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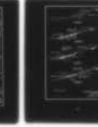
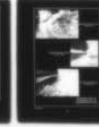
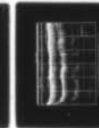
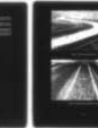
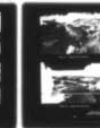
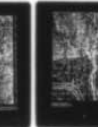
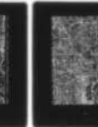
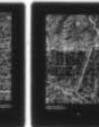
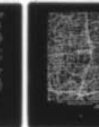
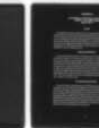
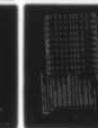
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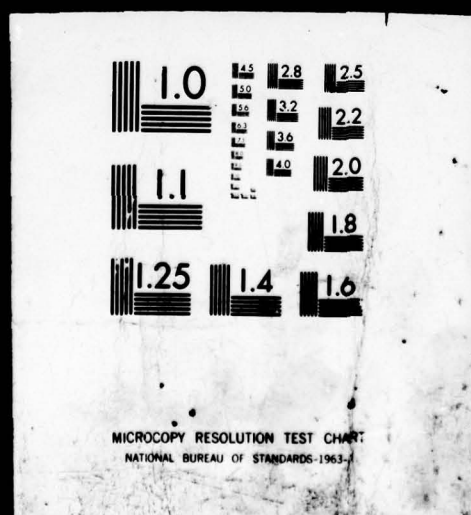
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INTERIM REPORT
TO CONGRESS

THE STREAMBANK EROSION CONTROL
EVALUATION AND DEMONSTRATION ACT OF 1974

September 1978



U. S. ARMY
CORPS OF ENGINEERS

September 1978

INTERIM REPORT TO CONGRESS

THE STREAMBANK EROSION CONTROL
EVALUATION AND DEMONSTRATION ACT OF 1974

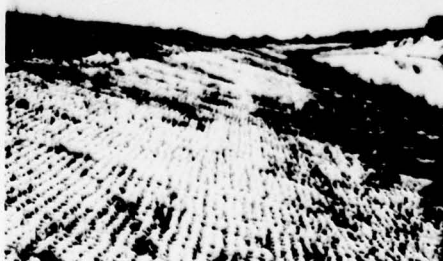
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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

April 10, 1979

Honorable Clifford Alexander
Secretary of the Army
Washington, D.C. 20310

Dear Mr. Secretary:

Deputy Under Secretary of the Army Michael Blumenfeld's letter of November 1, 1978, transmitted the interim report of the Chief of Engineers on the Streambank Erosion Control Evaluation and Demonstration Program, and requested information on the report's relationship to the program of the President, in accordance with Section 4 of Executive Order No. 9384, dated October 4, 1943.

We would have no objection to the transmission of the report to the Congress for its information.

Sincerely,

(Signed) D. E. Crebill

For Eliot R. Cutler
Associate Director for
Natural Resources,
Energy and Science

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

MAY 2 1979

Honorable Walter F. Mondale
President of the Senate
Washington, D.C. 20510

Dear Mr. President:

I am transmitting herewith an interim report dated 28 September 1978 from the Chief of Engineers, Department of the Army, on the Streambank Erosion Control Evaluation and Demonstration Program. The report has been prepared in response to Section 32 of the Water Resources Development Act of 1974 (Public Law 93-251), as amended.

The Office of Management and Budget advises that there is no objection to the submission of the Chief of Engineers' report to the Congress for its information. A copy of the letter from the Office of Management and Budget is enclosed as part of the report.

Sincerely,

Michael Blumenfeld
Assistant Secretary of the Army
(Civil Works)

Enclosure
Report



**DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310**

MAY 2 1979


Honorable Thomas P. O'Neill, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

I am transmitting herewith an interim report dated 28 September 1978 from the Chief of Engineers, Department of the Army, on the Streambank Erosion Control Evaluation and Demonstration Program. The report has been prepared in response to Section 32 of the Water Resources Development Act of 1974 (Public Law 93-251), as amended.

The Office of Management and Budget advises that there is no objection to the submission of the Chief of Engineers' report to the Congress for its information. A copy of the letter from the Office of Management and Budget is enclosed as part of the report.

Sincerely,

/s/ 

Michael Blumenfeld
Assistant Secretary of the Army
(Civil Works)

Enclosure
Report

⑥
**INTERIM REPORT TO CONGRESS
30 SEPTEMBER 1978**

**Section 32 Program •
Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
acres	4046.856	square metres
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometers
square yards	0.8361274	square metres

INTERIM REPORT TO CONGRESS

30 SEPTEMBER 1978

Section 32 Program Streambank Erosion Control Evaluation and Demonstration Act of 1974

Abstract

INTRODUCTION

The United States contains nearly 3.5 million miles of rivers, creeks, and other such streams. Erosion is occurring on over half a million miles of bank lines along these streams. The resulting total annual damages of about \$270 million are a serious economic loss to both private and public interests located along these streambanks. The U. S. Congress has recognized this problem and the potential benefits to be derived by controlling bank erosion. Legislation has been enacted to develop low-cost-effective bank protection guidelines for both public works and private citizens. A developmental program is being conducted by the U. S. Army Corps of Engineers for execution. An interim status report on the program is presented herein.

Abstract

BACKGROUND

The River and Harbor Act of 1968 (Title 1 of Public Law 90-483, Section 120) authorized and directed the Secretary of the Army, acting through the Chief of Engineers; "... to make studies of the nature and scope of the damages which result from streambank erosion throughout the United States...." The ensuing Report of the Chief of Engineers to the Secretary of the Army, *A Study of Streambank Erosion in the United States, August 1969*, indicated that total annual damage resulting from streambank erosion in the United States amounted to approximately \$90 million. In comparison, the estimated total annual cost of conventional bank protection required to prevent the damage was estimated to be \$420 million, which emphasized the importance of developing low-cost methods for eliminating most streambank erosion problems. The 1969 report recommended a vigorous research and development effort, under existing agency authorities, to improve and develop the required low-cost remedial measures and to more fully understand the erosion process and its effects.

AUTHORIZING LEGISLATION

In recognition of the serious economic losses occurring throughout the Nation due to bank erosion, the U. S. Congress passed the Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, Public Law 93-251 (as amended by Public Law 94-587, Section 155 and Section 161, October 1976). This legislation authorizes a five-year program consisting of an updated analysis of the extent and seriousness of streambank erosion, research studies of soil stability and hydraulic processes to identify causes of erosion, an evaluation of existing bank protection techniques, and construction and monitoring of demonstration projects to evaluate the most promising bank protection methods and

techniques. The program thus established and now in progress will hereinafter be referred to as the "Section 32 Program." A copy of the Section 32 Program legislation is attached as Exhibit 1.

IMPLEMENTATION OF PROGRAM TASKS

A Steering Committee was formed to organize the program, develop the scope of the work, review recommended demonstration project sites and types of protection to be investigated, establish monitoring guidelines, evaluate results, and prepare interim and final reports on the program. The Committee, composed of representatives from the Office, Chief of Engineers (OCE), each Continental United States Division of the Corps, and the Hydraulics and Geotechnical Laboratories of the U. S. Army Engineer Waterways Experiment Station (WES), has met seven times since the beginning of the Section 32 Program. Minutes of each Committee meeting are distributed to all Corps of Engineers Divisions and Districts to aid in technical and administrative coordination of the Section 32 Program Corps-wide.

PROGRAM SCOPE

To accomplish the broad objectives of the authorizing legislation, the Steering Committee has developed a program consisting of the following work units.

1. Evaluation of extent of streambank erosion, nationwide.
2. Literature survey and evaluation of bank protection methods.
3. Hydraulic research on effectiveness of bank protection methods.
4. Research on soil stability and identification of causes of streambank erosion.
5. Ohio River demonstration projects.
6. Missouri River demonstration projects.
7. Yazoo River Basin demonstration projects.
8. Demonstration projects on other streams, nationwide.
9. Reconstruction at demonstration projects.
10. Reports to Congress.

Brief descriptions of these work units are given in subsequent paragraphs.

The demonstration projects specified by the Section 32 Program legislation encompass a major portion of the programmed work. These projects are being undertaken on streams selected to represent a variety of geographical and environmental conditions, including streams with naturally occurring erosion problems and streams with erosion caused or increased by man-made structures or activities. Current funded and proposed demonstration projects are listed in Exhibit 2.

Evaluation of Extent of Streambank Erosion, Nationwide (Work Unit 1)

This evaluation consists of an updating of the Corps of Engineers 1969 report *A Study of Streambank Erosion in the United States*. Districts and Divisions reviewed the findings given in the 1969 report and made additional field reconnaissance surveys to update the extent of streambank erosion. This work was completed in FY 77 and is summarized in Appendix A. The current total assessment is

summarized below. This further confirms the need for lower cost methods to provide the desirable and, in many cases, the urgently needed protection.

Length of channels	3.5 million stream-miles
Length of erosion	575,000 bank-miles
Length of serious erosion	142,000 bank-miles
Total damages	\$270,000,000 per year
Total damages from serious erosion	\$200,000,000 per year
Estimated protection costs for serious erosion (by conventional methods)	\$870,000,000 per year

Literature Survey and Evaluation of Bank Protection Methods (Work Unit 2)

WES has completed a literature survey and preliminary evaluation of streambank protection methods. The report* was published and widely distributed in FY 77. WES and Corps Districts are observing and evaluating the effectiveness of bank protection methods at existing Corps and other agency projects, as well as at Section 32 Program demonstration projects. Additional details of progress and proposed future work are given in Appendix B.

Hydraulic Research on Effectiveness of Bank Protection Methods (Work Unit 3)

Hydraulic research is being conducted at the WES and the Missouri River Division Mead Hydraulic Laboratories in scale models to evaluate existing and new methods and techniques of protecting streambanks subject to attack by flow, wave action, and fluctuating water stages. Model flume demonstration tests for comparative evaluation of riprap, rock windrow revetment, riprap hard points, riprap toe protection, rock-filled grids, gabion grids, gabion toe protection, and various wire fencing schemes have been conducted at the two laboratories. In addition, preliminary hydraulic tests have been completed on the effects of propeller wash on an alluvial bed. WES is currently conducting hydraulic research in laboratory test channels to investigate and develop more cost-effective techniques to protect banks against both wind- and boat-generated waves. Experimental facilities are being constructed to permit evaluation of the effects of tows and rapid fluctuation of water stages on streambank erosion and protection. The WES hydraulic research efforts for the Section 32 Program are being closely coordinated with those of the Coastal Engineering Research Center for the Section 54 Program, Shoreline Erosion Control Demonstration Act of 1974 (Public Law 93-251). Additional details on the hydraulic research efforts are given in Appendix C.

Research on Soil Stability and Identification of Causes of Streambank Erosion (Work Unit 4)

Geotechnical research being conducted by WES addresses three specific topics given in the Section 32 Program legislation: (a) **conduct research on soil stability**, specifically the influence of soil properties on bank stability and the development of procedures for evaluating bank stability; (b) **identify the causes**

* See Reference 1, Appendix B.

and mechanisms of streambank erosion, specifically the influence of alluvial geology and the techniques for monitoring the natural processes and changes caused by man-made obstructions; and (c) **investigate new methods and techniques for bank protection**, specifically recent developments in materials usage and soil treatments that may be applicable to bank protection or river training structures either as part of a restoration system or as preventive measures. Test apparatus has been designed for studying soil erosion in the laboratory and a contractual study for the "Development of a Quantitative Method to Predict Critical Shear Stress and Rate of Erosion of Natural Undisturbed Cohesive Soils" is in progress. Characteristics of approximately 20 sites have been investigated and waterborne geophysical surveys have been performed at three sites. Historical changes in fluvial geomorphology have been studied at selected sites by means of aerial photography and topographic maps. In the area of geotechnical research for new methods and techniques for bank protection, metal panels both with and without filter fabric and anchoring systems were subjected to several flow regimes in a curving, sand channel model. In addition, five materials were sprayed on a local denuded hillside for analysis as expedient upper bank protection. Further details on geotechnical research in progress are given in Appendix D.

Demonstration Projects of Streambank Protection (Work Units 5, 6, 7, and 8)

Corps of Engineers field offices are presently planning, designing, constructing, and monitoring demonstration projects at selected sites on numerous rivers and streams throughout the United States. The objective is to demonstrate economical and effective methods of streambank protection that will minimize bank recession and thus prevent the permanent loss of adjacent property. Promising low-cost methods and materials are therefore being tested at representative streambank sites to demonstrate their potential for wide-scale use. All proposed construction is first being coordinated with local authorities and/or private interests, and contractual agreements reached before work begins. The agreements include responsibilities for the projects after results of the demonstration program have been obtained. The status of work on the demonstration projects is summarized below. Detailed reports on Work Units 5, 6, 7, and 8 are included in Appendices E, F, G, and H, respectively.

Demonstration Project Development. The demonstration projects specified in the Section 32 Program legislation, subsequent amendments, and the 1978 appropriation act have been given first priority for construction. Additional projects have been selected for their potential as field test sites for certain protective methods and materials. However, the funds programmed for projects not specified in the legislation may be reduced at some future time if additional funds are required for the specified projects. Other considerations in selecting sites for unspecified projects include (a) active erosion area representative of a general region, (b) effective demonstration, (c) results to be available within the program time frame, (d) minimum environmental impact, (e) public interest, and (f) accessibility of area. Potential sites are selected and preliminary plans are prepared in coordination with local interests by District Offices and submitted through Division Offices to the Steering Committee for review. Steering Committee recommendations on site selection are submitted to OCE for approval. Preliminary plans for demonstration projects are approved by the Steering Committee and returned to Districts through Divisions for preparation of detailed construction plans and specifications.

Streambank Protection Selected for Testing. The streambank protection techniques approved for testing in the field must be generally capable of meeting the following criteria: (a) low construction and maintenance costs, (b) potential for long life, (c) environmentally acceptable, (d) ability to withstand expected waves and flow velocities, (e) 500- to 1000-ft length for each different protection method, and

(f) a minimum of three different protection methods at each site.

Project Monitoring. Performance of the demonstration projects is being monitored by the Districts with guidance and suggestions from the Steering Committee.* WES is responsible for ensuring that Committee recommendations concerning project monitoring are coordinated with all concerned. Plans for monitoring during the test period include observations and appropriate measurements of (a) the performance of the streambank protection method and materials, (b) any changes in the channel and bank-line configuration, (c) general streamflow and weather conditions, (d) flow and wave conditions adjacent to the protection works, (e) soils and foundation characteristics, and (f) aquatic and terrestrial habitat for fish and wildlife. A final report on each project will be prepared by the responsible District to formally record site, construction, and performance information in accordance with a standard format.

Ohio River Demonstration Projects (Work Unit 5)

The Districts in the Ohio River Division have investigated numerous sites on the Ohio River where active streambank erosion is occurring. Letter reports have been prepared for most of those sites, and projects for 15 of the sites have been reviewed and approved by the Steering Committee. Funds have been made available to the Districts for construction at 11 of the sites (although one has been canceled), construction has been completed at 6 of the sites, and construction at the remaining 4 sites will be completed in the summer of 1978. The approved and funded project at Henderson County, Kentucky, had to be canceled due to the failure of the local interests in the Commonwealth of Kentucky to provide assurance agreement. The demonstration projects at Milford, Ohio, on the Little Miami River and South Charleston, West Virginia, on the Kanawha River have also been included with the Ohio River Demonstration Projects. A tabulation of pertinent data for all of the proposed, approved, or funded projects and individual summary descriptions for all of the constructed or funded projects are given in Appendix E.

Missouri River Demonstration Projects (Work Unit 6)

Thirty demonstration projects have been programmed for construction on the Missouri River—21 below Garrison Dam in North Dakota, 1 below Fort Randall Dam in Nebraska, and 8 between Gavins Point Dam and Ponca, Nebraska. Demonstration projects at all the sites specifically authorized by Congress to date have been programmed. Six specified demonstration projects on the Missouri River, one below Garrison Dam and five below Gavins Point Dam, either have been or are presently under construction. Construction is scheduled to begin on five more in FY 78—two below Garrison Dam in North Dakota, one below Fort Randall Dam in Nebraska, and two below Gavins Point Dam in Nebraska and South Dakota. The remainder of the presently programmed demonstration projects on the Missouri River will be constructed during FY 79, FY 80, and FY 81. A table of pertinent information including funding status on each proposed, approved, or funded project and individual summary descriptions on several funded projects are included in Appendix F.

* See Reference 2, Appendix B.

Yazoo River Basin Demonstration Projects (Work Unit 7)

Section 32 of the 1974 Water Resources Development Act (Public Law 93-251) authorizes construction of demonstration projects in "the delta and hill areas of the Yazoo River Basin generally in accordance with the recommendations of the Chief of Engineers in his report dated September 23, 1972." Twenty demonstration projects have been programmed for the Yazoo River Basin as listed in Appendix G. To date, 11 demonstration projects have been constructed and are presently being monitored. Construction is in progress on three additional projects, and plans are being formulated for six more. Construction of all 20 of these demonstration projects is scheduled for completion in FY 1981 and the protective techniques will be evaluated before the conclusion of the Section 32 Program. In addition to these projects, cooperative efforts with other agencies have been initiated to address special areas of interest regarding streambank erosion in the Yazoo River Basin. This work includes studies of sediment transport, tests of vegetal covers for possible use in this region, and an inventory of potential bank stabilization methods used by the U. S. Soil Conservation Service. Appendix G includes additional details on the work being conducted under Work Unit 7.

Demonstration Projects on Other Streams, Nationwide (Work Unit 8)

Potential low-cost streambank protection methods and materials are being evaluated at other selected sites nationwide to demonstrate their capability to perform under a broad range of geographical and environmental conditions. The sites are selected by Districts on the basis of their potential for demonstration and testing of improved techniques. Work Unit 8 is composed primarily of demonstration projects that were not specified by the Section 32 Program legislation. The Eel and Yellowstone Rivers sites were added as an amendment in 1976 and are included under this work unit for reporting purposes. The work unit presently consists of 38 approved or proposed demonstration projects on 32 different streams throughout the United States. Eight of the projects have been approved for construction and monitoring. Construction of all but one or two of these projects should be completed in FY 78 or early in FY 79. Seven other projects have been allotted minimal funding to permit preliminary planning and feasibility studies to commence. These projects are scheduled for construction in FY 1979. No funds have been allocated to date for the remaining 24 proposed projects; however, a number of these will be approved for construction in future years, depending on the allocation of funds by Congress and the actual costs required to complete the projects specified. Further information on Work Unit 8 is given in Appendix H.

Reconstruction at Demonstration Projects (Work Unit 9)

Some of the experimental bank protection methods being tested in the demonstration projects may be damaged during the monitoring period. These would be reconstructed, as necessary, with funds budgeted under this work unit of the Section 32 Program to provide adequate bank protection before turning the projects over to the local sponsors.

Reports to Congress (Work Unit 10)

The interim and final report on Section 32 Program are specified by the current legislation to be completed and submitted to Congress by 30 September 1978 and 31 December 1981, respectively. This

interim report consists of a brief main report and appendices that summarize the status of activities and funding of the program through FY 1978 and present proposed activities and funding for the remainder of the program. The final report will consist of a main report with recommendations and appendices that will summarize activities and funding of the completed program. The final report will be supplemented by a public information pamphlet to assist local interests in self-help protection work for streambank erosion control. New technical knowledge resulting from the program will be incorporated into pertinent Corps of Engineers design manuals.

PROGRAM SCHEDULE AND FUNDING

The original Act of 1974 (see Exhibit 1) authorized to be appropriated for the five- (fiscal) year period ending 30 June 1978 funds not to exceed \$25,000,000 to carry out the program. The 1976 amendment to the Act increased the authorized funding to not exceed \$50,000,000, indicated a final reporting date of 31 December 1981, and added a number of specified demonstration project site locations. However, the President's Fiscal Year 1979-1983 Budget program projects a funding schedule that will extend the program through FY 1983, with a final reporting date of 30 September 1983. Actual funding through FY 1978 and additional scheduled funding to complete the Section 32 Program in FY 1983 in accordance with the President's Fiscal Year 1979-1983 Budget are shown in Exhibit 3.

FISH AND WILDLIFE COORDINATION ACT REPORT

The Section 32 Program is being coordinated with the U. S. Fish and Wildlife Service (USFWS) under provisions of the Fish and Wildlife Coordination Act of 1958. This coordination is primarily between Corps District Offices responsible for planning and construction of the demonstration projects, and Fish and Wildlife area offices. A Fish and Wildlife representative is also located at the WES in Vicksburg, Mississippi, for coordination and consultation. Funds are transferred to the USFWS annually for their activities.

The Denver Regional Director of the USFWS has furnished an interim report addressing the Section 32 Program in the Missouri River Basin (Appendix I). Although this report has been prepared for and is directed toward demonstration projects along the Missouri and Yellowstone Rivers, recommendations contained therein will be given Corps-wide consideration as the nationwide Section 32 Program is administered. This report was circulated to the States of Montana, North Dakota, South Dakota, and Nebraska by the USFWS, and comments on the report by representative agencies of these states and of the U. S. Army Engineer District, Omaha, are included in Appendix I. The State of Montana has prepared and furnished a separate report on its view of the program along the lower Yellowstone River. This is also included in Appendix I.

Coordination with the USFWS in the Missouri River Basin involves initial review of proposed erosion control measures, review of plans and specifications prior to awarding of construction contracts, and field inspections of completed works. The USFWS has also been requested to assist in the development of monitoring and evaluation of completed projects, and to participate in the actual monitoring of the projects with a view toward determining the influence of specific control measures on adjacent habitat loss and/or development. The USFWS will furnish a final report at the completion of the demonstration program.

Exhibit 1

SECTION 32 PROGRAM LEGISLATION

Public Law 93-251, Section 32, March 1974

As amended* by Public Law 94-587, Sec 155 & Sec 161, October 1976

(a) This section may be cited as the "Streambank Erosion Control Evaluation and Demonstration Act of 1974".

(b) The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to establish and conduct for a period of five fiscal years a national streambank erosion prevention and control demonstration program. The program shall consist of (1) an evaluation of the extent of streambank erosion on navigable rivers and their tributaries; (2) development of new methods and techniques for bank protection, research on soil stability, and identification of the causes of erosion; (3) a report to the Congress on the results of such studies and the recommendations of the Secretary of the Army on means for the prevention and correction of streambank erosion; and (4) demonstration projects, including bank protection works.

(c) Demonstration projects authorized by this section shall be undertaken on streams selected to reflect a variety of geographical and environmental conditions, including streams with naturally occurring erosion problems and streams with erosion caused or increased by manmade structures or activities. At a minimum, demonstration projects shall be conducted at multiple sites on:

- (1) the Ohio River;
- (2) that reach of the Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa;
- (3) that reach of the Missouri River in North Dakota at or below the Garrison Dam, ~~and including areas on the right bank at river miles 1345; 1310; 1311; 1316.5; 1334.5; 1341; 1343.5; 1379.5; 1385; and on the left bank at river miles 1316.5; 1320.5; 1323; 1326.5; 1335.7; 1338.5; 1345.2; 1357.5; 1360; 1366.5; 1368; and 1374.~~
- (4) the delta and hill areas of the Yazoo River Basin generally in accordance with the recommendations of the Chief of Engineers in his report dated September 23, 1972.
- (5) the delta of the Eel River, California;
- (6) the lower Yellowstone River from Intake, Montana, to the mouth of such river.

(d) Prior to construction of any projects under this section, non-Federal interests shall agree that they will provide without cost to the United States land, easements, and rights-of-way necessary for construction and subsequent operation of the projects; hold and save the United States free from damages due to construction, operation, and maintenance of the projects; and operate and maintain the projects upon completion.

(e) There is authorized to be appropriated ~~for the five fiscal year period ending June 30, 1978, not to exceed \$25,000,000~~ \$50,000,000 to carry out ~~subsections (b), (c), and (d) of this section~~ this action.

(f) The Secretary of the Army shall make an interim report to Congress on work undertaken pursuant to this section by September 30, 1978, and shall make a final report to Congress no later than December 31, 1981.

The Public Works for Water and Power Development and Energy Research Appropriation Bill, Fiscal Year 1978, specified: " work on the Fort Randall--Sioux City, Iowa reach of the Missouri River, including the Sunshine Bottom, Goat Island and Ionia Bend sites," at miles 868.5 right, 796.5 left and 761.0 right, respectively (see Section 32 paragraph (c)(2)).

* In the Section 32 Program legislation above, amendment additions are underlined and amendment deletions are lined through.

EXHIBIT 2: LIST OF DEMONSTRATION PROJECT SITES

A. Ohio River and Tributaries

- * 1. Moundsville (at Grave Creek), WV (102.0 L) **
- * 2. Moundsville, WV (107.0 L)
- * 3. Powhatan Pt., OH (110.0 R)
- 4. New Matamoras, OH (142.7 R)
- † 5. St. Mary's, WV (155.0 L)
- * 6. Ravenswood, WV (220.6 L)
- 7. South Point, OH (316.9 R)
- 8. Ashland - Boyd County Airport, KY (330.9 L)
- 9. Wheelersburgh, OH (346.2 R)
- * 10. Portsmouth, OH (355.4 R)
- * 11. Moscow, OH (443.5 R)
- * 12. Mt. Vernon, IN (829.0 R)
- * 13. South Charleston (Kanawha River), WV (52.3 L)
- * 14. Milford (Little Miami River), OH (Left Bank)

B. Missouri River

- * 1. Sandstone Bluff I, ND (1368.0 L)
- * 2. Sandstone Bluff II, ND (1366.5 L)
- * 3. Lewis and Clark 4-H Camp, ND (1357.5 L)
- * 4. Eagle Park, ND (1323.0 L)
- * 5. Sunshine Bottom, NB (868.5 R)
- * 6. Goat Island, SD (796.5 L)
- * 7. Vermillion Boat Club, SD (786.0 L)
- * 8. Brooky Bottom Rd., NB (784.0 R)
- * 9. Mulberry Point, SD (777.0 L)
- * 10. Mulberry Bend, NB (775.0 R)
- * 11. Vermillion River Chute, SD (771.0 L)
- * 12. Ryan Bend, NB (767.0 R)
- * 13. Ionia, NB (761.0 R)
- 14. Right bank at river miles 1385, 1379.5, 1345, 1343.5, 1341, 1338.5, 1334.5, 1316.5, 1311 and 1310, and on the left bank at river miles 1374, 1360, 1345.2, 1338.5, 1335.7, 1326.5, 1320.5 and 1316.5; ND. (These sites along with items B1, B2, B3, and B4 are specified in PL 94-587.)

(Sites B5, B6, and B13 are specified in the FY 1978 appropriation bill.)

* Funded projects.

** River mile and bank location (either left or right bank looking downstream) are shown in parentheses.

† Only minimal funding to cover preliminary planning and design has been allocated.

EXHIBIT 2 (Sheet 1 of 3)

C. Yazoo River Basin

- * 1. Batupan Bogue, FY 74
- * 2. Batupan Bogue, Item 4A
- * 3. Goodwin Creek, Item 8
- * 4. Hotophia Creek, Item 7
- * 5. Hunter Creek, Item 1A
- * 6. Johnson Creek, Items 9, 11, 12
- 7. Long and Caney Creeks, Items 10, 11, 12
- * 8. Perry Creek, Item 6A
- * 9. Perry Creek, Item 6B
- 10. Perry Creek, Item 6C7
- 11. Perry Creek, Item 6D
- * 12. Tillatoba and Hunter Creeks, Item 1
- * 13. Tillatoba Creek, North Fork, Item 2
- * 14. Tillatoba Creek, North Fork, Item 3A
- * 15. Tillatoba Creek, North Fork, Item 3C
- * 16. Tillatoba Creek, South Fork, FY 72
- * 17. Tillatoba Creek, South Fork, FY 73
- * 18. Tillatoba Creek, South Fork, Item 5A
- * 19. Tillatoba Creek, South Fork, Item 5B
- * 20. Tillatoba Creek, South Fork, Item 5C

Note: All the projects are located in the State of Mississippi. Fiscal year designations and item numbers are for District administrative control.

D. Yellowstone River (Specified in PL 94-587)

- * 1. Right bank at mile 27.5, MT
- 2. Right bank at mile 20.0, ND
- 3. Right bank at mile 11.5, ND

E. Eel River Delta (Specified in PL 94-587)

- 1. Eel River at Fortune, CA
- * 2. Van Duzen River at Carlotta, CA

F. Sites on Other Streams Nationwide Not Specified in Authorizing Legislation

- * 1. Connecticut River at Haverhill, NH
- 2. Connecticut River at Northfield, MA
- + 3. Delaware River at Paulsboro, NY
- + 4. Hudson River at Coxsackie, NY
- * 5. Pearl River at Monticello, MS
- * 6. Roanoke River at Leesville, VA
- + 7. Roaring River at Wilkes County, NC
- * 8. Allegheny River at Wattersonville, PA
- 9. Cumberland River at Tennessee State University
- 10. Cumberland River at Iuka, KY

F. (Continued)

11. Kanawha River at St. Albans, WV
12. Wabash River at Maunie, IL
13. Wabash River at New Harmony, IN
- * 14. Iowa River at Wapello, IA
- † 15. Lower Chippewa River at Eau Claire, WI
16. Bayou Sara at St. Francisville, LA
17. Kaskaskia River at Fayetteville, IL
18. St. Catherine Creek at Natchez, MS
- * 19. White River at Des Arc, AR
20. Brazos River at Sealy, TX
21. Rio Chama at Espanola, NM
22. Sabine River at Deweyville, TX
- † 23. White River at Jacksonport, AR
24. Kansas River at Eudora, KS (Fall Leaf Drainage District)
25. Kansas River at De Soto, KS
26. Knife River at Mercer, ND
27. Middle Loup River at Loup City, NE
28. Nemaha River at Sterling, NE
29. Nemaha River, Elk Creek Site, NE
30. Platte River at Columbus, NE
31. Platte River at Easton - Saxton Rd., MO
32. Powder River at Arvada, WY
33. White River at Presho, SD
34. Yellowstone River at Worden, MT
35. Russian River at Dry Creek, CA
36. Sacramento River at Glen, CA (176.5 R)
- † 37. Green River at Kent, WA (King County)
- † 38. Walla Walla River at Milton-Freewater, OR

EXHIBIT 3

EXHIBIT 3: SECTION 32 PROGRAM FUNDING SCHEDULE
(Program Completion - 30 Sep 83)

No.	Work Unit Title	FY Funds in \$1,000										Totals
		75	76	76T	77	78	79	80	81	82	83	
1	Evaluation of Extent of Streambank Erosion, Nationwide	0	200	50	300	0	0	0	0	0	0	550
2	Literature Survey and Evaluation of Bank Protection Methods	0	100	25	75	105	150	150	150	150	150	1,055
3	Hydraulic Research on Effectiveness of Bank Protection Methods	0	200	50	400	370	275	275	275	275	125	2,245
4	Research on Soil Stability and Identification of Causes of Streambank Erosion	0	100	25	375	370	275	275	275	275	125	2,095
5	Ohio River Demonstration Projects (1)	0	1000	250	1000	250	250	200	150	150	100	3,350
6	Missouri River Demonstration Projects	50	1000	250	1000	2500	3000	2500	2500	200	150	13,150
7	Yazoo River Basin Demonstration Projects (2)	200	1850	500	3000	2500	1500	2700	1500	380	0	14,130
8	Demonstration Projects on Other Streams, Nationwide (3)	0	400	100	0	1870	2500	1900	1150	970	250	9,140
9	Reconstruction at Demonstration Projects	0	0	0	0	0	0	0	0	2500	1500	4,000
10	Reports to Congress	0	0	0	0	35	0	0	0	100	150	285
Totals		250	4850	1250	6150	8000	7950	8000	6000	5000	2550	50,000

(1) Includes Milford, OH (Little Miami River), and South Charleston, WV (Kanawha River).

(2) Mississippi River and Tributaries funds are used for Yazoo River Basin Demonstration Projects. All other funds are Construction, General.

(3) Includes Yellowstone and Bel Rivers.

APPENDIX A

An Evaluation of the Extent of Streambank Erosion in the United States (Work Unit 1)

APPENDIX A

An Evaluation of the Extent of Streambank Erosion in the United States (Work Unit 1)

SCOPE

This appendix presents an evaluation of the extent of streambank erosion currently existing in the United States. Data on natural and man-induced streambank erosion were assembled or estimated for all rivers, streams, and man-made channels with drainage areas generally larger than one square mile and were compiled by water resources regions (Figure A1). The banks of estuaries, seacoasts, lakes, and reservoirs were excluded. Funds and time permitted more extensive field investigations, reconnaissance surveys, and use of sampling and extrapolation techniques than for the 1969 study. Other agencies which participated in the 1969 study, particularly the Soil Conservation Service, contributed to the new evaluation of extent of streambank erosion.

EVALUATION METHOD

As for the 1969 study, the method of evaluating the extent of streambank erosion in the Nation was to determine for each of the 19 major water resources basins: (a) total length of channels in stream-miles, (b) total length of erosion in bank-miles, (c) length of erosion in bank-miles meriting further examination, (d) average annual damages of erosion meriting further examination, and (e) average annual treatment cost for preventing erosion meriting further examination. Average annual damages and treatment costs were determined by using the same average unit costs per bank-mile as were used in the 1969 report, multiplied by 2.08 to account for the price increase from 1 July 1969 to 1 January 1978, according to the Engineering News Record's construction cost index. National values were obtained by adding regional values, as shown in Table A1, which is essentially an update of Table 1 in the 1969 study report. The current evaluation of the extent of streambank erosion, including damages and treatment costs, is based on the national values.

EVALUATION LIMITATIONS

The current evaluation confirms the previous 1969 finding that only a small amount of reliable data is available on the extent and nature of streambank erosion. Of the approximately 3,463,000 stream-miles in the United States, only about 20,000 stream-miles have been subjected to prior detailed studies. It was necessary to develop estimated data on the remaining 99 percent of the country's streams. These data were developed by numerous individuals and teams from the Corps of Engineers and several participating agencies, using techniques considered appropriate for the streams in question. Despite these limitations, the data help fill an important water resources information gap, and provide a more reliable overall evaluation of the extent of streambank erosion in the United States. However, as for the 1969 study, the data contained herein are generally not of sufficient accuracy and detail to serve other purposes such as project justification and authorization.

EXTENT OF STREAMBANK EROSION

The current evaluation reveals that out of an estimated 3-1/2 million miles of streams (7 million bank-miles), a total of approximately 8 percent or about 575,000 bank-miles are experiencing erosion to some degree. Available data indicate the total damages for all degrees of bank erosion to be about \$270 million annually. Much of the total erosion is quite mild in degree and low in damage. Consequently, the evaluation concentrated on streambank erosion that appeared severe enough to merit further examination to determine if some form of action should be undertaken to prevent or reduce the damages. A total of about 142,000 bank-miles were reported to have this degree of erosion. While this degree of erosion occurs on only 2 percent of the 7 million bank-miles in the Nation, it results in an estimated total damage of about \$200 million annually.

TREATMENT COSTS

The estimated annual cost to prevent the more serious streambank erosion meriting further examination is over \$870 million, based on methods presently in use. Lower cost methods of erosion control being evaluated by research and demonstration projects under the Section 32 Program should reduce this cost. These estimates indicate that for many stream reaches the cost of preventing streambank erosion would greatly exceed the damages being sustained. There are many locations, however, where detailed studies would show that prevention of damage merits the cost of protection. The cost of detailed studies for all 142,000 bank-miles of erosion meriting further examination to appraise the need for and feasibility of reducing the damages is estimated to be about \$330 million. This figure assumes that every mile of erosion would be investigated to the same degree. Relatively early in each study it would become obvious that a substantial number of miles could not satisfy economic justification criteria and would be excluded from further consideration, thereby lowering the total study cost considerably.

SUMMARY AND CONCLUSIONS

Evaluation of the extent of streambank erosion under the Section 32 Program now shows a total of nearly 3-1/2 million stream-miles in the Nation, 575,000 miles of streambank erosion, and 142,000 bank-miles of erosion meriting further examination. While some regional values differed significantly, particularly those for length of bank-miles meriting further examination, national values differ only small amounts from 1969 values. The average annual damages of about \$200 million and average annual treatment costs of over \$870 million for erosion meriting further examination are approximately double the corresponding values for the 1969 study. These increases correspond closely to the 108 percent increase in prices between 1 July 1969 and 1 January 1978. The current evaluation confirms the 1969 study that streambank erosion is widespread. Of the 19 water resources regions, only Hawaii is essentially unaffected. The annual cost of treatment for the prevention of erosion damages indicates that many areas suffering damages cannot be economically treated. Stream reaches meriting treatment will, for the most part, be widely scattered and located in substantially populated and developed areas. Development of low-cost protection methods under the Section 32 Program will hopefully increase the number of areas for which bank protection can be justified.

TABLE A1: 1977 NATIONAL ASSESSMENT OF STREAMBANK EROSION

Region	Region Totals		Extent of Erosion Meriting Further Examination	
	Length of Channels Stream-Miles	Length of Erosion Bank-Miles	Average Annual Damages \$1,000	Average Annual Treatment Cost \$1,000
Alaska	568,000	58,000	0*	700
Arkansas-White-Red	218,300	56,500	22,800	220,000
California	133,000	50,600	8,100	37,200
Pacific Northwest	345,400	33,600	21,200	40,700
Colorado (Upper and Lower)	295,900	24,600	3,900	7,600
Great Basin	152,700	5,000	300	400
Great Lakes	66,100	9,100	4,500	17,100
Hawaii	2,600	0	0	0
Lower Mississippi	88,400	15,500	12,700	125,000
Middle Atlantic	95,700	28,500	8,000	32,600
Missouri Basin	538,200	52,800	11,800	52,400
New England	48,200	1,900	400	2,800
Ohio	147,200	27,300	6,800	26,400
Rio Grande	101,800	54,800	7,100	121,000
Souris-Red-Rainy	67,200	1,200	100	800
South Atlantic Gulf	213,300	37,900	22,300	26,800
Tennessee	32,800	4,100	1,700	1,200
Texas Gulf	149,500	98,300	4,300	142,000
Upper Mississippi	198,200	14,800	6,100	16,700
United States Total	3,462,500	574,500	142,100	\$871,400

* Less than 50 bank-miles.

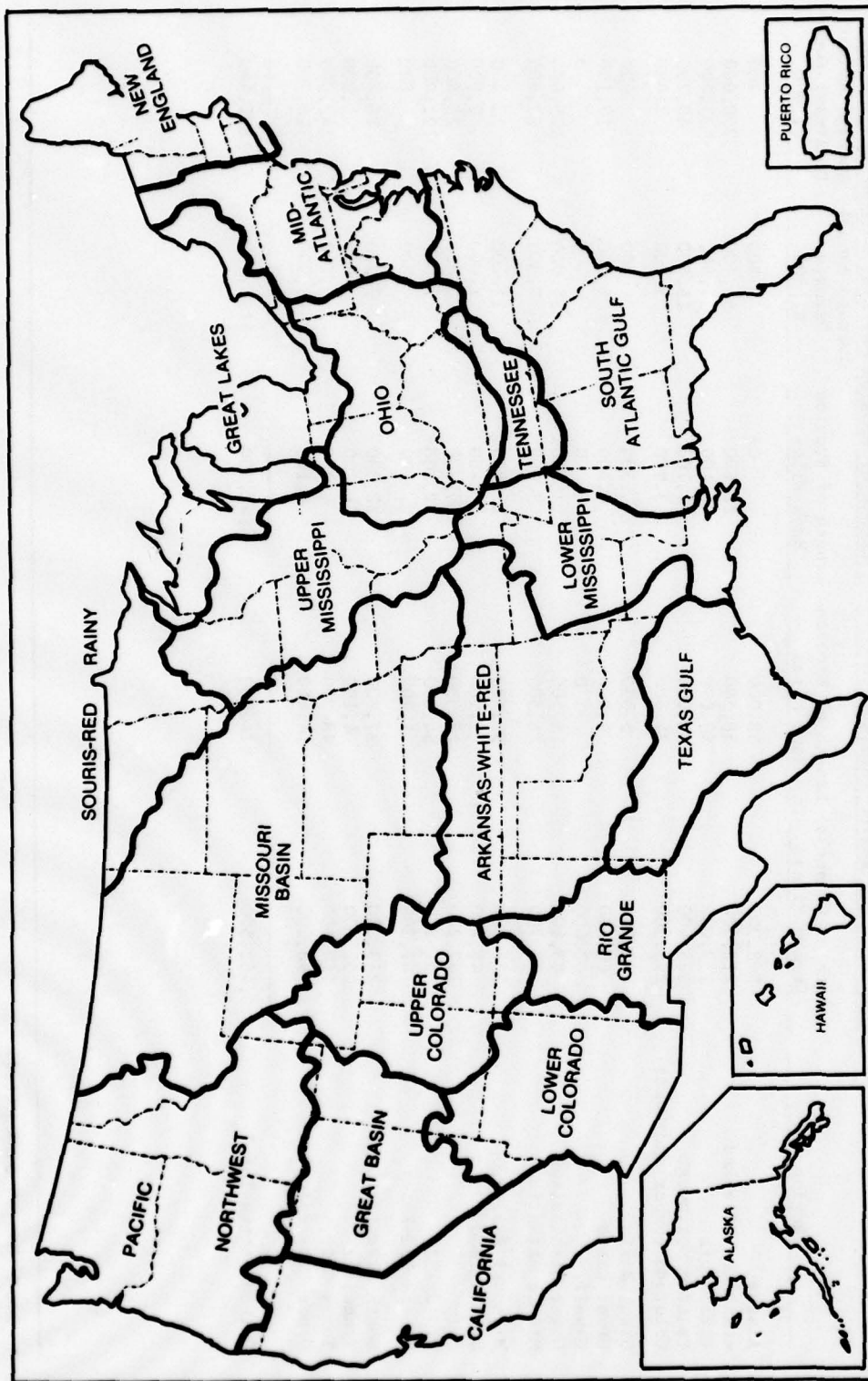


Figure A1. Water resources regions

APPENDIX B

**Literature Survey and Evaluation of
Bank Protection Methods
(Work Unit 2)**

APPENDIX B

Literature Survey and Evaluation of Bank Protection Methods (Work Unit 2)

Work Unit 2 has two objectives: (a) to conduct a literature survey and evaluation of bank protection methods and (b) to evaluate existing bank stabilization projects. The first objective was accomplished during 1975 and 1976 by collecting all known and available sources of literature pertaining to previous causes of bank erosion and the methods of protection used, and by assessing the most effective available methods of streambank protection. Results of this effort are given in Reference 1. This widely distributed report includes information relevant to the mechanics of streambank erosion, preliminary assessment of existing methods for bank stabilization, a listing of some new methods of protection, conclusions relative to the current state of the art, recommendations of needed research and criteria, a listing of commercial concerns that market streambank protection products, a glossary of streambank protection terminology, and selected bibliographies on streambank protection.

In carrying out the second objective, existing streambank protection projects at 58 sites throughout the United States have been selected for limited monitoring and evaluation. The general location of these projects is shown in Figure B1 and information on each project is summarized in Table B1. The evaluation of existing streambank protection from previous and additional field data will allow determination of which protection types have experienced either good or bad performance to supplement the final evaluation of the Section 32 Program demonstration projects being constructed under Work Units 5, 6, 7, and 8.

Engineers in the Corps Districts and laboratories have inspected and evaluated numerous existing bank stabilization and newly constructed Section 32 Program demonstration projects. Also, several streambank protection works constructed by the Soil Conservation Service, the U. S. Bureau of Reclamation, local governments, and private interests have been observed. This monitoring and inspection program is conducted to the extent practical in accordance with Reference 2. A sample inspection report is shown in Exhibit B1 of this appendix. Field inspections conducted during FY 77 and FY 78 include:

- a. Lower Mississippi Valley Division - Vicksburg District, November 1976. Bank conditions on the unprotected navigable reach of the lower Yazoo River in Mississippi and the probable cause of intermittent bank erosion were documented.³
- b. North Central Division - St. Paul and Rock Island Districts, May 1977. Ten existing sites in Minnesota, Illinois, and Iowa were inspected and detailed narratives relevant to each of these sites were prepared.⁴
- c. Southwestern Division - Albuquerque District, June 1977. Detailed narratives pertinent to two existing sites in New Mexico were prepared based on inspection of the sites and review of project data notebooks.⁵
- d. Missouri River Division - Mead Laboratory and Omaha District in Nebraska, June 1977.
- e. Lower Mississippi Valley Division - Science and Education Administration-Federal Research, USDA Sedimentation Laboratory, Oxford, Mississippi, August 1977, Goodwin and Peters Creek Watershed in Mississippi.
- f. Lower Mississippi Valley Division - Vicksburg District, June and October 1977 and January 1978. Numerous field demonstration and existing streambank protection sites were observed, photographed, evaluated, and documented on the tributaries of the upper Yazoo River Basin in Mississippi.^{6,7}

REFERENCES

1. Keown, M. P. et al., "Literature Survey and Preliminary Evaluation of Streambank Protection Methods," Technical Report H-77-9, May 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
2. Pickett, E. B. and Brown, B. J., "Guidelines for Monitoring and Reporting Demonstration Projects, Section 32 Program, Streambank Erosion Control Evaluation and Demonstration Act of 1974," Instruction Report H-77-1, Sep 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
3. Maynard, S. T., "Field Inspection of Yazoo River (Vicksburg to Redwood, Mississippi)," Section 32 Program Inspection Report 1, Oct 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
4. Keown, M. P., "Field Inspection of Sites in St. Paul and Rock Island Districts," Section 32 Program Inspection Report 2, Nov 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
5. Keown, M. P., "Field Inspection of Sites in Albuquerque District," Section 32 Program Inspection Report 3, Nov 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
6. Maynard, S. T., "Field Inspection of Bank Protection Measures on the Upper Yazoo River," Section 32 Program Inspection Report 4, Feb 1978, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
7. Keown, M. P. and Dardeau, E. A., Jr., "Field Inspection of Sites in Vicksburg District in the Upper Yazoo Basin," Section 32 Program Inspection Report 5 (in preparation), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Table B1
Summary of Existing Bank Stabilization Projects

Stream	Project Location	CE Office	Protection Method	Year Constructed	Present Condition	Remarks	Map No.*
<u>Projects in Lower Mississippi Valley Division</u>							
St. Francis	Clark's Corner, AR	Memphis	Lumber mat w/cribs filled w/stone	1964	Excellent	Bridge abutment	1
Caney Creek	Caney Creek, AR	SCS (in Memphis District)	Vegetation, clay gravel, hydrated lime, gypsum	1975	Excellent	Test channel in dispersive clay	2
Red River	Moramecal, LA	New Orleans	Local and specified stone, sand-filled bags, soil-cement blocks, gabions, and cellular block on upper bank	1975	Satisfactory	No high-water test in first 2 years	3
Red River	Fausse, LA	New Orleans	Trench-fill and pipe revetment, pile dikes w/stone-fill	1974	Satisfactory	Bank protection	4
Red River	Perot, LA	New Orleans	Permeable spur jetties	1970	Jetty being flanked	Pipeline crossing	5
Big Creek	Big Creek, LA	Vicksburg	Drop (weir) sheet pile structures	1976	Riprap failure	Grade-control structures	6
Homochitto	Homochitto River, MS (Site 1)	Vicksburg	Dikes of steel pipe piling w/movable board panels	1966	Failed	Pipeline crossing	7
Homochitto	Homochitto River, MS (Site 2)	Vicksburg	Lumber mat and upper bank stone	1956	Failed	Bridge abutment	8
St. Catherine Creek	St. Catherine Creek, MS	Vicksburg	Local materials (auto bodies and tires, timber piles, and surface drainage)	NA	Bank caving arrested	Bank protection by local residents	9
<u>Projects in Missouri River Division</u>							
Little Blue River	Independence, MO	Kansas City	Horizontal rock toe	Summer 1977	Minor damages only	Bank protection of large diversion channel to stop erosion of side slopes	10
Republican River	Milford Dam, KS	Kansas City	Heavy horizontal blankets or rock, 4 test sections with various toe configurations	Summer 1968	Some riprap failures	Outlet channel of Milford Dam	11
Elk Creek	Clyde, KS	Kansas City	Three sheet piling and grouted rock sills	1974	Excellent	Bed grade stabilization	12
Several small tributaries of the Black Vermillion River	Frankfort, KS	Kansas City	Series of sheet piling and rock sills	1963	Only minor erosion	Protection against degradation and channel erosion	13
Mud Creek	Lawrence, KS	Kansas City	Three sheet piling and rock blankets upstream and downstream from piling, channel widened and toe protection installed	1977	Excellent; no high flows experienced to date	To prevent upstream migration of channel degradation	14
Little Blue River	Independence, MO	Kansas City	Sheet piling and rock blanket	1976-1977	Good	To prevent erosion and degradation of low flow channel	15
Little Blue River	Independence, MO	Kansas City	Overexcavation and clay blanketing of sand areas with traffic-compacted clay	1974-1977	Good	To protect high-flow berms and channel side slopes	16
Big Blue River	Near Marysville, KS	Kansas City	Double-row fencing filled with stone or hay bales	1963-1969	Very Good	Purpose is to promote deposition and encourage growth of vegetation	17
102 River	Bedford, IA	Kansas City	Fabriform mat	Spring 1974	Limited damage	Bridge abutment, dam abutment, bank protection	18
Gering Drain	Near Gering, NE	Omaha	Double-row fencing filled with stone or hay bales	1963-1969	Very Good		19
Plum Creek	Near Denver, CO	Omaha	Woven wire fencing, on steel rail post, stone root, and 4 perpendicular stone dikes	Summer 1970	Good	Waterline crossing	20
Battle Creek	Battle Creek, NE	Omaha	Rock toe protection, grass upper bank	March 1973	Excellent	Bridge abutment	21
Gering Drain	Gering, NE	Omaha	Several low broad-crested rock sills	1963-1969	Very Good	To reduce stream gradient and provide lateral stability in the channel	22
Little Sioux River	Omaha, IA	Omaha	Gabion mats	1969	Effective	Protection against degradation of channel and undermining riprapped side slopes	23

(Continued)

* See Figure B1 for project locations.

Table B1 (Continued)

Stream	Project Location	CE Office	Protection Method	Year Constructed	Present Condition	Remarks	Map No.
<u>Projects in Missouri River Division (Continued)</u>							
Deadman's Run & Antelope Creek	Lincoln, NE	Omaha	Gabion baskets along base of side slopes with grass seeding and drop structures	1968-1971	Excellent	Channel and bank protection	24
Floyd River	Sioux City, IA	Omaha	Sheet piling and rock sills (design based on extensive model tests at the University of Iowa by CE personnel)	1965	Excellent	Protection against degradation of channel and undermining riprapped side slopes	25
West Fork Ditch	Omaha, IA	Omaha	Low rock sills in channel bottom; repairs (based on limited model studies at Mead Hydraulic Laboratory) consisted of creating positive sheet pile crest and short length of rock toe	1969	Extensive erosion during high flows of 1973; no damage thereafter	Protection against degradation	26
Missouri River	Below Oshe Dam, SD	Omaha	Channel blocks (sand core, erosion-resistant fencing, locally adaptable vegetation)	1963-1964	Good	Channel stabilization	27
Missouri River	Below Garrison Dam, ND	Omaha	Three structures ranging in length from 781-1176 ft placed from mile 1312.2-1332.0	1974	Good to Excellent	Flow and erosion control	28
Lower Yellowstone River	Lower Yellowstone River	Omaha	Steel jacks	1965-1969	Good	Bank protection by Bureau of Reclamation	29
<u>Projects in North Central Division</u>							
Illinois Waterway	Banner Levee, IL	Chicago	Stone riprap	1976	Good	Prop wash and wave attack	30
St. Marys River	Mission Point, MI	Detroit	Stone riprap	1975	Fair	Rapid drawdown and wave attack	31
Bureau Creek	Bureau County, IL	Rock Island	Kellner jacks	1973	Good	Current erosion at river junction	32
Iowa River	Louisa County, IA	Rock Island	Timber spur jetties	1975	Fair	Current erosion	33
Minnesota River	Savage, MN	St. Paul	Quarry-run stone	1966	Poor	Damage from prop wash	34
Minnesota River	Mankato, MN	St. Paul	Stone riprap of 2 gradations	1971	Good	Comparison of quarry-run with well-graded riprap	35
<u>Projects in New England Division</u>							
Connecticut River	Hanover, NH	New England	Rock revetment	1954	Very Good	Property is owned by Dartmouth University. Constructed by New England Power Co.	36
Connecticut River	Thetford, VT	New England	Rubber tires	1971	Very Good	Constructed by private individuals	37
Connecticut River	Turners Falls Pool, MA	New England	Hydroseeding	1977	Good	Nine miles of river bank protected by Northeast utilities	38
Hayward Creek	Quincy, MA	New England	Paving block (monoslab)	1977	Good	Some failure from overland flow in 1978	39
<u>Projects in North Pacific Division</u>							
Tanana River	Fairbanks, AK	Alaska	Tree revetment	1977	Very Good	Site belongs to Fairbanks North Star borough	40
<u>Projects in Ohio River Division</u>							
Hocking River LPP	Hocking River LPP, Athens, OH	Huntington	Gravel blanket and crown vetch interceptor drains and grouted rock breaks	1971	Blanket failures and vegetation loss	90 ft of bank protection	41
Ohio River Mile 606	Clarksville, IN	Louisville	Dumped quarrystone revetment	1976	Satisfactory	25 ft x 350 ft highway protection	42
Ohio River Mile 711	Cloverport, KY	Louisville	Stone blanket	1974	Satisfactory	350 ft of highway protection	43
Ohio River Mile 788	Newburgh, IN	Louisville	Stone blanket	1975	Satisfactory	30 ft of bank protection	44
White River	Levee Unit 8 Edwardsport, IN	Louisville	Stone blanket	1940	Satisfactory	17.6 miles of agricultural levees with spur dikes	45
Monongahela River	California, PA	Pittsburgh	Coarse-rock-filled tires	1977	Satisfactory	90 ft of bank protection by private resident	46

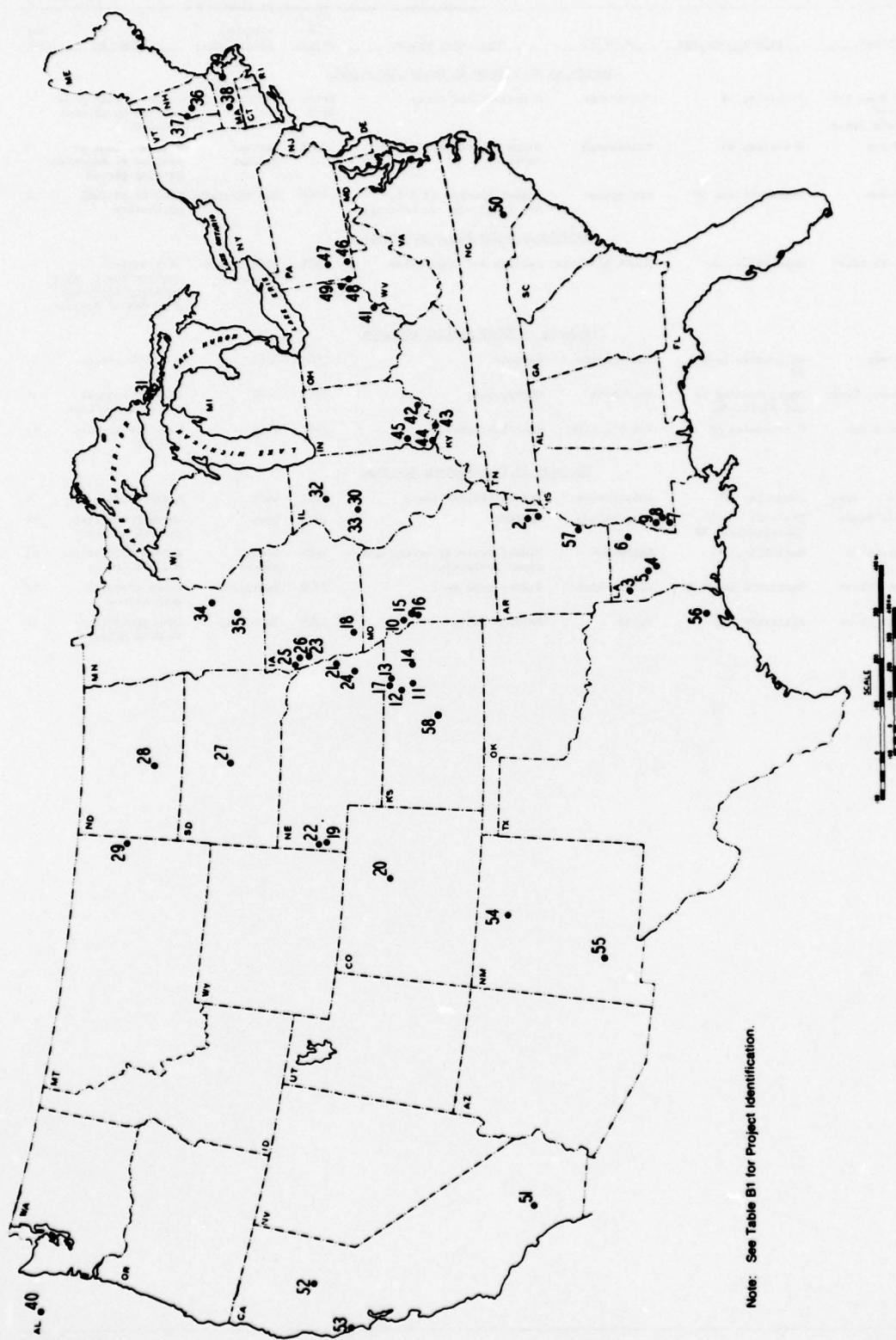
(Continued)

(Sheet 2 of 3)

Table B1 (Concluded)

Stream	Project Location	CE Office	Protection Method	Year Constructed	Present Condition	Remarks	Map No.
<u>Projects in Ohio River Division (Continued)</u>							
Girtys Run, tributary of Allegheny River	Millvale, PA	Pittsburgh	Gravel-filled tires	Prior 1970	Satisfactory	25 ft of bank protection by private resident	47
Ohio River	Wheeling, WV	Pittsburgh	Stone blanket on filter cloth	1972	Partial failure	Pier and bank protection at municipal parking garage	48
Ohio River	Tiltonville, OH	Pittsburgh	Gravel blanket (3/8 to 4-1/2 in. agg. no bedding)	1968	Satisfactory	2600 ft of bank protection	49
<u>Projects in South Atlantic Division</u>							
Little Rockfish Creek	Hope Mills, NC	South Atlantic	Gabions and vegetation	1976	Good, minor failure	Bank subject to erosion due to high-velocity flows and groundwater seepage	50
<u>Projects in South Pacific Division</u>							
Mill Creek	Mill Creek Levee, CA	Los Angeles	Gabions	1967	Good	Low-flow attack	51
Sacramento River	Chico Landing to Red Bluff, CA	Sacramento	Quarrrystone	1975	Good	Low and intermediate bank attack	52
Russian River	Cloverdale, CA	San Francisco	Flexible fencing	1962	Good	Low-flow meander problem	53
<u>Projects in Southwestern Division</u>							
Rio Grande River	Espanola, NM	Albuquerque	Trees, Kellner jacks	1951	Good	Minor repairs	54
Cuchillo Negro Creek	Truth or Consequences, NM	Albuquerque	Gabions	1974	Good	Levee protection, current attack	55
Trinity River	Moss Hill, TX	Galveston	Timber fence diverters and stone protection	1967	Needs repairs	Bridge protection, current attack	56
Arkansas River	Merrisach Lake, AR	Little Rock	Timber pile wall	1972	Excellent	Shore protection, wave attack	57
Arkansas River	Ellinwood, KS	Tulsa	Kellner Jetty	1974	Excellent	Bank protection current attack	58

(Sheet 3 of 3)



Note: See Table B1 for Project Identification.

Figure B1. Existing projects

SECTION 32 PROGRAM
STREAMBANK EROSION CONTROL EVALUATION AND DEMONSTRATION
WORK UNIT 2 - EVALUATION OF EXISTING BANK PROTECTION

FIELD INSPECTION OF BANK PROTECTION MEASURES
ON THE UPPER YAZOO RIVER

1. A field inspection was conducted by the U. S. Army Engineer Waterways Experiment Station (WES) personnel on 1-3 June 1977 to observe bank protection measures on the tributaries of the Upper Yazoo River. The following were in attendance:

Jim Hines	Vicksburg District
Dr. Vic Zitta	Mississippi State University
Steve Maynard	Waterways Experiment Station

2. A general location map is shown in Figure 1. Figures 2 and 3 are location maps of the protection methods observed on Big Sand Creek and Figure 4 shows locations of sites inspected on Tillatoba Creek.

3. The first site observed was the Big Sand Creek near Greenwood, Mississippi, where the Vicksburg District, Soil Conservation Service, and others have undertaken various bank protection projects. About 52 percent of the Big Sand drainage basin is controlled by 40 Soil Conservation Service detention basins that were built in the early 1960's. Drop inlet spillway structures (Photo 1) assist in regulating flow for flood control purposes.

4. The first protection method observed on Big Sand Creek was a system of board fencing parallel to the streambank on the outside bank of a channel bend with concrete jacks upstream and downstream of the fencing (Photos 2 and 3). Fencing and jacks have been used in several locations on the Big Sand Creek and have worked well for the 10 years they have been in place. The next area observed on the Big Sand was where kudzu had been planted to stabilize the bank (Photo 4). The kudzu was not doing an adequate job of stabilizing the bank and had taken over the overbank vegetation.

5. In the upper reaches of the Big Sand Creek, an outcropping of a clay-sand mixture forms a natural grade control structure (Photo 5). If the Big Sand were to cut through this natural control, additional degradation and subsequent bank erosion would most likely occur upstream of the outcropping.

6. At the lower end of the drainage basin near Greenwood, the channel has been straightened and levees have been built to confine

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the flow. A series of low-head sheet pile (Photo 6) and concrete drop structures (Photo 7) were built to control the grade and act as sediment basins. The channel upstream and downstream of the concrete structure is completely filled with sediment.

7. Next, riprap revetment was observed at the junction of the Greenwood diversion canal and the Tallahatchie River (Photo 8). The riprap was being placed on a 1V-on-2H slope on a black plastic filter cloth. Toe protection for the revetment was being extended well out into the river.

8. The inspection continued to Tillatoba Creek near Charleston, Mississippi, where the Vicksburg District has a very active bank protection program under way. Many of the Section 32 demonstration sites are located on Tillatoba Creek. The first area observed was a mattress of tires connected together with steel bands around the periphery and anchored with cables attached to guy wire anchors (Photos 9 and 10). Willow shoots were planted in the tires and about 50 percent were growing.

9. Another Section 32 demonstration site was observed consisting of sand-cement bag protection (Photo 11). These bags were placed on a steep slope (1V on 1.5H) and some evidence of toe launching was observed. The next protection method observed on Tillatoba Creek was a site under construction using a double row of wire fencing parallel to the stream (Photos 12 and 13). The space between the double fence will be filled with old tires. Farther upstream a double-row wire fence will be constructed and filled with hay bales.

10. Timber pile groins that had been in place many years were observed in a bend upstream of the highway bridge (Photo 14). These groins had trapped debris and appeared effective in halting the erosion of the outside bank of the bend. Riprap hard points were observed at two locations on Tillatoba Creek (Photos 15 and 16). Kudzu was well established between the riprap hard points at one location.

11. The last protection type observed on the trip was riprap toe protection (Photos 17 and 18). This type of protection consists of a large section of rock placed at the toe of the slope extending up the bank as high as one half of the total bank height. The bank is usually graded to a 1V-on-2H slope before rock placement and the upper bank is vegetated after the rock is in place. The Vicksburg District has constructed several Section 32 demonstration sites using this scheme and all are performing satisfactorily.

12. A total evaluation of the demonstration sites will be made during FY 81 by the Vicksburg District after they have collected enough data from several years flow.

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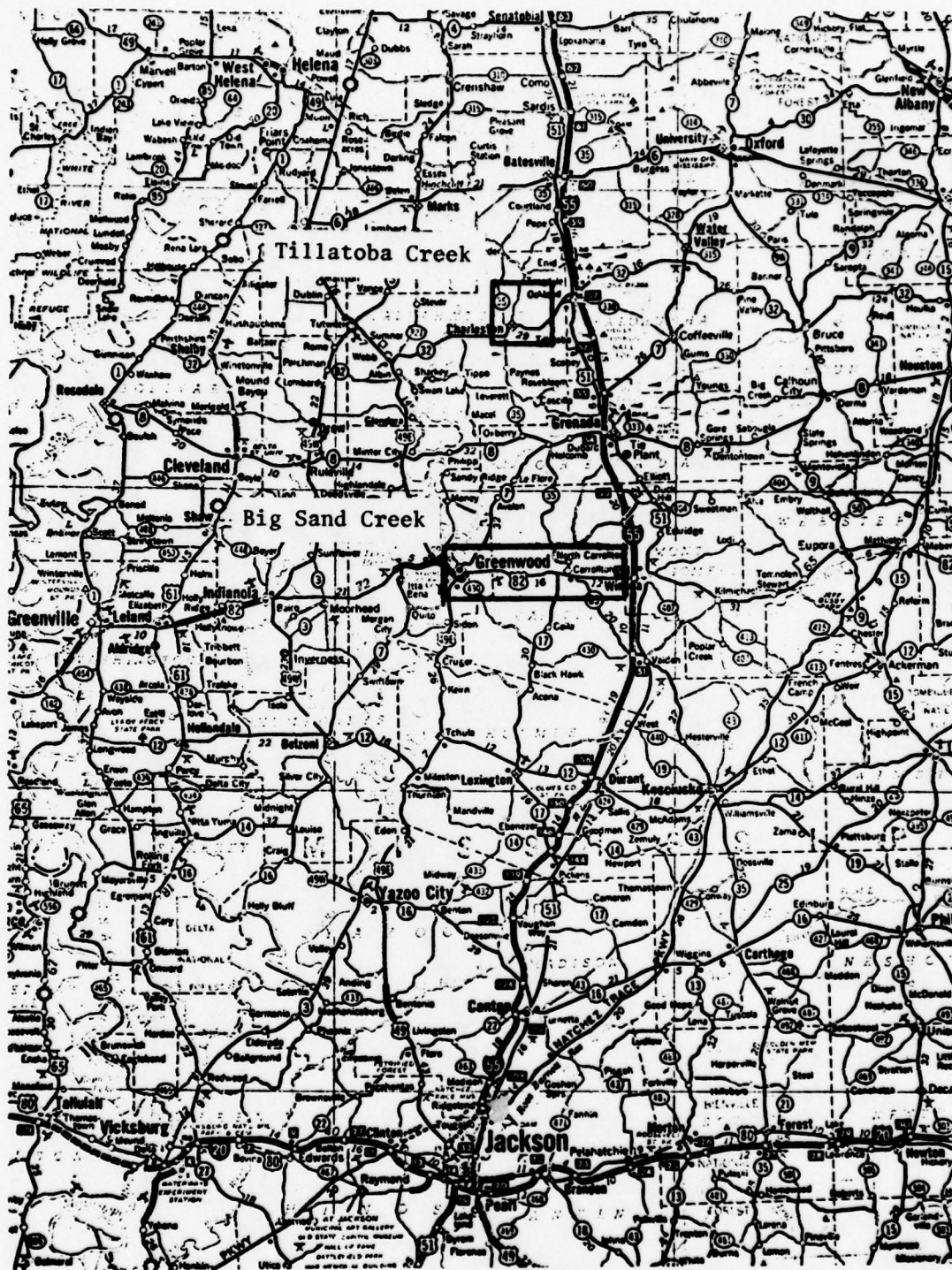


Figure 1. General location map for Greenwood and Charleston inspection sites

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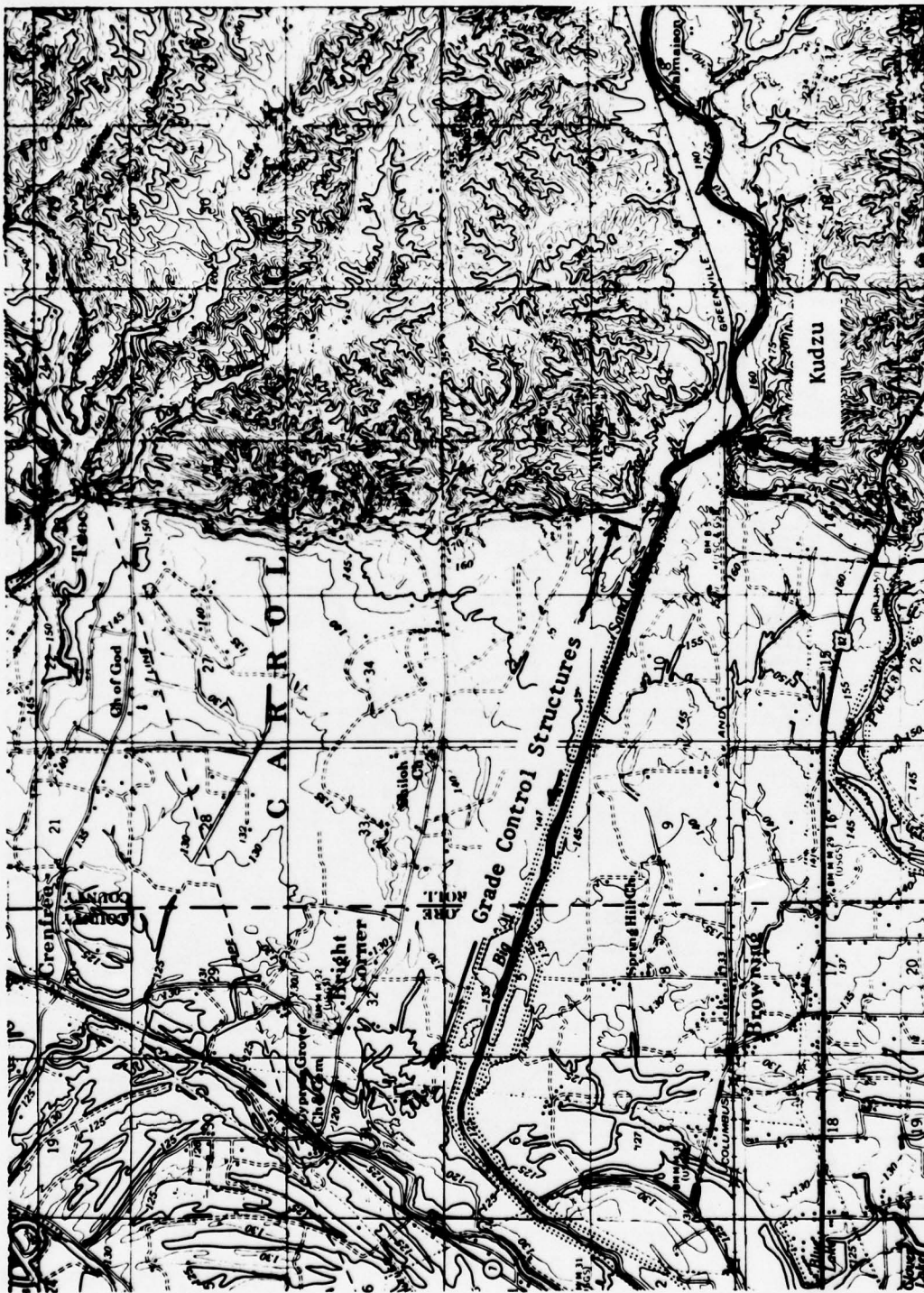


Figure 2. Location of protection methods, Big Sand Creek, Lower Reach. Scale: 1 inch = 1 mile

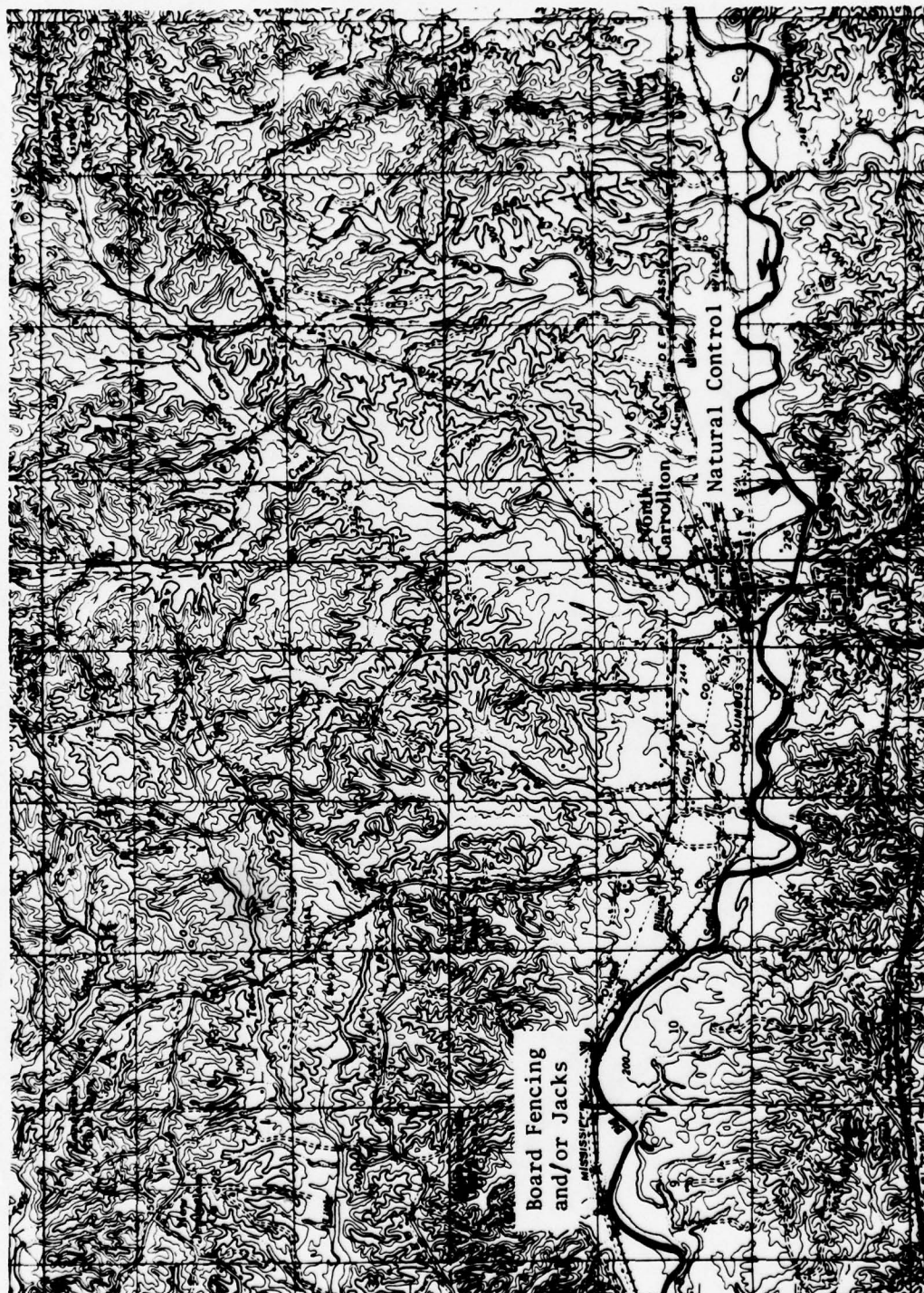


Figure 3. Location of protection methods, Big Sand Creek, Upper Reach. Scale: 1 inch = 1 mile

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Figure 4. Location of protection methods, Tillatoba Creek basin. Scale: 1 inch = 1 mile



Photo 1. Soil Conservation Service flood control structure



Photo 2. Board fencing with concrete jacks upstream and downstream

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Photo 3. Board fencing



Photo 4. Kudzu on outside bank of bend



Photo 5. Natural grade control



Photo 6. Low-head sheet pile grade control structure

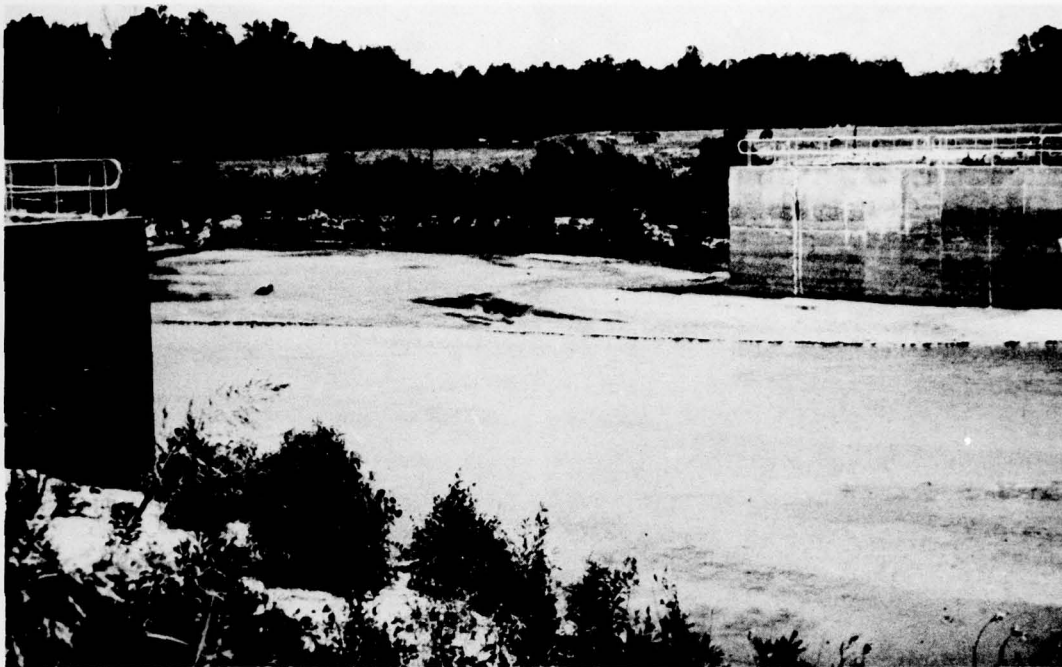


Photo 7. Concrete grade control structure
silted in both upstream and downstream



Photo 8. Riprap placement on black plastic filter material



Photo 9. Tire mattress

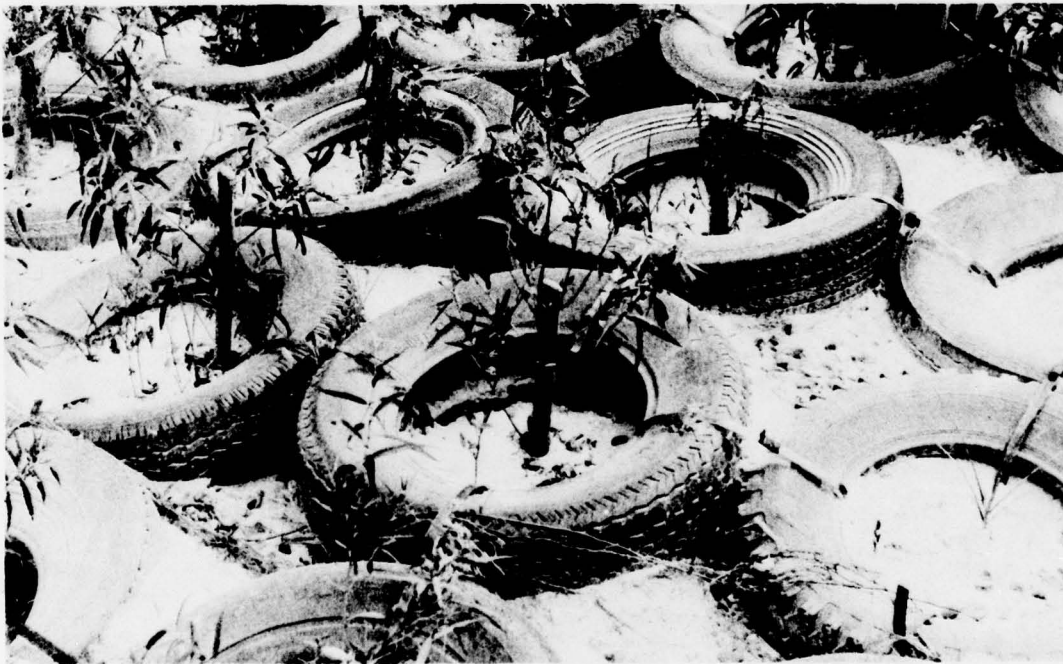


Photo 10. Tire mattress with willow shoots
planted to increase stability

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Photo 11. Sand-cement bags with toe launching

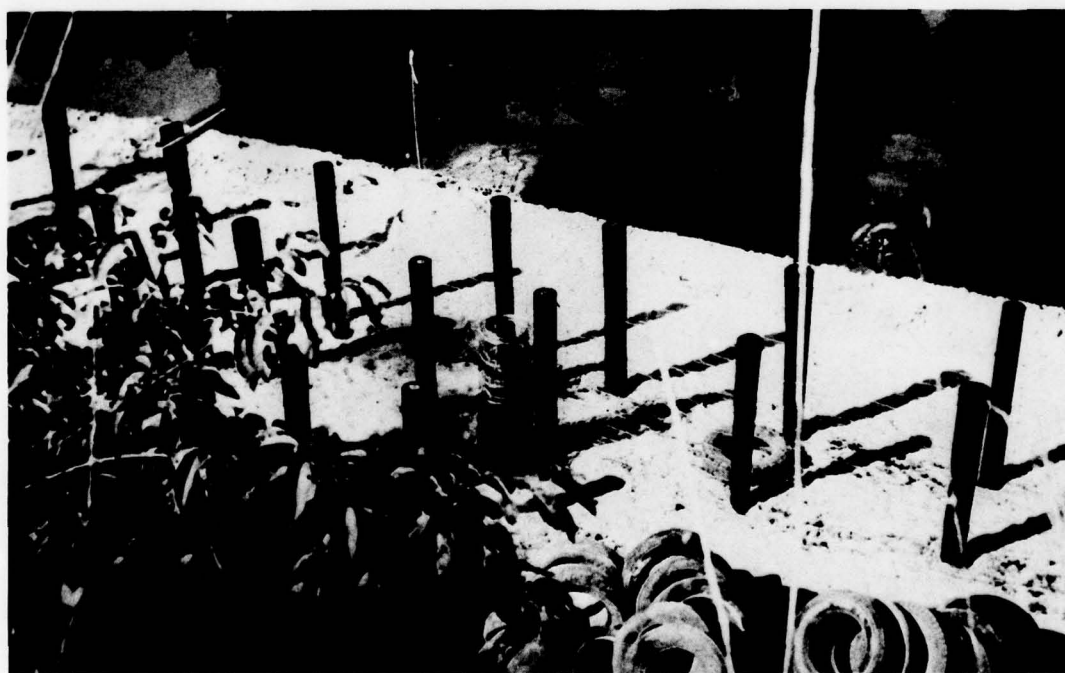


Photo 12. Double-row wire fence (to be filled with tires)

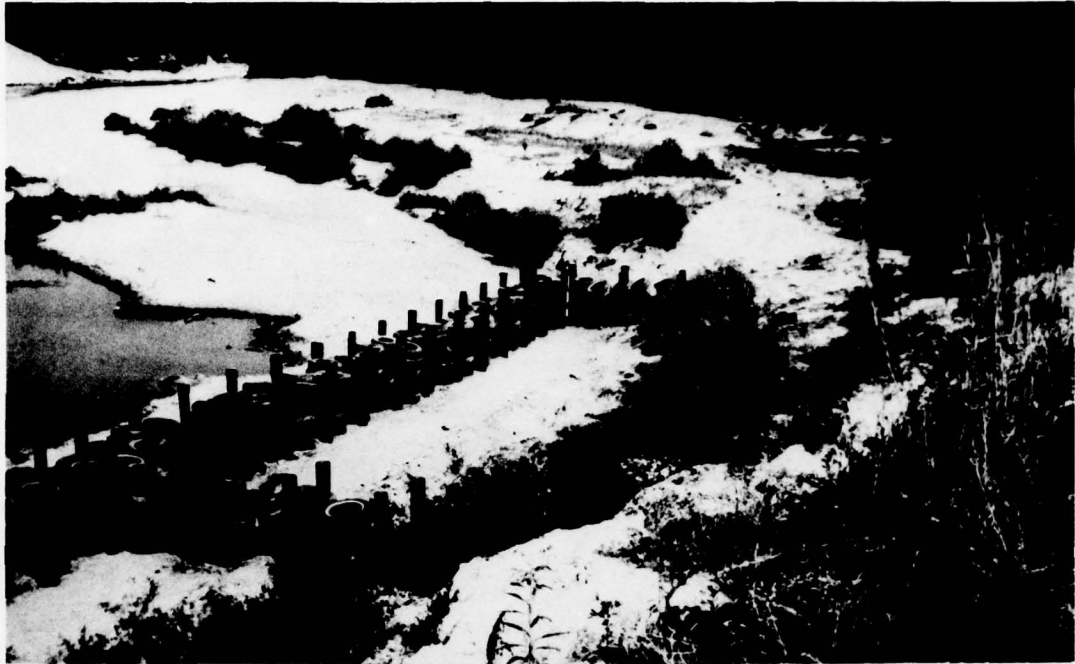


Photo 13. Double-row wire fence with tiebacks



Photo 14. Timber pile groins



Photo 15. Riprap hard points with kudzu



Photo 16. Riprap hard points

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Photo 17. Riprap toe protection



Photo 18. Riprap toe protection

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APPENDIX C

**Hydraulic Research on Effectiveness of
Bank Protection Methods
(Work Unit 3)**

APPENDIX C

Hydraulic Research on Effectiveness of Bank Protection Methods (Work Unit 3)

The general plan of hydraulic research is to use scale models to investigate and define the effects of streamflow, wave action, fluctuating water stages, and tows on streambank erosion and protective works for evaluation and development of existing and new methods and techniques of protecting streambanks. To date, hydraulic research has been conducted at both the WES, Vicksburg, Mississippi, and Mead Laboratory, Omaha, Nebraska, to evaluate various existing methods and to develop new cost-effective and environmentally acceptable methods and techniques for preventing streambank erosion due to flow and wave action. Selected methods and techniques that are impossible, or at best difficult, to simulate in a hydraulic model will be evaluated, if possible, in the various field demonstrations.

Model demonstration tests for comparative evaluation of riprap revetment, riprap hard points, riprap toe protection, rock-filled grids, gabion grids, gabion toe protection, and various wire fencing schemes have been conducted by WES in two model flumes (Figures C1 and C2). Also, rock windrow revetment has been tested at Mead Laboratory (Figure C3). Results of these tests have been shared with the Corps Divisions and Districts involved in field demonstration projects through laboratory demonstrations and in the minutes of meetings of the Steering Committee. Results of laboratory tests of hard points (Figure C4) are presented in Mead Laboratory Report No. 9.¹

Preliminary hydraulic research has been completed to determine the effects of propeller wash on an alluvial bed.² The influence of water depth, tow speed, flow velocity, and direction of travel (upstream and downstream) on the movement of bed material was demonstrated with a 1:80-scale model of a 200-ft-long by 45-ft-wide towboat typical of those used on the Ohio River and having twin screws, main and flanking rudders, and a 120-ft-wide by 460-ft-long barge fleet with a draft of 8 ft. The bed material used in the qualitative model demonstration was crushed coal having a specific gravity of 1.3. Results indicated the need for the additional hydraulic research with 1:20-scale model facilities that was initiated during FY 78 to evaluate the effects of tows on streambank erosion and protection.

WES is conducting hydraulic research in both two- and three-dimensional wave test flumes (Figure C5) to investigate and develop more cost-effective bank protection against wind- and boat-generated waves. Various directions of wave attack, wave periods, wave heights, and bank slopes are being investigated. A report on "Wave Stability Study of Cellular Concrete Blocks" was completed and published.³ Although some tests of these blocks have been conducted by others (U. S. Army Engineer Coastal Engineering Research Center and Delft Hydraulic Laboratory), the rather significant effects of extremely short-period waves that can exist on inland waterways were not investigated. The adequacy of other protective measures is being investigated in the continuing wave research. Preliminary evaluation of 1-ft by 1-ft and 4-ft by 4-ft rectangular grids, half-filled and completely filled with small stones has been encouraging and indicates that small stone approximately one-tenth the size required for wave breakwaters will remain stable on many bank slopes when encased in a rectangular grid.

The effectiveness of several schemes of using gabions for bank protection has been investigated,⁴ and the effects of fluctuating water levels and rapid drawdown on streambank stability and protection are being investigated in a joint hydraulics and geotechnical research effort at WES.

REFERENCES

1. Mead Hydraulic Laboratory, "Laboratory Investigation of Erosion Control Using Hard Points," MRD Hydraulic Laboratory Series Report No. 9, Nov 1977, U. S. Army Engineer District, Omaha, Omaha, Nebr.
2. Maynard, S. T., "Model Demonstration of the Effects of Propeller Wash on the Bed of an Alluvial River," Section 32 Program Research Report 1, Nov 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
3. Markle, D. G., "Wave Stability Study of Cellular Concrete Blocks," Section 32 Program Research Report 2, Nov 1977, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
4. Oswalt, N. R. and Maynard, S. T., "Bank Protection Techniques Using Gabions," Section 32 Program Research Report 3, Apr 1978, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.



Figure C1. Multicurved channel flow facility



Figure C2. Straight and single-curved channel facility

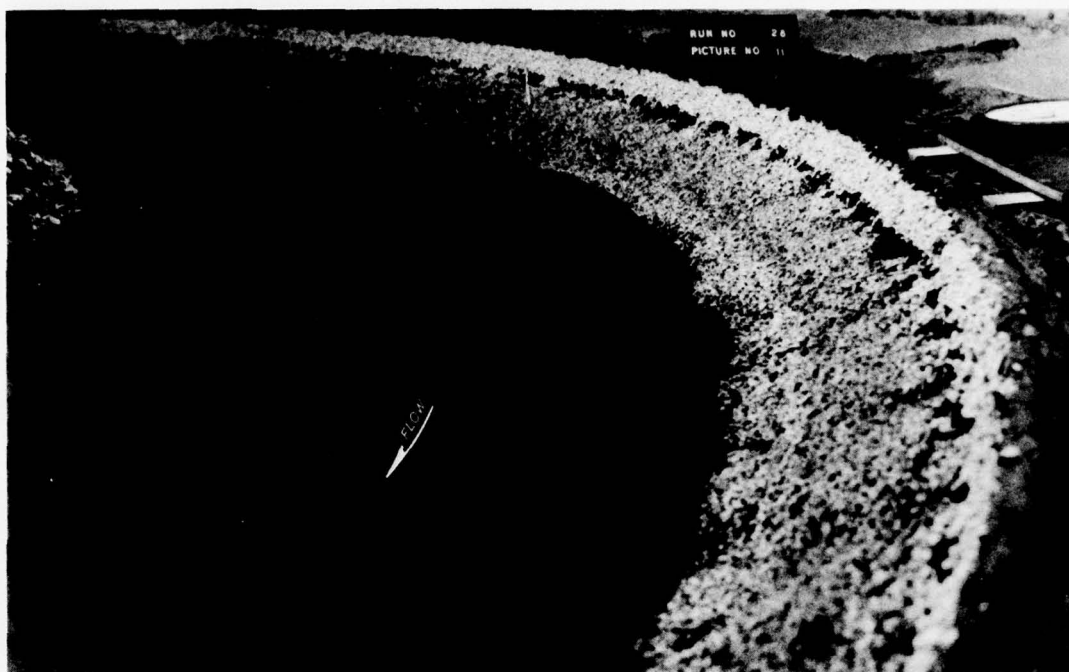


Figure C3. Windrow revetment study

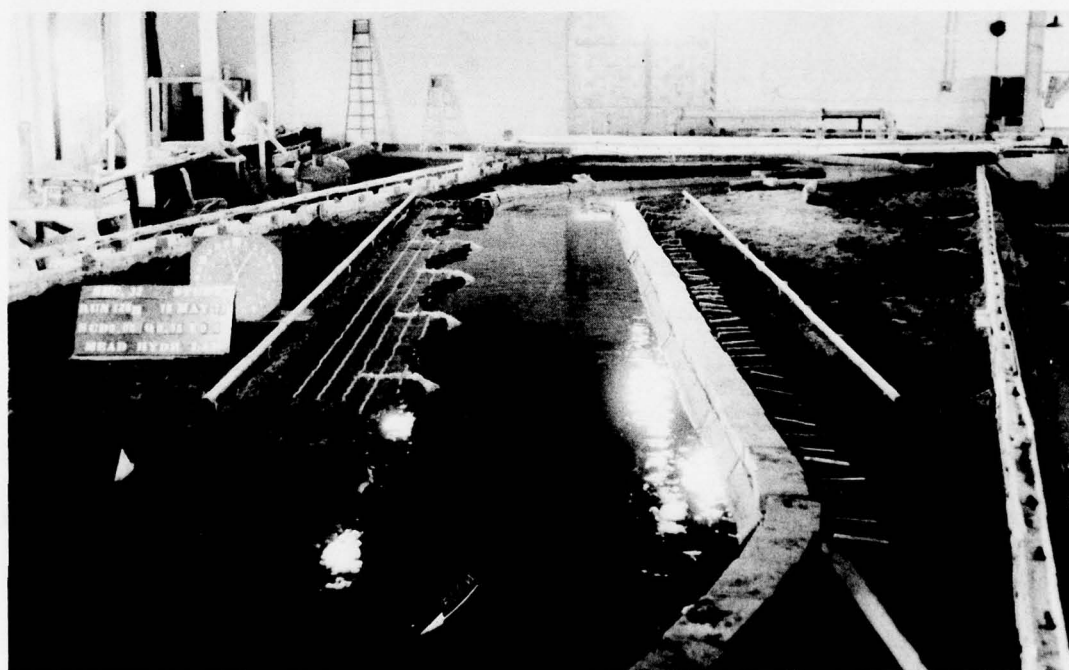


Figure C4. Intermittent hard-point study

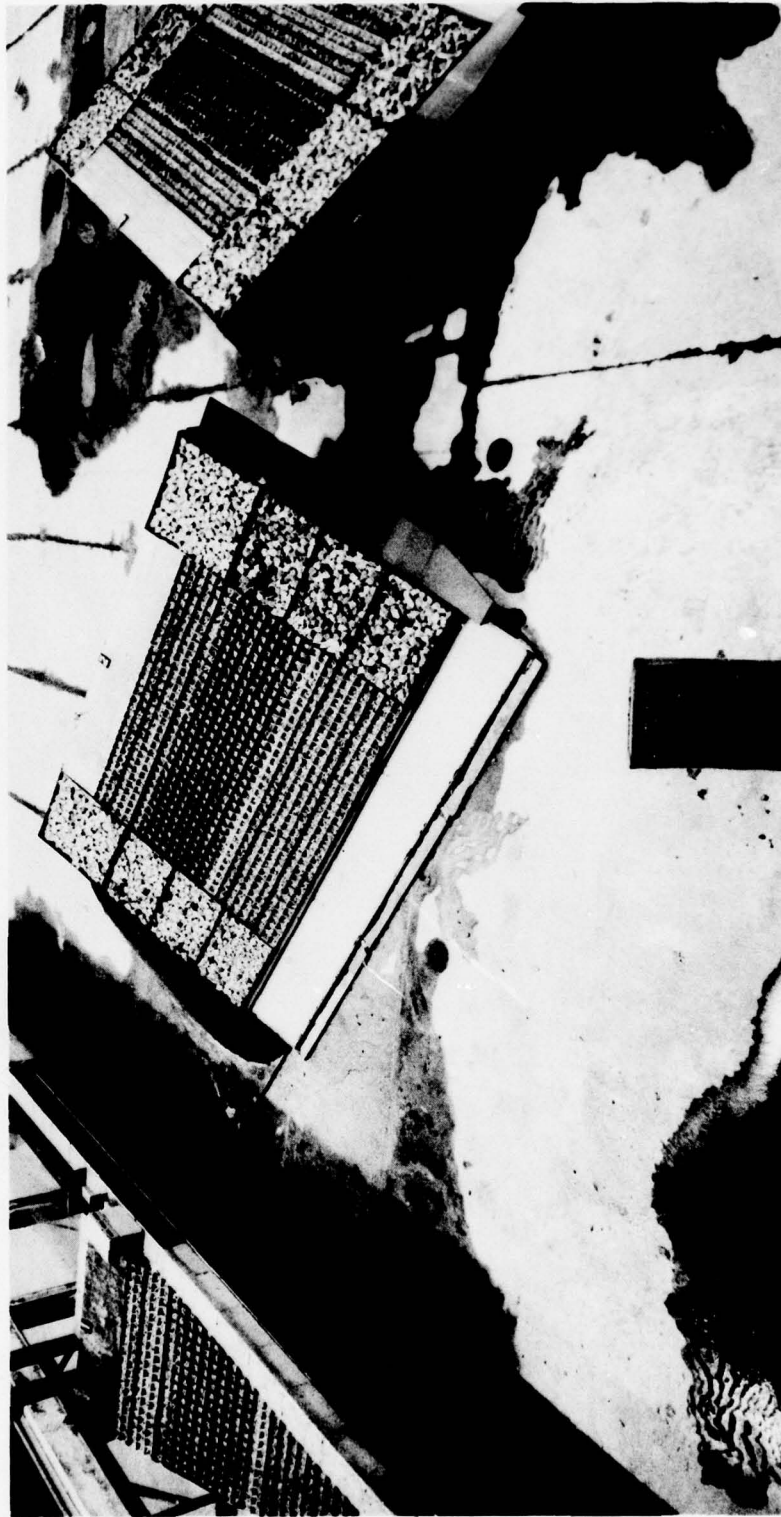


Figure C5. Wave test facility (two-dimensional installation at left; three-dimensional installation at center and right)

APPENDIX D

**Research on Soil Stability and Identification
of Causes of Streambank Erosion
(Work Unit 4)**

APPENDIX D

Research on Soil Stability and Identification of Causes of Streambank Erosion (Work Unit 4)

INTRODUCTION

Studies are being conducted to better understand the erosion resistance or susceptibility of various soils and the effects of these characteristics on streambank stability. Additional knowledge and experience are needed to identify more accurately other causes of streambank erosion and the mechanisms involved in the complex erosion process. Also, recent developments of erosion control materials and soil treatments must be tested under a wide variety of soils and environmental conditions for their potential application in bank protection projects. The specific objectives of this work unit, the progress to date, and plans for future work are summarized in this appendix.

TASKS

The tasks of Work Unit 4 are to: (I) *Conduct Research on Soil Stability*, specifically the influence of soil properties on bank stability and the development of procedures for evaluating bank stability; (II) *Identify the Causes and Mechanisms of Streambank Erosion*, specifically the influence of fluvial geology and the techniques for monitoring the natural processes and the changes caused by man-made obstructions; and (III) *Investigate New Methods and Techniques for Bank Protection*, specifically recent developments in materials usage and soil treatments that may be applicable to bank protection or river training structures either as part of a restoration system or as preventive measures.

To accomplish the tasks of Work Unit 4 and other related activities under the Section 32 Program, WES established ad hoc research teams combining specialized technology in the areas of geology, soil mechanics, soil stabilization, data-gathering systems, and materials development into a single coordinated effort. Supportive input and related tasks with other disciplines, notably hydraulics, are coordinated as appropriate. In addition to the research teams, well-known consultants in the academic and private communities are engaged to effectively utilize and demonstrate the state of the art.

TASK I. RESEARCH ON SOIL PROPERTIES AFFECTING BANK STABILITY

Research Plan

The objectives of this research are to (a) develop equipment and test procedures for measuring erosion rate versus local hydraulic shear stress for samples of natural soils having sufficient cohesiveness to allow undisturbed samples to be taken, (b) conduct laboratory tests on representative samples of natural soils and river water furnished by CE Districts to develop generalized procedures for predicting critical shear stress, rate of erosion, and rate of slaking of natural cohesive soils caused by current action along streambanks, and (c) develop a procedure for evaluating streambank stability using general erosion rate and shear strength properties determined from laboratory tests conducted on undisturbed samples of natural soil to estimate bank recession resulting from erosion and slope failure of similar natural soils for flows at normal water level and for rapid drawdown at selected time intervals.

Progress to Date

Following a review of the literature and discussions with various researchers working in this field, a duct (closed flume) laboratory erosion test apparatus has been designed. A two-year contract study for the "Development of Quantitative Method to Predict Critical Shear Stress and Rate of Erosion of Natural Undisturbed Cohesive Soils" is in progress. Preliminary testing has been completed on representative samples of a number of uniform natural soils and river water.

Future Research

Future work includes (a) constructing and calibrating a duct-type, laboratory erosion test apparatus, (b) continuing work to develop a procedure for streambank stability analysis, and (c) conducting laboratory tests under contract to determine the influence of various parameters on the erosion of soils. Technical guidelines for use of the apparatus and analyses procedures will be prepared.

TASK II. INFLUENCES OF FLUVIAL GEOLOGY ON CAUSES AND MECHANISMS OF STREAMBANK EROSION

Research Plan

The objective of this research program is to define some of the causes and mechanisms of streambank erosion in terms of the influence of fluvial geology and to develop techniques for monitoring sedimentological conditions in stream channels. Initially, some representative river sites nationwide where erosion is occurring will be studied to identify factors relative to site characteristics that may cause or affect erosion. This investigation includes historical analyses of streams exhibiting diverse geologic, hydraulic, and hydrologic conditions. A partial list of general data elements to be collected and analyzed includes stream depth and velocity, channel and valley geometry, meander configuration, climatic influences, and data from material investigations. This last element includes compositional and index properties of bed and suspended loads, channel deposits, bank materials, and sediment sources.

Selected sites will be chosen for monitoring by sidescanning sonar and acoustical subbottom profiling techniques (Figure D1) to determine the feasibility of using such methods to monitor features and events occurring on channel beds and subaqueous portions of channel banks. Basically, these methods are believed capable of providing general data on the effect of sediment transport on the streambed and may also give some indication of changes taking place along the banks.

The product of these studies will be the identification of some site-specific factors that may cause or contribute to streambank erosion and the evaluation of erosion or accretion occurring under various conditions. Hopefully, this work will lend itself to the development of a sound basis for prediction of erosion problems in diverse geologic, hydraulic, and hydrologic regimes by identifying factors contributing to erosion. The monitoring program is expected to contribute to the understanding of relations between sediment transport accretion and erosion and to provide additional site data to the inventory.

Progress to Date

Approximately 20 sites have been investigated and waterborne geophysical surveys have been performed at 3 sites. Historical changes in fluvial geomorphology have been studied at selected sites

using aerial photography and topography maps to interpret the causes of geomorphic changes and to determine the mechanisms involved in bank erosion.

Future Work

The waterborne geophysical techniques will be validated at selected sites, and technical guidelines for their use will be prepared. The historical analyses will be used to aid in the formulation of a working hypothesis for the causes and mechanisms of streambank erosion and to develop a systematic approach to identifying erosion-susceptible banks.

TASK III. GEOTECHNICAL RESEARCH ON NEW METHODS AND TECHNIQUES FOR BANK PROTECTION

Research Plan

The objective of Task III is to study the application of new methods and techniques in geotechnical engineering to streambank protection. Additionally, materials and methods developed for other applications, such as pavements and waterproofers, are to be investigated as to their applicability for streambank protection and restoration.

Fabricated metal panels used to provide large bearing areas for concentrated loads will be investigated for lower bank protection. Many panels of different materials and configurations have been developed, and extensive studies of various panel joints, connectors, and anchoring devices conducted. A vast amount of experience and technology exists with this type of material. Concepts for the use of prefabricated membranes include average-weight and lightweight membranes as well as perforated membranes and double-walled membranes that can be filled with soil or grout. Various applications of existing membrane will be evaluated with attention directed to anchoring configurations, construction techniques, and cost analysis. Streambank protection using chemical soil stabilization techniques will proceed on two fronts: (a) lower bank protection where the chemical is admixed with the in situ bank material, and (b) upper bank protection where liquid polymers are placed on denuded areas to protect the bank until vegetation becomes established and provides protection.

Progress to Date

Two fabricated metal panels were simulated using aluminum plates and placed along the bank of a curving sand channel model (Figure D2). The panels were placed with and without filter cloth and anchoring systems while several flow regimes were investigated. Several prefabricated membranes were tested concurrently, and their ability to sustain the various flow regimes without erosion and movement of the underlying sand particles was noted. Other factors such as flexibility, ease of placement, and cost effectiveness were noted. These model studies are complete. Five materials were sprayed on a local hillside (Figure D3) for study as upper bank protectors. These materials were a polyvinyl acetate emulsion, "balanced copolymers of materials in the plastic resin range," a cutback asphalt, an acrylic resin emulsion, and a material processed from oil shale. These five materials are still in place and under observation. Automated data processing devices are collecting and recording meteorological data, soil temperature, and soil moisture periodically.

Future Research

Bank protection will be investigated using membrane-encapsulated soil concepts. Additional soil

stabilizing materials that appear to be potentially suitable for retarding streambank erosion will be evaluated. The use of soil admixtures as a protection measure against sudden drawdown phenomena will be studied. The potential usefulness of materials such as shotcrete, as well as new materials that are continuously emerging on the market, will be examined and compared. Technical guidelines for all practicable bank protection systems studied will be developed.

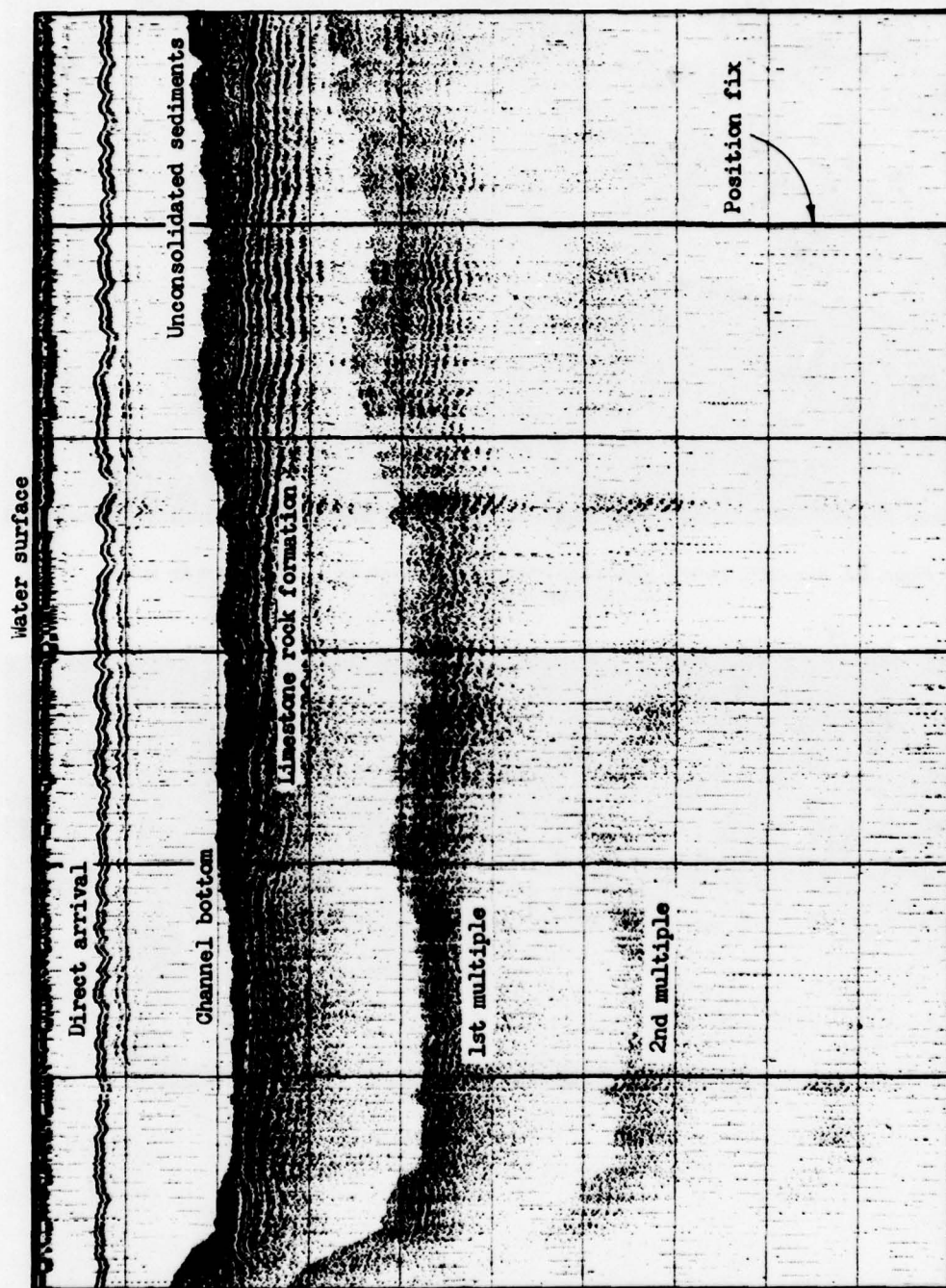


Figure D1. Example acoustical subbottom profile across a river channel. ("Direct arrival" and "multiple" traces are from false signals inherent in the sounding techniques.)

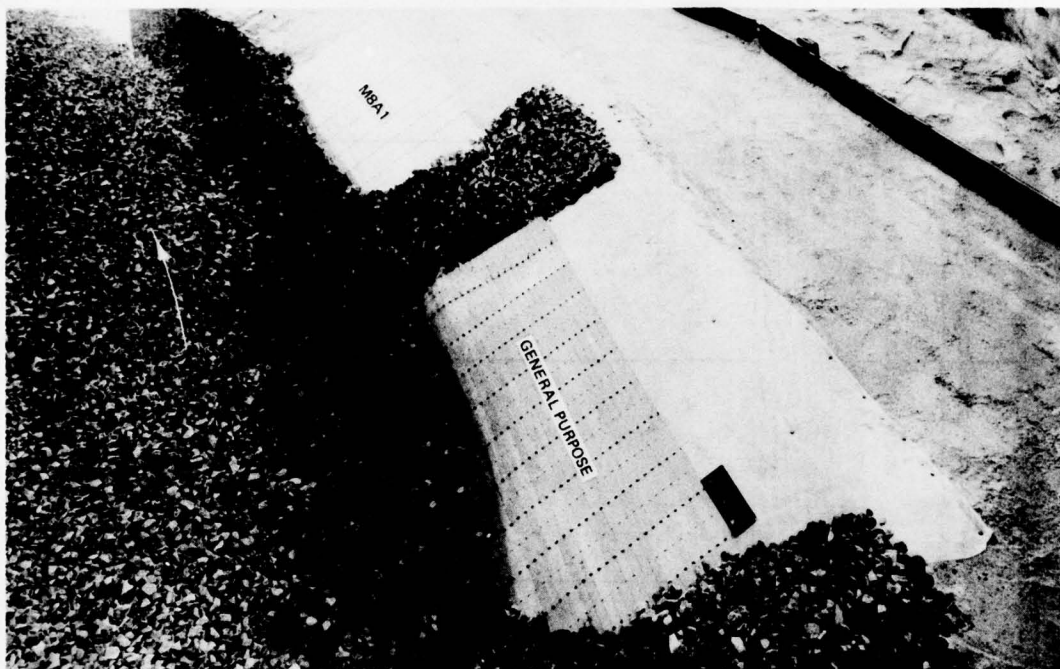


Figure D2. Simulated general purpose and M8A1 metal panels laid on filter cloth for testing in 1:25-scale model river bend

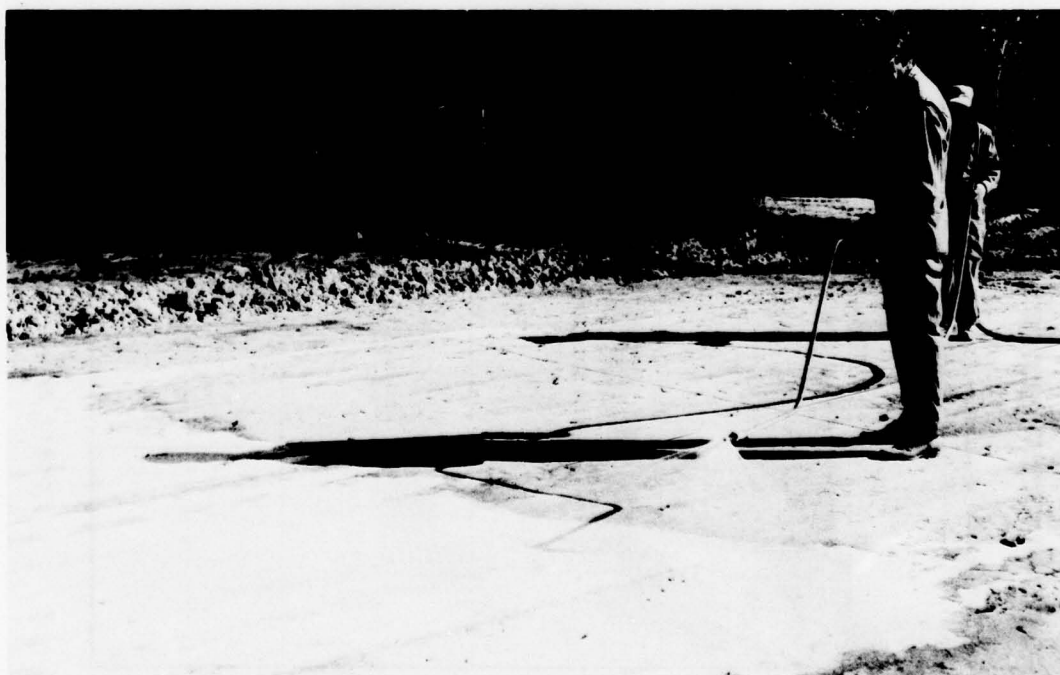


Figure D3. Applying spray-on chemical, soil-surface stabilizer to test section

APPENDIX E

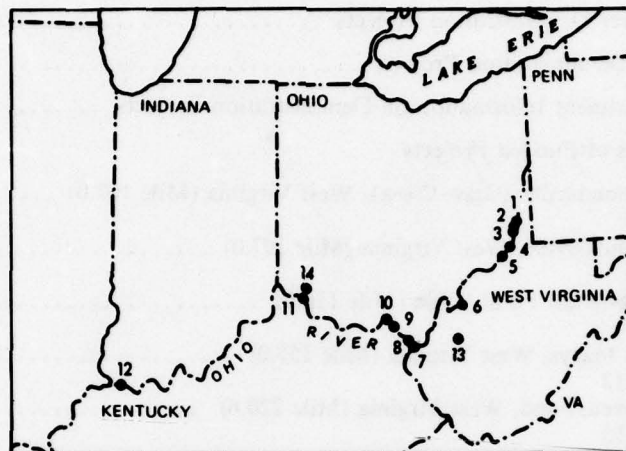
**Ohio River Demonstration Projects
(Work Unit 5)**

APPENDIX E

Ohio River Demonstration Projects (Work Unit 5)

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FUNDED PROJECTS

1. MOUNDSVILLE (GRAVE CREEK), WV (102.0 L)*
2. MOUNDSVILLE, WV (107.0 L)
3. POWHATAN POINT, OH (110.0 R)
5. ST. MARY'S, WV (155.0 L)
6. RAVENSWOOD, WV (220.6 L)
10. PORTSMOUTH, OH (355.4 R)
11. MOSCOW, OH (443.5 R)
12. MT. VERNON, IN (829.0 R)
13. SOUTH CHARLESTON (KANAWHA RIVER), WV (52.3 L)
14. MILFORD (LITTLE MIAMI RIVER), OH (LEFT BANK)

PROPOSED PROJECTS (UNFUNDED)

4. NEW MATAMORAS, OH (142.7 R)
7. SOUTH POINT, OH (316.9 R)
8. ASHLAND-BOYD COUNTY, KY (330.9 L)
9. WHEELERSBURGH, OH (355.4 R)

* RIVER MILE AND BANK LOCATION (EITHER LEFT OR RIGHT BANK LOOKING DOWNSTREAM) ARE SHOWN IN PARENTHESES.

*Figure E1. Locations of Ohio River Demonstration Projects
(Work Unit 5)*

APPENDIX E

Status of Ohio River Demonstration Projects (Work Unit 5)

The Ohio River is one of the major navigable waterways in the United States. For many years bank erosion has been a serious problem along the nearly 2000 bank-miles of this river. Today, many public parks and roads, sewer outfalls, residential areas, railroads, and commercial properties urgently require protection from undermining and ultimate destruction by the encroaching waters. Bank recession in the more remote areas is resulting in the loss of large trees as well as the valuable land itself. Therefore the purpose of the bank protection projects constructed under this work unit is to evaluate the effectiveness of many different, potentially low-cost materials and techniques and to determine the optimum protection for any given condition along the Ohio River.

The Ohio River and some of its tributaries provide a wide variety of conditions for testing different bank protection materials and techniques. Wave wash from passing tows and the scouring effects of water flowing against outer side banks in channel bends are only two of the causes of bank erosion and failure along this river. In addition, upper sections of the bank sometimes cave and slough from the action of groundwater seepage following local rainfall or high river stages. Another problem prevalent on the Ohio is the gulying caused by overland flow over unprotected upper banks. These and other causes of bank failure and instability thus provide many possible sites for the construction of a variety of demonstration projects. For this reason, more different types of bank protection probably will be tested on the Ohio River than on any other stream.

The Districts in the Ohio River Division have investigated numerous sites on the Ohio River and some of its tributaries where active streambank erosion is occurring (Figure E1). Letter reports have been prepared for most of those sites and reports on 15 of the sites have been reviewed and approved by the Section 32 Program Steering Committee as feasible locations for demonstration projects. Funds have been made available to the Districts for the construction of 11 demonstration projects, of which 6 have been completed to date and 4 are scheduled to be completed during the summer of 1978. A table of pertinent data for all of the proposed, approved, or funded projects (Table E1) and individual summary descriptions for all of the constructed or funded projects are given in this appendix.

A project on the Ohio River at Henderson County, Kentucky, which had been approved and funded, was canceled due to failure of the local interests in the Commonwealth of Kentucky to provide an assurance agreement. The demonstration projects at Milford, Ohio, on the Little Miami River and South Charleston, West Virginia, on the Kanawha River, though not sited on the Ohio River mainstream, have also been included under this work unit because of their close relation to the Ohio River system.

Some of the experimental bank stabilization materials and techniques used to date include the following: (a) various combinations of graded furnace slag and vegetation; (b) rubber automobile tires in a staggered stacking arrangement; (c) wooden breakwater fence with reshaping and vegetative cover; (d) stacked arrangement of gabions filled with waste firebrick; (e) toe revetment of compacted quarry-run rock fill with granular fill above the revetment; (f) Longard tubes (3.3-ft diam) with backfill and vegetative cover; (g) chained concrete-filled tire wall; (h) nylon-reinforced paper bags filled with a sand-cement mixture; (i) nylon mattresses filled with grout; (j) riprap dikes; (k) stone bedding material

(Text continued on page E6)

TABLE E1: SUMMARY OF PERTINENT INFORMATION ON DEMONSTRATION PROJECTS
Ohio River and Tributaries (Work Unit 5)

Stream, Mile, & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
Ohio R. 102.0 Left	Moundsville (Grave Creek)	Wheeling	Marshall	WV-1	Pittsburgh PA	Bank instability due to drawdown, waves, and possibly river current	a. Graded steel-furnace slag b. Automobile tires c. Vegetation
Ohio R. 107.0 Left	Moundsville	Wheeling	Marshall	WV-1	Pittsburgh PA	Bank instability due to waves and drawdown	a. Graded-steel furnace slag b. Vegetation to top of bank
Ohio R. 110.0 Right	Powhatan Point	Wheeling	Belmont	OH-18	Pittsburgh PA	Bank instability due to waves and drawdown	a. Graded-steel furnace slag b. Gravel-filled rubber tires c. Vegetation to top of bank
Ohio R. 142.7 Right	New Matamoras	New Matamoras	Washington	OH-10	Huntington WV	Bank instability	a. 24-in. layer of 18-in. top size quarry-run stone placed 1V on 1.5H b. 4-in. top size quarry-run stone placed at toe of slope with minor reshaping and vegetative cover c. Single line of floating tire break- waters anchored on pipe supports placed at normal pool d. Protection between existing barges at the toe of the slope with tire mat
Ohio R. 155.0 Left	St. Marys	St. Marys	Pleasants	WV-1	Huntington WV	Bank instability	a. Chained concrete-filled tire wall b. Dump oversized quarrystone approxi- mate to normal pool c. 4-in. top size stone supporting concrete-block stacks
Ohio R. 220.6 Left	Ravenswood	Ravenswood	Jackson	WV-3	Huntington WV	Bank instability	a. Wooden breakdown fence b. Stacked gabions filled with firebrick c. Toe revetment of waste rock, top size of 10 and 9 in. d. 3.3-ft Longard tube
Ohio R. 316.9 Right	South Point	South Point	Lawrence	OH-10	Huntington WV	Bank instability	a. Two rows of barrels filled with soil- cement with rubble between b. 18-in. top size quarry-run stone near normal pool c. Compacted rubble-toe revetment d. Rubble pad with stocked rubble-filled gabions
Ohio R. 330.9 Left	Ashland- Boyd Co. Airport	Worthington	Greenup	KY-7	Huntington WV	Bank instability	a. 10-ft Gobimat on filter cloth with vegeta- tive cover on a reshaped 1V-on-2H slope b. 10-ft Fabriform with vegetative cover on a reshaped 1V-on-2H slope c. 10-ft PVC-coated gabion with vegeta- tive cover on a reshaped 1V-on-2H slope d. A keyed section of dumped stone will be placed near toe with vegetative cover on a reshaped slope of 1V on 2H
Ohio R. 346.2 Right	Wheelersburg	Wheelersburg	Scioto	OH-6	Huntington WV	Bank instability	a. Armco Bin-Wall installed at toe of the bank with reshaped slopes and vegetative cover on remaining bank b. Massive buttress of stone and demoli- tion rubble with backslope reshaped to 1V on 3H or 1V on 3.5H with vegeta- tive cover provided c. PVC-coated gabion counterfort retain- ing structure with reshaping of upper slope similar to b. above
Ohio R. 355.4 Right	Portsmouth	Portsmouth	Scioto	OH-6	Huntington WV	Bank instability	a. Dumped slag at toe with vegetative slope protection b. Quarry-run rock faces with granular fill stepped up the bank with vegeta- tive slope protection c. Quarry-run rock revetment at toe with vegetative slope protection d. Blanket of dumped rock along lower bank with vegetative slope protection
Ohio R. 443.5 Right	Moscow	Cincinnati	Clermont	OH-6	Louisville KY	Bank instability due to drawdown and waves	a. Riprap toe b. Gravel c. Vegetation to top of bank
Ohio R. 820.0 Left	Henderson Sloughs Wildlife Mgt. Area	N/A	Henderson	KY-1	Louisville KY	Wave action caused by pre- vailing westerly winds, erodible layered clay soil and the lack of adequate vegetation	a. Sand-cement filled bags b. Stone bedding material secured by wired mats c. Riprap toe with bank vegetation
Ohio R. 829.0 Right	Mt. Vernon	Evansville	Posey	IN-8	Louisville KY	Bank instability due to drawdown and waves	a. Riprap b. Sand-cement mixture bags c. Fabriform
Kanawha R. 52.3 Left	South Charleston	South Charleston	Kanawha	WV-3	Huntington WV	(1) Bank instability (2) Toe scour	a. Chain-connected used-tire mat at toe b. Soil-cement filled burlap bags stacked near toe c. Floating tire breakwater d. Waste rock (top size 6 in.) toe revetment
Little Miami R. Left	Milford	Cincinnati	Clermont	OH-6	Louisville KY	Bank instability due to river current	a. Gabions b. Reinforced earth c. Rock dikes

Ohio River and Tributaries (Work Unit 5) (Concluded)

Stream, Mile, & Side	Project Length ft	Funding in \$1000				Status	Remarks	Map No.
		Est Costs	Engr, Monitor & Reporting	Allocated thru FY 78	Expended as of 3/31/78			
Ohio R. 102.0 Left	1850	131.0	47.0*	246.5	173.0	Construction completed	*E&D costs, District proposes a 5-year monitoring program for \$74K	1
Ohio R. 107.0 Left	2130	113.0	68.0*	266.8	175.0	Construction completed	*E&D costs, District proposed a 5-year monitoring program for \$130K	2
Ohio R. 110.0 Right	2100	140.0	58.0*	207.7	38.0	Plans and specifications under preparation	*E&D costs, District proposed a 5-year monitoring program for \$74K	3
Ohio R. 142.7 Right	3150	50.0	72.0	None	None	Brief letter report prepared and local contacts made	Scheme A is 1700 ft long and was built in 1974 by Huntington Dist under separate authority. Scheme D incorporates existing protection placed by private concerns	4
Ohio R. 155.0 Left	1200	80.0	40.0	22.0	10.0	Plans and specifications are scheduled for August 1978 completion. Construction scheduled for summer of 1979		5
Ohio R. 220.6 Left	1390	133.5	62.0	240.0	182.8	Construction of major components completed in late summer 1977. Outstanding work items are to be completed this FY	Overland flow from above the bank is causing gullying. Protection Scheme A is not high enough and wave washing at frequently encountered pool elevations is causing problems.	6
Ohio R. 316.9 Right	1600	111.0	92.0	None	None	Brief letter report prepared and local contacts made		7
Ohio R. 330.9 Left	1600	118.6	92.0	None	None	Brief letter report prepared and local contacts made		8
Ohio R. 346.2 Right	1200	244.0	69.0	None	None	Brief letter report prepared and local contacts made		9
Ohio R. 355.4 Right	1585	182.2	73.0	332.0	251.2	Basic construction completed in January 1977 with remedial planting of vegetative cover to be completed in summer of 1978	Scheduling problems in completing planting of vegetation on the slopes and drainage-related seepages existing back of bank have caused deterioration of the protective measures.	10
Ohio R. 443.5 Right	1300	200.0	100.0	240.0	50.0	Plans and specifications prepared	Right-of-way not secured, also need permit for borrow area	11
Ohio R. 820.0 Left	1400	150.0	60.0	23.0	23.0	Canceled	Project was canceled because of lack of assurance agreement with the Commonwealth of Kentucky	--
Ohio R. 829.0 Right	1200	70.0	45.0*	110.0	115.0	Construction completed	*E&D, estimated monitoring cost for 5 years \$40K	12
Kanawha R. 52.3 Left	1550	190.0	60.0	303.0	30.0	Plans, specifications, and local assurances are completed; however, sufficient funds to complete the project are not available		13
Little Miami R. Left	2000	500.0	100.0	650.0	61.0	Plans and specifications prepared, presently revisions are being made		14

secured by wire mats; (l) plantings through woven plastic filter cloth; and (m) different types of matting and granular bedding.

All completed projects are being monitored to evaluate the materials and techniques for durability and performance and for possible application in protecting other unstable and eroding banks. The monitoring program includes observations and measurements of: (a) dimensional changes in the banks and protection works, (b) plant growth, (c) channel cross-sectional changes, and (d) hydraulic and weather conditions.

A field inspection of the projects this spring revealed that the recently planted vegetal cover at the Moundsville, West Virginia, site was lost during the recent high water and some of the sand-cement bag revetment at Mt. Vernon, Indiana, also sustained limited ice damage. Restoration of these projects will be accomplished this summer and all of the completed projects will be closely monitored for at least three years.

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**OHIO RIVER AT MOUNDSVILLE, WEST VIRGINIA,
GRAVE CREEK SITE,
DEMONSTRATION PROJECT**

Problem. The left bank of the Ohio River immediately upstream of the mouth of Grave Creek, at the city of Moundsville, West Virginia (Plate E1), was rapidly eroding an area leased by the city as a recreational area. The 8- to 10-ft-high bank is composed of highly erodible fine-grained soil and is located on the outside of a sharp river bend. The site lies within the Hannibal Locks and Dam navigation pool.

Protection. Six distinct schemes of erosion control were constructed along 1850 ft of riverbank (Plate E1). Each scheme consists of a different method of bank protection incorporating structural, vegetal, or combined erosion-control features in various combinations. Plate E2 details the schemes of protection. Graded steel-furnace slag was specified in lieu of stone for schemes with structural protection because it is an economical, locally available material. Scheme 2 consists of a rubber tire wall requiring the placement of 2200 rubber automobile tires in a staggered stacking arrangement.

Cost. The contract price for construction was \$131,000. This price reflects the complexity of constructing six different schemes with the required cutoff and transition features.

Monitoring Program. Dimensional changes, plant growth, and hydraulic conditions will be monitored. Visual observations, automatic and manual measuring devices, and periodic photography will be employed. Plate E3 shows photographs of the site.

Status. Construction of the project was recently completed.

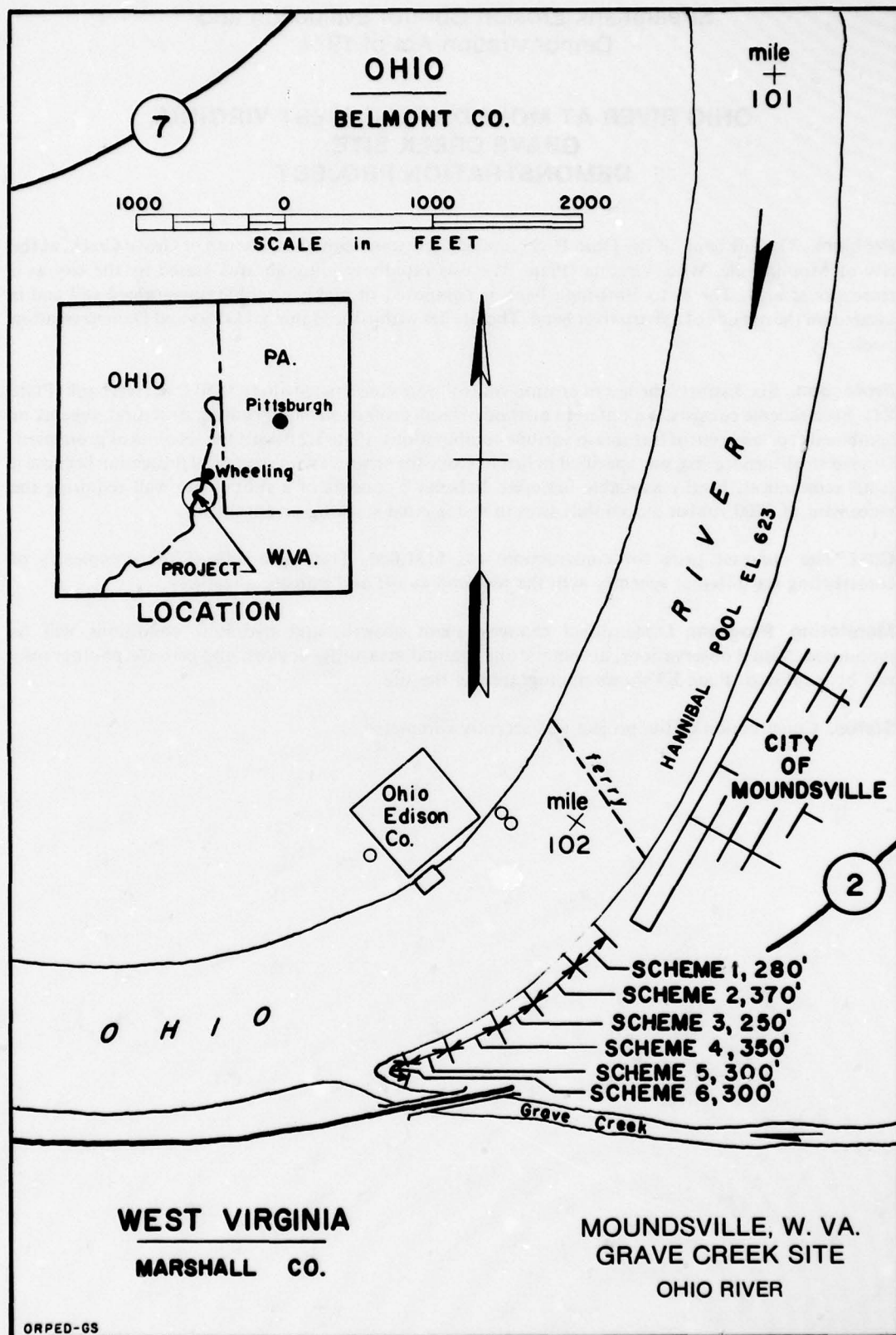
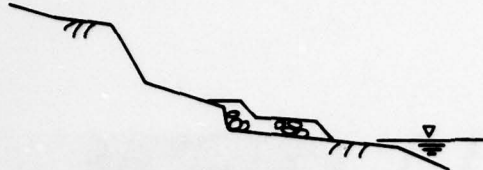
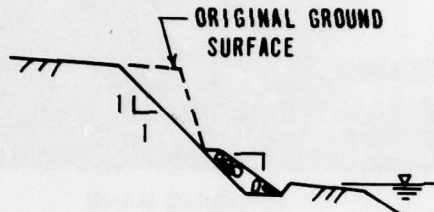


PLATE E1



18-in.-THICK GRADED STEEL FURNACE
SLAG BLANKET FROM EL 623.0 TO EL 627.0

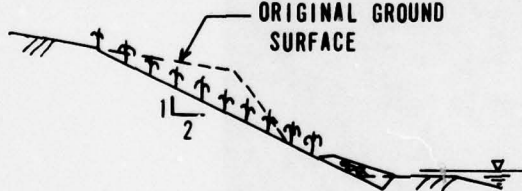
SCHEME 1



ORIGINAL GROUND SURFACE

SEEDING AND MULCHED FROM EL 627.0 TO
TOP OF CUT SLOPE. GRADED STEEL FURNACE
SLAG WEDGE FROM EL 622.0 TO EL 627.0

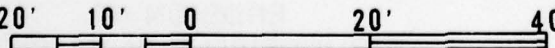
SCHEME 3




ORIGINAL GROUND SURFACE

PLANT SHOOTS WITH MAT COVER FROM EL
625.0 TO TOP OF CUT SLOPE. GRADED
STEEL FURNACE SLAG WEDGE FROM EL
621.0 TO EL 625.0

SCHEME 5



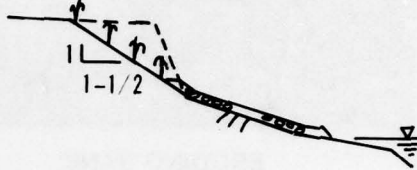
20' 10' 0 20' 40'



ORIGINAL
GROUND SURFACE

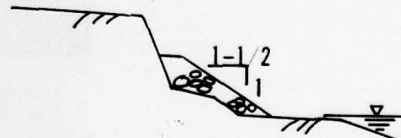
PLANT SHOOTS WITH MAT COVER FROM
EL 630.0 TO TOP OF CUT SLOPE.
RUBBER TIRE WALL FROM EL 623.0
TO EL 630.0

SCHEME 2



PLANT SHOOTS WITH MAT COVER FROM
EL 630.0 TO TOP OF CUT SLOPE.
12-in.-THICK GRADED STEEL FURNACE
SLAG BLANKET FROM EL 623.0 TO
EL 630.0

SCHEME 4



GRADED STEEL FURNACE SLAG WEDGE
FROM EL 623.0 TO EL 630.0

SCHEME 6

SCHEMES 1-6
MOUNDSVILLE, W. VA.
GRAVE CREEK SITE
OHIO RIVER

ORPED-GS

PLATE E2



ERODING BANK
8 MARCH 1977



ERODING BANK
13 DECEMBER 1977



ERODING BANK
21 JUNE 1977

EROSION AT
MOUNDSVILLE, W. VA. SITE
GRAVE CREEK SITE
OHIO RIVER

Streambank Erosion Control Evaluation and Demonstration Act of 1974

OHIO RIVER AT MOUNDSVILLE, WEST VIRGINIA, DEMONSTRATION PROJECT

Problem. The left bank of the Ohio River, approximately 4 miles downstream of Moundsville, West Virginia (Plate E4), was actively eroding. The eroding bank had undercut many large trees and was encroaching on land used as a golf course. The property owner, a nonprofit corporation, had attempted to protect the bank with brick and concrete rubble with limited success. The bank is composed of fine-grained soil highly susceptible to erosion. The top of the bank varies between 8 and 15 ft above the Hannibal Locks and Dam navigation pool with relatively flat landward topography.

Protection. Six distinct schemes of erosion control were constructed along 2130 ft of riverbank and integrated with a 560-ft reach of previously placed rubble protection (Plate E4). Each scheme consisted of a different method of bank protection incorporating structural, vegetal, or combined erosion-control features in various combinations. Plate E5 details the schemes of protection. Graded steel-furnace slag was specified in lieu of stone for schemes with structural protection because it is an economical, locally available material.

Cost. The contract price for construction of the demonstration project was \$113,000. This price reflects the complexity of constructing six different schemes with the required cutoff and transition features.

Monitoring Program. Dimensional changes, plant growth, hydraulic conditions, and atmospheric conditions will be monitored. Visual observation, automatic and manual measuring devices, and periodic photography will be employed. Plate E6 shows photographs of the site.

Status. Construction of the project was completed in May 1977. Moderately high flows have occurred several times since completion. Significant deterioration has been observed in Scheme 4 where recently planted vegetal cover was lost during high water. Restoration of this area will be done during the summer of 1978.

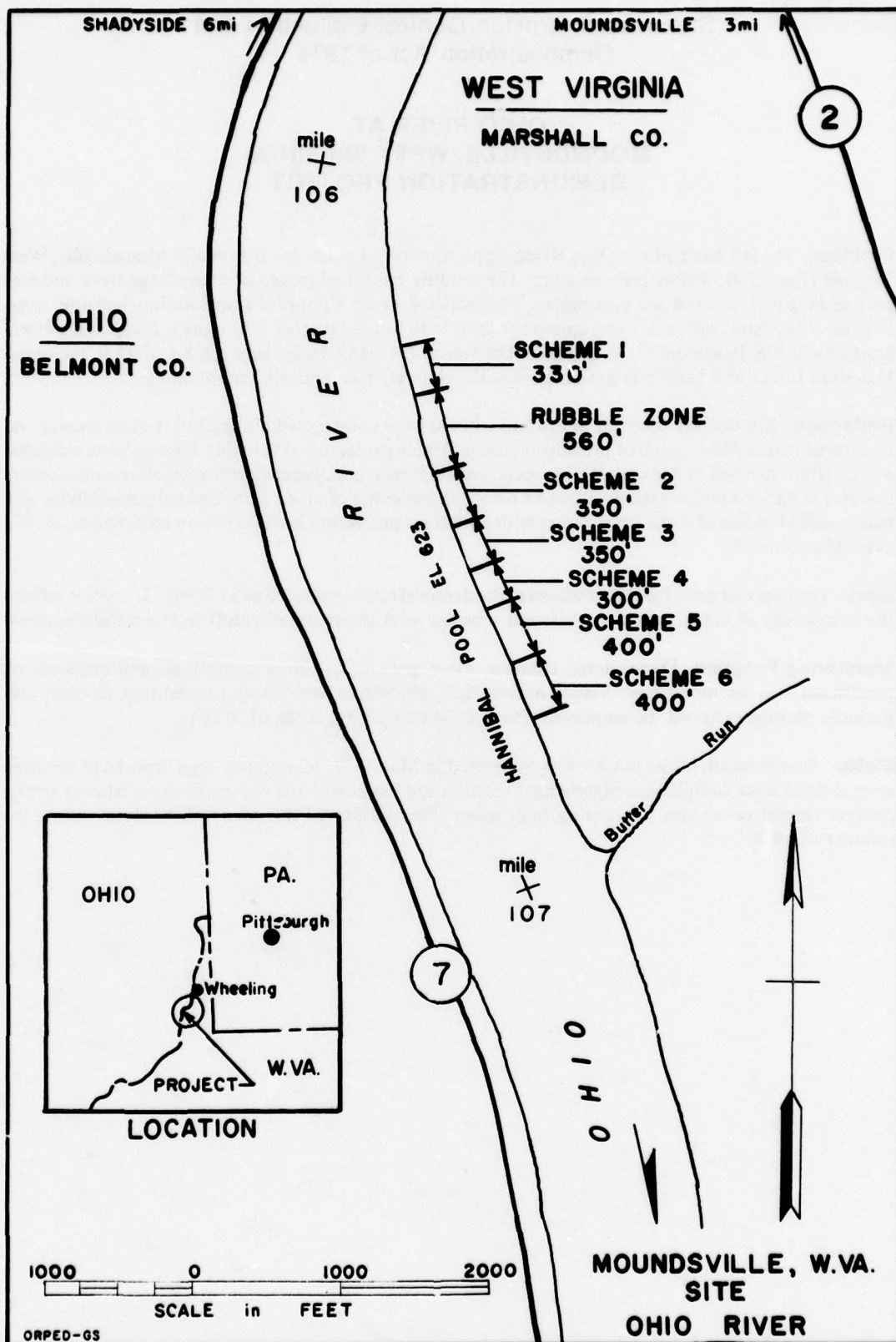
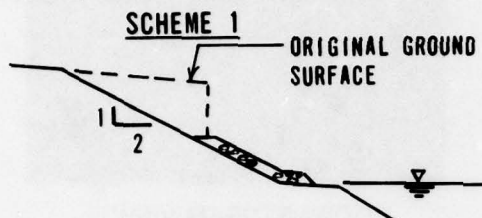


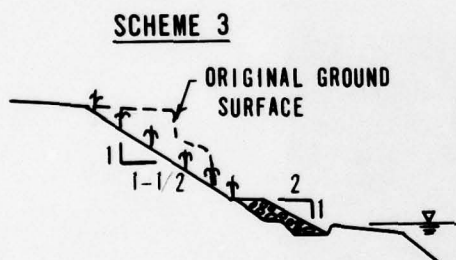
PLATE E4



PLANT SHOOTS WITH MAT COVER FROM EL 626.0 TO TOP OF CUT SLOPE. 8-in.-THICK GRADED STEEL FURNACE SLAG BLANKET ATOP FILTER CLOTH FROM EL 623.0 TO EL 626.0

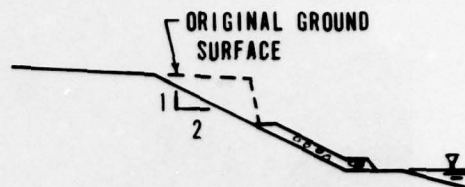
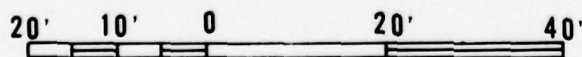


SEEDING AND MULCHING FROM EL 628.0 TO TOP OF CUT SLOPE. 12-in.-THICK GRADED STEEL FURNACE SLAG BLANKET ATOP FILTER CLOTH FROM EL 623.0 TO EL 628.0

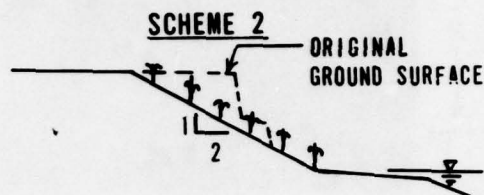


PLANT SHOOTS WITH MAT COVER FROM EL 626.0 TO TOP OF CUT SLOPE. 18-in.-THICK GRADED STEEL FURNACE SLAG WEDGE FROM EL 622.0 TO EL 626.0

SCHEME 5

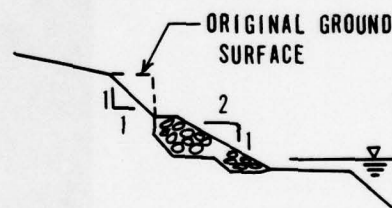


SEEDING AND MULCHING FROM EL 628.0 TO TOP OF CUT SLOPE. 8-in.-THICK GRADED STEEL FURNACE SLAG BLANKET ATOP FILTER CLOTH FROM EL 623.0 TO EL 628.0



PLANT SHOOTS WITH MAT COVER FROM EL 628.0 TO TOP OF CUT SLOPE. PLANT SHOOTS WITH FILTER CLOTH COVER FROM EL 623.0 TO EL 628.0

SCHEME 4



SEEDING AND MULCHING FROM EL 628.0 TO TOP OF CUT SLOPE. 18-in.-THICK GRADED STEEL FURNACE SLAG WEDGE FROM EL 622.0 TO EL 628.0

SCHEME 6

PROTECTION SCHEMES 1-6
MOUNDSVILLE, W. VA. SITE
OHIO RIVER

ORPED-GS

PLATE E5

10 FT



DOWNSTREAM VIEW
FROM SCHEME 3
BEFORE CONSTRUCTION
17 NOVEMBER 1976



DOWNSTREAM VIEW
FROM SCHEME 3
6 JUNE 1977



DOWNSTREAM VIEW
FROM SCHEME 3
1 SEPTEMBER 1977

EROSION AT
MOUNDSVILLE, W. VA.
OHIO RIVER

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**OHIO RIVER AT
POWHATAN POINT, OHIO,
DEMONSTRATION PROJECT**

Problem. The right bank of the Ohio River immediately downstream of the mouth of Captina Creek, at the Village of Powhatan Point, Ohio (Plate E7), is actively eroding a number of residential and small commercial properties. The bank is variable in height and is composed of highly erodible fine-grained soil overlain by coal waste in some areas. The site lies within the Hannibal Locks and Dam navigation pool.

Protection. Six distinct schemes of erosion control are planned which will encompass 2120 ft of riverbank (Plate E7). Each scheme will consist of a different method of bank protection incorporating structural, vegetal, or combined erosion-control features in various combinations. Plate E8 details the schemes of protection. Graded steel-furnace slag is specified in lieu of stone for schemes with structural protection because it is an economical, locally available material. Scheme 5 will require the placement of 1800 rubber automobile tires in various arrangements as shown in Plate E8.

Cost. Construction cost of this project is anticipated to be approximately \$140,000. This cost reflects the complexity of constructing six different schemes with the required cutoff and transition features.

Monitoring Program. Dimensional changes, plant growth, and hydraulic conditions will be monitored. Visual observation, automatic and manual measuring devices, and periodic photography will be employed. Plate E9 shows photographs of the site.

Status. The project is designed; however, local sponsorship must be secured before construction can begin.

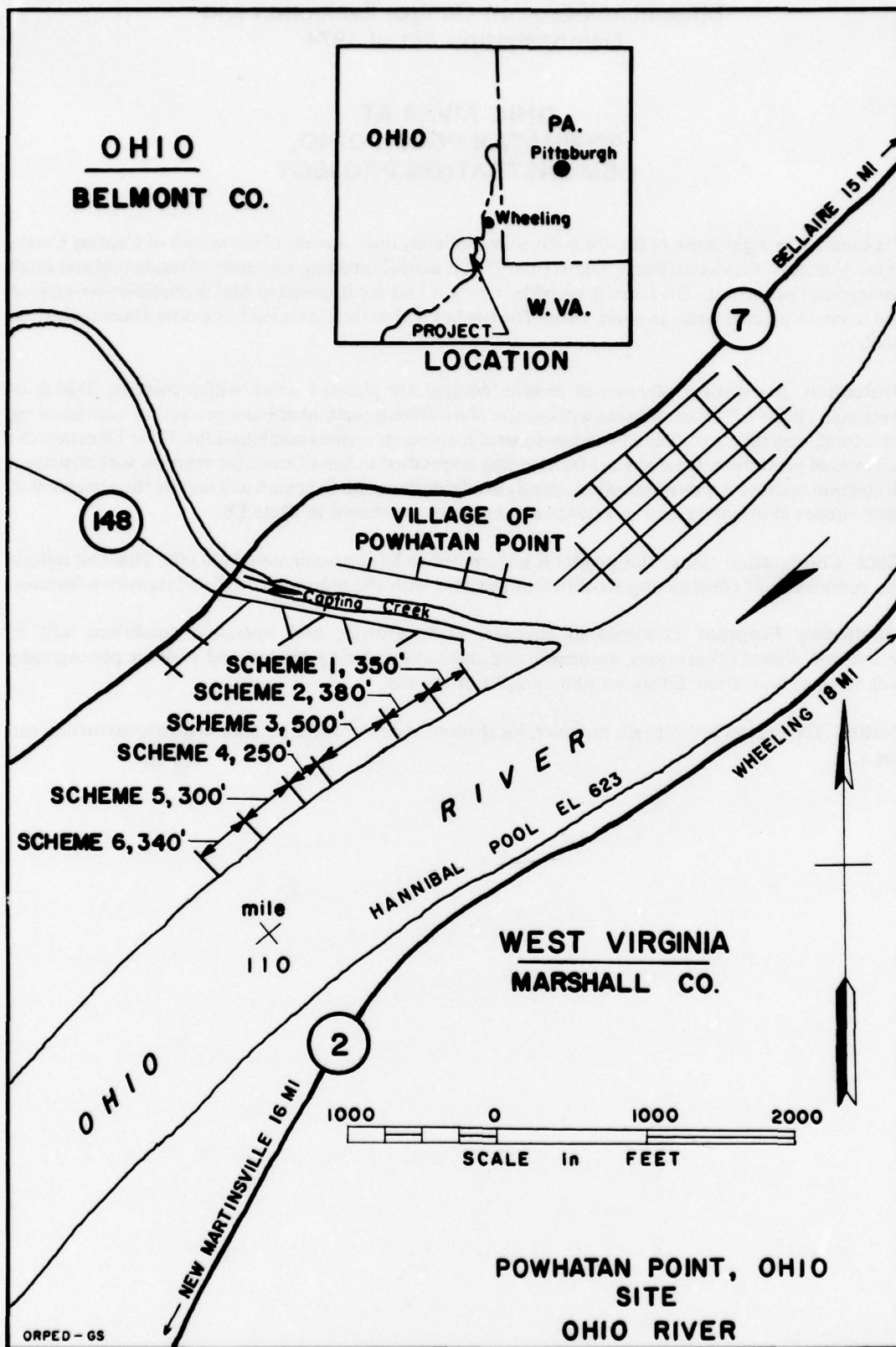
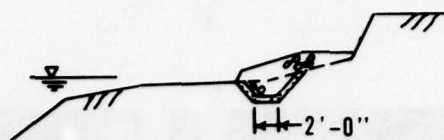


PLATE E7



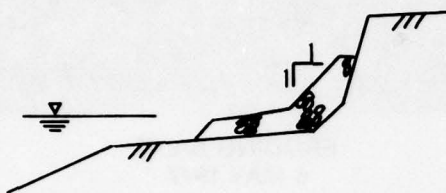
12-in.-THICK GRADED STEEL FURNACE
SLAG BLANKET ATOP 6-in.-THICK
GRADED SAND AND GRAVEL FILTER FROM
EL 623.0 TO EL 628.0.

SCHEME 1



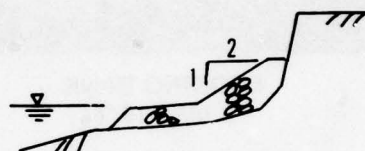
WEDGE OF GRADED STEEL FURNACE
SLAG FROM EL 621.0 TO EL 626.0 SET IN
TRENCH LINED WITH 6-in.-THICK
GRADED SAND AND GRAVEL FILTER.

SCHEME 2



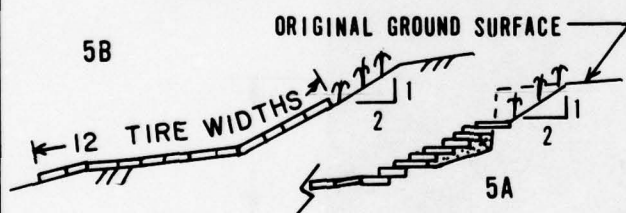
24-in.-THICK GRADED STEEL FURNACE
SLAG BLANKET FROM EL 621.0 TO
EL 630.0 WITHOUT FILTER.

SCHEME 3



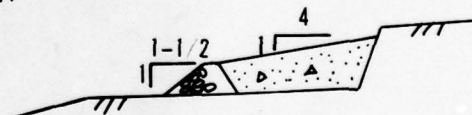
24-in.-THICK GRADED STEEL FURNACE
SLAG BLANKET FROM EL 622.0 TO EL
627.0 WITHOUT FILTER.

SCHEME 4



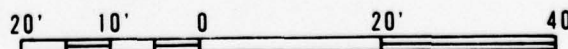
PLANT SHOOTS WITH MAT COVER FROM EL
628.0 TO TOP OF CUT SLOPE. SCHEME 5A
IS STACKED RUBBER TIRE WALL FROM EL
623.5 TO EL 628.0 WITH GRAVEL-FILLED
TIED TIRE BLANKET 6 TIRE WIDTHS BELOW
EL 623.5. SCHEME 5B IS GRAVEL-FILLED
TIED TIRE BLANKET 12 TIRE WIDTHS BELOW
EL 628.0

SCHEMES 5A & 5B



GRADED STEEL FURNACE SLAG WEDGE TO EL
625.0. SAND AND GRAVEL BACKFILL FROM
EL 625.0 TO EL 628.0

SCHEME 6



PROTECTION SCHEMES 1-6
POWHATAN POINT, OHIO SITE
OHIO RIVER

ORPED-GS

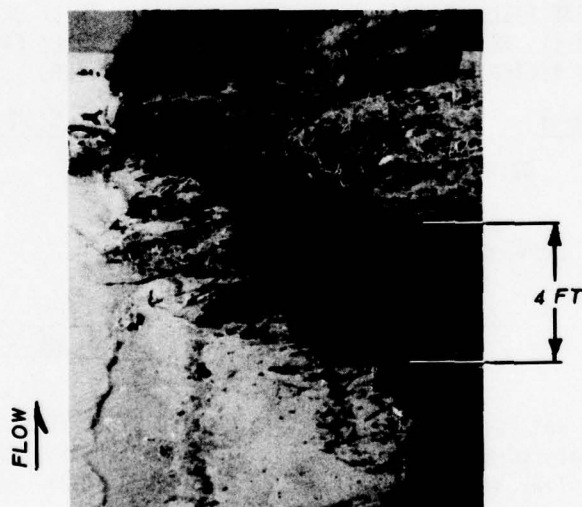
PLATE E8



ERODING BANK
5 MAY 1977



ERODING BANK
5 MAY 1977



ERODING BANK
8 MARCH 1977

EROSION AT
POWHATAN POINT, OHIO SITE
OHIO RIVER

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**OHIO RIVER AT
ST. MARYS, WEST VIRGINIA,
DEMONSTRATION PROJECT**

Problem. The lower bank within the project area has failed as a result of drawdown-related slumping. Cracking and vertical displacement of soil within the upper bank reach have been observed during the last two years. These indicators of bank and slope failure are close to several residential properties, a church, commercial building, and street. The site as shown in Plates E10 and E12 is within a back channel area associated with the downstream end of Middle Island.

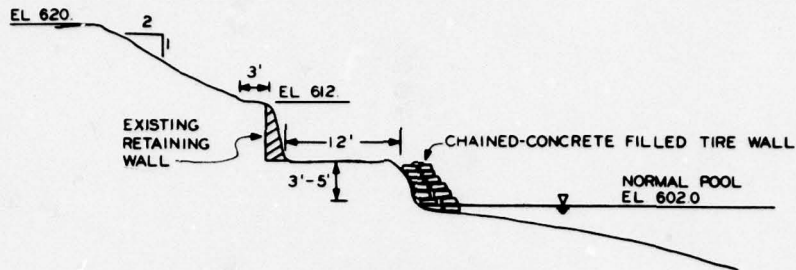
Protection. Three schemes are proposed for a 1200-ft stretch of bank as follows:

- a. The downstream section consists of chained concrete-filled tire wall 3 to 5 ft above normal pool (Plate E11, Scheme A). The length of scheme is 350 ft.
- b. The adjacent scheme has a dumped, oversized quarystone section sloped at 1V on 3H near the normal pool. Above this is a gravel fill with 3-in. top size stone which tapers to a point of confluence with the existing bank (Plate E11, Scheme B). Length of scheme is 500 ft.
- c. The last scheme consists of 4-in. top size stone with a 1V-on-3H slope at the toe of the bank. Stacked on this stone section are concrete blocks with filter cloth placed against the bank (Plate E11, Scheme C). Length of scheme is 350 ft.

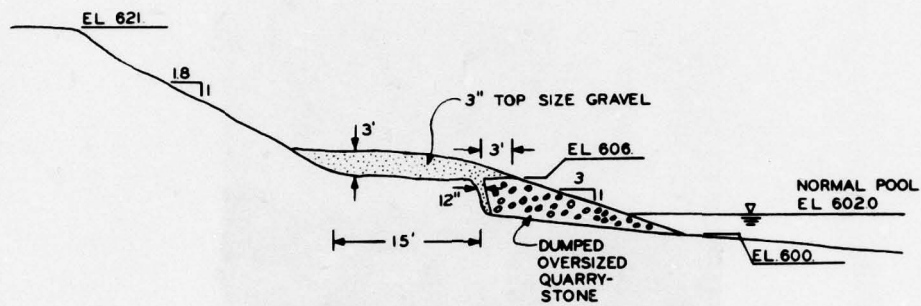
Cost. Total estimated construction cost for the three schemes will be \$80,000 or \$67 per foot of bank protection.

Monitoring Program. Primary observations would include baseline and special cross-section surveys, visual inspections, aerial and terrestrial photography, and recording of stages.

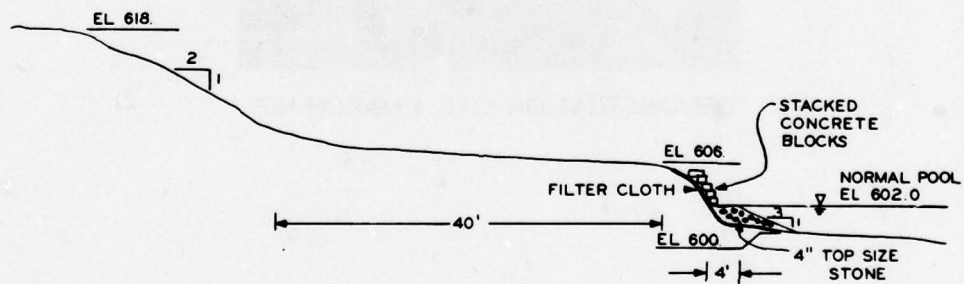
Status. Plans and specifications for the project are scheduled to be completed by August 1978. Construction will start in the summer of 1979.



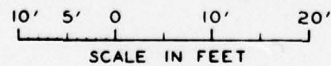
SCHEME A



SCHEME B



SCHEME C



PROTECTION SCHEMES A-C
OHIO RIVER
ST. MARYS, W. VA.

PLATE E11



DEMONSTRATION SITE, 4 MARCH 1977

DEMONSTRATION SITE
OHIO RIVER AT
ST. MARYS, WEST VIRGINIA

PLATE E12

Streambank Erosion Control Evaluation and Demonstration Act of 1974

OHIO RIVER AT RAVENSWOOD, WEST VIRGINIA, DEMONSTRATION PROJECT

Problem. The left bank of the Ohio River at Ravenswood was raw and sloughing large chunks of material in an active condition of failure, and several feet of bank-line recession has been noted during recent years. A public park area was being actively eroded and a public road had been abandoned. Historically, the affected land has been a dumping area for various debris and has a layered soil of fine sand and clay-silt lenses with debris horizons. The banks were steep to nearly vertical in places. An old ferry landing in the middle of the project was in active use.

Protection. At Ravenswood, four schemes are proposed extending along the Ohio River a distance of 1390 ft upstream of Sandy Creek. Also, a 50-ft reach extends along the north bank of Sandy Creek (Plate E13). The schemes are as follows:

- a. The upstream scheme consists of a wooden breakwater fence with reshaping and vegetative cover on the banks (Plate E14, Scheme A). Length of scheme is 407 ft.
- b. The next scheme consists of a stacked arrangement of gabions filled with waste firebrick. The gabions are near normal pool and granular fill at 1V-on-3H slopes tapers from the top of the gabions to the recontoured banks (Plate E14, Scheme B). Length of scheme is 328 ft.
- c. A toe revetment of compacted quarry-run rock fill (two layers of 10- and 8-in. top size) and with granular fill behind the revetment is provided in this scheme. The fill and revetment are covered by 3-in. top-size graded gravel tapered into the upper bank (Plate E14, Scheme C). Length of scheme is 376 ft.
- d. A 3.3-ft-diam Longard tube is provided near normal pool in this scheme located farthest downstream. A backfill tapers from the tube to the regraded slope and the whole scheme has vegetative cover (Plate E14, Scheme D). Length of scheme is 300 ft.

Cost. Total construction cost of the four schemes was \$133,500 or about \$96 per linear foot of bank protection.

Monitoring Program. Primary observations include baseline and site special channel cross-section surveys, visual inspections, aerial and terrestrial photography, and recording of stages.

Status. Construction of the major components of the protection works was completed in late summer 1977. Observations to date indicate that overland flow from the bank is causing gullyng within upper bank areas. The elevation of the breakwater fence is not high enough and wave washing at frequently encountered pools is causing problems (Plate E15). Additionally, the protection of the Longard tube with an acceptable epoxy coating is an outstanding work item.

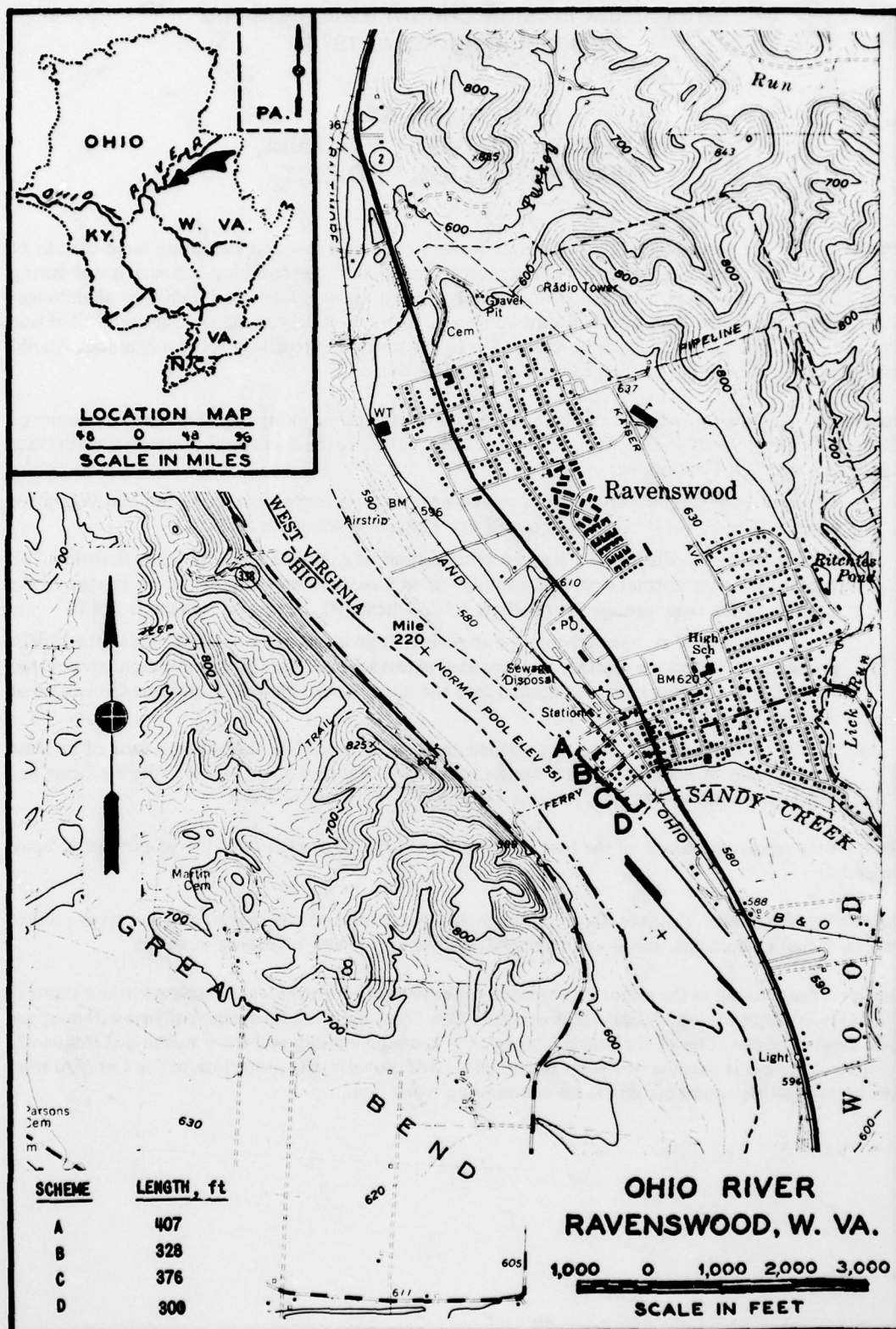


PLATE E13

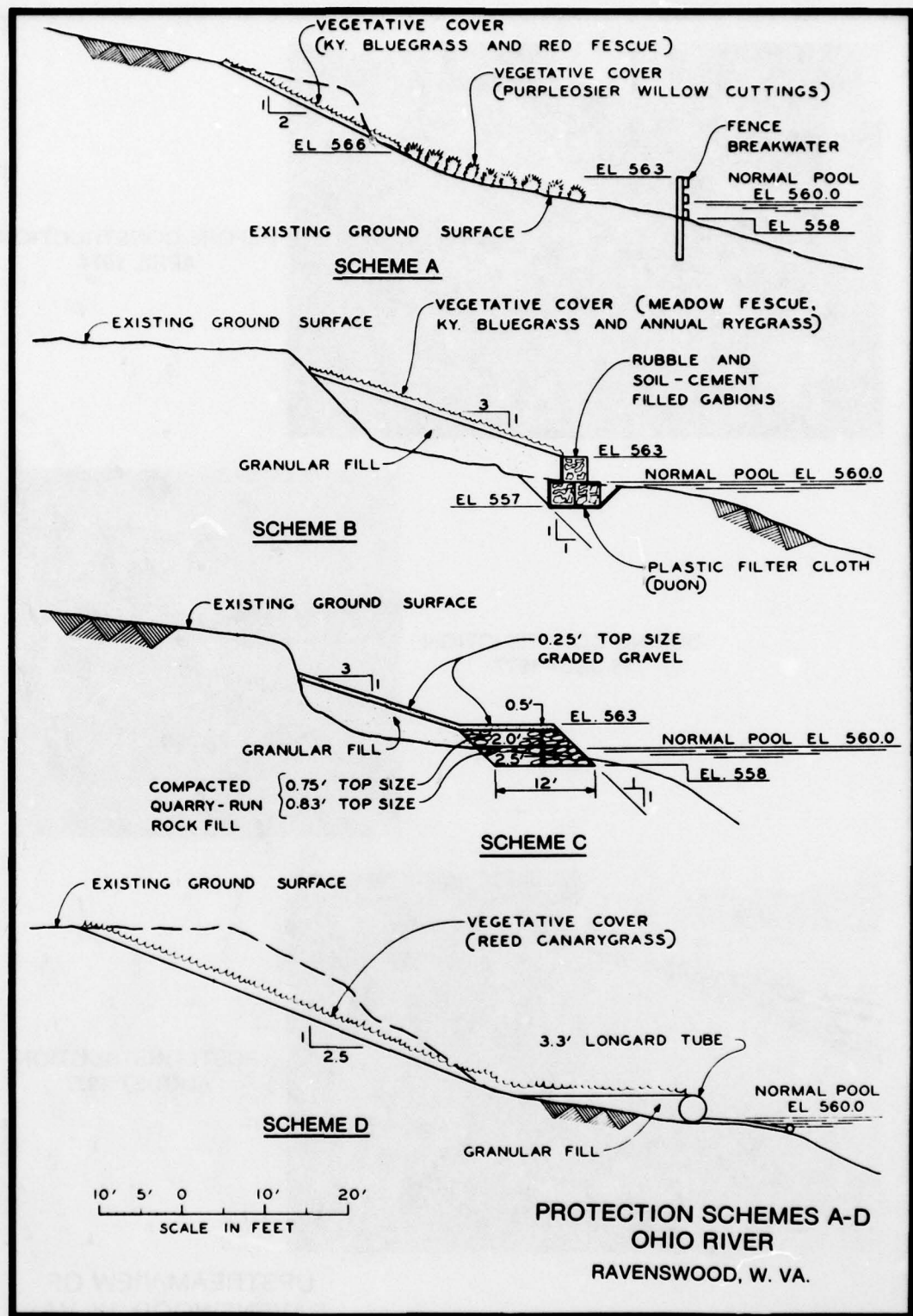


PLATE E14



BEFORE CONSTRUCTION
APRIL 1974



DURING CONSTRUCTION
15 JULY 1977



POSTCONSTRUCTION
AUGUST 1977

UPSTREAM VIEW OF
RAVENSWOOD, W. VA.
DEMONSTRATION SITE

Streambank Erosion Control Evaluation and Demonstration Act of 1974

OHIO RIVER AT PORTSMOUTH, OHIO, DEMONSTRATION PROJECT

Problem. The right bank of the Ohio River upstream of the U. S. Route 23 Bridge (Plate E16) was eroding with resulting detrimental impacts on adjacent city park area developments. The bank area has a history of erosion and various land uses including municipal and industrial waste dumping along the length of the project. As such, the adjacent land and banks contain heterogeneous debris and layered soils consisting of fine sand/clayey silt lenses typical of the Ohio River Valley. More recently, the city has randomly placed demolition debris on the banks, largely by end-dumping and with little selective placement of the material. In this way the project area has evidenced bank deposition, erosion, and slopes that were unstable and raw.

Protection. The project consists of about 1585 ft of bank protection by four protection schemes as follows:

- a. For the scheme farthest downstream, the existing bank was regraded to a maximum slope of 1V on 2H with slag dumped within a trench near the normal pool and the remaining bank covered with vegetation (Plate E17, Scheme A). The length of scheme is 304 ft.
- b. The existing bank was regraded to a maximum slope of 1V on 3H with quarry-run rock protection placed at the face of granular fill prisms stepped up the bank. Revegetation was attempted on the remaining bank (Plate E17, Scheme B). Length of scheme is 372 ft.
- c. The next scheme is a toe of bank revetment constructed of quarry-run rock placed on a soil stabilization mat and revegetation attempted on the upper slope of the bank (Plate E17, Scheme C). Length of scheme is 391 ft.
- d. The final scheme regraded the existing bank to 1V on 3H and spread dumped rock along the lower bank, and revegetation was effected (Plate E17, Scheme D). Length of scheme is 518 ft.

Cost. Total construction cost to date is \$182,200 or \$115 per foot of bank protection.

Monitoring Program. Primary observations include baseline and special channel cross-section surveys, velocity measurements, visual inspections, terrestrial and aerial photographs, and recording of stages.

Status. The basic construction was completed in January 1977 with remedial planting of vegetative cover scheduled for the spring and summer of 1977. At present, the project has remedial work to be completed in the summer of 1978 (Plate E18). The scheduling problems which precluded the planting of vegetative cover on the slopes and drainage-related seepages existing back of bank have caused deterioration of the protective measures. Remedial work scheduled for this summer will address these problems.

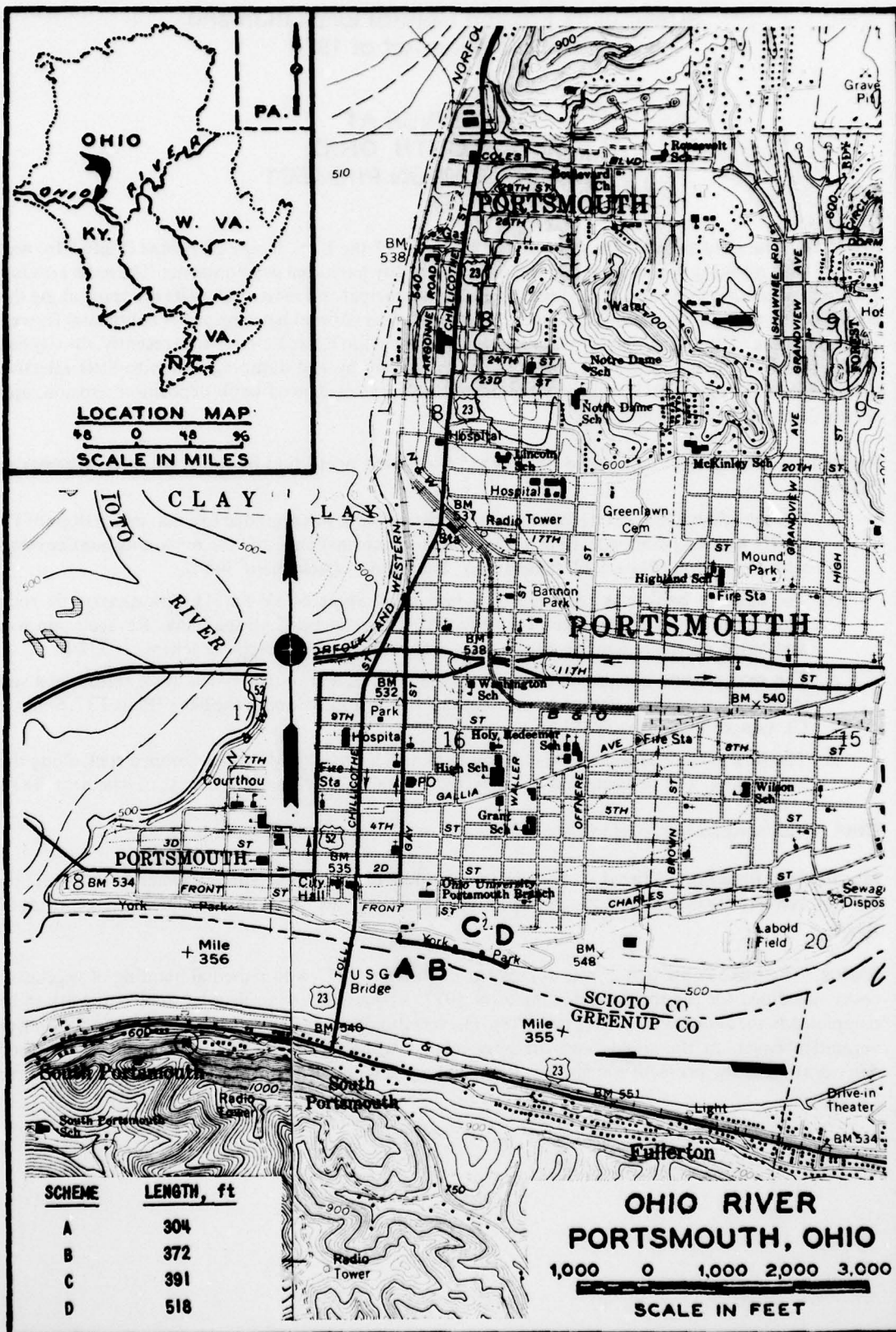
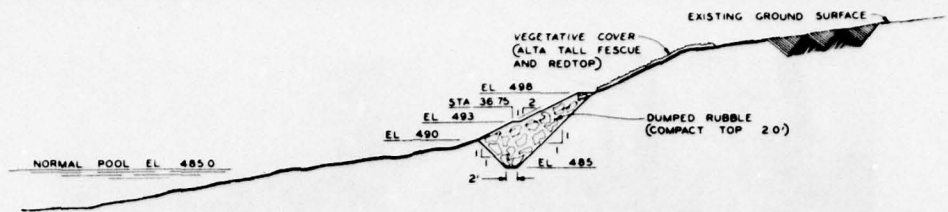
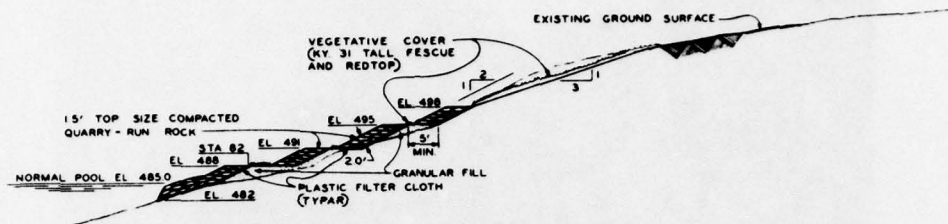


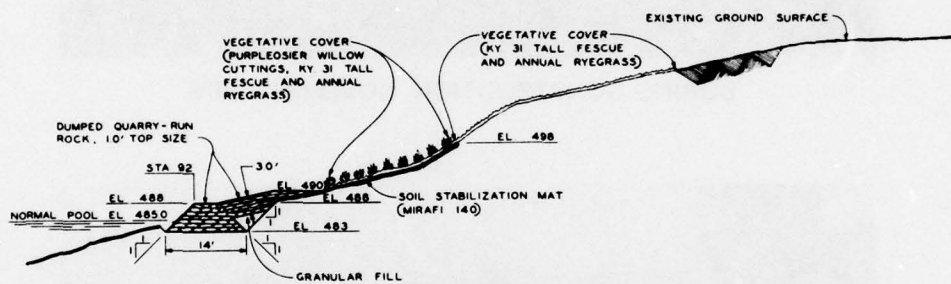
PLATE E16



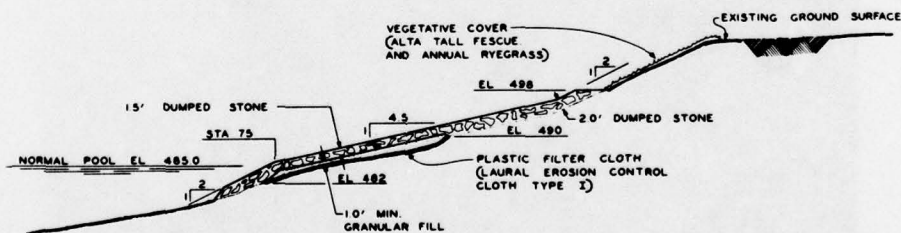
SCHEME A



SCHEME B



SCHEME C



SCHEME D

10' 5' 0' 10' 20'
SCALE IN FEET

PROTECTION SCHEMES A-D
OHIO RIVER
PORTSMOUTH, OHIO

PLATE E17



DURING CONSTRUCTION, NOVEMBER 1976



POSTCONSTRUCTION, APRIL 1977

DEMONSTRATION SITE,
LOOKING UPSTREAM
PORTSMOUTH, OHIO

PLATE E18

Streambank Erosion Control Evaluation and Demonstration Act of 1974

OHIO RIVER AT MOSCOW, OHIO, DEMONSTRATION PROJECT

Problem. The project is located on the right (north) bank of the Ohio River within the Village of Moscow, Ohio, at river mile 442.5 as shown on the location map in Plate E19. Proposed stabilization measures would protect about 650 ft of residential frontage upstream from a 300-ft public wharf area and about 650 ft of residential frontage downstream from the wharf. The wharf area, paved with cobblestones during the last century, is relatively stable. The area of recession is the former site of Water Street and is mostly within the right-of-way of Water Street. In recent years, stone retaining walls built along the land side of this right-of-way have begun to fail due to recession of the riverbank within the right-of-way. The amount of bank recession upstream and downstream from the wharf area appears to be about 50 ft. Since 1970, such measures as riprap, tires, and wood fencing have been used by landowners to stabilize the banks with some measure of success.

Protection. The proposed work would be accomplished in four areas, each using a different type of bank protection. The plan of protection and selected cross sections are shown in Plates E19 and E20. Beginning at the upstream limit of the project, stone riprap toe protection is to be installed up to el 458 (3 ft above normal pool) along 300 ft of shorefront. The shore area between el 458 and the top of bank (about el 485) is to be protected by plantings through woven plastic filter cloth that will secure 4 in. of granular bedding. The next 350 ft of shore would also be protected by a riprap toe up to el 458. The shore area between el 458 and 485 would be protected by plantings through a mesh combining nylon and paper and a 4-in. layer of granular bedding. About 350 ft of riverbank downstream (west) of the wharf area would be protected by a riprap toe up to el 462. The shore area between el 462 and 485 will be protected by selected plantings through Excelsior Erosion Control Mats and a 4-in. layer of granular bedding material. The remaining 300 ft (to the downstream limit of the project) will also be protected by a riprap toe to el 462. The shore area between el 462 and 485 will be protected by selected plantings in mulch over granular bedding material.

Cost. While no bids have been received, the cost of the proposed protection is expected to average about \$150 per linear foot or about \$200,000 including contingencies.

Monitoring Program. Primary observations will include annual cross-section surveys, velocity distribution determinations, wave-height measurements, bimonthly visual inspections, and periodic and special photography.

Status. Plans and specifications are in preparation. The Village has not secured all rights-of-way needed for construction and still needs a permit from the State of Ohio to open an off-site borrow area. The public notice has been issued and no public meeting was requested. Construction is planned for the summer of 1979. A report on the effectiveness of measures employed will be prepared by the end of 1982. Photographs of existing conditions are shown in Plate E21.

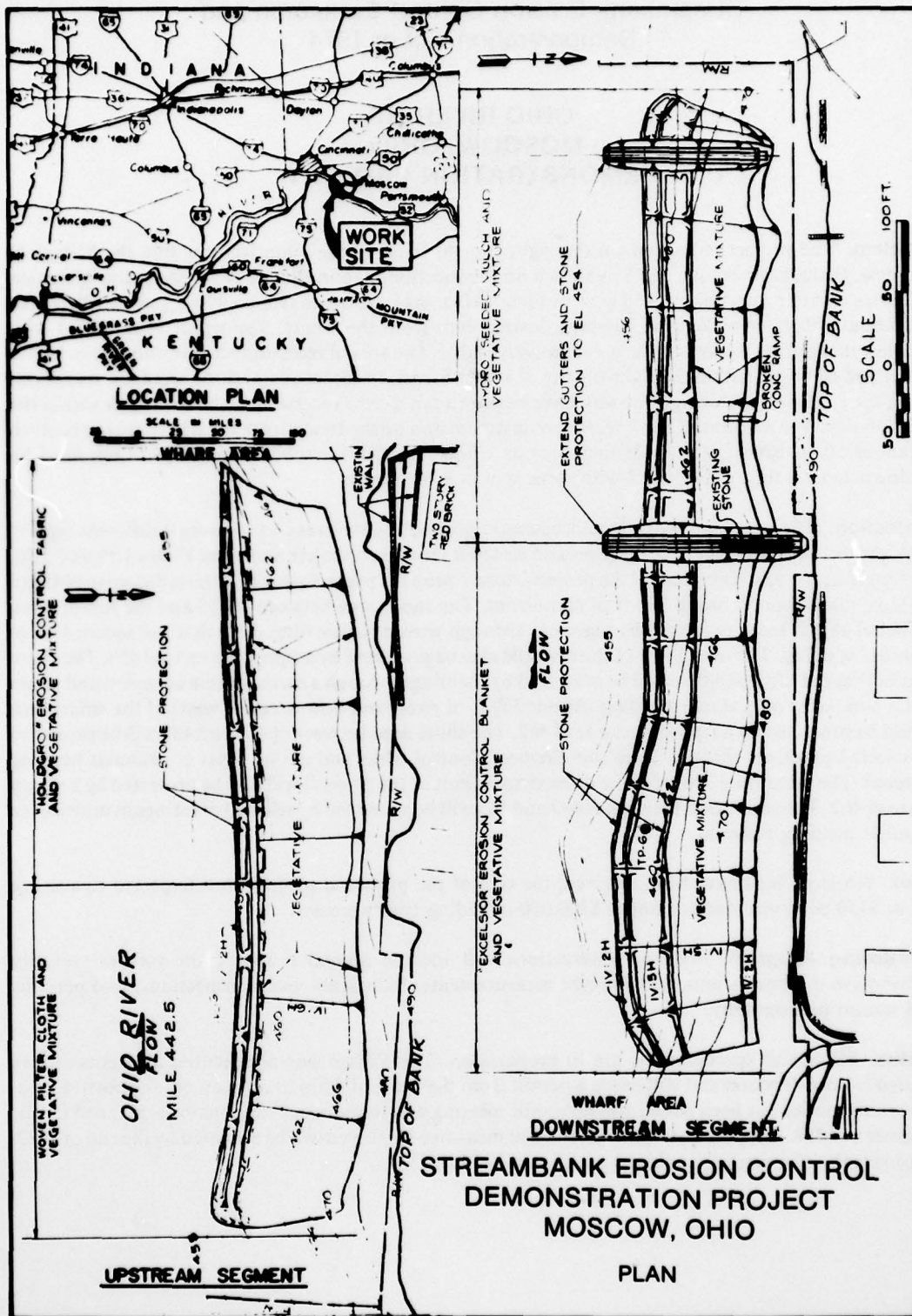


PLATE E19



EXISTING BANK NEAR UPSTREAM LIMIT OF PROJECT. VIEW IS FROM DOWNSTREAM. BANK IS ABOUT 36 FT HIGH AND CHANNEL IS ABOUT 1500 FT WIDE AT THIS POINT. JUNE 1976



ERODED AREA AT DOWNSTREAM LIMIT OF PROJECT. VIEW IS FROM DOWNSTREAM. JUNE 1976

DEMONSTRATION SITE
MOSCOW, OHIO

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**OHIO RIVER AT
MT. VERNON, INDIANA,
DEMONSTRATION PROJECT**

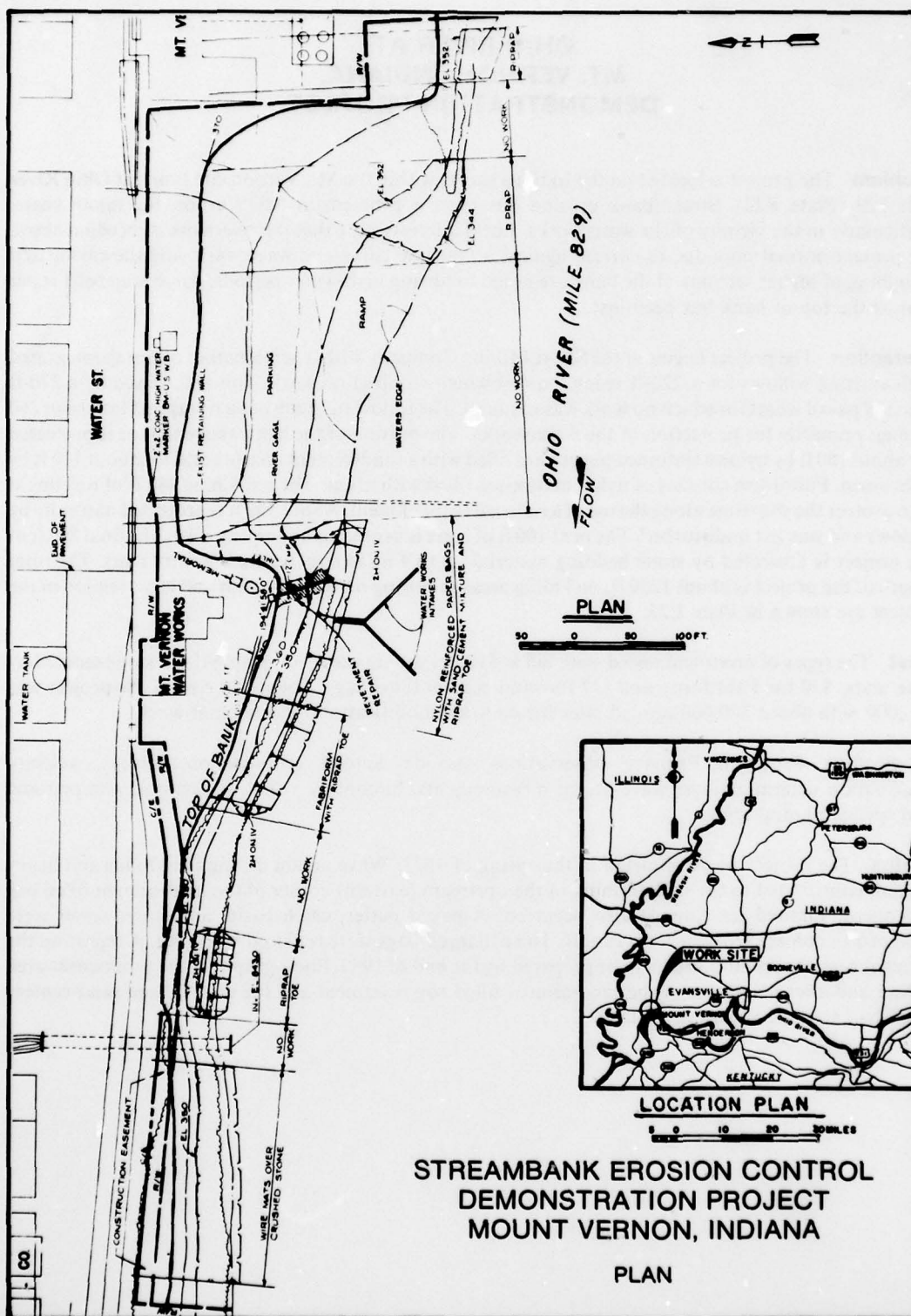
Problem. The project is located on the Indiana shore, within the Mt. Vernon city limits at Ohio River mile 829 (Plate E22). Streambank erosion has been a problem at Mt. Vernon for many years, particularly in the vicinity of the waterworks. Local interests state that the riverbank is receding above the present normal pool due to current against an outside curve and wave wash, and the caving and sloughing of higher sections of the bank are noted following high-water periods. An average of 1 ft per year at the top of bank has been lost.

Protection. The project begins at the Short Milling Company with a combination of riprap integrated with existing willows for a 220-ft reach, part of which required no work. This is followed by a 270-ft reach of paved wharf for which no work was required. The following reach has a riprapped toe about 260 ft long, primarily for protection of the waterworks. The portion of the bank above the toe is protected for about 150 ft by nylon-reinforced paper bags filled with a sand-cement mixture and for about 110 ft by Fabriform. Fabriform consists of nylon mattresses filled with grout. The remaining 440 ft of revetment is to protect the shoreline along the toe of a railroad embankment. About 100 ft is protected naturally by willows and was left undisturbed. The next 100 ft of bank is protected by a riprap dike. The final 200 ft of the project is protected by stone bedding material up to 4 in. in size, secured by wire mats. The total length of the project is about 1250 ft, including areas requiring no work. A plan and cross section of the project are shown in Plate E23.

Cost. The types of revetment tested were bid at \$10 per square yard for riprap, \$10 for stone secured by wire mats, \$30 for Fabriform, and \$17 for sand-cement filled bags. The initial cost of the project was \$70,000 with about \$30,000 needed later for contract modifications and remedial work.

Monitoring Program. Primary observations include annual cross-section surveys, velocity distribution determinations, wave-height measurements, bimonthly visual inspections, and periodic and special photography.

Status. The project was completed in the spring of 1977. Wave action during two floods and heavy rainfall contributed to the undermining of the upstream (eastern) corner of the sand-cement filled bag revetment. Limited ice damage also occurred. A paved gutter, catch basin, and storm sewer were designed to control erosive storm runoff. The collapsed bags were replaced by riprap. A report on the effectiveness of measures used will be prepared by the end of 1980. Photographs of the waterworks area before and after placement of the sand-cement filled bag revetment and the undermined sand-cement filled bag area are shown in Plate E24.



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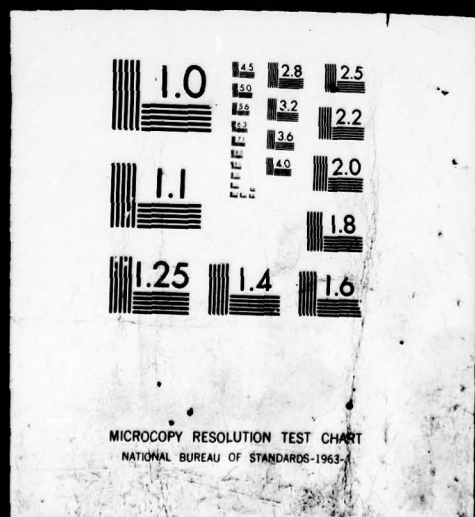
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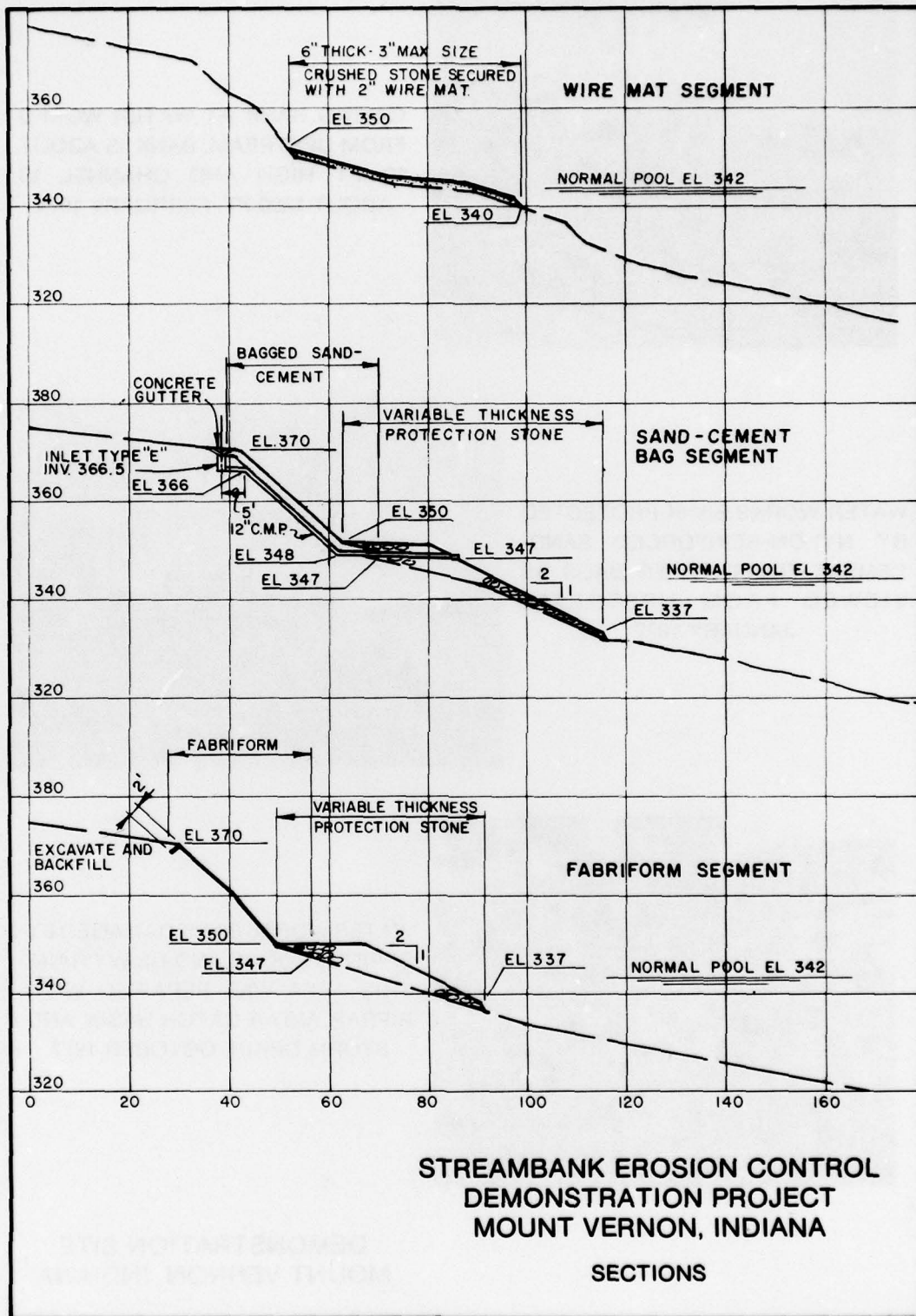
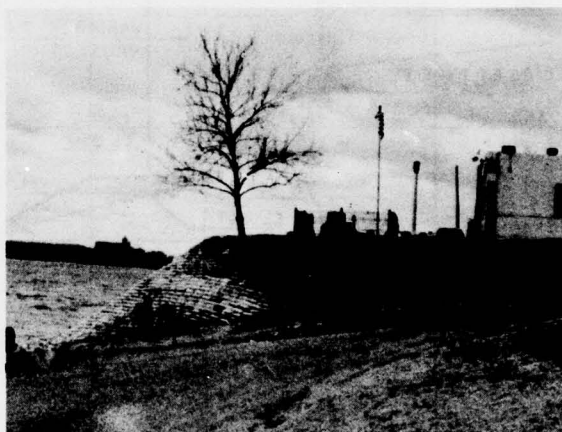


PLATE E23



CAVING BANK AT WATER WORKS
FROM UPSTREAM. BANK IS ABOUT
30 FT HIGH AND CHANNEL IS
ABOUT 1900 FT. FEBRUARY 1974

WATER WORKS BANK PROTECTED
BY NYLON-REINFORCED SAND-
CEMENT FILLED PAPER BAGS AS
VIEWED FROM UPSTREAM.
JANUARY 1977



WATER WORKS BANK DAMAGED BY
SPRING FLOODS AND HEAVY RAIN.
THIS AREA WAS REPAIRED WITH
RIPRAP AND A CATCH BASIN AND
STORM DRAIN. OCTOBER 1977

DEMONSTRATION SITE
MOUNT VERNON, INDIANA

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**KANAWHA RIVER AT
SOUTH CHARLESTON, WEST VIRGINIA,
DEMONSTRATION PROJECT**

Problem. Erosion and slumping of debris and soil along the left bank for about a 4-mile reach is affecting residential, commercial, and city properties, sewer outfalls, and local streets. The bank is about 25 ft high with an existing slope of 1V on 1.5H. Nearly vertical failure planes of 1 to 2 ft occur throughout the slope.

Protection. The designed protection consists of four schemes for 1550 ft along the bank (Plates E25 and E27).

- a. The upstream scheme consists of toe protection comprised of a mat of used tires connected with welded chain placed on filter cloth. The chain and connectors include corrosion protection. The slopes will be selectively graded to 1V on 2H and vegetation reestablished (Plate E26, Scheme A). The length of the scheme is 480 ft.
- b. The adjacent scheme will have soil-cement filled burlap bags stacked near the toe and downslope below the normal pool. Above this protection is a soil-cement revetment with a riverward slope of 1V on 2H and underlain by a filter cloth. The existing slope above the revetment will not be regraded (Plate E26, Scheme B). Length of scheme is 300 ft.
- c. The next scheme consists of a floating tire breakwater anchored by concrete deadmen. The existing bank slope will be revegetated (Plate E26, Scheme C). Length of scheme is 470 ft.
- d. The downstream scheme will use a wedge-shaped section of 5-in. top-size rock at the toe of the bank and will have a riverward slope of 1V on 2H to 1V on 3H. The upper bank will be revegetated (Plate E26, Scheme D). Length of scheme is 300 ft.

Cost. Total estimated construction cost is \$190,000 or \$123 per linear foot of protection.

Monitoring Program. Primary observations include baseline and special channel cross-section surveys, visual inspections, aerial and terrestrial photography, and nearby recording of stages.

Status. The project has the necessary plans and specifications complete plus the local assurances; however, sufficient funds to complete the project are not available. Additional first construction costs and necessary remedial work, resulting from unusual adverse weather conditions during construction at Portsmouth and Ravenswood, plus reach of riverbank erosion studies, inspections, technical testing, assistance, and report updates have resulted in the expenditure of funds initially allocated for completion of South Charleston protection project.

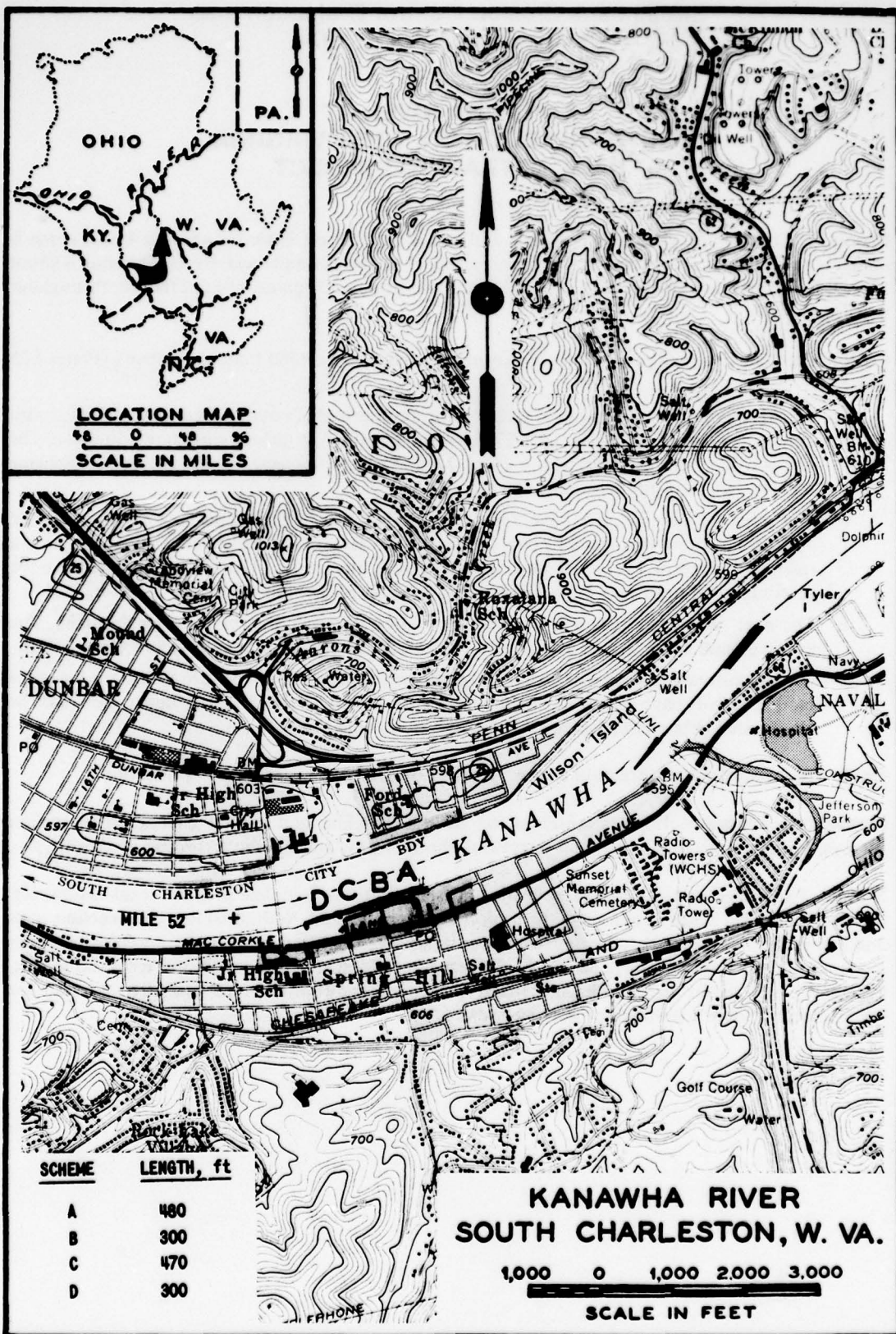


PLATE E25

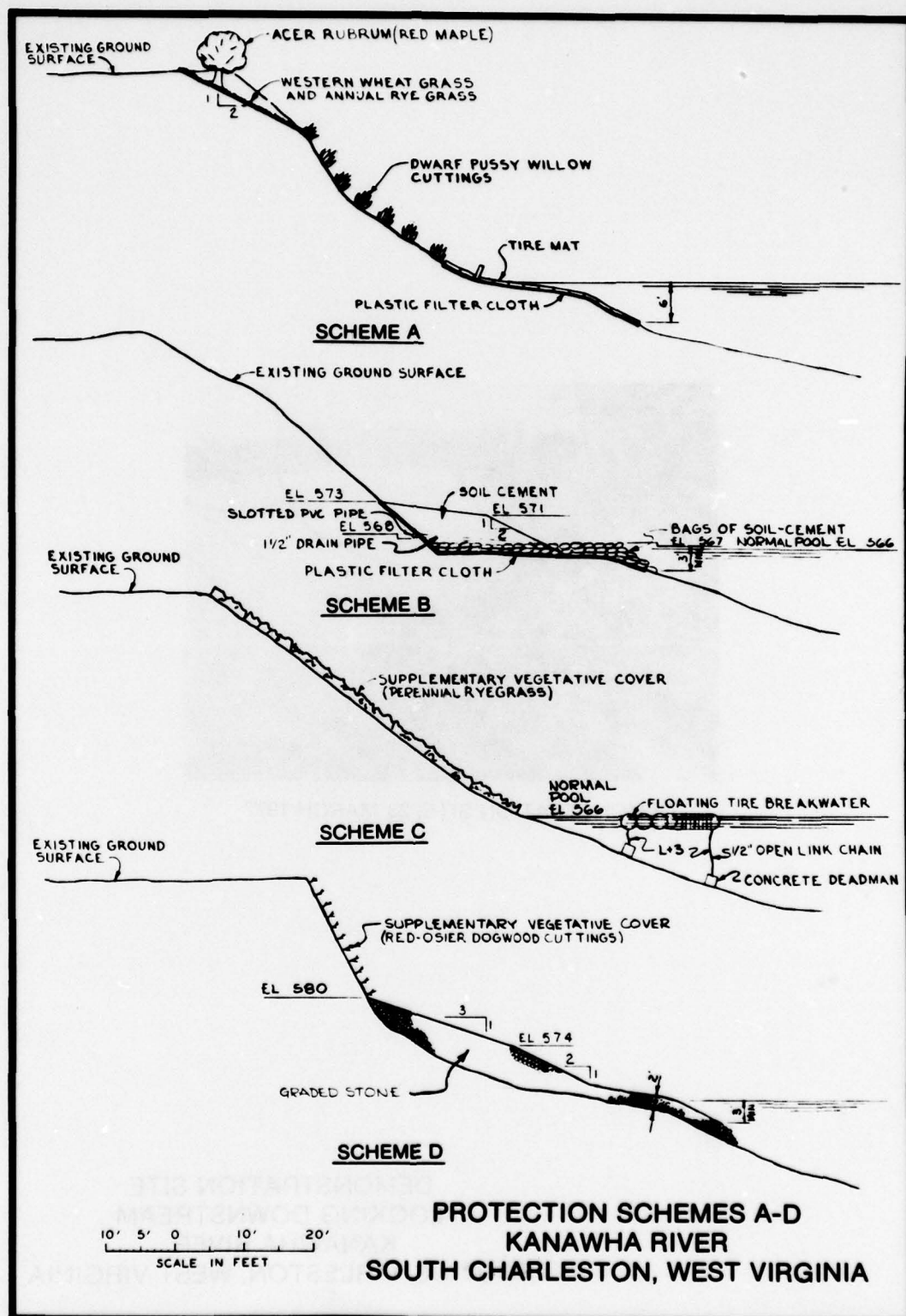


PLATE E26



DEMONSTRATION SITE, 23 MARCH 1977

DEMONSTRATION SITE
LOOKING DOWNSTREAM
KANAWHA RIVER,
SOUTH CHARLESTON, WEST VIRGINIA

PLATE E27

Streambank Erosion Control Evaluation and Demonstration Act of 1974

LITTLE MIAMI RIVER AT MILFORD, OHIO, DEMONSTRATION PROJECT

Problem. The Village of Milford, Ohio, is approximately 10 miles east of Cincinnati. Milford lies along both banks of the Little Miami River about 12 miles upstream from its mouth on the Ohio and about 1 mile upstream from its confluence with the East Fork of the Little Miami River as shown on the location map in Plate E28. The critical caving bank area on the left (east) bank is composed of thick deposits of permeable sand and gravel underlying relatively thin layers of fine sand and clay. The area of erosion is about 800 ft long and 75 ft high. Erosion has taken an alley and a sanitary sewer line. The sanitary sewer line has since been relocated about 50 ft away from the bank. The purpose of the project is to prevent the bank from eroding further and endangering private property, including garages, houses, and the relocated sewer.

Protection. The proposed work is to be accomplished in three sections. Two types of revetment, gabions and concrete cribbing, would be placed on a riprap dike which will provide a foundation. The riprap dike would be about 8 ft high and extend the length of the project. Its top surface would be above ordinary high water. Beginning at the upstream limit of the project, a riprap bank 10 ft high will extend for about 200 ft. About 500 ft of concrete cribwall, 10 ft high, would follow. As shown on the plans, the top of cribwall is at el 510, the 5-year flood level. Following the concrete cribwall segment would be 300 ft of gabion walls extending to the downstream limit of the project. The selection of gabions and cribwall was meant to present a rustic appearance consistent with Ohio's scenic river designation for this portion of the Little Miami River. Plan and cross sections are shown in Plates E28 and E29. Fill is to be placed behind the revetment by the Village to provide a uniform slope to the top of bank.

Cost. Preliminary cost estimates indicate that the 1,000 ft of rock dike, averaging about 8 ft in height, will cost about \$100 per linear foot or about \$20 per cubic yard. The 300 ft of gabions, averaging 10 ft in height, would cost about \$200 per linear foot or \$100 per cubic yard. The 500 ft of concrete cribwall, averaging 10 ft in height, would cost about \$300 per linear foot or about \$100 per cubic yard. Total cost of the project has been estimated at \$650,000 including engineering, monitoring, and reporting.

Monitoring Program. Primary observations will include annual cross-section surveys, velocity distribution determinations, bimonthly visual inspections, and periodic and special photography.

Status. Plans and specifications are in preparation. All necessary rights-of-way have been obtained. Construction is planned for the fall of 1978. A report on the effectiveness of measures employed will be prepared by the end of 1981. Photographs of existing conditions are shown in Plate E30.

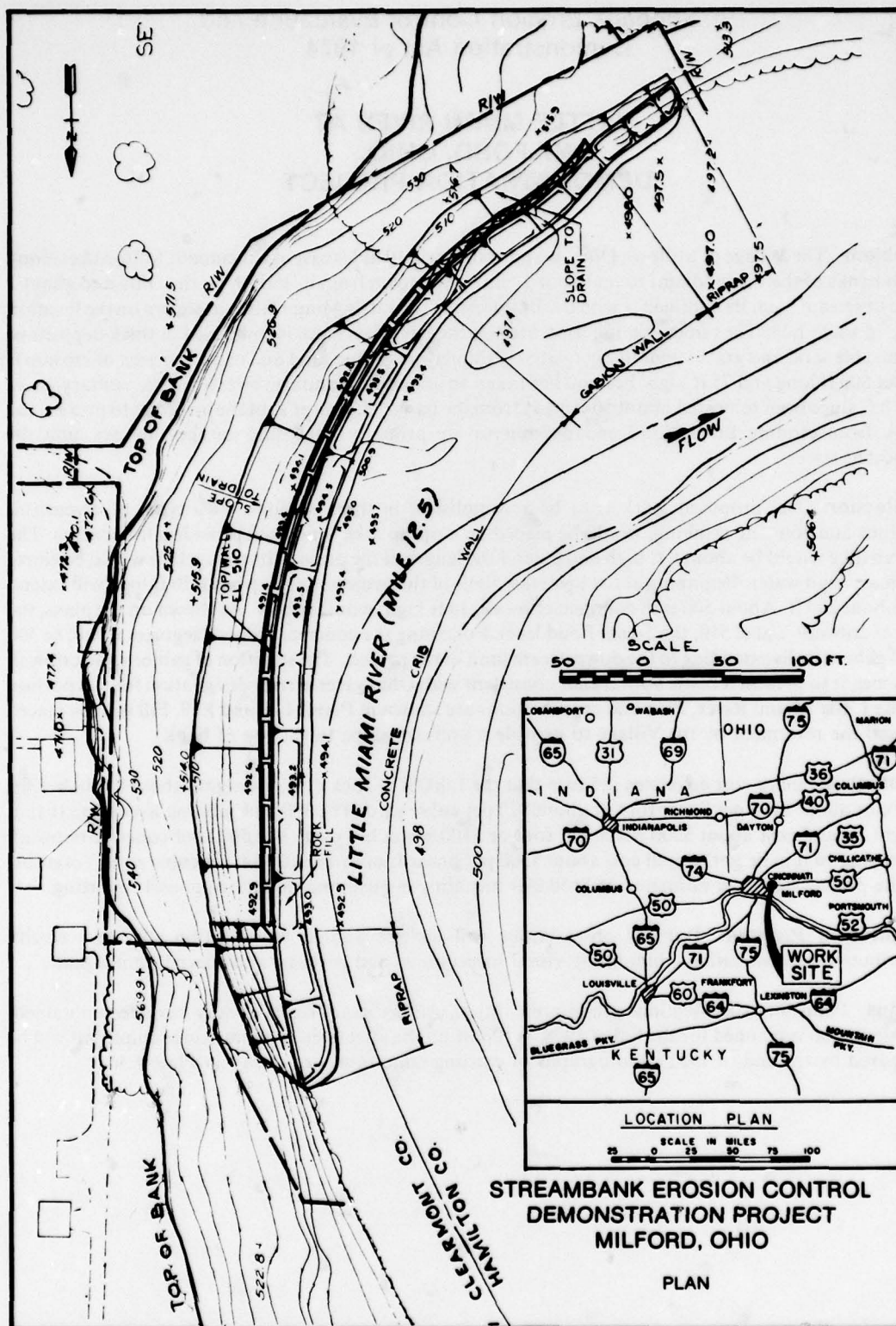
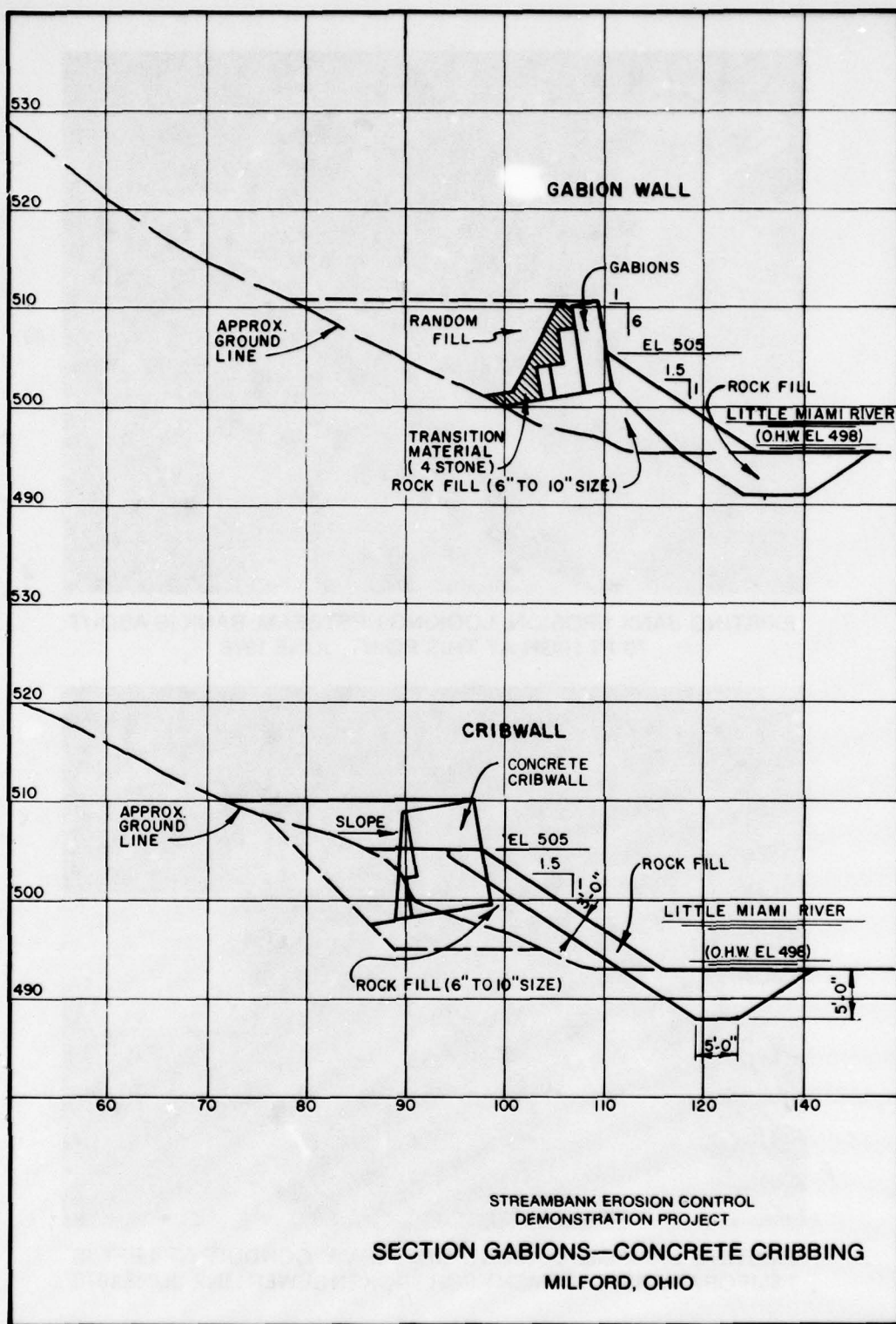


PLATE E28



STREAMBANK EROSION CONTROL
DEMONSTRATION PROJECT
SECTION GABIONS—CONCRETE CRIBBING
MILFORD, OHIO

PLATE E29



EXISTING BANK EROSION, LOOKING UPSTREAM. BANK IS ABOUT
70 FT HIGH AT THIS POINT. JUNE 1976



EXISTING DAMAGE, LOOKING UPSTREAM. CONDUIT AT LEFT IS
TEMPORARY REPLACEMENT FOR BROKEN SEWER LINE. JUNE 1976

DEMONSTRATION SITE
MILFORD, OHIO

PLATE E30

APPENDIX F

**Missouri River Demonstration Projects
(Work Unit 6)**

APPENDIX F

Missouri River Demonstration Projects (Work Unit 6)

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FY 78 Missouri River Demonstration Projects	
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Lewis & Clark 4-H Camp Area, McLean County, North Dakota (Mile 1357.5)	F35
Sunshine Bottom Area, Boyd County, Nebraska (Mile 868.5)	F36
Goat Island Area, Yankton County, South Dakota (Mile 796.5)	F37
Ionia Bend Area, Dixon County, Nebraska (Mile 761.0)	F38
Plates F19-F23	
*Mulberry Point, Nebraska (Mile 775.0)	

* Summary description not provided in this report. Project sponsor and location and construction schedules not yet established.

FUNDED PROJECTS IN NORTH DAKOTA

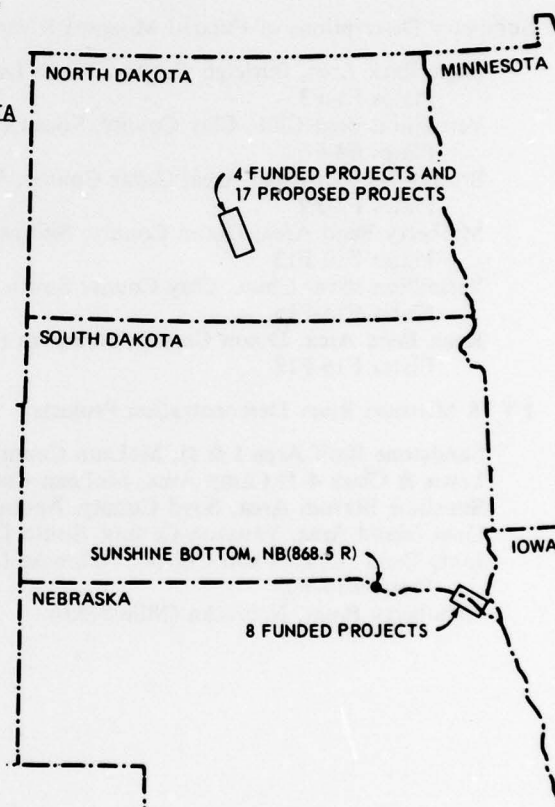
1. SANDSTONE BLUFF I, ND (1368.0 L)*
2. SANDSTONE BLUFF II, ND (1366.5 L)
3. LEWIS AND CLARK 4-H CAMP, ND (1357.5 L)
4. EAGLE PARK, ND (1323.0 L)

FUNDED PROJECTS IN NEBRASKA AND SOUTH DAKOTA

1. SUNSHINE BOTTOM, NB (868.5 R)
2. GOAT ISLAND, SD (796.5 L)
3. VERMILLION BOAT CLUB, SD (786.0 L)
4. BROOKY BOTTOM RD., NB (784.0 R)
5. MULBERRY POINT, SD (777.0 L)
6. MULBERRY BEND, NB (775.0 R)
7. VERMILLION RIVER CHUTE, SD (771.0 L)
8. RYAN BEND, NB (767.0 R)
9. IONIA, NB (761.0 R)

PROPOSED PROJECTS (UNFUNDED)

1. HANCOCK, ND (1385.0 R)
2. KNIFE POINT II, ND (1379.5 R)
3. KNIFE POINT I, ND (1374.0 L)
4. COAL LAKE COULEE, ND (1360.0 L)
5. WILDWOOD, ND (1345.2 L)
6. SANGER, ND (1345.0 R)
7. PRETTY POINT, ND (1343.5 R)
8. PRICE I, ND (1341.0 R)
9. PRICE II, ND (1388.5 R)
10. WOGANSPOUT, ND (1335.7 L)
11. HORSEHOE BUTTE, ND (1334.5 R)
12. INDIAN MOUND, ND (1326.5 L)
13. BURNT CREEK, ND (1320.5 L)
14. I-94 HWY, ND (1316.5 R)
15. PIONEER PARK, ND (1316.5 L)
16. FT. LINCOLN, ND (1311.0 R)
17. CUSTER FLATS, ND (1310.0 R)



* RIVER MILE AND BANK LOCATION (EITHER LEFT OR RIGHT BANK LOOKING DOWNSTREAM) ARE SHOWN IN PARENTHESES.

Figure F1. Locations of Missouri River Demonstration Projects (Work Unit 6)

APPENDIX F

Status of Missouri River Demonstration Projects (Work Unit 6)

Thirty demonstration projects have been programmed for construction on the Missouri River: twenty-one below Garrison Dam in North Dakota, one below Fort Randall Dam in Nebraska, and eight between Gavins Point Dam, Nebraska, and Ponca, Nebraska (Figure F1). Demonstration projects at all the sites specifically authorized by Congress to date have been programmed. Six demonstration projects on the Missouri River, one below Garrison Dam, and five below Gavins Point Dam have either been completed or are presently under construction. Construction is scheduled to begin on six more in FY 78: three below Garrison Dam in North Dakota, one below Fort Randall Dam in Nebraska, and two below Gavins Point Dam in Nebraska and South Dakota. The remainder of the presently programmed demonstration projects on the Missouri River will be constructed during FY 79, FY 80, and FY 81. A table of pertinent information, including funding status, on each project (Table F1) and detailed descriptions of several funded projects are included in this appendix.

The objective of the Missouri River demonstration projects is to achieve bank protection with low-cost techniques that are compatible with the environment of the natural river. Protective works are placed along the existing high bank lines, leaving the river channel free to meander within the vegetated sandbar areas between high banks. All work is being coordinated with Federal and State fish and wildlife agencies in attempts to arrive at mutually acceptable construction techniques, and techniques employed to date are gaining acceptance from those individuals who have observed them in the field. Specific objectional features noted by the agencies have been minimal; however, they continue to reserve judgment until completion of the monitoring period. Techniques used to date include: (a) windrow revetment (both buried and surface); (b) underwater tree retards spaced intermittently on eroding banks; (c) use of low-grade material (chalk); (d) intermittent hard points; (e) composite revetment—various combinations of underwater toe protection and upper bank protection. Design details aim at making the structures as inconspicuous as possible, either by keeping them at low elevations or by covering them with earth and vegetation.

An Environmental Impact Statement was prepared for proposed demonstration projects along the open river reaches of the Missouri River in the States of Montana, North Dakota, South Dakota, and Nebraska. This document was filed with the Environmental Protection Agency (EPA) on 1 June 1978. Demonstration projects constructed prior to this date were determined to have a negligible environmental impact, resulting in a minor effects assessment. All works constructed under the Section 32 Program are also subject to review by individuals and interested agencies under the Section 404 Permit Program.

Coordination with local, State, and Federal agencies has been an ongoing process since inception of the program in the Missouri River Basin. Formal and informal contacts have been made with these groups to explain the program and seek their input. The State Water Commission is the sponsoring agency for demonstration sites in North Dakota, the adjacent Natural Resource District in Nebraska, and local county commissions in South Dakota.

Detailed monitoring and evaluation plans are prepared for all demonstration sites. These plans include monitoring both the physical and environmental aspects of the projects, and will continue until completion of the program. The U. S. Fish and Wildlife Service is also evaluating the projects under the provisions of the Fish and Wildlife Coordination Act (see Appendix I).

TABLE F1: SUMMARY OF PERTINENT INFORMATION ON DEMONSTRATION PROJECTS
Missouri River (Work Unit 6)

Stream, Mile, & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
Missouri R. 1385.0 Right	Hancock	Stanton	Mercer	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Revetment
Missouri R. 1379.5 Right	Knife Pt. II	Stanton	Mercer	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1374.0 Left	Knife Pt. I	Stanton	Mercer	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1368.0 Left	Sandstone Bluff I	Washburn	McLean	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment, flow-control structure
Missouri R. 1366.5 Left	Sandstone Bluff II	Washburn	McLean	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment, flow-control structure
Missouri R. 1360.0 Left	Coal Lake Coulee	Washburn	McLean	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points
Missouri R. 1357.5 Left	Levis & Clark 4-H Camp	Washburn	McLean	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment
Missouri R. 1345.2 Left	Wildwood	Washburn	McLean	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points
Missouri R. 1345.0 Right	Sanger	Center	Oliver	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1343.5 Right	Pretty Point	Center	Oliver	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1341.0 Right	Price I	Center	Oliver	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1338.5 Right	Price II	Center	Oliver	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points
Missouri R. 1335.7 Left	Wogansport	Bismarck	Burleigh	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points
Missouri R. 1334.5 Right	Horseshoe Butte	Center	Oliver	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points and revetment
Missouri R. 1326.5 Left	Indian Mound	Bismarck	Burleigh	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Flow-control structure
Missouri R. 1323.0 Left	Eagle Park	Bismarck	Burleigh	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard point, tree retards, composite and window revetment
Missouri R. 1320.5 Left	Burnt Creek	Bismarck	Burleigh	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points
Missouri R. 1316.5 Right	I-94 Hwy	Mandan	Morton	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Revetment
Missouri R. 1316.5 Left	Pioneer Park	Bismarck	Burleigh	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Flow-control structure
Missouri R. 1311.0 Right	Ft. Lincoln	Mandan	Morton	ND-1	Omaha NE	Extend periods of high volume flow producing high velocities	Revetment

Missouri River (Work Unit 6) (Continued)

Stream, Mile, & Side	Project Length ft	Funding in \$1000		Allocated thru FY 78	Expended as of 3/31/78	Status	Remarks
		Est Costs Construc- tion	Engr, Monitor & Reporting				
Missouri R. 1385.0 Right	3,500	69.0	23.0	None	None	Scheduled FY 81	
Missouri R. 1379.5 Right	5,200	281.0	89.0	None	None	Scheduled FY 79	
Missouri R. 1374.0 Left	7,800	294.0	93.0	None	None	Scheduled FY 80	
Missouri R. 1368.0 Left	9,500	390.0	123.0	200.0	5.0	Scheduled FY 78	
Missouri R. 1366.5 Left	9,800	430.0	135.0	202.0	None	Scheduled FY 78	
Missouri R. 1360.0 Left	7,000	88.0	28.0	None	None	Scheduled FY 79	
Missouri R. 1357.5 Left	5,600	271.0	85.0	329.0	5.0	Scheduled FY 78	
Missouri R. 1345.2 Left	7,000	91.0	28.0	None	None	Scheduled FY 81	
Missouri R. 1345.0 Right	2,700	145.0	45.0	None	None	Scheduled FY 79	
Missouri R. 1343.5 Right	7,000	384.0	120.0	None	None	Scheduled FY 80	
Missouri R. 1341.0 Right	17,400	537.0	169.0	None	None	Scheduled FY 81	
Missouri R. 1338.5 Right	5,500	69.0	24.0	None	None	Scheduled FY 79	
Missouri R. 1335.7 Left	3,000	305.0	96.0	None	None	Scheduled FY 81	
Missouri R. 1334.5 Right	9,700	283.0	89.0	None	None	Scheduled FY 81	
Missouri R. 1326.5 Left	3,000	40.0	13.0	None	None	Scheduled FY 81	
Missouri R. 1323.0 Left	11,000	367.0	109.0	446.0	415.0	Construction complete	
Missouri R. 1320.5 Left	7,500	90.0	28.0	None	None	Scheduled FY 79	
Missouri 1316.5 Right	8,000	626.0	196.0	None	None	Scheduled FY 79	
Missouri 1316.5 Left	3,500	100.0	32.0	None	None	Scheduled FY 81	
Missouri 1311.0 Right	4,000	355.0	112.0	None	None	Scheduled FY 79	

(Sheet 1 of 2)

Missouri River (Work Unit 6) (Concluded)

Stream, Mile, & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
Missouri R. 1310.0 Right	Custer Flats	Mandan	Morton	ND-1	Omaha NE	Extended periods of high volume flow producing high velocities	Revetment
Missouri R. 868.5 Right	Sunshine Bottom	Butte	Boyd	NE-1	Omaha NE	Extended periods of high volume flow producing high velocities	Revetment
Missouri R. 796.5 Left	Goat Island	Yankton	Yankton	SD-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment
Missouri R. 784.0 Left	Vermillion Boat Club	Vermillion	Clay	SD-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment
Missouri R. 784.0 Right	Brookly Bottom Road	Hartington	Cedar	NE-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, composite and windrow revetment
Missouri R. 777.0 Left	Mulberry Pt.	Vermillion	Clay	SD-1	Omaha NE	Extended periods of high volume flow producing high velocities	Flow-control structure
Missouri R. 775.0 Right	Mulberry Bend	Ponca	Dixon	NE-1	Omaha NE	Extended periods of high volume flow producing high velocities	Earth-fill revetment
Missouri R. 771.0 Left	Vermillion River Chute	Vermillion	Clay	SD-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, vane dike
Missouri R. 767.0 Right	Ryan Bend	Ponca	Dixon	NE-1	Omaha NE	Extended periods of high volume flow producing high velocities	Reinforced revetment
Missouri R. 761.0 Right	Ionia Bend	Ponca	Dixon	NE-1	Omaha NE	Extended periods of high volume flow producing high velocities	Hard points, revetment

Missouri River (Work Unit 6) (Concluded)

Stream, Mile, & Side	Project Length ft	Funding in \$1000				Status	Remarks
		Est Costs	Engr, Monitor & Reporting	Allocated thru FY 78	Expended as of 3/31/78		
Missouri R. 1310.0 Right	3,000	121.0	39.0	None	None	Scheduled FY 80	
Missouri R. 868.5 Right	3,000	212.0	67.0	258.0	5.0	Project to be constructed FY 78	
Missouri R. 796.5 Left	10,500	757.0	238.0	920.0	5.0	Scheduled FY 78	
Missouri R. 784.0 Left	16,800	216.0	63.0	263.0	25.0	Construction to be complete FY 78	
Missouri R. 784.0 Right	16,800	288.0	91.0	350.0	346.0	Construction complete	
Missouri R. 777.0 Left	7,500	274.0	90.0	333.0	None	Contract terminated	New contract to be awarded
Missouri R. 775.0 Right	7,900	185.0	58.0	225.0	35.0	Project to be completed FY 78	
Missouri R. 771.0 Left	15,900	367.0	111.0	446.0	375.0	Project to be completed FY 78	
Missouri R. 767.0 Right	15,800	214.0	62.0	260.0	5.0	Project to be constructed FY 78	
Missouri R. 761.0 Right	6,000	426.0	134.0	518.0	5.0	Project to be constructed FY 78	

Streambank Erosion Control Evaluation and Demonstration Act of 1974

MISSOURI RIVER AT EAGLE PARK AREA, BURLEIGH COUNTY, NORTH DAKOTA, DEMONSTRATION PROJECT

Problem. This left bank area is located at river mile 1323. In recent years, there has been a major change of flow patterns through this wide, split-channel reach. Erosion evaluations indicated that over 300 acres of mixed cropland and timber were being threatened by erosion rates as high as 10 acres per bank-line mile per year (Plate F3). Several dwellings, private recreational improvements, and irrigation facilities were also endangered.

Protection. Erosion control demonstrations included variation of composite revetment, windrow revetment, hard points, and tree retards (Plates F1 and F2). This report discusses composite revetment and tree retards which were the predominant techniques used. The other two types of protection used are discussed in detail in the Vermillion River Chute and Brooky Bottom Road Area Demonstration Project reports. Composite revetment has three distinct zones where stresses and thus material requirements differ for each zone. The toe zone located below normal low water is subject to river current erosion. This zone is seldom exposed to freeze-thaw or wet-dry action; therefore lower grade material can be used. The splash zone is located between normal high and low water. This is the zone of highest stress; thus it requires stronger, more durable materials. The bank zone, located above normal high water, is continually exposed to weathering, wave wash, ice, and debris. Various treatments were used including vegetation, clay, and gravel cover to give the bank a beachlike appearance. Each tree retard structure consists of one or more trees 30 to 40 ft in length placed horizontally in the river, perpendicular to the bank, and securely anchored. The branched portion should act as a net for collection of debris and sediment, thus causing sandbars to form between the structures. The bars, in turn, should shield the bank from erosion.

Cost. Cost to construct 11,000 linear feet of bank-line protection was \$367,000, or approximately \$35 per bank foot. Composite revetment totaled 2,200 ft in length, protecting approximately 3,000 ft of the 11,000 ft of bank line, at a cost of \$120,000.

Monitoring Program. The monitoring program is divided up into five major subprograms: PHYSICAL FEATURES—channel cross sections, bank-line surveys, and velocity measurements; MATERIAL TESTING—bank, streambed, and construction materials; PHOTOGRAPHY—aerial obliques and controlled vertical, ground-level and videotape; BIOLOGICAL—evaluation of project effects on riparian and aquatic habitat; REVIEW—field inspections, data analyses, and reports.

Status. Construction was largely completed by November 1977. Monitoring will continue through 1981. Presently, all revetment structures and hard points are operational. Tree retard function is marginal and will be reevaluated.

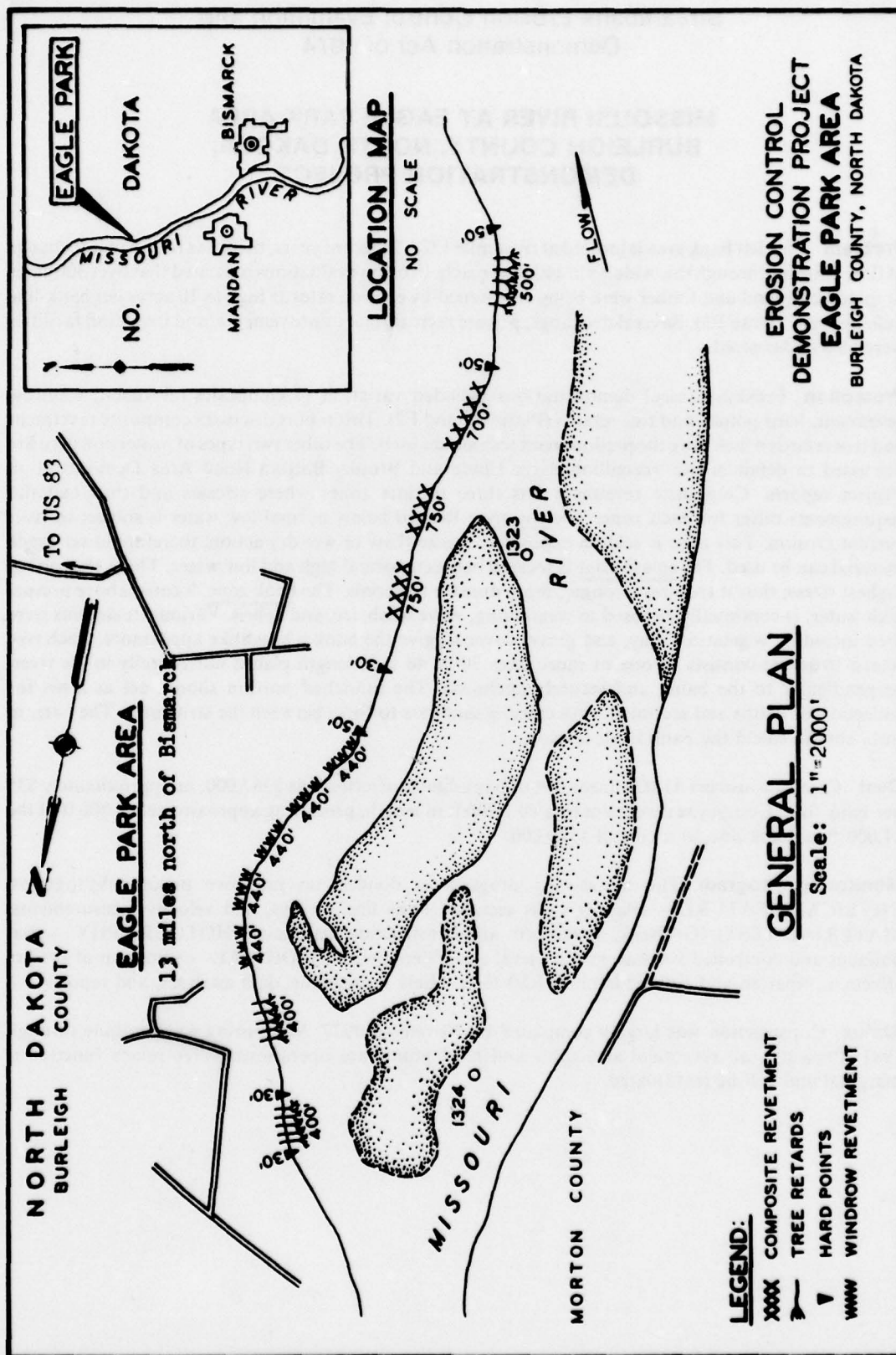
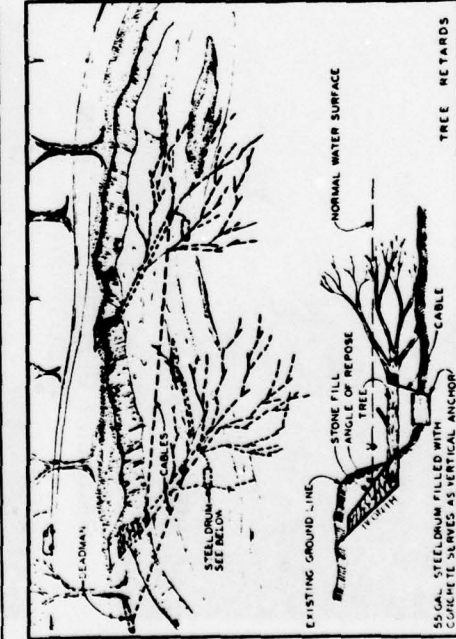
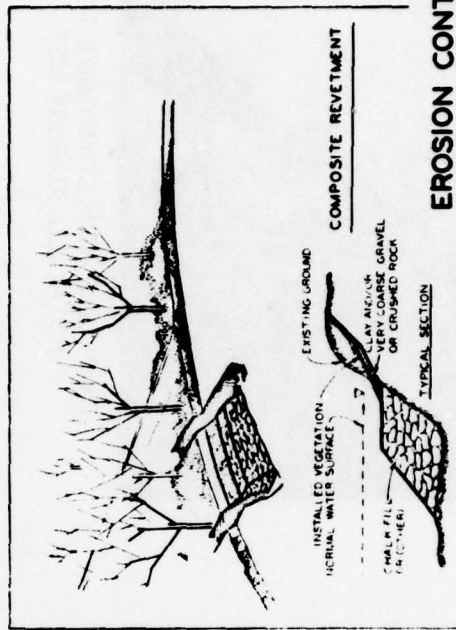


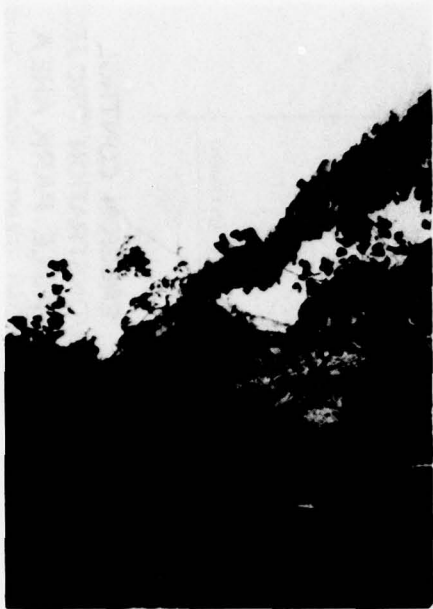
PLATE F1



**EROSION CONTROL
DEMONSTRATION PROJECT
EAGLE PARK AREA
BURLEIGH COUNTY, NORTH DAKOTA**



BANK LINE BEFORE PROTECTION,
AUGUST 1977



BANK LINE WITH COMPOSITE TOE
INSTALLED, AUGUST 1977



BANK LINE WITH COMPOSITE REVETMENT
INSTALLED, SEPTEMBER 1977

EROSION CONTROL
DEMONSTRATION PROJECT
EAGLE PARK AREA
BURLEIGH COUNTY, NORTH DAKOTA

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**MISSOURI RIVER AT VERMILLION BOAT CLUB,
CLAY COUNTY, SOUTH DAKOTA,
DEMONSTRATION PROJECT**

Problem. This area is located along the left bank between river miles 786 and 782. The eroding lands are 80 percent agricultural and 20 percent timber, with substantial private recreational development, including cabins, boat docks, and park areas. The average erosion rate is 10 acres per bank-line mile per year.

Protection. The demonstration consists of multiple variations of composite revetment and hard-point erosion control structures (Plate F4). Composite revetment, described below, is the predominant technique used at this site. Composite revetment is also discussed in the Eagle Park Area report. Hard-point details are discussed in the Brooky Bottom Road Area report. Composite revetment features the use of locally available, low-grade chalk for the bulk of the structure underwater toe. Thus the chalk is seldom exposed to destructive freeze-thaw and wet-dry cycles, or to ice and debris. The second major composite revetment feature is the use of minimum elevation for upper bank paving, which consists of a thin gravel blanket placed on a gentle slope to give a natural beachlike appearance (Plate F5).

Cost. Total estimated construction cost is \$216,000. Construction will protect approximately 16,800 linear feet of bank line, with two thirds of this bank line being protected by composite revetment.

Monitoring Program. The monitoring program is divided into five major subprograms: **PHYSICAL FEATURES**—channel cross sections, bank-line surveys, and velocity measurements; **MATERIAL TESTING**—bank, streambed, and construction materials; **PHOTOGRAPHY**—aerial oblique and controlled vertical, ground-level and videotape; **BIOLOGICAL**—evaluation of project effects on riparian and aquatic habitat; **REVIEW**—field inspections, data analyses, and reports. Plate F6 shows photographs of the site.

Status. Construction began in January 1978 and was anticipated to be completed by July 1978. Monitoring will continue, tentatively, through 1981. A performance evaluation will be made of the project, utilizing all field data obtained, after completion of the monitoring schedule.

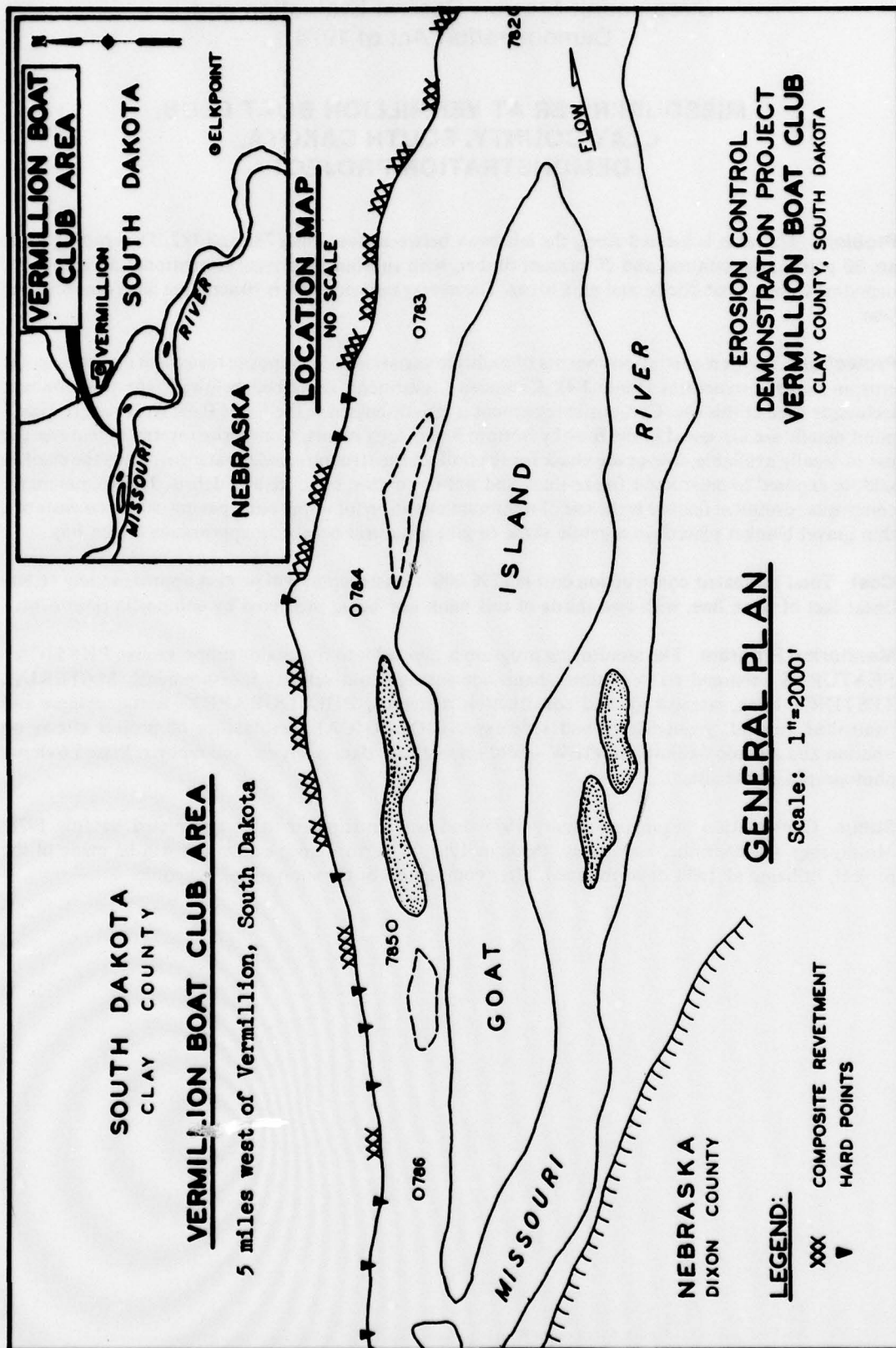
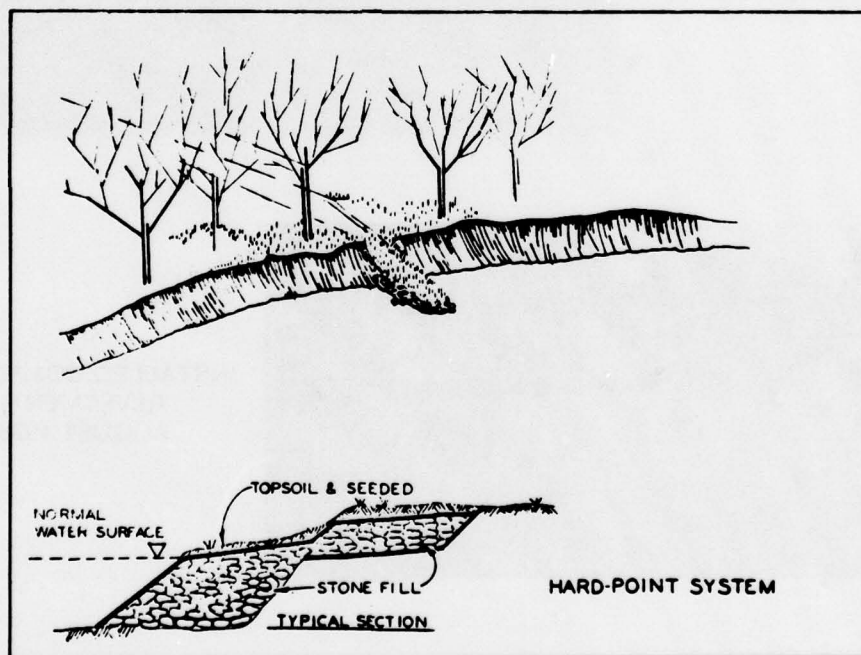
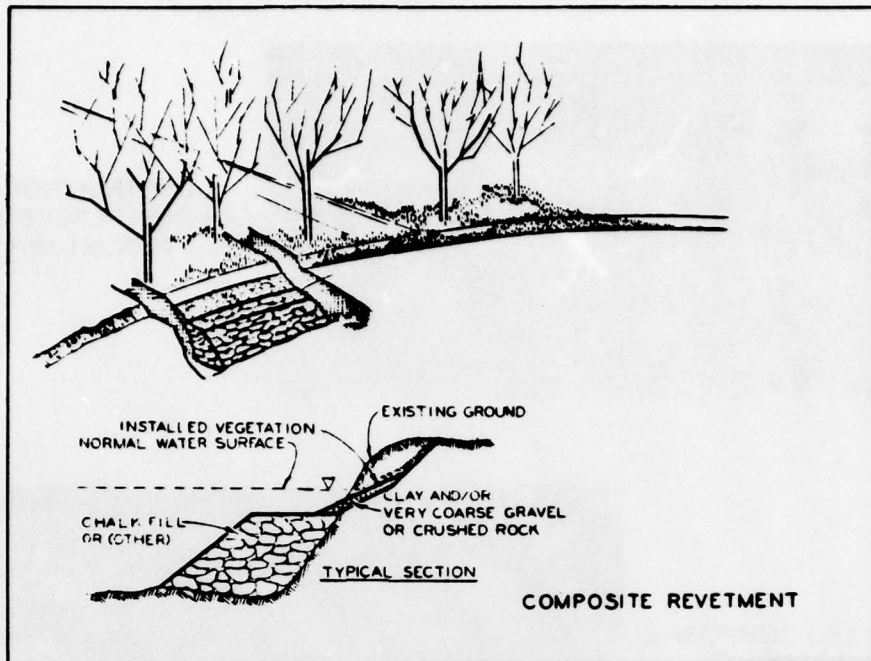
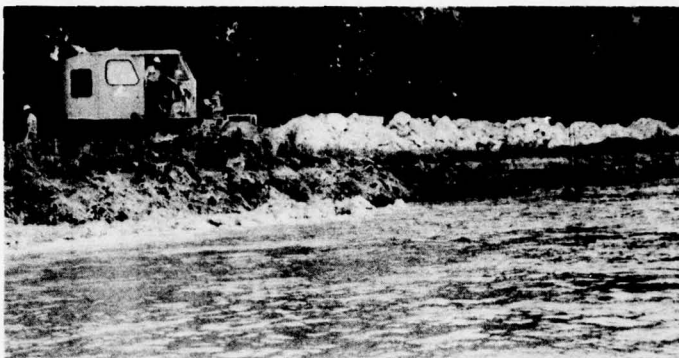


PLATE F4



EROSION CONTROL
VERMILLION BOAT CLUB
CLAY COUNTY, SOUTH DAKOTA

PLATE F5



CONSTRUCTION OF
COMPOSITE REVETMENT,
AUGUST 1978



INSTALLED COMPOSITE
REVETMENT,
AUGUST 1978



INSTALLED COMPOSITE
REVETMENT,
AUGUST 1978

EROSION CONTROL
VERMILLION BOAT CLUB
CLAY COUNTY, SOUTH DAKOTA

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**MISSOURI RIVER AT BROOKY BOTTOM ROAD AREA,
CEDAR COUNTY, NEBRASKA,
DEMONSTRATION PROJECT**

Problem. The project is on the right bank between river miles 786 and 783. This river reach is straight, with split channel flows occupying chutes on both sides of a large island. Major flows shift periodically from chute to chute, causing severe erosion along the banks of the more active chute. Erosion rates of 13 acres per mile per year were destroying prime cropland and timber. Extensive private developments, a county road, power lines, and telephone lines were endangered (Plate F9).

Protection. The project included variations of hard points, composite revetment, and windrow revetment (Plates F7 and F8). Hard points were the predominant technique and are discussed below. Windrow and composite revetment are discussed in detail under Vermillion River Chute and Eagle Park Area Demonstration Project reports. Each hard point consists of a stone point protruding into the river 30 to 50 ft and a massive stone root buried in the bank 30 to 50 ft to prevent flanking. Theoretically, the riverbank between hard points will scallop back to some point of equilibrium and erosion will then cease. For testing purposes, hard points were spaced at different intervals and constructed to various sections and orientations. Small back-eddies or quiet, deepwater pools should form downstream of each hard-point structure, which should provide excellent aquatic habitat and fishing opportunity as a supplemental benefit to erosion control.

Cost. Construction cost to protect 16,800 linear feet of bank line amounted to \$288,000. These totals include 14 hard-point structures, which protect 8,900 ft of bank line at a cost of \$46,000.

Monitoring Program. The monitoring program is divided into 5 major subprograms: PHYSICAL FEATURES—channel cross sections, bank-line surveys, and velocity measurements; MATERIAL TESTING—bank, streambed, and construction materials; PHOTOGRAPHY—aerial oblique and controlled vertical, ground-level and videotape; BIOLOGICAL—evaluation of project effects on riparian and aquatic habitat; REVIEW—field inspections, data analyses, and reports.

Status. Construction was completed in August 1977. Monitoring will continue through 1981. After completion of the monitoring program, a performance evaluation will be made utilizing all the obtained data. All structures presently are functioning as expected.

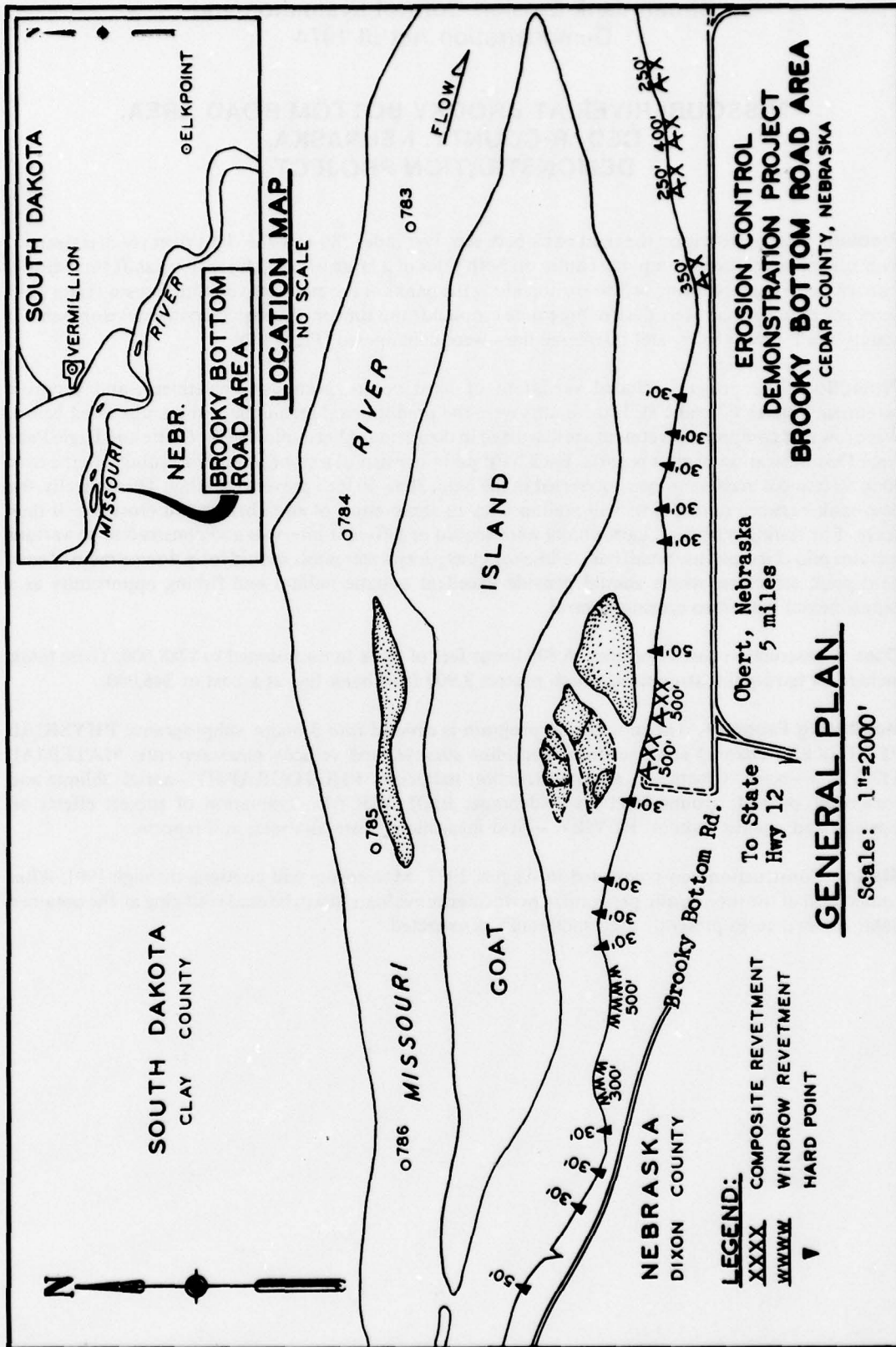
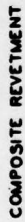
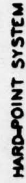


PLATE F7

CEDAR COUNTY, NEBRASKA





**BANK LINE BEFORE PROTECTION,
AUGUST 1977**



**BANK LINE WITH HARD POINT
INSTALLED, DECEMBER 1977**

**EROSION CONTROL
DEMONSTRATION PROJECT
BROOKY BOTTOM ROAD AREA
CEDAR COUNTY, NEBRASKA**

Streambank Erosion Control Evaluation and Demonstration Act of 1974

MISSOURI RIVER AT MULBERRY BEND AREA, DIXON COUNTY, NEBRASKA, DEMONSTRATION PROJECT

Problem. This area is located along the right bank between river miles 776 and 775. Approximately 1-1/2 miles of bank line was eroding at an average rate of 17 acres per mile per year. A 1500-ft segment of a county road and a farmstead are in imminent danger. The rapid downstream erosion migration of this bend poses a long-term threat to several thousand acres of prime cropland and timber.

Protection. Three types of erosion control structures (earth-fill revetment, vane dikes, and composite revetment) were designed for this project (Plates F10 and F11). Earth-fill revetment and the vane dikes are discussed below. Composite revetment is discussed in detail under Vermillion River Chute and Eagle Park Demonstration Project reports. Earth-fill revetment consists of sand- or earth-filled embankment protected by a combination of erosion-resistant materials, including stone, gravel, and vegetation. In addition to erosion control, this type of structure creates a river-connected, slack backwater that is ideal for aquatic habitat. The vane dike is a low-elevation fill of stone or lower grade material that holds the high-velocity, erosive flows away from the banks and accumulates sedimentation on the landward side. However, the flow is allowed to course both ends and overtop the structure to create and preserve environmentally desirable shallow, braided channels.

Cost. Estimated construction cost for this project is \$185,000, which will protect 7900 linear feet of bank line. Of the total, the vane dike and earth-filled revetment will shield about 4000 ft of bank line at a cost of \$100,000.

Monitoring Program. The monitoring program is divided into five major subprograms: PHYSICAL FEATURES—channel cross sections, bank-line surveys, and velocity measurements; MATERIAL TESTING—bank, streambed, and construction materials; PHOTOGRAPHY—aerial oblique and controlled vertical, ground-level and videotape; BIOLOGICAL—evaluation of project effects on riparian and aquatic habitat; REVIEW—field inspections, data analyses, and reports. Plate F12 shows photographs of the site.

Status. Construction began in September 1977. The project was scheduled for completion in June 1978. Monitoring will continue through 1981. After completion of the monitoring program, a performance evaluation will be made utilizing all of the obtained data.

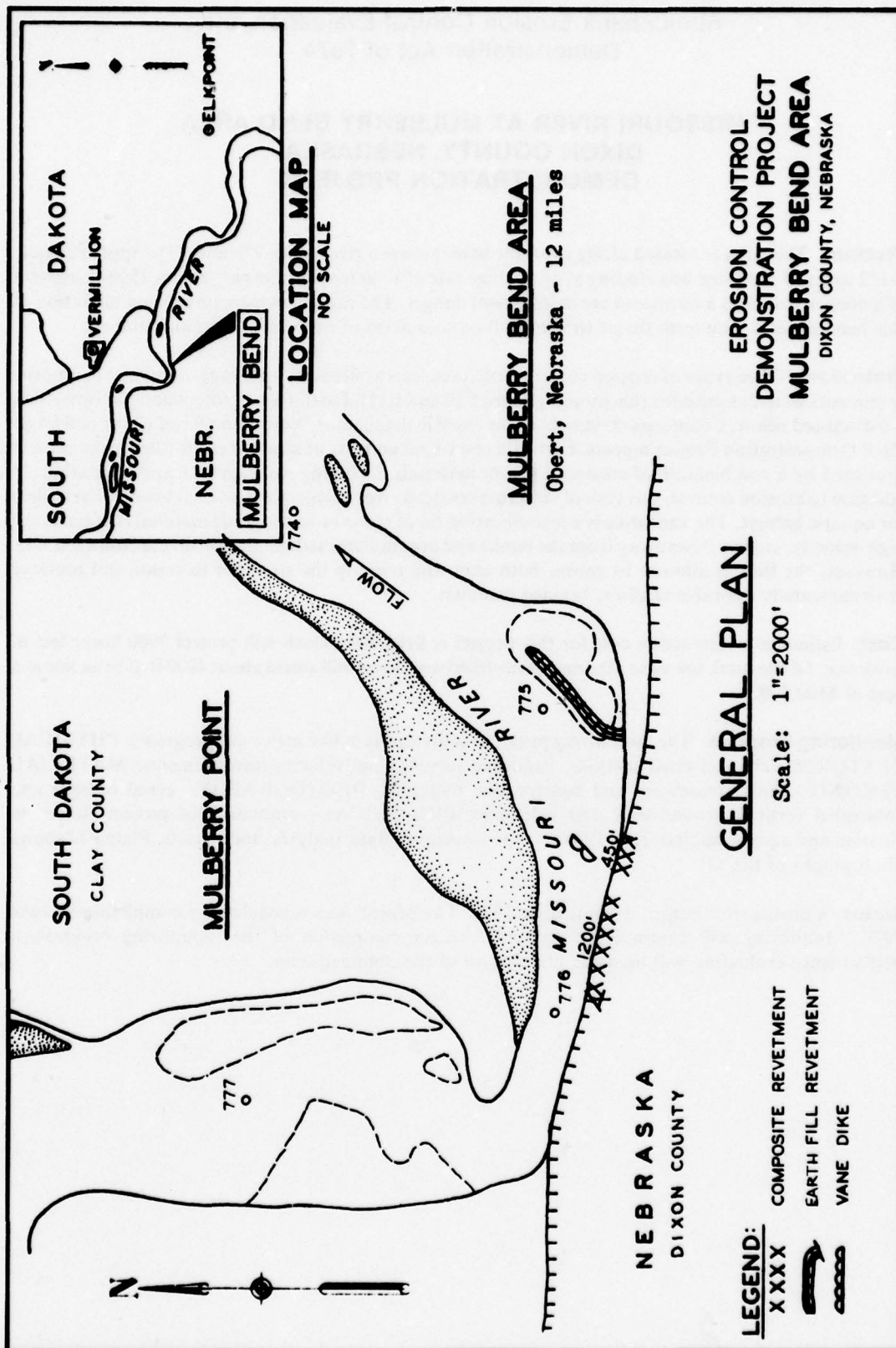
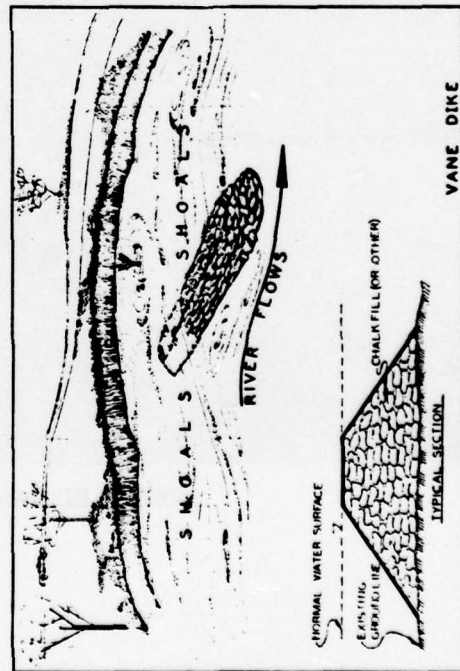
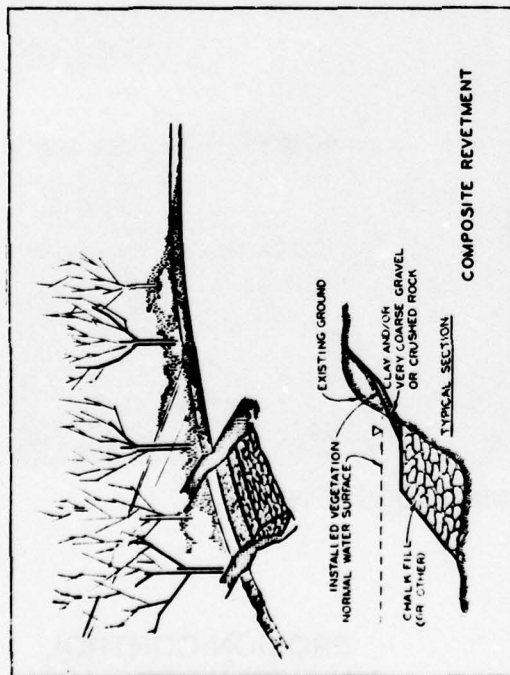
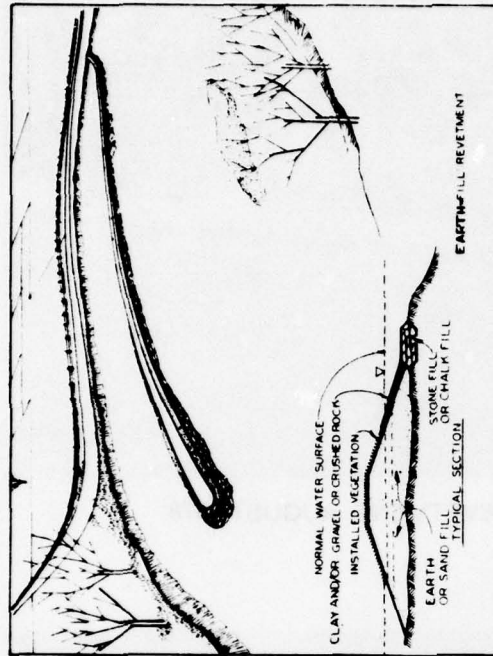
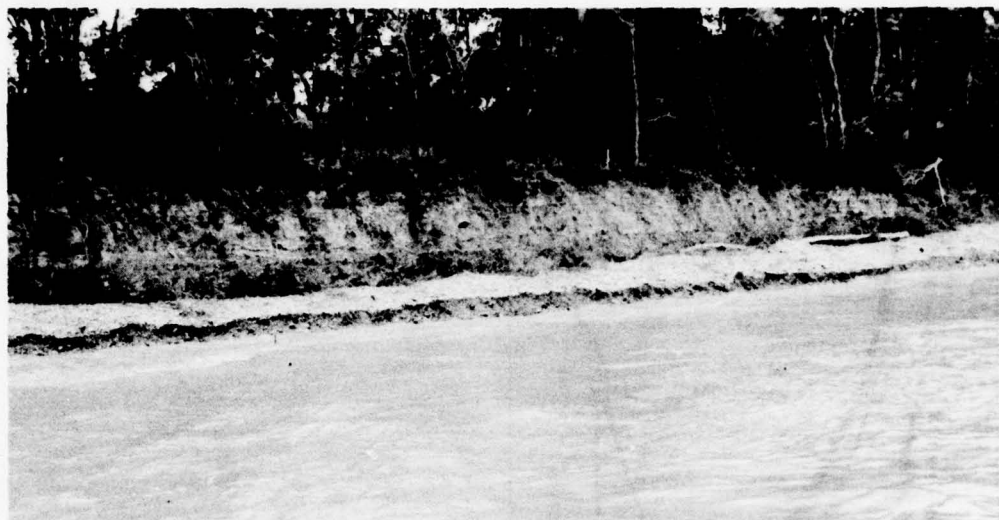


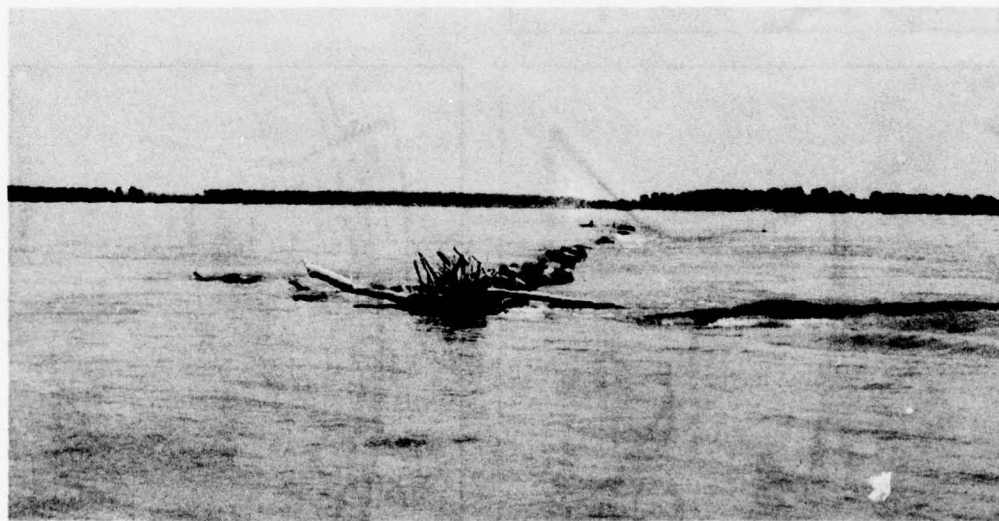
PLATE F10



EROSION CONTROL
DEMONSTRATION PROJECT
MULBERRY BEND AREA
DIXON COUNTY, NEBRASKA



INSTALLED COMPOSITE REVETMENT, AUGUST 1978



INSTALLED VANE DIKE, AUGUST 1978

EROSION CONTROL
MULBERRY BEND AREA
DIXON COUNTY, NEBRASKA

Streambank Erosion Control Evaluation and Demonstration Act of 1974

MISSOURI RIVER AT VERMILLION RIVER CHUTE, CLAY COUNTY, SOUTH DAKOTA, DEMONSTRATION PROJECT

Problem. The project is on the left bank between river miles 772 and 769.5. During the last 8 years, the entire river shifted into a previously minor shallow chute, which expanded from 100 ft wide to over 600 ft wide, with channel depths exceeding 20 ft. This flow concentration caused tremendous erosion along both the island and mainland banks of the chute. A considerable section of a county road was destroyed, along with several hundred acres of mixed cropland, pasture, and timberland. An extensive residential/recreational area was also imperiled. The erosion rate averaged 12 acres per bank-line mile per year (Plate F15).

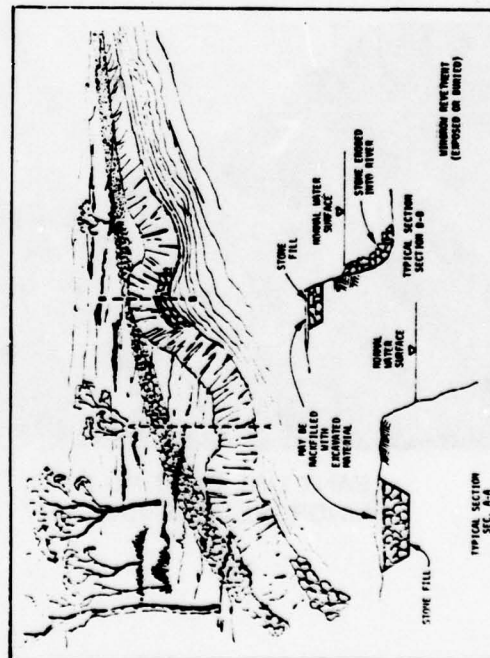
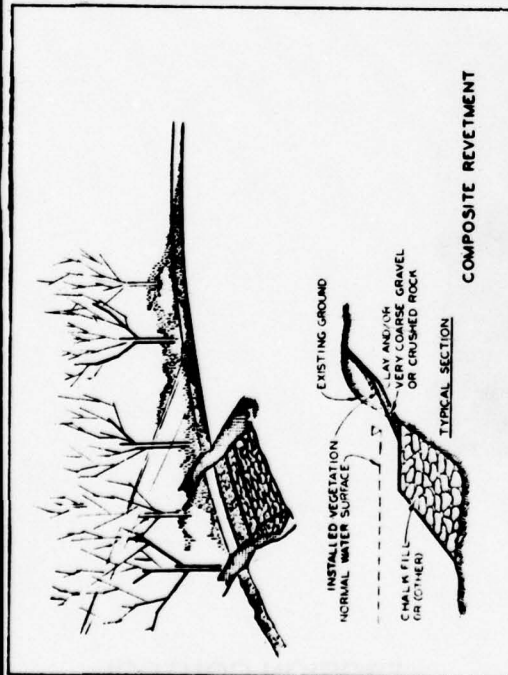
Protection. The demonstration included variations of windrow revetment, composite revetment, and hard points (Plates F13 and F14). Windrow revetment was the predominant technique used at this site and is discussed below. Composite revetment and hard points are discussed in detail in Eagle Park and Brooky Bottom Area Demonstration Project reports. Windrow revetment consists of a linear mound of stone placed immediately adjacent and parallel to the general alignment of the eroding bank. The stone is placed on existing ground or in an excavated trench, depending upon field conditions. As the bank erodes and undercuts the stone mound, the stone sloughs and blankets the new bank at a naturally established slope. Excess stone can be salvaged if the bank stabilizes prior to utilization of the entire windrow. Otherwise, stone material can be added on an as-needed basis until a stable bank is established, thus optimizing material quantities. Demonstration tests include variations of windrow slopes, material gradations, materials, and material application rates.

Cost. The cost to protect 15,900 linear feet of bank line amounted to \$367,000. Approximately \$120,000 of that cost was spent on 3,750 ft of windrow revetment, which protects approximately 5,800 ft of bank line.

Monitoring Program. The monitoring program is divided into five subprograms: **PHYSICAL FEATURES**—channel cross sections, bank-line surveys, and velocity measurements; **MATERIAL TESTING**—bank, streambed, and construction materials; **PHOTOGRAPHY**—aerial oblique and controlled vertical, ground-level and video tape; **BIOLOGICAL**—evaluation of any changes in riparian and aquatic habitat; **REVIEW**—including field inspections, data analyses, and reports.

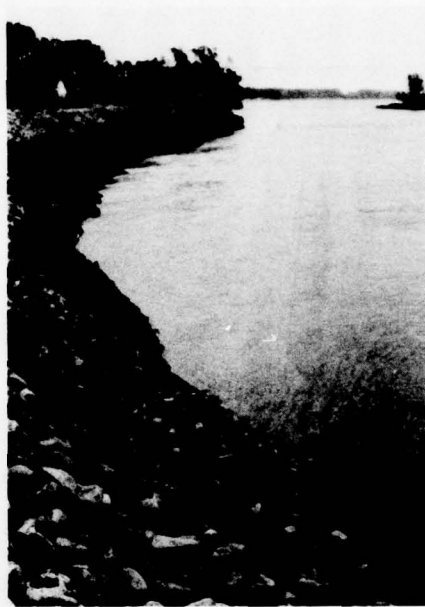
Status. Construction of the project works was virtually completed by November 1977. Monitoring will continue through 1981. After completion of the monitoring program, a performance evaluation will be made utilizing all of the data obtained. To date, all structures are performing adequately.

PLATE F14

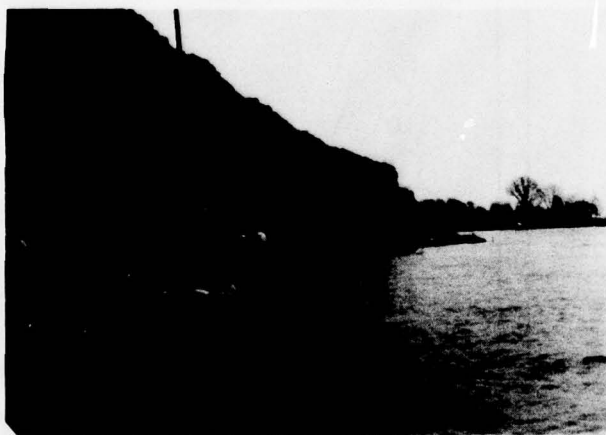




**BANK LINE BEFORE PROTECTION,
FEBRUARY 1977**



**BANK LINE AFTER INSTALLATION
OF WINDROW REVETMENT,
MAY 1977**



**BANK LINE CUTTING INTO
WINDROW, DECEMBER 1977**

**EROSION CONTROL
VERMILLION RIVER CHUTE
CLAY COUNTY, SOUTH DAKOTA**

Streambank Erosion Control Evaluation and Demonstration Act of 1974

MISSOURI RIVER AT RYAN BEND AREA, DIXON COUNTY, NEBRASKA, DEMONSTRATION PROJECT

Problem. This area, located on the right bank between river miles 769 and 767, includes 7000 ft of eroding bank line. Threatened lands are composed of 400 acres of prime cropland and 100 acres of timber. The erosion rate exceeds 12 acres per mile per year. Several farm operations are in immediate danger of becoming unviable economic units.

Protection. The project included variations of reinforced revetment, composite revetment, and windrow revetment (Plates F16 and F17). Reinforced revetment, as discussed below, is the predominant technique. Composite and windrow revetments are discussed in detail in the Eagle Park and Vermillion River Chute Area Demonstration Project reports. Reinforced revetment is similar to composite revetment in the toe zone. In the splash zone and upper bank zone, however, the reinforced revetment relies on intermittent tie-backs or "reinforcing" instead of the continuous bank treatments used in composite revetment. The toe consists of a fill of stone or low-grade material, with a top elevation at normal water surface, placed immediately adjacent to the existing bank line. Each tie-back extends from this bank line landward a distance of 20 ft or more, oriented perpendicular to the bank line. Each of the tie-backs, which are spaced at various intervals, consists of an excavated trench, backfilled with stone and covered with topsoil.

Cost. Total estimated construction cost of this project is \$214,000. Construction will protect 7,000 linear feet of bank line; 2,700 ft of this bank line will be protected with reinforced revetment totaling 1,300 ft. Cost for the 1,300 ft of reinforced revetment is \$67,000.

Monitoring Program. The monitoring program is divided into five major subprograms: PHYSICAL FEATURES—channel cross sections, bank-line surveys, and velocity measurements; MATERIAL TESTING—bank, streambed, and construction materials; PHOTOGRAPHY—aerial oblique and controlled vertical, ground-level and videotape; BIOLOGICAL—evaluation of project effects on riparian and aquatic habitat; REVIEW—field inspections, data analyses, and reports. Plate F18 shows photographs of the site.

Status. Construction began in September 1977 and was scheduled for completion in July 1978. Monitoring will continue tentatively through 1981.

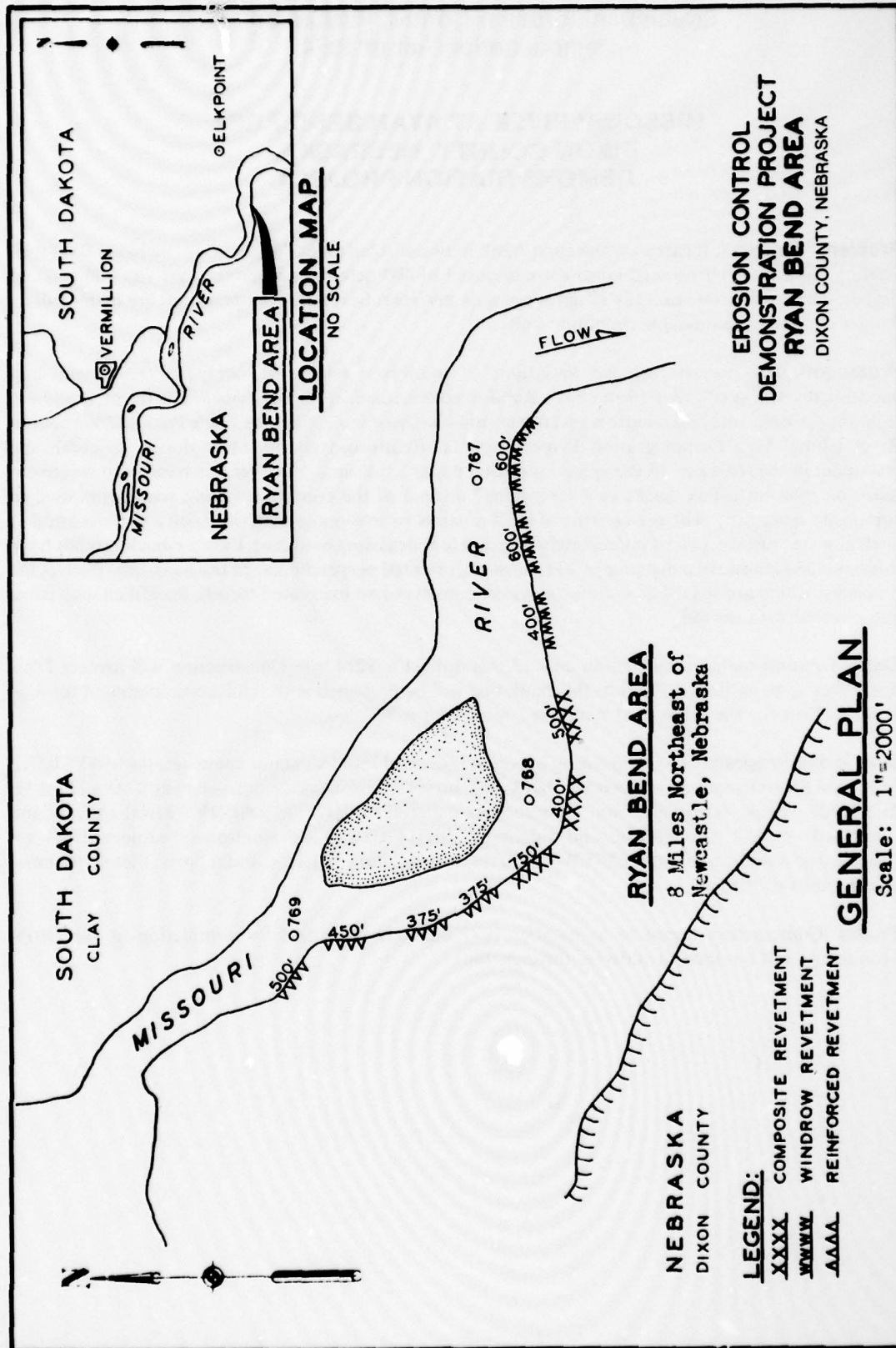


PLATE F16



BANK LINE BEFORE CONSTRUCTION, JULY 1978



INSTALLED REINFORCED REVETMENT, AUGUST 1978

**EROSION CONTROL
RYAN BEND AREA
DIXON COUNTY, NEBRASKA**

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

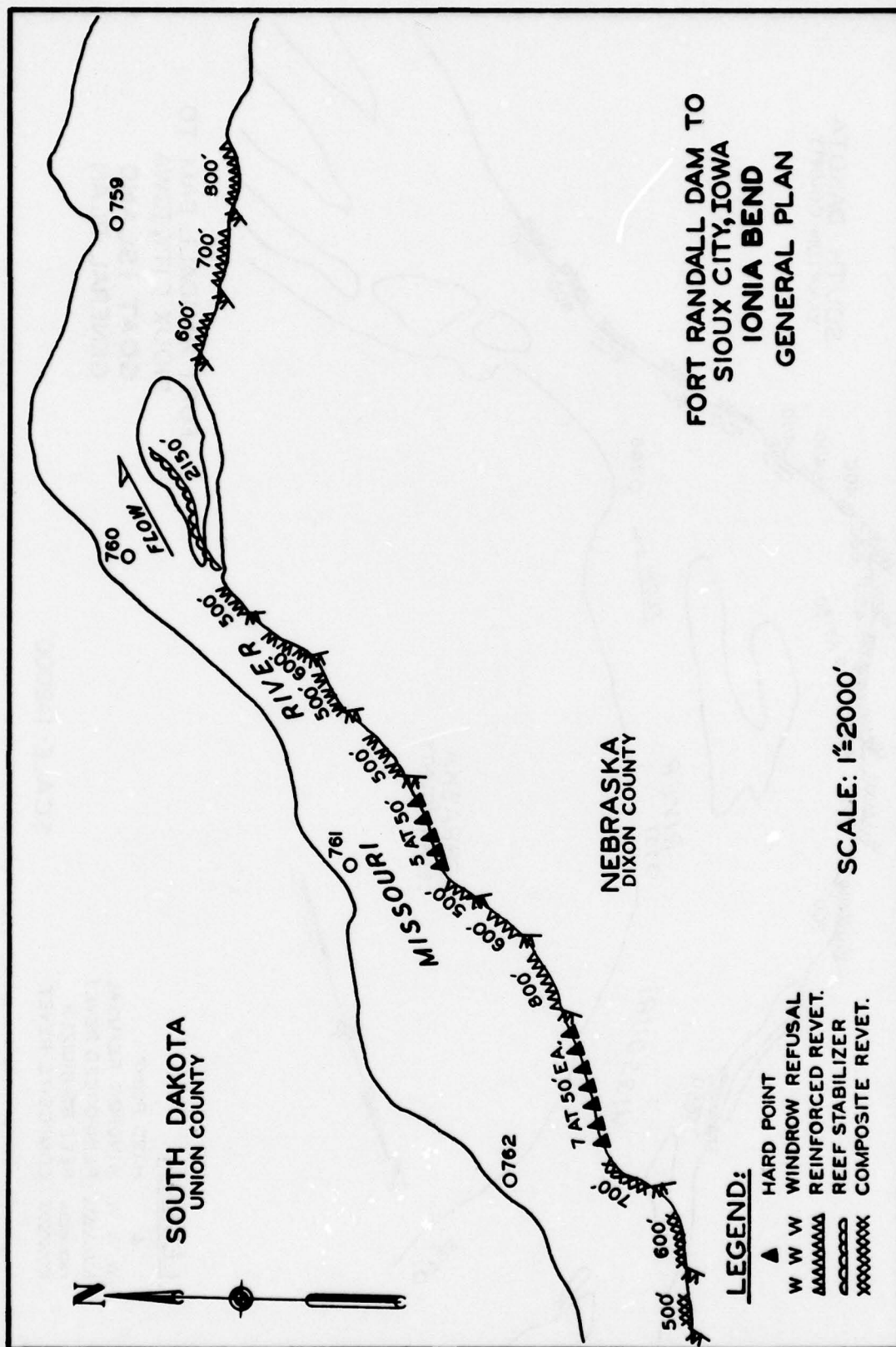
**FY 1978 MISSOURI RIVER
DEMONSTRATION PROJECTS**

Six additional Missouri River Erosion Control Demonstration Projects are scheduled for construction to begin in 1978. The erosion control plans for the projects are shown on the attached sketches and include multiple variations and combinations of hard points, revetments, and reef stabilizer structures. The six demonstration project titles, locations, and estimated construction costs are listed below.

<u>Project Title</u>	<u>Location</u>	<u>Bank</u>	<u>River Mile</u>	<u>Estimated Construction Cost</u>
Sandstone Bluff Area I	McLean County, ND	Left	1368.0	\$390,000
Sandstone Bluff Area II	McLean County, ND	Left	1366.5	430,000
Lewis & Clark 4-H Camp Area	McLean County, ND	Left	1357.5	271,000
Sunshine Bottom Area	Boyd County, NE	Right	868.0	212,000
Goat Island Area	Yankton County, SD	Left	796.5	757,000
Ionia Bend Area	Dixon County, NE	Right	761.0	426,000

The planned monitoring program for the above projects consists of five major subprograms: **PHYSICAL FEATURES**—channel cross sections, bank-line surveys, and velocity measurements; **MATERIAL TESTING**—bank, streambed, and construction materials; **PHOTOGRAPHY**—aerial oblique and controlled vertical, ground-level and videotape; **BIOLOGICAL**—evaluation of project effects on riparian and aquatic habitat; **REVIEW**—field inspections, data analyses, and reports.

Construction contracts for these projects were scheduled for award in July 1978 with estimated contract completion by the end of the year. Preconstruction site condition documentation has begun and monitoring will continue through 1981. A performance evaluation report will then be submitted that encompasses the total time interval for each project.



**FORT RANDALL DAM TO
SIOUX CITY, IOWA
IONIA BEND
GENERAL PLAN**

SCALE: 1"=2000'

LEGEND:

- ▲** HARD POINT
- W W W** WINDROW REFUSAL
- MAA** REINFORCED REVET.
- COO** REEF STABILIZER
- XXXXX** COMPOSITE REVET.

PLATE F23

APPENDIX G

**Yazoo River Basin Demonstration Projects
(Work Unit 7)**

APPENDIX G

Yazoo River Basin Demonstration Projects (Work Unit 7)

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1. GOODWIN CREEK (ITEM 8)*
 2. HOTOPHIA CREEK (ITEM 7)*
 3. JOHNSON CREEK (ITEMS 9, 11, 12)*
 4. LONG AND CANEY CREEKS (ITEMS 10, 11, 12)

- SITE 2 - CHARLESTON, MS
1. HUNTER CREEK (ITEM 1A)*
 2. TILLATOBA AND HUNTER CREEKS (ITEM 1)*
 3. TILLATOBA CREEK, NORTH FORK (ITEM 2)*
 4. TILLATOBA CREEK, NORTH FORK (ITEM 3A)*
 5. TILLATOBA CREEK, NORTH FORK (ITEM 3C)*
 6. TILLATOBA CREEK, SOUTH FORK (FY 72)*
 7. TILLATOBA CREEK, SOUTH FORK (FY 73)*
 8. TILLATOBA CREEK, SOUTH FORK (ITEM 5A)*
 9. TILLATOBA CREEK, SOUTH FORK (ITEM 5B)*
 10. TILLATOBA CREEK, SOUTH FORK (ITEM 5C)*

- SITE 3 - GRENADA, MS
1. BATUPAN BOGUE (FY 74)*
 2. BATUPAN BOGUE (ITEM 4A)*
 3. PERRY CREEK (ITEM 6A)*
 4. PERRY CREEK (ITEM 6B)*
 5. PERRY CREEK (ITEM 6C7)
 6. PERRY CREEK (ITEM 6D)

NOTE: PROJECT IDENTIFICATION NUMBERS ARE SHOWN
IN PARENTHESES.
* FUNDED PROJECTS.

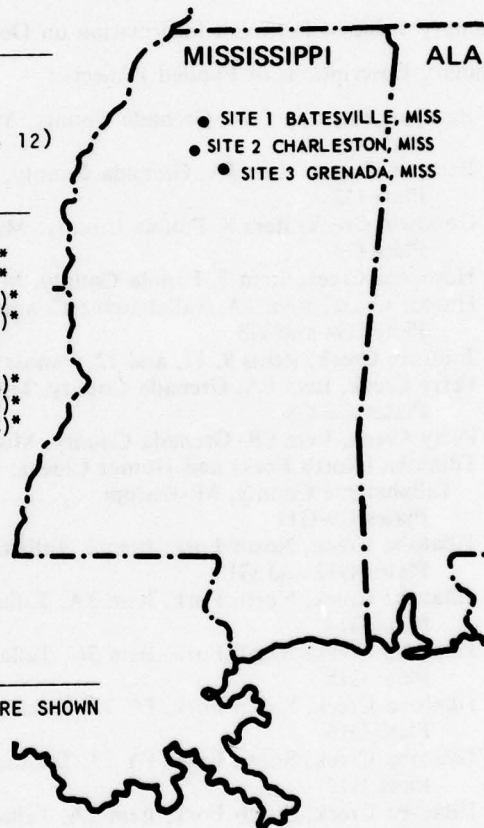


Figure G1. Location of Yazoo River Basin Demonstration Projects (Work Unit 7)

APPENDIX G

Status of Yazoo River Basin Demonstration Projects (Work Unit 7)

The objectives of Work Unit 7 are to construct and evaluate various bank protection and stabilization and grade-control structures for demonstration throughout the Yazoo River Basin (Figure G1). The streams draining into the Yazoo Basin have been a source of problems for many decades. Their instability results in many costly responses, both in the hills and in the delta. Hill streams are generally degrading, resulting in land loss, bank caving, and damage to highway bridges. The resulting aggradation in the delta streams causes losses of navigation and flood control. This work unit is directed toward determining the causes of stream instability and how to best work with natural controls and to develop the least expensive construction to aid in reestablishing a drainage basin stability factor. A wide variety of bed and bank stability measures are being tested to determine the most economical and effective means of providing the needed protection.

To date, 11 demonstration projects have been completed and are being monitored, work is in progress on 3 projects, and planning is in progress for at least 6 more projects. A table of pertinent information, including funding status, on each project under the work unit (Table G1) and detailed descriptions of the funded projects are included in this appendix. The work that has been done to date includes the following:

- a. Transverse and longitudinal dikes constructed of stone, concrete piling and steel cables, and lumber.
- b. Revetments constructed of stone, used automobile tires, sand-cement bags, and lumber.
- c. Retards constructed of timber piling and wire and filled with hay or used automobile tires.
- d. Grade-control structures constructed of stone with sheet pile cutoff walls.
- e. Stabilization of upper banks at various sites has been accomplished by placing stone on the bank, sprigging willow, and using a number of commercial mulches.

In addition to the work described above, the following cooperative efforts have been initiated:

- a. A joint venture with the Science and Education Administration—Federal Research, USDA Sedimentation Laboratory at Oxford, Mississippi, to define and monitor amounts, sources, direction, and time of travel of sediments. This will include complete analysis of the drainage basin morphology, geology, soils, land use, vegetation, basin stratigraphy, hydrology, climatology, and stream hydraulics. Particular emphasis will be in the Goodwin Creek Basin, and the results will be used to determine the performance of selected channel stabilization methods and to determine the influence of grade-control structures on channel stability.
- b. A program to test a wide variety of vegetation controls, both on the floodplain and on the beds and banks of the streams, has been initiated with the combined efforts of the USDA Soil Conservation Service (SCS) agronomy teams from an 11-state area.
- c. A complete inventory of SCS bank stabilization efforts for the past two decades. This will include location, type, and purpose of stabilization; results and maintenance; and effects on geology and soils, stream and basin hydraulics and hydrology, and land use.
- d. A cooperative agreement with the U. S. Army Engineer Division, North Central, of the Corps of Engineers to use Dr. C. T. Yang's concept of "Unit Stream Power" to develop a more theoretical approach to stream stabilization.

(Text continued on page G8)

TABLE G1: SUMMARY OF PERTINENT INFORMATION ON DEMONSTRATION PROJECTS
Yazoo River Basin (Work Unit 7)

Stream, Item No., & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
Batupan Bogue FY 74 Both sides	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Board fence and stone dikes and board-fence revetment
Batupan Bogue Item 4A Both sides	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Tire revetment, sand-cement sacks, longitudinal and trans- verse stone dikes, and peaked stone toe dikes
Goodwin Creek Item 8 Across channel	--	Batesville	Panola	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Grade control
Hotophia Creek Item 7 Across channel	--	Batesville	Panola	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Grade control
Hunter Creek Item 1A Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Stone dikes
Johnson Creek Items 9, 11, 12 Both sides	--	Batesville	Panola	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Vegetation, bank and bed stabilization (grade-control structures)
Long and Caney Creeks Items 10, 11, and 12 Both sides	--	Batesville	Panola	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Bank and bed stabilization
Perry Creek Item 6A Both sides	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Longitudinal and transverse stone dikes, wire cribs, tire post retards, and longitudinal peaked stone dikes
Perry Creek Item 6B Across channel	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Grade control
Perry Creek Item 6C7 Across channel	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Grade-control structure
Perry Creek Item 6D Both sides	--	Grenada	Grenada	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Bank stabilization
Tillatoba & Hunter Creeks Item 1 Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use	Stone dikes

Yazoo River Basin (Work Unit 7) (Continued)

Stream, Item No., & Side	Project Length	Funding in \$1000				Status	Remarks
		Est Costs	Engr, Monitor & Reporting	Allocated thru FY 78	Expended as of 3/31/78		
Batupan Bogue FY 74 Both sides	1-3/4 mi	565.0	141.2	565.0	565.0	Construction completed	Construction not funded under the Section 32 Program but evaluation of protective methods will be performed and reported under Section 32
Batupan Bogue Item 4A Both sides	3 mi	795.0	198.0	795.0	715.5	Construction complete	Additional tire revetment is presently being constructed at this site under a new Item 4A-1
Goodwin Creek Item 8 Center line of channel	10 mi	975.0	2,349.4	975.0	None	Final design phase	To be constructed FY 79
Hotochia Creek Item 7 Center line of channel	2 mi	300.0	250.0	300.0	None	To be constructed FY 80	
Hunter Creek Item 1A Both sides	1-1/4 mi	111.6	22.3	111.6	111.6	Construction completed	
Johnson Creek Items 9, 11, and 12 Both sides	2-1/2 mi	1,100.0	750.0	747.0	None	Final design phase	To be constructed FY 79. Items 11 and 12 of this project are vegetative treatment and training structures to be constructed concurrently with Item 9
Long and Caney Creeks Items 10, 11, and 12 Both sides	3 mi	850.0	625.0	None	None	Initial design	Items 11 and 12 of this project are vegetative treatment and training structures to be constructed concurrently with Item 10
Perry Creek Item 6A Both sides	3 mi	575.0	74.0	575.0	None	Under construction	
Perry Creek Item 6B Center line of channel	800 ft	500.0	70.0	500.0	None	Under construction	
Perry Creek Item 6C7 Center line of channel	200 ft	225.0	56.0	None	None	Initial design phase	
Perry Creek Item 6D Both sides	1/2 mi	400.0	50.0	None	None	Initial design phase	Type of bank stabilization has not been determined
Tillatoba & Hunter Creeks Item 1 Both sides	2-1/2 mi	625.8	145.2	625.8	625.8	Construction completed	Yazoo Basin (Tribes) = \$250K, Section 32 = \$375.8K

(Sheet 1 of 2)

Yazoo River Basin (Work Unit 7) (Concluded)

Stream, Item No., & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
Tillatoba Creek, North Fork, Item 2 Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Stone dikes
Tillatoba Creek, North Fork Item 3A Across channel	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Grade control
Tillatoba Creek, North Fork Item 3C Across channel	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Grade control
Tillatoba Creek, South Fork FY 72 Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Stone dikes
Tillatoba Creek, South Fork FY 73 Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Cable and board-fence dikes, stone dikes
Tillatoba Creek, South Fork Item 5A Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Tire revetment and sand-cement sacks
Tillatoba Creek, South Fork Item 5B Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Hay- and tire-filled cribs
Tillatoba Creek, South Fork Item 5C Both sides	--	Charleston	Tallahatchie	MS-1	Vicksburg MS	Loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and con- trol levels, and changes in land use	Stone dikes and used-tire revetment

Yazoo River Basin (Work Unit 7) (Concluded)

Stream, Item No., & Side	Project Length	Funding in \$1000				Status	Remarks
		Est Costs	Construc- tion	Mgr, Monitor & Reporting	Allocated thru FY 78	Expended as of 3/31/78	
Tillatoba Creek, North Fork Item 2 Both sides	2-1/2 mi	529.9	126.0		529.9	529.9	Construction completed
Tillatoba Creek, North Fork Item 3A Center line of channel	200 ft	210.0	52.0		210.0	200.0	Construction completed
Tillatoba Creek, North Fork Item 3C Center line of channel	200 ft	128.4	25.7		128.4	128.4	Construction completed Construction not funded under the Section 32 Program but evaluation of protective methods will be performed and reported under Section 32
Tillatoba Creek, South Fork FY 72 Both sides	1-1/4 mi	237.7	47.5		237.7	237.7	Construction completed Construction not funded under the Section 32 Program but evaluation of protective methods will be performed and reported under Section 32
Tillatoba Creek, South Fork FY 73 Both sides	2 mi	222.9	44.6		222.9	222.9	Construction completed Construction not funded under the Section 32 Program but evaluation of protective methods will be performed and reported under Section 32
Tillatoba Creek, South Fork Item 5A Both sides	1/4 mi	99.9	19.9		99.9	99.9	Construction completed
Tillatoba Creek, South Fork Item 5B Both sides	1-1/4 mi	160.4	32.2		160.4	160.4	Construction completed
Tillatoba Creek, South Fork Item 5C Both sides	1 mi	355.0	71.0		355.0	None	Under construction Construction not funded under the Section 32 Program but evaluation of protective methods will be performed and reported under Section 32

All efforts under this work unit are directed toward achieving economical and effective stabilization measures that are compatible with the environment of the natural streams. All work completed or planned has been or will be coordinated formally and informally to assure that the latter aim is achieved.

Detailed monitoring and evaluation plans are being followed at all completed demonstration sites and will be implemented as future sites are completed. These plans provide for monitoring of the environmental as well as the physical aspects of the projects and will continue until completion of the program.

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**BATUPAN BOGUE, FY 74,
GRENADA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Bed degradation and width increases have endangered local urban property since the early 1950's. A local bridge was moved once to a more stable reach; however, a geologic (rock sill) control on the bed upstream of the relocated bridge appears to be in the process of deterioration. A residential area is also endangered by the rapidly caving bank.

Protection. Four types of bank protection were used: (a) transverse stone dikes; (b) board-fence transverse dikes; (c) board-fence longitudinal revetment with tie-backs; and (d) longitudinal stone dikes with one tie-back. Material from the bar side of the river was used for a limited amount of backfill. See Plate G1 for the project plan and location, Plates G21-G23 for typical construction details, and Plates G31-G34 for photographs of typical eroding and failed banks and completed protective structures.

Cost. Total cost of construction was \$565,010. The stone dikes cost \$2,287 per 100 linear feet, the board-fence transverse dike cost \$2,608 per 100 linear feet, the board-fence revetment cost \$11,520 per 100 linear feet, and the longitudinal stone dikes cost \$10,890 per 100 linear feet.

Monitoring Program. Visual inspections, surveys, and photography.

Status. All structures appear to be working satisfactorily. Additional sediments have accreted within the structures, adding to their stability. Several very high flows have been experienced with an all-time high flow during November 1977, and there does not appear to be any serious damage to any of the structures. The November 1977 flood was at least a 100-year event and possibly a 500-year event. The bridge on Highway 7 lost one span due to possibly two factors: (a) excessive buildup of debris on the failed pier; and (b) loss of the geologic control just upstream of the bridge, allowing further bed degradation at and above the bridge.

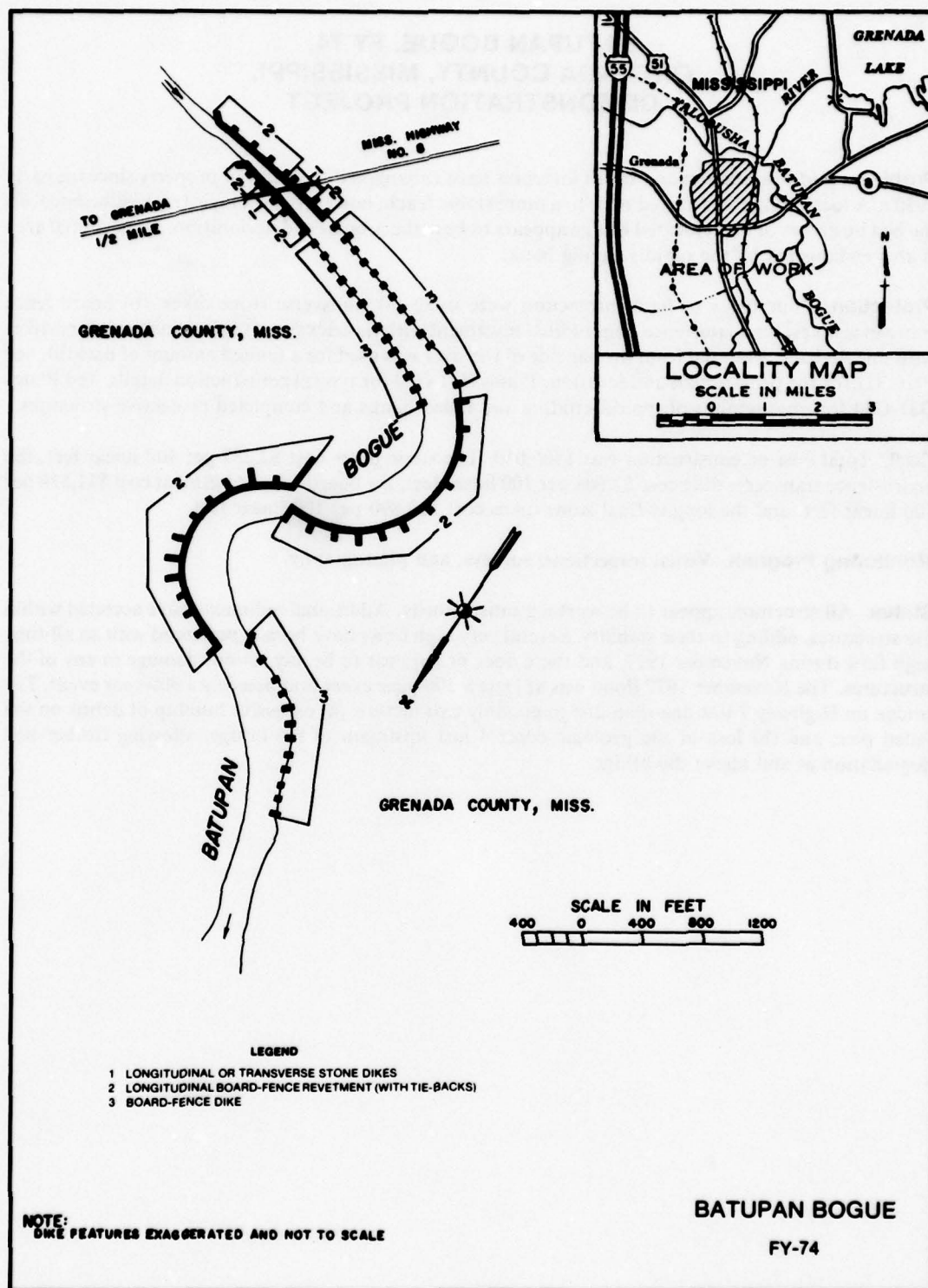


PLATE G1

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**BATUPAN BOGUE, ITEM 4A,
GRENADA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

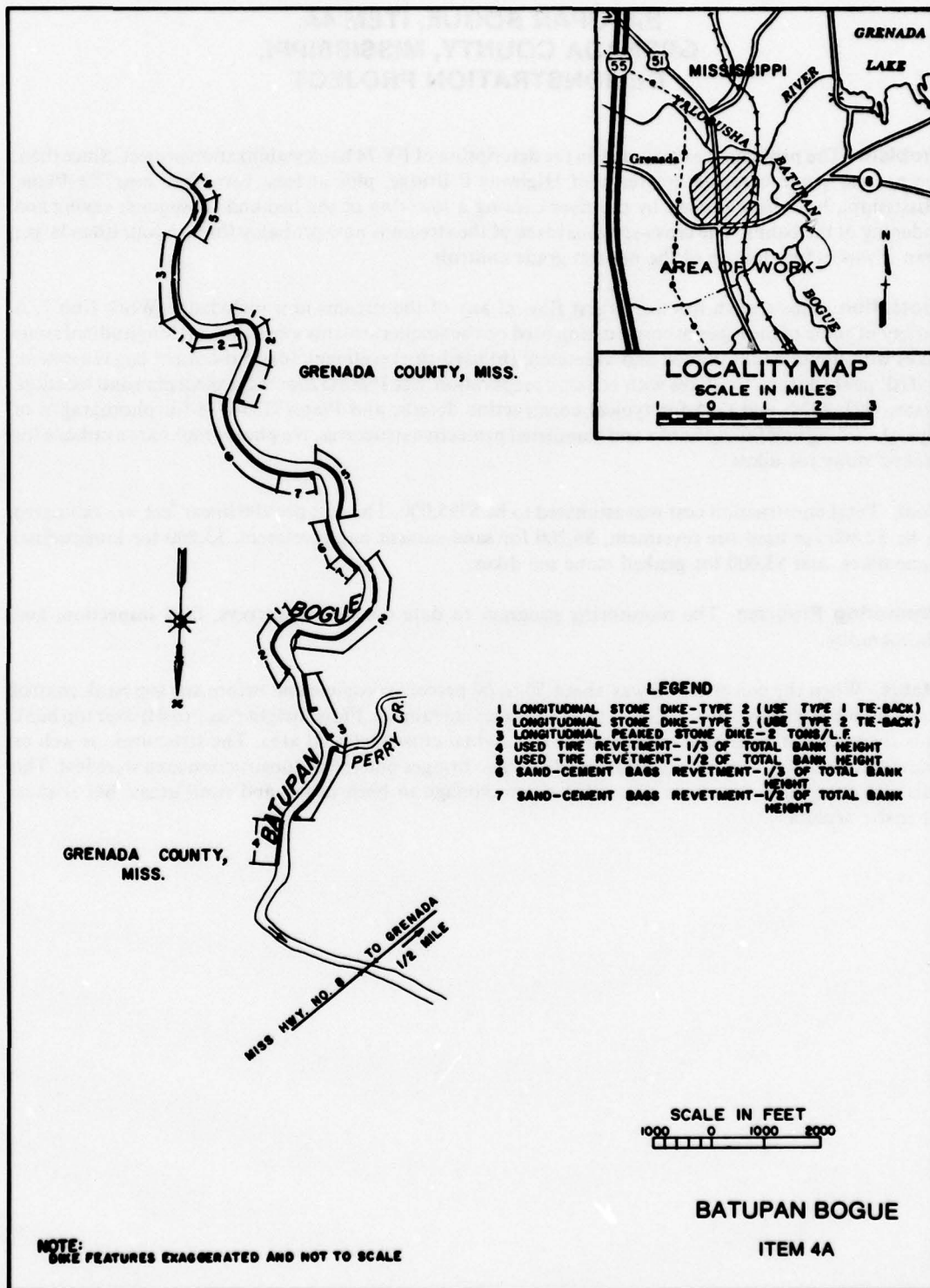
Problem. The problem was included in the description of FY 74 bank stabilization project. Since then, the natural grade controls upstream of Highway 8 Bridge, plus at least two more near Tie-Plant, Mississippi, have been eroded by the river causing a lowering of the bed and subsequent caving and widening of the banks. The cross-sectional area of the stream is now probably three to four times larger than it was before failure of the natural grade controls.

Protection. This stream has the largest flow of any of the streams now included in Work Unit 7. A variety of some of the types of construction used on the smaller streams were tried: (a) longitudinal stone dikes with upper banks graded and vegetated; (b) used-tire revetment; (c) sand-cement bag revetment; and (d) peaked stone toe dikes with no bank preparation. See Plate G2 for the project plan and location; Plates G21, G24, and G25 for typical construction details; and Plates G35-G38 for photographs of typical eroding and failing banks and completed protective structures. No photographs are available for peaked stone toe dikes.

Cost. Total construction cost was estimated to be \$795,000. The cost per 100 linear feet was estimated to be \$2,800 for used-tire revetment, \$6,200 for sand-cement bag revetment, \$2,800 for longitudinal stone dikes, and \$3,000 for peaked stone toe dikes.

Monitoring Program. The monitoring program to date consists of surveys, field inspection, and photography.

Status. When the construction was about 50 to 60 percent complete and before any top bank control could be accomplished, this stream experienced a severe rainfall. Flood height was 2 to 4 ft over top bank in a channel that had three to four times its original cross-sectional area. The structures, as well as unprotected banks, were severely damaged and two bridges outside of construction area were lost. The partially completed structures prevented much damage to both urban and rural areas, but require extensive repairs.



Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**GOODWIN CREEK, ITEM 8,
PANOLA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. The problems of instability are many and varied. Part of the efforts of the Vicksburg District are directed to learning more about the causes of streambank erosion and to effect means of economically controlling erosion. In general, Goodwin Creek is experiencing severe erosion as a result of the loss of geologic controls, channelization and straightening of streams, flood-control activities, changes in base and control levels, and changes in land use.

Protection. Goodwin Basin has been chosen as the primary study site because of the equal and varied land uses and the similarity of stream characteristics with the many other streams. This basin will be heavily instrumented and will incorporate grade-control structures with data-gathering needs. See Plate G3 for the project plan and location, Plate G26 for typical construction details, and Plate G39 for an artist's conception of another type of grade-control structure. Photographs of similar completed structures on another stream in the Yazoo Basin are given in Plates G40 and G41.

Cost. Construction costs are estimated to be \$975,000.

Monitoring Program. Soils, geologic, land use, hydrologic, hydraulic, etc., data will be gathered. The USDA Sedimentation Laboratory at Oxford, Mississippi, will continue the project for 5 to 10 years after 1982.

Status. Final design is now being accomplished with construction scheduled to be completed in FY 79.

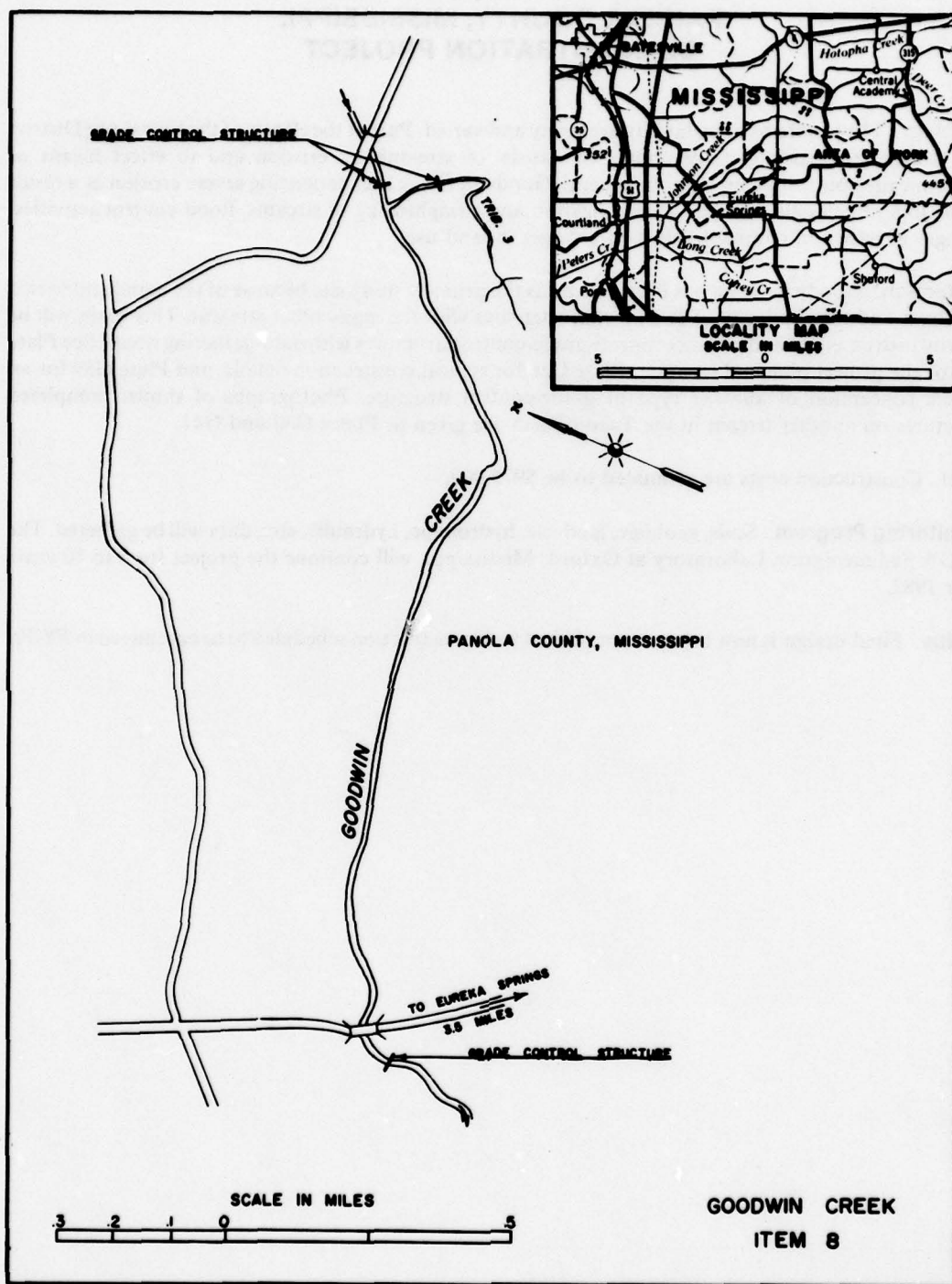


PLATE G3

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**HOTOPHIA CREEK, ITEM 7,
PANOLA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Hotophia Creek is experiencing a detrimental phenomenon known as "head cutting" whereby degradation of the bed progresses upstream in a steplike fashion. This is common on other streams in the hilly section of the Yazoo Basin and the variety of causes of head cutting in the Yazoo Basin hill streams prevail on this stream. Streambank instability has been further aggravated by the straightening of this stream by local interests. The bridge pier on Highway 7 indicated 4- to 5-ft degradation in the past year. Borings show that the geologic controls are almost gone and below those elevations are 30 to 60 ft of very easily erodible sands.

Protection. The above head cuts, amounting to 20 ft of drop, are now concentrated over a half-mile reach. Three grade-control structures are planned to control this stream. See Plate G26 for typical construction details of a grade-control structure and Plates G40 and G41 for photographs of similar completed projects on another stream in the Yazoo Basin. An artist's conception of a grade-control structure with provisions to measure total sediment load and discharge is shown in Plate G39.

Cost. Construction costs are estimated to be \$300,000.

Monitoring Program. Unknown at this time.

Status. Construction is planned for FY 80.

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**HUNTER CREEK, ITEM 1A,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Instability results from such problems as loss of geologic controls, early work by local interests, and flood-control activities in the delta. This creek is a tributary to South Fork with its mouth about 2 miles upstream from the confluence of North and South Fork Tillatoba Creeks.

Protection. A combination of two variations of longitudinal stone dikes and one type of transverse stone dike was used. This work was originally planned as part of Tillatoba (North Fork) and Hunter Creeks, Item 1, but rights-of-way delays required that this work be performed under a separate contract at a later date. See Plates G4 and G5 for project plan and location, Plate G21 for typical construction details and Plates G31, G32, and G35 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Total cost of construction was \$111,600. The cost per 100 linear feet for transverse stone dike or type 1 tie-back was \$2,746; type 1 longitudinal dike with one type 1 tie-back, \$1,826; type 1 longitudinal dike with more than one type 1 tie-back, \$2,447; and type 2 longitudinal dike with one type 1 tie-back, \$4,339.

Monitoring Program. Visual inspections, surveys, photography, land use, geology, and soils.

Status. This stream has been subjected to the same high flows as described on other streams in this basin. All structures seem to be operating as planned.

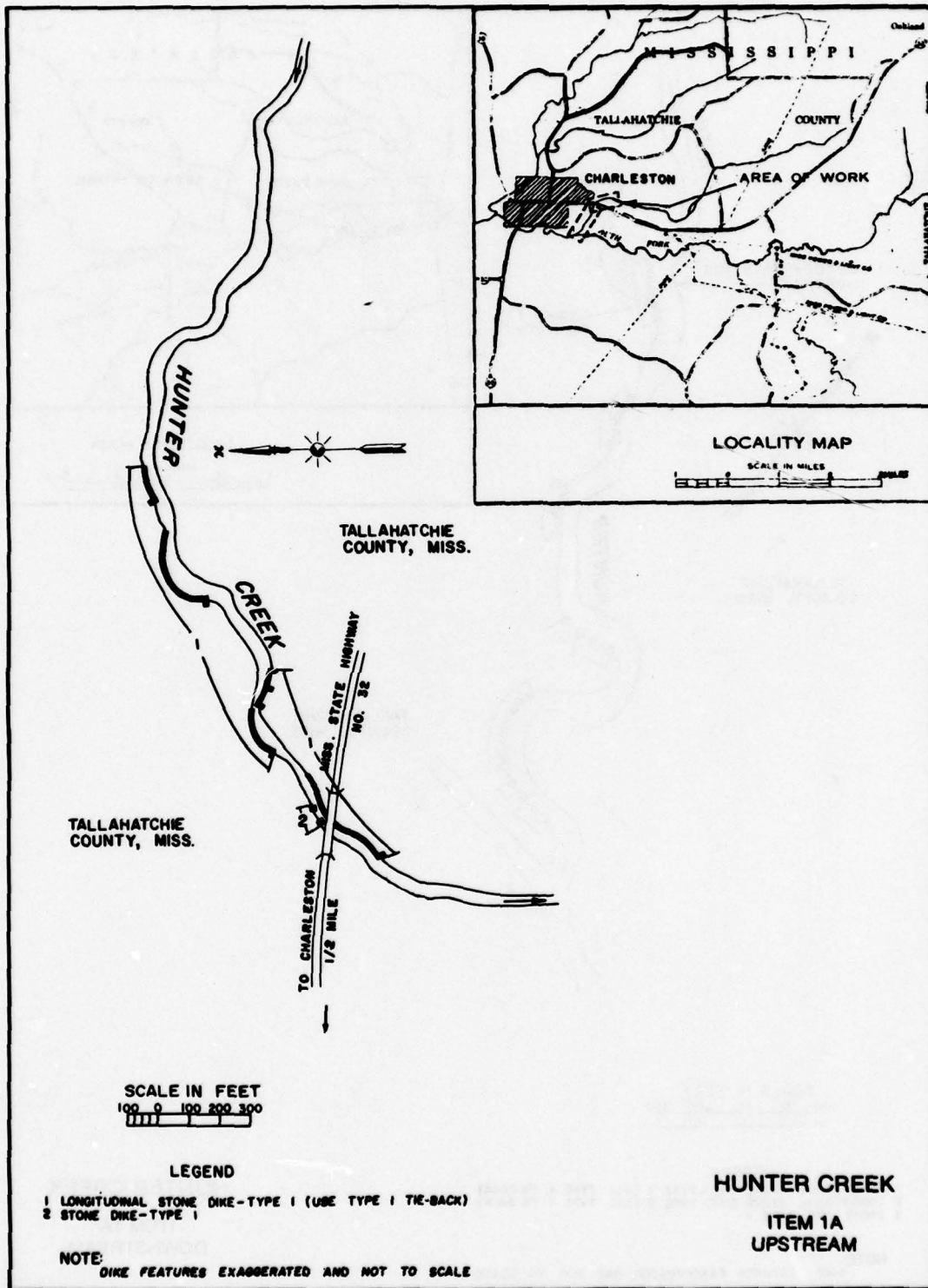


PLATE G4

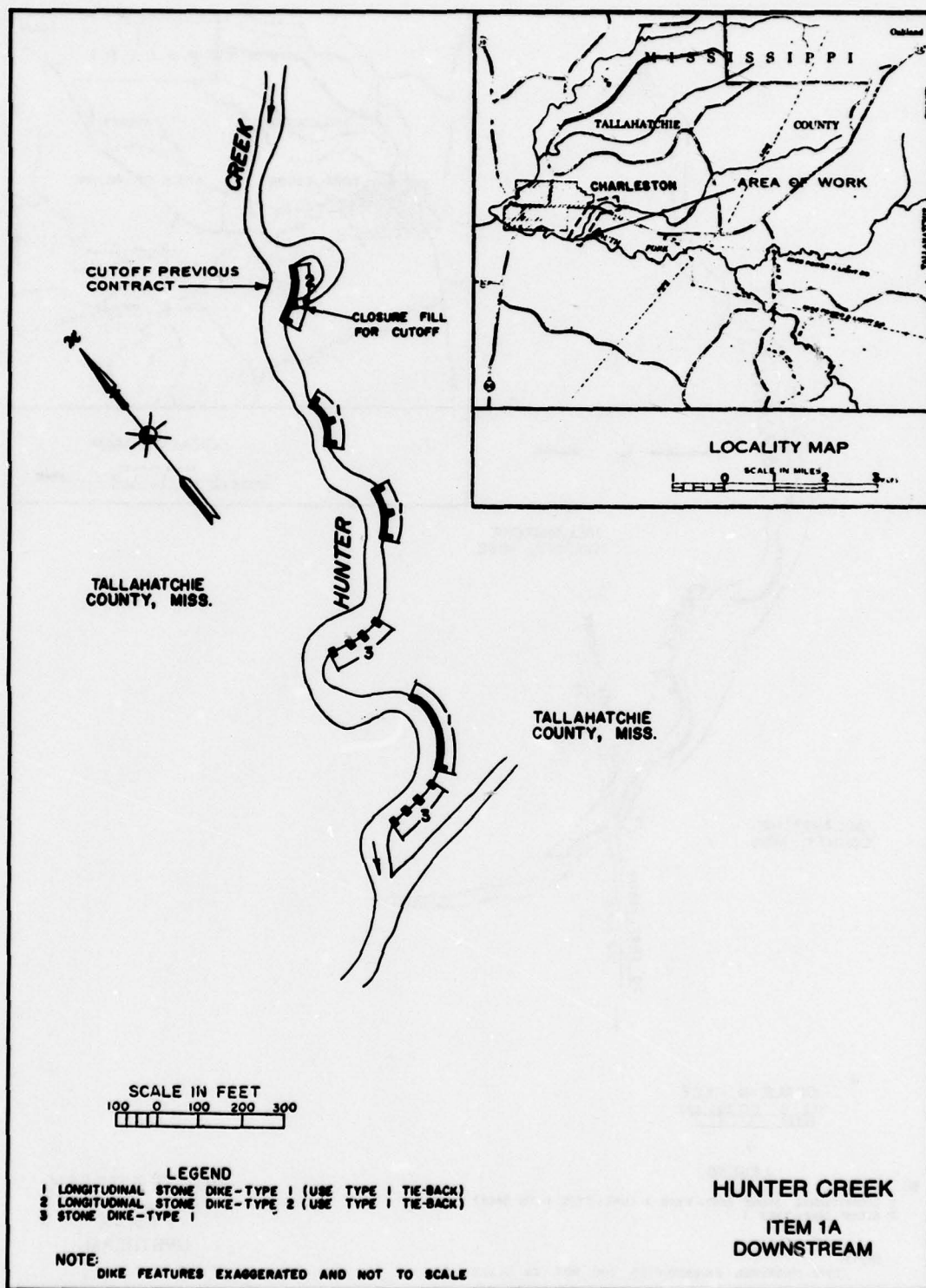


PLATE G5

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**JOHNSON CREEK, ITEMS 9, 11, AND 12,
PANOLA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. The same degradation problems occur here as on other streams in the basin. Also, local interests have straightened out various reaches at various times over the past three to five decades, thus contributing to further bank degradation.

Protection. Grade-control structures will be used to stabilize the bed, then a variety of bank stabilization, vegetation (the District working with the State and SCS agronomists on this), and training structures will be tried. See Plate G26 for typical construction details of a grade-control structure and Plates G40 and G41 for photographs of similar completed projects on another stream in the Yazoo Basin. An artist's conception of a grade-control structure with provisions to measure total sediment load and discharge is shown in Plate G39.

Cost. Construction costs are estimated to be \$1.1 million.

Monitoring Program. Same as on Goodwin Creek, but less extensive.

Status. Initial design work is being done and construction will begin in FY 78. Items 11 and 12 are vegetative treatment and training structures.

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**PERRY CREEK, ITEM 6A,
GRENADA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Same problems as described for Batupan Bogue. Degradation worked up this creek during the 1960's and 1970's, causing extensive bank caving in urban and rural areas near Grenada, Mississippi. Several bridges have problems; the box culvert under Interstate Highway 55, constructed in 1963, stopped an 8-ft head cut but now the highway is endangered.

Protection. A series of bed stabilizing grade-control structures with bank stabilization is planned for FY 78 construction on Perry Creek. Item 6A consists of bank stabilization with stone dikes, wire crib retards, tire post retards, and longitudinal peaked stone dikes. See Plates G6-G8 for project plan and location; Plates G21 and G27-G29 for typical construction details; and Plates G31, G35, and G42-G44 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Estimated cost of construction is \$575,000.

Monitoring Program. Surveys, photographs, and visual inspections.

Status. To be constructed during FY 78.

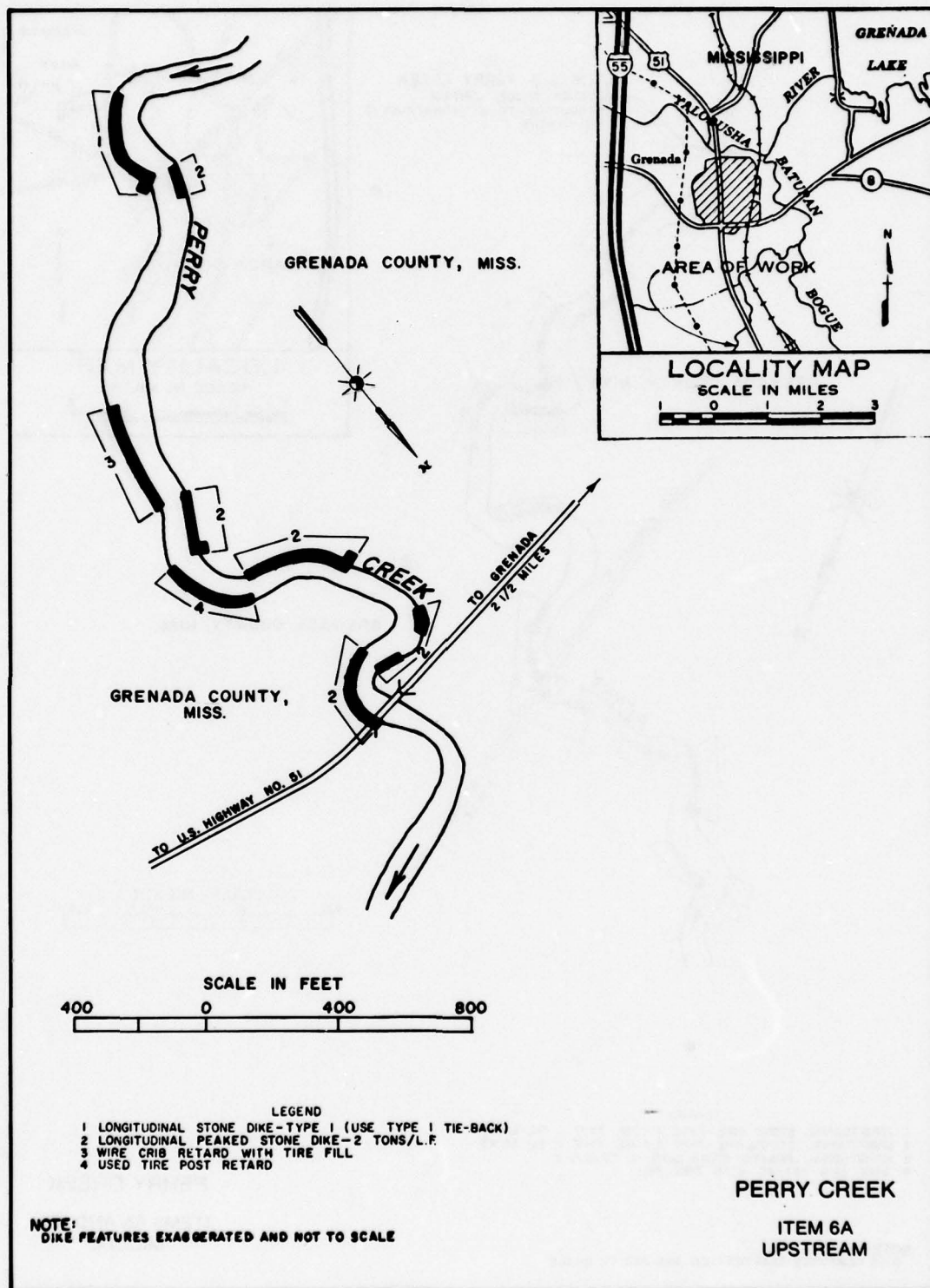


PLATE G6

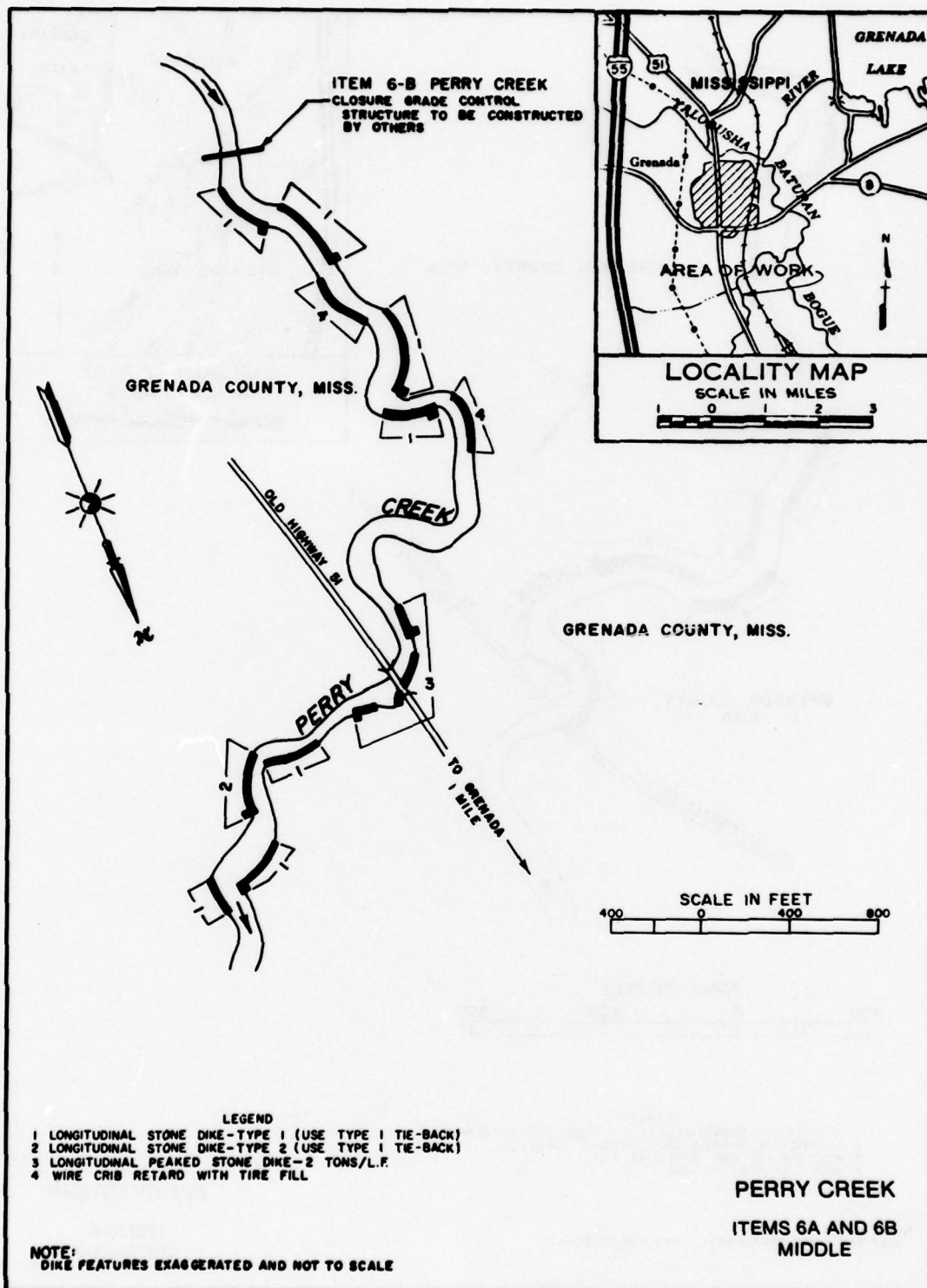


PLATE G7

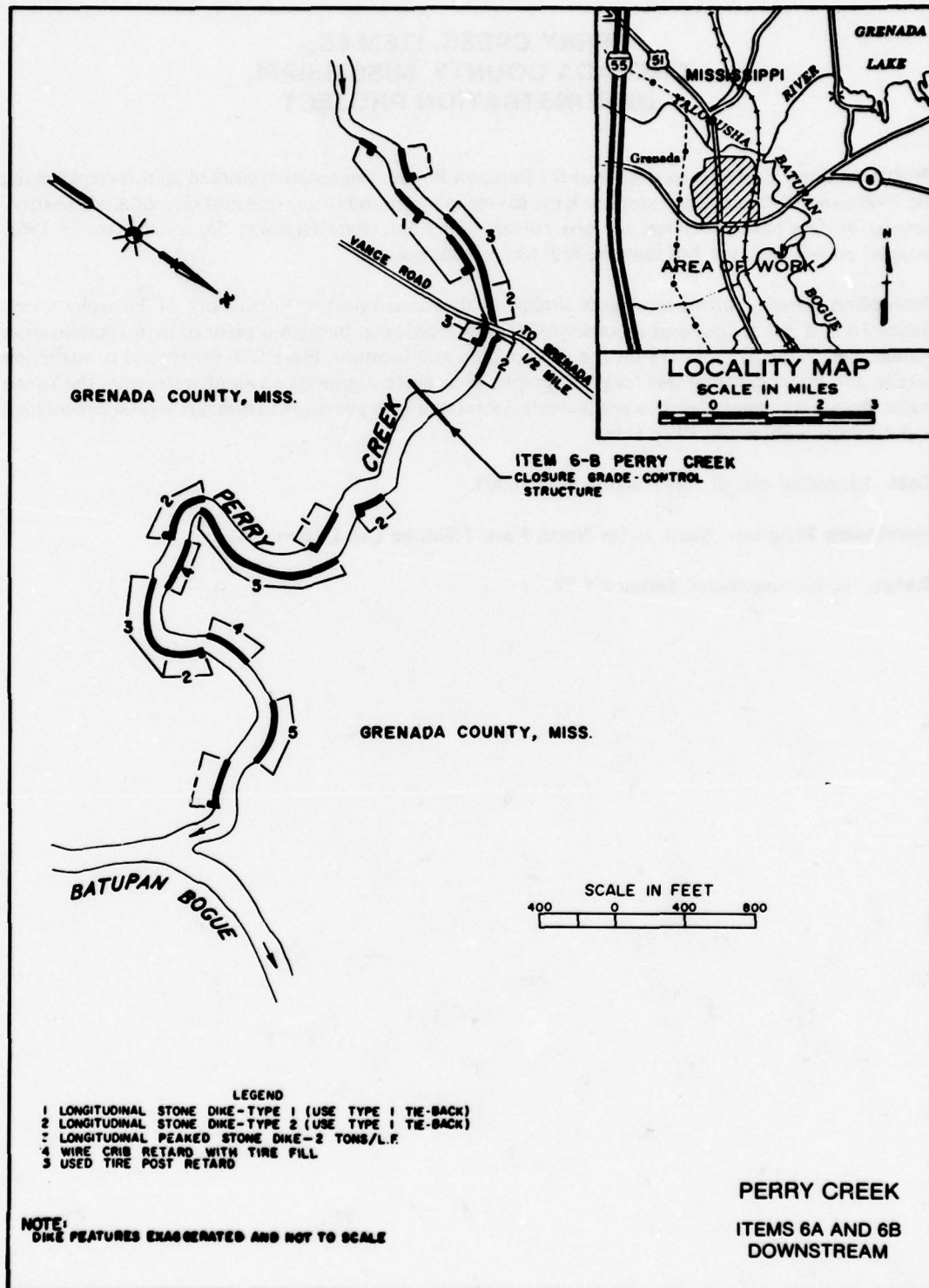


PLATE G8

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**PERRY CREEK, ITEM 6B,
GRENADA COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Same problems as described for Batupan Bogue. Degradation worked up this creek during the 1960's and 1970's causing extensive bank caving in urban and rural areas near Grenada, Mississippi. Several bridges have problems; the box culvert under Interstate Highway 55, constructed in 1963, stopped an 8-ft head cut but now the highway is endangered.

Protection. Grade-control structures similar to those used on the North Fork of Tillatoba Creek (Items 3A and 3C) are planned. A variety of bank protection in Item 6A is planned in this stabilization system. See Plates G7 and G8 for the project plan and location, Plate G26 for typical construction details, and Plates G40 and G41 for photographs of completed projects on another stream in the Yazoo Basin. An artist's conception of a grade-control structure with provision to measure total sediment load and discharge is shown in Plate G39.

Cost. Estimated cost of construction is \$500,000.

Monitoring Program. Same as for North Fork Tillatoba Creek (Item 3A).

Status. To be constructed during FY 78.

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA (NORTH FORK) AND HUNTER CREEKS, ITEM 1,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Severe meandering and bank caving. Cause of this instability seems to be a result of a combination of things—loss of geologic control, early work done by local interests, and flood-control activities in the delta. The result, regardless of the cause, was a severe head cut (bed degradation) that initiated excessive bank caving.

Protection. A combination of six types of longitudinal and two types of transverse stone dikes was used. Some upper banks were graded, others were left natural. See Plates G9-G11 for the project plan and location; Plate G21 for typical construction details; and Plates G31, G32, and G35 for photographs of bank failure on Tillatoba Creek, North and South Forks, and completed protective structures.

Cost. Total cost of construction was \$625,821. The cost per 100 linear feet for transverse stone dikes was \$2,398, \$4,064 for longitudinal stone dikes with one tie-back, \$5,561 for longitudinal stone dikes with two tie-backs, \$6,578 for longitudinal stone dikes with more than two tie-backs, \$3,453 for type 1 stone dikes, \$3,106 for type 1 longitudinal dike with more than one type 1 tie-back, \$4,820 for type 2 longitudinal dike with one type 1 tie-back, and \$2,021 for type 1 longitudinal dike with one type 1 tie-back.

Monitoring Program. Visual inspections, surveys, and photography.

Status. Minor adjustments in the alignment on one dike field were made 1 year after construction. Most structures are performing satisfactorily. Some upper bank vegetation control was damaged by high water prior to adequate germination.

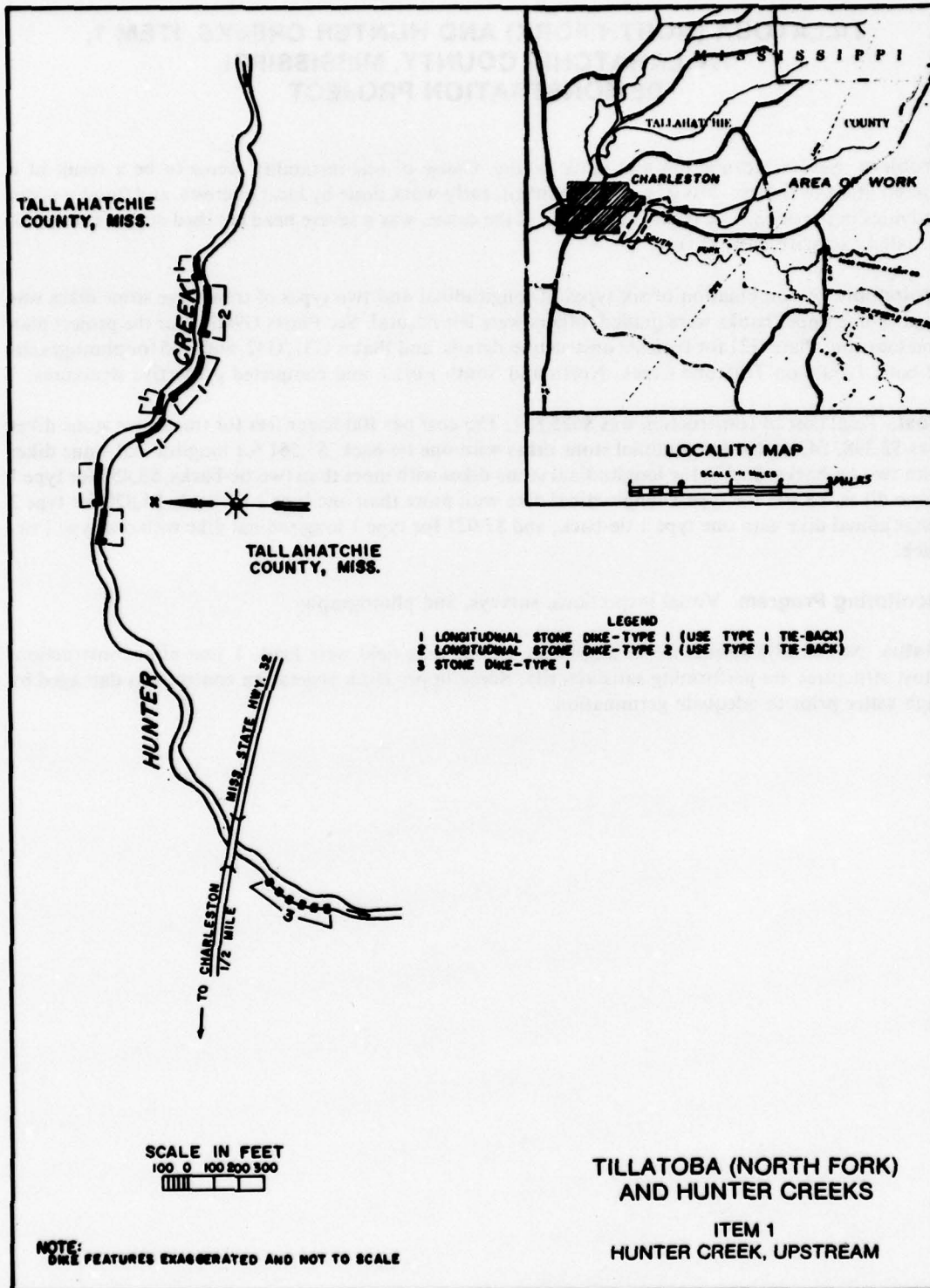


PLATE G9

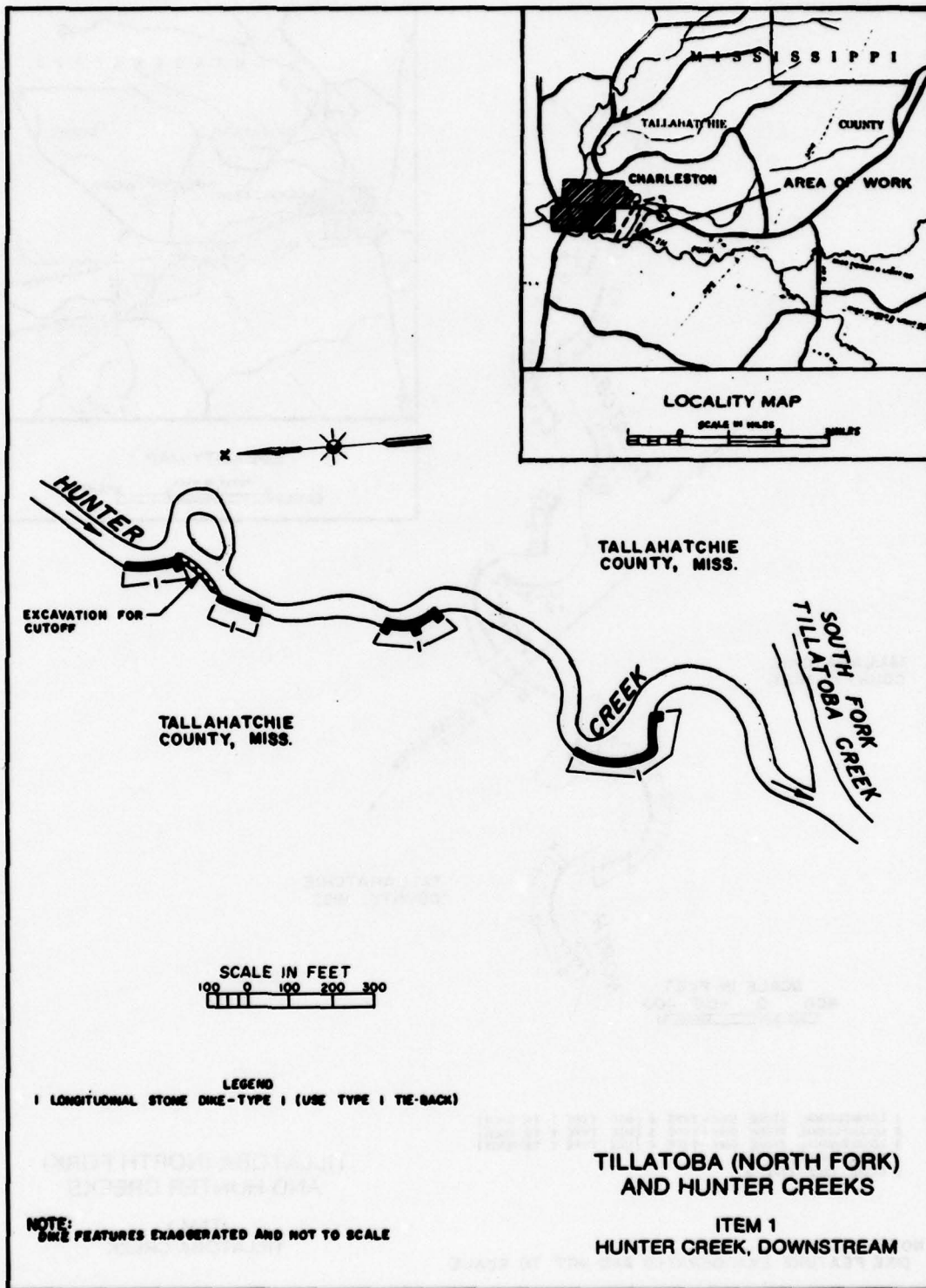


PLATE G10

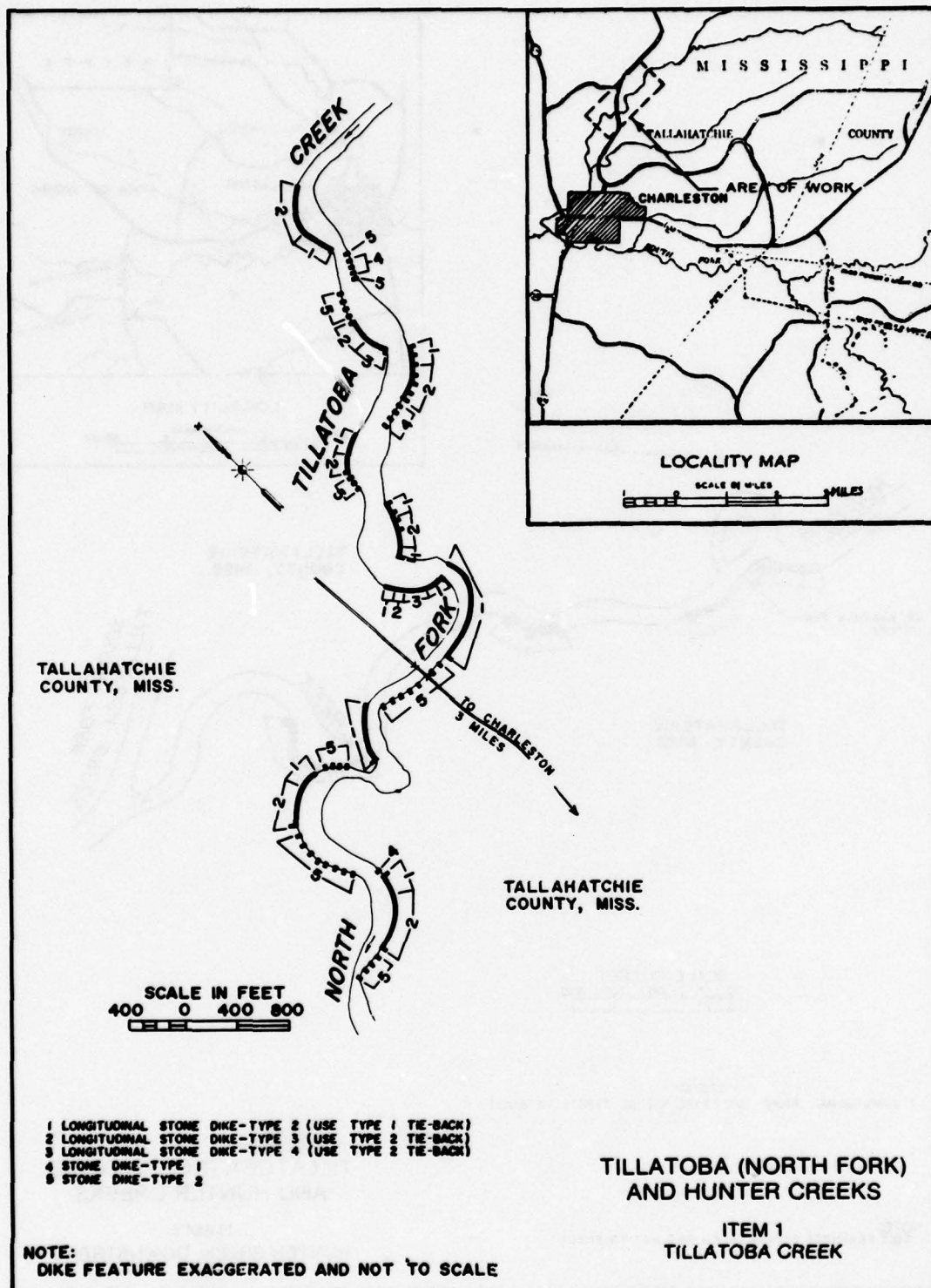


PLATE G11

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA CREEK, NORTH FORK, ITEM 2,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Severe meandering and bank caving.

Protection. The types of bank protection used were the same as on Tillatoba and Hunter Creeks, Item 1, but the application varied. See Plates G12 and G13 for the project plan and location, Plate G21 for typical construction details, and Plates G31, G32, and G35 for photographs of bank failure on Tillatoba Creek, North and South Forks, and completed protective structures.

Cost. Total construction cost was \$529,879. The cost per 100 linear feet for transverse dikes was \$2,398, \$2,100 for stone paving, \$4,204 for longitudinal stone dikes with one tie-back, \$4,276 for longitudinal stone dikes with two tie-backs, \$4,426 for longitudinal stone dikes with more than two tie-backs.

Monitoring Program. Visual inspections, surveys, and photography.

Status. A few minor alignment problems have been experienced with some bank caving during the recent high water. Overbank drainage was stabilized during construction but needs some modifications.

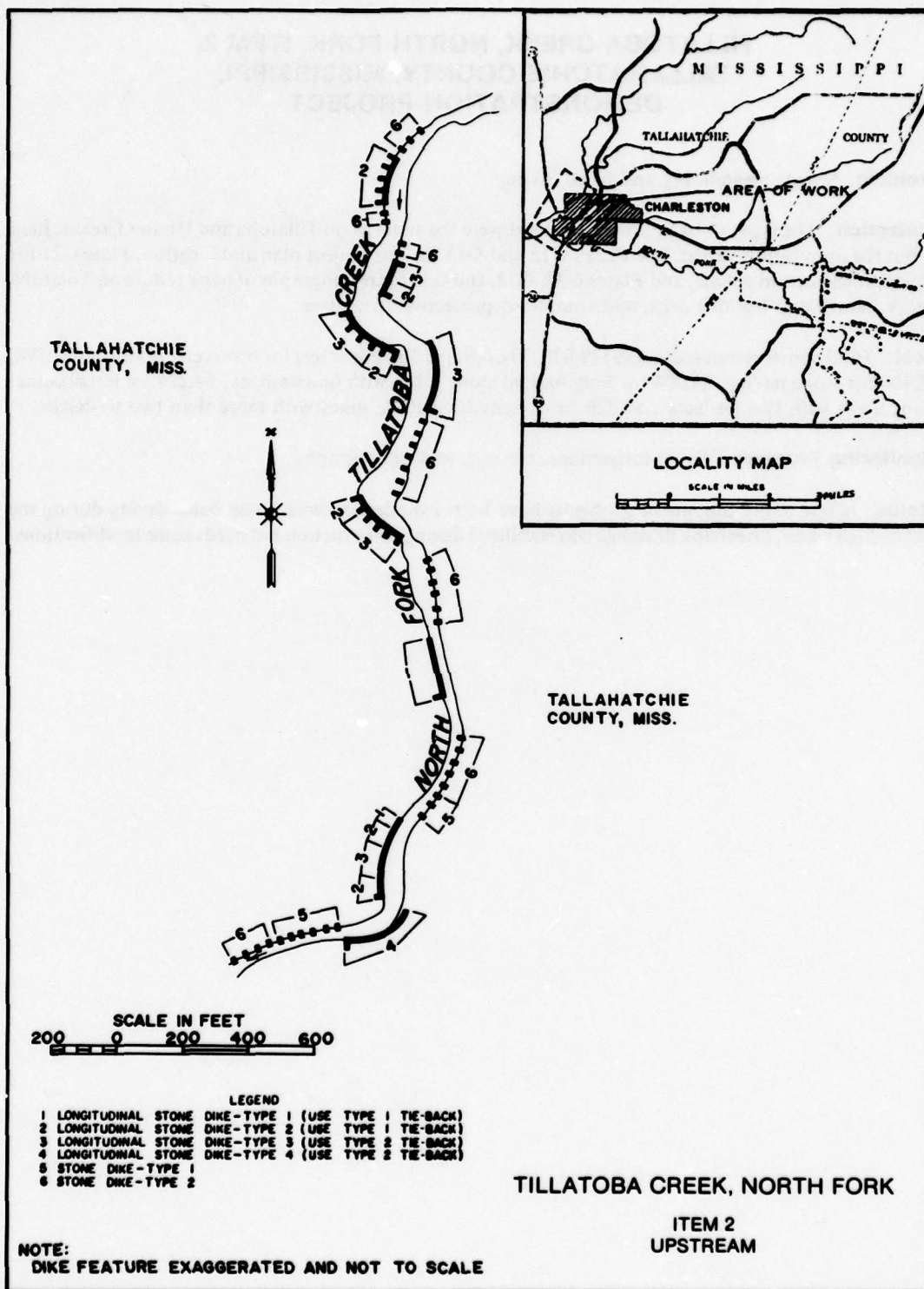


PLATE G 12

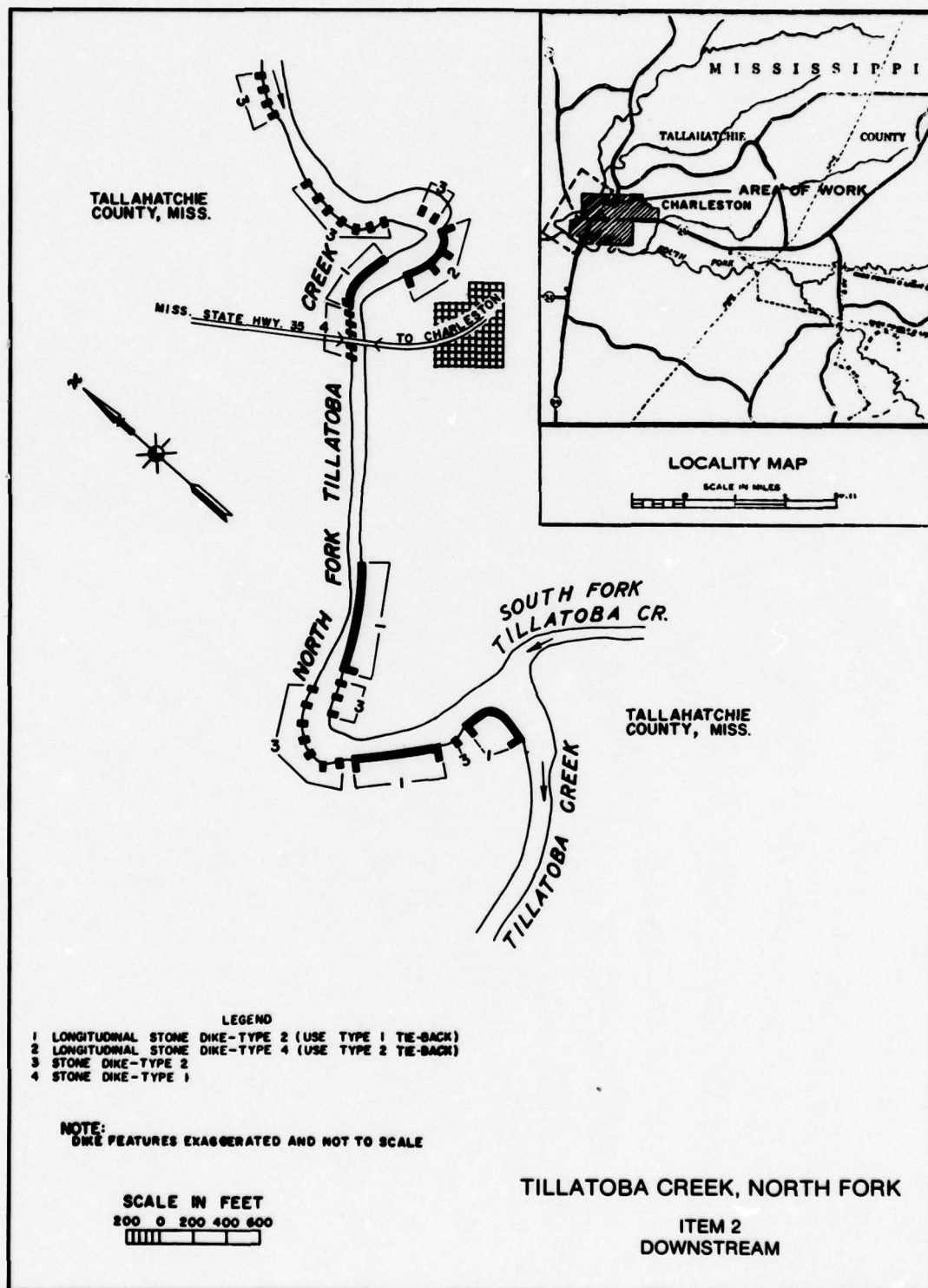


PLATE G 13

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**TILLATOBA CREEK, NORTH FORK, ITEM 3A,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Severe meandering and bank caving is a serious problem on the North Fork of Tillatoba Creek. Cause of this instability seems to be a result of a combination of things—loss of geologic control, early works by local interests, and flood-control activities in the delta. Regardless of the cause, the result was a severe head cut (bed degradation) that initiated excessive bank caving.

Protection. The key to bank stabilization is to stabilize the bed. This will prevent a high percentage of bank caving. A simplified grade-control structure has been laboratory-tested and incorporates a design to minimize the excess energy that usually creates bank caving below weirs. Additional laboratory flume work will be done at the USDA Sedimentation Laboratory in Oxford, Mississippi, and St. Anthony Falls Laboratory in Minneapolis, Minnesota, to finalize design criteria that will enable this grade-control structure to be used by any river engineer as needed. See Plate G14 for the project plan and location, Plate G26 for typical construction details, and Plate G40 for photographs of the completed structure. An artist's conception of a grade-control structure with provisions to measure total sediment load and discharge is shown in Plate G39.

Cost. Total construction cost was \$210,000.

Monitoring Program. Visual inspections, surveys, photography, and stage/slope recording gages.

Status. Contractor had problems during construction, mostly due to lack of experience. An undersized riprap was placed below the weir and a large overbank drain just upstream on left bank had inadequate protection. Several large flows were experienced during construction and one extremely high flow after construction in November 1977. The only damage to the structure was loss of top bank which had improper time for vegetation germination.

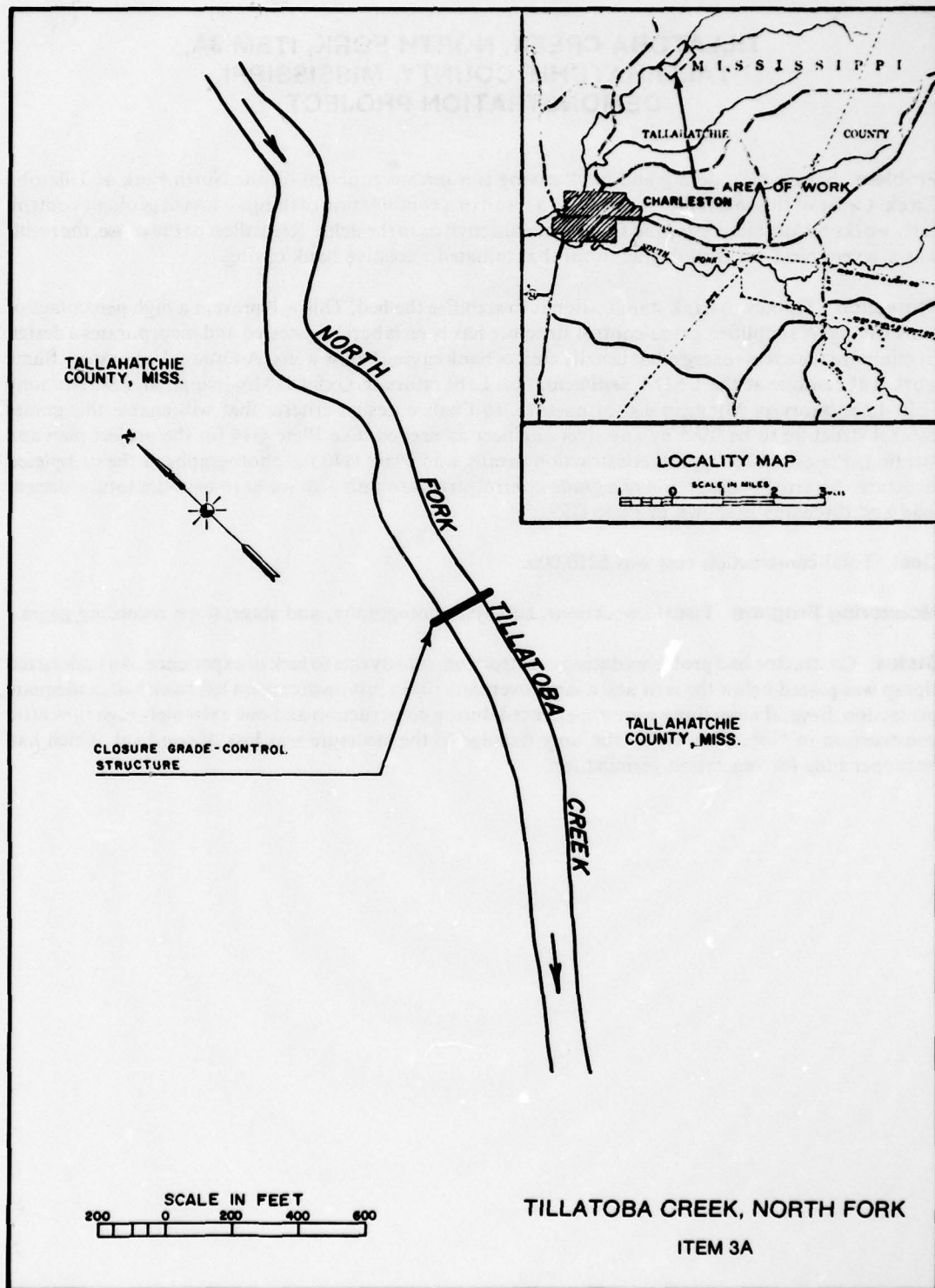


PLATE G14

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA CREEK, NORTH FORK, ITEM 3C,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Serious head cut and bank caving were progressing upstream and had reached a point 600 ft downstream of the structure. A straight reach is needed for proper alignment through a grade-control structure so the design was altered to allow for the head cut moving up to the structure.

Protection. A grade-control structure similar to the one constructed under Item 3A except for above change and a variation in the energy dissipating baffle. See Plate G15 for the project plan and location, Plate G26 for typical construction details, and Plate G41 for photographs of the completed structure. An artist's conception of a grade-control structure with provisions to measure total sediment load and discharge is shown in Plate G39.

Cost. Total construction was \$128,400.

Monitoring Program. Visual inspections, surveys, photography, and stage/slope recording gages.

Status. The above-stated head cut has now moved to within 200 ft of the structure. There is an overbank drainage problem below structure on the left bank. Several high flows and one 4-ft overbank flow have occurred since completion in September 1977, but every stone still seems to be in place.

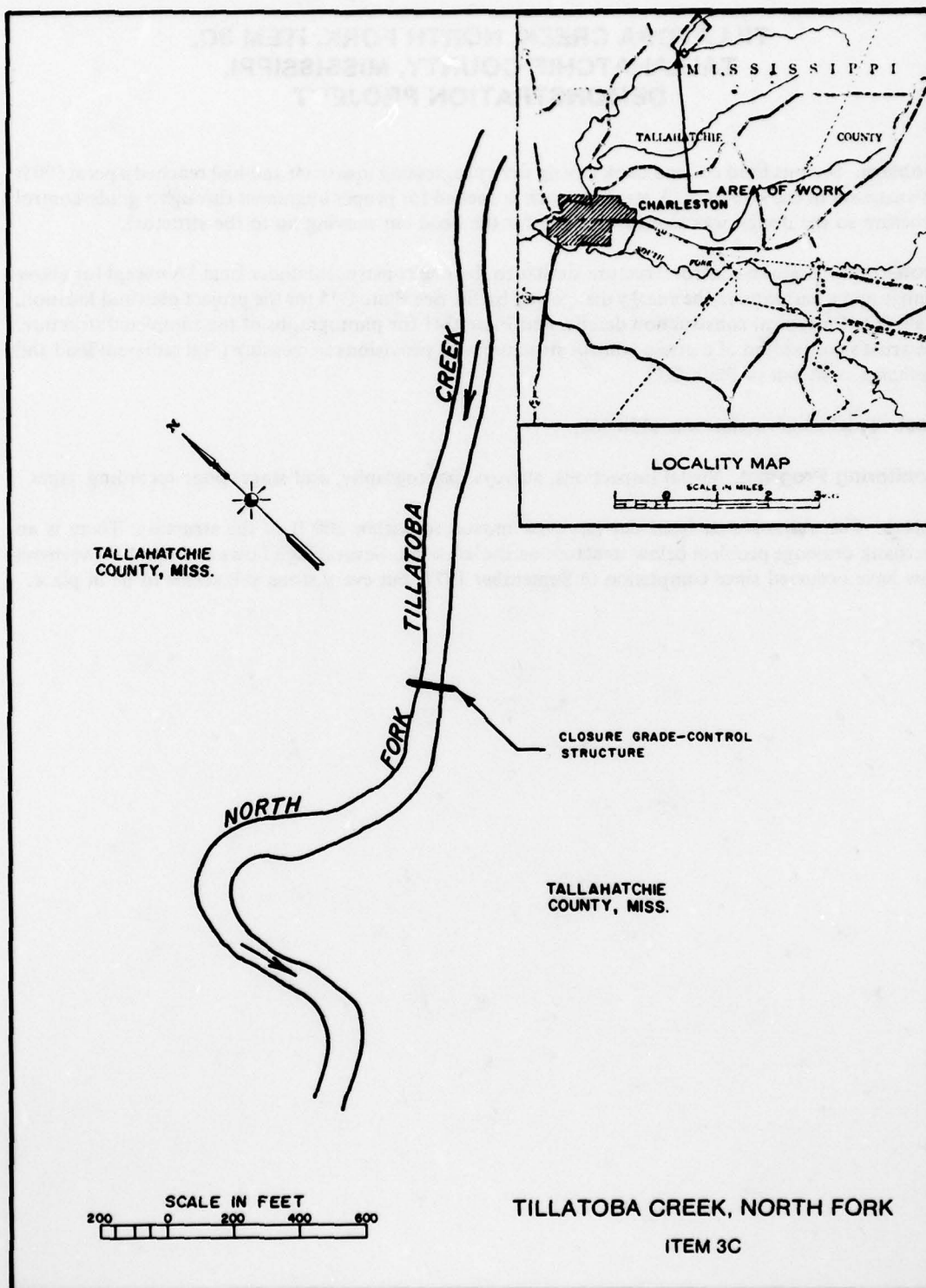


PLATE G15

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA CREEK, SOUTH FORK, FY 72,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Serious bed degradation has been progressing upstream during the past several decades. Causes seem to be a result of: (a) straightening out the 7-plus miles of the stream below the hill line during the 1920's, (b) lowering the base level at the mouth of the stream, and (c) loss of natural geologic controls in the streambed. The combined result was a lowering of the bed elevation and severe bank caving. Soil Conservation Service constructed jacks and fences on over 20 bends on the lower 5-plus miles of the stream in FY 68. Bank failures increased during the early 1970's as a result of above normal rainfall.

Protection. A series of stone dikes with some variation of design and longitudinal toe protection were built on 12 bends over 1-1/4 miles of stream. These dikes were mostly transverse groins on the outside of the bend. See Plate G16 for a partial location and plan, Plate G21 for typical construction details, and Plates G31 and G32 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Total cost of construction was \$237,664. The cost per 100 linear feet for stone dikes was \$2,881, and for longitudinal toe protection was \$7,745.

Monitoring Program. Visual inspections, periodic aerial and ground photographs, thalweg surveys, geologic soils analysis, and land use.

Status. The area has been subjected to unusual high rainfall with several storms exceeding 5 in. in 24 hours during 1973 and 1977. In general, the structures have performed adequately except where stream alignment allowed high flows to impinge directly on the unprotected bank between dikes, allowing some bank erosion. Natural vegetative growth is helping to correct some of the problems. Overland flow has caused some erosion in backfilled areas where the dikes tie into the top bank.

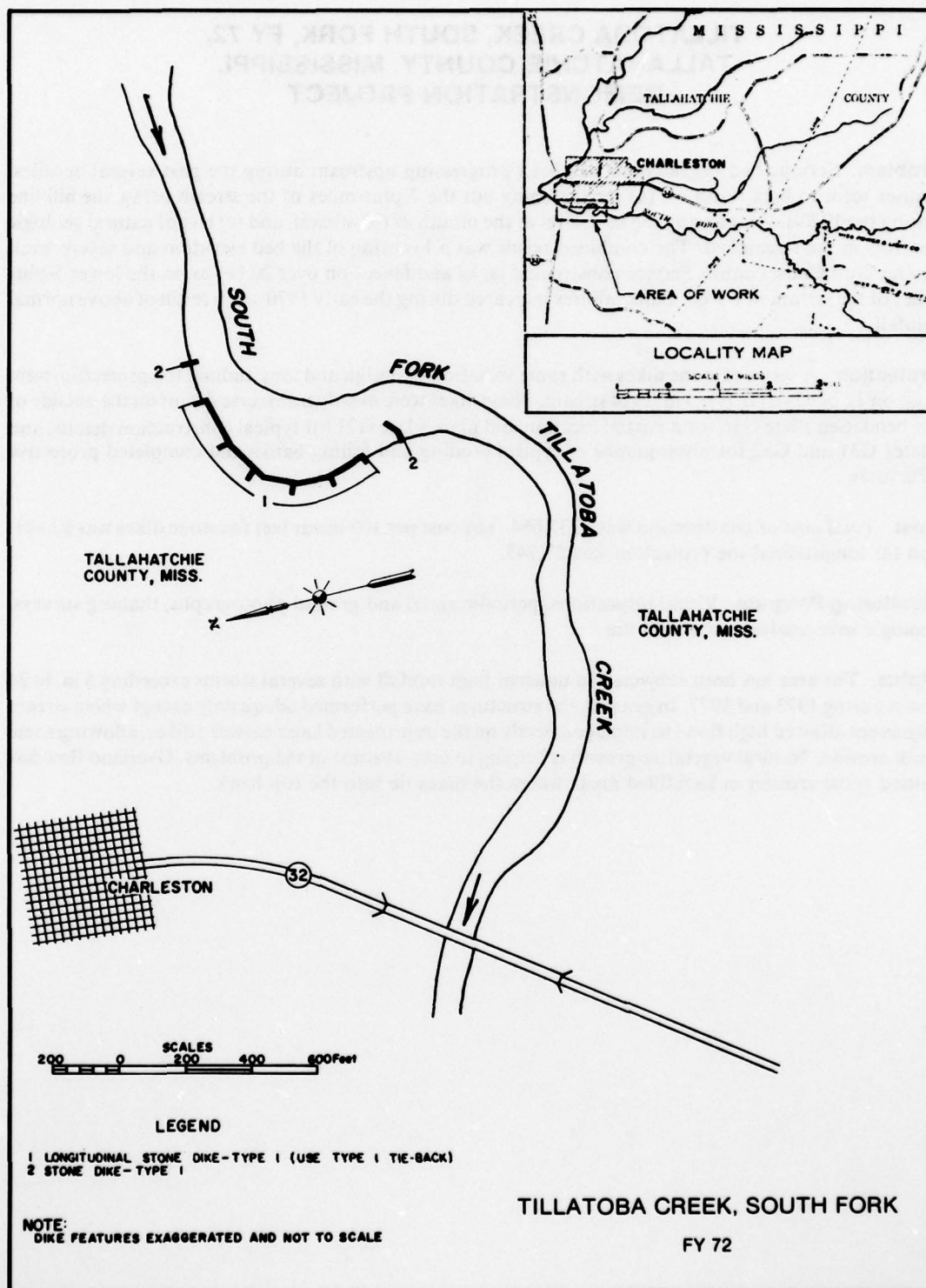


PLATE G16

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**TILLATOBA CREEK, SOUTH FORK, FY 73,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Serious bed degradation progressing upstream. See problems discussed under the Tillatoba Creek, South Fork, FY 72 project.

Protection. Four types of bank protection were used: (a) longitudinal stone dike toe protection, (b) transverse stone dikes, (c) board-fence dikes, and (d) cable-fence dikes. This work began at the upper end of FY 72 work and extended 1-1/4 miles upstream for 10 bendways. See Plate G17 for the project plan and location; Plates G21, G22, and G30 for typical construction details; and Plates G31-G33, G35, and G45 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Total cost of construction was \$222,890. The cost per 100 linear feet for stone dikes was \$3,665, \$7,734 for longitudinal stone dikes, \$3,780 for fence dikes, and \$4,455 for cable-fence dikes.

Monitoring Program. Visual inspections, periodic aerial and ground photographs, thalweg surveys, geologic soils analysis, and land use.

Status. The structures were subjected to the same flow conditions as those cited in FY 72 Tillatoba Creek, South Fork, description. These dikes further exemplified the fact that the lower end of a short radius bend is subjected to more severe bank erosion problems during high water and needs design modifications. The board- and cable-fence dikes trapped much debris, especially large sections of full-grown trees. This caused damage to some structures by subjecting them to excessive loading; however, most structures withstood these loads. Volunteer vegetation has minimized erosion in recent years and as in the FY 72 work, the structures have prevented excessive bank caving so that vegetation could get a foothold. Where radius of curvature was small, scour has occurred under the structures even though a riprap blanket was installed.

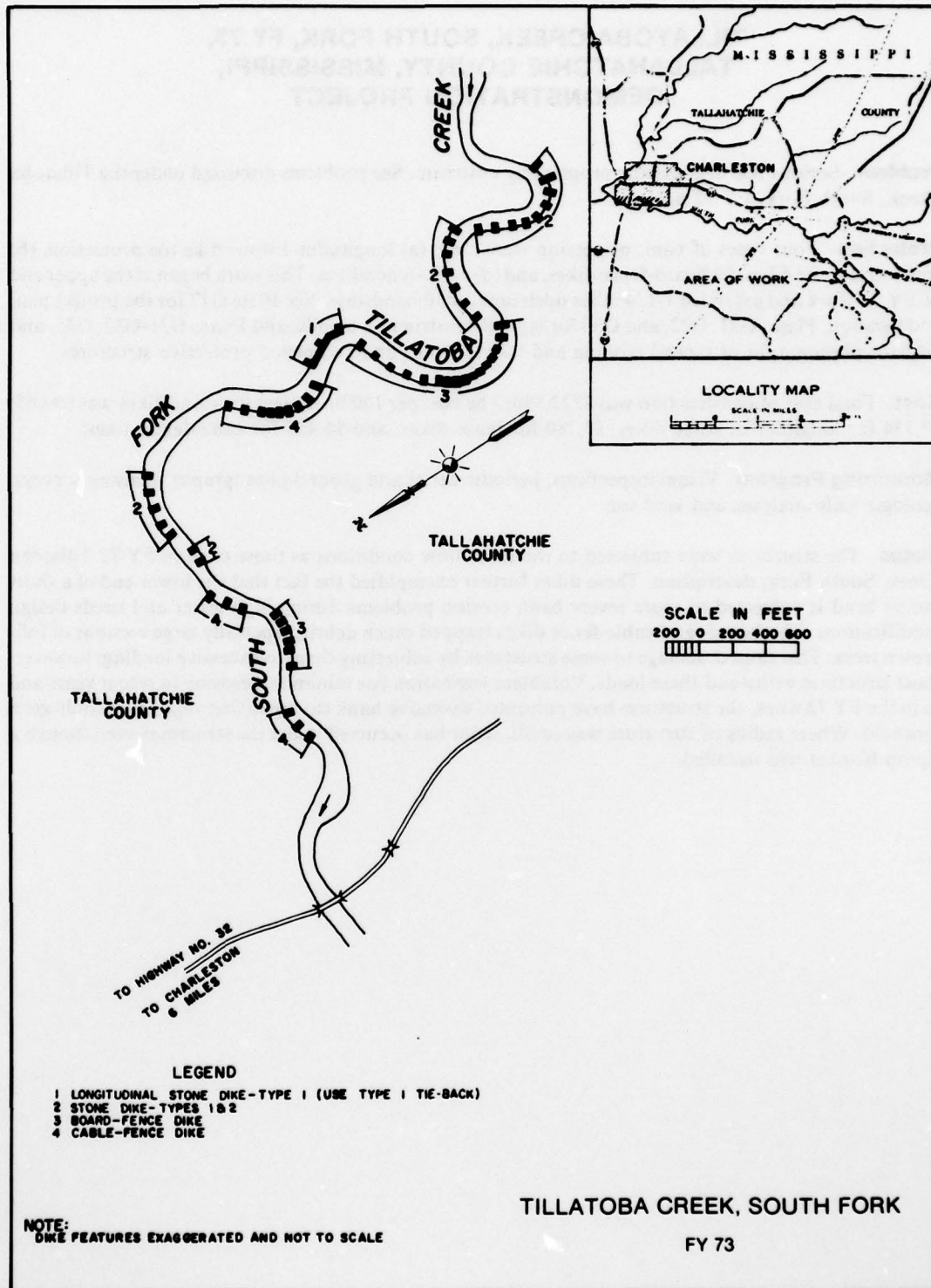


PLATE G 17

G40

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**TILLATOBA CREEK, SOUTH FORK, ITEM 5A,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Refer to problems cited previously under project description for Tillatoba Creek, South Fork, FY 72.

Protection. Two methods of utilizing local material and hired labor were used on this project: (a) bagged sand-cement placed and backfilled on a graded bank over a city dump with additional bags used as toe protection; and (b) rubber tire revetment on a graded bank with willow cuttings. See Plates G18 and G19 for the project plan and location, Plates G24 and G25 for typical construction details, and Plates G36 and G38 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Total construction cost was \$99,900. Cost per 100 linear feet for used-tire revetment was \$3,300 and for sand-cement bag revetment was \$9,900.

Monitoring Program. Surveys, field inspections, and photography.

Status. Some variations are needed on the sacked sand-cement revetment design because it tends to act as a monolithic structure without internal strength. Also, better toe protection is needed to allow launching during scour. A variation in anchoring the toe of the tire revetment is needed. Some means, such as tires filled with concrete, is needed to hold tires in place and to allow for normal toe scour. These structures have been subjected to at least four rainfalls of over 4 in. each in a 24-hour period. The work has performed well, even with the present design.

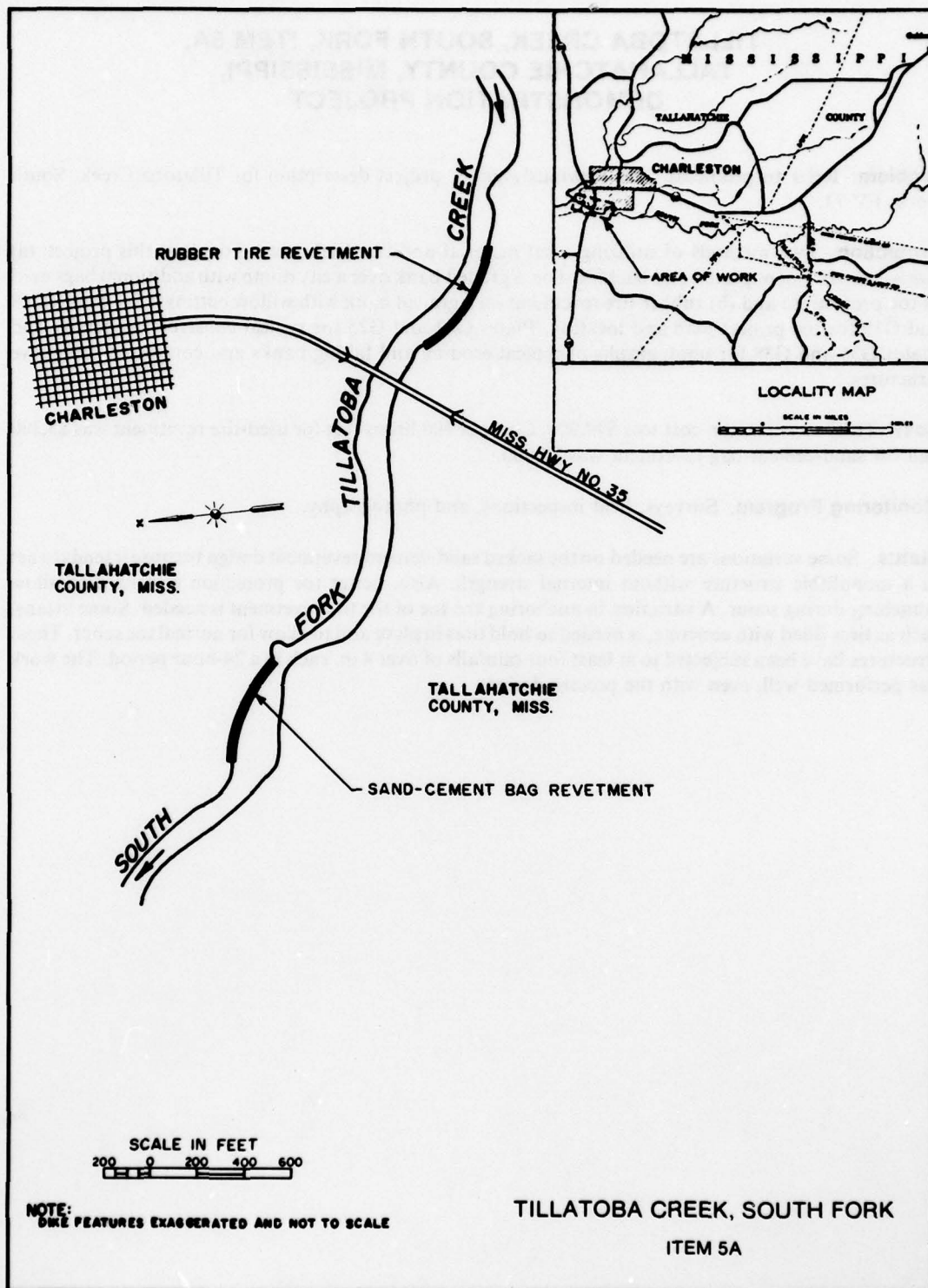


PLATE G18

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA CREEK, SOUTH FORK, ITEM 5B,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Serious bed degradation progressing upstream. See problems cited earlier under FY 72 work on this stream.

Protection. Two methods using local material were used on this item. Cribs were constructed with treated piles driven 7 ft into the ground and fenced as shown in Plates G27 and G28. The cribs were filled with either baled hay or used tires. The existing bank was left untreated and in a natural condition, where possible; however, construction techniques required clearing in some locations. See Plate G19 for project plan and location, and Plates G42 and G43 for photographs of typical eroding and failing banks and completed protective structures.

Cost. Total construction cost was \$160,400. The cost per 100 linear feet was \$2,500 for wire crib retards (tire-filled) and \$2,500 for wire crib retards (hay-filled).

Monitoring Program. Surveys, field inspections, and photography.

Status. These structures were subjected to four or five high-water conditions during the first year of operation. Several problems are currently apparent: (a) streambed scour, occurring between surveys and construction, was backfilled with local material; this did not stay, even during moderately low flows; (b) alignment was not always compatible with high flows because of above changes between survey and construction; (c) bags filled with sand-cement used for toe protection were inadequate, leaving portions of structure unprotected when above scour reoccurred; and (d) when scour, possibly 4 to 7 ft, occurred during high water, the tires and hay bales were removed under the wire crib which rested on natural or man-made fill. Some structures were scoured to the point that cribs were emptied, the outside piles scoured below maximum penetration, and then the entire structure swung up and over the rear piles.

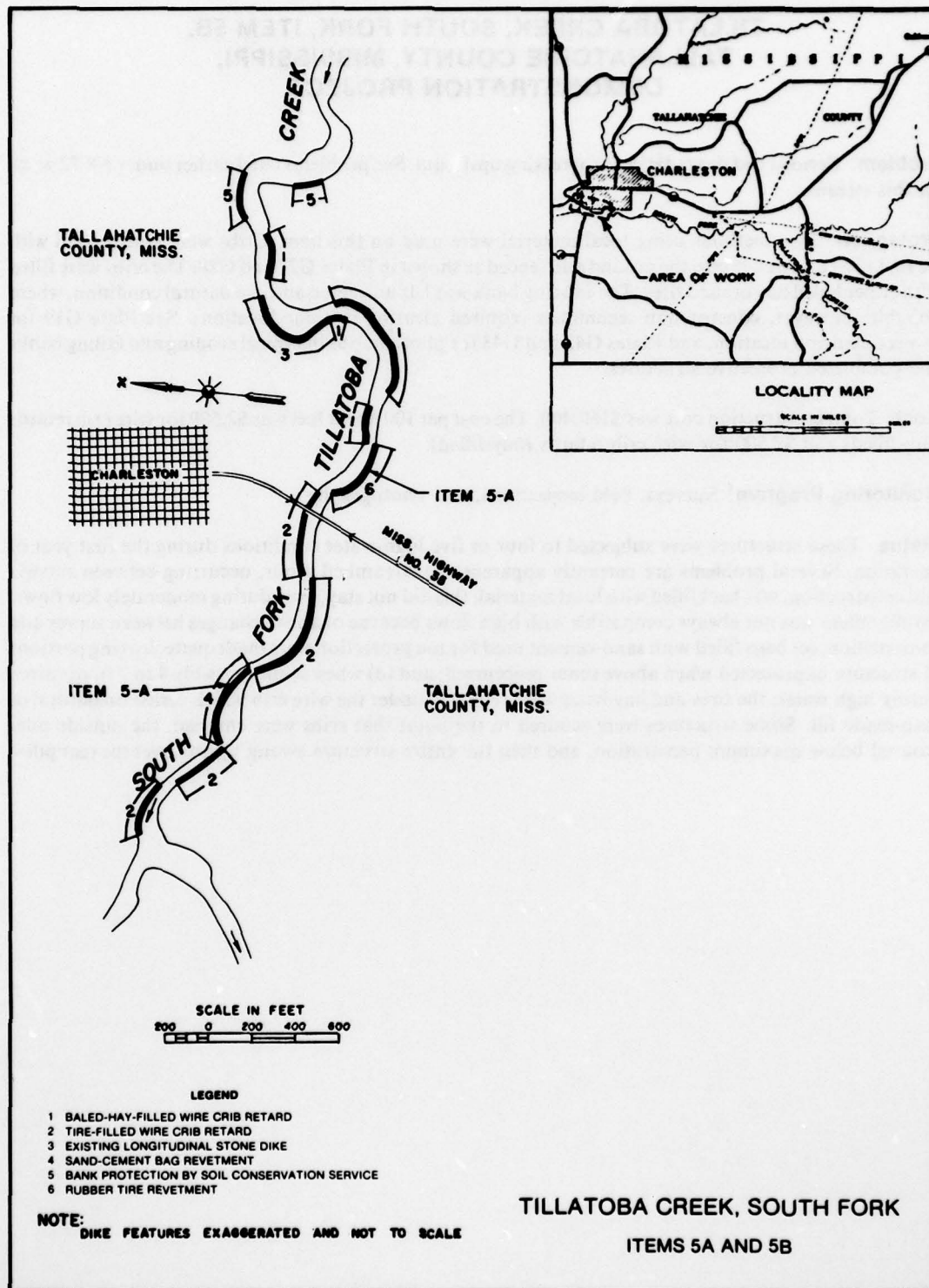


PLATE G19

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**TILLATOBA CREEK, SOUTH FORK, ITEM 5C,
TALLAHATCHIE COUNTY, MISSISSIPPI,
DEMONSTRATION PROJECT**

Problem. Serious bed degradation progressing upstream. See problems cited under FY 72 work on this stream.

Protection. Longitudinal stone dikes with vegetation and modified used-tire revetment with vegetation. See Plate G20 for the project plan and location, Plates G21 and G24 for typical construction details, and Plates G32, G35, and G36 for photographs of typical eroding and failing bank and completed protective structures at other locations.

Cost. Construction costs are estimated to be \$355,000.

Monitoring Program. Surveys, photographs, and visual inspections.

Status. To be constructed in FY 78.

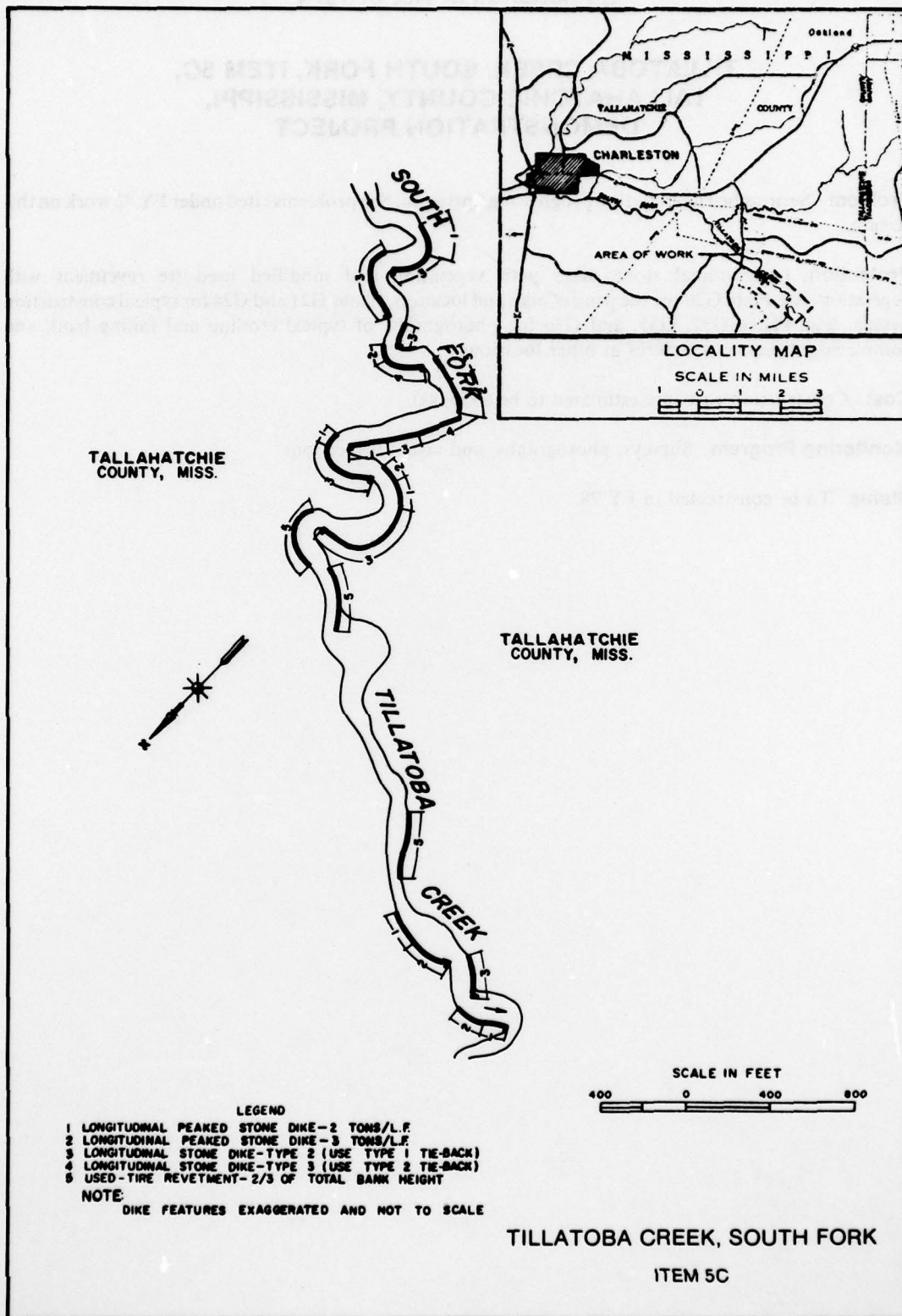
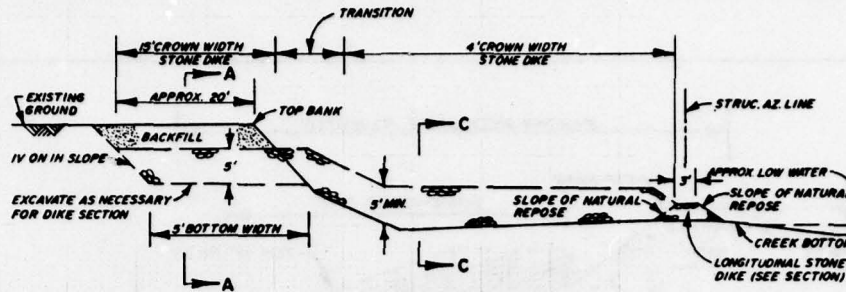
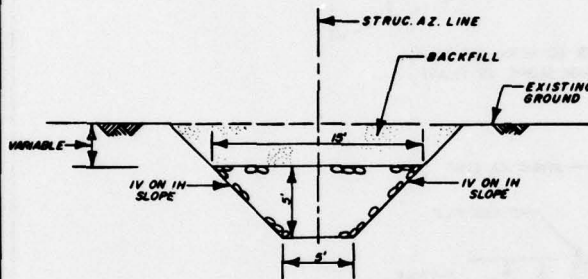


PLATE G20

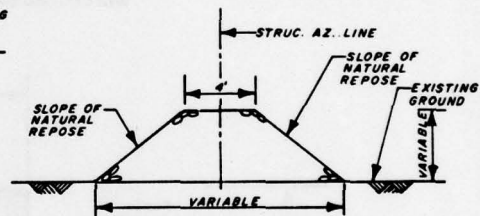


TYPICAL PROFILE

SCALE IN FEET (HORIZ. & VERT.)
20 FT

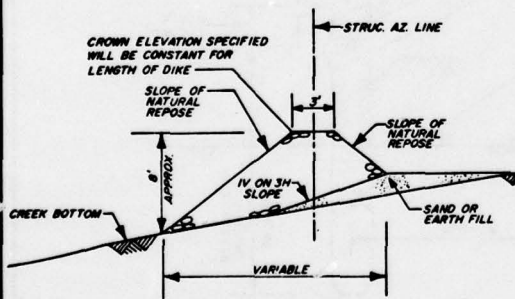


SECTION A-A

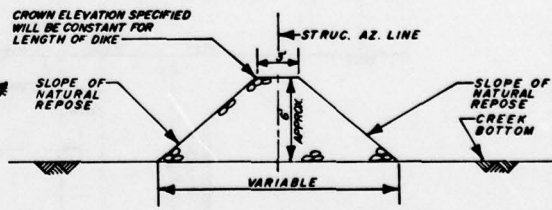


SECTION C-C

TRANSVERSE



SECTION
LONGITUDINAL DIKE
(BETWEEN DIKES 2-7 APPROX. 610 L.F.)

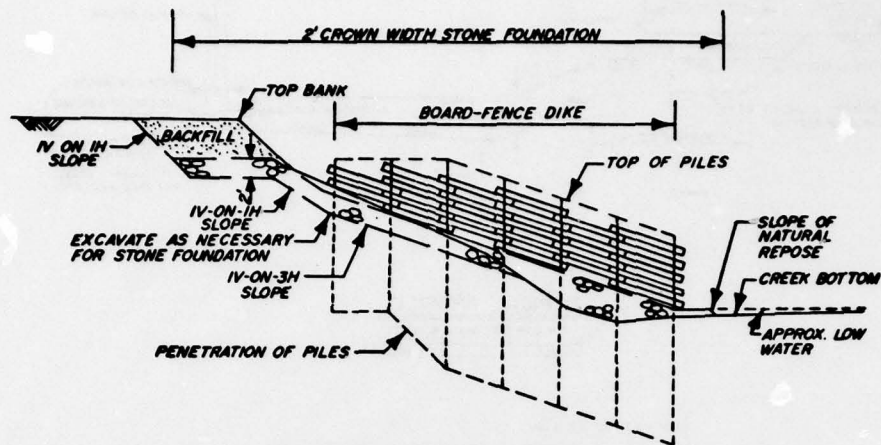


SECTION
LONGITUDINAL DIKE
(BETWEEN DIKES 37-39, APPROX. 300 L.F.)

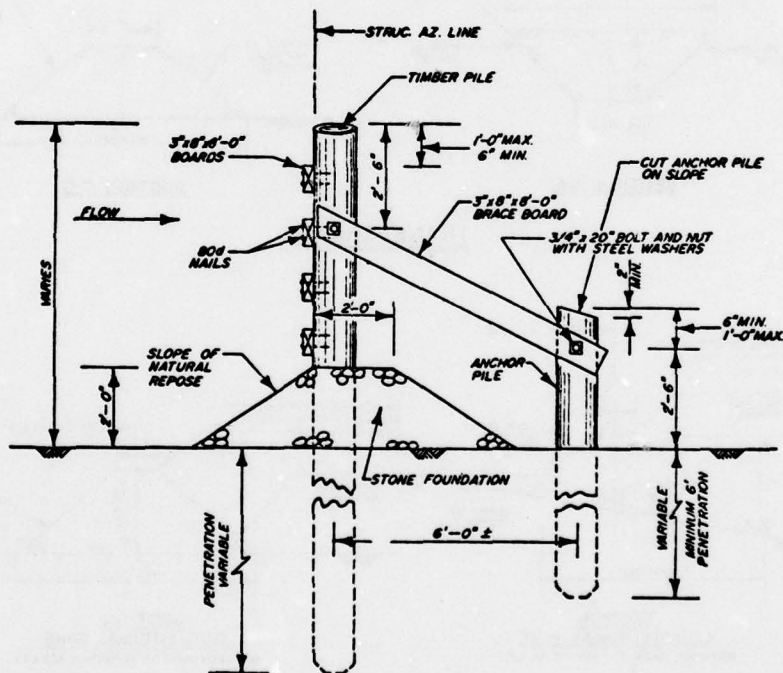
LONGITUDINAL

TYPICAL TRANSVERSE AND LONGITUDINAL STONE DIKES

PLATE G21



(WHERE DIKE TIES TO HIGH TOP BANK,
AND EXISTING BANK SLOPE IS FLAT)



END VIEW

(SHOWING BRACE ARRANGEMENT-ONE TO THREE REQUIRED PER DIKE)

TYPICAL BOARD-FENCE DIKE

PLATE G22

AD-A073 673

CORPS OF ENGINEERS WASHINGTON D C
INTERIM REPORT TO CONGRESS, 30 SEPTEMBER 1978. SECTION 32 PROGR--ETC(U)
SEP 78

F/G 5/2

UNCLASSIFIED

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3 OF 4

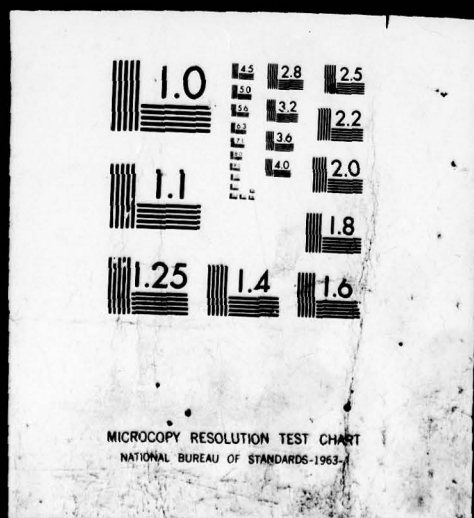
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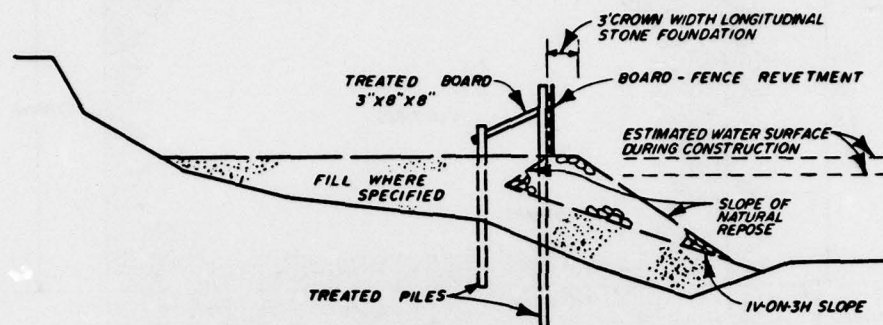


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3 OF 4

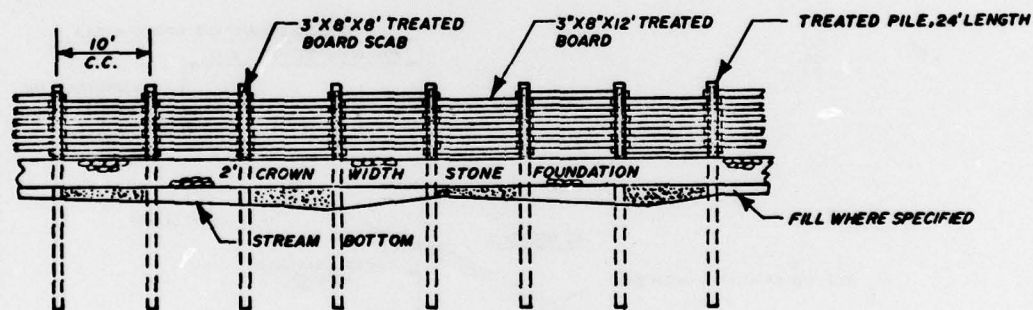
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PROFILE

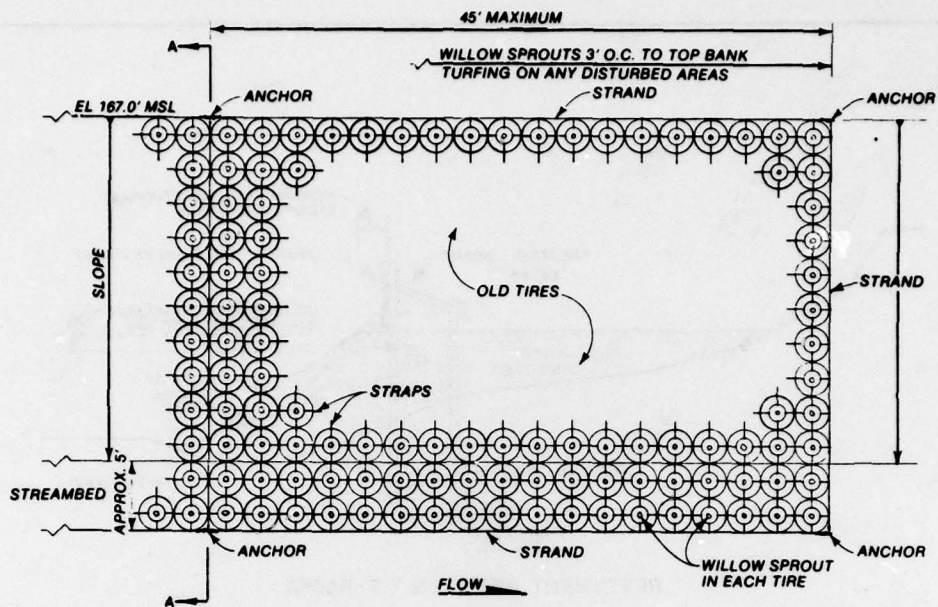
REVTMENT BETWEEN TIE-BACKS



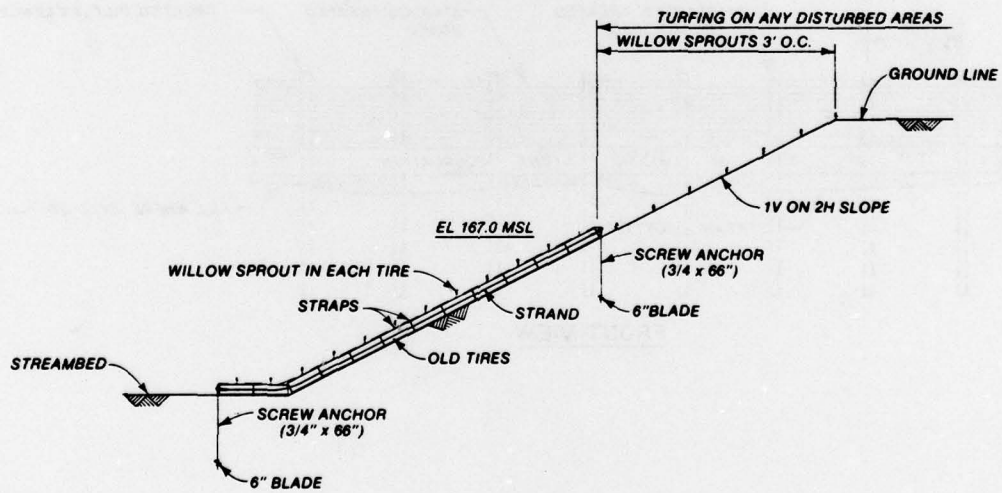
FRONT VIEW

TYPICAL BOARD-FENCE
LONGITUDINAL REVTMENT

PLATE G23

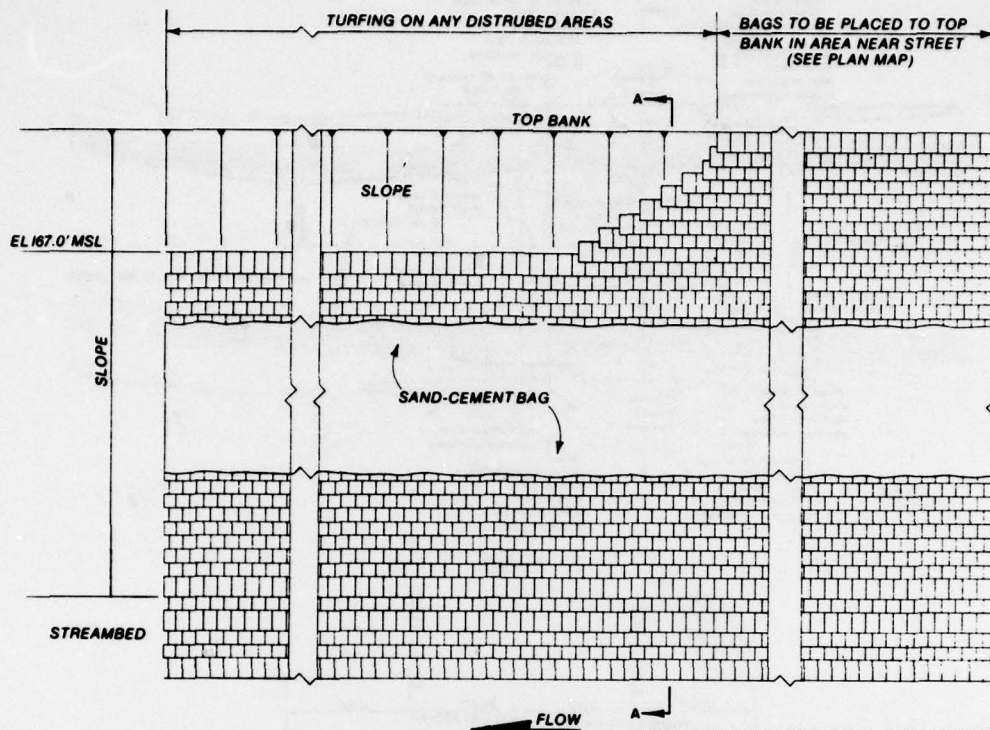


PLAN



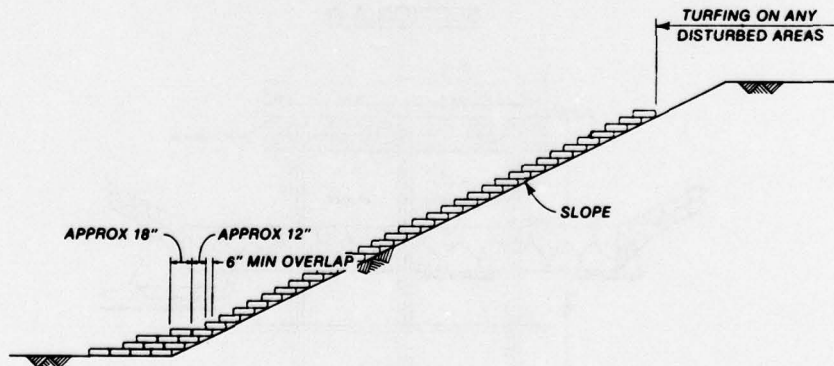
SECTION A-A

**TYPICAL
RUBBER-TIRE REVETMENT**



NOTE: LAP UNFILLED PORTION OF BAG UNDER NEXT BAG. TIEING OR SEWING BAG IS NOT NECESSARY. CLOSE ALL SPACE BY TAMPING EACH BAG AS LAID.

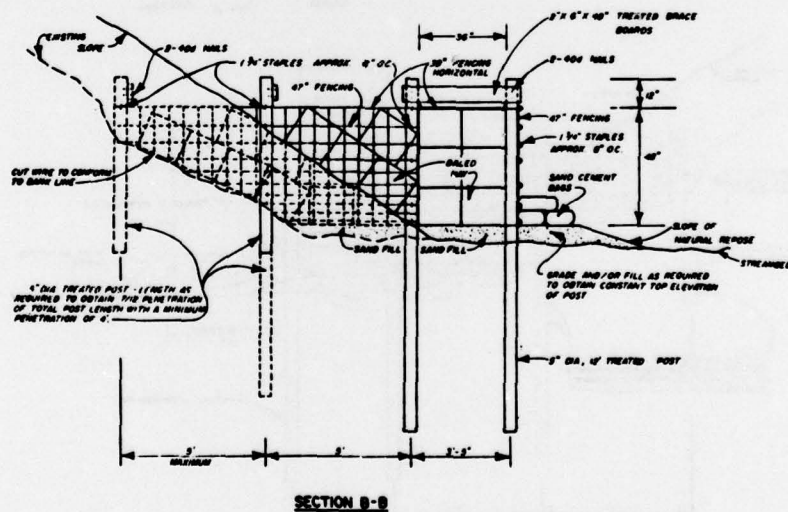
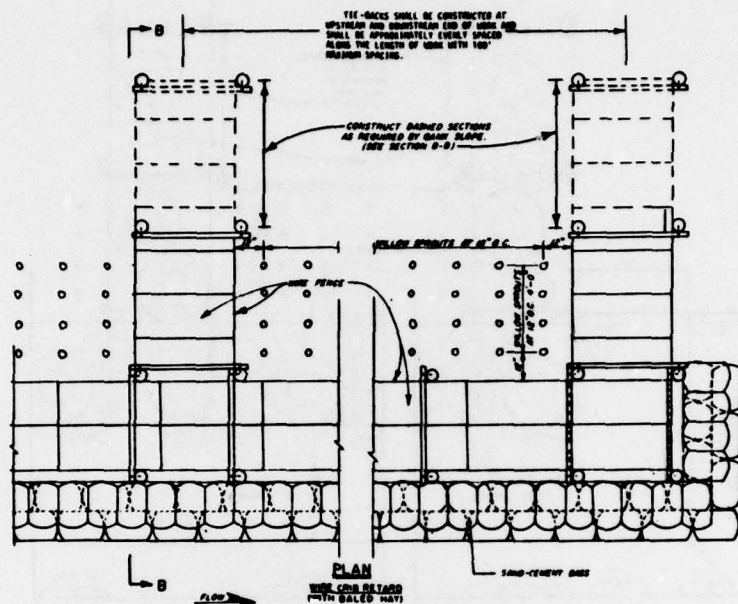
PLAN



SECTION A-A

**TYPICAL
SAND-CEMENT BAG REVETMENT**

PLATE G25



TYPICAL WIRE CRIB RETARDS
BALED-HAY-FILLED

PLATE G27

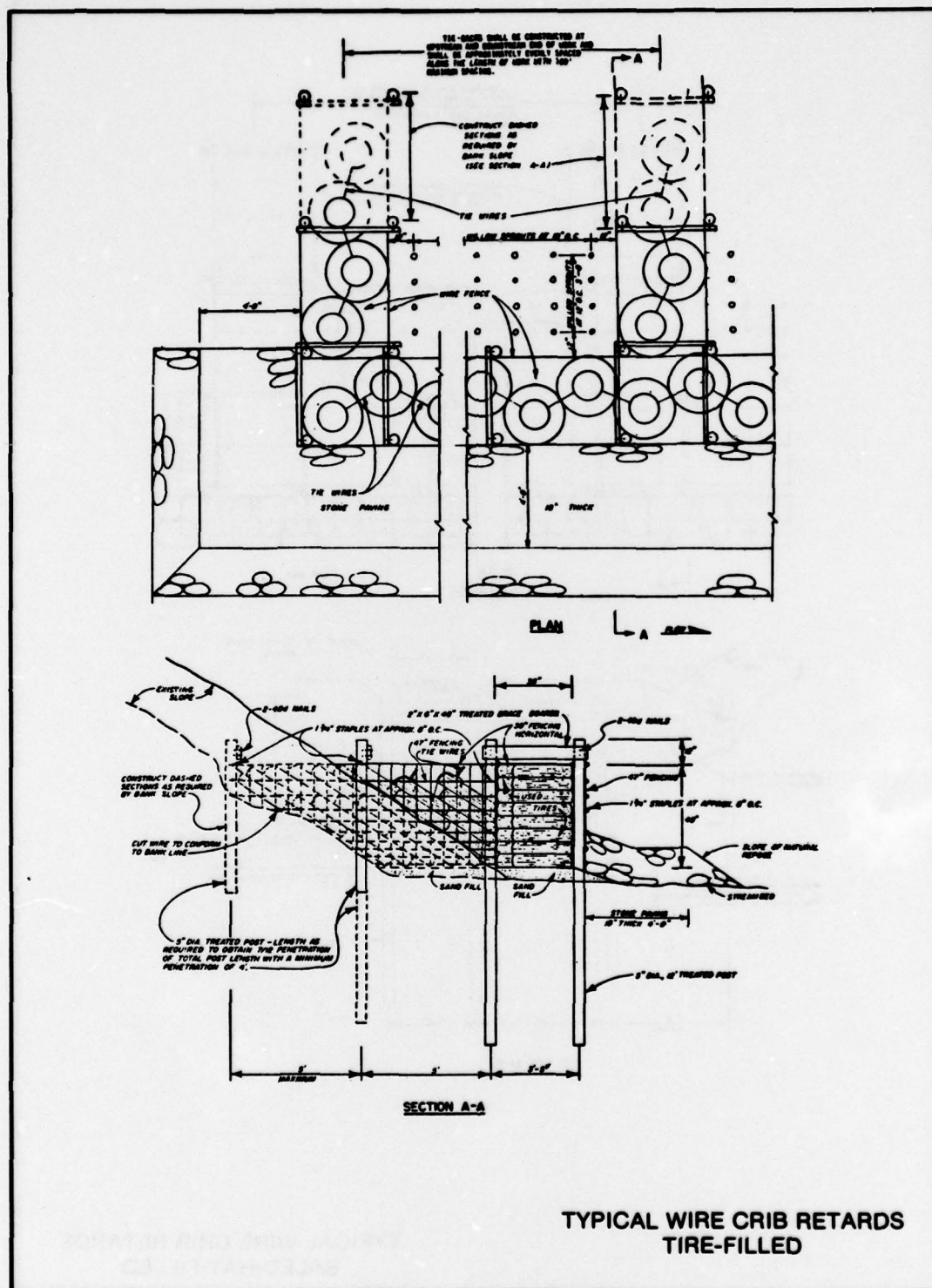


PLATE G28

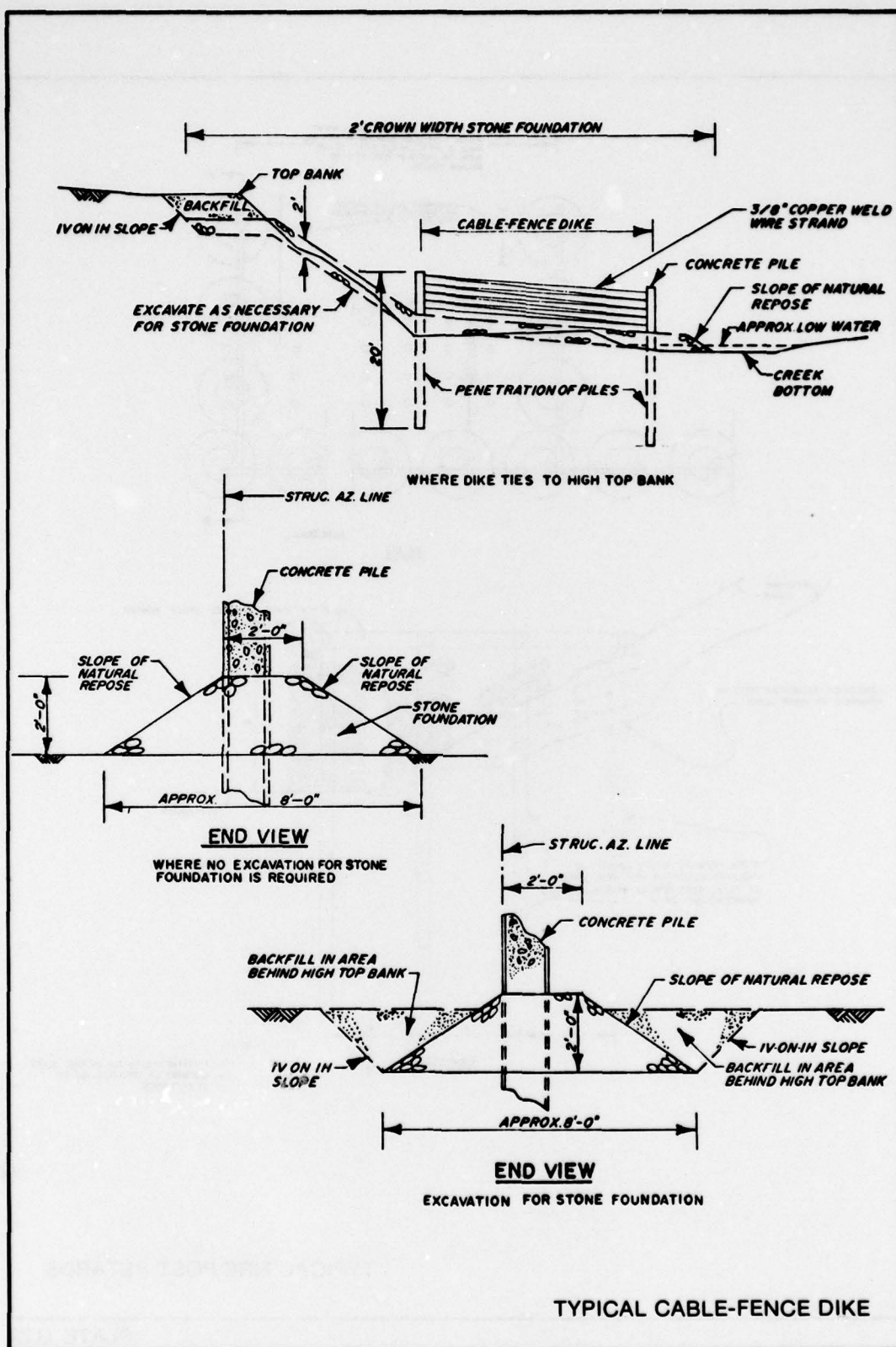


PLATE G30



PHOTO 1
BEFORE CONSTRUCTION
11 MAY 1971



PHOTO 2
AFTER CONSTRUCTION
1 MAY 1972



PHOTO 3
14 FEBRUARY 1974

TILLATOBA CREEK, SOUTH FORK
TRANSVERSE STONE DIKES

18-FT-HIGH BANK

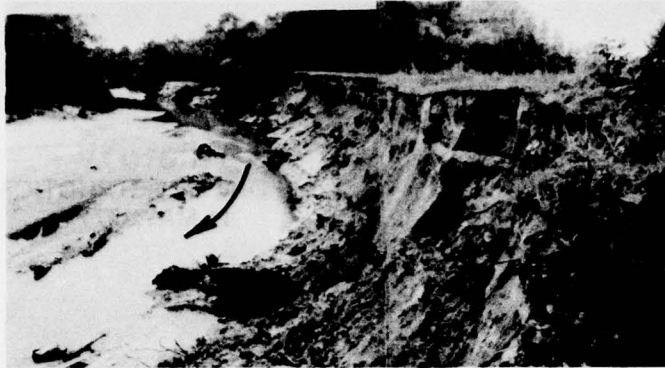


PHOTO 1
BEFORE CONSTRUCTION
10 MAY 1971

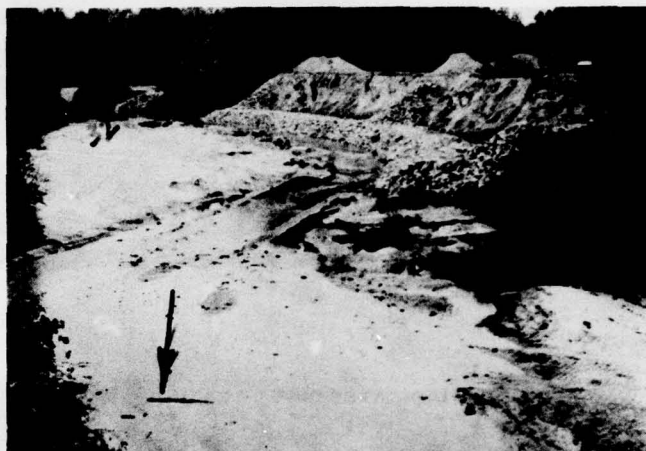


PHOTO 2
AFTER CONSTRUCTION
20 OCTOBER 1971



PHOTO 3
19 MARCH 1975

TILLATOBA CREEK, SOUTH FORK
LONGITUDINAL DIKE WITH TIE-BACKS
15-FT-HIGH BANK

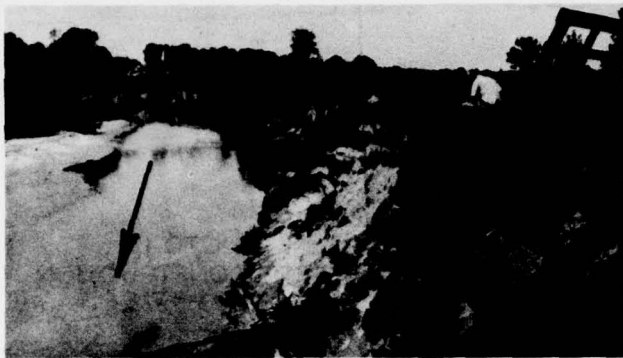


PHOTO 1
BEFORE CONSTRUCTION
8 MAY 1972



PHOTO 2
AFTER CONSTRUCTION
30 MAY 1973



PHOTO 3
19 MARCH 1975

TILLATOBA CREEK, SOUTH FORK
TRANSVERSE BOARD-FENCE DIKES

16-FT-HIGH BANK

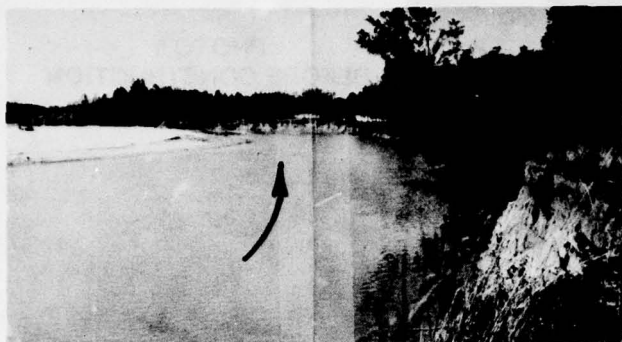


PHOTO 1
BEFORE CONSTRUCTION
5 MAY 1973

PHOTO 2
AFTER CONSTRUCTION
11 APRIL 1974

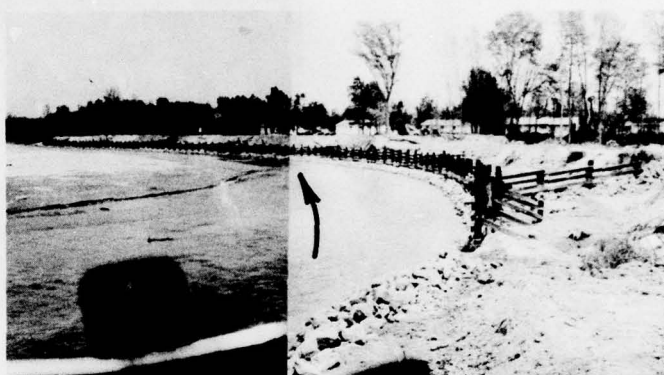


PHOTO 3
17 NOVEMBER 1975

BATUPAN BOGUE
BOARD-FENCE REVETMENT
12-FT-HIGH BANK



PHOTO 1
BEFORE CONSTRUCTION
18 MARCH 1975



PHOTO 2
AFTER CONSTRUCTION
22 JUNE 1976



PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(8 DECEMBER 1977)

TILLATOBA CREEK,
NORTH FORK, ITEM 1
LONGITUDINAL DIKE WITH
BANK GRADING AND VEGETATION
18-FT-HIGH BANK



PHOTO 1
DURING CONSTRUCTION
9 FEBRUARY 1977



PHOTO 2
AFTER CONSTRUCTION
11 MARCH 1977



PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

TILLATOBA CREEK,
SOUTH FORK, ITEM 5A
TIRE REVETMENT WITH
WILLOW CUTTINGS

16-FT-HIGH BANK



PHOTO 1
BEFORE CONSTRUCTION
13 APRIL 1977



PHOTO 2
AFTER CONSTRUCTION
11 OCTOBER 1977



PHOTO 3
AFTER FLOOD OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

BATUPAN BOGUE, ITEM 4A
TIRE REVETMENT (FAILURE)

16-FT-HIGH BANK

PLATE G37



PHOTO 1
BEFORE CONSTRUCTION
9 FEBRUARY 1977



PHOTO 2
AFTER CONSTRUCTION
15 JULY 1977



PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

TILLATOBA CREEK,
SOUTH FORK, ITEM 5A
SACKED SAND-CEMENT REVETMENT

19-FT-HIGH BANK

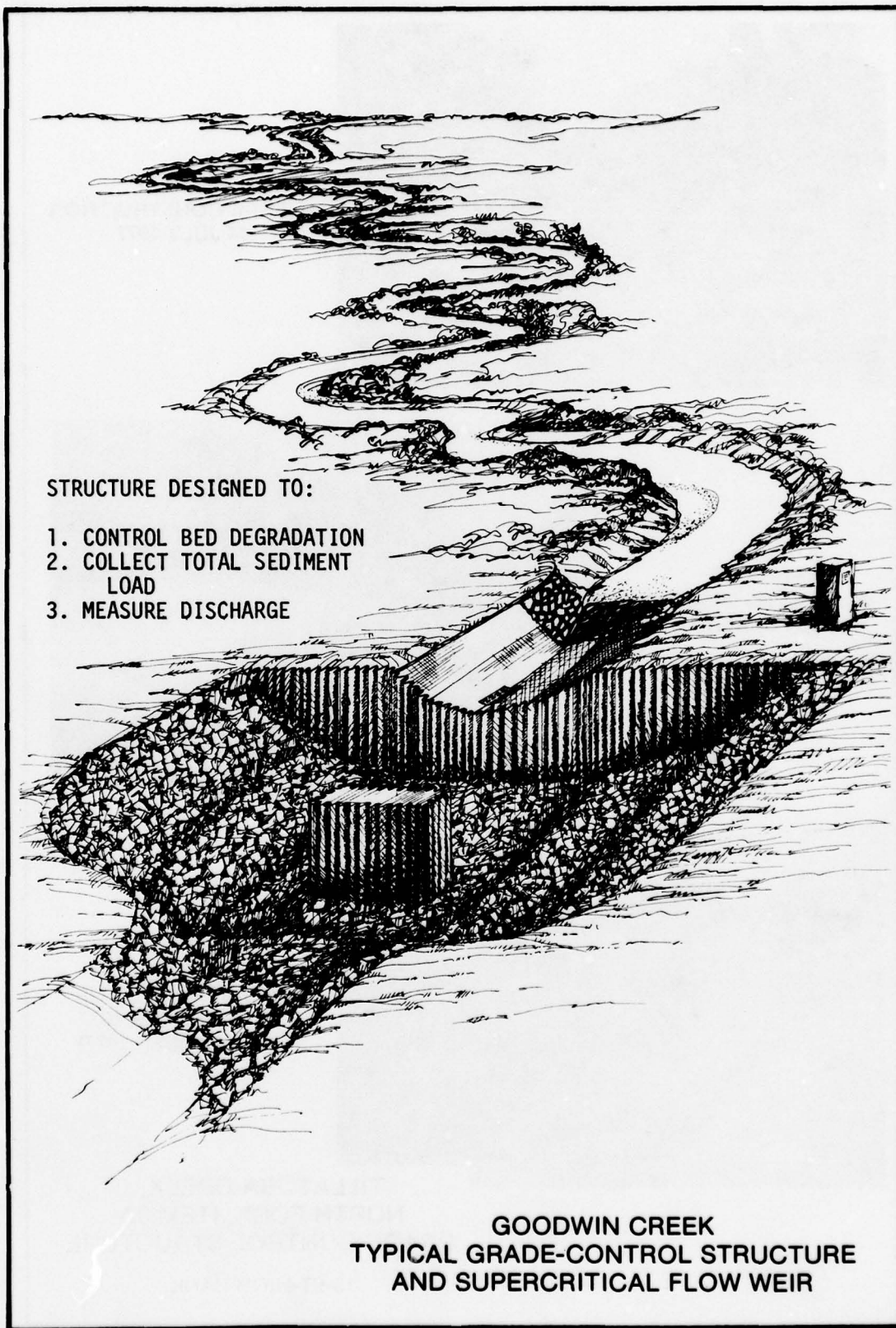


PLATE G39



**PHOTO 1
BEFORE CONSTRUCTION
14 JULY 1977**



**PHOTO 2
AFTER CONSTRUCTION
15 NOVEMBER 1977**



**PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)**

**TILLATOBA CREEK,
NORTH FORK, ITEM 3A
GRADE-CONTROL STRUCTURE**

15-FT-HIGH BANK

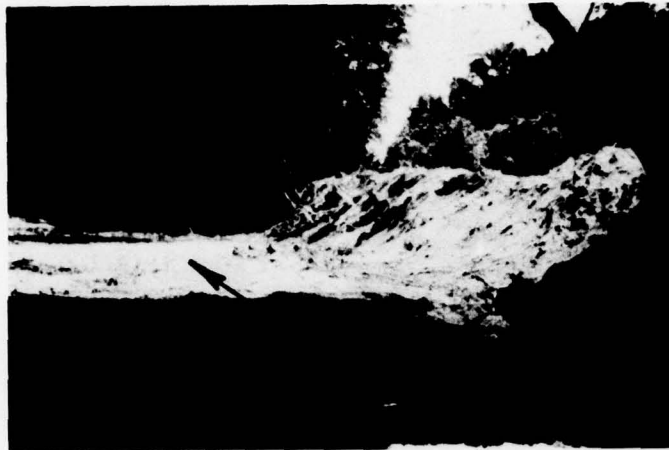


PHOTO 1
BEFORE CONSTRUCTION
14 JULY 1977

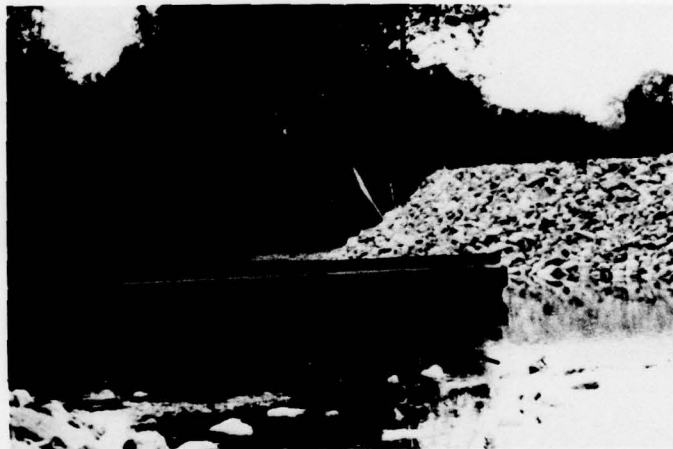


PHOTO 2
AFTER CONSTRUCTION
25 AUGUST 1977



PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

TILLATOBA CREEK,
NORTH FORK, ITEM 3C
GRADE-CONTROL STRUCTURE
12-FT-HIGH BANK

PLATE G41



PHOTO 1
BEFORE CONSTRUCTION
7 MARCH 1977

PHOTO 2
AFTER CONSTRUCTION
14 JULY 1977

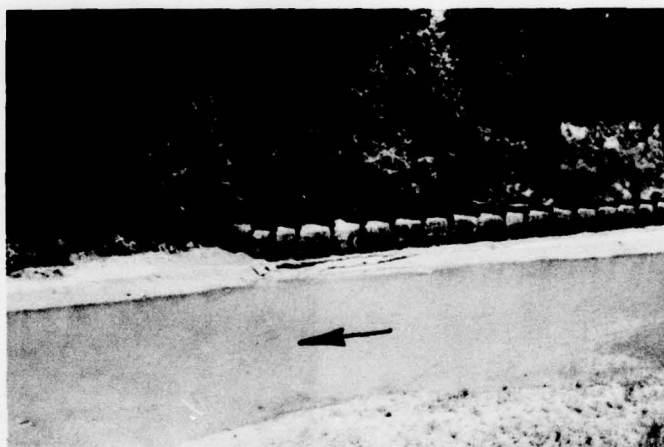


PHOTO 3
AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

TILLATOBA CREEK,
SOUTH FORK, ITEM 5B
WIRE CRIB RETARD, HAY-FILLED
18-FT-HIGH BANK



PHOTO 1 AFTER CONSTRUCTION
14 JULY 1977



PHOTO 2 AFTER RUNOUT OF
21 NOVEMBER 1977
(7 DECEMBER 1977)

TILLATOBA CREEK,
SOUTH FORK, ITEM 5B
WIRE CRIB RETARD, TIRE-FILLED
15-FT-HIGH BANK

PLATE G 43



PHOTO 1 BEFORE CONSTRUCTION
30 MARCH 78



PHOTO 2 AFTER CONSTRUCTION
13 JUNE 78

PERRY CREEK ITEM 6A
TIRE-POST RETARDS



PHOTO 1
BEFORE CONSTRUCTION
8 MAY 1972

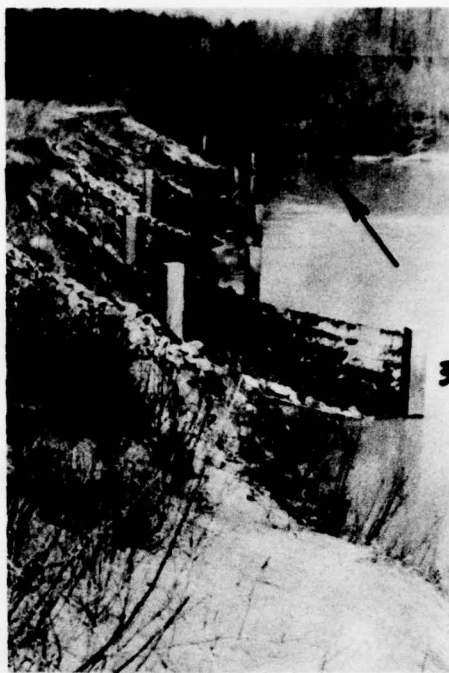


PHOTO 2
AFTER CONSTRUCTION
16 JANUARY 1973



PHOTO 3
19 MARCH 1975

TILLATOBA CREEK, SOUTH FORK
CABLE-FENCE DIKES
15-FT-HIGH BANK

APPENDIX H
Demonstration Projects on Other
Streams, Nationwide
(Work Unit 8)

APPENDIX H

Demonstration Projects on Other Streams, Nationwide (Work Unit 8)

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* Yellowstone River, River Road, Montana (Mile 27.5)	

* Summary description not provided in this report. Project sponsor, location, and construction schedules not yet established.

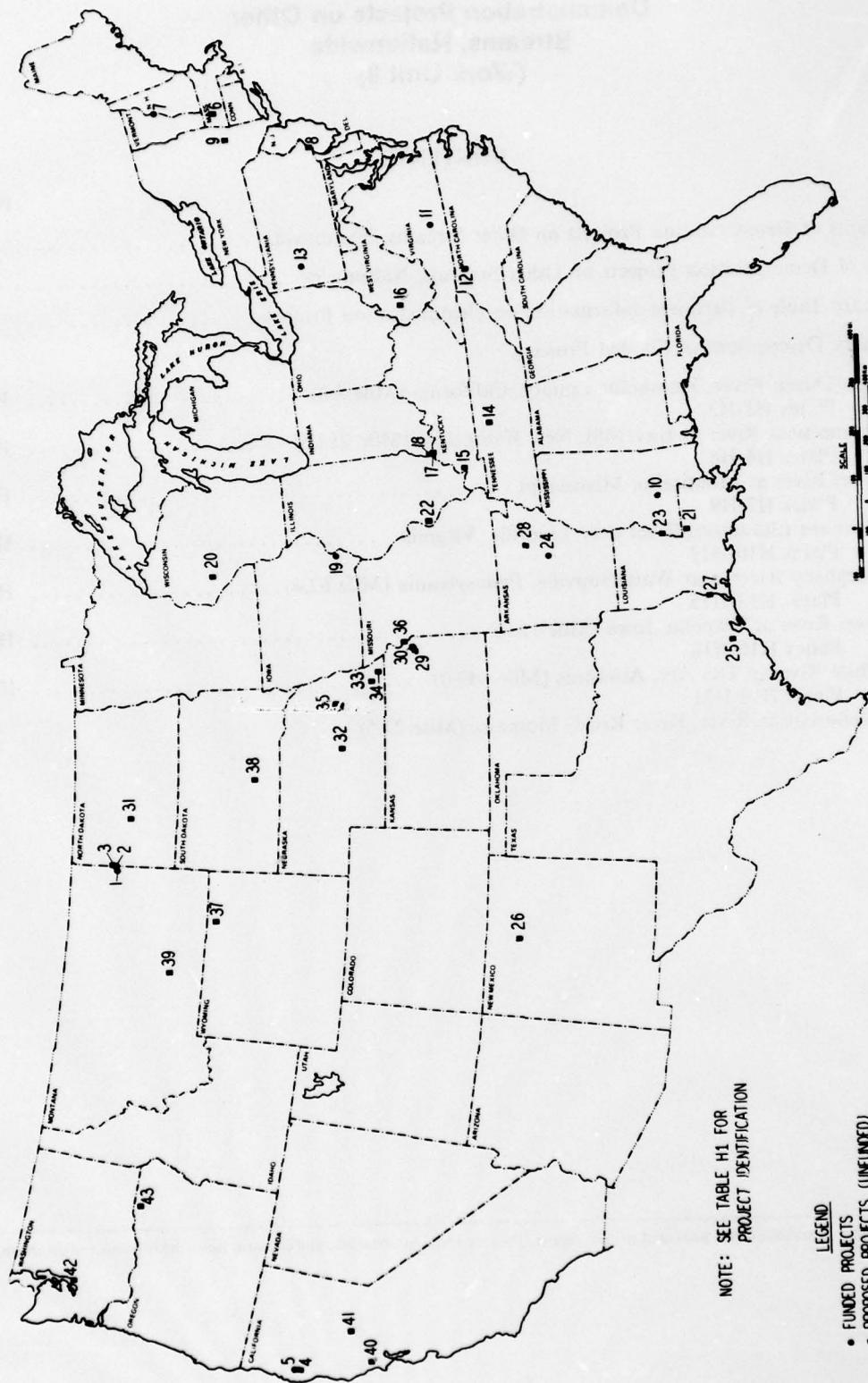


Figure H1. Locations of Demonstration Projects on Other Streams, Nationwide (Work Unit 8)

APPENDIX H

Status of Demonstration Projects on Other Streams, Nationwide (Work Unit 8)

Under this portion of the Section 32 Program, potentially low-cost streambank protection methods and materials are being evaluated at a variety of selected sites to demonstrate their capability to perform under a broad range of geographical and environmental conditions. The sites are chosen by Corps field offices on the basis of their potential for demonstration and testing of new techniques. The Eel and Yellowstone River sites, which were added as amendments to the Section 32 Program legislation in October 1976, are also included (Figure H1).

This work unit presently consists of 43 approved or proposed demonstration projects on 35 different streams throughout the United States. Eight of the projects have been approved for construction and monitoring. Construction of all but one or two of the funded projects should be completed in FY 78 or early in FY 79. Seven other projects which are scheduled for construction in FY 1979 have been allotted only minimal funding to permit preliminary planning and feasibility studies to commence. No funds have been allocated to date for the remaining 24 proposed projects; however, a number of these will be approved for construction in future years, depending on the allocation of adequate funds by Congress and the actual costs required to complete the projects specified in the legislation.

All necessary coordination with Federal, State, and local agencies is being accomplished by the responsible Districts. Local approval and support is being obtained for each project before construction begins; and upon completion of the program, maintenance of the projects becomes a local responsibility. Environmental considerations are addressed during the planning and design phases of each project.

Bank protection materials and methods being tested include the following or combinations thereof: pavement, rock hard points, pile fences, gabion mattresses, sand- and cement-filled paper-bag riprap, interlocked baled hay, various vegetative covers, rock riprap, tire mattresses, concrete blocks, windrows, and filter cloths.

Detailed monitoring and evaluation plans are being developed for each demonstration project. The plans will include monitoring both the physical and environmental aspects of the projects, and will continue until completion of the program. A table of pertinent information, including funding status, on each project under this work unit (Table H1) and descriptions of the funded projects are provided in this appendix.

TABLE H1: SUMMARY OF PERTINENT INFORMATION ON DEMONSTRATION PROJECTS
Other Streams Nationwide (Work Unit 8)

Stream, Mile, & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
<u>Yellowstone River (specified in PL 94-587)</u>							
Yellow- stone R. 27.5 Right	River Road	Sidney	Richland	MT-2	Omaha NE	High-flow veloc- ity, wave wash and ice gorging during annual spring floods	Revetment and hard points
Yellow- stone R. 20.0 Right	Cheney Creek	Cartwright	McKenzie	ND-1	Omaha NE	High-flow veloc- ity, wave wash and ice gorging during annual spring floods	Revetment and hard points
Yellow- stone R. 11.5 Right	Horse Creek	Cartwright	McKenzie	ND-1	Omaha NE	High-flow veloc- ity, wave wash and ice gorging during annual spring floods	Revetment and hard points
<u>Del River Delta (specified in PL 94-587)</u>							
Eel R. 6.0 Right	D/S of Fernbridge	Fortuna	Humboldt	CA-2	San Francisco CA	Velocity eroding bank toe	Rock hard points, pile fences with rock toe, and rock toe with planting
Van Duzen R. 8.0 Right	D/S of Fielder Creek	Carlotta	Humboldt	CA-2	San Francisco CA	Velocity eroding bank toe	Tree pendants, light pile fence, and dense pile fence
<u>Sites on other streams nationwide not specified in authorizing legislation</u>							
Connect- icut R. 132.5 Left	Northeast Utilities, Inc.	Northfield	Franklin	MA-1	New England MA	High velocities during spring runoff; hydro- electric pool operation con- sisting of rapid pool drawdown and surged dis- charges; natural and boat-induced waves; ice	Gabion mattresses, interlocked rubber tires, sand-cement filled paper riprap bags, interlocked baled hay and wire mesh over filter cloth below the normal waterline. Vegetative cover above the waterline
Connect- icut R. 254.6 Left	Dean Thorburn Farm	Haverhill	Grafton	NH-2	New England MA	High velocities during spring runoff; hydro- electric pool operation con- sisting of rapid pool drawdown and surged dis- charges; natural and boat-induced waves; ice	a. 9-in. gabion mattresses b. 3 ft x 3 ft gabion underwater toe and interlocked rubber tires c. Sand-cement filled paper riprap bags d. Interlocked baled hay e. Vegetative cover above the waterline
Delaware R. 13.6 mi D/S of Phil., PA East side	Billingsport	Paulsboro	Gloucester	NJ-1	Philadel- phia PA	Ship wake and currents	Tentative methods: a. Riprap b. Precast concrete grillage c. Groins d. Gabions e. Tire mats
Hudson R. 19.0 mi D/S of New Albany, NY East side	Nutten Hook	Coxsackie	Columbia	NY-29	New York NY	Tidal fluctua- tions, wash from oceangoing vessels and possible ice erosion	a. Riprap b. Vegetation c. Tire mats
Pearl R. 3 sites Both sides	Monticello	Monticello	Lawrence	MS-3	Mobile AL	Rapid stage recession and local drainage	Concrete blocks, dumped rubble, used tires
Roanoke R. 3 sites Both sides	D/S of Lees- ville Dam	Leesville	Campbell	VA-5	Wilmington NC	Erosion and sloughing caused by vary- ing water levels	Riprap, Fabriform, reno mattress
Roaring R. 0.25 Right	Roaring River	Roaring River	Wilkes	NC-5	Charleston SC	High-velocity flows undermin- ing noncohesive soils	Gabions, riprap and fabric mulch/grass
Allegheny R. 62.4 Right	U/S of L&D 9	Watterson- ville	Armstrong	PA-12	Pittsburg PA	High-velocity flows acting on highly erodible, fine-grained soil; winter ice floes which gorge soil from the riverbank	Potential protective scenes include: a. Hard points b. Windrows

Other Streams Nationwide (Work Unit 8) (Continued)

Funding in \$1000								
Stream, Mile, & Side	Project Length ft	Est Costs		Allocated thru FY 78	Expended as of 3/31/78	Status	Remarks	Map No.*
		Construc- tion	Engr, Monitor & Reporting					
<u>Yellowstone River (specified in PL 94-587) (Continued)</u>								
Yellow- stone R. 27.5 Right	5,200	158.0	52.0	230.0	3.0	Scheduled FY 78		1
Yellow- stone R. 20.0 Right	5,800	150.0	47.0	None	None	Scheduled FY 79		2
Yellow- stone R. 11.5 Right	10,600	200.0	63.0	None	None	Scheduled FY 79		3
<u>El River Delta (specified in PL 94-587) (Continued)</u>								
El R. 6.0 Right	2,400	468.0	132.0	None	None	Awaiting funding	Tentatively approved in the FY 79 budget	4
Van Duzen R. 8.0 Right	900	80.0	97.0	150.0	21.5	Basis of design completed; pre- paring plans and specifications		5
<u>Sites on other streams nationwide not specified in authorizing legislation (Continued)</u>								
Connect- icut R. 132.5 Left	2,600	140.0	130.0	None	None	Awaiting FY 79 funding	Tentatively approved in FY 79 budget. Bank protection methods are tentative	6
Connect- icut R. 254.6 Left	2,600	190.0	135.0	325.0	64.0	Project layout and design 80% complete. Local assurances 80% complete. Construction contract award scheduled for 31 May 1978		7
Dela- ware R. 13.6 mi D/S of Phil., PA East side	2,500	185.0	29.0	10.5	4.5	Preliminary report prepared and approved. District has been authorized to proceed with development of local cooperation	Cost estimate is based on present level; tentatively approved in FY 79 budget	8
Hudson R. 19.0 mi D/S of New Albany, IN East side	1,500	192.0	99.0	4.5	4.5	Preliminary report prepared and approved		9
Pearl R. 3 sites Both sides	1,000	178.0	105.0	450.0	40.5	Completed plans and specifica- tions in April 1978	Construction costs will probably increase due to unforeseen foundation problems at one site. Estimated in- crease not available at this time.	10
Roanoke R. 3 sites Both Sides	2,400	255.0	20.0	120.0	0.6	Under design		11
Roaring R. 0.25 Right	445	185.0	60.0	5.0	5.0	Construction not authorized to date. Project assigned a No. 3 priority		12
Allegheny R. 62.4 Right	2,000	133.0	--	134.0	5.2	Avenues for securing local sponsorship are being sought		13

(Continued)

* See Figure H1 for project locations.

(Sheet 1 of 3)

Other Streams Nationwide (Work Unit 8) (Continued)

Stream, Mile, & Side	Local Vicinity	At or Near City	In County	State- Cong Dist	CE Office	Erosion Causative Agents	Protective Methods to be Tested
<u>Sites on other streams nationwide not specified in authorizing legislation (Continued)</u>							
Cumber- land R. 185.0 Left	Tennessee State Univ.	Nashville	Davidson	TN-5	Nashville TN	Bank instability due to drawdown and waves	Structural (gabions and gabimats), vegetal
Cumber- land R. 26.0 Left	Grand Rivers	Iuka	Harlan	KY-5	Nashville TN	Bank instability due to drawdown and waves	Structural, vegetal, tires filled with concrete
Kanawha R. 46.6 Left	St. Albans	St. Albans	Kanawha	WV-3	Huntington WV	Bank instability	a. 3-ft layer of demolition brick placed on filter cloth with reshaping of bank to LV on 2H and vegetative cover b. Sand- and epoxy-covered Longard tube cloth anchored to the bank approxi- mate to normal pool and supplement existing vegetation c. Slag revetment near toe of reshaped slopes with selective vegetation cover
Wabash R. 34.0 Right	Maunie	Evansville	White	IL-24	Louisville KY	River current	50-ft stone spur dikes, Fabriform, con- struction of a pilot cut across bend
Wabash R. 41.0 Left	New Harmony	Evansville	Posey	IN-8	Louisville KY	Predominantly river current	Fabriform, bend mattress, quarry-run riprap, changing downstream slope
Iowa R. 16.0 Right	Wapello	Wapello	Louisa	IA-1	Rock Island IA	Poor soil con- dition and high velocity at 90° angle of attack	Fabriform mat, steel jacks, timber jetties
Lower Chippewa R. 21.0, 35.0, 46.0 Right 54.0, 22.0, 19.0, 15.0 Left	Durand	Eau Claire	Pepin	WI-3	St. Paul MN	Poor soil con- dition and river stage fluctua- tion due to reservoir releases	Flatten bank, soil-cement, wing dams, flow retards, vegetation, rock riprap, different filter cloths
Bayou Sara 0.5 Left	St. Francisville	St. Francisville	West Feliciana	LA-8	New Orleans LA	High-velocity flows on non- cohesive soils; mining of coarse sediments	a. 1050 ft of gabions b. 200 ft of gabimats with filter cloth c. 625 ft of ballasted filter cloth d. 625 ft of Fabriform
Kaskaskia 36.0-46.0 Left	Immediately above head of navigation	Fayetteville	St. Clair	IL-23	St. Louis MO	High-velocity flows on non- cohesive soils	a. Quarry-run stone b. Gabion mattress c. Filter cloth
St. Catherine Creek 5.0 Right	Natchez	Natchez	Adams	MS-4	Vicksburg MS	Bank instability	a. Stone toe protection b. Stone training dikes
White R. 143.0 Right	Des Arc	Des Arc	Prairie	AR-2	Memphis TN	Velocity scour, massive sliding	a. Stone toe, used tires, crushed rock b. Stone toe, Fabriform c. Stone toe, soil-cement d. Stone toe, used tires, filter mat
Brazos R. 151.0 Right	Stephen F. Austin State Park	Sealy	Austin	TX-10	Fort Worth TX	Alluvial plain with a short radius bend. Erosion occurs on concave side	Patented fence-jetty system developed by A-E firm Hold-That-River Engineering Co., Houston, TX
Rio Chama R. 14.0 and 3.0 Both sides	Abiquiu and Chamita	Espanola	Rio Arriba	NM-1	Albuquer- que NM	Erosion and sloughing of both banks, aggrada- tion, velocity scour, and stage fluctuation	Groins that would not require rock for scour protection. Materials to be used-- earth, wire, vegetation, timber--that would be aesthetically and environmentally acceptable
Sabine R. 40.6 Right	Deveyville	Deveyville	Newton	TX-2	Galveston TX	Flow impinging on concave bank and frequent and rapid changes in water-surface elevation	Test sections of gobimat, Fabriform, and sacked soil-cement with riprap end sections

Other Streams Nationwide (Work Unit 8) (Continued)

Funding in \$1000								
Stream, Mile, & Side	Project Length ft	Est Costs		Allocated thru FY 78	Expended as of 3/31/78	Status	Remarks	Map No.
		Construc- tion	Engr, Monitor & Reporting					
Sites on other streams nationwide not specified in authorizing legislation (Continued)								
Cumber- land R. 185.0 Left	1,000	200.0	45.0	None	None	Preliminary letter report 1976 estimate. Project approved, not funded		14
Cumber- land R. 26.0 Left	1,000	250.0	None	None	None	Preliminary letter report 1976 estimate. Project approved, not funded		15
Kanawha R. 46.6 Left	1,500	87.0	69.0	None	None	Brief letter report prepared and local contacts made	Tentatively approved in FY 79 budget	16
♦								
Wabash R. 34.0 Right	2,000	200.0	70.0	None	None	Preliminary letter report 1977 cost estimate. Project approved, not funded		17
Wabash R. 41.0 Left	2,000	200.0	70.0	None	None	Preliminary letter report 1977 cost estimate. Project approved, not funded		18
Iowa R. 16.0 Right	1,700	210.0	30.0	360.0	21.0	Approved and funded for construction	Project completion is scheduled for October 1978. There is a strong local support for the project	19
Lower Chippewa R. 21.0, 35.0, 46.0 Right 54.0, 22.0, 19.0, 15.0, Left	10,560	400.0	60.0	25.0	15.0	The project is approved for construction	Engineering plans, baseline surveys, environmental impact assessment, Section 404 permit requirements, and local cooperation agreement are scheduled for completion in early FY 79. Construction is scheduled for FY 79. The project is under contract with the Colorado State University	20
Bayou Sara 0.5 Left	2,500	500.0	50.0	None	None	Preliminary planning only		21
Kaskaskia 36.0-46.0 Left	720	340.0	100.0	None	None	Preliminary planning only		22
St. Catherine Creek 5.0 Right	1,000	65.0	20.5	None	None	Preliminary planning only		23
White R. 143.0 Right	1,200	602.0	135.0	290.6	10.0	Preliminary work such as agreements with local interests is under way	Tentatively approved for construction in FY 79 budget	24
Brazos R. 151.0 Right	4,000	225.0	75.0	None	None	Work has not been started	A private A-E firm consulted by the Parks Dept. estimated 94 acres of park land had been lost in the past 30 years. Cost estimates for protection (1973 prices) ran from \$529K to \$915K by the A-E firm	25
Rio Chama R. 14.0 and 3.0 Both sides	2,000 (1,000 ea)	172.0	28.0	None	None	No work accomplished to date. Local sponsor not yet identified		26
Sabine R. 40.6 Right	750	265.5	34.5	None	None	Not scheduled		27

Other Streams Nationwide (Work Unit 8) (Concluded)

<u>Stream, Mile, & Side</u>	<u>Local Vicinity</u>	<u>At or Near City</u>	<u>In County</u>	<u>State- Cong Dist</u>	<u>CE Office</u>	<u>Erosion Causative Agents</u>	<u>Protective Methods to be Tested</u>
<u>Sites on other streams nationwide not specified in authorizing legislation (Concluded)</u>							
White R. 259.7 Left	Jacksonport State Park	Jacksonport	Jackson	AR-1	Little Rock AR	Concave river- bank is subject to continuous attack by river currents. River- bank along the along the bend is practically vertical	Stone-filled trench revetment of various dimensions and upper banks protected with alternate areas of stone riprap and com- pacted clay
Kansas R. 43.0-44.0 Left	Eudora (Fall Leaf)	Eudora	Leavenworth	KS-2	Kansas City KS	Fluctuating flows and easily eroded soils	Windrow revetment using three different application rates
Kansas R. 31.0 Right	DeSoto	DeSoto	Johnson	KS-3	Kansas City KS	Fluctuating flows and easily eroded stone soils	Low elevation revetment using low-quality stone
Knife R. 20.0 Right	Stanton	Stanton	Mercer	ND-1	Omaha NE	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Revetment
Middle Loup R. 51.0 Left	Loup City	Loup City	Sherman	NE-1	Omaha NE	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Tetrahedrons
Memaha R. (North Fork) 75.0 Both sides	Sterling	Sterling	Johnson	NE-1	Kansas City MO	Meandering channel; bank instability	Fence revetments
Memaha R. (North Fork) 53.5 Right	Elk Creek	Elk Creek	Johnson	NE-1	Kansas City MO	Meandering channel; bank instability	Fence revetments and stone baffle
Platte R. 106.0 Right	Columbus	Columbus	Polk	NE-1	Omaha NE	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Revetment
Platte R. 71.2 Right	St. Joseph	St. Joseph	Buchanan	MO-6	Kansas City	Meandering channel; bank instability	Low elevation revetment (poor quality)
Powder R. 200.0 Left	Arvada	Arvada	Sheridan	WY-1	Omaha NE	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Double fence retard
White R. 55.0 Left	Presho	Presho	Lyman	SD-1	Omaha	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Steel jacks
Yellow- stone R. 330.0 Right	Worden	Worden	Yellow- stone	MT-2	Omaha NE	High-flow veloc- ities impinging on sandy silty banks during high-water periods	Revetment
Russian R. (Dry Creek) 8.0 Left	U/S of Grape Creek	Healdsburg	Sonoma	CA-2	San Francisco CA	Velocity induced erosion	a. Rock toe b. Plank fence c. Rock groins
Sacra- mento R. 176.5 Right	D/S of Sidds Landing	Glenn	Glenn	CA-1	Sacramento CA	Velocity erosion of toe	a. Soil-cement trenches b. Piles c. Vegetation
Green R. 26.5 Left	Kent	Kent	King	WA-6	Seattle WA	Velocity erosion	Native brush plantings, grass salvaged rubber tires, quarry spalls in conjunc- tion with conventional riprap lower bank toe protection
Walla Walla R. 50.0-55.0 Both sides	Milton- Freewater	Milton- Freewater	Umatilla	OR-2	Walla Walla	Scour undermin- ing of riprap	Various riprap sizes, vegetation with riprap toe, wire netting over riprap, groins and piling

Other Streams Nationwide (Work Unit 8) (Concluded)

Stream, Mile, & Side	Project Length ft	Funding in \$1000				Status	Remarks	Map No.
		Est Costs		Allocated thru FY 78	Expended as of 3/31/78			
		Construc- tion	Engr, Monitor & Reporting					
<u>Sites on other streams nationwide not specified in authorizing legislation (Concluded)</u>								
White R. 259.7 Left	3,600	800.0	108.0	10.0	None	The project was approved 20 March 1978	Tentatively approved for con- struction in the FY 79 budget. High flow on the White River delayed obtaining data for final layout and design of the project	28
Kansas R. 43.0-44.0 Left	3,500	179.4	38.0	None	None	Preliminary planning	Tentatively approved in the FY 79 budget	29
Kansas R. 31.0 Right	600	12.5	21.0	None	None	Preliminary planning		30
Knife R. 20.0 Right	2,500	40.0	13.0	None	None	Not scheduled		31
Middle Loup R. 51.0 Left	1,000	15.0	5.0	None	None	Not scheduled		32
Nemaha R. (North Fork) 75.0 Both sides	1,800	48.0	52.0	None	None	Preliminary planning		33
Nemaha R. (North Fork) 53.5 Right	900	26.0	42.0	None	None	Preliminary planning		34
Platte R. 106.0 Right	2,000	40.0	13.0	None	None	Not scheduled		35
Platte R. 71.2 Right	750	17.0	28.0	None	None	Preliminary planning		36
Powder R. 200.0 Left	1,900	38.0	12.0	None	None	Not scheduled		37
White R. 55.0 Left	2,000	47.0	15.0	None	None	Not scheduled		38
Yellow- stone R. 330.0 Right	7,900	137.0	45.0	None	None	Not scheduled		39
Russian R. (Dry Creek) 8.0 Left	2,150	325.0	95.0	None	None	Awaiting funding		40
Sacra- mento R. 176.5 Right	2,000	220.0	80.0	None	None	Awaiting funding		41
Green R. 26.5 Left	1,400	326.0	145.0	10.0	10.0	Approved but unfunded	Engineering, monitoring, and reporting cost estimates in- clude environmental assessment and are as of Dec 1976	42
Walla Walla R. 50.0-55.0 Both sides	26,400	350.0	113.0	11.0	11.0	Approved but unfunded	Dec 1976 estimate	43

(Sheet 3 of 3)

Streambank Erosion Control Evaluation and Demonstration Act of 1974

VAN DUZEN RIVER, HUMBOLDT COUNTY, CALIFORNIA, DEMONSTRATION PROJECT

Problem. The demonstration project site is located on the right bank (north side) of the Van Duzen River, at river mile 8, about 2 miles east of Carlotta, California (Plate H1). Serious bank erosion is threatening several homes and yards at the site, which is located on the outside of a curve in the river. The site is just downstream of where Fielder Creek enters the Van Duzen River. The riverbanks, which are about 10 ft high, are very steep. The upper half of the bank is nearly vertical; the lower half of the bank, which is comprised of material that has fallen from the bank, is less steep. Erosion of the bank is caused by the river, which may reach a velocity of 10 fps, flowing against the loose, sandy, and gravelly riverbank material.

Protection. The 900-ft-long demonstration project, which will be constructed in 1978, will make extensive use of native, readily available materials (Plates H2 and H3). Tree pendants will be used to protect the upstream 300-ft reach of the project; the trees will be lashed together with wire rope and will be tied to the riverbank. The remaining 600 ft of the project will consist of two types of pile fence. Variations in the fence—light and heavy density—will allow alternative methods to be evaluated. The fence will be made of timber members; also, a 4-ft-high wire mesh fence will be placed along the bottom of the fence. The works will retard the flow of water along the bank, which will reduce erosion, and will encourage sediments and debris to be deposited behind the fence; this will encourage growth and the subsequent stabilization of the bank. If growth at the site is not adequate, willow cuttings will be planted.

Cost. The original cost estimate to plan, design, and construct the project was \$124,000 plus \$20,000 for data collection and analysis. Inflation and more detailed studies have increased the cost estimate to \$150,000 plus \$20,000 for monitoring the project for three years and \$7,000 for preparation of the final report, a total cost of \$177,000.

Monitoring Program. The project will be monitored on a regular, frequent basis by personnel from the Eureka Field Office (about 25 miles northwest of the project). In addition, personnel from the District will visit the project about four times a year. Monitoring will primarily consist of taking photographs, surveying the riverbank, reading groundwater levels, reading staff gages and a crest-stage gage, taking velocity measurements along the project, and noting direction of currents and eddy characteristics.

Status. A public notice was distributed in February 1978. The basis of design and the monitoring program were submitted for approval in March 1978. The subsurface exploration program and the preconstruction surveys, which had to be delayed due to poor weather conditions, were conducted in March 1978. Plans and specifications were completed in June and construction is scheduled to begin in mid-August and be completed in October 1978.

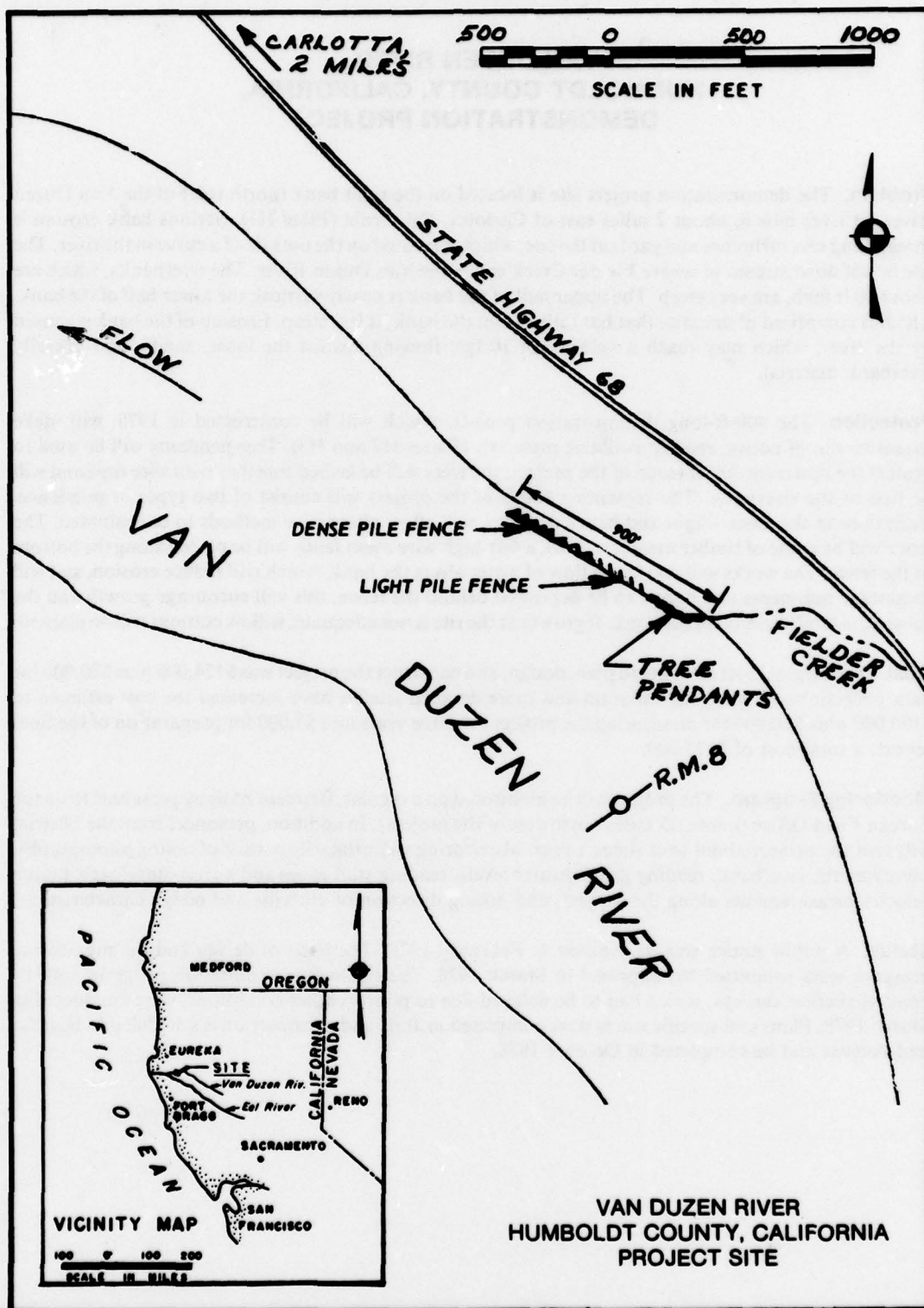
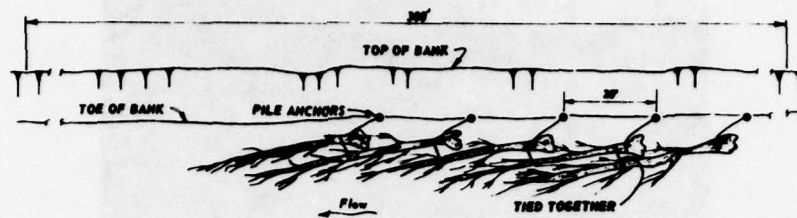
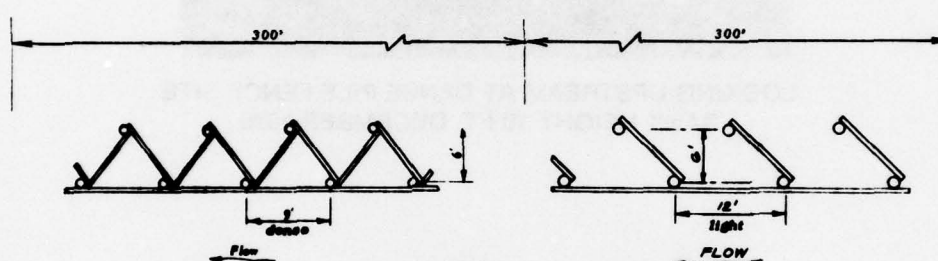


PLATE H1

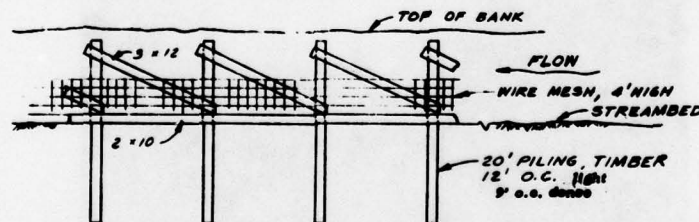


PLAN

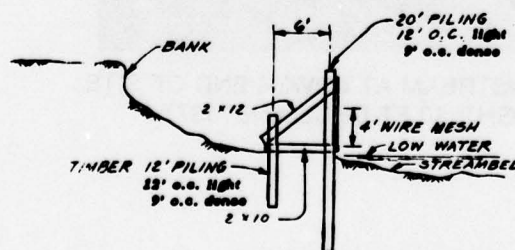
TREE PENDANTS



PLAN



FRONT ELEVATION



SECTION

PILE FENCE

VAN DUZEN RIVER
HUMBOLDT COUNTY, CALIFORNIA
TREE PENDANTS AND
PILE-FENCE PROTECTION



LOOKING UPSTREAM AT DENSE PILE FENCE SITE
BANK HEIGHT 10 FT, DECEMBER 1976



LOOKING DOWNSTREAM AT LOWER END OF SITE
BANK HEIGHT, 10 FT, DECEMBER 1977

VAN DUZEN RIVER
HUMBOLDT COUNTY, CALIFORNIA
BEFORE CONSTRUCTION

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**CONNECTICUT RIVER AT
HAVERHILL, NEW HAMPSHIRE,
DEMONSTRATION PROJECT**

Problem. The left bank of the Connecticut River in the project area is 7 to 22 ft above the normal water level and it erodes at an average rate of about 10 ft per year. The lower banks are inundated by the annual spring high water and the whole bank is inundated by unusually high spring flows. The land being lost is prime farmland, and there is a likelihood that a continuous erosion of the low banks will result in a new channel cut and the loss of some 60 acres of farmland in two ownerships.

Protection. The total project length including tie-ins is 2600 ft (Plate H4). Five techniques of bank protection, described below and shown in Plate H5, will be installed in bank reaches of approximately 500 ft each:

- a. Gabion mattresses 12 in. thick will be placed from the underwater toe of the bank to a point 3 ft vertical above the normal waterline. Filter fabric will be used on one half of this reach. The bank above will be dressed to its natural slope (1V on 1.5H) and seeded.
- b. A matting of interlocked rubber tires will be placed on the underwater slope from the toe up to a point 3 ft above the normal water surface. The tires in one half of this reach will be filled with rock. The bank above will be dressed and seeded to its natural slope (1V on 1.25H).
- c. Sand-and-cement-filled paper riprap bags will be placed against the underwater portion of the bank up to a point 3 ft above the normal waterline. Filter fabric will underlie the bags on one half of this reach. The upper bank will be formed to a 1V-on-2H slope and seeded.
- d. The underwater bank will be re-formed to a 1V-on-2H slope and overlaid with baled hay which is contained by a wire mesh. The upper bank will also be formed to a 1V-on-2H slope and overlaid with baled hay which is contained by a wire mesh. The upper bank will also be formed to a 1V-on-2H slope and seeded.
- e. The final section will remain in its present condition below the waterline. The upper bank will be formed to a 1V-on-2H slope and seeded.

Cost. Total project construction cost is estimated at \$190,000.

Monitoring Program. Primary observations include a topographic survey (1 in. = 20 ft, 1-ft contours) along the top of bank to the waterline. Fathometer sections of the river bottom have been taken on 50-ft centers. Subsurface soil samples have been taken at four locations to a depth of 30 ft and provisions have been made so that continuous water-level recording devices can be installed in the boreholes. Preconstruction photographs are shown in Plate H6.

Status. Construction was scheduled to begin in May 1978.

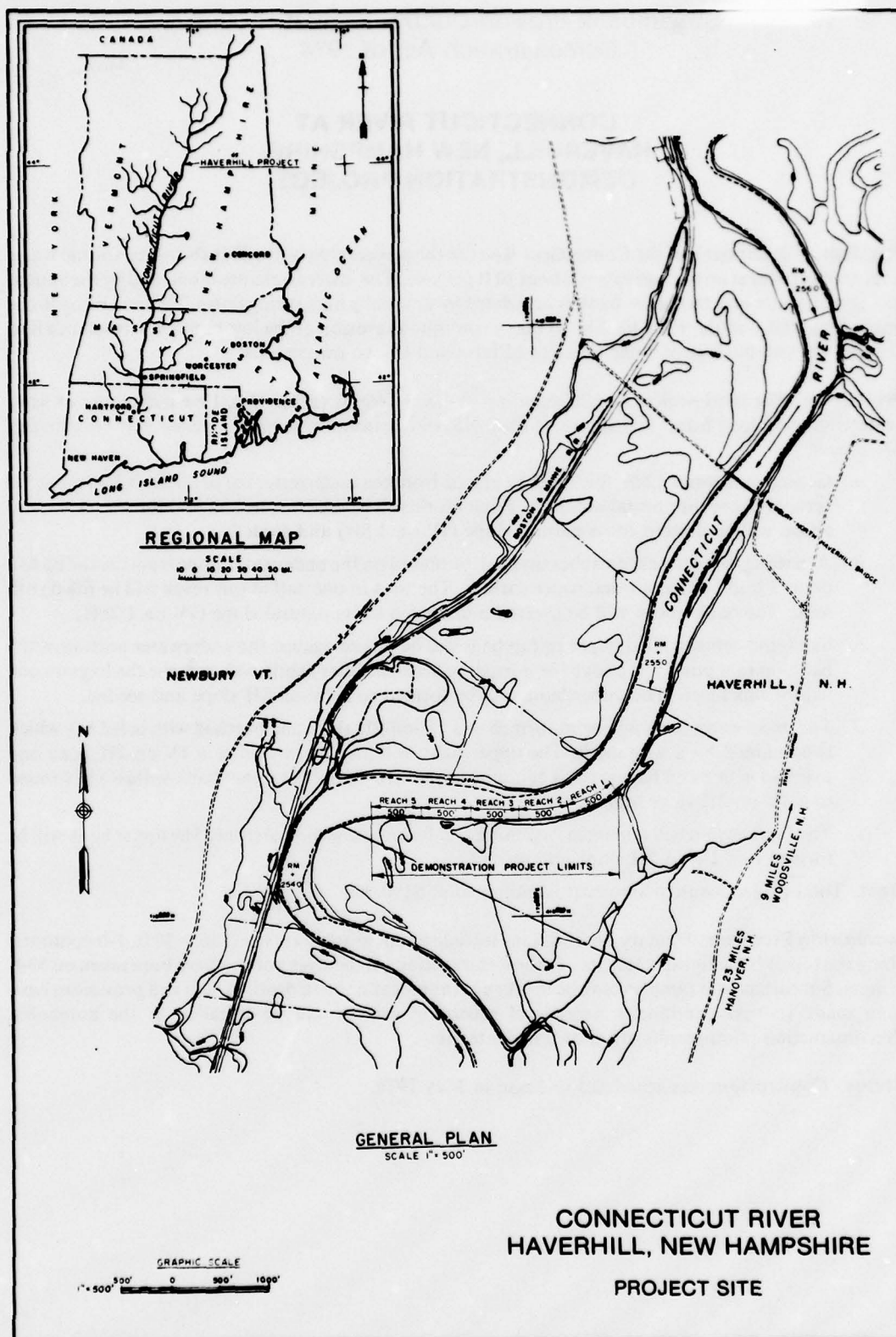
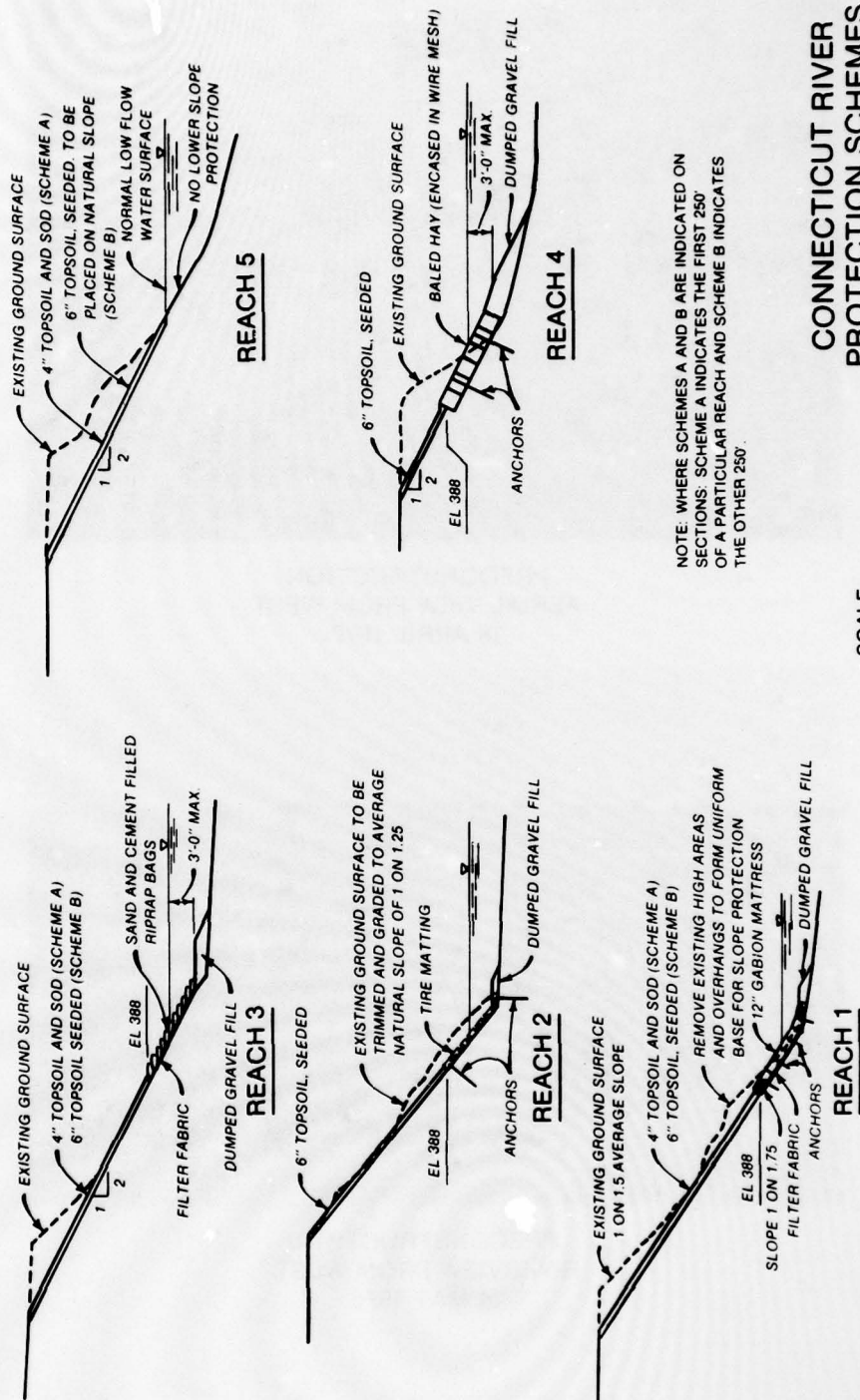


PLATE H4

H16

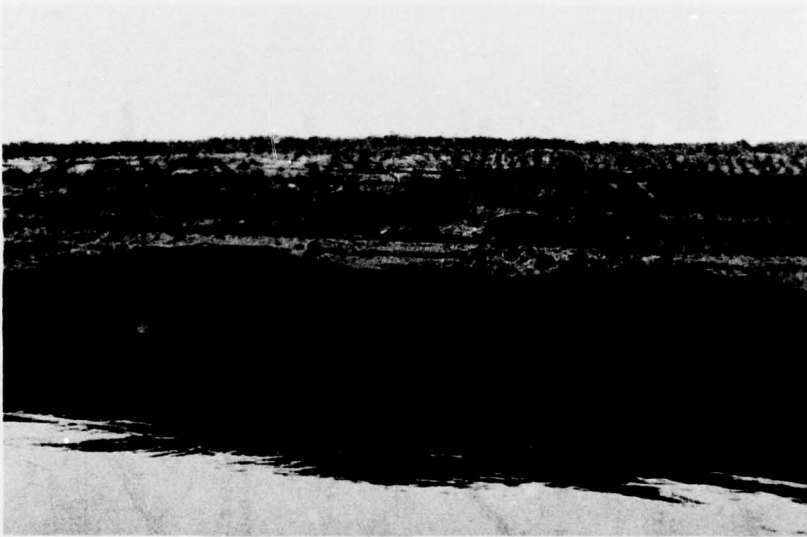


CONNECTICUT RIVER PROTECTION SCHEMES HAVERHILL, NEW HAMPSHIRE

TYPICAL SCHEMES



PRECONSTRUCTION
AERIAL VIEW FROM WEST
18 APRIL 1977



PRECONSTRUCTION
RIVERVIEW FROM WEST
14 MAY 1975

CONNECTICUT RIVER
HAVERHILL, NEW HAMPSHIRE
DEMONSTRATION SITE

Streambank Erosion Control Evaluation and Demonstration Act of 1974

PEARL RIVER AT MONTICELLO, MISSISSIPPI, DEMONSTRATION PROJECT

Problem. Bank caving along the Pearl River at Monticello, Mississippi, is of major concern. Several buildings and a boat ramp are threatened by steady erosion which is attributed to direct current attack, hydrostatic forces induced in slopes after periods of rapid stage recession, and local drainage.

Protection. Three sites are in particular need of protection. For protection of site 1, dumped rubble consisting of stone, concrete, masonry, brick, and/or asphalt will be utilized. Site 2 will be protected with used tires placed over and around existing vegetation and fastened together with wire ties to form a tire-mat. Deadman anchors will be used to hold tires on the slope. For protection of site 3, concrete blocks will be used, positioned with cells up to encourage the growth of vegetation. The blocks will be laced with wire and stakes in an approximate 10-ft grid system. The intended function of these different types of protection is to form a protective barrier against direct current attack and, to a lesser extent, against local drainage. Effective stabilization of bank sections which are failing due to hydrostatic forces acting within the soils during or after periods of rapid stage recession may not be possible, however, unless slopes are flattened. The site location of protection works is shown in Plate H7 and section details of protection used at each site are shown in Plate H8.

Cost. Total estimated construction cost of site 1 protection is \$66,000 or about \$165 per bank-foot; site 2 is \$56,000 or about \$140 per bank-foot; and site 3 is \$56,000 or about \$280 per bank-foot.

Monitoring Program. The preconstruction observations for each site include visual inspections, cross-section surveys, and photography (Plate H9). Velocity, stage frequency, and rating curves were furnished in a previous report to the Steering Committee.

Status. The construction drawings have been completed and specifications have been written. Construction of the project was scheduled to commence in June 1978 and to be completed in October 1978.

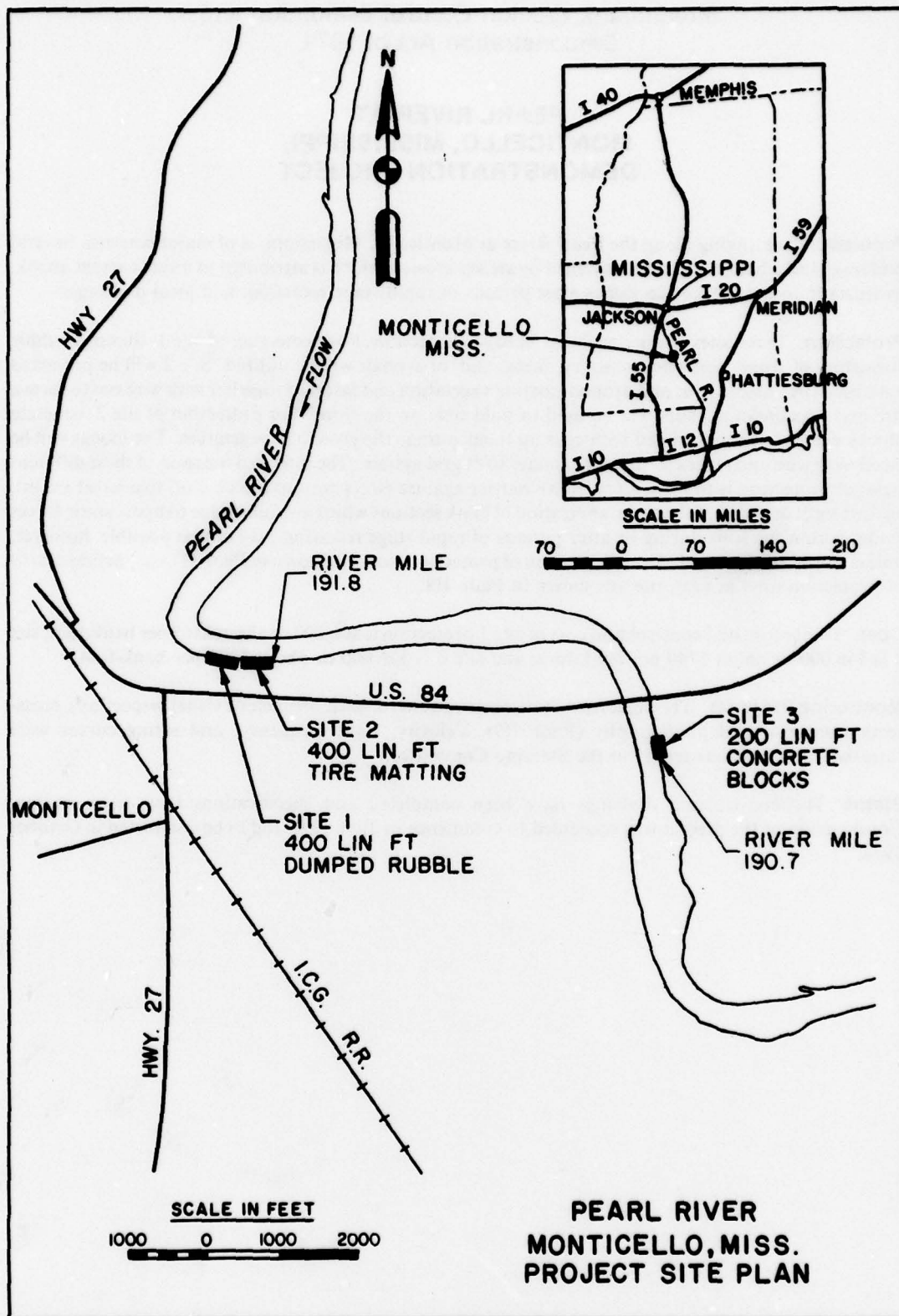
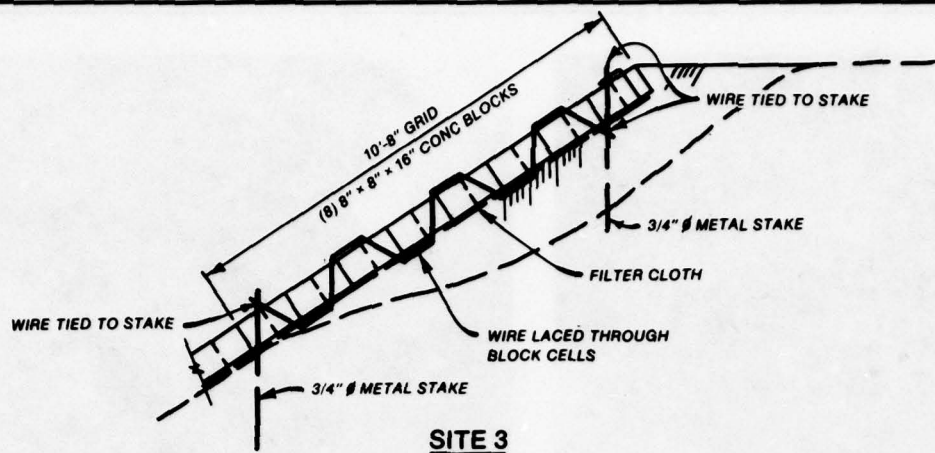
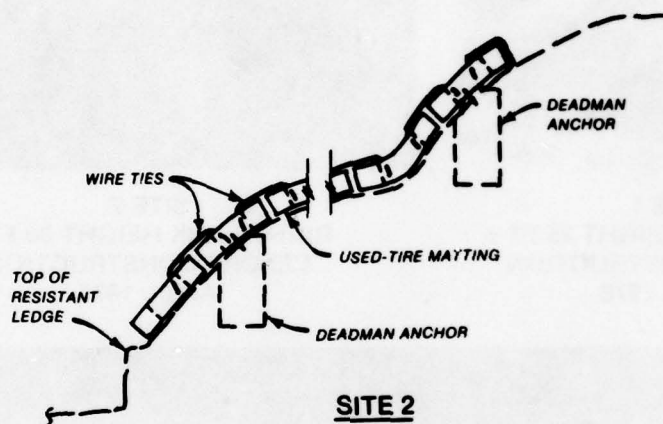


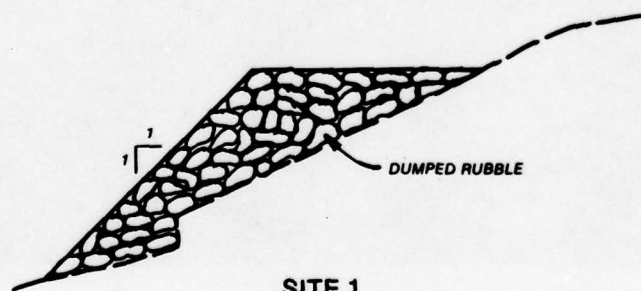
PLATE H7



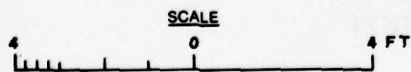
SITE 3



SITE 2



SITE 1

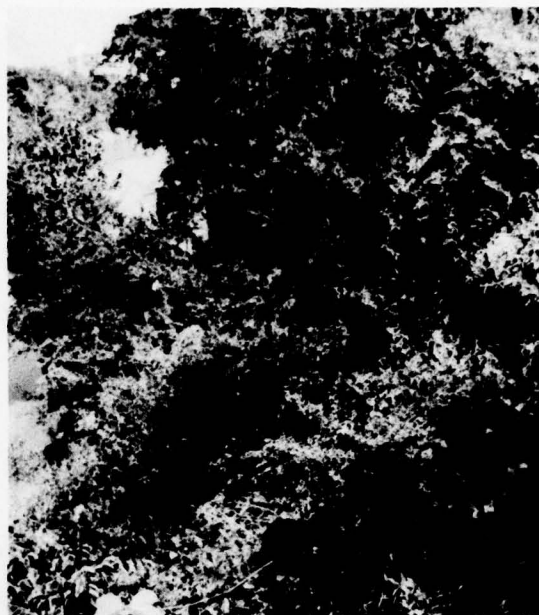


PEARL RIVER
MONTICELLO, MISS.
TYPICAL PROTECTION SCHEMES

PLATE H8



SITE 1
RIGHT BANK HEIGHT 25 FT ±
BEFORE CONSTRUCTION
APRIL 1978



SITE 2
RIGHT BANK HEIGHT 30 FT ±
BEFORE CONSTRUCTION
APRIL 1978



SITE 3
LEFT BANK HEIGHT 15 FT ±
BEFORE CONSTRUCTION
APRIL 1978

PEARL RIVER
MONTICELLO, MISSISSIPPI
DEMONSTRATION SITES

Streambank Erosion Control Evaluation and
Demonstration Act of 1974

**ROANOKE (STAUNTON) RIVER
NEAR LEESVILLE, VIRGINIA,
DEMONSTRATION PROJECT**

Problem. Portions of both banks in a reach 1 to 5 miles below the Leesville Dam are eroding at a substantial rate. Maximum width of erosion since about 1960, when the dam was built, is about 150 to 200 ft. Bank material is silty sand alluvium, and bank height ranges from about 8 to 15 ft. Leesville hydropower dam releases water two to three times daily for several hours' duration and the stages vary from 0 to 10 ft. The continuous wetting and drying of these erodible soils seems to be the prime cause of bank erosion.

Protection. Three physically separated sites (Plate H10) will receive treatment. Each site will be graded to form a new 1V-on-3H slope treated with seed, fertilizer, and protective covering. Each site will also have a rock toe with rock groins, extending into the river 50 ft, spaced approximately 100 ft apart. Site A will receive three types of protection (Plate H11), each covering 450 ft of bank. Type 1 protection is a rubber tire mattress with the tires tied to each other and anchored. Type 2 protection is a series of wooden fence groins spaced 20 ft apart. Type 3 protection involves the placing of horizontal drains within every 10 ft of bank. Site B has about 400 ft of type 3 protection (drains), with an additional 50 ft of grading at each end. Site C has 300 ft each of type 1 (tire mattress) and type 2 (groins) protection.

Cost. Construction cost of the total of three sites (2,600 bank-feet) is estimated at \$255,000, or about \$98 per bank-foot. Design and inspection will cost an additional \$20,000.

Monitoring Program. Observations include stage-discharge data in the tailwater of Leesville Dam, USGS stage-discharge data at Altavista (15 miles below dam), baseline surveys, velocity distribution, visual inspections, periodic ground and aerial photography, and measurements from baseline points to top of bank (Plate H12).

Status. Design is under way and draft plans and specifications were submitted for review about 1 June 1978 concurrent with advertising. Monitoring has started. Wilmington District currently (31 May 1978) has only sufficient funds to accomplish work on site A. Construction scheduled for FY 78, with advertising for bids on site A work on 15 June 1978, award 24 July 1978, construction complete on 15 October 1978. If additional funds become available, sites B and C could be advertised and awarded separately, or as an amendment to the contract to accomplish work on site A.

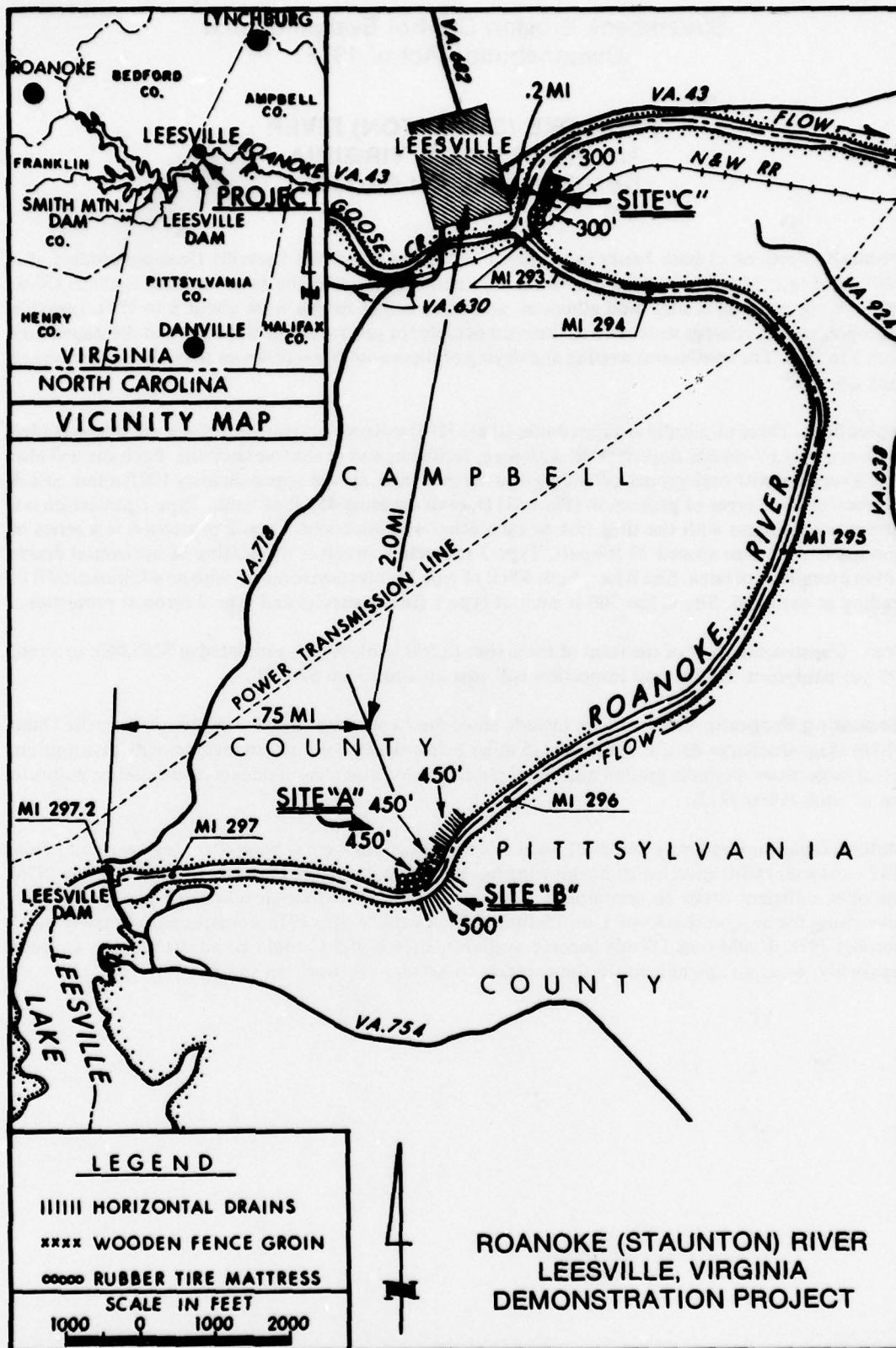


PLATE H10

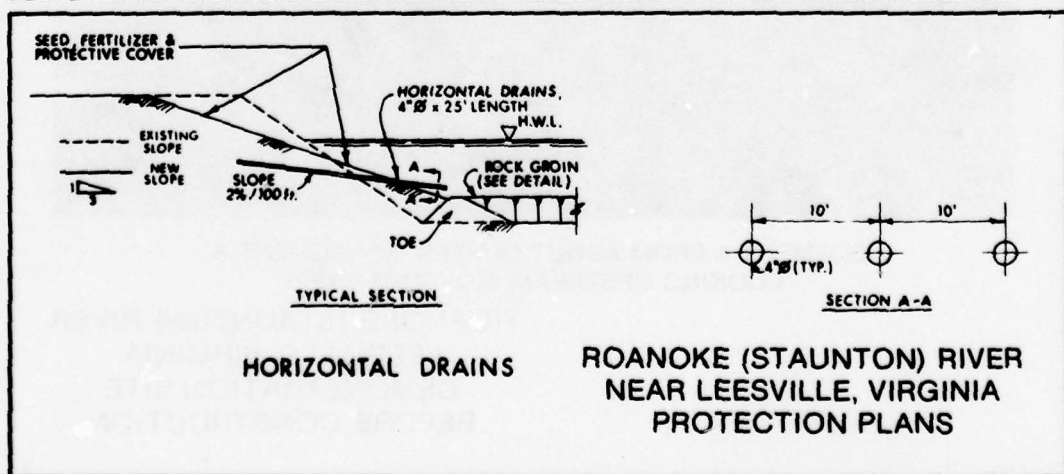
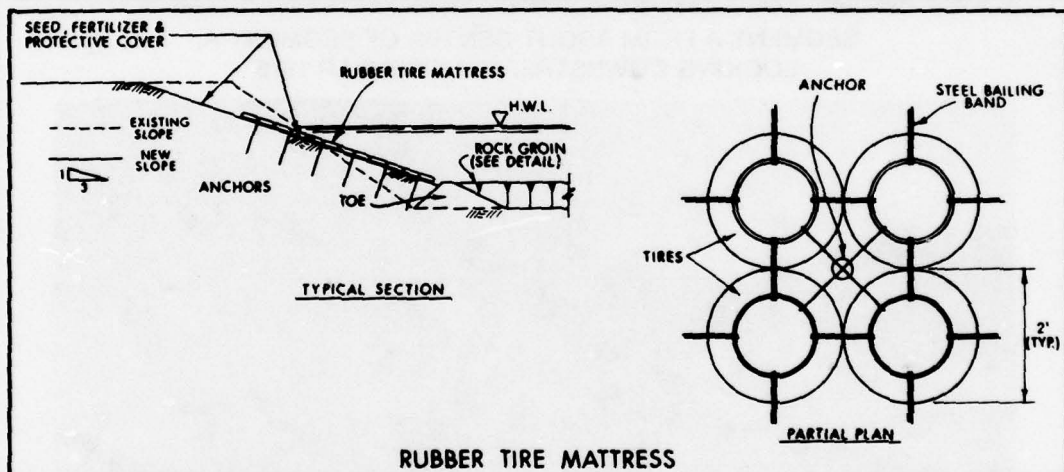
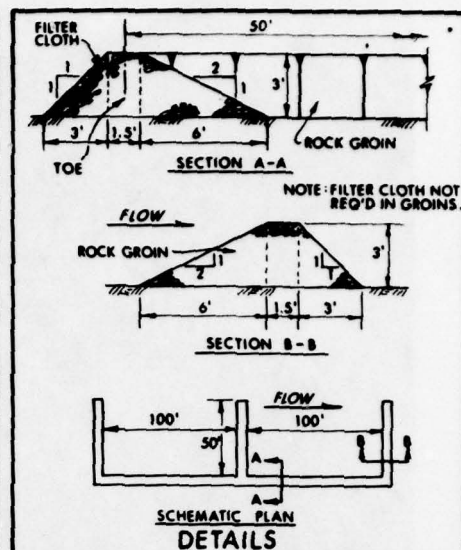
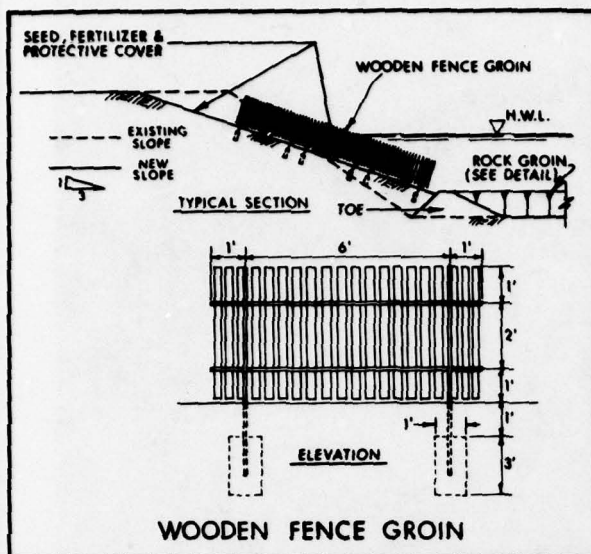


PLATE H11



SEGMENT A FROM ABOUT CENTER OF SEGMENT A,
LOOKING DOWNSTREAM, NOVEMBER 1976



SEGMENT A FROM ABOUT CENTER OF SEGMENT A,
LOOKING UPSTREAM, NOVEMBER 1976

ROANOKE (STAUNTON) RIVER
LEESVILLE, VIRGINIA
DEMONSTRATION SITE
BEFORE CONSTRUCTION

**Streambank Erosion Control Evaluation and
Demonstration Act of 1974**

**ALLEGHENY RIVER NEAR
WATTERSONVILLE, PENNSYLVANIA,
DEMONSTRATION PROJECT**

Problem. The right bank of the Allegheny River approximately 1-1/2 miles downstream of Wattersonville, Pennsylvania, and immediately upstream of Lock and Dam 9 (Plate H13) is actively eroding a number of residential properties. The bank is variable in height and is composed primarily of highly erodible fine-grained soil. In addition to other natural influences on the riverbank, the upper Allegheny River also develops massive winter ice floes which gouge soil from the riverbanks.

Protection. Approximately 2000 ft of riverbank will be protected by schemes designed to resist ice gouging. Although the final protection schemes to be used have not been selected, two potential schemes are illustrated by Plate H14.

Cost. Construction cost of this project is anticipated to be approximately \$133,000.

Monitoring Program. Dimensional changes, hydraulic conditions, and atmospheric conditions will be monitored. Visual observations, automatic and manual measuring devices, and periodic photography will be employed. Plate H15 shows photographs of the site.

Status. Avenues for securing local sponsorship are being sought.

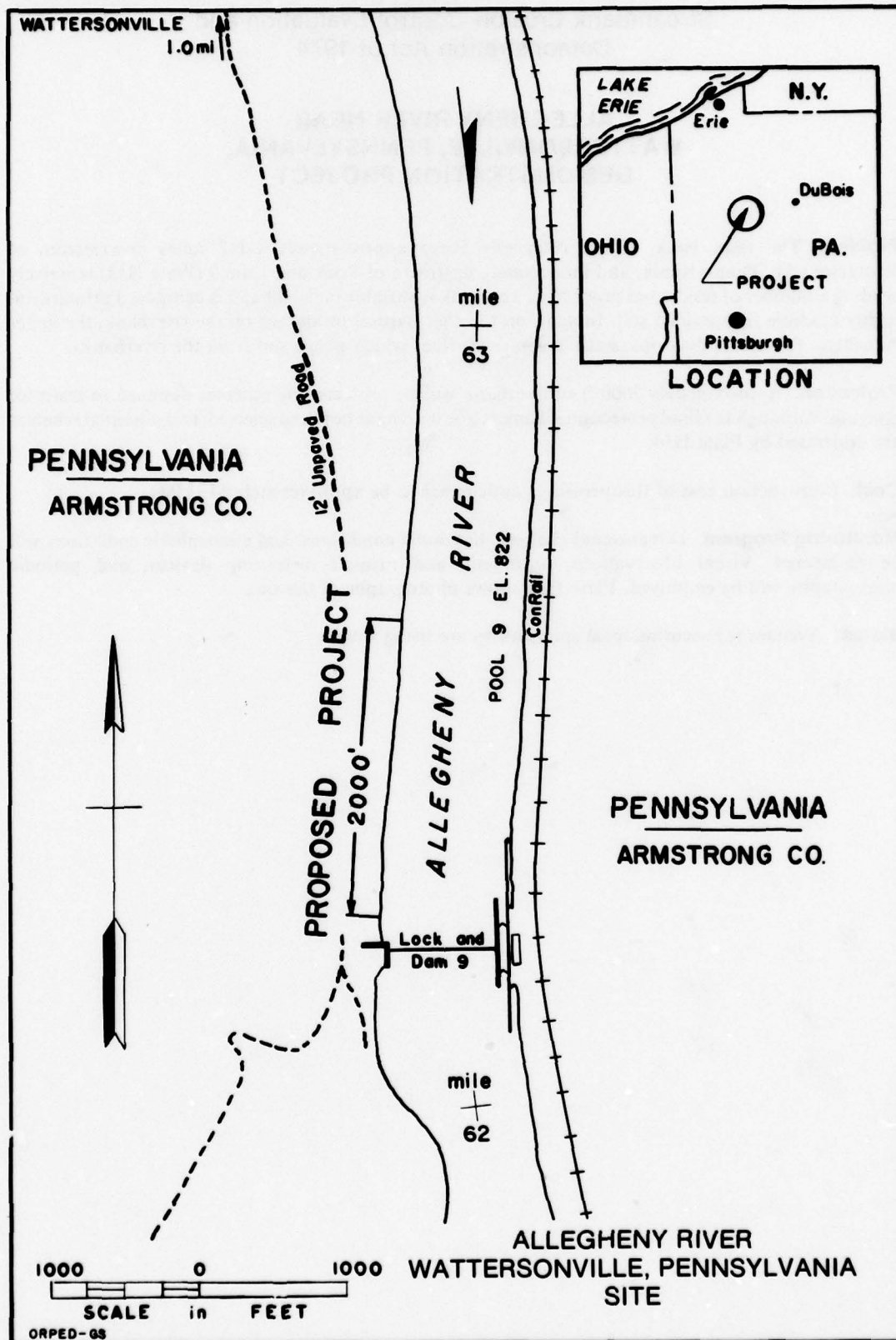


PLATE H13

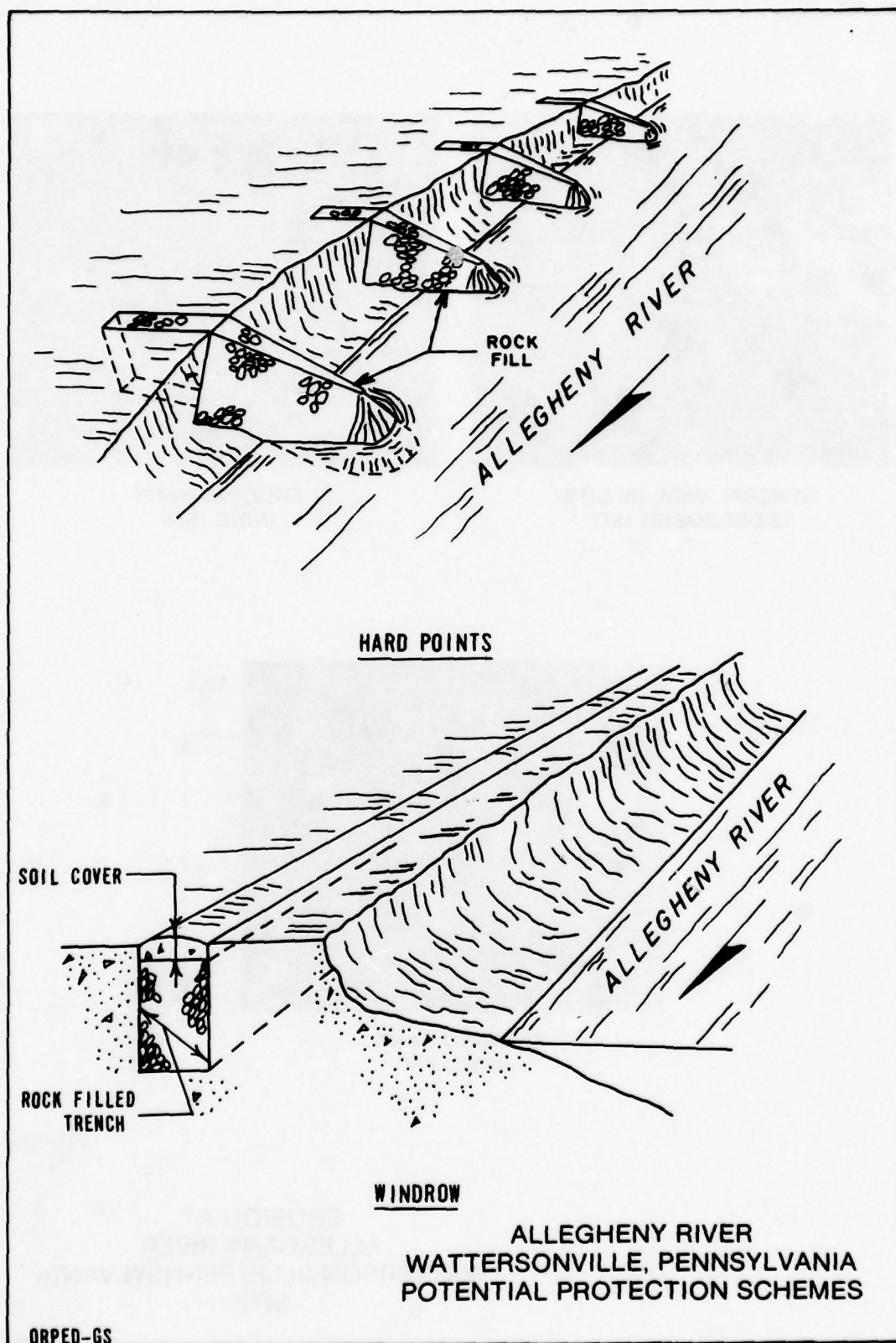
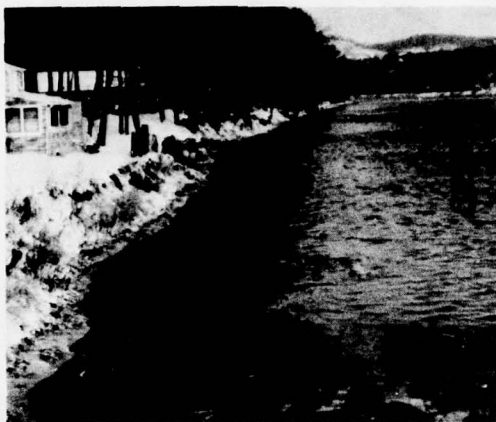


PLATE H14



GENERAL VIEW OF SITE
12 DECEMBER 1977



ERODING BANK
JUNE 1976



ERODING BANK
JUNE 1976

EROSION AT
ALLEGHENY RIVER
WATTERSONVILLE, PENNSYLVANIA
SITE

Streambank Erosion Control Evaluation and Demonstration Act of 1974

IOWA RIVER AT WAPELLO, IOWA, DEMONSTRATION PROJECT

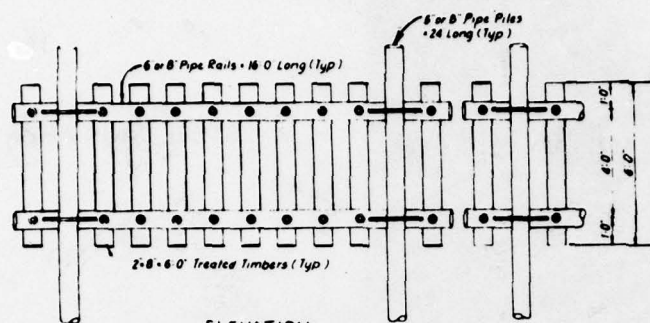
Problem. The right bank, upstream of State Highway 99 Bridge (Plate H16), has been eroding at a rate of 1 to 2 ft per year in the area where the river makes approximately a 90-degree bend. The area of bank erosion includes nearly the entire riverfront of the city. The rate of erosion is controlled by the rate that the Iowa River flows can tear away the clay which makes up the lower portion of the riverbank. The Wapello community and individual property owners have placed large quantities of rubble along the riverbank. These efforts have reduced the erosion rate but they have not eliminated the problem. The high-bank land is 25 to 30 ft above the normal river levels and is not subject to inundation.

Protection. The protection plan consists of a combination of permeable timber jetties, erosion control mat, and steel jacks. The jetties consist of steel pipe pilings 8 in. in diameter, at approximately 15-ft intervals at each jetty alignment. Timbers are 2 in. by 8 in. mounted on 1-ft centers to horizontal steel pipe to form 6- by 6-ft panels. These panels are mounted on the steel pipe piling. The jetties are designed and spaced along the riverbank to direct flows to the center of the channel. The erosion control mat is a fabric sack pumped full of mortar to form a mat approximately 4 in. thick with filter points to relieve the uplift pressure. The mat is designed to protect the bank against erosion during high flows. The steel jacks consist of three steel angles bolted together at the midpoint of the angles. Steel wire is laced between the angles at equal spacing. These jacks are connected by steel cable and anchored with deadmen along the length of installation. The steel jacks are placed to stabilize the toe of the sloping bank. The layout of the protection works is shown in Plate H16 and the details in Plate H17.

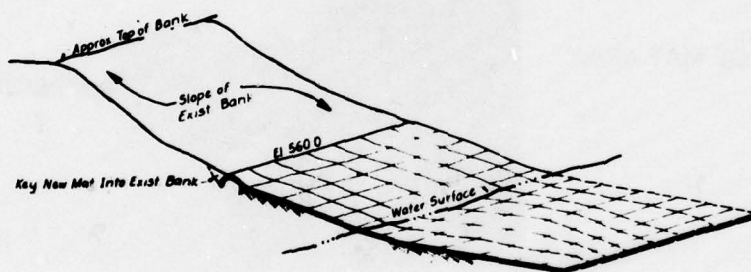
Cost. Construction of the project is estimated to cost \$210,000.

Monitoring Program. The preconstruction monitoring consists of visual inspections, baseline and special channel cross-section surveys, velocity measurements, and ground level photographs. After construction and annually these same monitoring devices will be used along with oblique aerial photographs. Preconstruction photographs are shown in Plate H18.

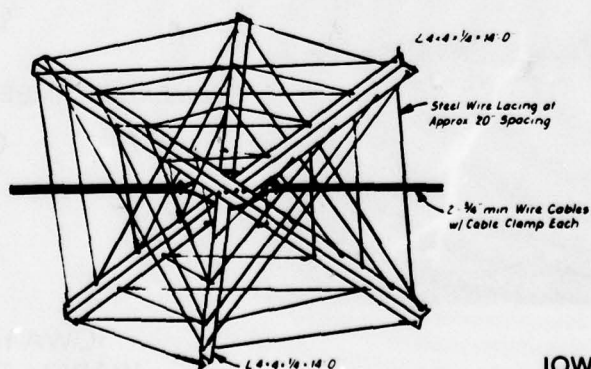
Status. The construction contract for the project was scheduled for advertisement in May 1978 and bid opening was held on 6 June 1978. The project construction is scheduled for completion September 1978.



ELEVATION
PERMEABLE TIMBER JETTY DETAILS
 (NO SCALE)



CONCRETE-FILLED MAT DETAILS
 (NO SCALE)



STEEL JACK UNIT
 (NO SCALE)

**IOWA RIVER
 WAPELLO, IOWA
 PROTECTION PLAN DETAILS**

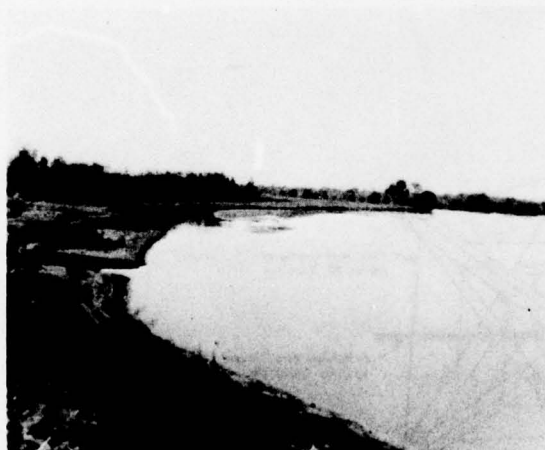
PLATE H17



STEEL JACK AREA



EROSION CONTROL MAT AREA



PERMEABLE TIMBER JETTY AREA

IOWA RIVER
WAPELLO, IOWA
BEFORE CONSTRUCTION,
JUNE 1978

Streambank Erosion Control Evaluation and Demonstration Act of 1974

WHITE RIVER AT DES ARC, ARKANSAS, DEMONSTRATION PROJECT

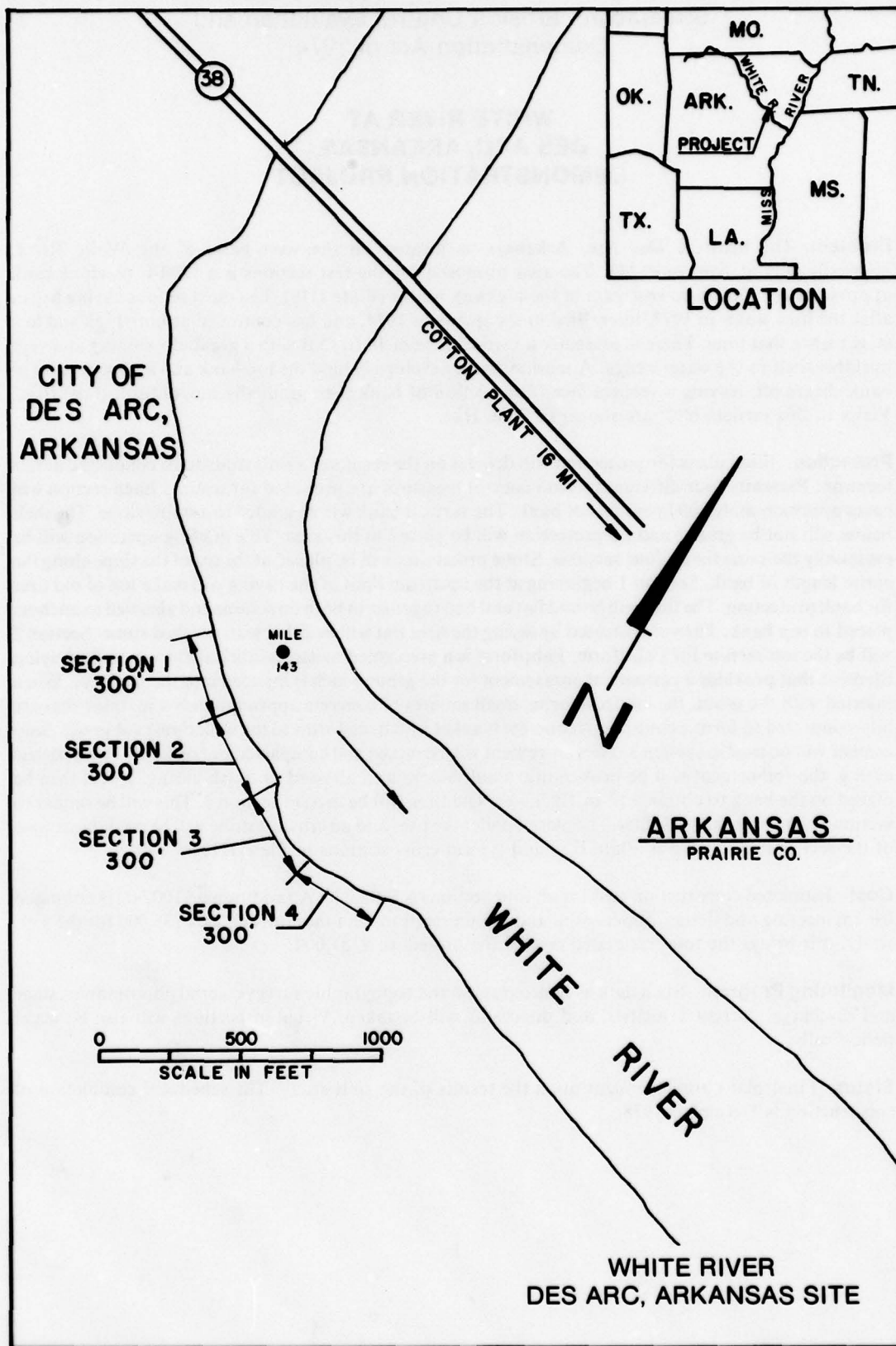
Problem. The town of Des Arc, Arkansas, is located on the west bank of the White River, approximately at river mile 143. The area proposed for the test sections is a 1200-ft reach of bank approximately 2000 ft downstream of the highway bridge (Plate H19). The most serious caving began after the high water in 1973, intensified in the spring of 1974, and has continued at both high and low stages since that time. There is presently a vertical face of 10 to 15 ft with a gradually sloping and very unstable shelf to the water's edge. A tension crack develops behind the top bank and a large section of bank shears off, leaving a vertical face. This section of bank then gradually moves toward the river. Views of this vertical bluff are shown in Plate H21.

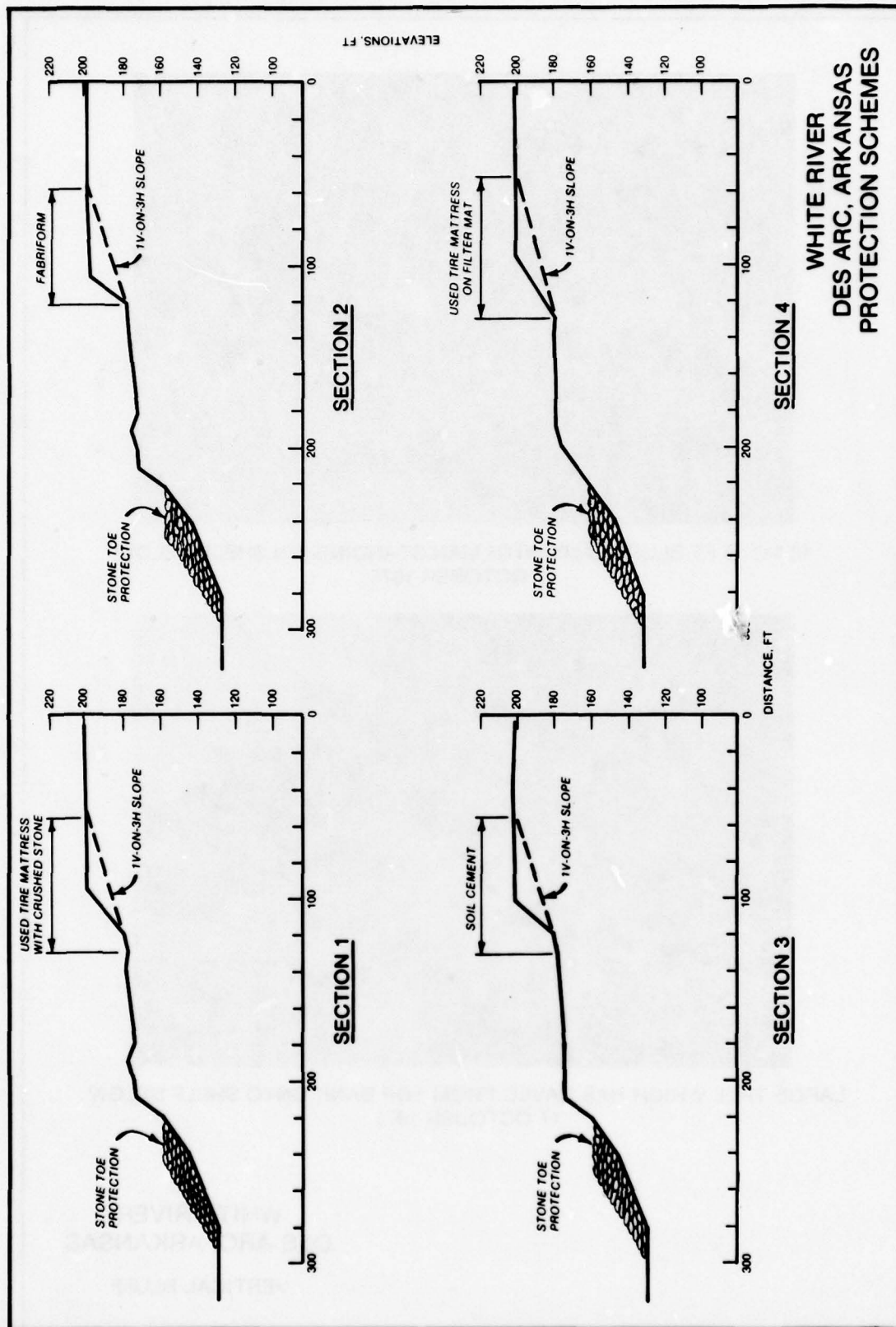
Protection. Final plans for protection will depend on the results of a soils study to be conducted at this location. Presently four different erosion control measures are proposed for testing. Each section will cover approximately 300 linear feet of bank. The vertical bank will be graded to a stable slope. The shelf below will not be graded and no protection will be placed in this area. This grading operation will be essentially the same for all four sections. *Stone protection will be placed at the toe of the slope along the entire length of bank.* Section 1 beginning at the upstream limit of the caving will make use of old tires for bank protection. The tires will be laid flat and tied together in both directions and also tied to anchors placed in top bank. The voids created by laying the tires flat will be filled with crushed stone. Section 2 will be the test section for Fabriform. Fabriform is a preformed mattress fabricated from bulked nylon filament that provides a permanent encasement for the grout which is injected into the mattress. When injected with the grout, the mattress forms small squares of concrete approximately 4 in. thick that are interconnected to form a continuous concrete blanket which conforms to the underlying subgrade. Soil-cement will be used in section 3. The soil-cement will be mixed and compacted on top bank. After partial curing, the soil-cement will be broken into small blocks and allowed to finish curing. It will then be placed on the bank to obtain a 12-in. thickness. Old tires will be used in section 4. This will be similar to section 1; however, filter cloth will be placed under the tires and no crushed stone will be used. Locations of the sections are shown in Plate H19 and typical cross sections in Plate H20.

Cost. Estimated construction cost for all four sections is \$602,000. An additional \$100,000 is estimated for engineering and design, supervision and administration, and monitoring, and \$35,000 for the soils study; this brings the total estimated cost of the project to \$737,000.

Monitoring Program. Such data as hydrographic and topographic surveys, aerial photographs, stage and discharge, current velocities, and directions will be taken. Visual inspections will also be made periodically.

Status. Final plans are dependent upon the results of the soils study. The scheduled completion of construction is December 1978.





WHITE RIVER
DES ARC, ARKANSAS
PROTECTION SCHEMES

SECTION 4

SECTION 3

SECTION 2

SECTION 1



10 TO 15 FT BLUFF BANK WITH MAN STANDING ON SHELF BELOW
17 OCTOBER 1975



LARGE TREE WHICH HAS CAVED FROM TOP BANK ONTO SHELF BELOW
17 OCTOBER 1975

WHITE RIVER
DES ARC, ARKANSAS
VERTICAL BLUFF

APPENDIX I

Fish and Wildlife Coordination Act Report



United States Department of the Interior
FISH AND WILDLIFE SERVICE

MAILING ADDRESS:
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
10597 West Sixth Avenue
Lakewood, Colorado
Across From Federal Center

IN REPLY REFER TO:

ENV

MAY 26 1978

Colonel James W. Ray, U.S.A.
District Engineer
U.S. Army Corps of Engineers
6014 U.S. Post Office and Court House
Omaha, Nebraska 68102

Dear Colonel Ray:

Enclosed is our interim Fish and Wildlife Coordination Act report on the Streambank Erosion Control Evaluation and Demonstration Project, Missouri and Yellowstone Rivers. We have considered your comments and made changes wherever appropriate.

This report does replace the planning aid letter aimed at assisting the Corps prepare its interim report. We will, of course, provide additional assistance as appropriate in the form of planning aid letters and other inputs as work on the project continues, and provide a final Coordination Act report in 1981.

If there are specific points in our report that you would like to discuss in detail, please contact us.

Sincerely yours,

James C. Gutman
JAMES C. GUTMAN
Acting Regional Director



Save Energy and You Serve America!



IN REPLY REFER TO:

ENV

United States Department of the Interior
FISH AND WILDLIFE SERVICE

MAILING ADDRESS:

Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:

10597 West Sixth Avenue
Lakewood, Colorado
Across From Federal Center

MAY 26 1978

Colonel James W. Ray, U.S.A.
District Engineer
U.S. Army Corps of Engineers
6014 U.S. Post Office and Court House
Omaha, Nebraska 68102

Dear Colonel Ray:

The purpose of this letter is to outline the views and concerns of the Fish and Wildlife Service regarding the Streambank Erosion Control Evaluation and Demonstration Program on the Missouri and Lower Yellowstone Rivers. It is an interim report prepared under the authority of the Fish and Wildlife Coordination Act, 16 U.S.C. 661; et seq., and is provided you at this time to accompany the Corps of Engineers' interim report on the Demonstration Program when it is submitted to Congress, in accordance with 16 U.S.C. 662(b). We understand the Corps' interim report is being prepared by the Waterways Experiment Station and the Office of the Chief of Engineers.

The States of Montana, North Dakota, South Dakota, and Nebraska have reviewed the report as it pertains to their respective States. The North Dakota Game and Fish Department, South Dakota Department of Game, Fish, and Parks, and Nebraska Game and Parks Commission have concurred in the report as is indicated by the enclosed letters. Another Fish and Wildlife Coordination Act Report will be furnished to you in 1981 for inclusion with your final study report to Congress.

The State of Montana has completed a separate report on the effects of the Demonstration Program on the Lower Yellowstone River in Montana. We understand that document, which has our informal concurrence, has already been forwarded to you.

Legislative Background

Initial authorization of the Missouri River Demonstration and Evaluation project was granted under Section 32 of the Water Resources Development Act of 1974. This Act directed the Chief of Engineers to:

- a. Evaluate the extent of streambank erosion nationwide.

b. Develop new methods and techniques for bank protection and research on soil stability and identify the causes of bank erosion.

c. Prepare a report to Congress on the results of such studies and recommend means for the prevention and correction of streambank erosion.

d. Construct demonstration projects, including bank protection works, at a minimum at multiple sites on

(1) the Ohio River;

(2) that reach of the Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa;

(3) that reach of the Missouri River in North Dakota at or below the Garrison Dam; and

(4) the delta and hill areas of the Yazoo River Basin generally in accordance with the recommendations of the Chief in his report dated September 23, 1972.

Section 155 of P.L. 94-587 amended the original Act by adding two additional reaches for construction of demonstration projects. These are:

a. the delta of the Eel River in California, and

b. the Lower Yellowstone River from Intake, Montana, to the mouth of that river.

This section also increased the funding level from \$25 million to \$50 million.

Section 161 of P.L. 94-587 further amended the original Act by listing 21 specific sites below Garrison Dam where demonstration sites may be constructed. It required an interim report to Congress by September 30, 1978, and extended the date of the final report to Congress from June 30, 1978, to December 31, 1981.

Although the original Act has been amended, the original purposes of the Act have not been changed.

Description of Project

For purposes of this report, the "project area" is considered to be the Lower Yellowstone River from Intake, Montana, to its mouth and moving

water reaches of the Missouri River from Garrison Dam to Lake Oahe, from Fort Randall Dam to Lewis and Clark Lake, and Gavins Point Dam to Sioux City, Iowa.

Under authorization granted by Congress in 1963 and 1968, bank protection works have been completed in three areas and are under construction in four more on the stretch of the river between Garrison Dam and Bismarck, North Dakota. Generally, structures built at those sites are extensive. They are much like structures built to support barge traffic on the Lower Missouri. For instance, at the normal waterline, rock jetties may be 10 feet or more out of the water and several hundred yards long. Wing dams and other types of flow deflectors are the rule rather than the exception. Approximately 30 miles of the bankline will be controlled by structures at these sites.

Amendments to Section 32 in 1976 authorized 21 additional sites on the Missouri River in North Dakota. Construction at these sites would control another 20 to 25 percent of the bankline. The big difference between construction at these sites and the original seven sites is that new "soft techniques" are to be employed. These include tree retards, windrow revetments, composite revetments, flow control structures, vane dikes, and hardpoints. These new techniques are expected to be less costly and more environmentally compatible than the old ones.

On the Missouri below Fort Randall Dam, projects were planned initially at six sites, three on the Nebraska side and three on the South Dakota side of the river, each covering 1 to 3 miles of eroding bankline. They were to include a variety of structures of less traditional design or materials. The six projects were to be constructed and then the environmental impacts were to be evaluated.

In August 1977, Congress appropriated \$2 million for bank stabilization structures at three more sites between Fort Randall Dam and Sioux City, Iowa; at Sunshine Bottom below Fort Randall Dam; and at Goat Island and Iona Bend below Gavins Point Dam. Local interests have clearly identified intentions to seek additional erosion control projects each year until the entire erosion problem is solved.

Amendments to the original authorization called for erosion control demonstrations at multiple sites on that segment of the Yellowstone between Intake, Montana, and the river's mouth in North Dakota. The Fish and Wildlife Service provided comments on a proposal that outlined 24 "projects" in a letter to the Corps dated August 15, 1977. In that letter, we pointed out potential impacts, indicated concern about the

need for the work, and suggested that many planning sites, in fact, were unsuitable for the purpose intended. Current planning for the Lower Yellowstone portion of the program calls for construction of three sites as a high priority demonstration program.

General Description of Area

Yellowstone River

Emerging from the northern boundary of Yellowstone National Park, the Yellowstone River flows easterly through Montana for approximately 540 miles before entering North Dakota. In North Dakota the river flows some 20 miles prior to its confluence with the Missouri River. Throughout this distance the river is free of main stem reservoirs. Several tributaries to the Yellowstone are controlled by dams, the most notable of which is Yellowtail Dam on the Bighorn River. Several irrigation diversion dams extend across the channel of the Yellowstone River and seasonally divert water to irrigable lands. The most downstream diversion is at Intake, Montana, approximately 70 river miles upstream from its mouth. The demonstration sites under consideration are all downstream of this structure.

Despite the tributary dams, the Yellowstone River is essentially an uncontrolled free flowing river. Accordingly, the lower river fluctuates seasonally in discharge and characteristically carries a wide range of flows. Generally, the low flow periods occur during the winter and late summer months. Ice jams are common and the grinding action of ice often results in bottom scour and alteration of the bankline. However, the bulk of the bank erosion occurs during the spring runoff period when bankfull flows predominate for several weeks. Flooding also occasionally occurs from rapid melting of an above average snowpack.

Roughly the lower 50 miles of the valley lie in the glaciated plains region. Except for occasional lenses of bedrock scattered throughout the area the soils within the confines of the valley are principally alluvium and or other easily erodible material. The rate of lateral erosion is conditioned to some degree by the stability afforded by the root structure of streamside vegetation.

The hydrology of the basin, the hydraulics of the channel, plus the erodibility of the soil, allow the river to wander back and forth across the valley. Accordingly, the riverine and flood plain ecosystems have also developed naturally and their maintenance is largely dependent on these processes.

Although a site specific observation may indicate extensive erosion engulfing soil and bankline vegetation, checks and balances interplay spatially (such as over the lower 70 miles) to maintain relatively stable ecosystems. A free flowing stream system such as the Yellowstone is self-perpetuating, maintaining the integrity of the natural ecosystems and providing a wide range of habitat conditions suitable for a diversity of plant and animal species. Essentially, this stable system can only be interfered with by manmade projects or land management practices which impede or accelerate channel formation and adjustment processes.

Because of the characteristics outlined above, lateral erosion in the Lower Yellowstone River is relatively common. This phenomenon creates meandering, straight, and braided stream reaches and maintains overall channel length. This condition preserves the quantity of water surface and associated habitat for aquatic species, and thereby maintenance of aquatic animal populations. The variable channel conditions also provide a wide array of water depth-water velocity combinations which is desirable to maintain a good variety of fish species.

Associated with the braided channels is an extensive amount of wildlife habitat in conjunction with the "edge effect" afforded by the water-land interface and the large quantity of water surface. Since discharge is split in such areas the water depth-water velocity combinations add to the variability of the aquatic habitat in the system. Also as the river meanders, oxbow lakes and backwater areas often develop. These areas are "recharged" with water during the spring runoff. Maintenance of such areas is also related to summer freshets.

The river channel also contains numerous lateral, point, and central bars comprised principally of sand and gravel materials. These bars are exposed during low flow periods.

Water quality of the Yellowstone is generally good. There is some degradation of quality downstream from the cities, stemming largely from domestic effluents. Water quality is also adversely impacted in lower reaches during late summer by the introduction of sediment, turbidity, and warm water from irrigation return flows. During the spring runoff period, the river is generally quite turbid and carries a heavy sediment load. Much of this sediment results naturally because of unstable soils within the drainage network. This generally increases as one proceeds downstream. However, prevailing land use practices throughout the watershed also appear to contribute significant quantities of sediment, from both overland erosion and increased bank erosion on tributaries and the main stem.

Missouri River from Garrison Dam, North Dakota, to Sioux City, Iowa

Unlike the Yellowstone, the Missouri River in the project area is controlled by several main stem reservoirs. These include Garrison Dam, Oahe Dam, Big Bend Dam, Fort Randall Dam, and Gavins Point Dam. From the headwaters of Lake Sakakawea (Garrison Dam) to Sioux City, Iowa, a distance of 836 miles, the main stem reservoirs occupy more than 620 miles of the river valley. Open reaches of river exist between Garrison Dam and Lake Oahe (87 miles), between Oahe Dam and Lake Sharpe (5 miles), between Fort Randall Dam and Lewis and Clark Lake (45 miles), and between Gavins Point Dam and Sioux City, Iowa (79 miles).

As a result of dam construction, flooding outside the present channel banks has been largely eliminated. In addition, bottom degradation has occurred and continues to occur in many parts of the study reaches. Below Garrison and Fort Randall Dams, water levels fluctuate as a result of changes in power production.

Nevertheless, except for stabilized sections below Garrison Dam and below Ponca, Nebraska, each of the study reaches has many characteristics of a pristine Missouri, although in varying degrees. The river is split into multiple channels in many locations, at least when flows are reduced, and is free to meander among sandbars, marsh areas, and islands within a channel that ranges to over 6,000 feet wide. The river sometimes flows between higher river bluffs or through stands of riparian bottomland hardwoods occupying the adjacent flood plain.

Less than 200 miles of the Missouri River from the upper end of Lake Sakakawea to its confluence with the Mississippi--some 16,000 miles--still have these characteristics. Most of the river above Sioux City, Iowa, is impounded and the river below Sioux City has been reduced to a channel that serves few purposes other than commercial navigation. All but 5 miles of the nearly 200-mile remnant are currently included in Bank Erosion Control and Demonstration Program.

Description of Existing Fish and Wildlife Resources

Yellowstone River

The lower 70 miles of the Yellowstone River below Intake, Montana, are known to be inhabited by approximately 40 species of fish. Because of relatively warm water temperatures during late summer, the Lower Yellowstone is often referred to as supporting "warm water" fish species.

Very few salmonids occur this far downstream. However, some of the species in the lower river are also found in cooler water environments.

Popular game species in the Lower Yellowstone included walleye, sauger, northern pike, paddlefish, shovelnose sturgeon, burbot, and channel catfish. Goldeye, smallmouth buffalo, carp, shorthead redhorse, longnose sucker, and river carsucker are other prominent components of the aquatic ecosystem. The rare pallid sturgeon is also found in the river. These species require diverse habitats, attesting to a diversified habitat base in the Lower Yellowstone River.

Paddlefish and walleye spawning activities occur in the lower river in open water with certain water depth, water velocity, and substrate requirements. Channel catfish and various cyprinids probably use side channels for spawning and rearing activities. In fact, most of the species listed above spawn either in the Yellowstone, or in its tributaries or both.

Approximately 25 species of mayflies, stoneflies, and caddisflies provide food for goldeye, channel catfish, freshwater drum, young sauger, young burbot, and other fishes. Backwater areas are particularly desirable feeding areas for sauger and burbot.

Because of an interconnected drainage network, the Lower Yellowstone River, the Missouri River in Montana and North Dakota downstream from Fort Peck Reservoir, and Lake Sakakawea in North Dakota, are not compartmentalized ecosystems in terms of aquatic species. Each system has its own "unique" attributes and a few fish species may be found in only one of these areas or may exhibit only localized seasonal movements. However, other species "winter over" in the reservoir and then migrate up the Yellowstone and Missouri River systems during spring for spawning and rearing purposes. For this reason, maintenance of both the reservoir and stream fishery resources is highly dependent on the maintenance of spawning and rearing habitat in the rivers and their tributaries. The spring paddlefish run of the Yellowstone River, probably one of the largest in the country in terms of fish numbers, is an example.

Terrestrial wildlife along the river is dependent on the extent, diversity, and types of riparian vegetation present. The nature of this vegetation is also molded in significant degree by hydraulic and hydrologic processes. Riparian plant communities in the Lower Yellowstone range from those representing very early successional stages to representations of quite late stages of development. Because of elevational differences in a point bar from the water's edge landward, these areas are suitable for the genesis of vegetative succession. Vegetation representing an early successional stage, often annual plant species, develops near the river. As erosion of the opposite bank progresses and the river channel moves laterally, the bar becomes less and less subject to inundation. This provides for a sequential development of vegetation over time. This example represents a simplified but typical sequence in the developmental process of soil and vegetative types along the river.

On the other hand, in the area of active erosion this "raw bank" provides some habitat conditions favorable to certain streamside dwelling mammals. In addition, the trees and brush eroded from the bank become integral parts of the aquatic ecosystem by providing areas of cover for fish. They also provide a source of energy to the system. The dislodged trees themselves may, over time, affect the hydraulic processes and become important in initiating the development of central bars and, subsequently, island areas. Accordingly, naturally eroding areas is one of the fundamental processes at work within the confines of the flood plain to maintain the integrity of the ecosystem.

Because of the diversity of vegetative types and successional vegetative stages, as already described, a wide variety of terrestrial wildlife species inhabit the Lower Yellowstone area. Large populations of white-tailed deer, mule deer, and pheasant occupy bottom lands and island areas. These areas provide year-round habitat for these species, as well as important winter cover for pheasants. Waterfowl, such as Canada goose, mallard, blue-winged teal, and merganser, commonly use the Yellowstone River and adjacent land areas during spring, summer, and fall. Gravel bars provide loafing and foraging areas for some species of waterfowl and shorebirds. Some of the islands are used for nesting by the Canada goose. Backwater areas and adjacent riparian vegetation are sites commonly used by mallard and other species of waterfowl for the same nesting purpose.

Because many of the areas are comprised of vertically stratified vegetation, many species and large numbers of songbirds seasonally use the area. The bald eagle, an endangered species, and other birds of prey are also common inhabitants.

Besides deer, a number of other mammals are found throughout this section of the Yellowstone. Common species include beaver, mink, muskrat, raccoon, badger, coyote, weasel, cottontail rabbit, and a variety of ground squirrels.

The black-footed ferret is the only endangered mammal which may be found in the flood plain of the Lower Yellowstone and Missouri Rivers. Little is known about this species; however, there is a relationship between black-footed ferret and prairie dog towns. Therefore, all prairie dog towns should be considered as possible ferret locations.

Reptiles and amphibians include several species of turtles, toads, frogs, snakes, and the tiger salamander.

Missouri River

The Missouri River between Garrison Dam and Lake Oahe supports a fishery containing 54 species of fish representing 16 families. Aquatic productivity below Garrison Dam is low because of the cold water releases at the dam and the unstable nature of the channel bottom. In addition, fluctuating water levels, the result of power production, prevent the establishment of rooted vegetation on bars and points. In spite of these shortcomings, the river provides an excellent sport fishery for walleye, trout, and northern pike. Much of this fishery is dependent on recruitment from Oahe Reservoir and annual stocking by the North Dakota Game and Fish Department.

The terrestrial habitat found along the Missouri River is some of the best in the State. Recent estimates by the North Dakota Game and Fish have indicated there are 3,655 deer on the Missouri River flood plain downstream of Garrison Dam. In addition, a majority of the statewide turkey harvest occurs in this stretch of the river. Pheasants, squirrels, rabbits, and various furbearers provide other recreational opportunities for sportsmen from many areas, both rural and urban alike. Canoeing is another recreational activity on the river that is drawing more participants every year. The North Dakota Parks and Recreation Department estimates that approximately 2,000 canoeists took to the Missouri River downstream of Garrison Dam last year. This number is expected to increase dramatically as this recreational pastime continues to attract followers. Scenic and other aesthetic qualities associated with the basin are enjoyed by many people. It is readily apparent that the Missouri River Valley provides quality recreational experiences for many thousands of people annually.

Bald and golden eagles make use of the Missouri River flood plain for nesting, as a wintering ground, and as a major migratory route north and south. Especially heavy use is made of the Karl Mundt Eagle Refuge, below Fort Randall Dam. As many as 200 eagles congregate in this area during the November-February period. The eagles' principal food is fish which during the winter are readily available in the project tailwaters and ice-free river downstream. Use is also made of the mature flood plain forest as a shelter against winter storms.

U.S. Fish and Wildlife Service personnel (North Central Reservoir Investigations) conducted a study in 1976 of the fish communities in the Missouri River below Fort Randall and Gavins Point Dams. It is evident from the study results that most of the 46 fish species that were collected utilized several habitats during their life span, and that disruption of any portion of this system of habitats would adversely affect the fish community. Backwater and marsh areas appeared to be of particular importance, since over 50 percent of the species used them as spawning and nursery grounds.

In addition a very important fish spawning area is located between Fort Randall and Lewis and Clark Lake near the State line between Nebraska and South Dakota. This area is important in that it is perhaps the only spawning area of significance in this stretch of the river and is believed to supply much of the fishery for the Missouri River between Fort Randall Dam and Lewis and Clark Lake. Young fish from this spawning site may well contribute to the fish population in the Gavins Point Dam tailwaters and possibly further downstream.

A recent study conducted by the South Dakota State University, using the Fish and Wildlife Habitat Evaluation Procedures indicates the relatively high value to wildlife of the flood plain habitat along the river below Fort Randall Dam. Based on a scale of 1 to 10 with 10 being excellent, the average habitat value for the five habitat types rated was 7.2.

Potential Impacts--Stream Control Devices

Yellowstone River

Bank stabilization has the potential for damaging or destroying aquatic and terrestrial habitat. For example, structures on the Yellowstone, if used extensively, could effectively reduce lateral erosion and stream length. These activities could eliminate some islands, reduce the rate of development or formation of new islands, restrict the amount of land-water interface, reduce the diversity of riparian vegetation by eliminating or limiting successional phases, and decrease water surface acreage, thereby directly affecting quantity and quality of aquatic habitat.

Even structures at only a few sites have the potential for extreme damage. Since the system equilibrium is affected, stream channel changes may take place in areas upstream or downstream of a site. Accordingly, cumulative impacts may accrue due to the loss of "new" areas which would have been created over time and also because additional projects may subsequently be required to stabilize the bank in newly affected areas. This latter process would lead directly to further modification and reduction in habitat.

Stabilization of the bankline also appears to encourage additional land clearing. This results in a direct loss of riparian habitat and further reduces bank stability. This further precipitates the entire "erosion control" cycle. Based on visual evidence, recent reconnaissance of the Lower Yellowstone River suggested that land clearing (past and present) is significantly influencing erosion rates along the bankline. Previous attempts to use local structural measures to control bank erosion also appear to be a factor.

The Missouri River

On the Missouri, actions which reduce channel widths, eliminate oxbows, reduce bank cover or streamside canopy, eliminate well-developed island habitat, result in the loss of terrestrial riparian habitat, or otherwise reduce habitat diversity will result in losses of fish and wildlife and associated environmental values.

Loss Prevention Potentials

Riverine habitats such as those in the project area have become and are becoming increasingly scarce in much of the West and in many other parts of the Nation. As a result, those remaining have a high value and are becoming increasingly valuable.

Actions to solve bank erosion problems have the potential for preserving these habitats. However, they also have the potential for destroying or significantly damaging them if carried to extremes or carried out without sensitivity to environmental values. Measures can be taken to prevent or reduce losses or preserve and restore these environments.

High value riparian terrestrial habitats can be protected in some instances by installing appropriate erosion control devices in specified locations. However, this action itself can precipitate land clearing when carried out to protect private land. Therefore, it must be followed up by acquisition in fee or easement to place these habitats in public ownership.

In other instances, no action at all, or acquisition of adjacent eroding lands, may be the least-cost alternative to solving a bank erosion problem while at the same time maintaining the existing riverine ecosystem. Such action would not only maintain the diversity of terrestrial habitat adjacent to the river, but would preserve aquatic habitats as well. This may be most applicable to the Yellowstone where essentially balanced erosion and accretion are an ongoing phenomena and where lateral erosion itself contributes to the quality of fishery habitat. This or another nonstructural alternative could emerge as the best solution as a result of studies of the causes of erosion.

In the reach below Garrison Dam, the existing, rather massive structures may be modified to restore habitat. Other methods for improving habitat may emerge as a result of further study.

We recognize that some structures will be necessary. However, wherever structures are built, they should be of the "soft" type--no more than necessary to check erosion--and installed with due regard to potentials

for changing instream hydraulics which could affect aquatic environmental values. They should not reduce channel widths, nor eliminate oxbows, nor should they induce erosion at new locations that will require additional structures.

Proper maintenance that will allow the reestablishment of native vegetation on structures will not only provide wildlife and fishery habitat but will meet aesthetic criteria as well. These potentials can be developed by incorporating these fish and wildlife environmental concerns into the study and planning process.

Discussion

Bank stabilization on the Yellowstone and on the three remaining moving water reaches of the Missouri River within the project area can have significant impacts on fish and wildlife and associated habitats. However, these impacts can be prevented or reduced, and there may be ways that habitats can be improved or restored. These potentials cannot be realized unless the Bank Erosion Control Evaluation and Demonstration Study is carried out as authorized and specific steps taken to prevent or reduce adverse effects on the environment.

In view of the purposes of the project, as stated in the Act and as substantiated by its legislative history, we are unable to view it as any more than a feasibility-level study to determine the extent and causes of and new methods and techniques for bank protection, with authorization to construct a limited number of erosion control structures for evaluation and demonstration.

This was the initial approach applied to the reach below Fort Randall Dam. Fish, wildlife, and recreation interests familiar with that reach recognized the potential of this program to develop into a comprehensive bank stabilization program which, if implemented, would degrade the natural beauty and alter the ecological regimen of these river segments. These interests sought and received assurances that the demonstration and evaluation program would not progress beyond the initial six demonstration sites without a full evaluation and Environmental Impact Statement and that it would not evolve into a comprehensive stabilization program. Colonel Russell A. Glenn, District Engineer, in his letter of January 15, 1976, to the Fish and Wildlife Service, stated, "The work to be performed is a research, development, and demonstration effort to develop methods and techniques to control streambank erosion. It is not designed as an operational authorization to correct all of the erosion problems between Fort Randall Dam and Sioux City."

Upon receiving such assurances, conservation interests agreed that construction of the initial six demonstration sites was a minor Federal action in the Gavins Point to Ponca State Park reach of the Missouri River, and that an EIS, therefore, was not required.

However, in August 1977, Congress appropriated an additional \$2 million for bank stabilization structures at three additional sites between Fort Randall Dam and Sioux City, Iowa. Local interests clearly identified intentions to seek additional erosion control projects each year until the entire erosion problem was solved. As a result, the initial agreement could no longer be considered valid.

Recent actions have been taken that can lead to designation of the reach of the Missouri River from Gavins Point Dam to Ponca State Park as a Recreational River under the Wild and Scenic Rivers Act. These actions can include provisions for the installation of bank erosion control measures that will be compatible with Recreational River concepts and maintain fish and wildlife and associated environmental values. These actions are the result of coordination among and the participation of a wide range of interests, including the Corps of Engineers; the Heritage Conservation and Recreation Service; and the Fish and Wildlife Service; State and local agencies; and private organizations and individuals. Implementation of this proposal can assure that environmental as well as bank erosion control concerns will be adequately addressed.

This is not the case for the other reaches of the river. Prior to 1976 bank stabilization structures were built below Garrison Dam without adequate coordination with fish and wildlife interests and without full consideration of fish and wildlife and associated environmental impacts and potentials. These actions have already stabilized 20 percent of the bankline in this reach, and the additional work planned would bring this to roughly 40 to 45 percent. We are uncertain at this time precisely how the Corps plans to proceed on the Missouri River immediately below Fort Randall Dam and on the Lower Yellowstone.

We recognize that bank stabilization along the Missouri was addressed in the reports for Water Resources Development, Missouri River, North Dakota, South Dakota, Montana (the "Umbrella Study"), and in the EIS for that study. Subsequent to public review of the draft report and EIS, however, the Corps determined that:

specific and general authorities of Section 32 are broad enough to solve all erosion problems in the subject river reach, and that no additional legislative action will be needed to solve the problems if future Congressional appropriations for Section 32 work are sufficient to do all the work.

We are uncertain whether the Corps continues to hold this view. In any event, neither the Act itself, even as amended, nor the legislative history support that view. Furthermore, it seems inappropriate and inconsistent to proceed with extensive bank stabilization works on either the Missouri or the Yellowstone before the Bank Erosion Control Evaluation and Demonstration project is completed and the results of studies called for in the legislation are available, unless protective actions are taken as may be implemented for the Gavins Point to Ponca reach.

Federal responsibility for bank erosion control is also an issue which should be addressed by the Corps in its studies. It has been suggested that the Federal Government may have incurred a responsibility to protect private property where it can be demonstrated that erosion problems were caused by or accentuated by Federal projects. This may apply downstream from the dams and reservoirs on the Missouri. However, no question of such responsibility exists on the Yellowstone River. It is not only free-flowing but is free of any substantial Federal structural modifications.

Other factors are at work. For example, a major factor aggravating natural bank erosion on the Yellowstone River is poor land use practices, including overgrazing and unwise clearing of vegetation. Therefore, serious consideration should be given to the potential for incurring a Federal responsibility to carry out a progressively expanding erosion control program on the Yellowstone at high construction costs, including extensive cumulative loss of fish and wildlife resources associated with this highly valuable natural riverine ecosystem. It is our view that bank erosion control on the Yellowstone cannot be justified.

Recommendations

We recommend that before proceeding with extensive bank stabilization work on the Lower Yellowstone and the moving water reaches of the Missouri River between Garrison Dam and Lewis and Clark Lake:

1. the reach on the Yellowstone below Intake, Montana, and the remaining reaches of the Missouri be treated as individual planning units,
2. land and water management alternatives be developed for each of these planning units which fully consider environmental concerns, as prescribed by the Water Resources Council's Principles and Standards,
3. an EIS be prepared for each planning unit,
4. public meetings be held on these management alternatives,
5. management alternatives be selected for each planning unit,
6. legislation then be recommended to carry out the land and water management plan,

7. as a part of the process, discussions similar to those which were held for the reach below Gavins Point Dam be held and agreement reached on the number of sites that would be sufficient for demonstration purposes on each of the planning units above Gavins Point,

8. selection of study sites be coordinated through a task force composed of Federal and State wildlife officials and concerned local interests as well as the Omaha District Corps of Engineers and sponsoring local government units,

9. studies undertaken to evaluate the physical consequences of installing bank erosion control structures not be limited simply to determining the effectiveness of specific structures in checking erosion but that they also include their effects on river hydraulics, including determining to what extent the structures affect flow velocities and directions; their impact on stream cross-sections, especially degradation; the potential for initiating erosion at new locations; and their impact on river aesthetics, and

10. concurrent studies be carried out to determine definitively the impacts on fish and wildlife and the environment and measures for preventing losses and improving habitat.

We further recommend that:

1. each site selected for demonstration purposes be treated individually and that an adequate mitigation plan be developed for each site, as is done with other water projects, pursuant to the Fish and Wildlife Coordination Act, 16 U.S.C. 661; et seq., and

2. such mitigation plans assure that aquatic habitats and terrestrial wildlife habitats on the high banks will be preserved and not cleared for agricultural purposes once the banks are stabilized.

It is our view that the Fish and Wildlife Coordination Act provides the Corps with sufficient authority to prevent or mitigate losses associated with construction at demonstration sites without additional Congressional authorization, including authority to acquire land or interests in land sufficient to preserve high bank habitats. However, if the Corps of Engineers believes it needs additional, explicit approval to implement such measures, we recommend that the Corps seek necessary approvals.

This report only addresses our concerns on the Yellowstone and Missouri Rivers. The Bank Erosion Control Evaluation and Demonstration Program is, however, a National program. The magnitude of the work that is authorized warrants a programmatic EIS that addresses the potential impacts nationwide. It is not too late to prepare this, and we recommend that the Corps of Engineers give this serious consideration.

Sincerely yours,



JAMES C. BRITMAN
Acting Regional Director

Enclosure



Department of Game, Fish and Parks
Pierre, South Dakota 57501 • Phone 224-3387

Division of Administration

May 11, 1978

Harvey Willoughby
Regional Director
United States Department of the Interior
Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, CO 80225

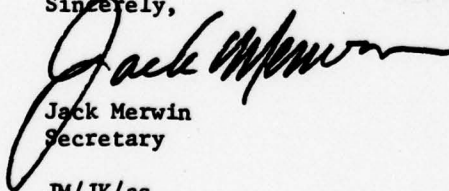
Dear Mr. Willoughby:

My staff has reviewed the Service interim report on the Streambank Erosion Control Evaluation and Demonstration Project, Missouri and Yellowstone Rivers.

We concur with the report and recommendations as they pertain to South Dakota.

The South Dakota Department of Game, Fish and Parks would suggest consideration be given in the near future to designation of the reach of Missouri River from Fort Randall to Lewis & Clark Lake as a recreational river component of Wild and Scenic Rivers Act.

Sincerely,

A handwritten signature in black ink, appearing to read "Jack Merwin". The signature is written in a cursive, flowing style. Below the signature, the name "Jack Merwin" and the title "Secretary" are printed in a small, sans-serif font.

Jack Merwin
Secretary

JM/JK/as





NORTH DAKOTA GAME AND FISH DEPARTMENT

PHONE - 224-2180

BISMARCK, N. DAK.

58505

May 5, 1978

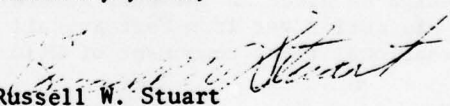
U.S. Department of the Interior
Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225
Attention: Environment

Dear Sirs:

The Department has reviewed the draft interim Fish and Wildlife Coordination Act Report on the Demonstration and Evaluation Project, Missouri and Yellowstone Rivers, Montana, North Dakota and South Dakota. We are in complete agreement with the contents of the report and the recommendations set forth in the document.

Thank you for the opportunity to review this report.

Sincerely yours,


Russell W. Stuart
Commissioner

RS/dd
cc: FWS (Zschomler)



Nebraska Game and Parks Commission

2200 North 33rd Street / P.O. Box 30370 / Lincoln, Nebraska 68503

May 9, 1978

Mr. Harvey Willoughby, Regional Director
U.S. Fish and Wildlife Service
P. O. Box 25486
Denver Federal Center
Denver, Colorado 80225

Dear Mr. Willoughby:

We have reviewed the draft of your Service's interim report on the Streambank Erosion Control Evaluation and Demonstration Project, Missouri and Yellowstone Rivers provided by Mr. Sowards, Acting Area Manager, Pierre, South Dakota.

We generally concur with that portion of the report pertaining to the Missouri River below Fort Randall Dam. More specifically, we strongly support the approach arrived at for the Missouri River below Gavins Point Dam. This approach consists of designation as a National Recreation River by an amendment to the Wild and Scenic Rivers Act that provides for preservation of the river including installation of needed bank erosion control features similar to those installed in the reach under provisions of Section 32.

While we agree with the conclusion that demonstration projects should be subjected to continuing evaluation as to effectiveness and long-term impacts, we are also concerned with losses being sustained by private landowners as a result of bank erosion. Therefore, we favor an approach for the Fort Randall Dam - Lewis and Clark Lake Reach similar to that for the unchannelized reach below Gavins Point Dam. A suggested first step is inclusion of the Fort Randall - Lewis and Clark segment in the Section 5 Study list of Wild and Scenic Rivers Act.

Very truly yours,

EUGENE T. MAHONEY,
DIRECTOR

cc: F&WS, Pierre, South Dakota

RESPONSES TO COMMENTS MADE BY THE DENVER REGIONAL OFFICE
OF THE U.S. FISH AND WILDLIFE SERVICE ON SECTION 32
STREAMBANK EROSION CONTROL ON THE MISSOURI RIVER AND
YELLOWSTONE RIVERS

PREPARED BY THE OMAHA DISTRICT
CORPS OF ENGINEERS

1. Page 10, paragraph 4. Limited erosion control projects designed with proper consideration of existing river conditions and characteristics do not cause increased problems elsewhere; overall river conditions can actually be improved. At the very most, a limited project has no more effect than when the river encounters a naturally erosion resistant area.
2. Page 10, last paragraph. Clearing along the project river reaches (Yellowstone and Missouri) in recent years has occurred almost totally in the absence of erosion control measures.
3. Page 11, paragraph 4. The Omaha District supports the concept of land use preservation adjacent to those river reaches. However, as noted in comment 2, the clearing is occurring without erosion control measures.
4. Page 11, paragraph 5. Acquisition of eroding lands is an alternative to erosion control relative to cost only. It is not an alternative solution to the erosion problems. The economic cost of the erosion losses would be transferred to the public; however, the physical impact of loss of a terrestrial resource would not be solved. This is particularly true for the Missouri River reaches where erosion rates are greater and erosion losses are not offset by accretion.

5. Page 11, last paragraph and Page 12, first paragraph. The actions and considerations addressed in these paragraphs are an integral part of the erosion control demonstration project planning and design.

6. Page 12, paragraph 3. The Omaha District basically concurs with your position concerning interpretation of the original legislation. However, the District must comply with subsequent specific Congressional directives to provide erosion control at very clearly identified sites on the Missouri River.

7. Page 12, last paragraph and Page 13, paragraphs 1 and 2. The "subsequent Congressional directives" mentioned in comment 6 occurred in October 1976 and August 1977. Legislative interpretations established prior to these actions obviously required substantial reevaluation.

8. Page 13, paragraph 4.

a. Since 1976, the Omaha District has made extensive efforts to improve coordination of all erosion control projects on the Missouri River reach downstream of Garrison. Significant structure modifications to reduce adverse environmental and esthetic effects have resulted from these efforts.

b. Implementation of the projects in the Fort Randall reach and the Yellowstone River reach has been and will continue to be coordinated through the "task forces" approach. These task forces include Federal and State fish and wildlife officials and concerned local interests, as well as the Omaha District and sponsoring local Government units.

9. Page 13, last paragraph thru Page 14, paragraph 2.

a. The issue of Federal responsibility for erosion on the Missouri River was considered in previous evaluations; the most recent being the "Umbrella" study.

b. Federal involvement on the Yellowstone, as with all of the Section 32 work, is the result of specific Congressional directives. Congress did not ask the Corps to justify a Federal involvement.

10. "Recommendations." As summarized below, the recommendations fail to recognize the existing situation and the enormous efforts already expended toward developing solutions for the subject erosion problems, particularly on the Missouri River reach downstream from Gavins Point Dam and downstream from Garrison Dam.

a. The existing statutory authorities provide directions to conduct very specific actions.

b. The alternatives to erosion problems on the Missouri River reaches have been discussed numerous times. Literally dozens of public forums have been conducted since 1971 on this topic. The results of these forums and the great majority of correspondence received concerning the erosion problems provide an overwhelming expression by those being adversely affected by erosion that:

(1) The erosion problems downstream from the dams is a Federal responsibility and the enormous regional and national benefits from the reservoir system are provided at the expense of the few downstream interests.

(2) Solutions or alternatives leading to further loss of now scarce Missouri River bottomland are opposed both by local residents and most State and local Government interests.

(3) Any attempts to control or limit the rights and activities of the local interests are strongly opposed.

c. The optimum "management alternative" for the Gavins Point reach has already been determined and agreed upon by way of a multiple-interest task force. Action is underway to implement this alternative via designation as a "National Recreational River," including essential erosion control.

d. Congress has already established the number of locations for erosion control demonstration sites downstream of Garrison Dam; thus this determination is no longer an administrative prerogative.

e. Selection of site priorities for demonstration projects has been and shall continue to be accomplished through the task force approach.

f. The physical consequences of installing erosion control structures are carefully considered during planning and design, and are thoroughly monitored after construction. This has been done regularly on Omaha District erosion control projects, long before the Section 32 program was authorized. Monitoring and evaluation of esthetic and environmental values, including fish and wildlife values, has been initiated on all erosion control projects since the authorization of the Section 32 Demonstration Program.

STATE OF MONTANA



DEPARTMENT OF

FISH AND GAME

Helena, MT 59601
April 25, 1978

Col. James W. Ray, District Engineer
U. S. Army Corps of Engineers
6014 U. S. Post Office and Courthouse
Omaha, NE 68102

Dear Col. Ray:

The purpose of this letter is to address several matters arising from discussions with your staff at a meeting in Bismarck, North Dakota on February 8, 1978, regarding the Streambank Erosion Control and Demonstration Act of 1974 (Section 32, as amended) as it pertains to the lower Yellowstone River.

As a result of those discussions, and as requested, the fish and wildlife agencies agreed to provide a report for your use in preparing the interim report to be submitted to Congress in September 1978. That report, which has the informal concurrence of the U. S. Fish and Wildlife Service, is enclosed. We understand this document will be appended to or accompany the interim report.

At the Bismarck meeting, the question arose as to whether limiting the demonstration to three sites on the lower Yellowstone River would necessitate preparation of an environmental impact statement. Our department and the U. S. Fish and Wildlife Service have discussed that question in some detail since the Bismarck meeting. It was the general consensus that there is no assurance that only three projects will be constructed under the existing authorization. There has been no written statement from the Corps concerning present intentions, and we have no description of the specific measures proposed for construction. In addition, there is a question as to whether the proposed "River Front" area near Sidney, Montana, or the other sites, represent proper choices for the three demonstration projects. As far as we know, none of these areas have been evaluated in the field to determine their suitability as demonstration sites by the Corps or any other agency.

The extent of the demonstration project appears to be specifically limited only by the total monies authorized and, of course, subsequently appropriated. Our major concern, however, relates to the limits of the total proposal and the specifications for each project site.

In view of these uncertainties, the Fish and Wildlife Service and this department agreed that we cannot concur in a "minor action" determination in lieu of preparing an impact statement. This position may

be modified if you could supply a description, in writing, of activities (structural and nonstructural) the Corps intends to carry out on the Yellowstone River under this authorization.

We have not attempted to discuss site-specific impacts, nor any needed constraints or mitigation needs for the three proposed demonstration projects on the Yellowstone, inasmuch as we understand that these sites remain tentative and will not be finally selected pending the outcome of field surveys this summer. We are prepared to assist you in that selection process, as was requested and agreed on informally at the Bismarck coordination meeting.

We have previously indicated our concern that the only activity contemplated on the Yellowstone River appears to be construction of bank stabilization measures. Nonstructural needs will apparently not be addressed, although there appears to be no reason to assume that Congress was interested only in structural measures. If our belief that natural erosion processes are aggravated by unwise land use practices (especially land clearing) is valid, it appears that identification of the causes of erosion, as called for in Section 32(b), and evaluation of nonstructural measures for reducing erosion rates, could be a valuable contribution to the public interest on the Yellowstone River. We would be prepared to assist in such an undertaking.

Thank you for the opportunity to submit these comments and the enclosed report.

Sincerely,

Robert F. Wambach
State Fish and Game Director

By: *R. W. Boland*
Ralph W. Boland, Assistant Administrator
Ecological Services Division

RWB/sd

Enc

cc: Burt Rounds, Attn: Gary Wood
Office of the Governor
Office of the Lt. Governor
Ted Doney, Director, Department of Natural Resources
Regional Director, U. S. Fish & Wildlife Service (Environment)

COMMENTS ON

Erosion Control Demonstration Program for
the Yellowstone River: Intake, Montana to the Mouth
Omaha District, Corps of Engineers

February 1977

Prepared by

Montana Department of Fish and Game, Helena, Montana
in cooperation with

U. S. Fish and Wildlife Service, Billings, Montana

April 1978

For

Corps of Engineers, Omaha District
September 1978 Interim Report to Congress

CONCERNS

This section of the report includes brief statements of concern relating to the proposed lower Yellowstone River project in Montana. It is placed in the "up front" position for the convenience of those not wishing to read the supportive explanatory discussions in the report. Statements are not listed in any particular order of importance.

The uniqueness of the lower Yellowstone River valley, combined with the high quality and diversity of the natural riverine ecosystem, make it imperative that this system be preserved. We are concerned generally that structural bank stabilization does not consider the basic cause of bank erosion, and will finally result in destroying the natural hydraulic pattern of river flow; and subsequently, the ecological system that has developed and is maintained as a result of that flow.

Specifically, items which in our opinion need to be addressed to avoid the disruption of the natural hydraulic and ecological system which exists on the lower Yellowstone River, or are cause for our concern, include:

(1) Streambank structures impede natural erosion, eventually reducing stream length and directly affecting the quantity and quality of terrestrial and aquatic habitats.

(2) Bank stabilization will encourage further land clearing of the floodplain.

(3) Poor land use practices and their ultimate adverse impact on wildlife is encouraged by federally funded stabilization projects.

(4) A proliferation of project requests will follow because of the lack of landowner understanding of river mechanics and the requirement for any commitment from the landowner for project funding.

(5) Access roads and areas for construction activities will destroy both game and nongame wildlife habitat.

(6) Maintenance of projects will require periodic disturbance of floodplain habitat.

(7) Channel modification and maintenance tends to perpetuate a disequilibrium in the system.

(8) Bank stabilization will affect natural vegetative succession and reduce "edge effect."

(9) Long-term adverse effects will outweigh short-term benefits from bank stabilization.

(10) The reduction of the diversity of aquatic habitat such as loss of backwater areas will have an adverse impact on the number of fish species present and on the life history requirements of both game and nongame species of fish.

(11) Other federal agencies, such as the Soil Conservation Service, have begun to see the value of deemphasizing structural stabilization measures. This project proposal is contradictory to that informed enlightenment.

(12) Changes in hydraulic patterns will cause erosion of island habitat (two of which are owned by this department) with subsequent reductions of secure goose nesting areas and wildlife habitat.

(13) Diversity of vegetative and wildlife habitat types will be reduced, thereby reducing wildlife species diversity.

(14) Resting and feeding areas of the bald eagle will eventually be destroyed.

(15) Proposed projects will reduce the aesthetic value of the area for floating and other recreational uses.

(16) Critical winter cover for wildlife will be removed.

(17) Habitat losses are generally irretrievable and irreplaceable. Streambank erosion control projects lack recommendations or sufficient funding for restoration or mitigative measures, particularly when these involve encroachment on private lands.

INTRODUCTION

On April 14, 1977, the Montana Department of Fish and Game requested a copy of a February 1977 Corps of Engineers report tentatively outlining that portion of the Erosion Control Demonstration and Evaluation Project applicable to the lower Yellowstone River. The document outlined 24 "projects" for possible construction on that segment of the Yellowstone River between Intake, Montana, and the river's mouth in North Dakota. The Fish and Game Department provided comments on that document in a letter to the Corps which outlined potential impacts, questioned the need for the work, and suggested that many of the sites were, in fact, unsuitable for the purpose intended. The U. S. Fish and Wildlife Service also corresponded with the Corps, raising many of the same questions.

Subsequently, at a meeting in Bismarck, North Dakota on February 8, 1978, the Corps clarified the intent of the program, indicating informally that only three projects would be constructed on the Yellowstone River under present legislation. These three projects would be for the sole purpose of "demonstrating" effectiveness of certain streambank stabilization measures on a free-flowing stream.

Since 1974 intensive wildlife (including waterfowl), recreational and fisheries studies have been conducted by this department on the lower Yellowstone River. The Montana Department of Fish and Game is vitally concerned with these natural resources of the lower Yellowstone River. The Yellowstone from Intake, Montana to the mouth (approximately 70 river miles) offers a recreational resource potential to future generations which is difficult to measure in terms of monetary value.

This report addresses those aspects of the Yellowstone River Erosion Control Demonstration Project (Section 32, PL 93-251, Stream Bank Erosion Control Evaluation and Demonstration Act of 1974, as amended) that apply to the Montana portion of the project area. It has been prepared by the Montana Department of Fish and Game in cooperation with the U. S. Fish and Wildlife Service, and has the general concurrence of the latter agency.

DESCRIPTION OF AREA

The Yellowstone River flows easterly through Montana for approximately 540 miles before entering North Dakota. In North Dakota the river flows some 20 additional miles to its confluence with the Missouri River. The entire river is free of mainstem reservoirs. Two major tributaries are controlled by dams, the largest of which is Yellowtail Dam on the Bighorn River. Despite the tributary dams, the mainstem of the Yellowstone functions as a free-flowing river system and exhibits pronounced seasonal fluctuation in flow. Since the flows of the Yellowstone River are largely unregulated, it exhibits the biotic and hydrologic characteristics of a natural, dynamic system. It is, in fact, the largest remaining "free-flowing" stream within the conterminous United States.

Ice jams are common in the lower Yellowstone, and the grinding action of ice often results in bottom scour and alteration of the bankline. The bulk of the bank erosion, however, occurs during the spring runoff period when high flows may predominate for several weeks.

The channel morphology of the lower Yellowstone River is primarily a function of hydraulic, hydrologic, edaphic and geologic features. Approximately the lower 50 miles of the valley lie in the glaciated plains region. Except for occasional lenses of bedrock scattered throughout the area, the soils within the confines of the valley are comprised principally of alluvium or other easily erodible material. The rate of lateral erosion is conditioned to some degree by the stability afforded by the root structure of streamside vegetation.

The hydrology of the basin, the hydraulics of the channel plus the erodibility of the soil allow the river to meander as a natural system across the valley floor. Accordingly, the riverine and floodplain ecosystems have also developed naturally, and their maintenance is largely dependent on these processes. Preservation of this natural system is critical to the economic, social and environmental values of the lower Yellowstone River basin.

All of the proposed erosion control demonstration projects are confined to the lower 70 miles of the Yellowstone. In Montana, the project area encompasses braided sections of river where the Yellowstone splits into several channels and large, stable island systems are common. The channel slope, sediment load, and spring flood characteristics are important factors in channel formation processes. Of equal importance in braided sections is the erodibility of the banks. As sediment and bedload deposits occur in island sections, channel capacity is maintained by streambank erosion.

Although a site-specific observation may indicate extensive erosion of soil and bankline vegetation, checks and balances occur over time and space (such as over the lower 70 miles) to maintain relatively stable ecosystems. A comparison of recent aerial photos with 1878 survey maps indicates little change in the braided condition of the channel and illustrates the long-term stability of the island complexes. Although erosional areas exist, it is doubtful any net loss of land has occurred along the 70-mile reach of river.

Because of the characteristics outlined above, lateral erosion in the lower Yellowstone River is relatively common. This phenomenon is essential for the continued existence of braided sections of river, since lateral erosion maintains channel length and channel capacity.

Associated with the braided channels is the extensive amount of "edge effect" afforded by the water-land interface and the large quantity of water surface. "Edge effect" is one of the most important ecological concepts functioning in the system for the maintenance of diverse wildlife populations. The braided section of river in the project area provides a quantity and diversity of both aquatic and riparian wildlife habitat seldom encountered in this region.

FISH AND WILDLIFE RESOURCES

A free-flowing stream system is self perpetuating. The system maintains the integrity of the natural ecosystem and provides a wide range of habitat conditions suitable for a diverse plant and animal community.

The lower Yellowstone River contains significant aquatic resources. Approximately 40 species of fish are known to inhabit the lower 70 miles of the Yellowstone. Popular game species include walleye, sauger, northern pike, paddlefish, shovelnose sturgeon, burbot, and channel catfish. Goldeye, smallmouth buffalo, carp, shorthead redhorse, longnose sucker and river carpsucker are other prominent components of the aquatic ecosystem. The rare pallid sturgeon is also found in the river. Two important species, walleye and paddlefish, move from Garrison Reservoir and utilize the lower Yellowstone as a spawning area. The spring paddlefish run is probably one of the largest in the country, and provides an exceptional fishery for this species.

Because of an interconnected drainage network of the lower Yellowstone River, the Missouri River in Montana and North Dakota downstream from Ft. Peck Reservoir, and Garrison Reservoir in North Dakota, these segments are not compartmentalized ecosystems in terms of aquatic species. Each system has its own "unique" attributes and a few fish species may be found in only one of these areas or may exhibit only localized seasonal movements. However, other species "overwinter" in the reservoir and then migrate up the Yellowstone and Missouri River systems during spring for spawning and rearing purposes. For this reason, maintenance of both the reservoir and stream fishery resources is highly dependent on the maintenance of spawning and rearing habitat in the rivers and their tributaries. The spring paddlefish run is an example. A major portion of these fish from Garrison Reservoir migrate up the free-flowing Yellowstone.

The maintenance and well-being of existing fish populations are dependent on the quantity, quality and diversity of the existing habitat. In a braided river, this habitat includes side channels, backwaters, shoal areas, submerged gravel bars and deep water main channel areas. This diversity of habitat provides spawning, rearing, feeding and refuge areas for fish populations and their prey organisms.

Terrestrial wildlife along the river is highly dependent on the amount and diversity of riparian vegetation. The nature of this vegetation is determined to a significant degree by hydraulic and hydrologic processes. The plant communities classified as riparian in the lower Yellowstone are represented by very early to quite late successional stages. Elevational differences of a point bar from the water's edge landward cause vegetation representing an early successional stage, often annual plant species, to develop near the river. As erosion of the opposite bank progresses and the river channel moves laterally, the bar becomes less and less subject to inundation. This

provides for sequential development of vegetation types over time - a simplified but typical sequence in soil and vegetative development along the river.

On the other hand, in an area of active erosion the land mass is reduced. This "raw bank," however, provides habitat favorable to streamside dwelling mammals such as mink and beaver. Accordingly, natural erosion is one of the fundamental processes at work within the confines of the floodplain to maintain the integrity and diversity of the ecosystem.

The diversity of vegetative types found in braided sections of the river allows a wide variety of terrestrial wildlife species to inhabit the lower Yellowstone. Large populations of white-tailed deer, mule deer, and pheasant as well as nongame species of wildlife occupy bottom land and island areas. These areas provide year-round habitat for these species and are especially important as winter cover for pheasants. Waterfowl, such as the Canada goose, mallard, blue-winged teal and merganser, commonly use the Yellowstone River and adjacent land areas during spring, summer and fall. Gravel bars provide loafing and foraging areas for some species of waterfowl and shorebirds. Islands are used for nesting by the Canada goose. Backwater areas and adjacent riparian areas are commonly used by the mallard and other species of waterfowl for the same purpose.

Because many of the areas contain vertically stratified vegetation, they are used seasonally by many species and large numbers of songbirds. The bald eagle, an endangered species, and other birds of prey are also common inhabitants. Other common wildlife species include beaver, mink, muskrat, raccoon, badger, coyote, weasel, cottontail rabbit, and a variety of ground squirrels.

The Montana Department of Fish and Game considers this section of the Yellowstone to contain such prime wildlife habitat that it has recently purchased two bottom land and island complex areas for game management. These are the Elk Island and Seven Sisters game management areas. Both are in the Montana portion of the project area. The purchase and development of these two areas attest to the department's interest and concern for the exceptionally high wildlife values present in the riparian habitat and associated island complexes found in this section of river.

The project reach offers solitude and unique scenery to the boating enthusiast. The increasing recreational usage of the river by non-residents as well as residents also indicates that there is broad public interest in maintaining the existing values of the river in its natural setting.

POTENTIAL IMPACTS - STREAM CONTROL DEVICES

As pointed out above, natural processes in alluvial stream channels interact to provide a diversity of aquatic and terrestrial wildlife

habitats and to establish and maintain ecosystems in a quasi-equilibrium condition. It cannot be overemphasized that natural bank erosion is an integral and important part of this overall process. According to Yang^{1/}, stream length must increase to minimize the time rate of energy expenditure and accordingly, the morphology of the channel must facilitate such an energy distribution. Keller and Melhorn^{2/} state that the only way a stream can increase its channel length, with the exception of headward erosion, is by lateral erosion, which increases sinuosity.

The Department of Fish and Game is concerned that structural streambank modifications as proposed by the Corps for the demonstration project could effectively reduce lateral erosion and eventually, stream length. External constraints already imposed by the geology of the area, plus reduction of lateral erosion, could have a dramatic effect on the riverine ecosystem. Islands will probably be diminished or eliminated, new island formation or development could be slowed considerably, the amount of land-water interface will be restricted, diversity of riparian vegetation will be reduced by the elimination or reduction in successional phases, and water surface acreage will be reduced. Thus, in our opinion, it is evident the proposed streambank modifications will have severe adverse effects on the quality and quantity of aquatic and terrestrial habitat. The loss or reduction of island, side channel and gravel bar areas can significantly reduce the aquatic and wildlife populations of a given area, as was demonstrated on the Bighorn River^{3/}.

The long-term environmental consequences of building only a few projects also concerns us. Since the quasi-equilibrium state of the river system will be affected by any structural works, streambank and channel changes may result in areas upstream or downstream from a project. It is becoming increasingly obvious that additional projects are needed to repair the bank and "stabilize" the channel in areas affected by new works; i.e., new works spawn the need for additional new works. These modifications lead to cumulative adverse impacts and a reduction in habitat.

Public funding for bank stabilization appears to encourage additional land clearing and is frequently requested after lands are cleared. Recent reconnaissance of the lower Yellowstone River suggested that past and present land clearing is significantly influencing erosion rates along the river. Previous attempts to use structural erosion control measures have met with mixed success and very likely contribute to the problem. Thus, the entire "erosion control" cycle is perpetuated.

^{1/} Yang, C. T. 1971. On river meanders. J. Hydrology: pp. 231-25

^{2/} Keller, E. A. and W. N. Melhorn. 1974. Form and fluvial processes in alluvial stream channels. Purdue University, Water Res. Inst. Tech. Rep. No. 47. 124 p.

^{3/} Martin, P. 1976. Yellowtail dam eliminates habitat. Montana Outdoors, Nov./Dec. p. 18.

CONCLUSION

It has been suggested that the federal government may have incurred a responsibility to prevent excessive erosion to private property caused or accelerated by construction of dams on rivers. No question of such responsibility exists on the Yellowstone River because it is free flowing. Bank erosion on the Yellowstone River is aggravated by poorly conceived land use practices which include overgrazing, clearing of riparian vegetation, and tilling to the stream's edge. Considering the general lack of federal responsibility for any erosion problem impacting private property, the potential for setting in motion a self-proliferating "need" for erosion control measures, the high cost of such construction, and the probable long-term adverse cumulative impacts on the fish and wildlife components of the natural river ecosystem, it is our view that extensive bank control is not justified and does not serve the total public interest.

Except for appropriate action under existing Corps authorities (i.e., Section 14 activities) to protect public property under emergency conditions, it is our view that no large scale federal construction of erosion control measures should be considered prior to completion of detailed studies including analysis of (a) economic efficiency, (b) environmental impacts, (c) careful consideration of nonstructural alternatives, and (d) a documented finding that such erosion control work on the Yellowstone River is in the public interest. The Department of Fish and Game especially recommends that any effort toward reduction of erosion on the Yellowstone River emphasize preventative and nonstructural alternatives.

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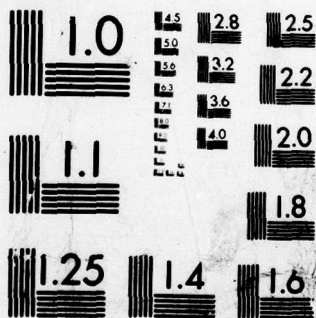
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CONCLUSION

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RESPONSES TO COMMENTS MADE BY THE MONTANA DEPARTMENT OF
FISH AND GAME ON SECTION 32 STREAMBANK EROSION CONTROL
ON THE YELLOWSTONE RIVER

PREPARED BY THE OMAHA DISTRICT
CORPS OF ENGINEERS

1. As indicated in the cover letter, the Montana Department of Fish and Game (MDFG) did not attempt to discuss site - specific impacts of Section 32 erosion control on the Yellowstone River, because no Section 32 demonstration program has been firmly established for the Yellowstone River. The Omaha District has, however, indicated to the MDFG and others that, for the purposes of demonstration, the Omaha District is recommending construction of only three erosion control demonstration sites on the Yellowstone River. The MDFG recognizes, however, that the Omaha District is not in complete control of the Section 32 Demonstration Program. They are also aware of the history of Section 32 on the Missouri River, where limited Section 32 demonstration programs have evolved or are evolving into rather extensive programs. They feel that the Section 32 Demonstration Program on the Yellowstone River has the same potential to evolve into an extensive program. Consequently, the MDFG has directed their comments toward the potential impacts of an extensive program in an effort to discourage one.

2. The MDFG cites numerous adverse environmental effects that would result from bank stabilization. The most significant and perhaps the most valid of the adverse effects cited is a reduction in the quantity and quality of riparian habitat along the Yellowstone River. Bank stabilization would tend to reduce lateral movement of the channel.

Reduced lateral movement of the channel would reduce primary succession, "edge effect," along the riverbanks. This "edge effect" is vital to the long term maintenance of diverse plant and wildlife populations in the riparian ecosystem. The three Section 32 Erosion Control Demonstration projects recommended for construction on the Yellowstone River would probably not result in significant impacts as described above. The cumulative impacts of many such projects, however, would be significant.

3. The MDFG states that there will also be a reduction in the quantity of aquatic habitat resulting from a reduction in stream length. This particular effect cannot be clearly substantiated at this time. The Omaha District is currently in the process of securing a contract with an engineering and environmental consulting firm to conduct studies on the Yellowstone River. These studies will give us a better understanding of the dynamics of the Yellowstone riverine system and will enable us to intelligently speculate on this and other potential impacts.

4. The MDFG states that, in general, there will also be a reduction in the diversity of aquatic habitat and a loss of backwater areas. We anticipate that the types of erosion control measures employed on the Yellowstone will not significantly alter the cross section of the river, and that alteration to significant fish production areas and backwater areas can be avoided with good project planning.