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BUFFALO METROPOLITAN AREA, NEW YORK WATER RESOURCES MANAGEMENT.--ETC(U)

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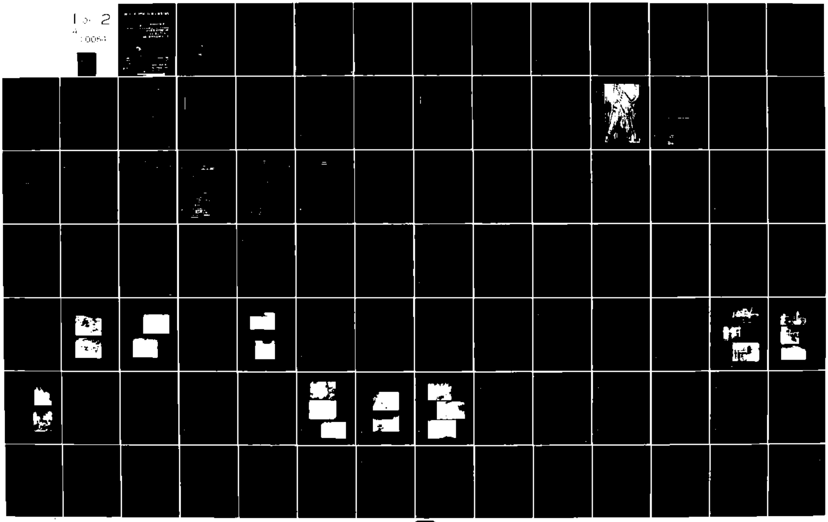
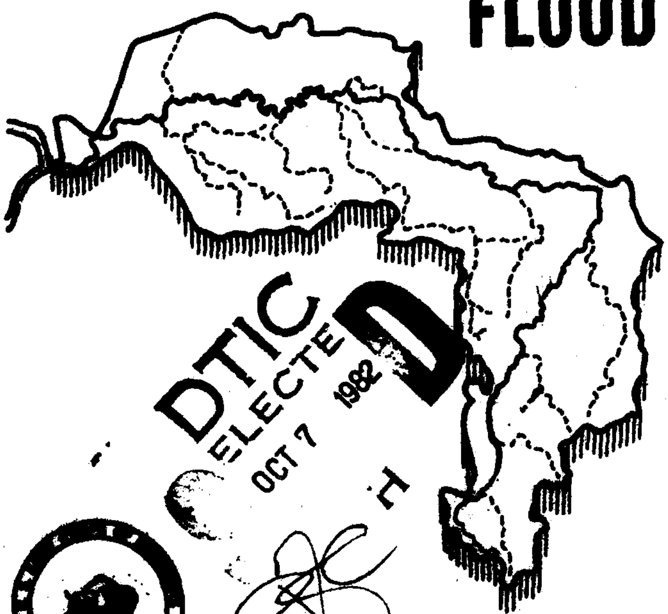


BUFFALO METROPOLITAN AREA, NEW YORK
WATER RESOURCES
MANAGEMENT

INTERIM REPORT ON FEASIBILITY OF FLOOD MANAGEMENT IN



TONAWANDA CREEK WATERSHED

FINAL FEASIBILITY REPORT

U.S.ARMY
BUFFALO DISTRICT
CORPS OF ENGINEERS

MAIN REPORT
November 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A120054	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Interim Report on Feasibility of Flood Management in Tonawanda Creek Watershed. Final Feasibility Report: Main Report.		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, Buffalo 1776 Niagara St. Buffalo, N.Y. 14207		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE November 1981
		13. NUMBER OF PAGES 140
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Flood management
Tonawanda Creek

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report recommends construction of the Batavia Reservoir Compound modified alternative to provide flood damage reduction in the Tonawanda Creek Watershed, N.Y. The alternative consists of two shallow detention reservoirs (normally dry) arranged in series. The reservoirs would be formed by construction of two earth dams. Each dam would have principle outlet works comprised of side-by-side conduits; five for the upper dam and four for the lower, with dimensions of 11 feet by 11 feet. Each conduit

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) would be equipped with an electrically operable gate and provisions for manual operation. The spillways of both dams would be riprapped on the upstream and downstream and crests.

The amount of reservoir flood control storage and operation of the selected plan were developed to meet the planning objectives of the study. The degree of protection afforded by the plan is approximately 500-year in the city of Batavia and variable downstream.

ADDENDUM

TONAWANDA CREEK, NY

FINAL FEASIBILITY REPORT

July 1982

TONAWANDA CREEK, NY
FINAL FEASIBILITY REPORT

ADDENDUM

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ADDENDUM

Tonawanda Creek, NY
Final Feasibility Report

INTRODUCTION

This addendum to the Final Feasibility Report, Tonawanda Creek, NY, was prepared to address issues presented by North Central Division and OCE reviewers. An Issue Resolution Conference Meeting was held initially on 17 February 1982 at the North Central Division Office. Two major issues were discussed among Division and Buffalo District representatives; (1) Regional Protection/Cost Sharing, and (2) Design of the Selected Structural Plan and Spillway, Hydraulics, and the Degree of Safety. Further Issue Resolution Conference meetings were held 24, 25, March 1982 at the Buffalo District Office. Representatives from OCE, WES, NCD, and Buffalo District were in attendance. For Issue 1, it was agreed among OCE, NCD, and Buffalo District representatives that the selected plan, Batavia Reservoir Compound-Modified, was a regional plan. Therefore, the plan should be constructed, operated, and maintained with cost-sharing policies and financing arrangements with the responsible non-Federal agencies sponsoring the project which are satisfactory to the President and the Congress. For Issue 2, an alternative design concept to the selected plan, but one which provides the same degree of protection as the selected plan, was developed by Buffalo District that addresses all OCE, WES, and NCD concerns. The benefit-cost ratio of this alternative design, referred to as the PMF design, is 1.09. For comparison, the benefit-cost ratio of the selected plan is 1.32. It is the opinion of Buffalo District that the final plan design which would incorporate features of the selected plan and the PMF design plan can be developed during detailed design and would have a benefit-cost ratio between the other two plans.

The criteria for the final design features will be determined after Congressional authorization during Milestone 41, General Design Conference, between Buffalo District, NCD, OCE, and WES technical personnel.

Buffalo District recommends that the selected plan, Batavia Reservoir Compound-Modified, as presented in the Final Feasibility Report be authorized for construction. Detailed design studies should be initiated at Milestone 41 to expedite the project.

The two mentioned issues are addressed in more detail in the following pages.

REGIONAL PROTECTION/COST SHARING

The selected plan, Batavia Reservoir Compound-Modified, is presented in the report as a regional plan. Therefore, the construction cost and the operation/maintenance cost are all designated strictly as a Federal responsibility with no non-Federal cost-sharing. The current trend of the present administration is to increase the non-Federal involvement in Civil Works projects and increase the non-Federal cost-sharing contribution.

The benefits and effects of the selected plan for the Tonawanda Creek Watershed can be termed "widespread and general" based on the impacts on five counties, thirteen townships, three cities, two villages and an Indian nation. Table Ad.1 summarizes the flood damages and residual damages with the proposed project in place by geographic and governmental areas. In the State of New York, the township government is very strong and is an important entity, due to the highly residential-suburban characteristics of the townships adjacent to major metropolitan areas. The existing average annual flood damages are extensive throughout the downstream reaches. With the project in place, flood damages throughout the downstream reaches would be significantly reduced. Overall, the plan would reduce existing tangible average annual flood damages by roughly 74 percent, 20 percent in the Erie Plain that includes the city of Batavia, and 54 percent in the Huron Plain (downstream of Batavia). The city of Batavia receives a large degree of protection (500 years), but the amount of urban average annual damages is only a moderate portion of the total average annual damages for the watershed. Note that 85 percent of the average annual damages in the Erie Plain and 71 percent of the average annual damages in the Huron Plain are prevented.

Buffalo District recommends that the Batavia Reservoir Compound-Modified Plan in the Tonawanda Creek Watershed be constructed, operated, and maintained with 100 percent Federal funding and that there would be no non-Federal cost-sharing. North Central Division representatives agreed that 100 percent Federal cost-sharing appeared appropriate under traditional policies but that in view of the recent cost-sharing initiatives, the issue should be discussed with OCE at an Issue Resolution Conference held 24 March 1982. The Office, Chief of Engineers, agreed that the project provided regional protection and should be a 100 percent Federal cost. It was noted that specific cost-sharing policy has not been defined and recent cost-sharing initiatives do not change existing policy.

The Main Report, page 76, cost-sharing, and page 84, recommendations, was revised to further reflect the project's regional protection and to present current cost-sharing and financing arrangements with the responsible non-Federal agencies sponsoring the project with the provision that they are satisfactory to the President and the Congress.

DESIGN OF THE SELECTED PLAN AND ALTERNATIVE DESIGN

SELECTED PLAN DESCRIPTION

The selected plan, Batavia Reservoir Compound-Modified, consists of two shallow detention reservoirs (normally dry) arranged in series. The reservoirs would be formed by construction of two earths dams (lower dam approximately 10 feet high to the spillway crest and upper dam 15 feet high). Each dam would have principal outlet works comprised of side by side conduits, five for the upper dam and four for the lower, with dimensions of 11-feet by

Table A4.1 - Regional Protection, Flood Damages by Geographic and Governmental Areas

Reaches	Areas Inundated (1): 100 Year	SPF	Existing (2) Average Annual Flood Damages	Residual Average Annual Flood Damages	Geographic and Governmental Areas: County, Town, City, Village
			$	$	
			(3)	(3)	Erie
T 1-T 10	16,500	29,200	1,041,350	288,050	Niagara County
			310,990 (4)	91,210 (4)	Township of Pendleton (5)
					Township of Wheatfield
					Township of Lockport
					Township of Royalton
					Township of Amherst
					Township of Clarence
					Township of Newstead
					City of Tonawanda
					City of North Tonawanda
					Tonawanda Indian Nation
				(3)	Erie County
RB 1-RB 4	8,770	9,850	547,810	170,190	Township of Clarence
			75,180 (4)	23,320 (4)	Township of Amherst
			(3)	(3)	Niagara County
M 1-M 6	5,430	7,590	76,130	20,940	Township of Pendleton
			49,770	17,110	Township of Lockport
					Township of Royalton
			(3)	(3)	Orleans County
T 11-T 12	6,710	7,460	82,230	4,110	Genesee County
			6,510	740 (4)	Township of Alabama
					Township of Pembrook
					Township of Batavia
			(3)	(3)	Genesee County
B 1-B 5	710	840	326,000	11,240	City of Batavia
			- (4)	- (4)	Township of Batavia
			(3)	(3)	Genesee County
T 13	5,190	5,470	46,260	0	Township of Batavia
			28,590 (4)	29,580 (4)	Township of Alexander
					Township of Bethany
			(3)	(3)	Genesee County
A 1-A 3	250	280	55,210	55,210	Wyoming County
			- (4)	- (4)	Village of Alexander
Totals					
Urban			2,174,990	549,740	Village of Attica
Rural			471,050	161,960	Township of Attica
					Township of Bennington
Total			2,646,040	711,700	

(1) Page 30, Main Report.
(2) Pages S-33 and S-34, page 28, Main Report.
(3) Residential, Commercial, Industrial, Public, and other damages (1981).
(4) Page S-17, Agricultural Damages (1976).
(5) Townships include both residential (urban) and agricultural areas.

The benefits and effects are contained in the following political entities as shown below:

County

Erie
Niagara
Orleans
Genesee
Wyoming

Township

Pendleton
Wheatfield
Lockport
Royalton
Amherst
Clarence
Newstead
Alabama
Batavia
Alexander
Bethany
Attica
Bennington

City

Tonawanda
North Tonawanda
Batavia

Indian Nation

Tonawanda

Village

Alexander
Attica

5 Counties
15 Townships
3 Cities
2 Villages
1 Indian Nation

11-feet. Each conduit would be equipped with an electrically operable gate and provisions for manual operation. The spillways of both dams would be riprapped on the upstream and downstream slopes and crests. Plate Ad.1 shows a plan view of the selected plan. Table Ad.2 lists pertinent features of the plan and features for an alternative plan (PMF Design), which is subsequently discussed.

The amount of reservoir flood control storage and operation of the selected plan were developed to meet the planning objectives of the study. Flood control storage provided by the lower and upper reservoirs would be 1.7 and 1.2 inches, respectively. The degree of protection afforded by the plan, is approximately 500-year in the city of Batavia and variable downstream. The degree of protection for the alternative plan (PMF Design) is the same as the selected plan because the amount of flood control storage and the operation are identical.

DESIGN PROCEDURE

The hydrologic, hydraulic, and structural design of the selected plan followed, to the most part, traditional Corps procedures.

A preliminary design was investigated that included a short ogee-shaped concrete emergency spillway and long non-overflow earthen embankments. Routing of both the Standard Project Flood and Probable Maximum load resulted in the lower reservoir being a three-sided box (similar to the Batavia Reservoir shown on Plate 10, Main Report) formed by the dam and training dikes due to the low topography of the area. A similar design for the Upper Reservoir would result in relocation of the entire village of Alexander. The cost of this design coupled with the cost to relocate the village of Alexander did not make this plan economically feasible to construct.

The selected plan would use almost the entire length of the Upper and Lower dams for spillways. The subsequent reduction in nonoverflow length and height, the elimination of the need to relocate the village of Alexander, and the usage of riprap, in lieu of a concrete spillway, resulted in a benefit-cost ratio of 1.32 for this plan.

DESIGN ASSUMPTIONS-SELECTED PLAN, SPF DESIGN

The selected plan was designed based upon the following assumptions and criteria:

a. Both the Lehigh Valley and Conrail Railroad embankments just downstream from the lower dam would not be washed out during rare floods, i.e., SPF or PMF.

b. Weir flow coefficients ranging from 1.6 to 2.5 were used for spillway rating curve development.

c. Standard Project Flood as the Spillway Design Flood.

d. Minimize use of abutments.

Table Ad.2 - Design Features

Description	Upper Reservoir		Lower Reservoir	
	SPF Design	PMF Design	SPF Design	PMF Design
Spillway Design Flood (cfs)				
Inflow	38,800	81,200	50,200	104,400
Outflow	38,600	81,100	28,400	104,000 (1)
Controlled	2,000	2,000	6,000	6,000
Maximum through Culvert	10,700	10,700	6,000	6,000
Overflow	27,900	70,400	22,400	96,000
Elevations (USC&GS Datum) and Storage				
Maximum Pool				
Headwater Elevation (feet)	924.5	925.7	902.5	905.9 (1)
Tailwater Elevation (feet)	915.0	919.0	902.0 (1)	900.9 (2)
Storage (inches)	1.6	1.8	2.5	3.8
Flood Control				
Headwater Elevation (feet)	922.5	922.5	900.0	900.0
Tailwater Elevation (feet)	910.9	910.9	893.9	893.9
Storage (inches)	1.2	1.2	1.7	1.7
Channel Bottom Elevation Near Dam (feet)	900.0	900.0	880.0	880.0
Outflow Section				
Riprap size (inches) - Upstream	12.0	18.0	12.0	18.0
- Downstream	18.0	36.0	18.0	18.0
Crest Elevation (feet)	922.5	922.5	900.0	900.0
Length (feet)	5,600	4,500	4,000	4,000
SDF Unit Discharge (cfs/feet)	6.9	18.0	7.1	26.0
Nonover Flow Section				
Dam Abutment				
Elevation (feet)	N/A	930.0	905.5	910.0
Length (feet) - Left	N/A	1,675	370	160
- Right	N/A	1,260	1,230	1,770
Training Dikes				
Elevation (feet)	None	None	905.5	910.0
Length (feet) - Dike "a"	None	None	950	1,650
- Dike "b"	None	None	150	200
- Dike "c"	None	None	600	840
- Dike "d"	None	None	3,300	3,670
Culverts and Sluice Gates				
Invert Elevation (Inlet and Outlet at Same) (feet)	900.0	900.0	880.0	880.0
Height and Width (feet)	11 X 11	11 X 11	11 X 11	11 X 11
Number (3)	5	5	4	4
Location	Nonoverflow/ left abutment	Nonoverflow Section/ left abutment	Overflow Section/ right abutment	Nonoverflow/ right abutment
Stilling Basin (4)	Yes	Yes	Yes	Yes
Contributing Drainage Area (square miles)	102	102	171	171
Channel Capacity Downstream from Dam (cfs)	2,000	2,000	6,000	6,000

(1) LVRR and Conrail embankments remain.
(2) LVRR and Conrail embankments out.
(3) Includes one spare gate.
(4) Concrete Basin with end sill and baffle blocks.

e. Locate gated outlet works near the natural stream channel away from the abutments.

f. Size riprap for spillways using Rend Lake Model study based upon assumptions a. through c.

g. Develop cross section of embankments utilizing, to the maximum extent practicable, local materials with consideration given to the potential structural distress that may occur from liquifaction during seismic activity.

The Technical Appendices present design analyses using these assumptions. Plates Ad.2, Ad.3, Ad.5, and Ad.6 present profiles and cross sections of the selected plan dams. They are labeled "SPF Design" for ease of comparison with the alaternative plan (PMF Design) which is subsequently discussed.

ALTERNATIVE PLAN, PMF DESIGN

During the previously mentioned design conferences, the selected plan, its features and design assumptions were discussed. Conference attendees recognized that a high level of detail was adhered to by Buffalo District in developing each project feature. Further, it was recognized that the use of long riprapped spillways and use of the SPF for the spillway design flood was unique.

It was concluded that an alternative with a more conservative design should be developed for comparison with the selected plan using the PMF for the spillway design flood. This plan, called the PMF Design, will afford the same degree of protection as the selected plan and was developed using the following assumptions and criteria:

a. Both the Lehigh Valley and Conrail Railroad embankments just downstream from the Lower Dam would be washed out during the PMF for riprap design. However, the railroads were assumed to remain in sett ing the height of the nonoverflow sections. This condition results in a higher pool elevation for the PMF in the Lower Reservoir due to the shift in control from the Lower Dam to the 5-foot higher Conrail embankment, and hence an accompanying increase in abutment crest elevation.

b. Weir flow coefficients ranging from 1.1 to 3.0 were used for spillway rating curve development.

c. The Probable Maximum Flood was used for the Spillway Design Flood.

d. Relocate gated outlet works to abutment areas.

e. Increase the lengths of abutments to minimize potential crossflow problems along the downstream face of each spillway.

f. Resize riprap for spillways using Rend Lake model study based upon assumptions a. through c. Consider the full range of discharges throughout the PMF.

g. Modify toe protection to minimize potential for scour.

h. Increase O&M costs for hydromet system and personnel costs for project operation.

Plates Ad.4 and Ad.7 present the PMF Design cross sections for the Upper and Lower Dam, respectively. For comparison purposes, the profiles of the dams for the PMF Design have been superimposed on the SPF Design and are shown on Plates Ad.2 and Ad.5. The major differences between the designs is that the PMF Design has larger abutments and training dikes, additional toe protection, and larger riprap protection on the upstream and downstream faces of the Upper Dam, and larger riprap on the downstream face of the Lower Dam. Additionally, the gated cutlet works in the Lower Dam have been moved in the right abutment for the PMF Design. For specific dimensions of abutments, training dikes, and riprap, refer to Table Ad.2.

BENEFITS AND COSTS OF SPF AND PMF DESIGNS

A cost estimate for the PMF Design was developed and a summary is presented in Table Ad.3 along with the costs for the SPF Design. Both cost estimates are based on June 1981 price levels. Also, presented are the benefits and benefit-cost ratios for both designs.

DISCUSSION

Both the selected plan (SPF Design) and alternative plan (PMF Design) would be economically feasible to construct and provide the same degree of protection. A high level of conservatism was adhered to in developing the design configurations and cost estimates for each design. The use of riprap for spillway slope protection is considered to be a very expensive alternative. Other alternatives could include gabions and pre-cast units. It is expected that these and other alternatives will be investigated during Detailed Design Studies with the aid of hydraulic model studies to be performed by WES.

The Buffalo District believes that studies after authorization will reveal a design with a benefit-cost ratio between those developed for the selected plan (SPF Design) and alternative plan (PMF Design).

Table Ad.3 - Summary of Estimated Costs and Benefits for Batavia Reservoir Compound (Modified), SPF and PMF Designs

Item	Selected Plan (SPF Design)	Alternative Plan (PMF Design)
	$	$
First Cost		
Property	6,800,000	7,400,000
Construction	19,000,000	24,800,000
Total	25,800,000	32,200,000
Investment Cost		
Property	6,800,000	7,400,000
Construction	19,000,000	24,800,000
Subtotal	25,800,000	32,200,000
Interest During Construction (7-5/8 percent)	1,600,000 (1)(3)	2,000,000 (2)(3)
Total	27,400,000	34,200,000
Average Annual Cost		
Interest (7-5/8 percent)	2,089,000	2,608,000
Amortization (0.00005)	1,000	2,000
Operation and Maintenance	400,000 (4)	400,000
Total	2,490,000	3,010,000
Benefits		
Average Annual Benefits	3,290,500	3,290,500
Benefit/Cost Ratio	1.32	1.09

(1) Includes interest, on $1,591,750 for lands (fee simple) and construction cost.

$ 528,500	Upper
1,063,250	Lower
$1,591,750	Total

(2) Includes interest, on $1,661,000 for lands (fee simple); and construction cost.

$ 538,000	Upper
1,123,000	Lower
$1,661,000	Total

(3) Assume 2-year construction period.

(4) Value erroneously contains O&M on E&D and S&A. True value would be less than PMF Design.

CONCLUSIONS

The results of studies presented in the Main Report, Appendices and this Addendum support the main report recommendation that the selected plan, Batavia Reservoir Compound Modified, be authorized for construction, subject to cost sharing and financing arrangements with the responsible non-Federal agencies sponsoring the project which are satisfactory to the President and the Congress. It is further recommended that after authorization, studies proceed directly to Milestone 41, General Design Conference. Conference attendees would include hydrologic, hydraulic, geotechnical, and structural design staff elements of Buffalo District, NCD, OCE, and WES. The purpose of the conference would be to discuss and develop strategies for (1) a model study; (2) alternative slope protection analysis; (3) embankment cross section design; (4) spillway design and flood selection; (5) dam break analysis and flood inundation mapping; and (6) other pertinent design feature refinements.

Robert R. Hardiman
ROBERT R. HARDIMAN
Colonel, Corps of Engineers
District Engineer

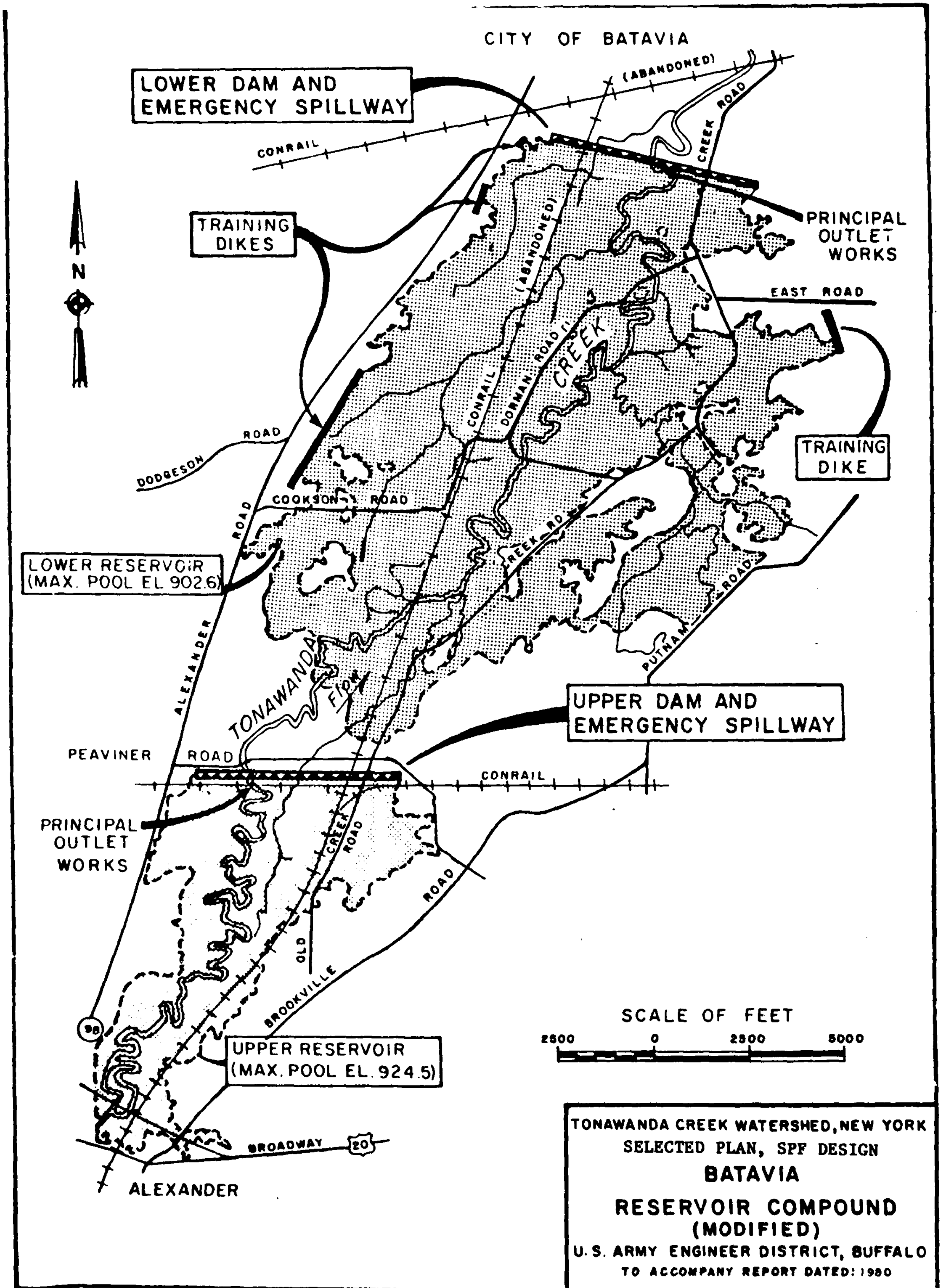
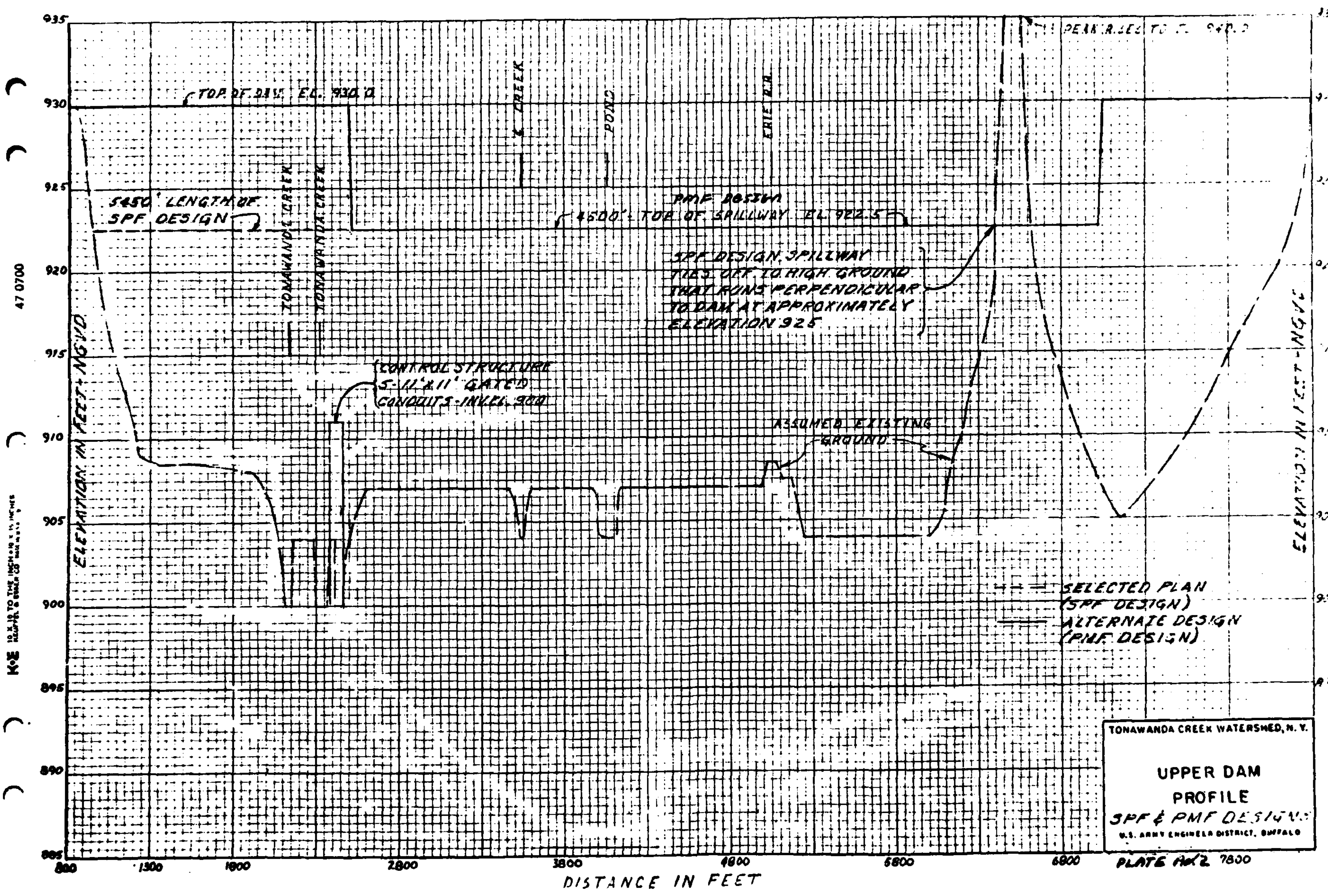
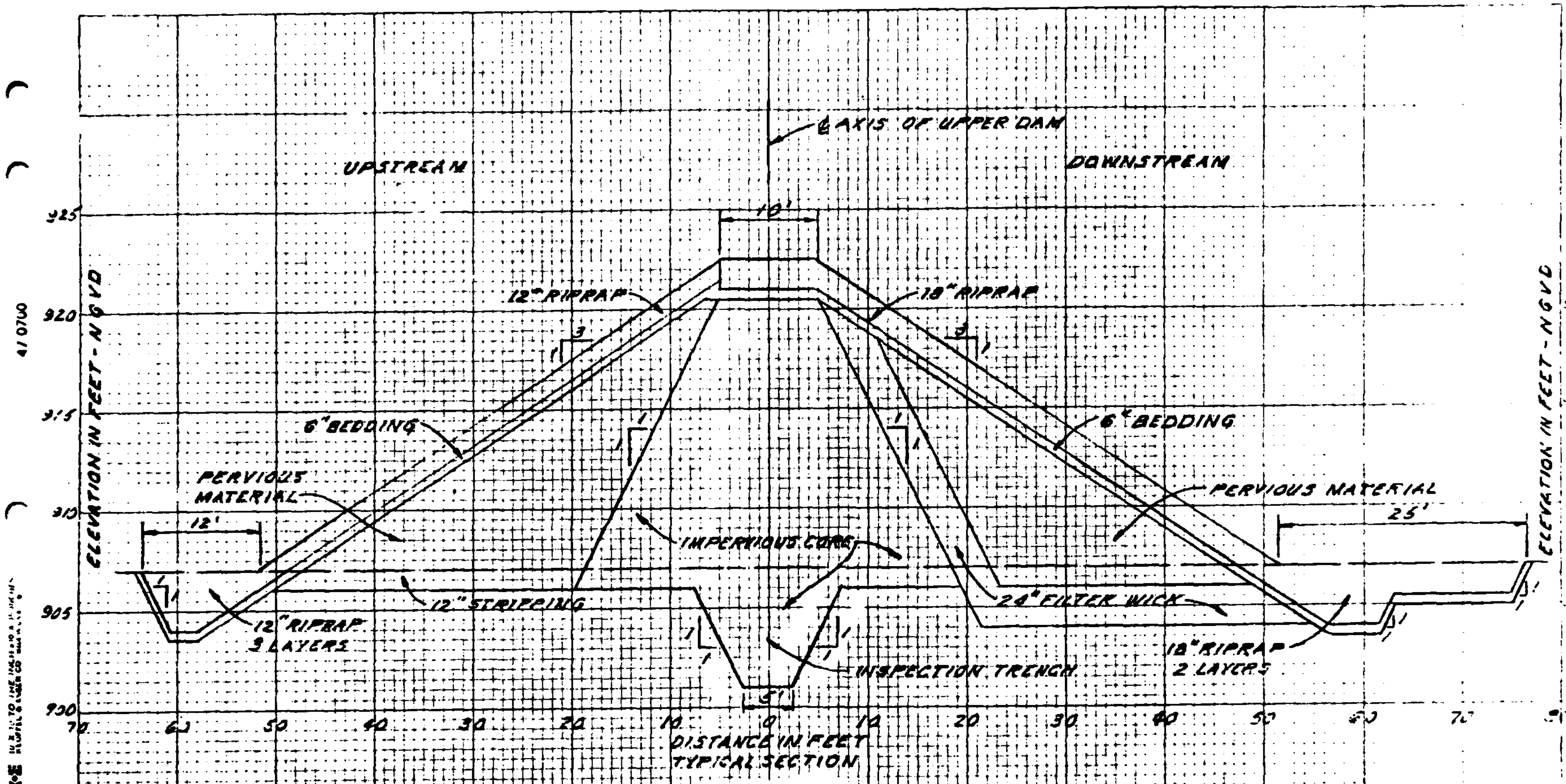

CITY OF BATAVIA
LOWER DAM AND EMERGENCY SPILLWAY
(ABANDONED)
CONRAIL
CREEK ROAD
TRAINING DIKES
PRINCIPAL OUTLET WORKS
N
(ABANDONED)
EAST ROAD
CREEK
DORMAN ROAD
CONRAIL
TRAINING DIKE
DODGESON ROAD
COOKSON ROAD
ROAD
LOWER RESERVOIR (MAX. POOL EL 902.6)
CREEK RD
PUTNAM ROAD
ALEXANDER
TONAWANDA
UPPER DAM AND EMERGENCY SPILLWAY
PEAVINER ROAD
CONRAIL
PRINCIPAL OUTLET WORKS
CREEK ROAD
OLD
ROAD
BROOKVILLE
SCALE OF FEET
2500 0 2500 5000
98
UPPER RESERVOIR (MAX. POOL EL. 924.5)
BROADWAY
20
ALEXANDER
TONAWANDA CREEK WATERSHED, NEW YORK
SELECTED PLAN, SPF DESIGN
BATAVIA
RESERVOIR COMPOUND
(MODIFIED)
U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED: 1980

PLATE A-1


TOP OF DAM EL. 930.0
5450' LENGTH OF SPF DESIGN
TONAWANDA CREEK
TONAWANDA CREEK
CONTROL STRUCTURE 5-11'x11' GATED CONDUITS-INV.EL. 900
CREEK
POND
PMF DESIGN
4500' TOP OF SPILLWAY EL. 922.5
ERIE R.R.
SPF DESIGN SPILLWAY TIES OFF TO HIGH GROUND THAT RUNS PERPENDICULAR TO DAM AT APPROXIMATELY ELEVATION 925
ASSUMED EXISTING GROUND
SELECTED PLAN (SPF DESIGN)
ALTERNATE DESIGN (PMF DESIGN)
ELEVATION IN FEET-NGVD
DISTANCE IN FEET
TONAWANDA CREEK WATERSHED, N.Y.
UPPER DAM PROFILE
SPF & PMF DESIGNS
U.S. ARMY ENGINEER DISTRICT, BUFFALO
PLATE AV-2
47 0700

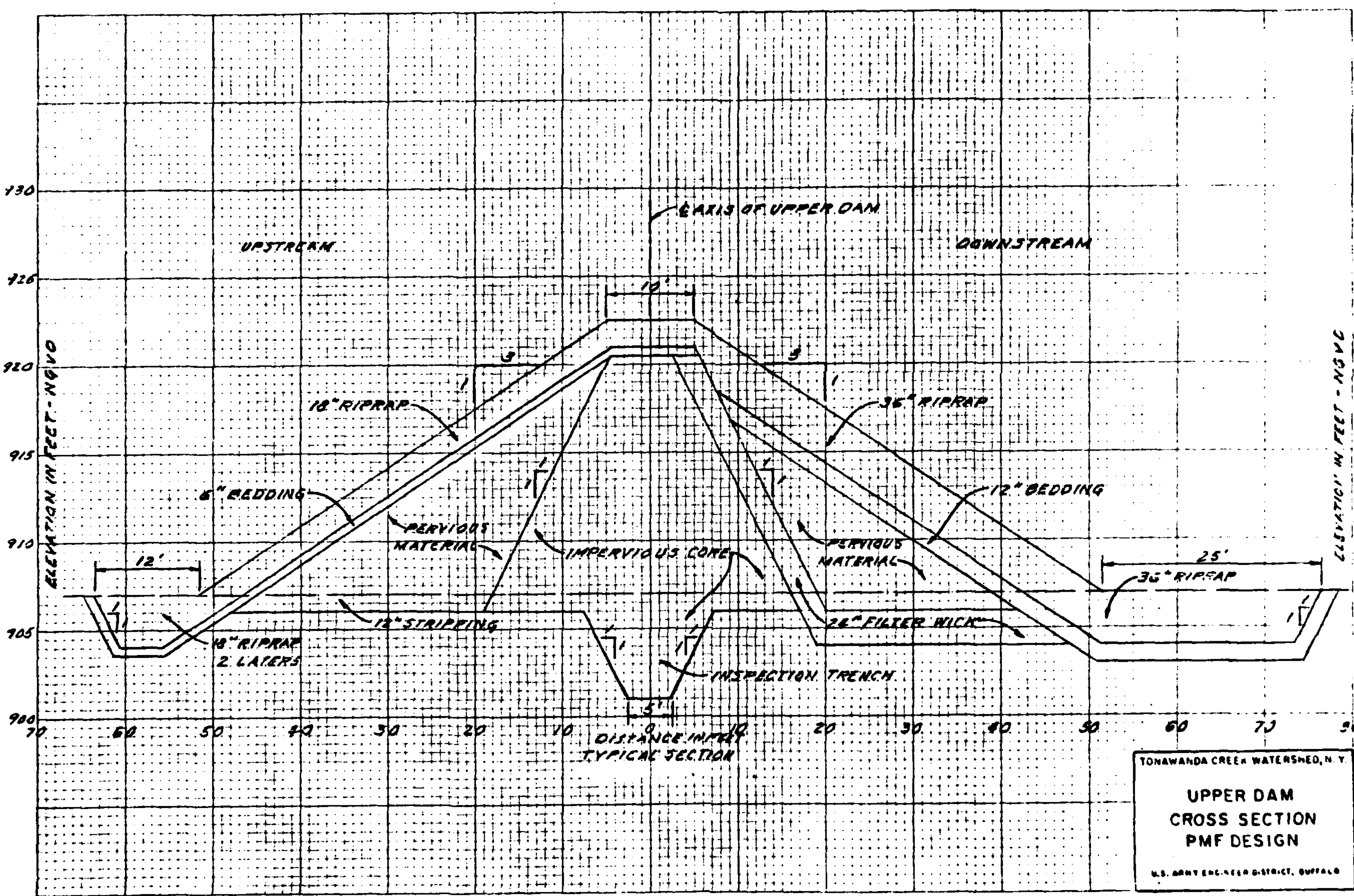


TONAWANDA CREEK WATERSHED, N. Y.

UPPER DAM
CROSS SECTION
SPF DESIGN

U.S. ARMY ENGINEER DISTRICT, BUFFALO

PLATE No. 3

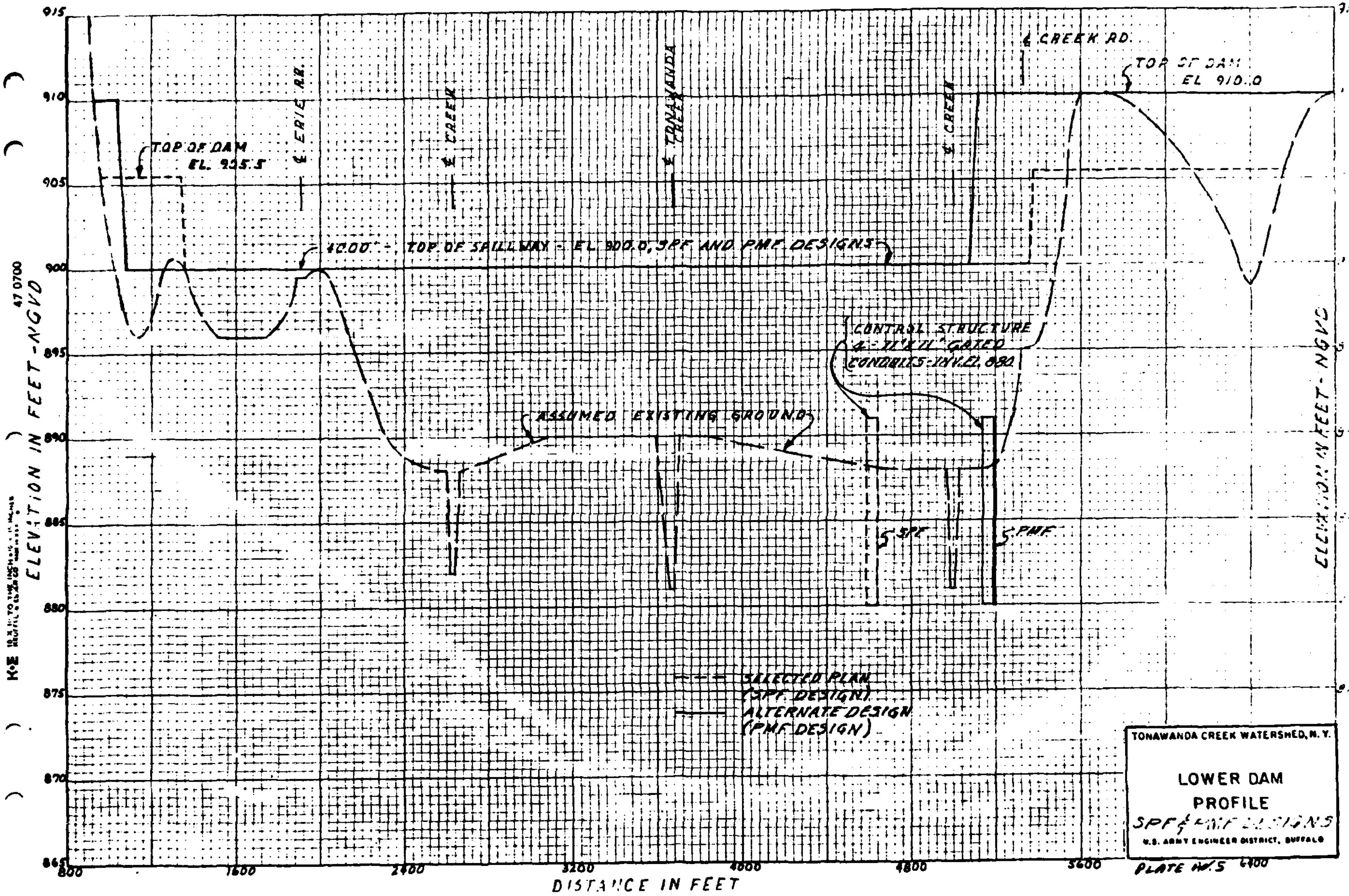


TONAWANDA CREEK WATERSHED, N. Y.

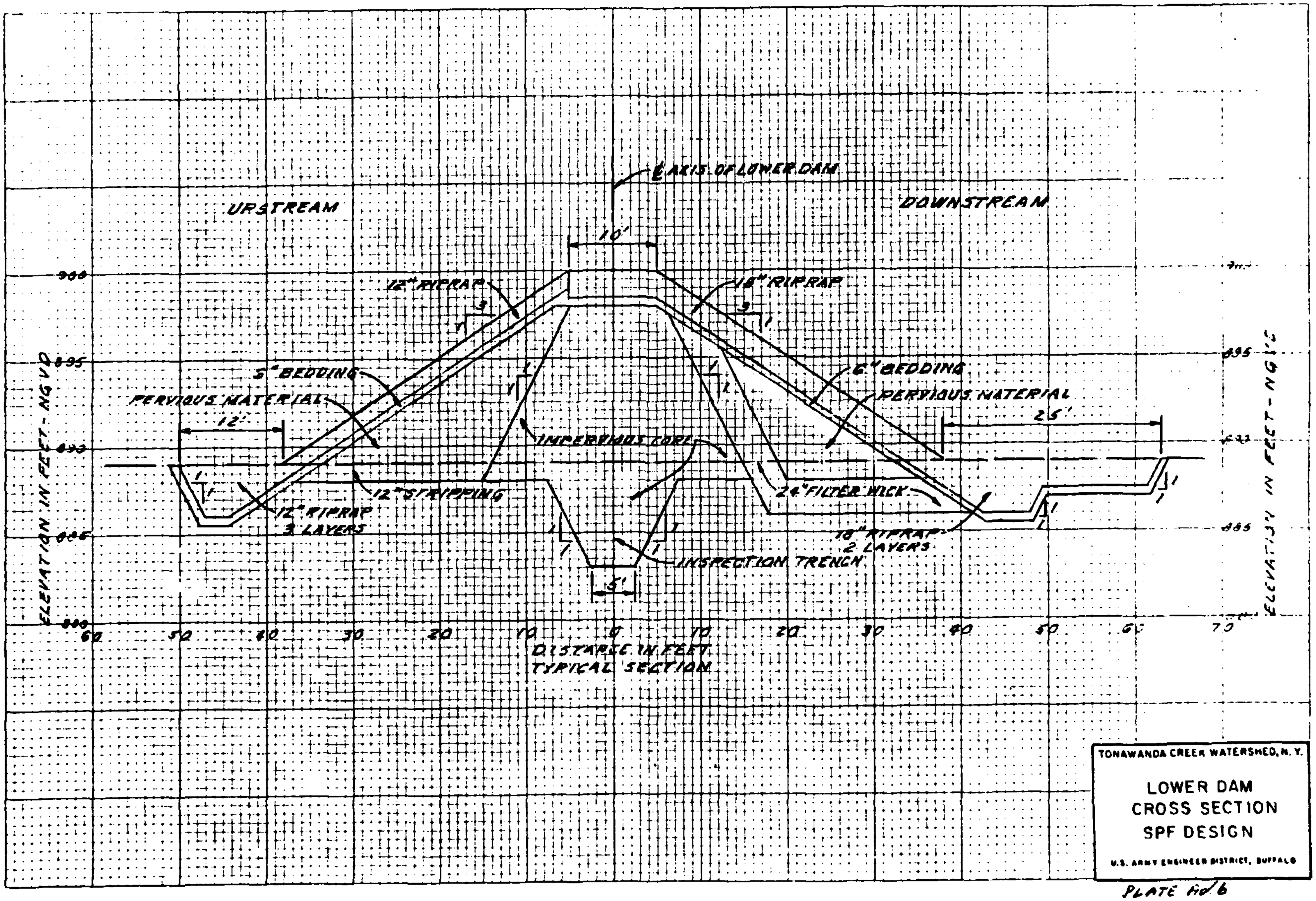
UPPER DAM
CROSS SECTION
PMF DESIGN

U.S. ARMY ENGINEER DISTRICT, BUFFALO

PLATE NO. 4



TOP OF DAM EL. 905.5
℄ ERIE R.R.
℄ CREEK
℄ TONAWANDA CREEK
℄ CREEK
℄ CREEK RD.
TOP OF DAM EL 910.0
40.00 - TOP OF SPILLWAY - EL 900.0, SPF AND PMF DESIGNS
CONTROL STRUCTURE 4 - 11'x11' GATED CONDUITS - INV. EL. 880
ASSUMED EXISTING GROUND
SPF
PMF
SELECTED PLAN (SPF DESIGN)
ALTERNATE DESIGN (PMF DESIGN)
ELEVATION IN FEET - NGVD
DISTANCE IN FEET
TONAWANDA CREEK WATERSHED, N. Y.
LOWER DAM
PROFILE
U.S. ARMY ENGINEER DISTRICT, BUFFALO
PLATE NO. 5

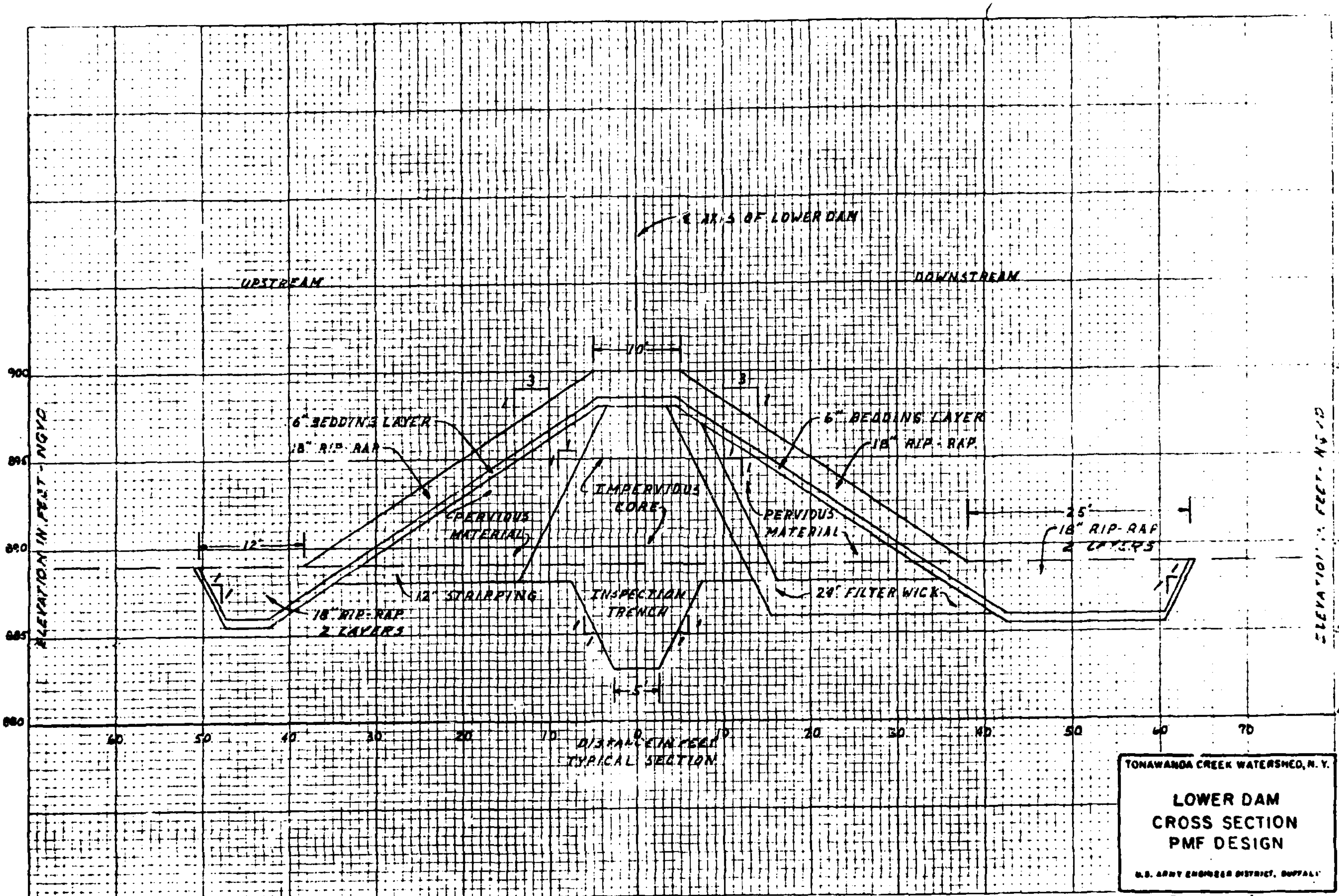


TONAWANDA CREEK WATERSHED, N. Y.

LOWER DAM
CROSS SECTION
SPF DESIGN

U.S. ARMY ENGINEER DISTRICT, BUFFALO

PLATE No 6



℄ AXIS OF LOWER DAM
UPSTREAM
DOWNSTREAM
10'
3
1
6" BEDDING LAYER
18" RIP-RAP
PERVIOUS MATERIAL
IMPERVIOUS CORE
12"
18" RIP-RAP 2 LAYERS
12" STRIPPING
INSPECTION TRENCH
5'
24" FILTER WICK
25'
ELEVATION IN FEET - NGVD
900
895
890
885
880
60
50
40
30
20
10
0
70
DISTANCE IN FEET
TYPICAL SECTION
TONAWANDA CREEK WATERSHED, N. Y.
LOWER DAM
CROSS SECTION
PMF DESIGN
U.S. ARMY ENGINEER DISTRICT, BUFFALO

PLATE NO. 7

BUFFALO METROPOLITAN AREA, NEW YORK
WATER RESOURCES MANAGEMENT STUDY

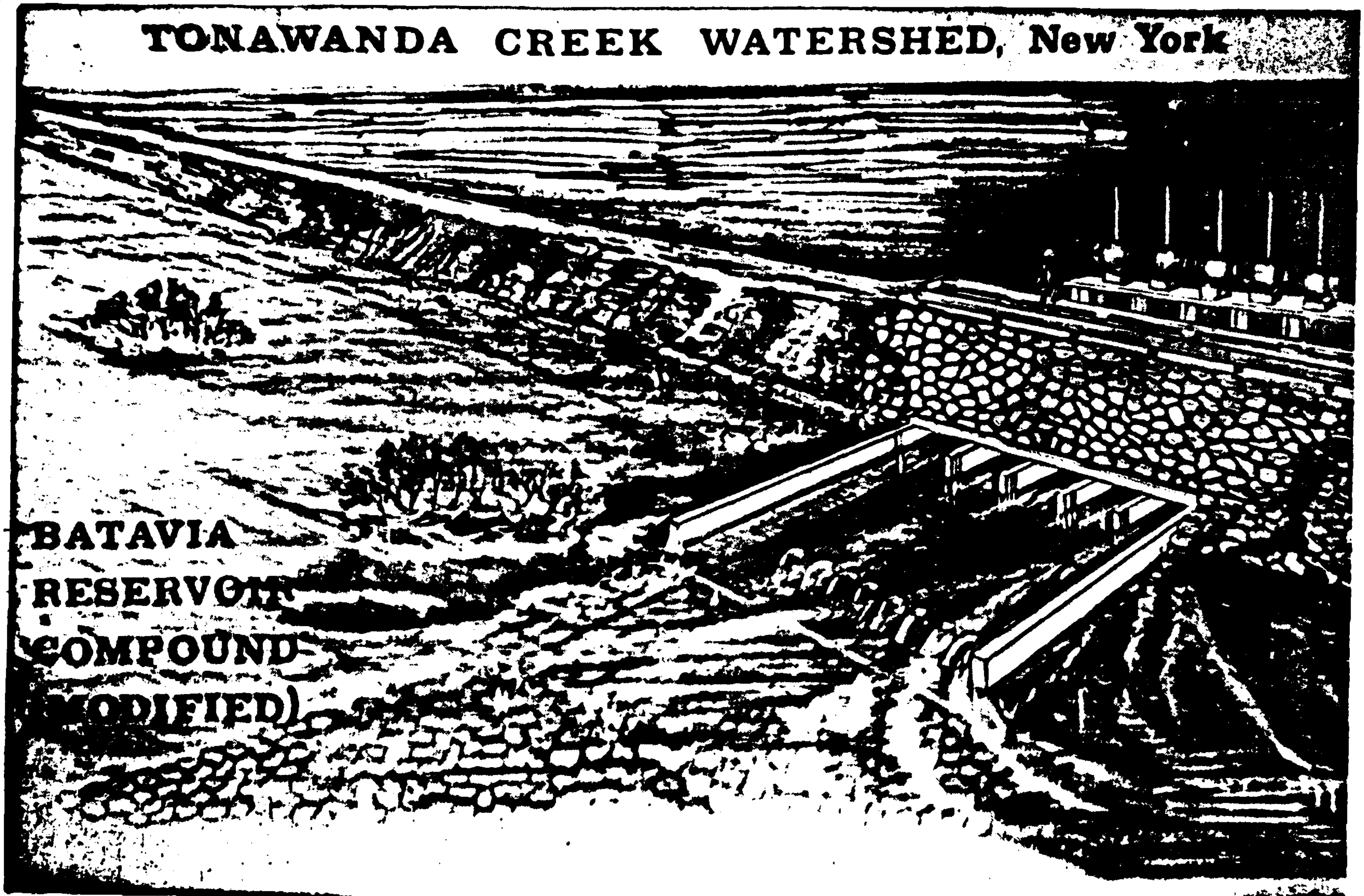
TONAWANDA CREEK WATERSHED
INTERIM FLOOD MANAGEMENT STUDY

FINAL FEASIBILITY REPORT

November 1981

MAIN REPORT

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, New York 14207


TONAWANDA CREEK WATERSHED, New York
BATAVIA
RESERVOIR
COMPOUND
(MODIFIED)

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SECTION I

INTRODUCTION

AUTHORIZATION FOR THE STUDY AND REPORT

Authorization for study of the feasibility of flood management in the Tonawanda Creek Watershed, NY, derives from a resolution of the Committee on Public Works, Senate, United States Congress, adopted 15 June 1950, which reads as follows:

> "Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby, requested to review the report on Tonawanda Creek, New York, published as Senate Document Numbered 46, Eightieth Congress, First Session, with a view to determining the feasibility of providing flood protection along Mud Creek in Niagara and Orleans Counties, New York."

This authorization was expanded by resolutions of the Committee on Public Works, House of Representatives, United States Congress, adopted 16 August 1950 and 23 July 1956, which requested a review of reports. On 5 March 1973, the Chief of Engineers, Corps of Engineers, authorized study of water resources management in the Buffalo Metropolitan Area, NY, and directed that the Study Area include the Buffalo Urban Area (SMSA) and its tributary watersheds. Since the Tonawanda Creek Watershed is part of the Buffalo Metropolitan Area, the study of flood management needs in the Tonawanda Creek Watershed is part of the Buffalo Metropolitan Area Study.

THE STUDY AND REPORT

Purpose of the Study.

The purpose of the Tonawanda Creek Watershed, NY, Flood Management Feasibility Study is to develop and evaluate alternative plans to provide for flood and flood-related management needs in the Tonawanda Creek Watershed.

Accomplishment of the Study.

In accordance with Corps policy, this Study has been accomplished in two phases. During the first phase, all significant flood and flood-related management needs in the Tonawanda Creek Watershed were identified. Then measures to provide for these needs were identified and appraised. These measures were considered alone, and in combination, in development of alternative plans. The alternative plans were then evaluated and those which appeared viable were recommended for further study. During the second phase, those plans recommended for further study, and alternative plans introduced following completion of the first phase, were evaluated, and the optimum plan has been recommended for implementation. This report presents the findings of the second phase of the study.

STUDY PARTICIPATION AND COORDINATION

This study was accomplished by a Buffalo District interdisciplinary study team under the direction of the District Engineer. During the development of the study, coordination and input was provided by the following agencies: U.S. Fish and Wildlife Service; U.S. Environmental Protection Agency; United States Department of Agriculture, Soil Conservation Service (SCS); the New York State Department of Environmental Conservation (NYSDEC); and the Erie and Niagara Counties Regional Planning Board (ENCRPB).

PRIOR STUDIES, REPORTS, AND IMPROVEMENTS

Prior Studies and Reports by the Corps.

In 1887, the Corps conducted a feasibility study of a plan to improve Tonawanda Harbor for navigation. The study report contained a recommendation that the harbor be dredged to provide a navigable depth of 16 feet. Since then, studies of the feasibility of various plans to facilitate navigation in Tonawanda Creek and/or Harbor have been accomplished. A description of significant improvements provided since 1888 is included in the sub-section entitled Improvements Provided by the Corps.

On 8 June 1940, the Corps submitted an unfavorable report on the feasibility of improving flood management in Ellicott Creek Watershed, the major tributary of Tonawanda Creek.

On 29 March 1943, the Corps submitted an unfavorable report on the feasibility of improving flood management along Tonawanda Creek in the city of Batavia, the largest city in the upper part of the Watershed.

On 7 February 1947, the Corps submitted a report recommending channel improvement and related work along Tonawanda Creek over a distance of about 2 miles (from near the upstream limit of the city of Batavia, downstream to near the hamlet of Bushville.) Much of the work was authorized by Congress and it was completed in 1956. See Improvements Provided by the Corps.

In a report dated 3 February 1958, the Corps recommended reconstruction and extension of a levee in the vicinity of Kibbe Park in the city of Batavia. However, the Chief of Engineers directed that this feasibility study be expanded, so further consideration of the recommended work was deferred until 1962. On 16 February 1962, the Corps submitted a report on the expanded study, recommending the following work: construction of a levee to extend from an embankment of the then New York Central Railroad near the southern limit of the city of Batavia, northward approximately 3,200 feet along the Creek, to Chestnut Street; protection of the left bank of the creek channel over a distance of approximately 1,300 feet from a small municipal dam on the Creek, upstream, within the city of Batavia; and enlargement and protection of the Creek channel over a distance of approximately 2-1/2 miles from the downstream end of the reach of channel improved by the Corps in 1956 (as described subsequently), to the hamlet of Bushville. Although the District and Division Engineers recommended this work, staff of the Board of Engineers for Rivers and Harbors requested that alternative plans for flood management in the watershed, including regional measures, be considered further. Consequently, further consideration of the recommended work was deferred until this Feasibility Study.

In August 1967, the Corps completed a Flood Plain Information Report on the Huron Plain floodland of the Tonawanda Creek Watershed. The floodland is depicted in Plate 3. This report delineated the extent of flooding expected to occur in an Intermediate Regional Flood (100-year flood) and during a much greater flood referred to as the Standard Project Flood.

In January 1968, a Flood Plain Information Report was completed for the section of the Ellicott Creek Watershed from its confluence with Tonawanda Creek, upstream to Stony Road in the town of Lancaster. This report was reprinted in 1971. Information presented in the Floodplain Information Report was made available for use by local governments in developing flood plain management regulations and planning land use of affected areas in the Watershed.

In 1969, the Corps submitted a report recommending further study of a plan for improved flood management in the Bull Creek Watershed, a tributary to Tonawanda Creek. Further study, completed in May 1974, showed that the considered plan was not economically justified.

In May 1970, the Corps completed a report on a study, conducted in cooperation with the State of New York, to determine the feasibility of improving water resources management in the Ellicott Creek Watershed. Three alternative plans were found to be feasible: one provided for a multi-purpose reservoir on Ellicott Creek at a site near the village of Alden; another provided for this reservoir in combination with minor improvement of the Creek channel downstream in the town of Amherst; and, the third provided for major improvement of the Creek channel over a distance of about 7 miles in the town of Amherst. The plan providing for the reservoir in combination with channel improvement was recommended. On 31 December 1970, Congress directed that alternatives to the recommended plan be restudied and that the recommended plan be authorized only if no alternative plan could be developed that would be more acceptable to local parties. In August 1973, the restudy report of alternative plans for the Ellicott Creek Watershed was submitted to the Chief of Engineers. Of plans considered, that providing for a diversion channel and improvement of the Creek channel over a distance of about 7 miles in the town of Amherst was found to be most acceptable to local parties. Accordingly, the District and Division Engineers recommended this plan. However, the Board of Engineers for Rivers and Harbors returned the restudy report to the Buffalo District for further coordination with New York State since the State indicated it would not provide local assurances for the diversion plan. The Corps has recently developed a combination channel improvement diversion channel plan for Ellicott Creek that is acceptable to New York State. Accordingly, by letter, dated November 1974, the State assured its intent to cooperate to implement the plan. The draft Phase II General Design Memorandum for the combination channel improvement/diversion channel plan for Ellicott Creek is currently being prepared. The Phase I GDM is at the Water Resources Council awaiting reauthorization to construct the diversion channel plan. The future of the Water Resources Council is in question due to fiscal reductions by the present Administration.

Improvements Provided by the Corps.

Since 1888, the Corps has completed several improvements on Tonawanda Creek and Harbor, to include construction and maintenance of: a channel 6,800 feet long, 400 feet wide and 16 feet deep for the Tonawanda Inner Harbor in the Niagara River; and, a channel 1,400 feet long, 180 feet wide and 16 feet deep for Tonawanda Creek from its mouth upstream of State Route 265.

In 1956, the Corps completed an improvement which included: minor clearing of the Tonawanda Creek channel from the Lehigh Valley Railroad bridge near the southern limit of the city of Batavia to a municipal dam on the Creek near the center of the city; removal of an abandoned bridge pier in this reach; widening and shaping of the Creek channel over a distance of approximately 2 miles from the municipal dam downstream; and, protection of the channel banks between Oak and Walnut streets. The project is shown on Plate 15.

In 1958 and 1959, the Corps spent $75,000 to clear and snag the lower 7-mile reach of the Ellicott Creek channel in the town of Amherst. Since this work was completed, local interests have maintained the reach.

In 1975, the Corps spent $7,200 to remove a debris-jam from the channel of Tonawanda Creek in the town of Alexander.

Prior Studies and Reports by Others.

In August 1966, the Division of Water Resources, of the since reorganized New York State Conservation Department, reported on several reconnaissance studies on the water resources of the State, including those of Tonawanda Creek Watershed. In 1967, the Division of Water Resources completed a report summarizing the findings presented in the reconnaissance reports.

In December 1968, the Erie-Niagara Basin Regional Water Resources Planning Board completed a comprehensive study of water resources management needs in the Erie-Niagara Basin, which includes the Tonawanda Creek Watershed. Four plans were recommended to meet needs in the Tonawanda Creek Watershed - one providing for improvement in the Ellicott Creek Watershed, and three providing for improvement in the remainder of the Tonawanda Creek Watershed. The plan for improvement in the Ellicott Creek Watershed recommended construction of a multi-purpose reservoir on Ellicott Creek near the village of Alden, and complementary dikes and channel improvement. The plans for improvement in the remainder of the Tonawanda Creek Watershed provided for construction of two multi-purpose reservoirs, one on Tonawanda Creek near the hamlet of Sierks and one on a tributary, Little Tonawanda Creek, near the hamlet of Linden, and a group of eight associated multi-purpose reservoirs in the Tonawanda Game Management Area of the New York Conservation Department adjacent to Tonawanda Creek near the hamlet of Alabama. None of these plans has been implemented.

In June 1974, the Erie and Niagara Counties Regional Planning Board completed a study of storm drainage needs in Erie and Niagara counties, which include much of the lower Tonawanda Creek Watershed. The report recommended: construction of a floodway to extend roughly 7 miles from Tonawanda Creek near its junction with Ransom Creek in the town of Amherst, generally parallel to Black Creek, to Tonawanda Creek near its junction with Beeman Creek in the town of Clarence; reservation of land in the Oak Orchard Swamp near Alabama for possible floodwater storage; zoning to limit development in the 10-year flood plains of the lower watershed to non-flood-vulnerable use; and, enlargement and realignment of the channel of Bull Creek over a distance of 6 miles from near the hamlet of Martinsville in the town of Wheatfield, upstream into the town of Cambria. The recommended plan has not been implemented.

Improvements Provided by Others.

During construction of the Erie Canal, the State of New York constructed a canal to connect Tonawanda Creek to Oak Orchard Creek to supply the Erie Canal at the village of Medina. This feeder canal extends approximately 4-1/2 miles north from the Tonawanda Creek channel, across the western limit of the Oak Orchard Swamp to the Oak Orchard Creek channel east of the hamlet of West Shelby. In 1820, the State constructed a dike along the western bank of the feeder canal to prevent high water in the Oak Orchard Swamp from overflowing into the Tonawnada Creek Watershed.

In 1825 the State of New York completed the Erie Canal (later modified and renamed the New York State Barge Canal) to provide a navigable water route from Lake Erie to the Atlantic Ocean. The Canal and Tonawanda Creek channel are one and the same from the mouth of the Creek on the Niagara River to near the hamlet of Pendleton, a distance of 11.4 miles. Near Pendleton, the canal turns north and passes from the Tonawanda Creek Watershed in the city of Lockport. Presently, the canalized reach of the Tonawanda Creek channel has capacity to conduct flows likely to be exceeded, on the average, no more frequently than once in 100 years, under existing natural runoff and storage conditions.

In 1860, the State of New York completed construction of a ditch to drain the western part of Tonawanda Swamp north of the city of Batavia.

In 1900, the State of New York spent $4,000 to clear the channels of Beeman, Black, Ransom, and Got Creeks.

In 1901, the State of New York spent $8,600 to clear, widen, and deepen Mud Creek channel over a distance of approximately 20,000 feet.

Prior to 1915, New York State tax law provided that an individual could pay his taxes by working on roads and ditches. Therefore, before that time, many natural drainage channels in the lowlands of the watershed were improved and maintained and many artificial channels were constructed and maintained by the State of New York and local agenices, through the work of persons paying their taxes with their labor.

In 1916, structural changes were made in the New York State Barge Canal which included removal of a dam between the cities of Tonawanda and North Tonawanda. Since that time, high discharges have caused relatively little damage in the two cities.

In 1938, the city of Batavia removed an unused mill dam across Tonawanda Creek in the hamlet of Bushville.

Some time prior to 1942, the city of Batavia constructed a levee in the vicinity of Kibbe Park on Tonawanda Creek near the southern limit of the city. In 1942, a flood of probable 7-year frequency overtopped this levee and spread throughout the southern part of the city to cause widespread damage.

In 1940 and 1943, the State of New York straightened the Tonawanda Creek channel between the city of Batavia and hamlet of Bushville to protect Route 5.

In the 1950's, the town of Amherst cleared Black and Ransom creeks.

In 1965, Erie County constructed a flood diversion channel through Ellicott Creek Park in the town of Tonawnada to connect the channels of Elicott and Tonawanda Creeks. The diversion diverts peak flows from the Ellicott Creek channel to the Tonawanda Creek channel.

Over a period of years, prior to 1973, segments of floodwalls have been constructed or reconstructed along both banks of the Tonawanda Creek channel within the village of Attica. These floodwalls are situated roughly opposite each other, and extend from an embankment of Erie Railroad, downstream, past the bridge of State Route 268 (Main Street). The wall on the left side extends a total of 400 feet; that on the right extends a total of 450 feet. In 1973, the floodwall on the right (east) bank of the channel was reconstructed by the Office of Emergency Preparedness as a result of damages which occurred during Tropical Storm Agnes.

SECTION II

DESCRIPTION OF THE TONAWANDA CREEK WATERSHED

INTRODUCTION

The Tonawanda Creek Watershed, an area of about 648 square miles, is located in western New York and includes substantial portions of Erie, Genesee, Niagara, and Wyoming Counties and a minute portion of Orleans County. The Watershed comprises many tributary watersheds, including those of Ellicott Creek and Bull Creek which join the mainstream, Tonawanda Creek, near its mouth on the Niagara River. Because flood management needs in the Bull Creek and Ellicott Creek watersheds are normally independent of those in the remainder of Tonawanda Creek Watershed, studies of those needs have been accomplished separately. That part of the Tonawanda Creek Watershed considered in this study is shown in Plate 1. The area represents the whole Watershed less the subwatersheds of Bull and Ellicott Creeks, an area of about 511 square miles.

PHYSICAL CHARACTERISTICS

Geology.

a. History.

(1) Bedrock - Bedrock of the watershed was formed during the Silurian and Devonian periods of the Paleozoic era. It includes sedimentary formations of the Lockport Group of the Middle Silurian System through the Canadaway Group of the Upper Devonian System.

The softer strata were easily eroded; consequently, places formerly occupied by them became lowlands. The harder strata, which resisted erosion, are visible today as escarpments. The strata of the bedrock in the lowlands generally dip 1/2° - 3° southwardly and strike subparallel to the faces of the escarpments. Only minor undulations have been found in such strata.

A fault system extending from Linden, NY, vicinity (southeast of the city of Batava) to the vicinity of Clarendon, NY (southeast of the village of Albion in adjacent Oak Orchard Creek Watershed) has been found. It strikes north-south and has a throw of more than 100 feet. Numerous small thrust faults and superficial faults, caused by mining of salt and gypsum from the substrata and surface loading, have also been found in the watershed.

According to the Corps of Engineers Seismic Zone Map (ER 1110-2-1806) dated April 1977, the Tonawanda Creek Watershed is located in a zone 3 area where major destructive earthquakes could occur. The severest recorded earthquake in the watershed, which occurred near the village of Attica in August 1929, had an intensity of VIII on the 12-point Modified Mercali Intensity Scale of 1956. The epicenters of most quakes occurring in the watershed are located near the above-mentioned fault and near the village of Attica, NY.

(2) Soils - There are five major types of soil in the watershed. In the upper part, in Wyoming County, the subsoil is glacial till derived primarily from sandstone, shale, and siltstone. The subsoil formation is generally deep and stoney. The overlying surface soil is stoney and highly acidic. The generally stoney, highly acidic surface soil and steep terrain limit cultivation potential of this part of the watershed.

In the valley of Tonawanda Creek, from the town of Java to the city of Batavia, the subsoil is predominantly sediment from glacial meltwater. The surface soil overlying this formation includes alluvium from post-glacial flooding. The gentle terrain and good quality surface soil of this part of the watershed are conducive to cultivation.

In most of the remaining part of the watershed within Genesee County and in parts of the towns of Newstead and Clarence, the subsoil is glacial till including large quantities of limestone. The overlying surface soil reflects the agriculturally desirable limey characteristic of the subsoil. The gently rolling terrain and limey surface soil of this part of the watershed promote extensive cultivation.

In a small part of the watershed, primarly within the town of Pembroke in Genesee County, the soil includes lacustrine deposits of sand and gravel. The formation was deposited at the margin of a glacial lake; consequently, it is well washed, poorly graded, and coarse-textured. The surface soil reflects the agriculturally poor quality of this subsoil. It is coarse-textured, acidic, and poor in organic matter.

In the remainder of the watershed, in Erie and Niagara counties, the soil is derived from glacial lake sediment generally comprising clay, silt, and sand. The formation is relatively shallow and generally slightly undulating. The surface soil is generally fine-to-medium textured and contains enough lime to support heavy plant growth.

b. Resources.

(1) Bedrock - Bedrock resources in the watershed include four rocks of economic value - salt, gypsum, limestone, and dolomite - and five known fields of natural gas.

Salt beds or the Silurian System underlie all of the Wyoming County part of the watershed and the Genesee County part upstream from the city of Batavia. Gypsum formations generally underlie the Onondaga Escarpment in the Erie, Niagara, and Genesee Counties sections of the watershed. Closely associated limestone and dolomite formations underlie the Niagara Escarpment in Niagara and Orleans Counties and the Onondaga Escarpment in Erie and Genesee Counties.

(2) Soils - Soils resources in the watershed include clays, sands, and gravels. Clay deposits occur in the lowlands of watershed, primarily in Erie County. Substantial sand and gravel deposits, generally occurring together, are found throughout the watershed.

c. Physiography.

(1) Introduction - Pertinent physiography of the watershed and its waterways is depicted in Plate 2.

(2) Watershed - The Tonawanda Creek Watershed includes parts of two physiographic provinces. The glaciated Allegheny Plateau south of the Portage Escarpment belongs to the Appalachian Upland, while the larger portion of the watershed north of the Portage Escarpment is part of the Erie-Ontario Lowland of the Central Lowlands Physiographic Province. The Allegheny Plateau stands approximately 1,800 feet above sea level and is discected by deeply eroded valleys with relatively steep sides and slopes.

The Portage Escarpment crosses the watershed near the Wyoming-Genesee County line.

The Erie-Ontario Lowland part of the watershed includes much of the Southern Ontario Plain lying between the Portage Escarpment and the Niagara Escarpment to the north. This plain includes two subplains, the Erie and Huron plains which are separated by the east-west striking Onondaga Escarpment.

The Erie Plain is rolling with gentle slopes. Within the watershed, the plain slopes in two directions. The eastern and greater part of the plain slopes northward from approximately 1,000 feet above sea level near the Portage Escarpment to approximately 800 feet near the Onondaga Escarpment. The western part of the plain slopes westerly from a height of approximately 1,000 feet near the Portage Escarpment in the town of Bennington to approximately 700 feet near the Onondaga Escarpment in the town of Amherst.

The Huron Plain is only slightly undulating with gentle slopes. This plain slopes westerly from a height of approximately 650 feet near the Onondaga Escarpment in the Tonawanda Indian Reservation to approximately 600 feet in the town of Tonawanda. The eastern boundary of the watershed in the Huron Plain lies near the western limit of Oak Orchard Swamp. Formerly, the Oak Orchard Swamp was a significant source of runoff to the Mud Creek watershed. However, the State's construction of an extensive dike network has made such overflow largely preventable.

(3) Waterways - There are numerous natural and man-made waterways within the Tonawanda Creek Watershed. The principal natural waterways are the channels of Tonawanda Creek and its tributaries. The major man-made waterways include part of the New York State Barge Canal and the above-mentioned Feeder Canal. Many of the natural waterways have adequate capacities to conduct runoff from their own watersheds. However, several of them in the essentially flat Huron Plain are often subjected to overflow from adjacent watersheds. Such overflow combines with indigenous runoff to cause flow out of channel. Waterways known to have inadequate capacities under high runoff conditions are described below.

Tonawanda Creek, the major stream of the watershed, rises in the Cattaraugus Hills in the town of Wethersfield in Wyoming County. From its source, approximately 1,930 feet above sea level, the creek flows northward approximately 22 miles through deep valleys with steep sides and slopes to enter the Erie Plain near the village of Attica. In this reach, the creek flows rapidly and usually well within its channel. From the village of Attica the creek continues to flow northward for nearly 20 miles through essentially flat bottomland to the city of Batavia. The channel of this reach is often inadequate; the creek flows slowly and, during periods of high flow, often floods. In the city of Batavia the creek is turned by erosion resistant rock formations of the Onondaga Escarpment to begin flowing westward through the Erie Plain and parallel to the escarpment. The channel of this reach is often inadequate; the creek continues to flow slowly and flood frequently during periods of high flow. In the town of Pembrike near its boundary with the Tonawanda Indian Reservation, the creek breaches the escarpment to enter the Huron Plain within the Reservation. From the Reservation the creek winds approximately 27 miles westward along the axis of the plain to its confluence with the New York State Barge Canal in the town of Pendleton. The channel of this reach is often inadequate; the creek flows sluggishly and often floods extensively during periods of high flow. From this confluence the creek continues to flow westward approximately 11.4 miles to its mouth on the Niagara River. As described in Section I, this lower 11.4 mile reach has been improved to serve as part of the Barge Canal; consequently, although the creek flows sluggishly here, it normally flows well within the channel.

Little Tonawanda Creek, a major tributary of Tonawanda Creek, rises in the town of Middlebury in Wyoming County. From its source approximately 1,280 feet above sea level, the creek flows northward approximately 8 miles through valleys with steep sides and slopes to enter the Erie Plain near the hamlet of Linden. In this reach the creek flows rapidly and usually within its channel. From the hamlet of Linden the creek continues to flow northward nearly 10 miles along a sinuous course through an undulating plain to its confluence with Tonawanda Creek in the town of Batavia near the Bethany - Batavia town line. The channel of this reach is generally adequate. However, during periods of high flow in Tonawanda Creek, Little Tonawanda Creek often floods near its mouth.

Ledge Creek, a major tributary of Tonawanda Ceek, rises near the crest of the Onondaga Escarpment in the town of Pembroke. From its source approximately 680 feet above sea level the creek flows northwestward approximately 4 miles to enter the Huron Plain at the base of the escarpment in the ton of Newstead. In this reach the creek flows rapidly and usually within its channel. From the base of the escarpment the creek continues to flow northwestward approximately 3 miles through flatland to its confluence with Tonawanda Creek in the town of Newstead. Throughout this reach, the creek flows slowly and often out of channel during periods of high flow. Near the base of the escarpment the creek receives its major tributary, Murder Creek, which rises in the town of Bennington. From its source approximately 1,380 feet above sea level the creek flows northward approximately 5 miles to enter the Erie Plain at the base of the Portage Escarpment in the town of Darien. From the base of the escarpment the creek winds northwestward 25 miles across the Erie

Plain to the crest of the Onondaga Escarpment in the village of Akron. From the village of Akron the creek descends to the Huron Plain to join Ledge Creek.

Beeman Creek, a minor tributary of Tonawanda Creek, rises near the crest of the Onondaga Escarpment in the town of Newstead. From its source approximately 740 feet above sea level the creek flows northwestward approximately 6 miles to enter the Huron Plain at the base of the escarpment in the town of Clarence. In this reach the creek flows rapidly and usually within its channel. From the base of the escarpment, the creek flows northward approximately 3 miles through flatland to its confluence with Tonawanda Creek in the town of Clarence. Throughout this reach the creek flows sluggishly and usually out of channel during periods of high flow.

Mud Creek, a major tributary of Tonawanda Creek, rises near the western periphery of the Oak Orchard Swamp in the town of Royalton. From its source approxiamtely 600 feet above sea level the creek winds westward approximately 18 miles through flatland of the Huron Plain to its confluence with Tonawanda Creek in the town of Pendleton. Throughout its length the creek flows sluggishly and usually out of channel during periods of high flow.

Ransom Creek, a major tributary of Tonawanda Creek, rises near the crest of the Onondaga Escarpment in the town of Newstead. From its source approximately 745 feet above sea level the creek flows northwestward approximately 13 miles to enter the Huron Plain at the base of the escarpment in the town of Amherst. Throughout this reach the creek usually flows fast enough to pass within its channel during periods of high flow. From the base of the escarpment, the creek continues to flow northwestward for 4 miles through flatland to its confluence with Tonawanda Creek in the town of Amherst. The channel of this reach is often inadequate; the creek flows generally sluggishly and usually out of channel during periods of high flow. Near the base of the escarpment the creek receives a major tributary, Got Creek, which rises in the town of Clarence and flows northwestward 10 miles to its confluence with Ransom Creek. Approximately 1 mile downstream from its confluence with Got Creek, Ransom Creek receives a second major tributary, Black Creek, which rises in the Huron Plain in Clarence and flows westward 8 miles through flatland to its mouth. Throughout its length Black Creek flows sluggishly and often out of chanel during periods of high flow.

<u>Climate</u>.

The climate of the Tonawanda Creek Watershed is moderate and humid. Average monthly temperatures range from approximately 25°F in January to 70°F in July.

Air above the watershed is usually brought in by westerly winds. This air has been carried over Lake Erie, from which it picks up considerable moisture. But before the air reaches the watershed, it is carried over the northern parts of the Appalachian Uplands, which lift and cool the air mass and cause it to precipitate much of its moisture. Thus, the lowlands of the watershed lie in a precipitation "shadow" and receive considerably less precipitation than adjacent uplands to the southwest. Within the watershed, greater amounts of precipitation fall at the higher elevations than at the lower. Intense precipitation usually occurs only in summer, most commonly during thunderstorms in June, July, and August. Approximately 30 thunderstorms occur on the watershed annually. The time distribution of precipitation is fairly uniform; the watershed receives approximately 3 inches per month. Annually, the watershed receives approximately 34 inches of water, including approximately 76 inches of snow.

Water Resources.

a. Groundwater.

Groundwater reservoirs capable of yielding 100 gallons per minute or more underlie much of the watershed. These reservoirs are provided primarily by snad and gravel deposits and solution cavities in limestone and dolomite formations. Much of the water stored in these groundwater reservoirs seeps into creeks of the watershed during periods of little runoff. This water contains high concentrations of dissolved solids and is, therefore, of generally poor quality.

b. Surface Water.

The stored surface water of the watershed includes a few small deep-water bodies and several large shallow-water bodies. Only in the Cattaraugus Hills is the watershed's physiography suitable for deep-water storage. However, because natural development of waterways in this upland has been rapid and generally complete, natural surface storage is scant. The largest natural deep-water body in the upland is Faun Lake, located in the headland of the East Fork of Tonawanda Creek in the town of Wethersfield. It has a surface area of approximately 45 acres. A few small reservoirs have been constructed in the upland area, and on the Onondaga Escarpment. The largest of these, the Attica Reservoir, has a surface area of approximately 200 acres.

The expansive lowlands of the watershed accommodate many swamps and other wetlands which provide large reservoirs for storage of surface water. The largest of these are located near the Onondaga Escarpment in the northeastern part of the watershed.

c. Water Quality.

Based on information gathered by the New York State Department of Environmental Conservation, the quality of the water in the Tonawanda Creek is good. The upstream reaches of Tonawanda Creek and most of the tributaries have an "A" classification, which are waters that are inhabited by trout. The downstream reaches decrease in quality toward the mouth of the creek, but are of adequate quality for fishing and fish propagation.

Additional sampling data was obtained by the Erie County Department of Health (1970, 1973) and by the U. S. Geological Survey (1971, 1974, 1975). The water qualities of Tonawanda Creek and tributaries are discussed in more detail in Section 2 of the Environmental Impact Statement (EIS).

The Erie and Niagara Counties Regional Planning Board (ENCRPB) is developing a comprehensive plan for areawide wastewater management under Section 208 of Public Law 92-500. Since the ENCRPB study will consider needs for water quality management in most of the Tonawanda Creek Watershed, such needs were not addressed in this study.

Biota.

a. Flora.

The natural flora of the watershed consists mainly of wetland and hardwood forest species. The forests have, for the most part, been cleared and replaced by cultivated crops. In the agriculturally poor uplands, forage crop predominate, while in the more productive lowlands fruit and vegetables are also grown.

Natural floral resources of the watershed include small stands of sawtimber; larger stands of postwood and firewood; many small sugar orchards which yield sap for production of maple syrup; peat moss; and other vegetation providing habitats for wildlife and recreational enjoyment for people.

Cultivated floral resources of the watershed include abundant growths of plants providing grain and forage, and lesser, but substantial, growths of plants providing fruits and vegetables.

Information regarding existing and anticipated habitats in the watershed are discussed in the EIS.

b. Fauna.

(1) Fish - The cool, fast flowing creeks of the uplands are generally well-oxygenated and support sizeable brown trout fisheries. The slower-moving, lower qulity, lowland creeks support smallmouth bass, northern pike, panfish, and bullheads.

(2) Other Aquatic Wildlife - The swamps and marshes of the watershed provide extensive habitats for wildlife, including beaver, mink, muskrat, and marsh birds. The wetlands also serve as feeding and nesting grounds for ducks from the Atlantic Flyway.

(3) Terrestrial Wildlife - Terrestrial wildlife found in the forested upland includes raccoon, red fox, ruffed grouse, and white-tailed deer. In the lowlands, pheasant, red and gray squirrels, and opossum are common.

(4) Domestic Animals - Domestic animals found within the watershed include those commonly kept as pets, and those raised or used to support industries, such as cattle, horses, swine, and poultry.

Information on threatened and endangered species inhabiting the watershed is presented in the EIS.

SOCIO-ECONOMIC CHARACTERISTICS

Cultural History.

Based on an investigation carried out under contract to the Buffalo District by the SUNY-Binghamton, Public Archaeological Facility, there are 23 sites of cultural resource interest within the project area.

Details of the cultural resources investigations at these sites and recommendations are presented in the Environmental Impact Statement.

Demography.

In 1970 approximately 112,800 persons resided within the watershed. Approximately 59,800 resided either in communities of 1,000 residents or more or in incorporated communities.

Parts of four cities having populations greater than 10,000, namely, Batavia, Lockport, North Tonawanda, and Tonawanda, are located within the watershed. Communities with populations of 1,000 or more in 1970 include the village of Attica in Wyoming and Genesee Counties; the villages of Akron, Clarence Center, and Clarence in Erie County; and the hamlet of South Lockport in Niagara County.

Populations of long-established communities and most rural areas have changed very little recently. However, populations of suburbs within the watershed have grown substantially. Recent rates of growth in these suburbs have been proportionate to the sizes of adjacent cities. The cities of Batavia and Lockport, although not small, are isolated; therefore, recent population growths in nearby suburbs have been only moderate. On the other hand, the metropolitan area within and beyond the western boundary of the watershed, including the cities of Buffalo, Tonawanda, and North Tonawanda, is large; consequently, populations in the suburbs of Wheatfield, Pendleton, Amherst, and Clarence have grown rapidly.

Economy.

a. Industry.

(1) Primary - Primary industries within the watershed include farming, lumbering, and mining. Although these industries prevail in rural parts of the watershed, mechanization, and automation have greatly diminished need for workers to support them. Furthermore, the viability of lumbering and mining has been greatly diminished by depletion of the watershed's forest and mineral resources. Consequently, opportunity for employment in primary industries within the watershed will continue to decline, as it has for many years.

(2) Secondary - Secondary industries within the watershed include construction and manufacturing industries of various kinds. Typically, these construction and manufacturing industries are concentrated within or near cities. Although mechanization and automation have reduced opportunity for employment in them, growing demands for new construction and manufactures has well sustained such opportunity for the past century.

(3) Tertiary - Tertiary industries within the watershed comprise marketing and service activities of various kinds. Marketing industries

include the wholesaling and retailing of goods and the selling of real property. Service industries include those providing care and protection, education and research, recreation and entertainment, public utilities, maintenance and repair, planning, designing, financing, and public administration and service. These industries flourish throughout the watershed, particularly in or near places of concentrated population. The very mechanization and automation which have reduced employment opportunity in primary and secondary industries have served to increase and expand employment opportunity in tertiary industries. Present opportunity in them is far greater than that in the two other industries combined, and it is expected to continue growing.

b. Employment.

(1) General - In 1970, approximately 40 percent of the watershed's population were in its labor force. Of this number, approximately 5-1/2 percent were unemployed, which was representative of the Buffalo area. (Presently, roughly 14 percent of the labor force is unemployed). The remainder were gainfully employed in industries of the three general types described above.

(2) Primary - In 1970, fewer than two percent of employed persons residing within the watershed worked in primary industries and of these persons, most worked in agriculture. Because opportunity in these industries is expected to continue to decline, employment in them is expected to continue decreasing until, eventually, it represents no more than approximately one-third of one percent of total employment.

(3) Secondary - In 1970, approximately 38 percent of employed persons residing within the watershed worked in secondary industries. Most of these persons worked in manufacturing industries, and particularly in the manufacture of durable goods. Although employment opportunity in secondary industries is expected to be frustrated by improved technology, increased demand for products of these industires, especially construction products, is expected to sustain opportunity in the near future. Accordingly, employment in these industries is expected to remain generally stable for some time.

(4) Tertiary - In 1970, more than 60 percent of employed persons residing within the watershed worked in tertiary industries. Most of these persons worked in service industries. Because employment opportunity in tertiary industries is expected to grow at an increasing rate, employment in thee industries is expected to grow, and more rapidly as time passes.

c. Income.

In 1970, the median, or middle-ranking income of families residing within the watershed was approximately $10,100. Of these families, roughly 6-1/2 percent received incomes below the poverty level.

Land Use.

a. General.

Presently, approximately 30 percent of the watershed is used for housing, recreation, and transportation; the remainder is used for industrial purposes (principally farming).

b. Non-Industrial Use.

(1) Housing - In 1970, approximately 37,000 permanent dwellings suitable for year-round use occupied lots within the watershed. Most of these were included within hamlets and villages. Those parts of the cities of Batavia and North Tonawanda included within the watershed and including approximately 5,800 and 8,200 dwellings, respectively, embraced the greatest concentrations within the watershed. Many lesser concentrations of newer and more expensive dwellings are located in the towns of Clarence and Amherst.

(2) Recreation - Because the watershed includes very few ponds or lakes, and sustained flows of its creeks during warm weather are generally low, recreation within the watershed has been restricted generally to non-water-based activities such as picnicking, camping, hiking, and hunting. Presently, at least six areas within the watershed have been allotted for intensive recreational use. Kibbe Park, a tract adjacent to Tonawanda Creek within the city of Batavia and developed for picnicking and games, is provided by the city. Three more areas are provided by Erie County. They include: a site developed for picnicking and games and including Akron Falls in the town of Newstead; an undeveloped site on Beeman Creek in the town of Clarence; and Ellicott Creek Park, comprising an island within Tonawanda Creek and a tract between Tonawanda and Ellicott Creeks within the town of Tonawanda, developed for picnicking, games, and boating. The Tonawanda Game Management Area, a wetland tract of roughly 5,500 acres in Genesee and Niagara counties, is provided by the State of New York. The sixth area, a tract of the Oak Orchard Swamp within Genesee and Orleans counties, and part of the Iroquois National Wildlife Refuge adjacent to the Tonawanda Game Management Area, is provided by the Federal Government.

Information regarding fishing and hunting is presented in the EIS.

(3) Transportation - The northern end of the watershed is part of a lowland province which extends to the Hudson River. This lowland province accommodated rapid development of several transportation systems, during the early 1800's: first, the turnpike system (a forerunner of the present New York State Thruway), then the Erie Canal (a forerunner of the present New York State Barge Canal), and later, the New York Central Railroad system.

Numerous lesser roads have been constructed within the watershed so that, today, all parts are readily accessible from major routes. Additionally, the original railroad of the watershed was later complemented by five more lines: two more New York Central Railroad lines, and three lines of the Lehigh Valley Railroad and the Erie-Lackawanna Ralroad. These lines are now operated by the recently formed Conrail Corporation.

Presently, three small airports are located within the watershed: the Akron Airport in the town of Newstead, and the Amherst and County Line airports in the town of Amherst. Four other landing areas, one in the town of Batavia, two in the town of Clarence, and one in the town of Pendleton, are located within the watershed.

c. Industrial Use.

(1) Primary - Primary industries including farming, lumbering, and mining use approximately 70 percent of land within the watershed. Most of this percentage is used for farming, primarily dairy farming. Sawmills are operated at several sites throughout the watershed. They are typically small and often supplied with foreign stock. However, small-scale lumbering of hardwoods is still done within the watershed, particularly in the upland areas.

Currently, rocks, soils, and natural gas are mined within the watershed. Salt is mined in the town of Attica, gypsum is mined in the towns of Clarence and Newstead, and limestone and dolomite are mined in the town of Clarence. Clay deposits, plentiful in the lowlands, are mined very little now. Sand and gravel deposits are mined at many different sites throughout the watershed. A large mining and fractionation operation is conducted in the towns of Alexander, Bethany, and Batavia. Although gas is mined from all five fields underlying the watershed, most indigenous gases have been nearly exhausted. However, supplies of gas mined elsewhere are now being stored in some of them.

(2) Secondary - Construction and manufacturing industries use approximately 1 percent of land within the watershed, generally either within or near urban areas. The largest manufacturing industry, the Durez Chemical Co., is located within the city of North Tonawanda. Several other sizable manufacturing industries are located there and within the city of Batavia.

(3) Tertiary - Marketing and servicing industries use approximately 1 percent of land within the watershed. The greatest number of them are concentrated within or near suburban developments. Many market and service establishments are located along State Routes 62 and 78 and are included as parts of large shopping malls.

d. Hydropower.

Presently there is no hydropower generation in the Tonawanda Creek Watershed. Though a hydropower investigation was not specifically included in the study authorization, the Corps is allowed to expand the study scope to include other related water resources.

It could be engineeringly feasible to include hydropower development in a reservoir plan for the Tonawanda Creek Watershed. However, several geologic factors would make the actual construction of the hydropower facilities too costly. The soils contain a large portion of sand and gravel which would make it difficult to maintain a permanent pool behind the dam. Construction of impervious curtains would not be economically feasible. The area also has an earthquake potential. Construction of a larger dam for hydropower generation would increase the potential for catastrophic loss if an earthquake were to occur. Hydropower development was not considered further in this study due to these factors.

SECTION III

DESCRIPTION OF FLOOD MANAGEMENT NEEDS IN THE TONAWANDA CREEK WATERSHED

HISTORY OF FLOODING

Runoff Characteristics.

Most creeks in the Tonawanda Creek Watershed flow within their channels even during periods of high flow; however, Tonawanda and Mud Creeks flood frequently and augment flows of other creeks enough to cause them to flood also.

Much of the runoff contributing to flooding by Tonawanda Creek is shed by the Cattaraugus Hills in Wyoming County. The soil in this area is moderately permeable glacial till which admits water readily and thereby tends to reduce surface runoff despite the area's steep slopes. During summer, the runoff from them is low. During winter, moisture in the soil freezes and most precipitation accumulates on the hills as snow. In early spring, however, air temperatures often rise enough to melt the snow before the ground has thawed, so that almost all snow melt and spring rain is shed immediately to Tonawanda Creek, causing large flow increases in short periods of time.

Approximately 30 thunderstorms annually produce high intensity precipitation which can occur anywhere over the watershed. Most of these thunderstorms occur in summer when soil moisture is low; consequently, much of the rainfall produced by them infiltrates into soils of the watershed. However, thunderstorms can also occur in spring and early summer when soil moisture of the watershed is either still frozen or high enough to inhibit infiltration, with the result that flooding occurs.

Floods of Record.

Major floods of Tonawanda Creek occurred in March 1902, March 1916, March 1942, March 1956, January 1957, January 1959, March 1960, September 1977, March 1978, and March 1979. Hydrologic data on these floods are presented in Tables 1 and 2. The 1902 and 1916 floods caused considerable damage in the lower part of the Tonawanda Creek Watershed in the cities of Tonawanda and North Tonawanda. Since modification of the Barge Canal in the vicinity of the two cities in 1916, as described in Section I, high discharges have caused relatively little damage in the two cities. The 1960 flood, the largest flood of record, caused an estimated $1,500,000 worth of damage. According to a Buffalo District post-flood report, 450 residential units, 48 commercial units, 250 agricultural units, and an undetermined number of roads and public facilities were affected by the flood.

Table 3 presents estimates of damage (based on December 1975 development and prices) that recurrences of the 1942, 1956, and 1960 floods would cause in the floodlands of the watershed.

Table 1 - Hydrologic Data for Major Floods by Tonawanda Creek at Batavia

Year	Date	Peak Discharge at Batavia, cfs	Rainfall Inches	Runoff Inches	Snow on Ground, Inches	Temp °F Max.	Temp °F Min.
1902	6 July	5,350 1/	4.2	2/	0	2/	2/
1916	28 March	7,050 1/	0.4	2/	2/	58	40
1942	17 March	6,000 1/	1.5	2/	2/	59	33
1956	7 March	6,480	2.5	1.9	1-2	46	22
1957	23 January	6,090	1.8	2.1	12-18	55	12
1959	22 January	5,230	1.5	1.7	12-18	52	12
1960	31 March	7,200	0.2	3.3	23 3/	61	33
1977	25 September	5,120	7.7	5.5	0	69	56
1978	22 March	3,800	0.6	3.6	15 4/	45	31
1979	5 March	5,570	0.3	3.0	11-18 5/	52	35

1/ Corps of Engineers estimate based on highwater marks and backwater computations.
2/ Unknown.
3/ Average value from snow survey made by Corps of Engineers. Water content of snow was 5.2 inches.
4/ U.S.G.S. New York Cooperative Snow Survey. March 13-15, 1978.
5/ Based upon NWS records and USGS New York Cooperative Snow Survey taken 5-7 February 1978 and 5-7 March 1978.

Table 2 - Recorded Peak Discharges for Notable Floods in the Tonawanda and Little Tonawanda Creek Watersheds

Gage Location	Drainage Area sq. mi.	March 1942 cfs	March 1942 cfs/sq. mi.	March 1956 cfs	March 1956 sq. mi.	Jan. 1957 cfs	Jan. 1957 cfs/sq. mi.	Jan 1959 cfs	Jan 1959 cfs/sq. mi.
Linden	22.1	2,130	97	2,700	122	1,500	68	1,630	74
Batavia	171.0	6,000	35	6,480	38	6,090	35	5,230	30
Alabama (Hopkins Rd)	231.0	6,860	30	6,850	30	6,180	27	9,000 1/	39
Rapids 2/	358.0	-	-	5,090	14	5,210	15	4,450	12
3/		-	-	7,780	22	7,790	22	6,700	19

Gage Location	Drainage Area sq. mi.	March 1960 cfs	March 1960 cfs/sq. mi.	September 1977 cfs	September 1977 sq. mi.	March 1978 cfs	March 1978 cfs/sq. mi.	March 1979 cfs	March 1979 cfs/sq. mi.
Attica	82	-	-	-	-	1,380	17	-	-
Linden	22.1	1,830	85	-	-	631	29	913	42
Batavia	171.0	7,200	42	5,120	30	3,620	22	5,570	33
Alabama (Hopkins Rd)	231.0	7,980	35	5,020	22	3,680	16	6,710	29
Rapids 2/	358.0	6,280	18	-	-	5,100	14	5,500	15
3/		12,380	35	-	-	7,200	20	9,050	25

1/ This discharge was determined by the U.S.G.S. from an ice-affected stage.

2/ Does not include flow which enters mud and Black Creek upstream from the gage as discussed in Appendix A1.

3/ Includes flow to Black and Mud Creek.

Table 3 - Estimates of Tangible Damages That Recurrences of the 1942, 1956, and 1960 Floods Would Cause Now 1/

	Erie Plain Floodland		Huron Plain Floodland		Tonawanda Watershed
Flood Date	Recurrence Interval In Years	Estimated Damages 2/	Recurrence Interval In Years	Estimated Damages 2/	Estimated Damages 2/
1942	11	620,000	2	750,000	1,370,000
1956	12	1,350,000	5	1,600,000	2,950,000
1960	30	3,140,000	10	2,500,000	5,640,000

1/ Based on 1975 development and prices.

2/ Estimated damages do not include agricultural damages.

In the past, major flooding has occurred in the spring and has been caused by snow melt augmented by rainfall. Major flooding caused by ice jams has been rare. Maximum flood discharges recorded at various gaging stations in the Tonawanda Creek Watershed are given in Table 2.

Extent of Flooding.

Major floodlands of the Tonawanda Creek Watershed are depicted in Plate 3.

Flooding by the lower reaches of Tonawanda, Mud, and Ransom Creeks, upstream of the State Barge Canal, often inundates vast areas of flatland. This type of flooding extends upstream nearly 20 miles to the Tonawanda Indian Reservation. See Photos 1 thru 4. The flood plains of the three creeks overlap in some areas, and, during the 1960 flood, reached a maximum width of about four miles. From the Tonawanda Indian Reservation upstream to the village of East Pembroke, flooding is generally restricted to narrow overbank areas. From the village of East Pembroke to the city of Batavia, the flood plain varies in width from 500 to 1,500 feet. Above the city of Batavia, the flood plain is wide and extends upstream about six miles to the village of Alexander. Flooding in this area, during the 1960 flood, reached a maximum width of about 12,000 feet. From the village of Alexander to the village of Attica, the flood plain varies in width from 1,000 to about 2,000 feet. Above the village of Attica, flooding and flood damages are minimal.

The physiography of the watershed is such that, typically, the time required for a flood peak to travel from the city of Batavia to the Barge Canal is several days. During the 1960 flood, the travel time was about three days. Once flooded, the lowlands on either side of the creek may remain inundated for several weeks, functioning as a natural storage reservoir that considerably reduces downstream discharges.

During major floods, water from Tonawanda Creek leaves its channel and flows parallel to the channel in areas both north and south. Often flood elevations are higher over the flood plain than in the creek channel. Parallel flow along the north side begins near Ditch Road and finally returns to the main stream near Rapids. Parallel flow along the south side begins near Beeman Creek and eventually reaches the watersheds of Ransom, Black, and Got Creeks before returning to the main stream.

PRESENT NEED FOR FLOOD MANAGEMENT

Introduction.

Flooding has caused damage and threatened loss in the Tonawanda Creek Watershed for many years. The recent increase in development of forest and farmland for industrial and residential use has increased the long-standing need for flood management.

Human Health and Safety.

The health and safety of the residents in the floodprone areas of the watershed are an important consideration in determining the need for flood

Photo 1. Aerial view of flooding during the 1960 flood, in the vicinity of Burdick Road, roughly 3-1/2 river miles above mouth of Beeman Creek.

Photo 2. Extensive flooding during the 1960 flood in the vicinity of Tonawanda Creek, Black Creek and Beeman Creek.

Photo 3. Aerial view of flooding along Ransom Creek in the vicinity of Millersport Highway during the 1960 flood.

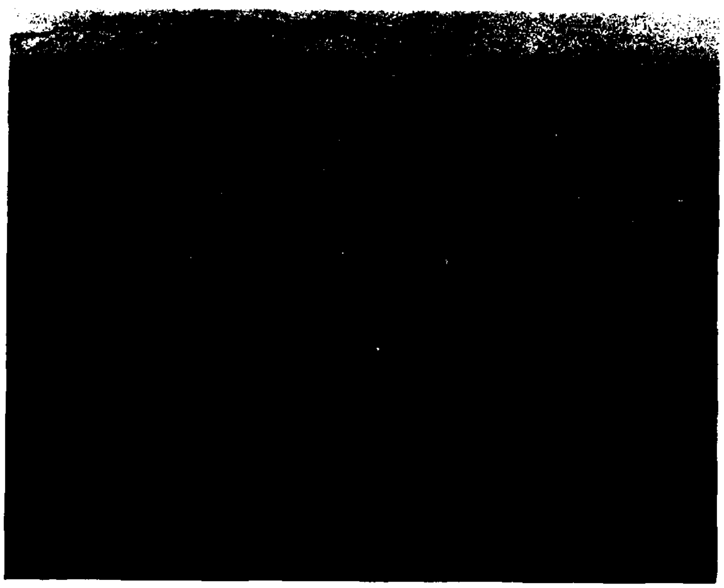

Photo 4. Widespread flooding in the vicinity of Transit Road and Wolcott Road along Black Creek during the 1960 flood.

management. Flooding could temporarily deprive persons of necessary supplies, services, and facilities, as well as cause psychological hardship. Floodwaters could also spread disease by causing back-up of sewers and inundation of septic tanks and leach beds. The largest concentrations of persons needing flood protection are in the cities of Batavia and North Tonawanda and in new developments in the towns of Clarence, Amherst, Pendleton, and Wheatfield.

Photos 5 and 6 show effects of flooding on residents of the Huron Plain floodland.

Property.

a. General.

In order to determine existing average annual damage caused by flooding in the watershed, damages caused in selected reaches were determined separately, and then combined. The limits of these selected "damage reaches" were based on hydrologic characteristics and land use. Pertinent characteristics of these reaches are presented in Table 4. Similar data presented in Table 4A reflect hydrology-hydraulic investigations made since 1976 and completed in 1979.

The floodlands of the watershed include properties used for nonindustrial, transportation, and industrial purposes. Presently, existing average annual flood damage in and about these floodlands is $2,174,990 at June 1981 prices. An itemization of this damage is presented in Table 5. Table 6 shows the approximate number of units of various kinds, and acreages of land, that would be affected by the Intermediate Regional Flood (100-year) and Standard Project Flood.

b. Nonindustrial Properties.

Nonindustrial properties susceptible to flood damage include residential, public recreation, and transportation properties. Although residential properties exist throughout the floodlands, most are situated within the cities of Batavia and North Tonawanda or within new developments in the towns of Clarence, Amherst, Pendleton, and Wheatfield. Flood damage to these properties would be caused by floodwater inundation and deposition. Photos 7 thru 9 show flooding of residential properties.

Three public recreation properties susceptible to flooding are Kibbe Park in the city of Batavia, Ellicott Creek Park in the town of Tonawanda, and the Tonawanda Game Management Area in Genesee and Niagara Counties. Kibbe Park, including picnic and playground facilities, is used intensively during warm weather. Ellicott Creek Park, located on the low-stage boundary between the Tonawanda and Ellicott Creek Watersheds, contains numerous picnic, playground, and boating facilities which are used continually during warm weather.

Photo 5. Person stranded in his home by flooding, roughly 2 miles from the mouth of Ransom Creek (1960).

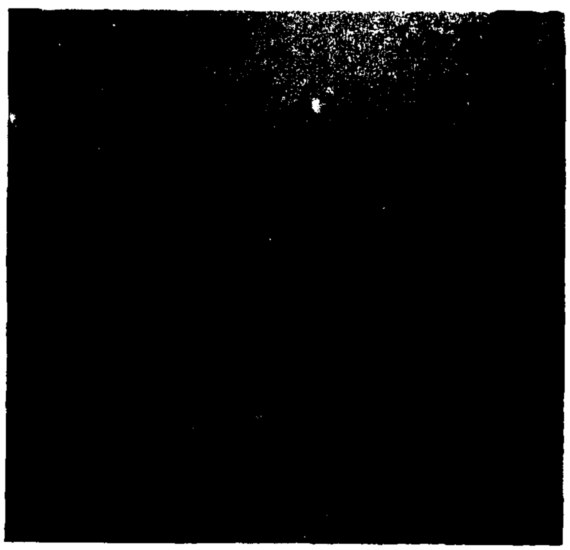

Photo 6. Rescue of residents affected by flooding along New Road, roughly 3 miles from the mouth of Ransom Creek (1960).

Table 4 - Damage Reaches

Reach No.	Location of Index Point	Damaging Elevation	Approximate Recurrence Interval In Years	Limits of Damage Reach
HURON PLAIN FLOODLAND				
	TONAWANDA CREEK VALLEY-MOUTH TO MEADVILLE ROAD			
T-1	2.4 Stream miles from mouth	568.0	1	Stream mile 0.0 to 6.0
T-2	8.9 Stream miles from mouth	572.0	1	Stream mile 6.0 to 10.2
T-3	12.8 Stream miles from mouth	578.0	1	Stream mile 10.2 to 12.8
T-4	15.2 Stream miles from mouth	584.6	2	Stream mile 12.8 to 17.4
T-5	17.4 Stream miles from mouth	582.0	1	Stream mile 17.4 to 22.8
T-6	22.8 Stream miles from mouth	584.0	1	Stream mile 22.8 to 28.0
T-7	28.0 Stream miles from mouth	593.0	1	Stream mile 28.0 to 32.3
T-8	32.3 Stream miles from mouth	597.0	2	Stream mile 32.3 to 34.9
T-9	34.9 Stream miles from mouth	598.0	1	Stream mile 34.9 to 38.9
T-10	41.5 at Alabama gage location	616.0	1	Stream mile 38.9 to 41.5
	MUD CREEK WATERSHED			
M-1	1.6 Stream miles from mouth	580.0	1	Stream mile 0.0 to 3.5
M-2	3.5 Stream miles from mouth	583.0	2	Stream mile 3.5 to 7.0
M-3	7.0 Stream miles from mouth	590.3	4	Stream mile 7.0 to 10.8
M-4	10.8 Stream miles from mouth	596.0	2	Stream mile 10.8 to 12.3
M-5	12.5 Stream miles from mouth	596.0	1	Stream mile 12.3 to 15.0
M-6	15.1 Stream miles from mouth	603.5	2	Stream mile 15.0 to Ditch
	RANSOM AND BLACK CREEK WATERSHEDS			
RB-1	2.4 Stream miles from mouth	577.0	1	Stream mile 0.0 to 2.4
RB-2	4.9 Stream miles from mouth	579.0	1	Stream mile 2.4 to 4.9
RB-3	7.2 Stream miles from mouth	584.0	1	Stream mile 4.9 to 8.6
RB-4	8.6 Stream miles from mouth	586.7	2	Stream mile 8.6 to Salt Road

Table 4 - Damage Reaches (Cont'd)

Reach No.	Location of Index Point	Damaging Elevation	Approximate Recurrence Interval In Years	Limits of Damage Reach
TONAWANDA CREEK VALLEY-MEADVILLE ROAD TO VICINITY OF ROUTE 5				
T-11	52.5 Stream miles from mouth	847.0	3	Stream mile 41.5 to 59.5
T-12	60.3 Stream miles from mouth	876.5	3	Stream mile 59.9 to 62.8
ERIE PLAIN FLOODLAND				
	CITY OF BATAVIA AND VICINITY			
B-1	Upstream Side of South Lyon Street Bridge	886.0	12	West City Limit to Walnut Street
B-2	Kibbe Park Between Elmwood and Jackson Avenues	893.2	18	Walnut Street to Lower P.C.R.R. Bridge
B-3	Kibbe Park Between Elmwood and Jackson Avenues	893.2	18	Lower P.C.R.R. Bridge to upper P.C.R.R. Bridge, right bank
B-4	Downstream side of Chestnut Street Bridge	889.0	2	Lower P.C.R.R. Bridge to southern city limit left bank
B-5	Downstream side of Chestnut Street Bridge	891.5	12	Lower P.C.R.R. Bridge to Chestnut Street, right bank
	CITY OF BATAVIA TO VILLAGE OF ALEXANDER			
T-13	65.5 Stream miles from mouth	890.4	1	Stream mile 65.4 to 77.5
	VILLAGE OF ALEXANDER			
A-1	Upstream side of Railroad Ave.	925.0	2	State Rte.20 to 500 feet upstream from Railroad Avenue
	VILLAGE OF ATTICA			
A-2	Upstream side of Prospect St. Bridge	952.0	1	Prospect Avenue upstream to Main Streeet
A-3	Upstream side of Main Street Bridge	964.0	2	Main Street upstream to Dunbar Road

Table 4A - Damage Reaches

Reach No.	Location of Index Point	Damaging Elevation	Approximate Recurrence Interval In Years	Limits of Damage Reach
HURON PLAIN FLOODLAND				
	TONAWANDA CREEK VALLEY-MOUTH TO MEADVILLE ROAD			
T-1	2.4 Stream miles from mouth	568.0	6	Stream mile 0.0 to 6.0
T-2	8.9 Stream miles from mouth	572.0	3	Stream mile 6.0 to 10.2
T-3	12.8 Stream miles from mouth	579.0	6	Stream mile 10.2 to 12.8
T-4	15.2 Stream miles from mouth	584.0	0	Stream mile 12.8 to 17.4
T-5	17.4 Stream miles from mouth	583.0	1	Stream mile 17.4 to 22.8
T-6	22.8 Stream miles from mouth	587.0	1	Stream mile 22.8 to 28.0
T-7	28.0 Stream miles from mouth	593.0	1	Stream mile 28.0 to 32.3
T-8	32.3 Stream miles from mouth	597.0	1	Stream mile 32.3 to 34.9
T-9	34.9 Stream miles from mouth	601.0	1	Stream mile 34.9 to 38.9
T-10	41.5 at Alabama gage location	616.0	1	Stream mile 38.9 to 41.5
	MUD CREEK WATERSHED			
M-1	1.6 Stream miles from mouth	580.0	3	Stream mile 0.0 to 3.5
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M-3	7.0 Stream miles from mouth	590.3	4	Stream mile 7.0 to 10.8
M-4	10.8 Stream miles from mouth	596.0	2	Stream mile 10.8 to 12.3
M-5	12.5 Stream miles from mouth	598.0	1	Stream mile 12.3 to 15.0
M-6	15.1 Stream miles from mouth	603.5	2	Stream mile 15.0 to Ditch
	RANSOM AND BLACK CREEK WATERSHEDS			
RB-1	2.4 Stream miles from mouth	578.0	1	Stream mile 0.0 to 2.4
RB-2	4.9 Stream miles from mouth	580.0	1	Stream mile 2.4 to 4.9
RB-3	7.2 Stream miles from mouth	584.0	1	Stream mile 4.9 to 8.6
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Table 4A - Damage Reaches (Cont'd)

Reach No.	Location of Index Point	Damaging Elevation	Approximate Recurrence Interval In Years	Limits of Damage Reach
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T-11	52.5 Stream miles from mouth	847.0	4	Stream mile 41.5 to 59.5
T-12	60.3 Stream miles from mouth	876.5	2	Stream mile 59.9 to 62.8
ERIE PLAIN FLOODLAND				
	CITY OF BATAVIA AND VICINITY			
B-1	Upstream Side of South Lyon Street Bridge	886.0	12	West City Limit to Walnut Street
B-2	Kibbe Park Between Elmwood and Jackson Avenues	893.2	20	Walnut Street to Lower P.C.R.R. Bridge
B-3	Kibbe Park Between Elmwood and Jackson Avenues	893.2	20	Lower P.C.R.R. Bridge to upper P.C.R.R. Bridge, right bank
B-4	Downstream side of Chestnut Street Bridge	889.0	2	Lower P.C.R.R. Bridge to southern city limit left bank
B-5	Downstream side of Chestnut Street Bridge	891.5	12	Lower P.C.R.R. Bridge to Chestnut Street, right bank
	CITY OF BATAVIA TO VILLAGE OF ALEXANDER			
T-13	65.5 Stream miles from mouth	890.4	1	Stream mile 65.4 to 77.5
	VILLAGE OF ALEXANDER			
A-1	Upstream side of Railroad Ave.	925.0	2	State Rte.20 to 500 feet upstream from Railroad Avenue
	VILLAGE OF ATTICA			
A-2	Upstream side of Prospect St. Bridge	952.0	1	Prospect Avenue upstream to Main Streeet
A-3	Upstream side of Main Street Bridge	964.0	2	Main Street upstream to Dunbar Road

Table 5 - Estimated Average Annual Damages, Existing Conditions by Reach, June 1981 Prices and December 1975 Conditions of Development

Reach No.	Residential	Commercial and Industrial	Public and Other	Total
T-1	46,590	100	5,460	52,150
T-2	19,250	20	13,940	33,210
T-3	13,490	3,790	18,400	35,680
T-4	590	0	1,680	2,270
T-5	151,690	20	21,690	173,400
T-6	309,580	0	17,780	327,360
T-7	93,480	0	24,450	117,930
T-8	149,380	80	22,000	171,460
T-9	98,270	0	23,210	121,480
T-10	4,500	0	1,900	6,400
RB-1	37,650	0	1,030	38,680
RB-2	128,630	2,200	17,480	148,310
RB-3	180,330	0	88,920	269,250
RB-4	82,750	1.070	7,750	91,570
M-1	890	0	5,120	6,010
M-2	1,230	0	0	1,230
M-3	3,840	0	330	4,170
M-4	4,900	0	300	5,200
M-5	29,210	0	1,200	30,410
M-6	26,400	0	2,710	29,110
T-11	11,060	0	14,570	25,630
T-12	23,160	4,260	29,180	56,600
B-1	40,650	9,960	36,650	87,260
B-2	3,270	0	6,940	10,210
B-3	83,160	90,880	16,950	190,990
B-4	29,560	610	2,200	32,370
B-5	830	940	3,400	5,170
T-13	34,270	0	11,990	46,260
A-1	23,360	(1)	(1)	23,360
A-2	21,790	(1)	(1)	21,790
A-3	10,060	(1)	(1)	10,060
TOTAL	1,663,830	113,930	397,230	2,174,990

(1) Included in residential.

NOTE: Totals may not add due to rounding.

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Table 5A - Estimated Average Annual Damages, Existing Conditions by Reach (December 1975 Development and Prices)

Reach No.	Residential	Commercial and Industrial	Public and Other	Agricultural 1/	Total
T-1	30,210	60	3,500	0	33,770
T-2	12,480	10	8,940	0	21,430
T-3	8,750	2,380	11,800	1,560	24,490
T-4	380	0	1,080	110	1,570
T-5	98,360	10	13,910	17,010	129,290
T-6	200,740	0	11,400	70,950	283,090
T-7	60,620	0	15,680	18,770	95,070
T-8	96,860	50	14,110	38,020	149,040
T-9	63,720	0	14,880	29,050	107,650
T-10	2,920	0	1,220	0	4,140
RB-1	24,410	0	660	520	25,590
RB-2	83,410	1,380	11,210	1,750	97,750
RB-3	116,930	0	57,020	32,420	206,370
RB-4	53,660	670	4,970	17,440	76,740
M-1	580	0	3,280	50	3,910
M-2	800	0	0	2,790	3,590
M-3	2,490	0	210	3,060	5,760
M-4	3,180	0	190	800	4,170
M-5	18,940	0	770	15,410	35,120
M-6	17,120	0	1,740	14,500	33,360
T-11	7,170	0	9,340	1,270	17,780
T-12	15,020	2,670	18,710	1,710	38,110
B-1	26,360	6,250	23,500	0	56,110
B-2	2,120	0	4,450	0	6,570
B-3	53,920	57,000	10,870	0	121,790
B-4	19,170	380	1,410	0	20,960
B-5	540	18,590	2,180	0	21,310
T-13	22,220	0	7,690	6,830	36,740
A-1	15,150	**	**	*	15,150
A-2	14,130	**	**	*	14,130
A-3	6,520	**	**	*	6,520
TOTAL	1,078,880	89,450	254,720	274,020	1,697,070

1/ For the agricultural sector, development conditions and prices are at 1978 levels.

* Not calculated on those reaches as they are located upstream of the project sites.

** Included in residential.

Table 6 - Approximate Number of Units and Acreages, that the IRF and SPF Would Flood 1/

Reach	Units Affected							
	Residential		Commercial & Industrial		Public & Other		Acres Inundated	
	IRF	SPF	IRF	SPF	IRF	SPF	IRF	SPF
T-1 through T-10	890	2,690	60	98	7	21	16,500	29,200
RB-1 through RB-4	386	419	5	6	2	2	8,770	9,850
M-1 through M-6	185	210	0	0	4	4	5,430	7,590
T-11 and T-12	138	213	21	24	0	1	6,710	7,460
B-1 through B-5	1,815	2,021	106	140	9	17	710	840
T-13	69	72	0	0	0	0	5,190	5,470
A-1 through A-3	8	40	10	15	0	0	250	280
TOTAL	3,491	5,665	202	283	22	45	43,560	59,690

1/ An Intermediate Regional Flood (IRF) is of 100-year degree; a Standard Project Flood (SPF) is a flood of the greatest degree reasonably likely to occur.

Photo 7. Residence at the intersection of Goodrich and Brauer Road, south of the village of Rapids (1960).

Photo 8. View, in northerly direction, along Wolcott Road, *roughly* 9 miles from the mouth of Black Creek (1960).

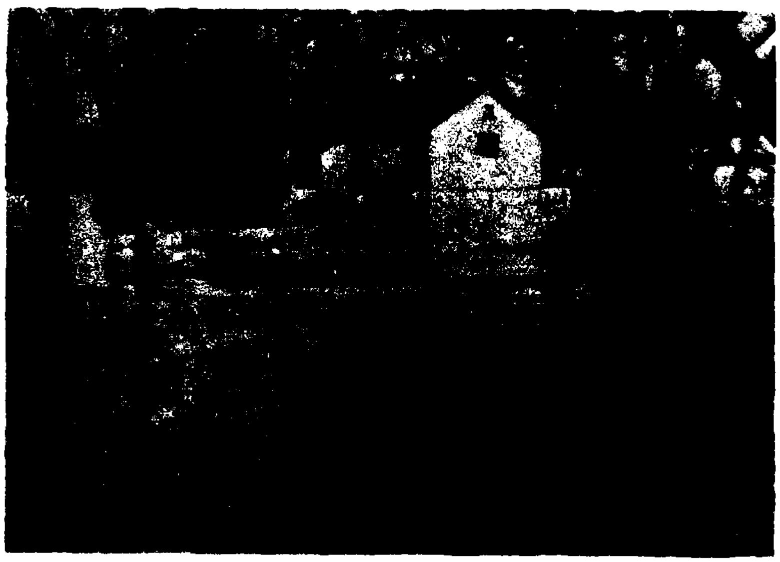

Photo 9. Flooding of residence near mouth of Ransom Creek (1960).

Photo 10. View, in northerly direction, along New Road near Ransom Creek, roughly 3 miles from its mouth (1940).

Photo 11. Persons stranded by flooding near the mouth of *Beeman Creek* (1954).

Photo 12. View, in northerly direction, along Millersport Highway near Ransom Creek, roughly 3 miles from its mouth (1940).

Photo 13. View, in easterly direction, of flooding along Railroad Avenue in village of Alexander (1956).

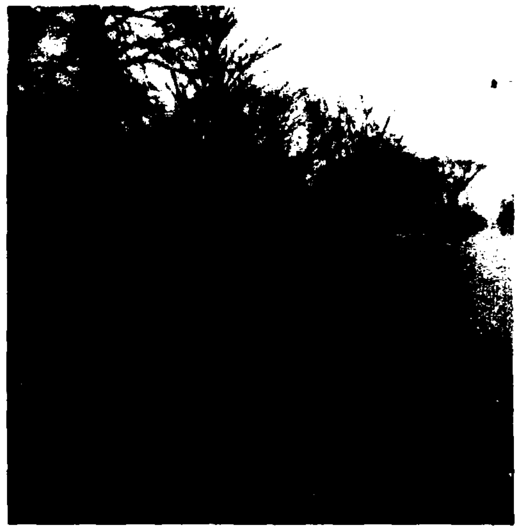

Photo 14. View of damage caused by flooding shown in Photo 13.

These parks could be damaged by hydraulic loading, erosion, and deposition effects of flooding.

The Tonawanda Game Management Area, a wetland tract, is generally open and only partially developed by man. Some damage to the area could be caused by floodwater deposition.

Transportation properties susceptible to erosion and other flood damage include the Amherst and County Line airports in the town of Amherst; three air strips, two in the town of Clarence and one in the town of Amherst; four railroads previously extended through the towns of Alexander and Batavia (Conrail now operates all of them and some are inactive); and many State, county, and local roads throughout the floodprone areas. Photos 10 thru 14 show flooding of roads in the watershed.

c. Farmland.

Farmland occupies large tracts of the floodlands. See Photos 1 thru 4. This farmland is subject to several kinds of flood damage. Floodwater erodes fertile topsoil from farmlands, greatly diminishing their crop production capabilities. Often land damaged by erosion must be graded and heavily fertilized to restore it for crop production. In addition to eroding topsoil, floodwaters erode soils from creek channels and from locations below the topsoil in flood plains, which are generally unsuitable for sustaining plant life. These soils are often deposited on fertile land and must be either removed or fertilized in order to reclaim such land for crop production.

d. Properties of Secondary and Tertiary Industries.

Most properties used for secondary tertiary industries are located either within the cities of Batavia and North Tonawanda or within the towns of Clarence, Amherst, Pendleton, and Wheatfield near Routes 78 and 62. Most possible flood damages to these properties would be caused by floodwater inundation, loading, and deposition.

Industry.

a. Introduction.

Industries within the two floodprone areas of the watershed include some of each of the three types: primary, secondary, and tertiary, described in Section II.

b. Primary.

Primary industries which could be encumbered by flooding include farming, lumbering, and mining; however, only farming is now, and would be encumbered appreciably.

The earthmoving and fertilizing necessary to restore croplands damaged by floodwater erosion and deposition within the watershed require considerable time, labor, and expense.

Standing floodwater also causes considerable damage to affected farmlands. Many of these properties, especially in the Huron Plain, are nearly flat; consequently, floodwater stays on them for as long as several weeks. Occupying floodwater not only precludes use of these lands, but also promotes saturation of their soils, so that long after floodwater has run off, the lands are too wet to support farm use.

Early spring flooding often delays planting until well into the growing season, so that many of the characteristically fertile lands, generally capable of supporting at least two crops per year, are used for generally no more than one. Some of the slower-draining properties have even been abandoned as useless for farming.

The considerable loss of possible agricultural production on these farmlands results in appreciable loss of possible income for affected farmers. Estimated average annual flood damage to the agricultural industry of the watershed is shown in Table 7.

c. Secondary and Tertiary.

Secondary industries which could be encumbered by flooding. Although construction industries could be encumbered also, most would likely be bolstered by post-flood reconstruction. Tertiary industries which could be encumbered include both marketing and servicing.

Extensive flood damage possible to establishments, facilities, and goods of secondary and tertiary industries could hinder or halt the industries themselves. Affected real properties, capital stock, and inventories might need to be restored or replaced. Some industries, especially those of small-scale manufacturing, might be relocated or simply shut down. Persons employed in them could lose their jobs and incomes, temporarily or permanently.

Environment.

a. Land and Water.

In late winter and early spring, creek channels often carry high flows for prolonged periods and their banks become saturated. Then, the floodwaters subside much more rapidly than the saturated banks can drain, so the banks fail, sliding into the channels to obstruct and divert their flows. Such slides are common following spring flooding along the Tonawanda Creek channel, particularly downstream from the Tonawanda Indian Reservation. Eroded material is generally deposited a short distance downstream, either in the channels or on adjacent flood plains. Depositions in the channels typically form bars on the insides of bends, which later deflect lower flows to erode the outsides of these bends. The result is erosion of outside banks and, ultimately, extensive meandering of the channels. Such meandering of channels within the floodlands, and particularly of the Tonawanda Creek channel,

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Table 7 - Summary of Existing Average Annual Equivalent Agricultural Damages and Benefits (1978 Land Use Patterns)

Reach	Existing Damages
T-1	1/
T-2	1/
T-3	2,580
T-4	140
T-5	29,580
T-6	112,340
T-7	32,670
T-8	79,770
T-9	53,910
T-10	
RB-1	1,340
RB-2	2,510
RB-3	47,940
RB-4	23,390
M-1	140
M-2	4,240
M-3	5,370
M-4	1,480
M-5	20,740
M-6	17,800
T-11	2,170
T-12	4,340
T-13L	28,590
T-13U	2/
A-1	2/
A-2	2/
A-3	2/
Total	471,050

1/ Nonagricultural reaches

2/ These reaches are upstream of the upper dam

NOTE: Total may not add due to rounding

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continually changes and/or destroys land, habitats, and life of the watershed. Photos 15 thru 19 show slide and erosion damage.

The need for protection of creek channels and contiguous floodlands from flood-related landsliding and erosion has been confirmed by recent field inspections. In 1973, a field investigation was made of an erosion problem on the west bank of Tonawanda Creek downstream from the Main Street Bridge in the village of Attica. In 1974, field inspections were made of two properties along Tonawanda Creek Road in Clarence Center that had suffered erosion.

Much of the soil eroded by high-flowing creeks is deposited near the source of erosion. However, large quantities of fine-grained fractions are suspended by the fast-flowing, turbulent floodwaters and borne great distances downstream. The creeks carrying such suspended soils are polluted by them, and often rendered unfit for established uses.

In addition to eroding soils, floodwaters tend to flush plants and other debris into stream channels where they snag and accumulate, impeding flow and causing further erosion by diverting water. Debris blockages are commonplace throughout reaches of the Tonawanda Creek channel downstream of Attica. On 18 May 1973, the Buffalo District provided technical assistance to resolve a debris and sedimentation problem at the municipal sewage treatment plant in the village of Attica. In the Spring of 1975, the District removed a major timber debris jam on Tonawanda Creek near the town of Alexander. See Photos 20 thru 22.

b. Biota.

(1) Flora - Since most flooding of this area occurs in late winter or early spring, cultivated vegetation, except for winter wheat and hay crops, is seldom damaged. Natural vegetation, however, is subject to damage by the floodwater itself and by flood-carried debris. Bushes and trees growing near the banks of creeks are often toppled when flood-eroded banks collapse.

(2) Fauna - Flooding within the watershed could directly destroy wildlife inhabiting the floodlands, and could also damage or destroy established animal habitats and food supplies.

Heavy concentrations of eroded soil in creek water could injure the gills of fish. More sensitive species, such as trout, can only survive for a short time in polluted water. While flooding, creeks could also scour or bury spawning beds, to destroy fish eggs.

Waterfowl and other birds could also be disrupted or destroyed by flooding, particularly if it occurs during the nesting season. Floodwaters could inundate eggs, destroy newly hatched young birds, ruin food, and destroy brood habitat.

Photos 15 and 16. Post-flood slide of Tonawanda Creek channel bank, west of the village of Rapids (1973).

Photo 17. View of post-flood slide of Tonawanda Creek channel bank, roughly 1 mile downstream from the mouth of Mud Creek (1956).

Photo 18. Aerial view of recently eroded channel of Tonawanda Creek between the village of Alexander and the city of Batavia. (1975)

Photo 19. View of eroded channel of Tonawanda Creek near village of Attica, after flooding caused by tropical storm Agnes. (1972)

Photos 20 thru 22. Views of debris jam in Tonawanda Creek channel, downstream from village of Alexander. (1975)

PROJECTED NEED FOR FLOOD MANAGEMENT

Projected Need for New Development Within the Watershed.

a. Introduction.

As mentioned previously, land uses within floodlands of the watershed have changed very little in the past 30 years. Recently, however, tracts within the Buffalo Metropolitan Area in the towns of Wheatfield, Pendleton, Amherst, and Clarence, formerly forested or used for farming, have been developed for residential and industrial use. This development is necessary for socio-economic growth of the Buffalo Metropolitan Area. Statistics on future growth in the area are taken from the 1972 OBERS Projections, compiled by the President's Water Resources Council.

b. Nonindustrial Growth.

(1) Housing - In its 1972 edition of OBERS Projections the Water Resources Council projects that the population of the Buffalo Standard Metropolitan Statistical Area (SMSA) will increase from 1,350,597 in 1970 to 1,521,300 by 2020. This represents an increase of 170,703 persons, or roughly 13 percent of the 1970 population. At the present average rate of three persons per occupied dwelling in the Buffalo SMSA, approximately 57,000 new dwellings (apartments, townhouses, and single-family structures) will be needed in the area by 2020. Some access is now available for hunting, hiking, trapping, bird watching, and other recreational use. The access is over private lands provided by the owners and considered to be an important element of all flood management plans selected for implementation by the Corps.

(2) Recreation - Although need for recreational land is well established, the amount of land needed per person is open to discussion, so projection is difficult. Based on the standard used by the Erie and Niagara Counties Regional Planning Board which requires 25 acres per 1,000 persons, an additional 4,300 acres of land suitable for recreation will be needed within the SMSA by the year 2020.

(3) Transportation - Most parts of the Buffalo SMSA are already served by elaborate road, rail, water, and air transportation systems. These systems include the New York State Thruway and Queen Elizabeth Way, railroads of Conrail, Amtrak, and Canadian National Railways, the Great Lakes Navigation System and New York State Barge Canal, and the international airports of Buffalo and Niagara Falls. Although the growing shortage of petroleum is likely to induce a reduction in per capita transportation need, some expansion of existing facilities, particularly in the area of mass transit, should be anticipated.

c. Industrial Growth.

(1) General - According to the 1972 OBERS Projections, the number of employed persons living within the Buffalo SMSA will rise from 515,261 in 1970, to 677,700 in 2020. During the same time period, the total income of

persons living in the Buffalo SMSA is expected to rise from $4,820,299,000 to $20,993,200,000. Correlating these projections, the incomes of employed persons residing within the SMSA are expected to grow, between 1970 and 2020, an average of 331 percent.

(2) Primary Industries - According to the 1972 OBERS Projections, total personal income in primary industries within the Buffalo SMSA was $19,975,000 in 1970, and will increase to $46,900,000 by 2020. Presently, about two percent of employed persons residing within the SMSA work in primary industries; however, only about one-third of one percent of the work force is expected to be working in primary industries by 2020. Purportedly then, in 2020, a primary work force only one-fifth as large as today's will be earning over twice as much. This projected tenfold increase in incomes of primary workers is far greater than the projected average and suggests a greater production per primary worker in 2020. Then, as now, most primary workers are expected to be employed in agriculture; yet, in the next 50 years some land now used for agriculture is expected to be developed for other uses. Consequently, in 2020, land within the SMSA used for agriculture must be used more intensively than it is now used.

(3) Secondary Industries - According to the 1972 OBERS Projections, total personal income in secondary industries within the Buffalo SMSA was $1,771,136,000 in 1970, and will increase to $5,056,000,000 by 2020. Presently, about 40 percent of employed persons residing within the SMSA work in secondary industries, principally manufacturing. Many of these persons work in the manufacture of petroleum-powered transportation equipment. Because of the growing shortage of petroleum, previously anticipated expansion of such industry now seems less likely. According to OBERS statistics, incomes of persons employed in secondary industries are expected to grow an average of approximately 285 percent. This projected average growth, appreciably less than the industry-wide average of 331 percent, suggests that, within the SMSA, employment in secondary industries will grow somewhat more slowly than total employment. Accordingly, need for new development within the SMSA to accommodate secondary industries in 2020 is expected to be small.

(4) Tertiary Industries - According to the 1972 OBERS Projections, total personal income in tertiary industries within the Buffalo SMSA was $2,110,962,000 in 1970, and will increase to $11,128,300,000 by 2020. Correlation of these two amounts bears that from 1970 to 2020, incomes of persons residing within the SMSA and employed in tertiary industries are expected to grow an average of 527 percent. This projected average growth, considerably more than the industry-wide average of 331 percent, suggests that development within the SMSA to accommodate tertiary industries in 2020 will be considerable. Most of this development is expected to be compatibly integrated with residential development.

Projected New Development Within Floodlands Without Corps-Sponsored Flood Management.

a. Introduction.

In 1971, the New York State Office of Planning Coordination (later reorganized and renamed the New York Office of Planning Services) in collaboration with the U.S. Department of Housing and Urban Development, published a document entitled New York State Development Plan 1. This document presents the State's comprehensive plan for land use in New York State in 1990. The plan is depicted in Plate 4.

In projecting new development within the western part of the Huron Plain floodland, the State assumed construction of a new campus for the State University of New York at Buffalo and construction of the Audubon New Community in the northern part of the town of Amherst, both in the adjacent Ellicott Creek Watershed. Construction of the new campus and new community are well underway. Both developments will create new jobs in and near them. The State estimates that the new campus alone will create 50,000 jobs in and around it. The certainty that jobs will be created by these two developments greatly strengthens the credibility of the State's projection of development in this part of the watershed.

b. Nonindustrial Development.

(1) Housing - In its Development Plan 1, the State proposes that the need for residential development in the SMSA will be partially met by new development in the towns of Amherst, Clarence, Pendleton, and Lockport. Development is also projected for the city of Batavia. Projected population densities for these towns are shown in Plate 4. Some of the areas indicated for development lie within the Tonawanda Creek flood plain. Most large-scale residential development within the floodlands is expected to occur within the town of Amherst, where development of a new community, Ransom Oaks, has already begun and is expected to provide approximately 1,000 apartment, townhouse, and single-family dwellings before 1990. The 100-year flood outline is shown on Plate 4.

(2) Recreation - The State proposes that additional land within the watershed especially suited for recreational use, for instance, land adjacent to surface water bodies, be reserved for recreation. Most surface water bodies within the watershed are wetlands located near the Onondaga Escarpment in the northeastern part of the watershed; accordingly, as shown in Plate 4, much of the land designated by the State for recreation is located there. Within the Huron Plain floodland, the State is currently developing the 5,500-acre Tonawanda Game Management Area, both to improve wildlife habitats and to increase their accessibility to sportsmen. Additional land designated for recreational use is located in the Cattaraugus Hills, either adjacent to existing ponds and reservoirs or near the sites of proposed reservoirs.

(3) Transportation - The State proposes development of new transportation facilities, particularly mass transit facilities, to afford better service between present and new residential and industrial developments.

Of facilities proposed to serve development within floodlands of the watershed, those of principal importance are the Outer Belt Expressway and Lockport Expressway. Proposed alignments of these two expressways are shown on Plate 4. Other facilities proposed to service development within floodlands include arterials, local roads, and streets in the towns of Amherst, Clarence, Pendleton, and Lockport. Some of them would be provided by modifying existing roads to increase their traffic capacities; others would require new construction.

c. Industrial Development.

(1) Primary - Because soils in the lowlands of the watershed are especially fertile, the State proposes that all suitable tracts within these lowlands, not needed for urbanization in 1990, be used for farming. Plate 4 shows that large tracts allotted by the State for farm use in Development Plan 1 are within the two floodlands.

(2) Secondary - The State proposes that suitable tracts, strategically located within newly designated urban areas, be developed for use by secondary industries by 1990. Some construction industries which will be needed to effect development within the watershed, and some manufacturing industries, especially those to produce lightweight, high-cost, durable goods, are expected to be established within the floodlands soon. Most new development to accommodate secondary industries will likely occur in the towns of Amherst and Clarence. A land use plan recently developed by the town of Amherst provides for industrial development of a large tract bounded by the proposed Lockport and Outer Belt Expressways and Ransom and Tonawanda Creeks. Part of this tract is within the Huron Plain floodland.

(3) Tertiary - The State proposes that developments to accommodate tertiary industries be provided throughout newly designated urban areas by 1990. Some of these developments, particularly within the towns of Amherst and Clarence, are likely to be located within floodlands. The land use plan of the town of Amherst provides for development of five separate tracts within floodland there for use by tertiary industries. The largest development is to occupy a tract astride Ransom Creek, adjacent to the Ransom Oaks new community.

Need for Flood Management for Projected Development.

In view of projected need for new development within the watershed and vicinity, and the State's Development Plan 1 which places some of that new development within the floodlands, the need for flood management within the watershed is expected to increase substantially.

SECTION IV

IDENTIFICATION OF MEASURES TO PROVIDE FOR FLOOD MANAGEMENT NEEDS

INTRODUCTION

Measures considered for flood management in the Tonawanda Creek Watershed are of two different kinds, nonstructural and structural. The two kinds are not necessarily different in physical character, as their names imply, but rather are different in function. Nonstructural measures protect against flood damage at specific sites but do not manage the flooding itself. Conversely, structural measures protect against flood damage by altering the characteristics of flooding.

During this study, local parties have expressed little interest in nonstructural protection. However, several nonstructural and structural measures are discussed in this Section and subsequent Sections of this report. This is part of a screening process to develop, identify, and select the most suitable, feasible, and appropriate plan to satisfy the Planning Objectives stated in Section V of this report and still be a reasonably socially acceptable plan for implementation.

NONSTRUCTURAL MEASURES

Introduction.

Nonstructural measures for use in flood management have two general functions: to protect against flood-related losses at individual sites, and to reduce overall need for flood protection. Flood warning and emergency action, floodproofing, and flood insurance are designed to partially protect against flooding at individual sites of possible flood damage. Flood plain management and permanent evacuation reduce need for flood protection by regulating flood-damageable uses, but provide no protection for existing development.

The five kinds of nonstructural measures described below have been considered, in combination with other nonstructural measures and structural measures, for flood management in the Tonawanda Creek Watershed. Plans including nonstructural measures are presented in Section V.

Flood Warning and Emergency Action.

Flood warning measures provide information about possible flooding so that those who might be affected by such flooding can escape with some belongings, or can employ emergency measures, such as sandbags, to protect themselves.

Flood warning could serve floodprone areas in the lower watershed. Normally, floodwaters flow slowly enough so that there are several hours or even days for warning in downstream areas of the watershed. However, there is no formal warning system in the watershed.

Two plans including this measure are presented in Section V.

Floodproofing.

Floodproofing measures, both temporary and permanent, provide onsite protection of individual properties against flood-related damages. Temporary measures include closure devices and barricades. Permanent measures include watertight substructures, building anchors, pedestal foundations, and individual dikes, levees, and floodwalls. Floodproofing should only be considered on a voluntary basis. Condemnation is not considered practicable.

Many of the older houses and farm buildings within the watershed have been located on knolls or rises. Normally, the structures remain dry, although they are sometimes isolated for periods of time. Newer residential structures, however, even in rural areas, have not always been placed on higher ground and are more susceptible to damage. Floodproofing, therefore, may be most applicable for the newer residential areas in the watershed.

The time available for placing temporary floodproofing structures varies depending on location. In upstream areas of the watershed, in the vicinity of the villages of Attica and Alexander, the warning time is normally too short. In areas downstream from the city of Batavia, particularly in the vicinity of the hamlet of Wolcottsville and Rapids, there is adequate time.

A plan including this measure is presented in Section V.

Flood Insurance.

Flood insurance provides some financial protection to victims of flood-related property losses, but does nothing to prevent such losses.

In the 1968 National Flood Insurance Act, Congress designated the Secretary of Housing and Urban Development (HUD), to establish and prosecute a National Flood Insurance Program to promote regulation of uses of lands susceptible to special flood hazards, to curb risks of future flood damage, and to afford Federally insured flood insurance at low premium rates. The amended law provides that such insurance is to be made available under the program only to those communities having assured the Secretary that they would develop, by 30 June 1975, adequate regulations governing use of all lands under their jurisdictions susceptible to special flood hazards.

Because local response to provisions of the National Flood Insurance Act of 1968 was generally apathetic, Congress later enacted the Flood Disaster Protection Act of 1973. In this act, Congress stipulated that a community having jurisdiction over lands susceptible to special flood hazards could not receive Federal assistance of any kind unless it participated in the flood insurance program established by the 1968 act, and that an owner of flood-damageable property within such lands, could not receive assistance of any kind from the Federal Government (or any agency or institution supervised, regulated, or insured by the Federal Government) in acquiring or improving such property unless he purchased flood insurance to protect it.

All communities within the Tonawanda Creek Watershed are eligible for flood insurance. Various areas within some communities, including the villages of Attica and Alexander and the city of Batavia, have been identified as special flood hazard areas. These communities may purchase flood insurance to be eligible for any new or additional Federal, or Federally-related, financial assistance for any building within community limits.

A plan including this measure is presented in Section V.

Flood Plain Management. (Land Use Regulation)

Flood plain management measures regulate land use to prevent or reduce future flood-damageable development in flood plains. Flood plain management does not address the problem of damageable structures already in the flood plain.

One intent of the National Flood Insurance Program, discussed above, is to encourage communities to adopt effective flood plain management regulations. By means of zoning laws, building codes, and subdivision regulations, a flood plain management program would prevent highly damageable uses of floodlands, while permitting less susceptible uses such as farming and recreation. Regulations keeping obstructive developments out of floodways, would not only prevent damages to such developments themselves, but would also prevent flow obstructions which might raise stages and worsen flooding upstream. Presently, large tracts of the floodlands of Tonawanda Creek Watershed are free of highly damageable developments, and could be kept so by effective flood plain management. However, small tracts of these floodlands, particularly in the towns of Batavia, Clarence, and Amherst, are already occupied by highly damageable developments. In some places, developments extend to the channel banks. Perpetuation of such undesirable development could be prevented by regulations permitting local governments to acquire such flood-susceptible property for flood-compatible purposes, or to require that new developments be floodproofed. Since flood plain management regulations and flood insurance zones are based on a 100-year frequency of flooding, any structural measures which reduce the 100-year flood plain would also affect flood plain management regulations.

A plan including this measure is presented in Section V.

Permanent Evacuation.

Permanent evacuation measures remove existing flood-damageable structures from flood susceptible lands and thereby eliminate to some degree the need for flood damage management.

A plan including this measure is presented in Section V.

STRUCTURAL MEASURES

Introduction.

There are two basic kinds of structural measures for flood management: local protection and regional protection measures. Local protection measures, such as modified channels, diversions, levees, and floodwalls, conduct floodwater through or away from flood-damageable areas, and protect properties only in their immediate vicinities. Regional protection measures, such as detention reservoirs and storage reservoirs, store floodwater upstream from damageable areas and release it at nondamaging rates. Regional measures protect, to some degree, all properties within the watershed downstream from them.

The following structural measures have been considered for flood management in the Tonawanda Creek Watershed. Proposed locations are shown on Plate 5. In 1976, the Erie-Lackawanna Railroad operated a line that ran north and south between the village of Alexander and the city of Batavia. This line, between the Lehigh Valley Railroad overpass near the city limits of Batavia and the Erie-Lackawanna Railroad overpass near the village of Alexander, has recently been abandoned and is no longer needed. However, the description of the plans, costs, and plates associated with the Alexander Reservoir, Batavia Reservoir, and the Batavia Reservoir Compound reflect conditions in 1976 when the line was active. Other data related to the structural measures and their effectiveness in reducing flood damages are based upon data available in 1976.

Local Protection Measures Considered.

a. Introduction.

Local parties have expressed interest in modifying the existing channel of Tonawanda Creek to increase its capacity in both floodlands of the watershed. Suggested work includes channel clearing and snagging, and channel enlarging and straightening. Such work was considered during the preliminary phase of this study but was found to be economically unjustifiable and environmentally unacceptable. Therefore, such work was not considered further during this final phase of study. Two sets of local protection measures: the Batavia Project Modification and the Clarence-Amherst Diversion, have been considered during this final phase of study.

b. Batavia Project Modification.

In 1962, the Corps completed a study in which the following local protection work was found to be feasible: construction of a levee to extend from an embankment of the New York Central Railroad near the southern limit of the city of Batavia, northward approximately 3,200 feet along the creek, to Chestnut Street; protection of the left bank of the creek channel over a distance of approximately 1,300 feet from a small municipal dam on the creek, upstream, within the city of Batavia; and enlargement and protection of the creek channel over a distance of approximately 2-1/2 miles from the downstream end of the reach of channel improved by the Corps in 1956, to the village of Bushville. See Plates 5 and 11. Although the District and

Division Engineers recommended this work, the Board of Engineers for Rivers and Harbors requested that alternative plans for flood management in the watershed be considered further. The recommended work has been reconsidered in this study.

A plan including this measure is presented in Section V.

c. Clarence-Amherst Diversion Measure.

The Erie and Niagara Counties Regional Planning Board (ENCRPB) recommended provision of a diversion measure in the Huron Plain. The measure would include a diversion channel, an associated dike, and two associated levees. The channel would be located in the towns of Clarence and Amherst, would extend from the Tonawanda Creek channel, near its junction with Beeman Creek, approximately seven miles along an east-west course south of Tonawanda Creek to near its junction with Ransom Creek, and would conduct flood flows of Tonawanda and Black Creeks to the New York State Barge Canal. See Plate 5. The dike would be located in the town of Clarence, would extend in a north-south direction near State Route 78, and would divert flood flows of Black Creek to the diversion channel. The levees would be located in the town of Clarence. One would extend from the inlet of the diversion channel along a north-west course west of, near, and generally parallel to the Tonawanda Creek channel. The other would extend from the inlet of the diversion channel along a southerly course west of, near, and generally parallel to the Beeman Creek channel.

The two levees would prevent overland flow from the Tonawanda Creek valley and Beeman Creek Watershed into the Black Creek Watershed.

The diversion measure would lessen flooding in the western part of the Huron Plain. However, the measure would increase the risk of flooding along the New York State Barge Canal, which is now capable of conducting flows likely to occur once in 6 to 20 years. Additionally, the levees would worsen flooding upstream from them in the eastern part of the Huron Plair.

This measure is discussed further in Section V.

Regional Protection Measures Considered.

a. Introduction.

Local parties have expressed interest in developing a group of small reservoirs in headlands of the Tonawanda Creek Watershed. A group of seven small reservoirs was considered during this study. The sites for these reservoirs were identified as worthy of further consideration by the U.S. Department of Agriculture in its 1967 report entitled Erie-Niagara Basin Preliminary Upstream Reservoir Studies. The sites for the reservoirs are on

the East Fork of Tonawanda Creek in the southeastern part of the town of Sheldon;

an unnamed tributary of Tonawanda Creek in the northeastern part of the town of Pembroke;

an unnamed tributary of Murder Creek, in the southeastern part of the town of Darien;

Huron Creek in the northeastern part of the town of Darien;

Bowen Creek in the northwestern part of the town of Alexander;

Bowen Creek in the southwestern part of the town of Batavia; and

Little Tonawanda Creek near the Wyoming-Genesee County line (for the Linden Reservoir).

The total drainage area above these sites is 56.3 square miles. Of the seven reservoirs considered, only the Linden Reservoir would have enough flood management capability to warrant further consideration. The other six reservoirs would intercept runoff from a total drainage area of only 34.90 square miles, or about 7 percent of the watershed, and would be far upstream from major damage areas. Since these six small reservoirs would provide only minimal protection in the major floodlands of the watershed, they were not considered further.

Six regional flood management measures have been considered in this final phase of study. They include the Sierks Reservoir; Linden Reservoir; Alexander Reservoir; Batavia Reservoir Compound; Batavia Reservoir; and Alabama Reservoir Compound. As a result of additional engineering studies and public input since 1976, the Batavia Reservoir Compound plan has been modified. However, the operational concept is similar to the plan discussed in this Section of the report. The modified plan, designated "the Batavia Reservoir Compound (Modified)," is discussed in Sections VI, VII, and VIII of this main report and in the appropriate appendices to this report. These reservoirs are of two types: storage reservoirs with permanent pools that are used for nonflood management purposes, such as water supply and recreation; and detention reservoirs, which are normally dry and impound water only during flooding.

Each of these measures has been considered alone and in combination with other measures described in this Section. Plans including them are presented in Section V.

b. Sierks Reservoir.

This measure, shown on Plates 5 and 6, would be a storage reservoir on Tonawanda Creek in the Cattaraugus Hills, near the hamlet of Sierks. It could serve five purposes: flood management, fishery enhancement, recreation, water quality management, and irrigation. (Because of limited time and money, only the first purpose was considered in this study). The measure would comprise an earth dam and a permanent pool normally having a maximum depth of 87 feet and surface area of 1,050 acres. The dam would be located approximately three miles upstream from the village of Attica.

The principal outlet works and emergency spillway would be one and the same, constructed of reinforced concrete, and would be located near the west abutment of the dam. This spillway would comprise an ogee-shaped weir equipped with four manually operable tainter gates, and would have capacity to discharge a maximum probable flow.

The Sierks Reservoir would intercept runoff from 61.3 square miles of the Cattaraugus Hills, which are a major source of runoff presently contributing to flooding in the watershed. This tract represents approximately 35.6 percent of the watershed above the city of Batavia and 9.5 percent of the whole watershed.

Two alternative plans including the Sierks Reservoir are presented in Section V.

c. Linden Reservoir.

This measure, shown on Plates 5 and 7, would be a storage reservoir on Little Tonawanda Creek in the Cattaraugus Hills, near the hamlet of Linden. The measure could serve the same five purposes as the Sierks Reservoir; however, for reasons cited above, only flood management was considered in this study. It would comprise a dam constructed of earth fill, principal outlet works constructed of reinforced concrete, an emergency spillway excavated in natural soils formations, and a pool normally having a maximum depth of 63 feet and surface area of 1,015 acres. The dam would be located approximately 0.2 mile upstream from the hamlet of Linden. The principal outlet works would be located near the west abutment of the dam; would be equipped with manually operable gates; and would have capacity to discharge a probable 100-year degree peak flow of approximately 6,500 cubic feet per second. The emergency spillway would be located in the east abutment of the dam and would have capacity to discharge a maximum probable flow.

The Linden Reservoir would intercept runoff from a tract of the Cattaraugus Hills 21.4 square miles in area. This tract represents approximately 12.4 percent of the watershed above the city of Batavia and approximately 3.3 percent of the whole watershed.

An alternative plan including the Linden Reservoir is presented in Section V.

d. Alexander Reservoir.

This measure,shown on Plates 5 and 8, would be a detention reservoir (normally dry) on Tonawanda Creek near the upstream limit of the Erie Plain, near the village of Alexander. It would serve flood management only.

The reservoir would have a dam adjacent to, and, downstream from an abandoned embankment of the Erie-Lackawanna Railroad, extending across the flood plain between the hamlets of North Alexander and East Alexander. The dam would stand roughly five feet higher than the railroad embankment.

A line of the Erie Railroad would pass through an opening in the dam. The opening would be equipped with means for floodproofing it temporarily during flooding.

The principal outlet works and emergency spillway of the reservoir would be one and the same, and would be located in the dam, near its intersection with the Tonawanda Creek channel. The spillway would comprise an articulated weir with its crest near the elevation of the adjacent flood plain. It would be equipped with five electrically operable tainter gates and would have capacity to pass the Standard Project Flood flow.

The Alexander Reservoir would intercept runoff from a tract of the Cattaraugus Hills 102 square miles in area. This tract represents approximately 59.3 percent of the watershed above the city of Batavia and approximately 20.0 percent of the whole watershed.

An alternative plan including the Alexander Reservoir is presented in Section V.

e. Batavia Reservoir Compound.

The Batavia Reservoir Compound, depicted in Plates 5 and 9, would serve only flood management. It would comprise two shallow detention reservoirs (normally dry) arranged in series. The reservoirs would have dams provided adjacent to two railroad embankments. Each would have its own principal outlet works and emergency spillway. Together, they would include a tract of roughly 4,840 acres within the floodland between the village of Alexander and the city of Batavia.

The upper dam would be adjacent to and downstream from the Erie-Lackawanna Railroad embankment and would stand roughly the height of the embankment. A line of the Erie Railroad would pass through an opening in this dam. The opening would have to be provided with means for floodproofing it temporarily during flooding.

The principal outlet works of the upper reservoir would be located in its dam, at or near its intersection with the Tonawanda Creek channel. These outlet works would pass flows up to approximately 2,000 cubic feet per second as open channel flow.

The emergency spillway of the upper reservoir would extend across the dam. The spillway would have capacity to discharge a maximum probable flow.

Land to be used for the upper reservoir would include roughly 940 acres of farmland, wetland, and woodland.

The lower dam would be adjacent to and upstream from the Lehigh Valley Railroad embankment. It would extend roughly along the railroad embankment, from near State Route 98 to near Ellicott Street. A line of the Erie Railroad also passes through an opening in this embankment. This opening would be provided with means for floodproofing it temporarily during flooding, to insure intended storage capacity of the lower reservoir. Low dikes would be constructed adjacent to Ellicott Street between the Lehigh Valley Railroad embankment and Shepard Road, and adjacent to State Route 98, between the intersections with the railroad embankment and Dodgeson Road.

The principal outlet works of the lower reservoir would be located in the dam adjacent to the existing railroad bridge over the creek, and would have capacity to discharge approximately 6,000 cubic feet per second.

The emergency spillway of the lower reservoir would be located in a saddle in the divide between the Tonawanda Creek valley and adjacent Bowen Creek Watershed, near the intersection of State Route 98 and Dodgeson Road. The spillway would have capacity to discharge the maximum probable flow. Land to be used for the emergency spillway would include roughly 1,730 acres of farmland, wetland, and woodland. Part of this land would likely be flooded once in about 500 years. All of it would likely be flooded far less frequently than this.

Land to be used for the lower reservoir would include roughly 3,900 acres of principally farmland, wetland, and woodland.

The Batavia Reservoir Compound would intercept all runoff from that part of the Tonawanda Creek Watershed upstream from the city of Batavia - a tract of 172 square miles representing approximately 33.7 percent of the whole watershed. This tract includes all of the major source of runoff - the Cattaraugus Hills - contributing to flooding in both floodlands of the watershed.

A plan including the Batavia Reservoir Compound is presented in Section V.

f. Batavia Reservoir.

This measure, shown in Plates 5 and 10, would be a detention reservoir (normally dry) on Tonawanda Creek immediately upstream from the city of Batavia. It would serve flood management only.

The reservoir would have a dam adjacent to, and upstream from, an embankment of the Lehigh Valley Railroad. The dam would stand roughly seven feet higher than the railroad embankment.

A line of the Erie Railroad would pass through an opening in the dam. The opening would be equipped with means for floodproofing it temporarily during flooding.

The principal outlet works of the resevoir would be located in the dam near its intersection with the Tonawanda Creek channel. They would comprise four closed conduits, located side-by-side and equipped with electrically operable gates which would be operated so that they would never pass more than 3,000 cubic feet per second.

The emergency spillway of the reservoir would be located in a saddle in the divide between the Tonawanda Creek valley and adjacent Bowen Creek Watershed, near the intersection of State Route 98 and Dodgeson Road. Bowen Creek is a small tributary of Tonawanda Creek, joining it downstream from the city of Batavia and near the village of East Pembroke. The spillway would be a grassed channel. It would be 5,000 feet wide and would have capacity to pass the probable maximum flow. Land to be used for the emergency spillway would be the same to be used for the emergency spillway of the Batavia Reservoir Compound.

Land to be used for the reservoir would include roughly 6,460 acres of principally farmland, wetland, and woodland.

The Batavia Reservoir would intercept runoff from the same part of the Tonawanda Creek Watershed as the Batavia Reservoir Compound, described above.

Two alternative plans including this measure are presented in Section V.

g. Alabama Reservoir Compound.

This measure would be a complex of reservoirs including both storage and detention reservoirs in the Huron Plain floodland near the hamlet of Alabama in adjacent Oak Orchard Creek Watershed. The measure, depicted in Plates 5 and 12, would serve flood management only. It would include eight reservoirs (two storage reservoirs and six detention reservoirs) a diversion measure to convey floodwater from nearby Tonawanda Creek to the storage reservoirs; internal principal outlet works to discharge water from the storage reservoirs to the detention reservoirs; an internal emergency spillway to discharge water from the storage reservoirs to the detention reservoirs; two external principal outlet works to discharge water from the reservoir compound; one emergency spillway to discharge water from the compound; and periodically, two pools, one in each storage reservoir, each having a maximum depth of roughly 17 feet, and together having a maximum surface area of approximately 1,460 acres.

The reservoir compound would occupy about 3,000 acres within the northern part of the 5,500-acre Tonawanda Game Management Area mentioned in Section II. The dikes providing the reservoirs would include 27,000 feet of existing embankments along Feeder Road, Meadville Road, and Wagoner Road (modified as necessary) and 45,600 feet of new earth fill embankments. The dikes would stand about 17 feet above the adjacent flood plain.

The Alabama Reservoir Compound would intercept most excess runoff from that part of the Tonawanda Creek Watershed above its inlet structure - a tract of 230 square miles comprising approximately 45 percent of the whole watershed. Furthermore, the measure could cooperate with an existing dike along Salt Works Road to prevent overflow from Oak Orchard Creek Watershed.

As mentioned previously, New York State has constructed an extensive network of dikes on the proposed site of the Alabama Reservoir Compound. The arrangement of dikes in the network is slightly different from that previously considered by the State, and shown in Plate 12. However, most dikes of the network are situated within the tract delineated by the perimeter dike.

SECTION V

DEVELOPMENT OF ALTERNATIVE PLANS FOR FLOOD MANAGEMENT

RATIONALE FOR PLAN DEVELOPMENT

The rationale used to develop alternative plans for flood management in the Tonawanda Creek Watershed was that each plan to be developed should meet the flood management objectives identified below.

PLANNING OBJECTIVES

Introduction.

Two general planning objectives were pursued during this study. One was to address the Congressional resolutions authorizing this study. The second was to address the National Water and Related Land Management Objectives prescribed by the U.S. Water Resources Council. Each of these two general planning objectives has been defined in terms of the specific objectives identified below.

Flood Management.

The Congressional resolutions authorizing this study require that consideration be given to providing for all needs for flood management in the Tonawanda Creek Watershed. The specific flood management objective, then, was to develop alternative plans to protect, as fully as practicable:

human health and life;

property;

industry; and

environment

in the Tonawanda Creek Watershed. One hundred-year protection was considered reasonable wherever human health and life, property other than land, and industry other than agriculture were to be protected. Lesser protection was considered reasonable for land, including farmland, and the non-land environment. Alternative plans were designed to enhance the natural environment as much as possible, while providing protection to development.

National Water and Related Land Resources Management.

The Principles and Standards for Planning Water and Related Land Resources requires that alternative plans for flood management include a plan designed to maximize national economic development, and one designed to emphasize enhancement of environmental quality.

Because non-structural flood damage management measures generally tend to cause fewer adverse impacts to the environment than structural measures, an optimum non-structural plan for a watershed was developed. A no-action plan was developed as a base condition by which the other considered alternatives were considered.

The specific National Water and Related Land Resources Management Objectives, then, were to develop alternative plans to:

maximize national economic development (NED);

emphasize enhancement of environmental quality (EQ); and

provide optimum non-structural flood damage management in the Tonawanda Creek Watershed.

PLANNING CRITERIA

Criterion for Flood Management.

In accordance with the Congressional resolutions authorizing this study, plans were developed to provide, as fully as practicable, for all flood management needs in the watershed.

Criteria for Developing the Non-structural Base Plan.

Criteria applied to develop the Non-structural Base Plan, are contained in the Corps Engineering Regulation (ER) 165-2-500 and ER 1165-2-26.

Criteria for Maximizing NED.

Criteria applied to achieve the NED objective are contained in Senate Document No. 97, 87th Congress, entitled Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use in Development of Water and Related Land Resources. These criteria require that, in order to be recommended,

a plan's benefit (tangible and intangible) must exceed its costs (tangible and intangible);

each separable part of a plan must provide benefit at least equal to its cost;

a plan should optimize net benefit (although a plan that afforded less than maximum benefit could be considered provided adequate gains in environmental quality and/or social well-being would result); and

implementation of a plan must not preclude some other more economic plan capable of serving equally well.

Criteria for Emphasizing Enhancement of EQ.

Criteria applied to achieve the EQ objective are contained in three separate documents: Public Law 91-190, published 1 January 1970, and entitled National Environmental Policy Act of 1969; Public Law 91-611, published 31 December 1970, and entitled Flood Control Act of 1970; and the above-mentioned Principles and Standards.

Criteria contained in the National Environmental Policy Act of 1969 require that the reporting officer:

analyze the environmental impact of a considered action;

identify unavoidable adverse effects which such action would cause;

evaluate alternatives to the considered action;

determine the relationship between local short-term uses of man's environment and maintenance and enhancement of long-term productivity; and

account for irreversible and irretrievable commitments of resources which such considered action would cause.

Criteria contained in the Flood Control Act of 1970 require that the reporting officer consider eliminating or minimizing:

air, noise, and water pollution;

destruction or disruption of man-made and natural resources, aesthetic values, community cohesion, and the availability of public facilities and services;

adverse employment effects and tax and property value losses;

injurious displacement of people, businesses, and farms; and

disruption of desirable community and regional growth.

Criteria contained in the Principles and Standards require that the reporting officer consider the desirability of increasing the costs of plans to enhance environmental quality. Specifically, it requires that he consider the need to:

manage, protect, enhance, and create areas of natural beauty and human enjoyment;

manage, preserve, and enhance especially valuable or outstanding archeological, historical, biological, and geological resources and ecological systems;

harmonize use of land, water, and air resources for economic development and gain with need to conserve these resources; and, to that end, to enhance quality of air, land, and water by control of pollution, and prevention of erosion; and to

avoid irreversible commitments of resources which might cause undesirable and irreversible changes in the natural environment.

APPRAISAL OF CONSIDERED MEASURES

Introduction.

Measures considered for flood management in the Tonawanda Creek Watershed, as part of a screening process, were identified in Section IV. These measures were considered equally and impartially for designation in one or more alternative plans. But none of these measures would serve the need for flood management equally. Logical combinations of them could be determined only after thorough appraisal of flood management capabilities of each.

A brief appraisal of the capability of each measure considered in this study to serve the flood management objectives except for the Batavia Reservoir Compound (modified) that is discussed in Sections VI and VII of this report, is presented below.

Certain characteristics and impacts of each measure pertaining to the planning objectives are presented in Table 8.

Nonstructural measures.

a. Flood Warning and Emergency Action.

Flood warning and emergency action measures could significantly protect human life, health, and property. The actual degree of protection would depend on the ability and willingness of 'ndividuals to act quickly when warned of possible flooding. A possible adverse effect of these measures is that, having taken emergency action, some residents would be inclined to stay in floodprone areas. In a serious flood, these people could suffer greater loss than if they had simply evacuated.

b. Floodproofing.

Floodproofing could protect to some extent life, health, and property but should be considered on a voluntary basis only. Condemnation is not considered practicable. The degree of protection would depend on the depth, duration and speed of flood flows and the amount of debris carried by them. Serious flooding could strand people for extended periods in floodproofed structures, cutting them off from necessary supplies and services. Hydraulic loading of floodwaters against the walls of floodproofed structures could cause them to collapse, resulting in greater damage than might have occurred without floodproofing. Fast-flowing and/or debris-laden flood currents could cause considerable damage to floodproofed structures, reducing the supposed benefits of the floodproofing measures.

Table 8 - Characteristics of Considered Measures

Item	Flood Warning and Emergency Action	Flood-proofing	Flood Insurance	Floodplain Management	Permanent Evacuation	Sierks Reservoir	Linden Reservoir	Alexander Reservoir	Batavia Reservoir Compound	Batavia Reservoir	Batavia Project Modification	Alabama Reservoir Compound	Clarence-Amber Diversion Measure
ENVIRONMENTAL QUALITY													
Woody Scrubland Gained or Lost (+ acres)	None	None	None	None	None	Consider. Loss	Consider. loss	-4	-22	-28	Negligible	-105	Some loss
Wetlands Gained or Lost (+ acres)	None	None	None	None	None	None	None	-6	- 8	- 6	None	None	None
Natural Channel Bottom Gained or Lost (+ acres)	None	None	None	None	None	- 3	-3.5	Some loss	Some gain	Some gain	Some loss	None	Some loss
Improved Channel Bottom Gained or Lost (+ acres)	None	None	None	None	None	None	None	Some gain	Some gain	Negligible	Some gain	None	Some loss
Unvegetated Land Areas Gained or Lost (+ acres)	None	None	None	None	None	-20	-5	None	Some gain	Negligible	None	None	None
Revegetated Area Gained or Lost (+ acres)	None	None	None	None	None	+10	+10	Some gain	Some gain	Some gain	Some gain	Possible +1540	Some gain
Cultivated Land Gained or Lost (+ acres)	None	None	None	None	None	Some loss	Some loss	Some gain	Consider. gain	Some gain	None	Some gain	Some loss
Pool Environment Gained or Lost (+ acres)	None	None	None	None	None	+810	+920	None	None	None	None	+1460	None
Effect on Stream Quality	None	None	None	None	None	Positive	Positive	Positive	Positive	Positive	Negative	Positive	Negative
Effect on Air Quality	None	None	None	None	None	None	None	None	None	None	None	None	None
Effect on Local Wildlife Breeding Habitat	None	None	None	None	None	Negative	Negative	Negligible	Positive	Negligible	Negative	3/	1/
Rare, Endangered, or Unique Species Affected	None	None	None	None	None	None	None	None	None	None	Unknown	Blue heron	1/
Scenic, Recreation, or Wilderness Area Affected	None	None	None	None	None	s.,r.gain;w loss	s.,r.gain;w loss	None	None	None	Unknown	r.gain;s,w loss	None
Historical and/or Archeological Sites Affected	None	None	None	None	None	Unknown	Unknown	None	To be determined	1	Unknown	None	1/
Effect on Stream Erosion	None	None	None	None	None	Positive	Positive	Positive	Positive	Positive	Negative	Positive	Negative
Mineral Resources Affected	None	None	None	None	None	Maybe salt or natural gas	Maybe salt	None	None	Gravel	None	None	3/
Effect on Area Water Table	None	None	None	None	None	Positive	Positive	Negligible	None	Negligible	Negligible	Positive	Negligible
SOCIAL WELL-BEING													
Flood Protection													
Residences Protected	None	1/	None	None	Some	All downstream	All downstream	All downstream	All downstream	All downstream	Some locally	All downstream	Some locally
Businesses Protected	None	1/	None	None	Some	All downstream	All downstream	All downstream	All downstream	All downstream	Some locally	All downstream	Some locally
Farmlands Protected (acres)	None	1/	None	None	Some	All downstream	All downstream	All downstream	All downstream	All downstream	None	All downstream	Some locally
Total Flood Damage Reduction (percent)	None	1/	None	None	Positive	Roughly 38	Roughly 10	29	53	62	14	42	1/
Effect on Downstream Flooding	None	None	None	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Negative	Positive	Negative
Relocations Required (residences)	None	None	None	None	Neg impact	26	23	8	82	40		9	1/
Bridge Modifications or Removal	None	None	None	None	None	1	1	None	None	None	None	1	1/
Roads Severed	None	None	None	None	None	4	2	1	None	1	None	None	1/
Socially Important Sites Affected (churches, etc)	None	None	None	None	Some	1	1	None	None	None	None	None	1/
Effect on Public Health and Safety	Minor	None	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
Effect on Available Water Supply	None	None	None	Positive	None	Positive	Positive	None	Positive	Some	Negligible	Positive	None
Effect on Recreation Activities	None	None	None	Positive	Positive	Positive	Positive	Negligible	Positive	Negligible	Negligible	Positive	Positive
REGIONAL DEVELOPMENT													
Loss in Area Tax Base	None	Negative	None	Some	Some	Considerable	Considerable	Some	Negligible	Considerable	Some	Some	Some
Effect on Community Development Patterns	None	Negative	Positive	Negative	Negative	Negative	Negative	Negative	None	Negative	Positive	None	Negligible
Effect on Recreation Developments	None	None	None	Positive	Positive	Positive	Positive	None	Positive	Negative	Negative	Positive	Positive
Effect on Regional Economic Growth	None	Negative	Positive	Negative	Negative	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive

1/ Not determined
2/ Value is likely low
3/ Cannot be determined

c. Flood Insurance.

Flood insurance is available to watershed residents through private programs and through the Federally subsidized National Flood Insurance Program.

Most communities having jurisdiction over the floodlands of the watershed receive Federal assistance of some kind, and under the Flood Disaster Protection Act of 1973, these communities must participate in the National Flood Insurance Program in order to continue to receive Federal funds. Therefore, it is likely that most of these communities will participate in the national program, which provides for land use regulation to prevent further development in floodprone areas.

However, flood insurance would provide no direct protection for life, health, or property; its sole benefit would be to financially compensate flood victims for their losses.

d. Flood Plain Management (Land Use Regulation).

Flood plain management would provide no protection for existing flood-susceptible development. However, additional susceptible development could be prevented or reduced by local land use regulation. The amount of damage prevented would depend on the stringency of regulation.

A flood plain management program consistent with the provisions of the National Flood Insurance Program would restrict development within lands susceptible to flooding of 100-year degree. Such a program would reduce the value and utility of some 11 percent of land in the watershed, large tracts of which have been designated by New York State to be developed to meet projected growth needs in the watershed.

Damages from flooding of greater than 100-year degree would not be prevented under the National Program.

e. Permanent Evacuation.

Permanent evacuation would eliminate the need for flood protection where implemented. Permanent evacuation might prove the most economical solution to flood problems at isolated sites within rural parts of the floodlands shown on Plate 4.

Structural Measures.

One type of structural measure that was investigated for flood damage reduction was a levee system. The levees would have to be built along the entire length of the creek for containment of the flood waters. The cost of such an extremely large project could not be justified. Therefore, this measure was not considered further. The following pages provide a description of several other local and regional protection measures that were considered.

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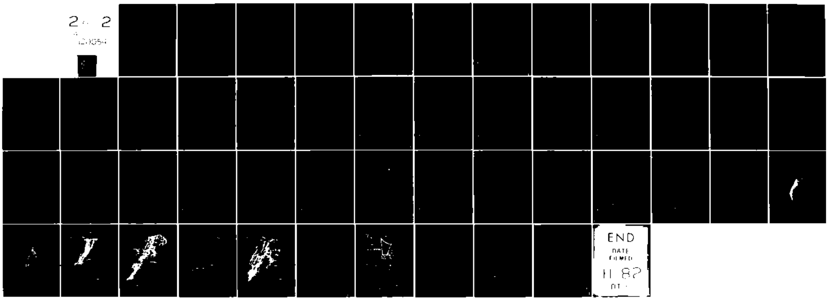

a. Local Protection Measures.

(1) Batavia Project Modification. Modification of the Corps project in the city of Batavia would satisfy to some extent three of the four flood management objectives. Need to protect the environment would not be satisfied appreciably. The modification would provide 25-year protection, and would benefit the city of Batavia and downstream vicinity only. During flows exceeding design flow, operation of the measure would cause some erosion damage throughout the improved reach of channel, and throughout a short

reach of channel downstream. It would cause increased deposition damage in flood-susceptible parts of the watershed downstream.

(2) Clarence-Amherst Diversion Measure. The Clarence-Amherst Diversion Measure would satisfy to some extent three of the four flood management objectives. Need to protect environment would not be satisfied appreciably. The measure would provide 25-year protection and would benefit parts of the towns of Clarence and Amherst only. Operation of the measure would worsen flooding upstream from its flow-training entrance levees. It would tend to increase flows in the Tonawanda Creek channel downstream from it; and, accordingly, would increase risk of flooding in adjacent, highly developed, areas. Because this measure would provide only limited protection in the Huron Plain and could cause significant external flood damage, it is not considered a viable local protection measure. Accordingly, this measure has been eliminated from further consideration.

Regional Protection Measures.

a. Sierks Reservoir. The Sierks Reservoir would satisfy to some extent all four flood management objectives in both floodlands of the watershed. It would provide roughly 100-year degree protection in the Erie Plain floodland, including the villages of Attica and Alexander, and the city of Batavia. It owuld provide only marginal protection in the Huron Plain floodlands.

b. Linden Reservoir. The Linden Reservoir would satisfy to some extent all four flood management objectives in both floodlands of the watershed. It would provide roughly 200-year degree protection in most of that part of the Erie Plain within the Little Tonawanda Creek Watershed. It would provide nominal protection in the Huron Plain floodland.

c. Alexander Reservoir. The Alexander Reservoir would satisfy to some extent all four flood management objectives in both floodlands of the watershed. It would provide roughly 20-year degree protection in that part of the Erie Plain downstream from it, including the city of Batavia. It would provide nominal protection in the Huron Plain floodland.

d. Batavia Reservoir Compound. The Batavia Reservoir Compound would satisfy to some extent all four flood management objectives in both floodlands of the watershed. It would provide protection of roughy 10-year degree in tract of the Erie Plain floodland between its upper and lower dams, and would provide essentially total flood protection for the city of Batavia and village of Bushville. Neither community would be damaged by flooding, even of the greatest degree likely to occur (probably maximum flooding). The Compound would provide roughly 50-year protection in the Huron Plain floodland. A discussion of the modification of this plan is presented in Sections VI and VII of this report.

e. Batavia Reservoir. The Batavia Reservoir would satisfy to some extent all four flood management objectives in both floodlands of the watershed. It would provide protection essentially identical to that the Batavia Reservoir Compound would provide in that part of the Erie Plain floodland downstream from it and in the Huron Plain floodland.

f. Alabama Reservoir Compound. The Alabama Reservoir Compound would satisfy to some extent all four flood management objectives, but only in the Huron Plain floodland. Operation of the measure would cause overriding damage to the environment at the site of the measure. The Compound would provide protection of roughly 100-year degree in the Huron Plain.

IDENTIFICATION OF ALTERNATIVE PLANS

No Action Plan.

The No Action Plan is a plan to do nothing to provide for flood management. It would recommend that nothing be done, if, in fact, to do nothing would be the most desirable course of action.

Non-structural Base Plan.

The Non-structural Base Plan provides for flood warning and emergency action, floodproofing, flood insurance, floodplain management, and permanent evacuation. This plan is described in detail in Appendix F.

Sierks Reservoir - Linden Reservoir Plan.

This plan provides for construction of the Sierks and Linden Reservoirs. It would provide significant flood protection for the villages of Attica and Alexander, the city of Batavia, and other properties within the Erie Plain floodland, but would provide only nominal protection in the remainder of the watershed.

Sierks Reservoir - Alabama Reservoir Compound Plan.

This plan provides for construction of the Sierks Reservoir and the Alabama Reservoir Compound. It would provide considerable flood protection for the villages of Attica and Alexander, the city of Batavia, and other properties in the Erie Plain floodland. Additionally, it would provide significant flood protection for all properties within the Huron Plain floodland, including new developments within the towns of Clarence and Amherst.

Alexander Reservoir Plan.

This plan provides for construction of the Alexander Reservoir. It would provide low protection in the Erie Plain floodland and minimal protection in the Huron Plain.

Batavia Reservoir Compound Plan.

This plan provides for construction of the Batavia Reservoir Compound. It would provide total protection for the city of Batavia, and significant protection for other properties in the Erie Plain floodland and would provide lesser, but significant, protection for properties in the Huron Plain floodland, including new developments in the towns of Clarence and Amherst. A discussion of the modification of this plan is presented in Sections VI and VII of this report.

Batavia Reservoir Plan.

This plan provides for construction of the Batavia Reservoir. It would provide total protection for the city of Batavia and significant protection for other properties in the Erie floodland, and would provide protection essentially identical to that of the Batavia Reservoir Compound in the Huron Plain.

Batavia Reservoir - Alabama Reservoir Compound Plan.

This plan provides for construction of the Batavia Reservoir and the Alabama Reservoir Compound. It would provide protection identical to that of the Batavia Reservoir in the Erie Plain floodland. Additionally, it would provide roughly Standard Project Flood protection for all properties within the Huron Plain floodland, including new developments in the towns of Clarence and Amherst.

Batavia Project Modification Plan.

This plan provides for construction of the Batavia Project Modification. It would provide nominal protection to the city of Batavia and vicinity, adjacent to the considered works.

SECTION VI

SELECTION OF AN ALTERNATIVE PLAN FOR FLOOD MANAGEMENT

RATIONALE FOR PLAN SELECTION

The rationale used to select an alternative plan for flood management in the Tonawanda Creek Watershed was that the plan to be selected should be whatever socially acceptable plan would best serve the Planning Objectives, including National Objectives (NED and EQ) identified in Section V.

COORDINATION WITH PUBLIC INTERESTS

Introduction.

In order to determine the social acceptability of basic alternative plans considered in this study, the Corps has presented them publicly, and has solicited concerns, opinions, and suggestions for change on each. The various means used to present the basic plans to the public, and to solicit its input, are presented below.

Public Meetings.

Introduction. Two public meetings were held during the development of the alternative plans described in Section V. These meetings were formally organized and announced by the Corps.

Transcripts of the two meetings are available from the Buffalo District Corps of Engineers.

Alternatives Meeting. The Alternatives Public Meeting was held 20 November 1975. There were three specific purposes for this meeting:

to establish the relative social acceptability of the basic alternative plans identified during the preliminary phase of this study;

to provide an opportunity for public interests to suggest modification of these plans which might make them more acceptable; and

to provide an opportunity for public interests to identify whatever other basic plans they thought should be considered.

Input obtained during this meeting was used to: refine those basic alternative plans found to be generally acceptable; develop the new basic plans identified; and, eliminate those plans which were found to be clearly unacceptable.

Formulation Meeting. The formulation Public Meeting was held 27 April 1976. The two specific purposes of this meeting were:

to present the plan tentatively selected for recommendation; and

to provide opportunity for public interests to suggest modification of this plan which might make it more acceptable.

Input obtained during this meeting was used during the final stage of this study to modify, refine, and finalize the selected plan.

Workshops.

Four informal workshops were held during the development of the alternative plans presented in Section V. The function of the workshops was to identify the specific concerns of special interests who would be directly affected by the basic plans, and to address and resolve these specific concerns, as fully as possible. Input obtained during these workshops was used throughout the final phase of this study to modify, refine, and finalize the alternative plans. Three other informal meetings, requested by local interests, were held after the final feasibility report was completed in 1976 and submitted for Corps review by the Division Engineer and the Chief of Engineers. The meetings were held to advise local interests of the status of the study and to obtain current views of those who would be directly affected by the plan recommended in the 1976 report. Input obtained during these meetings, and data developed from additional engineering studies determined to be necessary after Corps review of the 1976 report were used to further refine the selected plan and resulted in a substantial modification. After development of the modified plan, three additional workshops were held to obtain the views of affected interests and their comments are included in Appendix G of the Technical Appendices.

Public Review of Preliminary Feasibility Report.

The Preliminary Feasibility Report was sent to concerned Congressmen, Federal, State, and local agencies, and special interest groups. Each was asked to review the report and provide whatever concerns, opinions, or suggestions it thought should be considered during the final phase of study. Comments received from reviewers of the Preliminary Feasibility Report were used during the final phase of study to modify, refine, and finalize the alternative plans. These comments are presented in Appendix G.

Consultations and Correspondence.

During the final phase of this study, the Corps consulted with local officials to determine what provisions might be included in the various alternative plans to render them more acceptable to various public interests. Additionally, the Corps received and addressed correspondence from many private parties interested in flood management in the Tonawanda Creek Watershed. Opinions, suggestions, and other information obtained in consultation and correspondence were considered thoroughly during the final phase of study. Correspondence regarding basic alternative plans is presented in Appendix G.

APPRAISAL OF ALTERNATIVE PLANS

Introduction.

Each of the alternative plans described in Section V has been considered for designation as the selected plan. The social acceptability of each plan was determined through coordination with public interests, as described above. All of these plans, except the Batavia Reservoir Compound Plan (Modified) are those submitted in the 1976 Final Feasibility Report. The Batavia Reservoir Compound Plan presented in the 1976 report has been modified for reasons discussed previously in this Section regarding workshops. Data related to the Batavia Reservoir Compound Plan (Modified) are discussed in subsequent paragraphs of this Section. Costs and benefits developed in the 1976 report have not been updated to current price levels but are adequate for selecting the most suitable alternative plan for more detailed study. Cost for the Batavia Reservoir Compound (Modified) are based on June 1981 price levels. The capability of each plan to meet the planning objectives was determined by evaluating the following characteristics:

flood management capability;

economic efficiency;

operational dependability; and

flood damage effects. 1/

No Action Plan.

The No Action Plan would not satisfy the planning objectives. It would be acceptable only if no plan for flood management were feasible, or if no feasible plan were socially acceptable.

Non-structural Base Plan.

The Non-structural Base Plan (N.-SB Plan) would partially satisfy two of the four flood management objectives identified in Section V. Specifically, it would protect human health and life, and property. It would not protect industry or environment. The plan would provide protection against flood damage in both floodlands shown in Plate 3. It would provide 100-year degree protection at 4,647 individual residential and commercial sites. The plan would reduce existing tangible average annual flood damage by roughy 35 percent. Residual average annual damage would be very high.

1/ Principles and Standards requires that the "externality" of each plan considered for flood management be evaluated. The externality of a plan is the flood damage which would be induced by it, particularly in nonbenefiting areas.

The economic efficiency of the N-SB Plan, based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 0.67. The plan would provide no net benefit.

Operational dependability of the N-SB Plan is indeterminate. It would depend largely upon the abilities and inclination of people to implement the emergency action and floodproofing provisions of the plan in time. Furthermore, adequate provisions and facilities for the feeding, housing, and health care of flood victims would have to be made available.

Flood damage effects of the N-SB Plan would be negligible.

Few parties affected by flooding in the watershed have expressed views regarding the N-SB Plan. Generally, those who have would prefer structural plans which would manage not only flood damage, but also flooding. They might accept the N-SB Plan if nothing else were available.

Sierks Reservoir - Linden Reservoir Plan.

The Sierks Reervoir - Linden Reservoir Plan (SR-LR Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would reduce flooding and flood damage in both floodlands of the watershed. It would provide roughly 100-year degree protection in the Erie Plain floodland, and 1 to 25-year protection in the Huron Plain. The plan would reduce existing tangible average annual flood damage by roughly 48 percent. Residual average annual flood damage would be moderate.

The economic efficency of the SR-LR Plan, based on previously developed designs, an economic life of 100 years, and an interest rate of 6-1/8 percent, is 0.58. As mentioned in Section II, the proposed sites of the Sierks and Linden Reservoirs have experienced severe earthquakes. The previously developed designs of the dams for these reservoirs do not account for the risk of earthquake. Adequately designed dams would be far more costly and, in turn, less efficient. The plan would provide no net benefit.

The SR-LR Plan could be expanded to serve fishery enhancement, recreation, water quality management, and irrigation, in addition to flood management. The greater cost of adequately designed dams for the Sierks and Linden Reservoirs could be offset by the possible benefits of providing for the recreation purpose, and one or more of the other additional purposes mentioned above. But the benefit of providing for these other purposes has not been determined because, as evidenced in the transcript of proceedings of the Alternatives Public Meeting, local parties strongly oppose provision for the recreation purpose. Accordingly, there seems to be no chance to improve the efficiency of the SR-LR Plan to make it feasible.

Operational dependability of the SR-LR Plan is practically absolute.

Flood damage effects of the SR-LR Plan would be minimal.

Sierks Reservoir - Alabama Reservoir Compound Plan.

The Sierks Reservoir - Alabama Reservoir Compound Plan (SR-ARC Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide protection against flooding and flood damage in both floodlands shown in Plate 3. It would provide roughly 100-year degree protection in the Erie Plain floodland, and 200-year degree protection in the Huron Plain. The plan would reduce existing tangible average annual flood damage by roughly 86 percent. Residual average annual damage would be low.

The economic efficiency of the SR-ARC Plan, based on the previously developed design for the Sierks Reservoir, an economic life of 100 years, and an interest rate of 6-1/8 percent, is 1.03. As explained above, an adequately designed dam for the Sierks Reservoir would be more costly and, in turn, less efficient. The average annual net benefit of the plan is $90,400.

The SR-ARC Plan could be expanded to serve fishery enhancement, recreation, water quality management, and irrigation, in addition to flood management. But the benefit of providing for these other purposes has not been determined for the same reason explained in the appraisal of the Sierks Resevoir-Linden Reservoir Plan.

Operational dependability of the SR-ARC Plan is good.

Flood damage effects of the SR-ARC Plan would be considerable at the proposed site of the Alabama Reservoir Compound. According to biologists of the State of New York, Department of Environmental Conservation, flooding of the already developed wetland management area there, would cause extensive damage, and would likely defeat efforts for wetland management there.

Alexander Reservoir Plan.

The Alexander Reservoir Plan (AR Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide protection against flooding and flood damage in both floodlands of the watershed. It would provide roughly 20-year degree protection in that part of the Erie Plain floodland downstream from it, and would provide incidental protection in the Huron Plain. The plan would reduce existing tangible average annual flood damage by roughly 29 percent. Residual average annual damage would be high.

The economic efficiency of the AR Plan, based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 1.27. The average annual net benefit of the plan is $189,100.

Operational dependability of the AR Plan is practically absolute.

Flood damage effects of the AR Plan would be minimal.

The AR Plan is generally well received by all parties who would be involved. It is especially well received by those residing along Railroad Avenue in the village of Alexander who would be relocated under the plan. These parties are now victimized by frequent flooding.

Batavia Reservoir Compound Plan.

The Batavia Reservoir Compound Plan (BRC Plan) would satisfy to some extent all four flood management objectives identified in Section V.

The plan would provide protection against flooding and flood damage in both floodlands of the watershed. It would provide roughly 10-year degree protection between its upper and lower dams, and would provide Standard Project Flood protection in that part of the Erie Plain floodland downstream from its lower dam. It would provide roughly 50-year protection in the Huron Plain floodland. The plan would reduce existing tangible average annual flood damages by roughly 62 percent. Residual average annual damage would be moderately low.

The economic efficiency of the BRC Plan is based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 1.46. The average annual net benefit of the plan is $616,000. The operational dependability of the BRC Plan is essentially absolute.

Flood damage effects of the BRC Plan would be negligible.

The BRC Plan is generally well received by all parties who would be involved, including those who would have to relocate to accommodate the plan. At each of the four workshops held during development of the Basic Alternative Plans, the consensus was that this plan was preferable to all others considered. A modification of this plan was made to realign the dams for the upper and lower reservoirs. In the Batavia Reservoir Compound Plan, the dams would be located along the abandoned railroad embankments. This design, upon further investigation by the District's Hydraulic Branch and Geotechnical Section, proved to be engineeringly unfeasible due to stability problems. In addition, it was found that there was a potential for a serious subsurface problem in the vicinity of the lower dam. A modification to this plan was developed and is presented later in this section and in Section VII of this report.

Batavia Reservoir Plan.

The Batavia Reservoir Plan (BR Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide protection against flooding and flood damage in both floodlands of the watershed. It would provide Standard Project Flood protection of that part of the Erie Plain floodland downstream from it, and roughly 50-year degree protection in the Huron Plain. The plan would reduce existing tangible average annual flood damage by roughly 53 percent. Residual average annual damages would be moderate.

The economic efficiency of the BR Plan, based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 0.99. The plan would provide no net benefit.

Operational dependability of the BR Plan is practically absolute.

Flood damage effects of the BR Plan would be minimal.

The BR Plan is not acceptable to those who would have to accommodate it. Generally, parties who would be affected contend that the plan would require excessive detrimental change in land use and local environment. Property to be bought under the plan would include 6,460 acres of land, 82 residences, and seven farms.

Batavia Reservoir - Alabama Reservoir Compound Plan.

The Batavia Reservoir - Alabama Reservoir Compound Plan (BR-ARC Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide protection against flooding and flood damage throughout both floodlands of the watershed. It would provide roughly Standard Project Flood protection in that part of the Erie Plain floodland downstream from it and in the Huron Plain. This is the only alternative plan which would provide Standard Project Flood protection in both floodlands of the watershed. The plan would reduce existing tangible average annual flood damage by roughly 91 percent. Residual average annual damages would be minimal.

The economic efficiency of the BR-ARC Plan, based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 1.19. The average annual net benefit of the plan would be $529,200.

Operational dependability of the BR-ARC Plan is good.

Flood damage effects of the BR-ARC Plan would be considerable. As mentioned previously, flooding of the wetland management area within the proposed site of the Alabama Reservoir Compound would cause extensive damage there.

Both components of the BR-ARC Plan are unacceptable to parties who would have to accommodate them. (See appraisals of the SR-ARC Plan and the BR Plan).

Batavia Project Modification Plan.

The Batavia Project Modification Plan (BPM Plan) would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide protection against flooding and flood damage in the vicinity of the city of Batavia only. It would provide roughly 25-year degree protection in the western part of the city of Batavia, and downstream through the village of Bushville. Alteration of this plan to provide Standard Project Flood protection would require construction of levees and floodwalls along both banks of the Tonawanda Creek Channel, from the embankment of the Lehigh Valley Railroad near the southern limit of the city of Batavia, to beyond the downstream limit of the proposed Modification. Such construction would require extensive reconstruction in the city of Batavia and downstream vicinity. Many homes, places of business, and public facilities, including three State Routes and several local streets would have to be relocated and/or modified. At least one historic landmark, the Holland Land Company Office, would likely have to be relocated. Additionally, two railroad lines would have to be elevated several feet. This would require raising adjacent railroad yards, freight docks, and road crossings throughout the city of Batavia. Clearly, the cost to provide Standard Project Flood protection with local measures would be prohibitive. In fact, the considered plan would provide nearly the greatest degree of economically efficient local protection possible.

The plan would reduce existing tangible average annual flood damage in the watershed by roughly 14 percent. Residual average annual damages would be very high.

The economic efficiency of the BPM Plan, based on an economic life of 100 years and an interest rate of 6-1/8 percent, is 2.53. The average annual net benefit of the plan is $199,500.

Operational dependability of the BPM Plan is good.

Flood damage effects of the BPM Plan could be significant. High-velocity flows in the improved channel during flooding might cause considerable erosion throughout the length of the channel. The improved channel could worsen flooding in unimproved reaches downstream which would receive flows from the larger capacity improved channel. Increased flooding in these unimproved reaches could cause increased deposition of soils and other debris throughout them.

The BPM Plan is generally acceptable to those who would benefit from it. However, parties concerned with preserving and enhancing environmental quality and wildlife habitats are staunchly opposed to the Plan. They contend that the considered improvement of roughly 2-1/2 miles of the Tonawanda Creek channel would cause unacceptable damage to the local riparian environment.

<u>Batavia Reservoir Compound Plan (Modified)</u>.

The Batavia Reservoir Compound Plan (Modified) (BRC Plan (Modified)) would satisfy to some extent all four flood management objectives identified in Section V.

The plan would provide protection against flooding and flood damage in both floodlands of the Tonawanda Creek Watershed. It would provide roughly 10-year degree protection immediately below the upper dam and would provide 500-year in that part of the Erie Plain floodland downstream from its lower dam. It would provide roughly 1-5 year protection in the Huron Plain floodland. The plan would reduce existing tangible average annual flood damages by roughly 74 percent, 20 percent in the Erie Plain that includes the city of Batavia and 54 percent in the Huron Plain. Residual average annual damage would be moderately low.

The economic efficiency of the BRC Plan (Modified), based on an economic life of 100 years and an interest rate of 7-5/8 percent, is 1.32. The average annual net benefit of the plan is $800,500. The BRC Plan (modified) costs and benefits are based on June 1981 price levels, while all other previously presented plans were based on 1976 price levels. The price levels on the other plans were not raised to June 1981 price levels because the plans were found to be not viable and had already been eliminated from further study.

The operational dependability of the BRC Plan (Modified) is essentially absolute.

Flood damage effects of the BRC Plan (Modified) would be minimal.

The BRC Plan (Modified) is generally well received by those below the lower dam although many of the agricultural interests who farm between the two dams are those who would be most adversely affected. Their most recent views are expressed in Appendix G in letters received after a public information meeting held on 8 November 1979. The plan is preferable to all others considered and is based upon more detailed hydrology-hydraulics, and economic studies completed since the 1976 report was submitted.

Flood management capabilities of the alternative plans discussed above are summarized in Table 9. Detailed cost estimates are presented in Appendix C except for the Batavia Reservoir Compound (Modified) which is presented in Appendix E. Impacts of the plans on socio-environmental resources are described in Table 10 and in the Environmental Impact Statement.

IDENTIFICATION OF NED AND EQ PLANS

Introduction.

Principles and Standards requires use of an information display, commonly called system of accounts, to promote full and equal appraisal of considered plans, and to promote ease and accuracy in comparing them. The system of accounts displays information describing certain characteristics and impacts of all plans considered. The required system of accounts for all alternative plans considered is presented in Table 10.

In order to establish which of the alternative plans are the NED and EQ Plans, characteristics and impacts of each plan presented in Table 10 were considered in conjunction with the criteria for maximizing NED and emphasizing enhancement of EQ. Those plans considered to best satisfy these criteria, respectively, were identified as the NED and EQ Plans.

NED Plan.

That alternative plan which would provide the greatest average annual net benefit, or return, was considered to be the NED Plan. As Table 10 shows, the average annual net benefit of the Batavia Reservoir Compound Plan (Modified), is higher than the next highest. The Batavia Reservoir Compound (Modified) is based upon more recent engineering-economic studies and current price levels than the other plans presented in Table 10. The Batavia Reservoir Compound investigated in 1976 had significantly greater net benefits than the other plans investigated at the time. This clearly established that the Batavia Reservoir Compound or some modification of it would be the NED Plan. Recent hydrologic-hydraulic and foundation studies have established that the Batavia Reservoir Compound presented in the 1976 report did require modification. Accordingly, the Batavia Reservoir Compound Plan (Modified) is the NED Plan.

EQ Plan.

The EQ Plan is the alternative plan that maximizes net contributions to the EQ attributes of a study area and the EQ objectives that have been developed for a study. Beneficial effects on environmental quality are favorable changes in the ecological, aesthetic, and cultural attributes of the natural and cultural resources of the area. Of the numerous alternative plans considered in detail, in the Tonawanda Creek study, presented in Table 10, none provided overall net contributions to the ecological, aesthetic, and cultural attributes of the Tonawanda Creek watershed. Although all the regional flood control plans considered would provide considerable downstream flood control in the Tonawanda Creek watershed thereby favorably impacting on areas of ecological, aesthetic, and cultural significance, all have major impacts in the areas where they would be constructed. Therefore, a positive net contribution to the EQ account cannot be conformed for any of the plans. Considering the relative ecological, aesthetic, and cultural resources impacts of the various plans, as presented in Table 10, the Alexander Reservoir Plan provides a degree of regional flood control while minimizing impacts in the area where it will be constructed. The plan involves construction of a relatively small dam and flooding an area of about 1,000 acres, considerable less area than any of the other regional flood control plans. Therefore, the Alexander Reservoir Plan has the least impacts on fish wildlife and other ecological attributes of the Tonawanda Creek Watershed. It also floods about 1,000 acres of land, compared to 4,000 plus acres for most of the other plans, thereby minimizing aesthetic and cultural impacts. For these reasons the Alexander Reservoir Plan has been designated as the least environmentally damaging plan in lieu of an EQ Plan.

IDENTIFICATION OF THE SELECTED PLAN

After careful consideration of the alternative plans and variations thereof, the Batavia Reservoir Compound (Modified) was selected as the plan which would best meet the planning objectives discussed in Section V. Water quality in the streams downstream of the lower dam would be increased. The floodwater detention time in the upper and lower reservoirs are 1-3 days and 16 days, respectively. Suspended sediments and attached phosphorous should settle out improving the quality of the released water. There should be no significant release of nitrogen or pesticides from the inundated farmland since these materials are applied at planting and flooding usually occurs earlier in the spring. The dissolved oxygen level of the detained water will not be significantly changed because of the short detention time and low water temperature. These reservoirs will be used approximately once every 2 years. Water quality was considered in the alternative plan selection and the findings are displayed in Table 10.

The USFWS report dated 23 October 1980 is included in Appendix G and their recommendations are discussed in the FEIS and this section of the report. For clarity, reference is made to the 13 numbered recommendations of the USFWS report. The actual recommendations are not repeated here due to their length. The Corps has had numerous meetings and discussions with the USFWS and the NYSDEC regarding the recommendations and their implications for the

Selected Plan. The conclusions reached by the Buffalo District regarding each of the 13 recommendations are as follows:

1. The Corps present judgment on a system of managed/natural flood control based on knowledge of the basin, is that such a plan would neither be economically justified nor acceptable to property owners. The plan could not provide as great a level of flood protection as the Batavia Reservoir Compound Modified and the additional lands required and related levee costs, pumping stations, and flap gate costs could not be economically justified.

2. The Corps will apply for Research and Development (R&D) Funds to study and assess both the beneficial and adverse effects of irregularly flooded areas caused by the Batavia Reservoir Compound Modified Plan. Since R&D study costs cannot be charged against the project, a plan of study will not be initiated until Research and Development Funds become available.

3. All Corps plans are developed to minimize project caused erosion, siltation, and water pollution. The USFWS, EPA, SCS, and NYSDEC will be advised of our construction plans and the concerns expressed in the USFWS report will be carefully considered and adhered to in developing construction specifications.

4. The Corps will consider notching the sills of the dams during post-authorization studies and would develop other minor alterations in the final design of the project to provide free fish passage.

5. The Corps will minimize and attempt to restrict all construction activities associated with instream or streambank areas during periods of low stream flow and during times when surface runoff is at a minimum.

6. The plans and specifications for construction of the project related to snagging and clearing of Tonawanda Creek will specify measures to minimize adverse effects on fish and wildlife resources that might otherwise be impaired or destroyed. The EIS for the project contains the views and comments of all interested environmental interest and will be carefully considered in preparation of the plans and specifications.

7. The Corps cannot currently accept this recommendation due to the areas being used as disposal sites. However, the Corps will investigate and appraise alternative disposal sites during post-authorization studies when more data are available about the type and total volume of spoil to be generated by project construction.

8. The Corps will monitor vegetative plantings for a sufficient number of years to assure that revegetation was successful.

9. The gates of the two dams of the BRC (Modified) will be operated to retain water for the shortest periods of time as is necessary to provide the most appropriate flood management downstream. The project will be fully operated by the Corps rather than by another agency. The Corps will consider suggestions by NYSDEC and USFWS and implement them if they are in the best interest of regional flood management.

10. In lieu of protecting wetlands within the BRC (Modified) which is impractical and costly, the Buffalo District is proposing that mitigation (compensation) wetlands will be obtained outside the limits of the Compound. The proposed mitigation is discussed in more detail in response to USFWS recommendation 11 that follows and in Appendix H of this report.

11. The project induced habitat unit losses discussed in this recommendation are based upon the Habitat Evaluation Procedures (HEP) study conducted for the Tonawanda Creek study (Appendix G, USFWS report). It is basic Corps

policy that an alternative (traditional) analysis be provided to compare with a HEP study. Recommendations for mitigation are then based upon the most appropriate analysis. The Buffalo District prepared a separate traditional analysis which is included in Appendix H of this report. The Buffalo District had several problems with the HEP analysis as discussed in Appendix H. These problems were not resolved, although several meetings were held between Corps and Fish and Wildlife personnel. Therefore, the Buffalo District has made a recommendation for mitigation based upon the analysis contained in Appendix H. About 711 acres of compensatory wetlands will be purchased in fee title outside the limits of the BRC modified. The Corps will turn the compensation lands over to the NYSDEC if requested, however, at the present time the Corps has no authority to fund State wildlife agencies for the administration, co-operation, and maintenance) of such areas.

12. During post-authorization studies, the Corps will further develop plans for providing as much public access and use for recreation purposes as is possible consistent with the needs of those who would frequent the area. The design of such facilities would be not to impair the proper functioning of the flood management capabilities of the project. Public access for recreation purposes was stated in Section III of this report as a projected need in the Tonawanda Creek Watershed. The contingency cost in the project estimate is sufficient to compensate for losses of public access.

13. The Corps agrees with this recommendation but cannot fund the NYSDEC for such activities nor can the monitoring team of others be accomplished at project operation and maintenance cost.

Table 9 - Characteristics of Alternative Plans

Item	Basic Alternative Plan								
	Non-Structural: Base Plan	Sierks Reservoir Linden Reservoir	Sierks Reservoir-Alabama Reservoir Compound 2/	Alexander: Reservoir	Batavia Reservoir: Compound 2/	Batavia Reservoir 2/	Batavia Reservoir-Alabama Reservoir Compound 2/	Batavia Project Modification	Batavia Reservoir Compound (Modified)
Protection upstream from city of Batavia	3/	100-year	100-year	10-year 4/	10-year 4/	None	None	None	10-year 7/
Protection for the city of Batavia	3/	100-year	100-year	20-year	SPF 5/	SPF 5/	SPF 5/	25-year	500-year 5/
Protection downstream from the Tonawanda Indian Reservation	varies 6/	varies 6/	varies 6/	Nominal	varies 6/	varies 6/	varies 6/	None	varies 6/
Average Annual Damage Prevented in the city of Batavia and vicinity, and upstream	27%	92%	82%	49%	89%	82%	82%	52%	85%
Average Annual Damage Prevented downstream from the Tonawanda Indian reservation	38%	32%	88%	21%	52%	42%	100%	0%	71%

1/ The Clarence-Amherst Diversion Measure was excluded from considered plans because of its limited flood damage management capability and its high potential for worsening flooding in non-benefiting areas.

2/ The 1960 flood would have been prevented by the measure(s) of this plan.

3/ Cannot be determined.

4/ Downstream from the Alexander Reservoir, or the upper reservoir of the Batavia Reservoir Compound.

5/ SPF is the Standard Project Flood. This flood is of the greatest magniude reasonably likely to occur within the Watershed.

6/ The degree of protection provided is a function of physical conditions, including channel size and slope and elevations of flood-damageable properties. Since these conditions are variable along Tonawanda Creek, downstream from the Tonawanda Indian Reservation, the degree of protection afforded there is also variable.

7/ Immediately downstream of upper dam.

Table 10 - Accounts for Alternative Plans 1/

Account		No Action: Floodlands	No Action: Rest of Nation	Non-Structural Base Plan: Floodlands	Non-Structural Base Plan: Rest of Nation	Stocks Reservoir - Linden Reservoir: Floodlands	Stocks Reservoir - Linden Reservoir: Rest of Nation	Stocks Reservoir - Alabama Reservoir Compound: Floodlands	Stocks Reservoir - Alabama Reservoir Compound: Rest of Nation	Alexander Reservoir: Floodlands	Alexander Reservoir: Rest of Nation
NATIONAL ECONOMIC DEVELOPMENT											
Average Annual Benefit											
Flood Damage Reduction		None	None	$775,800	None	$1,038,900	None	$1,066,900	None	$623,800	None
Use Intensification		None	None	None	None	18,600	None	347,700	None	12,400	None
Development Cost Savings		None	None	None	None	200,000	None	534,200	None	136,000	None
Construction Employment		None	None	$176,800	None	474,900	None	334,900	None	111,900	None
Total		None	None	$952,600	None	1,733,200	None	$3,283,700	None	$884,100	None
Average Annual Costs											
Interest and Amortization		None	None	N.D.	N.D.	Minor	$ 2,883,900	Minor	$ 3,093,300	N.D.	N.D.
Operation, Maintenance & Repair		None	None	$115,800	None	None	100,000	Minor	100,000	N.D.	N.D.
Total		None	None	N.D.	N.D.	Minor	2,983,900	Minor	$ 3,193,300	N.D.	N.D.
Average Annual Net Benefit		None	None	None	None	None	None	$ 90,400	None	$109,100	None
ENVIRONMENTAL QUALITY											
Land											
Soils Utility	(2,3,4,6,8,9)	Impaired	N.A.	N.A.	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
Topography	(1,9)	N.C.	N.C.	Slight.chg	N.C.	N.C.	Mod. chgd.	Mod. chgd.	Mod. chgd.	Slight.chgd	N.C.
*Air Quality	(1,9)	N.C.	N.C.	Decreased	N.C.	N.C.	Decreased	Decreased	Decreased	Decreased	N.C.
*Water Resources											
Groundwater											
Water Table	(2,3,5,11)	N.C.	N.C.	N.C.	N.C.	N.C.	Raised	Raised	Raised	N.C.	N.C.
Quality	(2,3,4,11)	N.C.	N.C.	N.C.	N.C.	N.C.	Increased	N.C.	Increased	N.C.	N.C.
Surface Water											
Stored											
Acreage	(2,3,6,8,11)	N.C.	N.C.	N.C.	N.C.	N.C.	1,730 gained	1,500 gained	1,200 gained	N.C.	N.C.
Volume	(2,3,6,11)	N.C.	N.C.	N.C.	N.C.	N.C.	Increased	Increased	Increased	N.C.	N.C.
Quality	(2,3,6,11)	N.C.	N.C.	N.C.	N.C.	Increased	Increased	Increased	Increased	N.C.	N.C.
Streams											
Supply	(2,3,5,11)	N.C.	N.C.	N.C.	N.C.	Increased	N.C.	Increased	N.C.	N.C.	N.C.
Quality	(2,3,5,11)	N.C.	N.C.	N.C.	N.C.	Increased	N.C.	Increased	N.C.	Slight.inc.	N.C.
*Ecosystems											
Floral Resources											
Natural											
Woodland Acreage	(1,6,8,9)	N.C.	N.C.	N.C.	N.C.	N.C.	500 destroyed	N.C.	600 destroyed	Slight.dec.	N.C.
Wetland Acreage	(1,6,8,9)	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	3,000 encumbered	N.C.	Slight.dec.	N.C.
Cultivated											
Grassland Acreage	(1,6,8,9)	N.C.	N.C.	Slight.dec	N.C.	N.C.	2,000 destroyed	N.C.	1,000 destroyed	Slight.inc.	N.C.
Cropland Acreage	(1,6,8,9)	N.C.	N.C.	N.C.	N.C.	N.C.	800 destroyed	N.C.	400 destroyed	N.C.	N.C.
Faunal Resources											
Fish	(2,3,4,5,9)	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	N.A.	Enhanced	N.A.
Other Aquatic Wildlife	(1,2,3,5,9)	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	N.A.	Enhanced	N.A.
Terrestrial Wildlife	(1,2,3,5,9)	Impaired	N.A.	Impaired	N.A.	Impaired	Impaired	Impaired	N.A.	Enhanced	N.A.
SOCIAL WELL-BEING											
Cultural Resources											
Archaeology	(2,3,4,9)	Impaired	N.A.	Impaired	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.
Educational Opportunity	(2,3,4,11)	Impaired	N.A.	Impaired	N.A.	Impaired	N.A.	Impaired	N.A.	N.A.	N.A.
Recreational Opportunity	(2,3,5,10)	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
*Aesthetics	(1,2,3,5,9)	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
Health and Welfare											
*Families Protected	(1,6,8,9)	None	None	4,507	None	Roughly 3,115	None	Roughly 4,853	None	Roughly 2005	None
*Community Cohesion	(1,5,9)	N.A.	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
*Community Growth	(1,5,11)	N.A.	N.A.	Impaired	Enhanced	Enhanced	Enhanced	Enhanced	N.A.	Enhanced	N.A.
*Noise	(1,5,9)	N.C.	N.A.	Increased	N.C.	N.C.	Increased	Increased	N.C.	Increased	N.C.
REGIONAL DEVELOPMENT											
Social Effects											
Population Growth	(2,3,4,9)	N.A.	N.A.	Impaired	N.A.	Enhanced	Impaired	Enhanced	N.A.	N.A.	N.A.
Population Distribution	(2,3,4,9)	N.A.	N.A.	Impaired	Enhanced	Enhanced	Enhanced	Enhanced	N.A.	Slight.imp.	N.A.
*Effects on Man-Made Resources											
Housing	(1,6,7,9)	N.C.	N.C.	140 relocated	N.C.	N.C.	49 relocated	9 relocated	26 relocated	8 relocated	N.C.
*Public Buildings	(1,6,7,9)	N.C.	N.C.	Included above	N.C.	N.C.	1 relocated	1 relocated	N.C.	N.C.	N.C.
Recreation Facilities	(1,2,3,5,9)	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	1 encumbered	N.C.	N.C.	N.C.
Roads	(1,6,7,9)	N.C.	N.C.	N.C.	N.C.	N.C.	4 severed	N.C.	4 severed	1 severed	N.C.
*Farms	(1,6,7,9)	N.C.	N.C.	N.C.	N.C.	N.C.	11 relocated	N.C.	7 relocated	N.C.	N.C.
*Non-Farm Businesses	(1,6,7,9)	N.C.	N.C.	Included above	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Economic Effects											
*Property Value	(2,3,5,9)	Decreased	N.C.	Decreased	N.C.	N.C.	Increased	Increased	N.C.	Increased	N.C.
*Property Tax	(2,3,5,9)	N.C.	N.C.	Increased	N.C.	N.C.	Increased	N.C.	Increased	Slight.inc.	N.C.
*Employment	(1,2,3,5,8,9)	N.A.	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Slight.enh.	N.A.
Income	(1,2,3,5,8,9)	N.A.	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Slight.enh.	N.A.
*Public Services	(2,3,4,11)	N.A.	N.A.	N.A.	N.A.	N.A.	Impaired	N.A.	N.A.	N.A.	N.A.
*Regional Growth	(2,3,4,8,11)	N.A.	N.A.	Impaired	Enhanced	Mod. enhanced	Enhanced	Greatly enhanced	N.A.	Slight.enh.	N.A.

Account	Batavia Reservoir Compound: Floodlands	Batavia Reservoir Compound: Rest of Nation	Batavia Reservoir: Floodlands	Batavia Reservoir: Rest of Nation	Batavia Reservoir - Alabama Reservoir Compound: Floodlands	Batavia Reservoir - Alabama Reservoir Compound: Rest of Nation	Batavia Project Modification: Floodlands	Batavia Project Modification: Rest of Nation	Batavia Reservoir Compound (Modified): Floodlands	Batavia Reservoir Compound (Modified): Rest of Nation
NATIONAL ECONOMIC DEVELOPMENT										
Average Annual Benefit										
Flood Damage Reduction	$1,343,000	None	$1,132,000	None	$2,087,100	None	$313,600	None	$2,120,500	None
Use Intensification	216,500	None	204,100	None	376,000	None	None	None	1,170,000	None
Development Cost Savings	200,800	None	272,700	None	524,200	None	None	None	None	None
Construction Employment	187,700	None	217,900	None	378,400	None	$ 15,900	None	None	None
Total	$1,948,000	None	$1,826,700	None	$3,365,700	None	$329,500	None	$3,290,500	None
Average Annual Costs										
Interest and Amortization	Minor	$ 1,233,000	Minor	$ 1,798,700	Minor	$ 2,736,300	$ 21,300	$84,700	Minor	$2,090,000
Operation, Maintenance & Repair	Minor	100,000	Minor	50,000	Minor	100,000	$ 25,000	None	Minor	400,000
Total	Minor	$ 1,332,000	Minor	$ 1,848,700	Minor	$ 2,836,300	$ 45,300	$84,700	Minor	$2,490,000
Average Annual Net Benefit	$ 616,000	None	None	None	$ 529,200	None	$190,500	None	$ 800,500	None
ENVIRONMENTAL QUALITY										
Land										
Soils Utility	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	Enhanced	N.A.
Topography	Mod. chgd.	N.C.	Mod. chgd.	N.C.	Consid. chgd	N.C.	N.C.	N.C.	Mod. chgd.	N.C.
*Air Quality	Decreased	N.C.	Decreased	N.C.	Decreased	N.C.	Decreased	N.C.	Decreased	N.C.
*Water Resources										
Groundwater										
Water Table	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Quality	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Surface Water										
Stored										
Acreage	N.C.	N.C.	N.C.	N.C.	1,500 gained	N.C.	N.C.	N.C.	N.C.	N.C.
Volume	N.C.	N.C.	N.C.	N.C.	Increased	N.C.	N.C.	N.C.	N.C.	N.C.
Quality	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Streams										
Supply	N.C.	N.C.	N.C.	N.C.	Increased	N.C.	N.C.	N.C.	N.C.	N.C.
Quality	Increased	N.C.	Increased	N.C.	Increased	N.C.	N.C.	N.C.	Increased	N.C.
*Ecosystems										
Floral Resources										
Natural										
Woodland Acreage	Slight. dec.	N.C.	Slight. dec.	N.C.	Slight. dec.	N.C.	N.C.	N.C.	Slight. dec.	N.C.
Wetland Acreage	Slight. dec.	N.C.	Slight. dec.	N.C.	Slight. dec.	N.C.	N.C.	N.C.	Slight. dec.	N.C.
Cultivated										
Grassland Acreage	Slight. inc.	N.C.	Slight. inc.	N.C.	Slight. dec.	N.C.	N.C.	N.C.	Slight. inc.	N.C.
Cropland Acreage	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Faunal Resources										
Fish	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Slight. imp	N.A.	Enhanced	N.A.
Other Aquatic Wildlife	Enhanced	N.A.	Enhanced	N.A.	Impaired	N.A.	Slight. imp	N.A.	Enhanced	N.A.
Terrestrial Wildlife	Enhanced	N.A.	Enhanced	N.A.	Impaired	N.A.	N.A.	N.A.	Enhanced	N.A.
SOCIAL WELL-BEING										
Cultural Resources										
Archaeology	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.
Educational Opportunity	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Recreational Opportunity	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.
*Aesthetics	Enhanced	N.A.	Impaired	N.A.	Impaired	N.A.	Enhanced	N.A.	Enhanced	N.A.
Health and Welfare										
*Families Protected	Roughly 3,085	None	Roughly 3,085	None	Roughly 4,853	None	Roughly 1,965	None	Roughly 3,085	None
*Community Cohesion	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	Enhanced	Enhanced	N.A.
*Community Growth	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	Enhanced	Enhanced	N.A.
*Noise	Increased	N.C.	Increased	N.C.	Increased	N.C.	Increased	Increased	Increased	N.C.
REGIONAL DEVELOPMENT										
Social Effects										
Population Growth	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	Enhanced	N.A.
Population Distribution	Slight. imp.	N.A.	Impaired	N.A.	Impaired	N.A.	N.A.	N.A.	Slight. imp.	N.A.
*Effects on Man-Made Resources										
Housing	40 relocated	N.C.	82 relocated	N.C.	91 relocated	N.C.	N.C.	N.C.	46 relocated	N.C.
*Public Buildings	N.C.	N.C.	1 relocated	N.C.	1 relocated	N.C.	N.C.	N.C.	N.C.	N.C.
Recreation Facilities	N.C.	N.C.	N.C.	N.C.	1 encumbered	N.C.	N.C.	N.C.	N.C.	N.C.
Roads	1 severed	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	1 severed	N.C.
*Farms	3 relocated	N.C.	7 relocated	N.C.	7 relocated	N.C.	N.C.	N.C.	6 relocated	N.C.
*Non-Farm Businesses	1 relocated	N.C.	5 relocated	N.C.	5 relocated	N.C.	N.C.	N.C.	1 relocated	N.C.
Economic Effects										
*Property Value	Increased	N.C.	Increased	N.C.	Increased	N.C.	Increased	N.C.	Increased	N.C.
*Property Tax	N.C.	N.C.	Increased	N.C.	Increased	N.C.	N.C.	N.C.	N.C.	N.C.
*Employment	Mod. enh.	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	Mod. enh.	N.A.
Income	Mod. enh.	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	Mod. enh.	N.A.
*Public Services	N.A.	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	N.A.	N.A.
*Regional Growth	Mod. enh.	N.A.	Enhanced	N.A.	Greatly enh.	N.A.	N.A.	N.A.	Mod. enh.	N.A.

*Section 122 of Public Law 91-611 requires assessment of impacts of alternative plans on this item.
(1) Impact expected before plan is completely implemented.
(2) Impact expected within 15 years after plan is implemented.
(3) Impact expected 15 or more years after plan is implemented.
(4) Certainty of impact is no greater than 50 percent.
(5) Certainty of impact is between 50 percent and 90 percent.
(6) Certainty of impact is greater than 90 percent.
(7) Impact fully monetized in N.E.D. account.
(8) Impact partially monetized in N.E.D. account.
(9) Impact caused by plan.
(10) Impact caused by outside-plan action currently considered.
(11) Impact caused by outside-plan not currently considered.
N.A. - Not Affected.
N.C. - Not Changed.
N.D. - Not Determined.

1/ The Batavia Reservoir Compound (modified) - costs and benefits were computed at June 1981 price levels and a 7-7/8 percent interest rate; all other plans were computed at 1976 price levels and a 6-1/8 percent interest rate.

SECTION VII

THE SELECTED PLAN FOR FLOOD MANAGEMENT IN THE TONAWANDA CREEK WATERSHED

DESCRIPTION OF SELECTED PLAN

The Batavia Reservoir Compound (Modified), shown on Plate 9A, would consist of two shallow detention reservoirs (normally dry) arranged in series. The plan would require construction of two earth dams, each with its own principal outlet works and emergency spillway and the lower dam with four training dikes. Snags and debris jams in the channel of Tonawanda Creek within the lower reservoir area would be removed to insure natural channel capacity of approximately 2,000 cubic feet per second and in the upper reservoir to restore natural channel conditions. The two reservoirs would include a tract of roughly 4,865 acres within the floodland between the village of Alexander and the city of Batavia. In addition, about 711 acres of land outside of the floodwater impoundment area but adjacent to it would be purchased to compensate for anticipated adverse impacts on existing fish and wildlife habitat that could occur with construction and operation of the project.

The upper dam, about 5,450 feet in length, would be adjacent to, and downstream from, an embankment of Conrail Railroad, and would stand approximately as high as the embankment.

The principal outlet works of the upper reservoir would be located in its dam, at or near its intersection with the Tonawanda Creek channel. These outlet works would include five closed conduits, side-by-side, each equipped with an electrically operable gate. The maximum opening of each would be 11 feet by 11 feet. See Plate 13.

The emergency spillway of the upper reservoir would be riprapped and extend across the top of the dam. The spillway would have capacity to discharge the SPF flood flow.

Land to be used for the upper reservoir would include about 1,208 acres of farmland, wetland, and woodland. Fifty acres of this land would be purchased and flowage easements would be obtained for 1,158 acres. No buildings are located within this tract; however, a maximum of 9 residences, 1 farm, and 1 business situated in the upper reservoir area might be included within the headwater fringe of floodpools caused by maximum probable flooding. These buildings include town equipment sheds and residences. The residences would be purchased and removed. These buildings comprise all buildings in the vicinity of the upper reservoir susceptible to frequent flood damage. The creek channel just upstream from the upper reservoir, in the village of Alexander, would be stabilized as part of the plan if it were determined that the operation of the compound would aggravate erosion there.

The lower dam would be located upstream from the abandoned Conrail Railroad embankment. The west end of the dam would be about 500 feet south of the railroad embankment and the east end about 3,100 feet south. The dam would extend 5,600 feet across the Tonawanda Creek Valley and the west end of the dam would be about 1,000 feet east of State Route 98. Three training dikes with lengths of 150 feet, 600 feet, and 3,300 feet would be constructed about 500 feet easterly and parallel to State Route 98 and another about 950 feet long would be constructed about 1 mile east of Tonawanda Creek.

The principal outlet works of the lower reservoir would be located in the dam about 900 feet east of the creek channel. They would include four closed conduits, side-by-side, each equipped with an electrically operable gate. The maximum opening of each would be 11 feet by 11 feet. See Plate 13.

The lower dam would be designed to function as an emergency spillway. The spillway section, with crest elevation of 900, would be riprapped and extend westward from Creek Road a distance of approximately 4,000 feet and would have capacity to discharge the SPF flood flow. Whatever water passed over the spillway would flow along the course of Tonawanda Creek.

Land to be used for the lower reservoir would include roughly 4,135 acres of principally farmland, wetland, and woodland. This land would be protected by the upper reservoir from flooding of up to 10-year frequency near the upper dam. Flowage easements allowing occasional flooding would be acquired over approximately 4,090 acres of land. Fee title to this land would remain with the owners, subject to the easement. A total of approximately 46 residences, six farms, and one business would have to be purchased.

A detailed cost estimate for the BRC. (Modified) Plan is presented in Appendix D.

OPERATION OF SELECTED PLAN

As mentioned in Section II, most runoff contributing to flooding within the Tonawanda Creek Watershed is shed by the Cattaraugus Hills, upstream from the Erie Plain floodland. Runoff from these hills would flow into the Batavia Reservoir Compound. Flows of Tonawanda Creek would enter the upper reservoir first. Flows of Little Tonawanda Creek would enter the lower reservoir.

Normally, both reservoirs would be dry. Usual flows of both creeks would pass through the reservoirs within their channels. This plan provides for the removal of snags and debris jams in the channel of Tonawanda Creek between the upper and lower limits of the Compound. At the present time, these obstructions severely limit the capacity of the natural channel so that even small flows are apt to overtop the banks and cause floods. Removal of these snags and jams would permit smaller flows, which now flood, to pass within channel. The effect of this would be that lands within the Compound, even those within the upper reservoir, would be flooded less frequently than now.

The upper dam would have electrically operated gates that would comprise the principal outlet works. When the floodpool reaches the crest of the emergency spillway (elevation 922.5), flow through the gates when fully opened would have a maximum discharge capacity of 10,700 cfs. Whatever excess inflow could not pass through the fully opened gates would then pass over the emergency spillway. Floods with a 100-year recurrence interval would cause the floodpool to reach elevation 922.5 with the gates fully opened and above this elevation the emergency spillway would be overtopped. During a Standard Project Flood, outflow over the emergency spillway would reach a maximum depth of 2.0 feet. The Tonawanda Creek channel downstream of the dam would have a channel capacity of 2,000 cfs after it has been snagged and cleared of debris. For floods less than a 100-year recurrence interval but greater than a 10-year, the gates would be operated to control discharges to 2,000 cfs as long as possible until the upper reservoir is filled. At that time the gates would be operated to maintain inflow equal to outflows. For floods less than a 10-year recurrence interval, the gates would be operated to minimize downstream flooding.

The lower dam would also have electrically operated gates that would comprise the principal outlet works. When the floodpool reaches the crest of the emergency spillway (elevation 900.0) flow through the gates when fully opened would have a maximum discharge capacity of 6,000 cfs. Whatever excess inflow could not pass through the fully opened gates would then pass over the emergency spillway. Flood with a 500-year recurrence interval would cause the floodpool to reach elevation 900.0 with the gates fully opened and above this elevation the emergency spillway would be overtopped. During a Standard Project Flood, outflow over the emergency spillway would reach a maximum depth of about 2.6 feet. During normal summer rainfall events the gates would remain fully opened. During snowmelt and for floods less than a 10-year recurrence interval, the gates will be operated to minimize damage in the lower watershed.

Land within the upper reservoir would be flooded more frequently than it is now and would be flooded deeper than normal. The reservoir would drain within 1-1/2 days after all floods of up to 500-year frequency. It would detain water somewhat longer after larger floods, but rarely more than 3 days.

Land within the lower reservoir would also be flooded more frequently than now. The reservoir would drain within 11 days after all floods of up to 500-year frequency. It would detain water somewhat longer for larger floods, but rarely more than 16 days.

Effects of the selected plan on 100-year degree flooding throughout the major floodlands of the watershed are shown in Plate 14. Further discussion on the operation of the reservoirs may be found in Appendix A.

PROVISIONS FOR OEPRATION, MAINTENANCE, AND REPAIR OF MEASURES OF THE SELECTED PLAN

Required Work.

Measurements of precipitation and snow-cover, and determinations of soil moisture and its state, would have to be made periodically at selected sites in the Cattaraugus Hills, in order to establish the likelihood and probable degree of possible flooding. This information would be used as the basis for operating the Batavia Reservoir Compound (Modified).

During flooding the principal spillway gates of at least the upper reservoir would have to be regulated. During major flooding, the spillway gates of both reservoirs would have to be regulated.

All structural components of the Batavia Reservoir Compound (Modified) would have to be maintained as constructed. Work to do this would include: periodic mowing of grassed portions of the lower and the training dikes; removal of undesirable vegetation and debris from the various structures; removal of obstructions from the Tonawanda Creek channel within the project limits; and periodic cleaning, lubrication, and painting of metal components.

After major flooding, certain structural repairs, such as the replacement of riprap on the emergency spillway of both dams, might be necessary.

Required Organization.

Corps of Engineers employees would be used to operate and maintain the Batavia Reservoir Compound (Modified) and to gather the information necessary for its operation. The services of permanent Corps employees, consultants, and contractors would be used as needed to accomplish repair damaged or deteriorated structures.

IMPLEMENTATION OF THE SELECTED PLAN

Introduction.

The Selected Plan for flood management in the Tonawanda Creek Watershed would be implemented over a period of several years. The established procedure requires that this report be reviewed by higher Corps authorities and other concerned Federal, State, and local agencies and then submitted to the Secretary of the Army and Congress. Congress would have to authorize the project and appropriate funds for it before the advanced engineering and design (AE&D) study could begin.

The AE&D study would be conducted in two phases. During the first phase, public interest in the Selected Plan would be re-established, and the first phase of a General Design Memorandum (a brief, letter type Phase I GDM) would be prepared. This report would be reviewed by higher Corps authorities, and if the reviewers still concur in it, then details of the Plan would be finalized and reported in the Phase II GDM. Plans and specifications would then be prepared and the construction work would be contracted out and necessary lands purchased. Construction would take approximately 2 years, after which operation of the Selected Plan would begin.

Time required for the entire process, is difficult to predict. However, if the Plan were authorized and funded without interruptions, construction of the Batavia Reservoir Compound (Modified) could be completed within 4 to 5 years afterward.

Acceptance of Selected Plan.

Because as explained below, all costs of providing, operating, maintaining, and repairing the Batavia Reservoir Compound (Modified) would be borne by the Federal Government, designation of an official local sponsor is unnecessary. However, the State of New York, by letter dated 17 February 1982, expressed general support for the Selected Plan. A copy of this and other letters generally supporting the Selected Plan are presented in Appendix G.

Responsibilities of Enabling Parties.

Operation, Maintenance, and Repair.

The Batavia Reservoir Compound (Modified) would provide significant regional flood protection by reducing existing tangible average annual flood damages by roughly 74 percent, 20 percent in the Erie Plain that includes the city of Batavia, NY, and 54 percent in the Huron Plain; therefore, in accordance with the Flood Control Act of 1970, it would be operated, maintained, and repaired by the Corps.

The average annual cost for OM and R of the Compound would be about $400,000. Ths estimate is based on OM and R costs for similar Corps of Engineer projects.

Cost Sharing.

The selected plan, Batavia Reservoir Compound (Modified), provides regional flood damage reduction. In accordance with existing cost-sharing policies, all costs of construction and acquisition of lands, easements, and rights-of-way would be borne by the Federal Government. The NYSDEC has provided a letter of support, dated 17 February 1982, for the project under existing cost-sharing policies (Appendix G).

However, construction authorization for the proposed project would be subject to cost sharing and financing arrangements which are satisfactory to the President and the Congress and may require responsible non-Federal agency to sponsor the project and share in the project cost.

The average annual cost of the Compound on June 1981 price levels, based on an economic life of 100 years and an interest rate of 7-5/8 percent, is $2,490,000. This total includes $400,000 for OM and R.

DATA NEEDS

Continuing additional hydrologic data are necessary to update generalized discharge-duration relationships established during preparation of final design studies, route floods, develop refinements in spillway design floods and refine operating procedures for the Compound.

Approximately four climatological stations are needed to obtain the necessary data on precipitation, snow pack and water content, temperature, and radiation. This data would be used in unit-hydrograph and spillway design flood determinations.

Stream gages have been reestablished on Little Tonawanda Creek in the hamlet of Linden and on Tonawanda Creek in the village of Rapids but require modification. Gages at Alabama, Attica, Batavia, and on Black Creek must also be modified. A new gage will be established on Ledge Creek and reservoir stage gages established on both the upper and lower reservoirs.

These stations and gages will be installed as early as possible since the data obtained will be necessary for the final design and operation of the project.

SECTION VIII

SUMMARY

CONCLUSIONS

Authority for Study.

This study of the feasibility of flood management in the Tonawanda Creek Watershed, NY, was authorized by a resolution of the Committee on Public Works, Senate, United States Congress, adopted 15 June 1950. This authorization was expanded by resolutions of the Committee on Public Works, House of Representatives, United States Congress, adopted 16 August 1950 and 23 July 1956. On 5 March 1973, the Chief of Engineers, Corps of Engineers, authorized study of water resources management in the Buffalo Metropolitan Area, NY, and directed that the Study Area include the Buffalo Urban Area (SMSA) and its tributary watersheds, including the Tonawanda Creek Watershed.

This study of flood management needs in the Tonawanda Creek Watershed is an interim report of the Buffalo Metropolitan Area.

Need for Flood Management in Tonawanda Creek Watershed.

Present needs for flood management in the Tonawanda Creek Watershed are to protect: human health and life, property, industry, and the environment. Recent land-use changes within floodlands of the watershed have increased flood management needs substantially. In the towns of Clarence, Amherst, Pendleton, and Wheatfield, land recently forested or used for farming is now developed or being developed for residential, transportation, and industrial uses. Existing average annual flood damage within floodlands of the Tonawanda Creek Watershed is $2,851,400 at the June 1981 price levels. Both of these damage estimates are based upon December 1975 price levels and conditions of development.

Public Involvement in Development of Alternative Plans for Flood Management.

During this study, four workshops and two public meetings were held in order to involve the public in development of the alternative plans for flood management. Input obtained at these workshops and meetings was used to develop and appraise considered plans.

Also, critiques of the Preliminary Feasibility Report provided by governmental agencies and others were considered during finalization of the alternative plans. In addition several informal workshops have been held since 1976 to provide local interests an update of the status of the project investigation and to obtain their comments on the Batavia Reservoir Compound Plan presented in the 1976 report. Their views, comments, suggestions, and concerns were carefully considered in Development of the Batavia Reservoir Compound

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Plan (Modified). The most recent meetings to discuss this modified plan were held on 24 September 1979 with personnel of the Soil Conservation Service and a dairy farmer, on 8 November 1979 with interests in Batavia and Alexander, and on 16 November 1979 with interests in Amherst-Clarence-Tonawanda. The views of these interests regarding the Batavia Reservoir Compound Plan (Modified) is contained in Appendix G.

Required Alternative Plans.

a. Introduction. The planning criteria described in Section V require that at least four alternative plans be developed. These four plans are: the Non-structural Base Plan, the National Economic Development Plan, the Environmental Quality Plan, and the Selected Plan. Corps policy also requires that a No Action Plan be considered. Each of these required plans, except an Environmental Quality Plan, was identified and evaluated during this study. Even though an Environmental Quality Plan was not developed, the plan that was least damaging to the environment was identified.

b. No Action.

The No Action Plan is to do nothing to provide for flood management in the Tonawanda Creek Watershed. This plan was considered unacceptable because it does not satisfy the planning objectives.

c. Non-structural Base Plan.

The Non-structural Base Plan provides for flood warning and emergency action, floodproofing, flood insurance, flood plain management, and permanent evacuation in both floodlands of the watershed. This plan was not selected because of its limited flood management capabiltiy and low economic efficiency.

d. NED Plan.

The Batavia Reservoir Compound Plan (Modified) was found to be the National Economic Development Plan.

e. EQ Plan.

The Alexander Reservoir Plan was found to be the least damaging to the Environment.

f. Selected Plan.

The Batavia Reservoir Compound Plan (Modified) is the Selected Plan for flood management in the Tonawanda Creek Watershed.

Significant characteristics of all plans considered during this study are presented in Table 11.

Table 11 - Significant Characteristics of Alternative Plans 1/

Item	No Action		Nonstructural Base Plan		Stokes Reservoir - Linden Reservoir		Stokes Reservoir - Alabama Reservoir Compound		Alexander Reservoir	
DESCRIPTION	The plan is to do nothing for flood damage management in the Tonawanda Creek Watershed.		The plan is to relocate or floodproof 4,447 floodprone units in the watershed. In the Erie plain, 46 units would be relocated; 1,990 units would be floodproofed. In the Huron Plains, 94 units would be relocated; 2,316 units would be floodproofed.		The plan is to provide storage reservoirs at Stokes and Linden, NY.		The plan is to provide a storage reservoir at Stokes and a combination of storage detention reservoirs in the town of Alabama, NY.		The plan is to provide a detention reservoir in the town of Alexander, NY.	
APPRAISAL										
Response to Planning Objectives										
Flood Management										
Degree of Protection (for Human Health and Life, Property, Industry, and Environment)	None		100-year protection for 4,447 individual residential and commercial sites in both floodlands of the watershed.		Roughly 100-year protection for the Erie Plain floodland; roughly 1- to 25-year protection for the Huron Plain floodland.		Roughly 100-year protection for the Erie Plain; roughly 200-year protection for the Huron Plain.		Roughly 20-year protection for the part of the Erie Plain downstream from it; minimal protection for the Huron Plain.	
Damage prevented (Percent of Existing Average Annual Damage)	None		35		46		56		29	
National Water and Related Land Resources Management										
Economic Impact										
Economic Efficiency	None		0.67		0.58		1.03		1.27	
Average Annual Net Benefit	None		None		None		$90,4[illegible]		$189,100	
Socio-Environmental Impact	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation
Environmental Quality										
Soils Utility	Impaired	N.A.	Impaired	N.A.	Enhanced	Impaired	Enhanced	Impaired	Enhanced	N.A.
Woodland Acreage	N.C.	N.C.	N.C.	N.C.	N.C.	60 destroyed	N.C.	600 destroyed	Slightly decreased	N.C.
Wetland Acreage	N.C.	N.C.	N.C.	N.C.	N.C.	Unchanged	3,000 encumbered	N.C.	Slightly decreased	N.C.
Grassland Acreage	N.C.	N.C.	Slightly decreased	N.C.	N.C.	2,000 destroyed	N.C.	1,000 destroyed	Slightly increased	N.C.
Cropland Acreage	N.C.	N.C.	N.C.	N.C.	N.C.	800 destroyed	N.C.	400 destroyed	N.C.	N.C.
Fish	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	N.A.	Enhanced	N.A.
Other Aquatic Wildlife	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Impaired	N.A.	Enhanced	N.A.
Terrestrial Wildlife	Impaired	N.A.	Impaired	N.A.	Impaired	Impaired	Impaired	N.A.	Enhanced	N.A.
Social Well-being										
Recreational Opportunity	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
Aesthetics	Impaired	N.A.	Impaired	N.A.	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced	N.A.
Families Protected	None	None	4,507	None	Roughly 3,115	None	Roughly 4,853	None	Roughly 2,005	None
Community Cohesion	N.A.	N.A.	Impaired	N.A.		-				
Regional Development										
Housing	N.C.	N.C.	140 relocated	N.C.	N.C.	69 relocated	9 relocated	26 relocated	8 relocated	N.C.
Recreation Facilities	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	1 encumbered	N.C.	N.C.	N.C.
Roads	N.C.	N.C.	N.C.	N.C.	N.C.	4 severed	N.C.	6 severed	1 severed	N.C.
Farms	N.C.	N.C.	N.C.	N.C.	N.C.	11 relocated	N.C.	7 relocated	N.C.	N.C.
Nonfarm Businesses	N.C.	N.C.	Included above	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Property Value	Decreased	N.C.	Decreased	N.C.	N.C.	Increased	Increased	N.C.	Increased	N.C.
Property Tax	N.C.	N.C.	Increased	N.C.	N.C.	Increased	N.C.	Increased	Slightly increased	N.C.
Operational Dependability										
Certainty	None		Intermediate		High		Moderate		High	
Stability	None		Moderate		Moderate		Moderate		High	
Resource Commitment										
During Construction										
Human	None		Moderate		High		High		Moderate	
Material	None		Moderate		High		High		Moderate	
After Construction										
Human										
Part-time	None		High		Low		High		Low	
Permanent	None		None		Low		Low		Low	
Material	None		Moderate		Low		High		Low	
Reversibility	Complete		Complete		Partial		Partial		Nearly Complete	
Social Acceptability	Low		Low		Low		Low		High	
IMPLEMENTATION										
Cost-sharing Responsibilities										
First Cost	None		$35,100,000		$66,969,500		$38,378,700		$109,905,700	
Federal	None		N.D.		All		All		N.D.	
Non-Federal	None		N.D.		None		None		N.D.	
Average Annual OM and R Cost	None		$ 115,000		$ 100,000		$ 100,000		$ 50,000	
Federal	None		None		All		All		N.D.	
Non-Federal	None		All		None		None		N.D.	
Total Average Annual Cost	None		$ 1,615,600		$ 3,903,900		$ 3,193,300		$ 645,000	
Federal	None		N.D.		All		All		N.D.	
Non-Federal	None		N.D.		None		None		N.D.	
Extra-plan Action Required	None		None		None		None		None	

Item	Batavia Reservoir Compound		Batavia Reservoir		Batavia Reservoir - Alabama Reservoir Compound		Batavia Project Modification		Batavia Reservoir Compound (Modified)	
DESCRIPTION	The plan is to provide a detention reservoir compound including one reservoir in the town of Alexander and one in the town of Batavia, NY.		The plan is to provide detention reservoir in the towns of Alexander and Batavia, NY.		The plan is to provide the Batavia Reservoir (described at left) and the Alabama Reservoir (also described at left).		The plan is to complement the existing Corps project in the city of Batavia with local protection measures including a levee, channel bank protection, and channel enlargement.		The plan is to provide a detention reservoir compound including one reservoir in the town of Alexander and one in the town of Batavia, NY	
APPRAISAL										
Response to Planning Objectives										
Flood Management										
Degree of Protection (for Human Health and Life, Property, Industry, and Environment)	Standard Project Flood protection in that part of the Erie Plain downstream from it; roughly 50-year protection for the Huron Plain.		Roughly same protection as that provided by the BRC Plan.		Roughly Standard project protection for both floodlands.		Roughly 25-year protection for the western part of the city of Batavia.		500-year flood protection in that part of the Erie Plain downstream from it; roughly 2-5 year protection for the Huron Plain.	
Damage prevented (Percent of Existing Average Annual Damage)	62		33		91		14		76	
National Water and Related Land Resources Management										
Economic Impact										
Economic Efficiency	1.46		0.99		1.19		2.93		1.32	
Average Annual Net Benefit	$616,000		None		$529,300		$199,5[illegible]		$800,500	
Socio-Environmental Impact	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation	Floodlands	Rest of Nation
Environmental Quality										
Soils Utility	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	N.A.	N.A.	Enhanced	N.A.
Woodland Acreage	Slightly decreased	N.C.	Slightly decreased	N.C.	Slightly decreased	N.C.	N.C.	N.C.	Slightly decreased	N.C.
Wetland Acreage	Slightly decreased	N.C.	Slightly decreased	N.C.	Slightly decreased	N.C.	N.C.	N.C.	Slightly decreased	N.C.
Grassland Acreage	Slightly increased	N.C.	Slightly increased	N.C.	Slightly increased	N.C.	N.C.	N.C.	Slightly increased	N.C.
Cropland Acreage	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
Fish	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Slgt. Imp.	N.A.	Enhanced	N.A.
Other Aquatic Wildlife	Enhanced	N.A.	Enhanced	N.A	Impaired	N.A.	Slgt. Imp.	N.A.	Enhanced	N.A.
Terrestrial Wildlife	Enhanced	N.A.	Enhanced	N.A.	Impaired	N.A.	N.A.	N.A.	Enhanced	N.A.
Social Well-being										
Recreational Opportunity	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.	Enhanced	N.A.
Aesthetics	Impaired	N.A.	Impaired	N.A.	Impaired	N.A.	Enhanced	N.A.	Impaired	N.A.
Families Protected	Roughly 3,085	None	Roughly 3,085	None	Roughly 4,853	None	Roughly 1,965	None	Roughly 3,085	None
Community Cohesion										
Regional Development										
Housing	40 relocated	N.C.	82 Relocated	N.C.	91 relocated	N.C.	N.C.	N.C.	46 relocated	N.C.
Recreation Facilities	N.C.	N.C.	N.C.	N.C.	1 encumbered	N.C.	N.C.	N.C.	N.C.	N.C.
Roads	1 severed	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	1 severed	N.C.
Farms	3 relocated	N.C.	7 relocated	N.C.	7 relocated	N.C.	N.C.	N.C	4 relocated	N.C.
Nonfarm Businesses	1 relocated	N.C.	5 relocated	N.C.	3 relocated	N.C.	N.C.	N.C.	1 relocated	N.C.
Property Value	Increased	N.C.	Increased	N.C.	Increased	N.C.	Increased	N.C.	Increased	N.C.
Property Tax	N.C.	N.C.	Increased	N.C.	Increased	N.C.	N.C.	N.C.	N.C.	N.C.
Operational Dependability										
Certainty	High		High		Moderate		Moderate		High	
Stability	High		High		High		Moderate		High	
Resource Commitment										
During Construction										
Human	High		High		High		Low		High	
Material	High		High		High		Low		High	
After Construction										
Human										
Part-time	Moderate		Moderate		High		Low		Moderate	
Permanent	Low		Low		Low		None		Low	
Material	Moderate		Moderate		High		Low		Moderate	
Reversibility	Nearly complete		Partial		Partial		Partial		Nearly complete	
Social Acceptability	High		Low		Moderate		Moderate		High	
IMPLEMENTATION										
Cost-sharing Responsibilities										
First Cost	$39,054,700		$29,295,200		$44,567,700		$1,710,600		$25,[illegible],098	
Federal	All		All		All		N.D.		All	
Non-Federal	None		None		None		N.D.		None	
Average Annual OM and R Cost	$ 100,000		$ 50,000		$ 100,000		$ 25,000		$ [illegible]	
Federal	All		All		All		None		[illegible]	
Non-Federal	None		None		None		All		[illegible]	
Total Average Annual Cost	$ 1,112,000		$ 1,968,700		$ 2,816,500		$ 170,0[illegible]		$ 2,[illegible]	
Federal	All		All		All		N.D.		All	
Non-Federal	None		None		None		N.D.		None	
Extra-plan Action Required	None		None		None		None		None	

1/ All costs are based upon those in 1976, except the Batavia Reservoir Compound (Modified) that is based upon 1981 costs.
N.A. - Not Affected
N.C. - Not Changed
N.D. - Not Determined

Summary of Selected Plan.

a. Flood Management Capability.

The Selected Plan would satisfy to some extent all four flood management objectives identified in Section V. The plan would provide roughly 10-year degree protection near its upper dam and would provide 500-year flood protection in that part of the Erie Plain floodland downstream from its lower dam. It would provide roughly 2-5 year degree protection in the Huron Plain floodland. The plan would reduce existing average annual flood damages by approximately 74 percent. Residual average annual damage would be low.

b. Economic Impact.

The economic efficiency of the Selected Plan, based on an economic life of 100 years and an interest rate of 7-5/8 percent, is 1.32. The average annual cost of the Plan, including cost for operation, maintenance, and repair, is $2,490,000. The average annual net benefit of the plan is $800,500.

c. Socio-environmental Impact.

Construction of the Selected Plan would provide a significant reduction in flood damages downstream of the lower dam and some lesser reduction in flood damages upstream. However, adverse effects within the project area would be minimal. The Selected Plan is generally well received by all parties who would be benefited. Views of these and others who have an interest in the project are included in Appendix G.

d. Information in Response to EO 11988.

(1) Floodplain development expected to occur after construction of the project consists of residential units and related structures that would be built under without-project conditions. There are three major reasons for future units locating in the eastern end of the lower watershed (EELW) under without project conditions.

Most of the employment opportunities have historically been located in the metropolitan area of Buffalo and Niagara Falls, NY, or in their adjacent suburbs. This employment has generated residential development that has already located in communities situated within the EELW. Replacement of houses and new families moving into the area is the primary basis for forecasting a net demand for new and additional residential units.

A well developed infrastructure has already been constructed in and around the EELW while recent completion of several "clean water" sanitary sewerage plants are now capable of serving the regional needs of existing and future floodplain residents. Lateral lines are now being extended towards the east through the town of Amherst into portions of the town of Clarence, NY. Most of the vacant areas in the town of Clarence, NY, lie within the SPF outline from Tonawanda Creek or its tributaries of Ransom, Black, and Beeman Creeks.

Population growth around Buffalo, NY, is somewhat restricted from moving to the east or south by either a lack of sewer lines or topographic restrictions. A snowbelt is located on the east and south sides of the city of Buffalo and discourages rapid development of this area. Also, eastern suburbs are already well developed which forces new residential construction to be built at increasing distances from the Buffalo Central Business District.

The level of protection attributed to the Selected Plan in downstream reaches is low. Downstream of Reach T-10 the flood plain will experience only a 2-5 year degree of protection and minor stage reductions at the 1 percent exceedence frequency. Level of protection and flood stage reduction should not significantly alter the perception of the residual flood hazard to such an extent that induced or project sensitive development would occur. No benefits have been credited to the Selected Plan for future inundation reduction or site development savings (i.e., landfill savings or floodproofing costs avoided). The Selected Plan is economically feasible based upon 1975 conditions of development.

(2) Losses to the natural and other beneficial resources without the project in the flood plain will basically remain unchanged except for those caused by erosion and innundation during flooding. The major activity within the project area above the lower dam of the proposed project is agriculture. Some improvement can be expected in this activity as well as significant improvement in agricultural activity downstream. In Batavia and downstream there would also be a significant reduction in property damages. Development within the project area would be controlled by conditions contained in the flowage easements that must be obtained before the project is operational. Control of development in floodplains downstream is a non-Federal responsibility but, as discussed in the above paragraph, there should be no inducement for development expected to be caused by the project.

(3) Alternate flood plain locations include vacant areas to the north of Tonawanda Creek in the towns of Wheatfield, Pendleton, Lockport, and Royalton, NY. Few floodfree alternate sites are to be found south of Tonawanda Creek since this area is either coincidental with the Ellicott Creek flood plain or is already fully developed. Three towns south of the creek that might be considered as alternate floodfree sites include Clarence, Newstead, or Pembroke, NY. Plate 3 in the Main Report indicates the extent of the flood plain and alternate floodfree locations that might be occupied by future residents. Much of this outlying area is dominated by agricultural activity which would very likely be displaced over time by urban development if non-flood plain lands are not developed. This would result in a large investment of public funds to construct facilities to support this new development (i.e., roads, water, gas, and sewer lines).

(4) Flood damages rise as a result of additional units expected to locate in the flood plain during the project planning period. This development is not related to completion of the project since it is based upon growth forecasted by local and regional planning agencies prior to the formulation of a flood damage management plan for Tonawada Creek. There is no development expected to locate in the flood plain as a result of the project.

The greatest contribution of the Selected Plan to National Economic Development is the reduction of average annual flood losses now affecting existing units on the flood plain. This project will reduce the hazard and risk associated with floods and reduce the present impact of floods on human activity, health, safety, and welfare.

(5) A very careful inventory of the natural environment within the project area will be made in sufficient time prior to construction to insure that any otherwise adverse impacts will be minimized. Destruction of trees, foliage, and other natural habitat will be avoided by constructing the structures and access roads in areas that would be the least destructive to these habitats. The plans and specifications for construction of the proposed project will contain items and clauses to minimize damages to the environment and will include items related to air, sound, and water pollution, as well as aesthetic and social disturbances. The Contractor will be required to maintain his equipment in good working condition as well as keeping his storage areas neat, orderly, and to minimize usage of space.

REVIEW OF PLAN SELECTION CONSIDERATIONS

I have reviewed, and thoroughly considered, findings presented in previous reports of the Corps and their agencies, regarding flood management in the Tonawanda Creek Watershed. I have considered plans presented in these reports in light of the planning objectives and criteria described in Section V, and have considered means of modifying these plans in order to improve them.

I have developed additional plans in order to better satisfy the planning objectives and criteria. I have considered means of eliminating or mitigating possible adverse social, regional development, and environmental impacts of each plan developed.

I have solicited, and thoroughly considered, views of concerned publics regarding all plans; and have evaluated all alternative plans based on the planning objectives and criteria, and the views of concerned publics. Finally, I have selected a plan for flood management in the Tonawanda Creek Watershed, based on an evaluation of all plans considered.

In view of the above considerations, I am convinced that the Selected Plan is, in fact, the best plan for flood management in the Tonawanda Creek Watershed.

RECOMMENDATIONS

I recommend construction authorization of the Tonawanda Creek Watershed flood damage reduction project, subject to cost-sharing and financing arrangements with the responsible non-Federal agencies sponsoring the project which are satisfactory to the President and the Congress.

ROBERT R. HARDIMAN
Colonel, Corps of Engineers
District Engineer

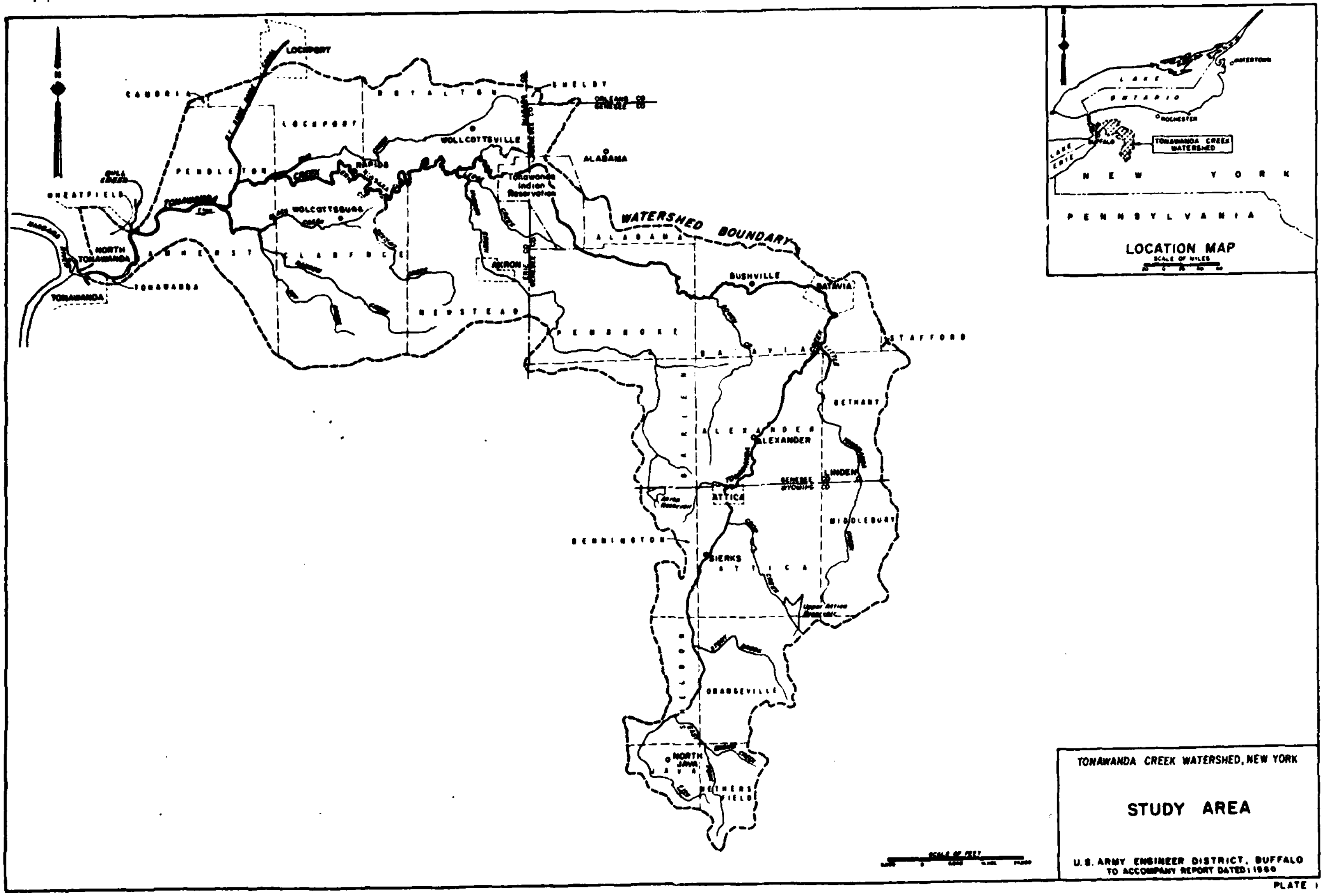
NCDPD-PF (November, 1981) 1st Ind
SUBJECT: Buffalo Metropolitan Area Study - Interim Report on Feasibility of Flood Management in Tonawanda Creek Watershed

DA, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605

TO: Cdr, USACE (DAEN-CWP-C), WASH, D. C. 20314

I concur in the analysis and recommendations of the District Engineer except for the purchase of 711 acres of land for mitigation. The need for mitigation to the "extent justifiable" as required by FWCA has not been demonstrated. The recommended plan is subject to cost sharing and financing arrangements which are satisfactory to the President and Congress.

SCOTT B. SMITH
Brigadier General, USA
Commanding

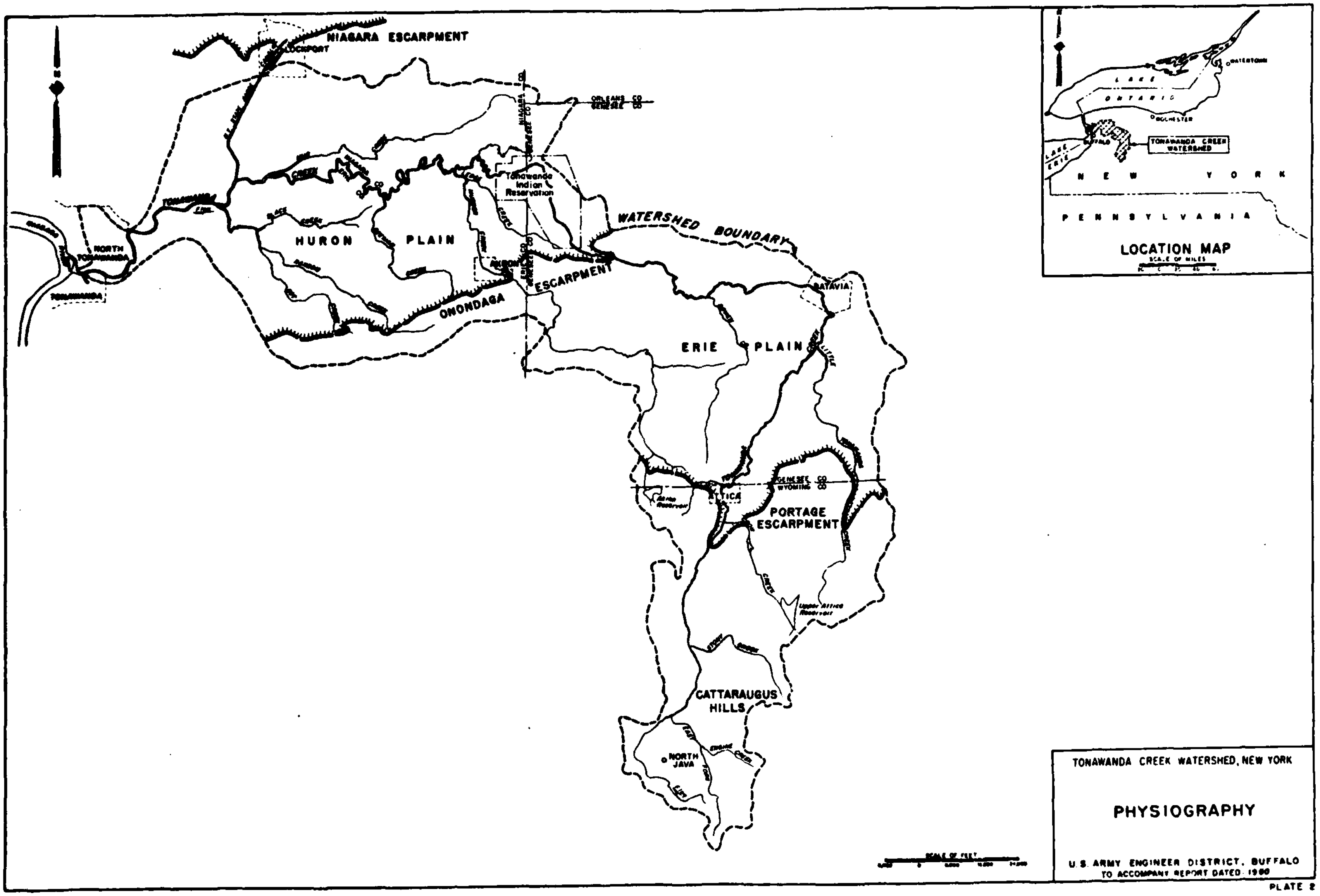


TONAWANDA CREEK WATERSHED, NEW YORK

STUDY AREA

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED: 1960

PLATE 1

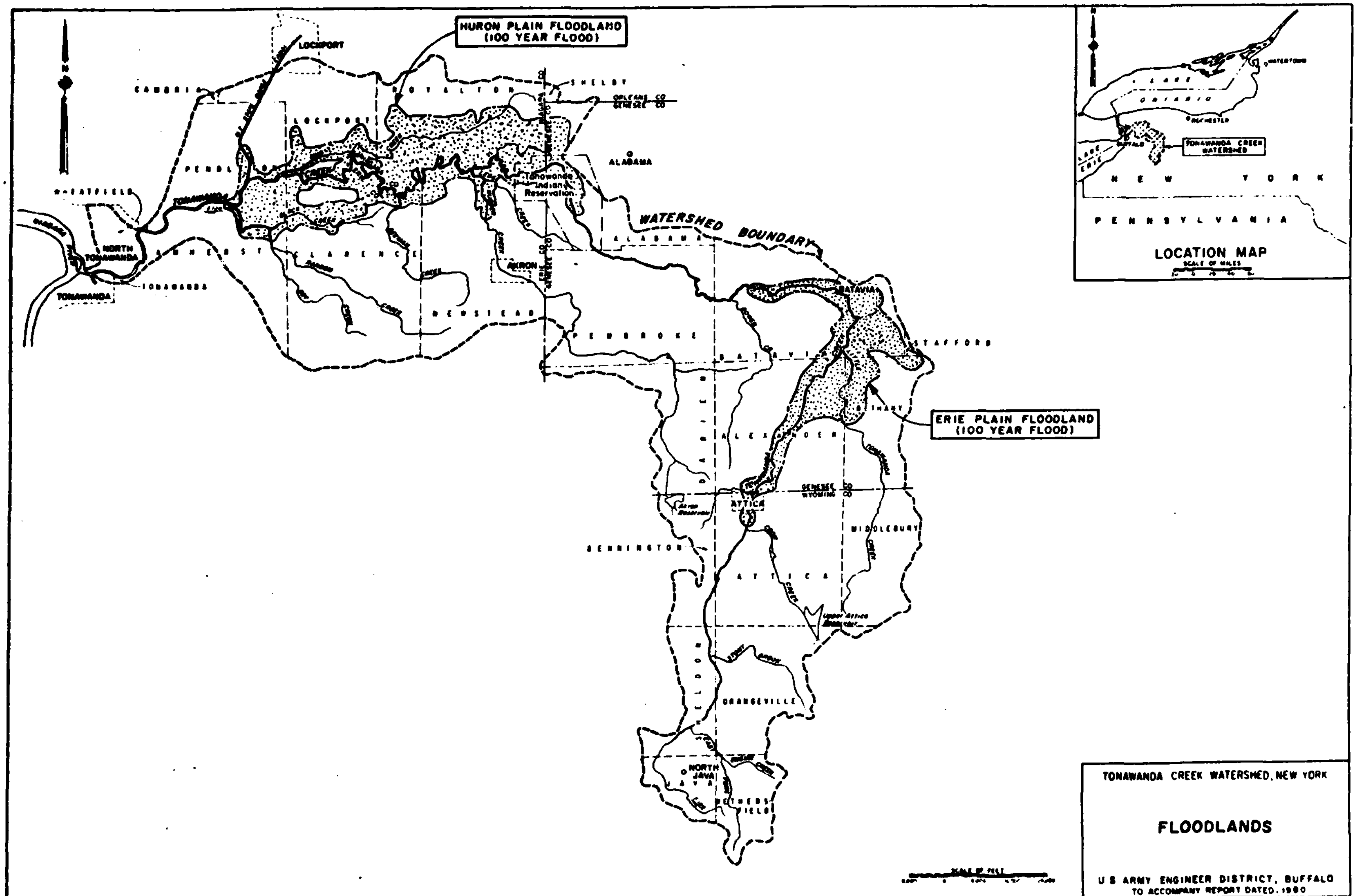


TONAWANDA CREEK WATERSHED, NEW YORK

PHYSIOGRAPHY

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED 1960

PLATE 2

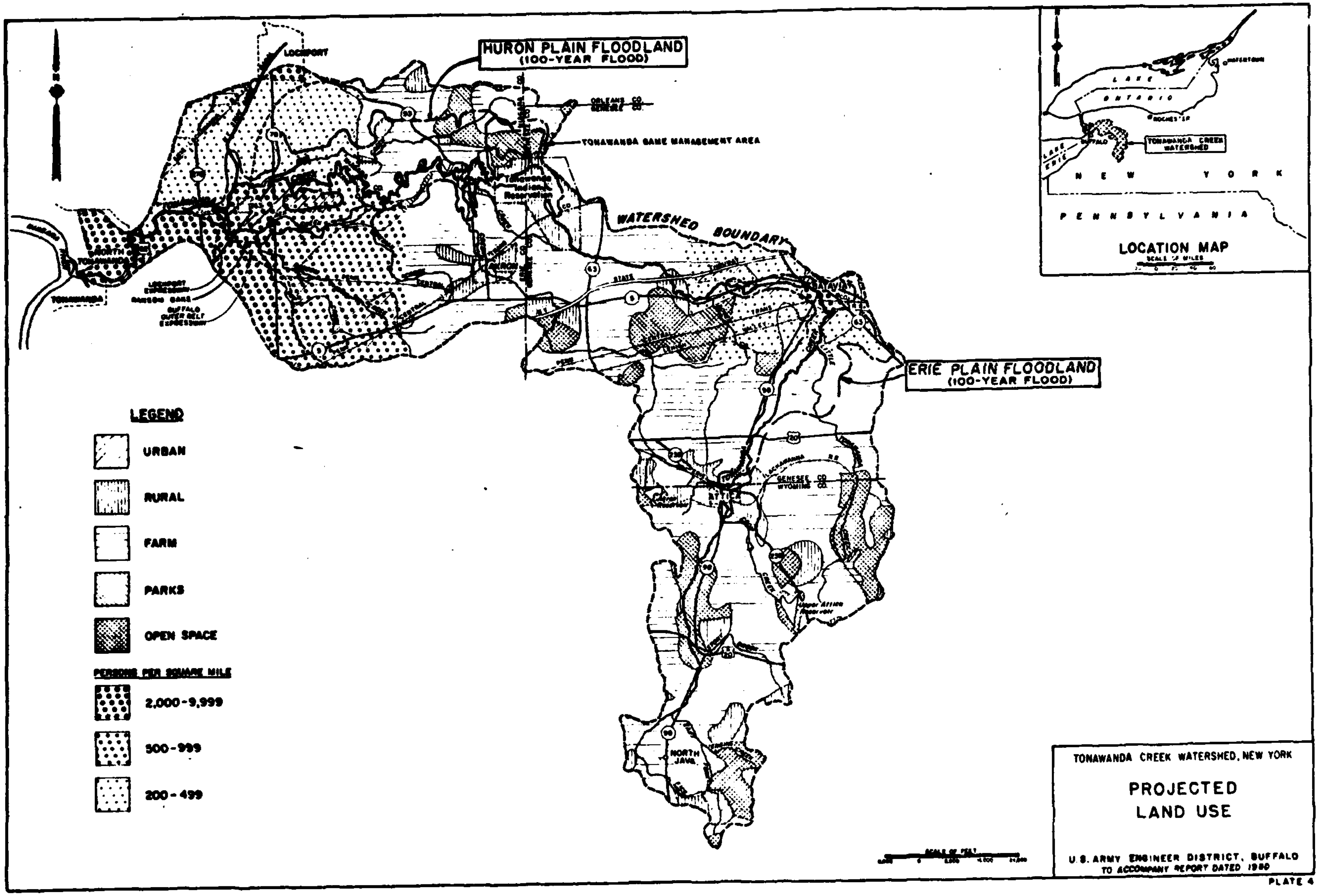


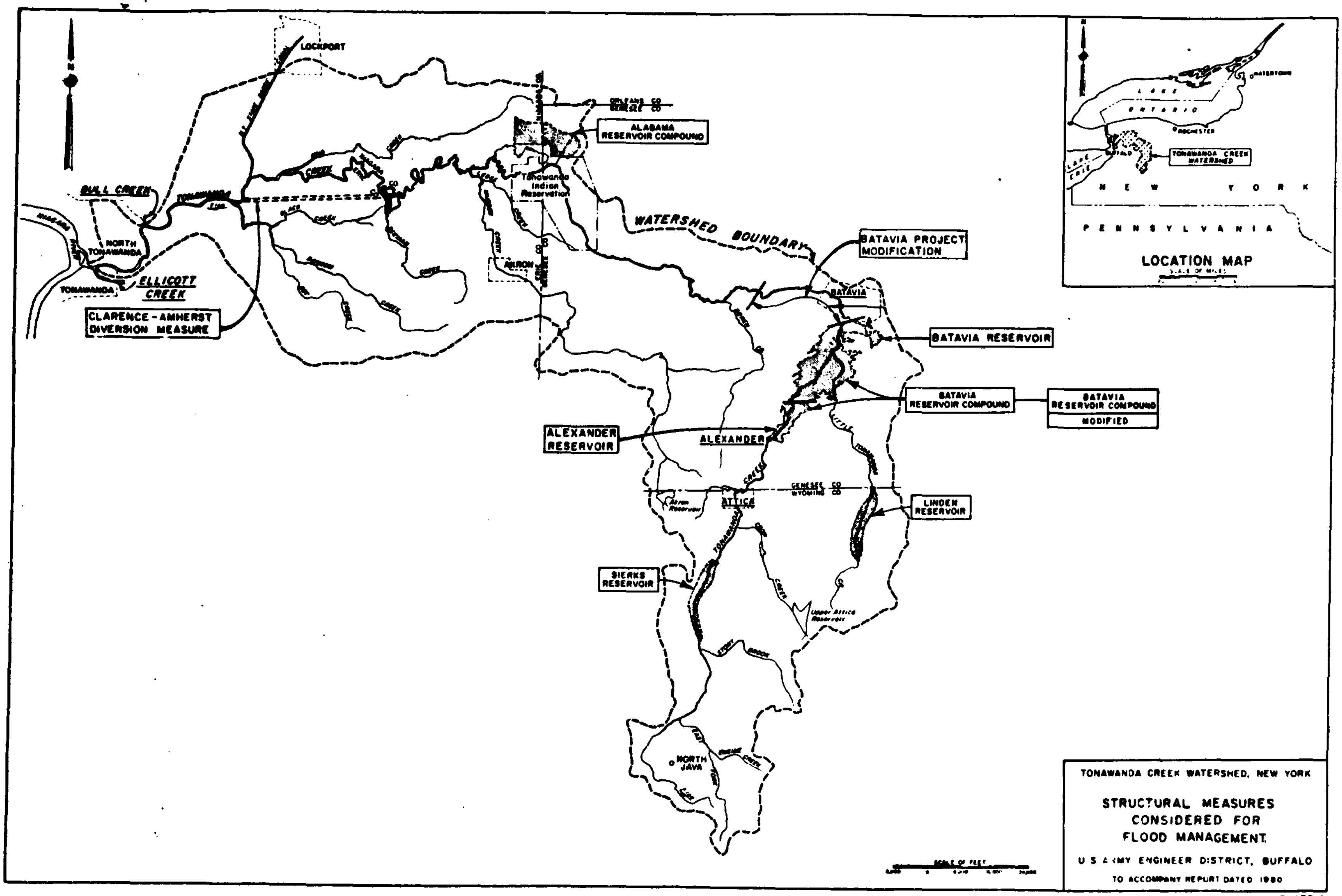
TONAWANDA CREEK WATERSHED, NEW YORK

FLOODLANDS

U S ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED 1960

PLATE 3


HURON PLAIN FLOODLAND
(100-YEAR FLOOD)
LOCKPORT
ORLEANS CO.
GENESEE CO.
TONAWANDA GAME MANAGEMENT AREA
WATERSHED BOUNDARY
NORTH TONAWANDA
TONAWANDA
BATAVIA
ERIE PLAIN FLOODLAND
(100-YEAR FLOOD)
GENESEE CO.
WYOMING CO.
NORTH JAVA
LAKE ONTARIO
LAKE ERIE
TONAWANDA CREEK WATERSHED
NEW YORK
PENNSYLVANIA
LOCATION MAP
LEGEND
URBAN
RURAL
FARM
PARKS
OPEN SPACE
PERSONS PER SQUARE MILE
2,000-9,999
500-999
200-499
TONAWANDA CREEK WATERSHED, NEW YORK
PROJECTED
LAND USE
U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED 1980
PLATE 4



TONAWANDA CREEK WATERSHED, NEW YORK

STRUCTURAL MEASURES CONSIDERED FOR FLOOD MANAGEMENT.

U S ARMY ENGINEER DISTRICT, BUFFALO

TO ACCOMPANY REPORT DATED 1980

PLATE 5

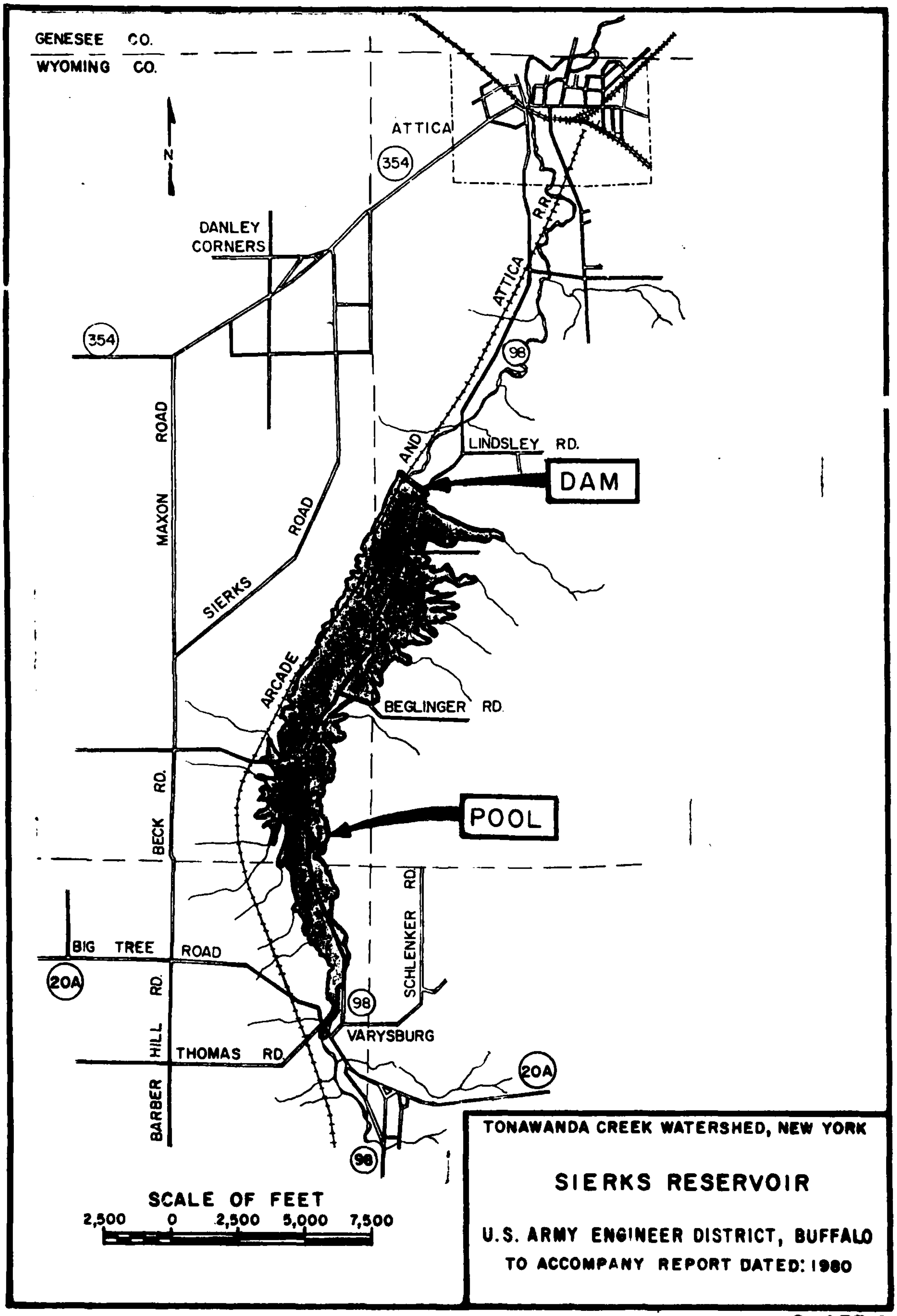
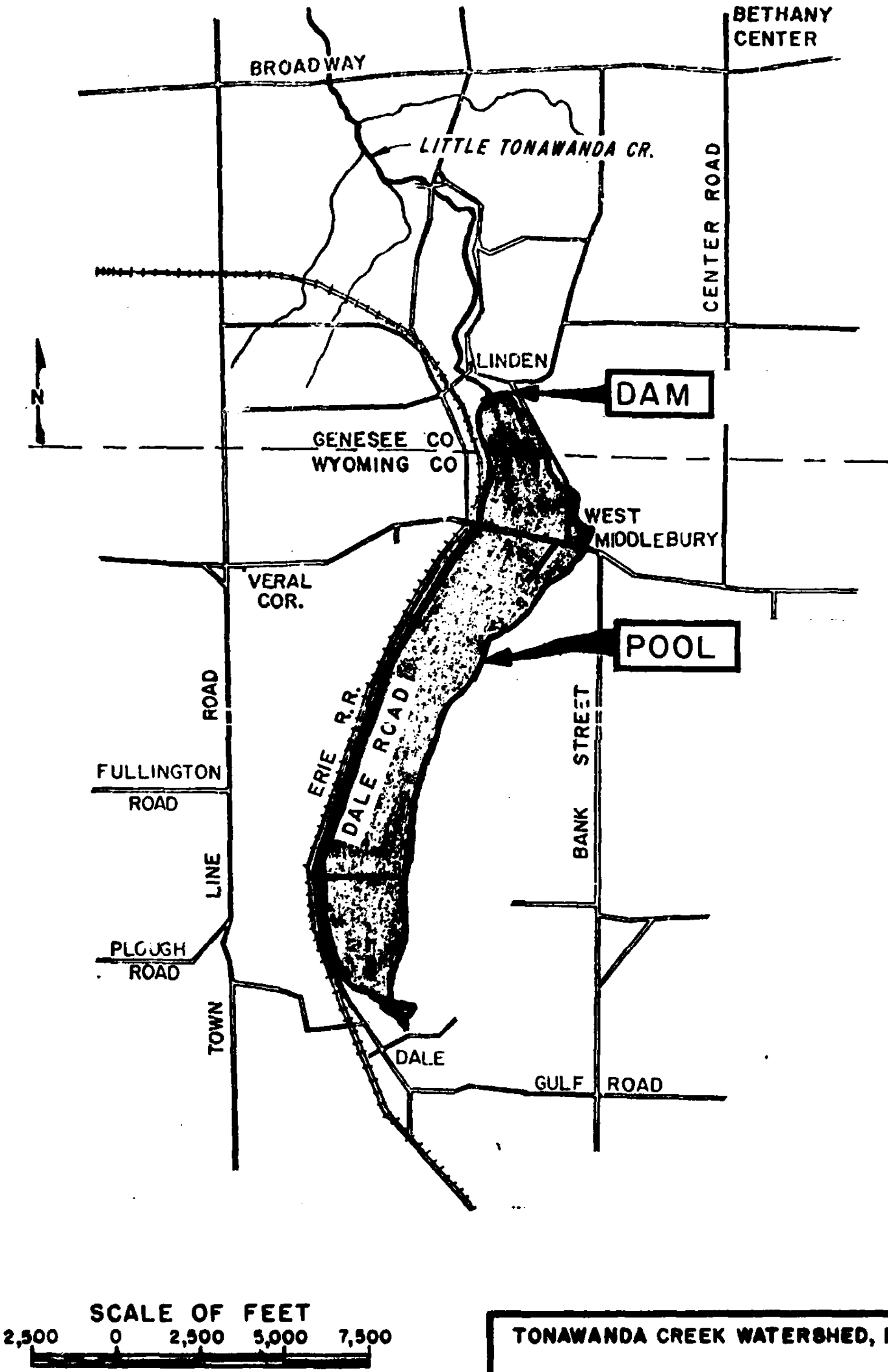

GENESEE CO.
WYOMING CO.
N
ATTICA
354
DANLEY CORNERS
R.R.
ATTICA
AND
ARCADE
98
LINDSLEY RD.
DAM
MAXON ROAD
SIERKS ROAD
BEGLINGER RD.
BECK RD.
POOL
SCHLENKER RD.
BIG TREE ROAD
20A
BARBER HILL RD.
THOMAS RD.
VARYSBURG
SCALE OF FEET
2,500 0 2,500 5,000 7,500
TONAWANDA CREEK WATERSHED, NEW YORK
SIERKS RESERVOIR
U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED: 1980

PLATE 6



TONAWANDA CREEK WATERSHED, NEW YORK

LINDEN RESERVOIR

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED: 1960

PLATE 7

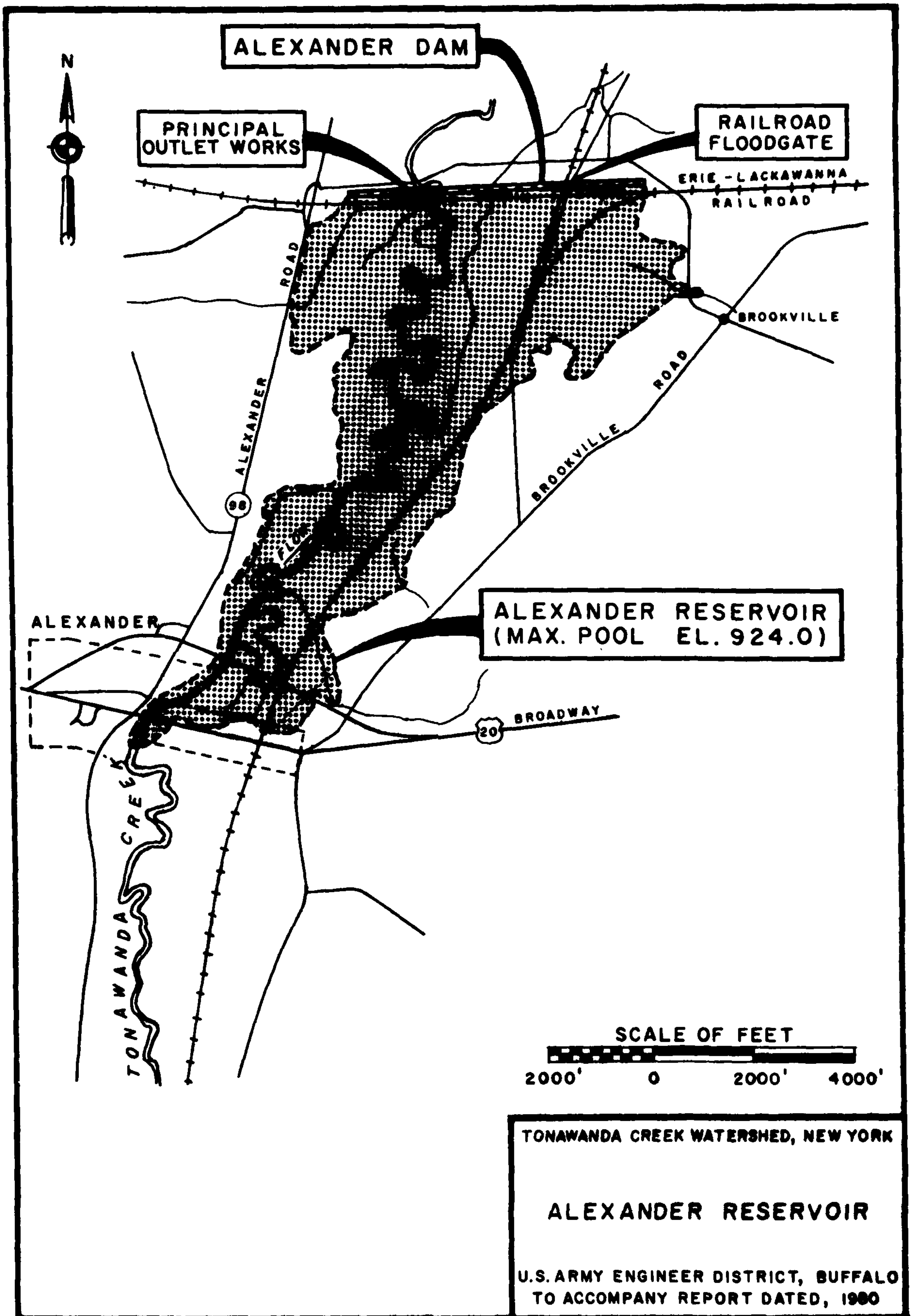
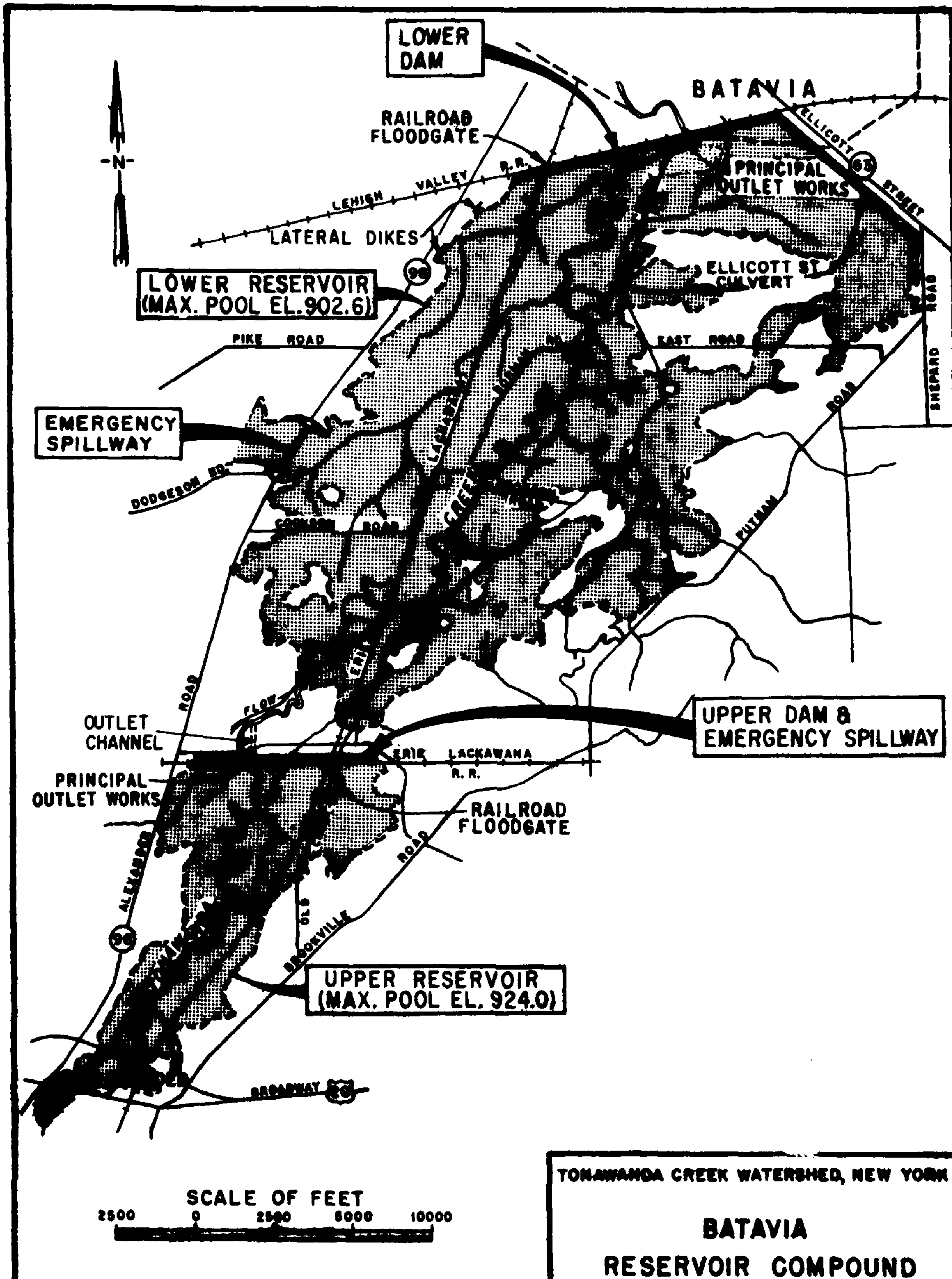

ALEXANDER DAM
N
PRINCIPAL OUTLET WORKS
RAILROAD FLOODGATE
ERIE - LACKAWANNA RAILROAD
ALEXANDER ROAD
98
BROOKVILLE
BROOKVILLE ROAD
FLOW
ALEXANDER RESERVOIR (MAX. POOL EL. 924.0)
ALEXANDER
BROADWAY
20
TONAWANDA CREEK
SCALE OF FEET
2000' 0 2000' 4000'
TONAWANDA CREEK WATERSHED, NEW YORK
ALEXANDER RESERVOIR
U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED, 1980

PLATE 8

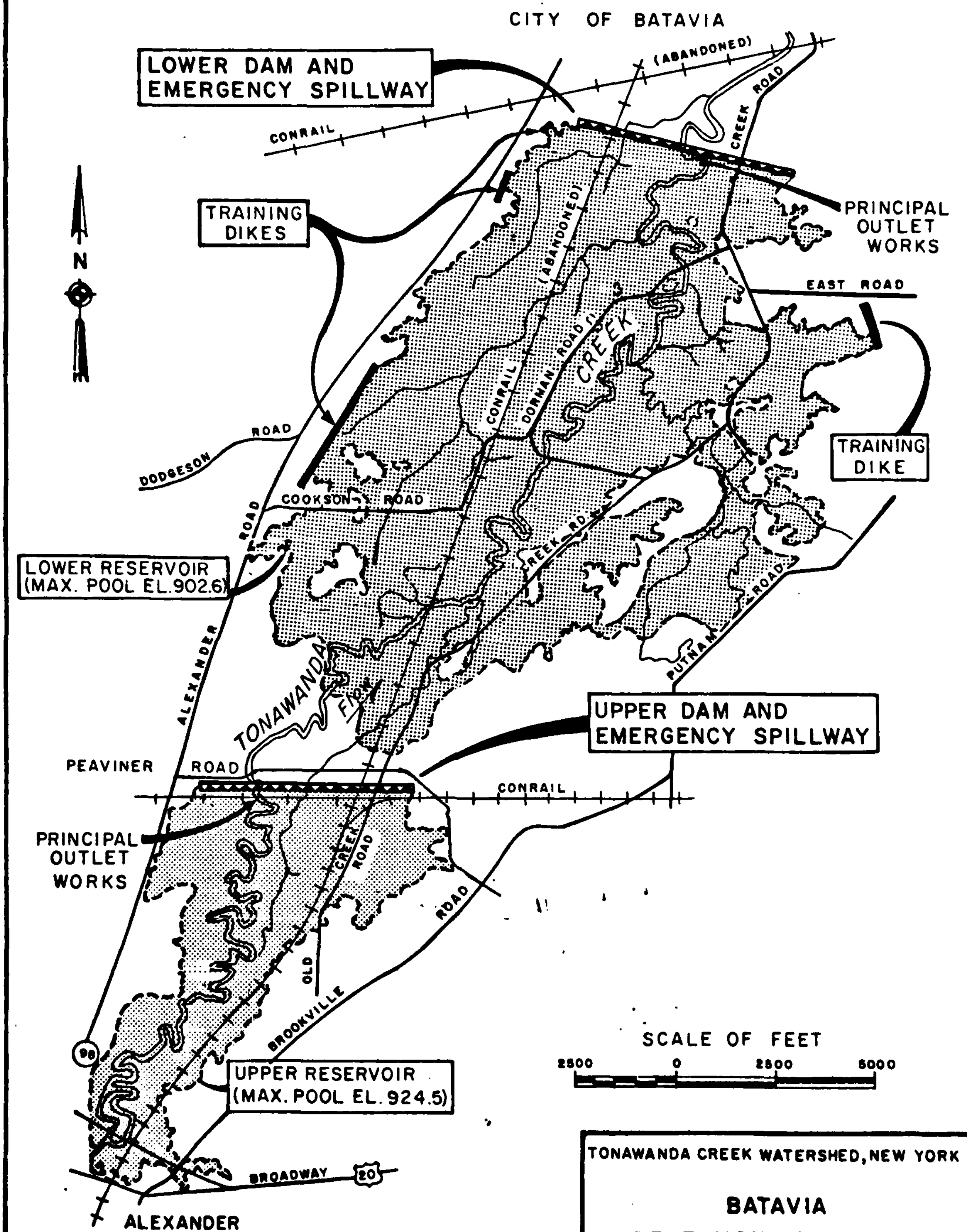


TONAWANDA CREEK WATERSHED, NEW YORK

BATAVIA
RESERVOIR COMPOUND

U. S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED: 1980

PLATE 9



TONAWANDA CREEK WATERSHED, NEW YORK

BATAVIA

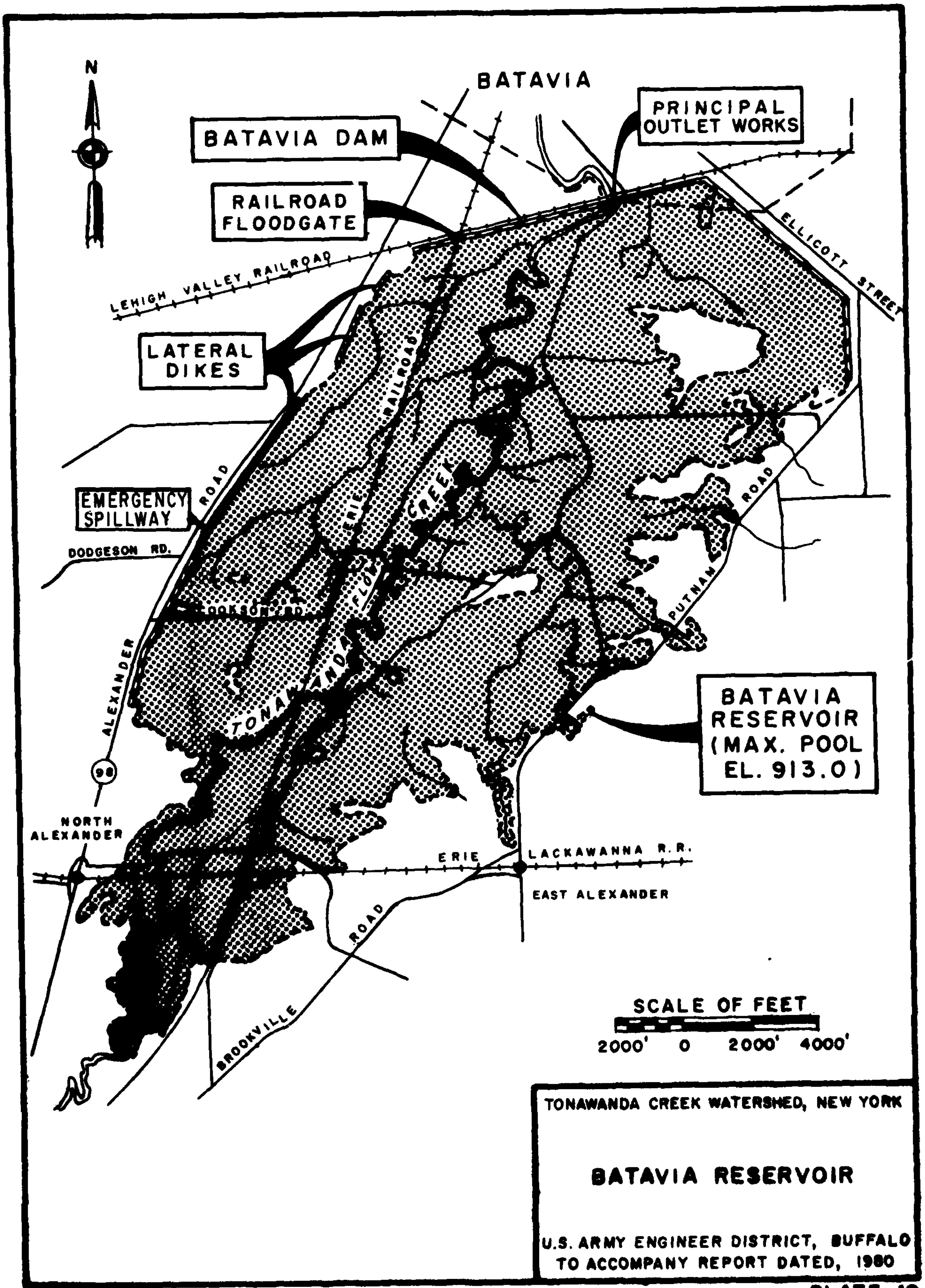
RESERVOIR COMPOUND

(MODIFIED)

U.S. ARMY ENGINEER DISTRICT, BUFFALO

TO ACCOMPANY REPORT DATED: 1980

PLATE 9A

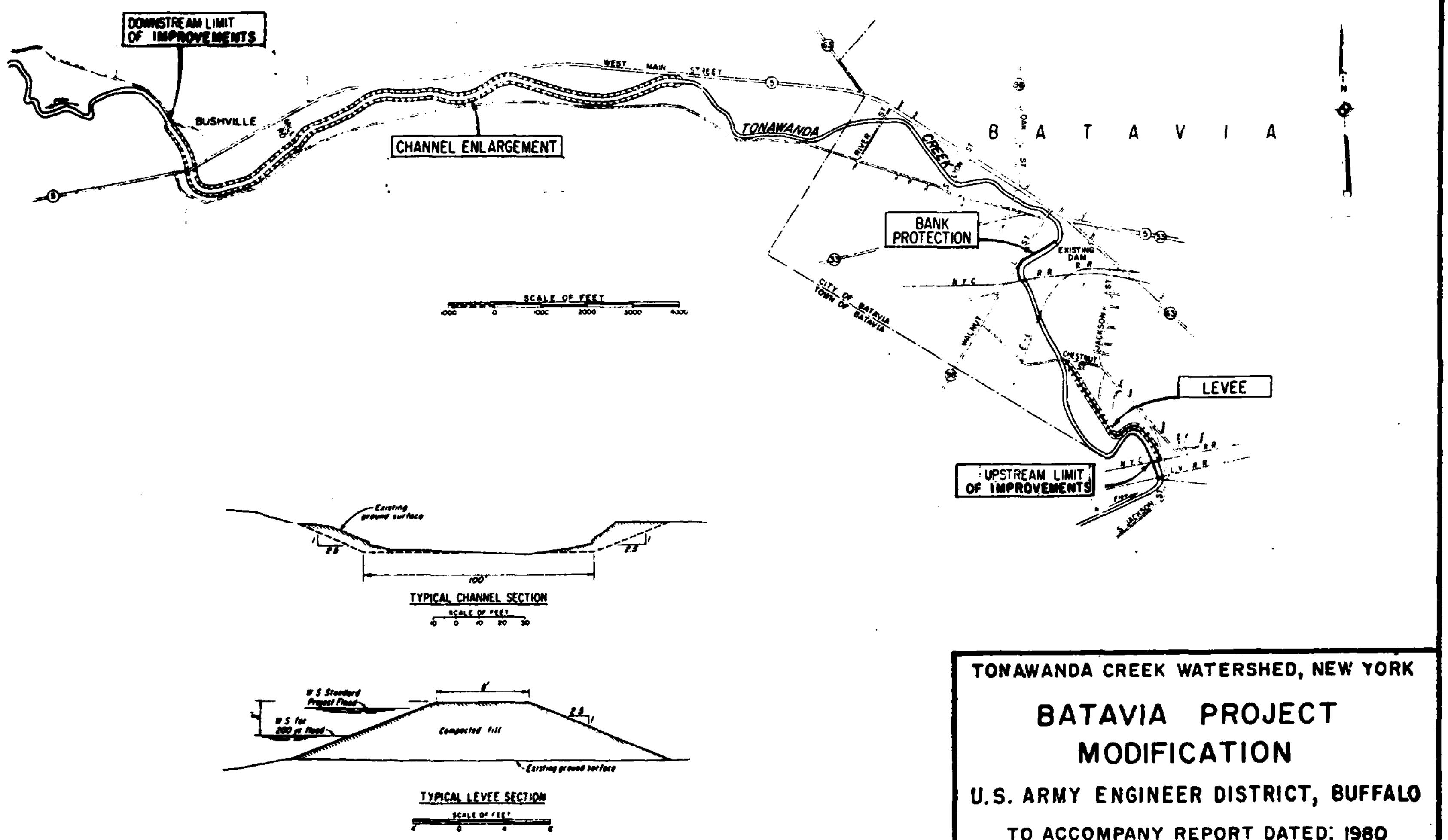


TONAWANDA CREEK WATERSHED, NEW YORK

BATAVIA RESERVOIR

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED, 1980

PLATE 10



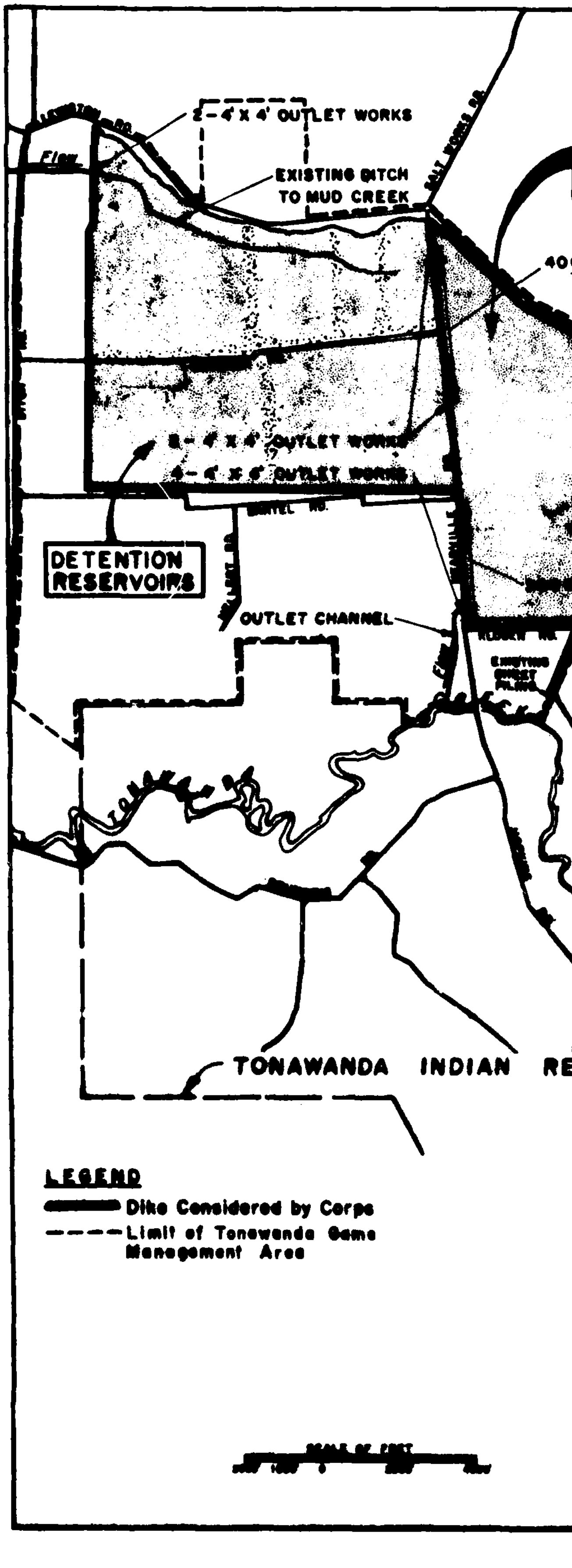
TONAWANDA CREEK WATERSHED, NEW YORK

BATAVIA PROJECT MODIFICATION

U.S. ARMY ENGINEER DISTRICT, BUFFALO

TO ACCOMPANY REPORT DATED: 1980

PLATE II



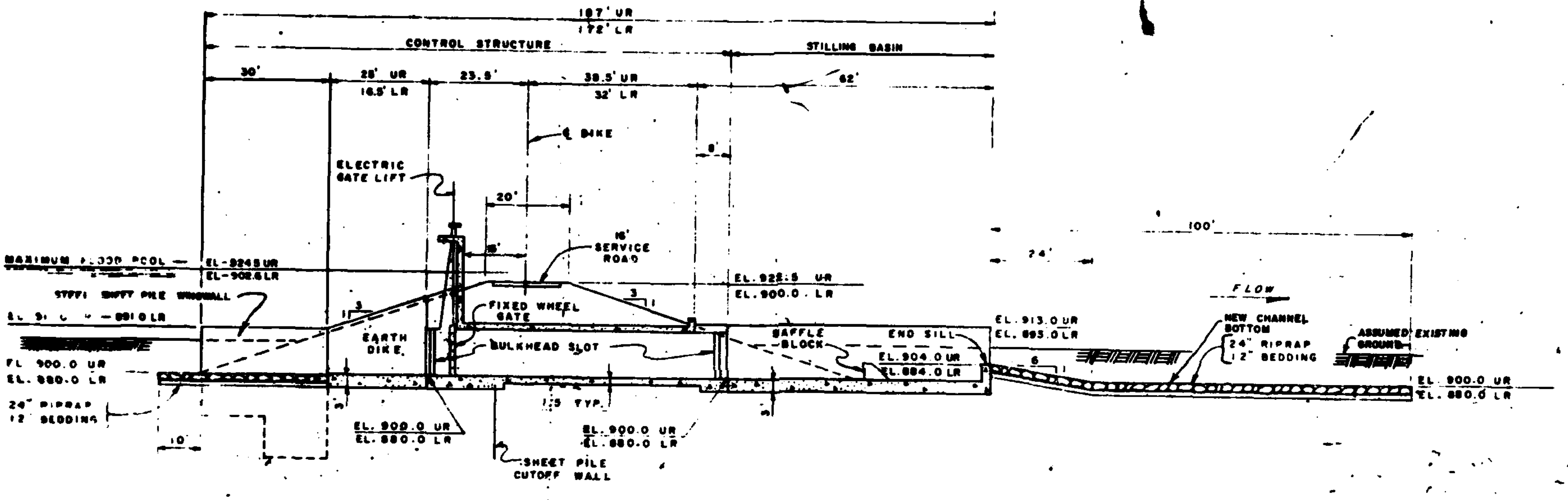
TONAWANDA CREEK WATERSHED, NEW YORK

ALABAMA RESERVOIR COMPOUND

U. S. ARMY ENGINEER DISTRICT, BUFFALO

TO ACCOMPANY REPORT DATED: 1980

PLATE 12



PRINCIPAL OUTLET WORKS

(CENTERLINE PROFILE OF TYPICAL CONDUIT)

NOT TO SCALE

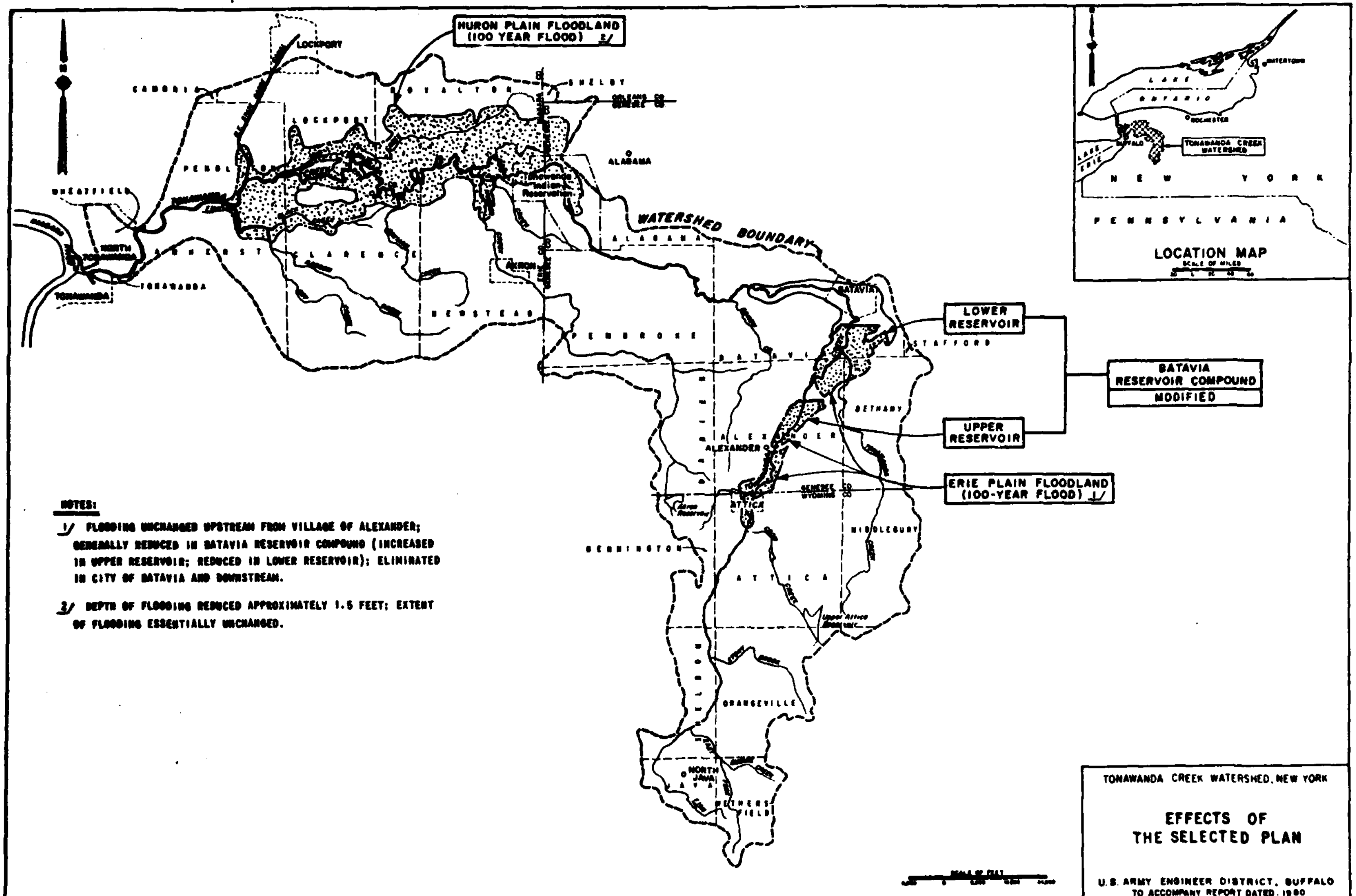
UPPER RESERVOIR (UR): 5 – 11' X 11' GATED CONDUITS
LOWER RESERVOIR (LR): 4 – 11' X 11' GATED CONDUITS

TONAWANDA CREEK WATERSHED, NEW YORK
BATAVIA RESERVOIR COMPOUND
(MODIFIED)

PRINCIPAL OUTLET WORKS

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED, 1980

PLATE 13



NOTES:

1/ FLOODING UNCHANGED UPSTREAM FROM VILLAGE OF ALEXANDER; GENERALLY REDUCED IN BATAVIA RESERVOIR COMPOUND (INCREASED IN UPPER RESERVOIR; REDUCED IN LOWER RESERVOIR); ELIMINATED IN CITY OF BATAVIA AND DOWNSTREAM.

2/ DEPTH OF FLOODING REDUCED APPROXIMATELY 1.5 FEET; EXTENT OF FLOODING ESSENTIALLY UNCHANGED.

TONAWANDA CREEK WATERSHED, NEW YORK

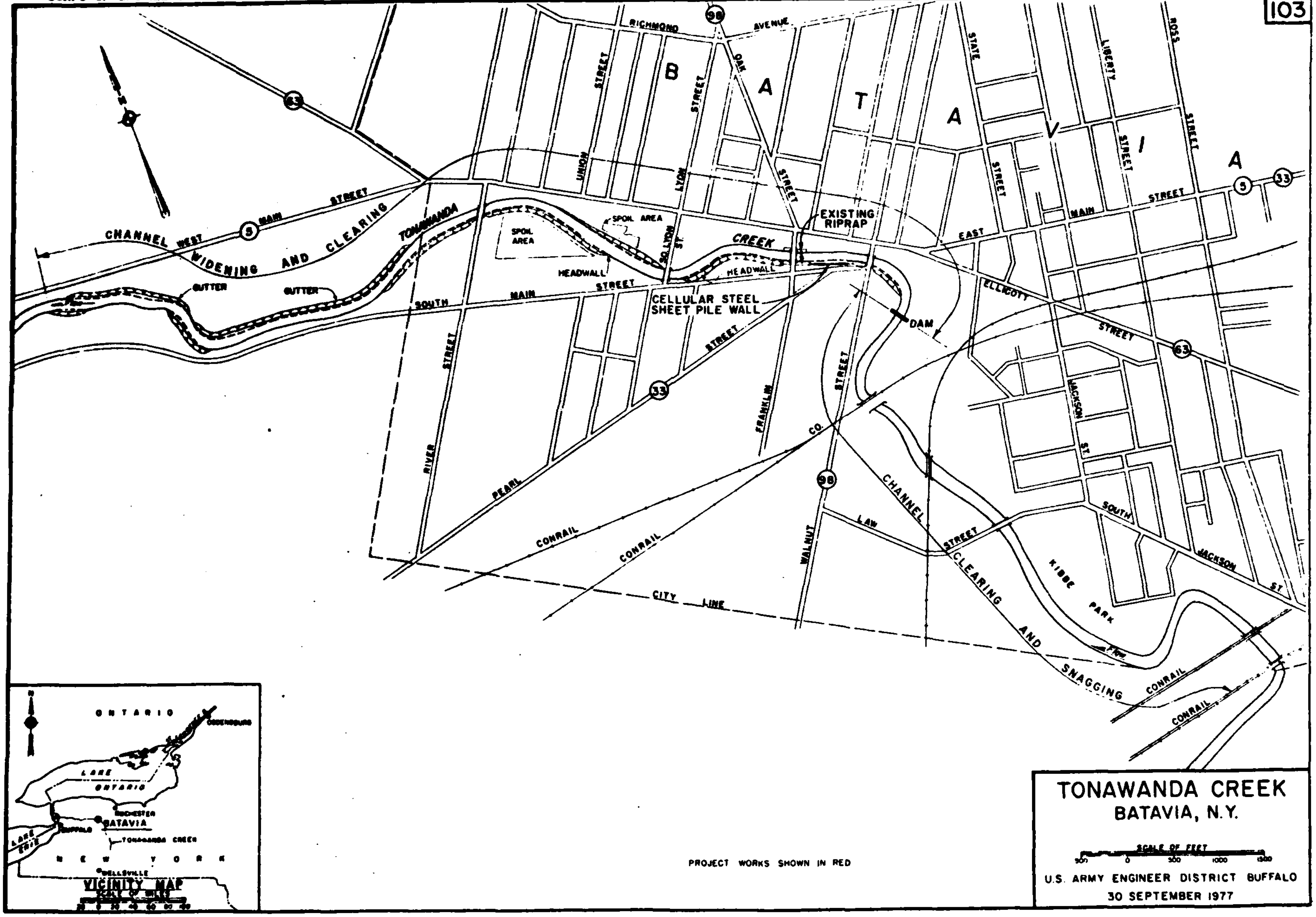
EFFECTS OF THE SELECTED PLAN

U.S. ARMY ENGINEER DISTRICT, BUFFALO
TO ACCOMPANY REPORT DATED 1980

PLATE 14

CORPS OF ENGINEERS

U. S. ARMY



PROJECT WORKS SHOWN IN RED

TONAWANDA CREEK
BATAVIA, N.Y.

SCALE OF FEET
500 0 500 1000 1500

U.S. ARMY ENGINEER DISTRICT BUFFALO
30 SEPTEMBER 1977

PLATE 15