694.9	6.5	306.5	2347.7	4042.6
"SIPHON ON":	RIVER GAINED 14% WSAc								491.8

FLOODWAY

Siphon OFF Or ON	US63 Fldwy Gage D'	River-front Gage D'	Ave D'	Upper Fldwy 26.94 Miles Ave WSW	WSAc	River-front D'	Lower Fldwy 46.45 Miles Ave WSW	WSAc	Total WSAc
OFF	6.8	9.8	8.3	198.3	647.5	9.8	264.8	1490.8	2138.3
ON	5.3	7.8	6.55	196.6	641.9	7.8	262.8	1479.5	2121.4
"SIPHON ON":	FLOODWAY LOST 1% WSAc								16.9

Results of all eight "case computations" are summarized in the table below. Where "N.A." is shown under "Siphon On," the amount of inflow to Upper Lock gage is not enough to maintain the Lake at 210.0 with the siphon on, so lowflow augmentation for that case is "Not Available;" this condition was described in detail in paragraph IVA-04 above.

TABLE IVA-09
SUMMARY OF SIPHON CHANGES IN WATER SURFACE AREA IN SYSTEM

Exceedence Percentages		River Water Surface Acres				Floodway Water Surface Acres			
		Siphon	Siphon	Gain		Siphon	Siphon	Loss	
Month	%	Off	On	WSAc	%	Off	On	WSAc	%
Jul	95	3325	3850	525	16%	2109	2074	35	2%
	50	3551	4043	492	14%	2138	2121	17	1%
Aug	95	3278	N.A.	None		2100	N.A.	None	
	50	3451	3941	490	14%	2125	2105	23	1%
Sep	95	3221	N.A.	None		2089	N.A.	None	
	50	3394	3862	468	14%	2111	2078	33	2%
Oct	95	3181	N.A.	None		2081	N.A.	None	
	50	3277	N.A.	None		2100	N.A.	None	

The water surface area changes shown are the principal parameter used in evaluating the siphon effect on environmental values in the system, regarding commercial fishing, sportfishing, and general recreation. In paragraph IVA-05 above, changes in flows and depths are developed in detail; changes in depths affect environmental values also, and are given consideration in the evaluation, although the River has deeper holes on the outside of bends even in times of extreme lowflow. Due to lack of detailed physical information, no attempt was made to extend this analysis into the connected old bendway channels and the tributary streams. These off-channel areas are mentioned in Section II, PHYSICAL FACTS, and there are some effects on their environmental values, but these must remain unquantified without unreasonable added effort.

IVA-07. LOWFLOW CONSIDERATIONS OTHER THAN ENVIRONMENTAL.

In Section V, BENEFIT EVALUATIONS, the use of the siphon for lowflow augmentation is discussed in three other categories: Channel Maintenance Cost Reduction, Irrigation and Rural Domestic Water Supply, and Aesthetics, though the last cannot be quantified. Data developed in this lowflow analysis for environmental parameters is also used in these evaluations.

WATER RESOURCES STUDY

MARKED TREE SIPHON

ST. FRANCIS RIVER BASIN

ARKANSAS

Study of Potential Need for and Value of
Streamflow Regulation for Control of
Water Quality Below the Marked Tree Siphon

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U.S. Army Engineer District--Memphis, Tennessee

FEBRUARY 1963

APPENDIX D

III. DESCRIPTION OF PROJECT

Location and Operation

As shown on Figure 1, the main flow of the St. Francis River is carried through a floodway canal from a point just upstream from Marked Tree for a distance of about 20 miles. Marked Tree, Arkansas, is located on the east bank of the St. Francis River at approximately river mile 75.

A siphon immediately upstream from Marked Tree (in the vicinity of St. Francis Lake*) is used to pass water over the levee to maintain flow in the original river channel. Operation of the siphon has been a function of the water level in the floodway canal. Erosion in the area of the diversion works (siphon) has resulted in reducing flows in the original St. Francis River channel. The proposed Project will control the erosion, thus restoring higher flows through the siphon to the original channel.

Streamflow

Most of the 8,400 square-mile drainage basin of the St. Francis River is located above Marked Tree. Combined discharge (floodway and river) at Marked Tree has averaged 5,930 cfs since 1935 with the river flow accounting for 1,670 cfs. 1/ Maximum recorded discharge in the river is 7,120 cfs. Minimum recorded discharge is 63 cfs.

The U.S. Geological Survey maintains a gaging station on the St. Francis River at Marked Tree and one three miles north of Marked Tree in the floodway which bypasses the town. Discharge records from 1935-1961 are available for both stations. Hydrographs of actual flow in the river at Marked Tree and estimated flow without the siphon were supplied by the Corps of Engineers for a 10-year period ending in 1961. 2/ Figure 2, a discharge frequency curve, was constructed utilizing these data.

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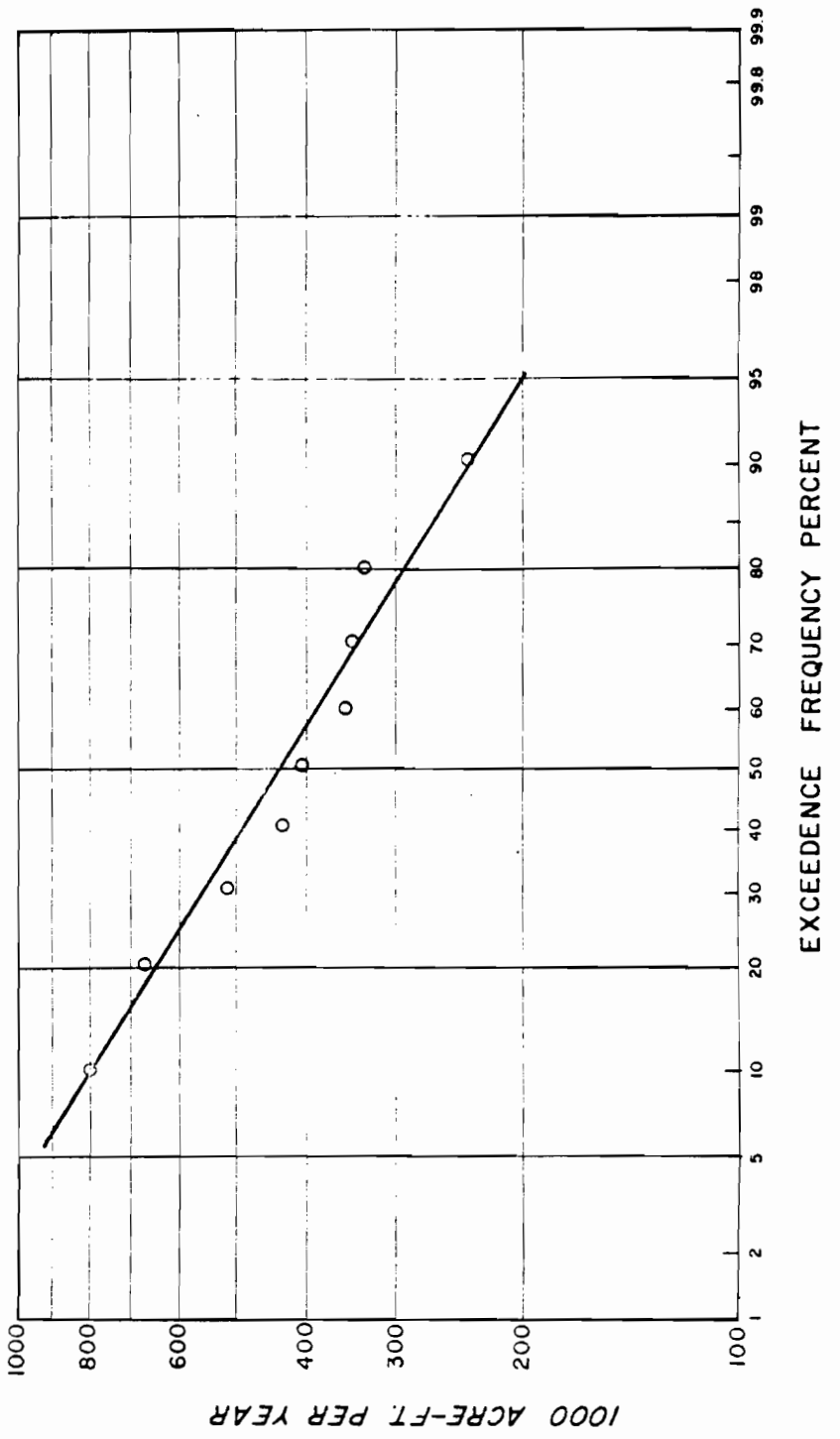
*The lake is generally no more than a marsh area.



WATER RESOURCES STUDY

ST. FRANCIS RIVER – ARKANSAS

MARKED TREE AREA

ANNUAL DISCHARGE FREQUENCY

FLOW IN RIVER AT MARKED TREE WITHOUT SIPHON

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

FIGURE 2

Table VI-2

Annual Low Flow Distribution (By Months)
in the St. Francis River at Marked Tree
(Without Siphon)

Month	Percent of Annual Flow	Total Discharge (Acre-Feet) At Various Exceedence Frequency Percentages		
		95%	90%	80%
January	8.2	16,000	19,000	24,000
February	13.3	27,000	31,000	39,000
March	15.5	31,000	36,000	45,000
April	13.8	28,000	32,000	40,000
May	12.0	24,000	28,000	35,000
June	9.5	19,000	22,000	28,000
July	7.6	15,000	18,000	22,000
August	5.3	11,000	12,000	15,000
September	3.7	7,000	9,000	11,000
October	2.7	5,000	6,000	8,000
November	3.2	6,000	8,000	9,000
December	5.2	10,000	12,000	15,000

Annual Flow

1. Exceeded 95% of time - 200,000 acre-feet.
2. Exceeded 90% of time - 235,000 acre-feet.
3. Exceeded 80% of time - 290,000 acre-feet.

Table VI-3

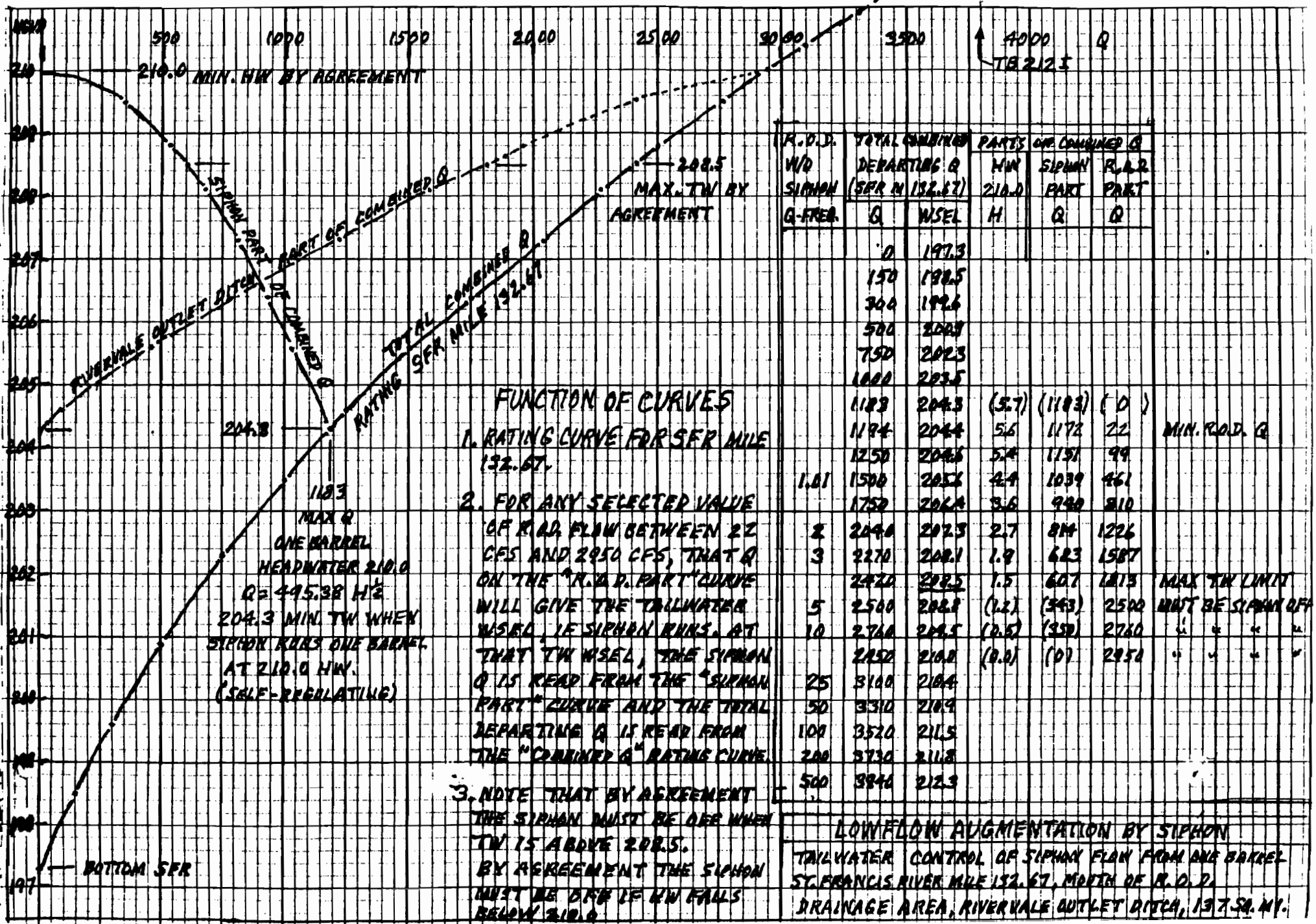
Projected Seasonal Flow and Dissolved Oxygen Conditions
in the St. Francis River Below Marked Tree

Season	Low Flow (mgd)	Low Flow (cfs)	D. O. Concentration at Critical Deficit (ppm)	Water Temperature (Degrees Centigrade)
Winter	109	169	10.2	8
Spring	252	390	7.3	22
Summer	112	173	6.7	28
Fall	57	88	7.8	18

IX. PROJECT BENEFITS

The expected monthly distribution of low flows expected to recur once in 20 years at Marked Tree is more than adequate to assimilate treated future waste discharges to the stream below the siphon.

There is, therefore, no need for or benefit from regulation of streamflow for the purpose of water quality control.



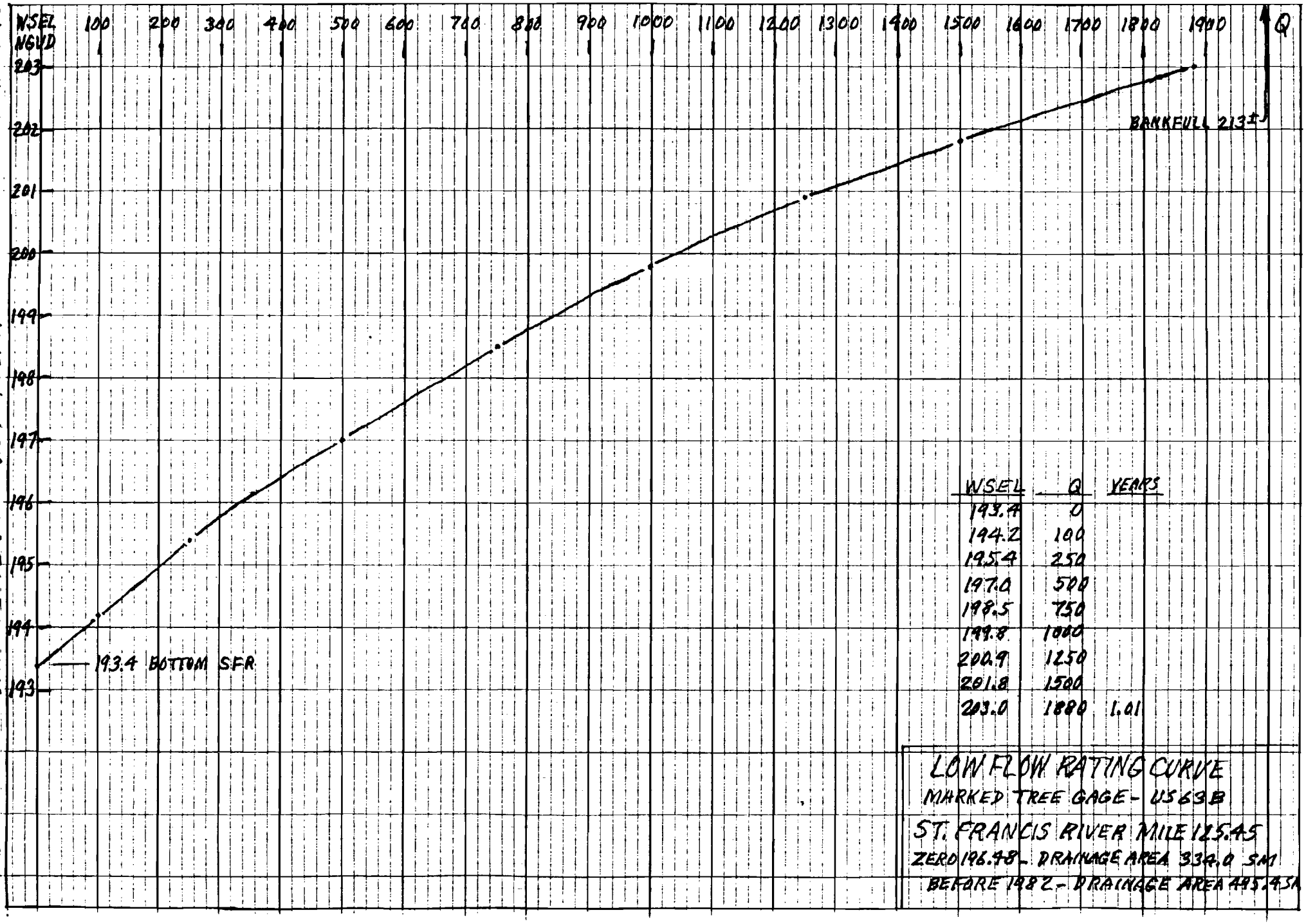
FUNCTION OF CURVES

1. RATING CURVE FOR SFR MILE 132.67.
2. FOR ANY SELECTED VALUE OF R.O.D. FLOW BETWEEN 22 CFS AND 2950 CFS, THAT Q ON THE "R.O.D. PART" CURVE WILL GIVE THE TAILWATER WSEL. IF SIPHON RUNS AT THAT TW WSEL, THE SIPHON Q IS READ FROM THE "SIPHON PART" CURVE AND THE TOTAL DEPARTING Q IS READ FROM THE "COMBINED Q" RATING CURVE.
3. NOTE THAT BY AGREEMENT THE SIPHON MUST BE OFF WHEN TW IS ABOVE 208.5. BY AGREEMENT THE SIPHON MUST BE OFF IF HW FALLS BELOW 210.0

R.O.D. W/O SIPHON Q-FREE.	TOTAL COMBINED DEPARTING Q (SFR M 132.67) Q	WSEL	PARTS OF COMBINED Q HW 210.0 H	SIPHON PART Q	R.O.D. PART Q	
	0	197.3				
	150	198.5				
	300	199.6				
	500	200.9				
	750	202.3				
	1000	203.5				
	1183	204.3	(5.7)	(1183)	(0)	
	1194	204.4	5.6	1172	22	MIN. R.O.D. Q
	1250	204.6	5.4	1151	99	
1.81	1500	205.6	4.4	1039	461	
	1750	206.4	3.6	940	810	
2	2046	207.3	2.7	844	1226	
3	2270	208.1	1.9	683	1587	
	2420	208.5	1.5	607	1813	MAX TW LIMIT
5	2500	208.8	(1.2)	(543)	2500	MUST BE SIPHON OFF
10	2760	209.5	(0.5)	(350)	2760	" " " "
	2950	210.0	(0.0)	(0)	2950	" " " "
25	3160	210.4				
50	3310	210.9				
100	3520	211.5				
200	3730	211.8				
500	3940	212.3				

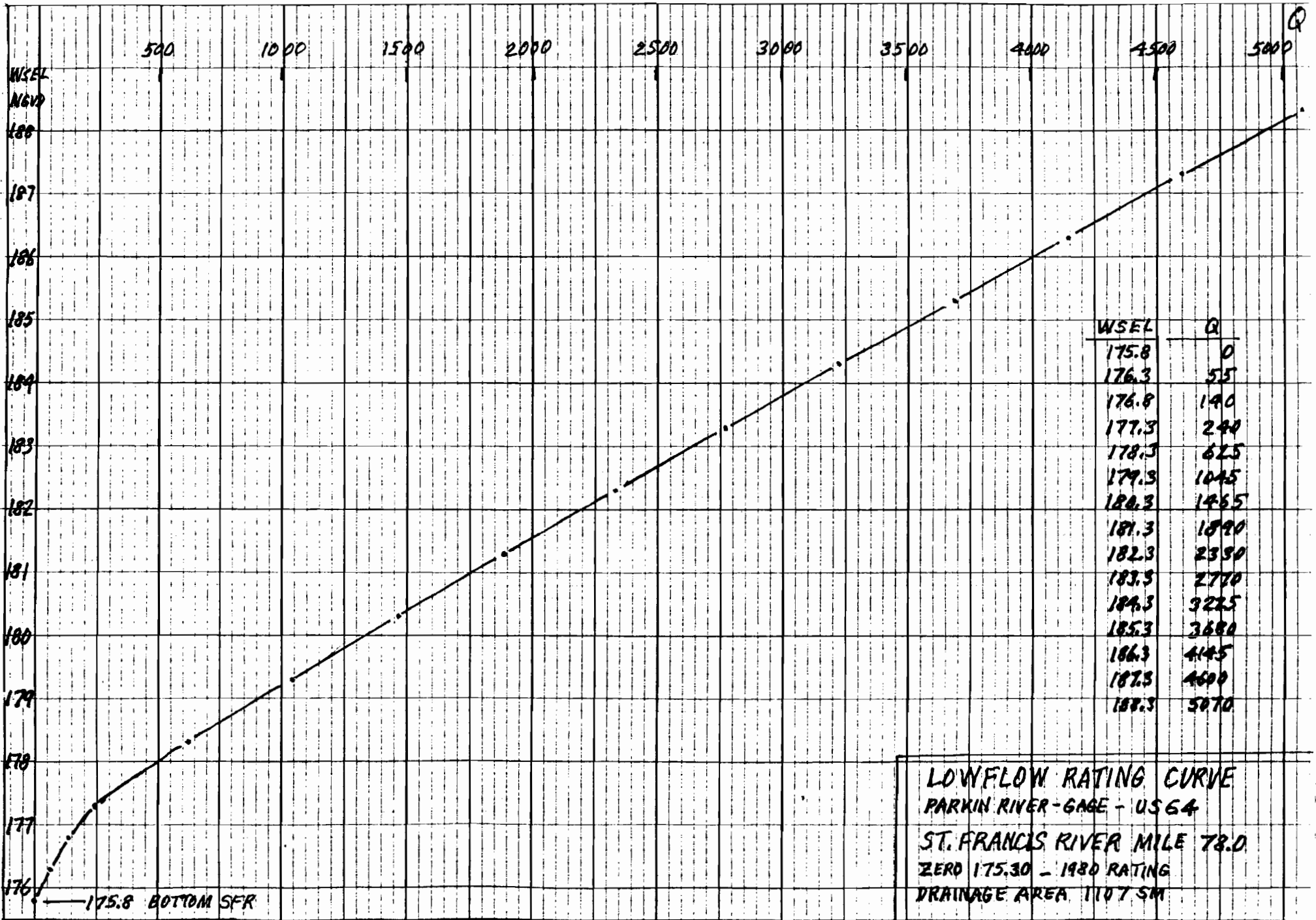
LOW FLOW AUGMENTATION BY SIPHON

TAILWATER CONTROL OF SIPHON FLOW FROM ONE BARREL
ST. FRANCIS RIVER MILE 132.67, MOUTH OF R.O.D.
DRAINAGE AREA, RIVERVALE OUTLET DITCH, 137 SQ. MI.



WSEL	Q	YEARS
193.4	0	
194.2	100	
195.4	250	
197.0	500	
198.5	750	
199.8	1000	
200.9	1250	
201.8	1500	
203.0	1880	1.01

LOW FLOW RATING CURVE
MARKED TREE GAGE - 05363B
ST. FRANCIS RIVER MILE 125.45
ZERO 196.48 - DRAINAGE AREA 334.0 SM
BEFORE 1982 - DRAINAGE AREA 495.4SM

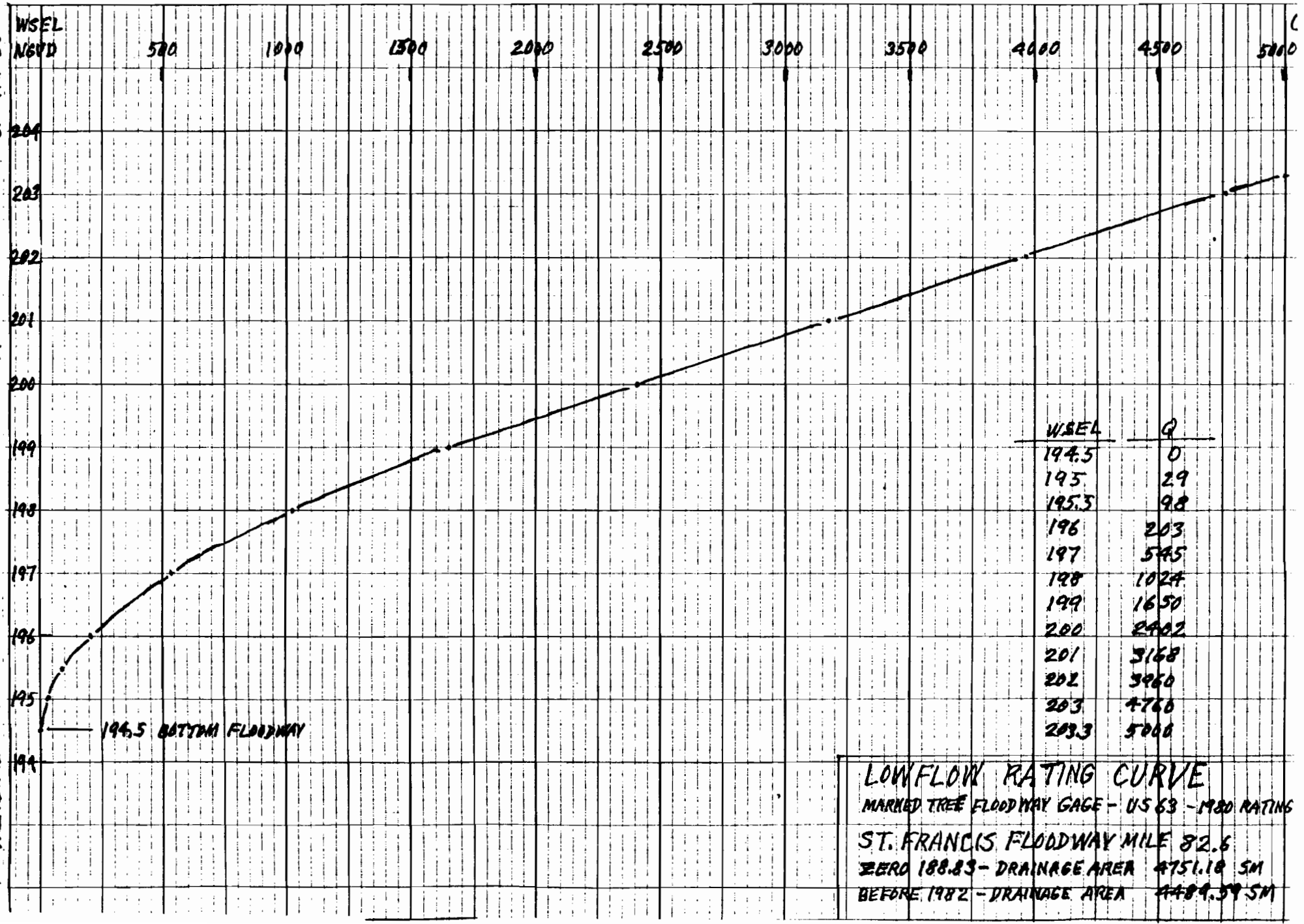


WSEL	Q
175.8	0
176.3	515
176.8	1190
177.3	2240
178.3	6225
179.3	10455
180.3	14655
181.3	18990
182.3	23590
183.3	27710
184.3	32225
185.3	36880
186.3	41455
187.3	46090
188.3	50710

LOWFLOW RATING CURVE
PARKIN RIVER-GAGE - US64
ST. FRANCIS RIVER MILE 78.0
ZERO 175.30 - 1980 RATING
DRAINAGE AREA 1107 SM

LOWFLOW RATING, PARKIN, RIVER GAGE

PLATE IVA-3



WSEL	Q
194.5	0
195	29
195.3	98
196	203
197	545
198	1024
199	1650
200	2402
201	3168
202	3960
203	4760
203.3	5000

LOWFLOW RATING CURVE

MARKED TREE FLOODWAY GAGE - US 63 - 1980 RATING

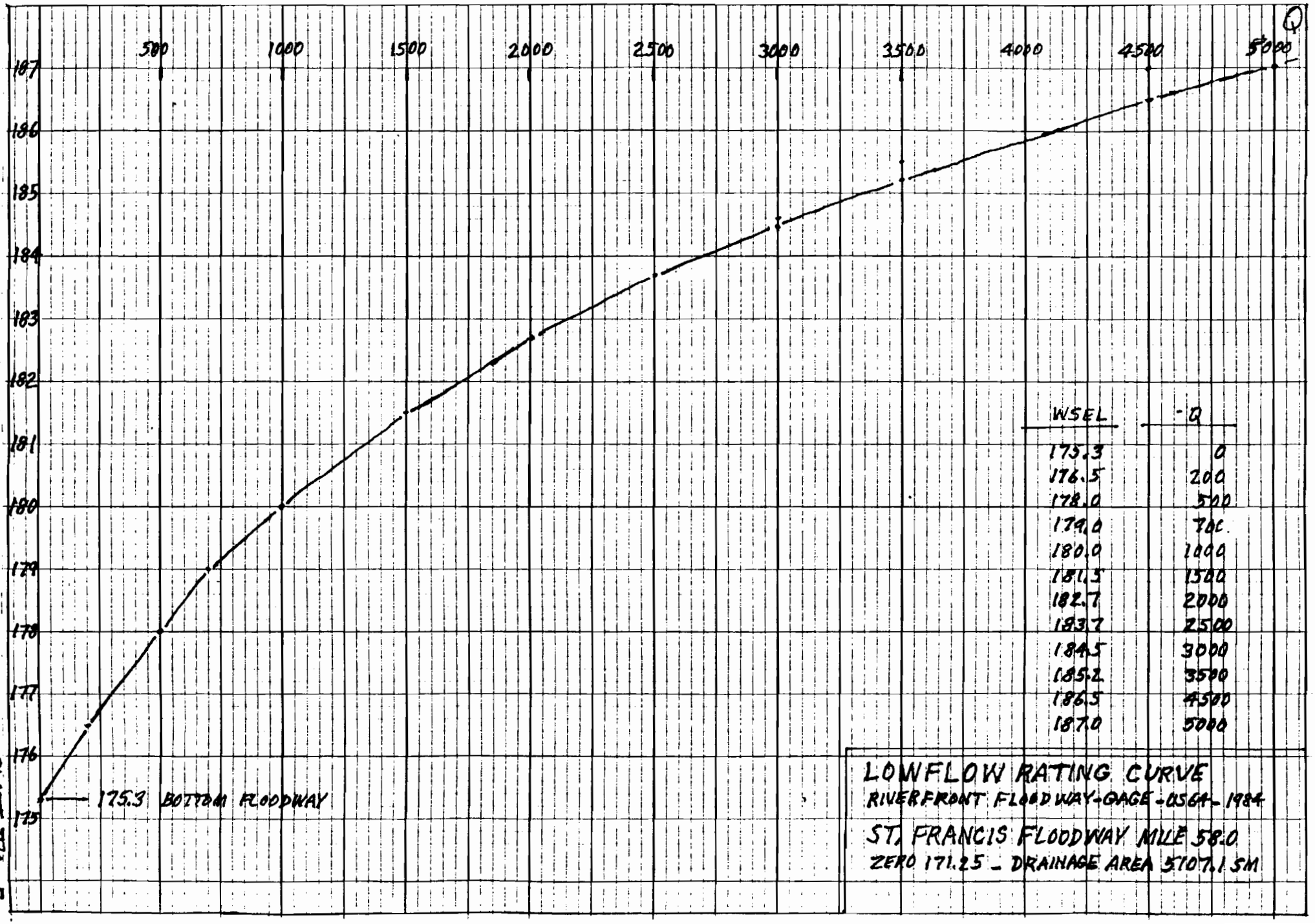
ST. FRANCIS FLOODWAY MILE 82.6

ZERO 188.83 - DRAINAGE AREA 4751.18 SM

BEFORE 1982 - DRAINAGE AREA 4484.39 SM

LOWFLOW RATING, MARKED TREE, FLOODWAY

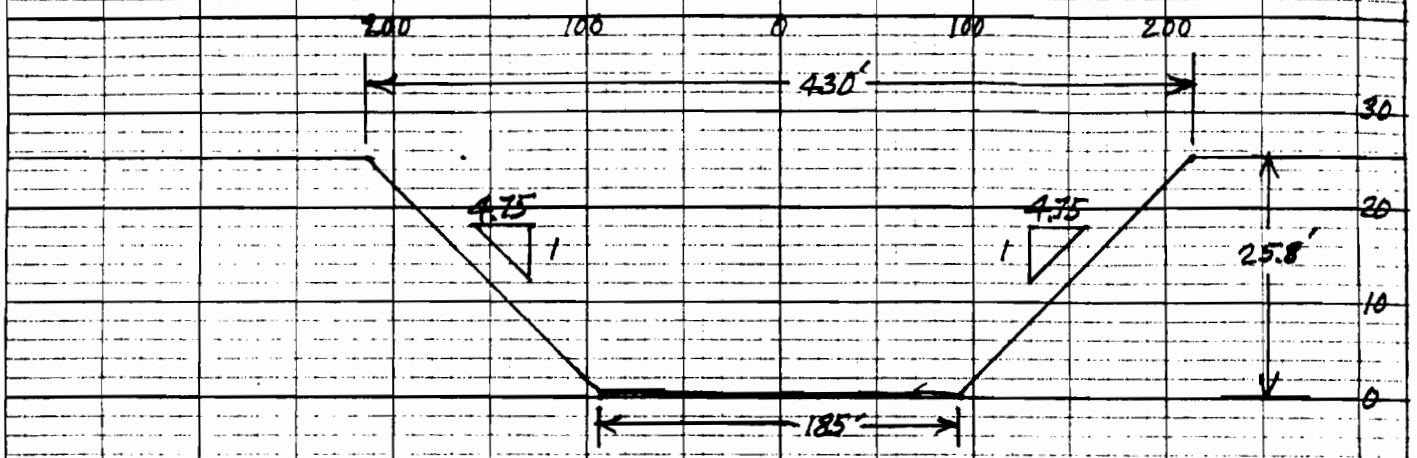
PLATE IVA-4



WSEL	Q
175.3	0
176.5	200
178.0	500
179.0	700
180.0	1000
181.5	1500
182.7	2000
183.7	2500
184.5	3000
185.2	3500
186.5	4500
187.0	5000

LOWFLOW RATING CURVE
RIVERFRONT FLOODWAY-GAGE-0564-1984

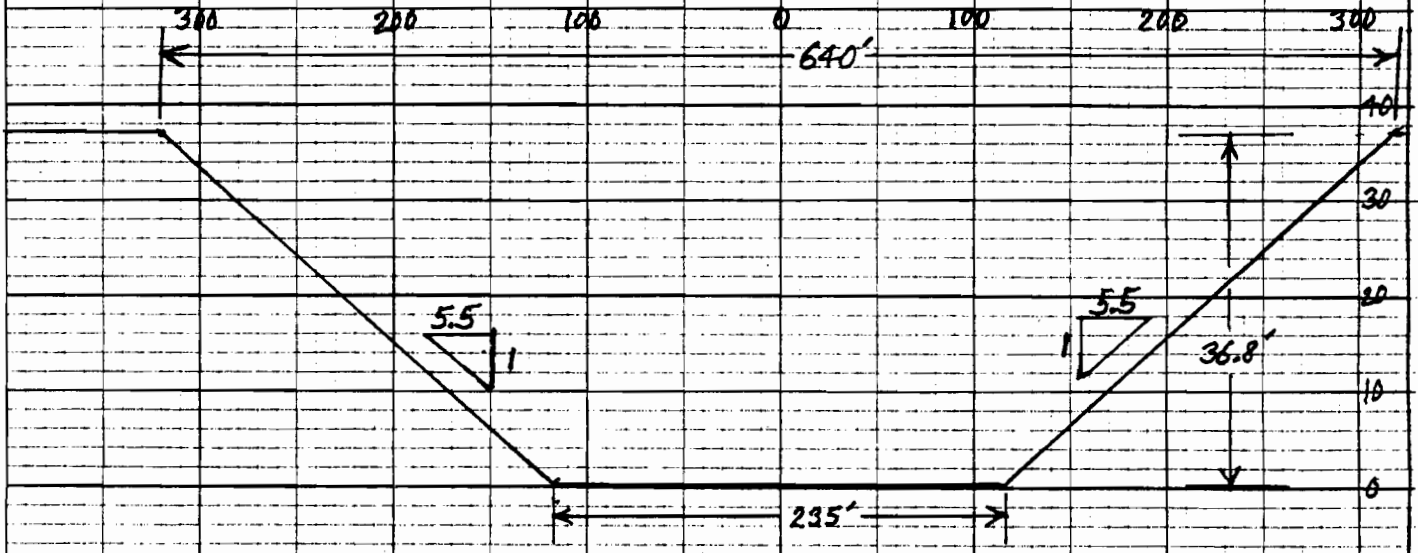
ST. FRANCIS FLOODWAY MILE 58.0
ZERO 171.25 - DRAINAGE AREA 5107.1 SM



TYPICAL EQUIVALENT SECTION, UPPER RIVER

FOOT OF RIVERVAL OUTLET DITCH, 132.67, TO PARKIN, 78.00 – 54.67 MILES

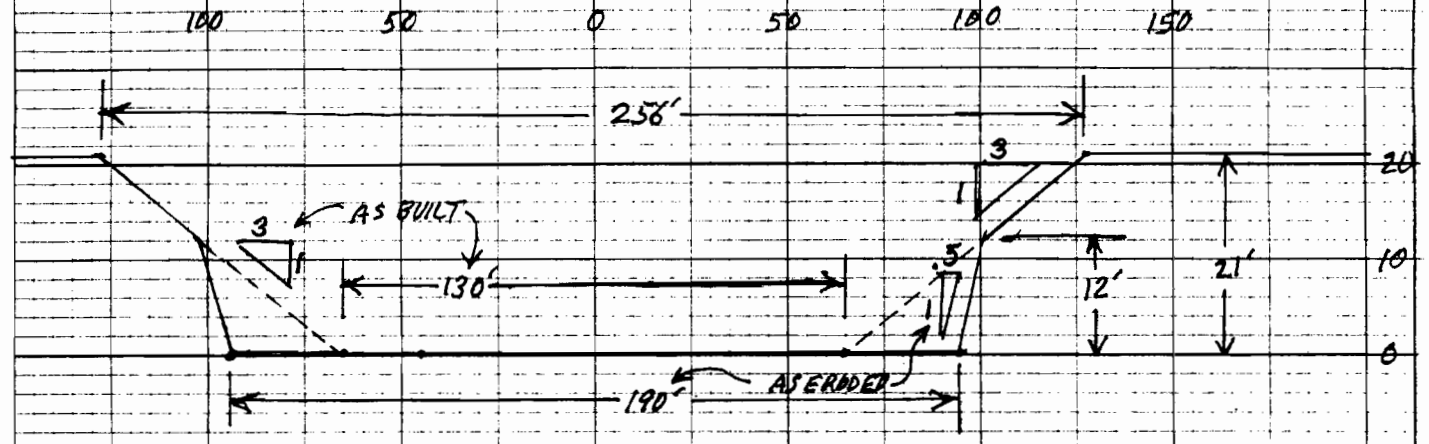
TO GET WATER SURFACE WIDTH AND ACRES, USE THE AVERAGE OF THE DEPTHS AT MARKED TREE GAGE AND PARKIN GAGE (TABLE IIIA-06) WITH THIS SECTION.



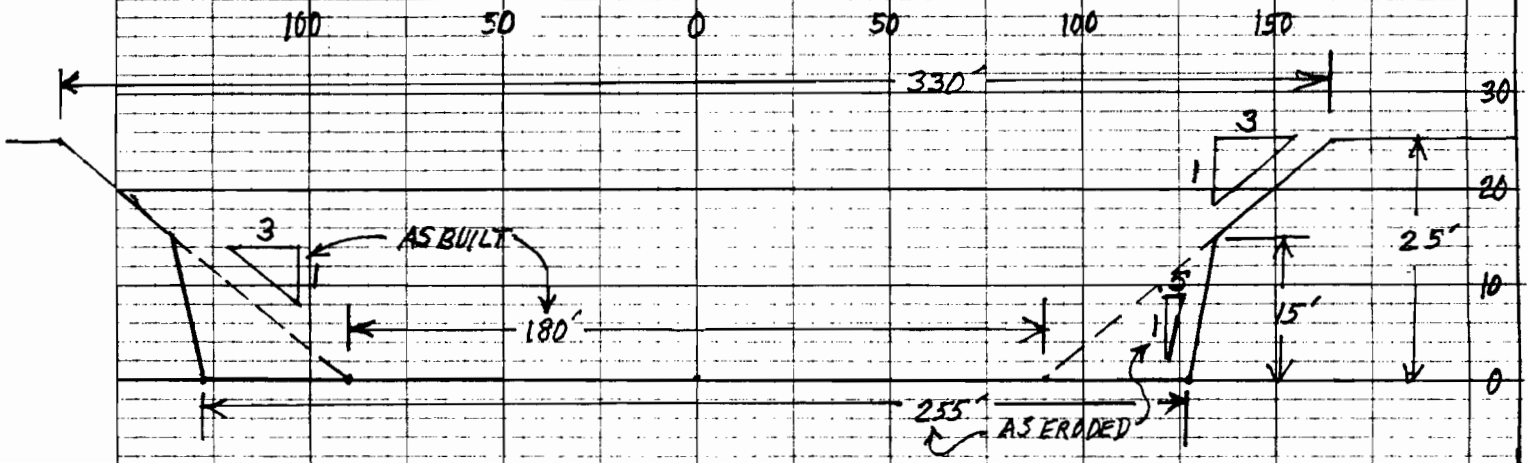
TYPICAL EQUIVALENT SECTION, LOWER RIVER

PARKIN, 78.0, TO HUXTABLE, 14.8 – 63.2 MILES

TO GET WATER SURFACE WIDTH AND ACRES, USE DEPTH AT PARKIN GAGE (TABLE IIIA-06) WITH THIS SECTION.



TYPICAL SECTION, UPPER FLOODWAY, 26.94 MILES
ST. FRANCIS LAKE GATE, 84.94, TO RIVERFRONT, 58.0
TO GET WATER SURFACE WIDTH AND ACRES, USE THE AVERAGE OF THE DEPTHS AT US 63 FLOODWAY GAGE AND RIVERFRONT (TABLE IIIA-07) WITH THIS SECTION.



TYPICAL SECTION, LOWER FLOODWAY, 46.45 MILES
RIVERFRONT, 58.0, TO JUNCTION OF SFR BELOW HUXTABLE, 11.55
TO GET WATER SURFACE WIDTH AND ACRES, USE DEPTH AT RIVERFRONT GAGE (TABLE IIIA-07) WITH THIS SECTION.

SECTION IVB - HYDROLOGY AND HYDRAULICS, FLOOD FLOWS

IVB-01. CONSIDERATION OF FLOOD FLOWS.

The effects of siphon operation during flood flows on conditions within the Floodway and within the River protected area are examined in detail in two Appendices to this report. APPENDIX A - IMPACT OF SIPHON ON HUXTABLE PUMPING OPERATION is the basis for paragraph IX-02d in SECTION IX - PLAN OF OPERATION OF SIPHON. APPENDIX B - EMERGENCY USE OF SIPHON TO AVOID A CREVASSE shows a net benefit to the Huxtable protected area in a flood emergency by transfer of the full capacity of the siphon, both under existing Floodway conditions and after Floodway improvements under study should be made. The procedures are described in paragraph IX-03.

IVB-02. SOURCES OF DATA.

It has not been necessary to develop from basics all the data used in these considerations. To the extent that conditions make the data still pertinent, sources have included: GDM 101, Lower St. Francis River; GDM 105, Lower St. Francis River, East of Floodways; GDM 107, St. Francis Basin, Left Bank Tributaries; GDM 108, Oak Donnick Floodway. A major source has been "Economic and Hydraulic Analysis for the Operation of the Huxtable Pumping Plant, January 1985, Appendix A." From a study recently completed, which considers Floodway maintenance from Madison to U.S. 64, this report uses crevasse damage estimates.

IVB-03. PLATES SHOWING DATA USED.

At the end of this SECTION there are seventeen plates, showing fifteen curves and, on all but four, tables of coordinates for plotted points. Plates MB-4, MB-19, and MB-21 are adapted from "Appendix B, Hydrology and Hydraulics" in the study of Floodway maintenance. Plates Maint. 6-2 and Maint. 6-6 are maps of flooded areas.

IVB-1 Rating, River Mile 125.45, Marked Tree Gage
IVB-2 Rating, River Mile 78.0, Parkin Gage
IVB-3 Rating, Floodway Mile 82.6, Marked Tree Gage
MB-4 Flowlines, 12 Frequencies, Existing Conditions, Floodway Miles 58.0, 58.5, 59.5
IVB-4 Rating, Floodway Mile 58.0, Riverfront Gage
IVB-5 Rating, Floodway Mile 58.5, Crevasse Site, Existing and Authorized (Modified) Conditions
IVB-6 Rating, Floodway Mile 59.5, Foot of Reach 7B, Existing Conditions
MB-19 Flowlines, 12 Frequencies, Authorized (Modified) Conditions, Floodway Miles 58.0, 58.5, 59.5
IVB-7 Stage-Frequency, Annual, Floodway Mile 58.5, Crevasse Site, Existing and Authorized (Modified) Conditions

MB-21 Stage-Frequency, Annual and Partial, Floodway Mile 59.5, Foot of Reach 7B, Existing Conditions, With and Without Historical Siphon Withdrawals

IVB-8 Discharge-Frequency, Floodway Miles 58.0, 58.5, 59.5, With and Without Siphon Withdrawals.

IVB-9 Rating, River Mile 132.67, Siphon Outlet, 1 Barrel Emergency Transfer

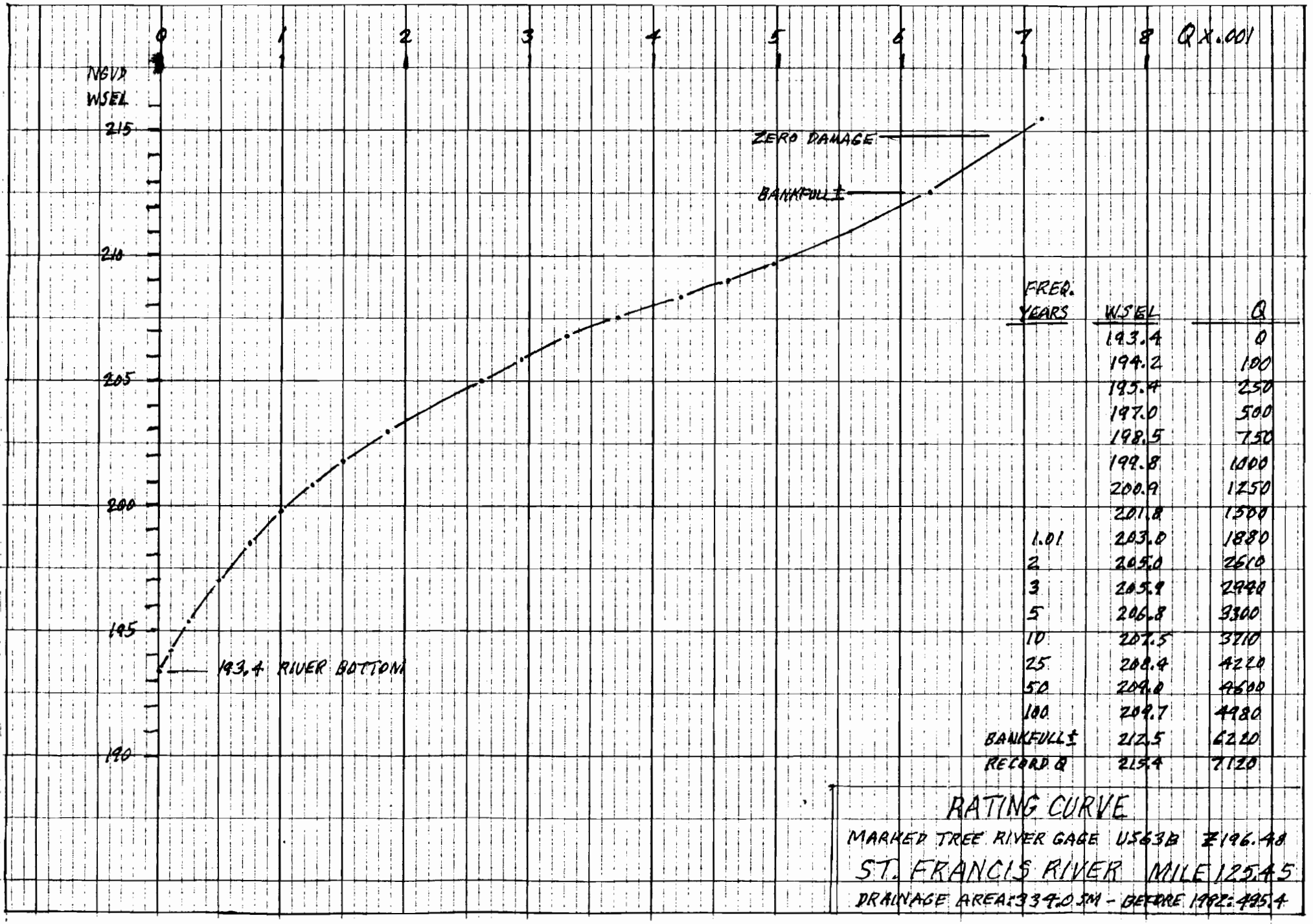
IVB-10 Rating, River Mile 132.67, Siphon Outlet, 3 Barrels Emergency Transfer

IVB-11 Stage-Frequency, Annual, River Mile 132.67, Siphon Outlet, Siphon Off, 1 barrel Flowing, 3 Barrels Flowing

IVB-12 Discharge-Frequency, Annual, River Mile 132.67, Siphon Outlet, Siphon Off, 1 Barrel Flowing, 3 Barrels Flowing

Maint. 6-2 Backwater Flooded Area (Reach 7B)

Maint. 6-6 Huxtable Pumping Plant Flooded Area



FREQ. YEARS	WSEL	Q
	193.4	0
	194.2	100
	195.4	250
	197.0	500
	198.5	750
	199.8	1000
	200.9	1250
	201.8	1500
1.01	203.0	1880
2	205.0	2610
3	205.9	2990
5	206.8	3300
10	207.5	3710
25	208.4	4220
50	209.0	4600
100	209.7	4980
BANKFULL ±	212.5	6220
RECORD Q	215.4	7120

RATING CURVE

MARKED TREE RIVER GAGE USGS # 196.48

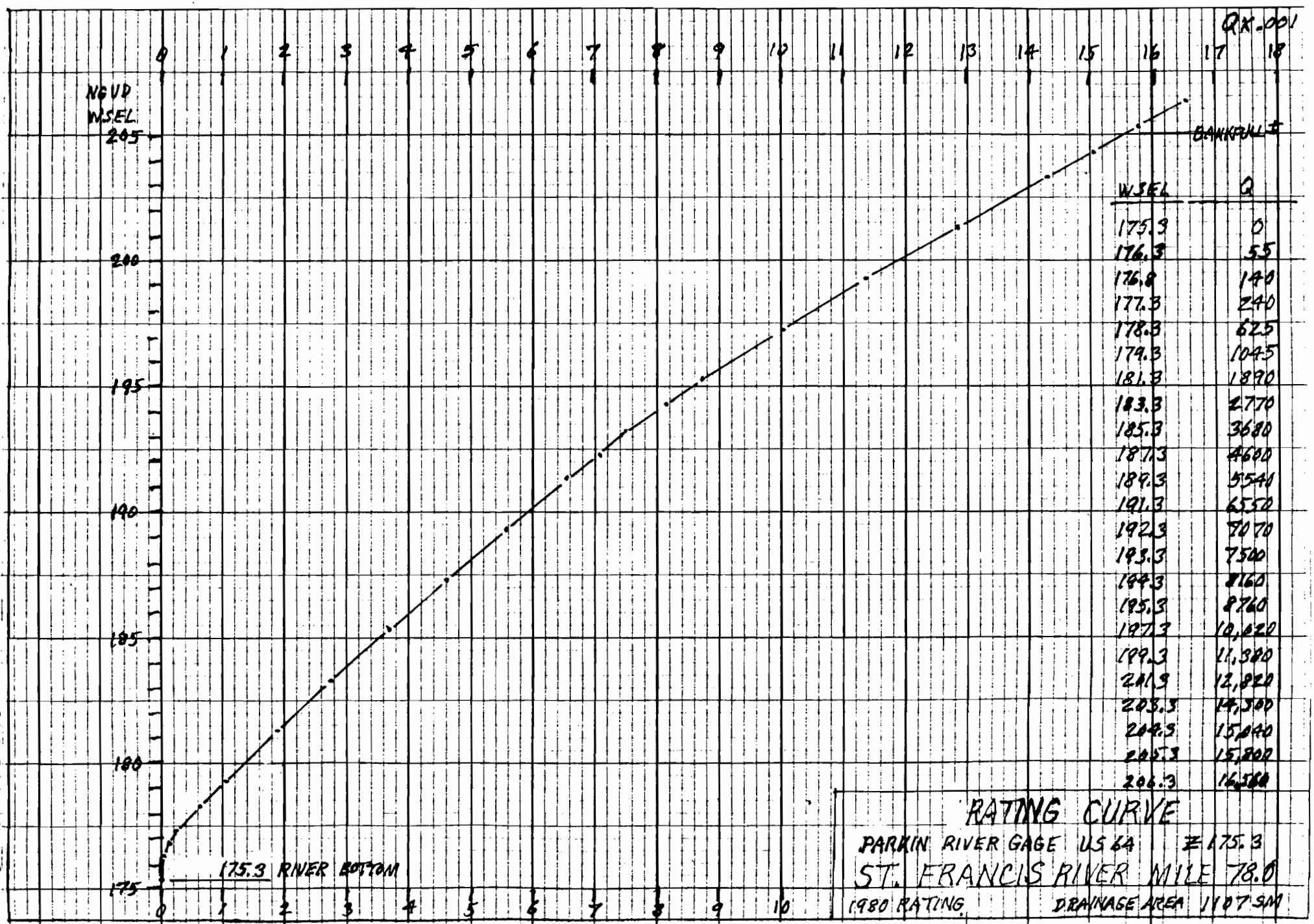
ST. FRANCIS RIVER MILE 125.45

DRAINAGE AREA: 334.0 SM - DATUM 1962: 495.4

RATING, GAGE, MARKED TREE, RIVER MILE 125.45

PLATE IVB-1

QX-001



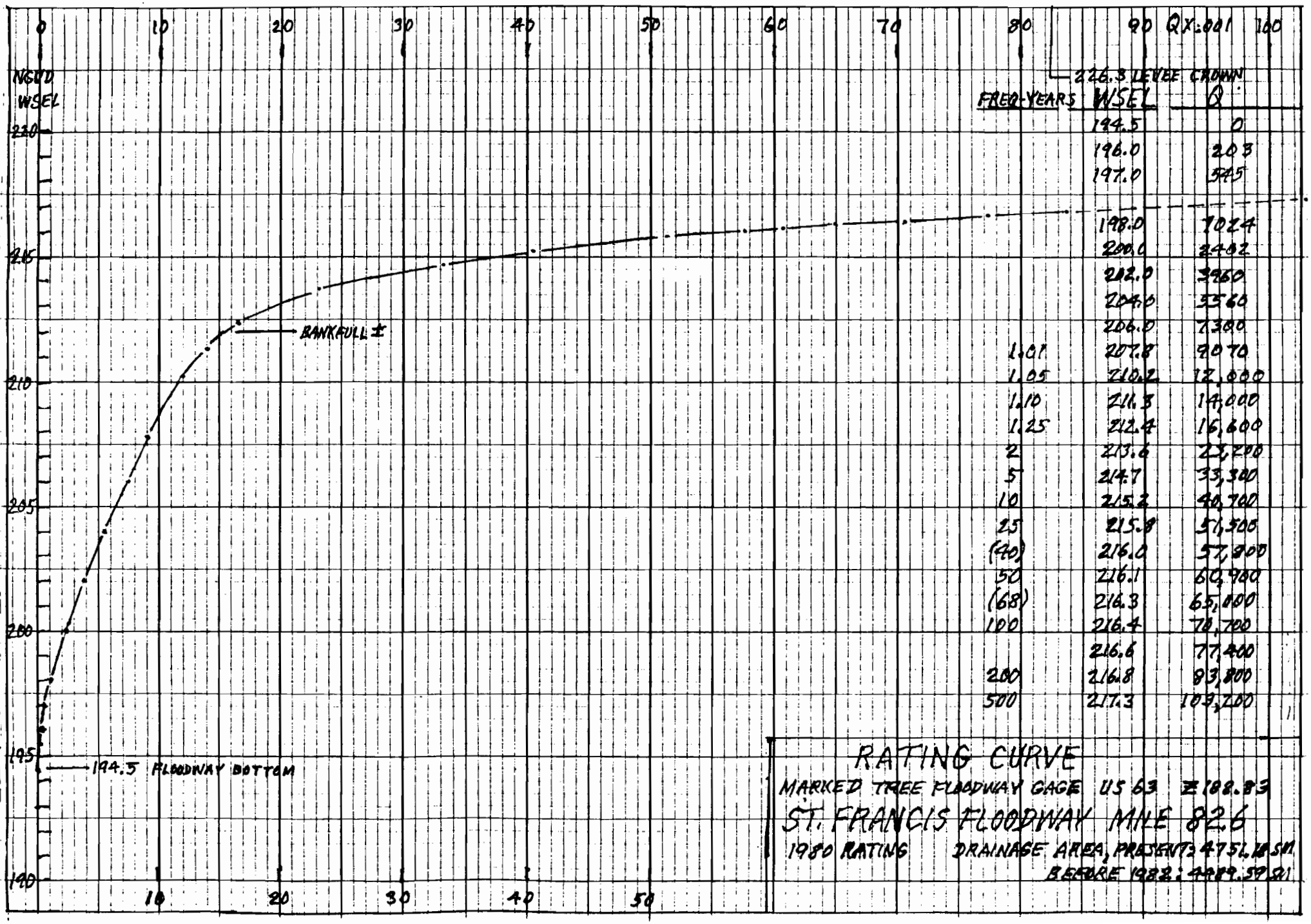
WSEL	Q
175.3	0
176.3	55
176.8	140
177.3	240
178.3	625
179.3	1045
181.3	1890
183.3	2770
185.3	3680
187.3	4600
189.3	5540
191.3	6550
192.3	7070
193.3	7500
194.3	8160
195.3	8760
197.3	10,020
199.3	11,380
201.3	12,820
203.3	14,300
204.3	15,040
205.3	15,800
206.3	16,560

RATING CURVE

PARKIN RIVER GAGE US 64 — Z = 175.3

ST. FRANCIS RIVER MILE 78.0

1980 RATING — DRAINAGE AREA 1107 SM



FREQ-YEARS	WSEL	Q
	194.5	0
	196.0	203
	197.0	345
	198.0	1024
	200.0	2402
	202.0	3960
	204.0	5560
	206.0	7300
1.01	207.8	9070
1.05	210.2	12,000
1.10	211.3	14,000
1.25	212.4	16,600
2	213.4	23,200
5	214.7	33,300
10	215.2	40,700
25	215.8	51,500
(40)	216.0	57,800
50	216.1	60,900
(68)	216.3	65,100
100	216.4	70,700
	216.6	77,400
200	216.8	83,800
500	217.3	103,200

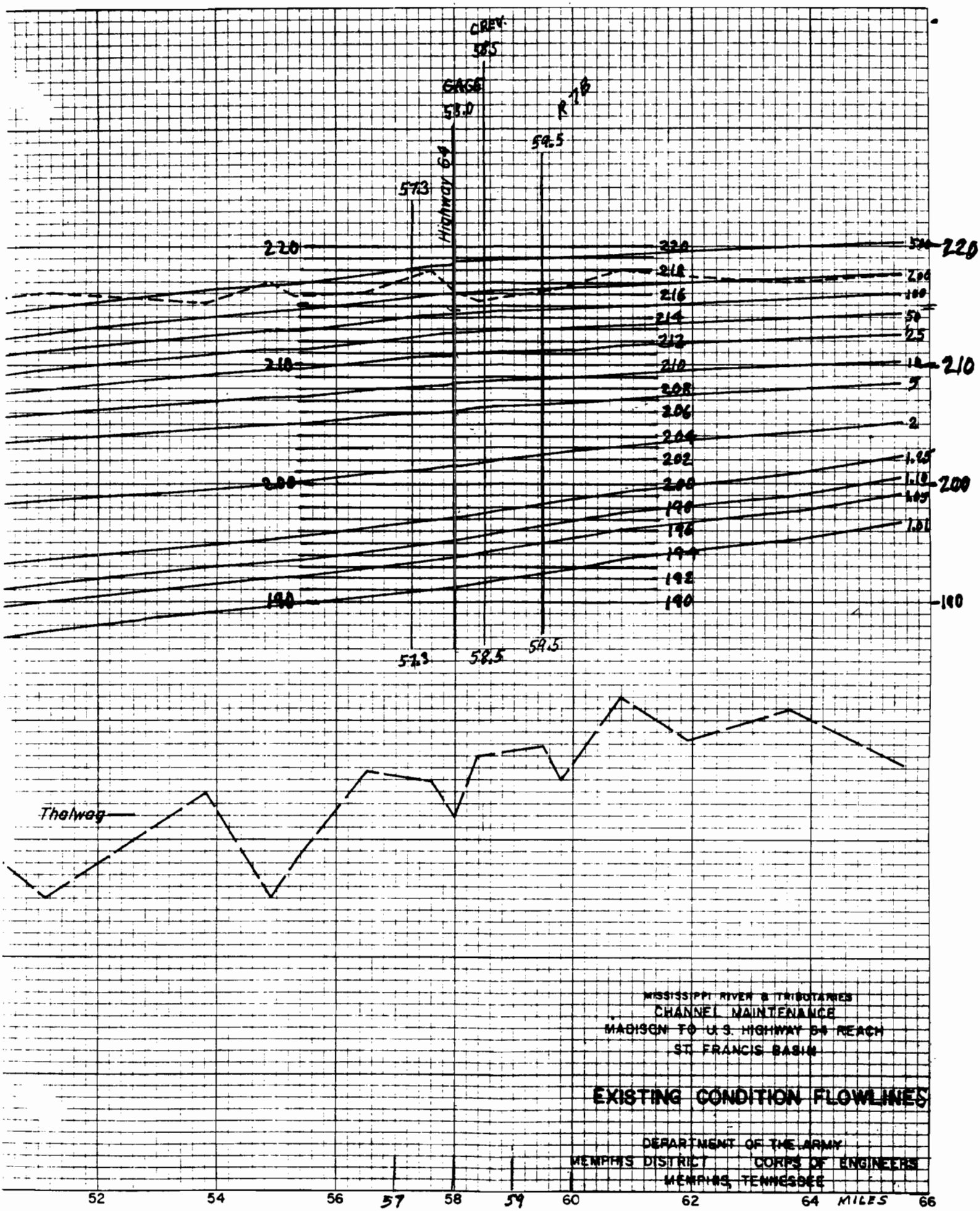
RATING CURVE

MARKED TREE FLOODWAY GAGE US 63 ≡ 188.83

ST. FRANCIS FLOODWAY MILE 82.6

1980 RATING DRAINAGE AREA, PRESENT: 4751.16 SM

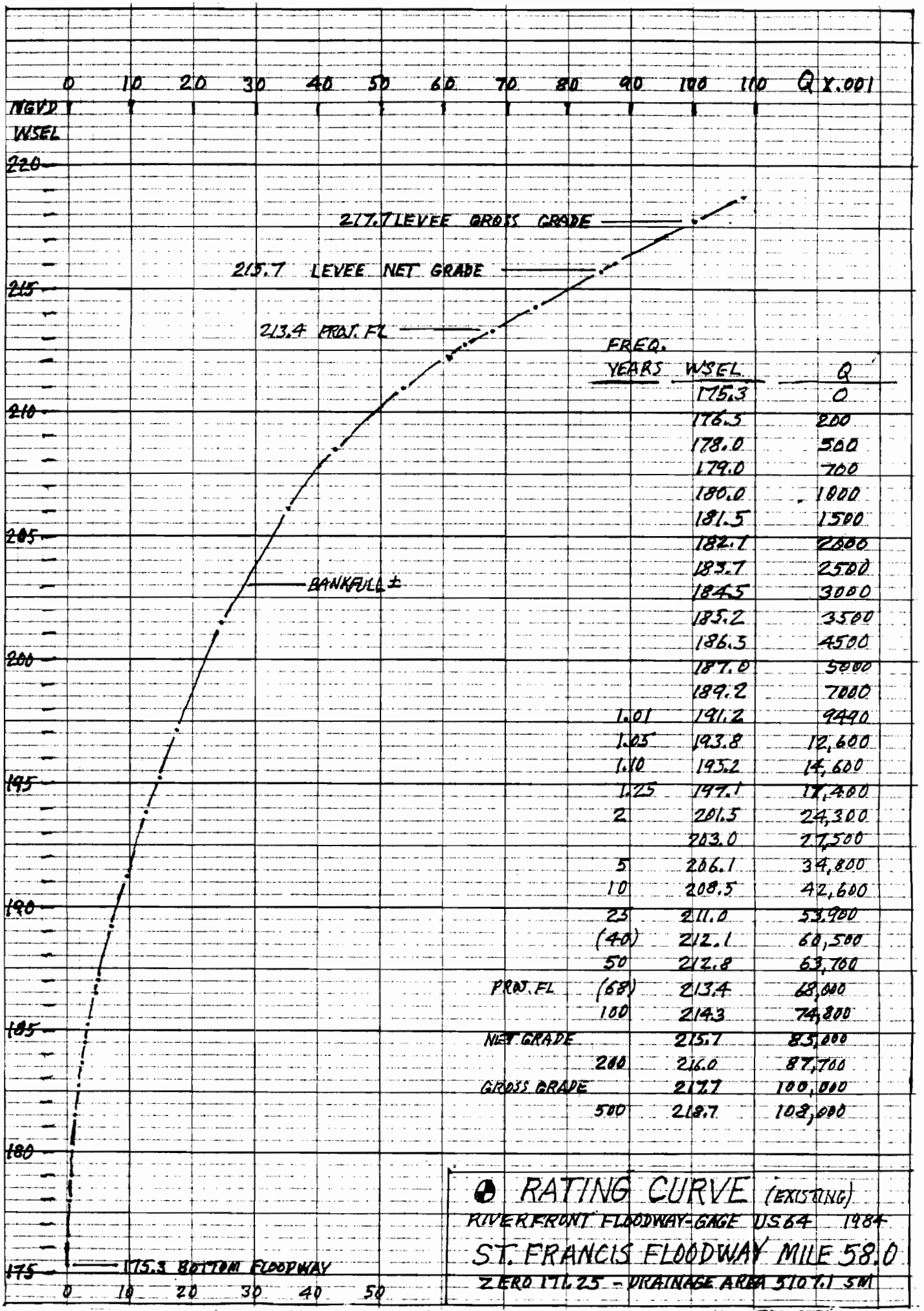
BEFORE 1982: 4789.59 SM



MISSISSIPPI RIVER & TRIBUTARIES
CHANNEL MAINTENANCE
MADISON TO U.S. HIGHWAY 61 REACH
ST. FRANCIS BASIN

EXISTING CONDITION FLOWLINES

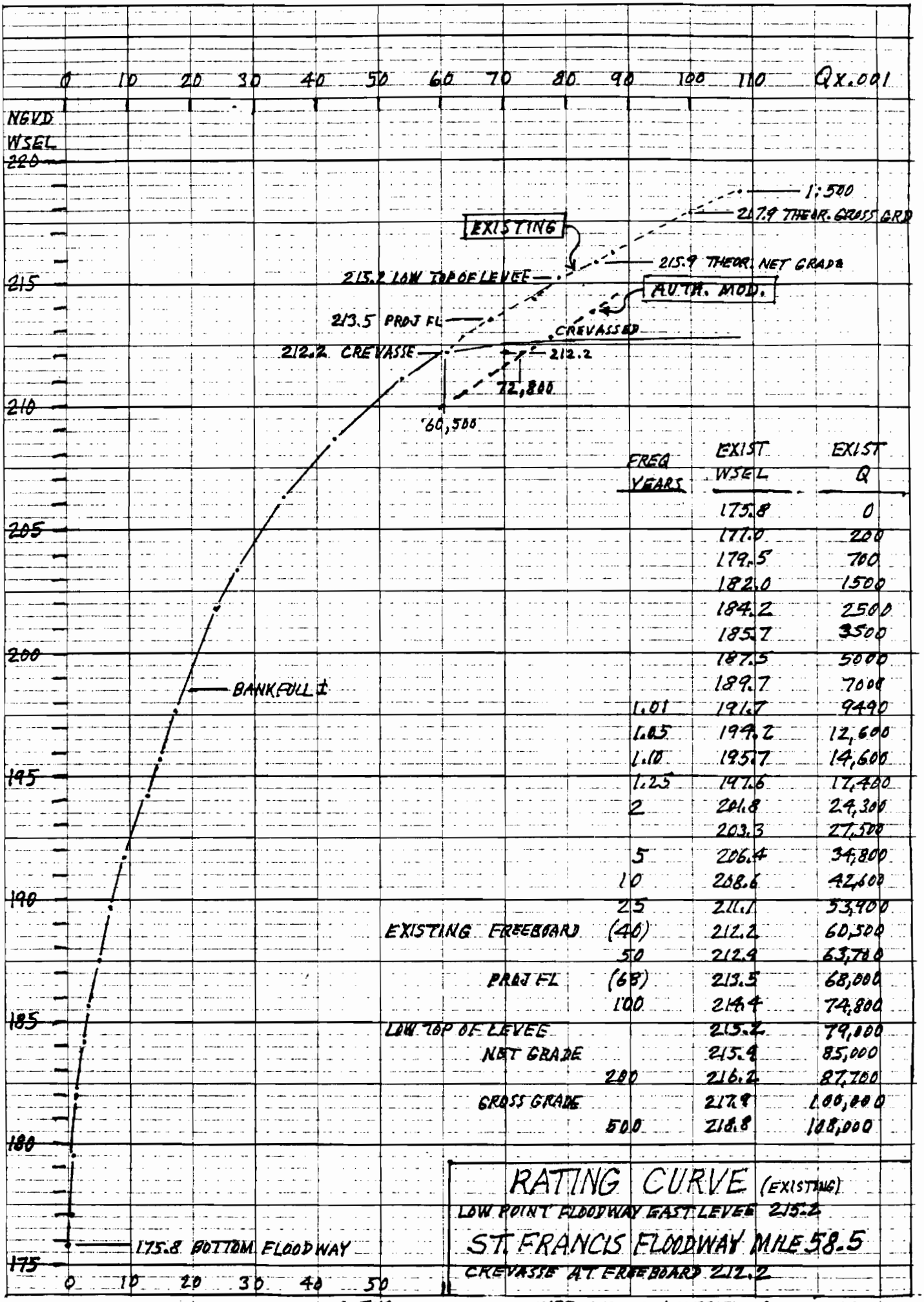
DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
MEMPHIS, TENNESSEE



FREQ. YEARS	WSEL	Q
	175.3	0
	176.3	200
	178.0	500
	179.0	700
	180.0	1000
	181.5	1500
	182.1	2000
	183.7	2500
	184.5	3000
	185.2	3500
	186.3	4500
	187.0	5000
	189.2	7000
1.01	191.2	9490
1.05	193.8	12,600
1.10	195.2	14,600
1.25	197.1	17,400
2	201.5	24,300
	203.0	27,500
5	206.1	34,800
10	208.5	42,600
25	211.0	53,900
(40)	212.1	60,500
50	212.8	63,700
PROJ. FL (68)	213.4	68,000
100	214.3	74,800
NET GRADE	215.7	85,000
200	216.0	87,700
GROSS GRADE	217.7	100,000
500	218.7	108,000

RATING CURVE (EXISTING)
RIVERFRONT FLOODWAY-GAGE US64 1984
ST. FRANCIS FLOODWAY MILE 58.0
ZERO ELEV. 175.25 - DRAINAGE AREA 3107.1 SM

RATING, GAGE, RIVERFRONT, FLOODWAY M58.0 PLATE IVB-4



FREQ YEARS		EXIST WSEL	EXIST Q
		175.8	0
		177.0	200
		179.5	700
		182.0	1500
		184.2	2500
		185.7	3500
		187.5	5000
		189.7	7000
1.01		191.7	9490
1.05		194.2	12,600
1.10		195.7	14,600
1.25		197.6	17,400
2		201.8	24,300
		203.3	27,500
5		206.4	34,800
10		208.6	42,600
25		211.1	53,400
EXISTING FREEBOARD	(40)	212.2	60,500
50		212.9	63,700
PROJ FL	(68)	213.5	68,000
100		214.4	74,800
LOW TOP OF LEVEE		215.2	79,000
NET GRADE		215.9	85,000
200		216.2	87,700
GROSS GRADE		217.9	100,000
500		218.8	108,000

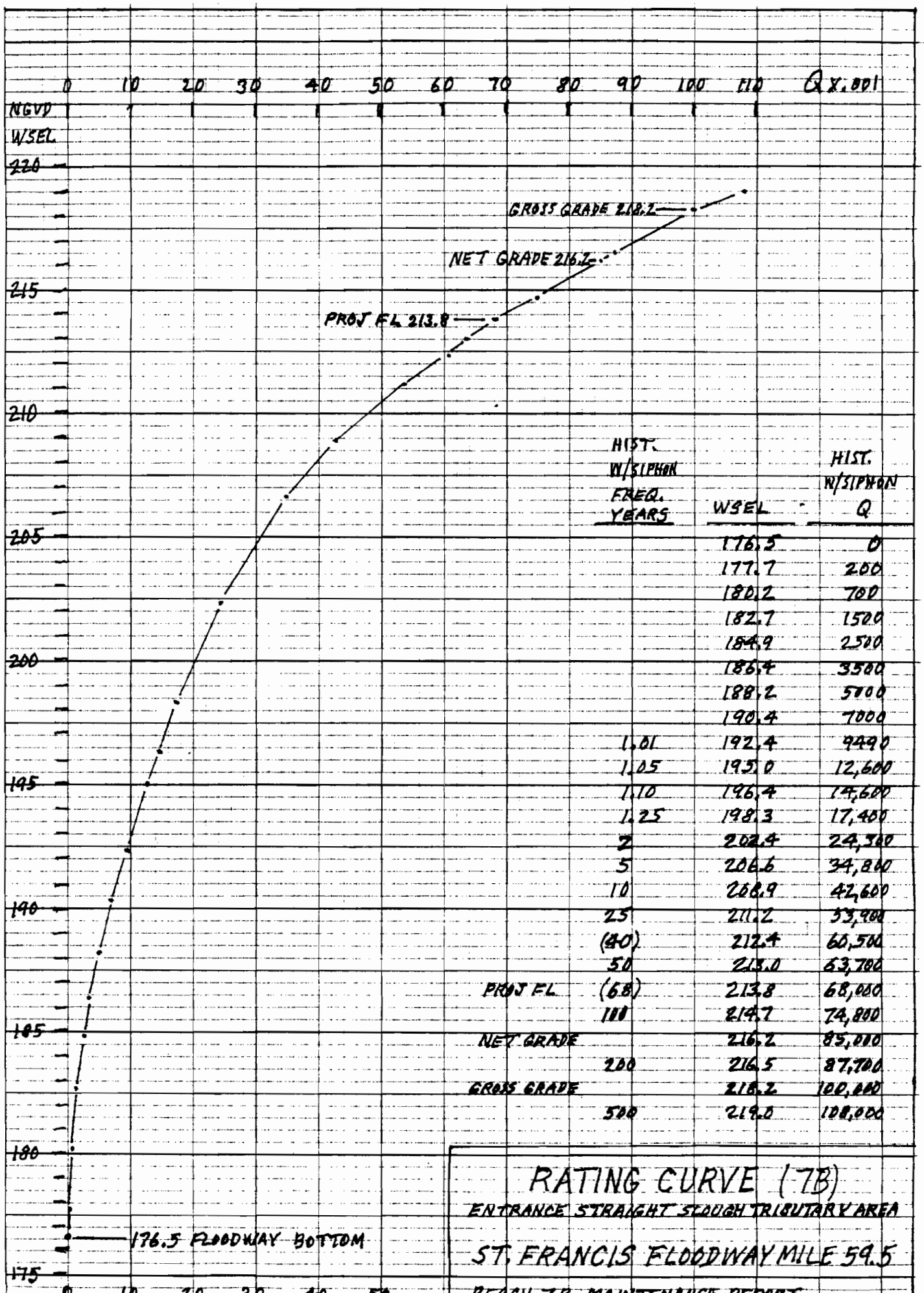
RATING CURVE (EXISTING)

LOW POINT FLOODWAY EAST LEVEE 215.2

ST. FRANCIS FLOODWAY MILE 58.5

CREVASSE AT FREEBOARD 212.2

RATING, LOW POINT ON LEVEE, FLOODWAY M58.5 PLATE IVB-5



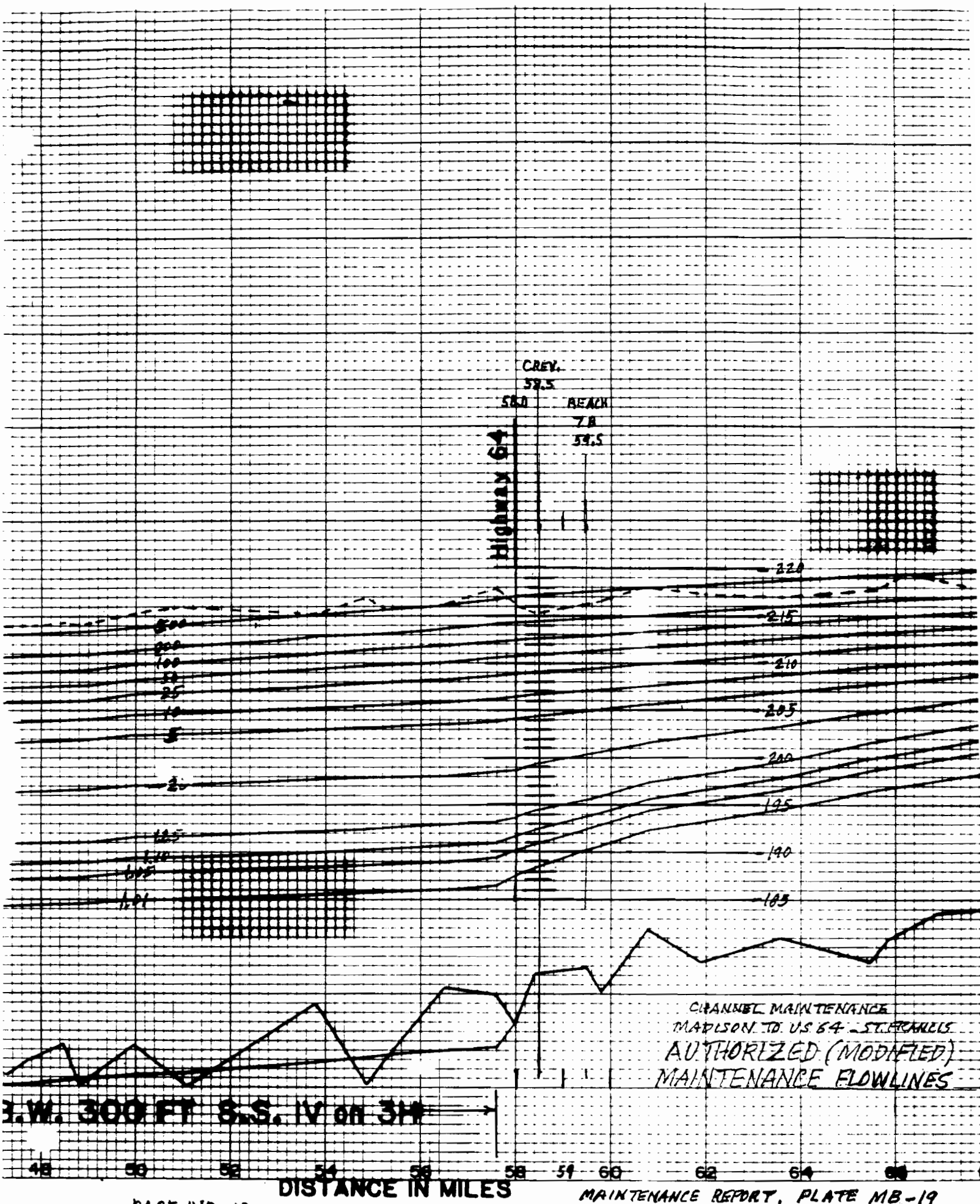
HIST. W/SIPHON FREQ. YEARS	W/SEL	HIST. W/SIPHON Q
	176.5	0
	177.7	200
	180.2	700
	182.7	1500
	184.9	2500
	186.4	3500
	188.2	5000
	190.4	7000
1.01	192.4	9490
1.05	193.0	12,600
1.10	196.4	14,600
1.25	198.3	17,400
2	202.4	24,300
5	206.6	34,800
10	208.9	42,600
25	211.2	53,900
(40)	212.4	60,500
50	213.0	63,700
PROJ FL (68)	213.8	68,050
100	214.7	74,800
NET GRADE	216.2	85,000
200	216.5	87,700
GROSS GRADE	218.2	100,000
500	219.0	108,000

RATING CURVE (7B)

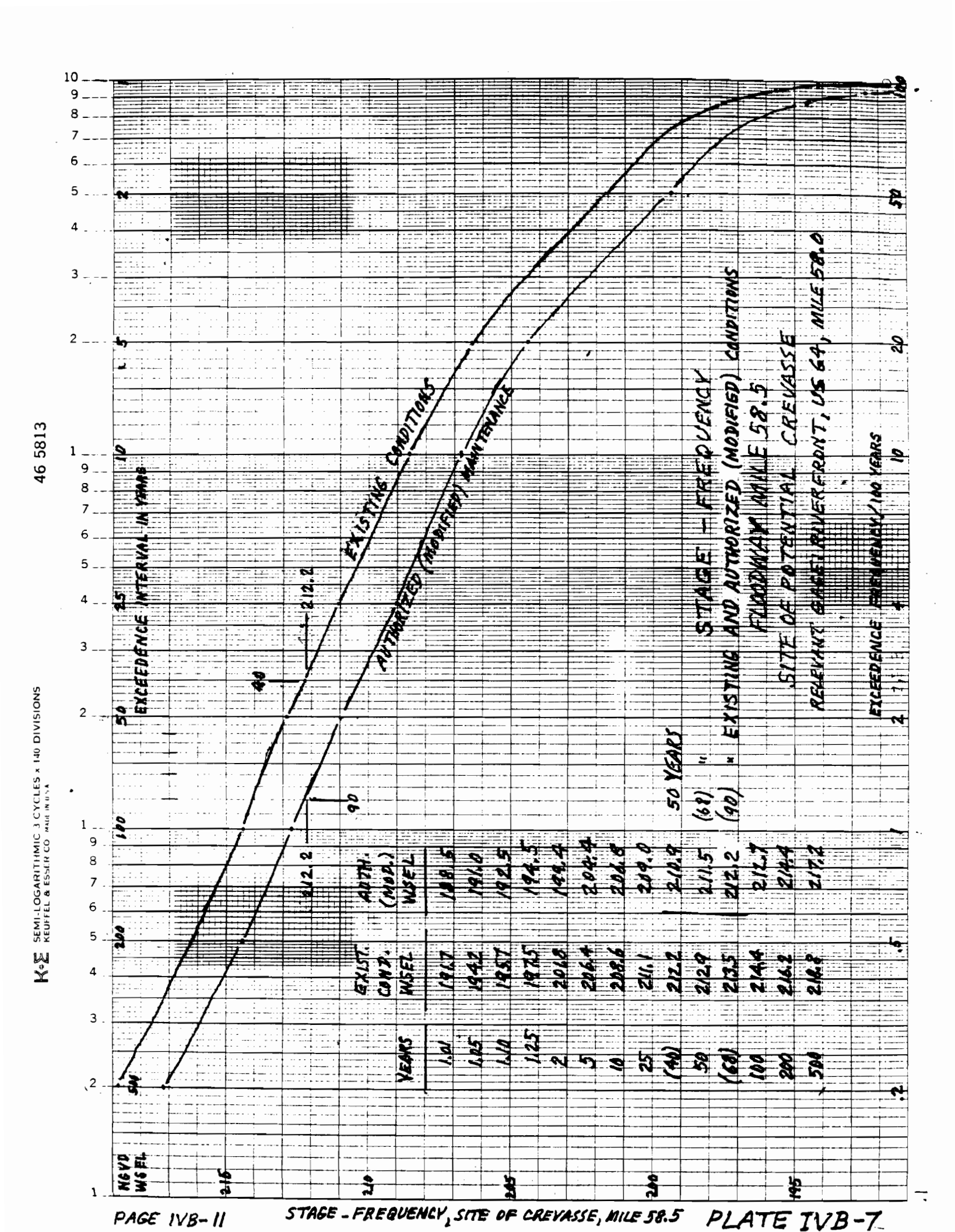
ENTRANCE STRAIGHT SLOUGH TRIBUTARY AREA

ST. FRANCIS FLOODWAY MILE 59.5

REACH 7B, MAINTENANCE REPORT



MAINTENANCE REPORT, PLATE MB-19

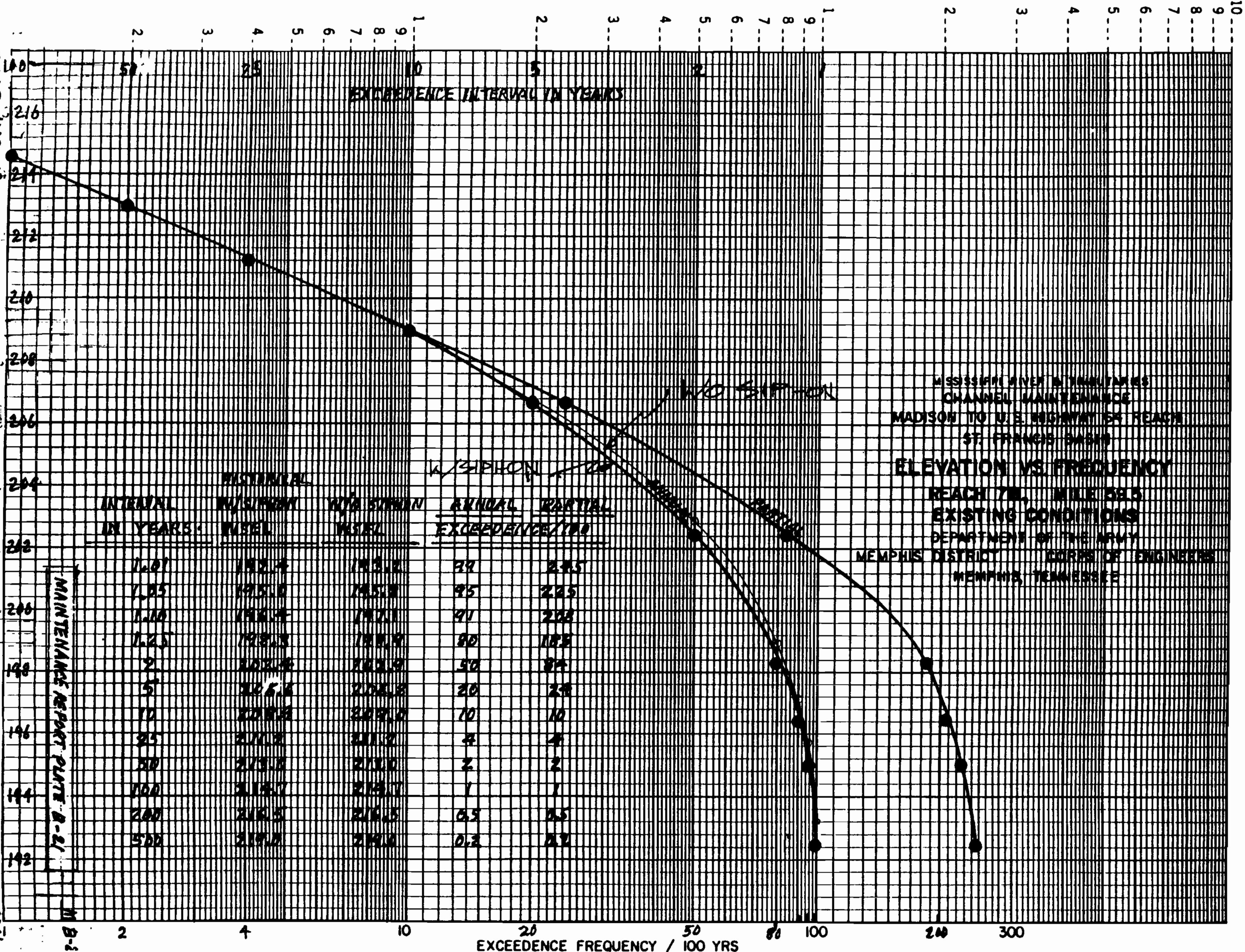


PAGE IVB-11

STAGE - FREQUENCY, SITE OF CREVASSE, MILE 58.5

PLATE IVB-7

46 5493



INTERVAL IN YEARS	HISTORICAL W/SIPHON WSEL	W/O SIPHON WSEL	ANNUAL EXCEEDENCE/100	PARTIAL EXCEEDENCE/100
1.01	192.4	193.2	99	245
1.05	195.0	195.8	95	225
1.10	196.4	197.1	91	208
1.25	198.3	198.9	80	185
2	202.4	202.9	50	84
5	206.6	206.8	20	24
10	208.9	209.0	10	10
25	211.2	211.2	4	4
50	213.0	213.0	2	2
100	214.7	214.7	1	1
200	216.5	216.5	0.5	0.5
500	219.0	219.0	0.2	0.2

PAGE IVB-13

EXCEEDENCE INTERVAL IN YEARS

Q x.001	YEARS	(WITH SIPHON ON) DISCHARGE	(WITHOUT SIPHON) DISCHARGE
	1.01	9,490	10,300
	1.05	12,600	13,500
	1.10	14,600	15,500
	1.25	17,400	18,300
	2	24,300	25,200
	5	34,800	35,300
	10	42,600	42,800
	25	53,900	53,900
	(40)	60,500	60,500
	50	63,700	63,700
	(68)	68,000	68,000
	100	74,800	74,800
	200	87,700	87,700
	500	108,000	108,000

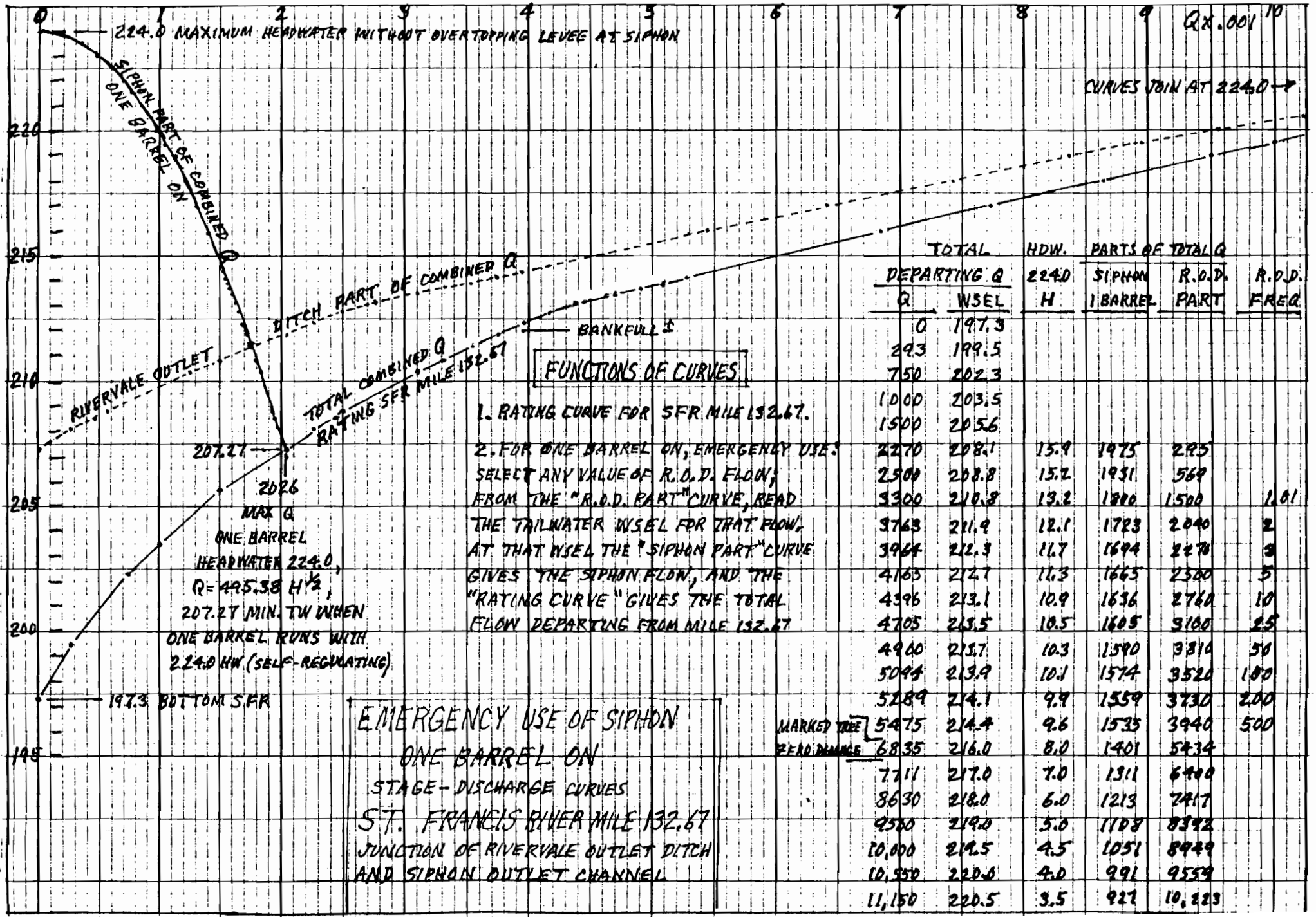
77,600
74,450
72,800 AUTH. MOD. CHAN. 212.2 CREVASSE
64,700
62,150
60,500 EXIST. CHAN. 212.2 CREVASSE

WITHOUT SIPHON
WITH SIPHON ON

DISCHARGE - FREQUENCY
RIVERFRONT GAGE, MILE 58.0
POTENTIAL CREVASSE SITE, MILE 58.5
MOUTH OF STRAIGHT SLOUGH, MILE 59.5

DISCHARGE-FREQUENCY MILES 58.0 TO 59.5

PLATE IVB-8

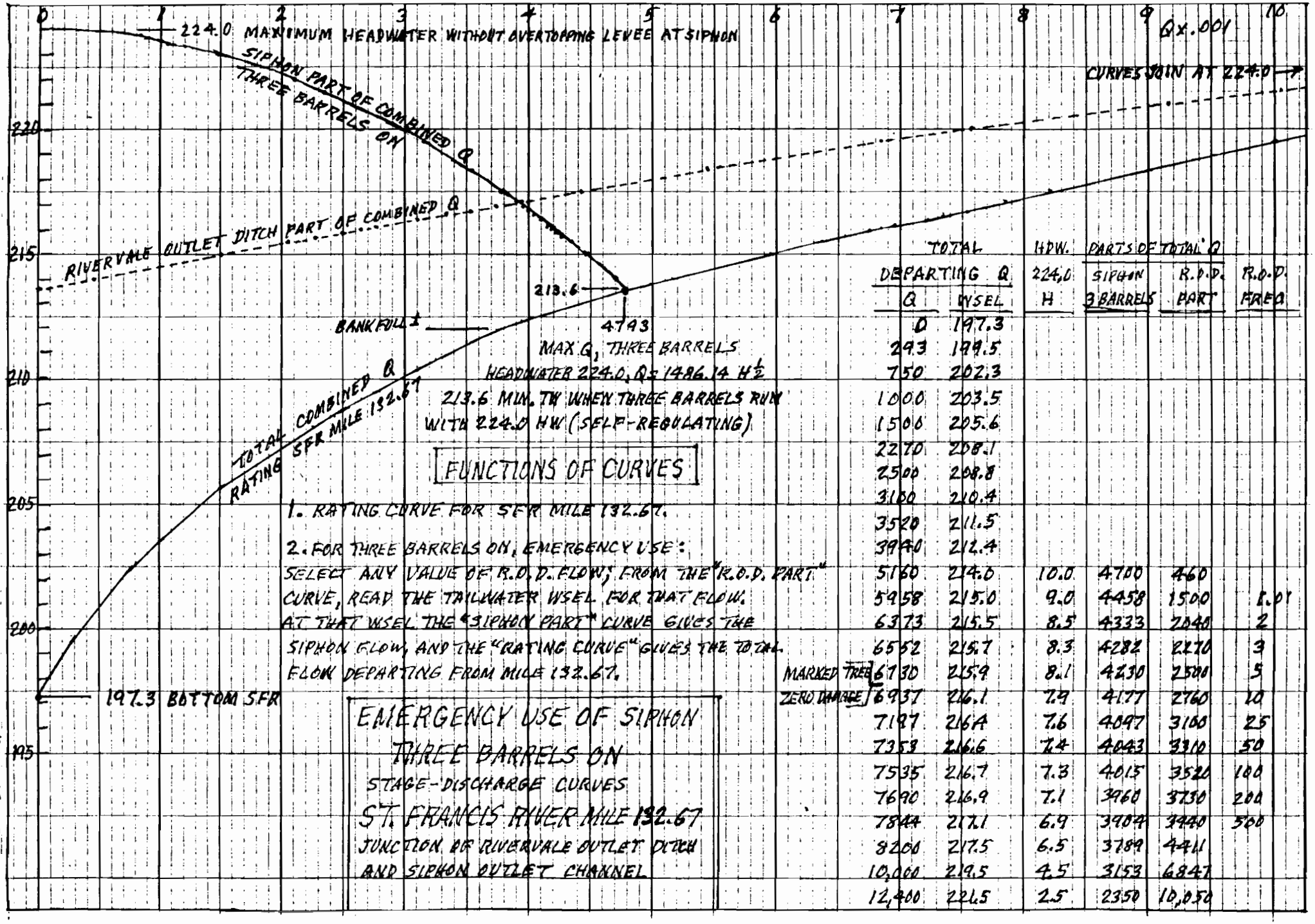


FUNCTIONS OF CURVES

1. RATING CURVE FOR SFR MILE 132.67.
2. FOR ONE BARREL ON, EMERGENCY USE: SELECT ANY VALUE OF R.O.D. FLOW; FROM THE "R.O.D. PART" CURVE, READ THE TAILWATER WSEL FOR THAT FLOW; AT THAT WSEL THE "SIPHON PART" CURVE GIVES THE SIPHON FLOW, AND THE "RATING CURVE" GIVES THE TOTAL FLOW DEPARTING FROM MILE 132.67

TOTAL DEPARTING Q		HDW. 224.0	PARTS OF TOTAL Q		
Q	WSEL	H	SIPHON 1 BARREL	R.O.D. PART	R.O.D. FREQ
0	197.3				
293	199.5				
750	202.3				
1000	203.5				
1500	205.6				
2270	208.1	15.9	1975	295	
2500	208.8	15.2	1931	569	
3300	210.8	13.2	1800	1500	1.01
3763	211.9	12.1	1723	2040	2
3964	212.3	11.7	1694	2270	3
4163	212.7	11.3	1665	2500	5
4396	213.1	10.9	1636	2760	10
4705	213.5	10.5	1605	3100	25
4960	213.7	10.3	1590	3370	50
5094	213.9	10.1	1574	3520	100
5289	214.1	9.9	1559	3730	200
MARKED TREE 5475	214.4	9.6	1535	3940	500
ZERO DAMAGE 6835	216.0	8.0	1401	5434	
7711	217.0	7.0	1311	6400	
8630	218.0	6.0	1213	7417	
9560	219.0	5.0	1108	8392	
10,000	219.5	4.5	1051	8949	
10,550	220.0	4.0	991	9559	
11,150	220.5	3.5	927	10,223	

EMERGENCY USE OF SIPHON
ONE BARREL ON
STAGE-DISCHARGE CURVES
ST. FRANCIS RIVER MILE 132.67
JUNCTION OF RIVERVALE OUTLET DITCH AND SIPHON OUTLET CHANNEL



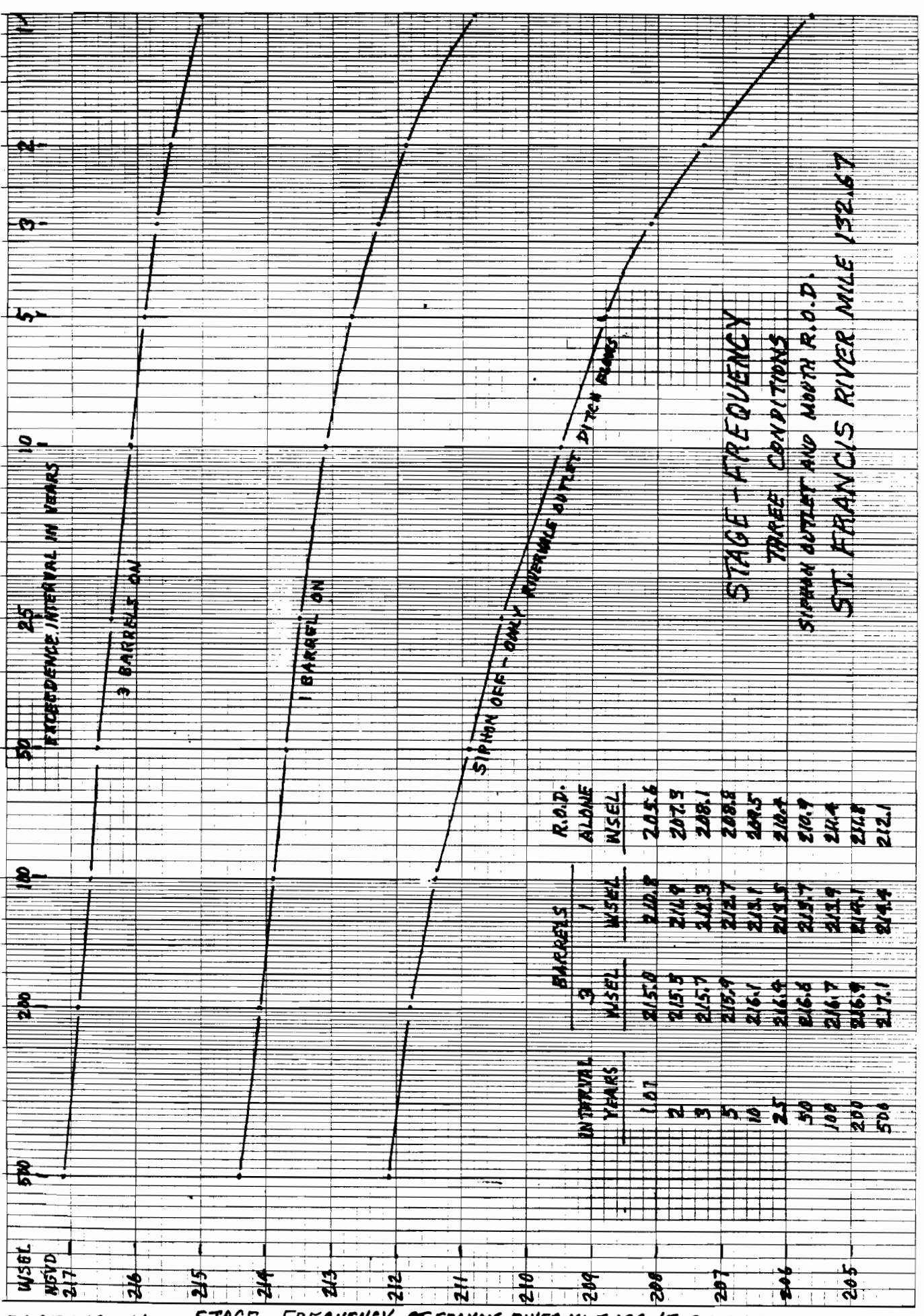
FUNCTIONS OF CURVES

1. RATING CURVE FOR SFR MILE 132.67.
2. FOR THREE BARRELS ON, EMERGENCY USE:
SELECT ANY VALUE OF R.O.D. FLOW, FROM THE "R.O.D. PART" CURVE, READ THE TAILWATER WSEL FOR THAT FLOW. AT THAT WSEL THE "SIPHON PART" CURVE GIVES THE SIPHON FLOW, AND THE "RATING CURVE" GIVES THE TOTAL FLOW DEPARTING FROM MILE 132.67.

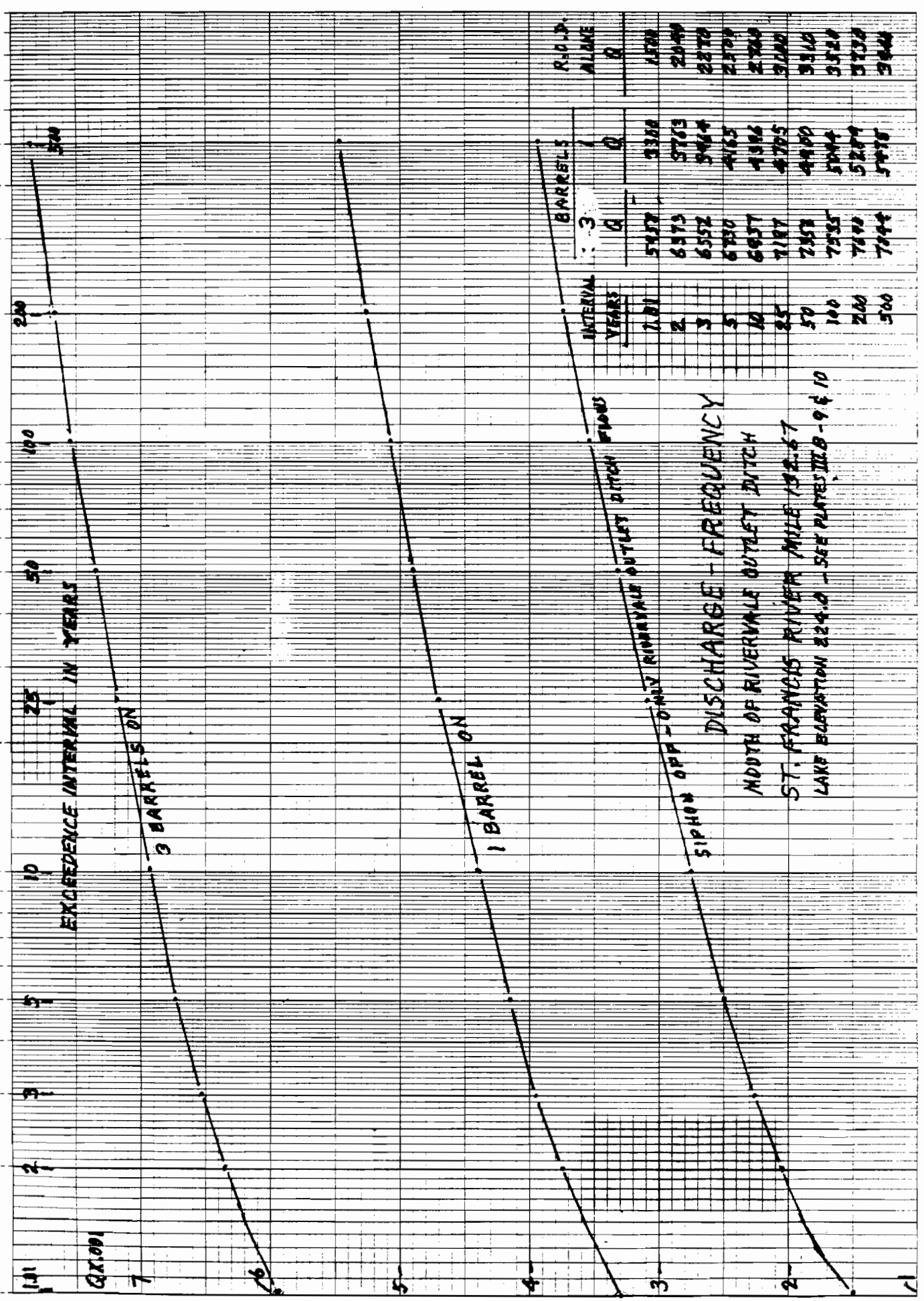
EMERGENCY USE OF SIPHON
THREE BARRELS ON
STAGE-DISCHARGE CURVES
ST. FRANCIS RIVER MILE 132.67
JUNCTION OF RIVERVALE OUTLET DITCH AND SIPHON OUTLET CHANNEL

TOTAL DEPARTING Q		HDW.	PARTS OF TOTAL Q		
Q	WSEL	224.0 H	SIPHON 3 BARRELS	R.O.D. PART	R.O.D. FREQ
0	197.3				
293	199.5				
750	202.3				
1000	203.5				
1500	205.6				
2270	208.1				
2500	208.8				
3100	210.4				
3520	211.5				
3940	212.4				
5160	214.0	10.0	4700	460	
5958	215.0	9.0	4458	1500	1.01
6373	215.5	8.5	4333	2040	2
6552	215.7	8.3	4282	2270	3
6730	215.9	8.1	4230	2500	5
6937	216.1	7.9	4177	2760	10
7197	216.4	7.6	4097	3100	25
7353	216.6	7.4	4043	3310	50
7535	216.7	7.3	4015	3520	100
7690	216.9	7.1	3960	3730	200
7844	217.1	6.9	3904	3940	500
8200	217.5	6.5	3789	4411	
10,000	219.5	4.5	3153	6847	
12,400	221.5	2.5	2350	10,050	

MARKED TREE ZERO DAMAGE



STAGE - FREQUENCY, ST. FRANCIS RIVER MILE 132.67, 3 CASES PLATE IVB - 11



46 5493

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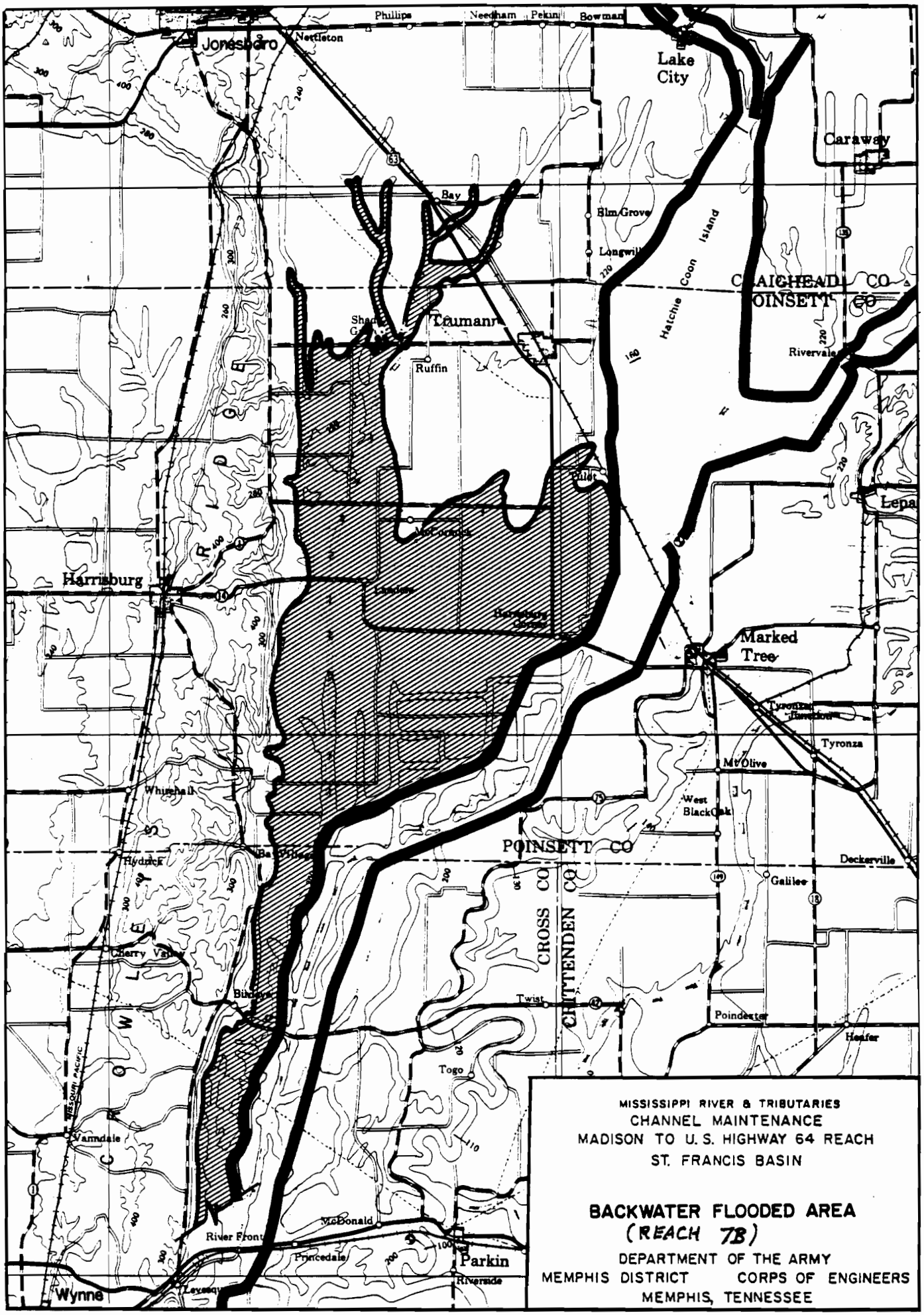
DISCHARGE-FREQUENCY, ST. FRANCIS RIVER MILE 132.67, 3 CASES

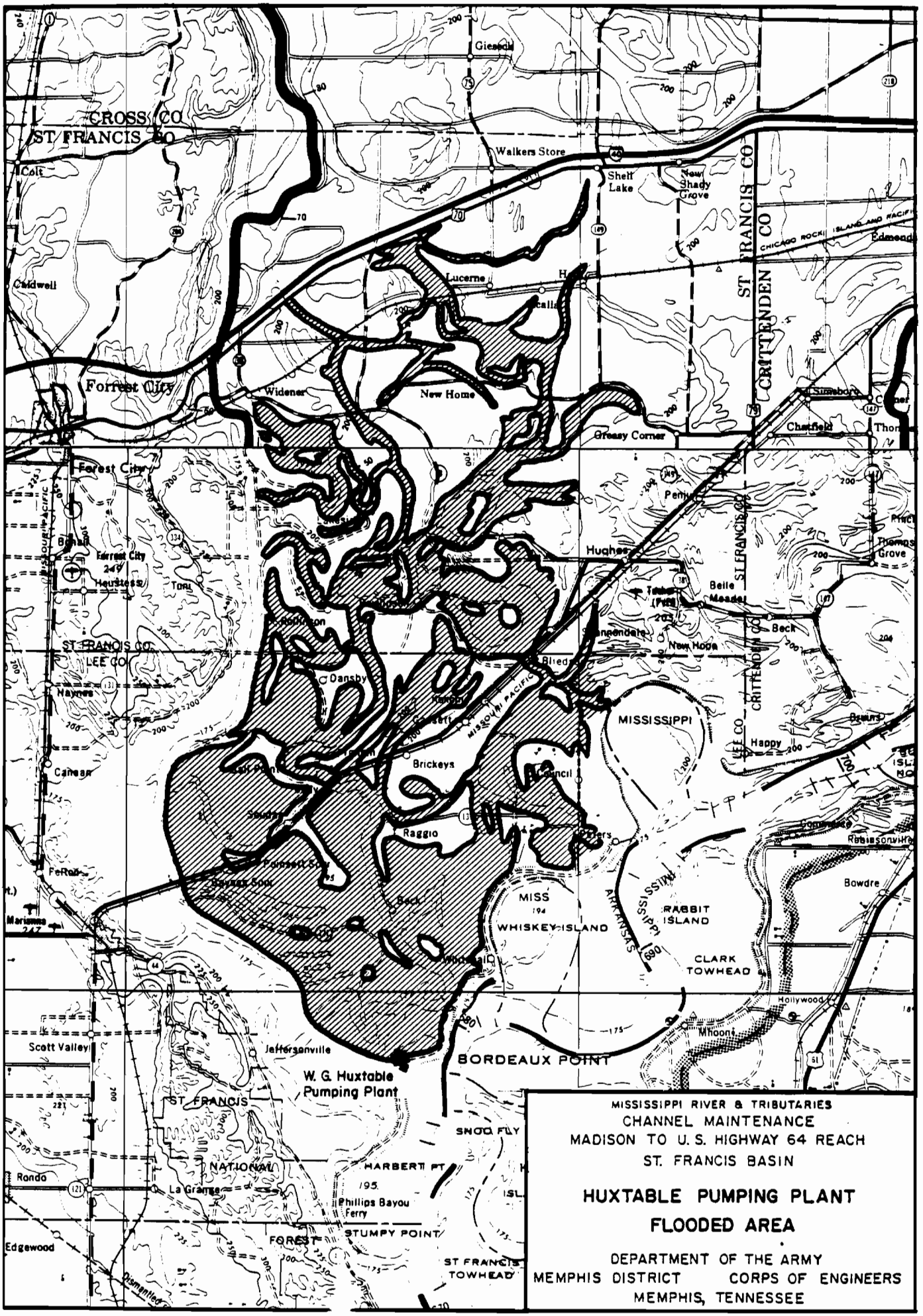
PLATE IVB-



MISSISSIPPI RIVER & TRIBUTARIES
CHANNEL MAINTENANCE
MADISON TO U. S. HIGHWAY 64 REACH
ST. FRANCIS BASIN

BACKWATER FLOODED AREA
(REACH 7B)

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
MEMPHIS, TENNESSEE



MISSISSIPPI RIVER & TRIBUTARIES
CHANNEL MAINTENANCE
MADISON TO U. S. HIGHWAY 64 REACH
ST. FRANCIS BASIN

HUXTABLE PUMPING PLANT
FLOODED AREA

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

MAINT, PLATE 6-6

SECTION V - BENEFIT EVALUATIONS

V-01. CHANNEL MAINTENANCE COST REDUCTION.

As stated in paragraph III 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 in 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). From Plate IVA-6, "Typical Equivalent Sections, River," the bank slopes average 1:4.75 in the Upper River and 1:5.5 in the Lower River. Brushkill costs escalated to January 1985 average $334.32/slope-acre. The cost in dollars/mile/foot of depth is now derived for both River reaches.

TABLE V-1a
BRUSHKILL COSTS ON RIVER IN $/MILE/FOOT OF DEPTH

Reach	Side Slope Ratio	Both Sides of Channel On Slope, Width/ Foot of Depth	Slope Acres/Mile/ Foot of Depth	Average Brushkill Cost $/Acre	Brushkill Cost in $/Mile/ Foot of Depth
Upper River	1:4.75	9.71'	1.18	334.32	343.45
Lower River	1:5.5	11.18'	1.36	334.32	453.00

Depth increases from "siphon off" to "siphon on" produce reductions in the slope-acreage to be sprayed and thus a reduction of Brushkill cost. The depth increases detailed in Table IVA-8 for July, August, and September, for lowflows of 50% exceedence percentage, are averaged for the three -month period and are representative of the overall effect. Depth increases in the Upper River reach, Siphon to Parkin, 54.67 miles, are the average between increases at Marked Tree Gage and Parkin Gage. Depth increases in the Lower River reach, Parkin to Huxtable Plant, 63.2 miles, are the increases at the Parkin Gage. The "siphon on" depth increases are here converted to reduction in maintenance cost of Brushkill spray every four years.

TABLE V-1b
REDUCTION IN MAINTENANCE COST BY "SIPHON-ON"

Reach	Average Depth Increases	Cost in $/Mile/ Foot of Depth	Cost Reduction, $/Mile	Reach Length Miles	Reduction of Brushkill Cost
Upper River	4.28'	$ 393.45	$ 1,683.97	54.67	$ 92,062.48
Lower River	2.53'	$ 453.00	$ 1,146.09	63.20	$ 72,432.89
					$ 164,495.31

Reduction in Maintenance Cost (every 4 years) $ 164,500.

The reduction in maintenance cost of $ 164,500 every fourth year, with a 50-year project life and 2-1/2% interest rate, gives an average annual equivalent benefit of $ 38,790. For a 50-year project life and 8.5/8% interest rate, the average annual equivalent benefit would be $ 36,065.

Study of Plate IVA-7, "Typical Sections, Floodway," and the averaged depth decreases of 2.37' and 2.90' in the Upper and Lower Floodway, with only 62% of the mileage in the River, shows that there would be an insignificant increase in Brushkill cost there, due to "siphon on." However, at this time, no Brushkill operation is contemplated in the Floodway.

V-02. IRRIGATION.

As discussed in paragraph III-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-3. 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 County. 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. County Agents say 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-02a, 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-02b, 2034 conditions. In this table, for the 9 reach subdivisions, the exceedence lowflow for July-August without siphon augmentation is shown, derived as stated in paragraph IVA-03. 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. As shown in paragraph IVA-05, use of the siphon will raise the water surface elevation in the River. This will also raise the elevation of the water table in the adjacent aquifer. Whether irrigation water is obtained by pumping out of the River or by wells from the aquifer, the reduction of lift resulting from siphon use causes a small reduction of fuel or electric energy at each installation. It is estimated that the cost of accurately quantifying this energy reduction could be greater than the benefit of this saving over a 50-year life. Recent studies of water

resources indicate that, unlike some basins in which groundwater is becoming more expensive, the St. Francis basin groundwater supply seems both adequate and economical for projected uses of all kinds. New wells are being located further from the River and feed distribution systems of PVC pipe rather than trunks and flumes. River pump-out plants are being discarded when repair or replacement is needed. Because of these trends, repair of the siphon is not needed to augment River lowflow for irrigation use.

Inquiry and observations show that there are about 60 families along the River between Marked Tree and Huxtable who obtain domestic water from private wells. These are shallow driven wells, most of which have surface pumps and pressure systems to provide water inside the buildings for human and animal use. The location of these rural residences varies from "riverbank" to one-half mile from the River. Within this zone groundwater elevation is affected by the water surface elevation in the River. During the infrequent periods described in paragraph IVA-04 when lowflow augmentation by the siphon has not been available from the Lake, most have had to haul water from towns to have a restricted domestic water supply. The increase in depth by siphon lowflow augmentation averages over 4 feet, as shown in paragraph IVA-05; this change appears to be critical for most of the wells. If siphon abandonment ended lowflow augmentation, most of these residents could avoid seasonal hauling of domestic water only by installing deep drilled wells with subsurface pumps. It would require a separate detailed study to quantify the benefit of the siphon in avoiding this expense, and the total dollar value could be small in average annual equivalent terms, but availability of siphon lowflow augmentation is of strong importance to those affected families.

TABLE V-02a 1984 CONDITIONS
ESTIMATED IRRIGATED ACREAGE AND RESIDUAL FLOWS

RIVER MILE	LOCATION	REACH	ESTIMATED 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
ESTIMATED 1984			7,635 Ac(9%)	81,236 Ac	+876	(26%)-230	646

TABLE V-02b 2034 CONDITIONS
PROJECTED IRRIGATED ACREAGE AND RESIDUAL FLOWS

RIVER MILE	LOCATION	REACH	ESTIMATED 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-03. FLOOD CONTROL, ST. FRANCIS LAKE (see paragraph III-04).

Lake Farming, Crop Loss Reduction, General Procedure.

Without and with the siphon, 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 siphon 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

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-03-a.

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. Daily records show that usually there is one barrel flowing, sometimes two barrels, and very rarely three barrels, depending on inflows into the Lake.

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 1985 adjusted to July 1985 dollars. 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, 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 $264,200. When abandoned siphon stage-cropland acres flooded data was run with the same crop budgets and crop control inputs, the resulting outputs also revealed damages only for the years 1977 and 1981. Total damages estimated under abandoned siphon conditions for 1977 and 1981 equaled $304,600. Total flood damages reduction benefits for this six and one half year period therefore are estimated to be $40,400 yielding an average annual benefit of $6,200. This estimate is taken to be the expected annual value of flood inundation reduction benefits for project base year 1987. The 2037 expected annual value was estimated by indexing this 1987 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 1987 and 2037, from which an index factor was calculated. The index factor for 2037 using a 1987 base is 1.6642 and, thus, 2037, inundation reduction benefits are estimated at $10,300.

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 1987 and amortized over 50 years at 2.5 percent to yield an average annual equivalent value of $8,200. Using 8-5/8 percent interest rate, the average annual equivalent value was $7,700.

V-04. FLOOD CONTROL, STRAIGHT SLOUGH AREA (see paragraph III-05).

With the operation of the siphon during times that Huxtable was not pumping, the Straight Slough area received benefits from a decrease in cropland and property flooding. The benefits were calculated and are shown in Appendix A. Table A-10 shows the AAE benefits from operating one or more siphon barrels when Huxtable was not pumping. Under Historical Condition, the benefits were $66,600 at 2-1/2 percent interest and $65,200 at 8-5/8 percent interest. With Improved Channel Maintenance in Floodway below River Mile 58.0 Condition, the benefits were $97,600 at 2-1/2 percent interest and $95,800 at 8-5/8 percent interest.

Table A-11 shows the benefits when only one siphon barrel is operating. The benefits fall to $41,625 at 2-1/2 percent interest and $40,750 at 8-5/8 percent interest under Historical Condition. The benefits fall to $61,000 at 2-1/2 percent interest and $59,875 at 8-5/8 percent interest under Improved Channel Maintenance Condition.

V-05. AQUATIC ENVIRONMENTAL VALUES.

SECTION VIII, ENVIRONMENTAL IMPACTS, analyzes the needs for siphon operation discussed in Paragraphs III-05, III-06, and III-07 and concludes that while the hydraulic quantity differences between siphon abandoned and siphon repaired conditions are considerable, they would not significantly affect the numbers and gross poundage of the various species in the fish population. The significant effect of siphon augmentation of lowflow in the River is to stimulate activity of sport fishermen, general recreationists, and commercial fishermen. Though general recreationists are more active when the siphon operates, there was not obtained any quantification of user-days under either condition. Commercial fishing in these waters being principally a part-time activity, catches are often unreported, and there is no rational direct relationship between commercial licenses issued and pounds harvested. Because of increased commercial-fisherman activity, there should be a larger poundage harvested under siphon operation conditions but there is no reliable quantification data. With regard to sport fishing user-days, enough information was obtained to enable estimates to be made with a reasonable degree of confidence. This benefit is analyzed in detail in SECTION VIII, giving three values for different locations, expressed as average annual equivalent benefits of siphon operation over siphon abandonment.

In the concentrated area in and just below the siphon outlet, with 2-1/2 percent interest benefits are $6,386, and with 8-5/8 percent interest benefits are $6,388. In the River between the siphon and Huxtable Pumping Plant, with 2-1/2 percent interest benefits are $606, and with 8-5/8 percent interest benefits are $621. In the Floodway the siphon operation causes a slight reduction of $29 for either interest rate. The net benefit to the system from siphon operation is thus $6,963 for 2-1/2 percent interest rate and $6,980 for 8-5/8 percent interest rate. These net values are repeated in the summary paragraph V-08, and are parts of the total benefits evaluated in SECTION VII, ECONOMIC JUSTIFICATION.

V-06. EMERGENCY OPERATIONS.

APPENDIX B: "EMERGENCY SIPHON USE TO AVOID A CREVASSE" analyzes in detail the use of siphon withdrawal from the Floodway into the River. At Floodway mile 58.5 the levee is critically low with respect to Floodway flowlines. Paragraph II-10 discusses the principle that some floods greater than critical can be reduced to the critical value or below, by siphon withdrawal. Thus, within a range of flows that have certain probabilities, siphon emergency operation can reduce the frequency of a crevasse that would cause damage to crops and structures in the Huxtable area, greatly increase the plant operation cost, and require levee repair. Prevention of these costs is a gross benefit of siphon operability. However, this use would increase flooding damage and operating costs in the Huxtable area, although to a much less degree than the crevasse event, by adding siphon transfer flow to the interior flooding already present. Thus, there is shown to be a net benefit from this use of the siphon. No attempt is made to quantify the risks to Huxtable area inhabitants that would attend a crevasse, but some danger would clearly exist. Even in clearly predictable, or deliberately caused, crevasses, under ideal time and weather conditions, there is always some potential danger to human life. Some persons do not receive or heed the warning. Crevasses on the main-stem and tributaries have occurred in the Valley, and are not merely hypothetical. Full repair of three barrels will produce the best effect in reducing this danger. The siphon benefit is not quantifiable with regard to human life. Net benefit evaluations have been made for the use of one barrel or three barrels; event values have been converted to average annual equivalent net benefits, for a 50-year life, and with interest rates of 2-1/2 percent (authorized St. Francis Basin Project) and 8-5/8 percent (current fiscal year). Recently another study has considered Floodway maintenance work which may give a future increase in Floodway capacity. This increase would change the magnitude of the crevasse-critical flood and would change benefits.

Benefits of crevasse prevention by siphon withdrawal, with existing Floodway capacity, are shown in Appendix B, Table B-13.

	2-1/2%	8-5/8%
One Barrel, Net Benefit	$10,181	$10,099
Three Barrels, Net Benefit	$33,870	$33,628

Benefits of crevasse prevention by siphon withdrawal, with possible increased Floodway capacity, are shown in Appendix B, Table B-14.

	2-1/2%	8-5/8%
One Barrel, Net Benefit	$ 3,408	$ 3,381
Three Barrels, Net Benefit	$13,105	$13,014

V-07. SUMMARY OF UNQUANTIFIED BENEFITS OF SIPHON REPAIR.

a. Needs Once Considered But No Longer Valid.

Navigation in the River
Irrigation from the River

b. Unquantifiable Benefits.

Preservation of Historical Significance
Aesthetics
Reduction of Hazard to Human Life in the Huxtable Area

c. Unquantified Benefits.

Rural Domestic Water Supply
General Recreation
Commercial Fishing
Water Quality
Flowage Easement Claims
Control Gate Maintenance Bypass

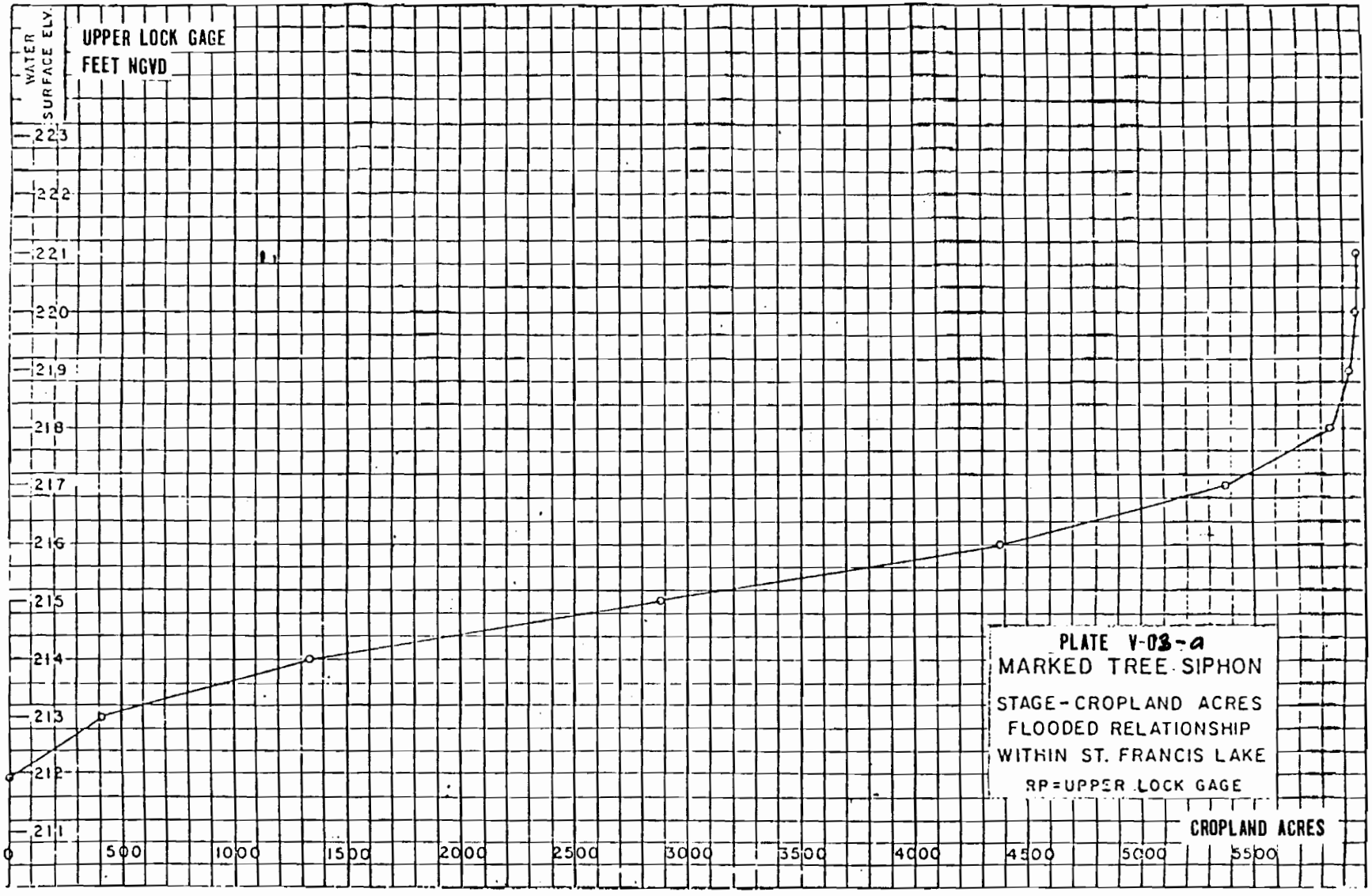
V-08. SUMMARY OF QUANTIFIED BENEFITS OF SIPHON REPAIR.

a. Floodway Below Mile 58.0 in Existing Condition: Average Annual Equivalent Benefits.

	2-1/2 Percent Repaired Barrels		8-5/8 Percent Repaired Barrels	
	One	Three	One	Three
Reduction, River Maintenance Cost	38,790	38,790	36,065	36,065
Flood Control, St. Francis Lake	8,200	8,200	7,700	7,700
Flood Control, Straight Slough Area	41,625	66,600	40,750	65,200
Sport Fishing	6,963	6,963	6,980	6,980
Crevasse Prevention, Emergency	10,181	33,870	10,099	33,628
Total Benefits (AAE)	105,759	154,423	101,594	149,573

b. Floodway Below Mile 58.0 With Future Maintenance: Average Annual Equivalent Benefits.

	2-1/2 Percent Repaired Barrels		8-5/8 Percent Repaired Barrels	
	One	Three	One	Three
Reduction, River Maintenance Cost	38,790	38,790	36,065	36,065
Flood Control, St. Francis Lake	8,200	8,200	7,700	7,700
Flood Control, Straight Slough Area	61,000	97,600	59,875	95,800
Sport Fishing	6,963	6,963	6,980	6,980
Crevasse Prevention, Emergency	3,408	13,105	3,381	13,014
Total Benefits (AAE)	118,361	164,658	114,001	159,559


WATER SURFACE ELV.
UPPER LOCK GAGE
FEET NGVD
223
222
221
220
219
218
217
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213
212
211
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
CROPLAND ACRES
PLATE V-03-a
MARKED TREE SIPHON
STAGE - CROPLAND ACRES
FLOODED RELATIONSHIP
WITHIN ST. FRANCIS LAKE
RP = UPPER LOCK GAGE

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-1985 unit prices.

TABLE VI-01-a. REPAIR OF THREE BARRELS

Mechanical Job	
Equipment	$ 34,780
Remove and replace siphon pipe ends	362,845
Labor for blast cleaning and painting pipes	24,345
Supplies for repairing pipes	4,635
Miscellaneous material and labor	13,910
Electrical Job	7,435
Net Costs	$ 447,950
Contingencies 10% ±	44,800
Total Costs of Work	$ 492,750
E&D	59,070
S&A	52,180
TOTAL FIRST COST (Jul 85)	$ 604,000

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

Mechanical Job	
Equipment	$ 11,590
Remove and replace siphon pipe ends	120,950
Labor for blast cleaning and painting pipes	8,120
Supplies for repairing pipes	1,545
Miscellaneous material and labor	4,640
Electrical Job	7,435
Net Costs	$ 154,280
Contingencies 10% ±	15,420
Total Costs of Work	$ 169,200
E&D	20,400
S&A	17,900
TOTAL FIRST COST (Jul 85)	$ 208,000

VI-02. ANNUAL CHARGES OF REPAIR WORK.

TABLE VI-02-a. REPAIR OF THREE BARRELS

Total First Cost	$ 604,000	604,000
Amortization Factor, 2-1/2%	0.03526	
Amortization Factor, 8-5/8%		0.08765
Average Annual Equivalent Value	$ 21,297	52,941

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

Total First Cost	$ 208,000	208,000
Amortization Factor, 2-1/2%	0.03526	
Amortization Factor, 8-5/8%		0.08765
Average Annual Equivalent Value	$ 7,334	18,231

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

		Present Value Factor		Present Value of Costs	
Year	Cost	2-1/2%	8-5/8%	2-1/2%	8-5/8%
5	$ 4,000	0.88385	.66123	3,525	2,645
10	6,000	0.78120	.43722	4,687	2,623
20	10,000	0.61027	.19116	6,103	1,912
30	10,000	0.47674	.08358	4,767	836
40	10,000	0.37243	.03654	3,724	365
		Total Present Value		$ 22,816	$ 8,381
		Amortization Factor		0.03256	0.08765
	Average Annual Equivalent Value			$ 804	$ 727

VI-04. TOTAL ANNUAL CHARGES (Jul 85).

TABLE VI-05-a. REPAIR OF THREE BARRELS

Average Annual Equivalent Costs	2-1/2%		8-5/8%	
	Federal	Non-Federal	Federal	Non-Federal
First Costs of Repairs	$ 21,297		$ 52,941	
Annual O&M		$ 7,000		$ 7,000
Major Replacements	804		727	
TOTALS	$ 22,101	$ 7,000	$ 53,668	$ 7,000
	$ 29,101		$ 60,668	

TABLE VI-05-b. REPAIR OF ONLY ONE BARREL

Average Annual Equivalent Costs	2-1/2%		8-5/8%	
	Federal	Non-Federal	Federal	Non-Federal
First Costs of Repairs	$ 7,334		$ 18,231	
Annual O&M		$ 7,000		$ 7,000
Major Replacements	804		727	
TOTALS	$ 8,138	$ 7,000	$ 18,958	$ 7,000
	$ 15,138		$ 25,958	

SECTION VII - ECONOMIC JUSTIFICATION

VII-1 BENEFIT/COST RATIOS AND EXCESS BENEFITS

Benefit totals for reduction in river maintenance (V-01), reduction of cropland flooding in St. Francis Lake (V-03) and Straight Slough (V-04), and sport fishing at siphon (V-05) are found in Section V. The crevasse prevention (emergency operation) total benefits also are shown in Section V, with detailed derivation in Appendix B, Tables B-13 and B-14. Cost estimates are located in Section VI, Tables VI-05-a and Table VI-05-b.

The benefits and costs were made comparable by conversion to an average annual equivalent value using the interest rate of 2-1/2 percent and 8-5/8 percent and a project life of 50 years. The total benefits were then divided by the total costs to calculate the B/C ratio. Tables VII-1 and VII-2 shows the B/C ratio for operating one and three siphon barrels Historical Condition. The B/C ratio computed at 2-1/2 percent interest rate for one siphon barrel is 6.99 and excess benefits of $90,621 and at 8-5/8 percent 3.91 with $75,636 excess benefits. The B/C ratio for operating three siphon barrels is 5.31 at 2-1/2 percent interest rate and excess benefits of $125,322 and 2.47 at 8-5/8 percent with excess benefits of $88,905.

Tables VII-3 and VII-4 show the B/C ratio for operating one and three siphon barrels With Improved Channel Maintenance in the floodway below River Mile 58.0. The operation of one siphon barrel gives a B/C ratio at 2-1/2 percent interest rate of 7.82 and excess benefits of $103,223 and 4.39 at 8-5/8 percent interest rate with $88,043 excess benefits. The B/C ratio for operating three siphon barrels is 5.66 at 2-1/2 percent interest rate and excess benefits of $135,557 and 2.63 at 8-5/8 percent with excess benefits of $98,891.

COMPARISON OF RESULTS

Number of Barrels Repaired	Floodway Channel Condition	Authorized Rate 2-1/2% Interest B-C	B/C	Current FY Rate 8-5/8% Interest B-C	B/C
One	Existing	$ 90,621	6.99	$75,636	3.91
Three	Existing	$125,322	5.31	$88,905	2.47
One	Maintained	$103,223	7.82	$88,043	4.39
Three	Maintained	$135,557	5.66	$98,891	2.63

TABLE VII-1
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALENT
BENEFITS AND COSTS
HISTORICAL CONDITION
WITH ONE SIPHON BARREL
(July 1985 Price Level)

Reduction in Damages by Use of One Siphon Barrel-Historical Condition

Benefits	2-1/2 percent $	8-5/8 percent $
Reduction in River Maintenance	38,790	36,065
Cropland Flood Control in St. Francis Lake	8,200	7,700
Cropland Flood Control in Straight Slough (Reach 7B)	41,500	40,625
Property Flood Control in Straight Slough (Reach 7B)	125	125
Sport Fishing	6,963	6,980
Crevasse Prevention, Emergency	10,181	10,099
Total Benefits (AAE)	$105,759	$101,594
	÷	÷
Costs (AAE)	15,138	25,958
	=	=
B/C Ratio:	6.99	3.91
Excess Benefits	$90,621	$75,636

TABLE VII-2
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALENT
BENEFITS AND COSTS
HISTORICAL CONDITION
WITH THREE SIPHON BARRELS
(July 1985 Price Level)

Reduction in Damages by Use of Three Siphon Barrels-Historical Condition

Benefits	2-1/2 percent $	8-5/8 percent $
Reduction in River Maintenance	38,790	36,065
Cropland Flood Control in St. Francis Lake	8,200	7,700
Cropland Flood Control in Straight Slough (Reach 7B)	66,400	65,000
Property Flood Control in Straight Slough (Reach 7B)	200	200
Sport Fishing	6,963	6,980
Crevasse Prevention, Emergency	33,870	33,628
Total Benefits (AAE)	$154,423	$149,573
Costs (AAE)	29,101	60,668
B/C Ratio:	5.31	2.47
Excess Benefits	$125,322	$ 88,905

TABLE VII-3
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALENT
BENEFITS AND COSTS
WITH MAINTENANCE CONDITION
WITH ONE SIPHON BARREL
(July 1985 Price Level)

Reduction in Damages by Operating One Siphon
With Improved Channel Maintenance in Floodway Below River Mile 58.0

Benefits	2-1/2 percent $	8-5/8 percent $
Reduction in River Maintenance	38,790	36,065
Cropland Flood Control in St. Francis Lake	8,200	7,700
Cropland Flood Control in Straight Slough (Reach 7B)	61,000	59,875
Sport Fishing	6,963	6,980
Crevasse Prevention, Emergency	3,408	3,381
Total Benefits (AAE)	$118,361	$114,001
	÷	÷
Costs (AAE)	15,138	25,958
	=	=
B/C Ratio:	7.82	4.39
Excess Benefits	$103,223	$ 88,043

TABLE VII-4
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALENT
BENEFITS AND COSTS
WITH MAINTENANCE CONDITION
WITH THREE SIPHON BARRELS
(July 1985 Price Level)

Reduction in Damages by Operating Three Siphon Barrels
With Improved Channel Maintenance in Floodway Below River Mile 58.0

Benefits	2-1/2 percent $	8-5/8 percent $
Reduction in River Maintenance	38,790	36,065
Cropland Flood Control in St. Francis Lake	8,200	7,700
Cropland Flood Control in Straight Slough (Reach 7B)	97,600	95,800
Sport Fishing	6,963	6,980
Crevasse Prevention Benefits	13,105	13,014
Total Benefits (AAE)	$164,658	$159,559
	÷	÷
Costs (AAE)	29,101	60,668
	=	=
B/C Ratio:	5.66	2.63
Excess Benefits	$135,557	$ 98,891

SECTION VIII - ENVIRONMENTAL IMPACTS

1. Environmental Setting.

a. St. Francis River. St. Francis River is a deltaic river typical of those in northeastern Arkansas. The section of river under study begins at the siphon and extends to the entrance of the Huxtable Pumping Plant at Mile 14.8. There are two cutoffs by artificial channels forming 12% of the total river length. The rest of the river is natural channel. There are approximately 118 river miles from the siphon to the Huxtable Pumping Plant. The bed and banks are relatively stable. Top bank widths average 430 feet on the upper river (north of Parkin, Arkansas) and 640 feet on the lower river. Channel depths below top bank in the upper river average 25.8 feet, and 36.8 feet in the lower river. Bottom material consists of varying mixtures of sand, silt, clay and organic matter. Banks are fairly well vegetated with a good canopy cover in many places. Seasonal river flows range from overbank flooding in late winter-early spring to shallow flows about 2 feet deep in late summer-early fall.

Species compositions of plants, fish and animals would not be expected to differ from those in the region and listed in available literature. Habitat for wildlife is representative of bottomland hardwood forests, but is limited to a narrow strip adjacent to the river. Almost all of the land along the St. Francis River is in agricultural production. Because of the sparse wooded habitat, small game species would most likely be the ones found along the river. Some white-tailed deer do live along the river in the edge habitat. Waterfowl use of the river is low. There are several old river sections in the lower river that were cut off when the floodway was made and now serve as bayous. These provide fishery habitat and sport fishing opportunities.

b. Oak Donnick Floodway. The Oak Donnick Floodway is about 73 miles long beginning below St. Francis Lake Control Gates and extending to the junction with St. Francis River below Huxtable at Mile 11.5. More than two thirds of the floodway channel is artificial with steep banks and a flat bottom. The upper floodway channel (above Highway 64) has an average top bank width of 256 feet and average channel depth below top bank of 21 feet. Lower floodway channel width averages 330 feet with a channel depth of 25 feet. Bottom material is similar to that in the St. Francis River. Almost all the floodway has been cleared of trees and is now in agriculture. The natural reaches have some tree canopy along the banks, while the channelized reaches have only a small strip of trees. Seasonal water flow conditions are like those in the river with winter-spring floods and summer-fall low flows.

Species compositions of plants, fish and animals would be similar to those along the river, but less in numbers and diversity where woody vegetation is scarce or absent. Channelized reaches of the floodway would have a less diverse fishery than the more natural reaches of the floodway. However, fish adapted to these conditions, such as carp,

buffalo and drum would be expected to occur in greater numbers in the channelized reaches.

c. Endangered Species. One endangered species, the fat pocketbook pearly mussel (Proptera (=Potamilus) capax) has been found in the floodway from below Mile 68 to Mile 36. In 1978 it was recorded only from the natural channel section in this reach, but is now expanding its distribution into adjacent channelized sections (Clark, unpubl. 1985) (Stieglitz 1981). The last paper is included in APPENDIX C as Item C-2 in this report. Clark also found this species below Levee Mile 91/92 in Straight Slough. A literature search and field survey of the floodway and the river produced no evidence of additional Federal or state listed threatened or endangered species using either waterway.

d. Historical and Cultural Resources. The siphon is considered by the Memphis District to be an eligible historic property. The siphon has operated without major renovation for 46 years and has been demonstrated to be 97.1% hydraulically efficient. This efficiency has attracted delegations of visiting engineers from Europe and South America. Accordingly, the siphon is deemed significant under criterion "C" of the National Register of Historic Places. It is a distinguishable entity, in which the method of construction achieved such excellence in design and workmanship as to render the structure significant.

2. Significant Resources.

The amount of water in St. Francis River and Oak Donnick Floodway is the most significant resource. Available water directly affects fishery and riparian habitats, commercial and sport fishing, general recreation, and amount of usable irrigation water. The siphon, itself, can also be considered a significant resource regarding its design, engineering, and historical aspects.

3. Environmental Impacts of the Proposed Action.

a. The condition of the siphon is such that without repair it will become inoperable, and the proposed action is to repair it. Based on the number and location of tributary streams entering both waterways there is sufficient water available to support fish populations throughout the year. However, siphon operation will provide a greater level of benefits to the old river than would be obtained by the release of water down the floodway. Also, there would not be any adverse impacts to St. Francis Lake with the siphon repaired. This would be guaranteed by a formal plan of operation being signed by Drainage District 7 of Poinsett County, Arkansas prior to any repair. This plan would not permit siphon operation if St. Francis Lake falls below 210.0 NGVD or when tailwater elevation at the Lower Lock Gage is higher than 208.5 NGVD.

b. Aquatic Habitats. Throughout the year, regardless of siphon operation, there is sufficient water flowing down the river and the

floodway to maintain aquatic habitats. Critical times would occur in late summer to early fall months of July, August, September and October when low flow conditions prevail. In those months there would be only limited periods when there may not be enough water in St. Francis Lake to permit siphon operation. This is illustrated in Section IVA and pertinent tables in that section which show the changes that would occur to flows, water depths and surface water acres for each waterway.

c. Riparian Habitats. Willows and other woody vegetation would start to encroach along the river if the siphon is abandoned. This would benefit riparian habitats. Periodic brush kill would maintain an early successional state by preventing large woody tree growth and promoting the development of a brushy edge along the riverbanks. There would be virtually no change to riparian habitat in Oak Donnick Floodway if the siphon is abandoned or repaired because of the steep banks, which for the most part are unvegetated.

d. Human Environment. Although not readily quantifiable, the human environment along the St. Francis River would benefit from increased water quantity due to the siphon operation and result in slightly higher values in commercial fishing, general outdoor recreation and boating on the entire St. Francis River due to deeper water and increased surface acreage. There would be a slight loss in these values on the Oak Donnick Floodway for these same items if the siphon is repaired.

Under the repaired condition, sport fishing on the river would show a slight gain while that on the floodway would show a negligible decrease. The reverse would be true if the siphon is abandoned. These determinations are presented in Tables VIII-01 and VIII-02. The values presented are estimates of potential benefits of siphon operation. They were developed in accordance with guidelines set forth in Principles and Guidelines for Water and Related Land Resource Planning, 1984. Final values were then discounted to derive an average annual amortized equivalent (AAE) value for each action for the life of the project. This resulted in an overall net gain of approximately $600 (AAE) under the repaired condition, see Tables VIII-01 and VIII-02.

Sport fishing at the siphon outlet is another item that would be impacted if the siphon is abandoned. The siphon has good access, stable banks, and a deep spillage basin pool all of which contribute to a high usage rate when the siphon operates. Without siphon operation, there would be very little sport fishing at the outlet. The following Table VIII-03 estimates manday and dollar values for sport fishing with the siphon repaired and with the siphon abandoned. Values were amortized the same way as was done for sport fishing in each waterway. Table VIII-03 indicates an overall net gain of approximately $6,400 (AAE) under the repaired condition.

Table VIII-01
Estimated Sport Fishing Values in St. Francis River
Below Marked Tree Siphon

St. Francis River, Repaired Condition

Year	Acres	X	Manday Acre	=	Manday	X	$ Value Manday	=	$ Value
0	3,948		.40		1,579		$2.90		$4,580
10	3,948		.40		1,579		2.90		4,580
20	3,948		.42		1,658		2.90		4,808
30	3,948		.44		1,737		2.90		5,037
50	3,948		.44		1,737		2.90		5,037

St. Francis River, Abandoned Condition

0	3,465		.40		1,386		$2.90		$4,019
10	3,465		.40		1,386		2.90		4,019
20	3,465		.42		1,455		2.90		4,220
30	3,465		.44		1,524		2.90		4,421
50	3,465		.44		1,524		2.90		4,421

Average Annualized Amortized Equivalent Values

	2-1/2%	8-5/8%
Repaired Condition	$ 4,956	$ 5,077
Abandoned Condition	4,350	4,456
Benefit from Repair	$ 606	$ 621

Table VIII-02
Estimated Sport Fishing Values in Oak Donnick Floodway
Below Marked Tree Siphon

Floodway, Repaired Condition

Year	Acres	X	Manday / Acre	=	Manday	X	$ Value / Manday	=	$ Value
0	2,101		.40		840		$2.90		$2,437
10	2,101		.40		840		2.90		2,437
20	2,101		.42		882		2.90		2,559
30	2,101		.44		924		2.90		2,680
50	2,101		.44		924		2.90		2,680

Floodway, Abandoned Condition

0	2,124		.40		849		$2.90		$2,463
10	2,124		.40		849		2.90		2,463
20	2,124		.42		892		2.90		2,587
30	2,124		.44		934		2.90		2,710
50	2,124		.44		934		2.90		2,710

Average Annual Amortized Equivalent Values

	2-1/2%	8-5/8%
Repaired Condition	$ 2,637	$ 2,702
Abandoned Condition	2,666	2,731
Benefit from Repair	$ - 29	$ - 29

Table VIII-03
Estimated Sport Fishing Values at Marked Tree Siphon

Repaired Condition

Year	Trips / Day	X Days Used / Week	X Weeks Used / Year	= Trips / Year	X Manday Value / Trip	= Manday Value / Year
0	10	5	40	2,000	$ 2.90	$ 5,800
10	10	5	40	2,000	2.90	5,800
20	11	5	40	2,200	2.90	6,380
30	12	5	40	2,400	2.90	6,960
50	12	5	40	2,400	2.90	6,960

Abandoned Condition

Year	Trips / Day	X Days Used / Week	X Weeks Used / Year	= Trips / Year	X Manday Value / Trip	= Manday Value / Year
0	.25	5	40	50	$ 2.90	$ 145
10	.25	5	40	50	2.90	145
20	.28	5	40	56	2.90	162
30	.30	5	40	60	2.90	174
50	.30	5	40	60	2.90	174

Sport Fishing at Siphon
Average Annual Amortized Equivalent Values
50-Year Project Life
Interest Rate

	2-1/2%	8-5/8%
Repaired Condition	$ 6,550	$ 6,552
Abandoned Condition	164	164
Benefit from Repair	$ 6,386	$ 6,388

e. Endangered Species. One Federally listed endangered species lives in the natural and artificial channels at the southern end of the Oak Donnick Floodway, and in the lower Straight Slough: the fat pocketbook pearly mussel (Proptera (=Potamilus) capax). There would not be any adverse impacts to the mussel under the abandoned or repaired state. The U.S. Fish and Wildlife Service stated in a 5 May 1981 Biological Opinion that Marked Tree Siphon repairs are not likely to jeopardize the continued existence of the fat pocketbook pearly mussel. They further found that repairs would not be expected to impact aquatic habitats nor would they be conducted in areas not consistent with

Proptera capax existence (Stieglitz 1981). The Biological Opinion is presented as Item C-2 in APPENDIX C of this report.

f. Historical and Cultural Resources. The Memphis District will provide necessary data to the Arkansas State Historic Preservation Officer in order that an official state opinion of the eligibility of the Marked Tree Siphon for the National Register of Historic Places can be rendered. The Memphis District will assert the property is eligible.Preparation of the recommendation is underway.

Should the State Historic Preservation Officer (SHPO) concur in the Memphis District's evaluation, the property may be considered procedurally eligible. Should the SHPO disagree or for any reason withhold comment, the Keeper of the National Register will be asked to decide the question.

Should the Keeper determine the structure to be not eligible, the abandonment or renovation will be a moot point in terms of cultural values. Should the Keeper determine the structure to be eligible, then alternatives of abandonment and renovation denote more precise impacts.

Also abandonment would be viewed as an adverse impact and coordination with the Advisory Council on Historic Preservation would have to persuasively argue that no other alternatives would be feasible. Furthermore, mitigation, probably in the form of original drawings retraced on archival quality paper, would be requested.

Renovation would likewise require comment from the Advisory Council, as well as coordination with the Historic American Engineering Record, to ensure that all retrofit procedures maintain the quality of the original design and appearance.

Operating procedures would also require that future impacts would be appropriate to the historic integrity of this structure.

g. Aesthetics. The aesthetic quality of the old river will be enhanced with siphon operation. This would be attributed to the less frequent exposure of bars and mud flats. There would be no difference in the aesthetic quality of the floodway under either the abandoned or repaired condition.

4. Summary. Repair of the Marked Tree Siphon will produce many tangible and intangible benefits. A brief description of intangible benefits is presented in Table VIII-04. Tangible benefits have been calculated at approximately $7,000 average annual equivalents.

Table VIII-04
Marked Tree Siphon Repair
Summary of Potential Impacts
Overall Conditions

Item	St. Francis River	Oak Donnick Floodway
Water Flow	Increase	Decrease
Surface Water Acres	Increase	Decrease
Water Depth	Increase	Decrease
St. Francis Lake	No Impact	No Impact
Aquatic Habitat Acres	Increase	Decrease
Riparian Habitat	Decrease	No Impact
Sport Fishing Overall	Slight Increase	Slight Decrease
Sport Fishing at Siphon	Increase	No Impact
Commercial Fishing	Slight Increase	Slight Decrease
Boating & Gen. Recreation	Slight Increase	No Impact
Water Quality	No Impact	No impact
Endangered Species	No Impact	No Impact
Historical Significance	Increase	No Impact
Aesthetics	Increase	No Impact

References Cited

Stiegitz, Walter O. 1981. Biological opinion of the U.S. Fish and Wildlife Service (FWS) regarding the effects of the St. Francis Basin project in Arkansas and Missouri (Log No. 4-3-78-F-393) on the fat pocketbook pearly mussel (Potamilus (=Proptera) capax). U.S. Fish and Wildlife Service, Atlanta. 9pp.

SECTION IX PLAN OF OPERATION OF SIPHON

IX-01. GENERAL CONSIDERATIONS.

As described in SECTION V, there are benefits derived from the operation of the siphon that will be lost when the siphon fails, if it is not repaired. Some of the benefits are obtained during periods of lowflow, and others in periods of moderate or frequent flood flows. Not all of the described benefits have been quantified. But there are certain constraints which limit the siphon's operation. A Plan of Operation stating these constraints is detailed below, and will be a part of a formal legal agreement between the concerned local interests and the United States. There should not be any further expense to the Federal Government for the repair of the Marked Tree Siphon Until that agreement has been signed by the Board of Commissioners of Drainage District 7 of Poinsett County, Arkansas, and by the District Commander. Memphis District, U.S. Army Corps of Engineers.

That part of the Plan of Operation which relates to the headwater elevation in St. Francis Lake is consistent with a "Memorandum of Understanding" agreement between Drainage District 7 of Poinsett County and the Arkansas Game and Fish Commission in 1977, still in force. Desired maximum tailwater elevation at the outlet of the siphon is based on their forty-six years of operating experience. Coordination with the operation of the Huxtable Pumping Plant is analyzed in Appendix A of this report. In addition to these provisions of normal operating, the emergency use of the siphon to reduce the probability of a downstream crevasse disaster is described in Appendix B of this report. The Plan of Operation is in the following paragraphs.

IX-02. NORMAL OPERATION OF THE SIPHON.

a. Headwater Regulation. The operation of the St. Francis Lake (Oak Donnick) Control Gate by an agent of the Arkansas Game and Fish Commission and of the siphon by Drainage District 7 of Poinsett is to be coordinated so as to maintain a minimum lake elevation of 210.0 NGVD on the Oak Donnick Gage. The siphon is shut off by D.D. 7 when the gage reading falls below 210.0.

b. Minimum Headwater Exception. When upstream indicators show the near approach of a rainfall runoff during crop season which would cause damage within the lake and floodways by rising above 212.0, D.D. 7 may request, in each separate case, from the Arkansas Game and Fish Commission their agreement for the lake to be lowered temporarily below 210.0 in order to increase flood storage ability and reduce interior flood damage. This lowering can be done by manual operation of the gate and/or by operation of the siphon, provided that siphon operation at that time does not violate other constraints specified in subparagraphs IX-02c and d, below. After agreement by the Arkansas Game and Fish Commission to lowering below 210.0, but before use of the siphon is allowed to facilitate such lowering, D.D. 7 will consult with the Wynne Area Engineer, U.S.A.C.E. The Area Engineer will determine the acceptability of this use of the siphon at that time, and will concur with its operation, or will not concur with its use, based on the criteria given in subparagraphs c. and d. below.

c. Maximum Tailwater Elevation. Except during declared emergency conditions described in IX-03, the siphon shall not be operated when its outflow will raise the tailwater elevation on the Lower Lock gage at the siphon outlet above 208.5 NGVD. Starting the siphon will significantly raise tailwater elevation above that existing before starting, so care must be taken to avoid violating this constraint. Tailwater elevation above 208.5 may not cause flooding in Marked Tree but will flood some cropland below the siphon.

d. Coordination with Huxtable Pumping Plant. At any time that upstream rainfall and river-gage reports on the Mississippi River and St. Francis River indicate that the plant operations of closing gates and starting pumps will begin in the near future, the District Commander will, through the Area Engineer, request D.D.7 of Poinsett to stop operation of the siphon three days before the predicted beginning of Huxtable Pumping Plant operations. Siphon flow will arrive at the plant within three days. If possible, D.D.7 of Poinsett will be notified at least twenty-four hours before siphon stoppage is required. Benefits in the lake and in the Straight Slough backwater area from siphon operation are far exceeded by the added plant operation costs and damages within the plant protected area if siphon flow adds to the plant operational burden, as explained in Appendix A of this report. The District Commander will, through the Area Engineer, notify D.D.7 when normal siphon operation may be resumed.

e. Lowflow Augmentation. The siphon may continue to be operated for lowflow augmentation as requested by people downstream, provided this is not in conflict with any provision in this agreement.

IX-03. EMERGENCY OPERATION OF THE SIPHON.

a. Principles. In Appendix B of this report it is shown that floodway flows of a specific probability will produce floodway critical water surface elevations in the vicinity of Riverfront Gage, mile 58.0, that could cause a crevasse. The properly timed use of the siphon in withdrawal of floodway water could reduce lake outflow of a greater flood, of less probability, to a flow of critical magnitude which could pass Riverfront without a crevasse. This emergency withdrawal use would effectively reduce the probability of major damage in the protected area and subsequent levee repair costs. The negative aspects of heavy siphon flow during a Huxtable pumping operation would be present but would be far exceeded by the overall damages and costs of a crevasse. If the proposed channel restoration or other floodway improvement below Riverfront should be made, the same principles would still apply. The probability of a crevasse, without siphon withdrawal, would be less than at present, but that probability would be still further reduced by emergency siphon withdrawal.

b. Procedures. When upstream rainfall and river-gage report on the Mississippi River and the St. Francis River are such that a floodway flood of sufficient magnitude to cause a levee crevasse is predicted, there will be a decision by the District Commander, whether or not to use emergency siphon withdrawal. Under present conditions in the Floodway below Riverfront Gage, mile 58.0, decision criteria have been developed. When significant changes in the capacity of the lower Floodway occur, these criteria should be reviewed and modified numerically. As of July 1985, it has been determined that there will be a potential for a crevasse at mile 58.5 when the water surface elevation at Riverfront Gage exceeds 212.2, corresponding to a flow of 60,500 cubic feet per second. With predictable headwater and tailwater elevations at the siphon, withdrawal from the Floodway will be 1650 cfs for 1 barrel, 3050 cfs for 2 barrels, and 4200 cfs for 3 barrels, as regulated by tailwater control. If the predicted flow at Riverfront Gage is between 60,500 cfs and 62,150 cfs, one barrel should be started 36 hours before the time when 60,500 cfs is predicted at Riverfront Gage. If the predicted peak flow is between 62,150 cfs and 63,550 cfs, two barrels should be started.

If the predicted peak flow is between 63,550 and 64,700 cfs, three barrels should be started. Decision to follow the procedure must allow time for communication and movement of those designated to operate. If the predicted peak flow is considerably greater than 64,700 cfs, the use of the siphon cannot prevent a crevasse by reducing the peak to 60,500 cfs. In that event it may be decided to avoid the added damages above the Huxtable protected area by not using the siphon at all. If the decision to use one, two, or three barrels of the siphon is made by the District Commander, he will so inform D.D. 7 of Poinsett, by immediate communication. The District Commander will direct the operation to begin, through the Area Commander, who will send a representative to D.D. 7 and the siphon. The number of siphon barrels in operation may be changed by the District Commander, if further developments indicate. The provision in paragraph IX-02 c., that the siphon shall not be operated when tailwater is above 208.5, will not apply to operation during a declared emergency. When siphon withdrawal is no longer needed, the District Commander will use the same procedures to direct that it be stopped.

SECTION X - DISCUSSION AND RECOMMENDATION

X-01. DISCUSSION.

SECTION III considers the past and future needs for siphon operation. Paragraphs V-07 and V-08 summarize the unquantified and quantified benefits. Since there is no longer any commercial navigation above the Huxtable Pumping Plant, siphon augmentation of lowflow for that purpose is not needed. Irrigation pumpout from the River, both present and predictable, is in quantities less than the seasonal River lowflow without augmentation, although siphon flow could be called qualitatively beneficial in maintaining past lowflow levels during the irrigation pumpout season, thus preserving the aquatic habitat to which the River fish population and other biota have become adjusted. Lowflow River depth increase from siphon augmentation raises ground water level and thus maintains rural domestic water supply from shallow wells. There have been frequent statements by those persons who reside near the River, work along its banks, or travel beside or across it to the general effect that a deeper and wider stream is to them more beautiful than a shallower and narrower flow; the aesthetic effects are unquantifiable but are widely recognized. Also unquantifiable is the historical significance of this unique structure, as discussed in detail in paragraph II-13. Paragraphs 1d and 3e in Section VIII further appraise historical values and propose a procedure for obtaining historical designation. Lowflow augmentation by the siphon will maintain desirable River depths and surface areas but will not significantly harm the Floodway channel because of its different configuration. While it is not considered that the effect of repaired siphon augmentation in the River, as compared to residual lowflow if the siphon were abandoned, will produce major differences in fish production, it is recognized that the activity of sport fishermen would vary with the augmented flow or lack of it. Evaluation of this variation in activity in Section VIII is summarized in Paragraph V-05. There could be a similar increase in general recreational activity on the River when lowflow is augmented, but no data is available to quantify the probably small overall activity. A difference in the activity of part-time commercial fishermen is reasonable, but lack of reliable harvest data prevents quantification. The effect on water quality in the River by adding Floodway water is not quantified; the accepted "wetlands decontamination effect" is present in much of the Flood- way, but believed to be of such small magnitude that the water analysis over a considerable time period would not be justified. The need for Floodway lowflow removal in order to do major maintenance on the St. Francis Lake (Oak Donnick) Control Gates cannot be quantified, since such maintenance is unpredictable; but paragraph III-10 shows the restabilization cost of an alternative "third channel" diversion to be so high that this siphon capability of preventing the necessity of such a diversion channel would justify the full repair of all three barrels without any other benefits, if major gate maintenance is ever required. Avoidance of potential flowage damage claims that might be presented when abandonment of the siphon became known is a benefit of full repair to three barrels, but is difficult to quantify without arousing suspicions or alarm. In paragraph V-08 four quantified benefits are summarized. Partial repair, renewing only one barrel, will reduce River channel maintenance cost and will preserve the value of sport fishing in the

siphon outlet. But reduction of crop losses within the Lake, as described in paragraph V-03, and the temporary Lake drawdown, described in paragraph IX-02b, will frequently require operation of more than one barrel, as will the obtaining of full benefits in the Straight Slough area; thus, full repair of all three barrels is needed for reliability. Emergency operation analyzed in detail in Appendix B shows that availability of all three barrels is essential to the full development of this benefit, as seen in Tables B-13 and B-14. Maximum crevasse prevention potential is needed for maximum human security within the Huxtable protected area, and this effect cannot be quantified. Tables VII-1, 2, 3, and 4 confirm that repair is justified and that full repair of all three barrels is more efficient than partial repair involving only one barrel, as well as providing maximum security. Appendix A clarified in detail the conclusion already stated in a previous report, that the siphon may not be operated later than three days before Huxtable Plant operation begins, unless as a flood emergency procedure directed by U.S. Army Corps of Engineers. The Plan of Operation in SECTION IX should be formally accepted as a necessary condition for Federal repair of the siphon. If the siphon were not to be repaired, either because DD7 would not execute Operation and Maintenance Agreement acceptable to both Agencies, or for other reasons not now foreseen, it would remain under control of DD7; by temporary expedient methods DD7 could preserve its partial operability for an indefinite period. In order to prevent operation of the siphon later than three days before Huxtable Plant started operation, the U.S. Army Corps of Engineers would have to establish control by acquiring an adequate interest in the siphon itself and rights-of-entry over St. Francis Levee right-of-way. This may be accomplished voluntarily through right-of-entry or purchase, or involuntarily through condemnation or physical seizure. USACE would appear to have three alternatives. One would be to abandon the structure in place, locked and so modified as to make it inoperable. Another would be to remove everything related to the siphon and to construct a gravel roadway across the levee crown gap that would have remained; this second alternative is estimated to cost $250,000. The third would be to repair and operate it at Federal expense. These measures should be considered in comparison with the average annual equivalent net loss of $214,700 in the Huxtable Protected Area due to siphon operation continuing while Huxtable operates, as analyzed in detail in Appendix A. The cost of acquiring a controlling interest in the siphon and its access has not been estimated.

X-02. RECOMMENDATION.

I recommend that a formal agreement containing the approved Plan of Operation be signed by Drainage District 7 of Poinsett County, Arkansas, and by the Commander, Memphis District, U.S. Army Corps of Engineers. After the execution of this agreement, I further recommend that the siphon be fully repaired, including restoration of all three barrels, as described in this report in paragraph I-04 and the cost estimate in SECTION VI.

DALE F. MEANS
Colonel, Corps of Engineers
Commanding

APPENDIX A - EFFECT OF SIPHON ON HUXTABLE PUMPING OPERATION

A-1. GENERAL.

The purpose of this Appendix is to determine if the Plan of Operation should permit the siphon to be operated at such times that its outflow would have to be pumped out of the protected area by the Huxtable Pumping Plant. The report of January 1985, "Economic and Hydraulic Analysis for the Operation of the Huxtable Pumping Plant," in its Appendix A, shows the increase in average annual damage and the increase in pumping costs, and thus the decrease in average annual benefits of the Pumping Plant if the siphon outflow is added to the inflow from the Pumping Plant drainage area. In the recently completed study of maintenance needs in the Floodway, Reach 7B is the backwater area between Crowleys Ridge and the rightbank Levee of the Floodway, from the entrance of Straight Slough at Floodway mile 59.5 northward into Poinsett County, as shown on Maint. Plate 6-2 in SECTION IIIB. Use of the siphon during flood flows reduces the damage in Reach 7B.

A-2. REDUCTION IN HUXTABLE BENEFITS WHEN SIPHON CONTINUES.

Source references in this paragraph are to parts of the January 1985 "Huxtable Report, Appendix A and Main Report."

Table A-1, Page A-3, identifies certain Alternatives considered.

Alternative	Pumping	Capacity	Siphon	Start	Stop	Condition
1	No	--	No	--	--	Base, gates only
2	Yes	12,000	No	177	175	Pumping without Siphon
19	Yes	12,000	Yes	177	175	Pumping with Siphon

Hydrology and Hydraulics in the referenced report are found in SECTION II, pages 6-16. Methodology from pages 11-16 is summarized. A basin unit hydrograph and rainfall records from combinations of stations were combined with computed levee underseepage inflows to develop sump inflow hydrographs for the (simulated) period of record, 1947-1983. For Alternative 19 the computed daily siphon discharge was lagged 3 days and added. New air photo topography revised the earlier sump-storage and stage-area curves, and stage-relationships between the Mississippi River gage at Helena and the outlet gage at the Plant were developed to use during the (simulated) period before completion of the Plant. Routing the inflow hydrographs through the gates with the authorized pumping plan as needed produced sump storage hydrographs. Those for Alternative 2 were reasonably compatible with the results of the original Plant Design Memoranda, though input parameters had been refined. Storage-frequency analysis was converted to stage-frequency curves, including those in the referenced report for Alternatives 1, 2, and 19. That report has in Table III-1, page 19, "Cleared Acres Flooded" for sump elevations from 175 to 205 by 0.1' increments. On page 31 a table shows values used in mentioned stage-frequency curves.

Table III-6 Huxtable Pumping Plant (Sump WSEL)
Return Interval in Years

Alternative	1.01	2	5	10	25	50	100	200	500
1	173.4	185.7	190.1	192.6	195.3	197.2	199.1	201.1	204.1
2	170.1	180.6	184.1	186.0	188.1	189.6	191.0	192.5	194.1
19	170.3	180.9	184.5	186.4	188.6	190.2	191.6	193.0	195.5

Pumping costs during actual operations were found to have a usable relation to fuel consumption. Fuel consumption was analyzed as: Gallons per pump hour = Coefficient X Differential Head + a constant. Thus overall operating cost was computed for each analyzed event. Interest and amortization on first costs does not change in comparing alternatives.

For structural damage, field survey data were used with depth-damage curves and stage-frequency relationships to obtain expected annual structural damage for each Alternative considered. Allowances were made for damage to contents and clean-up costs.

For crop damage, different crop distributions reflected changes in practice during the (simulated) period of record. The computer program CACFDAS, which considers all pertinent variables, produced damages under each Alternative operation for the period of record. Average annual damage for each Alternative was then derived.

Values developed are displayed for Alternatives 1, 2, and 19, in the following adaptation of Table A-2, page A-4, from the referenced report.

Huxtable Pumping Plant
Economic Effect in Dollars of Marked Tree Siphon Inflows
(January 1984 Prices)

Alternative Plan	Siphon Running	Crop Damage	Struct. Damage 1/	Total Damage	Damage Reduction	Operating Costs	Excess Benefits
1 No Pump	No	3,416,160	221,070	3,637,230	--	--	--
2 Pump	No	791,600	5,540	797,140	2,840,090	478,370	2,361,720
19 Pump	Yes	882,700	8,130	890,830	2,746,400	585,320	2,161,080
Siphon Effect: Increase Total Damage				93,690			
: Increase Operating Costs						106,950	
: Decrease Excess Benefits							200,640

The conclusion is that allowing the siphon to operate later than 3 days before Huxtable Plant begins its authorized operation will increase Expected Annual Damages by $93,690, will increase the Expected Annual Operating Cost by $106,950, and thus will decrease the Expected Annual Excess Benefits by $200,640.

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1984 were used in this analysis.

The following display shows the increase in damages with the index of property values to July 1985 prices and the change from FY 1984 to FY 1985 Agricultural Crop Normalized Prices.

Huxtable Pumping Plant
Economic Effect in Dollars of Marked Tree Siphon Inflows
(July 1985 Prices)

Alternative Plan	Siphon Running	Crop Damage 1/	Struct. Damage	Total Damage	Damage Reduction	Operating Costs	Excess Benefits 2/
1 No Pump	No	3,573,300	232,600	3,805,900	--	--	--
2 Pump	No	828,000	5,800	833,800	2,972,100	478,370	2,493,730
19 Pump	Yes	923,300	8,600	931,900	2,874,000	585,320	2,288,680
Siphon Effect: Increase Total Damage				98,100			
: Increase Operating Costs						106,950	
: Decrease Excess Benefits							205,050

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.
2/ Operating Costs remained the same.

The conclusion is that allowing the siphon to operate later than 3 days before Huxtable Plant begins its authorized operation will increase Expected Annual Damages by $98,100, will increase the Expected Annual Operating Cost by $106,950, and thus will decrease the Expected Annual Excess Benefits by $205,050.

A-3. ECONOMIC ANALYSIS OF DAMAGE REDUCTION IN STRAIGHT SLOUGH WITH SIPHON

Project justification is determined by comparing the average annual equivalent benefits with the average annual equivalent costs during the project life of 50 years. The value given to benefits and costs at their time of accrual is made comparable by conversion to an equivalent time basis, starting from the beginning of year 1987 and ending at the beginning of year 2037. This analysis used the project interest rate of 2-1/2 percent and the 1986 Fiscal Year rate of 8-5/8 percent. The common reference date or base year to which all benefits and costs were discounted was 1987, the first year in which any benefits will be realized. For comparative purposes, the benefits and costs were expressed in July 1985 dollars, except for prices received by farmers for crops, Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used which are in October 1984 prices.

A-4. STRAIGHT SLOUGH CROP LOSS REDUCTION

Land Use. Agriculture is the paramount economic activity in the Straight Slough Ditch, Reach 7B, area. The major crops grown are rice, soybeans and wheat with minor crops of cotton and milo. A small amount of land is in pasture. There are 61,000 cleared acres of existing cropland in Reach 7B and 1,800 acres in other non-crop uses such as

roads, ditches and farmsteads. The following is the cropland acreage within each flood zone:

Year Zone	Acres
0 - 10	15,200
10 - 25	20,300
25 - 50	11,500
50 - 100	12,000
100 - over	2,000
	61,000 Total Acres

Crop Yields. With the siphon flood free yields (output) are derived via study of regional topography, soil types, and yields developed for current projects such as L'Anguille and Ditch No. 1, Arkansas. Table A-1 shows the existing crop acre yields and the projected future yields.

Future crop output per acre yields, are projected from basic historical data located in the publication: Economic Indicators of the Farm Sector, Production and Efficiency Statistics, 1981, published by the Economic Research Service of the U.S. Department of Agriculture. Table 25, page 28, entitled: "Crop Production: Indexes of Crop Production Per Acre, by Regions, 1939-81," was used to develop a projection for existing yields to the future for the project area within the Delta States Region, (Arkansas, Mississippi, and Louisiana). Using the historical values in this table, the following linear equation was developed: $Y = -13.01492 + .00714 (X)$, where the (X) value represents the year and the (Y) value is the corresponding index for output. The yield factor of 1.025 and 1.34 was derived by dividing the (Y) value for year 1983 into the (Y) value derived for years 1987 and 2037, respectively. The equation's linear correlation coefficient is 0.57718 with a standard error of estimate of 0.12247.

Crop Acre Production Cost. With the siphon crop acre production costs were obtained from Arkansas Cooperative Extension budgets adjusted to the proposed project area as a result of information received from interviews with farmers of the region. Table A-2 lists the existing costs and the projected future costs.

Future crop input per acre production costs, are projected from basic historical data located in the publication: Economic Indicators of the Farm Sector, Production and Efficiency Statistics, 1981, published by the Economic Research Service of the U.S. Department of Agriculture. No input per acre indices appear in this report. However, the following procedure was utilized to develop historical input per acre indices, 1939 - 1981. Table 24, page 27, entitled: "Indexes of Cropland used for crops, Delta States Region, 1939-81," was divided into each year of the corresponding Delta States Region, "Indexes of Total Farm Input," Table 64, page 68, resulting in Input Per Acre Indices, 1939 - 1981. Using these per acre input indices, 1939 - 1981, the following linear equation was developed: $Y=11.53207 - 0.00521(X)$ where the X value represents the year and the Y value is the corresponding index for input. The input factor of 0.983 and 0.77 was derived by dividing the (Y) value for year

1983 into the (Y) value derived for years 1987 and 2037, respectively. The equation's linear correlation coefficient is 0.40085 with a standard error of estimate of 0.14443.

Using the input and output equations cited above and using 1983 as the zero year, input and output indices were projected for the years 1987 and 2037. The 1987 and 2037 budgets were developed (Tables A-1 and A-2) using the 1987 and 2037 year input and output indices.

Product Prices. In accordance with paragraph 2.3.3(b), Appendix A, ER 1105-2-40, Changes 2, 9 July 1983, the normalized crop prices issued by the Department of Agriculture will be used to evaluate NED agricultural benefits. Normalized crop prices (as provided in EC 1105-2-148, dated 26 April 1985 for use during Fiscal Year 1985) were used in this analysis.

Crop Net Revenues. With the siphon crop net acre revenues are the result of subtracting production cost per crop from gross revenues per crop and are shown in Table A-3.

Crop Acre Damage Rates. Crop damage rates per typical expected annual acre inundated were determined for Straight Slough, using the Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS) to estimate damage rates per expected annual crop acre flooded. General inputs for computation are crop budgets, historical flood hydrographs, and a cropland stage-area inundation table; output, in essence, is the total dollar loss from historical floods for all crops grown in the reach and the total reach area inundated. The total dollar loss divided by the total acreage inundated provides the dollar damage rate per typical expected annual acre inundated. These damage rates are applied to acres flooded during damaging and non-damaging times of the year.

More specifically, CACFDAS incorporates operation dates, costs and revenues associated with crop production and simulates historical floods to assess inundation damages to crops. Crop damage is dependent upon the duration of inundation and flood depth. A crop is completely lost once inundated for its critical duration period: the length of time required for water saturation to destroy a crop. If a crop is destroyed by a flood, the program can be assigned a replant crop.

Input to CACFDAS consists of:

a. Digitized stage data - the date and number of acres flooded for each flood event.
b. Flood damage tables - the date, cost, and revenue associated with each farming operation and the maximum period of time a crop can be inundated without incurring damages.
c. Crop mix - the proportion of land allocated to each crop for a given reach and zone.
d. Expected gross revenue and net revenue for each crop.
e. Replant crop associated with each initial crop.
f. Minimum operations data - last operation before planting of initial crops.
g. Last day of planting for replant crops.

Primary output of CACFDAS are:

a. Cumulative production costs for each damaged crop.
b. Net revenue foregone for each damaged crop.
c. Net revenue recovered from replant crops.
d. Total net damages by crop.
e. Total peak acres flooded.
f. Damage per peak acre flooded.

Output is summarized by flood event, year and period of analysis.

Based on the Huxtable Pumping Plant Area's historical flood history of 1947-1983, the following data demonstrates the general procedure used to calculate both existing and future crop acre damage rates per expected annual acre flooded from the input and output of CACFDAS:

Straight Slough - With Siphon Operating Present and Future
Crop Acre Damage Rate Determination

1. Composite Acre Revenue and Production Cost Projections

	1	2	3	4	5
	1983	1987 Index Factor	1987 (1X2)	2037 Index Factor	2037 (1X4)
Composite Gross Revenue 1/	384.31	1.025	393.89	1.34	514.77
Composite Production Cost 2/	-345.61	0.983	-339.74	0.77	-266.12
Net Revenue	38.70		54.15		248.65

2. Index Factors for Projections

Net Revenue Index Factor for Year 1987: 54.15 ÷ 38.70 = 1.399
Net Revenue Index Factor for Year 2037: 248.65 ÷ 38.70 = 6.43

3. CACFDAS 1983 Summary Information

	$
Production Cost Loss:	14,215,239
Net Revenue Loss:	1,880,700
Replant Recovery to Gross Revenue:	- 7,701,437

1/ Composite Gross Revenue was transcribed from Table A-1 of Appendix A. Pasture was not indexed in total 1987 and 2037 gross revenue.
2/ Composite Production Cost was transcribed from Table A-2 of Appendix A.

4. Damage Rates

	1 1983	2 1987 Index Factor	3 1987 (1X2)	4 2037 Index Factor	5 2037 (1X4)
Production Cost Loss:	$14,215,239	0.983	$13,973,580	0.77	$10,945,734
Net Revenue Loss:	1,880,700	1.399	2,631,099	6.43	12,092,901
Replant Recovery to Gross Revenue:	-7,701,437	1.025	-7,893,973	1.34	-10,319,926
Total Damage	$ 8,394,502		$ 8,710,706		$12,718,709
Total Inundated Acreage	208,463		208,463		208,463
Damage Rate	$40		$42		$61

With the siphon crop damage rates per expected annual acre flooded using Fiscal Year 1985 Agricultural Crop Normalized Prices, and base year 1987 is $42 per acre and $61 per acre projected to year 2037. Expected annual cropland damage rates for improved channel maintenance in floodway below River Mile 58.0 and base year 1987 is $42 per acre and projected to year 2037 at $60 an acre.

Expected Annual Crop Acre Benefit Determination. Straight Slough cropland stage-area curve was integrated with its partial duration stage frequency curve to form a cropland area frequency curve. The area beneath the latter curve is the expected annual cropland acreage inundated for the Straight Slough area at varying elevations. The expected annual crop acres flooded was calculated up to elevation 212.2 at which freeboard begins and down to elevation 200.0, where there are zero damages. The method used to derive crop benefits for With and Without siphon under existing and With maintenance conditions are shown in Tables A-4, A-5, A-6, and A-7.

Expected Annual Benefits. The difference between expected annual dollar crop acre damages under Without siphon conditions and the expected annual dollar crop acre damages under With siphon conditions is the agricultural inundation reduction benefit. Expected annual dollar crop acre benefits are shown in Table A-8.

Average Annual Equivalent Crop Benefits. A time stream of agricultural inundation reduction benefits was used and benefits were discounted to beginning year 1987 at an interest rate of 2-1/2 percent and 8-5/8 percent. This discounted stream was then amortized over 50 years (amortization factor for 2-1/2 percent is 0.03526 and 0.08765 for 8-5/8 percent). Table A-9 shows the average annual equivalent benefits for Straight Slough.

A-5. STRAIGHT SLOUGH PROPERTY LOSS REDUCTION

Property Inundation Reduction. Damage was calculated for each flowline for both Without and With siphon conditions. Based on the annual duration stage frequency of occurrence flowlines and their attendant damages, expected annual property damages were calculated to elevation 212.2 (freeboard elevation). The expected annual damages to Straight Slough Without siphon condition is $21,300 and $21,100 With siphon condition for a net benefit of $200. This will also be the average annual equivalent benefit since under both conditions future hydrology will remain essentially unchanged during the period of analysis.

With improved channel maintenance below River Mile 58.0 condition, the damage to property would decline to $10,800 under both Without and With siphon. Therefore, under this condition, no benefits from reduction in property inundation would occur.

A-6. STRAIGHT SLOUGH AVERAGE ANNUAL EQUIVALENT BENEFITS

Total AAE Benefits (Historical). Benefit ratios were calculated from the historical period of record 1 March 1977 thru 30 September 1985 for a total of 3,136 days. During this period, the siphon operated one or more barrels a total of 1,826 days. This historical condition includes operating the siphon a total of 32 days when the tailwater was above 208.5, 295 days when Huxtable was pumping, and 1,499 days when Huxtable was not pumping.

The total number of days the siphon operated (1,826 days) divided by 32 days, the number of days the siphon should not have been operating will give the ratio (0.0175). The total historical AAE benefits must be multiplied by this ratio with the end product to be substracted from the total AAE benefits. This invalid future benefit was calculated to be $1,400 at 2-1/2 percent and 8-5/8 percent with siphon operating historical condition, and with improved channel maintenance condition it was $2,000.

AAE Benefits With Siphon On and Huxtable Pumping. The total number of days that can be used in determining the ratio for benefits to the siphon is 1,826 days minus 32 days for a balance of 1,794 days. A ratio of 0.1644 was calculated by dividing the 295 days that Huxtable was pumping into 1,794 days. The remaining total AAE benefits were multiplied by this ratio (0.1644) in order to calculate the benefits that result from operating the siphon at the same time Huxtable was pumping. The benefits received while Huxtable pumps were calculated to be $13,100 at 2-1/2 percent and $12,800 at 8-5/8 percent under With Siphon Operating Historical Condition and With Improved Maintenance Condition below River Mile 58.0, the benefits were $19,200 at 2-1/2 percent and $18,800 at 8-5/8 percent interest.

AAE Benefits With Siphon On and Huxtable Off. To calculate the benefits that Straight Slough will receive, the benefits that came from operating the siphon when Huxtable was pumping were subtracted. Table A-10 shows the average annual equivalent benefit that the siphon (one or more barrels) received when Huxtable is not pumping. The benefits under With

Siphon Operating Historical Condition is $66,600 AAE at 2-1/2 percent interest and $65,200 AAE at 8-5/8 percent interest. With Improved Maintenance Condition below River Mile 58.0, the benefits were $97,600 AAE at 2-1/2 percent interest and $95,800 AAE at 8-5/8 percent interest.

AAE Benefits With One Siphon Barrel. The historical period of record that the siphon operated (1,499 days) and Huxtable did not pump was not confined to operating one siphon barrel. Of these 1,499 days, about 25 percent of the damage-level flows were low enough to operate one siphon barrel without any additional damages. However, the remaining 75 percent of the time, the damage-level flows were too high for one siphon barrel to prevent additional damages to Straight Slough. Therefore, these benefits was cut by 50 percent which meant that 37.5 percent would go to the operation of one siphon barrel for a total benefit of 62.5 percent.

This benefit percentage rate was then applied to the total AAE benefit for each interest rate and condition for repair of one siphon barrel. Table A-11 shows the benefits under With Siphon Operating Historical Condition, were $41,625 AAE at 2-1/2 percent interest and $40,750 AAE at 8-5/8 percent interest. With Improved Maintenance Condition below River Mile 58.0, the benefits were $61,000 AAE at 2-1/2 percent interest and $59,875 AAE at 8-5/8 percent interest.

A-7. MARKED TREE SIPHON ADVERSE EFFECTS ON HUXTABLE

The average annual equivalent disbenefits from the operation of the Marked Tree Siphon were calculated from cropland and property inundation damages that were caused by the increase in water to the Huxtable pool, in addition to increased Huxtable pumping expense. Data were used from January 1985 "Huxtable Report" pages A-4 and A-5 to determine the amount of damage in the Huxtable protected area. Alternative #2 Without siphon and Alternative #19 With siphon were used for this analysis.

Since the damages in the report used Fiscal Year 1984 Agricultural Crop Normalized Prices, new current FY 1985 prices were used with CACFDAS to obtain a weighted average to crop distribution index of 1.046. Cropland damage to Huxtable protected area from Alternative #19 With siphon was $882,700 and Alternative #2 Without siphon is $791,600 for a difference of $91,000. Multiplying this by index 1.046 gives the cropland damage to Huxtable from operating the siphon of $95,300 for FY 1985.

The structure damage from Alternative #19 With siphon is $8,130 (January 1984 dollars) and $5,540 for Alternative #2 Without siphon for a difference of $2,590. This was multiplied by July 1985 property and contents index of 1.052 for total damages of $2,725.

On page A-5 of above report, the average annual expense of pumping is $106,950 (December 1983 price). This expense remained the same when indexed to July 1985 dollars. The total annual average disbenefit for operating the siphon in 1983 was $204,975. In order to get the average annual equivalent value, the 1983 cropland damage ($95,300) was

multiplied by the 2037 index number of 1.423 ($135,600) the result of 2037 crop damage rate divided by the 1983 crop damage rate. The structure damage and fuel oil expense were held constant for the project life. However, if the relative price of fuel oil increases in the future, this would have the adverse effect of increasing the losses incurred at Huxtable.

The total 2037 average annual projection is $245,275. To obtain the average annual equivalent, these values were discounted to beginning year 1987 and amortized over 50 years at 2-1/2 percent and 8-5/8 percent interest rate. The AAE disbenefit at 2-1/2 percent is $227,800 and $226,900 at 8-5/8 percent interest rate. Table A-12 shows the average annual equivalent net effect of operating the siphon when Huxtable Pumping Plant is pumping.

A-8. NET SIPHON AAE DOLLAR IMPACT

The conclusion is that by allowing the siphon to operate later than 3 days before Huxtable Plant begins its authorized operation will increase the average annual equivalent damages to the Huxtable area by $-214,700 using 2-1/2 percent and $-214,100 using 8-5/8 percent. Therefore, the siphon should not be operating when Huxtable is pumping.

TABLE A-1
MARKED TREE SIPHON: CROP ACRE YIELDS
EXISTING AND PROJECTED, CROP ACRE GROSS REVENUE AND
COMPOSITE CONTRIBUTION TO STRAIGHT SLOUGH AREA

	Crop Acre Yield 1/				Crop Acre Gross Revenue				Contribution to Composite Gross Revenue		
	1	2	3	4	5	6	7	8	9	10	11
	Existing 1983	1987	2037	FY 1985 2/ Crop Prices	1983 (1X4)	1987 (2X4)	2037 (3X4)	Percent Crop Distribution	1983 (5X8)	1987 (6X8)	2037 (7X8)
Rice (cwt)	45.75	46.89	61.31	10.92	499.59	512.04	669.51	43	214.82	220.18	287.89
Cotton					376.40	385.58	504.01	10	37.64	38.56	50.40
Lint (lb)	480.0	492.00	643.20	0.668	320.64	328.66	429.66				
Seed (ton)	0.48	0.49	0.64	116.17	55.76	56.92	74.35				
Soybeans, Single (bu)	30.0	30.75	40.20	7.42	222.60	228.17	298.28	15	33.39	34.23	44.74
Milo (cwt)	40.0	41.00	53.60	4.87	194.80	199.67	261.03	1	1.95	2.00	2.61
Double Crop					319.86	327.89	428.61	30	95.96	98.37	128.58
Soybeans (bu)	23.0	23.58	30.82	7.42	170.66	174.96	228.68				
Wheat (bu)	40.0	41.00	53.60	3.73	149.20	152.93	199.93				
Pasture 3/				53.39	55.39	55.39	55.39	1	.55	.55	.55
Total								100	384.31	393.89	514.77

1/ The process used to acquire the yield factor index of 1.025 and 1.34 for years 1987 and 2037, respectively, is discussed under topic, "Crop Yields."

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

3/ Pasture was not indexed resulting in a very small projection growth rate loss to total.

TABLE A-2
MARKED TREE SIPHON: CROP ACRE PRODUCTION COST AND COMPOSITE PRODUCTION COST CONTRIBUTION TO STRAIGHT SLOUGH AREA

	Crop Acre Production Cost 1/				Contribution to Composite Production Cost		
	1	2	3	4	5	6	7
	Existing 1983	1987	2037	Percent Crop Distribution	1983 (1X4)	1987 (2X4)	2037 (3X4)
Rice	470.61	462.61	362.37	43	202.36	198.92	155.82
Cotton	377.44	371.02	290.63	10	37.74	37.10	29.06
Soybeans, Single	130.18	127.97	100.24	15	19.53	19.20	15.04
Milo	192.77	189.49	148.43	1	1.93	1.89	1.48
Double Crop	280.18	275.42	215.74	30	84.05	82.63	64.72
Soybeans	131.70	129.46	101.41				
Wheat	148.48	145.96	114.33				
Pasture	-	-	-	1	-	-	-
Total				100	345.61	339.74	266.12

1/ The process used to acquire the cost factor index of 0.983 and 0.77 for years 1987 and 2037, respectively, is discussed under topic, "Crop Acre Production Cost."

TABLE A-3
MARKED TREE SIPHON: CROP ACRE GROSS REVENUE, CROP ACRE PRODUCTION COST AND CROP ACRE NET REVENUE

	Crop Acre Gross Revenue 1/			Crop Acre Production Cost 2/			Crop Acre Net Revenue		
	1	2	3	4	5	6	7	8	9
	1983 3/	1987	2037	1983	1987	2037	1983 (1-4)	1987 (2-5)	2037 (3-6)
Rice	499.59	512.04	669.51	470.61	462.61	362.37	28.98	49.43	307.14
Cotton	376.40	385.58	504.01	377.44	371.02	290.63	-1.04	14.56	213.38
Soybeans, Single	222.60	228.17	298.28	130.18	127.97	100.24	92.42	100.20	198.04
Milo	194.80	199.67	261.03	192.77	189.49	148.43	2.03	10.18	112.60
Pasture	55.39	55.39	55.39	-	-	-	55.39	55.39	55.39
Double Crop	319.86	327.89	428.61	280.18	275.42	215.74	39.68	52.47	212.87
Soybeans	170.66	174.96	228.68	131.70	129.46	101.41	38.96	45.50	127.27
Wheat	149.20	152.93	199.93	148.48	145.96	114.33	.72	6.97	85.60

1/ Crop Acre Gross Revenue was transcribed from Table A-1 of Appendix A.

2/ Crop Acre Production Cost was transcribed from Table A-2 of Appendix A.

3/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in the determination of 1983 crop revenue. For this reason, revenue from each crop may be lower than the actual revenue received from Fiscal Year 1983 Normalized Prices.

TABLE A-4
MARKED TREE SIPHON: CROP DAMAGE CALCULATION
FOR STRAIGHT SLOUGH - WITHOUT SIPHON
EXISTING CONDITIONS USING PARTIAL DURATION STAGE
FREQUENCY AT RIVER MILE 59.5

Interval in Years	Elevation (M.S.L.)	Expected No. of Occurrences in a Single Year	Cleared Acres Flooded	Average Cleared Acres Flooded for Interval	Occurrence Interval	Expected Annual Cleared Acres Flooded
40	212.2	.025	42,900			
				39,200	.015	588
25	211.2	.04	35,500			
				29,283	.06	1,757
10	209.0	.10	23,065			
				19,562	.10	1,956
5	207.4	.20	16,059			
				12,385	.30	3,716
2	204.9	.50	8,711			
				6,100	.50	3,050
1	202.3	1.00	3,489			
				2,168	.48	1,041
.68	200.6	1.48	847			
				424	.14	59
.60	200.0	1.62	0			

	1983	1987	2037
Expected Annual Cleared Acres Flooded	12,167	12,167	12,167
Expected Annual Dollar Damage per Cleared Acre 1/	X 40	X 42	X 61
Expected Annual Crop Damage	$486,680	$511,014	$742,187
Rounded	$486,700	$511,000	$742,200

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used.

TABLE A-5
MARKED TREE SIPHON: CROP DAMAGE CALCULATION
FOR STRAIGHT SLOUGH - WITH SIPHON
HISTORICAL CONDITIONS USING PARTIAL DURATION STAGE
FREQUENCY AT RIVER MILE 59.5

Interval in Years	Elevation (M.S.L.)	Expected No. of Occurrences in a Single Year	Cleared Acres Flooded	Average Cleared Acres Flooded for Interval	Occurrence Interval	Expected Annual Cleared Acres Flooded
40	212.2	.025	42,900			
				39,200	.015	588
25	211.2	.04	35,500			
				29,000	.06	1,740
10	208.9	.10	22,500			
				18,850	.10	1,885
5	207.2	.20	15,200			
				11,250	.30	3,375
2	204.4	.50	7,300			
				4,850	.50	2,425
1	201.7	1.00	2,400			
				1,200	.48	576
.68	200.0	1.48	0			

	1983	1987	2037
Expected Annual Cleared Acres Flooded	10,589	10,589	10,589
Expected Annual Dollar Damage per Cleared Acre 1/	X 40	X 42	X 61
Expected Annual Crop Damage	$423,560	$444,738	$645,929
Rounded	$423,600	$444,700	$645,900

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used.

TABLE A-6
MARKED TREE SIPHON: CROP DAMAGE CALCULATION
FOR STRAIGHT SLOUGH - WITHOUT SIPHON OPERATING
AND WITH IMPROVED CHANNEL MAINTENANCE IN FLOODWAY
BELOW RIVER MILE 58.0

Interval in Years	Elevation (M.S.L.)	Expected No. of Occurrences in a Single Year	Cleared Acres Flooded	Average Cleared Acres Flooded for Interval	Occurrence Interval	Expected Annual Cleared Acres Flooded
78	212.2	.015	42,900			
				39,570	.005	198
50	211.3	.02	36,240			
				34,174	.005	171
40	210.6	.025	32,109			
				29,000	.015	435
25	209.5	.04	25,891			
				20,760	.06	1,246
10	207.3	.10	15,629			
				13,158	.10	1,316
5	205.6	.20	10,686			
				12,975	.30	3,893
2	202.9	.50	4,578			
				2,501	.50	1,251
1	200.3	1.00	424			
				212	.48	102
.68	200.0	1.48	0			
				1983	1987	2037
Expected Annual Cleared Acres Flooded				8,612	8,612	8,612
Expected Annual Dollar Damage per Cleared Acre 1/				X 40	X 42	X 60
Expected Annual Crop Damage				$344,480	$361,704	$516,720
Rounded				$344,500	$361,700	$516,700

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used.

TABLE A-7
MARKED TREE SIPHON: CROP DAMAGE CALCULATION
FOR STRAIGHT SLOUGH - WITH SIPHON OPERATING
AND WITH IMPROVED CHANNEL MAINTENANCE IN FLOODWAY
BELOW RIVER MILE 58.0

Interval in Years	Elevation (M.S.L.)	Expected No. of Occurrences in a Single Year	Cleared Acres Flooded	Average Cleared Acres Flooded for Interval	Occurrence Interval	Expected Annual Cleared Acres Flooded
78	212.2	.015	42,900			
				39,570	.005	198
50	211.3	.02	36,240			
				32,479	.005	162
40	210.0	.025	28,717			
				27,304	.015	410
25	209.5	.04	25,891			
				20,546	.06	1,233
10	207.2	.10	15,200			
				12,802	.10	1,280
5	205.4	.20	10,404			
				7,037	.30	2,111
2	202.4	.50	3,670			
				1,835	.48	881
1.02	200.0	.98	0			
				0	.02	0
1	199.7	1.00	0			

	1983	1987	2037
Expected Annual Cleared Acres Flooded	6,275	6,275	6,275
Expected Annual Dollar Damage per Cleared Acre 1/	X 40	X 42	X 60
Expected Annual Crop Damage	$251,000	$263,550	$376,500
Rounded	$251,000	$263,600	$376,500

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used.

TABLE A-8
MARKED TREE SIPHON: EXPECTED ANNUAL
CROPLAND BENEFITS FOR STRAIGHT SLOUGH
IN YEARS 1983, 1987 and 2037 USING
FISCAL YEAR 1985 AGRICULTURAL
CROP NORMALIZED PRICES

Existing Conditions

1983		1987		2037	
Without siphon	$486,700	Without siphon	$511,000	Without siphon	$742,200
With siphon	-423,600	With siphon	-444,700	With siphon	-645,900
	$ 63,100		$ 66,300		$ 96,300

With Improved Channel Maintenance in Floodway Below RM 58.0 Condition

1983		1987		2037	
Without siphon	$344,500	Without siphon	$361,700	Without siphon	$516,700
With siphon	-251,000	With siphon	-263,600	With siphon	-376,500
	$ 93,500		$ 98,100		$140,200

TABLE A-9
MARKED TREE SIPHON: AVERAGE ANNUAL
EQUIVALENT CROP BENEFITS FOR STRAIGHT SLOUGH
AT PROJECT INTEREST RATE
OF 2-1/2 PERCENT AND
FISCAL YEAR 1986 INTEREST RATE OF 8-5/8 PERCENT

Average Annual Equivalent Benefits

	2-1/2 percent	8-5/8 percent
Siphon Operating Historical Conditions 1/	$ 80,900	$ 79,200
With Improved Channel Maintenance in Floodway Below River Mile 58.0 and Siphon Operating	$118,800	$116,600

1/ Historical Conditions includes operating the siphon when Huxtable is pumping and times when the tailwater is above 208.5.

TABLE A-10

MARKED TREE SIPHON: STRAIGHT SLOUGH AVERAGE ANNUAL EQUIVALENT BENEFITS WITH ONE OR MORE SIPHON BARRELS OPERATING WHEN HUXTABLE PUMPING PLANT IS NOT PUMPING

With Siphon Operating - Historical Conditions	2-1/2 percent	8-5/8 percent
Siphon Operating (Historical Conditions) includes operating the siphon when Huxtable is pumping and times when the tailwater is above 208.5		
Crop Inundation Reduction 1/	$ 80,900	$ 79,200
Property Inundation Reduction	200	200
Straight Slough - Total AAE Benefits (Historical)	$ 81,100	79,400
Invalid Future Benefits, Tailwater above 208.5 2/	- 1,400	- 1,400
Benefits Received While Huxtable Pumps 3/	-13,100	-12,800
Total AAE Benefits (Siphon On and Huxtable Off)	$ 66,600	$ 65,200

With Improved Channel Maintenance in Floodway Below RM 58.0 Conditions	2-1/2 percent	8-5/8 percent
Siphon Operating (With Improved Channel Maintenance Conditions) includes operating the siphon when Huxtable is pumping and times when the tailwater is above 208.5		
Straight Slough - Total AAE Benefits 1/	$ 118,800	$116,600
Invalid Future Benefits, Tailwater above 208.5 2/	- 2,000	- 2,000
Benefits Received While Huxtable Pumps 3/	- 19,200	-18,800
Total AAE Benefits (Siphon On and Huxtable Off)	$ 97,600	$ 95,800

1/ Average Annual Equivalent Crop Benefits were transcribed from Table A-9 of Appendix A.

2/ The process used to acquire the invalid future benefits is discussed under topic, "AAE Benefits With Siphon on and Huxtable Pumping."

3/ The process used to acquire the benefits received while Huxtable pumps is discussed under topic, "AAE Benefits With Siphon On and Huxtable Pumping."

TABLE A-11
MARKED TREE SIPHON: STRAIGHT SLOUGH AVERAGE ANNUAL EQUIVALENT BENEFITS WITH OPERATING ONE SIPHON BARREL WHEN HUXTABLE PUMPING PLANT IS NOT PUMPING

With One Siphon Barrel Operating - Historical Conditions

	2-1/2 percent	8-5/8 percent
Total Crop Inundation Reduction 1/	$66,400	$65,000
One Siphon Barrel Percentage Benefit 2/	X .625	X .625
Crop Inundation Reduction (One Barrel)	$41,500	$40,625
Total Property Inundation Reduction	200	200
One Siphon Barrel Percentage Benefit 2/	X .625	X .625
Property Inundation Reduction (One Barrel)	125	125
Total AAE Benefits to Straight Slough (Historical Condition)	$41,625	$40,750

With Improved Channel Maintenance in Floodway Below RM 58.0 Conditions

Total Crop Inundation Reduction 1/	$97,600	$95,800
One Siphon Barrel Percentage Benefit 2/	X .625	X .625
Total AAE Benefits to Straight Slough (With Improved Maintenance Condition)	$61,000	$59,875

1/ Total AAE benefits from operating one or more siphon barrels when Huxtable was not pumping are shown in Table A-10. Property inundation reduction was subtracted from total.

2/ The process used to acquire the one siphon barrel percentage benefit is discussed under topic, "AAE Benefits With One Siphon Barrel."

TABLE A-12
MARKED TREE SIPHON: STRAIGHT SLOUGH AVERAGE ANNUAL EQUIVALENT NET EFFECT OF OPERATING THE SIPHON WHEN HUXTABLE PUMPING PLANT IS PUMPING

	2-1/2 percent	8-5/8 percent
With Siphon Operating - Historical Conditions		
Total AAE Benefits Received by Straight Slough when Huxtable is Pumping 1/	$ 13,100	$ 12,800
Decrease Excess Benefits With Siphon Operation to Huxtable Pumping Plant 2/	-227,800	-226,900
Net Loss to Huxtable	$-214,700	$-214,100
With Improved Channel Maintenance in Floodway Below RM 58.0 Conditions		
Total AAE Benefits Received by Straight Slough when Huxtable is Pumping 1/	$ 19,200	$ 18,800
Decrease Excess Benefits With Siphon Operating to Huxtable Pumping Plant 2/	-227,800	-226,900
Net Loss to Huxtable	$-208,600	$-208,100

1/ The process used to acquire the total AAE benefits are discussed under topic, "AAE Benefits With Siphon On and Huxtable Pumping."

2/ The process used to acquire the decreased excess benefits are discussed under topic, "Marked Tree Siphon Adverse Effects on Hustable."

APPENDIX B - EMERGENCY SIPHON USE TO AVOID A CREVASSE

B-01. CONCEPT AND PROCEDURE.

The report of January 1985, "Economic and Hydraulic Analysis for the Operation of the Huxtable Pumping Plant," and the recently completed study of maintenance needs in the Floodway, together provide much data already derived for other purposes but pertinent to this investigation of emergency siphon use. Here the basic concept is that a Floodway flow which produces a WSEL of 212.2 at Floodway Mile 58.5 could cause a crevasse in the east Floodway levee which would flood the eastward Huxtable protected area. The crevasse is assumed to develop to dimensions of large capacity soon enough that the Floodway WSEL would not rise above 212.2.

Emergency use of the siphon withdrawal capability will cause an upstream flood, of greater magnitude of flow, higher frequency interval in years, and a lower probability in any given year, to be reduced to that flow which will not exceed a WSEL of 212.2 at Floodway Mile 58.5. Thus the reduction of probability of crevasse damage in any given year is considered to be a benefit of siphon withdrawal. The cases to be analyzed are four: withdrawal by only one barrel, and withdrawal by three barrels, under existing Floodway capacity conditions, and also under increased Floodway capacity conditions produced by some maintenance operation which may later be the result of the recently completed study mentioned above. These changes in crevasse damage probability are computed in paragraphs B-02 and B-03, using data from cited Plates in SECTION IVB. The results of siphon withdrawal in reduction of probability of crevasse damage are analyzed separately for existing conditions and for a probably increased Floodway capacity in the future.

The costs of a crevasse event, whenever it might occur, include crop damage and structural damage in the Huxtable protected area, in excess of those damages already caused by interior flooding. Also included is the added pumping plant operating cost above that required by interior flooding. The estimated cost of a crevasse repair is also a crevasse cost. The costs of the crevasse-produced added interior flooding are adapted from data developed in the recently completed maintenance study mentioned above.

The gross benefit to the Huxtable protected area produced by reduction of crevasse probability must be diminished by the increased damages and operating costs produced by adding siphon transfers to the interior flooding inflows. Thus only a net benefit can be attributed to the emergency use of the siphon.

B-02. REDUCTION OF PROBABILITY OF CREVASSE BY SIPHON USE, WITH EXISTING CONDITIONS.

PLATE IIIB-5, "Rating, Floodway 58.5, Crevasse Site," shows that the critical WSEL 212.2 is the result of a flow of 60,500 cfs. PLATE IIIB-8, "Discharge Frequency, 58.0 to 59.5" shows that a flow of 60,500

cfs has a frequency-interval of 1:40 years. With withdrawal by one siphon barrel of 1,650 cfs, a flow of 62,150 cfs (1:47 years) is reduced to the critical flow of 60,500 cfs (WSEL 212.2), though it is still a 1:47 year event. With withdrawal by three siphon barrels of 4,200 cfs, a flow of 64,700 cfs (1:55 years) is reduced to the critical flow of 60,500 cfs (WSEL 212.2), though it is still a 1:55 year event. This effect is tabulated below:

Freq. Int. Years	Peak Q	Siphon - Q	Reduced Q	WSEL M 58.5	Probability Per Year
1:40	60,500	--	60,500	212.2	.02500
1:47	62,150	-1650 (1)	60,500	212.2	.02128
1:55	64,700	-4200 (3)	60,500	212.2	.01818

B-03. REDUCTION OF PROBABILITY OF CREVASSE BY SIPHON USE, WITH FUTURE FLOODWAY CAPACITY INCREASE.

A study recently completed indicates that under some favorable circumstances there may be a future maintenance operation by which the Floodway capacity in our area of interest would be significantly increased. Using data produced in that study for the alternative improvement most likely to be recommended in the future, the PLATE IIIB-5, "Rating, Floodway 58.5, Crevasse Site," was modified in the general range of WSEL 212.2 PLATE IIIB-5, as modified for increased capacity, shows that the critical WSEL 212.2 is the result of a flow of 72,800 cfs. PLATE IIIB-8, "discharge Frequency, 58.0 to 59.5," shows that a flow of 72,800 cfs has a frequency-interval of 1:90 years. With withdrawal by one siphon barrel of 1,650 cfs, a flow of 74,450 cfs (1:100 years) is reduced to the critical flow of 72,800 cfs (WSEL 212.2), though it is still a 1:100 year event. With withdrawal by three siphon barrels of 4200 cfs, a flow of 77,000 cfs (1:113 years) is reduced to the critical flow of 72,800 cfs (WSEL 212.2), though it is still a 1:113 year event. This effect is tabulated below:

Freq. Int. Years	Peak Q	Siphon - Q	Reduced Q	WSEL M 58.5	Probability Per Year
1:90	72,800	--	72,800	212.2	.01111
1:100	74,450	-1650 (1)	72,800	212.2	.01000
1:113	77,000	-4200 (3)	72,800	212.2	.00885

B-04. EFFECT IN STRAIGHT SLOUGH AREA OF SIPHON USE IN EMERGENCY.

a. With existing Floodway capacity, the Straight Slough area is subject to backwater flooding up to 212.2, at a frequency interval of 1:40 years without the use of siphon withdrawal. A Floodway flow of up to 1:55 years, without siphon withdrawal, would cause a crevasse when 212.2 was exceeded, after which the crevasse capacity development would be so much faster than the arrival of greater flow increments that the backwater flooding in the Straight Slough area would not exceed 212.2 and would soon begin to recede. The use of siphon withdrawal in the

1:55 year event would still flood the Straight Slough area up to 212.2. A Floodway greater than 1:55 year could not be compensated by siphon withdrawal (which might not be attempted then) and would in either case cause a crevasse when 212.2 was exceeded. As said above, the crevasse Floodway-flood-relief effect would still limit the Straight Slough damage to that of 212.2 WSEL. Thus, it is seen that use of siphon withdrawal or non-use will not change the damage in the Straight Slough backwater area.

b. With possible future maintenance work increasing the existing Floodway capacity, the flood which would reach 212.2 is of 1:90 years frequency interval instead of 1:40 years. This shows a clear benefit to the Straight Slough area (as also a benefit to the Huxtable area) from this possible Floodway capacity increase which would reduce the probability of reaching 212.2. But the absence of effect of siphon use or non-use follows the same concepts as in paragraph a above. For floods of 1:90 magnitude or above, there would be the same 212.2 damage in the Straight Slough area.

c. Whether under existing or improved Floodway conditions, the emergency use of the siphon would not alter the 212.2 damage. In comparing the effects of emergency withdrawal with those of non-use, there will be no further reference to the Straight Slough area.

B-05. ECONOMIC ANALYSIS.

The purpose of Appendix B was to logically develop and analyze various conditions of operating the Marked Tree Siphon in order to prevent a crevasse at River Mile 58.5, which would increase flooding in the protected Huxtable Pumping Plant area. The value given to benefits and costs were made comparable by conversion to an equivalent time bases, starting from the beginning of year 1987 and ending at the beginning of year 2037. This analysis used the project interest rate of 2-1/2 percent and the 1986 Fiscal Year rate of 8-5/8 percent. The common reference date or base year to which all benefits and costs were discounted was 1987, the first year in which any benefits will be realized. For comparative purposes, the benefits and costs were expressed in July 1985 dollars, except for prices received by farmers for crops, Fiscal Year 1985 Agricultural Crop Normalized Prices were used which are in October 1984 prices.

B-06. HUXTABLE PROTECTED AREA CROP LOSS REDUCTION.

Land Use. Agriculture is the paramount economic activity in the Huxtable protected area. The major crops grown are soybeans, wheat and cotton with minor crops of rice and milo. The total amount of cleared cropland flooded for the 500-year flood at elevation 199.0 NGVD is 136,700 acres (Table B-1). However, 27,800 acres of cropland are inundated at 187.4 NGVD and must be subtracted from the total cleared acres to show the net benefits or base condition for this analysis.

Crop Yields. The 1983 yields were estimated from county statistical data, conversations with county agents and familiarity with yields obtained on similar soil types in other parts of the St. Francis Basin. Table B-2 shows the existing and projected gross revenue from the crop yield using Fiscal Year 1985 Agricultural Crop Normalized Prices. See Appendix A, "Crop Yields," for method used in crop yield projection.

Production Cost. The 1983 budgets published by the Arkansas Cooperative Extension Service for the south, Delta Region, were used in this analysis. The timing of the expenditure of those costs was estimated for the project area based on four years familiarity with the St. Francis Basin and the immediate pumping plant area. Table B-3 lists the existing costs and the projected future costs. See Appendix A, "Crop Acre Production Cost," for the method used to project production cost.

Crop Net Revenues. To obtain the net revenues, production costs per crop must be subtracted from gross revenues per crop and are shown in Table B-4.

Crop Acre Damage Rates. Crop damage rates per typical expected annual acre inundated were determined for the Huxtable protected area, using CACFDAS to estimate damage rates per expected annual crop acre flooded. For a more detailed explanation of CACFDAS, see Appendix A, "Crop Acre Damage Rates."

Based on the Huxtable Pumping Plant Area's historical flood history of 1947-1983, the following data demonstrates the general procedure used to calculate both existing and future crop acre damage rates per expected annual acre flooded from the input and output of CACFDAS:

Huxtable Pumping Plant Protected Area Present and Future
Crop Acre Damage Rate Determination

1. Composite Acre Revenue and Production Cost Projections

	1 1983	2 1987 Index Factor	3 1987 (1X2)	4 2037 Index Factor	5 2037 (1X4)
Composite Gross Revenue1/	344.79	1.025	353.50	1.34	461.95
Composite Production Cost2/	-232.12	0.983	-228.18	0.77	-178.74
Net Revenue	112.67		125.32		283.21

2. Index Factors for Projections

Net Revenue Index Factor for Year 1987: = 125.32 ÷ 112.67 = 1.112
Net Revenue Index Factor for Year 2037: = 283.21 ÷ 112.67 = 2.51

1/ Composite Gross Revenue was transcribed from Table B-2 of Appendix B.
2/ Composite Production Cost was transcribed from Table B-3 of Appendix B.

3. CACFDAS 1983 Summary Information

	$
Production Cost Loss:	32,957,672
Net Revenue Loss:	18,467,208
Replant Recovery to Gross Revenue:	-17,262,467

4. Damage Rates

	1	2	3	4	5
	1983	1987 Index Factor	1987 (1X2)	2037 Index Factor	2037 (1X4)
Production Cost Loss:	$32,957,672	0.983	$32,397,392	0.77	$25,377,407
Net Revenue Loss:	18,467,208	1.112	20,535,535	2.51	46,352,692
Replant Recovery to Gross Revenue:	-17,262,467	1.025	-17,694,029	1.34	-23,131,706
Total Damage	$34,162,413		$35,238,898		$48,598,393
Total Flooded Acreage	366,388		366,388		366,388
Damage Rate	$93.24		$96.18		$132.64

The Huxtable Pumping Plant Protected Area has crop damage rates per expected annual acre flooded of $96.18 for base year 1987 and $132.64 per acre projected to year 2037 using Fiscal Year 1985 Agricultural Crop Normalized Prices.

Expected Annual Crop Acre Benefit Determination. Huxtable Pumping Plant Area cropland stage-area curve was integrated with its partial duration stage frequency curve to form a cropland area frequency curve. The area beneath the latter curve is the expected annual cropland acreage flooded for the Huxtable area at varying elevations, see Table B-1. The expected annual crop acres flooded was calculated from elevation 187.4 NGVD to elevation 199.0, the 500-year flood. The method used to derive crop benefits for With and Without Siphon Historical Conditions and Without and With Improved Channel Maintenance Conditions are shown in Tables B-5, B-6, B-7, B-8, B-9, and B-10.

Expected Annual Benefits. The difference between expected annual dollar crop acre damages with a levee crevasse under Without siphon conditions and the expected annual dollar crop acre damages under With siphon conditions is the agricultural flood reduction benefit. This method was also calculated for With and Without improved channel maintenance in the floodway below River Mile 58.0 conditions. Expected annual dollar crop acre benefits are shown in Table B-11.

Average Annual Equivalent Crop Benefits. A time stream of agricultural flood reduction benefits was used and benefits were discounted to beginning year 1987 at an interest rate of 2-1/2 percent and 8-5/8 percent. This discounted stream was then amortized over 50 years (amortization factor for 2-1/2 percent is 0.03526 and 0.08765 for 8-5/8 percent). Table B-12 shows the average annual equivalent benefits for the Huxtable protected area.

B-07. HUXTABLE PROTECTED AREA PROPERTY FLOOD DAMAGES.

Structure and content values (January 1984 and indexed to July 1985 by a factor of 1.052) were collected for the Huxtable protected area. The type of structure and ground to floor elevations were collected in order to utilize the depth of flooding to the percent of damage relationship developed by the Tennessee Valley Authority. Only the property damages that could be prevented from not having a crevasse were used for Appendix B.

Under Without Siphon Existing Condition, there are zero damages to property at elevation 187.4 NGVD (pool) in the Huxtable area. When you operate one barrel of the siphon, the new pool elevation becomes 191.7 (40- to 47-year flood zone), and with three barrels, the elevation rises to 193.8 (40- to 55-year flood zone). The total value of the 81 properties within the 40- to 55-year flood zone is $2,221,500 (structure and contents). The total amount of property damage prevented by operating the Marked Tree Siphon in the Huxtable protected area under Historical Conditions are $152,000 for operating one barrel of the siphon (40-to 47-year flood zone) and $642,600 when three barrels of the siphon are operating (40- to 55-year flood zone).

The average annual property damage for one barrel is $1,232 and $11,682 for three barrels, Historical Condition. This will also be the AAE benefits since under both conditions, future hydrology will remain essentially unchanged during the period of analysis.

With Improved Channel Maintenance below River Mile 58.0 Condition, Without Siphon Operating there are zero damages to property at elevation 187.4 NGVD (pool) in the Huxtable area. When one barrel of the siphon operates, the new pool elevation becomes 193.2 (90- to 100-year flood zone), and with three barrels, the elevation rises to 193.5 (90- to 113-year flood zone). The total value of the 82 properties within the 90- to 113-year flood zone is $2,234,800 (structure and contents). The total amount of prevented property damage while operating one barrel of the siphon (90- to 100-year flood zone) is $496,600 and $570,700 (90- to 113-year flood zone) when three barrels are operating.

The average annual property damage for one barrel is $614 and $5,051 for three barrels, With Improved Channel Maintenance Condition. This will also be the AAE benefits.

B-08. ADVERSE EFFECT OF EMERGENCY SIPHON USE.

Huxtable Protected Area - Cropland Flooding Disbenefit Penalty.

With the siphon operating, there is a disbenefit penalty to the Huxtable protected area's cropland which is the amount of additional cropland above the base condition (27,800 acres) that will be flooded in order to prevent a crevasse. When one siphon barrel is operating, 3,100 acres in the Huxtable area will be flooded and 7,800 acres flooded, when three siphon barrels are in operation.

The total number of acres flooded for occurrence interval were divided by two to get the average annual acres flooded (3,100 acres becomes 1,550 acres and 7,800 acres becomes 3,900 acres) and then multiplied by the probability of occurrence for that occurrence flood zone. The result is the expected annual acres flooded. The expected annual acres were multiplied by the 1987 and 2037 year damage rate per acre flooded with the results of the average annual cropland damages to the Huxtable protected area. A time stream was developed and amortized over 50 years at 2-1/2 percent and 8-5/8 percent interest rate to obtain the average annual equivalent cropland damages to the Huxtable area.

Siphon Operating-Historical
40- to 47-year (one bar.)

1987	2037
1550 acres	1550 acres
X.00372	X.00372
5.8	5.8
96.17	132.64
$557	$769

Average Annual Equivalent
2-1/2 percent -- $663
8-5/8 percent -- $656

40- to 55-year (three bar.)

1987	2037
3900 acres	3900 acres
X.00682	X.00682
26.6	26.6
96.17	132.64
$2,558	$3,528

Average Annual Equivalent
2-1/2 percent -- $3,045
8-5/8 percent -- $3,011

With Channel Maintenance
90- to 100-year (one bar.)

1987	2037
1550 acres	1550 acres
X.0011	X.0011
1.7	1.7
96.17	132.64
$163	$225

Average Annual Equivalent
2-1/2 percent -- $194
8-5/8 percent -- $192

90- to 113-year (three bar.)

1987	2037
3900 acres	3900 acres
X.00226	X.00226
8.8	8.8
96.17	132.64
$846	$1,167

Average Annual Equivalent
2-1/2 percent -- $1,007
8-5/8 percent -- $ 996

Huxtable Protected Area - Property Flood Damage Disbenefit Penalty.

The operation of the siphon to prevent a crevasse causes additional damage to property in the Huxtable protected area. This additional water will raise the Huxtable pool from the zero damage base condition of 187.4 NGVD to 187.9 (an increase of 0.5 feet) when one siphon barrel is operating. With the operation of three barrels, the Huxtable pool's new elevation will be 188.6 (an increase of 1.2 feet). The same method was used to obtain property damages that was used to get the reduction of property damage benefits listed in section B-07 of Appendix B.

There are 12 properties that are damaged when the siphon is operating with a total value of $397,700 (July 1985 structure and contents). With Siphon Operating Historical condition the average annual property damage to Huxtable for one siphon barrel is $442 and $2,899 for three siphon barrels (July 1985 structure and contents). With Channel Maintenance in the floodway below River Mile 58.0 condition, the July 1985 average annual property damage for one barrel is $164 and $1,412 for three barrels. The average annual property damage will also be the AAE disbenefit since conditions remain unchanged during the period of analysis. These damages would occur in the prevention of a crevasse and must be subtracted from the Huxtable protected area property inundation damage reduction.

Huxtable Protected Area - Pumping Disbenefit Penalty. There is also a pumping disbenefit penalty to the Huxtable protected area when the siphon is operating. The added expense of Huxtable pumping when one barrel is operating is $9,300 and $19,100 with three barrels. This expense was multiplied by the probability of occurrence for that occurrence interval flood zone in order to get the average annual penalty. Because the average annual penalty was held constant, this value will also be the average annual equivalent penalty.

Siphon Operating-Historical	With Channel Maintenance
40- to 47-year (one bar.)	90- to 100-year (one bar.)
$ 9,300	$9,300
X.00372	X.0011
$ 35 AAE	$ 10 AAE
40- to 55-year (three bar.)	90- to 113-year (three bar.)
$19,100	$19,100
X.00682	X.00226
$ 130 AAE	$ 43 AAE

B-09. LEVEE REPAIR REDUCTION.

The cost to repair the levee in the event of a crevasse is $600,000. This cost was multiplied by the probability of occurrence for that flood zone interval in order to get the average annual cost. Since this cost was held constant, it will also be the average annual equivalent cost. With the prevention of a crevasse, this cost will become a benefit With the Siphon Historical Condition.

Siphon Operating-Historical	With Channel Maintenance
40- to 47-year (one bar.)	90- to 100-year (one bar.)
$600,000	$600,000
X.00372	X.0011
$2,232 AAE	$ 660 AAE
40- to 55-year (three bar.)	90- to 113-year (three bar.)
$600,000	$600,000
X.00682	X.00226
$4,092 AAE	$1,356 AAE

B-10 BENEFITS FROM PREVENTION OF CREVASSE.

The average annual equivalent benefits from the prevention of a crevasse in the Huxtable protected area are shown in Tables B-13 and B-14. Benefits from the operation of one and three siphon barrels under Historical and With Improved Channel Maintenance Conditions are shown in the following comparison of benefits.

COMPARISON OF BENEFITS

Number of Barrels Repaired	Floodway Channel Condition	Authorized Rate 2-1/2% Interest Benefits	Current FY Rate 8-5/8% Interest Benefits
One	Historical	$10,181	$10,099
Three	Historical	$33,870	$33,628
One	Maintained	$ 3,408	$ 3,381
Three	Maintained	$13,105	$13,014

It is seen that the net average annual equivalent benefits from the use of three siphon barrels are between three and four times as great as the benefits from the use of one siphon barrel.

With regard to human safety, paragraphs B-02 and B-03 show that the use of three siphon barrels produces a reduction of crevasse probability that is from 1.8 to 2.0 times the reduction of probability by the use of only one siphon barrel.

TABLE B-1

HUXTABLE PROTECTED AREA

Stage-Cleared Acres Flooded
(Reference Point - Huxtable Pumping Plant)

Water Elevation Feet (NGVD)	Cleared Acres Flooded									
	0	.1'	.2'	.3'	.4'	.5'	.6'	.7'	.8'	.9'
175	0	77	154	231	308	385	462	539	616	693
176	770	847	924	1002	1079	1156	1233	1310	1387	1464
177	1541	1618	1695	1772	1849	1926	2148	2370	2592	2814
178	3036	3258	3480	3702	3924	4146	4368	4590	4813	5035
179	5257	5479	5701	5923	6145	6367	6589	6811	7033	7255
180	7477	7521	7566	7610	7655	7699	7743	7788	7832	7877
181	7921	7965	8010	8054	8099	8143	8187	8232	8276	8321
182	8365	8409	8454	8498	8543	8587	8980	9372	9765	10157
183	10550	10942	11335	11727	12120	12512	12905	13297	13690	14082
184	14475	14867	15260	15625	16045	16437	16830	17222	17615	18007
185	18400	18790	19181	19571	19961	20351	20742	21132	21522	21913
186	22303	22693	23083	23474	23864	24254	24644	25035	25425	25815
187	26206	26596	26986	27376	27767	28157	28831	29504	30178	30851
188	31525	32198	32872	33545	34219	34893	35566	36240	36913	37587
189	38260	38934	39608	40281	40955	41628	42302	42975	43649	44322
190	44996	45721	46446	47170	47895	48620	49345	50069	50794	51519
191	52244	52968	53693	54418	55143	55867	56592	57317	58042	58766
192	59491	60216	60941	61665	62390	63115	64195	65275	66356	67436
193	68516	69596	70677	71757	72837	73917	74998	76078	77158	78238
194	79319	80399	81479	82559	83640	84720	85800	86880	87961	89041
195	90121	91479	92837	94195	95553	96911	98269	99626	100984	102342
196	103700	105058	106416	107774	109132	110490	111848	113206	114564	115921
197	117279	118637	119995	121353	122711	124069	124914	125758	126603	127447
198	128292	129136	129981	130825	131670	132515	133359	134204	135048	135893
199	136737	138427	139271	140116	140962	141805	142649	143494	144338	145183
200	145183	145799	146415	147031	147647	148264	148880	149496	150112	150728
201	151344	151960	152576	153193	153809	154425	155041	155657	156273	156889
202	157505	158122	158738	159354	159970	160586	160664	160742	160820	160898
203	160976	161054	161132	161210	161288	161366	161444	161522	161600	161678
204	161756	161834	161912	161990	162068	162146	162224	162302	162380	162458

TABLE B-2
MARKED TREE SIPHON: CROP ACRE YIELDS
EXISTING AND PROJECTED, CROP ACRE GROSS REVENUE AND
COMPOSITE CONTRIBUTION TO HUXTABLE PUMPING PLANT AREA

	Crop Acre Yield 1/				Crop Acre Gross Revenue				Contribution to Composite Gross Revenue		
	1	2	3	4	5	6	7	8	9	10	11
	Existing 1983	1987	2037	FY 1985 2/ Crop Prices	1983 (1X4)	1987 (2X4)	2037 (3X4)	Percent Crop Distribution	1983 (5X8)	1987 (6X8)	2037 (7X8)
Rice (cwt)	49.50	50.74	66.33	10.92	540.54	554.08	724.32	3	16.22	16.62	21.73
Cotton					470.50	482.85	630.01	10	47.05	48.29	63.00
Lint (lb)	600.0	615.00	804.00	0.668	400.80	410.82	537.07				
Seed (ton)	0.60	0.62	0.80	116.17	69.70	72.03	92.94				
Soybeans, Single (bu)	35.0	35.88	46.90	7.42	259.70	266.23	348.00	25	64.93	66.56	87.00
Milo (cwt)	47.0	48.18	62.98	4.87	228.89	234.64	306.71	2	4.58	4.69	6.13
Double Crop					353.35	362.23	473.49	60	212.01	217.34	284.09
Soybeans (bu)	25.0	25.63	33.50	7.42	185.50	190.17	248.57				
Wheat (bu)	45.0	46.13	60.30	3.73	167.85	172.06	224.92				
Total								100	344.79	353.50	461.95

1/ The process used to acquire the yield factor index of 1.025 and 1.34 for years 1987 and 2037, respectively, is discussed under topic, "Crop Yields" in Appendix A.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-3
MARKED TREE SIPHON: CROP ACRE PRODUCTION COST AND COMPOSITE PRODUCTION COST CONTRIBUTION TO HUXTABLE PUMPING PLANT AREA

	Crop Acre Production Cost 1/				Contribution to Composite Production Cost		
	1	2	3	4	5	6	7
	Existing 1983	1987	2037	Percent Crop Distribution	1983 (1X4)	1987 (2X4)	2037 (3X4)
Rice	331.00	325.37	254.87	3	9.93	9.76	7.65
Cotton	386.11	379.55	297.30	10	38.61	37.96	29.73
Soybeans, Single	141.36	138.96	108.85	25	35.34	34.74	27.21
Milo	164.10	161.31	126.36	2	3.28	3.23	2.53
Double Crop	241.60	237.49	186.03	60	144.96	142.49	111.62
Soybeans	124.59	122.47	95.93				
Wheat	117.01	115.02	90.10				
Total				100	232.12	228.18	178.74

1/ The process used to acquire the cost factor index of 0.983 and 0.77 for years 1987 and 2037, respectively, is discussed under topic, "Crop Acre Production Cost," in Appendix A.

TABLE B-4
MARKED TREE SIPHON: CROP ACRE GROSS REVENUE, CROP ACRE PRODUCTION COST AND CROP ACRE NET REVENUE FOR THE HUXTABLE PUMPING PLANT AREA

	Crop Acre Gross Revenue			Crop Acre Production Cost			Crop Acre Net Revenue		
	1	2	3	4	5	6	7	8	9
	1983 1/	1987	2037	1983	1987	2037	1983 (1-4)	1987 (2-5)	2037 (3-6)
Rice	540.54	554.08	724.32	331.00	325.37	254.87	209.54	228.71	409.45
Cotton	470.50	482.85	630.01	386.11	379.55	297.30	84.39	103.30	332.71
Soybeans, Single	259.70	266.23	348.00	141.36	138.96	108.85	118.34	127.27	239.15
Milo	228.89	234.64	306.71	164.10	161.31	126.36	64.74	73.33	180.35
Double Crop	353.35	362.23	473.49	241.60	237.49	186.03	111.75	124.74	287.46
Soybeans	185.50	190.17	248.57	124.59	122.47	95.93	60.91	62.70	152.64
Wheat	167.85	172.06	224.92	117.01	115.02	90.10	50.84	57.04	134.82

1/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in the determination of 1983 crop revenue.

TABLE B-5
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
FREQUENCY OF OCCURRENCE CALCULATIONS
WITHOUT OPERATING SIPHON
HISTORICAL CONDITION

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.002	218
Crevasse	500	.002	108,900	199.0			
					94,450	.003	283
Crevasse	200	.005	80,000	196.3			
					72,500	.005	363
Crevasse	100	.01	65,000	195.2			
					56,100	.01	561
Crevasse	50	.02	47,200	193.6			
					23,625	.00494	117
Crevasse	40.1	.02494	50	187.41			
					25	.00006	0
212.2	40	.025	0	187.4			
					1983	1987	2037
		Expected Annual Acres Flooded			1,542	1,542	1,542
		Expected Annual Dollar Damage Per Acre 2/			X93.24	X96.18	X132.64
		Expected Annual Crop Damage			$143,776	$148,310	$204,531
		Rounded			$143,800	$148,300	$204,500

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-6
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
FREQUENCY OF OCCURRENCE CALCULATIONS
WITH OPERATING ONE SIPHON BARREL
HISTORICAL CONDITION

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.002	218
Crevasse	500	.002	108,900	199.0			
					94,450	.003	283
Crevasse	200	.005	80,000	196.3			
					72,500	.005	363
Crevasse	100	.01	65,000	195.2			
					56,100	.01	561
Crevasse	50	.02	47,000	193.6			
					38,250	.00123	47
Crevasse	47.1	.02123	29,500	191.71			
					14,750	.00005	1
	47	.02128	0	191.70			
					0	.00372	0
212.2	40	.025	0	187.4			
					1983	1987	2037
		Expected Annual Acres Flooded			1,473	1,473	1,473
		Expected Annual Dollar Damage Per Acre 2/			X93.24	X96.18	X132.64
		Expected Annual Crop Damage			$137,343	$141,673	$195,379
		Rounded			$137,300	$141,700	$195,400

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-7
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
FREQUENCY OF OCCURRENCE CALCULATIONS
WITH OPERATING THREE SIPHON BARRELS
HISTORICAL CONDITION

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.002	218
Crevasse	500	.002	108,900	199.0			
					94,450	.003	283
Crevasse	200	.005	80,000	196.3			
					72,500	.005	363
Crevasse	100	.01	65,000	195.2			
					57,200	.00815	466
Crevasse	55.1	.01815	49,400	193.81			
					24,700	.00003	1
	55.0	.01818	0	193.8			
					0	.00682	0
212.2	40	.025	0	187.4			

	1983	1987	2037
Expected Annual Acres Flooded	1,331	1,331	1,331
Expected Annual Dollar Damage Per Acre 2/	X93.24	X96.18	X132.64
Expected Annual Crop Damage	$124,102	$128,016	$176,544
Rounded	$124,100	$128,000	$176,500

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-8
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
WITH CHANNEL MAINTENANCE BELOW RM 58.0
FREQUENCY OF OCCURRENCE CALCULATIONS
WITHOUT OPERATING SIPHON

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.001	109
Crevasse	1000	.001	108,900	199.0			
					103,850	.001	104
Crevasse	500	.002	98,800	197.8			
					81,250	.003	244
Crevasse	200	.005	63,700	195.1			
					53,300	.005	267
Crevasse	100	.01	42,900	193.2			
					21,475	.0011	24
Crevasse	90.1	.0111	50	187.41			
					25	.00001	0
212.2	90	.01111	0	187.4			

	1983	1987	2037
Expected Annual Acres Flooded	748	748	748
Expected Annual Dollar Damage Per Acre 2/	X93.24	X96.18	X132.64
Expected Annual Crop Damage	$69,743	$71,943	$99,215
Rounded	$69,700	$71,900	$99,200

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-9
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
WITH CHANNEL MAINTENANCE BELOW RM 58.0
FREQUENCY OF OCCURRENCE CALCULATIONS
WITH OPERATING SIPHON, ONE BARREL

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.001	109
Crevasse	1000	.001	108,900	199.0			
					103,850	.001	104
Crevasse	500	.002	98,800	197.8			
					81,250	.003	244
Crevasse	200	.005	63,700	195.1			
					53,300	.005	267
Crevasse	100.1	.0099	42,900	193.21			
					21,450	.0001	2
	100	.01	0	193.2			
					0	.0011	0
212.2	90	.0111	0	187.4			
					1983	1987	2037
		Expected Annual Acres Flooded			726	726	726
		Expected Annual Dollar Damage Per Acre 2/			X93.24	X96.18	X132.64
		Expected Annual Crop Damage			$67,692	$69,827	$96,297
		Rounded			$67,700	$69,800	$96,300

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-10
MARKED TREE SIPHON: HUXTABLE PROTECTED AREA
WITH CHANNEL MAINTENANCE BELOW RM 58.0
FREQUENCY OF OCCURRENCE CALCULATIONS
WITH OPERATING SIPHON, THREE BARRELS

Floodway			Huxtable Area				
Crevasse Elevation (212.2)	Interval in Years	Expected Number Of Occurrences Per Single Year	Acres Flooded 1/	Elevation	Average Acres Flooded For Interval	Interval	Expected Annual Acres Flooded
Crevasse		.00	108,900				
					108,900	.001	109
Crevasse	1,000	.001	108,900	199.0			
					103,850	.001	104
Crevasse	500	.002	98,800	197.8			
					81,250	.003	244
Crevasse	200	.005	63,700	195.1			
					54,900	.00384	211
Crevasse	113.1	.00884	46,100	193.51			
					23,050	.00001	0
	113.0	.00885	0	193.5			
					0	.00226	0
212.2	90	.01111	0	187.4			
					1983	1987	2037
		Expected Annual Acres Flooded			668	668	668
		Expected Annual Dollar Damage Per Acre 2/			X93.24	X96.18	X132.64
		Expected Annual Crop Damage			$62,284	$64,248	$88,604
		Rounded			$62,300	$64,200	$88,600

1/ The stage-area relationship for the Huxtable area side of the levee indicates for base conditions (assuming no crevasse has occurred) 27,800 acres of cropland are inundated. In the computational process to estimate benefits these acres (27,800) were subtracted to show net effects of a levee crevasse.

2/ Agricultural Crop Normalized Prices for use during Fiscal Year 1985 were used in this analysis.

TABLE B-11
MARKED TREE SIPHON: EXPECTED ANNUAL
CROPLAND BENEFITS FOR HUXTABLE PROTECTED AREA
WITH OPERATING SIPHON, ONE AND THREE BARRELS

Siphon Operating - Historical Condition

1983		1987		2037	
Without siphon	$143,800	Without siphon	$148,300	Without siphon	$204,500
With (1 barrel)	-137,300	With (1 barrel)	-141,700	With (1 barrel)	-195,400
Cropland Benefits	$ 6,500	Cropland Benefits	$ 6,600	Cropland Benefits	$ 9,100
Without siphon	$143,800	Without siphon	$148,300	Without siphon	$204,500
With (3 barrel)	-124,100	With (3 barrel)	-128,000	With (3 barrel)	-176,500
Cropland Benefits	$ 19,700	Cropland Benefits	$ 20,300	Cropland Benefits	$ 28,000

With Improved Channel Maintenance in Floodway Below River Mile 58.0

1983		1987		2037	
Without siphon	$ 69,700	Without siphon	$ 71,900	Without siphon	$ 99,200
With (1 barrel)	- 67,700	With (1 barrel)	- 69,800	With (1 barrel)	- 96,300
Cropland Benefits	$ 2,000	Cropland Benefits	$ 2,100	Cropland Benefits	$ 2,900
Without siphon	$ 69,700	Without siphon	$ 71,900	Without siphon	$ 99,200
With (3 barrel)	- 62,300	With (3 barrel)	- 64,200	With (3 barrel)	- 88,600
Cropland Benefits	$ 7,400	Cropland Benefits	$ 7,700	Cropland Benefits	$ 10,600

TABLE B-12
MARKED TREE SIPHON: AVERAGE ANNUAL
EQUIVALENT CROP BENEFITS FOR
HUXTABLE PROTECTED AREA

	Average Annual Equivalent Benefits 1/	
	2-1/2 percent	8-5/8 percent
With Operating Siphon, One Barrel	$ 7,857	$ 7,768
With Operating Siphon, Three Barrels	$24,170	$23,894
With Improved Channel Maintenance in Floodway Below River Mile 58.0		
With Operating Siphon, One Barrel	$ 2,502	$ 2,473
With Operating Siphon, Three Barrels	$ 9,160	$ 9,058

1/ Cropland benefits from Table B-11 were used to develop a discount time stream to beginning year 1987, then amortized over a 50-year period.

TABLE B-13
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALANT
BENEFITS FROM PREVENTION OF CREVASSE IN HUXTABLE
PROTECTED AREA UNDER HISTORICAL CONDITIONS
WITH OPERATING ONE AND THREE SIPHON BARRELS
(July 1985 Price Level)

Reduction in Damages by Use of One Siphon Barrel

Huxtable Protected Area	2-1/2 percent $	8-5/8 percent $
Cropland Flood Reduction	7,857	7,768
Cropland Flooding Disbenefit Penalty	- 663	- 656
Property Flood Reduction 1/	1,232	1,232
Property Flooding Disbenefit Penalty	- 442	- 442
Pumping Disbenefit Penalty	- 35	- 35
Levee Repair 1/	2,232	2,232
Total	$10,181	$10,099

Reduction in Damages by Use of Three Siphon Barrels

Huxtable Protected Area	2-1/2 percent $	8-5/8 percent $
Cropland Flood Reduction	24,170	23,894
Cropland Flooding Disbenefit Penalty	-3,045	-3,011
Property Flood Reduction 1/	11,682	11,682
Property Flooding Disbenefit Penalty	-2,899	-2,899
Pumping Disbenefit Penalty	- 130	- 130
Levee Repair 1/	4,092	4,092
Total	$33,870	$33,628

1/ Benefits remain constant through 50-year life of project.

TABLE B-14
MARKED TREE SIPHON: AVERAGE ANNUAL EQUIVALANT BENEFITS FROM PREVENTION OF CREVASSE IN HUXTABLE PROTECTED AREA WITH CHANNEL MAINTENANCE CONDITIONS AND WITH OPERATING ONE AND THREE SIPHON BARRELS
(July 1985 Price Level)

Reduction in Damages by Use of One Siphon Barrel
With Channel Maintenance in Floodway Below River Mile 58.0

Huxtable Protected Area	2-1/2 percent $	8-5/8 percent $
Cropland Flood Reduction	2,502	2,473
Cropland Flooding Disbenefit Penalty	- 194	- 192
Property Flood Reduction 1/	614	614
Property Flooding Disbenefit Penalty	- 164	- 164
Pumping Disbenefit Penalty	- 10	- 10
Levee Repair 1/	660	660
Total	$ 3,408	$ 3,381

Reduction in Damages by Use of Three Siphon Barrels
With Channel Maintenance in Floodway Below River Mile 58.0

Huxtable Protected Area	2-1/2 percent $	8-5/8 percent $
Cropland Flood Reduction	9,160	9,058
Cropland Flooding Disbenefit Penalty	-1,007	- 996
Property Flood Reduction 1/	5,051	5,051
Property Flooding Disbenefit Penalty	-1,412	-1,412
Pumping Disbenefit Penalty	- 43	- 43
Levee Repair 1/	1,356	1,356
Total	$13,105	$13,014

1/ Benefits remain constant through 50-year life of project.

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE ARKANSAS GAME AND FISH COMMISSION

AND

DRAINAGE DISTRICT NO. 7, POINSETT COUNTY, ARKANSAS

RELATIVE TO

The control of the water level in St. Francis Lake

WHEREAS, the Arkansas State Game and Fish Commission is the duly constituted agency of the State of Arkansas entrusted with the responsibility and authority of fish and wildlife management; and,

WHEREAS, the Commission, at the request of the local sportsmen, signed assurances with the U. S. Army Corps of Engineers for the operation and maintenance of the newly constructed water control structure located in Ditch 60, known locally as the Oak Donnick Control Gates; and,

WHEREAS, Drainage District No. 7, Poinsett County, Arkansas, is a legal entity formed under the laws of the State of Arkansas; and,

WHEREAS, the Drainage District has a permit from the War Department to construct and operate certain levees, canals, ditches and structures in and around St. Francis Lake and is responsible for the operation of the siphons as specified in its permit; and,

WHEREAS, both Drainage District No. 7 and the Commission are desirous of working together in harmony, trust and cooperation for the ultimate benefit of the fish and wildlife resources as well as the agricultural resources.

NOW, THEREFORE, IT IS AGREED by and between the Arkansas State Game and Fish Commission and Drainage District No. 7, Poinsett County, Arkansas, that:

(1) The official, normal water level of St. Francis Lake shall be a minimum of 210 feet main sea level (m.s.l.) as measured on the historical Oak Donnick guage, provided there is adequate upstream inflow.

(2) Drainage District No. 7 will cut off the siphons when the water level of St. Francis Lake drops to elevation 210 feet m.s.l. as measured on the historical Oak Donnick guage.

(3) When the water level of St. Francis Lake is 210 feet m.s.l. or below, Drainage District No. 7 will not discharge by use of the siphons any water down the old channel of the St. Francis River, which flows past the City of Marked Tree, without first notifying and getting the approval of the Director of the Arkansas State Game and Fish Commission.

(4) The Arkansas Game and Fish Commission will train two local employees to operate the Oak Donnick Control Gates, one to be primarily in charge and one as an alternate when the principal operation is unavailable.

(5) The Arkansas Game and Fish Commission will also train the designated employee of Drainage District No. 7 to operate the Oak Donnick Control Gates; this is a safety and precautionary measure in case of an emergency only, and the local Game and Fish Commission employees are unavailable or cannot be found; the Drainage District No. 7 employee, however, must first call the Little Rock office of the Arkansas Game and Fish Commission and get permission from the Director or his designee before entering the control house; the designated employee of Drainage District No. 7 will be provided a key to the control house.

(6) The Arkansas Game and Fish Commission will not object to the clean out of Old Ditch 61 at the foot of St. Francis Lake and adjacent to the levee.

(7) The Arkansas Game and Fish Commission will cooperate with Drainage District No. 7 by agreeing to the lowering of the water level of St. Francis Lake for a few hours prior to the arrival of a known high stage of flood waters coming down the tributaries of St. Francis Lake. This will be done both by the use of the siphons as well as the Oak Donnick Gates.

(8) This Memorandum of Understanding can be amended upon mutual approval of both parties.

(9) This Memorandum of Understanding can be cancelled by either party upon a 60 day written notice.

(10) As between these parties, Drainage District No. 7 does not assume any liability whatsoever resulting from operation of the gate structure in accord with the terms of this document, nor does it assume any maintenance responsibilities.

THIS MEMORANDUM OF UNDERSTANDING approved by the Arkansas State Game and Fish Commission meeting in regular session on _____, 1977.

THIS MEMORANDUM OF UNDERSTANDING approved by Drainage District No. 7, Poinsett County, Arkansas, through its Board of Commissioners on August 10, 1977.

IN WITNESS WHEREOF, the parties thereto have executed this agreement this _____ day of _____, 1977.

ARKANSAS STATE GAME AND FISH COMMISSION

By: _____
Chairman

WITNESS: _____
Director

DRAINAGE DISTRICT NO. 7
OF POINSETT COUNTY, ARKANSAS

By: O. T. Portis
Chairman

WITNESS: Eugene Hinds

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303

MAY 5 1981

APPENDIX C, ITEM 2

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

Dear Colonel Reno:

This represents the Biological Opinion of the U.S. Fish and Wildlife Service (FWS) regarding the effects of the St. Francis Basin project in Arkansas and Missouri (Log No. 4-3-78-F-393) on the fat pocketbook pearly mussel (Potamilus (=Proptera) capax). This Opinion will address only those construction and maintenance projects submitted for consultation in your letter of October 21, 1980. For a review of the developments leading up to the submittal of this Opinion, I refer you to the administrative record found elsewhere in this document.

The St. Francis Basin project, as now authorized and partially constructed, consists of a detention reservoir at Wappapella, Missouri, a system of leveed floodways along portions of the St. Francis and Little Rivers, levees along the headwater diversion and above Crowleys Ridge, backwater levees in the lower part of the basin with the Huxtable Pumping Plant and floodgate for interior drainage, and an improved drainage system for flood control.

The following resources were used as the primary references in developing this Biological Opinion.

1. Corps of Engineers (COE), Memphis District (1972). Environmental Impact Statement, St. Francis Basin Project, Arkansas and Missouri.

2. Ecological Consultants, Inc. (1978). Status of Knowledge Report. Mussels of the St. Francis, Cache, and White Rivers in Arkansas.

3. Numerous publications and correspondence concerning the biology and range of Potamilus capax.

4. Ecological Consultants, Inc. (1980). Mussel (Naiad) Survey - St. Francis, White, and Cache Rivers, Arkansas and Missouri.

5. Specific mussel surveys conducted in the basin prior to the issuance of the final overall mussel survey report.

6. Conversations with Dr. David Stansbery (Ohio State University), Mr. John Bates (Ecological Consultants, Inc.), and staff of the Memphis District Corps of Engineers.

7. Numerous onsite inspections of project locations.

A number of projects requested for consideration with this consultation have previously received interim concurrence in accordance with a March 20, 1979, letter from FWS to the District Engineer. This procedure was formulated to allow an assessment of the effects of certain projects on P. capax prior to the issuance of the final Biological Opinion. A determination of no effect was made after the project area had been adequately surveyed and P. capax was not found; it was concluded that the project would have no cumulative or indirect effects on known populations. The following is a list of those projects.

1. Huxtable Pumping Plant: Inlet Channel Repairs, Outlet Channel Repairs, Water Well Repairs

2. Culvert Repair Ditch 19

3. Castor River

4. Big Creek

5. Ditch 19

6. Wappapella to Crowleys Ridge

7. Landside Ditch Below Marianna

It is our Biological Opinion that the following projects are not likely to jeopardize the continued existence of the fat pocketbook pearly mussel. This is based on the fact that these sites have been surveyed and the species was not found. It has also been determined that these project activities will not adversely affect any other known P. capax populations.

1. Ditches 21-a, 25, and 71

2. Rivervale Outlet Ditch, Part 3

3. Ditch 27 and Tributaries

4. Blackfish Bayou: Items 2 and 3

5. Belle Fountain and Tributaries

6. Buffalo Creek Ditch

7. Ditch 1

8. Landside Ditch Below Locust Creek Cleanout

9. Culvert Repair - Locust Creek

10. Shoal Removal - Rivervale Outlet Ditch

11. Shoal Removal - Tyronza River

It is our Biological Opinion that the following additional projects are also not likely to jeopardize the continued existence of the fat pocketbook pearly mussel. These are projects that would not be expected to impact aquatic habitats or would be conducted in areas not consistent with P. capax existence e.g., intermittent streams.

1. Ditch 60 Scour Repair

2. Marked Tree Siphons Repair

3. Deasons Lake Ditch Cleanout

4. Ditch 9 at Lake City

5. Wappapella Lake

6. Shoal Removal - Ditch 10 - Ark. Z14

7. Gravel Resurfacing, Levee - Madison to Marianna

8. Levee Repair - Oak Donnick

9. Buffalo Creek Diversion

10. Ditch 24

11. Ditches 7, 10, 12, and 13

12. Varney River

13. Honey Cypress

14. Sals Creek

It is our Biological Opinion that the Madison to Highway 64 Maintenance Dredging Project as presently proposed is likely to jeopardize the continued existence of the fat pocketbook pearly mussel.

The public notices issued on December 19, 1975, and June 8, 1977, describe this project as "maintenance dredging in the St. Francis River in Arkansas between Interstate 40 and U.S. Highway 64." The work will involve a cut in the streambed varying in width from 150 to 300 feet to restore the channel capacity.

Of the four locations where P. capax is currently known to exist, the greatest numbers and apparently the most successful reproduction occur in the St. Francis Basin. Within the basin live populations have only been found in one area, the reach north of Madison directly within the proposed work area.

The project will adversely impact the species in several ways. All individuals in direct contact with the cutterhead will be crushed and deposited on spoil banks. Those not directly impacted by the cutterhead will be subjected to decreased water quality resulting from increased silt loading as well as from the resuspension of various toxic components. Changes in the bottom profile will result in alterations in flow patterns which create scouring or deposition on the adjacent substrate.

We are unaware of any way that maintenance dredging could be carried out in the Madison to Highway 64 reach without jeopardizing the survival of the P. capax populations in that area.

In the evaluation and development of reasonable and prudent alternatives to the proposed Madison to Highway 64 Maintenance Dredging Project, the Memphis District Office was contacted for input.

On April 16, 1981, the Memphis District Engineer submitted a list of seven modifications that he felt could be studied in determining feasible alternatives to the following reasonable and prudent alternatives that could be implemented to achieve the goals and objectives of the project.

1. Raise all levees where necessary to provide authorized freeboard. Obtain flowage easements for lands that will experience increased flooding.

2. Excavate a channel that would augment the conveyance of high level flows. The new channel would be completely separate from the existing channel and would extend from Highway 64 to a location south of Madison, Arkansas. The control structure would divert water only during flood stages; average annual minimum flows would not be affected.

3. Construct a control structure in the Highway 64 area to divert excessive flood waters from St. Francis Bay into the St. Francis River. The Huxtable Pumping Plant would be used to move the increased flows out of the St. Francis River into the Mississippi River. The control structure would not be used to reduce flows in the Madison to Highway 64 area below the average annual minimum flow.

After completing your review of these alternatives, please notify the Jackson Area Office of your intended course of action to pursue one of these alternatives or develop additional ones. At that time we will work with your office in formulating more specific details to these alternatives.

BIOLOGY

The fat pocketbook pearly mussel (Potamilus (=Proptera) capax) was first described in 1832 by Green as Unio capax. The type locality is the upper Mississippi River at the Falls of St. Anthony, Minnesota.

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. Very little is known about the life history of the species. Practically nothing is known about its required host species and only a basic understanding of its habitat requirements.

Historically the species stronghold has been the upper Mississippi River. A survey conducted by Ellis in 1931 revealed P. capax rather widely distributed throughout the upper river. In fact, 29 specimens were collected at Hannibal, Missouri. More recent surveys have not been as successful in locating the species. Cawley (1947) and Fuller (1978) surveyed the Mississippi River without collecting a single specimen. Apparently the species has now been extirpated from the drainage or at least reduced to a population level below detection by these investigations.

Lesser collections of P. capax have been made from the Ohio River; the Wabash and White Rivers in Indiana; the Des Moines and Iowa Rivers in Iowa; the Spoon and Illinois Rivers in Illinois; the White, Black, and St. Francis Rivers in Arkansas; and the Neosho River in Kansas. Although the species has had a rather wide geographic range, it apparently has never existed in large numbers.

Recently the mussel has been found alive in only four rivers: the Wabash and White Rivers in Indiana, and the White and St. Francis Rivers in Arkansas. Of these, the St. Francis is the most important in terms of numbers of individuals and reproductive capability. This was confirmed by Bates (1980) in a survey of the St. Francis, Cache, and White Rivers in Arkansas. Although live P. capax were only found in a limited reach of the St. Francis River, moderate numbers were reported with evidence that reproduction was taking place.

At this time its survival is dependent upon, at a minimum, the perpetuation of the environmental conditions in which it presently exists.

There is, however, an adequate understanding of the factors that adversely affect naiad mollusks in general. Dredging has been found to be particularly detrimental to benthic organisms, the most obvious effect being the direct impact of the cutterhead or dragline bucket. Secondary impacts include the resuspension of sediment, toxic materials, and other components contributing to a degradation of downstream water quality. Depending upon the species, abnormal sediment deposition alone can have a devastating impact on mussel beds. Protection of the host species is vitally important to the life cycle of mussels. Many species have been extirpated through alterations in the water dynamics, such as impounding flowing streams to form lakes, which creates completely different ecological systems.

In a July 14, 1977, publication of the Federal Register, (Potamilus (=Proptera) capax) was formally designated as a federally protected Endangered species.

BACKGROUND

Negotiations between the FWS and the Memphis District COE concerning impacts of the St. Francis Basin project on Potamilus capax have been ongoing since the fall of 1977, when FWS requested that the COE initiate Section 7 consultation of the project. Because of the long duration of this consultation and the wealth of documentation that has ensued, this Opinion will only reference information deemed necessary in understanding the background and rationale for the development of the Opinion. A complete administrative record is maintained and available for review at the Jackson, Mississippi, Area Office, FWS.

Beginning in early 1977, FWS began corresponding with the Memphis District requesting that Section 7 consultation be initiated to evaluate the effects of the project on P. capax. On November 4, 1977, the Vicksburg Ecological Services (ES) Office, FWS, repeated this request in a letter to the District Engineer.

On May 18, 1978, the Vicksburg ES Office again wrote the District Engineer informing him that planned dredging operations (Madison to Highway 64) were in an area in which the Endangered P. capax had been previously collected. Once more the request was made that Section 7 consultation be initiated.

On May 30, 1978, the District Engineer replied to the Vicksburg ES Office referencing a previous request for the results of a recently completed study in the basin by Dr. Stansbery and stating that the area of concern would be surveyed by a COE contractor prior to any construction. He also expressed his intention to comply with the Endangered Species Act but felt it to be premature at this time to request consultation.

During the following months several letters were exchanged between the two agencies with FWS recommending consultation and the COE refusing, contending that it was not warranted based on available data. In a July 20, 1978, correspondence, the District Engineer stated that he believed that work now going on in the basin, including the maintenance dredging between Highway 64 and Marianna, Arkansas (Madison area), would have no impact on Endangered species. His position continued to be that the available evidence did not warrant consultation.

In a letter dated September 12, 1978, the Jackson Area Office informed the District Engineer of a P. capax collection on August 18, 1978, within the area of the Highway 64-Madison dredging project and requested that all construction work in the basin be halted until the effects of these activities on the species could be determined.

In light of these recent findings, the COE agreed in a letter dated September 18, 1978, to request consultation and meet with FWS representatives to discuss the consultation process.

On September 21, 1978, FWS personnel met with the COE staff in the Memphis District Office and discussed the consultation process as well as planned and ongoing basin activities. The FWS recommended that the Madison to Highway 64 Item 1 maintenance currently ongoing be stopped and that the Item 2 maintenance not be awarded until effects on P. capax could be evaluated. The COE agreed to consider these actions. It was also announced that the COE had awarded a contract for a mussel survey of the St. Francis, White, and Cache Rivers to be completed in approximately 1 year.

In spite of FWS recommendations to the contrary, the Madison to Highway 64 Item 1 dredging activities continued. On November 7, 1980, at a meeting in the Memphis District Office, the mussel survey contractor presented several freshly killed P. capax specimens (including soft parts) that were retrieved from the project's dredge spoil in the Madison to Highway 64 project area. After this development, dredging activities in the area were finally halted.

On November 24, 1978, the District Engineer wrote the Regional Director, FWS, requesting an explanation of a threshold examination and clarification of the consultation process.

The Regional Director responded in a letter dated December 4, 1978, explaining that all FWS Endangered species work had been halted for 41 days awaiting Presidential signing of the 1978 amendments to the Endangered Species Act. Threshold examination procedures were discussed as well as the apparent misunderstanding concerning cessation of maintenance dredging in the Madison to Highway 64 area as discussed in the September 21, 1978, meeting. It was requested that all construction in the lower St. Francis Basin be terminated until the consultation process was completed and that a time extension beyond the normal 90-day period be granted for the submittal of the Biological Opinion in order to gather additional data. Those data needs were discussed and broken down into four categories.

On December 12, 1978, a meeting was held in the Memphis District Office with Jackson Area Office personnel. Also in attendance were representatives of the COE mussel survey contractor and Ecological Consultants, Inc. The purpose of the meeting was to discuss additional data needs relative to the development of the Biological Opinion. The contractor expected to be finished surveying the St. Francis Basin by the spring or early summer of 1979. It was agreed that the COE would submit data as it became available and that a time extension to acquire all necessary data for the preparation of the Biological Opinion would be granted.

On January 2, 1979, in a letter to the Regional Director, the District Engineer agreed to a 30-day time extension with the Biological Opinion being due on March 1, 1979. He also confirmed his commitment to provide the requested data as it became available with all data submitted by January 30, 1979.

On January 19, 1979, the Regional Director acknowledged the COE agreement to a 30-day time extension and explained that if all necessary information was not available, an additional extension would be needed. It was also requested that the consultation address the entire basin including that part in Missouri.

On February 16, 1979, a meeting was held in the Jackson Area Office with personnel from the Memphis District and the Kansas City Area Office. The purpose of the meeting was to discuss data provided by the COE to date, project alternatives, and the possible necessity of an additional time extension for the submittal of the Biological Opinion. It was concluded that all the required information was not yet available primarily because of the yet to be completed basin-wide mussel survey. The COE agreed to discuss a time extension with the District Engineer. FWS requested that if an extension were unacceptable to the COE that they be notified no later than February 12, 1979, in order to have adequate time to prepare the Opinion from the existing data.

On February 20, 1979, in a letter to the Regional Director, the District Engineer agreed to a further time extension until 30 days after he had provided the results of the mussel survey of the basin including surveys of all streams with authorized but uncompleted work. This extension was contingent upon the COE being allowed to continue work on projects that had been surveyed for Endangered mussels with negative results.

On March 20, 1979, the Regional Director replied agreeing to the extension and interim concurrence on basin projects provided that certain procedures and conditions were carried out including the notification of and obtaining the approval of the Jackson Area Office and the Kansas City Area Office prior to the awarding of contracts for construction in areas of their respective geographical responsibility.

Since that time the COE has continued to supply survey and construction data and the FWS has provided concurrence on more than 25 projects.

On August 25, 1980, the Jackson Area Office was provided a copy of the report entitled "Mussel (Naiad) Survey - St. Francis, White, and Cache Rivers, Arkansas and Missouri, Interim Report" with a request for the development of a Biological Opinion.

Several meetings and information submittals ensued to clarify the report and delineate the particular projects to be evaluated in the Opinion. On March 5, 1981, during a telephone conversation between the District Engineer and Jackson Area Office staff, it was agreed that the COE would submit P. capax shells collected during the survey to a FWS consultant for examination. It was further agreed that the Biological Opinion would be issued 5 weeks after receipt of the shells.

On March 20, 1981, the COE submitted all P. capax that they could locate for examination.

CUMULATIVE EFFECTS

For years the St. Francis Basin has existed under the cycle of channelization and levee building for flood control followed by land clearing and increased acreage under agriculture. This transformation toward increased agriculture

has resulted in deteriorating water quality in the form of increased siltation, water temperatures, eutrophication, and altered natural substrates. Agricultural development has also resulted in increased pesticide application. Presently, toxaphene levels in the water, sediment, and organism body tissues are some of the highest in the nation. High heavy metal concentrations have also been reported in the basin.

These aforementioned conditions are primarily the result of past construction and ongoing land use practices.

There will potentially be some increase in acreage under agriculture as a result of these projects. However, the rate of increase in arable land is expected to be considerably less than that resulting from past projects. The acreage gained will be, for the most part, in the mid to upper basin, some distance from the P. capax populations. The effects on water quality associated with possible increases in agriculture as a result of these projects are not expected to impact significantly the already poor water quality within the area of the species. Therefore, there should be no significant indirect or cumulative effects as the result of these potential land use changes.

The actions being considered within this Opinion are not, in general, the major types of construction undertaken in the basin as in years past.

With the exception of the Madison to Highway 64 project, the activities being considered here are some distance upstream from known P. capax populations. Many of the projects are in drainage systems unconnected with those in which the species occurs. Because of these factors, plus the fact that the projects nearest to the P. capax populations are minor in nature, we have concluded that the projects being considered in this consultation (excluding Madison to Highway 64) will not act cumulatively or indirectly to adversely affect the species.

This Biological Opinion addresses only those projects listed in your letter of October 21, 1980. If significant modifications are made regarding these projects or changes made in the alternative courses of action, consultation should be reinitiated. If additional projects are proposed that could affect listed species or new species listed that may be affected by these projects, consultation should also be reinitiated.

We appreciate your cooperation and assistance in this consultation and look forward to working with you again in this area of mutual responsibility.

Sincerely yours,

Walter O. Stieglitz

Regional Director

DRAINAGE DISTRICT NUMBER SEVEN

POINSETT COUNTY
MARKED TREE, ARKANSAS 72365

November 2, 1982

APPENDIX C, ITEM 3

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

SUBJECT:	COMPUTED BY:	DATE:	FILE NO.
	CHECKED BY:	DATE:	SHEET NO.

River — 5930 Q — Floodway

	1670 Q		4260 Q	
3.37	495.40 M	THEN	4469.59 M	.949
		.282		
		28 %		
			4740 Q	
3.56	1190 Q	NOW	4643.47 OL M	1.021
	334 M	.287	4651.18 MT M	1.019
		29 %		

Arbitrarily the % was doubled. The above represents peak low flow conditions.

Had to be >30% and 100%

Matched