PATAPSCO RIVER BASIN STUDY

Prepared By:
Regional Planning Council
U.S.D.A. Soil Conservation Service
March 1980

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Prepared by:

Baltimore Regional Planning Council

U.S. Department of Agriculture

Soil Conservation Service

Forest Service

Economics Statistics and Cooperatives Service

for

Sponsoring Member Jurisdictions

Anne Arundel County

Baltimore City

Baltimore County

Carroll County

Howard County

March 1980

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SUMMARY

This is the final River Basin Report for the Patapsco River Basin Study. It is the culmination of a twenty month study coordinated through the Baltimore Regional Planning Council and the USDA Soil Conservation Service. Many other agencies of local, state, and federal governments have cooperated in bringing the report to this stage.

The Patapsco River Basin Study area includes the watersheds of both the Patapsco River and Gwynns Falls. It is located in Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City.

Most of the water resource problems in the study area relate to urban flood damage along the lower Patapsco and its tributaries, the main stem of Gwynns's Falls, and Maiden's Choice Run. At the initiation of the study in 1978, it was determined by the Patapsco River Basin Coordinating Committee that the major emphasis should be on solving the flooding problems. Thus, the major emphasis of this study was on the flooding problems and possible solutions, with brief discussions of problems in water supply, water quality, erosion and sedimentation, and recreation.

The objectives of the study were: 1) to determine whether a feasible PL-566 flood prevention project existed anywhere in the Study Area, 2) if a project existed, were there potential sponsors for such a project and was it environmentally acceptable, and 3) if a project did not exist, to make recommendations about what other courses of action could be followed.

The initial effort of the Study was to inventory the flood damages. In order to do this, it was necessary to determine the flood levels and the associated damages.

Hydrologic and hydraulic models were developed in cooperation with the Maryland Water Resources Administration. These models were used to determine flood levels for Tropical Storm Agnes, plus the 100 year frequency flood for both present and future land uses.

Flood damages were determined using a damage survey conducted by the U.S. Army Corps of Engineers in conjunction with additional surveys done during the study. This information was then combined with the flood level data to determine amounts of flooding damage for Agnes, the 100-year flood, and lesser floods.

The conclusions reached by the flood damage analysis indicate that although flood damages are high during major floods, these floods do not occur frequently. The ten percent chance (10-year frequency) flood causes minimal damage with the one percent chance (100-year frequency) flood causing relatively major damage, thus making the average annual damages low.

Based on the procedures for economic analysis set forth in the Water Resources Council's Principles and Standards, it was determined that at this time there is no feasible structural flood prevention project under authority of the Watershed Protection and Flood Prevention Act, PL 83-566, as amended. A federally assisted structural flood prevention project must have economic benefits exceeding costs.

No structural alternative examined during this study meets this criterion. However, a nonstructural project may be feasible for portions of the study area.

There are many other avenues which can be followed to help solve the problems in the watershed. Some of these may include U. S. Department of Agriculture participation, mainly in the form of technical assistance. Most of the coordination and funding must come from the local and state governments or other departments within the U. S. Government. Below is a summary of possible sources and types of assistance available from different government agencies.

Source	Type[1]
City and County Government	T, A, N, S
State of Maryland	
Legislative Action	A, N, S
Department of Natural Resources	T, A, N, S
Baltimore Regional Planning Council	T
U.S. Government	
Soil Conservation Service	T, A, N, S[2]
Corps of Engineers	T, A, N, S[2]
National Oceanic Atmospheric Administration	T, N
Bureau of Outdoor Recreation	A

[1]T = Technical Assistance
A = Acquisition
N = Non Structural Measures
S = Structural Measures

[2]Structural projects shown to be non feasible.

The following general suggestions are offered for consideration:

1. Continue and expand the acquisition programs. In areas where people prefer not to accept an offer to purchase, acquire the residences as they become available. Coordinate the land acquisition programs of the State Park with structure acquisition programs of the local jurisdictions.

2. Expand Howard County's flood warning program to include other areas along the Patapsco River. Utilize the hydraulic and hydrologic models developed during the study to increase the lead time in predicting flooding. Expand Baltimore County's program on Gwynns Falls to include Baltimore City.

3. Develop a basin wide stormwater management program. Coordinate policies and requirements of all jurisdictions in order to get the most effective results from the program.

4. Consider methods other than acquisition for flood damage control. In certain areas, dikes, floodwalls, or flood proofing may be more cost effective methods of controlling damages from a 100-year flood. This report notes several areas where this may be true, namely, Woodbine, Elkridge, Pumphrey, Lower Gwynns Falls, and the Brittany Apartments. Also, a water supply impoundment being investigated by Carroll County on Gillis Falls would provide significant flood reduction benefits.

5. Monitor any changes in Federal policy with respect to cost sharing on non-structural practices. It may be possible that the changes would provide cost sharing for non structural measures; include acquisition for cost sharing; or provide cost sharing if the benefit cost ratio is less than 1:1.

6. Investigate the possibilities of developing a land treatment plan for the area. It may be possible to receive funding under PL 83-566 for an accelerated land treatment program to improve water quality.

Suggestions for specific subareas are as follows:

South Branch

1. Howard and Carroll County could consider a minor acquisition program on the South Branch.

2. Efforts could be made to educate people on methods of flood proofing.

North Branch

1. Modification of the bridges under the Western Maryland railroad tracks at Carrollton and Patapsco could be considered.

2. Special efforts could be made to control urban runoff upstream of Carrollton and Patapsco.

3. Baltimore City and the Congoleum Corporation could develop a joint flood hazard management plan for the protection of Liberty Reservoir.

Main Stem

1. Future planning should not be limited to examining major structural measures.

2. Baltimore, Howard, and Anne Arundel County could consider modification of existing floodplain constrictions between Elkridge and Baltimore Harbor.

3. An expanded acquisition program could be considered in Anne Arundel County.

4. The Howard County Flood Warning System could be expanded and refined to include Anne Arundel and Baltimore Counties.

Gwynn's Falls

1. Baltimore County could consider installation of four small impoundments in lieu of or in addition to its acquisition program. The impoundments also provide some benefits to Baltimore City.

2. Baltimore County and City could jointly develop a flood warning system and a flood disaster preparedness plan.

3. Baltimore County and City could consider dikes or floodwalls at two areas of concentrated flood damage.

4. The county and the city could investigate opportunities for retrofitted stormwater control on the Maiden's Choice Run and Dead Run tributaries to Gwynns Falls.

These suggestions are given in more detail near the end of the report.

INTRODUCTION

The Patapsco River and its major tributaries have long been a subject of concern among Water Resource Planning Agencies and the private citizens who are periodically threatened by flooding. In 1968, officials from the five jurisdictions that comprise the Patapsco Basin, the four Soil Conservation Districts represented in the basin, and officials from the state and regional governing bodies, petitioned the Soil Conservation Service (SCS) for assistance through the Watershed Protection and Flood Prevention Act, Public Law 83-566 (as amended). The officials cited flood damage, sedimentation, water management, and recreation as major problems within the Patapsco Basin.

Due to prior commitments of planning resources, the Soil Conservation Service was unable to act on the application. Meanwhile, other agencies took action to define and recommend solutions for the problems in the Patapsco Basin. Studies were conducted by the U. S. Army Corps of Engineers, Maryland Water Resources Administration, U. S. Department of Housing & Urban Development Federal Insurance Administration, and Howard and Baltimore Counties. Most of these studies focused on the problems in one area or on one tributary. There was little effort to coordinate the studies on a basin-wide basis.

In 1976, members of the Patapsco River Watershed Association and the Patapsco State Park Advisory Committee reinitiated their efforts to obtain technical assistance through PL-566. Through the Maryland Congressional Delegation, they petitioned the Soil Conservation Service for assistance.

In February of 1978, the U.S. Department of Agriculture and the Baltimore Regional Planning Council entered into an Intergovernmental Personnel Agreement. This agreement authorized the creation of a three-man technical team to study the water resource problems in the Patapsco River Basin. A Field Advisory Committee was established to coordinate the efforts of agencies within the U.S. Department of Agriculture. This Committee consisted of representatives from the Economics, Statistics and Cooperatives Service, the Forest Service, and the Soil Conservation Service.

During the course of this study many state and local agencies contributed to or participated in the management of the study. Financial sponsorship was given by the Baltimore Regional Planning Council, Baltimore City, and Anne Arundel, Baltimore, Carroll, and Howard Counties. Representatives of these jurisdictions, the Army Corps of Engineers, the Maryland Department of State Planning, and the Maryland Water Resources Administration formed the Patapsco River Basin Coordinating Committee. The Coordinating Committee held periodic meetings to review the progress of the study and to make recommendations which would guide the study efforts. The Committee members submitted formal comments on the Plan of Work, the First and Second Status Reports, and the draft final report. The four Soil Conservation Districts represented within the basin lent their support to the study.

The objective of the study was to determine whether or not an economically feasible PL-566 project existed in all or part of the Patapsco or Gwynn's Falls Basins. Efforts were to be coordinated with

those of other water resource agencies which were conducting or had conducted studies in any part of the defined study area. The study would evaluate existing data and generate needed additional technical data to determine feasibility based on economic and environmental criteria. Further, through a program of public involvement, potential project sponsorship and public acceptability would be determined.

The study has relied on information from concurrent studies. Most notable among these were the Maryland Water Resource Administration's hydraulic modeling of the Patapsco River and the Army Corps of Engineers economic damage surveys. The Baltimore Regional Planning Council projected population and land use changes necessary for the hydrologic modeling of the Patapsco River. Background information has been supplied by local and state agencies. Original surveys were conducted when necessary to complement existing data.

Many actions have been initiated or accelerated as a result of this study. This will eventually contribute greatly to water resource management in the basin.

As its contribution to this study, the Maryland Water Resources Administration accelerated its program of hydraulic modeling of the Patapsco River. With some assistance from the study team they have completed hydraulic studies on the Main Stem and South Branch of the Patapsco, some major tributaries on the lower Patapsco, and tributaries in Carroll County. Water surface profiles and cross-section rating curves are available to help local planners in making decisions relative to flood plain management.

A hydrologic model was developed for the entire Patapsco River watershed using the Soil Conservation Service's TR-20 computer program. The model breaks the watershed into 101 subareas. It is calibrated using present hydrologic conditions and can be continually updated as land use changes alter hydrologic response. The model can be used by state and local water resource management personnel to predict peak discharges for storms with given recurrence intervals at critical points throughout the basin. The model can also be used to develop incremental and combined hydrographs to show how different hydrologic subareas interact with each other. The output from the model can be used in conjunction with the hydraulic model to predict the height to which water will rise during various storms at various points along the Patapsco and its tributaries. At the close of this study, both of these models will be maintained by WRA. (See Appendix A - Hydraulics and Hydrology.)

The Baltimore Regional Planning Council contributed to this study by completing a detailed study of anticipated land use/land cover changes. (See Appendix D) The study was based on local and regional population projections and land conversion relationships. Data generated was reviewed by local jurisdictions. As a result, RPC was able to develop a predictive tool that represents the best current data of both the local and regional planning agencies.

This data was initially developed for inclusion as input to the hydrologic model. However, the information is in such fine detail that

it will have application in water quality planning as well as other land and water resource management programs which will benefit RPC and its member jurisdictions.

Two ad hoc work groups have been formed during the course of this study. The Storm Water Management Task Force is made up of representatives from state and local governments, the Soil Conservation Service, and the Corps of Engineers. The purpose of this group is to explore the possibilities of a basin-wide stormwater management program and the mechanisms by which such a program could be implemented. Through the efforts of RPC, the group will continue after the current study is complete. A second work group is exploring the possibility of expanding the Howard County flood warning system to include Baltimore and Anne Arundel Counties. This group includes Civil Defense officials, hydrologists, and planners from the affected jurisdictions. The group is considering the use of the hydrologic and hydraulic models developed during this study to increase the predictive capabilities of the system.

The value of committees such as these involving interjurisdictional interaction and coordination is that they strengthen lines of communication. Discourse between committee members increases the exchange of information and ideas for their mutual benefit.

As a result of recent meetings of the Stormwater Management Task Force, the idea of a Water Resources Analyzer Office has developed. The function of such an office would be the continuous monitoring and evaluation of stormwater management throughout the basin. With the hydrologic model, the Analyzer Office could evaluate the impact of the most current land use planning information on the flow regime and suggest the most cost effective means of mitigating any adverse impacts.

NATURAL RESOURCES OF THE BASIN

I. Location

The Patapsco River lies in northcentral Maryland on the western shore of the Chesapeake Bay. The Patapsco flows south and east to its mouth which is the Baltimore Harbor. Within the Harbor the Patapsco is joined by Gwynn's Falls, Jones Falls, Curtis Bay Creek, Jones' Creek, and Bodkin Creek. This River Basin Study includes two distinct drainage systems, the watershed of Gwynn's Falls and the watershed of the Patapsco River above the Baltimore Harbor. (See map inside back cover.)

The Patapsco River drains an area of 365 square miles. The area includes much of Carroll County east of Westminster and south of Manchester, northern Howard County, southern Baltimore County, northwestern Anne Arundel County, and a small part of Baltimore City near the harbor. Gwynn's Falls drains an area of 67 square miles in West Central Baltimore County and Baltimore City. The two watersheds are located in Water Resources Council hydrologic unit 02060003.

On the North Branch, Liberty Reservoir straddles the Carroll County-Baltimore County line at approximately the geographic center of the study area. Baltimore Washington International Airport lies in the extreme southeast corner.

II. Climate

The study area has a humid continental climate with mild winters and warm moist summers. The Appalachain Mountains to the west and the Chesapeake Bay and Atlantic Ocean to the east have moderating influences on the local climate. Their effect produces a more equable climate than other continental locations farther inland at the same latitude.

Rainfall averages about 41 inches per year with a rather uniform distribution throughout the year. The greatest intensities occur in July and August, the season for severe thunderstorms and part of the hurricane season. Severe droughts are rare. See Table 1.

January is the coldest month and July is the warmest. The growing season or freeze-free period lasts from April to October averaging 177 days near Westminster to 194 days near Baltimore Washington International Airport.

III. Physiography and Geology

The Patapsco River and Gwynn's Falls lie within the Piedmont and the Coastal Plain Physiographic Provinces. The Coastal Plain lies southeast of Elkridge and the Piedmont lies northwest.

The Piedmont portion is made up of metamorphic and igneous rocks which have been intensively folded, fractured, or both. The drainage pattern is irregularly branching with many angular reaches and steep-sided valleys. Metamorphic rocks, in order from oldest to youngest, are the

Baltimore gneiss, the Setters formation (mainly quartzite), Cockeysville marble, and Wissahickon schist. Igneous rocks include the Baltimore gabbro and several granite areas. These rocks originated as molten masses which invaded the older metamorphic rocks.

The Coastal Plain in the basin consists of the Patuxent and Patapsco formations. These units overlap the Piedmont rocks to the west and are made up of sand and clay layers that dip very gently easterly. Valleys in the Coastal Plain tend to be broader than in the Piedmont because of softer materials and flatter stream gradient.

Sand and gravel are surface-mined at several localities. Crushed stone is quarried in the Cockeysville marble near Marriottsville. Slate and marble building stone is also quarried here.

Formerly, granite was quarried downstream from Ellicott City. Iron ore was taken from workings near Elkridge, Sykesville, and Mount Airy. Feldspar and quartz were mined along the Patapsco River below Marriottsville, and flint was quarried from schist in southeastern Carroll County. Soapstone was quarried until recently northwest of Marriottsville. These mines are presently inactive.

The topography is characterized by gently rolling to steep uplands with streams of fairly steep gradient feeding into wide bottomlands. Near Elkridge the River becomes tidal and its valley widens. Elevations range from 1100 feet at Manchester in eastern Carroll County to sea level at the Baltimore Harbor.

IV. Land Resources

The Piedmont portion of the River Basin is dominated by Chester, Glenelg, and Manor soils. These soils are, in general, of moderate fertility. They have moderate infiltration rates and retain moisture well for plant growth, yet are well drained. These characteristics make the area well suited for agriculture although there is potential for erosion problems.

On the coastal plain, soils have a wide range of properties. Among the more dominant soils are the Chillum, Sassafras, and Beltsville series. These soils are not naturally fertile but respond well to good management and fertilizer. Most of this area is being developed for residential, commercial, and industrial uses.

The objectives of the U. S. Department of Agriculture's prime lands program are (1) to prevent our most productive lands from being irrevocably committed to other purposes, and (2) to be advocates for the protection of prime lands. The Department's prime lands program identifies prime lands so they may be considered when planning for other uses.

Prime farmland is the land best suited for producing food, feed, forage, fiber, and oilseed crops, and also is available for these uses. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed according to modern farming methods. Prime farmland gives the highest

yields with the lowest inputs of energy or money, and with the least damage to the environment. There are approximately 115,000 acres of prime farmland in the Patapsco River Basin. This area includes prime land which is farmland, and prime land which could be converted to farmland. Urban or built-up land is not considered primeland. (See map inside back cover.)

Prime forestland is land that has soil capable of growing wood fiber at the rate of 85 cubic feet per acre per year, and is not in urban or built-up land uses. Currently about 3,300 acres of commercial forest are located on prime forestland. There is considerably more prime forestland within the basin which is not currently forested. It is important to note that there is a considerable overlap of prime farmland and prime forestland.

V. Water Resources

There are no natural lakes in the River Basin. However, there are two important man-made impoundments. Liberty Lake is a 3100 acre water supply reservoir located on the North Branch of the Patapsco River. Piney Run Lake is a 300 acre water supply and flood control reservoir located in southern Carroll County. In addition, several hundred man-made ponds are scattered thoughout the area. Most of these ponds are between one-half and one acre in size. Usually these ponds are designed for fishing, livestock watering, or aesthetics.

The Coastal Plain region contains most of the wetlands within the river basin. Located in this region are four acres of Type 3 wetlands, 140 acres of Type 5, 40 acres of Type 6, one acre of Type 7, and 350 acres of Type 12 wetlands.

The Piedmont region contains small acreages of wetlands scattered throughout the area. Most of these wetlands are classified Type 1 or Type 2.

Surface water flow records have been collected by the U. S. Geological Survey. Peak flood flows and annual low flows are summarized in Tables 2 and 3 for three locations along the Patapsco River.

Water quality and the related beneficial uses of the Patapsco River and its tributaries range from excellent to poor. In the Liberty Reservoir drainage, water quality is generally good. Liberty Reservoir has been identified as "mesotrophic" by EPA studies in 1974. Morgan Run is classified as a natural trout stream and several other streams are capable of supporting adult trout. The fecal coliform standard (an indicator of the possible presence of harmful bacteria) is the only standard which is violated in the Liberty Reservoir drainage. The City of Westminster has experienced occasional taste and odor problems in its municipal water supply.

In the drainage area of the South Branch, wastewater treatment plants contribute to water quality problems. The Mt. Airy plant increases the biochemical oxygen demand and suspended solids while the Freedom District

plant has a residual chlorine problem. Sediment deposition and high fecal coliform counts are especially significant due to the existence of highly erodible soils and several large livestock operations in the basin. Swimming and fishing are good in the area with several streams capable of supporting adult trout. The Piney Run water supply reservoir has good water quality.

The main stem has two tributaries, Granite and Mordella Branches, which are designated natural trout streams. Most of the stream is suitable for contact recreation and support of aquatic life. However, sampling programs in 1976 and 1977 noted frequent violations of fecal coliform standards and occasional violations of pH and turbidity standards.

Gwynn's Falls is designated suitable for contact recreation and aquatic life by the Maryland Department of Natural Resources. The upper portion of Red Run is designated as a natural trout stream. Sampling programs indicate frequent violations of fecal coliform and dissolved oxygen standards. The most important potential sources of pollution are sanitary sewers and related facilities.

Groundwater occurrence in the basin is of two main types: that in fractures in the Piedmont rocks and that in pervious layers in the Coastal Plain.

Of the Piedmont rocks, the highest yield seems to be in the Wissahickon formation. Yields are variable but may average 15 gpm. Average well yields tend to be much less than this in the igneous rocks. Most wells in the Piedmont rocks penetrate no deeper than 300 feet.

In the Coastal Plain, groundwater movement occurs principally through gently dipping pervious zones that are confined by relatively impermeable layers. Water enters the exposed (westerly) edges of these permeable layers and moves east-southeasterly. This artesian water will rise in varying degrees in wells intersecting the aquifer.

Most wells in the Coastal Plain portion of the basin are supplied from either recent alluvium or the Patapsco formation. The average well yield for the Patapsco formation is about 50 gpm.

VI. Fish and Wildlife Resources

Wildlife populations are present throughout most of the study area. Carroll County contains some of the best habitat available in Maryland for pheasant, with its numerous fields interspersed with grassy or wooded hedgerows and corners that are not easily cultivated. As the hedgerows become less numerous in Baltimore and Howard Counties and small woods become the major cover, pheasant populations decline and bobwhite quail populations increase. American woodcocks use the bottom lands during migration. Mourning dove populations are high each fall. Other game species are limited in numbers throughout this area. Cottontail rabbit populations are moderate to low due to the clearing of most of the brushy cover and mowing or pasturing of most of the grasslands. Only the large wooded areas around Liberty Reservoir and in Patapsco Valley State Park

support fairly high populations of deer. High squirrel populations are supported in the mature forest land that exists throughout this section of the study area.

As one approaches Baltimore, game species decline and small animals, such as raccoon, opossum, and songbirds become more dominant. Leakin-Gwynn's Falls Park provides the largest stands of woodland which provides the best quality wildlife habitat in this section.

The coastal plain region of the Patapsco River provides habitat for several wetland species. Several species of ducks, the least bittern, the cattle egret, and other shore and wading birds can be found. A few plovers and sandpipers can be found here too, especially during migration periods.

The streams throughout the study area provide habitat for raccoons, mink, and muskrat. Beaver have been planted along the South Branch of the Patapsco but are more numerous now near Liberty Reservoir.

A wide variety of sparrows, warblers, and other songbirds are supported in the woods and openlands. Hedgerows and woods edges are abundant for species such as the cardinal, mockingbird, and the bluebird. Several species of woodpeckers can be found in the wooded areas. The Baltimore Oriole is also a common resident in the area. Occasionally, a Bald Eagle may be seen, but it is not known to nest in the area. The Dickcissel can be found and it is listed in the "Threatened Birds of Maryland", a 1973 publication of Chandler S. Robbins. Mallards and wood ducks are the only waterfowl that are common throughout the study area.

The reptile species located here are numerous. Forty nine species of snakes, lizards, amphibians and turtles have been recorded in the Patapsco Valley State Park.

The lower section of the Patapsco River from the harbor to Elkridge is tidal. This segment of the river and the surrounding ponds support a variety of fish. Catfish, carp, brown bullheads, American eel, sunfish, white perch, and white suckers are the most common species present. Occasionally largemouth bass, pickerel, and yellow perch are caught, especially in the old gravel pits surrounding the river. Anadromous runs of yellow perch, herring, alewives, and white perch have been recorded in the river and its tributaries.

From the confluence of the North and South Branches of the Patapsco to the fall line at Elkridge, the river flows through a narrow valley and has a bed consisting mainly of large rocks and boulders. Yellow perch, white suckers, sunfish, rock bass, largemouth bass, catfish, bullheads, and carp are the most common species here.

The South Branch of the Patapsco flows rapidly over shallow, rocky beds interspersed with pools. The most common species present are smallmouth bass, suckers, sunfish, common shiners, and creek chubs. Trout may be found in the streams of this section of the Patapsco.

The North Branch is dominated by the 3,100 acre Liberty Reservoir. The reservoir is stocked with largemouth bass, smallmouth bass, sunfish,

carp, and catfish. Several of the tributaries of the reservoir support brook and rainbow trout.

Gwynns Falls has not been sampled for fish since 1940. The watershed has undergone major changes since then due to urbanization. At the time of the sampling, Gwynn's Falls was known as a source for all types of game fish but this is no longer true.

The bog turtle and the bobcat are two species of wildlife in the study area that are classified as endangered or threatened. The bog turtle is found only in the very northern section of the study area in Carroll County near Hampstead and Manchester. The bobcat is found only in the large uninterrupted stands of woodland of the Patapsco State Park and Liberty Reservoir or along wooded stream bottoms.

Table 1 Temperature and Precipitation Data

	Normal Temperature (°F)			Normal Precipitation (inches)		Mean Number of Days With		
	Daily Maximum	Daily Minimum	Monthly	Monthly Water Equivalent	Monthly Snowfall	Precipitation 0.1 in. or more	Temperature 90°F or above	Temperature 32°F or below
Westminster, Carroll County								
Jan	39.7	23.1	31.4	2.97	7.9	7	-	26
Feb	41.9	24.1	33.0	2.79	8.7	6	-	23
Mar	51.4	30.8	41.1	3.88	8.4	8	-	19
Apr	64.0	40.9	52.5	3.43	0.2	8	-	5
May	73.7	50.3	62.0	3.69	-	8	1	*
Jun	81.8	59.0	70.4	3.65	-	7	5	-
Jul	85.5	63.5	74.5	4.52	-	7	8	-
Aug	83.8	61.6	72.7	4.10	-	7	6	-
Sep	77.4	54.9	66.2	3.04	-	5	2	*
Oct	66.6	44.8	55.7	2.94	T	5	*	3
Nov	53.8	35.2	44.5	3.36	1.3	6	-	13
Dec	41.4	25.4	33.4	3.47	7.0	7	-	25
Year	63.4	42.8	53.1	41.84	33.5	81	22	114
Baltimore Washington International Airport								
Jan	41.9	24.9	33.4	2.91	-	10	0	25
Feb	43.9	25.7	34.8	2.81	-	9	0	21
Mar	53.0	32.5	42.8	3.69	-	11	0	15
Apr	65.2	42.4	53.8	3.07	-	11	*	3
May	74.8	52.5	63.7	3.61	-	11	1	*
Jun	83.2	61.6	72.4	3.77	-	9	7	0
Jul	86.7	66.5	76.6	4.07	-	9	11	0
Aug	85.1	64.7	74.9	4.21	-	10	8	0
Sep	79.9	57.9	68.5	3.12	-	7	3	0
Oct	68.3	46.4	57.4	2.81	-	7	*	2
Nov	56.1	36.0	46.1	3.13	-	9	0	12
Dec	43.9	26.6	35.3	3.26	-	9	0	21
Year	65.1	44.8	55.0	40.46	-	112	31	99

Source: Weather Bureau Cooperative Station in Westminster and National Oceanic & Atmospheric Administration, Weather Service at BWI

Note: Average duration of the frost free period: Westminster - 177 days; BWI Airport - 194 days

TABLE 2

STREAMFLOW RECORDS [1]

Patapsco River

Gage ID Number	Drainage Area sq. mi.	Years of Record
South Branch @ Henryton 01587500	64.4	1949 - 1979
North Branch @ Cedarhurst 01586000	56.6	1946 - 1979
Patapsco River @ Hollofield [2] 015890000	285.0	1945 - 1979

PEAK FLOOD FLOWS

Recurrence Interval (yrs.)	Percent Chance of Occurrences	Peak Discharges in cubic feet per second (cfs) Henryton	Cedarhurst	Hollofield
100	1	23180	16550	59320
50	2	16670	12320	40140
25	4	11800	9040	26740
10	10	7220	5790	15090
5	20	4770	3970	9380
2	50	2430	2120	4410

MAGNITUDE AND FREQUENCY OF ANNUAL LOW FLOWS

Annual Minimum	Discharge, in cfs, for indicated recurrence interval 2-year	5-year	10-year	100-year
Henryton				
1-day	14.2	7.2	5.0	1.5
7-day	16.1	8.6	6.0	2.0
30-day	20.2	12.1	9.0	4.0
Cedarhurst				
1-day	16.0	11.0	8.5	4.6
7-day	17.5	11.8	9.4	5.0
30-day	21.0	14.4	11.4	6.2
Hollofield				
1-day	41.4	21.0	13.0	-
7-day	47.0	23.6	15.7	-
30-day	56.8	29.4	19.5	-

1/ Source: U. S. Geological Survey Stream Gage Data
2/ Flows modified by Liberty Reservoir since 1954. Data requires modification.

TABLE 3

STREAMFLOW RECORDS [1/]

GWYNN'S FALLS

Gage	Drainage Area Sq. Mi.	Years of Record
Gwynn's Falls @ Owings Mills 01589200	4.9	1958 - 1975
Gwynn's Falls @ Villa Nova 01589300	32.5	1957 - 1979

PEAK FLOOD FLOWS

Recurrence Interval (years)	Percent Chance of Occurrence	Peak discharges in cubic feet per second (cfs) Owings Mills	Villa Nova
100	1	6,900	14,130
50	2	4,440	10,080
25	4	2,790	7,050
10	10	1,430	4,220
5	20	800	2,720
2	50	310	1,300

Source: U. S. Geological Survey Stream Gage Data

ECONOMIC RESOURCES

The economy of the Patapsco River Watershed has long been based upon the river. Since Europeans colonized the area the river has been used for transportation. Elkridge was once a prosperous port, rivaling Annapolis in its importance. The Patapsco provided power for many grist mills, textile mills, and iron works. Bloede Dam, near Elkridge, was the world's first underwater power plant. As the country grew the Baltimore and Ohio Railroad laid the first thirteen miles of public railroad track along the river from the harbor to Ellicott City.

As the river became less important for power and transportation, its importance grew in other areas. In 1912, the Patapsco River Forest Reserve was established on a 434 acre parcel donated to the State of Maryland. This site was the home of Americas first Civilian Conservation Corps in the 1930's. This parcel was also the beginning of the Patapsco Valley State Park, which now covers 9,655 acres. Today the park provides the residents of Maryland with tens of thousands of recreational opportunities each year.

In the early 1950's the City of Baltimore constructed Liberty Dam on the North Branch of the Patapsco. Since then the reservoir has provided the millions of gallons of water per day necessary for the economic growth of the region.

The Baltimore Harbor, which is the mouth of the Patapsco, provides the East Coast with one of America's finest ports. Today the port is the focal point of the region's economy.

According to Regional Planning Council estimates, the population of the Baltimore SMSA was 2,142,000 in 1975. This population reflects a 1.5% growth per year over the period 1950-1975. It is expected that growth will continue at a rate of 1.4% per year between 1975 and 2000.

The Regional Planning Council has also projected the population growth for the Patapsco River portion of each jurisdiction. The population in 1975 is estimated to have been 248,000. The population in the year 2000 is projected to be 389,000. This growth is equivalent to 1.8% per year. Thus the growth within the Patapsco area will be slightly greater than for the region as a whole.

Growth varies considerably from jurisdiction to jurisdiction. Baltimore City will experience very limited growth, gaining 1,000 people in the next twenty-five years. Most of the growth in the study area will occur in Baltimore, Howard, and Carroll Counties which will experience 35%, 31%, and 26% of all growth, respectively. Tables 4 and 5 show basic population characteristics.

The density of the population is shown in Table 6. Baltimore City, which is 100% urban, has a density of 11,600 people per square mile. Anne Arundel and Baltimore Counties have significantly lower densities at 700 and 1000 people per square mile, respectively. Howard County has a density of 250 people per square mile and Carroll County, which is 90% rural, has only 150 people per square mile.

Table 8 lists the major industries in the Baltimore Region and the number of people employed by these industries in 1970. The manufacturing and trade industries are by far the most important. Employment is centered around Baltimore City and the Port of Baltimore. Carroll and Howard Counties have fewer employment opportunities. The relative share of employment opportunities for each jurisdiction is closely related to the share of population in each jurisdiction as shown in Table 7. Thus residential and commercial/industrial growth seem to be balanced with each jurisdiction in the Baltimore Region. The distribution of family income, by jurisdiction, is shown in Table 9.

The economy of the entire region is dominated by the Port of Baltimore and its many supporting facilities and services. The economic well-being of the Baltimore area relies heavily on the health of the Port and of world trade. The efficient movement of goods, by land, to and from the Port is of critical importance in maintaining a competitive port facility. Baltimore is fortunate in having an excellent access to the Interstate Highway system. I-95 reaches south and to the northeast, I-70 leads to Pittsburgh and points west, and I-83 permits easy access to the north.

In the western part of the Patapsco River Basin, agri-business is a major influence. Carroll County is one of the most agriculturally productive counties in the state. Within the Patapsco River watershed, 45% of the land is used for agriculture. The acreage devoted to crops and pasture is decreasing and is projected to decrease further but agriculture will remain a major sector in the region's economy. The most important farm products in the Baltimore Region are milk, corn, and hay. Yields are good and are approximately the same as for the state as a whole. Of all counties in Maryland, Carroll County is second in production of hay and milk and third in production of corn. (See Table 11.)

The importance of the agricultural sector to the area goes far beyond the provision of food and fiber. In Maryland, the total farm income in 1977 was 761.7 million dollars. Production expenses were 638.4 million dollars. Thus 84% of the total farm income is spent for feed, seed, fertilizer and lime, repairs, hired labor, depreciation, taxes and other costs. Sixty million dollars were added to the economy of the four-county area for agricultural inputs. Additional millions are added each year for transportation, marketing, and processing of agricultural products. Many businesses rely on the farm base.

Land use figures show that 40% of the Patapsco and Gwynn's Falls watershed are in agriculture. Another 40% is in forest, brush, and other open space. The remaining 20% is in residential, commercial, or industrial use. The majority of this urban land is in the Gwynn's Falls watershed and along the lower portion of the Patapsco. As growth and development occur during the next twenty-five years, significant acreages will be converted to urban uses. (See Table 10.)

As population and the non-agricultural sectors of the region's economy expand, agriculture comes under increasing pressure. Local jurisdictions are attempting to relieve some of the pressure and to preserve a strong agricultural base. Baltimore and Howard Counties have growth management plans which recommend watershed protection areas and conservancy areas.

Carroll County has a zoning classification for agricultural districts which restricts other forms of development. In addition, Howard County has authorized the purchase of development rights on 20,000 acres of agricultural land.

These efforts should reduce some uncertainties associated with development patterns and schedules. Also some farmland owned by non-farmers may be converted to farmer ownership. Both of these policies will increase the willingness of farmers to make capital investments necessary to maintain and improve the productivity of agricultural land.

Forestland covers approximately 67,000 acres in the Patapsco River watershed and 12,500 acres in the Gwynn's Falls watershed. Most of this land is in small holdings. There are only two large blocks of forestland in the river basin, the Patapsco Valley State Park and the reservoir protection zone around Liberty Reservoir. Sixty percent of the forest in the river basin is oak-hickory and 15% is pine. Elm-ash-maple and maple-beech are the next most prevalent types, accounting for 10% and 8% of the forestland, respectively.

Over fifty percent of the commercial forestland supports stands of sawtimber but almost 90% of the forestland is understocked. Current annual growth is approximately 2300 thousand cubic feet. Improved management could increase growth rates to about 4100 thousand cubic feet per year. The major reason for low growth figures is the lack of investment in forestry. Landowners are hesitant to invest in forestry because a return on that investment would not be realized for many years. Additionally, many owners of forestland have primary interest in recreation, wildlife, speculation, or land uses other than fiber production.

In the recent past, annual growth of hardwood species has been almost double the annual harvest. The inventory, thus, is increasing. However, much of the growth occurs on small or less desirable trees. For softwood species, the annual harvest has been more than double the annual growth. This imbalance could seriously reduce softwood inventories if it continues much longer.

The forest sector does add to the local economy. The income to local landowners from the sale of standing timber approximates one million dollars annually. Additional income is generated for those employed in harvesting and transporting wood to mills for processing.

In addition to public facilities, the Baltimore Region has many outdoor recreation facilities on private lands. These facilities provide opportunities for recreation and contribute significantly to the local economy. (See Table 12.)

Table 4 Population Trends and Forecasts, in Thousands

	Baltimore City	Anne Arundel County	Baltimore County	Carroll County	Harford County	Howard County	Total
	Population Trends in the Baltimore Region[1]						
1930	804.9	55.2	124.6	36.0	31.0	16.2	1068
1940	859.1	68.4	155.8	39.1	35.1	17.2	1174
1950	949.7	117.4	270.3	44.9	51.8	23.1	1457
1960	939.0	206.7	492.4	52.8	76.8	36.2	1804
1970	905.8	297.5	621.1	69.0	115.4	61.9	2071
	Population Forecasts for the Baltimore Region[2]						
1975	845.1	342.7	639.6	81.2	135.7	98.0	2142
2000	866	593	923	131	211	266	3010
2025	955	830	1070	195	265	360	3675
	Population Forecasts for the Patapsco River Watershed[2]						
1975	23	32	109	57	--	27	248
2000	24	42	158	94	--	71	389
2025	26	50	183	141	--	95	495

[1] Source: U.S. Bureau of Census Data
[2] Source: Baltimore Regional Planning Council

Table 5 Population in the Baltimore Region by Age and Sex, in 1970

Age Class (in years)	Population (in thousands)	Age Class as Percent of Total	Males as Percent of Total
under 10	381.1	18.4	50.9
10 to 19	401.9	19.4	50.4
20 to 29	312.2	15.1	49.0
30 to 39	236.2	11.4	48.6
40 to 49	263.9	12.7	48.5
50 to 59	219.3	10.6	48.7
60 to 69	146.7	7.1	45.7
70 to 79	79.6	3.8	39.7
over 79	29.8	1.4	33.5
Total	2070.7	99.9	48.7

Source: U.S. Bureau of Census Data

Table 6 Population Densities, in 1970

	Population per Square Mile	Urban Population as Percent of Total
Baltimore City	11,612.3	100.0
Anne Arundel County	703.4	67.3
Baltimore County	1,038.6	88.7
Carroll County	151.3	10.4
Howard County	246.7	35.3

Source: U.S. Bureau of Census Data

Table 7 Distribution of Population and Employment, in 1970

	Percentage of Total Population	Percentage of Total Employment
Baltimore City	43.7	43.5
Anne Arundel County	14.4	13.3
Baltimore County	30.0	32.0
Carroll County	3.3	3.4
Harford County	5.6	4.9
Howard County	3.0	3.0
Total	100.0	100.1

Table 8 Employment by Industry, in 1970

Industry	Baltimore City	Anne Arundel County	Baltimore County	Carroll County	Harford County	Howard County	Total
Agriculture, Forestry, and Fisheries	1,431	1,506	2,226	1,824	1,389	831	9,207
Mining	212	149	229	76	110	69	845
Construction	18,315	8,569	15,481	2,904	2,996	2,176	50,441
Manufacturing	90,303	21,251	71,469	8,266	8,576	4,019	203,884
Transportation, Communication, and Utilities	27,262	8,521	17,445	1,562	2,425	1,587	58,802
Wholesale and Retail Trade	65,451	20,667	55,920	4,370	6,393	4,088	156,889
Finance, Insurance, and Real Estate	17,776	4,439	15,315	806	1,442	1,119	40,897
Business, Repair and Personal Services	30,623	7,259	13,984	1,616	2,303	1,815	57,600
Entertainment and Recreational Services	3,073	905	2,251	78	280	236	6,823
Hospitals and Health Services	27,066	4,179	13890	1,842	1,606	1,125	49,708
Educational Services	25,401	9,210	19,011	1,753	3,182	2,209	60,766
Welfare, Religious and Nonprofit Organization Services	5,995	1,189	3,497	389	483	389	11,897
Professional Services	10,023	3,412	6,843	508	880	950	22,616
Public Administration	29,769	16,517	21,790	1,349	7,345	3,400	80,170
Total	352,700	107,773	259,351	27,343	39,365	24,013	810,545

Source: U.S. Bureau of Census Data

Table 9 Family Income Distribution in 1970, in Thousands of Families and Percent of Total Families

Income Class (in dollars)	Baltimore City #	%	Anne Arundel County #	%	Baltimore County #	%	Carroll County #	%	Howard County #	%
Under 2000	16.4	7.6	2.2	3.1	3.5	2.1	0.7	4.2	0.3	2.3
2000 - 2999	10.6	4.9	1.5	2.1	2.5	1.5	0.5	2.9	0.2	1.6
3000 - 3999	11.0	5.1	1.7	2.4	3.2	2.0	0.5	3.2	0.3	1.9
4000 - 4999	12.3	5.7	2.2	3.1	3.8	2.4	0.8	4.5	0.4	2.4
5000 - 9999	75.5	35.0	20.3	28.4	42.9	26.4	5.7	33.7	3.2	21.1
10000 - 14999	54.0	25.0	23.2	32.5	54.9	33.8	5.3	31.4	4.5	29.6
15000 - 24999	28.6	13.2	16.4	22.9	39.8	24.5	2.8	16.7	4.9	32.2
Over 25000	7.5	3.5	3.9	5.5	11.7	7.2	0.6	3.4	1.4	8.9
Total	215.8	100.0	71.4	100.0	162.4	99.9	17.0	100.0	15.2	100.0
Median Income	$8815		$11478		$12081		$10204		$13472	

Source: Maryland Department of State Planning, Maryland Family Income Characteristics: 1970 Census

[1]Median family income for Maryland is $11,063

Table 10 Present and Future Land Use for the Patapsco River and Gwynns Falls Watersheds

Land Use Category	1975 Acres	1975 %	2000 Acres	2000 %	2075 Acres	2075 %
			Patapsco River			
Low Density Urban	8,300	3.5	11,900	5.1	17,000	7.3
Medium Density Urban	5,500	2.4	10,200	4.4	17,000	7.3
High Density Urban	1,500	0.6	2,800	1.2	4,650	2.0
Trees	66,800	28.5	62,800	26.8	57,950	24.5
Brush	27,800	11.9	26,100	11.2	23,950	10.2
Grass	57,500	24.6	54,900	23.5	50,700	21.7
Crops	51,000	21.8	48,600	20.8	44,800	19.1
Bare and Undefined	10,600	4.5	11,700	5.0	12,950	5.5
Water	4,400	1.9	4,400	1.9	4,400	1.9
Total	233,400	99.7	233,400	99.9	233,400	99.8
			Gwynn's Falls			
Residential	20,200	47.2			29,200	68.0
Commercial	2,000	4.6			1,700	4.0
Industrial	2,000	4.6			4,300	10.0
Open Space	6,200	14.4			6,400	15.0
Forest	5,400	12.7			900	2.0
Cultivated	2,600	6.0			400	1.0
Grass	4,500	10.6			0	0.0
Total	42,900	100.1			42,900	100.0

Table 11 Agricultural Production

	1000's of Acres Harvested						Milk Production In Millions of Pounds
	Corn	Soybeans	Wheat	Barley	Hay	Vegetables	
Anne Arundel	8	1.7	1.5	0.1	4.5	0.2	4.0
Baltimore	24	3.0	4.5	5.0	15.0	3.1	6.0
Carroll	57	2.5	12.0	8.5	29.7	0.7	251.0
Howard	12	0.5	2.5	1.5	12.3	0.1	41.0
Total	101	7.7	20.5	15.1	61.5	4.1	302.0
Weighted Average Yield	95 bu/acre	29 bu/acre	38 bu/acre	51 bu/acre	2.4 ton/acre		11,500/lb/cow
Price/Unit (1978)	$2.25/bu	$6.50/bu	$3.00/bu	$1.80/bu	$70.00/ton	$470/acre	$11 00/hwt
Value in Millions of Dollars	21.6	1.5	2.3	1.4	10.3	1.9	33.2

Source: Maryland Department of Agriculture. Maryland Agricultural Statistics: Summary for 1978. June, 1979

Table 12 Inventory of Outdoor Recreation Facilities on Private Lands

CAMPING			
Day Camping	181 acres	815 guests	
Resident Camping	1588 acres	1670 guests	
Transient Camping	31 acres	74 vehicle sites	
Vacation Camping	85 acres	155 vehicle sites	24 tent sites
FIELD SPORTS			
Archery	46 ranges	21 positions	
Shooting	32 positions		
Tennis	173 courts		
FISHING			
Ponds or Lakes	120 acres	17	
Enterprises	33 acres	33	
GOLFING			
Driving Range	56 acres	173 positions	
Executive Course	427 acres	63 holes	
Miniature Golf	9 acres	108 holes	
Regulation Course	4020 acres	441 holes	
ARCHAEOLOGICAL			
Historical Sites	3567 acres	92 sites	
HUNTING WILD GAME			
Total Hunting	3358 acres		
Type of Hunting	1787 big game	3213 small game	
NATURAL-SCENIC			
Roads & Railroads	1 mile		
Picnicking	130 acres	492 tables	
Racing (viewing)	486 acres	113431 guests	4 miles track
Outdoor Theater	148 acres		
Shooting Preserve	450 acres		
TRAILS			
Total Trails	57 miles		
Bicycling Trails	25 miles	6 rentals	
Hiking/Nature Trails	36 miles		
Horse Riding Trails	16 miles	189 rentals	342 boarded
BOATS			
Non-motor Boats	72 canoes	190 sailboats	343 other boats
Charter Boats	40 boats		
Dry Storage	8057 boats capacity		
Launch Ramps	237 lanes		
Slips or Moorings	18918 boats capacity		
SWIMMING			
Developed Beach	17655 linear feet		
Swimming Pond	12 acres		
Pools	881804 square feet		

Source: Maryland Association of Soil Conservation Districts, 1974
Note: Includes all of Anne Arundel, Baltimore, Carroll, and Howard Counties and Baltimore City

EXISTING WATER & RELATED LAND RESOURCE PROGRAMS

Currently, much work is being done to meet the water resource needs in the study area through programs of federal, state and local agencies.

Carroll County and other sponsoring agencies, with assistance from the USDA Soil Conservation Service, have constructed Piney Run Lake in southern Carroll County. (See study area map inside back cover.) The lake was recommended as a work of improvement in the Work Plan for the Piney Run Watershed developed under authority of PL 83-566. Problems identified in the Work Plan include flood and sediment damages downstream, lack of water based recreation, and water supply shortages. The lake, associated recreation facilities, and land treatment measures provide water supply and water based recreation for the region. It also provides significant flood damage reduction in Piney Run, and minor amounts of protection to downstream areas of the Patapsco River.

The local Soil Conservation Districts, in cooperation with the USDA Soil Conservation Service, provide technical assistance on conservation related problems. Land treatment assistance is available on both agricultural and urban land. The amount of land treatment assistance provided is summarized in Table 13. The cooperative state-federal forestry program provides technical assistance in meeting conservation and management needs on private and public forestlands. It also provides forest fire fighting assistance. The USDA Agricultural Stabilization and Conservation Service (ASCS) provides cost sharing to install conservation practices on agricultural land and to implement forest management practices on forest land.

The U.S. Army Corps of Engineers has studied the lower Patapsco and Gwynn's Falls to determine if a project could be implemented under their programs. They have decided there is no feasible project.

There is much local effort aimed at solving the water related problems in the area. Their efforts are concentrated on water supply development, flood damage reduction through flood warning and acquisition, and conservation of open space and agricultural land.

As part of their water supply system, Baltimore City has developed Liberty Lake, Carroll County has developed Piney Run Lake, and Westminster has developed Cranberry Reservoir. Carroll County is investigating a water supply reservoir on Gillis Falls. For a further explanation of water supply, see Appendix D.

Howard County maintains a flood warning system to alert them about impending flooding. A remote alarm attached to a staff gage on the Patapsco River at Woodstock is activated when water reaches a predetermined level. The alarm itself is no cause for immediate concern, but it is designed to alert county officials who then start monitoring the situation. The National Weather Service is contacted for a prediction of additional rainfall, and the water level at Liberty Dam is checked. The Fire Department is asked to monitor rainfall and readings on other staff gages along the Patapsco. Based on these inputs, county officials decide whether the situation is severe enough to evacuate people. If this is the case, they notify the fire stations who work from

a master list to notify affected property owners. Howard County also provides some information to the Civil Defense Directors in Anne Arundel and Baltimore County.

Acquisition of structures has been used to reduce flood damages. Several of the jurisdictions have acquired some of the residences damaged by flooding. Howard County has purchased 17 houses, a church, and a community bulding in Elkridge. Anne Arundel County is authorized to purchase 25 houses in Ridgeway Manor and near the Baltimore City line. Baltimore County has purchased 72 houses and plans to purchase 117 more. These houses are located on Gwynns Falls and Herbert Run. Baltimore City is beginning a floodplain acquisition program. For a more detailed explanation of the acquisition programs, see Appendix J.

Acquisition of land can also be used as a method of watershed protection. Land in public ownership can be kept out of urban development, thus reducing flooding and water quality problems. Baltimore City has acquired 6100 acres of land around Liberty Reservoir. Carroll County has acquired 470 acres around the potential site of a water supply reservoir on Gillis Falls and additional land around Piney Run Lake. In addition, all jurisdictions acquire land as part of their open space programs.

The Maryland Department of Natural Resources maintains the Patapsco River State Park, which borders both sides of the Patapsco River. Presently, there are 9655 acres of land in the park. They have been authorized to purchase an additional 1516 acres of land. The Patapsco Valley State Park Draft Master Plan recommends puchase of an additional 3317 acres. This land consists of significant portions of floodplain land. These purchases could aid significantly in flood control and watershed protection.

Land for Morgan Run State Park is currently being acquired. At least 680 acres have already been purchased, with an additional 820 acres to be purchased. This park is designed for passive recreation.

Howard County is presently buying development rights on 20,000 acres of farmland. Under this program, the owner sells the county his right to develop or sell his land for development.

Zoning and designation as special areas is also a method of watershed protection. Carroll County has zoned portions of the county as an Agricultural District in which the average density will be one residence for every 20 acres. As part of their General Plans, each jurisdiction has noted specific areas as conservacy districts or water supply protection areas. This means that limited development should occur in those areas. Each jurisdiction, along with the Maryland Water Resources Administration, has some type of restriction on development in floodplains, either through zoning or a permit process.

Stormwater management programs are designed to prevent damages caused by increased runoff due to urban development. Policies differ among the jurisdictions, but essentially they mandate that it is the developer's responsibility to store or otherwise adequately dispose of any increase in volume of runoff and to maintain post-development peak flows at

pre-development levels. The primary purpose is to prevent erosion of streambanks due to more frequent flood flows. The State of Maryland and each juriscition has a stormwater management policy of some type, but their use and effectiveness vary widely.

Each jurisdiction is in the process of mapping the 100-year floodplains. These maps will be used to enforce floodplain ordinances. They also provide a basis for determining where potential problems exist.

Water based recreation in the area is concentrated mainly in stream valley parks, and at Baltimore Harbor, Piney Run Lake and Liberty Reservoir.

The stream valley parks offer hiking, fishing, boating and picnicking. Baltimore Harbor offers fishing and boating. Piney Run Lake offers fishing, picnicking, boating and hiking. Liberty Reservoir offers picnicking, boating, and fishing.

The area has been included as a portion of several reports done on a regional basis. They include: Chesapeake Bay - Existing Conditions Report, December 1973; Northeastern United States Water Supply Study, November 1975; and North Atlantic Regional Water Resources Study, June 1972. There were many agencies involved in the development of these studies. Coordination was provided through the U. S. Army Corps of Engineers.

Table 13 LAND TREATMENT NEEDS

Item	Unit	Total Watershed Needs	Now on The Land	Additional Needs Provided by Ongoing Program 1/	Additional Needs Needed in Accelerated Program
Conservation Plans	No.	122,798	42,950	20,901	58,947
Site Plans Review	No.	2,925	1,136	463	1,326
Cropland Protection	Ac.	100,404	55,966	19,417	25,021
Pastureland Protection	Ac.	6,871	4,447	716	1,708
Woodland Protection	Ac.	85,262	65,908	9,554	9,800
Other Land Protection	Ac.	53,476	38,002	4,848	10,626
Conservation Crop System	Ac.	100,404	73,500	8,684	18,220
Grassed Waterway	Ac.	1,004	560	114	330
Diversions	Ft.	334,183	178,000	16,588	139,595
Ponds	No.	545	260	67	218
Critical Area Planting	Ac.	4,363	2,244	367	1,752
Waste Management Systems	No.	120	17	31	72
Spring Development	No.	69	15	20	34
Pasture Establishment	Ac.	2,952	2,300	83	569

Source: Soil Conservation Service

1/ Refers to existing programs of Soil Conservation District and Soil Conservation Service

WATER AND RELATED LAND RESOURCE PROBLEMS

I. FLOODING

Flooding along the Patapsco has been a problem since man first settled in the area. In the early part of the last century, mills and industries which depended on the water power that the Patapsco could supply grew up along the river. In conjunction with these grew the mill towns like Daniels, Oella, Ellicott City, and Ilchester. The railroad, running up the Patapsco valley, provided the transportation needed to move goods down to the port at Baltimore. As the Patapsco's potential as a source of power and transportation was exploited, so too was its potential for destruction felt. In 1869, runoff from the 250 square miles above Ellicott City came roaring down the valley causing great destruction and the loss of 39 lives. Again in 1923, and five times since, the river has caused severe damage. In 1972, Tropical Storm Agnes caused several deaths and millions of dollars in damages. In the 1800's, man colonized the floodplain because he was economically tied to the river. In this century, population increases, increased mobility, and affluence enticed man out of the city. In some cases, the pastoral setting of a rural stream became the ideal setting for his home.

The flooding problems and their causes throughout the study area are different and complex. They are best discussed within the context of each subbasin: South Branch, North Branch, Main Stem, and Gwynn's Falls. The problems in the first three are interrelated, while the problems in the latter can be viewed independently.

A. Major Causes of Flooding

The major causes of the flooding problems that now exist are:

1) Encroachment on the natural floodplain: Homes and businesses have been located within the 100-year floodplain (See Figure 2). This not only jeopardizes the buildings themselves, but it also reduces the efficiency of the natural stream floodplain system to convey water. This can increase flood stages upstream. Preventing encroachment will not reduce present damages, but it will assure that future damages will not increase.

2) Constriction of the natural floodplain by man-made obstructions: Roads and bridges which serve the area must necessarily follow or cross over the floodplain. In many cases they cause constrictions which back water upstream (See Figure 3). Recently man has learned to design such facilities properly so that they have a minimal impact on the ability of the floodplain to convey floodwater. However, in many cases, older or abandoned constrictions still have a great impact on flood levels.

   Many constrictions exist along the Patapsco and its tributaries. This study has noted four that deserve special consideration because they have a large impact on flooding potential. Two of the constrictions are landfills located near the mouth of the Patapsco. A third is an abandoned railroad

crossing in Elkridge. The final one is a railroad fill in the floodplain near Carrollton and Patapsco.

There are instances in which flooding is caused by materials being carried downstream and becoming lodged in the opening of a bridge creating a constriction in an otherwise well-designed structure. In many cases, the material lodged at the bridge consists of cars, trucks, uprooted trees, or parts of buildings which are swept downstream by the flood. Some of this material began as trees which were deposited on the floodplain during previous floods or the inventory of a lumber company on the floodplain. If proper precautions and maintenance were undertaken, some of these problems could be reduced.

3) Erosion and sedimentation: Increases in the rate of erosion can lead indirectly to increased flooding. If more soil erodes from farms, forests, construction sites, and urban land, the resulting sediments settle on the bottom of the stream, reducing its carrying capacity. Thus a given amount of water will flow at a higher level then previously. This reduction in carrying capacity will reach an equilibrium at some point in time. It has been documented that considerable sedimentation has occurred in the tidal portions of the Patapsco downstream from Elkridge since barges were brought up the river to load at Elkridge in the 18th century.

Due to the inability to predict future sedimentation rates in the river channel, future increases in flood damages caused by the reduced carrying capacity were not analyzed. The increases will probably be minimal, especially when considered with other long term influences such as rising ocean levels.

4) Urbanization: In the natural course of development, many acres of land become covered with homes, businesses, roads, driveways and parking lots. As land is converted from field, meadows or woodland to more impervious covers, a greater proportion of rainfall runoff flows overland to streams rather than being absorbed by the soil. (See Figures 4 and 5.) When hundreds of acres undergo such a transformation, the increase in runoff can increase the severity of flooding downstream. Although development must continue, it is possible to maintain the peak rate of runoff at or near pre-development levels. Stormwater management measures can be installed during construction to minimize increases in runoff or to temporarily store the increased runoff so it can be released slowly so as not to contribute to flooding downstream.

Increased acreage in urban land uses could dictate that flooding problems will become worse in the future. It is anticipated that in the next 20 years, approximately 30,000 acres of land within the study area will go from agriculture or open space, into residential, commercial, and industrial usage. This represents almost 15% of the total land area in the study area. Also, from 2000 to 2075, it is anticipated that an additional 40,000 acres will develop.

Thus, in the year 2075, it can be anticipated that a 100-year storm lasting a day will produce 3 billion more gallons of surface runoff than the same storm occurring today. This water running rapidly off the land surface into streams benefits no one. It is not available to infiltrate the ground to nourish plants or replenish groundwater. It increases flows in stream channels which causes increased erosion and it increases the volumes, peaks, and stages of floodwaters in the stream, thus increasing the size of the floodplain. (See Figures 4 & 5.)

However, urbanization will not have a significant effect on peak flows on the main stem of the Patapsco River. Near the harbor, future discharges will increase 100-year flood elevations by a maximum of one foot. The problem areas are on the tributaries and along Gwynns Falls.

B. Problems in Specific Areas

To analyze the flood damages, the different areas along the stream were grouped together based on similarities in type of damages, location, and factors affecting the flooding situation. These reaches and their locations, along with number of structures flooded are shown in Table 14 and Figure 1. Estimated monetary damages which would be caused by a recurrence of Agnes and the 100-year flood are shown in Tables 15 and 16. The 100-year flood damages are based on flooding caused by present land use conditions for the Patapsco River and future conditions without stormwater management for Gwynns Falls. Since future flooding will not increase significantly in the Patapsco, damages will also not increase significantly.

Although flooding is relatively infrequent in the basin, the damages during major floods are high. For example, estimated flood damages during the 10-year flood are minimal, but for the 100-year flood, they are major.

The following is a summary by reach of the damages caused by Tropical Storm Agnes in 1972.

South Branch

Agnes caused flood damages in six communities along the South Branch. These included Marriottsville, Henryton, Sykesville, Gaither, Morgan Station, and Woodbine. Almost every bridge over the South Branch had to be repaired or replaced. Also, many roads and bridges crossing tributaries to the South Branch were damaged or destroyed.

In Marriottsville (Reach PR-20), seven homes, one small apartment building, and a church were flooded. Damage levels were high. Water levels ranged from two to twelve feet above the first floor.

At Henryton (PR-21), a greenhouse and a power plant were flooded by seven feet of water. The power plant supplies a hospital with heat and hot water.

Sykesville (PR-22), had more commercial structures damaged than any other area along the South Branch. (See Figure 6.) Six businesses and two homes were flooded. Two taverns on the Howard County side of the river had from five to eight feet of water around them. The other businesses and homes had less of a problem with damage confined to basements and low levels on the first floor. In Gaither (PR-23), five houses were flooded with first floor depths rising to nearly six feet in three of them.

In Morgan Station (PR-25), two homes were flooded. Depths ranged from basement level to four feet above the first floor.

In Woodbine (PR-26), three businesses and one house were flooded. The businesses sustained three to four feet of water above the first floor. The home had basement damage.

North Branch

The flooding problems within the North Branch sub-basin occur in isolated areas. Some flooding in the communities of Carrollton and Patapsco was sustained during Tropical Storm Agnes. The Congoleum Plant in Finksburg, at the headwaters of Liberty reservoir, sustains a great deal of damage during major storm events.

The estimated 100-year flood discharge on the North Branch is less than the Agnes flood discharge, therefore, the depth of flooding that could be expected would be less than that from Agnes.

Near Westminster (PR-31), the filtration plant for the city's water supply is periodically flooded.

In the communities of Carrollton and Patapsco (PR-29 and 30), on the North Branch, a total of twenty residential structures were flooded during Agnes. One church and one store were also flooded. (See Figure 7.) While most of the flooding in these communities was limited to basements, several houses in Patapsco sustained as much as four feet of water on the first floor.

The problems in Carrollton and Patapsco are likely to get worse as upstream areas such as Westminster, Hampstead, and Manchester continue to urbanize. Increased urban runoff will increase the frequency and severity of flooding in the communities unless steps are taken to reduce increased runoff from major storms.

The Congoleum Corporation has a plant near Finksburg (PR-28) at the upstream end of Liberty Reservoir. During Agnes, the plant had as much as twelve feet of water in some of its buildings. The flooding situation at the Congoleum Plant has two unfortunate consequences. First, flooding causes economic hardship for the plant and its workers. Second, the flood washes chemicals and other materials stored at the plant into Liberty Reservoir, causing a potential health problem to the water users.

Lower Patapsco

It is the valley downstream of the confluence of the North and South Branches where the major concentrations of flood damages occur. Towns

such as Oella, Ellicott City, and Elkridge, and communities such as North Linthicum, Pumphrey, Raynor Heights, and Baltimore Highlands, as well as isolated homes and businesses along the Main Patapsco are susceptible to flooding. For homes and businesses in the flood fringe area, the flooding may be only a minor nuisance occurring once in a lifetime. But, for buildings in low lying areas, a flood threat may represent a frequently recurring threat to life and property.

The estimated 100-year flood on the main stem of the Patapsco River is much less than Agnes. Agnes was an extremely rare event as far as discharges on the main stem are concerned.

In Brooklyn, located at the mouth of the river (part of PR-1), one hundred twenty-one homes and two businesses were flooded during Tropical Storm Agnes. All but two of the houses flooded were brick row houses. The damage was concentrated in a relatively small area. (See Figure 7.) Almost all of the damage was limited to basements. In every case, Agnes was the only flooding any of the residents could recall.

In Pumphrey, North Linthicum, and Baltimore Highlands, located southeast of Landsdowne (PR-2), twenty commercial establishments, fifty-two houses, and seventeen trailers are susceptible to flooding. Most of the first floor flooding during Agnes was to depths of three feet or less. About twenty homes had basement flooding only. Damages in these communities are spread over a wide area. In Anne Arundel County, structures were flooded along Old Annapolis Road, in North Pumphrey, and in a trailer court on Belle Grove Road. In Baltimore County, houses were flooded in Riverview and Baltimore Highlands. Twenty houses were flooded in the development of Ridgeway Manor, but Anne Arundel County has begun a purchase program to remove them from the floodplain.

In Oak Park, located south of Landsdowne (PR-3), three businesses and one industry were flooded by Agnes. One restaurant had eight feet of water, and the Carling Brewing Company had more than five feet in and around the building.

Approximately twenty-five houses and thirteen businesses were flooded along Herbert Run (PR-4, 5, 6, 7, and 8), a major tributary to the Lower Patapsco. Few residents reported any flooding above the basement and most reported less than three feet in the basement. Baltimore County is presently buying 15 houses on a tributary to Herbert Run. These homes are not included in the above total.

The Patapsco River and Deep Run both caused damage in Elkridge (PR-11 & 14). Twenty-one homes and twelve businesses were flooded. Many of the businesses were seriously flooded, some receiving as much as ten feet of water on the first floor. (See Figure 9.) Seventeen more homes on Church Avenue were flooded by Agnes, but Howard County purchased these, along with a church and community building in 1976 as part of a floodplain acquisition program.

Of the twenty structures flooded in Ilchester, located midway between Elkridge and Ellicott City (PR-15), nine are commercial or industrial buildings associated with Simkins Industries. Flooding in these buildings averaged six feet during Agnes. The houses were, in general, flooded to lesser depths.

In or near Ellicott City and Oella (PR-16), forty-eight businesses and eight homes were flooded during Tropical Storm Agnes. Most of the damage occurred in stores on Main Street in Ellicott City. Water rose to over ten feet in the Historic District, enough to reach the second floor of many buildings. Although most damage was in Howard County, there is significant damage on the Baltimore County side of the river, particularly in the Wilkins-Rogers Plant.

Gwynns Falls

Flooding problems occur at many points along the Gwynns Falls. Flooding of industries at the mouth is caused by enroachment on the natural floodplain. The same is true of flooding in communities upstream such as Dickeyville, Gwynn Oak, Woodlawn, and Owings Mills. The problem is compounded by increased flood flows due to urbanization. The damage areas are spread out over the length of the stream. While there are some major concentrations of damage, such as the Owings Mills Industrial Park and the Brittany Apartments, most damages are so scattered as to make any consideration of structural measures unfeasible.

In the Westport area of lower Gwynns Falls, near the mouth of the stream (GF-1), there were eighty-nine structures flooded by Agnes. Seventy-three were residential structures, and sixteen were commercial or industrial enterprises. If such a flood would occur again, damages in the area would exceed $1.7 million. Although this is a relatively localized problem, the effects are widespread. The sixteen businesses employ many people and even when they are closed for short periods of time, many of the employees could experience temporary financial difficulties.

Along Maiden's Choice Run (GF-2, 3, 4, & 5), there are approximately one hundred fourteen structures which were flooded by Tropical Storm Agnes. No unit, except some basement apartments, received more than three feet of water. About sixty homes had basement flooding only. The greatest amount of damage occurred in a four block area just inside the city line. Along this reach, about 80% of the stream is enclosed. Flooding occurs because the culvert was not designed to carry the stream flow associated with a flood like Agnes.

Dead Run (GF-7 & 8), flooded many more than the fourteen residences shown in this survey. Baltimore County has already purchased many homes in this area. Most of the remaining fourteen residences are on the fringe areas of the floodplain, where they receive minor basement flooding.

In Woodlawn (GF-10), Gwynn's Falls flooded about eighty structures during Agnes. Baltimore County has begun an acquisition program which will reduce the number of susceptible structures along the reach by about one-half. Twenty-eight homes and fourteen businesses would still be flooded by a recurrence of a flood like Agnes. Of these, twelve homes and six businesses would have first floor flooding, usually limited to three feet or less. Most of the residential damage is on Gwynn Oak Avenue, but the houses are widely scattered. (See Figure 10.)

In the vicinity of Villa Nova, Milford, and Willow Glen, located near Woodlawn (GF-11), Agnes flooded about one hundred fifteen structures.

Baltimore County's current acquisition program will reduce that number to fifty-nine structures should such a storm reoccur. Of those forty-four structures, there are forty residences, eighteen businesses, and one church.

The homes are scattered along the reach, sometimes in groups of four or five. Most of the homes are separated from the stream by a street. Thus, the street was flooded as well as the homes above it. This made access to or from the house difficult or dangerous. (See Figure 11.)

In Silver Creek Park, located near I-695 (GF-12), twenty-two single family dwellings would be susceptible to flooding if Agnes were to reoccur. (See Figure 12.) Almost sixty other homes are covered by Baltimore County's acquisition program. Eleven of the homes had basement flooding. Of the others, several had up to 10 feet of water on the first floor. These homes are scattered along the east side of the stream.

Agnes flooded fifty units of the Brittany apartment complex, downstream of I-695 (GF-12). The buildings are close to one another so the damage is concentrated in a small area. Flooding ranged from two to six feet. In addition, residents of the second and third floors of these buildings were inconvenienced or denied access by the flooding occurring on the first floor.

Another area of high damages is in the Owings Mills area (GF-14), downstream of Reisterstown Road. Fourteen structures were flooded by Agnes. Most of the damage occurred in Owings Mills Industrial Park.

II. Erosion

Erosion is a natural geologic process. Problems arise when man interferes with nature by clearing the land for farms and towns.

Urbanizing land produces the greatest rate of erosion. However, relatively small amounts of land are undergoing urbanization at any one time.

Cropland produces the next highest rate of erosion. Due to the large amounts of land dedicated to cropland, this is the largest producer of sediment. Therefore, any attempts at reducing sediment production should concentrate heavily on the cropland.

Other significant sediment producing areas are mine spoil and streambanks. Streambank erosion is accelerated when development increases the flow in the stream channel. These problems are evident in urban stream systems such as Herbert Run and Gwynns Falls. For a complete tabulation of erosion rates and sediment yields see Table 17.

III. Sedimentation

The product of erosion is sediment. Some of this sediment enters the stream system and eventually is deposited. There are three major areas where sedimentation is occuring: Liberty Reservoir, Baltimore Harbor, and the river channel. In each case, different problems are dominant.

Liberty Reservoir is used as a source of raw water for the Baltimore Central (water) Supply System. Sedimentation reduces the water storage capacity of the reservoir. If sediment is deposited at rates greater than had been predicted during the design of the reservoir, this source of Baltimore's water could be reduced. (See Table 18.)

The main concern in the Baltimore Harbor is that shipping channels should be maintained at depths which allow modern ocean-going vessels to use the Harbor facilities when fully laden. There are many sources of sediment being deposited in the Harbor, only two of which are the Patapsco River and Gwynn's Falls. Problems in estimating the relative contribution of each source of sediment preclude an assessment of the harbor maintenance cost which should be assigned to either the Patapsco River or to Gwynn's Falls.

There are indications of sedimentation in the main stream of the Patapsco River, especially in the tidal section below Elkridge. Some of this sedimentation is part of the natural process by which the river changes its course, eroding the streambanks in some spots and depositing sediment in others. The greatest amount, however, is believed to be deposited from the upstream rural and urban land. Most damages caused by this sedimentation are not quantifiable in monetary terms.

IV. Water Quality

Along with erosion and sedimentation, other water quality problems caused by nonpoint sources of pollution are nutrients carried by sediments plus fecal coliform bacteria from septic tanks and animals wastes. In the Statewide Critical Areas for Nonpoint Sources of Soil Erosion and Animal Wastes, June, 1979, the Liberty Reservoir Drainage and South Branch Patapsco River were ranked 3 and 5, respectively, out of 12 critical areas identified throughout the state. This ranking was to be used in assigning priorities for the Rural Clean Water Program pursuant to Section 208 (j), Federal Clean Water Act. The ranking was based mainly on the severity of erosion and animal waste problems.

V. Water Supply

There are no areas where availability of water for municipal and industrial use is a problem at the present time. However, as areas of Carroll County undergo development in the future, such deficiencies may occur. Westminster is likely to experience limitations in the near future if additional sources are not developed. Carroll County obtains some water from the Patapsco/Liberty system under a long term contract with Baltimore City, but not nearly enough for its future needs. The county is looking for new sources of water, either in the form of surface impoundments or groundwater resources.

VI. Recreation

In an intensely urban setting, recreation demand in most major catagories exceeds supply. This is the case in the Baltimore Region according to the State Comprehensive Outdoor Recreation Plan (SCORP). Large deficiencies presently exist and will continue to increase in such activities as boating, fishing, picnicking, hiking, and biking. These

activities are either dependant on to an unpolluted and abundant surface water resource. For a detailed breakdown of recreation needs, see Appendix G.

TABLE 14

REACH IDENTIFICATION AND
SUMMARY OF DAMAGE BY REACH

Reach Number	Stream	Reach Location	Est. No. of Structures Subject to Flooding [1]	
			Agnes	100 Yr. Flood [2]
PR-1	Patapsco River	Hanover St. to Tunnel Thruway	123	0
PR-2	" "	Tunnel Thruway to Balto. Beltway	89	26
PR-3	" "	Balto. Beltway to Penn. Cent. R.R.	4	1
PR-4	Herbert Run	Patapsco River to E & W Br. Confluence	3	3
PR-5	East Branch	Confluence to Sulphur Spring Rd.	5	5
PR-6	" "	Sulphur Spring Rd. to Balto. Beltway	4	4
PR-7	" "	Balto. Beltway to Wilkens Ave.	11	11
PR-8	West Branch	Confluence to Shelbourne Ave.	15	15
PR-12	" "	Hanover Road to Rte. 176	3	3
PR-13	No name stream	Pfeiffers Corner	4	4
PR-14	Patapsco River	Penn. Central R.R. to Rte. I-95	16	5
PR-15	" "	Rte. I-95 to Grays Level	12	9
PR-16	" "	Ellicott City & Oella Areas	57	52
PR-17	" "	Hollofield	5	2
PR-19	" "	Woodstock	6	4
PR-20	South Branch	Marriottsville	9	7
PR-21	" "	Henryton	2	2
PR-22	" "	Sykesville	7	4
PR-23	" "	Gaither	5	4
PR-25	" "	Morgan Station	2	3
PR-26	" "	Woodbine	4	4
PR-28	North Branch	Finksburg	1	1
PR-29	" "	Patapsco	13	11
PR-30	West Branch	Carrollton	9	8
PR-31	" "	Cranberry Station to Westminster	1	1
GF-1	Gwynns Falls	Annapolis Rd. to Wilkens Ave.	116	116
GF-2	Maiden Choice Run	Gwynns Falls to Penn. Central R.R.	4	4
GF-3	" " "	Penn Central R.R. to Beechfield Ave.	11	11
GF-4	" " "	Beechfield Ave. to Overbrook Rd.	88	88
GF-5	" " "	North Prospect Ave. to Stoney Lane	11	11
Gf-6	Gwynns Falls	Wilkens Ave. to Dead Run	2	2
GF-7	Dead Run	Gwynns Falls to City Line	2	2
GF-8	" "	City Line to Baltimore Beltway	12	12
GF-9	Gwynns Falls	Dead Run to City Line	20	20
GF-10	" "	City Line to Liberty Road	42	42
GF-11	" "	Liberty Road to Milford Mill Rd.	61	61
GF-12	" "	Milford Mill Rd. to Balto. Beltway	72	72
GF-13	" "	Balto. Beltway to Painters Mill Rd.	2	2
GF-14	" "	Painters Mill Rd. to Reisterstown Rd.	31	31
GF-15	" "	Reisterstown Rd. to Kendig Mill Rd.	1	1

[1]The figures do not include the structures which are part of ongoing acquisition programs by Baltimore County and Howard County.

[2]Based on future without project conditions.

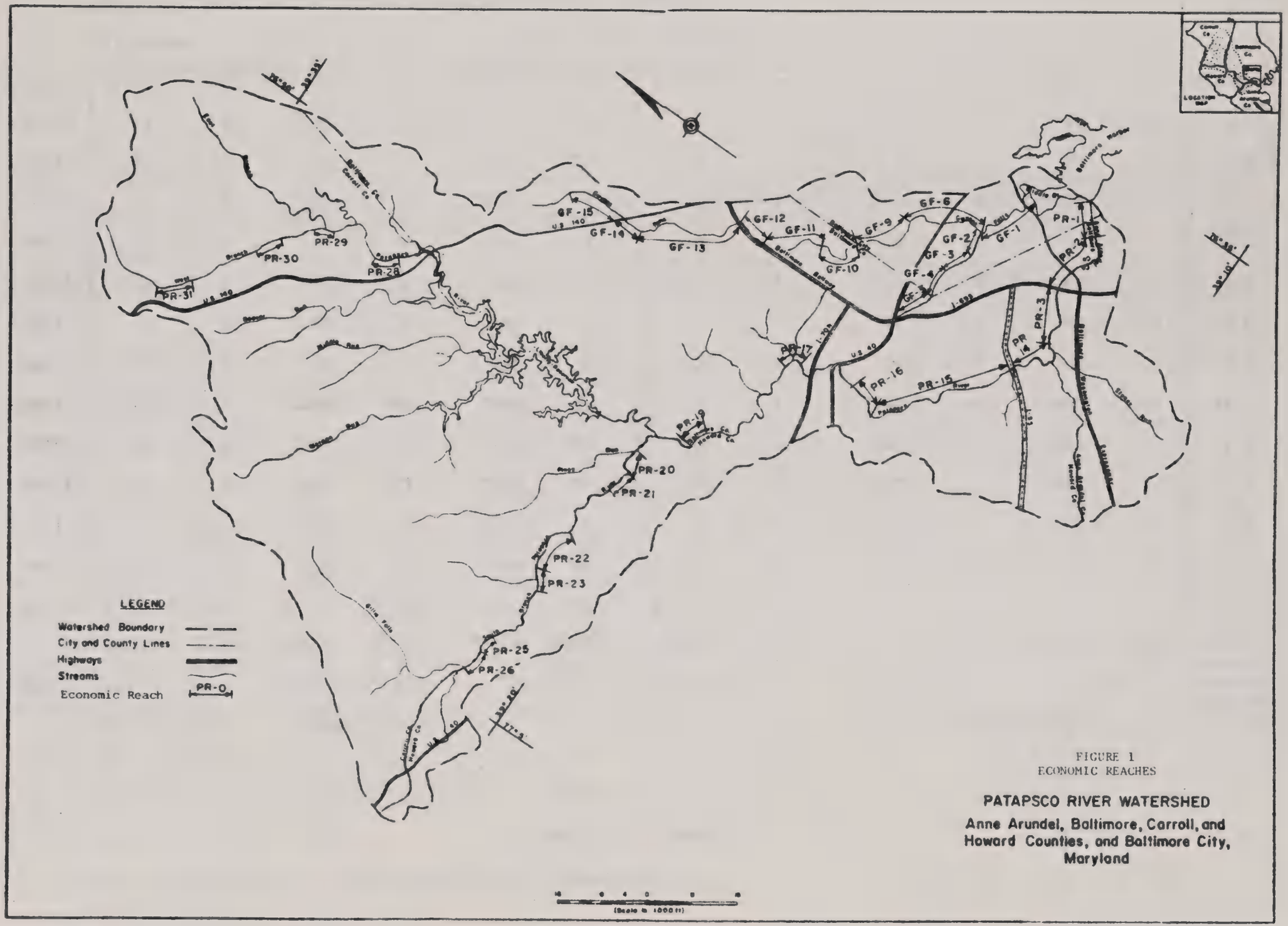


FIGURE 1
ECONOMIC REACHES

PATAPSCO RIVER WATERSHED

Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City, Maryland

TABLE 15

ESTIMATED FLOOD DAMAGES

PATAPSCO RIVER

Reach	Agnes						100-Year [1]						Average Annual Damages [2]
	Residential		Commercial/Ind.		Total		Residential		Commercial/Ind.		Total		
	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000
PR-1	$ 130	121	$ 20	2	$ 150	123	$ 0	0	$ 0	0	$ 0	0	$ 0
PR-2	852	69	1744	20	2596	89	47	21	116	5	163	26	1.7
PR-3	0	0	1059	4	1059	4	0	0	57	1	57	1	0.4
PR-14	50	4	1522	12	1572	16	16	1	671	4	687	5	6.7
PR-15	78	8	3052	4	3130	12	17	7	330	2	347	9	2.9
PR-16	218	9	2780	48	2998	57	71	7	1969	45	2040	52	41.0
PR-20	119	8	16	1	135	9	83	6	16	1	99	7	3.9
PR-22	13	2	69	5	82	7	3	2	43	2	46	4	0.6
PR-23	79	5	0	0	79	5	68	4	0	0	68	4	2.9
PR-25	10	2	0	0	10	2	26	3	0	0	26	3	0.5
PR-26	1	1	262	3	263	4	13	1	301	3	314	4	58.7
PR-29	55	12	6	1	61	13	35	10	2	1	37	11	1.0
PR-30	54	8	17	1	71	9	29	7	12	1	41	8	2.4
TOTAL	$1659	249	$10,547	101	$12,206	350	$ 408	69	$3,517	65	$3925	134	$122.7

1/ Based on present without project conditions. Future conditions do not vary significantly.

2/ For further explanation of damage computations, see Appendix B.

TABLE 16

ESTIMATED FLOOD DAMAGES

GWYNN'S FALLS

Reach	Agnes/100-Year [1] Residential $1000	Residential # of Bldgs.	Commercial/Ind. $1000	Commercial/Ind. # of Bldgs.	Total $1000	Total # of Bldgs.	50-Year [1] Residential Commercial Industrial Damage $1000	10-Year [1] [2] Residential Commercial Industrial Damage $1000	Average Annual Damages [3] $1000
GF-1	776	73	946	43	1722	116	407	0	26.9
GF-2	3	4	0	0	3	4	0	0	.1
GF-3	48	11	0	0	48	11	0	0	.2
GF-4	627	87	4	1	631	88	0	0	3.2
GF-5	70	8	45	3	115	11	0	0	.6
GF-9	205	17	202	3	407	20	141	22	13.7
GF-10	258	28	255	14	513	42	139	8	10.7
GF-11	306	41	355	20	661	61	312	30	24.6
GF-12	1596	72	0	0	1596	72	1268	72	82.3
GF-13	18	1	11	1	29	2	0	0	.1
GF-14	0	0	738	31	738	31	567	363	116.3
TOTAL	$3907	342	$2556	116	$6463	458	$2834	$ 495	$278.7

1/ Based on future without project conditions.

2/ Zero damage for 2-year flood.

3/ For further explanation of damage computations, see Appendix B.

TABLE 17

Gross Erosion and Sediment Yield by Sources (Average Annual) 1/

SOUTH BRANCH

	Land Use	Acres	Soil Loss (T/Ac)	Total Soil Loss (Tons)	Delivery Ratio (Pct)	Sediment Yield (Tons)
	Cultivated	38083.	7.03	267715.	13.	35606.
	Pasture	823.	1.51	1246.	13.	165.
	Woodland	12761.	2.21	28211.	13.	3752.
	Urbanized	2111.	1.62	3420.	60.	2052.
	Urbanizing	200.	150.00	30000.	10.	3000.
	Mine Spoil	0.	-	-	-	-
2/	Roadbank	110.	3.80	417.	20.	83.
3/	Streambank	439.	18.86	8278.	70.	5795.
	Non-sediment Contributing	0.	-	-	-	-

NORTH BRANCH

	Cultivated	64199.	7.46	479019.	18.	88618.
	Pasture	1373.	1.39	1913.	19.	354.
	Woodland	28671.	1.51	43258.	19.	8003.
	Urbanized	5600.	1.11	6196.	60.	3717.
	Urbanizing	400.	150.00	60000.	10.	6000.
	Mine Spoil	0.	-	-	-	-
2/	Roadbank	243.	0.08	19.	20.	4.
3/	Streambank	671.	22.45	15063.	70.	10544.
	Non-sediment Contributing	3123.	-	-	-	-

MAIN STEM

	Cultivated	7882.	14.23	112173.	5.	6058.
	Pasture	2861.	2.33	6679.	5.	361.
	Woodland	31978.	2.27	72645.	5.	3923.
	Urbanized	27172.	1.09	29620.	60.	17772.
	Urbanizing	1800.	138.89	250000.	10.	25000.
	Mine Spoil	735.	70.29	51665.	60.	30999.
2/	Roadbank	78.	3.96	308.	20.	62.
3/	Streambank	462.	7.51	3468.	70.	2427.
	Non-sediment Contributing	827.	-	-	-	-

1/ From Erosion and Sediment Survey of Baltimore Regional Planning Council Area U.S.D.A. Soil Conservation Service, College Park, MD. December, 1977 (Tables 12, 13, and 16)

2/ Roadbank Units (In Acres Column) Are Bank Miles

3/ Streambank Units (In Acres Column) Are Bank Miles

TABLE 17 (Cont'd)

Gross Erosion and Sediment Yield by Sources (Average Annual) 1/

PATAPSCO RIVER TOTAL

Land Use	Acres	Soil Loss (T/Ac)	Total Soil Loss (Tons)	Delivery Ratio (Pct)	Sediment Yield (Tons)
Cultivated	110164.	-	858907.	-	130282.
Pasture	5057.	-	9838.	-	808.
Woodland	73410.	-	144114.	-	15678.
Urbanized	34883.	-	39236.	-	23541.
Urbanizing	2400.	-	340000.	-	34000.
Mine Spoil	735.	-	51665.	-	30999.
2/ Road Bank	431.	-	744.	-	149.
3/ Stream Bank	1572.	-	26809.	-	18766.
Non-Sediment Contributing	3950.	-	0.	-	0.
Total Acres	230599.				
Total Tons			1471313.		254295.

GWYNN'S FALLS

Cultivated	2338.	5.15	12041.	13.	1565.
Pasture	544.	0.78	426.	13.	55.
Woodland	5874.	0.73	4283.	13.	557.
Urbanized	19737.	0.50	9869.	60.	5921.
Urbanizing	700.	150.00	10500.	10.	10500.
Mine Spoil	92.	21.68	1990.	60.	1194.
2/ Road Bank	81.	0.50	41.	20.	8.
3/ Streambank	195.	17.86	3488.	70.	2442.
Non-Sediment Contributing	92.	-	-	-	-
Total Acres	29376.				
Total Tons			137138.		22243.

1/ From Erosion and Sediment Survey of Baltimore Regional Planning Council Area U.S.D.A. Soil Conservation Service, College Park, MD. December, 1977 (Tables 12, 13, and 16)

2/ Roadbank Units (In Acres Column) Are Bank Miles

3/ Streambank Units (In Acres Column) Are Bank Miles

Table 18 Effects of Sedimentation on the Storage Capacity of Liberty Reservoir

(1)	(2)	(3)	(4)		(5)	(6)	(7)
year	sediment deposits (acre-feet)	reduction in usable storage (acre-feet)	reduction in water supply storage (acre-feet)	(%)		reduction in safe yield (mgd.)	(%)
1954	0	0	0	0		0	0
1973	7,185	1,660	1,490	1.3		0.6	0.6
2004	18,800	13,300	12,000	10.5		4.8	5.1
2020	24,900	19,400	17,500	15.3		6.9	7.3
2054	37,700	32,200	29,000	25.4		11.5	12.1

Column (2) 377 acre-feet per year, 1954-1973 average rate of sedimentation. From Reservoir Sediment Data Survey, USDA Soil Conservation Service, College Park, MD., August 1973.

Column (3) Column (2) less 5526 acre-feet allotted to sediment storage.

Column (4) 90% of Column (3).

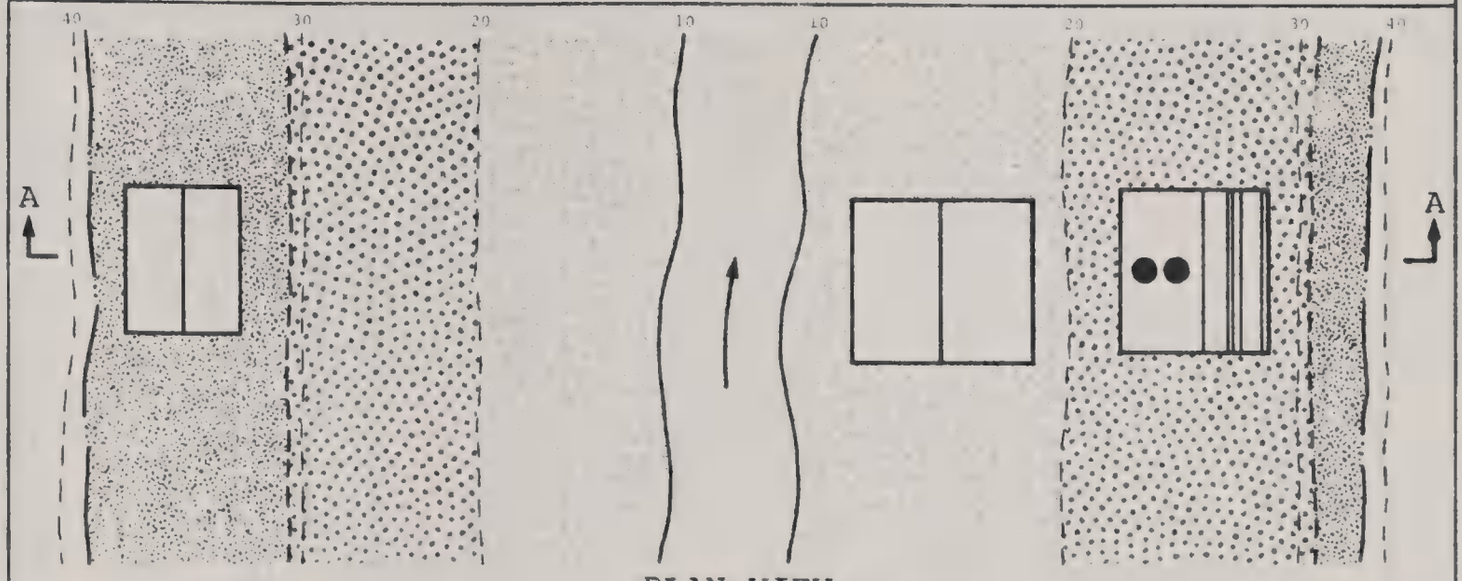
Column (5) Column (4) divided by 114,210 acre-feet, design water supply storage.

Column (6) Column (4) times .000397. $\frac{43560 \text{ cu. ft.}}{\text{acre-feet}} \times \frac{7.5 \text{ gal.}}{\text{cu. ft.}} \div 823 \text{ days}$

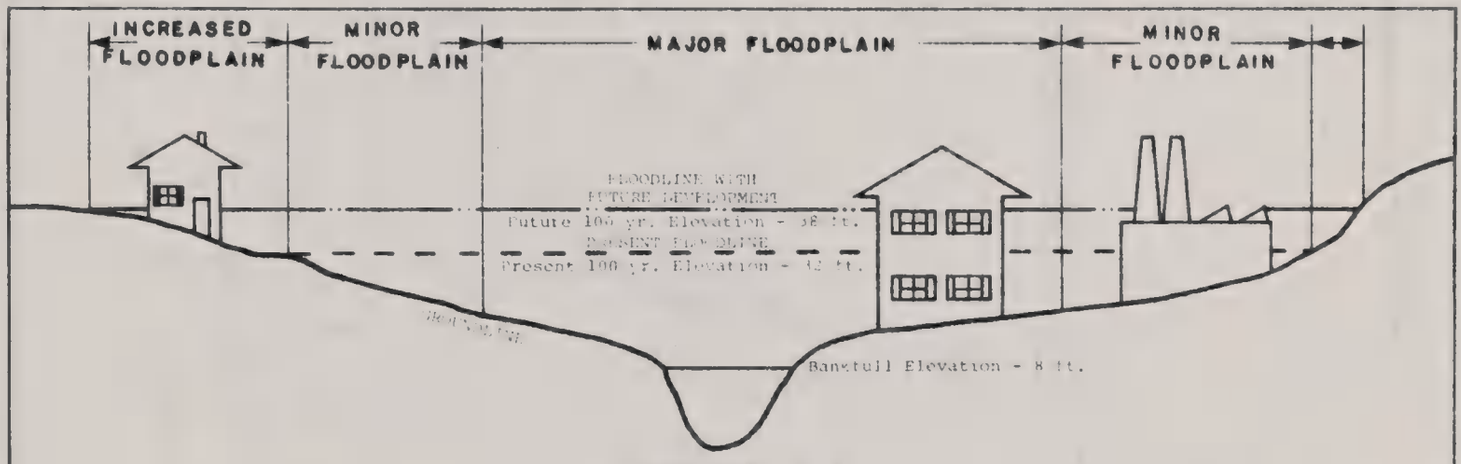
Column (7) Column (6) divided by 95 mgd.

Figure 2

COMPONENTS OF THE FLOOD PLAIN



PLAN VIEW



SECTION A-A

LEGEND

- Lines of Equal Contour Elevation
- Buildings
- MAJOR FLOODPLAIN
- MINOR FLOODPLAIN
- INCREASED FLOODPLAIN

MAJOR FLOODPLAIN	Water flowing at reasonable depth; net movement of downstream; greatest threat of loss of life; protect by acquisition, dams, channelization, diking
MINOR FLOODPLAIN	Slack water area, shallow depths, low velocities; small net movement perpendicular to channel flow only; property damage likely; little life threat; protect by floodproofing, warning, diking, channelization, insurance
INCREASED FLOODPLAIN	Increase in flood fringe caused by increased runoff due to urbanization upstream; protect by land use policy, zoning, storm water management

Figure 3

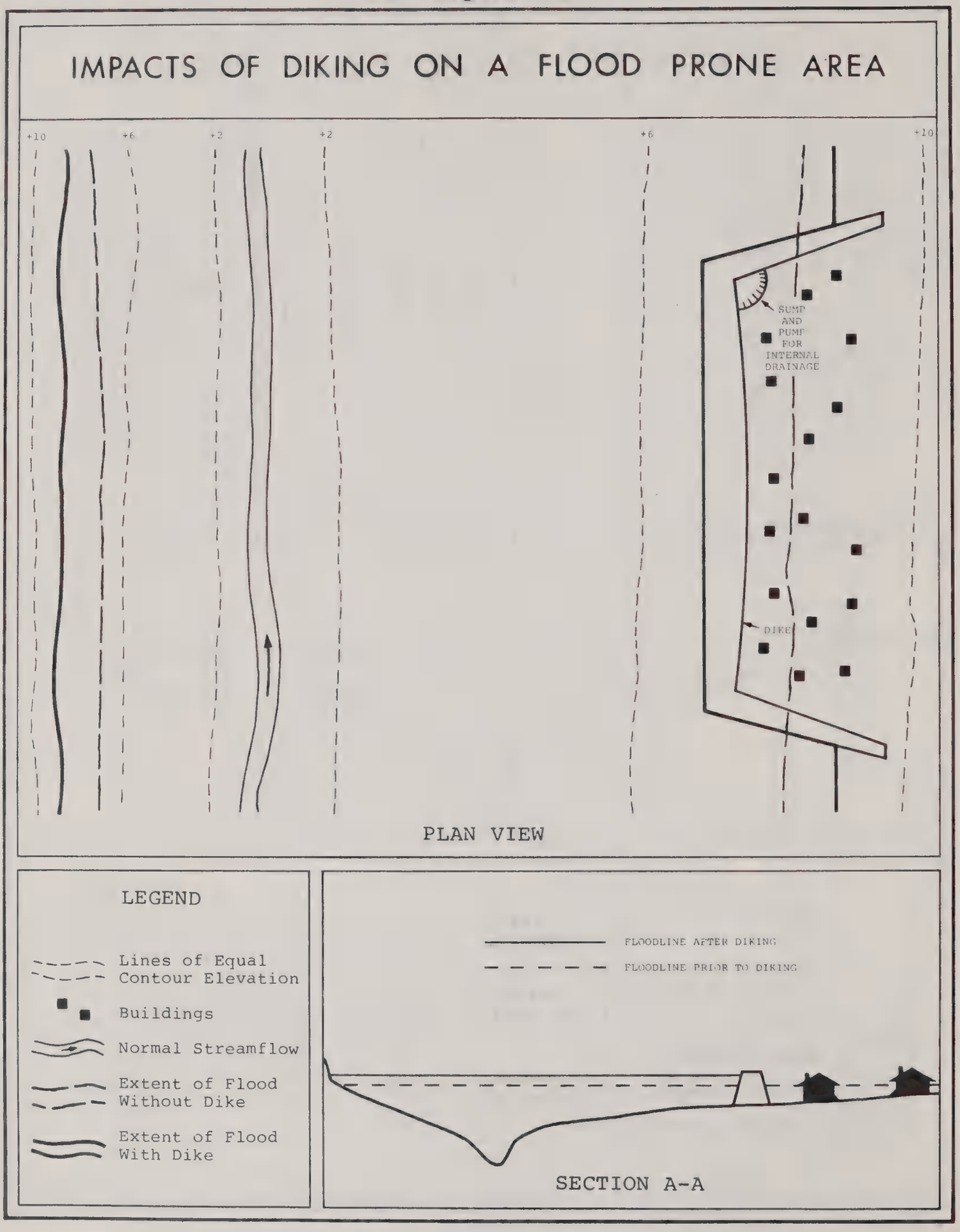
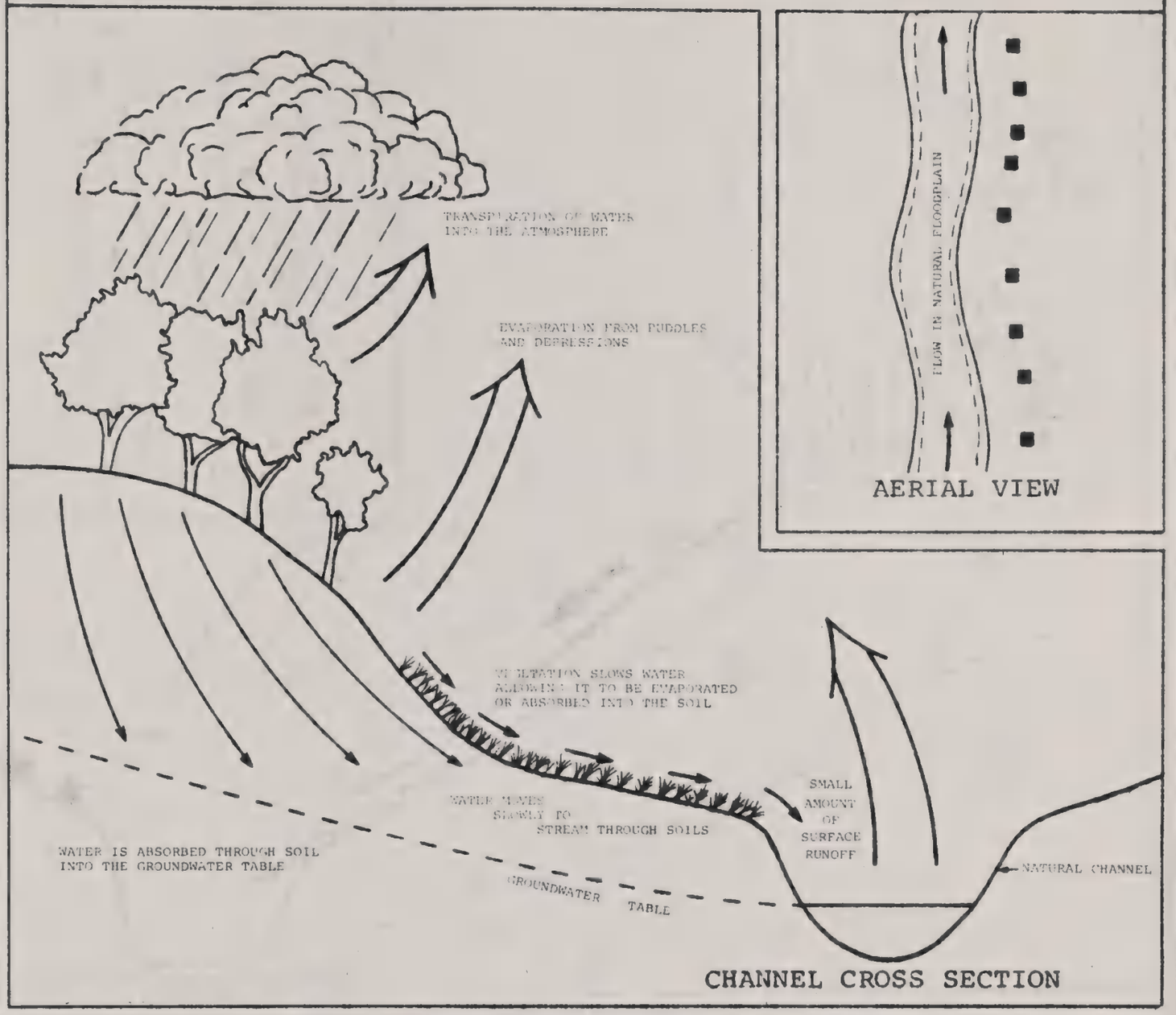

IMPACTS OF DIKING ON A FLOOD PRONE AREA
+10
+6
+2
+2
+6
+10
SUMP AND PUMP FOR INTERNAL DRAINAGE
DIKE
PLAN VIEW
LEGEND
Lines of Equal Contour Elevation
Buildings
Normal Streamflow
Extent of Flood Without Dike
Extent of Flood With Dike
FLOODLINE AFTER DIKING
FLOODLINE PRIOR TO DIKING
SECTION A-A

Figure 4

NATURAL HYDROLOGIC SYSTEM



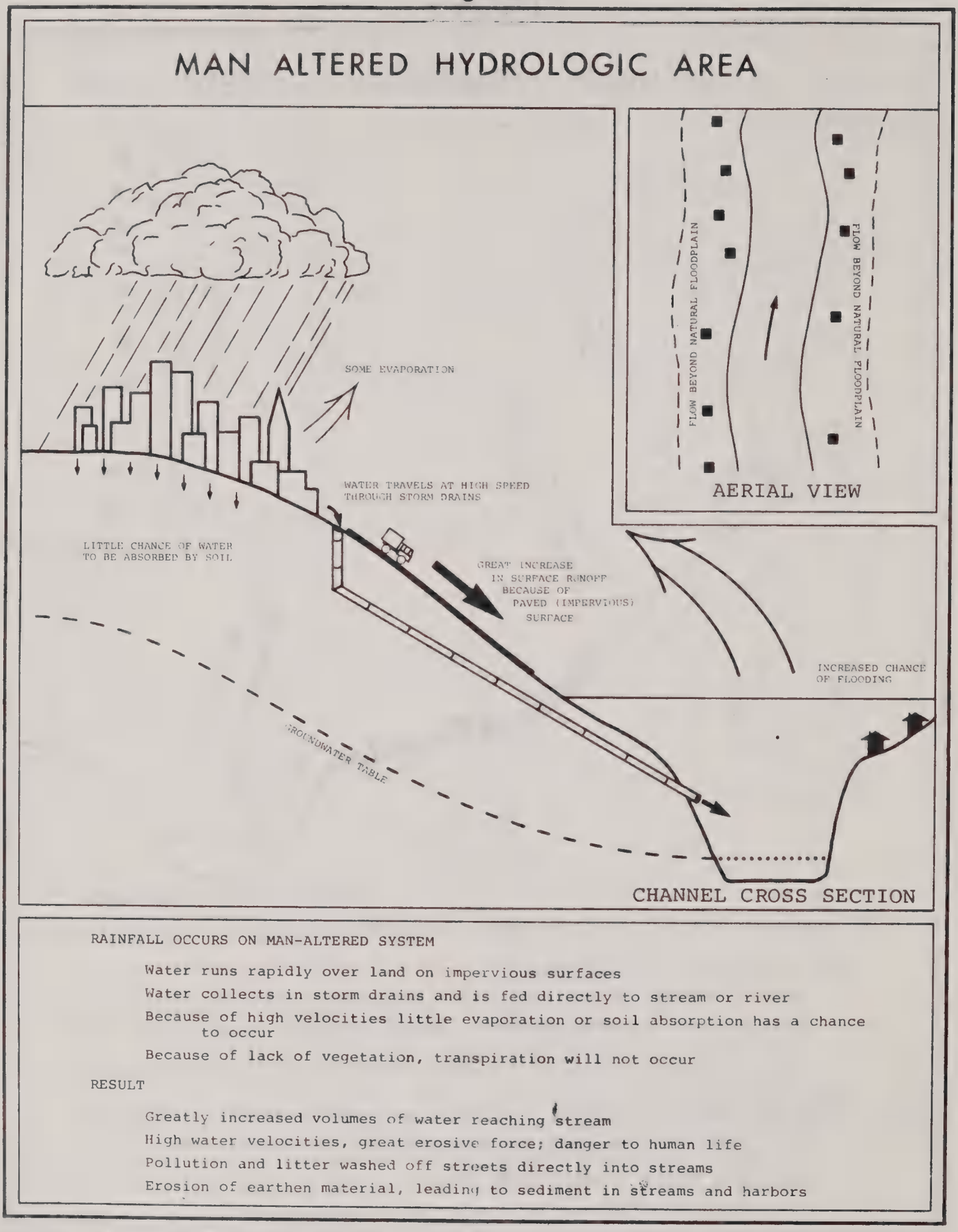
RAINFALL OCCURS IN A NATURAL SYSTEM

- Water is absorbed by trees and used in biological processes
- Water collects in natural depressions and is absorbed by soil or it evaporates
- Water flows slowly overland or through ground to stream
- Some water goes through soil to groundwater table

RESULT

- Water reaches stream slowly, reducing chances that the stream can not carry it
- Water moves slowly, allowing soil particles carried along to drop out (slower moving water is also less likely to erode the soil)
- Pollutants carried by the water are naturally filtered out by the soil

Figure 5



RAINFALL OCCURS ON MAN-ALTERED SYSTEM

Water runs rapidly over land on impervious surfaces

Water collects in storm drains and is fed directly to stream or river

Because of high velocities little evaporation or soil absorption has a chance to occur

Because of lack of vegetation, transpiration will not occur

RESULT

Greatly increased volumes of water reaching stream

High water velocities, great erosive force; danger to human life

Pollution and litter washed off streets directly into streams

Erosion of earthen material, leading to sediment in streams and harbors

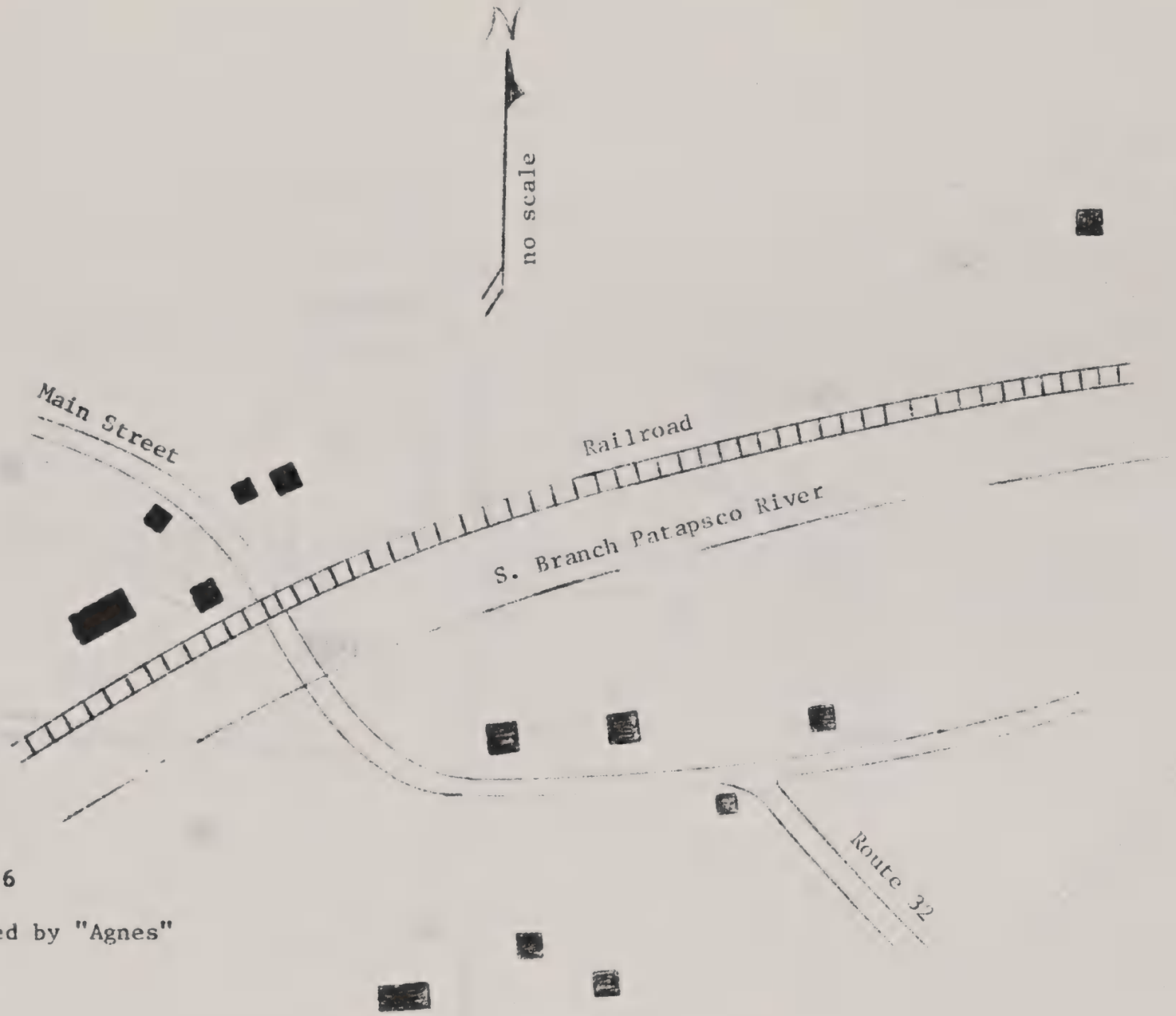


FIGURE 6

Structures Flooded by "Agnes"

Patapsco River

PR-22 Sykesville

FIGURE 7

Structures Flooded by "Agnes"

Patapsco River

PR-30 Carrollton

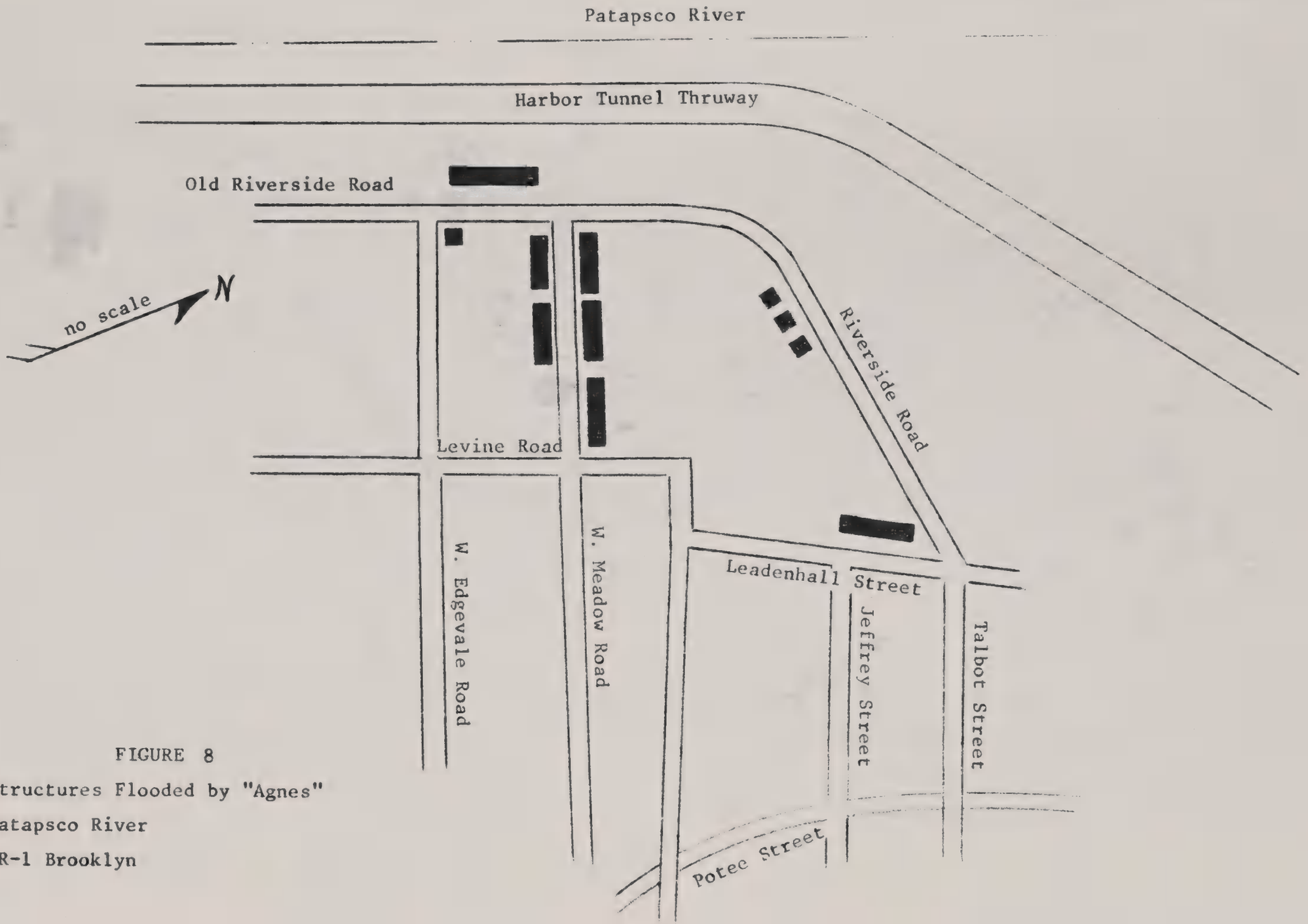


FIGURE 8

Structures Flooded by "Agnes"

Patapsco River

PR-1 Brooklyn

FIGURE 9
Structures Flooded by "Agnes"
Patapsco River
PR-14 Elkridge

Note: Shaded structures are to be acquired as part of Baltimore County's acquistion program

FIGURE 10

Structures Flooded by "Agnes"

Gwynns Falls

GF-10 Gwynn Oak

Note: Shaded structures are to be acquired as part of Baltimore County's acquisition program

FIGURE 11

Structures Flooded by "Agnes"

Gwynns Falls

GF-11 Villa Nova

Note: Shaded structures are to be acquired as part of Baltimore County's acquisition program

FIGURE 12

Structures Flooded by "Agnes"

Gwynns Falls

GF-12 Silver creek Park

SOLUTIONS TO WATER AND RELATED LAND RESOURCE PROBLEMS

I. FLOODING

There are many methods available for reducing flooding and flood damages. A partial list would include such measures as flood insurance regulations, flood warning, impoundments, channel improvement, dikes, floodwalls, property acquisition, stormwater management, conservation land treatment, removal of constrictions, and land use controls. All of the above measures were considered when looking at possible solutions for the flooding problems in the Patapsco River and Gwynn's Falls. In the Status Report for the Patapsco River Basin Study, November, 1978, the alternative solutions and their applicability to the problem areas were discussed. This initial screening of alternatives discarded many of the alternatives with little applicability for different areas of the stream systems.

Some of the measures, such as land treatment and flood insurance regulations, have beneficial effects which are difficult to measure. Others, such as stormwater management, do more to prevent future increases in flood damages rather than reducing present flood damages.

Some of the measures are unpopular because they may give a false sense of security. For example, dikes and flood proofing are installed to protect against a certain flood. If a larger flood occurs, the measures will be overtopped and damages would again occur.

The alternatives which were further considered are discussed in this section. First, there will be a discussion of the types of solutions considered and then their applicability to different areas along the river. An evaluation of the environmental effects of the measures is shown in Table 24.

Flood Plain Delineation

The initial step in formulating solutions to flooding problems is to delineate the floodplain.

This involves determining the extent of flooding on a stream for a flood of a particular recurrence interval. This is usually done for the 100-year flood under present development conditions, but may also be done using anticipated future conditions. This information is then displayed on maps to determine what areas are flooded. For the purposes of this study, floodplains were delineated at major damage areas along the Patapsco River and Gwynn's Falls. Using this information, alternatives were formulated using one or a combination of the measures discussed below.

Using the information developed during this study, floodplain maps could be produced. These maps could then be used to enforce floodplain regulations, which would prevent future damages caused by new development in the floodplains.

A. Types of Solutions Considered

Flood Insurance

Flood insurance obviously does not protect against physical flood damage or risk of loss of life. It does provide a peace of mind benefit with regard to the danger of direct economic loss. Flood Insurance Administration regulations require that the jurisdictions that wish to participate in the flood insurance program must enact ordinances limiting development in the floodplain. These regulations help control the growth of future flood damages.

The National Flood Insurance Program (NFIP) was established by Congress in 1968 to reduce flood damages and to relieve the drain on federal tax dollars for disaster relief. When communities elect to adopt appropriate floodplain management, residents become eligible to purchase flood insurance.

There are two phases in the NFIP. In most cases, communities first join the Emergency Program in which a preliminary Flood Hazard Boundary Map is issued by the Federal Emergency Management Agency (FEMA). The community agrees to enforce general floodplain management measures. In the Emergency Program limited amounts of flood insurance (coverages up to $35,000) are available at subsidized rates for all structures regardless of their risk. After a detailed floodplain study (Flood Insurance Rate Study) has been provided by FEMA the community is eligible to join the Regular Program. More comprehensive floodplain management measures are required at this stage and the limits of flood insurance coverage are increased from $35,000 to $185,000 for residential structures. Rates also are computed based on the amount of flooding which can be expected.

Of the jurisdictions affected by the Patapsco River Basin Study, those in the Regular Program are Baltimore City, Carroll County, Howard County and the incorporated areas of Sykesville, Westminster, and Hampstead. Baltimore and Anne Arundel counties are in the Emergency Program, but Flood Insurance Rate Studies are underway and are due for completion in the near future.

Communities may receive assistance on the NFIP through either the regional office of FEMA, or the State Coordinating Office, Maryland Water Resources Administration.

Flood Warning

For communities along the lower Patapsco from Ellicott City down to Baltimore Harbor, the full application of a flood warning system is probably the best, near-term, method of flood protection.

Flood warning involves devising a system whereby conditions monitored at an upstream area can be used to determine when flooding is imminent in downstream areas. Once this is determined, floodplain residents are notified. Depending on the size of the watershed above the damage area and the rate and timing of runoff, it may be possible to devise a system triggered by rainfall and upstream flow conditions. While such a system gives a few hours warning of an impending flood, it does not prevent a

flood. It allows downstream areas susceptible to flooding to prepare. This requires development of individual schemes for the removal of damageable material to higher elevations. Such a system can help reduce the risk of loss of life and reduce economic damages.

In most cases, property owners could protect a large percentage of their perishable household or commercial goods if they were given a 4-6 hour warning of imminent flooding. Some businesses indicated that they could have eliminated 50-70% of the flood damage sustained in Tropical Storm Agnes if they had been warned 6 hours in advance.

A flood warning system is already in operation in Howard County. It is coordinated by the Howard County Office of Civil Defense, and involves the cooperation of many branches of the county government. Howard County is already disseminating some information to the Civil Defense Directors in Anne Arundel and Baltimore County. However, a more systematic approach is warranted for the delivery of flood threat information to property owners. There is also a need to prevent the dissemination of misinformation which can cause needless evacuation.

Flood Proofing

In the majority of flooding occurrances, there is no major threat to human life. Homes or businesses located on the flood fringe experience rare instances of floodwater entering and causing property damage either to structures or contents. The water is usually slow moving or still, and is at depths under three feet.

In these cases, flood proofing is often appropriate. Flood proofing can either mean modifying a structure to physically prevent water from entering at or below a certain predetermined elevation; or it can mean modifying the structure to withstand the rigors of flooding with minimal structural damage. Flood proofing can be as simple and inexpensive as raising a sill around a basement door with a few bricks or concrete blocks to techniques as complex as raising an entire structure 8-10 feet vertically. The former extreme can usually be implemented by a private homeowner for $50-$100 with minimal technical advice while the latter extreme can cost $20,000-$30,000 for a single house and usually involves a great deal of technical expertise from engineers.

In the Patapsco, flood proofing is only suggested for those residences and businesses which sustain flooding of two feet deep or less during the 100-year storm. For such structures, flood proofing can usually be accomplished for a small fraction of the value of the property, and can be installed by the individual whose property is being affected with limited technical supervision. See Table 19 for a listing of areas where flood proofing was evaluated.

County governments could sponsor flood proofing seminars in communities where minor flood proofing would eliminate a large percentage of the flooding problem. Citizens have expressed interest in such seminars if they were held at a convenient time and place. Communities where such meetings might be considered include Elkridge, Ellicott City, Arbutus, Linthicum, Raynor Heights, Pumphrey and Carrollton.

The U. S. Army Corps of Engineers has excellent data on flood proofing techniques, and experience in costs of flood proofing implementation, maintenance, and operation. In their recently completed Baltimore Metropolitan Streams, Maryland Study, several areas were identified for possible technical assistance through their Floodplain Management Services Program. That assistance remains open upon request.

Acquisition

Fee simple acquisition of floodplain properties is perhaps the most direct means of eliminating flood problems. Relocation or removal of structures susceptible to damages completely eliminates the possibility of financial loss. Acquisition is often expensive when compared to other solutions. It is generally employed when the flood problem is frequent and severe.

Acquisition is one of the most environmentally sound methods of controlling flood damage. However, relocation of people can have great social costs. It may involve disruption of an old, established neighborhood. It may involve low or middle class housing stock whose availability may be limited elsewhere in the community. Criteria for relocation of persons displaced by Federal projects is established in the Uniform Relocation and Assistance and Real Property Acquisition Policies Act of 1971. This federal legislation guarantees equivalent, safe and sanitary replacement housing for displaced families or small businesses. In areas of Baltimore County, particularly along Gwynn's Falls, the county government has already begun an acquisition program. So far, many homes have been acquired and the families relocated. More homes are slated for acquisition over the next few years. In Howard County, several homes near the confluence of Deep Run and the Patapsco River have been acquired and demolished. The families have been relocated. In Anne Arundel County, several homes in the Brooklyn Park area have been acquired and demolished. Also, twenty-one homes in the Ridgeway Manor subdivision in North Linthicum are slated for acquisition over the next five years.

There is some popular opposition to relocation. Often, long time residents prefer the risk of periodic flooding to disruption of their household or community. Also, many people perceive the acquisition program as arbitrary. They observe floodplain acquisition on one hand and what they perceive as increases in flooding due to uncontrolled development upstream.

For the most part, however, the acquisition program serves a worthwhile purpose. While it may not be economically justifiable using federal criteria, it is, in some instances, the most cost effective, environmentally sound method of protecting people whose homes are susceptible to major, life threatening flooding. See Tables 19 and 20 for an analysis of the acquistion benefits and costs.

Impoundments

Earth impoundments or dams can be used as a flood control measure to retard large amounts of floodwater, thus reducing depths of flooding in

downstream areas. The dams impound floodwater, usually that occurring from a 100-year flood, and release it slowly.

The typical dam considered in this report is constructed of zoned earth fill with a concrete pipe-riser release structure. An earthen emergency spillway constructed around one end of the dam is used to carry flows in excess of the 100-year flood.

Depending on the needs and desires of the surrounding community, dams and their attendant reservoirs may be designed to provide multiple uses such as recreation, water supply, and fish and wildlife management.

Because dams do not protect the communities in the areas adjacent to or upstream of their location, they may be looked upon with disfavor by the portion of the public adjacent to them. People further downstream who either receive flood control benefits or, at least, do not have to surrender any land, are generally more tolerant of the idea of a dam.

The streams on which impoundments were considered to reduce flooding are shown in Table 21. They are located on the map on Figure 13. Several alternative combinations of these structures were compiled from this list of possible sites for analysis.

Alternative #1 consisted of all ten of the dams. (The dams were designed as single purpose structures providing only floodwater storage.) This alternative reduces the average annual damages on the South Branch from $66,600 down to $1,500 and on the Main Stem from $52,700 down to $6,800. Of the impoundments on the North Branch, only East Branch and Deep Run would significantly provide localized benefits. The benefit would accrue to the Congoleum Plant at Finksburg. The total cost of this alternative is $26,400,000.

Alternative #2 consisted of only the four largest dams. They included Gillis Falls, Morgan Run, East Branch and Beaver Run. Gillis Falls reduces average annual damages on the South Branch from $66,600 to $6,100. The four dams reduce damages on the Main Stem from $52,700 to $23,100. The total cost of this alternative is $13,000,000.

Alternative 3 consisted of only the Gillis Falls dam. This alternative was evaluated because of the great degree of control it provides. Also, Carroll County is investigating the possibility of constructing a water supply impoundment at that location. The dam reduces average annual damages on the South Branch from $66,600 to $6,100 and from $52,700 to $31,300 on the Main Stem. The total cost of this alternative is $3,600,000.

Tables 22 and 23 show a breakdown of the effect of the impoundment alternatives by economic reach.

Dikes and Floodwalls

To prevent flooding, earthen dikes can be placed in a floodplain between the stream and the area being flooded. Dikes generally encroach on the natural floodplain and thus may cause higher flood elevations than would otherwise occur. This must be taken into consideration in their design. Dikes must be coupled with a sump and pumping system to account for internal drainage, that is, for the area that would naturally drain through the protected area into the stream but will be prevented from doing so by the dike.

Floodwalls are similar in concept to dikes and usually replace them in urban areas or where space is at a premium. Floodwalls are generally vertical walls constructed of reinforced concrete or block.

Both dikes and floodwalls are very effective in preventing flood damages. Their use depends on topography and locations of houses and roads. Depending on their location and the materials used in construction, they may be unsightly. Some homeowners may prefer the risk of periodic flooding to the placement of a dike or floodwall near their properties. Questionnaire results have indicated marginal interest in diking, with interest depending on height of dike and frequency of flooding. Diking may also provide a false sense of security when people assume that the dike will not overtop during a flood larger than the design flood.

Diking is one structural alternative that has engineering feasibility and is applicable in situations where loss of life is a possibility. In some areas along the lower Patapsco, it would be physically possible to build earthen or concrete dikes to prevent floodwaters from encroaching on homes or businesses.

In certain areas, the use of dikes or floodwalls to protect flood-prone property is unfeasible. Gaither is an example. A dike or floodwall protecting homes would essentially isolate the homes from the rest of the community and from proper ingress and egress. See Tables 19 and 20 for an analysis of dikes and floodwalls where applicable.

Channel Improvement

Channel improvement involves altering a natural stream channel to allow it to more efficiently carry large quantities of water, thus lowering the depth of flooding. It changes the shape, capacity, alignment, or lining material of a stream. Channel improvement generally benefits the area immediately adjacent to it, while effects of higher than normal flows may be transferred downstream.

Channels do not involve a great deal of land. Depending on the nature and extent of the channel work, channels may have adverse environmental consequences for the fishery habitat, but such effects can often be mitigated. However, major changes in channel geometry or use of a concrete lining may have irreversible impacts on aquatic species.

pre-development levels. The primary purpose is to prevent erosion of streambanks due to more frequent flood flows. The State of Maryland and each juriscition has a stormwater management policy of some type, but their use and effectiveness vary widely.

Each jurisdiction is in the process of mapping the 100-year floodplains. These maps will be used to enforce floodplain ordinances. They also provide a basis for determining where potential problems exist.

Water based recreation in the area is concentrated mainly in stream valley parks, and at Baltimore Harbor, Piney Run Lake and Liberty Reservoir.

The stream valley parks offer hiking, fishing, boating and picnicking. Baltimore Harbor offers fishing and boating. Piney Run Lake offers fishing, picnicking, boating and hiking. Liberty Reservoir offers picnicking, boating, and fishing.

The area has been included as a portion of several reports done on a regional basis. They include: Chesapeake Bay - Existing Conditions Report, December 1973; Northeastern United States Water Supply Study, November 1975; and North Atlantic Regional Water Resources Study, June 1972. There were many agencies involved in the development of these studies. Coordination was provided through the U. S. Army Corps of Engineers.

Table 13 LAND TREATMENT NEEDS

Item	Unit	Total Watershed Needs	Now on The Land	Additional Needs Provided by Ongoing Program 1/	Additional Needs Needed in Accelerated Program
Conservation Plans	No.	122,798	42,950	20,901	58,947
Site Plans Review	No.	2,925	1,136	463	1,326
Cropland Protection	Ac.	100,404	55,966	19,417	25,021
Pastureland Protection	Ac.	6,871	4,447	716	1,708
Woodland Protection	Ac.	85,262	65,908	9,554	9,800
Other Land Protection	Ac.	53,476	38,002	4,848	10,626
Conservation Crop System	Ac.	100,404	73,500	8,684	18,220
Grassed Waterway	Ac.	1,004	560	114	330
Diversions	Ft.	334,183	178,000	16,588	139,595
Ponds	No.	545	260	67	218
Critical Area Planting	Ac.	4,363	2,244	367	1,752
Waste Management Systems	No.	120	17	31	72
Spring Development	No.	69	15	20	34
Pasture Establishment	Ac.	2,952	2,300	83	569

Source: Soil Conservation Service

1/ Refers to existing programs of Soil Conservation District and Soil Conservation Service

WATER AND RELATED LAND RESOURCE PROBLEMS

I. FLOODING

Flooding along the Patapsco has been a problem since man first settled in the area. In the early part of the last century, mills and industries which depended on the water power that the Patapsco could supply grew up along the river. In conjunction with these grew the mill towns like Daniels, Oella, Ellicott City, and Ilchester. The railroad, running up the Patapsco valley, provided the transportation needed to move goods down to the port at Baltimore. As the Patapsco's potential as a source of power and transportation was exploited, so too was its potential for destruction felt. In 1869, runoff from the 250 square miles above Ellicott City came roaring down the valley causing great destruction and the loss of 39 lives. Again in 1923, and five times since, the river has caused severe damage. In 1972, Tropical Storm Agnes caused several deaths and millions of dollars in damages. In the 1800's, man colonized the floodplain because he was economically tied to the river. In this century, population increases, increased mobility, and affluence enticed man out of the city. In some cases, the pastoral setting of a rural stream became the ideal setting for his home.

The flooding problems and their causes throughout the study area are different and complex. They are best discussed within the context of each subbasin: South Branch, North Branch, Main Stem, and Gwynn's Falls. The problems in the first three are interrelated, while the problems in the latter can be viewed independently.

A. Major Causes of Flooding

The major causes of the flooding problems that now exist are:

1) Encroachment on the natural floodplain: Homes and businesses have been located within the 100-year floodplain (See Figure 2). This not only jeopardizes the buildings themselves, but it also reduces the efficiency of the natural stream floodplain system to convey water. This can increase flood stages upstream. Preventing encroachment will not reduce present damages, but it will assure that future damages will not increase.

2) Constriction of the natural floodplain by man-made obstructions: Roads and bridges which serve the area must necessarily follow or cross over the floodplain. In many cases they cause constrictions which back water upstream (See Figure 3). Recently man has learned to design such facilities properly so that they have a minimal impact on the ability of the floodplain to convey floodwater. However, in many cases, older or abandoned constrictions still have a great impact on flood levels.

   Many constrictions exist along the Patapsco and its tributaries. This study has noted four that deserve special consideration because they have a large impact on flooding potential. Two of the constrictions are landfills located near the mouth of the Patapsco. A third is an abandoned railroad

crossing in Elkridge. The final one is a railroad fill in the floodplain near Carrollton and Patapsco.

There are instances in which flooding is caused by materials being carried downstream and becoming lodged in the opening of a bridge creating a constriction in an otherwise well-designed structure. In many cases, the material lodged at the bridge consists of cars, trucks, uprooted trees, or parts of buildings which are swept downstream by the flood. Some of this material began as trees which were deposited on the floodplain during previous floods or the inventory of a lumber company on the floodplain. If proper precautions and maintenance were undertaken, some of these problems could be reduced.

3) Erosion and sedimentation: Increases in the rate of erosion can lead indirectly to increased flooding. If more soil erodes from farms, forests, construction sites, and urban land, the resulting sediments settle on the bottom of the stream, reducing its carrying capacity. Thus a given amount of water will flow at a higher level then previously. This reduction in carrying capacity will reach an equilibrium at some point in time. It has been documented that considerable sedimentation has occurred in the tidal portions of the Patapsco downstream from Elkridge since barges were brought up the river to load at Elkridge in the 18th century.

Due to the inability to predict future sedimentation rates in the river channel, future increases in flood damages caused by the reduced carrying capacity were not analyzed. The increases will probably be minimal, especially when considered with other long term influences such as rising ocean levels.

4) Urbanization: In the natural course of development, many acres of land become covered with homes, businesses, roads, driveways and parking lots. As land is converted from field, meadows or woodland to more impervious covers, a greater proportion of rainfall runoff flows overland to streams rather than being absorbed by the soil. (See Figures 4 and 5.) When hundreds of acres undergo such a transformation, the increase in runoff can increase the severity of flooding downstream. Although development must continue, it is possible to maintain the peak rate of runoff at or near pre-development levels. Stormwater management measures can be installed during construction to minimize increases in runoff or to temporarily store the increased runoff so it can be released slowly so as not to contribute to flooding downstream.

Increased acreage in urban land uses could dictate that flooding problems will become worse in the future. It is anticipated that in the next 20 years, approximately 30,000 acres of land within the study area will go from agriculture or open space, into residential, commercial, and industrial usage. This represents almost 15% of the total land area in the study area. Also, from 2000 to 2075, it is anticipated that an additional 40,000 acres will develop.

Thus, in the year 2075, it can be anticipated that a 100-year storm lasting a day will produce 3 billion more gallons of surface runoff than the same storm occurring today. This water running rapidly off the land surface into streams benefits no one. It is not available to infiltrate the ground to nourish plants or replenish groundwater. It increases flows in stream channels which causes increased erosion and it increases the volumes, peaks, and stages of floodwaters in the stream, thus increasing the size of the floodplain. (See Figures 4 & 5.)

However, urbanization will not have a significant effect on peak flows on the main stem of the Patapsco River. Near the harbor, future discharges will increase 100-year flood elevations by a maximum of one foot. The problem areas are on the tributaries and along Gwynns Falls.

B. Problems in Specific Areas

To analyze the flood damages, the different areas along the stream were grouped together based on similarities in type of damages, location, and factors affecting the flooding situation. These reaches and their locations, along with number of structures flooded are shown in Table 14 and Figure 1. Estimated monetary damages which would be caused by a recurrence of Agnes and the 100-year flood are shown in Tables 15 and 16. The 100-year flood damages are based on flooding caused by present land use conditions for the Patapsco River and future conditions without stormwater management for Gwynns Falls. Since future flooding will not increase significantly in the Patapsco, damages will also not increase significantly.

Although flooding is relatively infrequent in the basin, the damages during major floods are high. For example, estimated flood damages during the 10-year flood are minimal, but for the 100-year flood, they are major.

The following is a summary by reach of the damages caused by Tropical Storm Agnes in 1972.

South Branch

Agnes caused flood damages in six communities along the South Branch. These included Marriottsville, Henryton, Sykesville, Gaither, Morgan Station, and Woodbine. Almost every bridge over the South Branch had to be repaired or replaced. Also, many roads and bridges crossing tributaries to the South Branch were damaged or destroyed.

In Marriottsville (Reach PR-20), seven homes, one small apartment building, and a church were flooded. Damage levels were high. Water levels ranged from two to twelve feet above the first floor.

At Henryton (PR-21), a greenhouse and a power plant were flooded by seven feet of water. The power plant supplies a hospital with heat and hot water.

Sykesville (PR-22), had more commercial structures damaged than any other area along the South Branch. (See Figure 6.) Six businesses and two homes were flooded. Two taverns on the Howard County side of the river had from five to eight feet of water around them. The other businesses and homes had less of a problem with damage confined to basements and low levels on the first floor. In Gaither (PR-23), five houses were flooded with first floor depths rising to nearly six feet in three of them.

In Morgan Station (PR-25), two homes were flooded. Depths ranged from basement level to four feet above the first floor.

In Woodbine (PR-26), three businesses and one house were flooded. The businesses sustained three to four feet of water above the first floor. The home had basement damage.

North Branch

The flooding problems within the North Branch sub-basin occur in isolated areas. Some flooding in the communities of Carrollton and Patapsco was sustained during Tropical Storm Agnes. The Congoleum Plant in Finksburg, at the headwaters of Liberty reservoir, sustains a great deal of damage during major storm events.

The estimated 100-year flood discharge on the North Branch is less than the Agnes flood discharge, therefore, the depth of flooding that could be expected would be less than that from Agnes.

Near Westminster (PR-31), the filtration plant for the city's water supply is periodically flooded.

In the communities of Carrollton and Patapsco (PR-29 and 30), on the North Branch, a total of twenty residential structures were flooded during Agnes. One church and one store were also flooded. (See Figure 7.) While most of the flooding in these communities was limited to basements, several houses in Patapsco sustained as much as four feet of water on the first floor.

The problems in Carrollton and Patapsco are likely to get worse as upstream areas such as Westminster, Hampstead, and Manchester continue to urbanize. Increased urban runoff will increase the frequency and severity of flooding in the communities unless steps are taken to reduce increased runoff from major storms.

The Congoleum Corporation has a plant near Finksburg (PR-28) at the upstream end of Liberty Reservoir. During Agnes, the plant had as much as twelve feet of water in some of its buildings. The flooding situation at the Congoleum Plant has two unfortunate consequences. First, flooding causes economic hardship for the plant and its workers. Second, the flood washes chemicals and other materials stored at the plant into Liberty Reservoir, causing a potential health problem to the water users.

Lower Patapsco

It is the valley downstream of the confluence of the North and South Branches where the major concentrations of flood damages occur. Towns

such as Oella, Ellicott City, and Elkridge, and communities such as North Linthicum, Pumphrey, Raynor Heights, and Baltimore Highlands, as well as isolated homes and businesses along the Main Patapsco are susceptible to flooding. For homes and businesses in the flood fringe area, the flooding may be only a minor nuisance occurring once in a lifetime. But, for buildings in low lying areas, a flood threat may represent a frequently recurring threat to life and property.

The estimated 100-year flood on the main stem of the Patapsco River is much less than Agnes. Agnes was an extremely rare event as far as discharges on the main stem are concerned.

In Brooklyn, located at the mouth of the river (part of PR-1), one hundred twenty-one homes and two businesses were flooded during Tropical Storm Agnes. All but two of the houses flooded were brick row houses. The damage was concentrated in a relatively small area. (See Figure 7.) Almost all of the damage was limited to basements. In every case, Agnes was the only flooding any of the residents could recall.

In Pumphrey, North Linthicum, and Baltimore Highlands, located southeast of Landsdowne (PR-2), twenty commercial establishments, fifty-two houses, and seventeen trailers are susceptible to flooding. Most of the first floor flooding during Agnes was to depths of three feet or less. About twenty homes had basement flooding only. Damages in these communities are spread over a wide area. In Anne Arundel County, structures were flooded along Old Annapolis Road, in North Pumphrey, and in a trailer court on Belle Grove Road. In Baltimore County, houses were flooded in Riverview and Baltimore Highlands. Twenty houses were flooded in the development of Ridgeway Manor, but Anne Arundel County has begun a purchase program to remove them from the floodplain.

In Oak Park, located south of Landsdowne (PR-3), three businesses and one industry were flooded by Agnes. One restaurant had eight feet of water, and the Carling Brewing Company had more than five feet in and around the building.

Approximately twenty-five houses and thirteen businesses were flooded along Herbert Run (PR-4, 5, 6, 7, and 8), a major tributary to the Lower Patapsco. Few residents reported any flooding above the basement and most reported less than three feet in the basement. Baltimore County is presently buying 15 houses on a tributary to Herbert Run. These homes are not included in the above total.

The Patapsco River and Deep Run both caused damage in Elkridge (PR-11 & 14). Twenty-one homes and twelve businesses were flooded. Many of the businesses were seriously flooded, some receiving as much as ten feet of water on the first floor. (See Figure 9.) Seventeen more homes on Church Avenue were flooded by Agnes, but Howard County purchased these, along with a church and community building in 1976 as part of a floodplain acquisition program.

Of the twenty structures flooded in Ilchester, located midway between Elkridge and Ellicott City (PR-15), nine are commercial or industrial buildings associated with Simkins Industries. Flooding in these buildings averaged six feet during Agnes. The houses were, in general, flooded to lesser depths.

In or near Ellicott City and Oella (PR-16), forty-eight businesses and eight homes were flooded during Tropical Storm Agnes. Most of the damage occurred in stores on Main Street in Ellicott City. Water rose to over ten feet in the Historic District, enough to reach the second floor of many buildings. Although most damage was in Howard County, there is significant damage on the Baltimore County side of the river, particularly in the Wilkins-Rogers Plant.

Gwynns Falls

Flooding problems occur at many points along the Gwynns Falls. Flooding of industries at the mouth is caused by enroachment on the natural floodplain. The same is true of flooding in communities upstream such as Dickeyville, Gwynn Oak, Woodlawn, and Owings Mills. The problem is compounded by increased flood flows due to urbanization. The damage areas are spread out over the length of the stream. While there are some major concentrations of damage, such as the Owings Mills Industrial Park and the Brittany Apartments, most damages are so scattered as to make any consideration of structural measures unfeasible.

In the Westport area of lower Gwynns Falls, near the mouth of the stream (GF-1), there were eighty-nine structures flooded by Agnes. Seventy-three were residential structures, and sixteen were commercial or industrial enterprises. If such a flood would occur again, damages in the area would exceed $1.7 million. Although this is a relatively localized problem, the effects are widespread. The sixteen businesses employ many people and even when they are closed for short periods of time, many of the employees could experience temporary financial difficulties.

Along Maiden's Choice Run (GF-2, 3, 4, & 5), there are approximately one hundred fourteen structures which were flooded by Tropical Storm Agnes. No unit, except some basement apartments, received more than three feet of water. About sixty homes had basement flooding only. The greatest amount of damage occurred in a four block area just inside the city line. Along this reach, about 80% of the stream is enclosed. Flooding occurs because the culvert was not designed to carry the stream flow associated with a flood like Agnes.

Dead Run (GF-7 & 8), flooded many more than the fourteen residences shown in this survey. Baltimore County has already purchased many homes in this area. Most of the remaining fourteen residences are on the fringe areas of the floodplain, where they receive minor basement flooding.

In Woodlawn (GF-10), Gwynn's Falls flooded about eighty structures during Agnes. Baltimore County has begun an acquisition program which will reduce the number of susceptible structures along the reach by about one-half. Twenty-eight homes and fourteen businesses would still be flooded by a recurrence of a flood like Agnes. Of these, twelve homes and six businesses would have first floor flooding, usually limited to three feet or less. Most of the residential damage is on Gwynn Oak Avenue, but the houses are widely scattered. (See Figure 10.)

In the vicinity of Villa Nova, Milford, and Willow Glen, located near Woodlawn (GF-11), Agnes flooded about one hundred fifteen structures.

Baltimore County's current acquisition program will reduce that number to fifty-nine structures should such a storm reoccur. Of those forty-four structures, there are forty residences, eighteen businesses, and one church.

The homes are scattered along the reach, sometimes in groups of four or five. Most of the homes are separated from the stream by a street. Thus, the street was flooded as well as the homes above it. This made access to or from the house difficult or dangerous. (See Figure 11.)

In Silver Creek Park, located near I-695 (GF-12), twenty-two single family dwellings would be susceptible to flooding if Agnes were to reoccur. (See Figure 12.) Almost sixty other homes are covered by Baltimore County's acquisition program. Eleven of the homes had basement flooding. Of the others, several had up to 10 feet of water on the first floor. These homes are scattered along the east side of the stream.

Agnes flooded fifty units of the Brittany apartment complex, downstream of I-695 (GF-12). The buildings are close to one another so the damage is concentrated in a small area. Flooding ranged from two to six feet. In addition, residents of the second and third floors of these buildings were inconvenienced or denied access by the flooding occurring on the first floor.

Another area of high damages is in the Owings Mills area (GF-14), downstream of Reisterstown Road. Fourteen structures were flooded by Agnes. Most of the damage occurred in Owings Mills Industrial Park.

II. Erosion

Erosion is a natural geologic process. Problems arise when man interferes with nature by clearing the land for farms and towns.

Urbanizing land produces the greatest rate of erosion. However, relatively small amounts of land are undergoing urbanization at any one time.

Cropland produces the next highest rate of erosion. Due to the large amounts of land dedicated to cropland, this is the largest producer of sediment. Therefore, any attempts at reducing sediment production should concentrate heavily on the cropland.

Other significant sediment producing areas are mine spoil and streambanks. Streambank erosion is accelerated when development increases the flow in the stream channel. These problems are evident in urban stream systems such as Herbert Run and Gwynns Falls. For a complete tabulation of erosion rates and sediment yields see Table 17.

III. Sedimentation

The product of erosion is sediment. Some of this sediment enters the stream system and eventually is deposited. There are three major areas where sedimentation is occuring: Liberty Reservoir, Baltimore Harbor, and the river channel. In each case, different problems are dominant.

Liberty Reservoir is used as a source of raw water for the Baltimore Central (water) Supply System. Sedimentation reduces the water storage capacity of the reservoir. If sediment is deposited at rates greater than had been predicted during the design of the reservoir, this source of Baltimore's water could be reduced. (See Table 18.)

The main concern in the Baltimore Harbor is that shipping channels should be maintained at depths which allow modern ocean-going vessels to use the Harbor facilities when fully laden. There are many sources of sediment being deposited in the Harbor, only two of which are the Patapsco River and Gwynn's Falls. Problems in estimating the relative contribution of each source of sediment preclude an assessment of the harbor maintenance cost which should be assigned to either the Patapsco River or to Gwynn's Falls.

There are indications of sedimentation in the main stream of the Patapsco River, especially in the tidal section below Elkridge. Some of this sedimentation is part of the natural process by which the river changes its course, eroding the streambanks in some spots and depositing sediment in others. The greatest amount, however, is believed to be deposited from the upstream rural and urban land. Most damages caused by this sedimentation are not quantifiable in monetary terms.

IV. Water Quality

Along with erosion and sedimentation, other water quality problems caused by nonpoint sources of pollution are nutrients carried by sediments plus fecal coliform bacteria from septic tanks and animals wastes. In the Statewide Critical Areas for Nonpoint Sources of Soil Erosion and Animal Wastes, June, 1979, the Liberty Reservoir Drainage and South Branch Patapsco River were ranked 3 and 5, respectively, out of 12 critical areas identified throughout the state. This ranking was to be used in assigning priorities for the Rural Clean Water Program pursuant to Section 208 (j), Federal Clean Water Act. The ranking was based mainly on the severity of erosion and animal waste problems.

V. Water Supply

There are no areas where availability of water for municipal and industrial use is a problem at the present time. However, as areas of Carroll County undergo development in the future, such deficiencies may occur. Westminster is likely to experience limitations in the near future if additional sources are not developed. Carroll County obtains some water from the Patapsco/Liberty system under a long term contract with Baltimore City, but not nearly enough for its future needs. The county is looking for new sources of water, either in the form of surface impoundments or groundwater resources.

VI. Recreation

In an intensely urban setting, recreation demand in most major catagories exceeds supply. This is the case in the Baltimore Region according to the State Comprehensive Outdoor Recreation Plan (SCORP). Large deficiencies presently exist and will continue to increase in such activities as boating, fishing, picnicking, hiking, and biking. These

activities are either dependant on to an unpolluted and abundant surface water resource. For a detailed breakdown of recreation needs, see Appendix G.

TABLE 14

REACH IDENTIFICATION AND
SUMMARY OF DAMAGE BY REACH

Reach Number	Stream	Reach Location	Est. No. of Structures Subject to Flooding [1]	
			Agnes	100 Yr. Flood [2]
PR-1	Patapsco River	Hanover St. to Tunnel Thruway	123	0
PR-2	" "	Tunnel Thruway to Balto. Beltway	89	26
PR-3	" "	Balto. Beltway to Penn. Cent. R.R.	4	1
PR-4	Herbert Run	Patapsco River to E & W Br. Confluence	3	3
PR-5	East Branch	Confluence to Sulphur Spring Rd.	5	5
PR-6	" "	Sulphur Spring Rd. to Balto. Beltway	4	4
PR-7	" "	Balto. Beltway to Wilkens Ave.	11	11
PR-8	West Branch	Confluence to Shelbourne Ave.	15	15
PR-12	" "	Hanover Road to Rte. 176	3	3
PR-13	No name stream	Pfeiffers Corner	4	4
PR-14	Patapsco River	Penn. Central R.R. to Rte. I-95	16	5
PR-15	" "	Rte. I-95 to Grays Level	12	9
PR-16	" "	Ellicott City & Oella Areas	57	52
PR-17	" "	Hollofield	5	2
PR-19	" "	Woodstock	6	4
PR-20	South Branch	Marriottsville	9	7
PR-21	" "	Henryton	2	2
PR-22	" "	Sykesville	7	4
PR-23	" "	Gaither	5	4
PR-25	" "	Morgan Station	2	3
PR-26	" "	Woodbine	4	4
PR-28	North Branch	Finksburg	1	1
PR-29	" "	Patapsco	13	11
PR-30	West Branch	Carrollton	9	8
PR-31	" "	Cranberry Station to Westminster	1	1
GF-1	Gwynns Falls	Annapolis Rd. to Wilkens Ave.	116	116
GF-2	Maiden Choice Run	Gwynns Falls to Penn. Central R.R.	4	4
GF-3	" " "	Penn Central R.R. to Beechfield Ave.	11	11
GF-4	" " "	Beechfield Ave. to Overbrook Rd.	88	88
GF-5	" " "	North Prospect Ave. to Stoney Lane	11	11
Gf-6	Gwynns Falls	Wilkens Ave. to Dead Run	2	2
GF-7	Dead Run	Gwynns Falls to City Line	2	2
GF-8	" "	City Line to Baltimore Beltway	12	12
GF-9	Gwynns Falls	Dead Run to City Line	20	20
GF-10	" "	City Line to Liberty Road	42	42
GF-11	" "	Liberty Road to Milford Mill Rd.	61	61
GF-12	" "	Milford Mill Rd. to Balto. Beltway	72	72
GF-13	" "	Balto. Beltway to Painters Mill Rd.	2	2
GF-14	" "	Painters Mill Rd. to Reisterstown Rd.	31	31
GF-15	" "	Reisterstown Rd. to Kendig Mill Rd.	1	1

[1]The figures do not include the structures which are part of ongoing acquisition programs by Baltimore County and Howard County.

[2]Based on future without project conditions.

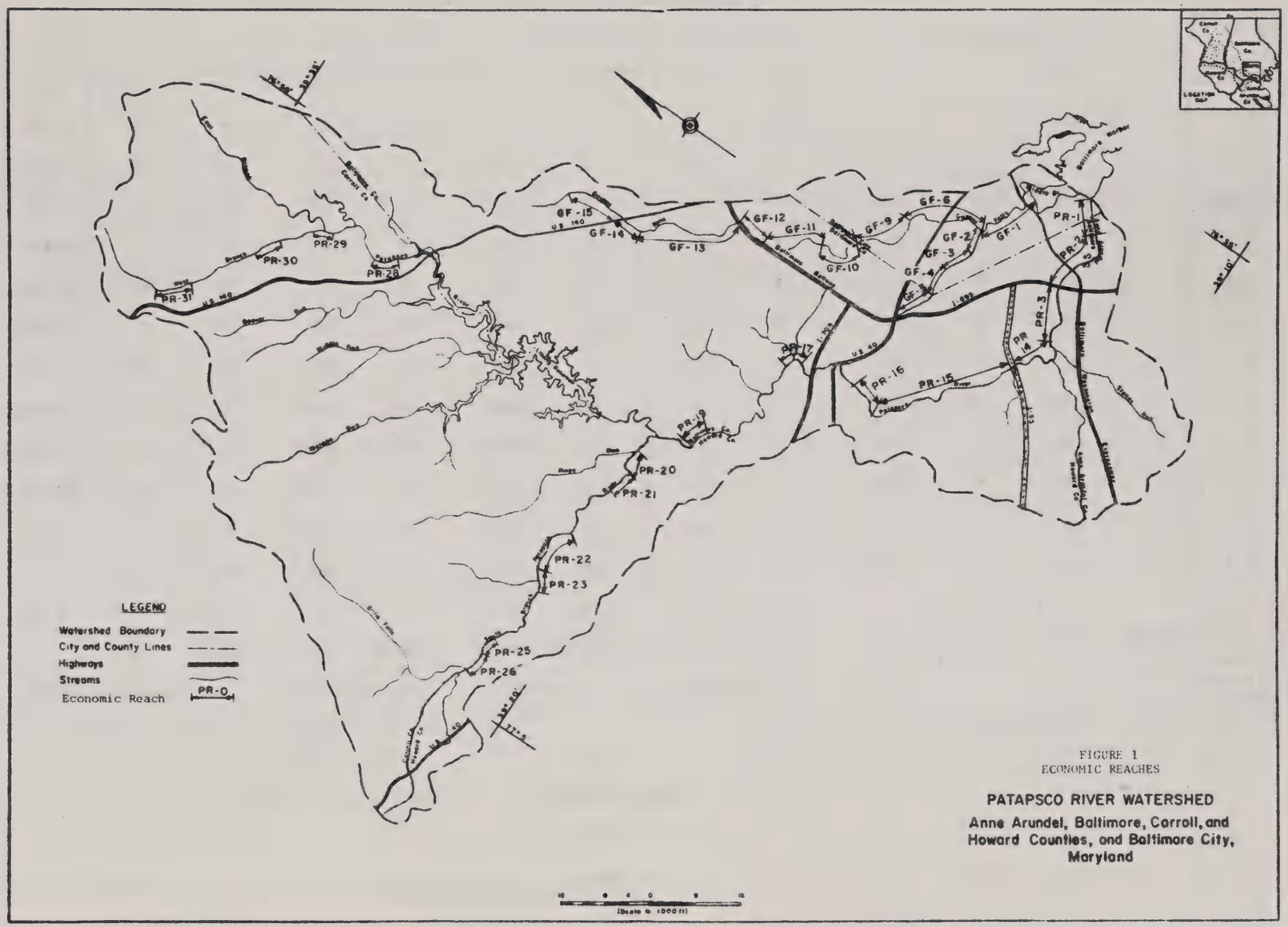


FIGURE 1
ECONOMIC REACHES

PATAPSCO RIVER WATERSHED

Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City, Maryland

TABLE 15

ESTIMATED FLOOD DAMAGES

PATAPSCO RIVER

Reach	Agnes						100-Year [1]						Average Annual Damages [2]
	Residential		Commercial/Ind.		Total		Residential		Commercial/Ind.		Total		
	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000	# of Bldgs.	$1000
PR-1	$ 130	121	$ 20	2	$ 150	123	$ 0	0	$ 0	0	$ 0	0	$ 0
PR-2	852	69	1744	20	2596	89	47	21	116	5	163	26	1.7
PR-3	0	0	1059	4	1059	4	0	0	57	1	57	1	0.4
PR-14	50	4	1522	12	1572	16	16	1	671	4	687	5	6.7
PR-15	78	8	3052	4	3130	12	17	7	330	2	347	9	2.9
PR-16	218	9	2780	48	2998	57	71	7	1969	45	2040	52	41.0
PR-20	119	8	16	1	135	9	83	6	16	1	99	7	3.9
PR-22	13	2	69	5	82	7	3	2	43	2	46	4	0.6
PR-23	79	5	0	0	79	5	68	4	0	0	68	4	2.9
PR-25	10	2	0	0	10	2	26	3	0	0	26	3	0.5
PR-26	1	1	262	3	263	4	13	1	301	3	314	4	58.7
PR-29	55	12	6	1	61	13	35	10	2	1	37	11	1.0
PR-30	54	8	17	1	71	9	29	7	12	1	41	8	2.4
TOTAL	$1659	249	$10,547	101	$12,206	350	$ 408	69	$3,517	65	$3925	134	$122.7

1/ Based on present without project conditions. Future conditions do not vary significantly.

2/ For further explanation of damage computations, see Appendix B.

TABLE 16

ESTIMATED FLOOD DAMAGES

GWYNN'S FALLS

Reach	Agnes/100-Year [1] Residential $1000	Agnes/100-Year [1] Residential # of Bldgs.	Agnes/100-Year [1] Commercial/Ind. $1000	Agnes/100-Year [1] Commercial/Ind. # of Bldgs.	Agnes/100-Year [1] Total $1000	Agnes/100-Year [1] Total # of Bldgs.	50-Year [1] Residential Commercial Industrial Damage $1000	10-Year [1] [2] Residential Commercial Industrial Damage $1000	Average Annual [3] Damages $1000
GF-1	776	73	946	43	1722	116	407	0	26.9
GF-2	3	4	0	0	3	4	0	0	.1
GF-3	48	11	0	0	48	11	0	0	.2
GF-4	627	87	4	1	631	88	0	0	3.2
GF-5	70	8	45	3	115	11	0	0	.6
GF-9	205	17	202	3	407	20	141	22	13.7
GF-10	258	28	255	14	513	42	139	8	10.7
GF-11	306	41	355	20	661	61	312	30	24.6
GF-12	1596	72	0	0	1596	72	1268	72	82.3
GF-13	18	1	11	1	29	2	0	0	.1
GF-14	0	0	738	31	738	31	567	363	116.3
TOTAL	$3907	342	$2556	116	$6463	458	$2834	$ 495	$278.7

1/ Based on future without project conditions.

2/ Zero damage for 2-year flood.

3/ For further explanation of damage computations, see Appendix B.

TABLE 17

Gross Erosion and Sediment Yield by Sources (Average Annual) 1/

SOUTH BRANCH

Land Use	Acres	Soil Loss (T/Ac)	Total Soil Loss (Tons)	Delivery Ratio (Pct)	Sediment Yield (Tons)
Cultivated	38083.	7.03	267715.	13.	35606.
Pasture	823.	1.51	1246.	13.	165.
Woodland	12761.	2.21	28211.	13.	3752.
Urbanized	2111.	1.62	3420.	60.	2052.
Urbanizing	200.	150.00	30000.	10.	3000.
Mine Spoil	0.	-	-	-	-
2/ Roadbank	110.	3.80	417.	20.	83.
3/ Streambank	439.	18.86	8278.	70.	5795.
Non-sediment Contributing	0.	-	-	-	-

NORTH BRANCH

Cultivated	64199.	7.46	479019.	18.	88618.
Pasture	1373.	1.39	1913.	19.	354.
Woodland	28671.	1.51	43258.	19.	8003.
Urbanized	5600.	1.11	6196.	60.	3717.
Urbanizing	400.	150.00	60000.	10.	6000.
Mine Spoil	0.	-	-	-	-
2/ Roadbank	243.	0.08	19.	20.	4.
3/ Streambank	671.	22.45	15063.	70.	10544.
Non-sediment Contributing	3123.	-	-	-	-

MAIN STEM

Cultivated	7882.	14.23	112173.	5.	6058.
Pasture	2861.	2.33	6679.	5.	361.
Woodland	31978.	2.27	72645.	5.	3923.
Urbanized	27172.	1.09	29620.	60.	17772.
Urbanizing	1800.	138.89	250000.	10.	25000.
Mine Spoil	735.	70.29	51665.	60.	30999.
2/ Roadbank	78.	3.96	308.	20.	62.
3/ Streambank	462.	7.51	3468.	70.	2427.
Non-sediment Contributing	827.	-	-	-	-

1/ From Erosion and Sediment Survey of Baltimore Regional Planning Council Area U.S.D.A. Soil Conservation Service, College Park, MD. December, 1977 (Tables 12, 13, and 16)

2/ Roadbank Units (In Acres Column) Are Bank Miles

3/ Streambank Units (In Acres Column) Are Bank Miles

TABLE 17 (Cont'd)

Gross Erosion and Sediment Yield by Sources (Average Annual) 1/

PATAPSCO RIVER TOTAL

Land Use	Acres	Soil Loss (T/Ac)	Total Soil Loss (Tons)	Delivery Ratio (Pct)	Sediment Yield (Tons)
Cultivated	110164.	-	858907.	-	130282.
Pasture	5057.	-	9838.	-	808.
Woodland	73410.	-	144114.	-	15678.
Urbanized	34883.	-	39236.	-	23541.
Urbanizing	2400.	-	340000.	-	34000.
Mine Spoil	735.	-	51665.	-	30999.
2/ Road Bank	431.	-	744.	-	149.
3/ Stream Bank	1572.	-	26809.	-	18766.
Non-Sediment Contributing	3950.	-	0.	-	0.
Total Acres	230599.				
Total Tons			1471313.		254295.

GWYNN'S FALLS

Cultivated	2338.	5.15	12041.	13.	1565.
Pasture	544.	0.78	426.	13.	55.
Woodland	5874.	0.73	4283.	13.	557.
Urbanized	19737.	0.50	9869.	60.	5921.
Urbanizing	700.	150.00	10500.	10.	10500.
Mine Spoil	92.	21.68	1990.	60.	1194.
2/ Road Bank	81.	0.50	41.	20.	8.
3/ Streambank	195.	17.86	3488.	70.	2442.
Non-Sediment Contributing	92.	-	-	-	-
Total Acres	29376.				
Total Tons			137138.		22243.

1/ From Erosion and Sediment Survey of Baltimore Regional Planning Council Area U.S.D.A. Soil Conservation Service, College Park, MD. December, 1977 (Tables 12, 13, and 16)

2/ Roadbank Units (In Acres Column) Are Bank Miles

3/ Streambank Units (In Acres Column) Are Bank Miles

Table 18 Effects of Sedimentation on the Storage Capacity of Liberty Reservoir

(1)	(2)	(3)	(4)		(5)	(6)	(7)
year	sediment deposits (acre-feet)	reduction in usable storage (acre-feet)	reduction in water supply storage (acre-feet)	(%)		reduction in safe yield (mgd.)	(%)
1954	0	0	0	0		0	0
1973	7,185	1,660	1,490	1.3		0.6	0.6
2004	18,800	13,300	12,000	10.5		4.8	5.1
2020	24,900	19,400	17,500	15.3		6.9	7.3
2054	37,700	32,200	29,000	25.4		11.5	12.1

Column (2) 377 acre-feet per year, 1954-1973 average rate of sedimentation. From Reservoir Sediment Data Survey, USDA Soil Conservation Service, College Park, MD., August 1973.

Column (3) Column (2) less 5526 acre-feet allotted to sediment storage.

Column (4) 90% of Column (3).

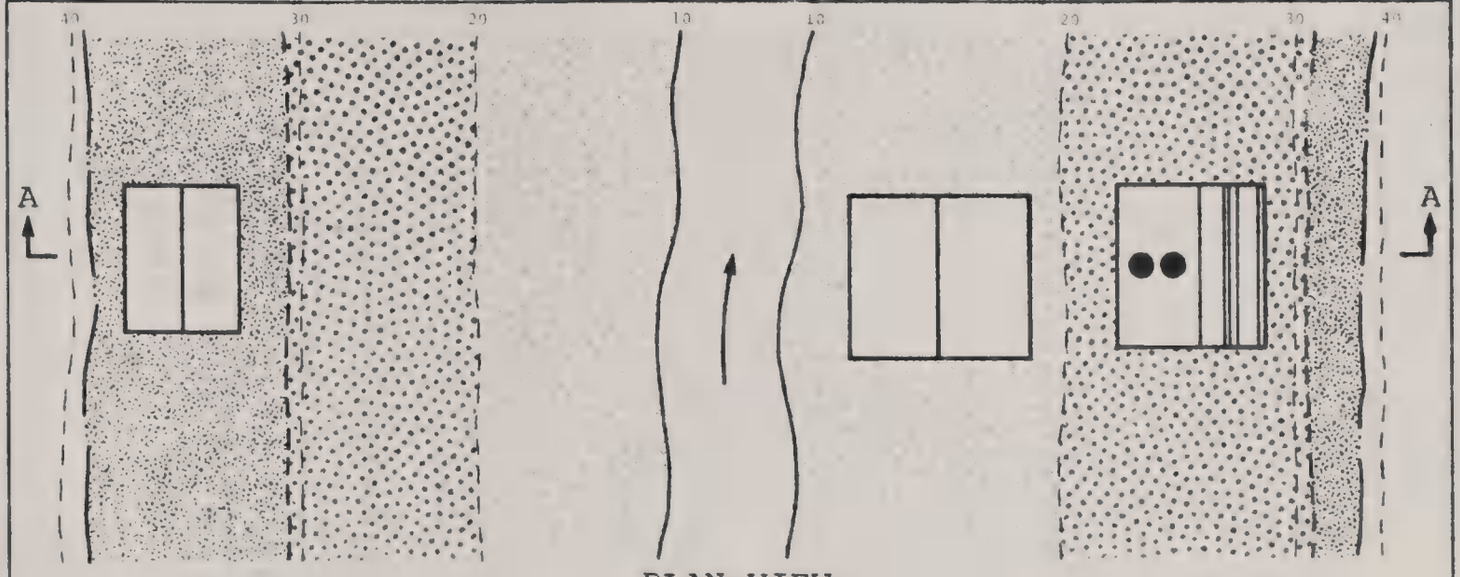
Column (5) Column (4) divided by 114,210 acre-feet, design water supply storage.

Column (6) Column (4) times .000397. $\frac{43560 \text{ cu. ft.}}{\text{acre-feet}} \times \frac{7.5 \text{ gal.}}{\text{cu. ft.}} \div 823 \text{ days}$

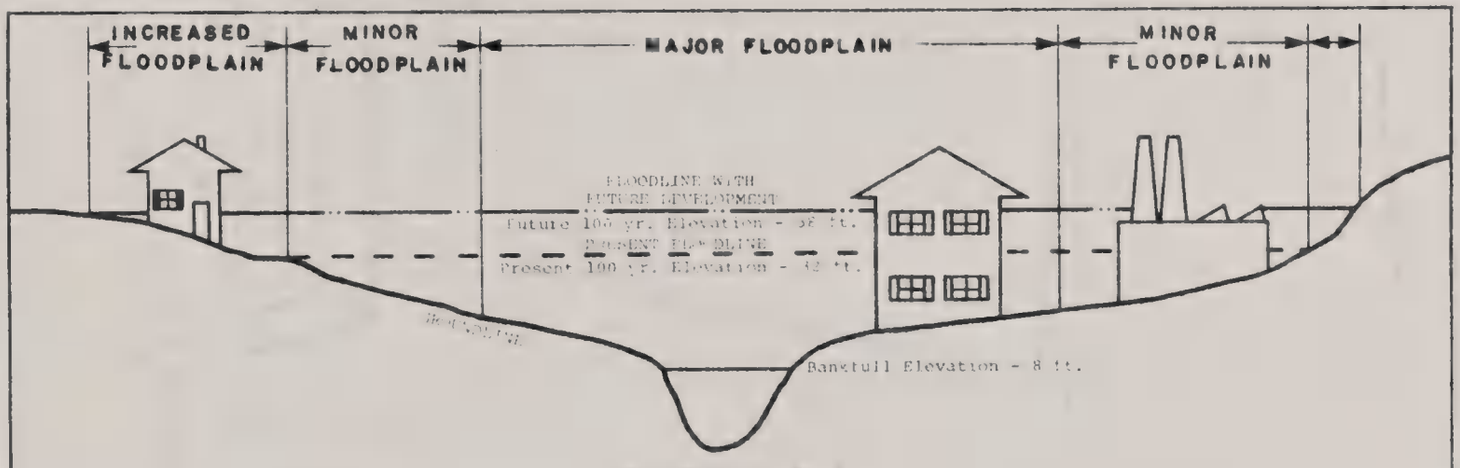
Column (7) Column (6) divided by 95 mgd.

Figure 2

COMPONENTS OF THE FLOOD PLAIN



PLAN VIEW



SECTION A-A

LEGEND

- Lines of Equal Contour Elevation
- Buildings
- MAJOR FLOODPLAIN
- MINOR FLOODPLAIN
- INCREASED FLOODPLAIN

MAJOR FLOODPLAIN	Water flowing at reasonable depth; net movement of downstream; greatest threat of loss of life; protect by acquisition, dams, channelization, diking
MINOR FLOODPLAIN	Slack water area, shallow depths, low velocities; small net movement perpendicular to channel flow only; property damage likely; little life threat; protect by floodproofing, warning, diking, channelization, insurance
INCREASED FLOODPLAIN	Increase in flood fringe caused by increased runoff due to urbanization upstream; protect by land use policy, zoning, storm water management

Figure 3

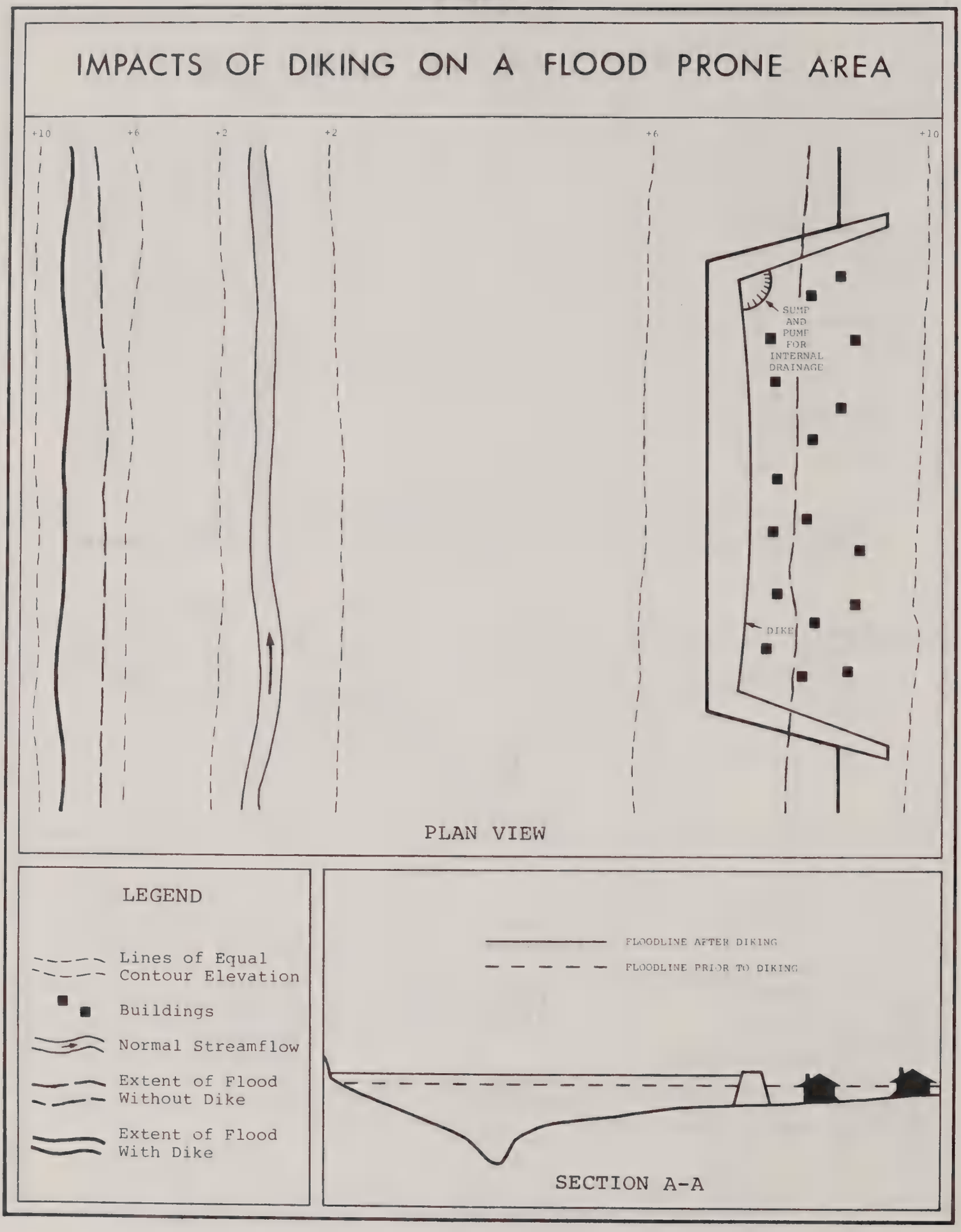
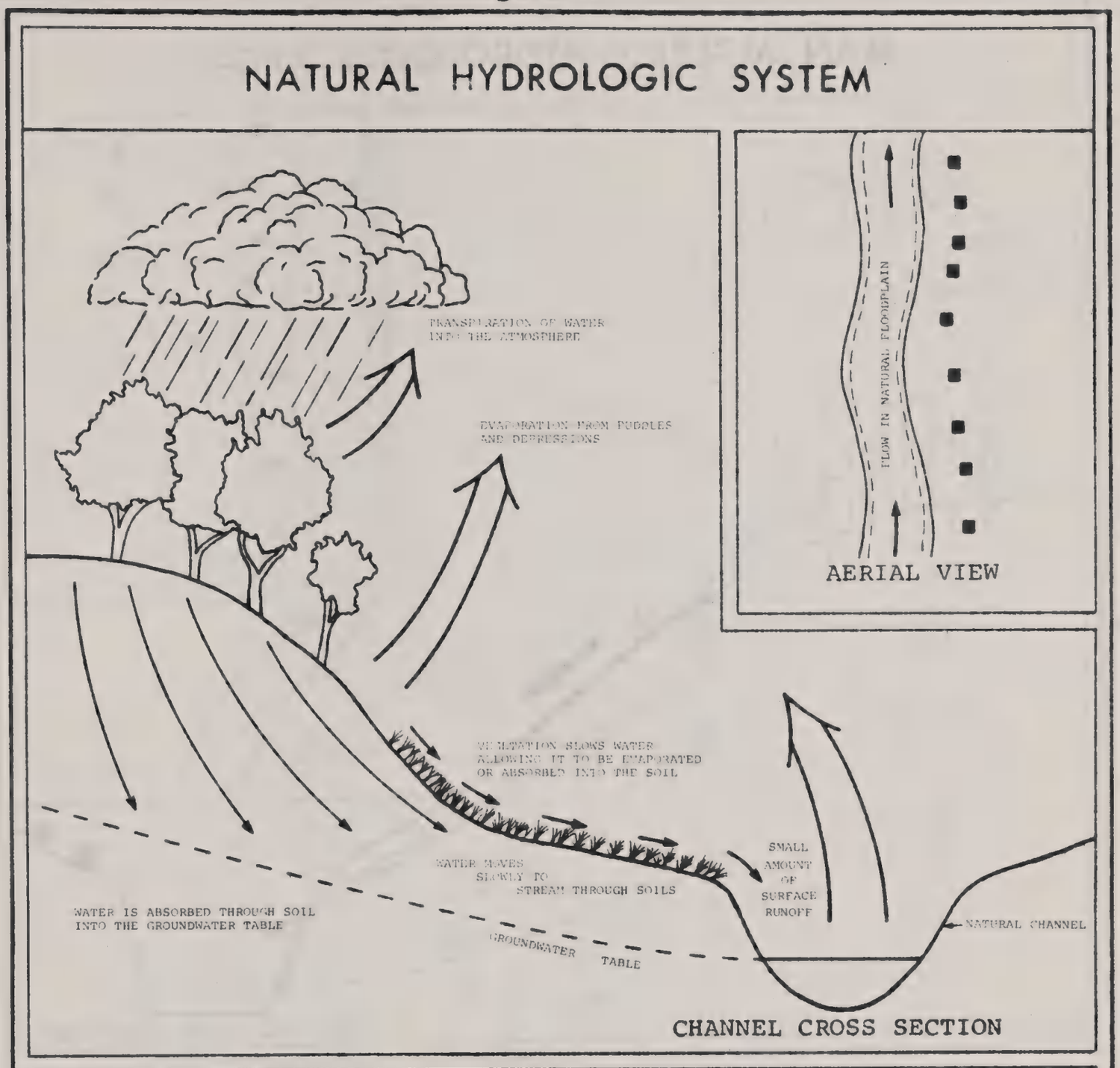

IMPACTS OF DIKING ON A FLOOD PRONE AREA
+10
+6
+2
+2
+6
+10
SUMP AND PUMP FOR INTERNAL DRAINAGE
DIKE
PLAN VIEW
LEGEND
Lines of Equal Contour Elevation
Buildings
Normal Streamflow
Extent of Flood Without Dike
Extent of Flood With Dike
FLOODLINE AFTER DIKING
FLOODLINE PRIOR TO DIKING
SECTION A-A

Figure 4



RAINFALL OCCURS IN A NATURAL SYSTEM

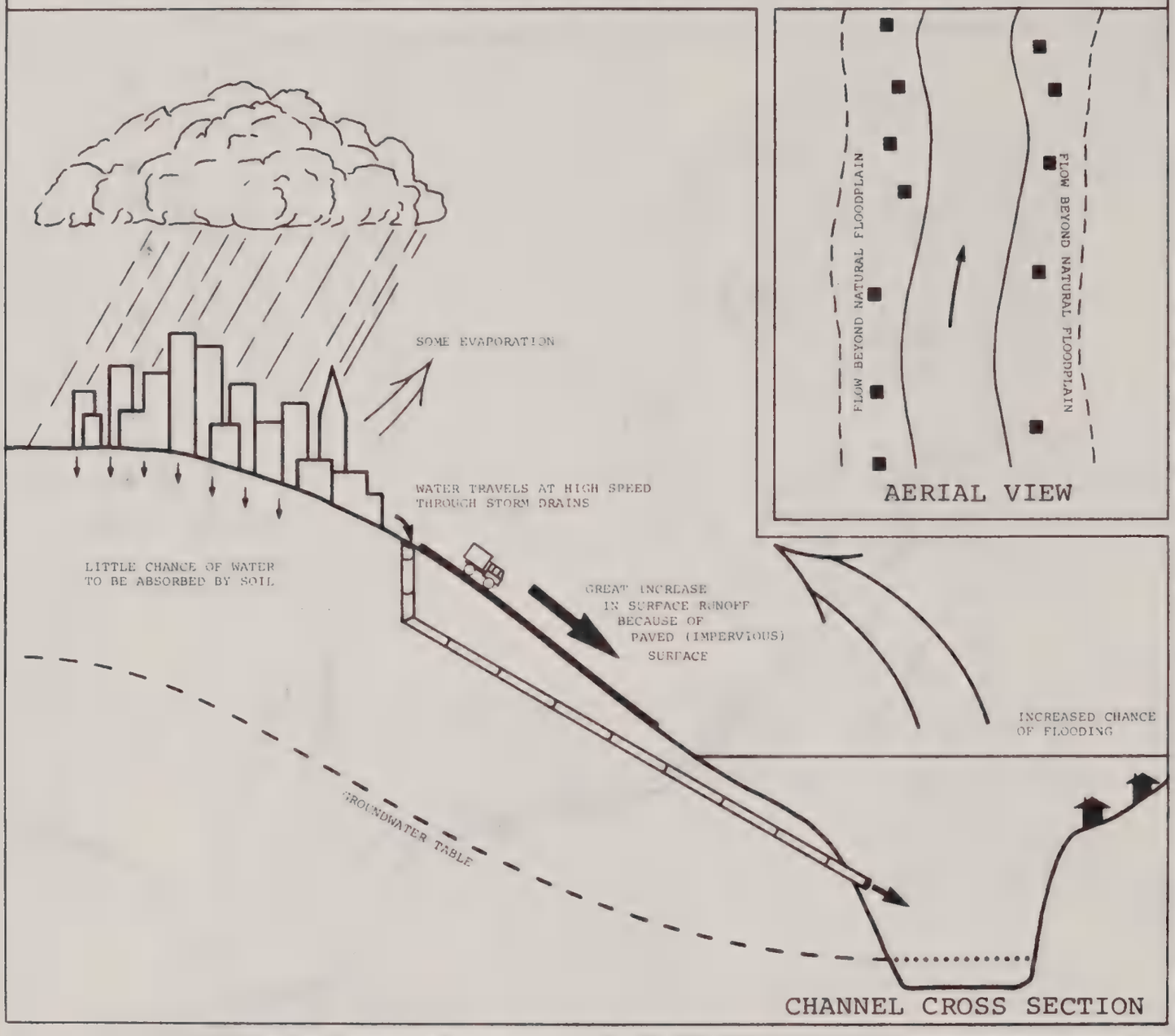
- Water is absorbed by trees and used in biological processes
- Water collects in natural depressions and is absorbed by soil or it evaporates
- Water flows slowly overland or through ground to stream
- Some water goes through soil to groundwater table

RESULT

- Water reaches stream slowly, reducing chances that the stream can not carry it
- Water moves slowly, allowing soil particles carried along to drop out (slower moving water is also less likely to erode the soil)
- Pollutants carried by the water are naturally filtered out by the soil

Figure 5

MAN ALTERED HYDROLOGIC AREA



RAINFALL OCCURS ON MAN-ALTERED SYSTEM

- Water runs rapidly over land on impervious surfaces
- Water collects in storm drains and is fed directly to stream or river
- Because of high velocities little evaporation or soil absorption has a chance to occur
- Because of lack of vegetation, transpiration will not occur

RESULT

- Greatly increased volumes of water reaching stream
- High water velocities, great erosive force; danger to human life
- Pollution and litter washed off streets directly into streams
- Erosion of earthen material, leading to sediment in streams and harbors

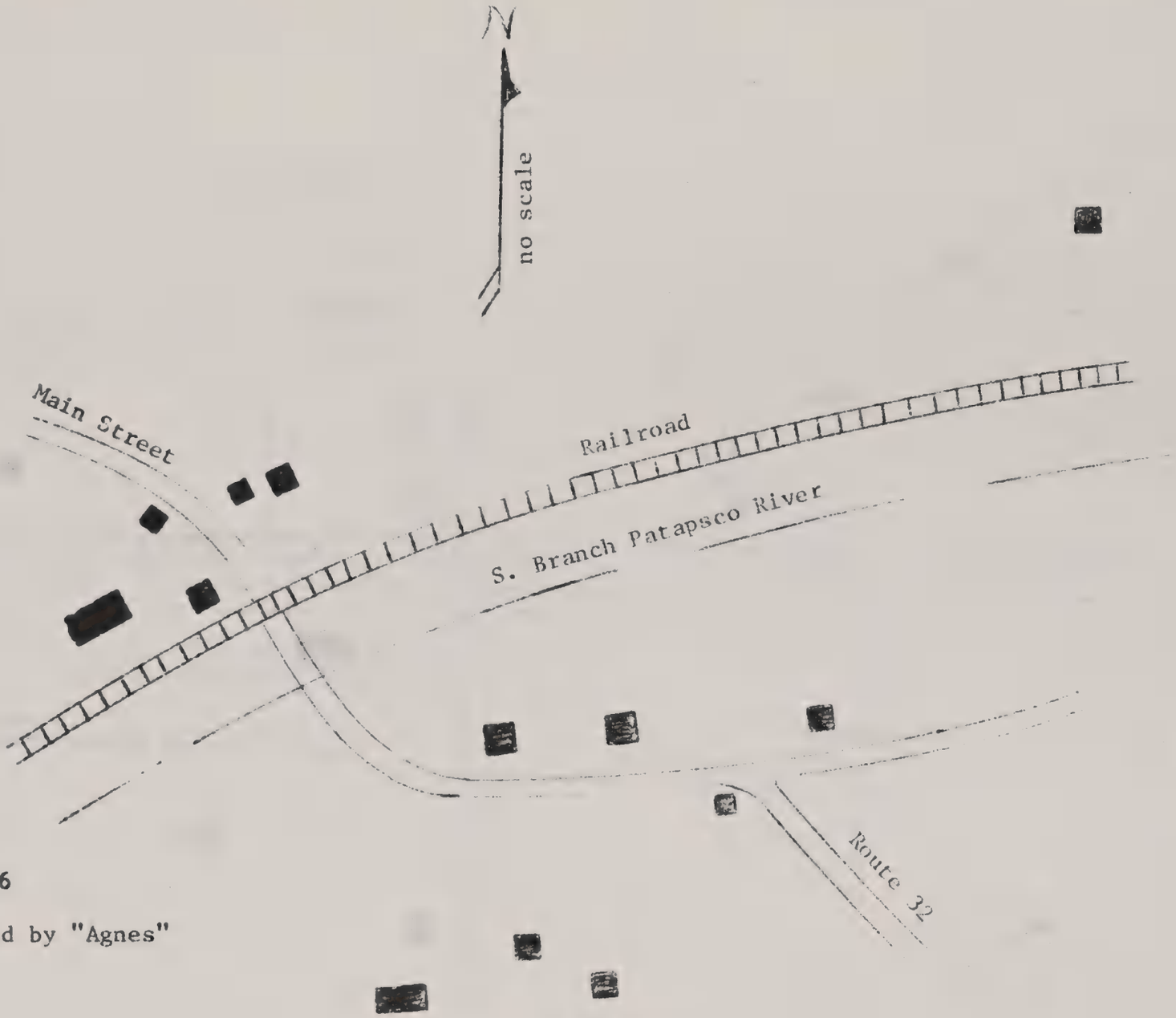


FIGURE 6

Structures Flooded by "Agnes"

Patapsco River

PR-22 Sykesville

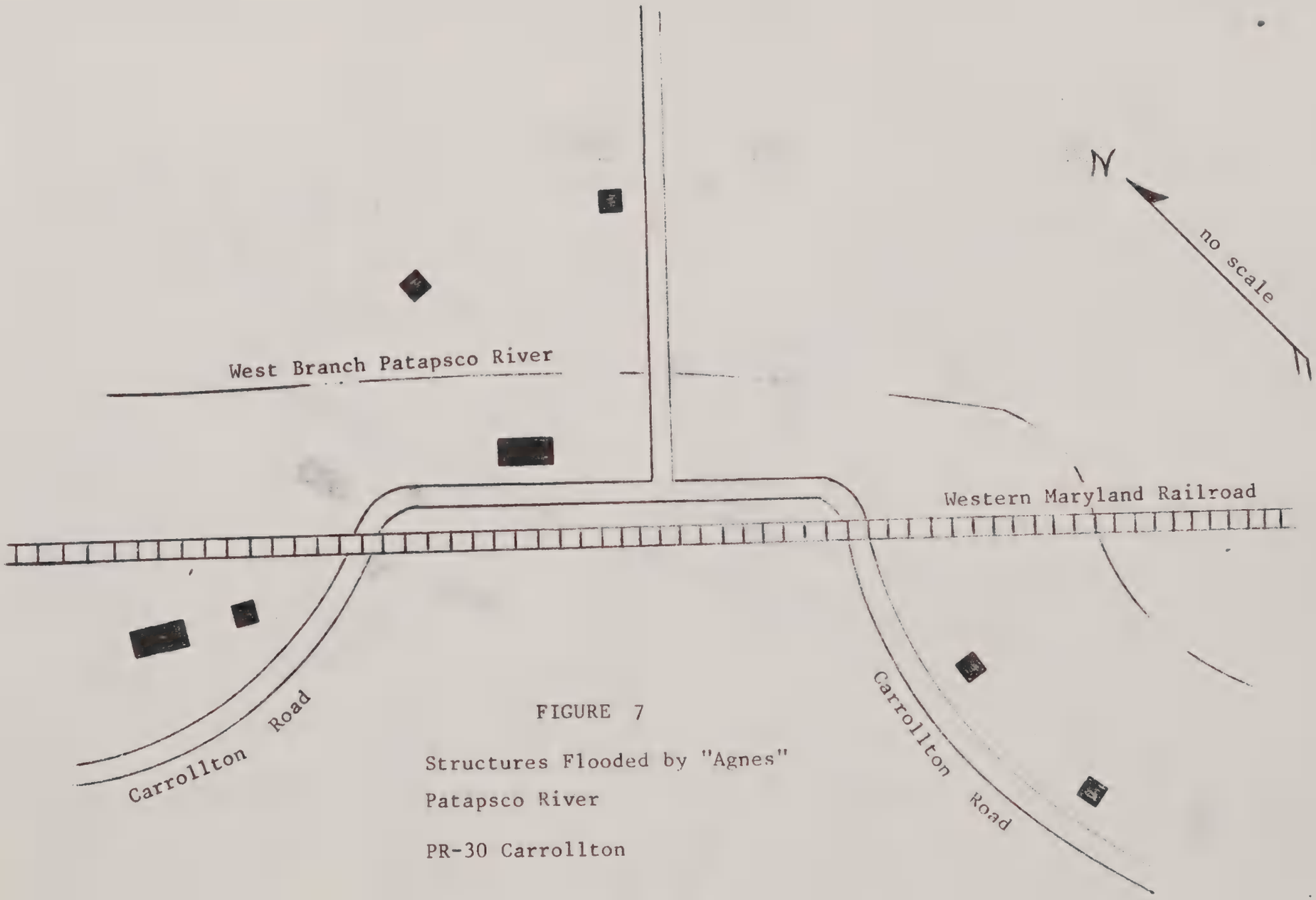


FIGURE 7

Structures Flooded by "Agnes"

Patapsco River

PR-30 Carrollton

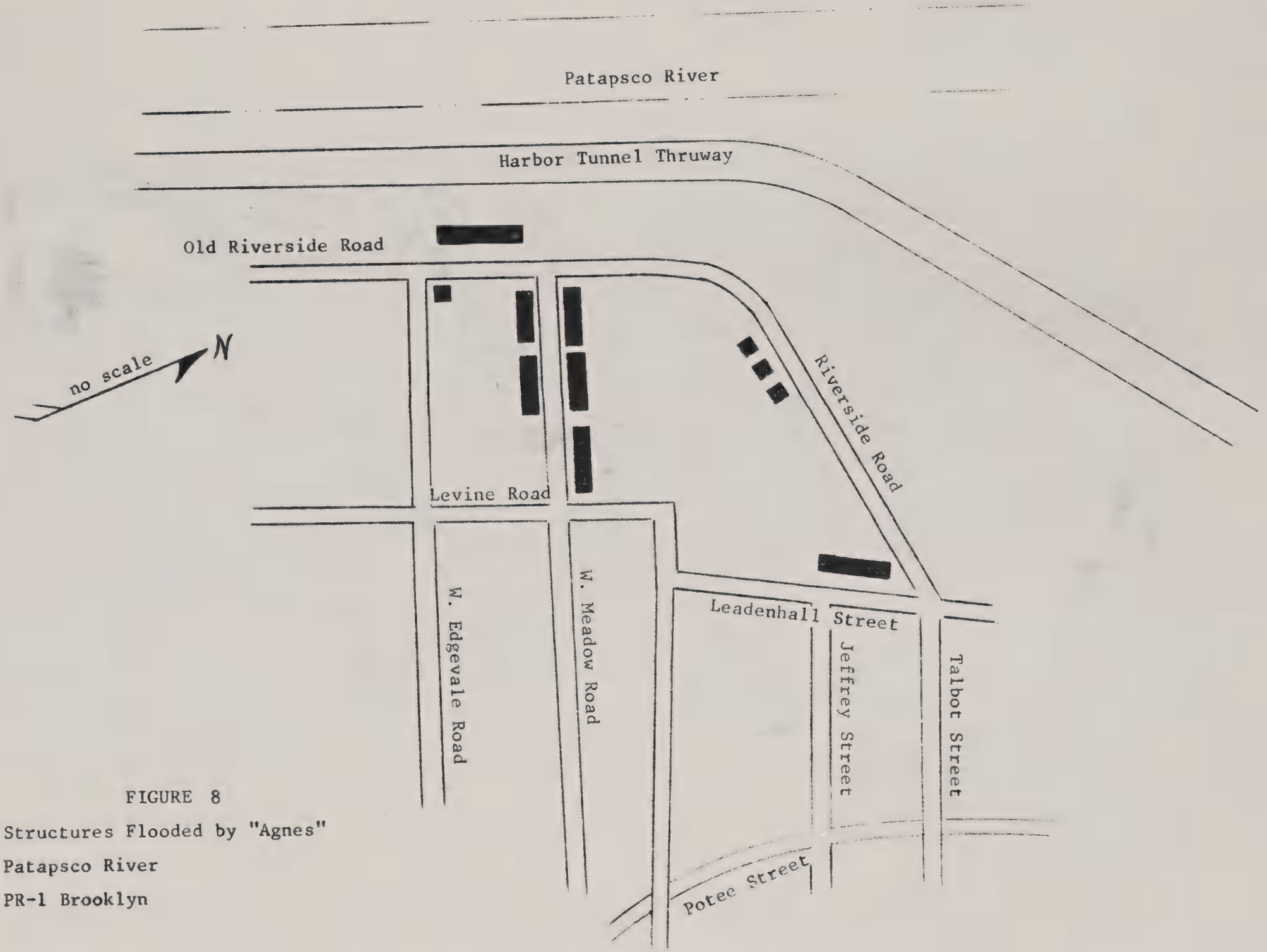


FIGURE 8

Structures Flooded by "Agnes"

Patapsco River

PR-1 Brooklyn

FIGURE 9
Structures Flooded by "Agnes"
Patapsco River
PR-14 Elkridge

Note: Shaded structures are to be acquired as part of Baltimore County's acquistion program

FIGURE 10

Structures Flooded by "Agnes"

Gwynns Falls

GF-10 Gwynn Oak

Note: Shaded structures are to be acquired as part of Baltimore County's acquisition program

FIGURE 11

Structures Flooded by "Agnes"

Gwynns Falls

GF-11 Villa Nova

Note: Shaded structures are to be acquired as part of Baltimore County's acquisition program

FIGURE 12

Structures Flooded by "Agnes"

Gwynns Falls

GF-12 Silver creek Park

SOLUTIONS TO WATER AND RELATED LAND RESOURCE PROBLEMS

I. FLOODING

There are many methods available for reducing flooding and flood damages. A partial list would include such measures as flood insurance regulations, flood warning, impoundments, channel improvement, dikes, floodwalls, property acquisition, stormwater management, conservation land treatment, removal of constrictions, and land use controls. All of the above measures were considered when looking at possible solutions for the flooding problems in the Patapsco River and Gwynn's Falls. In the Status Report for the Patapsco River Basin Study, November, 1978, the alternative solutions and their applicability to the problem areas were discussed. This initial screening of alternatives discarded many of the alternatives with little applicability for different areas of the stream systems.

Some of the measures, such as land treatment and flood insurance regulations, have beneficial effects which are difficult to measure. Others, such as stormwater management, do more to prevent future increases in flood damages rather than reducing present flood damages.

Some of the measures are unpopular because they may give a false sense of security. For example, dikes and flood proofing are installed to protect against a certain flood. If a larger flood occurs, the measures will be overtopped and damages would again occur.

The alternatives which were further considered are discussed in this section. First, there will be a discussion of the types of solutions considered and then their applicability to different areas along the river. An evaluation of the environmental effects of the measures is shown in Table 24.

Flood Plain Delineation

The initial step in formulating solutions to flooding problems is to delineate the floodplain.

This involves determining the extent of flooding on a stream for a flood of a particular recurrence interval. This is usually done for the 100-year flood under present development conditions, but may also be done using anticipated future conditions. This information is then displayed on maps to determine what areas are flooded. For the purposes of this study, floodplains were delineated at major damage areas along the Patapsco River and Gwynn's Falls. Using this information, alternatives were formulated using one or a combination of the measures discussed below.

Using the information developed during this study, floodplain maps could be produced. These maps could then be used to enforce floodplain regulations, which would prevent future damages caused by new development in the floodplains.

A. Types of Solutions Considered

Flood Insurance

Flood insurance obviously does not protect against physical flood damage or risk of loss of life. It does provide a peace of mind benefit with regard to the danger of direct economic loss. Flood Insurance Administration regulations require that the jurisdictions that wish to participate in the flood insurance program must enact ordinances limiting development in the floodplain. These regulations help control the growth of future flood damages.

The National Flood Insurance Program (NFIP) was established by Congress in 1968 to reduce flood damages and to relieve the drain on federal tax dollars for disaster relief. When communities elect to adopt appropriate floodplain management, residents become eligible to purchase flood insurance.

There are two phases in the NFIP. In most cases, communities first join the Emergency Program in which a preliminary Flood Hazard Boundary Map is issued by the Federal Emergency Management Agency (FEMA). The community agrees to enforce general floodplain management measures. In the Emergency Program limited amounts of flood insurance (coverages up to $35,000) are available at subsidized rates for all structures regardless of their risk. After a detailed floodplain study (Flood Insurance Rate Study) has been provided by FEMA the community is eligible to join the Regular Program. More comprehensive floodplain management measures are required at this stage and the limits of flood insurance coverage are increased from $35,000 to $185,000 for residential structures. Rates also are computed based on the amount of flooding which can be expected.

Of the jurisdictions affected by the Patapsco River Basin Study, those in the Regular Program are Baltimore City, Carroll County, Howard County and the incorporated areas of Sykesville, Westminster, and Hampstead. Baltimore and Anne Arundel counties are in the Emergency Program, but Flood Insurance Rate Studies are underway and are due for completion in the near future.

Communities may receive assistance on the NFIP through either the regional office of FEMA, or the State Coordinating Office, Maryland Water Resources Administration.

Flood Warning

For communities along the lower Patapsco from Ellicott City down to Baltimore Harbor, the full application of a flood warning system is probably the best, near-term, method of flood protection.

Flood warning involves devising a system whereby conditions monitored at an upstream area can be used to determine when flooding is imminent in downstream areas. Once this is determined, floodplain residents are notified. Depending on the size of the watershed above the damage area and the rate and timing of runoff, it may be possible to devise a system triggered by rainfall and upstream flow conditions. While such a system gives a few hours warning of an impending flood, it does not prevent a

flood. It allows downstream areas susceptible to flooding to prepare. This requires development of individual schemes for the removal of damageable material to higher elevations. Such a system can help reduce the risk of loss of life and reduce economic damages.

In most cases, property owners could protect a large percentage of their perishable household or commercial goods if they were given a 4-6 hour warning of imminent flooding. Some businesses indicated that they could have eliminated 50-70% of the flood damage sustained in Tropical Storm Agnes if they had been warned 6 hours in advance.

A flood warning system is already in operation in Howard County. It is coordinated by the Howard County Office of Civil Defense, and involves the cooperation of many branches of the county government. Howard County is already disseminating some information to the Civil Defense Directors in Anne Arundel and Baltimore County. However, a more systematic approach is warranted for the delivery of flood threat information to property owners. There is also a need to prevent the dissemination of misinformation which can cause needless evacuation.

Flood Proofing

In the majority of flooding occurrances, there is no major threat to human life. Homes or businesses located on the flood fringe experience rare instances of floodwater entering and causing property damage either to structures or contents. The water is usually slow moving or still, and is at depths under three feet.

In these cases, flood proofing is often appropriate. Flood proofing can either mean modifying a structure to physically prevent water from entering at or below a certain predetermined elevation; or it can mean modifying the structure to withstand the rigors of flooding with minimal structural damage. Flood proofing can be as simple and inexpensive as raising a sill around a basement door with a few bricks or concrete blocks to techniques as complex as raising an entire structure 8-10 feet vertically. The former extreme can usually be implemented by a private homeowner for $50-$100 with minimal technical advice while the latter extreme can cost $20,000-$30,000 for a single house and usually involves a great deal of technical expertise from engineers.

In the Patapsco, flood proofing is only suggested for those residences and businesses which sustain flooding of two feet deep or less during the 100-year storm. For such structures, flood proofing can usually be accomplished for a small fraction of the value of the property, and can be installed by the individual whose property is being affected with limited technical supervision. See Table 19 for a listing of areas where flood proofing was evaluated.

County governments could sponsor flood proofing seminars in communities where minor flood proofing would eliminate a large percentage of the flooding problem. Citizens have expressed interest in such seminars if they were held at a convenient time and place. Communities where such meetings might be considered include Elkridge, Ellicott City, Arbutus, Linthicum, Raynor Heights, Pumphrey and Carrollton.

The U. S. Army Corps of Engineers has excellent data on flood proofing techniques, and experience in costs of flood proofing implementation, maintenance, and operation. In their recently completed Baltimore Metropolitan Streams, Maryland Study, several areas were identified for possible technical assistance through their Floodplain Management Services Program. That assistance remains open upon request.

Acquisition

Fee simple acquisition of floodplain properties is perhaps the most direct means of eliminating flood problems. Relocation or removal of structures susceptible to damages completely eliminates the possibility of financial loss. Acquisition is often expensive when compared to other solutions. It is generally employed when the flood problem is frequent and severe.

Acquisition is one of the most environmentally sound methods of controlling flood damage. However, relocation of people can have great social costs. It may involve disruption of an old, established neighborhood. It may involve low or middle class housing stock whose availability may be limited elsewhere in the community. Criteria for relocation of persons displaced by Federal projects is established in the Uniform Relocation and Assistance and Real Property Acquisition Policies Act of 1971. This federal legislation guarantees equivalent, safe and sanitary replacement housing for displaced families or small businesses. In areas of Baltimore County, particularly along Gwynn's Falls, the county government has already begun an acquisition program. So far, many homes have been acquired and the families relocated. More homes are slated for acquisition over the next few years. In Howard County, several homes near the confluence of Deep Run and the Patapsco River have been acquired and demolished. The families have been relocated. In Anne Arundel County, several homes in the Brooklyn Park area have been acquired and demolished. Also, twenty-one homes in the Ridgeway Manor subdivision in North Linthicum are slated for acquisition over the next five years.

There is some popular opposition to relocation. Often, long time residents prefer the risk of periodic flooding to disruption of their household or community. Also, many people perceive the acquisition program as arbitrary. They observe floodplain acquisition on one hand and what they perceive as increases in flooding due to uncontrolled development upstream.

For the most part, however, the acquisition program serves a worthwhile purpose. While it may not be economically justifiable using federal criteria, it is, in some instances, the most cost effective, environmentally sound method of protecting people whose homes are susceptible to major, life threatening flooding. See Tables 19 and 20 for an analysis of the acquistion benefits and costs.

Impoundments

Earth impoundments or dams can be used as a flood control measure to retard large amounts of floodwater, thus reducing depths of flooding in

downstream areas. The dams impound floodwater, usually that occurring from a 100-year flood, and release it slowly.

The typical dam considered in this report is constructed of zoned earth fill with a concrete pipe-riser release structure. An earthen emergency spillway constructed around one end of the dam is used to carry flows in excess of the 100-year flood.

Depending on the needs and desires of the surrounding community, dams and their attendant reservoirs may be designed to provide multiple uses such as recreation, water supply, and fish and wildlife management.

Because dams do not protect the communities in the areas adjacent to or upstream of their location, they may be looked upon with disfavor by the portion of the public adjacent to them. People further downstream who either receive flood control benefits or, at least, do not have to surrender any land, are generally more tolerant of the idea of a dam.

The streams on which impoundments were considered to reduce flooding are shown in Table 21. They are located on the map on Figure 13. Several alternative combinations of these structures were compiled from this list of possible sites for analysis.

Alternative #1 consisted of all ten of the dams. (The dams were designed as single purpose structures providing only floodwater storage.) This alternative reduces the average annual damages on the South Branch from $66,600 down to $1,500 and on the Main Stem from $52,700 down to $6,800. Of the impoundments on the North Branch, only East Branch and Deep Run would significantly provide localized benefits. The benefit would accrue to the Congoleum Plant at Finksburg. The total cost of this alternative is $26,400,000.

Alternative #2 consisted of only the four largest dams. They included Gillis Falls, Morgan Run, East Branch and Beaver Run. Gillis Falls reduces average annual damages on the South Branch from $66,600 to $6,100. The four dams reduce damages on the Main Stem from $52,700 to $23,100. The total cost of this alternative is $13,000,000.

Alternative 3 consisted of only the Gillis Falls dam. This alternative was evaluated because of the great degree of control it provides. Also, Carroll County is investigating the possibility of constructing a water supply impoundment at that location. The dam reduces average annual damages on the South Branch from $66,600 to $6,100 and from $52,700 to $31,300 on the Main Stem. The total cost of this alternative is $3,600,000.

Tables 22 and 23 show a breakdown of the effect of the impoundment alternatives by economic reach.

Dikes and Floodwalls

To prevent flooding, earthen dikes can be placed in a floodplain between the stream and the area being flooded. Dikes generally encroach on the natural floodplain and thus may cause higher flood elevations than would otherwise occur. This must be taken into consideration in their design. Dikes must be coupled with a sump and pumping system to account for internal drainage, that is, for the area that would naturally drain through the protected area into the stream but will be prevented from doing so by the dike.

Floodwalls are similar in concept to dikes and usually replace them in urban areas or where space is at a premium. Floodwalls are generally vertical walls constructed of reinforced concrete or block.

Both dikes and floodwalls are very effective in preventing flood damages. Their use depends on topography and locations of houses and roads. Depending on their location and the materials used in construction, they may be unsightly. Some homeowners may prefer the risk of periodic flooding to the placement of a dike or floodwall near their properties. Questionnaire results have indicated marginal interest in diking, with interest depending on height of dike and frequency of flooding. Diking may also provide a false sense of security when people assume that the dike will not overtop during a flood larger than the design flood.

Diking is one structural alternative that has engineering feasibility and is applicable in situations where loss of life is a possibility. In some areas along the lower Patapsco, it would be physically possible to build earthen or concrete dikes to prevent floodwaters from encroaching on homes or businesses.

In certain areas, the use of dikes or floodwalls to protect flood-prone property is unfeasible. Gaither is an example. A dike or floodwall protecting homes would essentially isolate the homes from the rest of the community and from proper ingress and egress. See Tables 19 and 20 for an analysis of dikes and floodwalls where applicable.

Channel Improvement

Channel improvement involves altering a natural stream channel to allow it to more efficiently carry large quantities of water, thus lowering the depth of flooding. It changes the shape, capacity, alignment, or lining material of a stream. Channel improvement generally benefits the area immediately adjacent to it, while effects of higher than normal flows may be transferred downstream.

Channels do not involve a great deal of land. Depending on the nature and extent of the channel work, channels may have adverse environmental consequences for the fishery habitat, but such effects can often be mitigated. However, major changes in channel geometry or use of a concrete lining may have irreversible impacts on aquatic species.

Channel improvement could reduce or prevent flood damages along some areas of the river, particularly at Ellicott City. However, the costs would be so high, and environmental consequences so severe, that it was felt that it should not be given further consideration.

Modification of Liberty Reservoir

There have been several suggestions concerning the modification of Liberty Reservoir to afford flood control to the Main Stem of the Patapsco. Due to its location and area controlled, Liberty has much potential for flood control. It already provides significant flood control in conjunction with its operation as a water supply reservoir.

However, it is not reasonable to suggest that the construction or management of Liberty Reservoir be altered to reduce flood damage downstream. The detail necessary to make such decisions is beyond the scope of this study. Also, the legal agreements which would be necessary are very complicated. It would not be advisable to begin long, detailed studies until the parties concerned had established an agreement to consider, in principle, the recommendations of such a study.

Over the years, people have suggested: 1) introducing some flood storage into Liberty Reservoir by allowing water to run out prior to a storm; 2) building some additional storage above the existing reservoir; 3) ringing Liberty with some small floodwater impoundments; and 4) managing water supply withdrawals in order to increase the available flood storage when needed.

Suggestion #1 is extremely risky from a water supply standpoint. Also, it would require major structural modifications to allow timely withdrawal.

Suggestion #2 would require a major engineering evaluation of the existing dam structure to see it if could withstand the surcharges that would be introduced. Also, more land would be temporarily flooded by the lake.

Suggestion #3 is not cost effective. Imposing several impoundments on the hydrologic model does not prevent all damages below Liberty Reservoir. (See Table 20.)

Suggestion #4 would introduce an economic risk to Baltimore City water supply system rate payers, because it would increase the likelihood of having to use water from a more costly source namely the Susquehanna River.

Given the existing constraints, such modifications should be dropped from consideration.

Studies have shown that Liberty Reservoir already has a significant impact on reducing not only the number of flood events downstream, but also the severity. Throughout most of its life, Liberty has been drawn down below its crest. Thus, floodwaters coming in are trapped

behind the dam to a large extent. In fact, several "non events" have been documented as a direct result of Liberty storage, the most recent having occurred in early 1979.

Also, even when the reservoir is filled to capacity, the temporary storage that occurs on the top of the lake causes a large reduction in peak discharge. This does not prevent catastrophes such as Agnes, but it does reduce their severity considerably. (See Figure 14.)

Stormwater Management

Urbanization causes many interrelated land and water resource problems which are being studied by experts in many technical disciplines. It is beyond the scope of this study to analyze all of the problems other than to recognize that they are interrelated and to caution land use planners to analyze the interrelationships carefully before making land use decisions.

This report is concerned mainly with flooding and its causes. It will address one simple cause-effect relationship: increased impervious areas associated with urban development cause an increase in surface runoff volume. In recognition of this phenomenon, local jurisdictions, in compliance with the Maryland Sediment Control Law, have adopted local stormwater management policies. Policies differ from jurisdiction to jurisdiction, but essentially they mandate that a developer is responsible for the increase in runoff that his development creates. It is his responsibility, therefore, to store or otherwise dispose of any increase in volume and to reduce peak flows down to pre-development levels. The primary purpose within the jurisdictions is to prevent increased erosion of streambanks due to fairly frequent storm events.

Conservation Land Treatment

Land treatment has many forms and purposes. For example, contour plowing, strip cropping, and properly maintained logging roads reduce runoff and erosion; stream valley buffers and sediment basins reduce downstream sedimentation; and drainage systems remove excess ground water.

Application of conservation practices would have little effect on the discharge from a watershed area during large infrequent storms. They would have the effect of reducing amounts of runoff from small frequent storms. Properly applied practices would reduce non-point pollution and increase groundwater infiltration, thus offering benefits other than flood control.

Removal of Constrictions

Several landfills are located at the mouth of the Patapsco on either side of the river. The land which they occupy used to be part of the floodplain. Through the years, these areas have been used to dispose of solid waste material. These landfills along with other man-made features constrict the Patapsco floodplain at the mouth of the river.

Hydraulic studies have demonstrated that if the landfills were present in 1972, upstream flood stages during Tropical Storm Agnes would have been somewhat higher than they were. Thus, more areas in Baltimore County and Anne Arundel County would have been flooded.

It is unrealistic to suggest removal of the entire landfill, especially portions which are used as utility rights-of-way. However, it is possible that by cutting back portions of the landfills, flooding conditions can be improved somewhat.

The remnants of an old B & O Railroad Crossing in the residential portion of Elkridge has also been demonstrated to have an impact on flooding in that community. Removal and stabilization of the road bed would cost about $275,000 and reduce the 100-year flood stage immediately upstream by four feet.

In Carrollton, the roadbed which was a spur of the Western Maryland Railroad, cuts across the floodplain at the North Branch of the Patapsco. Relocation or removal of a short portion of this roadbed would reduce flood stages in Carrollton.

B. Solutions For Specific Areas

Using the above list of measures, alternatives were formulated for different reaches. The effects of these alternatives are outlined below. For an economic analysis of the alternatives, see Table 22.

South Branch Flooding

The flooding on the South Branch can be reduced or prevented in one of or a combination of methods. Impoundments on Gillis Falls, Hay Meadow Branch, and Piney Branch would reduce flooding in Woodbine, Morgan Station, Gaither, and Sykesville. They would reduce flooding by as much as 6 feet during the 100-year flood in Henryton and Marriottsville. An impoundment on Gillis Falls alone would have nearly the same effect.

Acquisition and flood proofing can serve to reduce flood damages. Diking and channel work could prevent damages at Woodbine and Marriottsville.

In Woodbine (PR-26), channel improvement, flood proofing, diking, impoundments, and acquisition were considered as methods of flood protection. Channel improvement would require the use of a concrete channel and the costs would be high. Diking is impractical due to the location of roads and the layout of the buildings. Since the buildings damaged are commercial enterprises, acquisition was not considered due to the high cost. Impoundments would reduce flooding considerably. Flood proofing of individual buildings could be a partial solution to flooding problems.

At Morgan Station (PR-25) and Gaither (PR-23), acquisition and impoundments were the only available solutions to the problem due to location and type of homes.

The flooding in Sykesville (PR-22) is mostly to commercial enterprises, therefore acquisition was not considered. Channel improvement was considered, but costs were prohibitively high. Diking was not feasible due to location of the buildings. Flood proofing and impoundments were the only measures considered further.

There was nothing that could be done at Henryton (PR-21) due to very small damages.

At Marriottsville (PR-20), measures considered were channel improvement, acquisition, and impoundments. Due to location and depth of flooding, dikes and flood proofing were not considered. Channel improvement costs would be high. Acquisition would require removal of approximately one-third of the homes in the community. Although this would cause a major social impact, the alternative was considered further. Impoundments cannot prevent damages, but they reduce the 100-year flood level by more than five feet, thus reducing damages considerably.

North Branch Flooding

The solutions to the problems on the North Branch are similar in several ways. Diking and channel work are not practical due to the scattering of the buildings and their proximity to the river. Flood proofing would prevent the low levels of flooding that occurs to most of the residences. Impoundments would serve to reduce flooding in Patapsco and at Finksburg, but would not prevent it. Acquisition would be practical everywhere but at the Congoleum Plant at Finksburg.

Lower Patapsco Flooding

Flooding on the lower Patapsco varies from not serious to very serious. The solutions are also varied. In some areas, the structures are scattered, making their protection difficult, while others are concentrated, making their protection easier. Impoundments constructed in Carroll County would reduce the flooding potential downstream considerably.

In Brooklyn (PR-1), most of the damage was limited to basement flooding in row houses. Agnes and tidal flooding in 1933 were the only flooding any of the residents could recall. Since basement flooding creates only minor damage, no extensive structural measures were considered. Minor flood proofing would prevent the damages. Impoundments would prevent it.

In Pumphrey, North Linthicum and Baltimore Highlands (PR-2), the damaged structures were scattered except for concentrations in Pumphrey and at a trailer court on Belle Grove Road. For scattered damages, the only practical solution is impoundments, acquisition, or flood proofing, if depths of flooding are low. For the area at Pumphrey, diking was considered. The trailer court is located in such a way to preclude diking, so acquisition was the only considered measure.

In Oak Park (PR-3), the damage to commercial structures was scattered. This precludes measures such as diking or channel improvement. Due to depth of flooding, flood proofing would not be feasible. Impoundments would reduce the flooding in this area. Acquisition would be too costly since the structures are businesses, including the Carling Brewing Company.

The flooding on Herbert Run (PR-4, 5, 6, 7 and 8) is confined mostly to basements. Minor flood proofing could prevent this type of damage. Diking, acquisition and channel work would be too costly because of the small amount of damage prevented. A present impoundment on the campus of UMBC and others proposed by Baltimore County may prevent or reduce the flood damages.

The residential damage in Elkridge (PR-14) was scattered while the commercial damage was mostly concentrated along Main Street. Diking would not be feasible because of scattered damages and location of the businesses on both sides of Main Street. Acquisition of the businesses would destroy most of the town center. Acquisition of the houses is a practical solution. Flood proofing of some of the structures where flooding depths are low is a viable alternative. Impoundments would also reduce flood damages in this area.

The industrial flooding in Ilchester (PR-15) is a major problem due to their proximity to the river. Diking and channel work are impossible due to space limitations. Acquisition of the industry would be prohibitively high. A concrete floodwall would prevent the damages, but would be costly and inconvenient due to the road closure which would be necessary. Impoundments would reduce the flooding here.

The flooding problem in Ellicott City (PR-16) is a unique situation. Ellicott City is an historic district, therefore, the solutions would have to be ones which would not interfere with the area's historic nature. The area can be divided into 2 sections for analysis; the businesses along Main Street on the west side of the B & O railroad tracks; and the Wilkins-Rogers Plant plus the scattered businesses and redidences on the east side of the tracks.

The flooding on Main Street, is for all intents and purposes, impossible to prevent. Due to its historic nature, acquisition and major flood proofing are not desirable. Minor flood proofing for shallow depths of flooding would be possible. Diking is impractical because the major inflow of the Tiber River would have to be pumped over a dike. Channel improvement would require the use of a concete lined channel which would not only be costly, but would be environmentally undesirable due to both the historic nature of the area and the natural river system.

The flooding at Wilkins-Rogers and other places on the east side of the Patapsco has different solutions. The Wilkins-Rogers plant is located next to the river, not much higher than the river bank. Flooding is almost impossible to prevent. Flood proofing could be used to prevent minor flooding, but major floods would still cause damage. Acquisition is also out of the question. Diking would

require a major reduction in floodplain width which would increase flooding upstream on Main Street. Impoundments in Carroll County would only reduce the flood damages, not prevent them. The same types of problems indicated above prevent protection of the remaining homes and businesses on the east side of the river. Acquisition, however, would be a solution to some of the problems.

At Hollofield (PR-17) and Woodstock (PR-19), the damages are to scattered homes and the damages are relatively minor. Minor flood proofing, acquisition and impoundments would be the only viable solutions to the problems.

Gwynn's Falls

The damages in Gwynn's Falls are scattered all along the stream. Structural protection measures are therefore unfeasible in most cases. Another problem arises from urbanization in the watershed. As upstream areas urbanize, the flows in the stream will increase. It has been estimated that future 100-year discharges will be greater than the Agnes discharge.

In Westport (GF-1), there were major damages during Agnes. The structures are scattered throughout the reach, making them difficult to protect. The one area which could be protected is downstream of Route 1. In the Baltimore Metropolitan Region Streams Study, the Corps of Engineer's evaluated a dike around commercial and industrial property and eighty-seven residential structures in this area. Flood proofing against low depths of flooding would be feasible. Acquisition of the residential structures would reduce the flood damages.

Along Maiden's Choice Run (GF-2, 3, 4 and 5), the major problem is an undersized culvert under Frederick Road. The Corps of Engineers evaluated an additional culvert to protect the area. The costs of the culvert were high. Due to the small depths of flooding (less than three feet), flood proofing could be used to protect many of the structures. Acquisition should be considered for the more heavily damaged structures. Dikes and channel work are impractical due to the dense development in the area.

The flooding damages along Dead Run (GF-7 and 8), have been greatly reduced by Baltimore County's acquisition program. The remaining houses are widely scattered along the stream. The only viable solutions in this case would be acquisition or flood proofing if depths of flooding were low.

In Woodlawn (GF-10), and Villa Nova (GF-11), most of the highly damaged residences are being purchased by Baltimore County. The County is not purchasing businesses however. Due to the scattering of the remaining damages, flood proofing and acquisition of the remaining structures is the only viable solution.

Another heavily damaged area is at the Brittany Apartment complex downstream of the Beltway. Due to their proximity to the stream, the depths of flooding incurred and the type of structure (apartments),

diking, flood proofing, and acquisition were not considered viable solutions. The only solutions were a floodwall or abandonment of the first floor apartments which were the only ones flooded. The Corps of Engineers analyzed a floodwall to protect the buildings. The costs and benefits of the floodwall are shown in Table 20.

The remaining heavily damaged area is at Owings Mills (GF-14). Most of the damages are to industrial buildings such as those in Owings Mill Industrial Park. The Corps of Engineers analyzed a floodwall in this area to protect the Industrial Park. The costs and benefits are shown in Table 20. Acquisition was ruled out due to the expense of purchasing industrial enterprises. Diking was not practical due to the buildings' proximity to the stream. Channel improvement would be too costly because it would require concrete lining.

II. EROSION AND SEDIMENTATION

Erosion and the resulting sedimentation can best be addressed at the source: erosion of soil particles. Many of the solutions available for controlling erosion and sedimentation also contribute to improvement in water quality problems from non-point sources of pollution.

Landowners can reduce erosion on agricultural land by pursuing an effective land treatment program. This involves efficient use of conservation practices such as minimum tillage, diversions, grass waterways, contour plowing, ponds, and strip cropping. Some of the practices not only reduce erosion but also affect other water quality parameters such as nutrients and fecal coliform.

Some of this land treatment is being provided through on going programs in which the landowner voluntarily installs practices, mostly at his own cost. Some cost sharing is provided through the Agricultural Stabilization and Conservation Service (ASCS) for agricultural practices.

However, this voluntary program is not meeting the total needs of the watershed. An accelerated program is required to meet the needs. This program could provide more technical and financial assistance in applying the practices. For a listing of the land treatment needs see Table 13.

Erosion on urbanizing land can be reduced by continued improvement of the existing Sediment Control Programs of the jurisdictions. Many of the practices used on agricultural land are suitable for erosion control on land being developed.

III. WATER SUPPLY

Carroll County is investigating a water supply site on Gillis Falls to supply its future needs. This site could be utilized as a multiple purpose, water supply-flood control site. This reservoir would reduce flood damages all along the river while supplying adequate water for Carroll County's needs along the South Branch.

IV. RECREATION

The existing stream valley acquisition programs could be utilized to supply much needed water based recreation. The acquired areas could be developed to the fullest extent possible. There are several sites in the watershed where impoundments could be built to provide some of the water based recreation.

TABLE 19

ANALYSIS OF ALTERNATIVES

PATAPSCO RIVER

Reach	Alternative	Description	Average Annual Damages* W/O Project	Average Annual Damages* W/Project	Average Annual Benefits*	Costs*	Average Annual Cost*	Benefit Cost Ratio
PR-2	2-1	Dike @ Pumphrey	1.7	1.4	0.3	450	32.1	0.01
	2-2	Acquire 21 Houses	1.7	1.0	0.7	850	60.6	0.01
	2-3	Acquire 6 Houses Floodproof 15 Houses	1.7	1.0	0.7	410	29.2	0.02
PR-3		Remove Fill @ Beltway	0.4	0.2	0.2	2500	178.3	0.01
PR-14	14-1	Remove Abandoned Railroad Fill	6.7	6.6	0.1	275	19.6	0.01
	14-2	Acquire 1 House.	6.7	6.4	0.3	40	2.9	0.10
PR-15		No Viable Alternative						
PR-16		Channel	41.0	0	41.0	3560	253.9	0.16
PR-17		Acquire 1 House Floodproof 2 Houses	0.7	0	0.7	65	4.6	0.15
PR-19		Acquire 4 Houses " 3 "	2.3	0	2.3	215	14.2	0.15
PR-20	20-1	Acquire 6 Houses	3.9	0.2	3.7	260	18.5	0.20
	20-2	Channel	3.9	0	3.9	2840	202.5	0.02
PR-21		No Viable Solution						
PR-22		Floodproofing 2 Houses	0.6	0.5	0.1	15	1.1	0.09
PR-23		Acquire 4 Houses	2.9	0	2.9	190	13.6	0.21
PR-25		Acquire 3 Houses	0.5	0	0.5	175	12.5	0.04
PR-26	26-1	Floodproof 4 Buildings	58.7	0	58.7	140	10.0	5.87
	26-2	Channel	58.7	0	58.7	1950	139.1	0.42
PR-29		Floodproof 7 Houses	0.7	0	0.7	55	3.9	0.18
PR-30		Floodproof 4 Buildings	0.4	0	0.4	30	2.1	0.19
PR-31		No Viable Alternative						

*In thousands of dollars

TABLE 20 1/

ALTERNATIVES FOR PATAPSCO RIVER

DAMAGE REACH	COMMENT ON FLOODING SITUATION	ALTERNATIVE	DESCRIPTION	ECONOMICS*	
Tunnel Thruway to Baltimore Beltway				SPF	FOR
PR-2	Flooding of residential structures	PR-2AI Plate 10	Earth levee protecting 55 residential structures around Shenandoah Avenue.	F.C. = $1,345,400 AAC = $102,700 AAB = $5,900 BCR = 0.06	$888,000 $67,800 $2,100 0.03
PR-2	Flooding in Raynor Heights	PR-2AII Plate 11	Earth levee protecting 25 residential structures around Manor Drive from flooding up to the FOR elevation	SPF F.C. = $1,981,800 AAC = $151,300 AAB = $10,200 BCR = 0.07	FOR $817,400 $62,400 $9,200 0.15
Baltimore Beltway to Penn Central RR					
PR-3	Flooding in Patapsco State Park; few structures involved.	No physically applicable alternative			
PR-2&3	Widespread flooding, but scattered development	Levee stream channelization, numerous bridge modifications not practical to protect widely scattered development.			
Penn Central RR - Route I-95					
PR-14	Flooding in vicinity of Elkridge	PR-14B	Purchase and removal of 2 residential and 2 commercial structures severely damaged by floods up to the FOR elevation	FOR F.C. = $668,600 AAC = $61,500 AAB = $8,000 BCR = 0.13	
Route I-95 to Gray Level					
PR-15	Mostly Patapsco Park Land with scattered commercial near Ilchester	No physically applicable alternative			
Ellicott City and Oella Areas					
PR-16	Flooding from Patapsco in Ellicott City and all downstream damage reaches	PR-(16-2) Plate 11	Dry dam protecting damage reaches PR-16 to PR-2 from flooding up to the 50-yr. elevation, constructed North of Oella.	FOR F.C. = $1,368,200 AAC = $139,500 AAB = $71,900 BCR = 0.52	

TABLE 20 (cont'd)
ALTERNATIVES FOR GWYNNS FALLS

DAMAGE REACH	COMMENT ON FLOODING SITUATION	ALTERNATIVE	DESCRIPTION	ECONOMICS*			
Annapolis Road to Wilkens Avenue					SPF	100-year	FOR
GF-1	Industrial and commercial between Russell St. and B&O Railroad	GF-1AI Plate 5	Earth levee constructed between the B&O RR and Russell St. protecting commercial and industrial property and 87 residential structures up to the SPF elevation	F.C. =	$1,572,800	$1,210,900	$1,049,100
				AAC =	$120,100	$100,100	$80,100
				AAB =	$54,200	$26,000	$13,600
				BCR =	0.45	0.26	0.17
					SPF	100-year	FOR
GF-1	Inundation of industrial and commercial property near US Route 1 (wilkens Ave.)	GF-1AII Plate 6	Concrete floodwall and earth levee around Industrial Park at US Route 1 protecting commercial and industrial property from flooding up to the SPF elevation.	F.C. =	$544,400	$391,600	$322,400
				AAC =	$39,300	$29,900	$24,600
				AAB =	$26,300	$24,900	$21,000
				BCR =	0.67	0.83	0.88
Gwynn Falls to Penn Central RR							
GF-2 (Maiden's Choice Run)	Flooding in vicinity of Wilhelm Park with very low average annual	No physically applicable alternative					
Penn Central RR to Beechfield Avenue							
GF-3 (Maiden's Choice Run)	No structures flooded	No physically applicable alternatives					
Beechfield Avenue to Overbrook Road					100-year		
GF-4 (Maiden's Choice Run)	Flooding in North Bend Area at Frederick Avenue	GF-4A Plate 7	Flood retention area between Boswell Road and downstream culvert, consisting of a concrete retaining wall and a new concrete box culvert, 100-year design discharge.	F.C. =	$3,794,100		
				AAC =	$404,500		
				AAB =	$9,600		
				BCR =	0.02		
N. Prospect Avenue to Stoney Lane							
GF-5 (Maiden's Choice Run)	Inundation of several commercial and residential structures	No physically applicable alternative					
Dead Run to City Line					SPF		100-year(FOR)
GF-9	Flooding in vicinity of Dickeyville	GF-9A Plate 8	Concrete floodwall protecting 1 residential structure and the commercial district of Dickeyville from flooding up to the SPF elevation.	F.C. =	$703,000		$451,000
				AAC =	$53,000		$34,400
				AAB =	$31,800		$29,200
				BCR =	0.60		0.85

TABLE 20 (cont'd)
ALTERNATIVES FOR GWYNNS FALLS

DAMAGE REACH	COMMENT ON FLOODING SITUATION	ALTERNATIVE	DESCRIPTION	ECONOMICS*		100-year
City Line to Liberty Road						
GF-10	Flooding along Gwynndale Avenue. Few structures flooded.	No physically applicable alternative				
				FOR		
GF-10	Flooding in Woodlawn Cemetery and to a few scattered structures.	GF-10A	Purchase and removal of 18 structures damaged by flooding up to the FOR elevation	F.C. = AAC = AAB = BCR =	$740,500 $68,100 $12,000 0.18	
Liberty Road to Milford Mill Road						
GF-11	Flooding in Villa Nova Area to a few scattered structures.	No physcially applicable alternative				
				FOR		
GF-11	"	GF-11A	Purchase and removal of 6 residential structures damaged by flooding up to the FOR elevation.	F.C. = AAC = AAB = BCR =	$688,100 $70,200 $22,900 0.33	
Milford Mill Road to Baltimore Beltway						
				SPF		100-year
GF-12	Flooding of Brittany Apartments	GF-12A Plate 8	Concrete floodwall protecting a 50 dwelling unit apartment community from flooding up to the SPF elevation.	F.C. = AAC = AAB = BCR =	$842,800 $64,400 $55,800 0.87	$748,500 $57,200 $50,700 0.89
Baltimore Beltway to Painters Mill Road						
GF-13	Flooding along Hawksbury Road to scattered development	No physically applicable alternative				
Painters Mill Road to Reisterstown Road						
				FOR		
GF-14	Flooding of commercial area in Owings Mills	GF-14A Plate 9	Concrete floodwall parallel to Gwynns Mill Court protecting commercial and industrial structures from flooding up to the FOR elevation	F.C. = AAC = AAB = BCR =	$1,118,000 $114,000 $33,500 0.29	

*SPF - Standard Project Flood
FOR - Flood of Record
F.C. - First Cost
AAC - Average Annual Cost
AAB - Average Annual Benefits
BCR - Benefit Cost Ratio

1/ Source: Review Report, Baltimore Metropolitan Streams, Maryland, U.S. Army Corps of Engineers

TABLE 21
STREAMS ON WHICH IMPOUNDMENTS WERE CONSIDERED

NUMBER KEY	STREAM	POTENTIAL FOR DEVELOPMENT
	NORTH BRANCH	
1	EAST BRANCH	LOW
2	DEEP RUN	VERY LOW
3	NEAR MT. GILEAD	VERY LOW
4	BEAVER RUN	VERY LOW
5	MIDDLE RUN	VERY LOW
6	MORGAN RUN	VERY LOW
7	LITTLE MORGAN RUN	VERY LOW
	SOUTH BRANCH	
8	GILLIS FALLS [1]	HIGH
9	HAY MEADOW BRANCH	LOW
10	PINEY BRANCH	LOW
	GWYNN'S FALLS	
11	MAIN STEM (DELIGHT) [2]	MODERATE
12	MAIN STEM (WOODLAWN) [2]	MODERATE
13	RED RUN [2]	MODERATE
14	HORSEHEAD RUN [2]	MODERATE

[1] Flood control potential good and Carroll County may develop for water supply.

[2] Will not justify by Federal Economic Criteria. However, Baltimore County is interested in lieu of floodplain acquisition.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LEGEND
Study Boundary
City and County Lines
Highways
Streams
APPROXIMATE LOCATION OF IMPOUNDMENTS
PATAPSCO RIVER STUDY AREA
Anne Arundel, Baltimore, Carroll, and Howard Counties, and Baltimore City, Maryland

Figure 13

Table 22 Economic Analysis of Impoundments on the Patapsco River

	Average Annual Damages (AAD) and Average Annual Benefits (AAB), in Thousands of Dollars						
	No Project	Ten Headwater Dams		Four Headwater Dams		Gillis Falls	
	AAD	AAD	AAB	AAD	AAB	AAD	AAB
PR-1	0	0	0	0	0	0	0
PR-2	1.7	0.1	1.6	0.3	1.4	0.7	1.0
PR-3	0.4	0	0.4	0.2	0.2	0.2	0.2
PR-14	6.7	0.4	6.3	1.8	4.9	2.8	3.9
PR-15	2.9	0.1	2.8	0.8	2.1	1.1	1.8
PR-16	41.0	6.2	34.8	20.0	21.0	26.5	14.5
PR-20	3.9	0.6	3.3	2.8	1.1	2.8	1.1
PR-22	0.6	0	0.6	0.2	0.4	0.2	0.4
PR-23	2.9	0.1	2.8	0.2	2.7	0.2	2.7
PR-25	0.5	0	0.5	0	0.5	0	0.5
PR-26	58.7	0.8	57.8	2.9	55.8	2.9	55.8
Total	119.3	8.3	111.0	29.2	90.1	37.4	81.9
Average Annual Cost of Alternative		1880		875		260	
Benefit Cost Ratio		0.06 : 1		0.10 : 1		0.32 : 1	

Table 23 Economic Analysis of Impoundment on Gwynn's Falls

Average Annual Damages (AAD) and Average Annual Benefits (AAB)
in Thousands of Dollars

	No Project	Four Headwater Dams	
	AAD	AAD	AAB
GF-1	16.3	5.3	11.0
GF-9	11.5	3.6	7.9
GF-10	8.1	0.1	8.0
GF-11	19.8	1.5	18.3
GF-12	64.1	5.1	59.0
GF-14	149.6	142.1	7.5
Total	269.4	157.7	111.7
Average Annual Cost of Alternative		475	
Benefit Cost Ratio		0.24 : 1	

TABLE 24

IMPACTS OF FLOOD MANAGEMENT
MEASURES ON VARIOUS ENVIRONMENTAL PARAMETERS

PARAMETERS AFFECTED

Flood Management Measure	Water Quality	Fish Habitat	Wildlife Habitat	Vegetation	Archeological and Historic	Mineral	Landscape and Visual	Wetlands	Rare & Endangered Species	Socio-Economic
Channel Improvement	Warmer stream temperature	Less shade, no natural runs, riffles, pools generally negative	Radically modifies habitat in vicinity of stream: adverse to some, beneficial to others	Destroys some woods & brush	Can jeopardize resource if present	May disturb some sand and gravel resource	Alter visual character of stream valley	Jeopardizes wetlands on or near right-of-way	Effect varies depending on species	Little effect
Diking	No effect	Slight negative effect	Destroys continuity of habitat	Destroys some woods & brush	Can jeopardize resource if present	Little effect	Destroy opportunities to view stream by homeowners	May inundate some and create others	"	Could bisect some communities
Impoundments	Generally better quality downstream	Destroys stream continuity; reservoir allows for certain species	Destroys many acres of habitat. Periodically threatens others	Inundates many acres of brush, grass, and woodland	May inundate or protect resource	Inundates resource	Radically alter valley appearance. Introduce land/water edge	May destroy wetland on valley floor, create some on lake edge	"	Remove land from tax base; could destroy character of rural areas
Acquisition & Relocation	No effect	Little effect	Provides opportunity for increase in habitat	May allow for revegetation	May eliminate historic resource	Little effect	Improve visual character of stream valley	May allow for reversion to wetlands	"	Could severely disrupt community structure
Removal of Constrictions	Little effect	"	Little effect	"	Can affect archeologic resource	"	Improve visual character of stream valley	"	Little effect	May have some effect depending on nature of construction
Flood Proofing	No effect	No effect	No effect	No effect	Alters character of historic resource	No effect	No effect	No effect	No effect	Increase peace of mind
Flood Insurance	" "	"	"	"	No effect	"	"	"	"	May reduce economic burden Increase peace of mind
Floodplain Regulation	Little Effect	"	Protects existing habitat	Protects vegetated areas	Protects setting of historic resource	May prohibit use of resource	Maintain visual quality of floodplain	"	"	No effect
Floodwarning	No effect	"	No effect	No effect	May lessen damage to resource	No effect	No effect	"	"	Increase peace of mind
Stormwater Management	Slight improvement downstream	Opportunity to manage some hardy warmwater species	Destroys small areas of vegetation	Destroys small areas of vegetation	Little effect	Little effect	May create small water surfaces providing attractive views	May create small wetland areas	Little effect	Little effect

EFFECT OF LIBERTY DAM ON FLOW IN THE PATAPSCO RIVER DURING HURRICANE AGNES

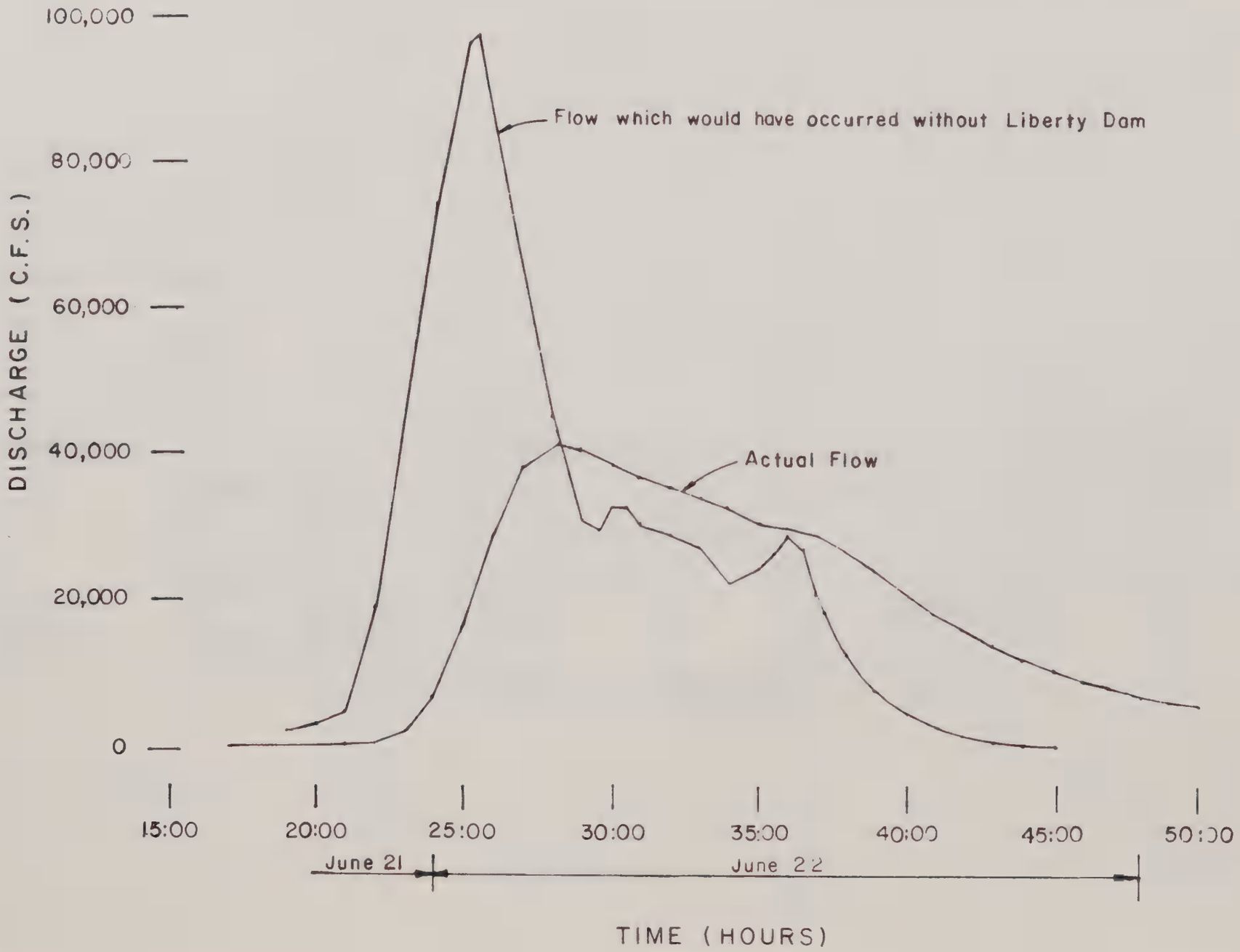

Figure 14

OPPORTUNITIES FOR USDA INVOLVEMENT

I. Public Law 74-46

Under authority of this law, USDA agencies provide technical assistance and payments or grants-in-aid to landowners for approved soil conserving or soil building practices. This is the basis for the Soil Conservation Service providing technical assistance to landowners through local Soil Conservation Districts and the Agricultural Stabilization and Conservation Service sharing costs of conservation practices through the Agricultural Conservation Program.

The Soil Conservation Service can provide continued technical assistance through its on-going programs in conjunction with the Soil Conservation Districts. These programs are mainly concentrated on applying land treatment. However, the on-going programs will not meet all the needs of the watersheds.

They can also continue to provide some technical assistance on programs which were begun as a result of the Patapsco River Basin Study. They can provide assistance in the use and updating of the TR-20 hydrologic model. Also, they can provide assistance in implementation of a basin-wide stormwater management program and flood warning system.

II. Public Law 83-566 The Watershed Protection and Flood Prevention Act

PL 83-566 authorizes the Soil Conservation Service, the Forest Service, and the Economic, Statistics and Cooperatives Service to provide technical assistance to local sponsoring agencies for watershed planning. It also authorizes financial assistance from the USDA to the local sponsoring agencies if the benefits of a proposed project exceed the costs of the project.

There is no economically feasible PL-566 structural flood prevention project in the Patapsco River or Gwynn's Falls Watersheds. In order to be eligible for cost sharing under PL-566, a project must have a benefit-cost ratio (B/C) of greater than 1:1.

Impoundments reduce or prevent the most damages on the Patapsco River. The highest B/C occurs using Alternative 3, Gillis Falls alone. The average annual damage reduction (benefit) is $85,600 and the average annual cost is $260,000, yielding a B/C of 0.33:1. This is less than required for SCS cost sharing.

Impoundments on Gwynns Falls will also not justify according to PL-566 criteria. The highest B/C occurs using Alternative #1, all four structures. The average annual benefit for this alternative is $111,700, and the average annual cost is $475,000, yielding a B/C of 0.24:1.

None of the other structural alternatives such as dikes, channels or floodwalls have a B/C greater than 1:1. Dikes or floodwalls in the areas of Pumphrey, Lower Gwynn's Falls, and Brittany Apartments are the closest to having a B/C equal to 1. The best of these measures has a B/C of 0.85:1.

In some areas, nonstructural measures could possibly economically justify according to PL-566 criteria. However, no funds have been allotted in the past for nonstructural measures. Therefore, this approach was not addressed with regard to PL-566 funding. It is, however, the most effective solution to some of the problems.

Recently, there have been indications that funds may soon be allotted for nonstructural PL-566 projects. There may also be provisions provided for cost sharing even if the B/C is less than 1. These changes should be monitored and when they become final, their applicability to the Patapsco River should be determined.

There is a possibility that a land treatment only project may exist for the Patapsco River Watershed under the authority of PL-566. This project could provide assistance for an accelerated land treatment program. It could make funds available for technical assistance and cost sharing on construction of conservation practices to improve water quality.

OPPORTUNITIES FOR LOCAL ACTION

Local jurisdictions can do much to reduce the impact of flooding in the future. Of utmost importance is a continued commitment of local and state agencies to act on flood related problems.

Local sponsors and citizens should not view this study as an end in itself. It is part of a continuing process, working toward solving flood problems. A great deal has been learned during this study. Following are several recommendations for the future. These are not necessarily new ideas. Most of them have been suggested long ago. In these cases, the recommendations are a reaffirmation of the present policy. In other cases, recommendations encourage expansion or refinement of existing programs.

I. GENERAL

The ongoing floodplain acquisition programs should continue. The program in Baltimore County prevented considerable damage as recently as Tropical Storm David in September, 1979. In those areas where no program is underway, consideration should be given to starting some type of program. In cases where people do not want to move from the floodplain, other methods could be investigated for their protection.

The Maryland State Park acquisition program should be coordinated with the County programs. Where a parcel of residential property subject to flooding is contiguous with the Park take line, it could be acquired as part of the Park. Possibly, some agreement for cost-sharing for acquisition could be formulated.

The existing Howard County flood warning program on the Patapsco should be expanded to include all jurisdications affected. At present Baltimore City, Anne Arundel, and Baltimore Counties are notified of potential flooding. Information developed by this study could be used to improve the prediction capabilities downstream. Based on stage readings at Woodstock, stages could be predicted for any downstream area using the output from the hydraulic program. Using the hydrologic program, discharges downstream could be predicted using actual rainfall information while it is still raining. This could increase the warning time for predicting flooding by two or three hours. At present, Anne Arundel County gets about four hours lead time after the alarm goes off at Woodstock. Utilization of the hydrologic model could increase this time to six or seven hours.

Individual property owners or entire neighborhoods could develop flood disaster preparedness plans in conjunction with the County Civil Defense Director. Owners of residences and businesses could be offered technical assistance, in the form of a handbook, regarding inexpensive means of preventing damage to perishable goods during a flood.

The system refinements mentioned previously could all be implemented through existing resources. They involve no new equipment or

personnel; simply a minor redirection of available resources and a reallocation of time by key personnel.

Further refinements might include the introduction of additional monitoring devices throughout the area. This might include additional remote sensing staff gages, recording streamflow gages, and rain gages. Rain gages could be installed in Carroll County since most of the contribution to discharges on the Main Stem comes from the watershed in Carroll County.

Several meetings were held during this study concerning flood warning. Those involved came from Civil Defense agencies and Departments of Public Works. This dialogue between the agencies should be continued. They could be the coordinators needed for implementing a basin wide system.

Baltimore County also has a flood warning system in operation on Gwynns Falls. The same type of cooperation and refinement as recommended for the Howard County system would be beneficial. Due to its small area, the warning time on Gwynns Falls is short. Any increase in warning time through use of a hydrologic model would be extremely helpful.

A more systematic approach is essential for dissemination of flood threat information to property owners. There is also a need to prevent the dissemination of misinformation which can cause needless evacuation. Assistance in developing flood warning systems is available through National Oceanographic and Atmospheric Administration, National Weather Service.

Technical studies for water quality and water quantity planning could be merged. Water quantity and water quality are intimately related. Techniques for solving the problems in one often lend themeselves to the solution of the other. For instance, debris basins for sediment control are easily modified into stormwater management basins which control increased runoff and reduce streambank erosion. Also, conservation land treatment practices designed to keep chemicals and pesticides on agricultural land have the added benefit of retarding increased surface runoff.

The Baltimore Regional Planning Council could provide the leadership in establishing a regional water resources management team which will jointly analyze water quality and quantity problems and solutions. A trial water resources analyzer program is currently being developed by RPC and WRA.

The stormwater management criteria of the jurisdications could be investigated to determine if they are compatible and solve the problem on a basin-wide basis. The stormwater management program could also be evaluated with a basin wide approach. There may be areas where stormwater management could be waived, while others would require more stringent measures.

It is not the purpose of this report to advocate any particular stormwater management policy, but rather to recognize the potential

of a coordinated basin-wide stormwater management program in floodplain management. Certainly much could be gained if state, regional and local governments coordinate their efforts in setting goals and policies for stormwater management. They could analyze the specific resource base and tailor a stormwater management program to complement that base.

Done in piecemeal fashion, thousands of small diverse stormwater management structures will be built throughout the study area at a cost of over $100 million dollars by the year 2000. The combined impact of these facilities several miles downstream from their outlets will be virtually indeterminable. Theoretically, they could actually create a worse situation than if they did not exist.

By planning facilities to handle 100 acres, the required number could be cut to 300 and the cost reduced to $15 million. Also, the hydrologic effect would be more easily ascertained.

By controlling 500 acres per facility, the number of total structures could be reduced to 60 and the cost reduced to $8 million. Also, the hydrologic effect at all points is relatively easy to determine. The trade-off in the latter case is that there are many increments of unprotected stream between the source of runoff and the stormwater management structure. Also, going from smaller to larger structures shifts the responsibility for installation and operation and maintenance from the private to the public sector.

In an intensly urban area such as Baltimore City and its immediate suburbs, consideration could be given to retrofitted stormwater management for areas which have developed prior to the adoption of a Stormwater Management Policy. In the study area, the primary opportunities for application of retrofitted stormwater management are on Dead Run and Maiden's Choice Run, both of which are tributaries to Gwynns Falls with headwaters in Baltimore County. The county and the city have an opportunity to evaluate the feasibility of stormwater management on these streams.

Future land use planning in the basin could be done with due consideration given to the impact of future development on the hydrologic process, not only immediately downstream of the development, but throughout the entire hydrologic system. Alternative development plans could be designed which consider the effects of soil, slope, vegetation, and land use on local hydrology. Developers could be encouraged to urbanize an area so that its post-development hydrology closely reflects its pre-development hydrology. In so doing, many of the structural stormwater management costs would be eliminated.

Encouragement of proper land use planning is a county prerogative. It could be done with the assistance of local Soil Conservation Districts as well as other technical groups knowledgeable in land-use planning.

There are many areas in the watershed which experience flood damage. Most of the flooding damages are relatively infrequent, but damage is

high when flooding does occur. It has been the policy of the counties to attack the problem through total protection of the properties. Normally, this is done by purchasing the property and removing or demolishing any structures. This is the most effective means of preventing further damages.

Consideration could be given to protection methods other than acquisition. Often diking or flood proofing would be a more cost-effective method of preventing or reducing damages from a 100-year flood. The problem with any of these types of measures is that at some point in time the dike or flood proofing will be overtopped, thus they may give a false sense of security.

II. SPECIFIC SUBAREAS

South Branch

A. Consideration could be given to public acquisition of twelve residences along the South Branch of the Patapsco, five of which are in Carroll County and seven of which are in Howard County. These residences are those most susceptible to major flood damage. Two taverns in Sykesville also sustain major flooding. However, the owners may rather risk periodic flooding than be relocated. This may also be true of the private residences. Evidence does not indicate that flooding is frequent or severe enough to mandate removal of the homes. Therefore, any such action should be undertaken with the full consent of the owners and a complete explanation of the nature and severity of the problem.

Fifteen homes or businesses along the South Branch are subject to infrequent, minor flooding. Homeowners could be given the opportunity to learn about inexpensive methods of flood proofing.

Responsibility for these actions would most appropriately fall on the county governments involved. Capital costs for Howard County would probably be between $350,000 and $450,000; Capital costs for Carroll County between $300,000 and $350,000. Measurable economic benefits would be far less than these amounts. Environmental benefits of structure removal would be minor. The justification, therefore, would have to come from social well being or peace of mind benefits. The importance of these benefits may be determined by personal contact with the affected individuals.

B. Consideration should be given to developing an impoundment on Gillis Falls. Besides supplying water for Carroll County, it could considerably aid in reducing flood damages along the South Branch and Main Stem.

North Branch

A. Consideration could be given to modification of the bridges on the Western Maryland Railroad track running through Carrollton and Patapsco. This would only be feasible if Western Maryland abandons the railroad. Flooding sustained by these towns during Tropical Storm Agnes could have been lessened if the railroad fill and bridges

had not constricted the floodplain. Altogether, approximately 1200 feet of track and roadbed would be involved.

B. The towns of Carrollton and Patapsco are especially susceptible to the effects of increased runoff due to urbanization in Westminster, Hampstead and Manchester. Therefore, it is especially important that development and the resulting increased runoff in these areas be analyzed for its impact on the smaller communities downstream.

C. In Finksburg, the Congoleum Floor Covering Plant is susceptible to periodic flooding. This causes both economic hardship on the plant and a potential threat to Baltimore City's Water Supply in Liberty Reservoir. A flood hazard management plan could be developed for the plant. The plan could include provisions for permanent reloction of some storage facilities as well as perishable goods. The plan could specify emergency ingress and egress routes and could analyze the feasibility of a flood warning system for the plant. The plan would most appropriately be developed jointly by the Congoleum Corporation and Baltimore City Department of Public Works.

D. Collection of data which lends itself to modeling the hydrologic performance and impact of Liberty has been completed. The data could be used to refine the hydrologic model resulting from this study.

Main Stem

A. Certain structural measures to control flooding on the Main Stem could be further analyzed for local jurisdictions' involvement. A Corps of Engineers Study indicated no economic justification for federally financed structural measures along the Main Stem. Headwater impoundments have also been demonstrated to be economically unjustifiable according to federal criteria. Main Stem impoundments are impractical because of the location of the railroad tracks. A large concrete channel could eliminate flooding in Ellicott City. However, its economic justification is questionable and the visual impact on the Historic District may be objectionable. Diking is impractical in most areas because damage areas are scattered, thus increasing the length of dike required and greatly increasing the cost of related pumping facilities.

B. Modification of the landfills on the Lower Patapsco and the abandoned B & O railroad right-of-way in Elkridge could be considered. These constrictions cause some rises in water surface profile upstream. The landfills increase chances for flood damage along the lower Patapsco almost up to Elkridge. The railroad increases chances of flood damage in the town of Elkridge.

Cutting back the landfills would be expensive, probably about $2.5 million for each 100 feet back from the river, and involve multi-jurisdictional cooperation between the State of Maryland, Anne Arundel and Baltimore Counties, and Baltimore City.

Removal of the railroad fill in Elkridge would be far less costly, approximately $275,000, and would involve only the Howard and

Baltimore County governments directly. Impacts, too, would be more localized. Only the community of Elkridge and the highways immediately upstream would benefit.

C. Consideration could be given to acquisition of houses most susceptible to flooding in Elkridge, North Linthicum, Pumphrey, and Brooklyn Park. Acquisition criteria should be based on elevation of the first floor with respect to the peak elevation of the 100-year flood; the greater the differential, the higher priority of acquisition. Acquisition may be undertaken by the appropriate counties. There may be some opportunity to acquire properties in conjunction with the state parkland acquisition program, as some of the properties are adjacent to proposed park taking lines.

D. The flood warning system currently employed in Howard County could be expanded to include Anne Arundel and Baltimore Counties. Prediction capability could be modified using the hydrologic model developed for this study. Flood preparedness plans similar to the one for Howard County should be developed for the other jurisdictions. Stage predictions for the lower counties could be tied to the hydraulic data generated by the study.

Incorporation of readily available data and technology should cost Baltimore and Anne Arundel County no more than $20,000-$30,000 yearly. Additional hardware, if deemed necessary, could cost $50,000-$100,000, in addition to an annual operation maintenance and replacement cost.

E. The fact that it is in an Historic District may preclude the use of structural measures to protect Ellicott City. The town, together with other communities along the lower Patapsco, could develop a flood disaster preparedness plan in conjunction with the County Civil Defense Director. Owners of residences and businesses could be offered technical assistance, in the form of a handbook, regarding flood proofing and other inexpensive means of preventing damage to perishable goods during a flood.

F. A detailed study on localized drainage could be done on Herbert Run. Most of the flooding along that stream seems to be associated with local drainage. Hydrologic and hydraulic data from this study that will assist the county can be made readily available.

Gwynn's Falls

A. Baltimore County may wish to consider reevaluation of its floodplain acquisition program. The basic idea is a valid one in terms of overall water resource management. However, in some instances, there may be a more cost effective way of providing protection.

For instance, in The Report on Gwynns Falls Floodplain Study, July, 1975, the four small impoundments analyzed provide protection for some residents in Upper Gwynn's Falls that are scheduled for acquisition.

While these impoundments do not meet federal economic criteria, they represent a cost effective way of providing flood protection to some of the downstream area. Also, alternatives other than acquisition could be considered in flood fringe areas where depths of water reach two feet or less for the 100-year storm. In these areas, flood proofing may be an appropriate method of protection.

However, the use of flood proofing requires that once installed, flood elevations cannot increase or the structure will again be flooded. This requires that there be no increase in discharge from upstream area. Therefore, effective stormwater management would be needed.

B. Citizens advisory groups could be included more directly in the acquisition process. This would allow the concerns of people whose homes are likely to be acquired to be considered more carefully in determining acquisition priorities. Several people have used the Patapsco study questionnaire to express their views on this matter. Whether or not their concerns are valid is somewhat irrelevant. The fact is they exist and could represent a severe stumbling block in the county's acquisition program.

C. Baltimore County and Baltimore City could work jointly on a flood warning system and a flood disaster preparedness plan. Baltimore County is already working on such a system for the upper Gwynns Falls. The system could incorporate hydrologic and hydraulic data being compiled by WRA and SCS to allow prediction of flood peaks and stages in the harbor area. A model of tidal hydrology would provide an additional refinement.

A warning system is the only feasible alternative for relieving the impacts of flooding on the highly industrial lower Gwynn's. The system would work like the one described on the Main Patapsco. It would involve close coordination between City and County Civil Defense personnel.

Assistance in developing such a system is available through National Oceanographic & Atmospheric Administration, National Weather Service.

D. Structural protection in the form of dikes or floodwalls could be considered in two areas of concentrated flood damage - Owings Mills Industrial Park and Brittany Apartments. The problem is more acute at the latter than at the former. Flooding is infrequent at Owings Mills. Therefore, structural protection would not be justifiable by federal economic criteria. However, because of the social well being benefits and high instance of secondary economic benefits, the county may still want to consider a floodwall.

The Brittany Apartments were seriously damaged by Tropical Storm Agnes. In some cases, flood water represented a clear threat to human life. A floodwall providing protection from the 100-year flood would cost about $1 million according to the Corps of Engineers. The cost is slightly in excess of economic benefits derived.

E. Opportunities for retrofitted Stormwater Management could be explored by the City and the County jointly, especially on the Maiden's Choice and Dead Run tributaries of Gwynn's Falls. It is unlikely that opportunities

for significant surface water storage exist on Maiden's Choice. The basin is almost entirely urbanized. However, pipe storage and other subsurface storage could be analyzed in some detail. Dead Run may present a slightly greater opportunity for surface storage.

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PATAPSCO RIVER BASIN STUDY

PRIME AGRICULTURAL LANDS

DEVELOPED BY

USDA SOIL CONSERVATION SERVICE

Cartographic work prepared by SCS, College park, Md

LOCATION MAP

SCALE IN MILES

1 0 1 2 3 4

SCALE IN KILOMETERS

1 0 1 2 3 4 5 6 7

N

77 00'

76 50'

76 40'

39 40'

39 30'

39 20'

39 10'

HAMPSTEAD

WESTMINSTER

CARROLL COUNTY

REISTERSTOWN

MT AIRY

HOWARD COUNTY

BALTIMORE CITY

BALTIMORE COUNTY

ANNE ARUNDEL COUNTY

LEGEND

COUNTY BOUNDARIES

STUDY AREA

SUB-WATERSHED BOUNDARIES

PRIME OR UNIQUE AGRICULTURAL LANDS

USDA-SCS HYATTSVILLE, MD 1979

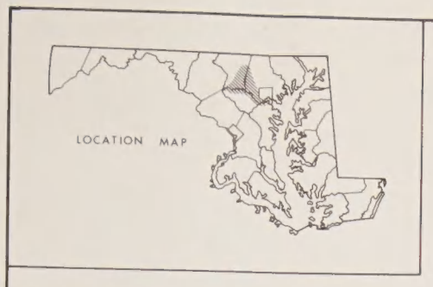
STUDY AREA MAP
PATAPSCO RIVER BASIN STUDY

DEVELOPED BY

BALTIMORE REGIONAL PLANNING COUNCIL

WITH ASSISTANCE FROM

USDA SOIL CONSERVATION SERVICE



SCALE IN MILES

1 0 1 2 3 4

SCALE IN KILOMETERS

1 0 1 2 3 4 5 6 7

N

77°00'

76°50'

76°40'

39°40'

39°30'

39°20'

39°10'

MANCHESTER

HAMPSTEAD

CRANBERRY RESERVOIR

WESTMINSTER

CARROLLTON

PATAPSCO

CARROLL COUNTY

PATAPSCO RIVER WATERSHED

REISTERSTOWN

LIBERTY RESERVOIR

OWINGS MILLS

ELDERSBURG

PINEY RUN LAKE

GWYNNS FALLS WATERSHED

MT. AIRY

SYKESVILLE

WOODBINE

MORGAN

GAITHER

HENRYTON

MARRIOTTSVILLE

RANDALLSTOWN

WOODSTOCK

HOWARD COUNTY

WOODLAWN

BALTIMORE CITY

BALTIMORE COUNTY

BALTIMORE HARBOR

ELLICOTT CITY

LANSDOWNE

ELKRIDGE

LINTHICUM

BALTIMORE WASHINGTON INTERNATIONAL AIRPORT

ANNE ARUNDEL COUNTY

LEGEND

- STUDY AREA BOUNDARIES
- SUB-WATERSHED BOUNDARIES
- COUNTY BOUNDARIES
- INCORPORATED AREAS
- PARKS AND PUBLIC LAND
- INTERSTATE HIGHWAYS
- U.S. HIGHWAYS
- STATE HIGHWAYS
- RAILROADS
- STREAMS

Base Source:
General Highway Map dated November 1978
Maryland Department of Transportation

USDA-SCS HYATTSVILLE MD 1979