Flood Proofing and Flood Damage Prevention

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Address by James E. Goddard, Chief, Local Flood Relations Branch, Tennessee Valley Authority, before the semi-annual meeting of the Tennessee Chapter, American Public Works Association, Memphis, Tennessee, 9 December 1960.

Millions of words and hundreds of headlines dramatically describe the floods and flood damages as they are experienced each year. Next to those which result in loss of life and widespread devastation, floods that receive the greatest attention and nearly always make the front page are those that have cut off public services. This is quite appropriate as human suffering is still of paramount interest. When drinking water is polluted or not available; when sewage plants are affected so as to threaten sanitation; or when loss of power leaves houses and office buildings dark and cold, and a good share of the populace hungry--those are the times when flood news is given great priority. Those are the times when the public works officials are often given the least credit, if any, for their contributions to a good life.

Let's consider why such unfortunate events have been permitted to occur. And also think about what can be done to reduce the likelihood of such catastrophies reoccurring.

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More than 100--possibly as many as 150--cities and towns in the State of Tennessee have the common problem of potential flood damage. The problem is more acute at some sites than at others and experience has shown that the problem at any location may be expected to grow as the area develops. Public works, such as water supply and sewage disposal, have often been designed to utilize the advantages of gravitating to low elevations along streams. Too many have done this without proper consideration of floods which have then interrupted the services and seriously affected the health and welfare of the community.

This description of conditions throughout Tennessee is also applicable to each of the other states in the Nation.

The historic approach to flood damage abatement had been to construct dams, levees and improved channels that would protect investments on the flood plains from floodwaters. TVA's system of multipurpose reservoirs, the Corps of Engineers' reservoirs on the Cumberland River, and the Corps' levees and appurtenant works along the Mississippi River are outstanding engineering achievements in this field. They give total or partial protection to huge areas of farmland and tremendous investments in urban communities.

The backlog of authorized feasible flood control projects in the United States is currently greater than the total amount of such construction completed since passage of the Federal Flood Control Act of 1936. It is so great that, at present rates of construction, it will be another 25 years before those projects can be completed. And there are already a great number of other areas with flood problems where similar projects will be found feasible.

The population explosion, coupled with the increasing rate of movement from rural to urban areas, has resulted in cities sprawling over wider and wider areas. Flood plains in the path of this growth are being intensively developed. Rate of encroachment on the flood plain is so great that, despite the efficient and effective flood control efforts, the flood damage potential is increasing.

I believe you will agree that a new and more comprehensive approach must be taken if we are to win this battle of man against the floods. Various adjustments can be undertaken by inhabitants or communities in flood plains to reduce flood losses. Chief among these are: (1) flood protection, (2) relief, (3) insurance, (4) land-use regulations, and (5) flood proofing. Although these five adjustments are known and proven methods of achieving flood damage reduction, flood protection by engineering works has been the favored one in our national flood program.

I have already discussed flood protection. Each of you are familiar with the various relief activities which seem so humanitarian at the time of need, but which are also, unfortunately, an encouraging factor in the continued occupance of flood hazard areas. Flood insurance is not available to the public, although Congress in 1958 attempted through the Federal Flood Insurance Act to establish an experimental Federal flood insurance program. I will discuss the other two types of adjustments in greater detail.

Land-Use Regulations

The first of these is land-use regulations. Flood damage can be prevented through man's controlling the floods, thus keeping the water away from him. And damage can also be prevented by man controlling himself and keeping away from the water! This latter action is accomplished through land-use regulations.

The Tennessee Valley Authority (TVA) has been cooperating with the State of Tennessee and the other six Tennessee Valley states and scores of local communities in a flood damage prevention program for more than seven years. TVA recognized that few systems of river regulation, including its own, can provide complete protection. As the major part of TVA's contribution to this cooperative program, it has prepared reports outlining the basic flood problems of local communities. Additional technical assistance and guidance is also available to the states and communities. This has given the local officials and planning technicians an understanding

of the problem and provided necessary data that permits them to determine and adopt reasonable, acceptable, and effective land-use controls and other flood plain regulations.

These reports--couched in terms laymen can understand--include maps, profiles, and cross sections clearly outlining the elevations and effects of past floods. Similar information is furnished concerning the future floods that may be expected. The rate of rise and fall of floodwaters as well as velocities in the main channel and in overflow areas is given.

The outlines of areas inundated by various floods are shown, as well as elevations of the floods from which depths of overflow can be determined. Rates of rise and of fall, and the duration of flooding above various elevations, are important as evacuation of people or equipment depends upon the time available. Duration of flooding indicates the length of time an industrial operation or a city's water supply may be interrupted. Velocities in the flood plain are included as they can be used to determine safe design of buildings and, coupled with depths of flooding, reflect dangers to occupants.

The studies made to determine the magnitude of floods that may reasonably be expected in the future are realistically based on historical records. From a study of the maximum storms and floods that are known to have occurred on similar watersheds in the immediate region a Regional Flood is determined. By expanding the study to a much larger region, actually most of the eastern United States, a Maximum Probable Flood is determined. This latter is a very infrequent flood that is used in the design of dams and other protective works, the failure of which may be disastrous. The Regional Flood may be expected to occur much more frequently. Either may occur in any year.

Results of these studies are most important to a community, as all communities have not experienced floods of excessive magnitudes during the past few generations.

The TVA reports do not suggest solutions. The community must take up the responsibility for determining the most reasonable program and promoting action. Decisions and action by the local people are necessary for maximum effectiveness. Additional technical assistance or guidance is given by TVA as planners and local officials study their problems and determine solutions.

Once the flood data are available the community is in a position to consider within the context of its general planning activities the alternatives in a comprehensive flood damage prevention program. Where the flood plain land is already intensively built up, investigations would include the economic feasibility of physical flood control or protective works either as a separate project or as part of an urban renewal program. Where the flood plain is sparsely developed or open, regulations covering the use of the flood hazard areas are considered. Both, however, would be related to the community's plan for development.

Flood reports for about 40 of the Tennessee cities have been completed by TVA. Additional studies are scheduled each year through the cooperation of TVA and the Tennessee State Planning Commission. In addition to these, adequate data has been obtained by the state from the Corps of Engineers to prepare satisfactory reports on two additional cities in the state.

The Corps of Engineers was authorized in July 1960 by Public Law 86-645 to compile and disseminate information on floods and flood damages and to provide engineering advice to local interests when requested by a state or a responsible local governmental agency. This makes it possible for the Corps to provide to the remainder of the State of Tennessee, and to the Nation, substantially the same kind of assistance that communities within the Tennessee Valley have been receiving during the past seven years.

More than one-third of the Tennessee Valley communities for which flood reports have been prepared, 17 of them in Tennessee, have in turn made supplemental planning studies. Several others have such studies under

way. Many of the communities have revised their subdivision regulations and zoning ordinances to include controls in flood hazard areas or have adopted other flood plain regulations. Some have initiated administrative steps for similar action. The majority of the communities have officially utilized the data. Citizens, businessmen, or industries have made good use of each of the flood reports completed.

The flood plain regulations which are being adopted by the cities of the Tennessee Valley and in Tennessee provide for an open floodway for the passage of floodwater and establish controlling elevations for development in the remainder of the flood plain that is subject to inundation. Determination of land requirements for floodway purposes is a technical task requiring engineering consultation. Areas adjacent to the floodways may be utilized by requiring improvements to be at elevations high enough for reasonable safety from flooding--the height of the Regional Flood in most instances. The attached figure illustrates the manner in which inundated areas and floodways are shown on maps.

But the use of zoning is only one part of flood plain regulations. The establishment of subdivision standards which recognize flood hazards, the municipal policies relating to utility expansion in flood areas, and standards for location of public buildings and facilities--all are important tools for regulating use within flood plain areas.

Based on the successful experience of this program in the Tennessee River Basin, TVA submitted a report to the Congress in 1959 recommending a national flood damage prevention program. Public Law 86-645, authorizing the Corps of Engineers to disseminate flood information put into effect one part of the recommendations in TVA's report. It is understood that the other recommendations are being given favorable consideration by Senator Kerr's Senate Select Committee on National Water Resources.

Flood Proofing

The other adjustment mentioned above is termed flood proofing. It is defined as adjustments to structures and contents which are designed or

adapted primarily to reduce flood damages. This approach to flood damage reduction is one that has never been tried in a comprehensive way or in a way which would permit comparison with the other types of adjustments.

With this in mind John R. Sheaffer, a graduate student in the Department of Geography, University of Chicago, conducted a study to estimate the feasibility of flood proofing. It was a cooperative study with Mr. Sheaffer, the University of Chicago, and the Tennessee Valley Authority participating. In addition to research on the subject, determination of the economic feasibility of flood proofing in Bristol, Tennessee-Virginia, was made. Results of the feasibility study were compared with those of a possible flood control project for that city. Mr. Sheaffer's report, Flood Proofing: An Element in a Flood Damage Reduction Program, has been published as Research Paper No. 65 of the Department of Geography, University of Chicago.

The report clearly shows that flood proofing warrants consideration as a possible alternative among the various adjustments to flood. It has special promise in situations where: (1) moderate flooding with low-stage, low velocity, and short-duration is experienced, (2) the traditional type of flood protection is not feasible, (3) individuals desire to solve their flood problems without collective action or where collective action is not possible, (4) activities which demand riverine locations to function need some degree of protection, and (5) a resource manager desires a higher degree of protection than that which is provided by a flood control project.

Flexibility is inherent in the flood-proofing approach. It can be used in conjunction with flood control projects, flood-plain regulations, and flood insurance in order to reduce flood losses. It can also be used separately for partial or interim relief. But it should normally be considered a supplement to the other approaches rather than an alternate.

A flood-proofing program may involve existing structures as well as proposed structures. An example of the former is the Joseph Horne Department Store in Pittsburgh, Pennsylvania. Examples of the latter are the various Gateway Center buildings and the new Pittsburgh Hilton Hotel in Pittsburgh.

There are three main classes of action that can be taken: permanent, contingent, and emergency. Permanent measures would be permanent protection against the floods for which they were designed and would not depend upon any judgment, flood forecast, or action to put them into effect. Examples would include permanently closing openings in outer walls with impervious material or installing automatic valves on sewer lines in such a manner that when floodwaters back up, the back pressure closes the valves.

Contingent measures would not be effective unless, upon the receipt of a warning or forecast, action would be taken to make the measures operational. An example of this would be a sewer valve which would have to be closed manually in order to prevent flooding. A show window equipped with a removable aluminum bulkhead would also exemplify a contingent measure, for if a decision were not made to put the bulkhead in place before the waters arrive, the measure will be worthless when evaluated in light of its effect upon reducing flood damages.

Emergency measures would be either improvised during an actual flood or carried out according to prior emergency plans of action. The temporary removal of merchandise from a threatened area would be an example of an emergency measure. The rescheduling of freight shipments so as to reduce the amount of damageable material stored on the flood plain is another example.

Many different flood proofing measures have been recognized and studied. The names given most of them are self-explanatory. The attached sketch illustrates how twelve of these may be used in flood proofing a structure. Included in those measures are:

Seepage control	Appliance protection	Watertight caps
Sewer adjustment	Utilities service	Proper anchorage
Permanent closure	Roadbed protection	Underpinning
Openings protected	Elevation	Timber treatment
Interiors protected	Temporary removal	Deliberate flooding
Protective coverings	Rescheduling	Structural design
Fire protection	Proper salvage	Reorganize use

Many of these measures are not applicable to public works problems. However, you public works officials are respected public servants who by the very nature of your offices are an important part of the city's leadership. Your interests must extend well beyond your immediate responsibilities. For that reason it is well for you to understand what can be done for the total flood problem as well as for the public works direct interests.

Seepage Control--The most common adjustment for controlling seepage is to seal walls with either asphalt or quick-set hydraulic compounds. Another approach to the seepage problem is to provide drainage and pumping facilities.

Sewer Adjustment--Various types of valves can be installed on sewer lines to eliminate this problem. In some instances these valves close automatically while others are closed manually.

Permanent Closure--Permanent closure of unnecessary openings in relatively impervious structures can be of masonry similar to the original construction or glass bricks which will allow the passage of light.

Openings Protected--Some openings must be maintained for structures to function. Sandbagging represents temporary emergency protection which can be utilized. Removable bulkheads or floodgates are perhaps the most effective way of sealing openings. These devices are bolted against a frame containing a neophrene gasket which provides a watertight seal. The bulkheads can be placed inside the windows so as not to affect the exterior appearance.

Interiors Protected--Perhaps the major attempt to reduce damages to interior decorations is the use of waterproof cements when installing asphalt tile or linoleum.

Protective Coverings--On occasion machinery has been packed with grease to minimize silt and rust damage from floodwaters. Practical temporary protective coverings could be made for machinery by using new plastic

materials. Warehouse storage could be given a degree of protection by placing strips of polyethylene between the layers of cartons. This forms moisture barriers and protects against water damage from capillary action.

Fire Protection--A separate power grid to service the flood plain would permit shutting off power during floods and thus remove the possibility of fire caused by electrical short circuits. Proper fuse protection for individual buildings would reduce the likelihood of fire.

Appliance Protection--Simply by throwing a switch or pulling a plug so that the power unit will not burn out, damages to some electrical appliances can be reduced substantially.

Utilities Service--Maintaining continuous service or minimizing the period of disruption of utilities are means of reducing flood losses. Systems or power grids can be modified so that electric power can be brought in from other sources; gas can be rerouted through lines remaining in service; wire levels or crossbars on utility poles can be raised above flood levels; utility intakes, pump houses, substations, switchboards, vaults, interconnections, and transformers can be elevated, moved, or protected. Wells can be protected by extending the casings above flood levels.

Roadbed Protection--Highway and railroad fills endangered by wave action or overflow can be protected by stone riprap or a similar blanket protection. In one area trees have been planted. The detrimental effects of burrowing by groundhogs, gophers, and other rodents can be dealt with by eradication programs. Excessive heading at bridges can often be reduced by replacing solid bridge railing by open railing.

Elevation--Damage could be avoided by land fill or elevating structures above expected flood levels.

Temporary Removal--Plans for emergency removal of goods, equipment, office records, and supplies can result in a substantial reduction of damages. Arrangements to evacuate inhabitants, such as those prepared by the Red Cross for the Lake Okeechobee area, are accepted practices.

Rescheduling--Outgoing shipments of finished products could be hastened and delivery of incoming supplies delayed.

Proper Salvage--Records, books, documents, and office equipment can be restored to usable condition following inundation if given prompt and proper care. Household damages could be reduced if electrical appliances were disconnected and then thoroughly cleaned and dried before being returned to use so the motors would not burn out.

Watertight Caps--Storage tanks in flood hazard areas could be fitted with watertight caps containing rubber gaskets.

Proper Anchorage--Anchorage of surface and underground storage tanks, open storage, and lumber can reduce damage. Proper anchorage of frame structures and bridges can save them from washing out.

Underpinning--Proper underpinning of structures can reduce subsidence and structural failure.

Timber Treatment--Creosoting of timbers exposed to floodwaters can protect them from rot following a flood.

Deliberate Flooding--Sometimes an area is deliberately flooded in order to relieve flood threats elsewhere and thus protect a more valuable area. Structures and tanks which are in danger of becoming buoyant or collapsed by hydrostatic pressure can be deliberately flooded to save them.

Structural Design--New structures can be designed to make them less vulnerable to floods.

Reorganize Use--Activities extremely susceptible to flood damage can be located at elevations above the potential flood level.

Before an effective flood-proofing program can be undertaken in a community, basic hydrologic and economic data must be available. A local flood report analyzing the flood hazard would facilitate planning for a desirable degree of protection. The report should be analogous to the TVA local flood reports which contain information on historical and future floods.

Flood forecasting appears to be essential for the effectuation of some of the flood-proofing measures. Federal, state, and local governments can work together to provide such services whenever it is feasible.

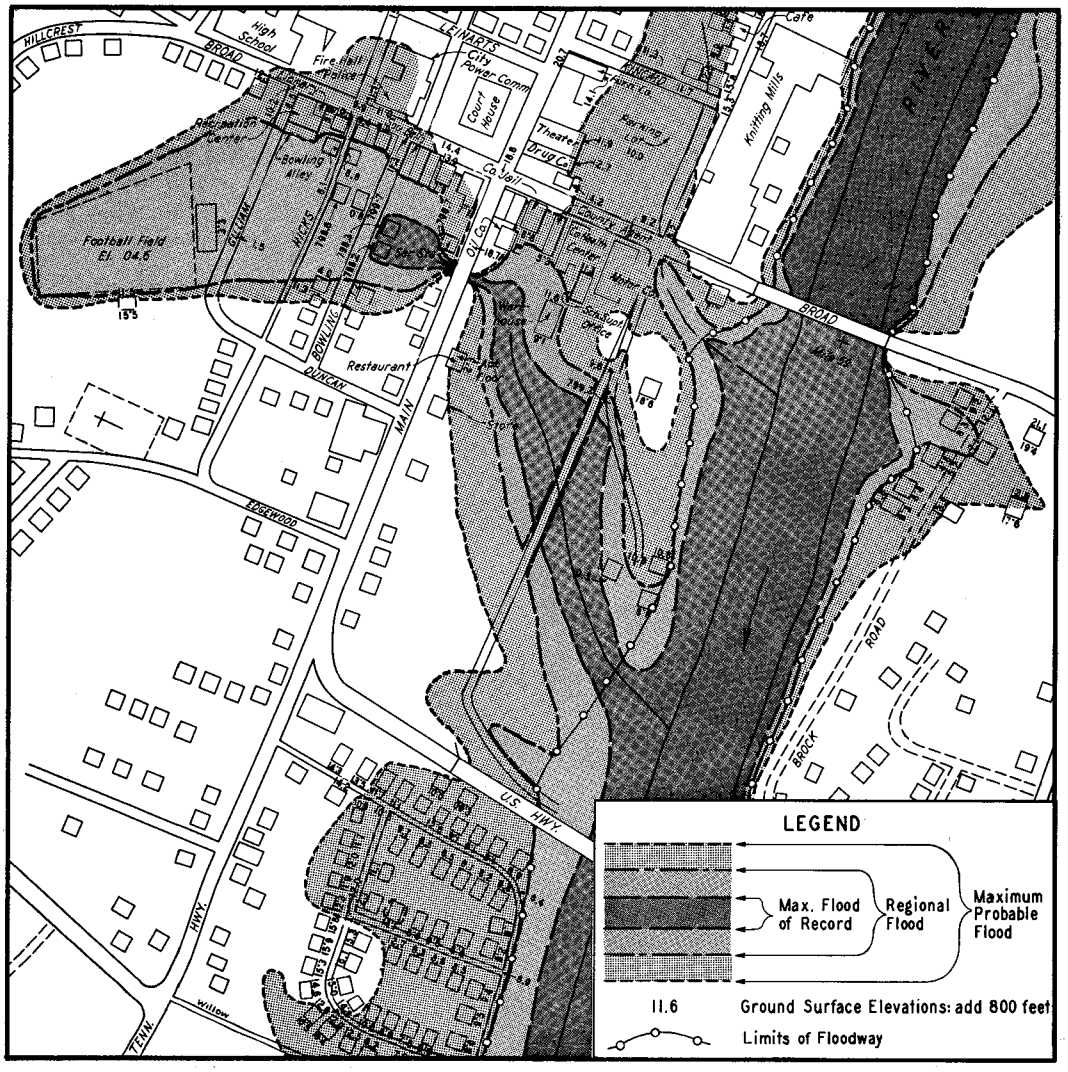
Local agencies generally do not have the ability and experience to cope effectively with their flood problems; technical assistance may be needed to demonstrate the range of adjustments available. Such technical aid can be provided by Federal or state agencies drawing upon experience from other areas.

There are thousands of structures, and unfortunately far too many public buildings, located in areas susceptible to flooding. Flood control projects that will regulate and reduce the height of floods at the sites have protected many of these and have reduced the flood threat at others. However, that residual threat and the total threat to the remaining sites remain as major problems to the respective communities. Effects on water supply and sewage disposal plants cannot be measured in terms of dollars alone but involve the health, safety, and welfare of thousands of citizens.

Flood proofing offers an encouraging way of economically giving existing structures variable degrees of protection from flooding. It also permits the design of plants and other structures for reasonable occupance of low areas that are not needed for floodways.

I encourage each of you to consider your respective problems in light of these remarks. Nearly all sound structures, with the exception of some frame buildings, can be adjusted. Most commercial and industrial enterprises can adjust by transfer of equipment critical to their operations in order to reduce interruptions or processing. Relatively minor structural adjustments at water supply plants, sewage disposal stations, power distributing systems, and other utilities can insure against minor disasters in your cities. Adjustments at courthouses, municipal buildings, Federal post offices and office buildings could protect the irreplaceable records that are so important to our personal as well as public lives. These actions will also reflect great monetary savings. The costs for such adjustments will be surprisingly small.

I must warn you of thinking that any one approach to flood damage prevention will satisfactorily solve your local problem. You should consider each of the possible approaches and use a combination of those that will permit the most practical and acceptable program.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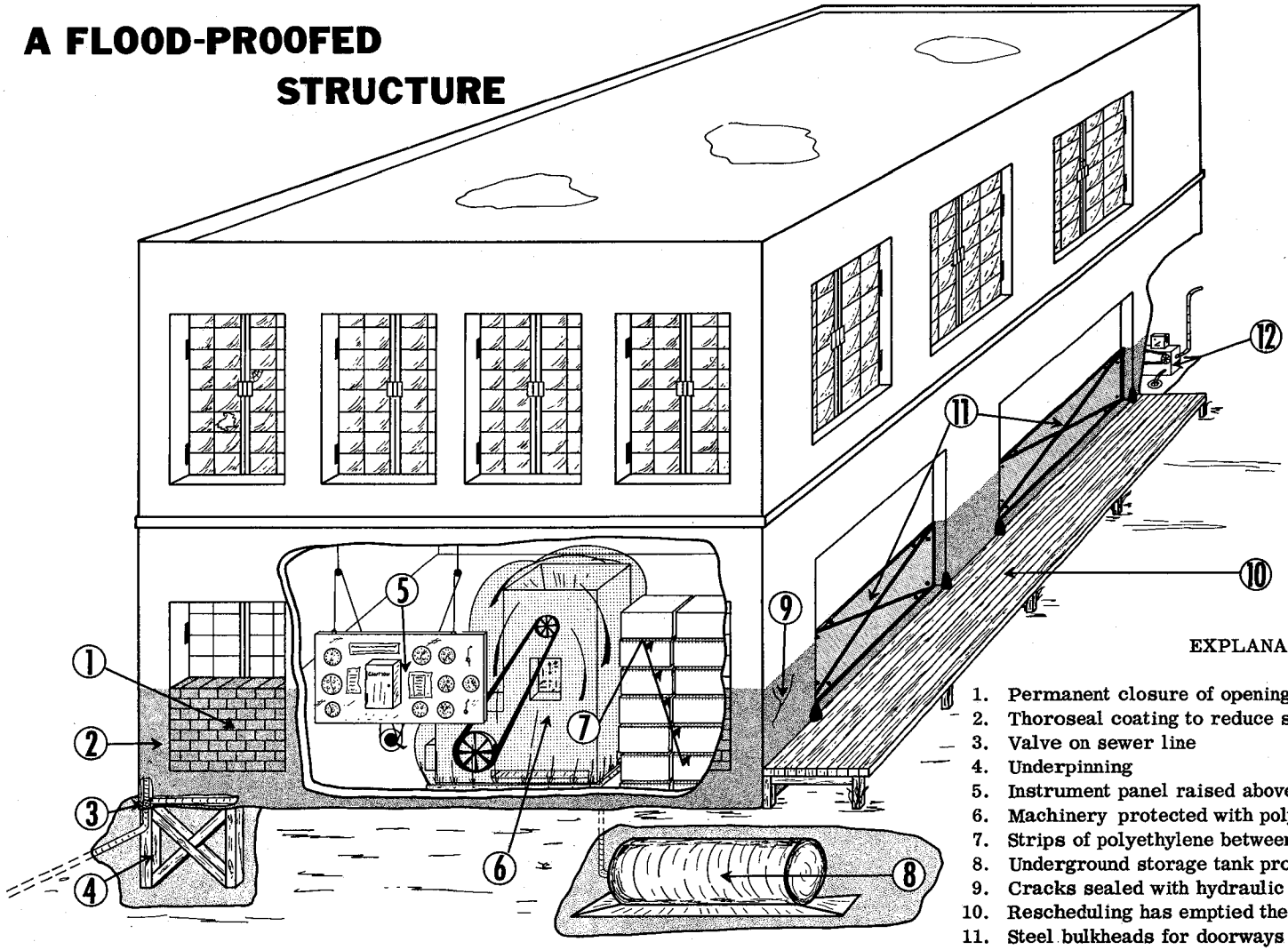
A FLOOD-PROOFED STRUCTURE



EXPLANATION

1. Permanent closure of opening with masonry
2. Thoroseal coating to reduce seepage
3. Valve on sewer line
4. Underpinning
5. Instrument panel raised above expected flood level
6. Machinery protected with polyethylene covering
7. Strips of polyethylene between layers of cartons
8. Underground storage tank properly anchored
9. Cracks sealed with hydraulic cement
10. Rescheduling has emptied the loading dock
11. Steel bulkheads for doorways
12. Sump pump and drain to eject seepage

Courtesy of John R. Sheaffer