

An aerial photograph of a flooded landscape. A winding, light-colored road or levee cuts through the water. In the foreground, a large building with a gabled roof is partially submerged, surrounded by smaller structures and trees. A small boat is visible in the water to the left. In the background, more buildings and trees are visible on a distant shore. The text "BF 74.02" is handwritten in the upper right area of the image.

Guidelines

for

REDUCING

FLOOD DAMAGES

U. S. Army
Corps of Engineers

Guidelines for Reducing Flood Damages

INTRODUCTION

Since the arrival of the pioneer settlers, man has been building on and occupying the flood plains of natural rivers and streams. The streams first provided transportation and water supply. Later, mill dams were built in the streams, and highways and railroads were constructed along the valleys. The continuing growth of cities today results in ever-increasing encroachment upon the flood plain.

In flood, streams may carry thousands of times more water than during low-flow periods. These floods caused very little damage until the works of man invaded the flood plains. Through bitter experience, man has learned that floods quite often cover portions of the flood plains, damaging or sweeping away roads, buildings, and homes, and often pose a severe threat to human life and health.

Over the years, reservoirs, channel improvements, levees, and other flood-protection works have been constructed to protect the works of man against the force of nature's floods. But encroachment on the flood plains has taken place faster than flood-protection works have been constructed with the result that flood damages have been steadily increasing across the nation.

Historically, man has tried to reduce flood damages through the exercise of control over the river in time of flood. Many different methods have been used for this purpose:

- Storing water in reservoirs for gradual release after the threat of flooding has passed,
- Improving flow conditions by channel improvement so that flood stages can be reduced,
- Reducing the rate of runoff from lands by watershed treatment,
- Confining the river to a definite course by building levees.

These methods are costly and are more often used in areas where delineation has already allowed heavy encroachment on the flood plain, or where future plans call for extensive use of the flood plain.

Despite the expenditure of tax funds running into billions of dollars for flood-control works, the increase in flood damages has led to a new approach for reducing these damages. This approach is the application of control over the use of land lying adjacent to the river through the planned development and management of flood-hazard areas. While flood-plain areas can probably never be considered flood-free, planning will allow selection of a flood risk according to the type of development desired. This will assure a reasonable level of protection during initial construction of a project.

Regulation of the flood plain can be carried out by a variety of means, such as encroachment lines, zoning ordinances, subdivision regulations, and building codes. Some details of these methods will be described later; however, no recommendations will be made for the use of a specific technique. Flood-plain regulations are the responsibility of State and local governments.

The chart, FLOOD DAMAGE PREVENTION (page 6), shows various measures for reducing or preventing flood damages. These measures can be divided into three groups:

- Control over the river,
- Control over the land,
- Other measures.

CONTROL OVER THE RIVER

With reliance mainly on physical alterations to the channel, flood plain, or watershed to control the river, the ultimate goal is to reduce the extent of overflow in the flood plain so as to insure a relatively harmless flow of floodwaters past an area. Types of flood-control works include but are not limited to the following:

Dams and reservoirs

Flood protection can be achieved by providing reservoirs to retard or delay excessive runoff for the purpose of reducing heights of floods. The function of reservoirs is to store water when stream-flow is excessive and to release it gradually after the threat of flooding has passed. This can be ac-

complished by building dams on the main stream and/or on the tributaries.

Levees or floodwalls

Levees or floodwalls protect the populace and exposed property by acting as a barrier and confining floodwaters to a floodway area where they would cause little or no damage. Levees are earthen bankments, whereas floodwalls are generally concrete walls. They are built in the flood plain near the normal stream and should be located to provide maximum protection while encroaching as little as possible on the natural floodway.

Channel improvements

Flood stages can be reduced by improving flow conditions within the channel and by increasing the stream's carrying capacity. Methods generally used to obtain improvements of channels are as follows:

- Straightening to remove undesirable bendways,
- Deepening or widening to increase size of waterway,
- Clearing to remove brush, trees, and other obstructions,
- Lining with concrete to increase efficiency.

Watershed treatment

Watershed treatment, generally applied to small areas, involves the treatment of lands to render the soil more capable of absorbing and retaining some of the excessive rainfall until flood heights in swollen streams have receded. Treatment includes such measures as:

- Crop rotation,

- Construction of terraces,
- Contour strip cropping,
- Selective planting or reforestation.

CONTROL OVER THE LAND

Land-use controls, most often known as "Flood Plain Regulations," do not attempt to reduce or eliminate flooding but are designed to mold the flood-plain development in such a manner as to lessen the damaging effects of floods. Flood-plain regulations imply the adoption and use of legal tools, by communities, with which to control the extent and type of future development which will be permitted in the valleys. For these controls to be effective, it is necessary that the public understand the general flood problem, the degree of risk, and the methods that can be used to control use of the land. There are various means of effecting such flood-plain management.

Designated floodways and encroachment lines

A designated floodway is the area of channel and those portions of the flood plains adjoining the channel which are reasonably required to carry floodwaters. Encroachment lines are the lateral boundaries of the floodway, one on each side of the river. No construction or land filling should be permitted between these lines if these works will interfere with the floodwaters.

Zoning

Zoning is the legal tool that is used to implement and enforce the detailed plans resulting from the

planning program. It is used by towns, cities, counties, and agencies of the States to control and direct the use and development of land and property within their jurisdiction. Zoning insures the safekeeping of property for the public health and welfare and the best use of available land. Division of communities into various zones should be the result of a comprehensive planning program for the entire area. Designated floodways may be zoned for the purpose of passing floodwaters and for other limited uses that do not conflict with that primary purpose. The ordinance may also establish regulations for the flood-plain areas outside the floodway. These include designating elevations below which certain types of development cannot be constructed. The drawing on page 7 illustrates how a flood plain can be properly regulated.

Subdivision regulations

A subdivision can be defined in a broad sense as a tract of land divided into lots for the purpose of sale or building development. Subdivision regulations are used by local governments to specify the manner in which land may be divided. They may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of land, freedom from flooding, size of floodways, and other points pertinent to the welfare of the community. Not only can public health and welfare benefit, but various municipal costs such as maintenance of streets and utilities can be reduced during flood periods. Subdivision regulations provide an efficient means of controlling construction in presently undeveloped flood-plain areas. The

following typical provisions which could be added to regulations would be helpful to flood damage prevention:

- Show extent of the flood plain on subdivision maps,
- Show floodway limits or encroachment lines,
- Prohibit fill in channel and floodway that would restrict flow,
- Require that subdivision roads be above the elevation of a selected flood level,
- Require that each lot contain a building site with an elevation above a selected flood level.

Building codes

A building code is a set of regulations adopted by a local governing body. It sets forth standards for the construction of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public. A well-written and properly enforced building code can effectively reduce damages to buildings in the flood plain. A few of the requirements which should be specified in a building code to reduce flood damages are:

- Prevent flotation of buildings from their foundations by requiring proper anchorage,
- Establish basement elevations and minimum first floor elevations consistent with potential floods,
- Require structural strength to withstand water pressure or high velocity of flowing water,
- Restrict the use of materials which deteriorate rapidly when exposed to water,
- Prohibit equipment that might be hazardous to life when submerged, such as chemical storage, boilers, or electrical equipment.

Development policies

Wise day-to-day policy and action decisions to prevent construction of streets and utility systems in undesirable areas will deter development in flood plains. Street improvements, schools, and other public facilities located elsewhere wield a "soft-sell," negative influence on flood-plain exploitation and a positive leadership toward the higher ground.

OTHER MEASURES

Flood damages can also be reduced by other measures. A few of these, flood proofing, flood forecasting, warning signs, and others, are described in the following paragraphs.

Flood proofing

Flood proofing is a combination of structural changes and adjustments to properties subject to flooding primarily for the reduction or elimination of flood damages. Although it is more simply and economically applied to new construction, flood proofing is also applicable to existing facilities. It has promise in one or more of the following situations:

- Where moderate flooding with low stage, low velocity, and short duration is experienced,
- Where the traditional type of flood protection is not feasible,
- Where individuals desire to solve their flood problems without collective action, or where collective action is not possible,
- Where activities dependent on riverine locations need some degree of protection,

- Where a resource manager desires a higher degree of protection than that which is provided by a flood-control project.

Many different flood-proofing measures have been recognized and studied. The names given most of them are self-explanatory. Included in those measures are the following items:

Seepage control	Appliance protection
Sewer adjustment	Utility adjustments
Permanent closure	Roadbed protection
Openings protected	Elevation or raising
Interiors protected	Temporary removal
Protective coverings	Rescheduling
Fire protection	Proper salvage

Watertight caps
Proper anchorage
Underpinning
Timber treatment
Deliberate flooding
Structural design
Reorganized use

A useful guide, "Introduction to Flood Proofing," prepared by the Center For Studies, University of Chicago, under the sponsorship of the Corps of Engineers and the Tennessee Valley Authority, is available. It presents many helpful suggestions and briefly outlines and illustrates the possibilities of this approach.

Flood forecasting

Reliable, accurate, and timely forecasts of floods and flood stages can be coupled with timely evacuation to save lives and reduce property losses. Because of the highly technical nature of the work and the interstate factors that must be considered, the Federal Government has provided leadership in developing and operating the major forecasting

system. The Environmental Science Services Administration (U. S. Weather Bureau) has the primary responsibility, although others, such as the Corps of Engineers, Bureau of Reclamation, and Tennessee Valley Authority, cooperate in providing services in selected areas.

There are many areas for which forecasts are not now available; and too few cities and communities have adequate plans to effectively disseminate the information, help with evacuation, and provide help to those temporarily displaced and distressed.

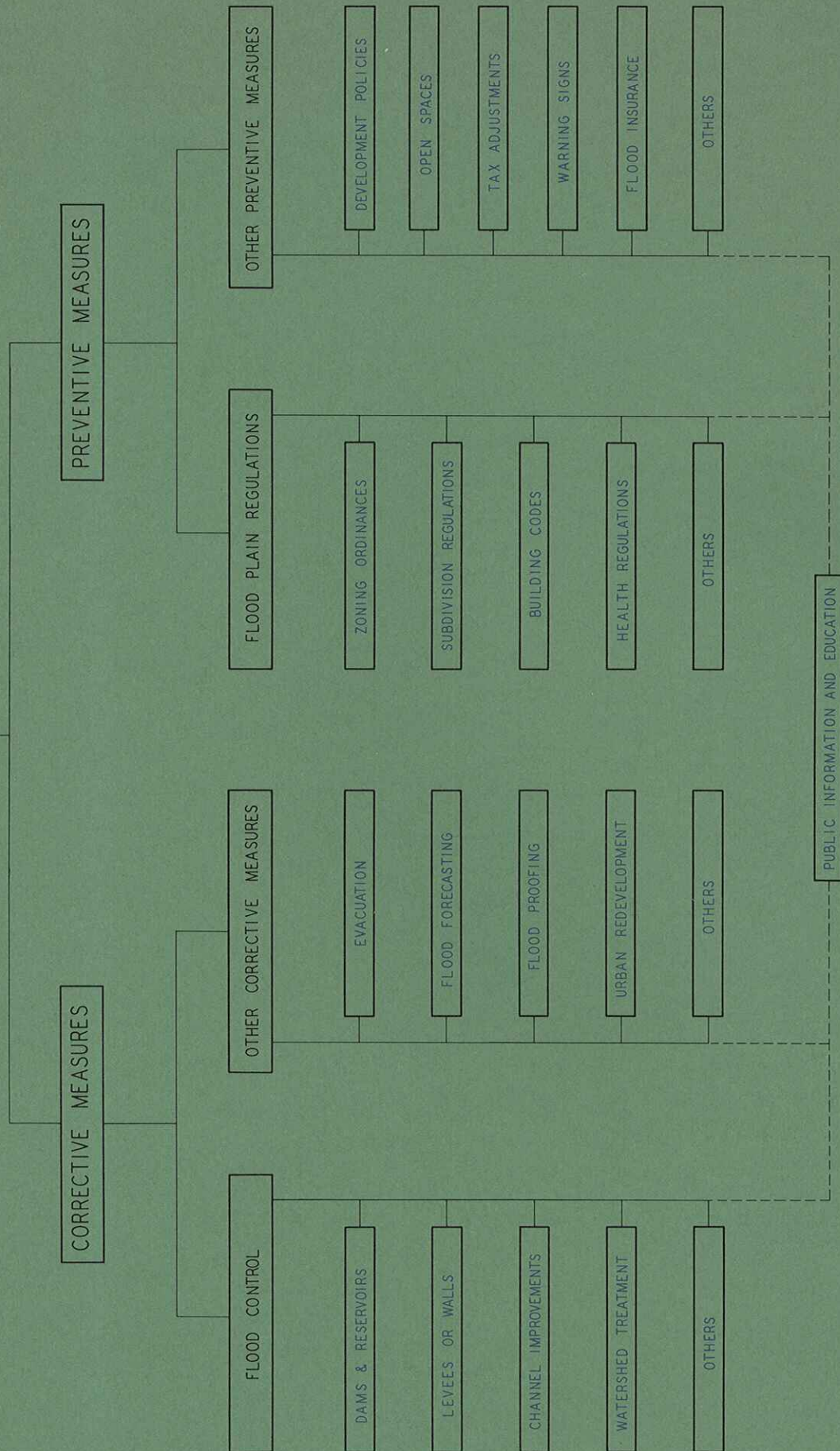
Communities should consider the possible benefits of having a forecasting service and should inquire into the availability of or plans for this service. Should forecasting service be available, they should prepare local plans for effectively using the information. Pamphlets and limited guides are available from the Environmental Science Services Administration (U. S. Weather Bureau).

Temporary evacuation

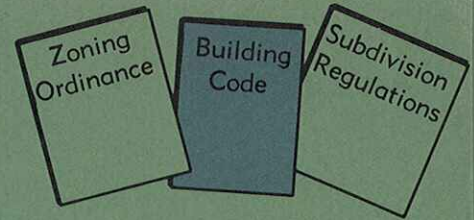
Temporary evacuation of persons and property from the path of floodwaters is another important part in reducing flood losses. After it is known that a flood can be expected,

- Buildings can be evacuated,
- Materials can be raised above floodwaters or removed to higher ground,
- Emergency protective measures can be undertaken,
- Flood fighting and relief agencies can be activated.

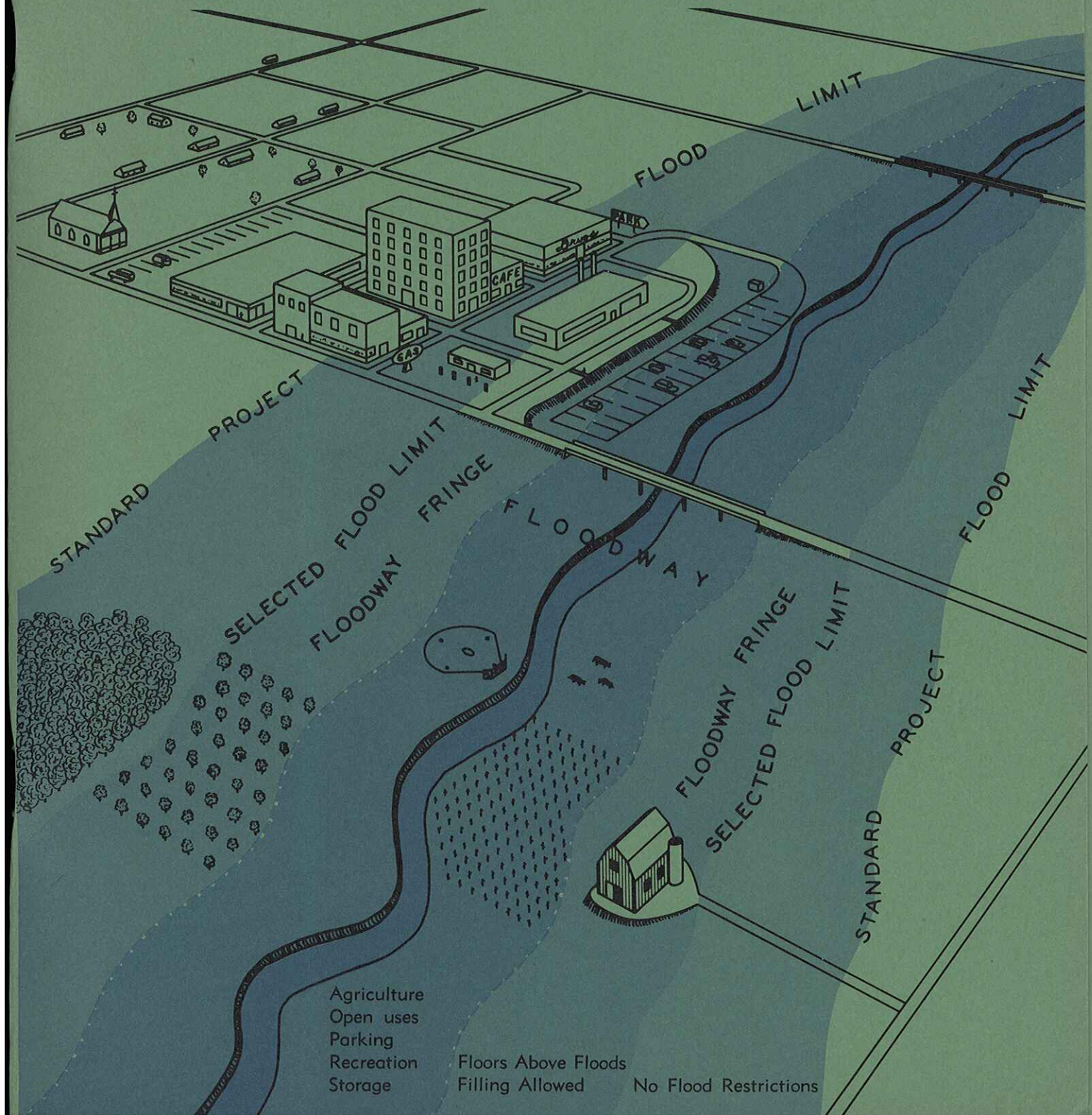
FLOOD DAMAGE PREVENTION



Flood plain regulations



TO ENCOURAGE WISE USE AND AVOID FLOOD DAMAGE



Permanent evacuation

Permanent evacuation of developed areas subject to inundation involves the acquisition of lands by purchase (through the exercise of the powers of eminent domain, if necessary), the removal of improvements, and the relocation of the population from such areas. Lands acquired in this manner could be used for agriculture, parks, or other purposes that would not interfere with floodflows or result in material damage from floods.

Open spaces

Great emphasis is being placed on the growing need for vastly increased areas for recreational and other open-space uses. Areas adjacent to streams and other bodies of water have a natural attraction and are readily adaptable to recreation and open areas. Parks, playgrounds, and picnic areas can utilize lands which would not be suitable for facilities requiring permanent structures. A number of localities throughout the country are using flood plains for such purposes and are reaping secondary benefits from the flood damage prevention. Federal grants are made to assist communities in acquiring such open spaces when linked with a program of comprehensive planning.

Urban redevelopment (renewal)

Urban renewal can be used in flood-blighted areas that are a drain on the economic life and welfare of the community and do not lend themselves to other methods of regulation and control. The Federal Urban Renewal Program provides substantial assistance to municipalities burdened with such conditions.

A redevelopment program should include flood-control works where appropriate and necessary as well as setting aside the lower flood-plain areas for parks, open spaces, and other uses not subject to substantial flood damages. Public parking areas may be designated, provided adequate regulations or precautions are established. To minimize flood damages, the upper areas can be utilized for new structures.

Warning signs

A method which may be used to discourage development is the erection of flood warning signs in the flood-plain area or the prominent posting of previous high-water levels. These signs carry no enforcement but simply serve to inform prospective buyers that a flood hazard exists.

Tax adjustment

Tax adjustments for land dedicated to agriculture, recreation, conservation, or other open-space uses may be effective in preserving existing floodways along streams. Unless such concessions are made, farmland adjacent to communities will become more valuable each year as residential or commercial developments move into parts of it, which will cause tax evaluation of all adjacent farmland to rise to the point where the land no longer can be used profitably for farming or other open uses.

Building financing

Very little building is carried on without financing. Therefore, lending institutions, both Federal and private, are in a position to exercise some control over flood-plain development by denying

mortgage guarantees or funds to subdivision or individual builders.

Flood insurance

Flood insurance, if established on a sound and equitable basis, could provide still another supplement to many programs for reducing flood damage. However, insurance rates should realistically reflect the flood risk in order to avoid encouragement of improper development of flood plains. Such risk would be reduced by regulation of use of the flood plain.

Bridges

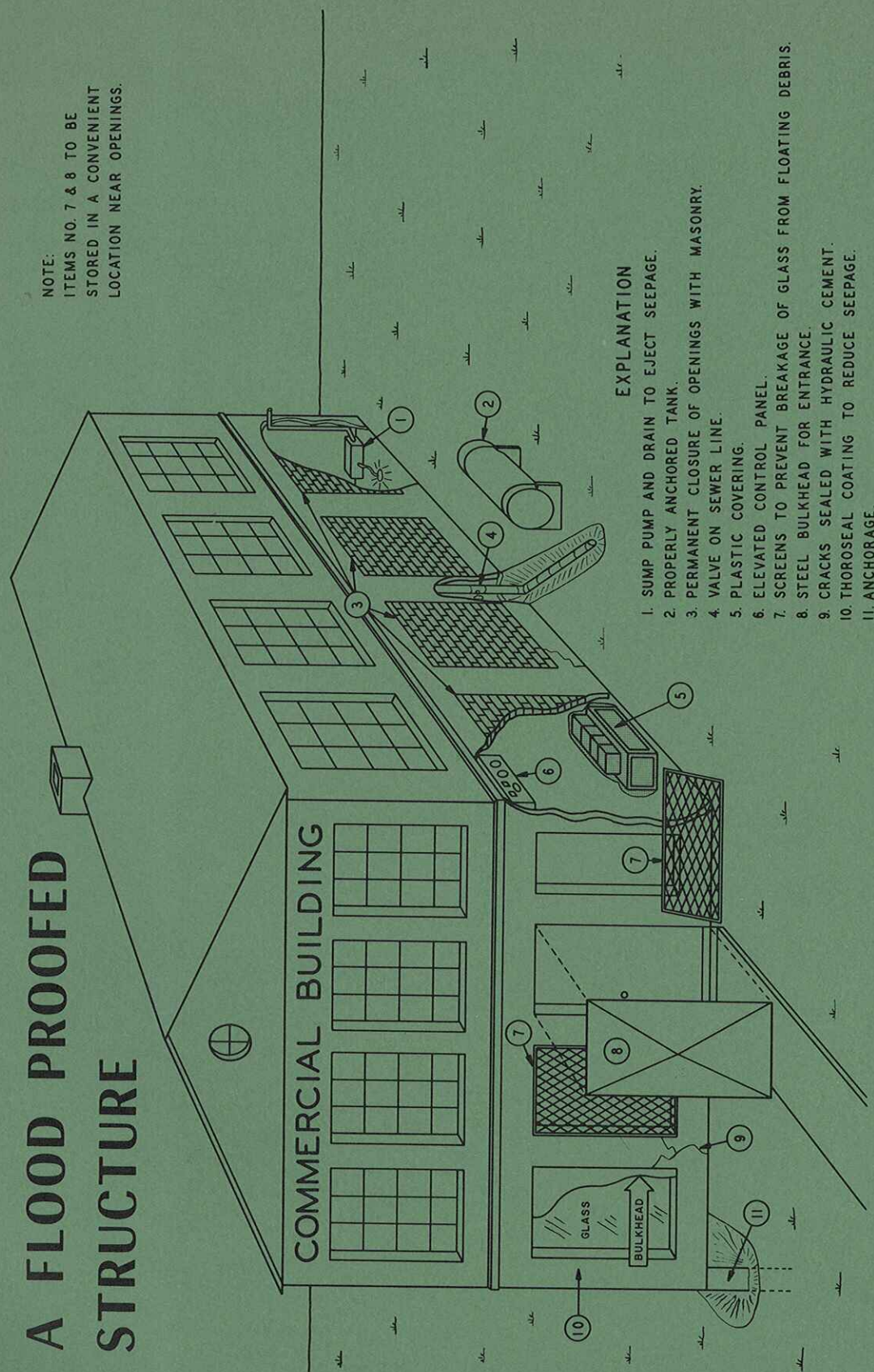
Community expansion brings about the desire for more stream crossings. From a construction stand-

point, perhaps the most economical method of providing crossings consists of roadways on earth embankments, with a small bridge or culvert to pass streamflows. However, this is often the least desirable from a flood damage point of view. If the structure is kept at a low elevation, it is frequently flooded and fails to serve its intended purpose. If the roadway is kept high, above the flood plain, it will act as a dam and increase flood stages upstream unless the waterway opening is adequate. Therefore, all future stream crossings should be designed to provide:

- Adequate waterway opening,
- Adequate bridge clearance above floodflows,
- Adequate roadway height above floodflows.

A FLOOD PROOFED STRUCTURE

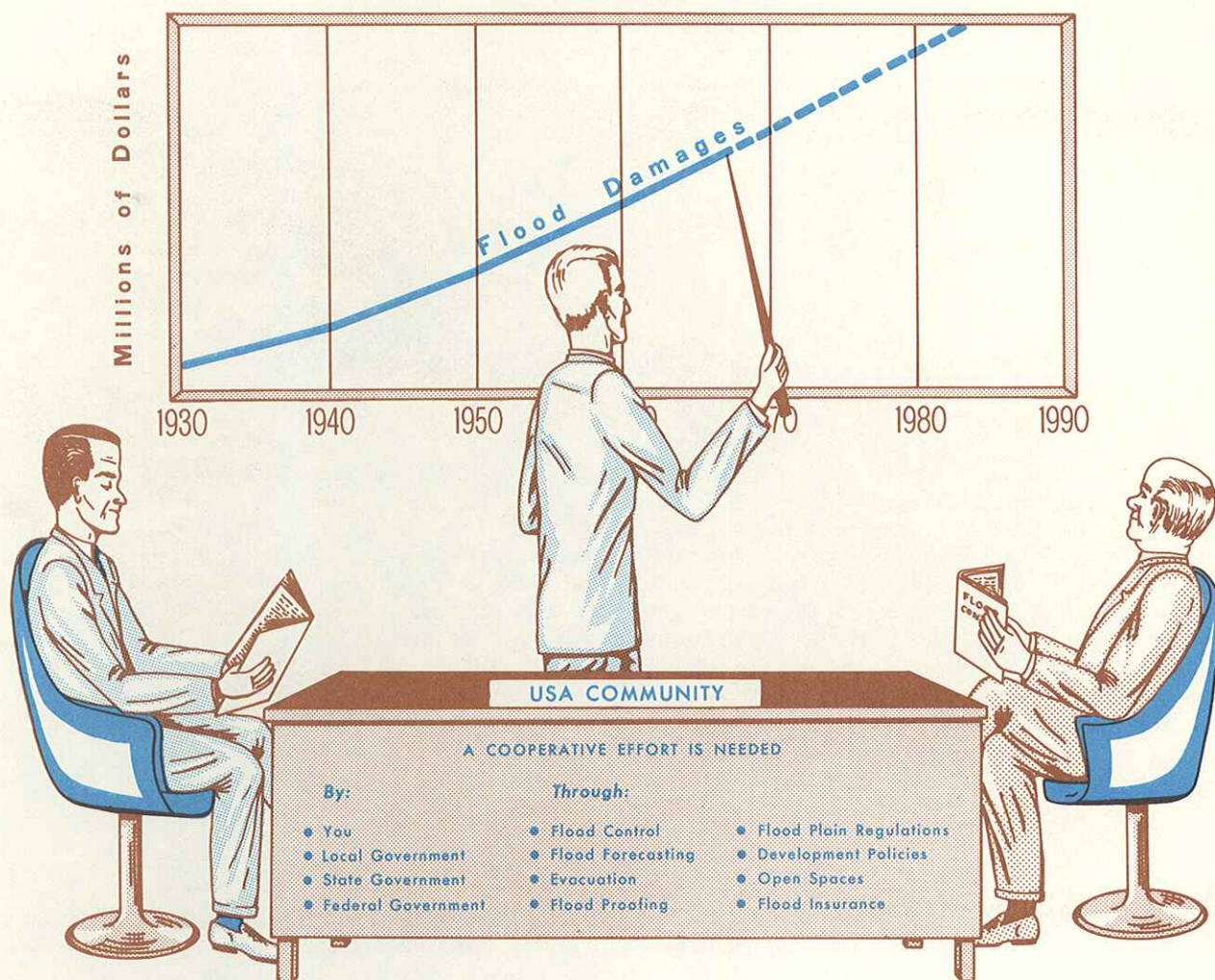
NOTE:
ITEMS NO. 7 & 8 TO BE
STORED IN A CONVENIENT
LOCATION NEAR OPENINGS.



EXPLANATION

1. SUMP PUMP AND DRAIN TO EJECT SEEPAGE.
2. PROPERLY ANCHORED TANK.
3. PERMANENT CLOSURE OF OPENINGS WITH MASONRY.
4. VALVE ON SEWER LINE.
5. PLASTIC COVERING.
6. ELEVATED CONTROL PANEL.
7. SCREENS TO PREVENT BREAKAGE OF GLASS FROM FLOATING DEBRIS.
8. STEEL BULKHEAD FOR ENTRANCE.
9. CRACKS SEALED WITH HYDRAULIC CEMENT.
10. THOROSEAL COATING TO REDUCE SEEPAGE.
11. ANCHORAGE.

FLOOD PLAIN MANAGEMENT CAN STOP THIS INCREASE



Damage to property, human suffering, and loss of life resulting from floods have been increasing year by year in spite of decades of effort and the expenditure of over seven billion dollars for flood control works. This losing battle stirred public officials, technical experts, and others throughout the Nation to take a critical look at the reasons for it.

The increase in flood damages has been due to the rapid growth of flood damageable improvements in the flood plains of the rivers and seacoasts. This growth has taken place at a rate greater than that of providing flood control works.

An obvious solution to this problem is to exercise greater wisdom in the use of flood plains. However, such wisdom cannot be exercised unless there is adequate knowledge of the flood hazard and a will on the part of the users of the flood plains to cope with the hazard.

Cooperative action by local, State, and Federal governments and private interests is essential.

At the Federal level, steps have been taken for paying greater heed to flood hazards and for making efforts to limit the increase in flood damages. At the

Flood Plain Management Services

Administration's request, a special task force reviewed the combined experience and judgment of various Federal, State, and local agencies, as well as outside experts, and submitted a report providing guidance in dealing with flood losses by a wide variety of means. This report was strongly endorsed by President Johnson in August 1966 when he forwarded it to Congress. He also issued Executive Order 11296 directing all Federal agencies to evaluate flood hazards in their programs involving structures, lands, grants, and loan or mortgage insurance.

The U. S. Army Corps of Engineers Flood Plain Management Services program plays a major role in this national effort to alleviate flood damages.

□ The Corps' Flood Plain Management Services program operates in each of 47 Division and District offices with nationwide coverage. The purpose is to make available to Federal, State, and local governmental agencies information, guidance, and advice on the flood hazard which will permit them to proceed with such planning, engineering studies, construction, and other action as may be necessary for wise use of flood plains.

The program includes:

- Flood plain information reports.
- ① Technical services and guidance.
- ① Guides, pamphlets, related research.
- Comprehensive flood damage prevention planning.
- Flood plain information reports are prepared upon request of State and local agencies to delineate flood problems in communities throughout the country. The Corps of Engineers has gathered much flood plain information during the conduct of its responsibilities for flood control. Such information is assembled and organized under this program. When necessary, additional physical surveys and hydrologic studies are undertaken. A typical report includes maps or mosaics, profiles, charts, tables, photographs, and a narrative describing the extent, depth, and duration of flooding by floods of the past and those that may reasonably be expected in the future.

○ It is the responsibility of the State and local governmental agencies to publicize the information and put it to use through planning groups, zoning boards, private citizens, engineering and planning firms, real estate and industrial developers, and others to whom it would be useful. Federal agencies use the flood information in their respective considerations and decisions.

① Technical assistance is given states and local governments in the preparation of flood plain regulations. Interpretation of flood data in the reports, provision of additional data, suggestions for floodway areas and evaluation of the effect of those floodways on flood heights, and related assistance are given planners and officials as they prepare and adopt flood plain regulations.

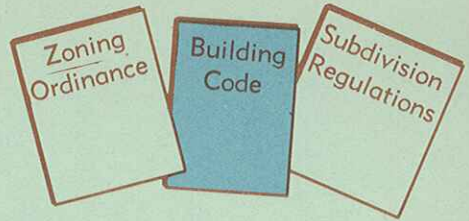
① Technical assistance is given states and local governments in evaluating and using flood data in making individual decisions concerning flood hazards. This includes brief, preliminary type flood plain information reports, where necessary, for specific sites. Necessary flood information and guidance are provided, on request, to permit wise decisions concerning locations of public buildings, subdivisions, and other land uses. Technical assistance and guidance are also given on flood proofing.

① Federal agencies are evaluating flood hazards in the conduct of their respective programs in accordance with Executive Order 11296. The Corps, upon request, provides them with flood hazard information and with guidance on flood proofing, except for the area within the Tennessee River Basin.

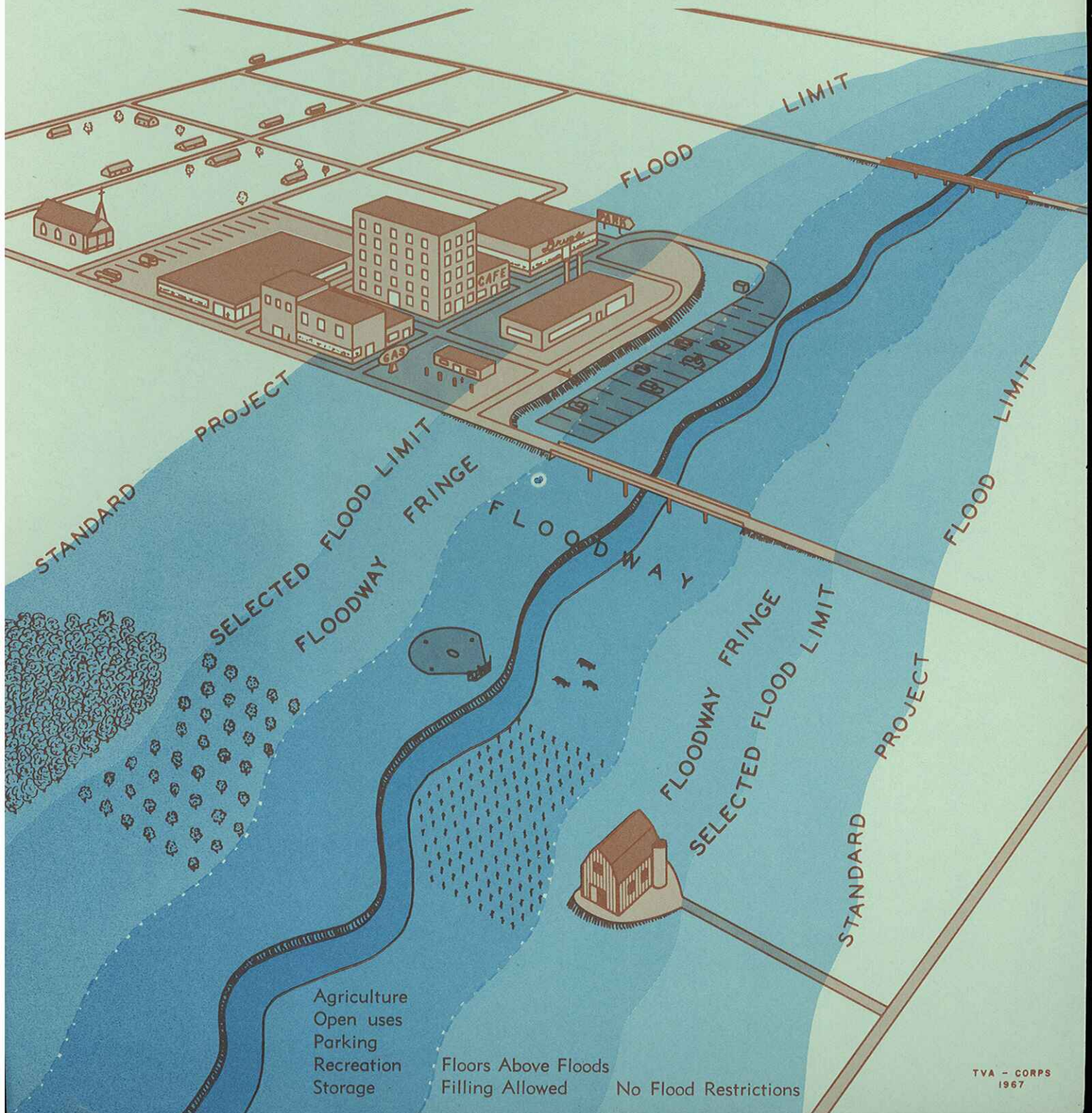
① Pamphlets and guides pertaining to flood plain regulations, flood proofing, and other related actions are prepared. They are made available for use of Federal, State, and local governments, and citizens in planning and taking action to reduce their flood damage.

● Comprehensive flood damage prevention planning, at all appropriate governmental levels, is the ultimate objective of the program. This brings State and local officials into the planning action to a greater degree and insures increased consideration of other alternative measures as well as flood control.

Flood plain regulations



TO ENCOURAGE WISE USE AND AVOID FLOOD DAMAGE



FLOOD PLAIN REGULATIONS —

To Avoid Flood Damages

In spite of a number of highly successful flood-control works throughout the Nation, hardly a year goes by without loss of life and an increasing amount of property damage due to flooding. These increasing losses are not due to lack of wisdom in planning flood-control systems. Most of this increase can be attributed to man's unwise use of nature's flood plains.

The need for preserving a portion of the flood plain for floodwater is not a new concept. In addition to other references since the turn of the century, the *Engineering News-Record* in 1937 said

... Rivers were here long before man, and for untold ages every stream has periodically exercised its right to expand when carrying more than normal flow. Man's error has not been the neglect of flood-control measures but his refusal to recognize the right of the rivers to their floodway....

The public has been slowly coming to a greater awareness of the need for recognizing the rivers' and oceans' rights. This awareness has led to a new trend of thought and action, in terms of the broader concept of flood damage prevention rather than the single action of flood control.

The importance of flood damage prevention is becoming more pronounced with our expanding population. Vacant lands are being covered with subdivisions, commercial centers, and industrial plants. Often these lands are subject to a serious flood hazard the developers do not or will not recognize. It then becomes the duty of governmental agencies at the various levels, in the public interest, to properly guide use of flood plains through flood plain regulations.

To be effective, flood plain regulations must be based on sound technical data. With suitable data, community leaders, aided by specialists, can select a flood of a magnitude suitable for regulatory purposes. Using this flood the appropriate governmental body, usually a city or county but in some instances the State, can draw up sound flood plain regulations.

There is no standard pattern for flood plain regulations. Those now in force vary

widely in form, but all have the same purpose—avoiding flood damages. Some states establish encroachment lines along streams between which no encroachment or obstruction may be placed. In other places the building code, zoning ordinance, and subdivision regulations contain provisions that establish minimum floor elevations and other construction criteria for buildings in the flood hazard areas. Others combine the two—a floodway to accommodate nature's floodwaters, and minimum floor elevations in the floodway fringe for man's welfare.

Communities in the Tennessee Valley prefer this combined approach. A floodway is established with a width based on the amount of channel and flood plain needed for safe passage of the selected flood, and the profile of the selected flood is developed. This establishes minimum floor elevations for buildings in the floodway fringe area. The illustration on the reverse page depicts the floodway and floodway fringes along a typical stream.

In a typical zoning ordinance the floodway is designated as a zone which has special requirements, much the same as a residential zone has specific requirements. Within the floodway zone only those land uses which are not subject to damage by floodwater and will not restrict its passage are permitted. In addition, minimum floor elevations are established for buildings in the floodway fringe area. Other provisions are included to prevent creation of hazardous conditions.

To guide development in new areas having flood hazards, subdivision regulations and building codes contain appropriate provisions to preserve a floodway. Subdivision regulations also contain provisions requiring each lot in a subdivision to contain a flood-free building site, while building codes provide for a minimum floor elevation and appropriate structural design.

The Corps of Engineers assists State agencies and local governments throughout the Nation in developing flood plain regulations by preparing flood plain information reports outlining flood conditions, and providing technical assistance in use of the data.