BALTIMORE CITY

FLOODPLAIN MANAGEMENT PLAN

William Donald Schaefer, Mayor

Larry Reich, Director, Baltimore City Department of Planning

Planning Commission
Charles S. Colson, Acting Chairman
William Donald Schaefer, Mayor
Mark Wasserman, Mayor's Representative
Nathan C. Irby, Jr., City Council Representative
Francis W. Kuchta, Department of Public Works
Sally James Michel
Carl M. Adair
James P. Grant
June Thorne
Thomas C. Barry

Plan prepared by Robert Perciasepe, Chief and Virginia Kearney of the Capital Improvement Programming Section of the Department of Planning, under the general supervision of Arthur Hilsenrad, Assistant Director.

Maps prepared by Candace Szabad, Bureau of Water and Waste Water, Department of Public Works

Typing and editing
Jacqueline Hagland
Rena Vandervall
Beverly Moore

Report reproduced by Arthur Alexander

December, 1981

Table of Contents

BALTIMORE CITY

FLOODPLAIN MANAGEMENT PLAN

ANALYSIS

SUMMARY OF FINDINGS AND RECOMMENDATIONS

PLAN ORGANIZATION

The Baltimore City Floodplain Management Plan is organized into six volumes:

- ANALYSIS
- APPENDIX
- JONES FALLS
- GWYNNS FALLS
- HERRING RUN
- PATAPSCO RIVER/HARBOR

The analysis volume is a review of a wide range of floodplain management techniques. Each technique is analyzed and from this, a set of alternatives is selected for Baltimore City. This volume also reviews the history and causes of flooding in Baltimore. Each floodplain management technique selected for application in Baltimore is detailed in terms of approach, objective, and implementation.

The appendix contains background material used to develop the plan and information of interest to users. Items such as an annotated bibliography, a list of flood-prone properties, a review of state and federal legislation, and examples of detailed flood maps are included.

The separate volumes for the Jones Falls, Gwynns Falls, Herring Run, and the Harbor detail, with maps and discussion, the location of recommended actions in each watershed.

FINDINGS

A review of the history of flooding in Baltimore reveals that severe flooding has occurred for almost two hundred years. Accounts of flooding disasters date back to the late 1700's. These records indicate that, while recent floods stand out in memory, the problem is not new. Factors such as increased urbanization of the upper watersheds, however, can contribute to an increase in the frequency of floods.

The plan reviews all previous reports and studies related to flooding in Baltimore City. These many documents have been summarized in the Appendix. The recommended actions of these studies have been, for the most part, traditional structural solutions to a specific flooding problem. Such solutions have included floodwalls, large conveyance systems, major channel improvements, and levees. A review of the status of these recommended actions reveals that most have never been implemented. Two major factors have led to this lack of implementation: uncertainty concerning the total benefits and the tremendous capital cost involved. Implementing the various proposals could cost up to 100 million dollars with little participation by the State or Federal government.

The plan has also examined a variety of "non-structural" approaches. In the absence of implementable structural solutions, the plan has concentrated on approaches to manage existing and future land use in order to minimize damages and risks from flooding.

RECOMMENDATIONS

The following floodplain management strategies are recommended by the Baltimore City Floodplain Mangement Plan:

- The building code and zoning ordinances of Baltimore City concerning flood hazard areas already meet the minimum requirements of the National Flood Insurance Program. The Plan recommends that these codes be upgraded to restrict all new residential development in areas eligible for acquisition and that new non-residential development be elevated above expected flood heights. These revisions will insure that future development will be immune to flood damages.

- There are approximately 150 residential structures located in high hazard flood areas. The plan recommends that these properties be eligible for public acquisition on a voluntary basis. This program will cost approximately 6.5 million dollars including relocation costs. In the first phase of the acquisition program, 66 residential properties have been identified as eligible for acquisition in the Gwynns Falls watershed, at an estimated cost of 1.1 million dollars. In the Jones Falls, 84 properties have been identified. These properties will constitute the second phase of the City's residential acquisition program. The identification of homes eligible for acquisition in the Herring Run watershed, the Harbor Area and in areas needing further study will constitute the third phase of the program. Owners of residential structures not located in the highest hazard areas but still subject to some flooding will be eligible for low-interest loans to floodproof the structure. Information on floodproofing will be disseminated to these owners to promote floodproofing. In the Gwynns Falls, this includes the Dickeyville area along the upper Gwynns Falls, homes near Maiden's Choice Run, and homes in flood-prone areas where detailed studies are needed. In the Jones Falls, this includes homes along Western Run, along the main stem north of Northern Parkway and along Stony Run, where detailed hydrologic data are needed. In addition, some homes in the Herring Run watershed, Harbor Flood Zone and other areas needing further study may benefit from this residential floodproofing program.

- There are approximately 30 non-residential structures located in high hazard flood areas. The plan recommends that, in cooperation with the Army Corps of Engineers, these structures be eligible for no-cost floodproofing surveys. To date, four floodproofing surveys have been done by the Corps of Engineers for industries in the Jones Falls Valley. Six major industries remain to be surveyed. In the Gwynns Falls there are approximately twenty commercial and industrial structures eligible for floodproofing surveys. Addition al non-residential structures prone to flooding are located in the lower Herring Run-Moores Run drainage area and the Harbor Flood Zone. These will be surveyed after the Jones Falls and Gwynns Falls have been completed. If the business decides to implement the recommendations of the surveys, the City will make low-cost loans available.

Several areas in the City, subject to flooding, have not received sufficient detailed hydrologic/hydraulic study needed to formulate final plans. The Plan recommends that detailed studies be performed under the State Water Resources Administration's floodplain management program. These areas include:

Maiden's Choice Run
Gwynns Run
Stony Run
Biddison Run
Upper Moores Run
Lower Jones Falls

- There are 1,270 flood insurance policies in Baltimore City with a total of over 62 million dollars in coverage. The Plan recommends an educational program to promote the benefits of flood insurance. This effort will consist of mailings to property owners and renters as well as workshops and publications.

- An element of any floodplain management plan must be a disaster warning system. Baltimore City has in place an existing system for snow, wind, ice, flood, and tornado (SWIFT). for which operating procedures have already been defined. Data developed by this planning effort, on locations of flood hazard, can be incorporated into the SWIFT program. The Plan recommends that these data be formatted for the Police and Public Works Departments' use in SWIFT.

- Debris of various types located in stream beds continues to aggravate flooding. The plan recommends that the City's erosion control and stream stabilization program be targeted to areas where debris accumulation is a problem. There should also be an annual commitment to stream cleaning of debris that accumulates in streams from illegal dumping (tires, shopping carts, refrigerators, cars, etc.) Areas in the Gwynns Falls requiring stream work include the lower portion of Maiden's Choice Run, a small area in the vicinity of Forest Park Drive on the upper portion of the main stem, and at the confluence of the main stem with the Middle Branch of the Patapsco River totalling approximately two miles.

  Along the Jones Falls, areas targeted for minor stream improvements include several segments on Western Run, the section of the main stem between Northern Parkway and the City/County line, and at various locations between Cold Spring Lane and North Avenue. Some work is needed along Stony Run as well for a total of approximately three miles.

All of these recommendations are discussed in detail in the analysis section of the plan.

IMPLEMENTATION SCHEDULE

The following schedule for implementation is proposed.

- Upgraded City building code and zoning ordinance: 1982 introduction to City Council.

- Acquisition of high hazard residential structures: Grant application for the acquisition of 66 properties in the lower Gwynns Falls and Maiden's Choice Run (first phase of the acquisition program) will be submitted to the State in January 1982. Grant applications for the second and third phases will be submitted at a later date. City matching funds are already approved by the voters and appropriated by City Council. Offers for acquisition should begin during 1982.

- Floodproofing: Non-residential program is already under way with the Army Corps of Engineers. It will take 5 to 6 years to finish all surveys.

  Promoting residential floodproofing will begin in 1982 with informational mailings to all home owners.

- Studies of the six areas in the city with insufficient data should begin in 1982 under the State Water Resources Administration Program.

- Flood insurance promotion will begin in 1982 with informational mailings to all property owners and occupants.

- Targeting of the erosion control/stream bank stabilization program will begin with the 1983-1988 Capital Improvement Program.

Finally, it should be noted that, while many of these recommendations will begin implementation in 1982, the plan is designed to reduce flood damage and risk over a period of time. Acquiring houses, floodproofing structures, implementing legislation for future development, and conducting studies all take time. The Plan envisions a period of 5 to 10 years before most of the recommendations are completely implemented. The result will be a substantial reduction in flood damage potential and a reduction in personal safety risks for residents currently located in flood hazard areas.

INTERJURISDICTIONAL COORDINATION

The Plan recognizes the interjurisdictional nature of flooding. To be complete, a system for coordination and cooperation with Baltimore County is essential. A letter outlining mutually agreed upon goals, and a process to implement coordination, will be signed by the representatives responsible for floodplain management in each jurisdiction.

CITY OF BALTIMORE

WILLIAM DONALD SCHAEFER, Mayor

DEPARTMENT OF PUBLIC WORKS

FRANCIS W. KUCHTA, Director
600 Municipal Building, Baltimore, Maryland 21202

December 28, 1981

Mr. Thomas Andrews, Director
Water Resources Administration
Department of Natural Resources
Tawes State Office Building
Annapolis, Maryland 21401

Dear Mr. Andrews:

Baltimore County and Baltimore City have, in the past, both experienced extensive flood damages.

Recognizing the need to establish programs to minimize safety risks and to protect property and natural resources, and recognizing the interjurisdictional nature of flooding and floodplain management, Baltimore City and Baltimore County have established a process for coordination. To guide this process each jurisdiction has adopted the following goals:

1. Floodplain management plans and programs will establish the necessary mechanisms to assure that actions in either jurisdiction will not result in aggravated flooding hazards.

2. Floodplain management plans and programs will establish the necessary mechanisms to assure that inappropriate development in flood hazard areas is prohibited.

3. Along open streams acquisition of residential property is the preferred floodplain management alternative except where shown to be not cost/effective.

In addition to these goals, Baltimore City and Baltimore County will mutually review and comment on all plans, projects, grant applications and studies related to interjurisdictional watersheds.

The goals and the process of coordination outlined in this letter are established to promote effective and coordinated floodplain management in shared watersheds and to fulfill requirements outlined in the Natural Resources Code 8-9A-03 (e).

The Department of Public Works and Planning from each jurisdiction will be responsible for implementing the goals and process outlined above.

Sincerely,

Francis W. Kuchta

Director

Director, Baltimore City
Department of Planning

FWK:eg

INTRODUCTION

INTRODUCTION

History shows that Baltimore City has experienced incidents of flooding for almost two centuries. It hasn't been until the last decade, however, that concerted efforts were begun to examine and address the problems.

While there are many reasons for this effort, three are most prominent.

1. Most major streams in the metropolitan area and Baltimore City have experienced their largest recorded flood within the last ten years. This has focused public attention on flood-related problems.

2. Several engineering and planning studies conducted by the Federal Government and the City have shown traditional structural solutions to be far too costly and not cost/effective in many instances. These findings have all but eliminated the possibility of federal financial assistance to control flooding.

3. Legislation at the State and Federal level has established a variety of plan and program requirements (flood insurance, floodplain management plans) and financial incentives to develop them.

The number of floods, their severity and the amount of damage experienced over the last ten years have clearly highlighted the flooding problem in Baltimore. Studies to examine solutions have underlined the tremendous cost of controlling flooding in our highest hazard areas, thus suggesting alternate approaches. State and Federal legislation have created incentives to develop broader management-oriented strategies to mitigate flood damages. These have come in the form of State grants contingent on floodplain management plans and eligibility requirements for subsidized flood insurance dependent on land use controls.

Each and all of these factors define the need, purpose and ultimately the goals of this plan. Floodplain management as an activity or function in and of itself has not been clearly and comprehensively defined in Baltimore City. Various flood control studies and projects have been completed in the past and land use regulations in hazard areas were implemented primarily based on Federal guidelines. None of these efforts made any attempt to examine flooding in a systematic way, City-wide, on a watershed-by-watershed basis.

The purpose of this plan is to assess the flooding problems in the City, to review all available management and control strategies and techniques and to select from among these, the most effective, within a defined set of constraints, which include social, economic, and environmental parameters.

The result of this review will be the identification of management approaches most effective and applicable to Baltimore's needs. These will then be applied, where appropriate, to specific flood hazard areas. If a selected strategy requires engineering beyond the scope of this plan, or if insufficient hydrologic information is available for certain areas, then more detailed studies are recommended.

Interjurisdictional coordination is an important element of the plan. The Jones Falls, Gwynns Falls and Herring Run are all interjurisdictional watersheds. Management alternatives selected for implementation must be compatible with Baltimore County's programs. Proposals of Baltimore County have been considered in this plan for each watershed. Interjurisdictional reviews for compatibility have been conducted and are reflected in the plan.

The goals guiding this plan are to reduce property damage and loss, to minimize risks to the health and safety of citizens, and to promote wise and compatible land uses in flood hazard areas. The identification of the most efficient and economical measures to meet these goals is the primary purpose of the Baltimore City Floodplain Management Plan.

The remainder of the plan examines in detail the history of flooding, its causes, the advantages and disadvantages of the many management alternatives, existing legislation, and the application of effective management to each watershed.

ASSESSMENT OF FLOODING PROBLEMS

HISTORY OF FLOODING IN BALTIMORE

With three major stream networks and the Patapsco River/Harbor, Baltimore City has always had its share of floods. Historical accounts, beginning in 1786, describe the sudden nature and tremendous magnitude of floods which time and again have caused extensive damages in the City. The proximity of homes, mills, factories and farms to the City streams and Harbor and the density of development in a growing city rendered these floods all the more destructive.

Major floods have occurred on October 5, 1786; August 8, 1817; June 14, 1837 and an especially dramatic flood took place on July 24, 1868. By this time, citizens had learned to expect some flooding as described in an historical article on the 1868 flood: "It had been some 30 years since a big flood had hit the area. Minor floods there had been almost every year, with the falls overflowing into the near-by streets and doing some damage, but these were hardly more than a nuisance" (Sun, July 21, 1957). Baltimore was recovering from the ravages of the Civil War, with cotton and grist mills, along with sugar refineries and iron works prospering, and a population of more than 200,000.

The storm of July 24, 1868 began early on a Friday morning. By sunset, the rain had stopped and the flood waters had begun to recede. In that short span of time, the Jones Falls rose 20 feet, claimed over 50 lives and caused millions of dollars in damages. The downtown area was hardest hit. The Patapsco River also flooded that day-Ellicott City was devastated. Harper's Weekly, in its August 8, 1868 account of the "Black Friday" flood, found the rapid rise in stream height "difficult to explain." Even today, citizens express consternation at the sudden and extremely violent nature of stream flooding in the City.

The Jones Falls is not the only City stream to overflow its banks in a sudden and forceful manner from severe rainstorms. On August 4, 1911, Herring Run flooded in both Baltimore County and City, sending horses, streetcars and people downstream. Fortunately, no deaths were reported, the major damages being to bridges, roads and adjacent houses. On July 23, 1923, the Patapsco River flooded very severely, incurring more damages than suffered during the 1868 flood.

The storm of 1933 caused tides of 8.33 feet at Fort McHenry, inundating the downtown area. A damage estimate of 5 million dollars included 350 flooded homes, as well as losses to the downtown wharves, warehouses, shops, lumber yards and factories. Homes and mills in the Jones Falls Valley also experienced severe flooding.

Hurricanes and tropical storms caused flooding damages in Baltimore during the 1950's (Hazel, 1954; Connie, 1955) and 1960's. However, 1971 and 1972 were particularly bad for Baltimore. In August of 1971, 7-1/2 inches of rain fell in less than 48 hours. Baltimore City was declared a disaster area. At least 8 lives were lost in the Baltimore area. Then, on September 11, 1971, another severe storm hit. Herring Run rose 15 feet above normal in some areas. On the other side of the City, Maidens Choice Run, which runs partially in culvert under Frederick Avenue near the western city boundary, flooded. Apartments were filled with 5 feet of water and cars were covered by the flood waters. A four-car garage on Maisel Street in the lower Gwynns Falls was swept off its foundations (Baltimore Sunpapers, September 12, 1971).

Tropical Storm Agnes struck the following year, on June 21-23, 1972. Statewide, 43 million dollars in damages to public land and 66 million dollars in private property damages were reported. Estimated losses in the Baltimore area were 33.9 million dollars. 1.7 million dollars in federal disaster relief funds were awarded to the City, to repair damaged public utilities, stream channels, roads and bridges, and other public facilities. Damages occurred in all three major watersheds- the Jones Falls, Gwynns Falls and Herring Run.

During Hurricane Eloise, in 1975, 10.8 million dollars worth of damages were reported for the Baltimore area. Ellicott City, in Howard County, was particularly hard-hit by Eloise.

Subsequent to Eloise, the most severe recent storm to strike the Baltimore area was Tropical Storm David. This storm occurred on September 5-6, 1979. Nearly four inches of rain fell in less than one hour over the northern and western Jones Falls watershed. Western Run and other tributaries overwhelmed adjacent properties causing extensive damage in the City. The Federal Emergency Management Agency has approved nearly 8.7 million dollars in Federal disaster relief funds to again repair public utilities, roads and bridges, stream channels and other public facilities damaged during David. These repairs have taken place over the past two years.

Thus, it can be seen that Baltimore City has been subjected throughout its history to the threat and reality of flooding. Yet, because several years may lapse between major flood disasters, there has been a tendency, as in all flood-prone communities, to forget the hazard and rebuild in the floodplains. In the next section, "Causes of Flooding Damage" the physical phenomena of flood events and the human alterations to the landscape will be examined to determine how these two interact to result in flooding damages.

CAUSES OF FLOODING

Meteorology

The climate of Baltimore is characterized by generally mild winters and summers with high humidity and relatively warm days and nights. Temperatures are moderated by proximity to the Chesapeake Bay. The area lies in the path of low pressure systems which move west to east across the country, causing frequent changes in surface wind direction and contributing to the changeable character of the weather.

In the Baltimore area, the prevailing wind direction from October to April is from the northwest. From May to September, the prevailing wind direction is from the south and southwest. It is during the latter range of months that most severe storms occur. The southwest is the most frequent direction of stormy weather. Heavy thunderstorms which often accompany rapidly moving storm fronts in the summer may cause severe flash floods and damage from high winds and lightning strikes. Hurricanes and tropical storms are more destructive, but more predictable. They are most numerous in the summer and early fall months. Hurricanes and tropical storms develop over the Atlantic Ocean near the Equator, move westward over the North American continent and then begin to travel northwestward. By the time a hurricane or tropical storm reaches the Baltimore region, much of its strength has been diminished from passing overland. However, high winds, heavy rains and exceptionally high tides accompanying the storm, occasionally cause severe damage and loss of life. During Hurricane Agnes, on June 21-23, 1972, $110 million in damages was reported in Maryland. Over 10 inches of rain fell in Baltimore during the hurricane.

The Floodplain

Flooding from severe thunderstorms, tropical storms and hurricanes occurs as the amount of precipitation exceeds the capacity of existing river and stream channels. Along coastal areas, the exceptionally high tides cause shoreline flooding and potentially destructive wave action. In Baltimore City, the floodplains of the three major watersheds (Jones Falls, Gwynns Falls and Herring Run) and the Patapsco River/Harbor system are flood hazard areas. Because of its sheltered location, the tidal areas in the City have historically received few damages from wind-generated waves.

The overflow of flood waters to adjacent land is a natural part of the hydrologic cycle. As waters overtop the banks of the waterway, materials eroded from the channel and banks are carried along. This gravel, sand, silt and clay is deposited as the water velocity decreases, forming a floodplain. The floodplain functions as a storage area for flood waters, thereby helping to lessen the flood severity downstream, and as a zone of deposition for eroded materials. Floodplains are characteristically fertile and therefore prime agricultural land. In addition, the gentle topography and proximity to water makes floodplains attractive sites for the development of towns and cities.

A flood causes abrupt and extensive changes to stream and river channels and banks, coastal shorelines and the floodplains adjacent to these waterways. The course of a stream or river may become radically altered by a severe flood. The channel may become deeper and wider, erosion and deposition may change its configuration, and the floodplain may be extensively disturbed. Vegetation is destroyed by streambank undercutting, and the floral and faunal associations are temporarily disrupted. Coastal areas may gain or lose fast land.

These abrupt changes are, just as the floods which cause them, a natural part of ecosystem development. Disruption of the riverine or coastal ecosystem by severe storms may cause the affected areas to revert to an earlier stage of ecological succession. At any given time, a segment of stream river or coastline may be in such an earlier stage of succession as the result of a major or minor storm. This state of dynamic equilibrium constitutes the biological, geologic and hydrologic development of a river, stream or coastal system.

Geology and Topography

The geology and topography of Baltimore City and surrounding counties influence the behavior of floods. Baltimore City lies within two physiographic provinces - the Coastal Plain and Piedmont. The Atlantic Coastal Plain in Baltimore is a gently rolling upland which leads to the Chesapeake Bay. It is underlain by the crystalline rocks of the Piedmont Plateau and is composed of many layers of unconsolidated water-deposited sedimentary rocks. These rocks dip southeastwardly from the Fall Line to the edge of the continental shelf. The rocks are formed of gravel, sand, clay and silt. The Eastern Division of the Piedmont province, which includes all of Baltimore City and Baltimore and Harford Counties north and west of the Fall Line, is characterized by low undulating hills and deep, narrow stream valleys. This province is underlain by a complex series of metamorphic (gneisses, slates, phyllites, schists, marble, serpentine and grannitic and gabbroic) rocks (Maryland Geological Survey, 1957). These rocks are resistant to erosion. Thus, streams running through the Piedmont province form steep gradients with waterfalls and rapids as common features, in contrast to the slower-moving, meandering nature of streams in the Coastal Plain.

The three major stream networks, Jones Falls, Gwynns Falls, and Herring Run, originate in the Piedmont province. During heavy rainstorms, runoff rapidly fills the narrow stream channels upstream from the Fall Line. The steep gradients cause the streams to flow rapidly. The steep valleys and low erodability of the rocks prevent the water from flowing laterally and thereby expending energy. The downstream effect is to receive a rapidly flowing high volume "wall" of water so often described in historical accounts of flooding. As the flood waters reach the Coastal Plain, lateral movement of water occurs causing flooding of the adjacent land.

Development in Watersheds

In pre-settlement times, flooding along the Baltimore area stream valleys was of little consequence. However, development along the streams, on the floodplains, and upland of these features has resulted in considerable loss of life and property, as well as social and economic disruption. The interplay between development and flooding is a complicated and on-going process. This discussion will attempt to identify those development patterns which have led to flooding damages, and development activities which tend to worsen flooding and its damages.

As mentioned earlier, waterways have historically been common and desirable locations for settlement. The Fall Line in Baltimore City was an ideal location for mills and factories. In the very early days of settlement, it was possible to bring ships up closer to these mills to transport the manufactured goods. As upland clearing for agriculture increased, siltation of the streams below the Fall Line made this practice impossible (Maryland Geological Survey, 1957). On the fertile Coastal Plain, agriculture thrived until the increasing pressures of urbanization led to the conversion of fields to homes, offices, shopping areas and paved streets. With its proximity to the Chesapeake Bay, Baltimore has evolved into a large city, and the fourth largest port in the country. This dependence on water resources has allowed Baltimore to grow and prosper, yet with this prosperity has come the problems of repeated flooding, and, as development has proceeded, worsening damages.

The conversion of forests and fields to impervious surfaces (roads, buildings, parking lots), decreases the ability of rain and snow to infiltrate into the ground. The loss of this infiltration capacity results in increased surface runoff. Water flowing over paved surfaces has a higher velocity than water which is first trapped by vegetation, transferred down into the soil and then flows laterally by gravity to a nearby stream.

To compensate for the loss of this infiltration capacity, it becomes necessary to install storm drains, diversion ditches and similar structures to conduct runoff away from areas where it may cause problems, such as in yards, on roads, and on parking areas. Drains, ditches and other drainage systems will also convey water at a faster velocity than under natural conditions. Therefore, from a given developed area with a drainage system, there is increased surface runoff due to greater impervious surface area, and accelerated runoff velocities due to the paved surfaces and artificial conduits. A storm drain system is designed to handle a certain amount of runoff. If a greater rainfall occurs, the amount of runoff will exceed drain capacity and localized flooding may occur.

Eventually this collected runoff is directed to a stream. The receiving stream may be the same stream which received the runoff in pre-development. In the post-development situation, however, the same stream receives an increased amount of water, in a shorter amount of time, and flowing at a greater velocity. This may lead to erosion of the streambanks and flooding along stretches of the stream which previously did not flood. This is one way in which development in a watershed may worsen both the amount of flooding and the degree of flooding damages.

The filling of floodplains for human activities is another way in which both flooding and flooding damages may be exacerbated. Filling will decrease the amount of natural storage area for flood waters. It also constricts the flow of flood waters. These two factors may raise the flood elevation. In addition, since filling is done to allow the development of new fast land, damages to the new structures become possible because of their location in a flood hazard area.

The construction of bridges over streams and rivers is another way in which development alters the behavior of flood waters. During a flood, bridges may act as dams, especially when debris accumulates on the upstream side of the structure. For example, in the 1800's, Baltimore had many bridges over the Jones Falls. During floods, these bridges blocked the free passage of water until the force of the water dominated:

> "The bridges over the stream were the first things to feel the full force of the flood. The small wooden one over Charles Street Avenue was torn loose and swept along . . . Pieces of the wrecked bridge smashed into the spans at Madison, Monument, Centre, Bath, Hillen and Fayette Streets and they too were destroyed. Some of them were carried away so suddenly that people on them could not escape." (Sunpapers, July 21, 1957, article on flood of 1868.)

Bridges today, which may be better able to withstand the force of flood waters, will in some cases force the waters to back up and spread laterally, inundating a larger land area.

By developing in the floodplain, human endeavors are made vulnerable to the dangers of flooding. Homes situated in flood hazard areas may be prone to basement flooding or total destruction. Public utilities (sanitary sewer and storm drain lines, natural gas and electrical lines, and telephone lines) are all susceptible to damage from flooding. Roadways may be washed out, or become too perilous to use due to flooding. Businesses and factories risk the loss of large investments when they are located in flood hazard areas, and the workers in these buildings are subjected to potential danger as well.

Today, Baltimore City must continue to develop management strategies for the reduction of damages from flooding in a highly urbanized setting. Homes, businesses and factories are located in the City's floodplains. However, it should be mentioned that much of the City's streams are surrounded by parkland. This is true for much of Gwynns Falls, Dead Run, Herring Run, Chinquapin Run and Stony Run. The approach to reducing damages where structures, roads and utilities are threatened, must be one of lowering risks and damages to an acceptable level, by using a combination of techniques in a cost-effective manner.

FLOODPLAIN MANAGEMENT STRATEGIES AND TECHNIQUES

STRUCTURAL AND NON-STRUCTURAL APPROACHES IN FLOODPLAIN MANAGEMENT

Structural approaches to floodplain management are engineering techniques which attempt to control the flow of flood waters and thereby reduce flood damages. Structural techniques include the construction of dams and reservoirs, dikes and levees, and the channelization of rivers and streams. These structures may reduce the magnitude of flooding by providing storage for water, by keeping flood waters out of developed areas, or by increasing channel capacity through either increased cross-sectional area, or increased stream velocity. Structural measures for flood damage reduction tend to be capital-intensive, and have been largely federally funded in the United States. It is estimated that more than $10 billion has been spent since 1936 by the federal government on flood control structures with an additional $1 billion contributed by states, local governments and special districts.

Non-structural approaches to floodplain management are those techniques and strategies which attempt to control land use and human behavior, rather than the flow of flood waters, to reduce or eliminate flood damages. Non-structural techniques include acquisition and relocation, flood insurance, floodproofing, early warning systems, land use regulation through federal, state and local legislation and programs for regular stream maintenance. Non-structural techniques are generally less capital-intensive than structural flood control techniques.

Emphasis has shifted in recent years from the use of structural techniques to non-structural alternatives in floodplain management. The role of the Army Corps of Engineers, for example, shifted radically from building flood control structures to offering technical assistance in floodproofing and other non-structural techniques. This shift occurred as it became clear that, in spite of the billions of dollars spent in local flood control projects, losses from flooding have continued to rise. The 1968 National Flood Insurance Act recognized the need for wise floodplain management, to reduce flood losses, and to maximize the benefits from a multi-disciplinary and comprehensive approach to land use in the Nation's flood-prone areas. Legislators, planners, engineers and natural resource managers have broadened the range of tools available for floodplain management. For local governments, this has meant increased technical and financial assistance to implement new programs for wise management of their flood hazard areas.

In this section there will be a discussion of the various structural and non-structural alternatives for floodplain management. A comparison of these alternatives appears in the next section of the Plan. It should be apparent that the application of one of these alternatives does not preclude use of other alternatives in the same flood-prone area. In fact, it is often the case that some combination of solutions will yield the greatest benefits.

STRUCTURAL APPROACHES

Structural approaches to flood damage reduction are often classified as traditional strategies. These measures attempt to affect the stream flow by storing water upstream in reservoirs or by altering the floodplain with levees, channalization and conveyance systems to pass the water downstream where it may be accommodated. These measures attempt to, in effect, reclaim the floodplain for some other use.

When implemented, structural approaches have proven effective in protecting property and lives against flooding frequencies they are designed for. These measures also have significant drawbacks. Large capital investments are required which limits the application of these structures to situations where the benefits are substantial. Even in these cases there are often burdensome operation and maintenance costs.

Structural improvements can also foster a false sense of security leading to inappropriate land use in protected areas. An example of this would be the occupancy of a floodplain protected from a 50 year flood by levees. When a 100-year flood occurs tremendous damage can occur. These structures also tend to have profound impacts on the hydrology and ecology of streams.

RESERVOIRS

Reservoirs can generally be classified as large or small depending on their location and tributary area. Major reservoirs are large structures located on the main stem of rivers and principal tributaries. They control runoff from large drainage areas and store large volumes of flood waters. Small reservoirs are located on smaller tributaries. They have a much more local effect than the larger reservoirs but can be grouped together in larger watersheds to achieve major flood control objectives.

The primary purpose of reservoirs is to protect downstream areas by storing flood waters upstream. To accomplish this the dam and water release system must be designed to reserve excess storage capacity. Some small storage areas may actually remain dry except during heavy rainfall, thus using the dam's entire capacity for flood storage. Other reservoirs may be maintained at a level below the crest of the dam, or its spillway, thus providing storage between the standing pool elevation and spillway.

Most reservoirs have a multi-use potential for recreation, flood control and water supply. To achieve these benefits requires compromise on other objectives. Constantly varying pool elevation can disrupt recreational benefits and recreational uses can effect water supply needs. Most reservoirs with flood control as their primary purpose have difficulty achieving these multi-use potentials due to pool fluctuation during wet weather.

LEVEES AND FLOODWALLS

Levees and floodwalls are designed to act as barriers against flood waters in the area where they are located. They can be earthen or masonary. These structures are effective in reducing damages, to areas protected, from floods for which they are designed. The larger the design flood the larger the structure and the more land area needed.

There are floodwalls in use in Baltimore City already, however, these are designed to protect only limited areas. These structures are, like dams, expensive to construct. There are also physical limits to their size. For some flood hazard areas construction of levees or floodwalls would require the removal of the land uses they are designed to protect.

These types of structures also cause more severe flooding downstream by eliminating flood storage capacity in floodplain areas.

CHANNEL IMPROVEMENTS

This approach consists of physical alteration to the stream channel to increase its efficiency. Measures such as widening, deepening, and lining are all used. The objective is to move floodwaters through an area more quickly thus reducing the depth they reach.

This approach is expensive but not as costly as reservoirs, levees, and floodwalls. It is often difficult to protect against large floods without widening the channel beyond the areas desiring protection. Flood heights can be increased downstream and stream ecology is severely disrupted.

UNDERGROUND CONVEYANCE

In some drainage areas the complete enclosing of a stream for flood protection has been used. In Baltimore the lower portion of the Jones Falls is completely within conduit.

This method provides more land for development after completion by allowing construction over the stream.

As in other structural approaches there is a tremendous cost involved. To accommodate large floods very large conduits must be constructed. This approach also fosters a false sense of security especially since the stream is completely hidden. Downstream flooding can be increased and stream ecology is completely destroyed.

NON-STRUCTURAL APPROACHES

Acquisition of Flood-Prone Properties

Introduction

The acquisition of flood-prone properties is a useful tool in the management of floodplains. It is a method whereby inappropriate land uses can be relocated to more appropriate sites, and the floodplain restored to a more natural state. An undeveloped floodplain can function to buffer upland development from the potential damages of severe floods. In addition, more open space is created, enhancing plant and wildlife habitats and recreational opportunities. It is a permanent solution to flooding damage, in that removal of buildings and restoration of the floodplain, combined with adequate long-term land use controls, will prevent future inappropriate uses. In its Flood Grant Program Policy statement, the Maryland State Board of Public Works states that "Acquisition and removal of flood-prone structures is considered as one of the most prudent investments of grant funds for flood control."

The decision to acquire properties in flood-prone areas involves the resolution of many problems and issues. Its selection as an alternative must be carefully analysed and shown to be a cost-effective, socially and politically acceptable solution to a flooding problem. Acquisition may be best suited to areas where the threat of flood damage is most severe (residential properties in high-hazard areas), where open space needs have a high priority, and where critical natural values (flood storage areas, and wetlands) must be restored or protected (Ralph M. Field, Associates, 1981).

In general, the areas of highest risk are residential properties which experience repeated and serious flooding, and where other flood control alternatives are ruled out. Floodproofing in these areas, for example, may not be a viable alternative, particularly if (1) the floodwaters exceed the first floor elevation, (2) the structure is old or has been damaged by previous floods, and (3) there is a desire or need by the community to restore a floodplain to a more natural state, for flood water storage and/or open space. Flood insurance, another non-structural alternative, may not adequately offset the flood damages and does not afford physical protection of life and property.

Acquisition can be a complicated process, since it involves legal, social and financial considerations. The basis for acquisition should be the knowledge of high hazard from flooding, and the recognition that other floodplain management alternatives alone will not solve the problem. The following discussion is based upon "State and Local Acquisition of Floodplains and Wetlands" (2nd Review Draft, May 1, 1981) prepared by Ralph M. Field Associates, Inc., for the U.S. Water Resources Council.

Voluntary vs. Mandatory

A major issue which must be addressed in acquisition is whether to institute a voluntary or mandatory program. A voluntary program avoids the problems of condemnation, and the potentially negative reaction that a compulsory system may evoke in floodplain residents and the general community. Condemnation also involves court proceedings and may slow down the acquisition program.

A voluntary program must rely upon the education and cooperation of affected citizens and (especially if the program is to receive public funds and/or affect nearby property owners) of the general community. Education can be accomplished through public meetings, letters to homeowners, and publicity for the program to enlist support. Reluctance on the part of homeowners to sell may be overcome when a few voluntary sales occur. In this way, other property owners see that the government is implementing the program in a socially and financially responsible manner.

The use of condemnation may at times be a necessary tool in floodplain management. The right of eminent domain is a power of government used for many purposes, for example, to protect public health and safety. The exercise of this power may be called upon where a property is in a high hazard area, and the surrounding properties have been voluntarily sold to the government body. The continued provision of services (road maintenance, water and sewer service, and trash pick-up) to a single or a few remaining "hold-outs" may not be cost-effective. In addition, condemnation may be used as a last resort, if property ownership is not clear and acquisition of the land has been agreed to by both parties, or if a fair market price cannot be agreed upon by the owner and the government body.

The lengthy and costly court proceedings and the uncertainty of the outcome (being decided by the court rather than by negotiations between parties) make condemnation less attractive than instituting a voluntary program. It may be wise to begin a well-organized voluntary program, with adequate information provided to affected property owners, and to use condemnation only in those cases where a high risk parcel of land cannot be acquired through voluntary means.

Approaches In Acquisition

Another aspect of acquisition is the manner in which a government body decides to acquire properties, other than by condemnation. A fee-simple arrangement will give the acquiring agency full title to and control of the land. Some techniques of fee-simple acquisition are:

1. Purchase at fair market value
2. Purchase at less than fair market value
   a. Tax delinquent properties-foreclosure
   b. Bargain sale-part sale and part donation (tax-deductible)
   c. Purchase and Leaseback-controls land use, may avoid maintenance costs to government
   d. Purchase with Reserved Life Estate-property sold to government, but owner has continued use and possession for remainder of owner's life
   e. Purchase with Exchange of Property-government exchanges publicly-owned land in another location for flood-prone property
   f. Purchase and Resale - property purchased by government body, then resold, with restrictions written into deed, for specific compatible uses

Less-than-fee simple (no transfer of title) procedures include:

1. Leases - government body controls land use for lease duration, pays rent and any other conditions of lease: may be more affordable than outright acquisition

2. Easement - government body is granted or purchases right to a portion of land for protection of floodplain; terms include activities to be allowed (or prevented) on easement, duration of easement; tax benefits to property owner (similar to donation; real estate taxes reflect lowered property value with restrictive easement)

3. Transfer of Development Rights - right of property owner to improve land transferred to government body; tax benefits to property owner

Donation is a third way in which floodplains can be managed to minimize damages and financial loss. Types of donation include:

1. Outright Donation - all rights given to recipient, but restrictions on future use and management may be in deed of transfer; tax benefits to donor

2. Reserved Life Estate - land donated but available to owner for remainder of owner's life; income tax and estate tax benefits to owner

3. Donation by will - property donated at time of owner's death, restrictions on land use may be stipulated; may not be subject to estate or inheritance taxes

4. Donation and leaseback - land donated as a gift to government body, which then leases it back to original owner; income tax-deductible

The ability of a community or government body to take advantage of these many options will depend on the number of properties to be acquired, the financial constraints of the program, the available professional staff to implement the program and the cooperation of the community at large.

Property Selection

Selecting properties for acquisition will entail setting policies, developing guidelines to follow in determining relative risk of the flood-prone properties, and the actual identification of specific properties for acquisition.

Policies may include a decision on whether to purchase strictly residential properties, or to extend the program to non-residential properties as well. In general, acquisition costs of commercial and industrial interests are higher than for residential properties. As already mentioned, setting a policy concerning the use of eminent domain should be considered. Another policy issue is the number of times the purchasing agency should approach a given property owner for acquisition. A "one-shot" deal may force the owners to think seriously and "get out while the getting is good." On the other hand, some owners who refuse acquisition may change their mind if they are subsequently flooded. The community agency should have a policy on reconsideration of these owners. The decision to reconsider such cases will probably depend on the amount of funds available the second time around.

Another policy issue is the relocation assistance to be provided to the owners of purchased residential properties. The implementing agency must be cognizant of all laws, regulations and precedents set by the government for relocation assistance. Paying resettlement fees to tenants of flood-prone homes may also require consideration in the program.

Policy formulation in a property acquisition program must allow sufficient flexibility to effectively deal with each acquisition. Each property and its owner present a different set of circumstances which will require some individualized attention by the acquisition program staff.

Developing the list of flood-prone properties for acquisition may require many sources of information. These may include hydrologic and hydraulic studies of the flood-prone areas, access to the names, addresses and property characteristics (acreage, assessment, etc.), historical information on flooding problems in the various areas, flood insurance and damage claim information, and field checks to verify, to the extent possible, flood damage potential and existing structures.

Implementation

After general policies have been set, properties have been identified, and the program has been set up, the process of notification must begin. Potential sellers should be notified as early in the process as possible, to prevent apprehension and encourage cooperation. For those property owners who express a desire to sell, the process then becomes very similar to a private sale arrangement. However, the relocation procedure and property management must also be activated.

In order to implement an acquisition program, there must be a designated agency with adequate staff. The personnel should be aware of the many potential approaches to acquisition and of the need for sensitivity to the apprehensions and needs of potential sellers and donors of flood-prone properties. The agencies chosen to implement the program should be capable of managing all necessary real estate transfers, relocation, the appraisal process, building demolition and site restoration. This kind of program will require cooperation and coordination among several agencies within a local government. Speed and efficiency in completing each acquisition will help to insure the success of the program.

Conclusion

As mentioned earlier, acquisition is a useful tool in floodplain management. It is an alternative which involves considerable capital investment, and is complicated in terms of the legal, social and financial arrangements necessary. There is a need for strong coordination to implement the program. Community opposition to the acquisition of private property will essentially halt its implementation. There will be some loss of tax revenue, as those acquired lands and structures become public property. This loss, however, will be offset by the taxes paid by resettled property owners within the jurisdiction and by reduced flood damage repair costs. Finally, the need for ongoing public management of acquired lands could involve public fund expenditures. Acquisition, used in those situations where lesser measures will not insure public health and safety, and where its application will have multiple benefits, is an effective method of significantly reducing flood damages and enhancing the value of floodplains as flood management components as well as natural and recreational areas.

FLOODPROOFING

Introduction

The term "floodproofing" in the literature on flood hazard mitigation, may have two different meanings. One definition used by the Army Corps of Engineers is "a method that reduces or eliminates flood damages to a structure and its contents." It has been suggested that "flood resistance" is a better term, since many of the techniques used to "floodproof" a structure accept the entrance of at least some water. For the purnoses of this report, "floodproofing" will include all those techniques that reduce or eliminate flood damages to a structure and/or its contents, by either altering the structure, or the organization of its interior space and use patterns.

Floodproofing as a viable alternative in flood damage mitigation gained recognition in the late 1950's. The Flood Control Act of 1960 recognized that floodproofing is one alternative by which some measure of protection may be gained against flood damages. In 1966 the Department of Housing and Urban Development issued the document Site Preparation and Flood Proofing of Buildings, and in 1972 the Army Corps of Engineers published it's Flood-proofing Regulations.

Methods of Floodproofing

Floodproofing methods may range from major structural design or alterations to "common sense" measures, such as moving inventory or belongings to the second floor. They may be applied when designing a new structure to be built in a known flood hazard area, or they may be measures retrofitted to existing structures.

Floodproofing techniques are often broken down into three main categories:

1. Permanent measures - these are such techniques as elevating new structures, raising existing structures, or permanently bricking up non-essential openings.
2. Contingency measures - these include pre-planned activities, such as having door and window flood shields ready to be put in place, and an evacuation plan.
3. Emergency measures - these are "spur-of-the-moment" preparations carried out during an actual flood experience and may include sandbagging, installation of wood plank and polyurethane sheets to keep out floodwaters, or moving contents to an upper floor.

Contingency and emergency measures require some warning time, and depend on the actions of persons present in the structure to perform needed tasks quickly and correctly.

A partial list of floodproofing measures includes:

1. Elevating structures above the 100-year flood level.
2. Placement or replacement of utilities to minimize flood damage.
3. Bricking up unnecessary doors and windows.
4. Flood shields over necessary doors and windows.
5. Contingency plans for movement of valuable items (inventory, furniture, mechanical and electrical equipment) to higher elevation.
6. Installation of sump pumps.
7. Installation of flap gates or one-way valves to prevent backflow from sanitary line into building.
8. Low floodwalls around unmoveable machinery in flood-prone areas such as basements.
9. Use of water-resistant materials (exterior grade plywoods, tempered hard boards, waterproof plaster, metal rather than wooden, windows, doors, and door jambs waterproof adhesives for tiling).

Floodproofing is used in both residential and non-residential structures. In general, more success is met when dealing with non-residential buildings. This is due to the (generally) stronger construction of these buildings, and the personnel available for implementation of floodproofing measures.

Residential Floodproofing

With both residential and non-residential structures, it is much easier to build floodproofing features into a new building than to retrofit an existing building. For residential structures, a common practice is to build the house up on pilings, posts, piers, or walls. The use of break-away walls, where it is desirable to enclose all or part of the ground level under the elevated structure, will prevent excess stress on the structure. Utilities to be hooked up should be brought into the house in one linkup "core". Furnace, hot water heater and electrical hook-ups should be in the attic rather than below. Knowledge of flood elevations and direction of flood flow are important for planning structure height and orientation. Construction materials must be able to withstand the hydrostatic and hydrodynamic forces, as well as the additional exposure of a raised structure, to be a safe residential building. (See Elevated Residential Structures, FIA 1976, for a more complete discussion.)

While there are many architectural and engineering techniques available to minimize flooding damage to new residential structures, there can be no guarantee of human safety. Injury or loss of life may occur while residents are travelling to and from their homes. Persons living in homes in flood hazard areas may be left stranded and isolated for hours or days after a severe storm. In addition, a house designed to be "floodproof" may instill a false sense of security. If the design storm is exceeded, the structure may fail, resulting in disaster.

It is therefore necessary, in conjunction with a floodproofing program to examine existing allowed land use in a jurisdiction's flood-prone areas, and to decide on a policy for future land use. One option is to prohibit all new residential development in the floodplain. This policy, combined with building codes which prevent substantial improvement to existing residential structures, and acquisition, will eventually result in floodplains with little or no residential structures. (See discussion on Building Codes and Acquisition.)

Floodproofing of existing flood-prone residential structures must be carefully evaluated by trained engineers to insure that any measures to reduce flood damages do not worsen flooding problems. One major consideration is the strength of the structure. Flood waters exert great vertical and lateral pressure on structural floors and walls. Residential buildings are generally not designed to withstand such pressures. Flooding often further weakens the structure by shifting the foundation, cracking joists or beams and causing warping of the lumber.

Sealing up foundation cracks, bricking up windows and doors, and other measures that result in keeping water out of the basement of a home may result in worse damage than if water were allowed to enter. This is due to the unequal pressure exerted from outside the foundation by the lateral and vertical forces of overland flow and groundwater seepage which occurs during a flood. A typical new or fully renovated residential structure can be safely made "watertight" to a maximal flood depth of 2 to 3 feet above the ground surface. Older homes will be less resistant to hydrostatic and hydrodynamic forces.

If it is found that a basement may be safely waterproofed to 2 or 3 feet, this can be done by bricking up any non-essential door and windows, sealing the foundation with epoxy or other waterproof sealer, installing a sump pump with a check valve (which cannot be hooked up to the sanitary sewer line in Baltimore City), and putting a check valve on the sanitary sewer pipe to prevent backflow. For residents' safety, evacuation plans should be part of the floodproofing scheme even with this level of protection. Should the flood exceed the design height, the structure may be severely weakened, and a potentially dangerous situation will exist.

For homes in which it is found that making the basement watertight is unsafe, several alternatives exist to minimize flood damages. Low flood walls surrounding window and exterior stair wells may prevent minor flooding from entering the basement. Electrical panels, furnace, hot water heater and other machinery, appliances and valuables should be either protected with low flood walls or relocated to the first floor. A sump pump can help minimize water damage. A flap gate or check valve should be installed on the sanitary line.

In either case, if flooding above the first floor is likely, an evacuation plan should be in place to remove citizens from their homes. Homeowners should be educated to the flood dangers and aware of local warning and evacuation procedures.

Non-Residential Floodproofing

Non-residential structures in flood-prone areas often represent large financial investments in spite of their hazardous locations. In many cases, industrial or commercial development in floodplains exists because of an historical link (for energy and/or transportation) with the water resource. In Baltimore, for example, there are industries in flood-prone areas for whom complete protection or relocation is not economically feasible. Floodproofing may be the cost/effective approach to preserving the employment and tax base while at the same time reducing flood-damages.

Floodproofing of non-residential structures includes many of the same features used in residential structures. In general, commercial or industrial buildings are of stronger materials and can withstand greater hydraulic pressures. This may not, however, be the case with older industrial buildings or with some of the new "pre-fabricated" structures used for factories and warehouses. In addition, buildings with many doors and windows would be difficult to floodproof.

Floodproofing features incorporated into the design of new non-residential structures can maximize the potential flood protection. Flood damages can be minimized by designing walls and floors to withstand hydraulic forces, using waterproof materials, orienting the building to alter flood flow least, eliminating openings below the 100-year flood level, installing flood shields near essential openings, flap gates on sewer lines, and carefully organizing the interior space (operations, storage, machinery placement). A consideration of the need for safe ingress and egress from the new building must also be included, and a standard operating procedure including evacuation plans should be developed and rehearsed by personnel.

Floodproofing existing buildings often poses more of a challenge. As already mentioned, some building designs do not lend themselves to the easiest and most effective techniques of floodproofing. In these cases, a combination of techniques may be used to minimize damages. The structure must be assessed for strength, anchorage, and position in relation to the flood waters. If it is found that the structure, or portions of it, will not withstand the hydrostatic and hydrodynamic pressures of the flood waters, floodwalls (where the flow, direction and velocity of the waters will not be changed to affect adjacent properties) may be useful. These walls may be constructed directly against existing walls to lend additional protection, or they may be constructed at a distance from the structure. A grout curtain may be constructed to help keep ground water from flooding the building. This type of structure consists of a non-porous material (concrete) poured into holes which are drilled into the ground around a building. The material forms an underground shield to prevent lateral seepage of water. The use of a grout curtain depends upon the surficial geology, the soil and topography of the site. Ideally, the grout curtain would extend downward in the soil to an impervious feature such as bedrock. Where the grout curtain will not form a completely impervious underground wall around a structure, it will lengthen the route of water flow by forcing the water to flow downward and around the curtain. This will slow the progress of the water, and thereby lower the chances of the water reaching the foundation. Flood waters may begin to recede before arriving at the structure.

The relocation of machinery, raw materials and inventory, either permanently or according to contingency plans, will reduce losses. For machinery which cannot be relocated, protection can be provided by building low floodwalls around the base of the equipment, or enclosing the equipment in floodproofed rooms. Alternatively, dismantling the equipment to move essential parts to a dry area, or covering the machinery with a protective substance such as plastic or navel jelly, may reduce damages. Storing materials and inventory on carts or tables with wheels will facilitate moving them to a second floor or protected area.

As with residential structures, any non-essential openings (doors, windows, vents) should be bricked up, providing this will not cause excess structural stress. Glass block may be used where natural light is required. Flood shields for essential doors and windows can be fitted to existing openings. These shields must be quickly and correctly placed to be of value. Personnel should be trained and given practice in the installation of any flood shields, the movement or protection of machinery and materials and in safe evacuation procedures. Sanitary sewer and sump pump drains should have backwater valves with gates installed to prevent backflow. Finally, a standing operating procedures manual should be prepared and periodically updated.

Conclusion

The decision to floodproof a structure depends first upon the owner's awareness of a flooding problem. First-hand experience, or a "close call" may be required before the reality of flood damages is perceived. Following this awareness, the owner must be cognizant of the various techniques available for reducing flood damages. Some of these, as mentioned earlier, are common sense, such as moving valuable objects to a higher level. However, other techniques will require an experienced engineer.

A floodproofing program must be cost-effective in order to be justifiable. For example, if it will cost nearly as much to floodproof a home as to relocate to a home outside the flood-prone area, floodproofing will be less attractive option. In general, if a benefit/cost analysis yields a ratio of at least 1.3:1, the floodproofing program is cost effective. To determine this ratio, the average annual damages from various frequency floods, are measured against the average annual cost of the floodproofing program.

Floodproofing is a valuable tool when used as part of a comprehensive floodplain management program. It is applicable where existing structures in the floodplain need flood protection, cannot be relocated (for economic or other reasons) and where it is not economically feasible to provide structural flood control measures. The incorporation of floodproofing requirements into local building codes enables the restriction of the construction of new structures and substantial improvements to existing structures. Other benefits of floodproofing include an increased awareness by the property owner of the risks of flooding, more favorable rates in flood insurance for the owner, and a reduction in actual monetary losses should a flood occur.

It must be remembered that floodproofing is not the preferred approach to flood damage reduction in every case. Its use requires a careful examination of the structure, an analysis of flooding conditions and of the soil foundation conditions, and a cost/benefit analysis to determine the effectiveness and financial implications of the program. Finally, any floodproofing measures require carefully developed plans for implementation to make them effective.

FLOOD INSURANCE

Title XIII of the Housing and Urban Development Act of 1968 (P.L. 90-448) established the National Flood Insurance Program. The impetus for this legislation was the realization that:

> " . . . despite the installation of preventive and protective works and the adoption of other public programs designed to reduce losses caused by flood damage, these methods have not been sufficient to protect adequately against growing exposure to future flood losses."

The Act established a flood insurance program to provide affordable insurance to property owners in flood-prone areas. The program was designed to help shift the burden from the general taxpayer to those who own flood-prone property, to encourage the development of sound local land use policies for flood-prone areas, and to become a part of a "unified national program for floodplain management."

As amended, the National Flood Insurance Program (NFIP) has an emergency and a regular phase. Communities in the emergency phase have made the commitment to develop local land use policies to restrict development in flood-prone areas. During the emergency phase, maps are prepared by FIA to delineate flood hazard areas. These maps serve as the basis for local regulations and for determining flood insurance rates. Once these maps are approved and adequate local ordinances are passed, the community enters the regular flood insurance program. Any individual within the community may then purchase flood insurance. Rates are based on the year of construction, the predicted flood hazard, and the type of structure. Insurance on existing structures (constructed prior to entry into the regular program) is partially subsidized by the Federal government. The Federal share is the difference between the so-called affordable premium which is charged to the policyholder, and the actuarial premium. The actuarial premium is that value affixed to insurance based on the statistical likelihood of flooding combined with the potential severity of flood damage. For structures built after community entrance into the program, insurance must be based on the actuarial (non-subsidized) rate. This includes both new construction and substantial improvements to existing structures (greater than 50% market value in improvements to existing structure).

Although the NFIP is voluntary, a 1973 amendment to the Act strongly encourages community and individual participation. The Flood Disaster Protection Act prohibited the Federal government from extending any financial assistance, such as mortgage loans, for the acquisition or development of properties in flood-prone areas without community participation in the NFIP. In addition, the individual property owner must purchase flood insurance to receive any Federal assistance.

Local regulations must meet minimal Federal requirements. These generally fall under zoning, subdivision and building and health code ordinances. Requirements include allowed and prohibited uses in certain portions of the floodplain, minimal first-floor, electrical and mechanical equipment elevations, and minimal standards for the strength and water resistance of construction materials.

The flood insurance program, cannot prevent floods, and does not eliminate flooding damages. It does, however, require that those property owners in flood-prone areas take financial responsibility for locating in a hazardous area. In addition, the NFIP fosters local land use controls to restrict inappropriate use of flood-prone land, and increases community awareness of flooding problems.

LOCAL LEGISLATION

Within the framework of Federal and State legislative authority, a local government can effectively use legislation to control development in flood-prone areas. The Federal government is involved with this local regulatory process through the National Flood Insurance Program, which requires the adoption by a community of local floodplain regulations. Although states generally leave land use decisions to the local jurisdictions, it may, be Constitutional authority, enact legislation to regulate floodplain development. The following is a discussion of local regulatory tools for floodplain management considered as an alternative in the comprehensive plan. For a full discussion of the federal and State legislative framework for floodplain management, see the Appendix.

A local government has several regulatory tools which may be used to implement floodplain management strategies. These tools fall into 2 major categories: those regulations which restrict new development in the floodplain, and those which regulate existing uses of the floodplain. In addition, regulations which address the flow of surface water in any portion of the jurisdiction may have effects on the floodplains. Storm water management and erosion/sediment control regulations, for example, may be applied upland from a floodplain in the watershed, yet affect the nature of that floodplain.

Three main types of local regulations may contain, or be amended to contain, provisions for floodplain management. These are zoning, subdivision and building code regulations. Local Health Codes may also contain sections on the prevention of health and safety risks related to flooding.

Zoning Regulations

The use of zoning laws is the principal land use tool of a local jurisdiction. Through zoning regulations, land is classified as appropriate for a range of human activities or purposes, and as inappropriate for other activities or purposes. Zoning may regulate the structural dimensions on a parcel of land, as well as allowable lot size and density. Regulations will vary from district to district to reflect allowable uses and to insure development according to the limits of prescribed uses. The power to regulate, through zoning, parcels of land differently within a single jurisdiction enables the jurisdiction to set special standards for land use in flood-prone areas. It can be used to regulate allowable or compatible uses in flood hazard areas where specific uses are to be conducted, and how uses are to be constructed or carried out (U.S. Water Resources Council, 1970).

The designation of special floodplain districts must reflect the kinds of flooding experienced, the severity of flooding and the purposes behind the special zoning. For example, a floodplain district may be best suited to open space or recreational uses, and completely inappropriate for residential use. Flood district zoning should be based on hydrologic studies to determine predicted flooding depths and the limits of the floodplain. Coastal flood hazard areas may require regulations that will differ from those required in riverine flood-prone areas. The districts should reflect any special conditions of the flood hazard areas.

The adoption of zoning ordinances for flood-prone areas will make some existing uses of the floodplain non-conforming. For these existing structures, provisions may be made to prevent substantial structural alterations that may increase flooding damage by limiting the allowable repairs or alterations to a percentage of the assessed or market value, or by providing for the amortization of non-conforming uses over a reasonable period of time.

The use of zoning to restrict land use in the floodplain was first exercised by a municipality in Vermont in 1930, only four years after the original approval of land use zoning by the U.S. Supreme Court (Platt, et.al., 1980). However, few municipalities in the United States followed suit, as flood management became a federal responsibility through the construction of large-scale flood control projects. It was not until the 1950's that local land use became recognized as a valuable tool in floodplain management. This realization was accompanied by the recognition that flood control projects did not stop heavy flood losses, that lack of local land use actually increased the damages suffered due to unrestricted development in flood hazard areas, and that encroachment in floodplains had serious environmental impacts (loss of water storage area, loss of sensitive or unique habitat, impact on fish and wildlife resources).

Federal mandates in the 1960's and 1970's have shifted, to a great extent, the burden of floodplain mangement from the Federal to the State and local levels of government. The exercise of floodplain zoning regulations requires that local governments, with the authority to do so vested in the State and delegated to the municipalities, be aware of and responsible toward the floodplains in that municipality. The Flood Insurance Act of 1968 gave the use of zoning restrictions in floodplains its greatest boost. Communities seeking participation in the Federal Flood Insurance Program must adopt floodplain regulations to restrict land use in flood hazard areas. Another federal involvement in local land use is the U.S. Army Corps of Engineers responsibilities in navigable waters.

At the State level, local land use control may be affected in several ways. The State may require that local subdivisions adopt zoning regulations that are approved by the State. The State may also require the development of local floodplain management programs, of which the zoning laws become a part. The strength of the State's approach in land use may vary widely, depending on the traditional role of that State in local land use planning and regulation.

Motz (1978) has discussed local aspects of floodplain zoning. The potential of property owners to influence zoning boundaries and regulations may come into play. In addition, the local implementing agents of zoning regulations will determine the effectiveness of the zoning. Included as local agents are the persons who issue permits, building inspectors, contractors and construction workers, real estate agents, and any other persons involved in development. Each one of these persons must perform his or her task to insure that the intent of floodplain zoning is carried out in that jurisdiction.

Subdivision Regulations

Subdivision regulations are intended to maintain control over land which is divided up into smaller lots for sale or development. These regulations prescribe lot sizes and layout, standards for street and utilities construction, requirements for the dedication of lands for public use, and requirements for adequate drainage of the subdivision. Subdivision plans are usually subject to review and approval by the local planning and zoning commission, as well as by other local agencies.

The use of subdivision regulations can play an important role in the control of flood-prone areas. Regulations for subdivision in flood prone areas may include requirements to avoid disturbance of the stream channel, floodway or the floodplain. Easements may be required to protect these sensitive areas, as well as to protect natural ponds or wetlands which may function in water storage. The placement of roads and utilities may be prescribed to avoid the floodplain, and to minimize obstruction to the flow of surface water on the subdivision. Subdivision regulations may require the inclusion of flood hazard areas on the plat (U.S. Water Resources Council, 1979).

Once subdivision regulations for flood-prone areas are in place, the local planning and zoning commission has additional tools with which to evaluate proposals for local subdivisions. Combined with local zoning, these regulations can help insure the protection and careful development of a community's resources.

Building Codes

Building Codes control building design and construction materials used within a jurisdiction. As a tool in floodplain management, building codes may be used to set specifications on:

1. minimum elevations of first floor;
2. adequate anchorage of structure;
3. placement of electrical and mechanical equipment above the regulatory flood level, or adequate floodproofing for same;
4. type of materials suitable for construction in flood-prone areas;
5. construction design to insure maximal protection from and minimal obstruction of flood waters.

Enforcement of building codes is essential if the specifications for flood-prone property development are to be included in building design and construction. First the enforcement agency must be aware that a property requesting a building application is in a flood-prone area. In addition, that agency must inform the owner of the special requirements and restrictions on construction in the floodplain. Thirdly, an inspection of the plans, site and structure during and after construction must be carried out by a knowledgeable inspector to insure that the structure was built according to the building code regulations.

Building codes work in conjunction with local zoning and subdivision regulations. Zoning regulations establish the kind of land use permitted in a given area. Subdivision regulations control the development of that land. Building codes regulate the actual development of the parcels to insure the safety and health of the property owners and users.

As a floodplain management tool, building codes cannot address existing unsafe construction in the floodplain. However, any substantial improvement to an existing structure may come under building code requirements. Under floodplain district zoning an existing structure may become a non-conforming use. As such, improvement to the structure, or redevelopment of the property, may be restricted. Any allowable new development or redevelopment must conform to the building codes for that floodplain district zone.

Need for Inter-local Cooperation

Local zoning, subdivision, and building code regulations for flood-prone areas help a community to manage the development of potentially hazardous areas within its jurisdiction. However, many flood problems are interjurisdictional in nature, as when a river or stream flows through two or more jurisdictions. Flooding may occur in one or more of these jurisdictions. Here, local ordinances alone cannot solve the problems of damages from flooding. It is important that adjacent governments cooperate to manage a common area - the floodplain. The effects of an upstream subdivision may be felt downstream in the next jurisdiction. Therefore, adjacent local governments should work together to see that local ordinances help solve flooding problems on a regional scale whenever possible. This can be accomplished by a mutual review of local ordinances, and a system whereby local subdivision plans are reviewed by all potentially affected jurisdictions. Coordinated floodplain management plans, as mandated by Maryland law, can help insure that land use and flood management is accomplished on a watershed, rather than political, basis.

Another means to accomplish inter-local cooperation is by the formation of special districts and authorities, which operate much the same as sanitary or water supply districts. A special district is a municipal corporation created by State law, having specified legal powers and geographical territory. A special district for floodplain management must be capable of implementing a comprehensive management plan, on a basin-wide basis, through the cooperation of all the jurisdictions within that basin.

Inter-local agreements and arrangements can be very effective in coordinating regional floodplain management. Letters and informal communications can keep communities informed of actions and plans in adjacent communities, and provide an exchange of ideas and opinions. Formal agreements may be drawn up as well, to implement wise floodplain management. Finally, the courts may be used when a jurisdiction determines that the actions of an adjacent political subdivision violate a formal contract, or when a jurisdiction wishes to challenge a zoning decision in a neighboring community. The challenge facing local governments to manage their floodplains is in maintaining control over local land use while promoting wise use on a watershed basis. Platt et.al. (1980) sum up this challenge in the following way:

> "Non-structural management cannot be piecemeal. Floodplain zoning by a responsible community may be nullified by floodplain filling within a neighboring upstream or cross-stream jurisdiction. In the absence of basinwide controls at the state or interstate level, local governments must jointly and severally coordinate their efforts to manage their mutual floodplains"

EARLY WARNING SYSTEMS

Introduction

An early warning system for floods is an essential element of a comprehensive floodplain management plan. In order for flood-proofing and emergency preparedness programs to function successfully, some warning time must be available. A warning system is intended first to minimize personal injury and loss of life, and second, to minimize property damages. It is a measure to protect the life and property of existing floodplain residents and property owners. It should not be considered a tool for making flood hazard areas more attractive for development.

The Data Base

There are several components necessary for the development of an effective early warning system. One component is the "data bank". Data should include records of rainfall and stream stage from previous floods and severe storms. These data are collected using stream stage gauges, and rain gauges placed at strategic or hydrologically significant locations. A strategic location for a rain gauge may be a fire station, where data collection will be prompt and reliable. A hydrologically significant location for a stream gauge may be a certain distance downstream from the confluence of two streams or rivers. The data on rainfall and stream stage can be used to develop a predictive model. With such a model, the rise in water surface elevation may be predicted from the inches of rainfall which have fallen in a given period of time.

Other important data are historical information on flooding, including areas of severe damage, water marks showing the height of past floods, rainfall history, and estimated personal and monetary losses. Information on dangerous roads or bridges which tend to wash out, as well as information on previously flooded structures can help in planning warning and evacuation precedures for future events.

The tracking of meteorological conditions is crucial in an early warning plan. At the first announcement of a storm watch key personnel should be ready to activate a community warning system. Close communication with the National Weather Service and a local television weather station will insure the latest information on the progress and behavior of a storm system. Knowing the direction, speed and relative intensity of a storm can help in decision-making during a flood alert. The most commonly used systems for receiving weather information are:

1. The National Weather Service - continuous weather reports may be obtained via teletype or radio broadcast. Telephone communication with National Weather Service meteorologists is also available.

2. NAWAS (National Alert and Warning System) - this nation-wide service broadcasts, via a special telephone installation, information on any regional emergency situations that may arise.

3. Other commercial weather services ("Accuweather", "Compuweather") - these services send daily weather reports via teletype for localized weather predictions.

4. Local television stations - television weather stations often have their own radar tracking systems and a certified meteorologist. This may be advantageous both to receive very localized weather updates and as a medium for keeping citizens informed of the weather situation.

As a result of all of the available data, both historical and current (updated weather reports; hourly or semi-hourly reports on stream stages and rainfall from stations), key personnel will have tools for assessing the severity of flooding threat and deciding upon the course of action to be taken.

Elements of an Early Warning System

In order to implement an early warning system, the incoming data must be first analyzed by persons in charge of the program, and then translated into action by involved agencies. Therefore, there must be an established procedure for the activation and implementation of a warning system. The development of a procedural manual will facilitate activation. A manual must carefully and simply describe each level or phase of warning, the people to be alerted, when and how they are to be alerted, and what the next course of action will be.

Motz (1978) describes the flood warning system in the following way:

> In viewing the social factors associated with flood warnings, the key concept is <u>communication</u>: who tells what to whom, when, where, and how - and with what effect. Naturally, the "why" is to protect people from potential damage due to flood waters. Three stages may be identifed with regard to the communication process (Susquehanna River Basin Commission, 1976). Firstly, there is the need for <u>preliminary notification</u>. This is the period when the national weather services notify federal, state and local officials to be on the watch. At this point in time, only officials are made cognizant of the possible occurrence. Then there is the <u>watch</u> stage. This is when the public is notified of the potential threatening condition. Local people are alerted to keep watch and be prepared to take action. Finally, there is the <u>warning</u> stage. People must take action at that point because the flood is imminent or in process.

Organization is as important as communication. Each involved agency should have its duties and responsibilities carefully outlined in the procedures manual. Duplication of effort should be avoided. Chain of command and priorities for action should be clearly defined to avoid confusion and maximize efforts. Time lost in deciding which agency will perform what tasks could result in loss of life. In addition, there should be clear leadership in any early warning system. A central emergency operations office should be established and outfitted with all necessary maps, communication tools, weather tracking devices and emergency equipment. Vehicles on the road during an emergency should be equipped with radios to relay any information to and receive any instructions or updates from the emergency operations center.

An important social aspect of an early warning system is the response of both public officials and the citizens of the community to initial flood warnings. If flooding is a common event, both are likely to respond quickly to the initiation of a warning and evacuation program. However, if flooding is a relatively rare event, and particularly, if a flood has not occurred in the recent past, initial response may be one of complacency or incredulity. To minimize this "psychological inertia" public officials may stage practice warning events, or "dry runs". Education in a community's schools could help keep the reality of flooding dangers in citizens' minds. Periodic public service announcements on local radio and television stations could serve as reminders to listeners that flooding can and does occur, and that there is a procedure for dealing with floods.

If flooding becomes imminent, the implementation of several non-structural flood management techniques will begin. These include the placement of flood protection devices such as flood shields, sandbags, the movement of valuable mobile objects to dry ground, and other preparations of a structure to be flooded (disconnection of electrical and sanitary lines, turning off machinery). Of course, many of these activities are feasible at the initial signs of potential flooding. Most important however, is the evacuation of persons from the flood hazard areas. Involved agencies should know in advance where the flood-prone homes and businesses are located. These should be notified early enough to allow time for preparation and departure. Flood-pone streets and highways should be closed to traffic. Evacuation routes should be known in advance to avoid meeting flood waters, and to minimize traffic problems.

Conclusion

Motz identifies some problems associated with the development and implementation of an early warning system for floods. One is that the time and expense may not seem justified if flooding does not occur frequently. A second is the arousal of fear and anxiety on the part of the community by organizing a warning system. A third is the possibility that an early warning system may result in too many false alarms that will eventually cause the community to lose faith in, and ignore, the system.

An early warning system, if well-organized, can be a useful tool in floodplain management. Its dependence upon the "human element" is its largest flaw, or potentially, its greatest asset, depending upon the care and on-going interest of the lead agency and the citizens.

Natural changes occur in the course and configuration of a stream channel throughout its geologic life. The action of water upon the geologic formations through which it flows causes differential erosion of these formations. Particles picked up by the water from eroding surfaces are deposited downstream. The interplay of erosion and deposition alters the streambed and its banks. Thus, a stream may become deeper by the action of high streamflow and turbulence. A slowly flowing stream will drop its sediment load, causing the stream bed to become more shallow.

In addition, the configuration of a stream channel may encourage erosion on one bank, and deposition on the other bank. This occurs at the bends in a stream channel. The outer side of each curve experiences faster water velocities. Hence the water scours and erodes materials from this bank. The inner side experiences slower currents. The stream therefore deposits its sediment load on the inner curve. Floods often cause abrupt changes in stream configuration as the high energy of the stream flow cuts through deposited material, scours out and undercuts streambanks, and carries off much of the eroded and deposited materials.

In an undeveloped watershed, the course and configuration of rivers and streams is in a state of dynamic equilibrium. The plants and animals of a riverine ecosystem adapt to this flux. However, in those areas where human activity has established political boundaries, property ownership, and physical development of homes or other structures, this natural flux is disturbed. Increased runoff and human alterations to the stream increase erosion and sedimentation where erosion from flooding threatens to wash out roads, bridges or utilities, and where property is being lost to the stream, it is often necessary or desirable to stabilize stream banks and prevent future erosion.

These techniques are considered separately, in this report, from channel improvements, which seek to alter floodwater management. Streambank erosion control and bank stabilization are techniques used to reduce the damages of water action, not flooding itself. The application of these techniques is most common and necessary in the more urbanized sections of streams and rivers.

There are several ways to deal with streambank erosion. One method commonly used in urbanized areas is stream channelization wherein the natural streambanks are replaced with concrete or a similar material. This protects adjacent properties by providing a material more resistant to erosion, and by altering the direction and velocity of water flow.

Potential disadvantages of channelization are the acceleration in stream velocity caused by reducing the roughness factor (friction generated by water in contact with its channel sides and bottom), the effects on downstream properties, and the vulnerability of concrete walls to undermining by the action of water at high flow periods. A decreased roughness factor will increase velocity, which may result in increased damage downstream. Cracks or breaks in the concrete will allow the ingress of water. As the water works its way behind and under the concrete, the channel wall will begin to deteriorate. The fallen concrete may then impede the flow of water downstream and exacerbate flooding problems. However, in some instances, hydraulic and hydrologic study may determine that channelization is the most cost-effective solution.

Channelization may have negative environmental impacts as well. The destruction of riparian vegetation will decrease the amount of shade along the streambanks, causing a temperature increase in the stream. Increases in stream temperature will alter the biotic composition of the stream, since many fishes and other aquatic organisms can tolerate only a narrow temperature range. Loss of streambank soil and vegetation may also mean the loss of floral and faunal habitats. It is also worth noting, however, that excessive riparian vegetation may exacerbate local flooding by impeding the flow of flood waters. Trees found growing on sandbars in streams where flooding is a problem should be removed. Similarly, large trees which have been undermined by erosion may contribute to local flooding by damming up at bridges, and should be removed.

The use of gabions is an alternative to concrete channelization in stabilizing streambanks. Gabions are rectangular wire baskets, filled with stones. They were first used in ancient Greece or Italy where the baskets were made of woven papyrus reeds. The gabions are placed in a "stair step" manner, so that the weight of the upper baskets keeps the baskets below in place, and a somewhat natural slope is approximated. In addition, as the gabions are installed to lean back into the streambank, there is less chance for destructive flood water to find its way behind the gabions. Because of the spaces between the stones in the baskets, gabions can be planted with grasses or other herbaceous plants to restore the streambank to a more natural state. Streambanks stabilized with gabions therefore function as natural streambanks by allowing water to seep from the adjacent floodplain to the stream channel.

Yet another method of stabilizing stream banks is the use of wire mesh or mat, placed over compacted backfill in an eroded section of streambank. The wire mesh, if properly place and securely anchored, will function similarly to a gabion structure. Revegetation is extremely important, as the plant roots bind the soil particles together and help to stabilize the banks. Riprap, another form of bank stabilization material, is less desirable due to its tendency to be washed out during floods.

Stream channel stabilization and erosion control accomplish more than one objective. In addition to preventing or minimizing the loss of land or damage to roads and utilities, water quality is also protected. Excessive sediment loading in streams caused by erosion has adverse environmental impacts. Increased turbidity decreases light penetration and affects the physiology of both plants and animals in the stream. Sediments also carry pollutants such as heavy metals and particles from sewage and urban runoff. Sediments in the stream may increase the erosive power of the water and worsen scouring in bends along the stream. Deposition of heavy sediment loads may result in the formation of stagnant pools or create a more shallow stream bed. Eventually, these sediments end up in receiving waters such as harbors or bays where delicate estuarine ecosystems, and human activities dependent upon these ecosystems, may be disrupted by the effects of excess sedimentation and accompanying pollution problems.

The use of stream stabilization and erosion control techniques may be useful and necessary, especially in urbanized areas, to reduce flooding damages and prevent water quality problems. In general, the use of this technique is not necessary in rural areas, where stream flow is in a dynamic state and no adjacent lands or physical improvements are threatened. Hydrologic and hydraulic studies should precede any projects of streambank stabilization, to ensure that no undesirable effects will result from these modifications to the natural stream channel.

The accumulation of debris, excessive growth of vegetation and siltation in streams may worsen flood damages by impeding the flow of flood waters. A regular program of checking streams for such conditions may help to reduce localized flooding and associated damages in several ways.

Streams in urban areas are particularly susceptible to being used as dumping grounds. The presence of trees and parkland along the banks obscures these activities and makes it difficult both to apprehend offenders and to locate areas where it has occurred. More than an aesthetic problem, debris, especially large objects, may cause the obstruction of culverts, bridge crossings and other constrictions to flow, and thereby exacerbate flooding. As debris piles up behind a bridge, the bridge becomes, effectively, a dam. Flood waters must then move laterally and may flood more of the adjacent properties than would occur without such obstruction. In addition, such large objects may in themselves become dangerous to motorists and pedestrians attempting to reach safety. Although a severe flood will sweep along with it many large objects and debris not already in the stream channels, minimizing obstruction to water flow by regular stream cleaning may contribute to reduced flood damages.

Excessive growth of vegetation, both along streambanks and in the stream channel, may retard or obstruct the flow of flood waters. Trees growing out into the channel may cause debris floating downstream during a flood to become caught and form a dam. Additionally, in stretches of stream channel where hydraulic studies indicate that rapid flow is most desirable for flood management, the reduction of trees and shrubs may be required. Plantings with grasses or other herbaceous species will insure both bank stabilization and a lower resistance to water flow.

Excessive siltation in streams may require removal if the sediments substantially reduce the capacity of the channel. A shallow stream will result in earlier overtopping of the banks and may worsen flooding problems. In addition, these accumulated sediments add erosive power to flood waters and may worsen stream bank erosion during a flood. The primary solution to a sedimentation problem is to discover the sources of soil erosion upland. Construction, failing slopes, poor agricultural practices and even natural conditions may require some management practices to reduce sediment loading to the receiving waters.

A scheduled program for stream cleaning and maintenance will not prevent flooding and flooding damages. However, such a program will maximize the natural capabilities of stream channels and streambanks to accommodate bankful conditions. It may often be the case that some flooding damages, particularly during the more frequent storm events, are preventable by keeping the streams free of debris and excessive vegetation and sediments.

SUMMARY ANALYSIS OF ALTERNATIVE MANAGEMENT STRATEGIES

FLOODPLAIN MANAGEMENT ALTERNATIVE ANALYSIS SUMMARY

INTRODUCTION

The Floodplain Management Alternative Analysis Summary which follows presents the characteristics, impacts, advantages and disadvantages of the various strategies discussed in the previous section. The matrix is intended as a comparative tool to illustrate the relative benefits of these alternatives.

The parameters expressed in the matrix address those issues which will dominate the selection of preferred alternatives. The impacts on water and land resources in the City are of great concern, because these resources are already stressed by urban development. The socio-economic impacts must be weighed to determine the acceptability of the project, as well as any new problems which a project may create. The relative cost of the project, expected life and long-term maintenance and/or operating costs are also important selection criteria. Finally, the manner in which an alternative accomplishes a reduction or elimination of flooding damages is an important factor. The distinction between those methods which alter the behavior of the water and those which modify human behavior is an important one. The approach will influence all other parameters in the selection matrix. The approach, therefore, is an element which must be carefully considered by the decision-maker in floodplain management.

On the pages following the Analysis Summary matrix, there will be a brief discussion of the alternatives emphasized by Baltimore City. In the next section, the implementation strategies of chosen alternatives will be discussed in detail.

MANAGEMENT ALTERNATIVE	MAJOR CHARACTERISTICS	APPROACH TO DAMAGE REDUCTION	SOCIO-ECONOMIC IMPACTS	IMPACTS ON STREAM HYDROLOGY	IMPACTS ON WATER QUALITY	IMPACTS ON RECREATION OPEN SPACE
Major Reservoir	Controls runoff from large drainage areas Multiple use potential for water supply, recreation, fish and wildlife.	Controls flood waters by retention	Severe	Severe	Moderate	Moderate
Small Reservoir(s)	Controls runoff from small portion of watershed, and protects adjacent areas to a specific flood height.	Controls flood waters by retention or detention	Moderate	Severe	Moderate	Moderate
Levees and Floodwalls	Earthen or concrete obstacles to flood waters. Designed to protect to a specific flood height.	Changes flood water direction, protects specific areas	Slight	Moderate-Severe	Moderate	Slight-Moderate
Major Channel Improvements	Local flood protection of small area to a specific flood height.	Controls flood waters by altering course direction, velocity	Slight	Severe	Moderate-Severe	Moderate-Severe
Underground Conveyance	Places stream in closed conveyance. Depends on flow and storage capacity to control specific flood height.	Controls flood waters by altering course, direction, velocity	Slight	Severe	Moderate-Severe	Moderate-Severe
Acquisition and Relocation	Removal of flood-prone structures from flood threat. Restoration of flood-plain to open space.	Removes persons and structures from flood threat	Moderate	Slight	Slight	Moderate (Enhancement)
Floodproofing	Individual structural adjustments to reduce flood damages.	Reduces damages to flood-prone structures	Slight-Moderate	Slight	Slight	Slight
Flood Insurance	Applies to all flood-prone structures. Involves local government as well as individual policy holder.	Financial protection for recovery after Flood.	Moderate	Slight	Slight	Slight
Early Warning and Evacuation System	Warns floodplain residents and communities of flood threat. Facilitates evacuation when necessary.	Reduces threats to lives, reduces property damages.	Slight	Slight	Slight	Slight
Legislation	Regulates types of structures and uses. Establishes construction standards. Useful as a land use planning tool.	Reduces the number and kinds of structures in floodplain	Slight-Moderate	Slight	Slight	Slight-Moderate (Enhancement)
Minor Channel Improvements	Includes cleaning streams of major debris shoal removal, and erosion control.	Reduces obstruction flow, maintains stream channel	Slight	Slight	Slight-Moderate	Slight

ALTERNATIVE ANALYSIS SUMMARY

Impacts On Existing Uses	Impact On Future Uses	Expected Life(Years)	Capital Cost Limitations	Annual Operation and Maintenance	Advantages	Disadvantages
Severe	Severe	15+	Severe	Severe	1. Protects large land area 2. Multiple use benefits	1. Disruption of existing development 2. High cost 3. False sense of security
Moderate-Severe	Moderate	15+	Moderate-Severe	Severe	1. Effective on small tributaries 2. Multiple use benefits	1. Protection limited to design storm 2. High cost & maintenance needs 3. False sense of security
Moderate	Slight	15+	Moderate-Severe	Moderate-Severe	1. Protects existing uses	1. Encourages continued development 2. High cost 3. False sense of security
Moderate	Slight	15+	Moderate-Severe	Moderate-Severe	1. Protection from minor floods 2. Protects adjacent properties	1. Disruption of natural streams 2. High cost 3. False sense of security
Moderate	Slight	15+	Severe	Moderate-Severe	1. Protection from minor floods	1. Disruption of natural streams 2. High Cost 3. Removes threat from visual perception
Severe	Severe	15+	Moderate	Slight	1. Permanent 2. Open Space benefits 3. Restored function of floodplain	1. Disruption of existing development 2. Moderate capital investment
Slight	Slight	15+	Slight-Moderate	Slight	1. Reduces damages to existing uses 2. Increases awareness of flooding 3. Affordable	1. False sense of security 2. Encourages continued occupance 3. Effective to specific flood height only
Slight	Slight-Moderate	NA	Slight-Moderate	Slight	1. Shifts burden to floodplain occupants 2. Protects investments 3. Linkage to Floodplain Legislation	1. Encourages continued occupance of flood-prone areas 2. Subsidized rates do not reflect actual costs
Slight	Slight	NA	Slight	Slight	1. Protects lives 2. Involves community	1. Depends upon human perception of and response to threat
Slight	Moderate-Severe	NA	Slight	Slight	1. Changes floodplain land use 2. Establishes construction standards	1. Does not affect existing uses 2. Subject to changing attitudes and policies
Slight	Slight	15+	Slight-Moderate	Moderate	1. Reduces excessive bank erosion, and protects utilities 2. Relatively low cost	1. Slight impact on stream ecology 2. Does not prevent flooding

DISCUSSION OF ALTERNATIVES

MAJOR RESERVOIR

This alternative is found to be unsuitable to the needs of Baltimore City. The environmental impacts would involve the need to acquire large land areas, to construct a dam which would alter stream hydrology and water quality by changing flow patterns, velocity and other established dynamic equilibria in the stream system. Most significantly, the availability of suitable sites for a major reservoir in the City is virtually non-existent. In addition, placing a major reservoir in the lower portions of watersheds may have few receiving waters flood control benefits. Given all these negative environmental impacts, it should also be mentioned that reservoirs create recreational opportunities as well as new habitat for fish, wildlife and flora.

The socio-economic impacts of a major reservoir would involve the displacement of families and businesses from the stream valley to be inundated. This would involve the relocation of roads, railroads, schools and other public facilities. Existing land uses would virtually disappear, and future land use would be limited to flood control.

The capital costs of a major reservoir would be prohibitive, especially without Federal participation. There are also high annual maintenance and operating costs. In this region of erodable soils, a flood control reservoir may require an on-going dredging program, which has serious environmental as well as economic implications.

In summary, while a large reservoir may have applicability for flood control in other locales, this alternative does not offer sufficient benefits in Baltimore City to be considered as a viable management tool.

SMALL RESERVOIR

A small reservoir, or a series of small reservoirs, will have limited effectiveness in Baltimore City. The primary reason for this is the position of the City at the lower end of the streams which travel through to the Patapsco River. Small reservoirs may have a complex impact on the floodplain environment. While they may enhance some opportunities for fish, wildlife and floral habitat, they may actually worsen flooding by altering the timing of peak discharges on tributary streams. Another problem is one siltation. Small ponds and reservoirs tend to silt in quickly in the middle-Atlantic regions of piedmont and coastal plain. This siltation shortens the effective life of the reservoirs and will require dredging at frequent intervals.

Socio-economic impacts include the acquisition of properties for the reservoir sites and the potential need to relocate roads, businesses and associated services. In addition, the construction of ponds or reservoirs to control floodwaters may allow further development in the floodplain. If the storm frequency for which the flood control system was designed is exceeded, worse damages will be incurred due to the allowed development. A false sense of security, encouraged by small ponds and reservoirs, is also a potential problem.

The construction, operation and maintenance costs of small reservoirs is a considerable expense and an ongoing responsibility. Again, the effectiveness of such structures is limited to the design storm frequency, which may be exceeded at any time.

It is recognized that small reservoirs and ponds do have applicability for flood control in some instances. They can be effective in reducing damages in areas affected by the more frequent storms. If designed, constructed and maintained properly, such detention or retention structures are useful flood management tools in the correct setting. Therefore, although the use of small reservoirs is not being considered in the comprehensive plan for the City at this time, their use would be considered if in the future adequately detailed hydrologic studies of a watershed determined the utility of such a flood control measure and its cost/effectiveness.

LEVEES AND FLOODWALLS

The use of levees and floodwalls to reduce flooding damages in Baltimore City is not being considered as a viable floodplain management alternative at this time. The impacts on stream hydrology are considered undesirable, as changing the flow, course or direction of water may result in worsened flooding downstream or cross-stream.

Levees and floodwalls encourage continued use and development in flood-prone areas. While the City recognizes the need for protecting existing structures and properties, the construction of levees and floodwalls is not considered wise floodplain management. First, levees and floodwalls, similar to reservoirs, are designed for specific frequency storms. If the frequency is exceeded, flooding damages are not prevented. Second, the presence of a levee or floodwall may cause a false sense of security. An over-topped or breached flood control structure will mean disaster to unsuspecting floodplain occupants. Third, the presence of a levee or floodwall will put additional development pressure on the protected portion of the floodplain. This situation would be highly undesirable in light of the approach to floodplain management being taken by Baltimore City.

UNDERGROUND CONVEYANCE

The use of underground conveyance systems to reduce or eliminate flooding damages will not be recommended in the Baltimore City comprehensive floodplain management plan. The use of culverts to collect and store floodwaters has several environmental impacts. The size of the culverts will determine the degree of flood protection afforded, and the size is in turn determined by the selection of a design storm. If this storm is exceeded, flooding will occur. In addition, blockage of the culverts will decrease efficiency. With trees and other large objects common floating debris in a severe storm blockage is likely. Underground conveyance will send the waters downstream faster, due to the smoothness of the pipe surfaces. This may worsen downstream flooding and increase damages. Underground conveyance eliminates the natural function of the floodplain as a water storage feature and has severe impacts on stream biota as well.

The socio-economic impacts of this alternative include the need for utility rights-of-way and easements for culvert maintenance and protection. More importantly, it removes the flood threat from the visual perception of floodplain occupants. The natural features and functions of a floodplain are removed, and further development will likely be encouraged. When a flood greater than that for which the conveyance system is designed occurs, extensive damages will result.

The costs of an underground conveyance system designed for flood control are prohibitive. Previous experience has shown the tremendous commitment of funds required, as well as the inherent difficulties and limitations with this management alternative. The application of this technique would require sound, detailed hydrologic and hydraulic studies, a large funding commitment, and the financial ability of the local government to maintain and repair the system. At this time, therefore, underground conveyance is not a recommended floodplain management alternative.

ACQUISITION

Based upon the comparative analysis presented above, background research and the needs of Baltimore City, the use of acquisition has been chosen as a major program element in the comprehensive floodplain management plan for the City.

As presented visually in the Alternative Analysis Summary acquisition does not involve negative environmental impacts. To the contrary, the removal of structures and restoration of portions of the City's floodplains to an undeveloped state will enhance recreational opportunities, create open space and allow the area to function as a water storage area, which may help reduce damages downstream. In Baltimore City, a good portion of the major stream valleys has already been preserved as parkland. The acquisition and removal of structures will add to this park system. For example, acquisition along the lower Gwynns Falls would further the progress of linking the Gwynns Falls-Leakin Park and Middle Branch Park systems.

In addition, the removal of development from the City's floodplains will lessen the need to plan for major stream alterations designed to protect adjacent property. Although acquisition will not eliminate the need to maintain stream channels and stabilize banks where erosion is serious, the City's stream-related capital and operational programs can be geared toward maintaining and improving stream quality rather than solely toward the need to control flood waters.

In addition to the environmental and socio-economic impacts discussed above, the costs of construction and maintenance of levees and floodwalls are prohibitive, especially without Federal participation. In the Army Corps of Engineers Baltimore Metropolilitan Streams study, none of the levees and floodwalls considered had a favorable cost/benefit ratio.

If future detailed hydrologic studies found a levee or floodwall to have a favorable cost-effectiveness without the drawbacks discussed above, Baltimore City would consider the application of this type of structural technique.

MAJOR CHANNEL IMPROVEMENTS

At the present time, a considerable portion of the City's streams have been altered by channel improvements, either in conjunction with bridge or road construction, or to alter stream flow and protect the stream banks from erosion. However, this alternative has several drawbacks which limit its applicability in the comprehensive floodplain management plan for Baltimore City. The environmental impacts on stream hydrology and water quality are severe. Stream channelization drastically alters the natural course and velocity of water. The energy dynamics are changed so that erosion and deposition, as natural processes, are arrested. The water quality is altered by changing the nature of the streambed and banks. Vegetation is removed, which may increase water temperatures. The biota in and adjacent to the channelized stream are, in turn, affected by these alterations. Channelization limits recreational opportunities be creating a less scenic and less accessible stream environment. Most importantly, stream improvements have a limited effectiveness in reducing or preventing flood damages. Channelization may help to control bank full condition during the storm for which the improvements were designed. However, once this design storm level is exceeded, the stream will revert to its natural course of flow for the duration of the overbanked phase of flooding. In addition, the reduced roughness coefficient of paved channels may increase stream velocities which, beyond the design storm, may cause worsened damages.

The socio-economic impacts from channel improvements are slight. However, such alterations may, again, cause a false sense of security to develop in the nearby floodplain occupants. The costs of channel improvements are high, and such structural improvements require periodic maintenance to repair broken concrete panels, remove trees or other vegetation which may be able to take root in cracks, and periodically remove accumulated silt and debris to ensure optional performance of the structure.

Although Baltimore City is not, at the present time, considering channel improvements as a capital project for floodplain management, its application would be considered if future hydrologic studies determined it to be a cost-effectiveness method, in certain cases, to reduce flood damages. In addition, the use of less environmentally damaging techniques, such as gabion mattresses or "Enka" matting, should be considered in any future designs for channel improvements in Baltimore City.

The social impacts of implementing a residential property acquisition program are more complex. As homes are purchased by the City, the nature of a affected community will change. The relocation of residents will entail personal adjustments in social ties, including perhaps changing schools, shopping and other services. Crucial in anticipating the degree of social disruption is the decision to implement a voluntary or a mandatory acquisition program.

The economic impacts of an acquisition program includes costs and benefits to all parties involved. From the property owners point of view, there may be, as mentioned earlier, a concern that equitable housing will not be available. In most cases, relocation will not mean a change in employment, if the property owner chooses to remain in the general area of Baltimore.

From the City's point of view, funds are being spent which will, it is anticipated, result in future savings. Relative to the structural improvements summarized in the Analysis Summary this cost is preferred for several reasons. First, the initial capital expenditures for the planning, design and construction of a dam and reservoir would be approximately an order of magnitude higher than a residential acquisition program. Dikes and levees are also prohibitively expensive. In addition, these structural measures have continuing operation and maintenance costs, environmental impacts, and provide protection only up to the water elevation for which the structure was designed. Failure of a dam, dike or levee may incur great loss of life and extensive property damage. Second, structural improvements such as the construction of a dam is impractical in Baltimore City. The land is not readily available and would be prohibitively expensive to purchase. In addition the extreme downstream position of the City is not a likely nor effective dam site. Because of the scattered location of many structures along the streambanks, a levee would not be appropriate in most cases.

The construction of storm drain systems large enough to handle the 100-year storm are likewise economically prohibitive. Improvements of this kind, proposed for a 10,400 foot stretch of Maiden's Choice Run were estimated to cost $10.5 million in 1973 dollars (almost $25 million in 1982). For major flood areas, a closed conveyance system would be too expensive and, similar to the other structural measures, would require continuing maintenance and repair.

Therefore, the initial economic impacts of acquisition are less than those of structural measures. The possible long-term loss from the tax base is also a concern in acquisition. However, this loss is probably balanced by the absence of required services such as sewer and water utilities, street maintenance, refuse collection, and the costs of repair to these facilities after a flood.

In conclusion, it can be seen that acquisition is a reasonable and effective floodplain management tool. Its application in Baltimore City will be of great value in reducing the dangers and damages of flooding in residential areas, as well as in restoring developed floodplains to a more natural and functional state. Acquisition is, therefore, recommended as a major component in the Baltimore City Floodplain Management Plan.

FLOODPROOFING

Floodproofing is considered a preferred technique in floodplain management for several reasons. The environmental impacts are slight, since the measures used in floodproofing alter existing structures rather then altering the flow of waters or the adjacent land. However, floodproofing will do little to enhance the environmental quality of a site, since it allows continued use and occupation of an existing structure or industrial operation. Floodproofing may help to reduce the amount of debris which is left after a flood by improving storage techniques, or strengthening walls and foundations. Floodproofing techniques applied to new non-residential structures may minimize environmental impacts by orientation of the structure, or by shape and design of the structure (building on piles or otherwise elevated). Unlike acquisition, which will reduce the amount of stream channel improvements necessary to protect adjacent land, floodproofing may have to be implemented in conjunction with erosion control and stream channel maintenance projects.

The social impacts of a floodproofing program are slight. It will allow the continued occupance and use of homes and non-residential structures without causing any serious disruption to daily routines or operations. The major social impact associated with floodproofing is the false sense of security which may result from the installation of floodproofing measures. There must be an educational component of the program, both to train involved persons in the implementation of floodproofing techniques and to make these persons aware of the limitations of the techniques and of the level of uncertainty concerning flood behavior.

Floodproofing is a valuable tool in Baltimore City's plan, in great part because of its economic benefits. It allows homeowners and industries to protect themselves against a certain degree of flooding damages at a reasonable cost. It is an excellent compromise for an urbanized environment such as Baltimore, where relocation of all affected interests is not feasible, where development is well-established and substantial, and where economic considerations limit the options of both the property owner and the municipality. The implementation of a floodproofing program will require an initial capital investment, and a small budget for maintenance. Floodproofing will require the involvement and cooperation of a family or the employees of a firm for success. For this reason, the development and practice of an emergency protocol and evacuation procedure is a vital part of all floodproofing plans.

FLOOD INSURANCE

From the matrix of alternatives, it can be seen that the use of flood insurance has several important benefits, but certain drawbacks and limitations as well. The environmental impacts of flood insurance are slight. It does not directly affect stream hydrology, water quality or recreation and open space. However, since it does allow continued use of the floodplain, given certain restrictions, it may be considered to indirectly contribute to flooding problems. It will more strongly affect future uses by the imposition of restrictive building code and zoning regulations on new construction proposals. In this way, it may have a beneficial environmental impact by preserving or restoring the floodplain as a more natural system.

One intention of the NFIP was to shift the economic burden of flood disaster recovery from the general population to those segments of the population who inhabit or own property in flood hazard areas. At the local level, community participation in the NFIP means Federal disaster relief assistance when a severe flood does occur. This disaster relief covers the repair costs of damages to public lands and utilities, while flood insurance covers a percentage of repair costs to individual insurance policy holders. Therefore the socio-economic impacts of the NFIP involve shifts in the burden of flood disaster recovery costs.

The availability of flood insurance is a low-cost, affordable way in which floodplain occupants in Baltimore City can financially protect their properties. At the same time, the NFIP offers another way in which a community can protect itself, namely through land use regulation. Therefore, the use of flood insurance has more than one benefit for Baltimore City. It directly affects land owners who must acquire insurance to receive Federally-subsidized loans or mortgages, it has required the City to tighten floodplain regulation, and increases public awareness of the flood hazard.

EARLY WARNING AND EVACUATION SYSTEM

Since many of the flood-prone areas in Baltimore City are already developed, a system for the protection of the occupants of structures in the floodplain is imperative. The environmental impact of an early warning and evacuation system is slight. Flooding is accepted as an inevitability; plans and procedures are developed to deal with this inevitability.

Socio-economically, it provides a tool with which to deal with communities who face dangers and threats from serious or repeated flooding. An important aspect of a warning and evacuation system is the awareness and involvement of the affected communities. In a large city, such as Baltimore, this is an important element of a comprehensive floodplain management plan. An emergency warning and evacuation system can be coupled with other plan elements, such as floodproofing, to effectively reduce flooding damages. More importantly, it can save lives.

There are capital and operating costs involved with the implementation of an early warning and evacuation system. Funds will be needed for monitoring equipment, vehicles, road signs and personnel. However, the use of volunteer help, existing agencies and technical support and assistance from State and Federal agencies can help keep these costs down. Relative to other alternatives, an early warning and evacuation system can be extremely cost-effective, particularly as part of a comprehensive plan.

Drawbacks to this alternative involve the high degree of dependence on weather forecasting and the human elements -- of responding in time, and in the correct manner, and in gaining citizen cooperation. The large number of affected human lives and properties mandates a major effort to utilize this alternative in Baltimore City.

LEGISLATION

For many of the reasons evident in the Alternative Analysis Summary, legislation presents many opportunities for the reduction and even the eventual elimination of flooding damages in Baltimore City, with relatively few negative effects. Through the regulation of land use, environmental quality may be enhanced by controlling the amount and kinds of development, or by requiring the dedication of undeveloped and acquired floodplain areas to open space. Legislation may severely impact future uses of floodplain land through such regulation.

Legislation may have socio-economic impacts such as the restriction of land use and human activities in floodplains. However, some of the effects of legislation on the community will be of a positive nature. For example, increased recreation areas, increased citizen safety, decreased burden on the taxpayer to repair damages incurred on facilities and utilities in flood-prone areas are all potential benefits of floodplain regulation. Legislation as a democratic process also presents opportunities for citizen input and guidance to help shape the future of local floodplain resources.

MINOR STREAM CHANNEL IMPROVEMENTS

This alternative has City-wide applicability in a comprehensive floodplain management plan. There will be some environmental impact, such as temporary disruption of stream channels and banks. Shoal removal may temporarily destroy the habitat of bottom-dwelling organisms such as crayfish and increase the stream sediment load. The repair of eroded stream banks may involve the removal of trees and other vegetation. The loss of trees may alter the temperature regime of the stream. However, the removal of excess stream sediments will help restore the natural stream gradient. Removal of debris will improve water quality and visual appeal. Bank protection will reduce the loss of land and thereby decrease the amount of sediment entering the stream. The increased channel capacity will help pass the peak discharge from minor floods.

The socio-economic impacts of minor channel improvements are slight. It will allow the continued occupance and use of homes and non-residential structures without causing any serious disruption to daily routines or operations. It may decrease local flooding damages from the more minor storms, thereby having a positive socio-economic impact on adjacent properties and persons.

The costs associated with minor channel improvements represent moderate capital investments in most cases. Because many miles of City streams have never received treatment of this kind, considerable work is needed to remove decades of debris and sediment accumulation, which are common problems in an urbanized area. In other cases, major channel improvements done many years ago have fallen into disrepair and require restoration. This should be a function of the program for minor channel improvements. A minor channel improvement program must also have a maintenance component to insure that the benefits gained by a capital project are not lost due to neglect. A maintenance program represents an on-going commitment to operations and maintenance.

A minor channel improvements program is seen as a useful component of an overall management plan for the floodplains in Baltimore City. It must be recognized that the restoration and maintenance of stream channels plays an integral role in the wise management of floodplain resources, and can help to reduce damages, improve water quality and enhance the stream valley environment.

CONCLUSION

On the basis of the Alternative Analysis Summary and discussion presented, Baltimore City's Floodplain Management Plan will emphasize acquisition of high-hazard residential properties, floodproofing existing residential, and existing and future non-residential structures, minor channel improvements, the continued participation in the National Flood Insurance Program, the use of an early warning and evacuation system, and upgraded floodplain legislation. In addition, where future detailed flood studies determine cost-effectiveness for floodplain management goals and objectives, structural measures on a limited basis may be considered as alternatives in the management of the floodplains of Baltimore City.

The following section will describe, in detail, the elements of the City's Floodplain Management Plan.

RECOMMENDED IMPLEMENTATION STRATEGIES

INTRODUCTION

This section will discuss in detail each of the floodplain management strategies recommended for implementation in the previous section. It should be remembered that there are very few cases where only one of the strategies will be implemented to deal with the flooding problems of a particular area. Rather, a combination of chosen strategies is recommended to achieve a comprehensive solution with both short-term and long-term management benefits.

Several of the selected strategies will be applicable in all flood-prone areas of the City. This includes flood insurance, floodplain regulations, and the early warning and evacuation system. Others, however, are more site-specific, such as floodproofing, acquisition, and minor stream channel improvements. Specific areas for which these techniques are recommended are identified in the subsequent sections which contain the Watershed Plans. The areas are shown on maps, and discussed regarding the types of flooding damage and the solutions which would best reduce these damages in a cost-effective manner.

There remain, in Baltimore City, several stream systems which require further study before any specific strategies can be effectively implemented. These are areas designated as approximated floodplains by the Federal Insurance Administration, or in some cases streams not included at all in the Flood Insurance Rate Maps for the City. Although flooding problems are known to occur in these areas, the hydrologic and hydraulic characteristics remain unknown. While these areas may benefit from a floodplain management alternative such as flood insurance, it is difficult to implement other more specific strategies in these areas. The priority of these areas for acquisition and floodproofing is difficult to assess because of the lack of data. Accurate delineation of the floodplain and a determination of water surface elevations for the 10-year and 100-year flood events are needed. In a few cases, the plan has recommended specific actions, such as acquisition, floodproofing and minor channel improvements, where there are sufficient historical data to justify such actions.

The areas in need of further study include Maiden's Choice Run, Gwynns Run, the lower Jones Falls (from North Avenue to the Harbor), Stony Run, the upper tributaries of Moore's Run, and several small drainage areas in the Herring Run watershed. These streams will be described in detail in each Watershed Plan.

Each selected strategy is described as it will be implemented in Baltimore City. The integration of non-structural approaches to floodplain management into City ordinances, public works projects, the planning process, and other City programs and policies will help to reduce and possibly eliminate many of the existing flood threats to human life, health, safety and property.

ACQUISITION AND RELOCATION

A flood-prone residential property acquisition program is recommended as a major component in the Baltimore City Floodplain Management Plan. Acquisition has been recognized as a cost-effective technique which permanently resolves the problem of flooding damages. As envisioned in the Plan, the acquisition program in Baltimore City will be voluntary, for several reasons. First, it is not desirable to force City residents unwillingly from their homes. The result of a mandatory program could be to alienate affected property owners and tenants, as well as the general public, from the program. Second, it is assumed that the owners of homes which have sustained serious and repeated damage from flooding will be eager to sell their property and relocate. This will remove the most seriously affected residents from the flood hazard areas. Third, the court proceedings involved in a mandatory program could slow the acquisition process substantially.

The City will offer fair market value to prospective property sellers. However, the payment of fair market value may not be sufficient to reasonably cover the costs of finding and relocating to safe and sanitary housing elsewhere. In many cases, the market value of homes in recognized flood-prone areas is lower than that of comparable units out of the floodplain. For this reason, and as an incentive to encourage property owners to sell their land, the City will include relocation benefits in its voluntary acquisition program. The amount of the benefits will be settled on an individual basis, along with the negotiated settlement on the property.

The selection of homes eligible for acquisition has been developed utilizing several sources of information on flood elevations, and known flood damages. The first step in this process was an identification, by block and lot, of all properties wholly or partially in the designated 100-year floodplains of the City. Using 1" = 200' scale topographic maps with the 100-year and, where available, the 25-year flood elevations each property was rated according to its vulnerability to flooding.

Augmenting the hydrologic maps were damage survey reports conducted by the Corps of Engineers, assessments of damage after Agnes and David by City agency personnel, and discussions with some property owners. Those residential structures situated in the floodway, or in the 25-year floodplain (where the information was available), or for which severe and repeated damages were documented, were included in the highest priority (Level I) for acquisition. Level II includes residential structures in the 100-year floodplain or floodway fringe.

It is expected that some properties were missed in this process, and that in several instances, structures included in the priority lists for acquisition may not experience the severe flooding indicated by computed hydrologic and hydraulic information. Therefore, a letter will be sent from the Mayor to the affected property owners' allotting enough time for missed properties or misjudged properties to be added or deleted.

The following outline is the methodology to be used by Baltimore City to implement the acquisition process. The City is fortunate in that its agencies are already fairly well equipped to handle the various phases of the program:

1. Identification of properties, uses, owners, estimated market value. (Department of Planning)
2. Letter from Mayor to property owners, asking if they want to sell. (Office of the Mayor)
3. Interim period for response from owners and any who may be missed in selection process, but are prone to flooding.
4. Assign two outside appraisers to appraise homes of interested owners. (Real Estate Department, Department of Housing and Community Development)
5. Letters to homeowners explaining that appraisers will be coming to homes. Give names of appraisers. (Real Estate Department, Department of Housing and Community Development)
6. Appraisal of homes offered for sale to City. (Real Estate Department, Department of Housing and Community Development)
7. In-house evaluation of the appraisals and selection of appraisal to be offered to homeowner. (Real Estate Department, Department of Housing and Community Development)
8. Contract offer. (Real Estate Department, Law Department, Department of Housing and Community Development)
9. Relocation counselling to homeowners. (Real Estate Department, Department of Housing and Community Development)
10. Contract signing. (Real Estate Department, Law Department, Department of Housing and Community Development)
11. Settlement (Real Estate Department, Law Department, Department of Housing and Community Development)
    a. 90 days to relocate; if not possible, rent must be paid under lease with time limit of 90 more days.
    b. Advertise for sale and salvage, 90 days for response.
    c. If no interest, City demolition immediately after vacated or 90 days, whichever comes first.
12. Property Management (Department of Housing and Community Development and Department of Recreation and Parks)
    a. HCD until contract for moving or salvage is complete or until razed by City.
    b. Recreation and Parks after improvements have been removed; land to be managed as natural areas where possible. (i.e. little or no maintenance).

In November, 1980, the voters of Baltimore City approved a 2 million dollar bond issue for residential acquisition in flood-prone areas. These funds will be matched by State Flood Management grant funds, if the City's program is part of an approved Comprehensive Floodplain Management Plan, and fulfills the State's criteria for grant eligibility.

Acquisition offers a permanent solution to existing flood hazards, does not require continuing operation, maintenance or repair, minimizes environmental impacts and has a useful life greater than 15 years. Acquisition of residential, flood-prone properties will greatly reduce the threat of injury and loss of life, and will also help reduce the financial burden borne by the general citizenry as well as by the residents of these homes when a flood event strikes the City. Acquisition will enhance the physical environment, will restore our floodplains to a more natural state to act as buffers during floods, and will decrease the need for Police and Fire Department monitoring of high-hazard flood-prone residential areas. Implemented carefully and with concern for the persons willing to relocate, it will be an example of what can be accomplished through State-local coordination and through the education and participation of local citizens.

FLOODPROOFING

As discussed in the previous Chapter, "Summary Analysis of Alternative Management Strategies, floodproofing is a reasonable and effective approach to reduce flooding damages in several areas of Baltimore City. It is recommended that programs be implemented and continued to floodproof both residential and non-residential structures in flood-prone areas, since a major goal of the Floodplain Management Plan is to protect existing structures. Floodproofing is indicated for residential properties whose occupant do not wish to relocate, or where flooding is not serious enough to warrant acquisition and relocation. It is also indicated for non-residential structures, which the City does not intend to acquire at this time.

The following is a discussion of the non-residential and residential floodproofing programs recommended for the City.

Non-Residential Floodproofing Program

The non-residential phase of the floodproofing program is currently being implemented in the Jones Falls Valley. Since the spring of 1980, the Baltimore District Army Corps of Engineers Floodplain Management Services Branch has been conducting floodproofing surveys for industries along the Jones Falls. This service is provided free of charge. The list of industries to be surveyed was developed from a meeting held with industrial owners and managers in the valley. The Corps will average two to three studies each year. To date four surveys have been conducted. The floodproofing survey process is as follows:

1. Industry selected for survey from priority list.
2. Preliminary meeting held (U.S. Army Corps of Engineers, Company Representatives, Representative from Department of Planning, and Baltimore Economic Development Corporation)
3. Preliminary survey with Company Representatives.
4. Detailed survey by U.S. Army Corps of Engineers - hydrologist, structural engineer, civil engineer, hydraulic engineer, appraiser, planner).
5. Findings and recommendations of Corps of Engineers presented to Planning Department for review and comments.
6. Meeting to present findings and recommendations tc Company, and to discuss financial arrangements of implementation, with Corps, Planning, BEDCO, Mayor's Office. Representative from the Federal Emergency Management Agency may be present to discuss flood insurance.
7. Follow-up meeting to review plans, and intentions of Company.
8. Implementation of recommendations.
9. Notification by Company to Federal Insurance Administration for rate adjustments based on floodproofing efforts.

After the surveys for all affected industries in the Jones Falls Valley have been completed, the Corps of Engineers will begin to work with industries along the lower Gwynns Falls.

Baltimore City is eager to help industries protect themselves from flooding damages. Therefore, low-interest loans are available for the implementation of floodproofing plans. Alternatively, should the Corps of Engineers conclude that floodproofing is not feasible, the City may become involved in assisting the relocation of a company to a non-hazard area in the City.

Residential Floodproofing Program

This phase of the floodproofing program will be an effort to inform and assist homeowners in the area of property floodproofing. An existing Home Improvement Loan Program, available through the Department of Housing and Community Development may be used for floodproofing. The program provides low-interest loans to homeowners in Baltimore City. The process would be as follows:

1. Availability of funds for floodproofing announced to homeowners in 100-year floodplain.
2. Application and determination of preliminary eligibility.
3. Development of improvement proposal (60 days for submittal).
4. Review of proposal by HCD.
5. Final financial review by HCD.
6. Approval of proposal.
7. Settlement
8. Establishment of escrow account for homeowner.
9. Disbursement of funds as work progresses.

A brochure explaining the principles and techniques of residential floodproofing will be mailed to all homes in the designated 100-year floodplain. It is hoped that this will increase homeowner awareness and engender an interest in the floodproofing program.

A residential floodproofing program could substantially reduce flooding damages in Baltimore City. During a "typical" flood, damages to appliances and other belongings in basements is the most common type of damage reported. By bricking up non-essential doors and windows, moving certain appliances to the first floor, repairing cracked foundations, and by scores of other minor adjustments, a substantial reduction in financial losses can be achieved. Because of the favorable cost of floodproofing, the limited funds available to the City to mitigate flood damages, and the large number of residential structures in the City, floodproofing is determined to be a valuable component in the comprehensive floodplain management plan. It must be emphasized, however, that a floodproofing program must be accompanied by an effective early warning and evacuation system, as well as a concerted effort to educate citizens to the dangers of flooding and the limitations of floodproofing.

FLOOD INSURANCE

Flood insurance is a major component of the recommended Floodplain Management Plan for the City. The continuation of this program should be supported and individual participation encouraged. Baltimore City has been participating in the National Flood Insurance Program (NFIP) since 1973. In 1978, the City entered the Regular phase of the program. Participation in the Regular program required the adoption of floodplain regulations to limit new construction and substantial improvements in the City's flood-prone areas. Flood Insurance Rate Maps, prepared by the Federal Insurance Administration and adopted by the City, delineate the floodplain and assign general risk ratings for various areas in the floodplain. Using these maps, property owners, insurance agents, lending institutions and government officials can determine whether or not a property will require flood insurance. The Baltimore City Department of Planning assists the public in ascertaining whether or not a property is located in a designated floodplain.

In 1978, the Mayor of Baltimore City sent a letter to all properties in these floodplains, to encourage the property owner to purchase flood insurance. In March of 1978 there were 901 policies with $24,090,400 in total coverage. City publicity efforts, along with one flood have helped increase the number of policies. As of April, 1981, there were 755 residential and 416 commercial flood insurance policies for a total of 1,271 policies. This represents nearly 62.4 million dollars in total coverage in Baltimore City. There are an estimated 2,900 residential and non-residential properties lying partially or wholly within designated floodplains. In order to further increase the number of policy holders, it is recommended that a second letter be sent to these property owners as well as to tenants in flood-prone areas to again remind them of the benefits of purchasing flood insurance.

Baltimore City has adopted the minimum regulations, as determined by FIA, to qualify the municipality for participation in the program. Restrictions on the kinds of structures and construction materials, and standards for construction have been set to limit further substantial capital investment and to reduce the potential threat to life by unwise development in flood hazard areas. These regulations are implemented, through zoning and subdivision regulations, and through the building code permit process, by the Department of Housing and Community Development and the Planning Department.

At the present time, Baltimore City and the Federal Emergency Management Agency are reviewing the results of a study which identifies areas around the Harbor where V-zones (wave height flood elevations) exist. V-zones, as high hazard coastal flood areas, will require additional regulation at the local governmental level. When the study has been reviewed and accepted by the Federal agency and Baltimore City, the maps showing these V-zones, as well as new local ordinances to regulate them, will be adopted by the City. V-zones have higher insurance rates to reflect the relative risk of construction and development in flood areas prone to wind-driven wave action during flood events. The affected areas in Baltimore are minimal, and are predominantly industrial in nature. The economic impacts of the new insurance rates to be assigned these areas is unknown at the present time, but are expected to be minimal.

Flood insurance does not directly protect against flooding damages. Its short-term benefit to the City is the economic protection it lends homeowners, tenants and commercial interests already located in flood hazard areas. The Federally-mandated changes in local ordinances which have affected recent development/improvement proposals enable the City to better guide appropriate land uses in the floodplain. Long-term benefits include a gradual decline in the number of structures in the floodplain, due to the restrictions on new development. In addition, the Federal program has helped to shift the burden of disaster relief and repairs somewhat from the general public to the floodplain occupant.

Baltimore City will continue its participation in the program and should continue to encourage property owners in flood hazard areas to purchase flood insurance. As more accurate floodplain delineations are made, through local State and Federal floodplain management programs, these delineations will be submitted to FEMA to update the F.I.R.M. maps and accordingly adjust insurance rates. In this way, coordination and dialogue is maintained between the Federal Insurance Administration and the local government, to help the Federal program meet the needs of Baltimore City, and to enable local citizens to protect themselves from severe financial losses from flooding.

EARLY WARNING AND EVACUATION SYSTEM

An early warning and evacuation system is considered a vital element in the Baltimore City Floodplain Management Plan. Such a system must be in place for contingency floodproofing measures to be implemented. Mor importantly, an effective, well-coordinated warning and evacuation system may prevent the injury and loss of life that has occurred during past floods in the City. The major elements of an early warning and evacuation system include:

(1) Hydrologic Data Base
(2) Continuous Meteorological Update
(3) Standing Operating Procedure (S.O.P.)
(4) Information on Flood Prone Areas
    a. Structures
    b. Streets and Highways

Directive No. 1 of the Baltimore City Emergency and Major Disaster Assistance Plan (See Appendix) was developed to organize a warning and evacuation procedure for flood-prone areas. This system sets up a three-phase operation (alert, warning and evacuation) to be activated by information from weather sources and stream and rainfall gages located in the metropolitan area. Tasks to be performed during these phases have been assigned to specific City agencies. The Department of Public Works was given the task of "Direction and Control" of the flood emergency system.

Action Plan SWIFT (Snow, Wind, Ice, Flood, and Tornado) was created to further detail and coordinate Department tasks during emergencies from severe weather conditions (See appendix). The SWIFT S.O.P. delegates emergency task responsibilities to City Departments, describes the role of the Mayor and of key Departmental personnel, and outlines the flow of operations, pre-alert preparedness status, and communications system for implementing SWIFT.

These documents form the basis for the Baltimore City Flood Warning and Evacuation Program. Because floods create problems different from severe ice or snow storms, additional information has been compiled to deal specifically with floods. For example, maps showing flood-prone areas of the City have been developed. Lists and maps of flood-prone homes and streets are, or shortly will be, available to personnel involved in flood emergency work. A list of properties to be notified in the warning phase will be available to Police, Fire and Public Works personnel. The Baltimore City Emergency Operations Center will also be in communication with Baltimore County during emergencies to exchange information on weather conditions and the local flood status.

Action Plan SWIFT and the S.O.P. for flood warning and evacuation could be upgraded in several ways. The installation of telemetric stream gauges, as has been done in Howard County, would eliminate the need for human monitoring of streams, and would quickly yield data to the decision-makers in the Emergency Operations Center. The installation of electronic warning signs, which are activated by water depth, at flood-prone intersections or stretches of roadway would deter the passage of vehicles. Similarly, permanently posting flood warning signs in areas of known flood hazard would increase public awareness and caution during rainstorms.

Another consideration in an warning and evacuation program for Baltimore City is the need to practice its implementation. "Dry runs" are a vital part of any emergency preparedness program. These practice sessions help to identify weak links, unworkable procedures, duplication of effort and oversights in program development. In addition, it accustoms involved personnel to the procedures, timing needs and routine of the program.

The Floodplain Management Plan recommends that data developed during the planning process on flood hazard properties and streets, be places in a format to be used by the City's SWIFT program. This data will greatly increase the efficiency of the SWIFT operation. Examples of a proposed format are included in the appendix.

MINOR STREAM CHANNEL IMPROVEMENTS

The accumulation of sediment and debris in City streams has reduced channel capacity and created obstructions to flow. While severe storms such as hurricanes or tropical storms will cause serious flooding even with clear, well-maintained stream channels, the damages caused by lesser storms may be decreased by the timely removal of large sediment deposits, fallen trees and other debris. Therefore, the Baltimore City Floodplain Management Plan recommends the scheduling of capital projects to perform much-needed shoal and debris removal on the City's streams.

A second component of the Minor Stream Channel Improvements program is the protection of eroding streambanks, to help curtail damages on adjacent lands, protect utilities and other public improvements, and lessen the sediment load in the streams. Reducing sediment loading will slow the accumulation of materials in the streambed, and ultimately, in the Patapsco River and Chesapeake Bay.

The third component of this program element is a recommendation that a Stream Cleaning and Maintenance program be re-instituted as an operating budget item on an on-going basis. The condition of many portions of the City streams requires a capital expenditure for restoration and rehabilitation. However, to avoid the deterioration of work accomplished in such a capital project, there must be a program in place to systematically inspect and maintain the streams.

Areas needing minor stream channel improvements are shown on the following maps for each riverine watershed in Baltimore City. The identification of reaches needing improvements was accomplished from damage surveys after major storm, (Tropical Storm David) observations made during systematic inspections of the streams for sanitary sewer overflows, and from discussions with several employees of the Department of Public Works. This work is considered especially important in reaches of streams where there is dense development or where constrictions such as bridges and culverts are prone to blockage by the accumulation of sediment and debris.

In some cases, shoal removal may be necessary where extensive stream channel alterations have already occurred. This is the case in many portions of the Jones Falls, where channel-widening projects consisting of concrete walls and streambed now show large accumulations of sediment in the streambed, and lack of maintenance along the banks. Concrete blocks have fallen into the stream channel, and trees have begun to grow out of cracks in the channelized banks. Silt traps have become clogged with debris and live vegetation. While large capital investments were made in the construction of these channels, funds were not provided for their maintenance. Floods have, over the years, destroyed portions of these projects. Plant growth, as well as seasonal shrinking and swelling of the earth beneath the concrete, and natural deterioration of the materials have also contributed to worsening stream conditions.

Unchannelized portions of streams have significantly deteriorated as well. Sedimentation, which raises the streambed elevation, provides a habitat for plant growth. Large trees may grow on shoals in mid-stream and become obstructions during floods. Natural streambanks often support dense growths of vegetation. This vegetation provides valuable bank stabilization and shade for aquatic life, but also screens illegal dumping activities and other stream channel obstructions. Years of neglect have resulted in the need for a program to systematically remove these obstructions and improve stream conditions.

Minor stream channel improvements as recommended in this report are not intended to include channelization projects. Rather, the objective of the program is to restore and rehabilitate existing natural as well as structurally improved portions of streams. Channelization projects are costly, have limited flood control capabilities, and require costly repair and maintenance work. The City must address the repair and rehabilitation needs of its already channelized stream lengths. The Minor Stream Channel Improvements program is intended to do this. However, it is also imperative that unaltered stream segments be restored and rehabilitated to minimize flooding damages and erosion. In addition, the restoration of natural streams has water quality, recreational and wildlife benefits.

Restoration of unimproved stream lengths will consist of shoal and debris removal, stream bank stabilization with gabion baskets, wire matting or other kinds of slope stabilization, and revegetation. This work will temporarily disrupt the stream system, but in the long-term will improve the natural functions of the stream by restoring natural gradients, and by removing debris and excess sediment.

The Stream Cleaning and Maintenance program, to be incorporated as an operating budget item, should be adequately funded and systematized to maintain the capital improvements accomplished under the Minor Stream Channel Improvements program. There must be personnel available to survey streams in a systematic manner. In addition, the program will require adequate personnel and equipment to remove accumulated sediment, trash and large fallen trees. Finally, there must be a specified dumpsite for these materials. It is suggested that the Bureau of Solid Waste (which currently implements erosion control projects), within the Department of Public Works, be given this responsibility.

It is fully recognized that stream channel cleaning and maintenance will not stop flooding. Its major impact will be in reducing damages from the more frequent, less severe floods which often cause localized problems due to obstructions in stream flow. In combination with the other elements of the comprehensive plan it will be a valuable tool in reducing flooding damages.

LEGISLATION

Baltimore City has already amended zoning and building codes restricting uses in flood hazard areas. The Zoning Ordinance establishes five new districts and permitted uses. The building code establishes standards of construction for each district. The floodplain zoning districts "overlay" the existing zoning.

This existing legislation does allow, with some construction standards, new residential development in the areas currently being considered for residential acquisition. To provide consistency in City policy, the plan recommends legislation to restrict new residential development in areas where residential structures will be purchased.

The following table outlines the recommended changes in each district.

	FOR NEW DEVELOPMENT	
FLOODPLAIN DISTRICT	EXISTING LEGISLATION	RECOMMENDED LEGISLATION
Floodway (F1)	Open space only permitted use	No change
Floodway fringe (F2)	Residential must be elevated, non-residential must be floodproofed	Residential prohibited, non-residential elevated
Approximated floodplain (F3)	Residential must be elevated, non-residential must be floodproofed	Residential and non-residential must be elevated
Harbor Floodzone (HFZ)	Residential must be elevated, non-residential must be floodproofed	No change
Shallow flood zone (SFZ)	Residential and non-residential must be elevated 2 ft. above the crown of the street	No change

The City is currently in the process of adopting new BOCA-based building codes. As soon as that process is complete these recommended changes to the existing code will be introduced to City Council. In addition the Federal Emergency Management Agency has recently completed a preliminary analysis of wave height and hazard in the Baltimore Harbor. This study resulted in the identification of hazard areas designated as V-Zones. Baltimore will be required to adopt special building code provisions for V-Zones under the Flood Insurance Program. These revisions will also be included with the overall upgrading of our legislation. In V-Zones certain types of fill will be restricted and new construction will be required to be placed on piles. Only a very small area will be affected.