CHAPTER V

COSTS AND BENEFITS OF FLOODPROOFING METHODS

A. INTRODUCTION

The primary goal of floodproofing is to reduce flood damages and flood losses. This chapter provides information that can be used to estimate the cost of anticipated floodproofing and the associated dollar benefit of reduced flood damages.

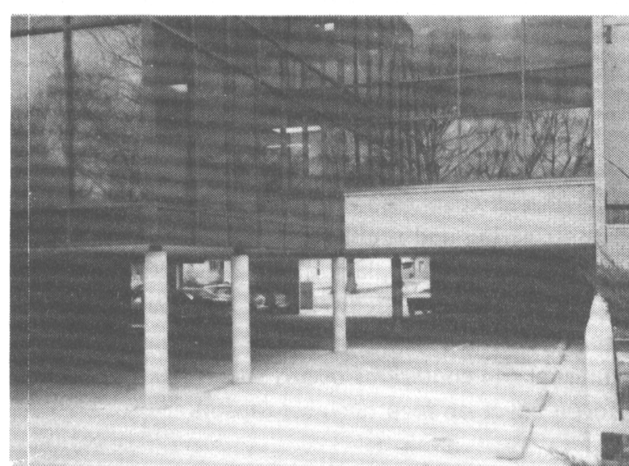
The costs of floodproofing a structure may be evaluated in terms of *primary* and *secondary* costs (Table V-1). *Primary costs* include the costs of the basic floodproofing elements: fill, columns, floodwalls, levees, and flood shields or closures. *Secondary costs* include the costs of auxiliary materials and activities that are required to assure that the primary floodproofing elements function properly. (Such as the cost for providing access to buildings on fill, or interior drainage for areas enclosed by levees or floodwalls). This chapter provides representative costs for each of the primary floodproofing elements and for some of the more common secondary elements.

Unit costs reported in this chapter have been based on an analysis of floodproofing literature, manufacturer's quotations, and information collected from the owners and builders of floodproofed structures (See Case Studies in Chapter VI). All costs are based upon September, 1985 price levels using the *Engineering News Record* cost index (20 cities average).

Cost estimates were developed using many sources. Most of the reported costs for a particular element were clustered in a narrow range around the average. Therefore, the average costs presented in this chapter should provide reasonable estimates for the evaluation of alternative floodproofing plans.

TABLE V-1
PRIMARY AND SECONDARY FLOODPROOFING ELEMENTS

Primary Elements	Secondary Elements
Elevation (fill, piles, posts, piers, walls)	Lost space Extending access and utilities Insulating/finishing lower surface of elevated floor Erosion protection
Flood Shields	Waterproofing walls and floors Subfloor drainage Backflow prevention Flood warning system Manpower training/ availability Testing
Floodwalls/Levees	Backflow prevention Interior drainage system and pump Lost space Erosion protection Access



B. PRIMARY COSTS

This section discusses primary costs associated with elevation, closures and flood shields, floodwalls, and levees. The primary costs include the costs of construction materials and associated placement or installation. Additional items included in the primary cost are described in the following subsections.

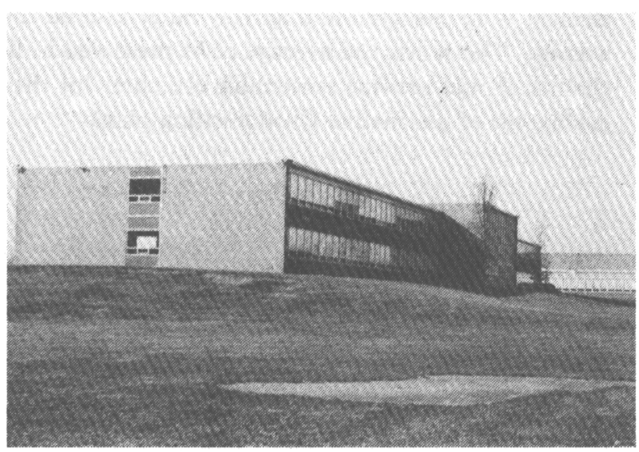
1. ELEVATION OF NEW STRUCTURES ON FILL. The use of fill for elevating new structures is a floodproofing technique that is widely practiced throughout the United States. To compute the cost of a fill operation, it is necessary to develop site-specific estimates of costs associated with:

- Clearing and grubbing the proposed fill area of vegetation.
- Stripping and removing any topsoil that is not capable of providing required stability.
- Obtaining, hauling, placing and compacting the fill.

Previous studies indicate that the costs for these activities can vary significantly as a result of regional and site specific characteristics. In general, costs of elevated fill construction in the eastern U.S. are higher than in the West. Cost of elevated fills are also higher in large metropolitan areas, and in many coastal and mountainous regions. Although specific costs representing any given location cannot be addressed, it is possible to present average costs which may be used to develop preliminary estimates.

For small and moderate size fills (up to 20,000 cubic yards) an average cost of $7 per cubic yard of compacted fill was found to be representative. This includes all costs associated with developing the final site - clearing and grubbing, topsoil removal, and obtaining, hauling, placing and compacting the fill material. This cost figure should be adjusted if fill must be hauled for more than several miles or if unusual site conditions occur, such as extremely dense forest cover or deep unstable topsoil.

It may be useful for planning purposes to have the cost of placing fill on a cost-per-square-foot basis. Figure V-1 has been included to provide this information. Figure V-1 illustrates the fact that when the usable fill area is relatively small (1,500 square feet) the cost per square foot increases very rapidly with increasing depth. For large areas (150,000 square feet or more), the cost per square foot of usable space increases approximately in direct proportion to the depth of fill.



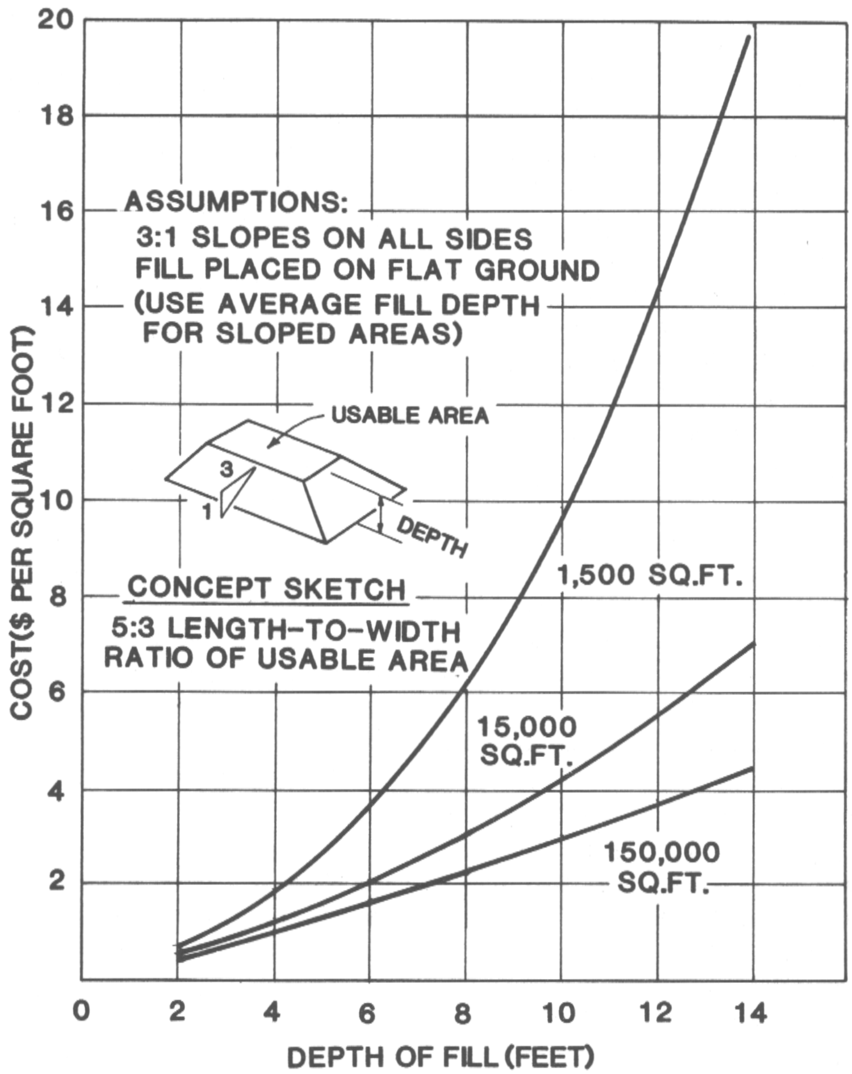


Figure V-1. Cost of Elevating on Fill

2. ELEVATION OF NEW STRUCTURES ON POSTS, PILES, PIERS OR WALLS. The cost of concrete column sections is considerably higher than the cost of piles or posts. However, since concrete columns can support significantly greater loads than piles or posts, the costs for each of these methods tend to converge. The height of elevation (between 4 and 12 feet) has little influence on the cost of the complete foundation system. Therefore, an average of $6.40 per square foot of single floor space was found to be representative as a preliminary cost estimate for any of these methods. This average includes all costs associated with the construction of the elevated foundation and supporting members.

Several of the sources reviewed in developing these cost data reported that there was no net additional cost for their structure due to the use of piles, posts, piers or walls for elevation. In these cases, the value of the open space beneath the structure (such as parking space in high land cost areas) was equal to or greater than the cost of elevation. This benefit of elevation on columns may often outweigh the primary cost advantage of elevation on fill.

3. ELEVATION OF EXISTING STRUCTURES ON POSTS, PILES, PIERS OR WALLS. It is technically feasible and cost-effective to elevate certain existing structures for protection against flood damages. As discussed in previous chapters, this approach has traditionally been limited to small frame structures that have a unified floor system.

The cost of elevating an existing structure includes two major components: (1) raising the structure, and (2) construction of a support system. The average cost for constructing a support system is the same as that for new structures, $6.40 per square foot of single floor space. The cost of raising the structure is presented below.

Generally, elevation of existing structures is most suitable for small to medium size wood-frame structures that are built on a crawl space or basement foundation. The average cost for raising this type of structure is $4.10 per square foot of floor area.

Brick veneer and masonry structures are the next most frequently raised. The average cost for raising this type of structure, $8.10 per square foot, is higher than that for a wood-frame structure primarily because of the greater weight and the care that must be taken to prevent excessive cracking.

The costs reported above are average costs. Factors that could cause variation from the average are accessibility (amount of clear space around and under the structure, proximity to trees or utility poles), and the existence of fireplaces and chimneys. The height a structure is raised has little influence on the total cost of raising.

4. FLOOD SHIELDS AND CLOSURES. The primary cost incurred when a structure is modified or designed to be watertight is the cost of the flood shield assemblies and closures.

Permanent closures are applicable for openings in existing structures that are not needed for normal or emergency access. These openings may be sealed by filling the opening with concrete block, reinforced concrete, brick, or some other material. The cost of this technique must include provisions to structurally integrate the closure with the existing wall to ensure that the closure will withstand flood-induced pressures. Due to the variation in existing types of structures and in the methods used to close an opening, there is considerable variation in the cost of this floodproofing technique. However, a cost of $45 per square foot of closure area should provide a reasonable preliminary estimate.

For new structures, or for existing structures that have openings that cannot be permanently closed, removable flood shields may be used for protection. Most flood shields are constructed of metal (primarily steel and aluminum). Plywood has also been used for flood shields in cases where Design Flood depths are relatively low. Flood shields also vary according to their method of application. Some are free standing and must be transported to and from the point of application and attached to a suitable supporting frame. Larger shields are often mounted on hinges or tracks so that they can be stored at the point of application and be easily and quickly installed.

Many steel free-standing flood shields have been fabricated at local machine shops or metal-working shops. The average cost of this type of shield has been calculated at $60 per square foot of shield. This includes the cost of manufacturing and installing the flood shield frame. Factory-produced shields are considerably more expensive. However, factory-produced shields have been fully tested and the reliability of these shields is very high. The average cost of various sizes of factory-produced shields can be derived from Figure V-2.

The costs of plywood floodshields are less variable and much lower than those discussed above. The average unit cost for plywood shields (including installation) is approximately $16 per square foot of flood shield.

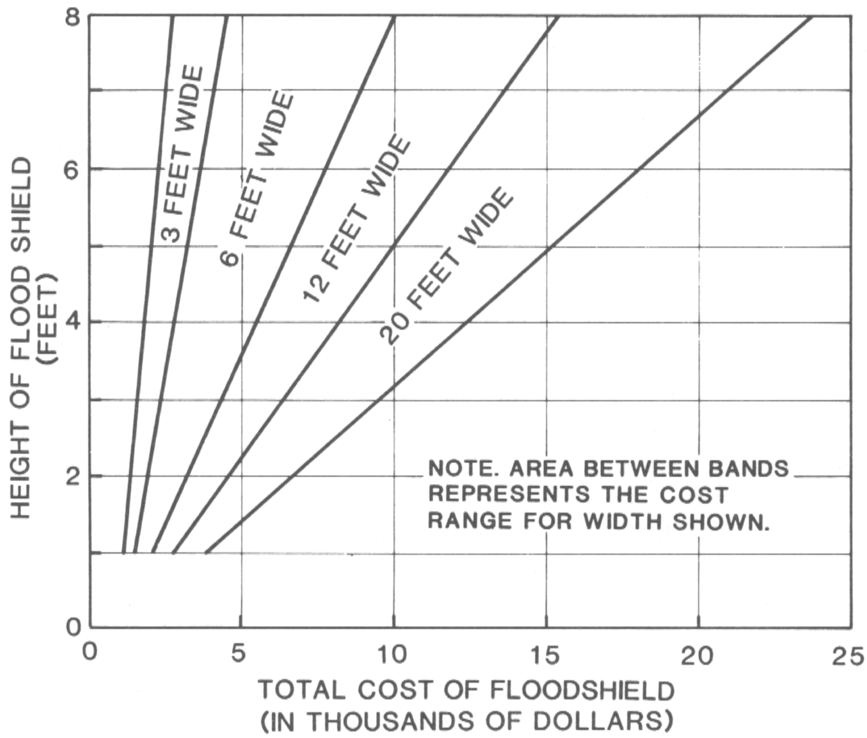


Figure V-2. Costs of Factory Produced Flood Shields Versus Shield Heights and Width

5. FLOODWALLS AND LEVEES. The costs of constructing floodwalls and levees are highly variable because of the wide range of site-specific physical and usage factors. Table V-2 presents average costs for three heights of floodwalls and levees. Although these costs may be used to develop preliminary estimates, specific site conditions could result in costs that vary considerably from those shown in Table V-2.

The levee costs shown in Table V-2 are for non-zoned structures (i.e., unsegregated fill material.) Levees with complex impervious cores to reduce seepage may cost up to four times more than non-zoned levees.

TABLE V-2
AVERAGE COST OF FLOODWALLS AND NON-ZONED LEVEES

Item	Height (feet)	Unit Cost ($/foot length)
Floodwall	3	110
Floodwall	5	165
Floodwall	10	410
Levee	3	13
Levee	5	30
Levee	10	85

C. SECONDARY COSTS

Secondary floodproofing costs were defined as the costs of items that are necessary to ensure the proper functioning of the primary floodproofing measure. Secondary costs that are often incurred are summarized in Table V-5 and are discussed below. Estimated average unit costs are provided where applicable.

1. LOST SPACE. Whenever an earth fill or a levee embankment is constructed, productive space is lost because of the outslopes required to maintain stability. The dollar cost associated with this lost space varies so widely with land costs and other factors that representative estimates cannot be given. Site specific costs must be derived from the geometry of the outslope fill and the unit value of the lost space.

Figure V-3, based on the assumptions of Figure V-1, shows lost space as a function of fill height and usable area. Lost space is considered to be only the area covered by the outslope.

2. EXTENDING ACCESS AND UTILITIES. Secondary costs of elevating a structure on posts, piles, piers, or walls include the costs required to provide access from the original ground level to the elevated level and to extend all utilities to the elevated structure. Experience has shown that this cost is approximately \$3.80 per square foot of single floor space. This estimate is based on the assumption that the structure is elevated 4 to 10 feet.

3. INSULATING AND FINISHING ELEVATED FLOORS. Elevation on an open support system exposes the area below the lowest floor to the weather and to public view. It may be

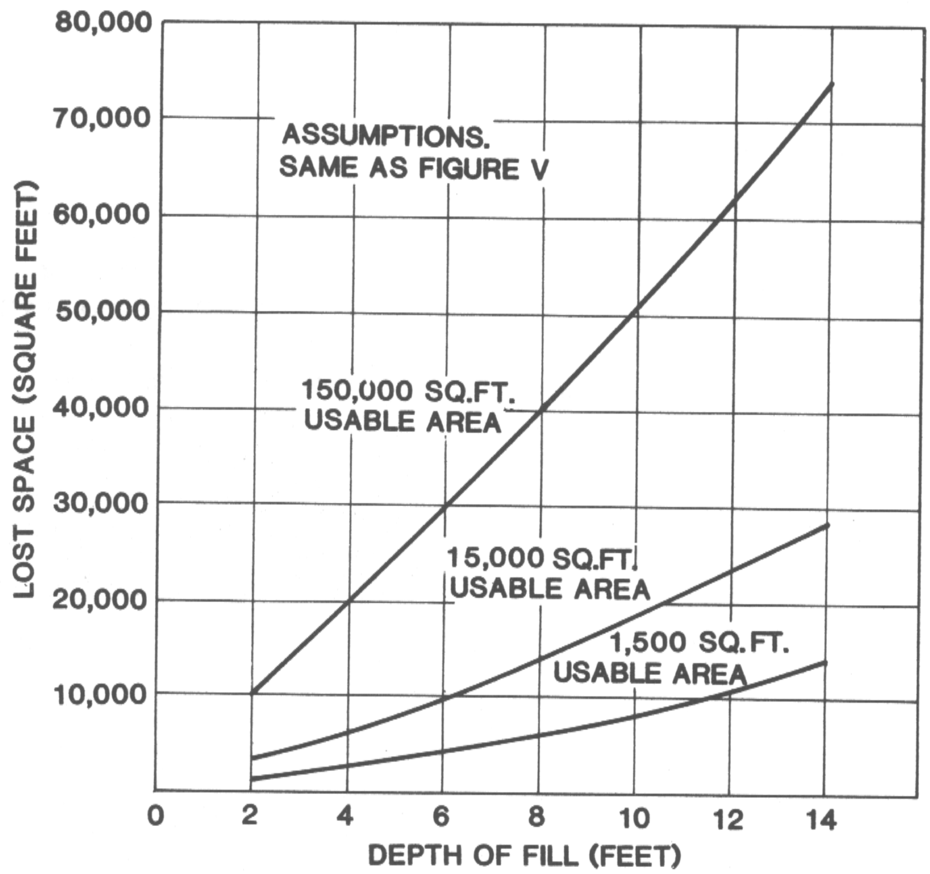


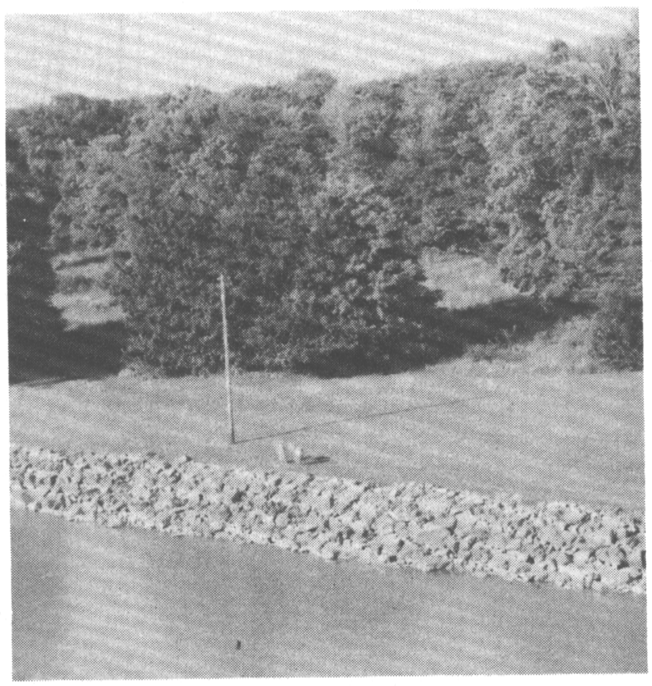
Figure V-3. Lost Space - Elevation on Fill necessary or desirable to insulate the bottom surface and/or provide a finish or covering that complements the architectural style of the building. Estimates of typical costs for this item cannot be presented due to the many site specific variables.

4. EROSION PROTECTION. High velocity floodwater can result in severe erosion of an earth fill or levee embankment. The most commonly used form of erosion protection for these embankments is rock riprap. The cost of riprap for this purpose is $22 per cubic yard installed. Information has been provided in Chapter III that describes when riprap should be used and what volume will be required. For embankments with 3:1 side slopes (3 horizontal to 1 vertical), and height H, a typical cost of $2.06 x H per linear foot of embankment may be used. For example, riprap protection for 100 feet of 5 foot embankment would cost about $1,025 ($2.06 x 5 x 100).

5. WATERPROOFING WALLS. The walls of structures that are protected with floodshields or closures must be substantially impermeable to the passage of water. For new construction, sufficient waterproofing provisions can often be included in the design of the building at no significant cost. For existing structures, sound masonry, brick, or concrete walls may be waterproofed by installing an impermeable membrane or by applying a number of products which can be painted, sprayed, or troweled onto the wall surface.

The costs of these waterproofing methods are quite comparable, with an average cost of approximately $1.85 per square foot of wall surface.

6. WATERPROOFING FLOORS. If the floor of a structure that has been floodproofed with shields and closures is strong enough to withstand the uplift forces that could be exerted against it, waterproofing techniques can be used to seal cracks and construction joints to prevent the entry of floodwater. The cost of sealing would be comparable to costs for sealing walls as described above. However, if the slab does not have sufficient strength to resist full hydrostatic pressure, a subsurface drainage system will probably be required to prevent floor failure.



A typical sub-floor drainage system is illustrated in Chapter III. The approximate costs per square foot for this type of system are illustrated in Figure V-4. The square footage costs shown in Figure V-4 are total system costs, including drainage pipe, gravel, sump area, and pumps. Installation of a sub-floor drainage system is usually not practical for an existing structure because of the high cost of removing the floor. In this case, a drainage system may be constructed around the perimeter of the structure at a level below the floor slab elevation. The installation cost of a perimeter drainage system can be estimated at $26 per linear foot.

7. BACKFLOW PREVENTION. Whenever flooding occurs above the lowest floor level, floodwater may enter the sewers and back up into the building. All floodproofed buildings should have a protection device on the service line to prevent backflow. The average price for placing a gate or flap valve for backflow prevention on a new sewer line is $720 installed. For an existing sewer, there are additional costs depending upon whether a suitable connection point can be obtained by excavating soil or whether concrete must be removed.

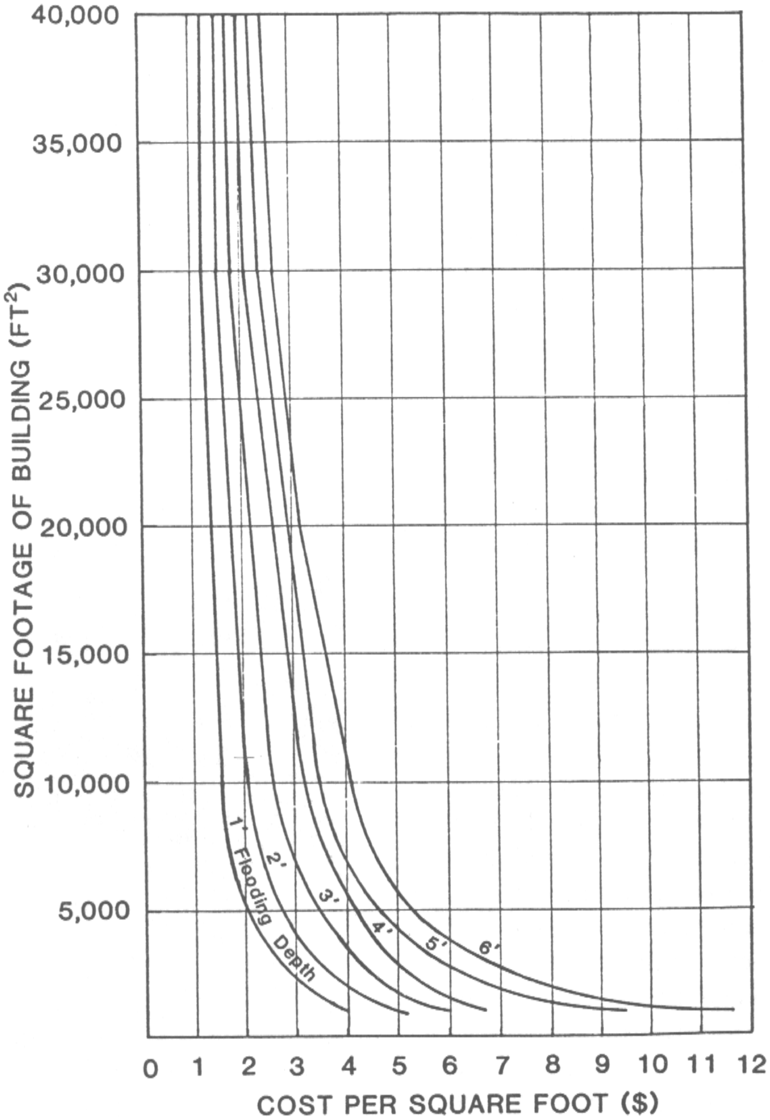


Figure V-4. Approximate Cost of Sub-floor Drainage System per Square Foot of Basement Floor Space

8. FLOOD WARNING AND PREPAREDNESS. An adequate flood warning system must be included in the cost of any floodproofing plan that requires adjustments to the structure prior to the flood (ie., contingent and emergency measures). In addition, a flood preparedness plan and training program is required to ensure that floodproofing elements are installed properly and efficiently.

Because an effective flood warning system must be developed in response to specific flooding source and structure characteristics, no representative cost can be given here. At many locations on major streams, the National Weather Service provides flood warnings. In addition, the cost of emergency preparedness depends on the non-residential structure's existing operations. Many facilities already have an extensive emergency preparedness program for fire or other hazards.

In this case, the cost of developing a preparedness plan for flooding may be minimal. Other facilities may incur a considerable annual cost to develop and maintain a preparedness plan and associated training program.

9. INTERIOR DRAINAGE PROVISIONS. As discussed in Chapter III, an interior drainage system to remove seepage and storm water may be required for floodwall and levee floodproofing systems. A significant cost of the interior drainage system will be the cost of the pump required to move water from the dry to the wet side of the wall or levee. Considerations for selecting an appropriate pump size were addressed in Chapter III. The approximate cost of various sizes of pumps is shown below:

Pump Rate Gallons Per Minute	Approximate Cost ($)
10	400
60	530
120	960
160	1,600
220	2,000

In addition to the cost of the pump, it may be necessary to re-grade the area behind the wall or levee to direct runoff and seepage to a sump area. Temporary detention areas may be created for sites that receive an extensive amount of runoff. If detention areas are not feasible, a permanent pump-house may need to be constructed to collect the water and to house the relatively large pump that will be required. Because the costs of these support facilities are based on site specific topography and other characteristics, typical costs cannot be estimated.

10. TESTING OF FLOOD SHIELDS. If flood shields are installed on a structure, a representative sample should be tested to ensure that they work properly. One method of testing is to build a concrete block wall around the opening to be tested, install the shield, fill the enclosure with water, and maintain the test depth for at least 48 hours. The cost of this type of test will range from $150 to $400 per opening depending upon the size of the flood shield.

11. ACCESS THROUGH FLOODWALLS AND LEVEES. Floodwalls and levees may require openings or other forms of access to allow traffic to move through the enclosure. Access points are often protected with flood shields. For small openings the cost of the closure can be estimated using the unit price given for flood shields. For larger openings, a value from Figure V-2 may be used.

D. FUTURE COST ADJUSTMENTS

The primary and secondary costs provided above are based on September 1985 estimates. These estimates can be adjusted using the *Engineering News Record's* (ENR) construction cost index. The value of the ENR index on September 19, 1985 was 4,194. The following formula may be used to adjust estimates to current levels:

$$\frac{\text{Current ENR Cost Index}}{4{,}194} \times \text{Unit Cost Listed in this manual} = \text{Current Unit Cost}$$

The ENR index can also be used to adjust costs to reflect regional differences. The unit costs included in this manual are based on the ENR '20 cities average.' Specific city index levels may be used in the above formula to correct the cost estimates for both time and location.

E. EXPECTED DAMAGE REDUCTION

The goal of flood protection is to reduce future flood damages. Some of these expected damages may be represented by dollar costs (that is, may be quantifiable), whereas other damages, such as loss of life, injury, or health hazards, may not be representable by dollar costs. A method for estimating quantifiable flood damage costs will be presented in this section.

Quantifiable damages that are normally expected to occur if a structure is not floodproofed include the costs to repair flood damages and business costs such as lost production and sales. The dollars expected to be saved by reducing flood damages should be viewed as the 'economic benefits' of floodproofing.

Two sets of information are required to estimate future flood damages to a facility: (1) frequency of flooding versus elevation of flooding at the site, and (2) the relationship of flood depth to flood damages. Figure V-5 and V-6 provide samples of how this information might be presented.

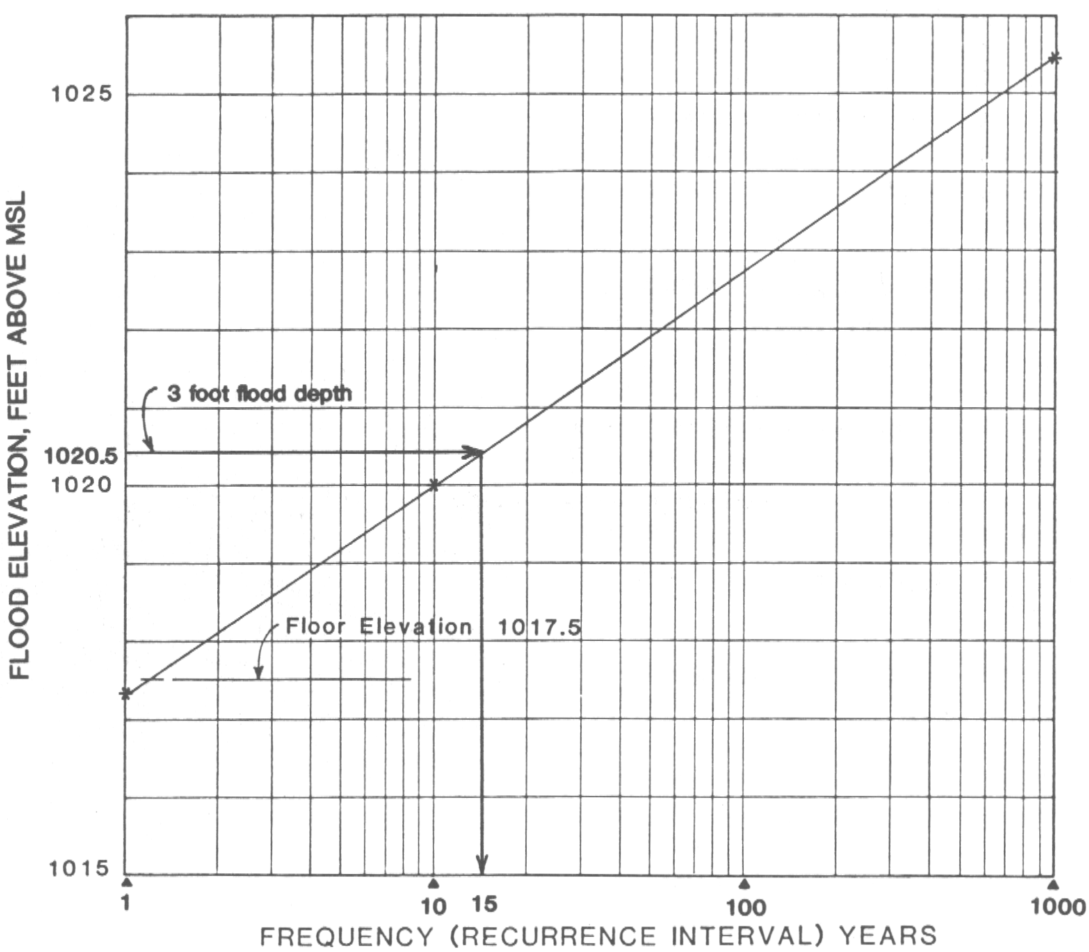


Figure V-5. Frequency - Elevation Curve for Example Site

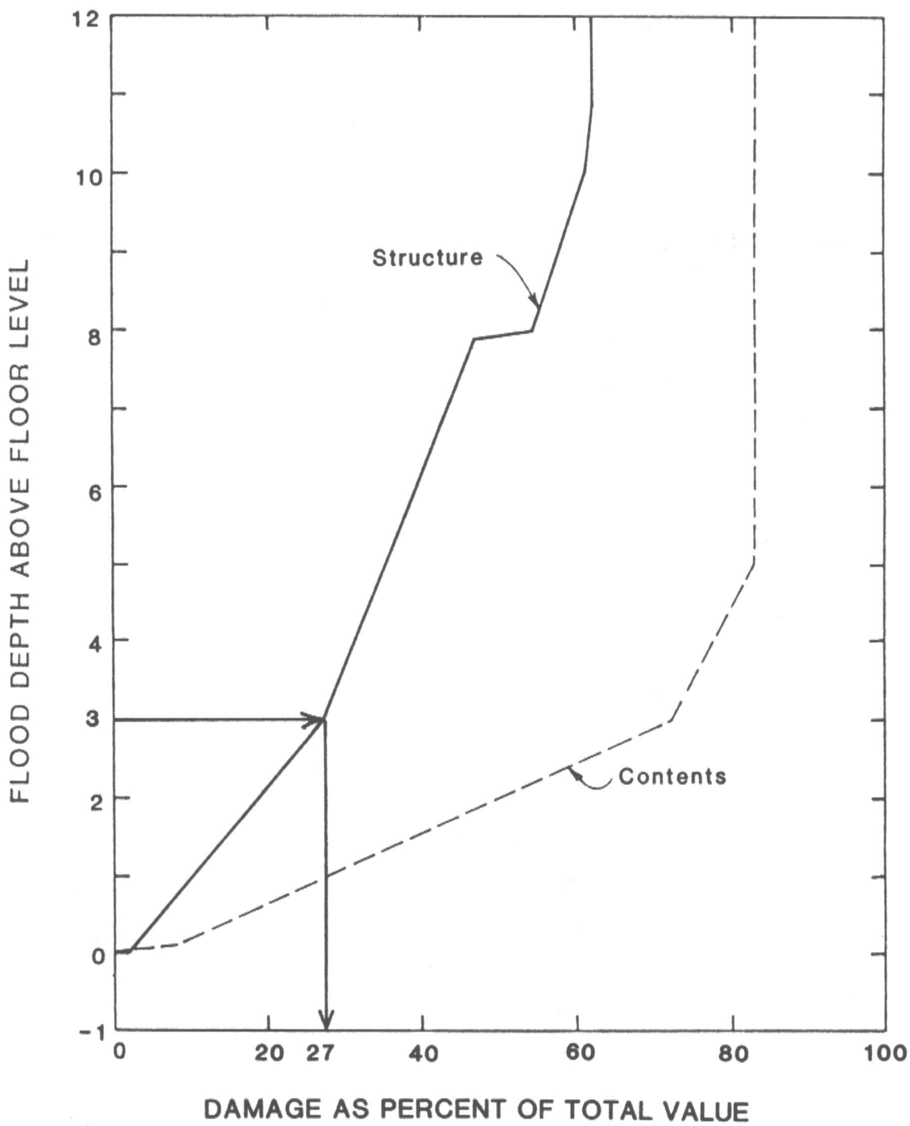


Figure V-6. Depth - Damage Relationship for Example Site

Flood elevation-frequency data may be obtainable from one of the sources listed in Appendix C. Flood Insurance Study Maps and Reports may be used to obtain flood depth and frequency at a structure using the methods shown in Appendix E. If flooding information is not available from any public agency, such data can be developed by a professional engineer. Generalized depth-damage information based on damages experienced by structures of similar size, construction, and use may be obtained from the Federal Emergency Management Agency, Corps of Engineers, or other agencies that have conducted flood damage reduction investigations.

Given the depth-frequency and depth-damage curves, the expected damage at the site can be computed by using a procedure similar to that shown in Table V-3. This method is used to compute the total expected annual flood damages, up to a given Design Flood level, that the unprotected facility would incur.

Using the method illustrated by Table V-3, expected damages from a range of flood depths may be calculated up to the Design Flood depth. In the example shown, the 100-year frequency flood was used as the Design Flood. Flood depths of 0.5, 1, 2, 3, 4, and 5.3 (the Design Flood depth) feet were used.

Assuming expected damages for floods up to two feet have been calculated, the steps for calculating expected annual damages for flooding from 2 to 3 feet are as follows:

1. Enter Figure V-5 at a flood depth of 3 feet. Because the floor elevation is 1017.5, the elevation for 3 foot flooding is 1020.5.

2. Find the point on the flood elevation curve corresponding to 1020.5. Move down to the frequency axis and find the corresponding flood frequency, 15 years.

TABLE V-3
CALCULATIONS FOR EXPECTED ANNUAL STRUCTURE DAMAGES

Flood Depth Over Floor (a)	Frequency (years) (b)	Probability (Inverse of Frequency) (c)	Change in Probability (d)	Struct. Damage (%) (e)	Average Struct. Damage (%) (f)	Expected Annual Damage (%) (g)
0	1.2	0.08333		0		
			0.27778		2.5	0.694
0.5	1.8	0.55555		5		
			0.19841		7.5	1.488
1.0	2.8	0.35714		10		
			0.20330		14.5	2.948
2.0	6.5	0.15385		19		
			0.08718		23	2.005
3.0	15	0.06667		27		
			0.03810		29	1.105
4.0	35	0.02857		31		
			0.01857		34	0.631
5.3	100	0.01000		37		

TOTAL EXPECTED ANNUAL STRUCTURE DAMAGE = 8.871
(percent of structure value or, $/$100 structure value)

3. Compute the probability, 1/15 = .06667. This is the probability that a flood greater than or equal to 3 feet will occur in any given year.

4. Compute the change in probability from the probability computed for the previous depth. The probability for the 2 foot or greater flood was 0.15385, so the change in probability is 0.15385 − 0.06667 = 0.08718. This represents the probability in any given year of a flood between 2 and 3 feet.

5. Enter Figure V-6 at the 3 foot depth and find the point on the structure curve at this level. Move down and find the corresponding damage value, about 27 percent.

6. Calculate the average percent damage between this level and the preceeding. The value for 2 feet was 19, so the average is (27 + 19)/2 = 23.

7. Refering to Table V-3, multiply the probability in column (d) times the average damage in column (f) to find the expected damage, column (g). For the current step, 0.08718 x 23 = 2.005.

The sequence or steps described above must be repeated for each flood level (in feet) up to the Design Flood depth. By summing the values in column (g), the expected annual structure damage from all flooding (up to the Design Flood level) is obtained as a percentage of total structure value (or $/$100 structure value).

Assuming that the flood protection measures are 100% effective (to the Design Flood level), the values computed above represent the dollar benefits associated with damage reduction. (*Structural damage reduction in the case of the illustrated example.*)

Similar computations may be carried out for contents damage. Flood damages such as lost production time, sales, wages, uninsured losses, etc. cannot be included in this type of analysis unless they can be represented by a flood elevation-damage relationship. Because the latter damages may, in fact, be more significant than damages to the structure, it is important to carefully consider the non-structural (business) damages in the analysis of economic benefits to be obtained from flood protection.

F. ANNUALIZED COSTS

Economics is not the only criteria for flood protection decision making. An economically unfeasible floodproofing program might still be desirable if floodproofing could significantly reduce non-quantifiable damages. After giving appropriate consideration to non-quantifiable benefits, however, it may also be desirable to examine economic feasibility.

If the economic benefits of floodproofing have been estimated, they may be compared with the costs of flood protection. The proposed floodproofing method will be economically feasible if the economic benefits are greater than the protection cost.

Economic benefits are generally calculated on an average annual basis. The major costs of floodproofing are generally estimated as total lump-sum costs that will occur when the structure is initially floodproofed. To compare annual benefits to costs, it is necessary to amortize the total initial project cost over the economic life of the structure.

The average annual cost depends on the amortization period and the applicable interest rate (see Table V-4 for amortization factors). Given the total initial floodproofing costs, the interest rate, and the amortization period (economic life of the floodproofing measures), an appropriate amortization factor can be determined. The annual cost is determined by dividing the total cost by the amortization factor.

As an example, let us assume that the total initial cost of a protective levee has been estimated at $39,825. If a 30-year amortization period is selected at an interest rate of 10%, the average annual cost would be $4,220 as shown below:

$$\frac{\text{Total Cost}}{\text{Amortization Factor}} = \text{Annual Cost}$$

or

$$\frac{39{,}825}{9.43} = \$4{,}220$$

TABLE V-4
AMORTIZATION FACTORS

INTEREST RATE	AMORTIZATION PERIOD 30 YEARS	50 YEARS
6	13.76	15.76
7	12.41	13.80
8	11.26	12.23
9	10.27	10.96
10	9.43	9.91
12	8.06	8.30
14	7.00	7.13
16	6.18	6.25
18	5.52	5.55

G. SUMMARY

The costs of floodproofing can be divided into *primary costs* (the costs of the major floodproofing element(s): flood shields and closures, elevation, floodwall, levee) and *secondary costs* (other costs necessary for proper functioning of the floodproofing system). Estimated average primary costs and common secondary costs are summarized in Table V-5. Many secondary costs are too site-specific for the reasonable estimation of representative values. Estimates for these costs must be developed from local sources and added to the cost estimates in this chapter.

TABLE V-5 SUMMARY OF FLOODPROOFING COSTS

PRIMARY COSTS

ELEVATION	
• Fill	$7.00 per cubic yard installed and compacted. See Figure V-1 for per square foot cost.
• **Piles, posts, piers, walls**	$6.40 per square foot of single story floor space.
• **Raising existing structures**	$4.10 per square foot for a single story wood-frame structure.
	$8.10 per square foot for a single story brick or masonry structure.
	$12.90 per square foot for a single story slab-on-grade structure.
FLOOD SHIELDS	
• **Metal**	$60 per squarefoot of opening. Also see Figure V-2.
• **Plywood**	$16 per square foot of opening
CLOSURES	
	$45 per square foot of opening
FLOODWALLS	
3′ high	$110 per foot of length
5′ high	$165 per foot of length
10′ high	$410 per foot of length
LEVEES	
3′ high	$13 per foot of length
5′ high	$30 per foot of length
10′ high	$85 per foot of length (not zoned)
10′ high	$300 per foot of length (zoned)

SECONDARY COSTS

• **Extending Access/ Utilities**	$ 3.80 per square foot of single story floor space
• **Erosion Protection**	$22 per cubic yard of riprap
• **Water-Proofing Walls/Floors**	$ 1.85 per square foot of surface area
• **Subfloor Drainage**	$ 3.00 per square foot
• **Periphery Drainage**	$26 per linear foot
• **Backflow Prevention Device**	$720 installed Concrete excavation extra $ 105 Earth excavation extra $ 27
• **Testing Of Flood Shields**	$150 to $400

The economic benefits derived from the implementation of a floodproofing plan are represented by the reduction in the expected cost (in dollars) of future flood damages. Expected annual damages may be estimated using flooding depth-frequency data and the relationship of flooding depth to structure, contents, and other damages. The latter may be obtained from existing general information or may be estimated for the given location by knowledgable personnel.

Ideally, the depth-damage relationship would quantify losses from decreased production, profits and wages, lost sales, flood fighting, flood cleanup, etc., which could be expected to occur if protective measures were not taken. It may even be possible to represent flood protection reductions in potential loss of life, injury, and short- or long-term health hazards by reductions in insurance premiums. The total initial project cost must be converted to an annual cost to allow a comparison with expected economic benefits. Initial cost can be converted to an annual cost by dividing by an appropriate amortization factor.

The following pages provide cost estimating forms which can be used to calculate the preliminary cost of the major flood protection alternatives discussed in this manual.

PRELIMINARY COST ESTIMATE STRUCTURE ELEVATION

USING FILL:

Approximate Cubic Yards Required
________ X $7.00 = ________
or
From Table V-6 = ________

USING PILES, POSTS, COLUMNS OR WALLS:

Single Story Floor Area ______ x $6.40 = ________

If Elevated Less than 5 feet, Multiply by 0.93. = ________

If Elevated 5 to 7 feet, Multiply by 0.96 = ________

If Elevated 7 to 9 feet, Multiply by 1.00 = ________

If Elevated 10 feet, Multiply by 1.04 = ________

RAISING EXISTING STRUCTURE:

Wood Frame with Joist Floor:
________s.f. x $4.10 = ________

Brick Veneer or Masonry with Joist Floor: ________ s.f. x $8.10 = ________

SECONDARY COSTS:

Lost Space Table V-7 (sq. ft.) ________
x Cost Per Sq. Ft. ________ = ________

or Lost Space (sq. ft./43560) (Acres)
x Cost per Acre ______ = ________

Extending Access and Utilities:

Square Feet of Single Story Floor Space
______ x $3.80 = ________

Insulting/Finishing Bottom of Buildings on Piles, Columns, etc. (Insert Lump Cost Based on Local Estimate) = ________

Erosion Protection (Table V-8) ______
cubic yards x $22 = ________

TOTAL PRIMARY AND SECONDARY COSTS (Sum of Above) = ________

Correcton Factor: Current ENR Construction Index/4194 x ________

Corrected Total Cost of Elevation (Multiply by Two Numbers Above) = ________

PRELIMINARY COST ESTIMATE FLOOD SHIELDS/CLOSURES

PRIMARY COSTS:

Metal Flood Shields Total Square Footage of Openings to be Closed ______ x $60 = ________

Plywood Flood Shields Total Square Footage of Openings to be Closed ______ x $16 = ________

Manufactured Shields Total Square Footage ______ x Value from Figure V-2 ______ = ________

Permanent Closures Total Square Footage of Openings to be Closed ______ x $45 = ________

SECONDARY COSTS:

Waterproofing: Surface Area (s.f.) Walls and Floors Below Design Flood Elevation ______ x $1.85 = ________

Subfloor Drain:

New: Floor Area (S.F.) ______ x Value from Figure V-4 = ________

Existing: Perimeter of Building (l.f.) ______ x $26 = ________

Backflow Prevention: Number of Valves Required x $720 = ________

Existing Sites: If Earth Excavation Required, Add Number of Valves ______ x $27 = ________

If Concrete Excavation Required, Add Number of Valves ______ x $105 = ________

Testing: Number of Shields to be Tested ______ x $250 = ________

Flood Warning and Preparedness (insert lump sum based on local estimate) = ________

TOTAL PRIMARY AND SECONDARY COSTS (Sum of Above) = ________

Correcton Factor: Current ENR Construction Index/4194 x ________

Corrected Total Cost of Flood Shields/Closures (Multiply Two Numbers Above) = ________

PRELIMINARY COST ESTIMATE FLOODWALL OR LEVEE

PRIMARY COST

Linear Feet of Floodwall/Levee ______
x Unit Cost (Table V-2) ______ = ________

SECONDARY COST

Backflow Prevention:
Number of Valves Required ______
x $720 = ________

Existing Sites Add:
Earth excavation, number of valves
______ x $27 = ________
Concrete excavation, number of valves ______ x $105 = ________

Interior Drainage System: enter lump sum including cost of pump, grading, pump house, and other site requirements. = ______

Lost Space:

Side Slope

3h:1v H(ft)________x L(ft)________ x 7 x Cost/Sq.Ft. = ________

2.5h:1v H(ft)________ L(ft)________x 6 x Cost/Sq.Ft. = ________

2h:1v H(ft)________x L(ft)________x 5 x Cost/Sq.Ft. = ________

or, /43560 x Cost/Acre = ________

H = Levee Height
L = Levee Length

Erosion Protection:

Side Slope

3h:1v H(ft)________x L(ft)________ x $2.06 = ________

2.5h:1v H(ft)________ L(ft)________x $1.76 = ________

2h:1v H(ft)________x L(ft)________x $1.46 = ________

H = Levee Height
L = Levee Length

Access Through Floodwall/Levee:

Metal Shields:
Total Square Feet x $60 = ________
Manufactured Shields:
Total Square Feet ____ x Fig. V-2 value ____ = ________

TOTAL PRIMARY AND SECONDARY COSTS (Sum of Above) = ________

Correction Factor:
Current ENR Construction Index/4194 = ________

Corrected Total Cost of Floodwall or Levee
(Multiply two numbers above) = ______

COST OF ELEVATED FILL CONSTRUCTION

Table V-6 may be used to estimate the cost of stripping the base, placing and compacting a fill area. To use the table, first determine the area you will need for the structure and adjacent areas at the top of the fill. For instance, the structure may occupy 5000 square feet and you need 1400 feet around the building for traffic. The total area required is 6,400 square feet, and this is the number used in Table V-6. To estimate the cost of fill, enter the table in the section for A<= 10,000, for this example, and move to the row corresponding to the height of elevation, say 8 feet. In this example we desire 3:1 side slopes, so we move under the column headed 3 and find the equation:

$$5,570 + 2.79*A = \text{Cost.}$$

For this example, the estimated cost for an 8 foot fill with a 6400 square foot top area is:

$$5,570 + 2.79 \times 6,400 = \$23,400.$$

For areas larger than 10,000 square feet, use equations in the section 10,000<A in a similar manner.

TABLE V-6
COST OF FILL
($)

Area Required (Sq. Ft.)	Elevation Height (Ft.)	SIDE SLOPE, Z (Z h:l v) 3	2.5	2
	4	1,140+1.24*A	910+1.21*A	690+1.18*A
	6	2,840+1.97*A	2,220+1.90*A	1,660+1.83*A
A<= 10,000	8	5,570+2.79*A	4,300+2.67*A	3,170+2.54*A
	10	9,540+3.70*A	7,310+3.51*A	5,330+3.31*A
	12	15,000+4.70*A	11,400+4.42*A	8,210+4.14*A
	14	22,100+5.78*A	16,700+5.41*A	11,900+5.03*A
	4	2,610+1.11*A	2,400+1.10*A	1,880+1.09*A
	6	6,040+1.69*A	5,470+1.66*A	4,260+1.63*A
10,000<A	8	11,200+2.30*A	9,990+2.24*A	7,720+2.20*A
	10	20,100+2.91*A	16,100+2.85*A	12,400+2.78*A
	12	30,100+3.56*A	24,000+3.47*A	18,300+3.39*A
	14	42,600+4.25*A	33,700+4.13*A	25,600+4.01*A

LOST SPACE

The lost space due to the outslopes of the fill may be estimated using Table V-7. Lost space is a function of the height of fill, (H), the slope of sides, (Z), and the usable area (A). Given the top area, say 6400 square feet as in the previous example, enter Table V-7 as the height of fill (8 feet in this example) and side slope (3 in this example), to find the estimating equation. For this example,

lost space = 2300 + 32.66 x SQR(A),

where SQR(A) is the square root of the top area,

or

lost space = 2300 + 32.66 x 80 = 4910 square feet.

TABLE V-7
LOST SPACE
(SQ. FT.)

Elevation Height (Ft.)	SIDE SLOPE, Z (Z h:1 v)		
	3	2.5	2
4	576 + 16.33xSQR(A)	400 + 16.33xSQR(A)	256 + 16.33xSQR(A)
6	1,296 + 24.49xSQR(A)	900 + 24.49xSQR(A)	576 + 24.49xSQR(A)
8	2,300 + 32.66xSQR(A)	1,600 + 32.66xSQR(A)	1,020 + 32.66xSQR(A)
10	3,600 + 40.82xSQR(A)	2,500 + 40.82xSQR(A)	1,600 + 40.82xSQR(A)
12	5,130 + 48.99xSQR(A)	3,600 + 48.99xSQR(A)	2,300 + 48.99xSQR(A)
14	7,060 + 57.15xSQR(A)	4,900 + 57.15xSQR(A)	3,140 + 57.15xSQR(A)

COST OF RIPRAP

Required quantities of riprap for the fill may be estimated using Table V-8. Riprap volume is also a function of the height of fill, (H), the slope of the sides, (Z), and the usable area, (A). Again, using the top area of 6400 square feet as in the previous example, enter Table V-8 at the height of fill (8 feet in this example) and side slope (3 in this example) to find the estimating equation. For this example,

Riprap volume (cubic yards) 5 43.2 + 1.53 x SQR(A),
where SQR(A) is the square root of the top area, or
Riprap volume (cubic yards) = 43.2 + 1.53 x 80 = 166 cubic yards.

TABLE V-8
RIPRAP VOLUME
(CUBIC YARDS)

Elevation Height (Ft.)	SIDE SLOPE, Z (Z h:l v) 3	2.5	2
4	10.8 + 0.77xSQR(A)	7.70 + 0.65xSQR(A)	5.10 + 0.54xSQR(A)
6	24.3 + 1.15xSQR(A)	17.2 + 0.98xSQR(A)	11.4 + 0.81xSQR(A)
8	43.2 + 1.53xSQR(A)	30.6 + 1.30xSQR(A)	20.3 + 1.08xSQR(A)
10	67.4 + 1.91xSQR(A)	47.8 + 1.63xSQR(A)	31.8 + 1.35xSQR(A)
12	97.1 + 2.30xSQR(A)	68.9 + 1.95xSQR(A)	45.8 + 1.62xSQR(A)
14	132.0 + 2.68xSQR(A)	93.8 + 2.28xSQR(A)	62.3 + 1.89xSQR(A)