

ENGINEERING FIELD MANUAL

CHAPTER 6. STRUCTURES

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ENGINEERING FIELD MANUAL

CHAPTER 6. STRUCTURES

1. GENERAL

DEFINITION

A structure is a designed device, constructed or manufactured, used in a soil and water conservation or management system to retain, regulate, or control the flow of water.

INTRODUCTION

Good vegetative practices, together with proper land use, are necessary in a sound soil and water management program. However, vegetative measures and simple practices alone may be inadequate to handle concentrations of water, and do not provide water storage for beneficial use. In such cases, structures are needed.

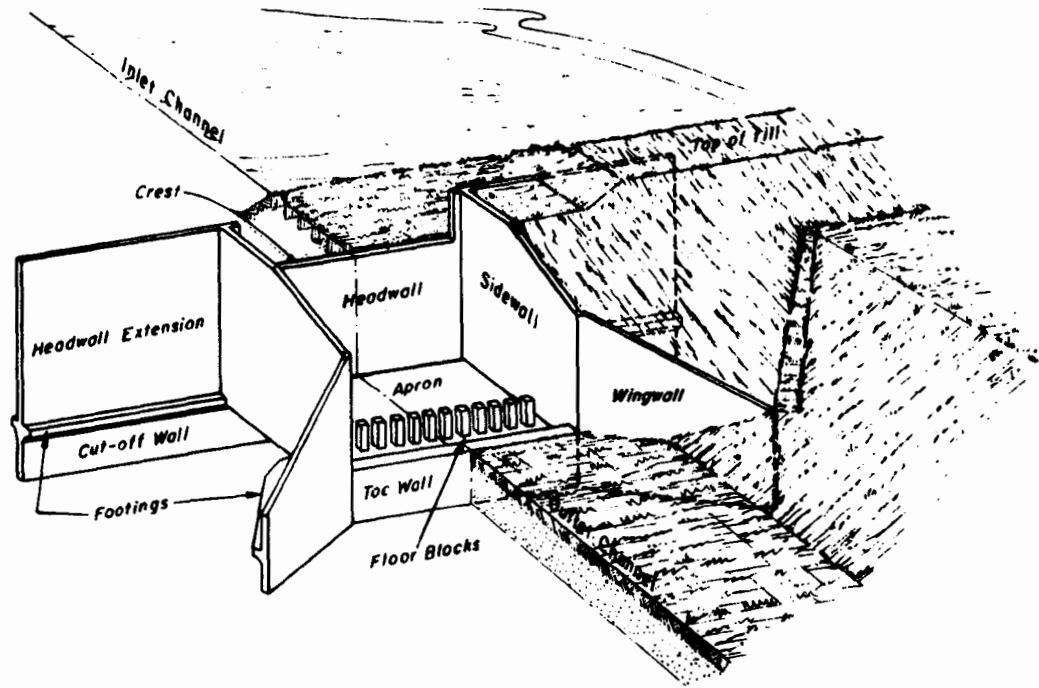
There are instances, also, where a high degree of safety and permanence is desired. Conservation measures may be required to provide insurance against loss of life or destruction of property. Vegetative control measures are subject to the influences of such uncertain factors as climate, diseases and insects, and are not always dependable. On the other hand, properly designed, installed and maintained structures are of long life and dependability.

Structures are used for the following soil and water conservation purposes:

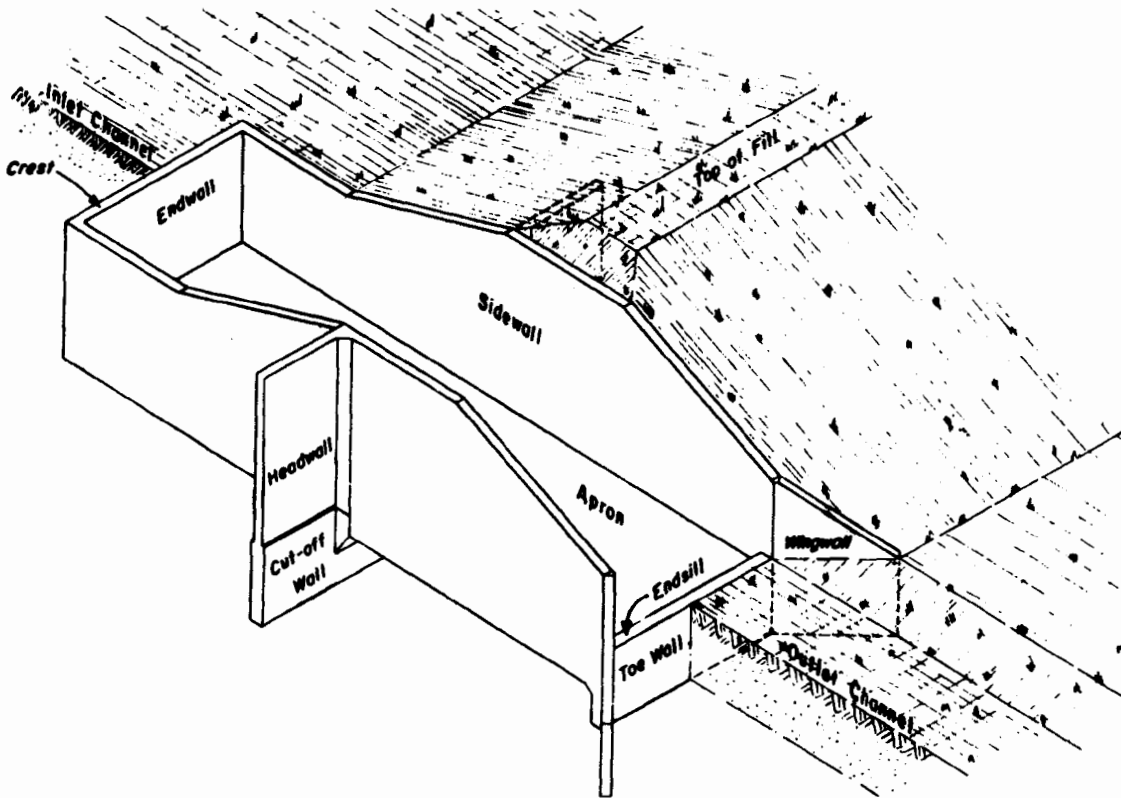
Grade and gully control	Drainage
Water storage	Irrigation
Water detention (flood prevention)	Shore protection
Sediment storage	Streambank protection
Surface water inlets	Tide protection
Water level control	

2. COMPONENT PARTS OF STRUCTURES

All technicians should know the various parts of a structure and their functions. Many structures are made up of four major parts - the earth embankment, spillway inlet, spillway conduit and spillway outlet. The three principal types of structural spillways used by the Soil Conservation Service are known as drop spillways, drop inlet spillways, and chute spillways. Nomenclature for the various parts of drop spillways are shown in Figure 6-1 and for chute spillways and drop inlet spillways in Figure 6-2.

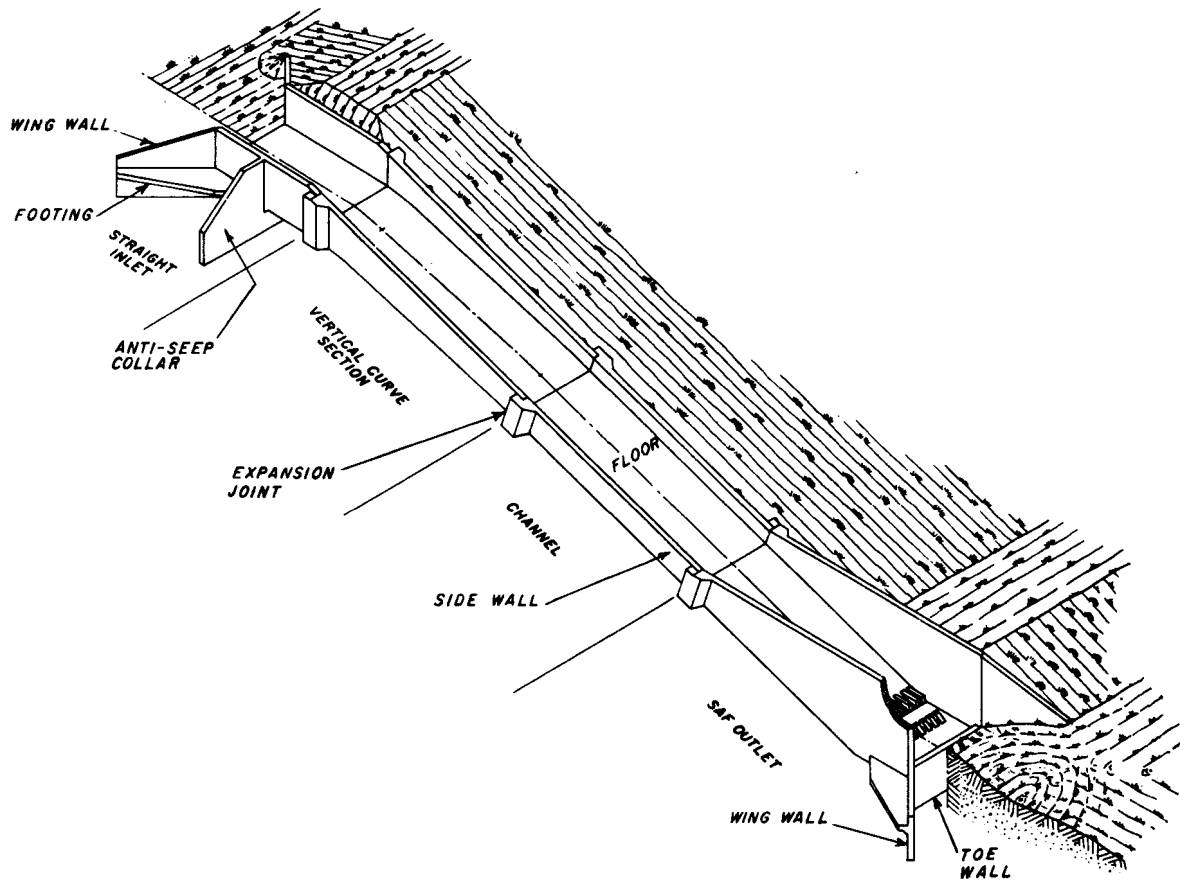


STRAIGHT DROP SPILLWAY

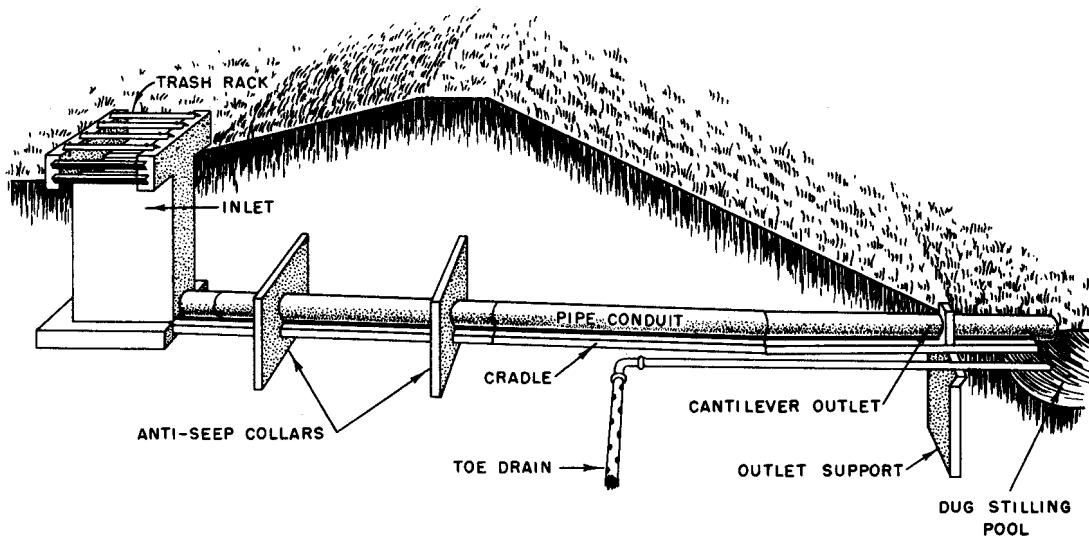


BOX INLET DROP SPILLWAY

Figure 6-1 Nomenclature for various parts of drop spillways



CHUTE SPILLWAY



DROP INLET SPILLWAY

Figure 6-2 Nomenclature for various parts of chute and drop inlet spillways

Various combinations of inlets, conduits, and outlets may be used. For example, a spillway for an earth dam consisting of a drop inlet, pipe conduit, and cantilever outlet is known as a pipe drop inlet spillway with a cantilever outlet. See Figure 6-3.

EMBANKMENT

The embankment directs the flow of water through the spillway. The embankment for a drop spillway or chute generally extends from the spillway to high ground or to a vegetative spillway. In the case of an earth dam (farm pond) the embankment detains and impounds water as well as forces storm flows through the spillway.

SPILLWAY INLET

Water enters the spillway through the inlet, which may be in the form of a box, a weir in a wall, or a culvert-type entrance. The box may be straight or flared, while the wall may be straight, flared, or curved. The culvert-type entrance may be round, square, or rectangular, with a square edge, hood, or flared entrance.

Vertical walls extending into the soil foundations under the inlet are known as cutoff walls. Their main purpose is to prevent water seepage under the structure. Similar walls, extending laterally from the inlet to prevent seepage and erosion around the ends of the structure, are called headwall extensions. These walls also protect against burrowing animals.

SPILLWAY CONDUIT

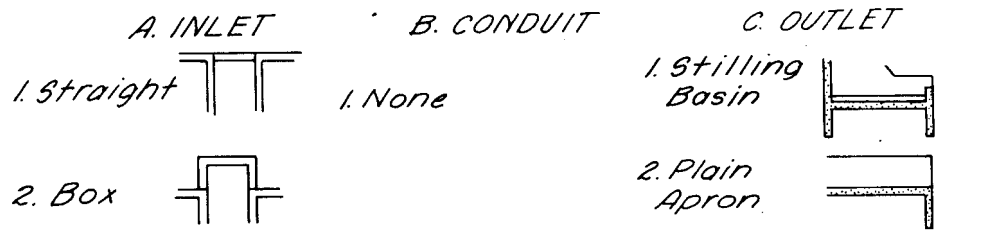
The conduit receives the water from the inlet and conducts it through the structure. The conduit may be closed in the form of a box or pipe, or it may be open as in a rectangular channel. Cutoff walls or antiseep collars usually are constructed as a part of the conduit to prevent seepage along its length and possible failure from this source.

SPILLWAY OUTLET

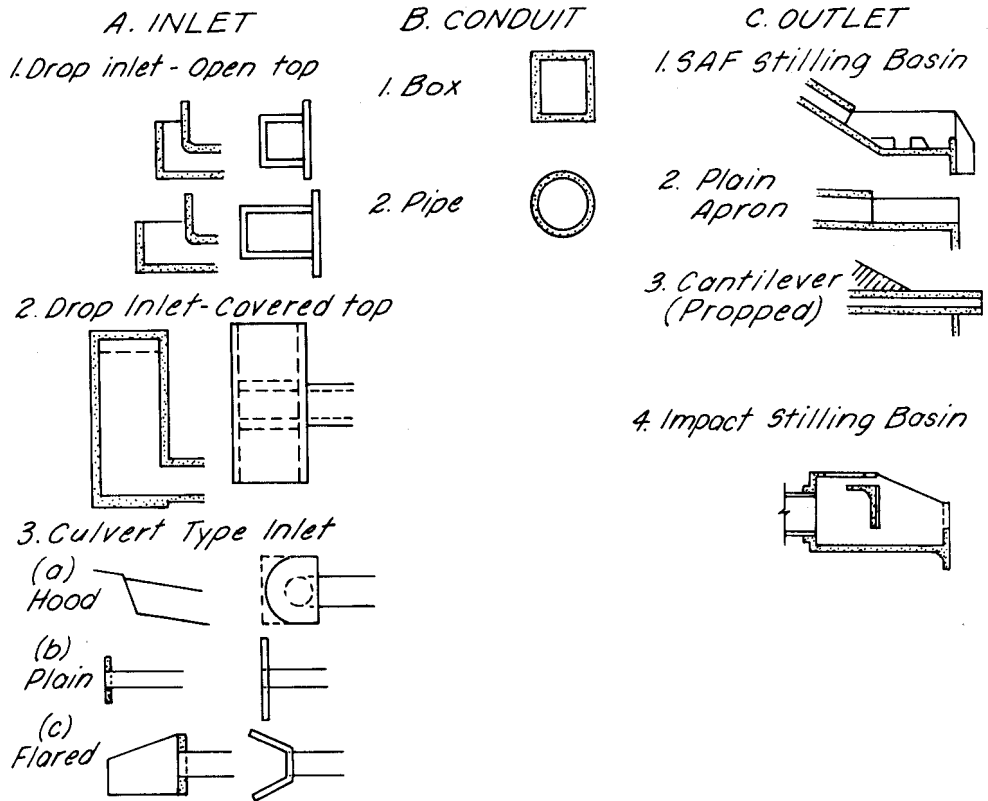
The water leaves the structure through the outlet. Its function is to discharge the water into the channel below at a safe velocity. The outlet may be of the cantilever (propped) type, a plain apron outlet, or an apron with any type of energy dissipator to minimize the erosive effect of the water. Cantilever outlets are necessary in locations where the channel grade below the structure is unstable.

Vertical walls, known as toe walls, are extended below the front of the apron to prevent undercutting. Wingwall are vertical walls, extending from the outlet into the channel banks, to protect against the swirling effect of the water as it leaves the structure.

SPILLWAY NOMENCLATURE
I DROP SPILLWAY



II. DROP INLET SPILLWAY AND CULVERT TYPE SPILLWAY



III. CHUTE SPILLWAY

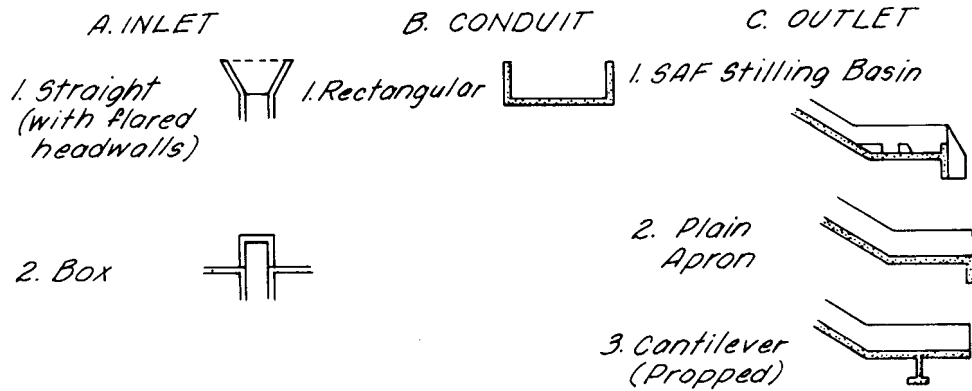


Figure 6-3 Nomenclature for inlet, conduit and outlet of spillway

3. STRUCTURE SELECTION

Selecting the proper structure for a given location and function is the key to successful and economical control of erosion or runoff. Each type of structure has its own range of use for a given set of conditions. Some sites will permit the use of more than one type of structure; however, there generally is one type that will provide the most economical control.

STRUCTURAL TREATMENT OF GULLIES

Treatment of gullies generally falls into two classes: control by shaping and seeding or sodding; or structural control, plus vegetation.

If slopes cannot be controlled by seeding or sodding due to an overfall or steep portion of channel, or the width of the gully or draw into which water is being discharged is materially less than the width of waterway being treated, permanent structures will be required.

STRUCTURE SELECTION

Generally, the degree of control or protection and the size of the watershed are the primary considerations in structure selection. The structure selection diagram, Figure 6-4, is useful in determining the type of structure needed.

This diagram is for average field conditions and is based on the most economical structure for the given head and discharge, provided the site will permit installation of the structure. Site and foundation conditions, therefore, are important factors in selecting the type of structure.

4. STABILITY OF GRADES BELOW SPILLWAYS

The outlet of a spillway should be so designed that its function or stability will not be reduced by scour or deposition in the exit channel.

The channel grade below the spillway should be stable to prevent undercutting of the outlet toe wall or cantilever support. Grade stability should be determined by comparing velocities for the design flow in the downstream channel with the permissible velocities for the soils and vegetation in the channel.

The possibility of sediment deposition in the channel below the spillway should be investigated. When sediment is a problem, the outlet of the spillway should be designed so that deposition will not interfere with the spillway discharge during the expected life of the structure.

5. STRAIGHT DROP SPILLWAY

DESCRIPTION

The straight drop spillway is a weir structure. Flow passes through the weir opening, drops to an approximately level apron or stilling basin and then passes into the downstream channel. (Figure 6-5)

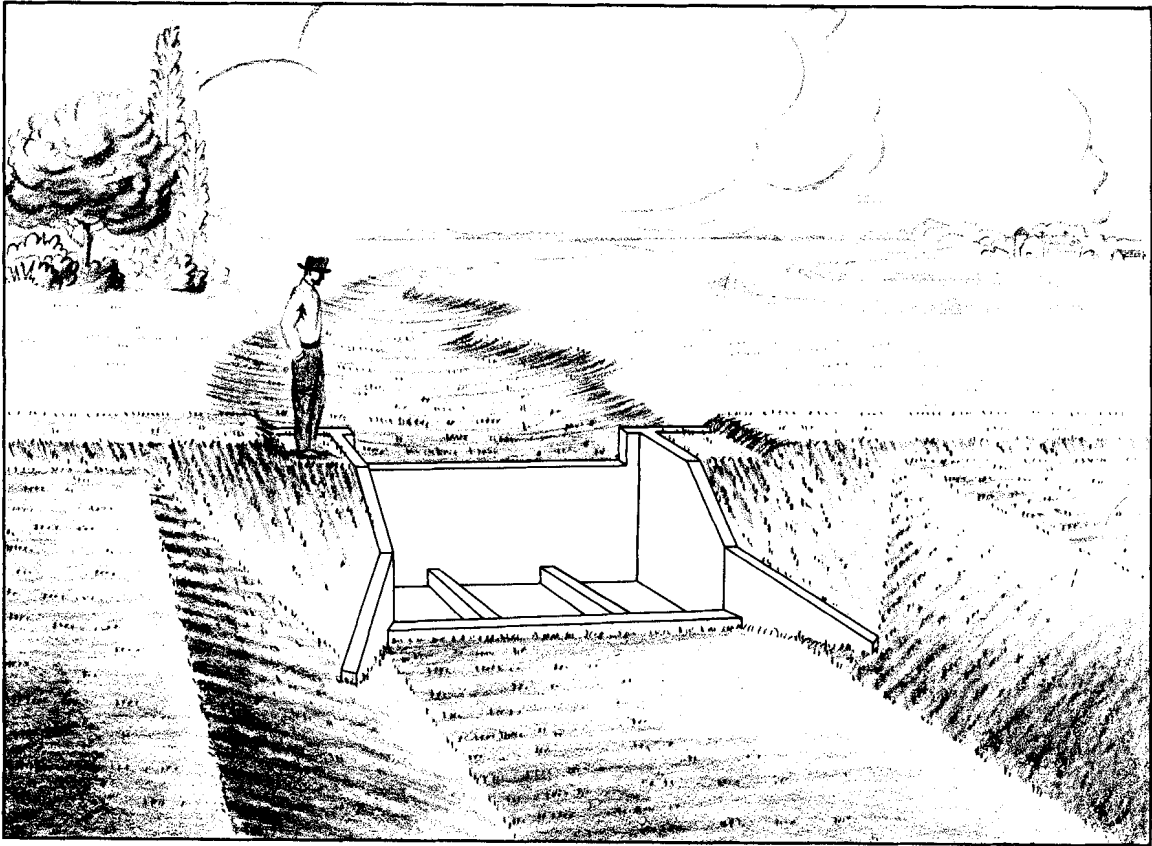
		DISCHARGE - C.F.S.								
		10	25	50	100	150	200	400	800	1500
CONTROLLED HEAD - FEET	4	Drop spillways or Hooded inlet spillways				Drop spillways				
	8	Hooded inlet or Pipe drop inlet spillways				Drop or chute spillways				
	12	Hooded inlet or Pipe drop inlet spillways				Monolithic Drop inlet spillways				
	16	Pipe drop inlet spillways				Chute spillways				
	20	Pipe drop inlet spillways				Chute spillways				
	25	Pipe drop inlet spillways				Chute spillways				
	30	Pipe drop inlet spillways				Chute spillways				
	40	Pipe drop inlet spillways				Chute spillways				
	80	Pipe drop inlet spillways				Chute spillways				

Note: Chart shows most economical structure as related to discharge and controlled head providing site conditions are adequate.

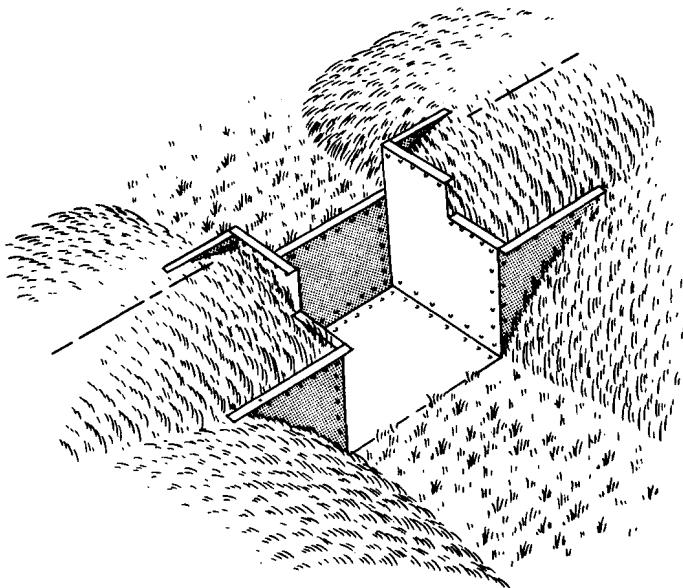
Figure 6-4 General guide to structure selection

MATERIALS

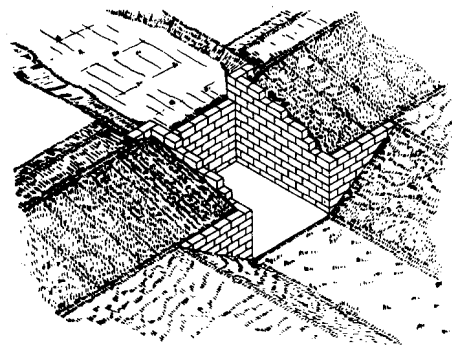
Straight drop spillways may be constructed of reinforced concrete, plain concrete, rock masonry, concrete blocks with or without reinforcing, sheet piling of steel, timber, and prefabricated metal.



Reinforced concrete



Prefabricated metal



Concrete block

Figure 6-5 Straight drop spillways

FUNCTIONAL USE

1. Grade stabilization in lower reaches of waterways and outlets.
2. Erosion control for protection of fields, roads, buildings and other improvements from gullies.
3. Grade control for stabilizing channels.
4. Outlets for tile and surface water at the upper end and along drainage ditches. Where the channel width below the proposed structure site is limited, the box inlet drop spillway is more effective.
5. Reservoir spillway where the total drop is relatively low.
6. Control of tailwater at the outlet of a spillway or conduit.
7. Protection of the outlet end of grass waterways and sod chutes. Low headwall structures for this purpose are sometimes referred to as a toe wall drop spillway. See Figure 6-9.
8. Control of irrigation water.

ADAPTABILITY

The straight drop spillway is an efficient structure for controlling relatively low heads, normally up to 10 feet.

ADVANTAGES

1. Very stable. The likelihood of serious structural damage is less than for other types of structures.
2. The rectangular weir is less likely to be clogged by debris than the openings or other structures of comparative discharge capacities.
3. They are relatively easy to construct. The concrete block type can be built with farm labor, while the reinforced concrete or steel sheet piling type usually requires the services of a contractor.

LIMITATIONS

1. It is more costly than some other types of structures where the required discharge capacity is less than 100 c.f.s. and the total head or drop is greater than 10 feet.
2. It is not a favorable structure where temporary spillway storage is needed to obtain a large reduction in discharge.

3. A stable grade below the structure is essential.

SITE SELECTION

Proper site selection is dependent upon adequate field surveys and foundation data. Attention must be given to changed water elevations caused by the proposed structures as they might affect adjacent highways and their drainage structures, railroads, pipelines and other improvements or properties.

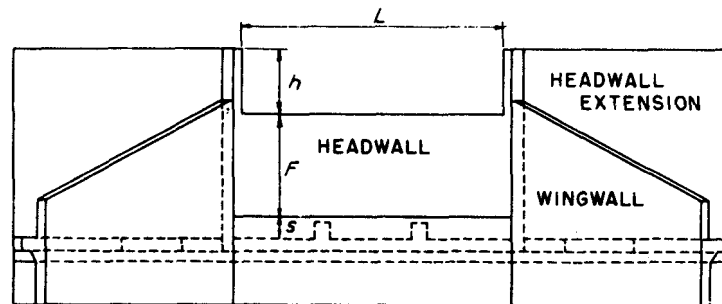
For grade control drops with definite approach channels, the site should be selected so that the spillway can be located on a reasonably straight section of channel, with no upstream or downstream curves within at least 100 feet of the structure. It often will be desirable to straighten the channel alignment above and below the spillway so that it merges smoothly with the existing channel. Poor alignment may result in a reduction in discharge capacity and excessive scour of the embankment and channel banks. There should be no channel restrictions or obstacles in the approach channel that would interfere with the design flow entering the spillway inlet.

The site selected should provide an adequate foundation for the spillway. The foundation material must have the required supporting strength, resistance to sliding and piping, and be reasonably homogeneous so as to prevent uneven settlement of the structure.

DESIGN

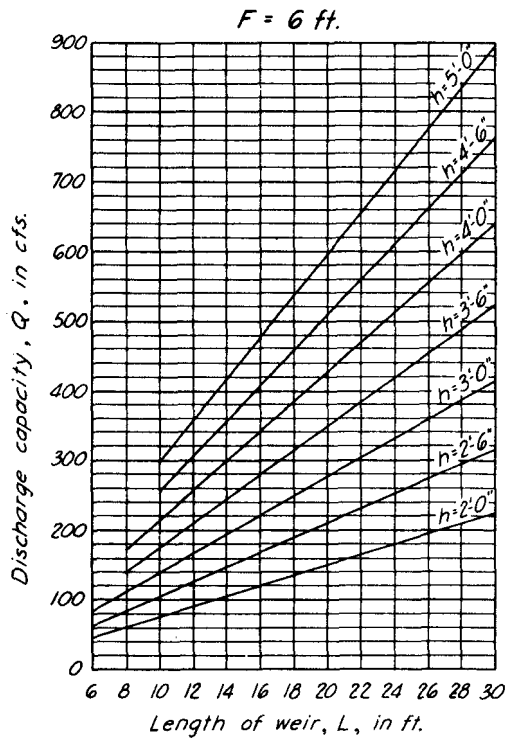
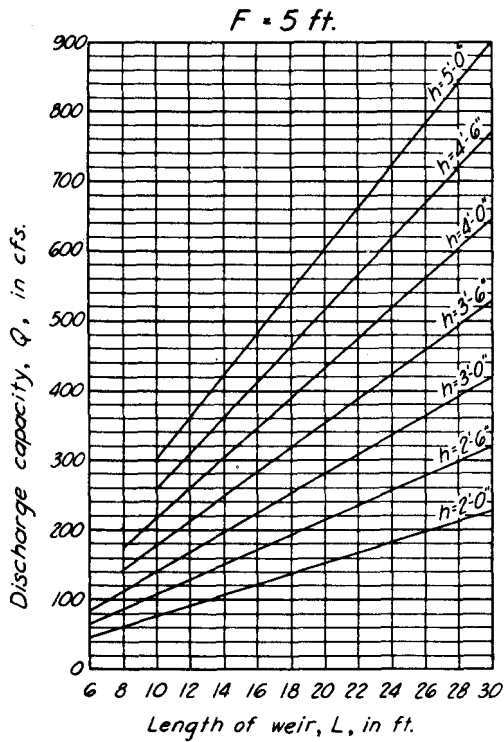
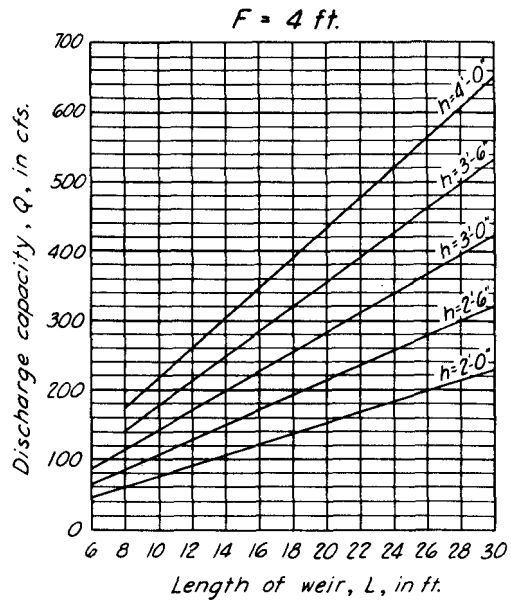
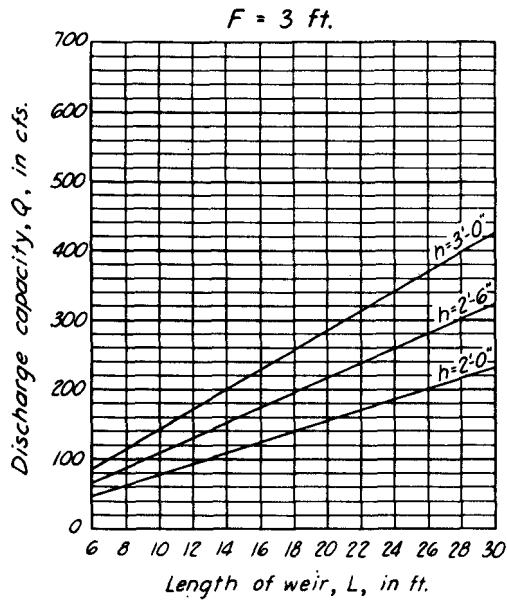
Planning and design of straight drop spillways normally require the assistance of an engineer. Local personnel may be trained to plan and install small drop spillway structures when standard plans are available.

Measurement locations for symbols F (overfall in feet), h (depth of weir in feet), s (depth of stilling pool in feet), and L (length of weir in feet) are shown in Figure 6-6.



DOWNSTREAM ELEVATION

Figure 6-6 Symbols for straight drop spillway



Note: *h* = total depth of weir, in feet (including freeboard)
F = net drop from crest to top of transverse sill, in feet
 (For type B drops keep $h \div F$ less than 0.75)

$$Q = \frac{3.1 L h^{3/2}}{(1.10 + 0.01 F)}$$

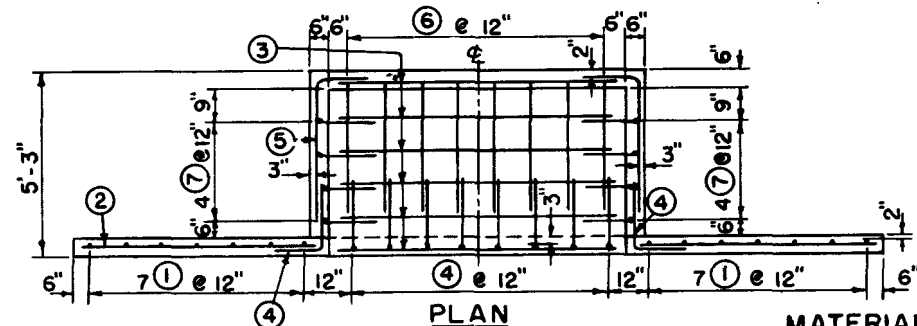
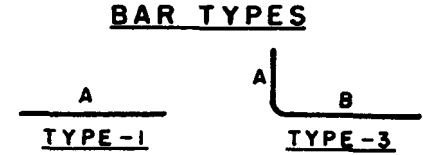
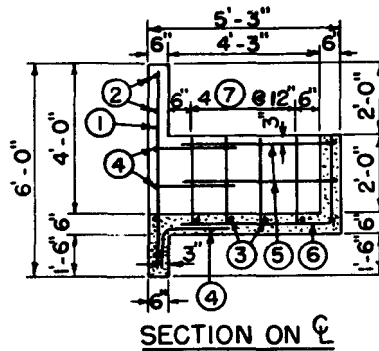
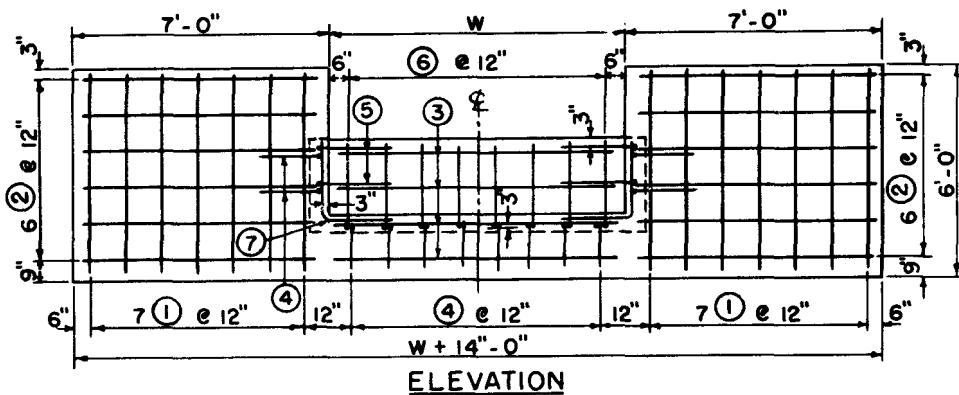
Reference - ES65
 Sec. II N.E.H.

Figure 6-7 Weir capacity for straight drop spillways

F	h/L	6	8	10	12	14	16	18	20	22	24	26	28	30
5	2-6	2051-6B 19.98 1400.47	2051-8B 21.32 1991.36	2051-10B 22.66 1853.29	2051-12B 24.13 1757.87	2051-14B 25.47 1682.85	2051-16B 26.81 1947.69	2051-18B 28.15 2148.58	2051-20B 29.49 2206.85	2051-22B 30.83 2376.90	2051-24B 32.17 2436.30	2051-26B 33.51 2548.91	2051-28B 34.84 2708.46	2051-30B 36.18 2923.96
	3-0	2052-6B 24.36 1975.81	2052-8B 25.78 2167.93	2052-10B 27.20 2416.75	2052-12B 28.79 2313.39	2052-14B 30.21 2464.78	2052-16B 31.63 2599.55	2052-18B 33.05 2780.18	2052-20B 34.46 2890.36	2052-22B 35.88 2966.63	2052-24B 37.30 3117.16	2052-26B 38.72 3250.65	2052-28B 40.14 3368.08	2052-30B 41.56 3551.59
	3-6										2053-24B 43.06 3457.55	2053-26B 44.56 3635.43	2053-28B 46.05 3812.61	2053-30B 47.55 4023.02
6	2-6	2061-6B 21.08 1601.43	2061-8B 22.50 1767.24	2061-10B 23.92 2034.92	2061-12B 25.49 1973.92	2061-14B 26.91 2092.83	2061-16B 28.33 2206.57	2061-18B 29.75 2433.87	2061-20B 31.17 2532.38	2061-22B 32.59 2734.61	2061-24B 34.01 2830.03	2061-26B 35.43 2986.35	2061-28B 36.85 3167.85	2061-30B 38.27 3405.80
	3-0	2062-6B 25.64 2103.37	2062-8B 27.14 2283.59	2062-10B 28.64 2592.72	2062-12B 30.33 2484.08	2062-14B 31.83 2626.73	2062-16B 33.33 2814.70	2062-18B 34.83 3023.87	2062-20B 36.33 3111.19	2062-22B 37.83 3309.80	2062-24B 39.33 3485.55	2062-26B 40.83 3622.38	2062-28B 42.33 3817.93	2062-30B 43.83 4055.17
	3-6										2063-24B 45.77 3961.17	2063-26B 47.36 4173.51	2063-28B 48.96 4424.57	2063-30B 50.55 4660.84
7	2-6	2071-6B 24.13 1770.40	2071-8B 25.64 1962.20	2071-10B 27.15 2281.97	2071-12B 28.81 2133.03	2071-14B 30.33 2291.06	2071-16B 31.84 2494.10	2071-18B 33.35 2630.02	2071-20B 34.86 2795.57	2071-22B 36.37 2983.80				
	3-0	2072-6B 27.21 2305.84	2072-8B 28.81 2594.80	2072-10B 30.41 2971.44	2072-12B 32.20 2768.73	2072-14B 33.79 2985.86	2072-16B 35.39 3108.17	2072-18B 36.98 3296.11	2072-20B 38.58 3456.31	2072-22B 40.17 3683.76	2072-24B 41.77 3934.24	2072-26B 43.37 4104.64	2072-28B 44.96 4308.07	2072-30B 46.56 4638.52
	3-6										2073-24B 47.94 4606.39	2073-26B 49.62 4881.46	2073-28B 51.29 5103.44	2073-30B 52.97 5389.76
8	2-6	2081-6B 28.52 2286.72	2081-8B 30.11 2580.93	2081-10B 31.70 2894.57										
	3-0	2082-6B 30.00 2606.59	2082-8B 31.67 2933.42	2082-10B 33.33 3393.86	2082-12B 35.22 3166.00	2082-14B 36.90 3418.33	2082-16B 38.57 3621.84	2082-18B 40.24 3842.53	2082-20B 41.92 4035.89	2082-22B 43.59 4296.86	2082-24B 45.26 4796.48	2082-26B 46.93 4846.29	2082-28B 48.59 5487.76	2082-30B 50.26 4800.91
	3-6										2083-24B 48.69 5045.69	2083-26B 50.45 5222.22	2083-28B 52.22 5396.68	2083-30B 54.03 5659.59
9	2-6	2091-6B 33.56 2886.37	2091-8B 35.34 3156.72	2091-10B 37.09 3298.05										
	3-0	2092-6B 35.02 3165.85	2092-8B 36.79 3573.92	2092-10B 38.77 3996.27	2092-12B 40.54 3853.91	2092-14B 42.31 4148.74	2092-16B 44.08 4398.32	2092-18B 45.85 4672.12	2092-20B 47.62 4995.58	2092-22B 49.39 4669.28	2092-24B 51.16 4889.04	2092-26B 52.93 5168.69	2092-28B 54.70 5478.30	2092-30B 56.47 5825.39
	3-6	2093-6B 36.91 3685.64	2093-8B 38.76 4022.45	2093-10B 40.61 4343.10	2093-12B 42.74 4405.33	2093-14B 44.59 4659.63	2093-16B 46.44 4949.23	2093-18B 48.28 5268.80	2093-20B 50.13 5668.76	2093-22B 51.99 5279.76	2093-24B 53.84 5586.79	2093-26B 55.69 5916.74	2093-28B 57.54 6187.86	2093-30B 59.39 6559.76
10	2-6	2094-6B 41.81 4376.42	2094-8B 43.74 4718.70	2094-10B 45.68 5193.83	2094-12B 47.95 5067.65	2094-14B 49.88 5353.07	2094-16B 51.81 5644.16	2094-18B 53.74 6034.57	2094-20B 55.66 5782.65	2094-22B 57.59 6148.78	2094-24B 59.52 6327.49	2094-26B 61.45 6602.44	2094-28B 63.38 6922.40	2094-30B 65.31 7406.17
	3-6											2095-26B 70.76 8571.17	2095-28B 72.79 8964.40	2095-30B 74.81 9317.86
	5-0	2096-6B 55.92 7504.69	2096-8B 58.02 7844.56	2096-10B 60.12 8305.86	2096-12B 62.72 8286.26	2096-14B 64.83 8639.17	2096-16B 66.93 9017.95	2096-18B 69.03 9353.63	2096-20B 71.13 9178.51	2096-22B 73.23 9909.13	2096-24B 75.33 9827.44	2096-26B 77.43 10311.98	2096-28B 79.53 10693.95	2096-30B 81.63 10990.97

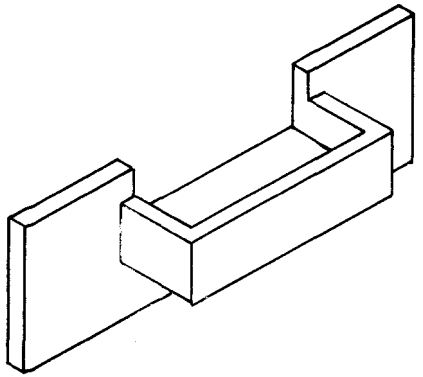
- (1) Notes: Drawing No., cu. yds of concrete, and lbs. of reinforcing steel are listed vertically in order for each size. Each drawing number shall be prefixed with the letters E. S.
- (2) *The ratio of L + h is less than 2.0 for these values. Correction for hydraulic losses due to end contractions must be considered in the solution of the weir formula, for discharge capacity, before these drop spillways can be applied.

Figure 6-8 Standard plans: series "B" reinforced concrete drop spillways schedule showing drawing number, cubic yards of concrete, and pounds of reinforcing steel



BAR SCHEDULE				
MARK	TYPE	QUAN.	A	B
1	1	14	5'-6"	
2	1	12	6'-6"	
3	1	8	W-6"	
4	3		1'-9"	1'-3"
5	3	4	4'-3"	1'-9"
6	3		4'-2"	2'-1"
7	3	8	1'-9"	2'-0"

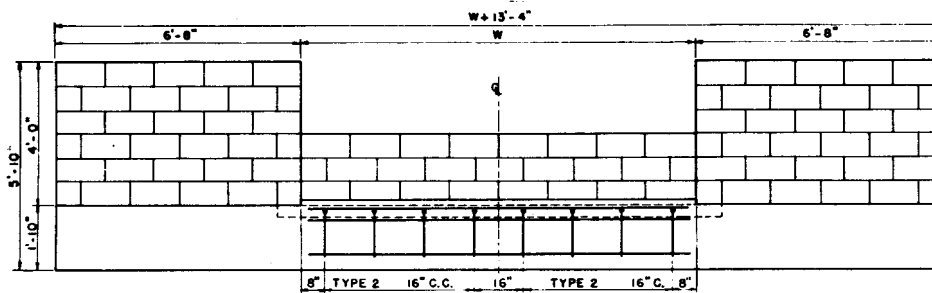
MATERIALS SCHEDULE									
WIDTH (W) (FT.)	8	10	12	14	16	18	20	22	24
NO. OF MARK 4 BARS	12	14	16	18	20	22	24	26	28
NO. OF MARK 6 BARS	8	10	12	14	16	18	20	22	24
STEEL (LBS.)	133.5	146.5	159.4	172.4	185.4	198.3	211.3	224.3	237.3
CONCRETE (CU. YDS.)	3.3	3.6	3.9	4.3	4.6	4.9	5.2	5.6	5.9



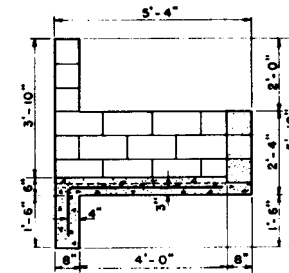
Notes:
 Where required length of Mark 3 bars is not available, two or three spliced bars may be substituted. A lap of 12" is required at each splice. The total spliced length shall equal W-6".

ALL BARS NO. 3 or 3/8" ϕ

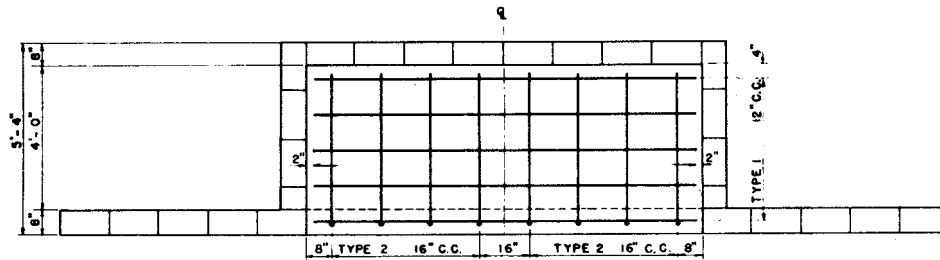
Figure 6-9 Standard plan for a reinforced concrete toe wall with 2'-0" overfall drop spillway



ELEVATION

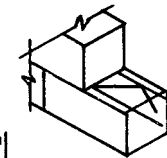


SECTION ON C



PLAN

BAR SCHEDULE				
TYPE	SIZE	QUAN	A	B
1	#3		W-4"	
2	#3		4'-4"	1'-4"

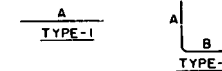


MASONRY WALL REINFORCEMENT
 9 Gage galvanized wire. Available in 4", 6", 8", 10" and 12" widths. Reinforcing placed between each course of blocks after cores have been filled with concrete.

6-14

WIDTH OF NOTCH	8'-0"	10'-8"	13'-4"	16'-0"	18'-8"	21'-4"	24'-0"
NO. OF BLOCKS	99	105	111	117	123	129	135
VOL. OF CONC. C. Y.	2.41	2.80	3.20	3.60	3.99	4.38	4.78
MORTAR C. Y.	0.10	0.11	0.11	0.12	0.12	0.13	0.14
STEEL LBS.	30	40	51	60	71	81	92
MASONRY WALL REIN.	106-8	112-0	117-4	122-8	128-0	133-4	138-8

BAR-TYPES



Notes: First Course of Blocks to be laid 2" in freshly poured concrete slab. Cores in Blocks to be filled with concrete. The mortar shall be 1 part portland cement to 3 parts torpedo sand. All Concrete Blocks shall be placed in a water bath a minimum of 10 minutes immediately before laying in the wall. All block cores shall be thoroughly sprinkled previous to placing of the Concrete Core Fill. Where Weir "W" exceeds 12'-0" provide Wall Reinforcing or use Concrete Block Buttresses. Vertical Wall Reinforcing Steel should be added where excessive loads are expected.

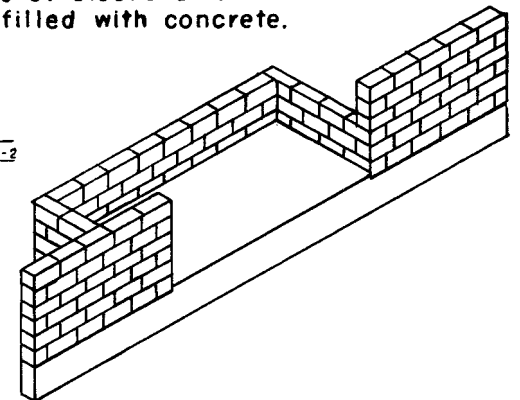


Figure 6-10 Standard plan for a concrete block toe wall drop spillway with 1'-10" overfall

Weir capacities for low-overfall straight drop spillways can be determined from Figure 6-7 for various combinations of F, h, and L. Standard plans are available for the Series "B" reinforced concrete drop spillways. Figure 6-8 can be used for estimating cost of these structures. The required cubic yards of concrete and pounds of reinforcing steel are shown for each size.

Figure 6-9 is an example of a standard plan for a reinforced concrete toe wall drop spillway. Concrete block toe walls are shown in Figure 6-10.

The earthfill embankment should conform to State Standards and Specifications.

6. BOX INLET DROP SPILLWAY

DESCRIPTION

The box inlet drop spillway structure is a rectangular box open at the top and at the downstream end. Storm runoff, directed to the box by dikes and headwalls, enters over the upstream end and two sides. The flow drops to an apron and leaves through the open downstream end. An outlet structure is attached to the downstream end of the box. (Figure 6-11)

MATERIALS

Reinforced concrete is best. However, reinforced concrete block structures can be used for low overfalls (3 feet or less) and narrow channels.

FUNCTIONAL USE

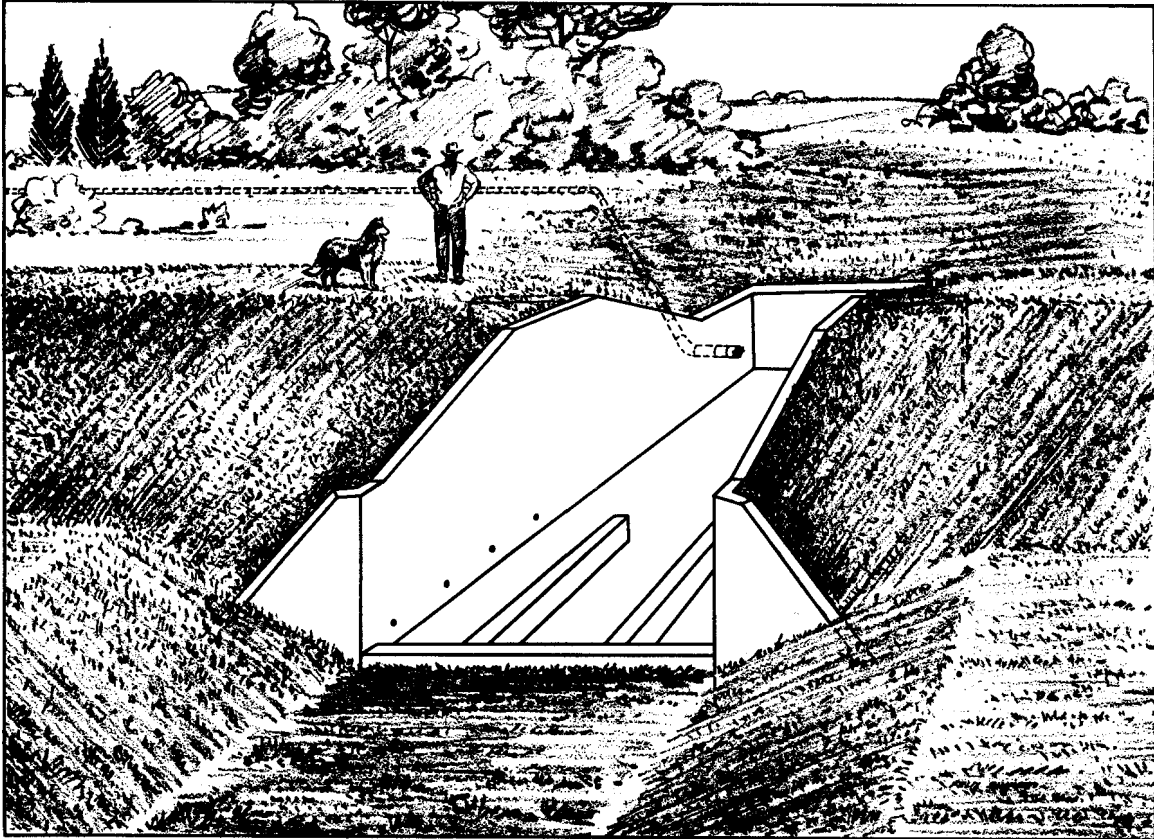
The box inlet drop spillway can be used for the same purposes as a straight drop spillway. One of its greatest uses is for grade and erosion control in open drainage ditches where the width of channel at the outlet is limited. It can serve also as a tile outlet at the head of the ditch. Like the drop spillway, it is limited to overfall heights up to 10 feet.

ADAPTABILITY

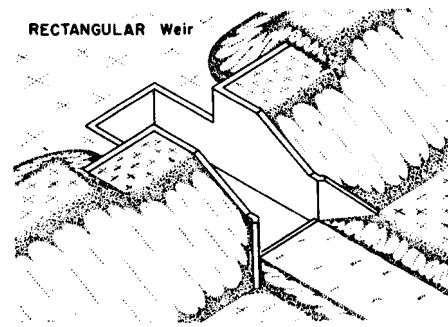
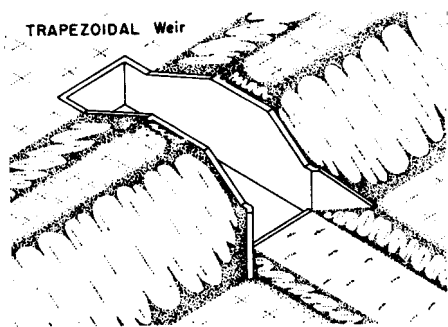
It is particularly adapted to narrow channels where it is necessary to pass large flows of water. The long crest of the box inlet permits large flows to pass over it with relatively low heads, and the width of the spillway need be little, if any, greater than that of the existing channel. When the required weir length of the structure is over twice the bottom width of the channel, the box inlet drop spillway should be considered. The box inlet drop spillway can be combined with a bridge to provide a road crossing, using the high portion of the sidewalls as abutments for the bridge. (Figure 6-12)

ADVANTAGES

Same as for the straight drop spillway, with added advantages of greater weir capacity for narrow outlet channels.



Reinforced concrete



Types of weirs for box inlet drop spillways

Figure 6-11 Box inlet drop spillway

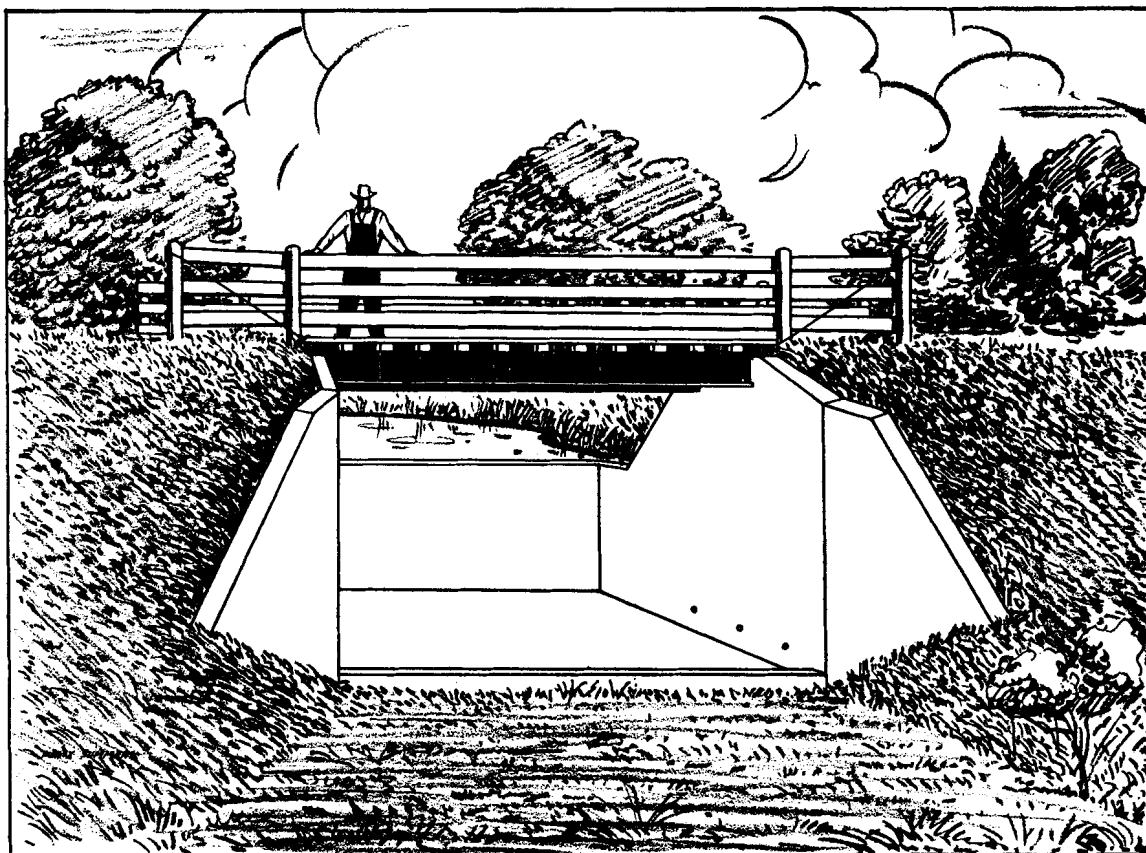


Figure 6-12 Box-inlet drop spillway with
a bridge over the top

LIMITATIONS

Same as for straight drop spillways.

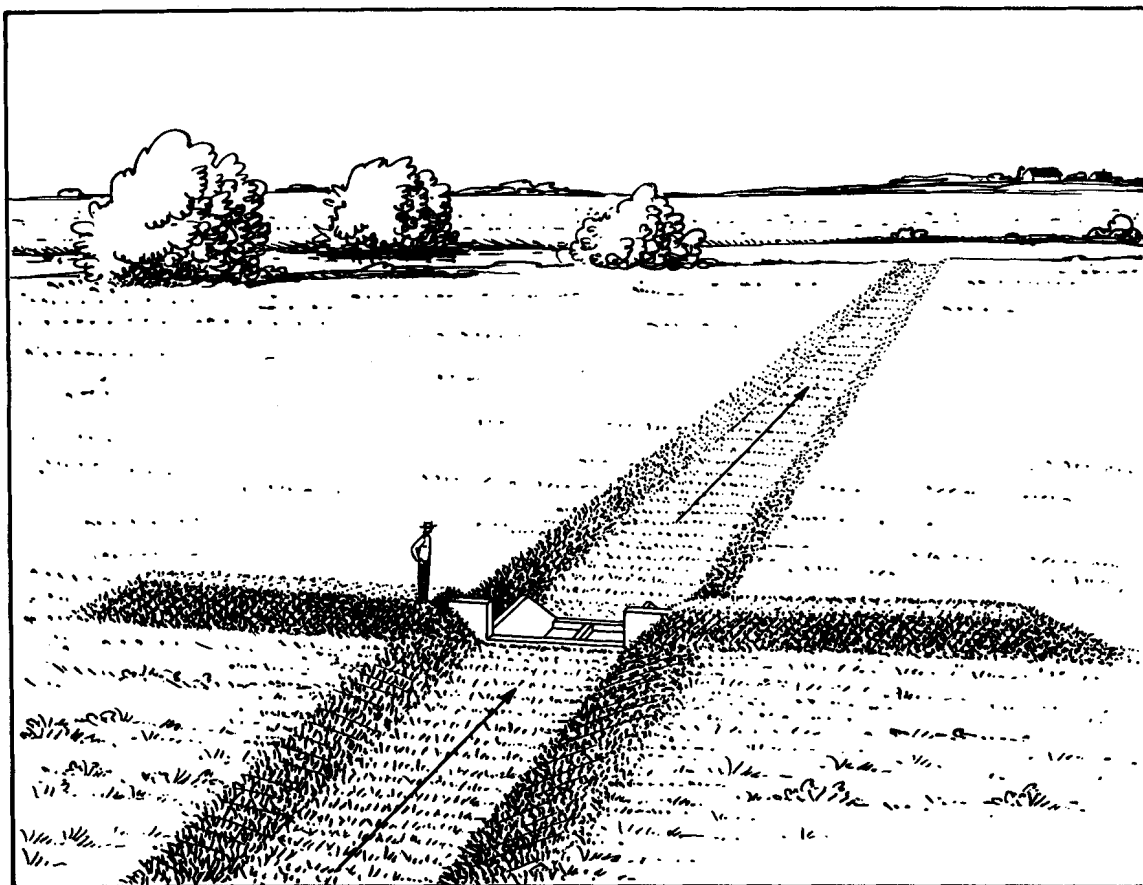
DESIGN

The complexity of design and layout of box inlet drop spillways requires the assistance of an engineer.

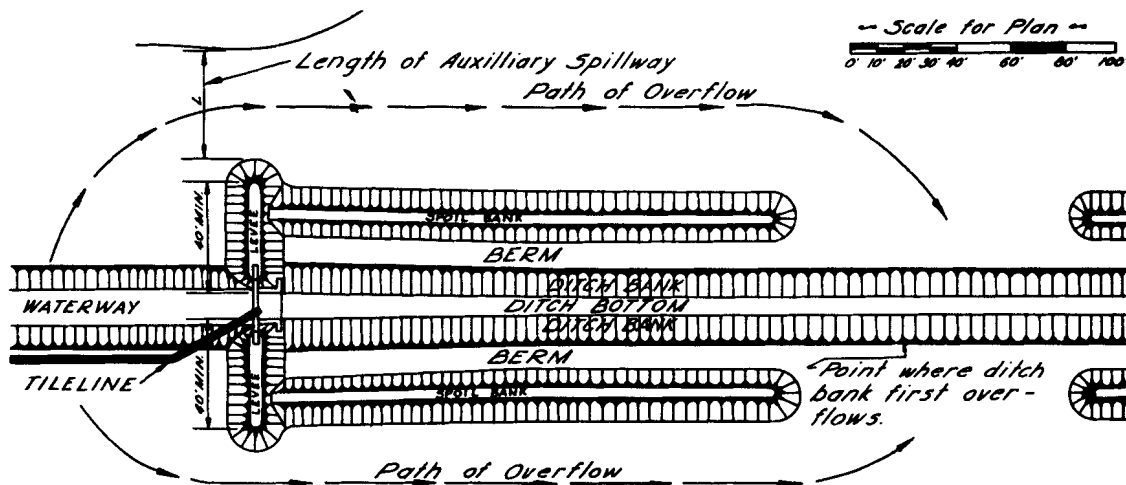
7. ISLAND-TYPE STRUCTURE

DESCRIPTION

The island-type spillway uses a drop spillway in the channel with auxiliary earth spillways for carrying excess flows around the structure. Either the straight drop spillway or the box inlet drop spillway can be used. (Figure 6-13) To prevent washing around the structure, dikes extending each way from the structure must be provided. In some cases the dikes



Island-type spillway showing embankments extending out from headwall extensions



Plan view of layout for island-type spillway with levees parallel to the ditch to force overflow some distance below structure

Figure 6-13 Island-type spillways

are joined to spoil banks provided there is an opening in the spoil bank downstream from the structure.

FUNCTIONAL USE

The island-type spillway is adaptable for grade control or use at the head of a channel to control the overfall. It is particularly adapted to sites where the design peak runoff is greater than the capacity of the outlet channel into which the structure is placed or empties. This structure can be used only where there is a sufficient area of nearly level land on either side of the dam that can be used as an earth spillway. Topography of the area must be such that the path of overflow around the structure will return to the channel a short distance below the structure without causing damage to the field or ditchbanks.

OPERATION OF STRUCTURE

The island-type spillway is designed so that the channel downstream from the structure will be full before the overflow around the dam reenters the channel. This reduces the possibilities of bank erosion from flow over the bank. To accomplish this, the crest of the weir must be set below the crest of the earth spillway. The vertical distance between these points must be sufficient to provide a weir notch capacity equal to the bank-full capacity of the channel at the place where the flow from the earth spillway reenters the channel. Large flows will then pass around the earth embankment of the drop spillway, forming an island composed of the drop spillway and the headwall extension levees.

The channel above the structure at the point where overflow begins must have the same capacity as the channel below the structure. In this way, the discharge from the channel above the structure will fill the channel below it before the banks at the structure are overtopped and flow is directed to the earth spillway. Also, the structure should be so proportioned that the channel banks will overflow near the structure as soon as the channel capacity flow has been reached.

ADVANTAGES

It permits the use of a drop spillway having less capacity than the peak runoff for the design storm.

LIMITATIONS

It often requires the construction of earth spillways in cropland areas. Therefore, it is harder to maintain the correct grade and elevation.

DESIGN

The layout and design of the island-type structure requires the assistance of an engineer.

8. DROP BOX (CULVERT INLET)

DESCRIPTION

A drop box is a rectangular box inlet drop spillway placed at the upstream end of a culvert. It may be built as an integral part of a new culvert, or it can be fastened by dowel bars to the upstream headwall of an existing culvert. Storm runoff is directed to the box by the highway fill. (Figure 6-14)

FUNCTIONAL USE

Drop boxes are used to control grades above culverts in either natural or constructed channels. They may serve as an outlet for tile drains. Cattle ramps can be incorporated into the design of the box when the culvert is used as a cattle pass. See Figure 6-15 - upper sketch. The drop box is very effective for erosion control in highway ditches as shown in Figure 6-15 - lower sketch.

MATERIALS

Reinforced concrete is the best and most commonly used material for constructing drop boxes. In some cases, concrete blocks or prefabricated metal can be used. Material used should be consistent with the expected remaining life of the culvert to which the drop box is to be attached. The addition of a headwall will be required where none exists.

ADVANTAGES

It is one of the most economical structures for controlling overfalls because the existing culvert and highway embankment replace the outlet portion of the typical drop spillway. It has the advantage of the box inlet drop spillway in that the weir length can be fitted to a narrow waterway.

LIMITATIONS

It requires the availability of structurally sound road culverts. The structure is often attached to a road culvert which is the property of a roadway governing body and, therefore requires its permission. They may not allow maintenance and control on the part of the landowner.

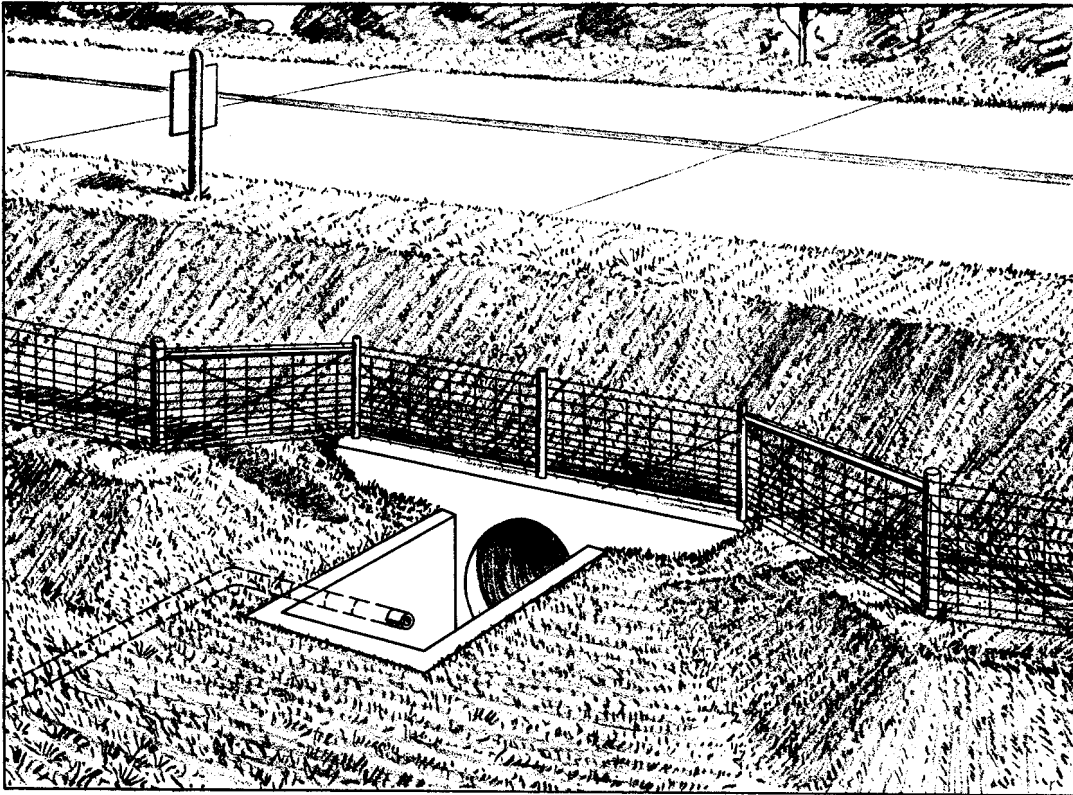
DESIGN

The design and layout of a drop box requires the assistance of an engineer.

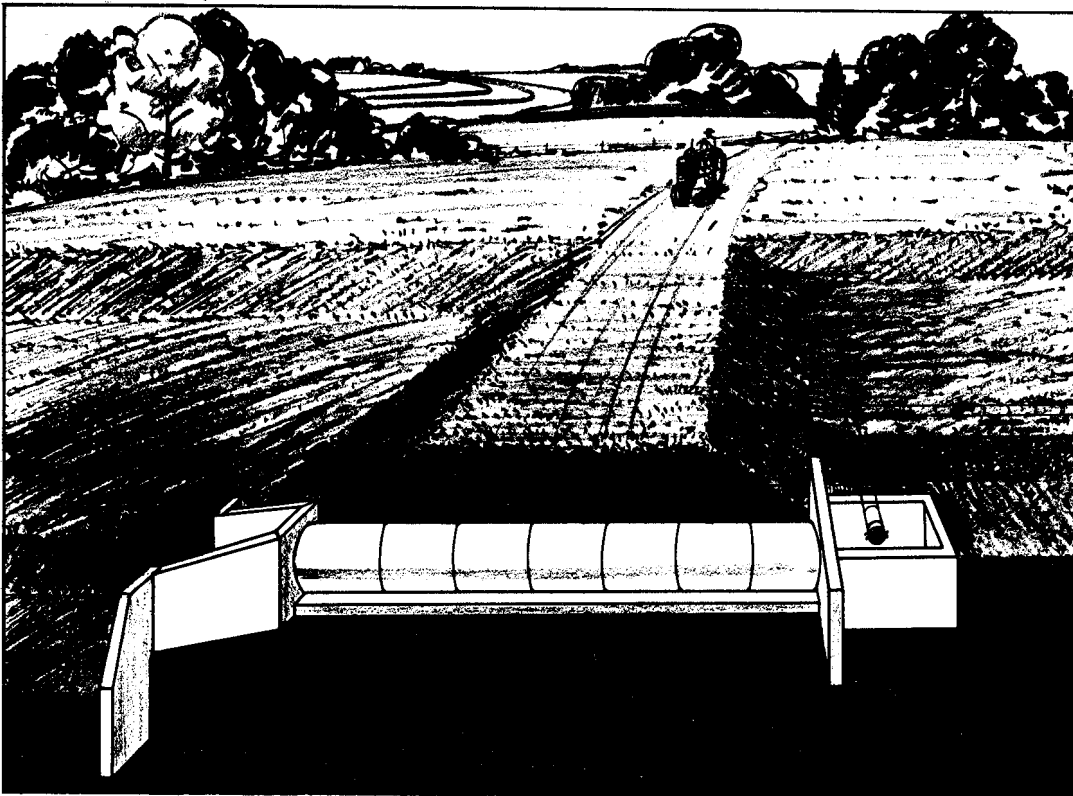
9. CONCRETE CHUTE SPILLWAY

DESCRIPTION

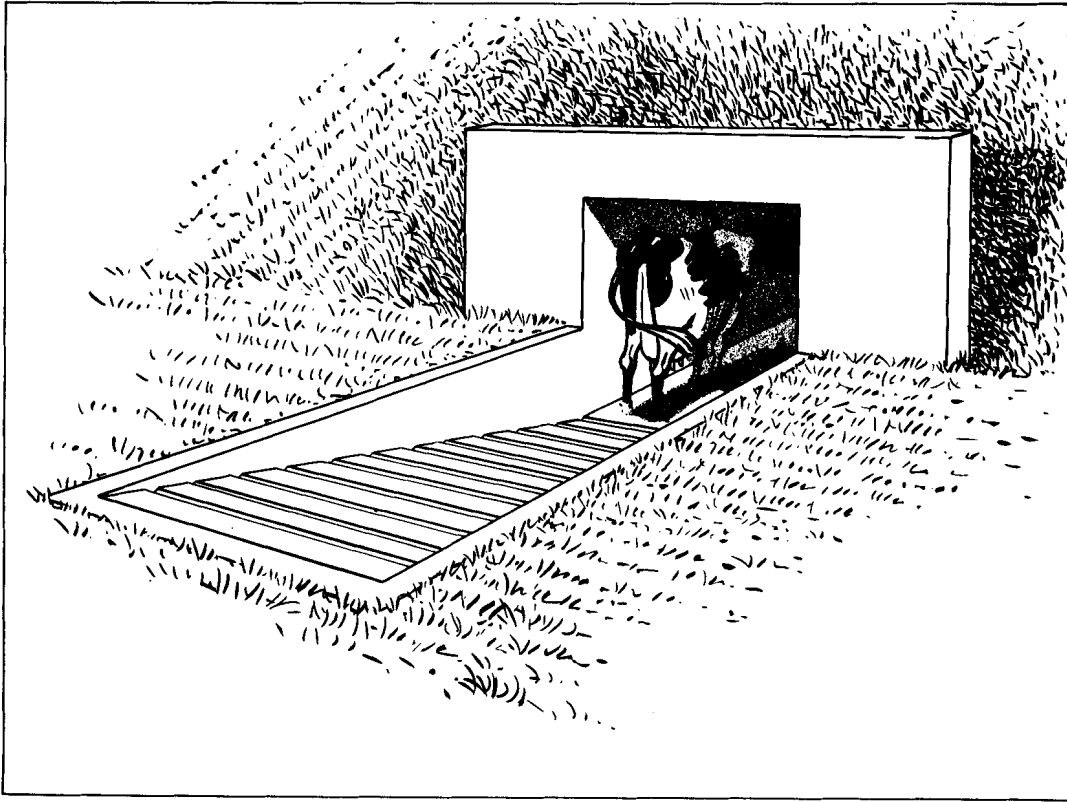
A chute spillway is an open channel with a steep slope in which flow is carried at supercritical velocities. It usually consists of an inlet,



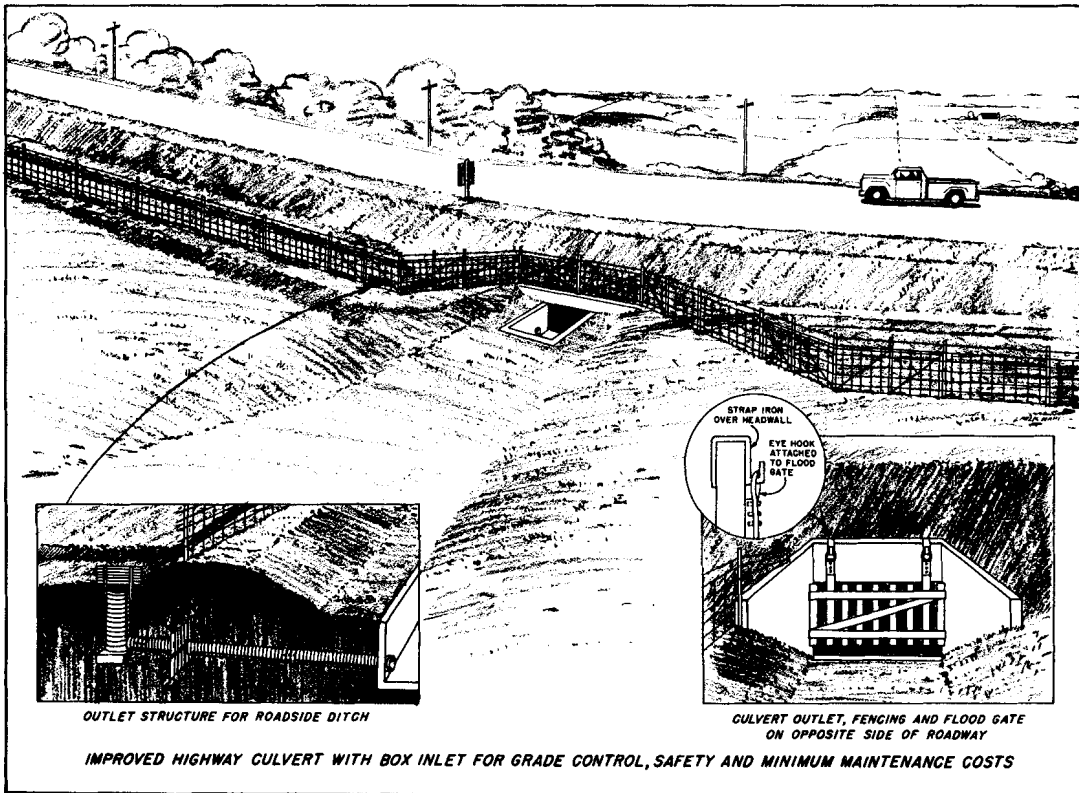
Drop box attached to existing culvert



New culvert with a box inlet
Figure 6-14 Drop box (culvert inlet)



Drop box with cattle ramp



Drop box for highway erosion control

Figure 6-15 Other uses for drop boxes

vertical curve section, steep-sloped channel, and outlet. The major part of the drop in water surface takes place in a channel. Flow passes through the inlet and down the paved channel to the floor of the outlet. (Figure 6-16)

MATERIAL

Reinforced concrete is the most widely used and safest material for large chutes.

FUNCTIONAL USES

1. To control the gradient in either natural or constructed channels.
2. To serve as a spillway for flood prevention, water conservation, and sediment-collecting structures.

ADAPTABILITY

The concrete chute is particularly adapted to high overfalls where a full flow structure is required and where site conditions do not permit the use of a detention-type structure. It also may be used with detention dams, taking advantage of the temporary storage to reduce the required capacity and the cost of the chute.

ADVANTAGES

It usually is more economical than a drop inlet structure when large capacities are required.

LIMITATIONS

There is considerable danger of undermining of the structure by rodents. In poorly drained locations, seepage may weaken the foundation. It must be placed on compacted fill or on undisturbed soil in an abutment.

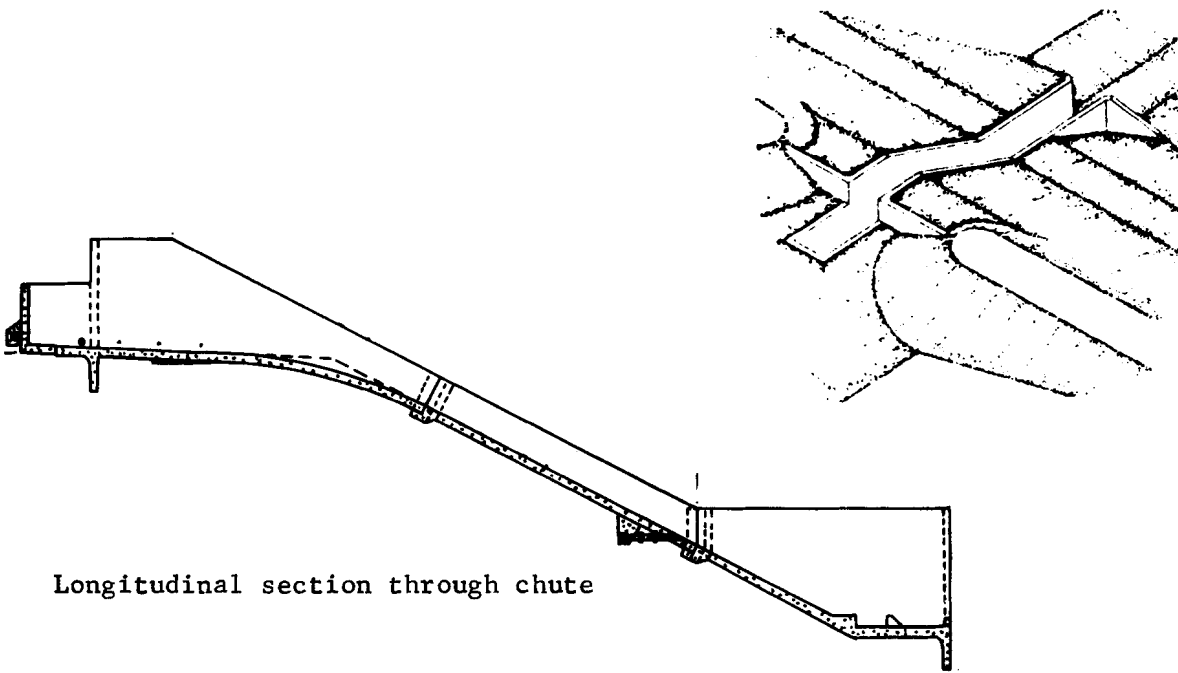
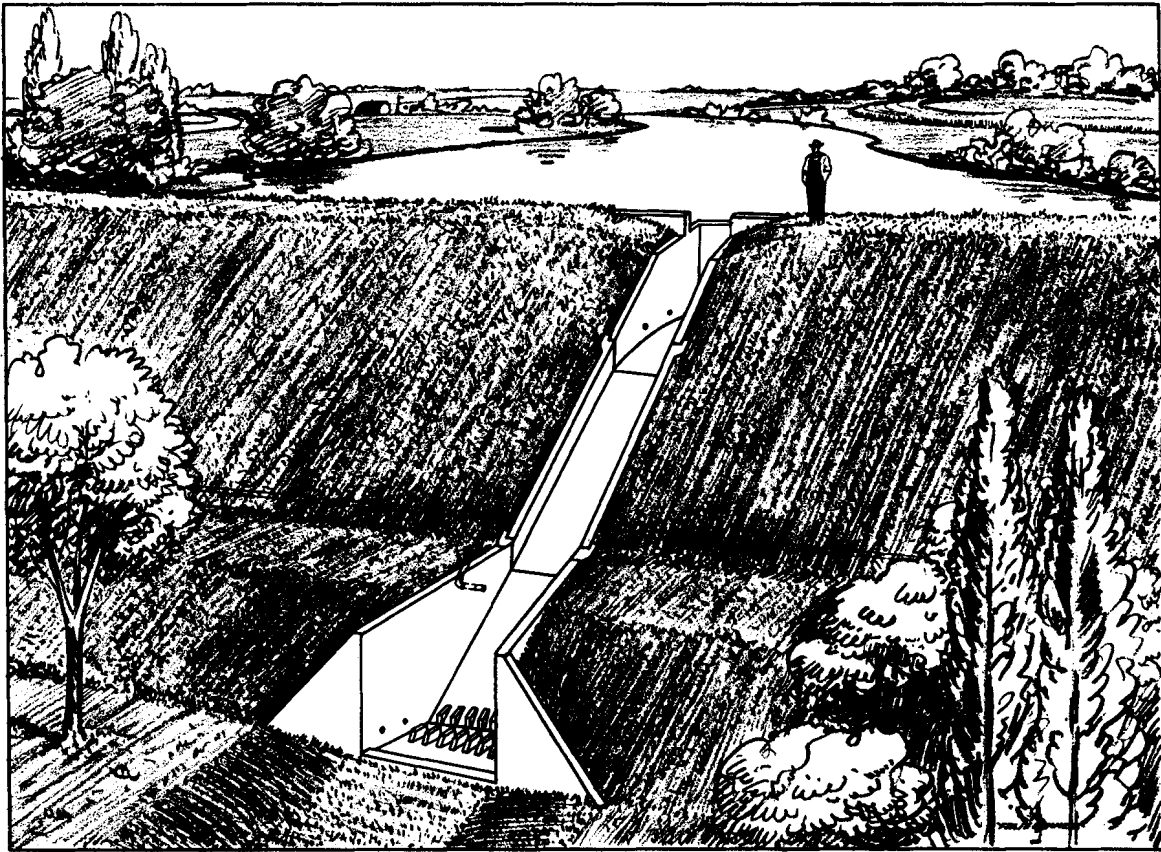
DESIGN

The chute spillway requires the assistance of an engineer.

10. FORMLESS CONCRETE CHUTE SPILLWAY

DESCRIPTION

The formless concrete chute spillway is a spillway constructed of concrete without special forming. The earth subgrade is excavated to the dimension and contour of the structure. Concrete is placed against this subgrade to the depth required and troweled into shape.



Longitudinal section through chute

Figure 6-16 Reinforced concrete chute spillway

MATERIALS

Concrete with at least a 28-day strength of 2,500 lbs. per square inch should be used. Temperature steel is required and may be either reinforcing steel or welded wire mesh.

FUNCTIONAL USE

The formless chute may be used to: control overfalls in natural and constructed waterways; prevent erosion at the ends of terraces, outlets and waterways; and to lower runoff water over drainage ditchbanks.

ADAPTABILITY

This type of structure is used for low heads and where low spillway capacities are required. It is adapted to regions that do not have extreme variations in temperature.

ADVANTAGES

The spillway is easy to construct. Inexperienced labor can be trained to install the formless chute in a relatively short time. The elimination of wall forming produces a major saving in time and costs.

LIMITATIONS

This structure is limited to sites that have good, natural drainage. It cannot be used as a water-impounding structure nor is the life expectancy as long as other permanent structures. It is limited to areas where temperature variations are moderate.

DESIGN

Standard plans usually are available. Figure 6-17 is a typical plan for a small, low-head formless chute. The sidewalls and chute bottom should be no steeper than $1\frac{1}{2}$:1 to permit placing of concrete.

CONSTRUCTION

Grading should be smooth and to line and grade, otherwise an excessive amount of concrete will be used to fill in rough grading and overcutting. This type of structure should be constructed on solid ground. Seep areas should be avoided or properly drained. The soil must be damp and firm to provide a good base for the concrete. A stiff mix is needed to prevent concrete from slumping down the slope of the apron and walls. The concrete is worked into place and finished with a wood float. A steel trowel is then used for final finishing.

Figure 6-17 Typical standard plan for low head formless concrete chute

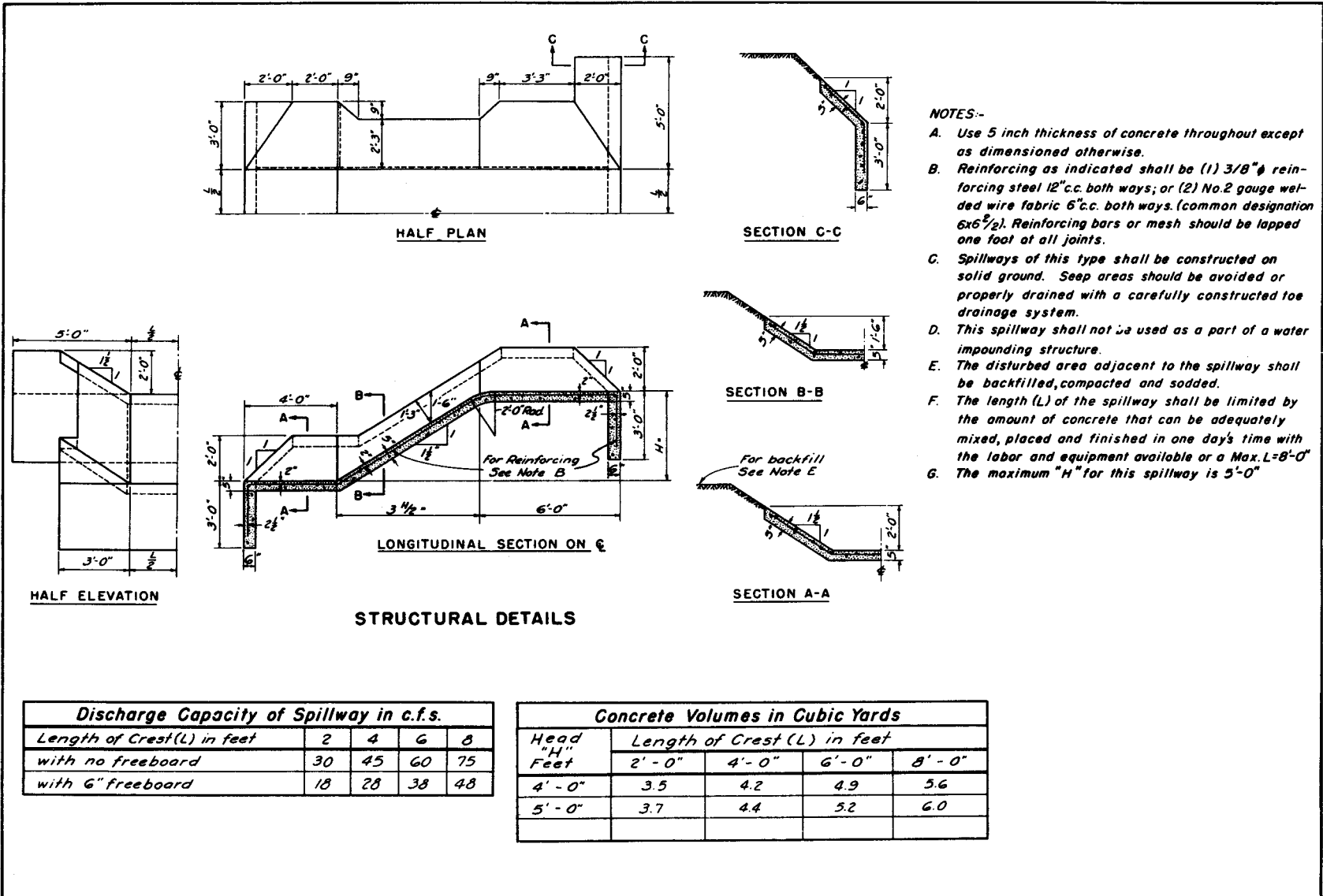
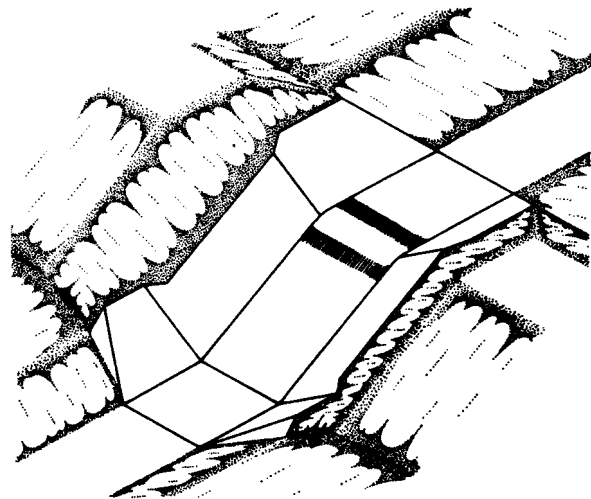
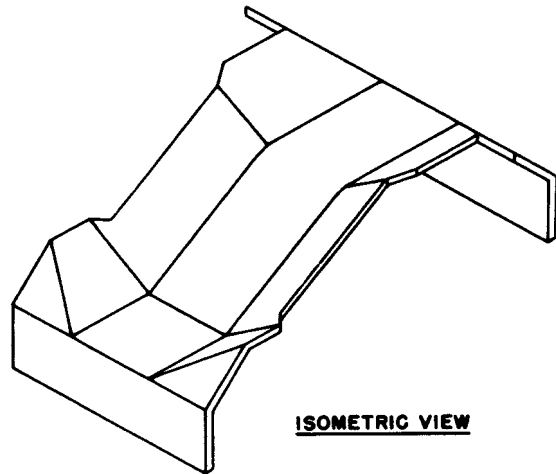


Figure 6-17 Typical standard plan for low head formless concrete chute

Sheet 2 of 2

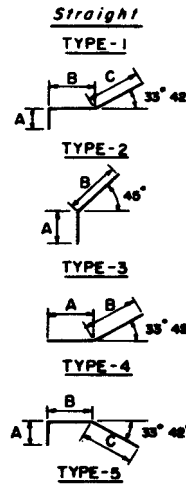


ISOMETRIC VIEW
SHOWING COMPLETED FILL



ISOMETRIC VIEW

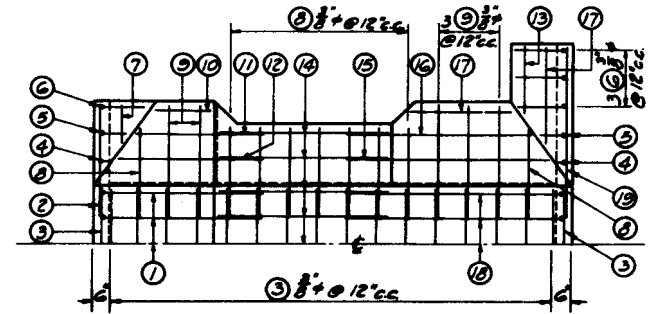
BAR TYPE DETAILS



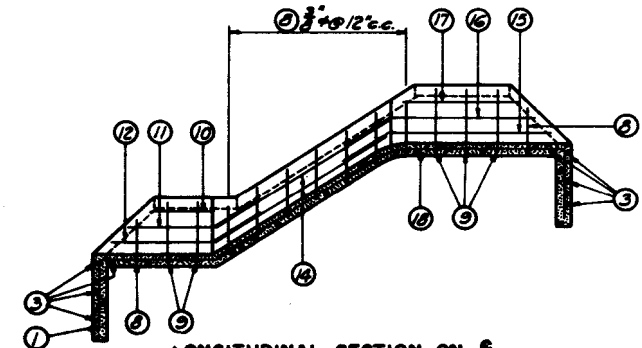
QUANTITIES

3/8" STEEL - FEET - POUNDS
VOLUME OF CONCRETE - CU. YDS.

STEEL SCHEDULE								
MARK	QUAN	SIZE	LENGTH	TYPE	A	B	C	TOTAL FT.
1		3/8" φ	7'-6"	2	2'-3"	4'-0"	1'-3"	
2	6	"	4'-0"	1	-	-	-	24'-0"
3	4	"	3'-0"	3	2'-3"	0'-9"	-	18'-0"
4	4	"	3'-0"	3	2'-3"	1'-9"	-	18'-0"
5	4	"	4'-3"	3	2'-3"	2'-0"	-	24'-0"
6	2	"	1'-3"	1	-	-	-	2'-6"
7	4	"	3'-3"	4	2'-3"	1'-0"	-	40'-0"
8	10	"	2'-0"	1	3'-0"	1'-0"	-	4'-0"
9	4	"	2'-0"	4	2'-3"	1'-3"	-	4'-0"
10	2	"	4'-6"	4	3'-3"	1'-3"	-	8'-0"
11	2	"	2'-3"	1	-	-	-	4'-6"
12	2	"	6'-0"	4	5'-0"	1'-0"	-	12'-0"
13	2	"	5'-6"	4	4'-6"	1'-0"	-	11'-0"
14	4	"	3'-6"	1	-	-	-	14'-0"
15	2	"	3'-6"	5	2'-3"	5'-9"	1'-6"	
16	2	"	2'-0"	1	-	-	-	24'-0"



HALF PLAN



LONGITUDINAL SECTION ON E-E

All Steel @ 12" o.c. UNLESS NOTED

11. SOD CHUTE SPILLWAY

DESCRIPTION

The sod chute is a steep, sodded section of a watercourse constructed to conduct the design flow through it at a safe velocity. (Figure 6-18) When water in a watercourse flows through a chute with a steeper grade, a change in flow takes place. A decrease in depth of flow occurs with an increase in velocity. Chute widths usually will be less than watercourse widths due to the increased velocity. Therefore, a transition section between the waterway and the chute is necessary to bring about an orderly change in velocity and channel widths. See Figure 6-19.

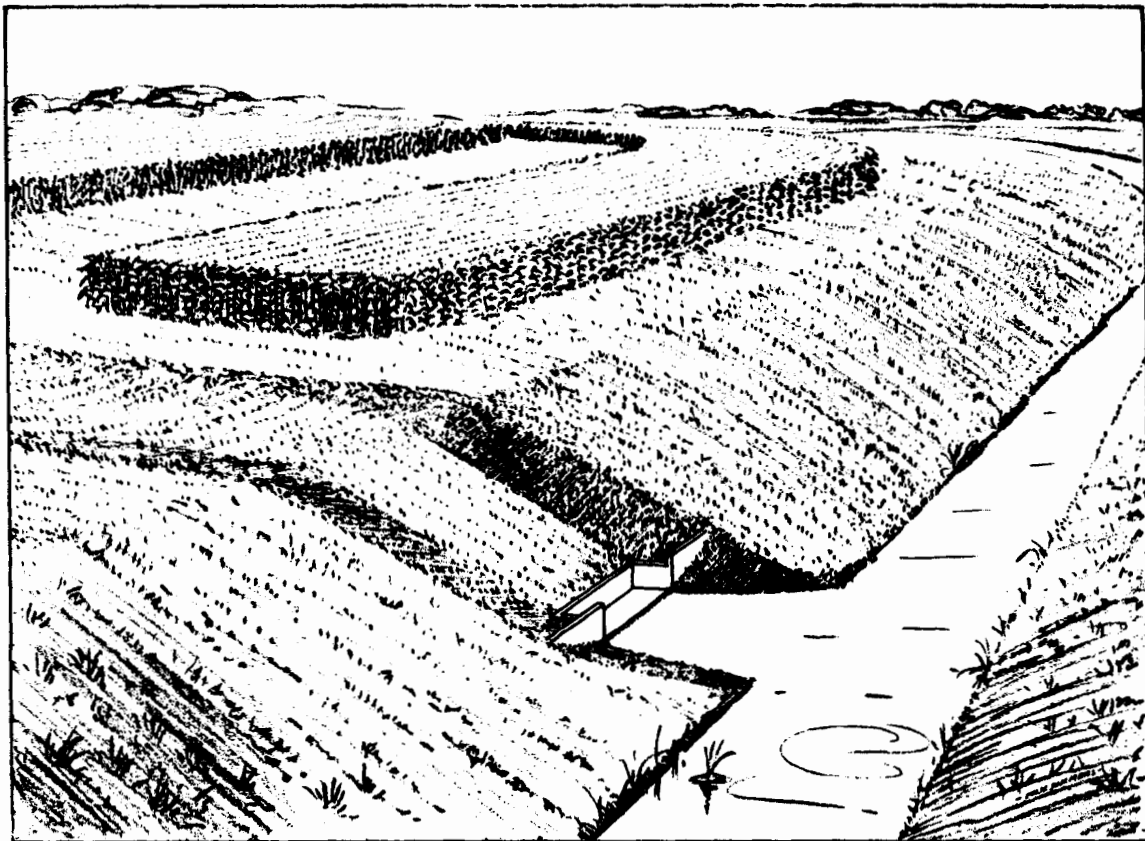


Figure 6-18 Sod chute with toe-wall drop spillway

MATERIALS

Required vegetation may be established by transplanting sod or, if the water can be diverted around the section for a sufficient time, it may be established by seeding.

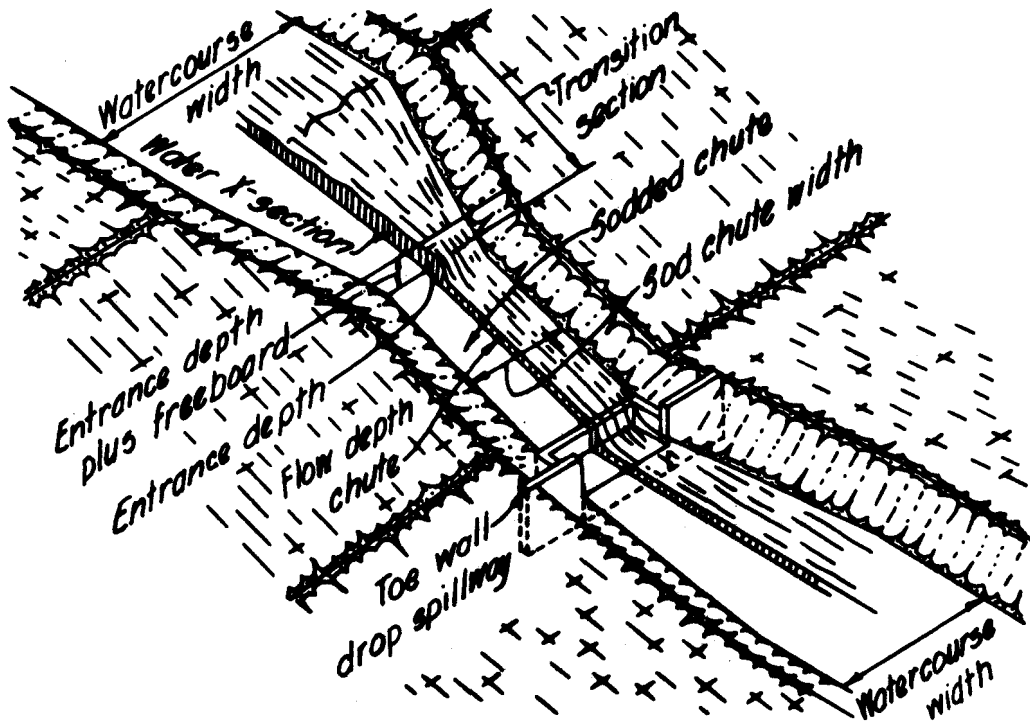


Figure 6-19 Nomenclature for sod chute design

FUNCTIONAL USE

1. To control overfalls or abrupt changes in the slope of a natural or constructed waterway.
2. At the lower end of a constructed channel, to conduct water over an overfall into a natural channel.
3. To conduct water from an adjacent flat area to the bottom of a ditch.

ADAPTABILITY

The sod chute is adapted to small watersheds and sites where good, dense sod can be developed and maintained. The watercourse below the chute must be stable. When the channel below the chute is narrow, or conditions at the lower end of the chute may not be favorable to establish and maintain vegetation, a toe wall drop spillway should be used. Unfavorable conditions include poor soil, rocky or wet conditions, or silting from adjacent ditches or streams. The toe wall drop spillway raises the end of the sod chute above these unfavorable conditions and permits the maintenance of a good sod. Refer to section on Straight Drop Spillways.

ADVANTAGES

Low material costs, and may be constructed with farm labor.

LIMITATIONS

The sod chute is limited to sites with good soil and where the velocity of flow in the chute is low enough to maintain the sod cover. This generally means small watersheds and low overfalls where there is no long, sustained flow. This type of structure is not adapted to areas where normal rainfall is inadequate for growing a good protective cover. Particular care must be taken in the design, layout, construction, and maintenance.

DESIGN

Design nomenclature is shown in Figure 6-19. Basically, the sod chute is designed the same as a vegetated waterway. However, since sod chutes are generally constructed by transplanting sod or protected by a diversion until seeding is established, the range of permissible velocities is higher than for watercourses where vegetation is established from seed without diverting the flow. Velocities of 6 feet per second are normally used when good quality sod is used or where water is diverted and a good vegetation can be established. Velocities of 7 to 8 feet per second should be used only on established sod of excellent quality on cohesive soil and where provisions are made for special maintenance.

The bottom slope of the sod chutes should not be steeper than 6:1; flatter slopes are better. The chute should be designed with a flat bottom.

Chute widths usually will be less than the watercourse width, with a tendency toward restriction of flow at the entrance. To overcome this, a transition section between the waterway and the entrance to the chute should be planned so that the width of the watercourse is gradually reduced to the required width of the chute. It is also necessary to provide for a definite depth of flow at the entrance of the chute in order to assure adequate entrance capacity. Sometimes dikes are required to provide the required depth. The sod chute design chart, Figure 6-20, gives the required entrance depth for the various bottom widths and depths of flow in the chute.

When adverse conditions mentioned under "Adaptability" are encountered, a toe wall drop inlet structure should be planned. Refer to the section on Straight Drop Spillways. Note toe wall structure in Figures 6-18 and 6-19.

CONSTRUCTION

These points should be followed to assure a properly constructed sod chute:

1. Do not build on fill material.
2. Fine grade by hand if necessary to assure a uniform flat bottom from side to side and leave surface in a condition similar to a seedbed.

SOD CHUTE — DIMENSION TABLE TRAPEZOIDAL CROSS SECTION

CHUTE SLOPE	2% SLOPE RATIO 50:1					4% SLOPE RATIO 25:1					6% SLOPE RATIO 16 1/4:1					8% SLOPE RATIO 12:1					10% SLOPE RATIO 10:1					14% SLOPE RATIO 7:1										
PERMISSIBLE VELOCITY, FT./SEC.	4	5	6	7	8	4	5	6	7	8	4	5	6	7	8	4	5	6	7	8	4	5	6	7	8	4	5	6	7	8						
CONDITION OF SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD	FAIR SOD	GOOD SOD	EXCELLENT SOD									
ENTRANCE DEPTH FT.	0.8	1.1	1.5	1.9	2.4	0.8	1.1	1.5	1.9	2.3	0.7	1.0	1.4	1.8	2.2	0.5	0.7	1.0	1.3	1.6	0.5	0.7	0.9	1.2	1.5	0.4	0.5	0.8	1.0	1.2						
CHUTE DEPTH FT.	0.6	0.8	1.0	1.2	1.4	0.5	0.7	0.9	1.1	1.3	0.4	0.6	0.8	1.0	1.2	0.3	0.4	0.5	0.7	0.9	0.2	0.3	0.4	0.6	0.7	0.2	0.3	0.3	0.4	0.5						
BOTTOM WIDTH OF CHUTE, FEET																																				
10																																				
15																																				
20																																				
25																																				
30																																				
35																																				
40	10																																			
45	12																																			
50	14																																			
60	18																																			
70	21	10																																		
80	25	11																																		
90	29	13																																		
100	33	15																																		
120	40	19	10																																	
140	48	24	11																																	
160	55	28	14																																	
180		33	16																																	
200		37	19																																	
220		41	22	10																																
240		45	25	12																																
260		50	27	14																																
280		54	30	16																																
300		58	33	18	10																															

REQUIRED CAPACITY
Q = C.F.S.

EXAMPLE

Given: Q = 90 c.f.s. Estimated runoff from watershed.
Height to control: 2.5 feet.
Try 8% slope of chute or 12:1. Chute length = 2.5 X 12 = 30 ft. (length is O.K. for site)
Good sod available and good soil.
Select velocity: 6 feet per second.



SOLUTION

In the left hand column under "REQUIRED CAPACITY" c.f.s. find "90" c.f.s. Follow this to right and under column "8%" slope and "6" ft. per second velocity find "31" feet bottom width. In same column on line "CHUTE DEPTH" find "0.5" foot. In same column on line "ENTRANCE DEPTH" find "1.0" foot.



CONSTRUCTION DIMENSIONS

Slope: 8% or 12:1 slope.
Bottom width: 31 feet.
Total depth: 1.0' (entrance depth) + 0.4' (freeboard) = 1.4 feet.
Chute depth: 0.5 feet. (Normal excavation and shaping will provide required depth plus additional depth for freeboard.)

NOTE: Minimum bottom width 10 feet.

BASIS OF DESIGN

$$v = \frac{1.486}{n} R^{2/3} S^{1/2} \quad n = 0.40$$

4:1 SIDE SLOPES

Figure 6-20 Sod chute design chart

3. Cut sod thin.
Lay sod in strips across the chute.
Start laying sod at the bottom.
Stagger joints of the sod strips.
Lay sod two feet up side slopes.
Fill any open joints with loose soil.
Tamp or roll all laid sod.
Sod should be pinned down in some manner. Wire (No. 9) staples, or chicken wire pegged down, are some successful methods used.
4. Protect from livestock during critical seasons.
Mowing or controlled grazing is a necessity for maintenance.

12. DROP INLET SPILLWAYS

DESCRIPTION

A drop inlet spillway is a closed conduit generally designed to carry water under pressure from above an embankment to a lower elevation. An earthen embankment is required to direct the discharge through the spillway. Thus, the usual function of a drop inlet spillway is to convey a portion of the runoff through or under an embankment without erosion. Vegetated or earth spillways around one or both ends of the embankment should always be used in conjunction with drop inlet spillways. (Figure 6-21)

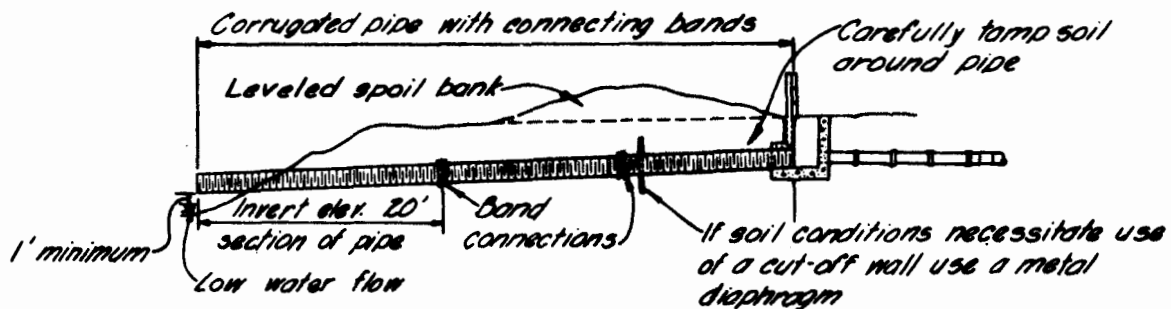
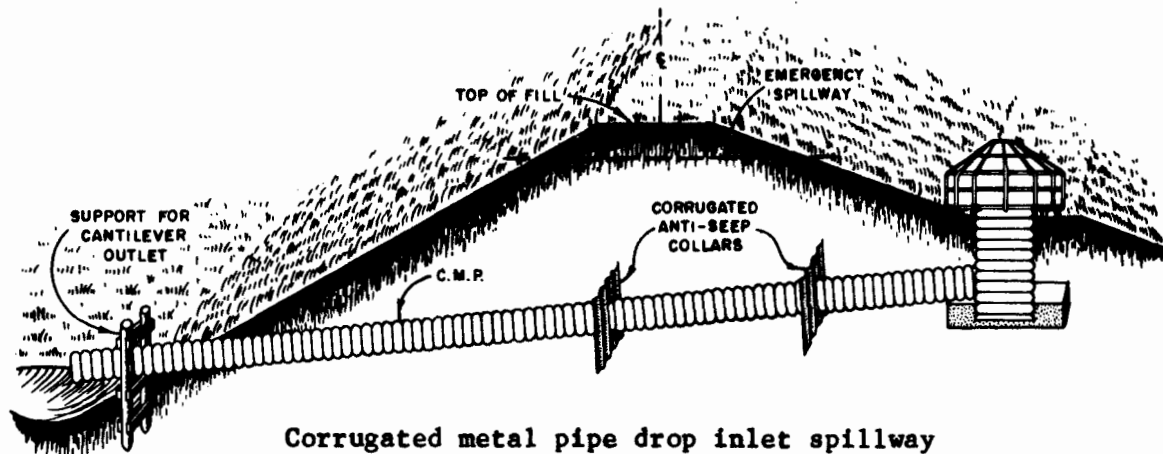


Figure 6-21 Examples of drop inlet spillways

MATERIALS

The riser of a drop inlet spillway may be of plain concrete, reinforced concrete, concrete blocks, or pipe. The barrel may be of reinforced concrete, concrete or clay tile, or corrugated or smooth metal pipe having watertight joints.

FUNCTIONAL USES

1. Principal spillways for farm ponds or reservoirs.
2. Grade stabilization.
3. At lower end of water disposal system.
4. Principal spillways for debris basins.
5. Roadway structures.
6. Flood prevention structures.
7. Surface water inlet for drainage or irrigation.

ADAPTABILITY

It is a very efficient structure for controlling relatively high gully heads, usually above 10 feet. It is well adapted to sites providing an appreciable amount of temporary storage above the inlet. It may also be used in connection with relatively low heads, as in the case of a drop inlet on a road culvert, or in passing surface water through a spoil bank along a drainage ditch.

ADVANTAGES

For high heads, it requires less material than a drop spillway. Where an appreciable amount of temporary storage is available, the capacity of the spillway can be materially reduced. Besides effecting a reduction in cost, this reduction of discharge results in a lower peak channel flow below, and can be a favorable factor in downstream channel grade stabilization and flood prevention.

LIMITATIONS

Small drop inlets are subject to stoppage by debris. It is limited to locations where satisfactory earth embankments can be constructed.

CLASSIFICATION

Drop inlet spillways are classified according to material into two general types: pipe drop inlets constructed of some type of pipe; and the monolithic box-type of reinforced concrete.

PIPE DROP INLET DESIGN

Pipe drop inlets usually are confined to smaller jobs where:

1. The value of the improvement may not justify the use and cost of monolithic reinforced concrete.

2. Where considerable storage is available in proportion to the size of the watershed.
3. Where the useful life of the project is limited.

Large size pipe drop inlets require the services of an engineer. The smaller sizes generally used in farm ponds can often be designed by the Work Unit staff when standard plans are available.

When corrugated or helical metal pipe is planned, only the heavier weight should be used, following the more conservative recommendations of culvert pipe manufacturers. A coating of bituminous material will extend the effective life of this type of pipe. All joints should be provided with watertight metal bands caulked or otherwise sealed against leakage, and antiseep collars used to prevent seepage along the pipe. Sheet metal antiseep collars, or diaphragms, furnished by culvert pipe manufacturers, have a watertight connection to the outside of the pipe. This type of collar is superior to concrete collars for metal pipe because distortion of the pipe from loading may crack the concrete collar or rupture the pipe; whereas a metal antiseep collar will adjust and remain intact.

Typical appurtenances for corrugated metal (C.M.) pipe drop inlets are shown in Figure 6-22 - sheets 1, 2 and 3. When pipe drop inlets are used as spillways for storage reservoirs where the water must be released downstream, such as irrigation reservoirs, some type of release facility must be provided. Figure 6-23, sheets 1 and 2, shows typical details for release by an inclined gate structure.

Figure 6-24 can be used to determine capacity of 8- and 12-inch C.M. pipe drop inlets, as well as the height of riser required to provide the capacities shown. Pipe capacities for larger corrugated metal pipe are given in Figure 6-25 and for concrete pipe in Figure 6-26 based on required inlet conditions for pipe flow. The required inlet condition can be determined from Figure 6-27.

Reinforced concrete culvert pipe or water pipe will make a more satisfactory pipe drop inlet than corrugated metal, particularly for embankment heights greater than 20 feet, or where long service life is desired. Concrete pipe must be properly cradled and bedded. All joints must be watertight.

The design of a drop inlet spillway cannot be made independently of the design of the earth embankment, emergency spillway, and other elements of the total structure.

The design should provide for sufficient temporary storage between the crest of the inlet and the emergency spillway to permit a drop inlet spillway of reasonable size and cost. The size of the drop inlet spillway depends largely on the amount of this temporary storage. Tailwater will influence the layout of the spillway outlet and the amount of hydraulic head available to produce discharge through the spillway. Therefore, it must be determined accurately for each location.

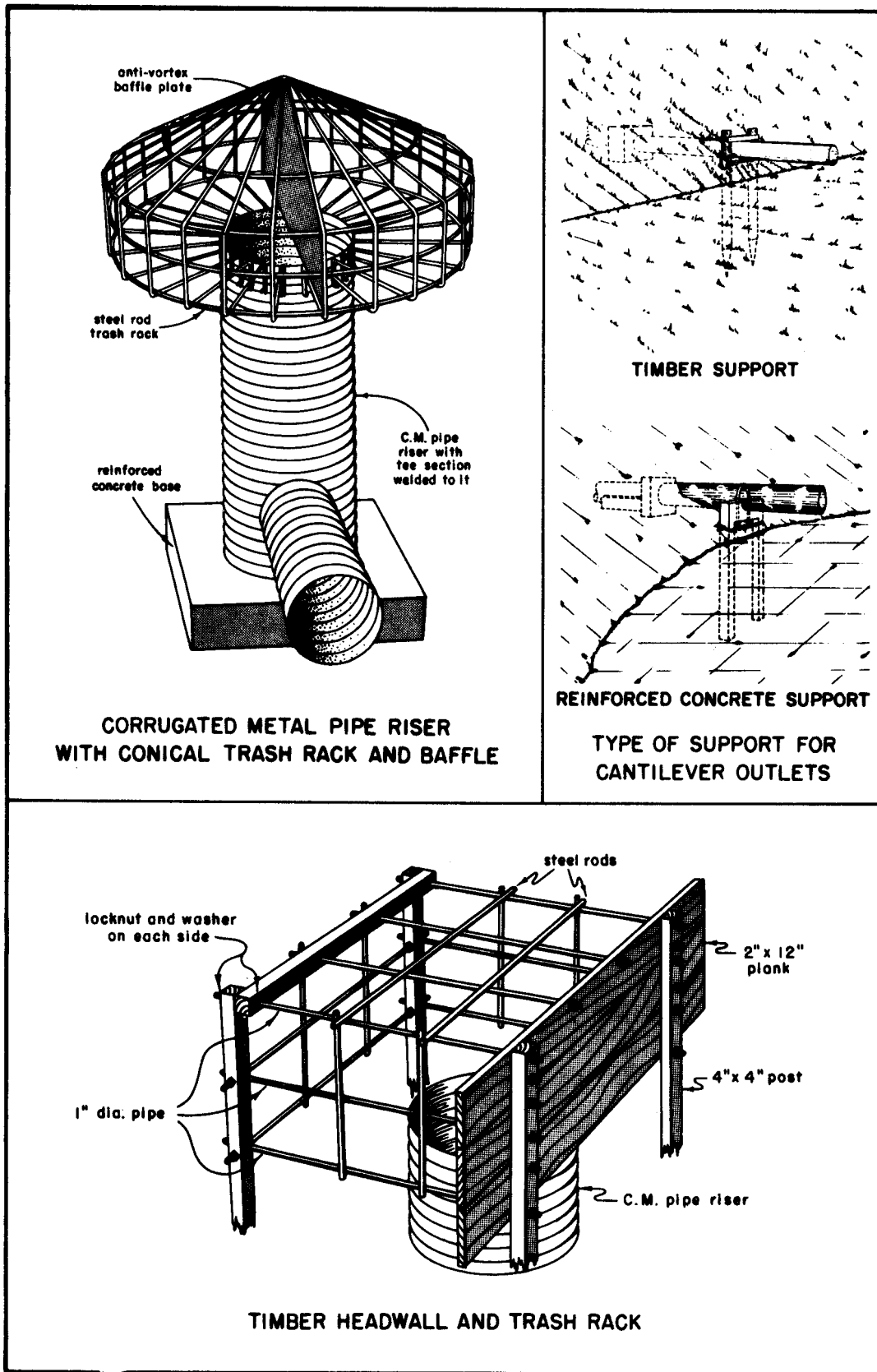


Figure 6-22 Appurtenance for metal pipe drop inlets

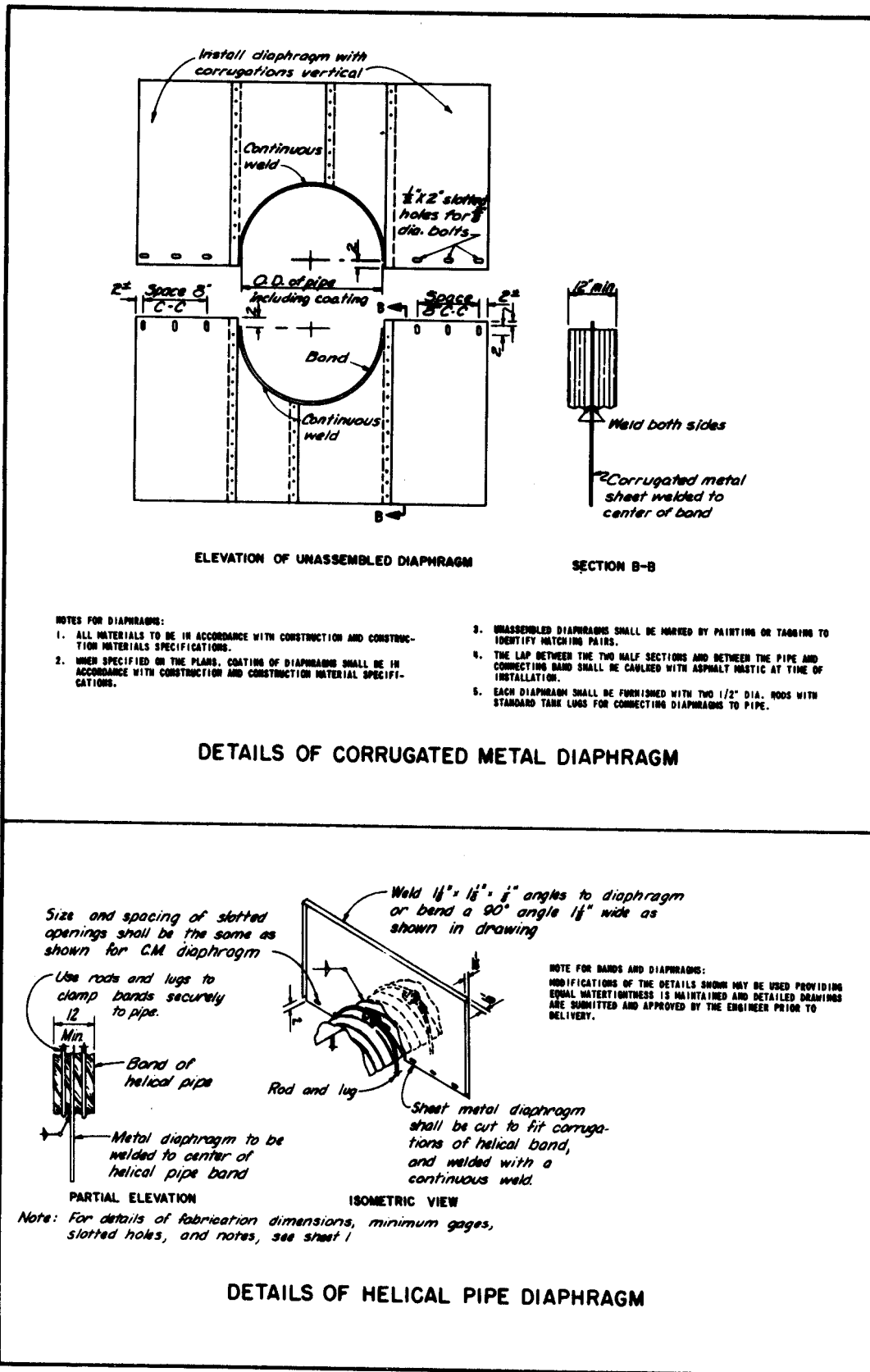


Figure 6-22 Appurtenances for metal pipe drop inlets (sheet 2 of 3)

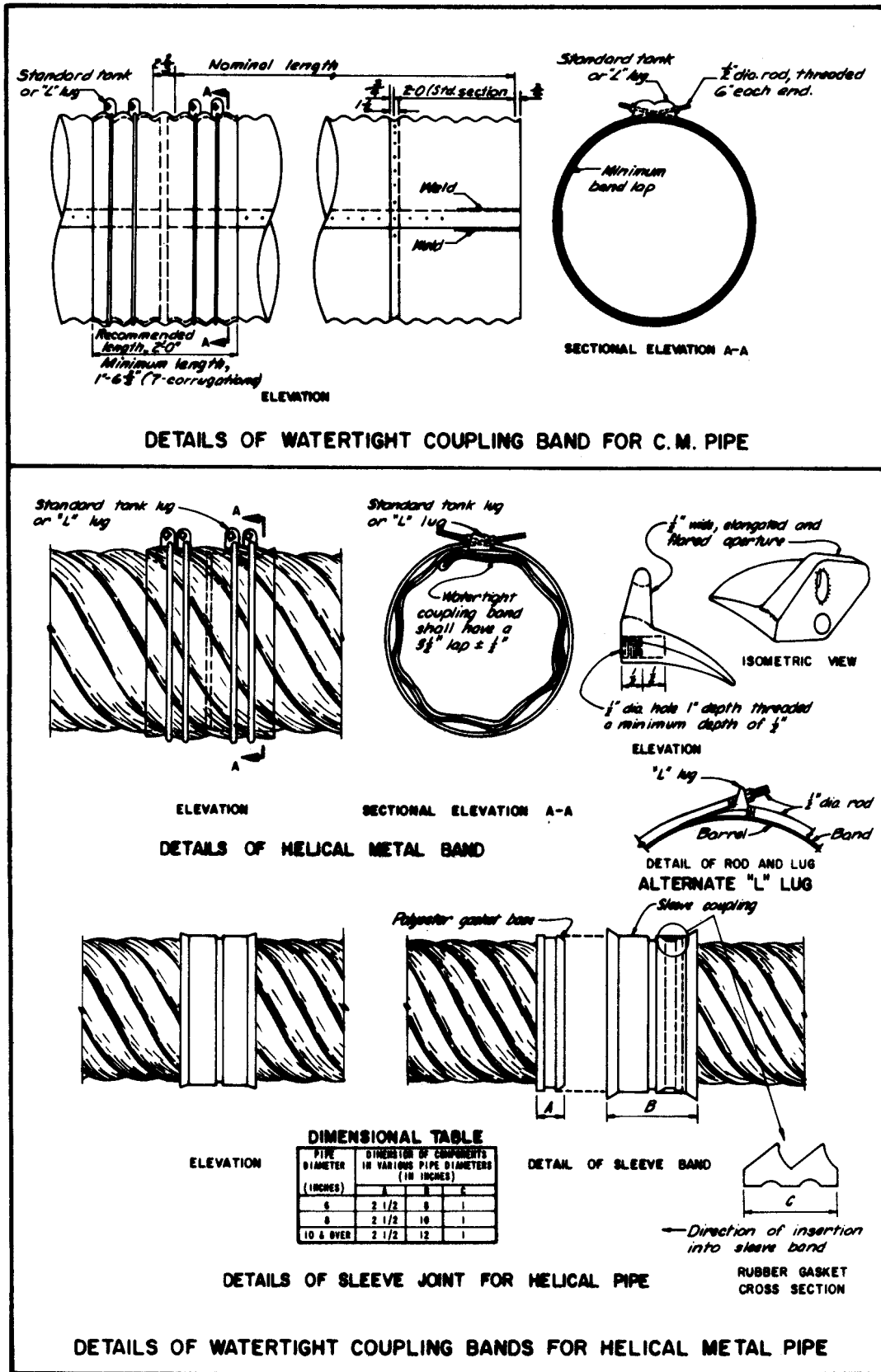


Figure 6-22 Appurtenances for metal pipe drop inlets

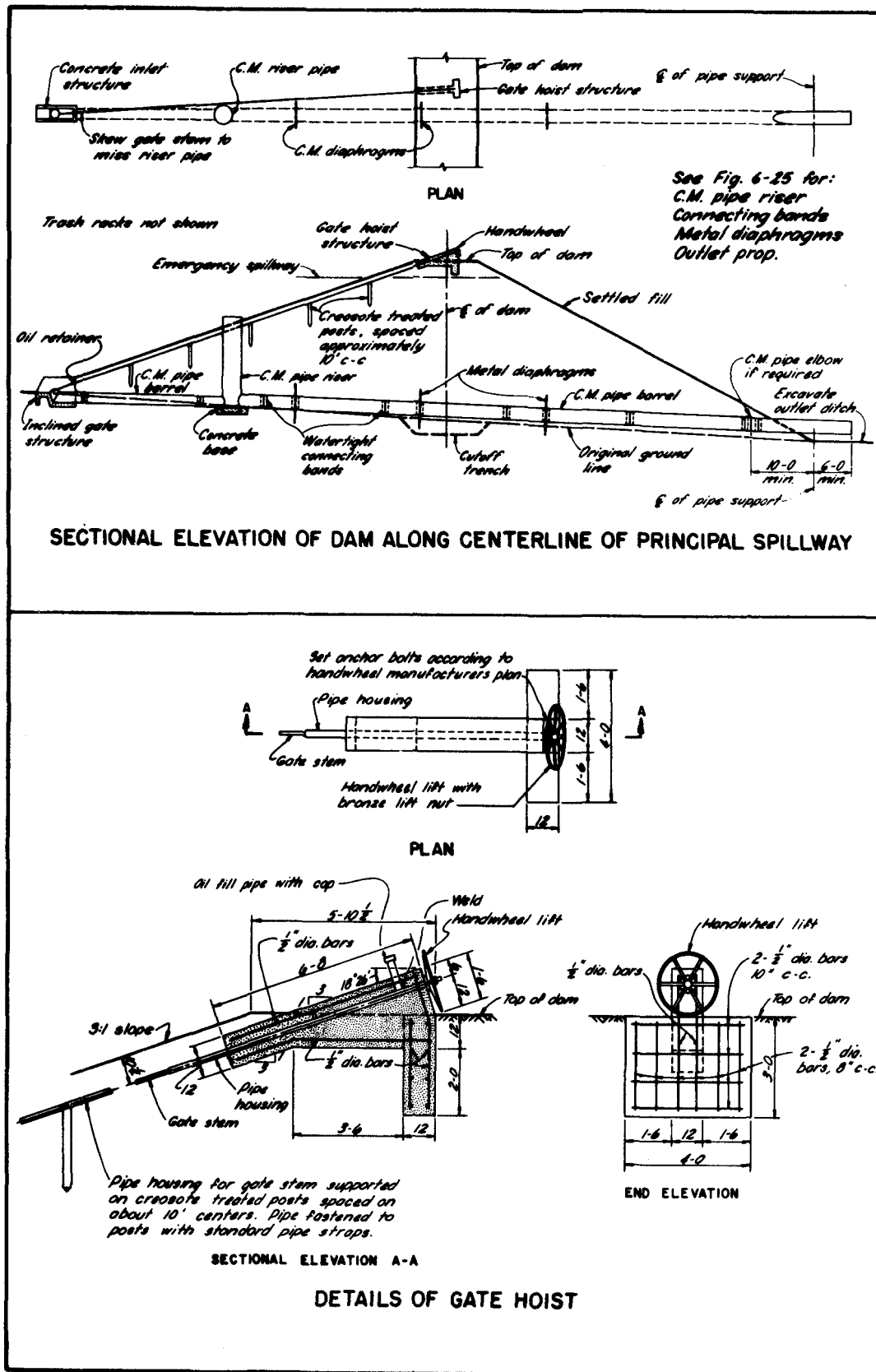


Figure 6-23 Typical appurtenances for pipe spillways with inclined gate release structure

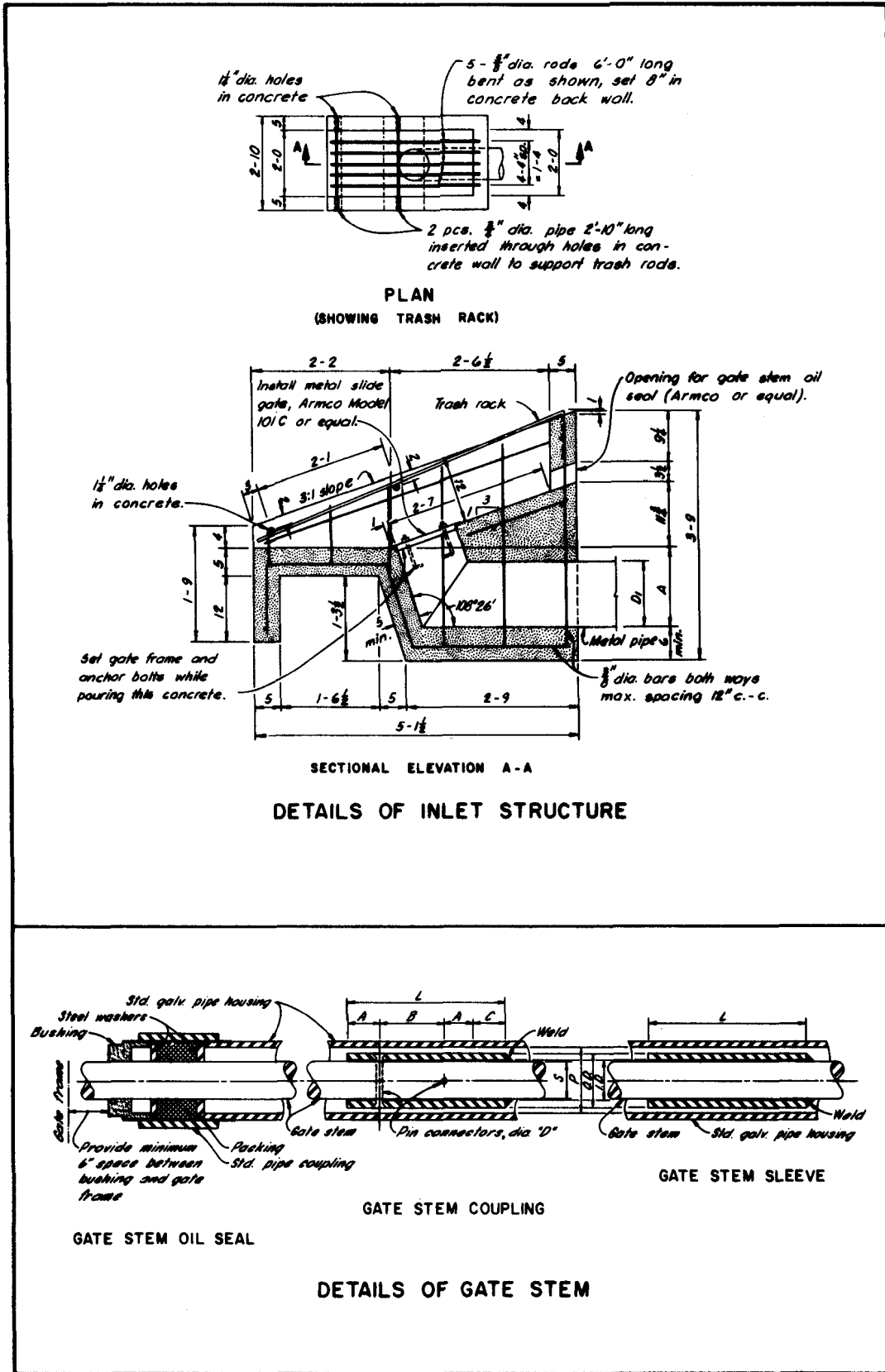
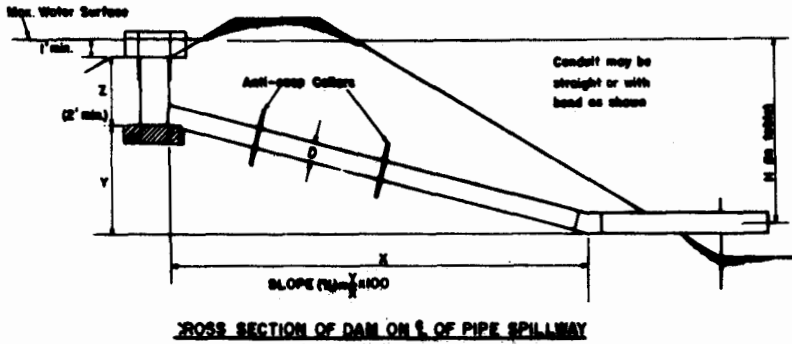


Figure 6-23 Typical appurtenances for pipe spillway with inclined gate release structure



CROSS SECTION OF DAM ON 1/2 OF PIPE SPILLWAY

Height of Dam

1. Enter Table No. 1 with the planned conduit slope. (See view above and use next largest whole number for entering table.)
2. From Table No. 1 obtain value for discharge (Q) for planned conduit size.
3. If Q obtained from Table No. 1 is:
 - (a) greater than Q shown in Table No. 2 (for the design head, conduit length and conduit size), a riser height (H) of 10' is required to provide full pipe flow.
 - (b) equal to or less than that Q shown in Table No. 2 a riser height (H) less than 10' can be used. (Minimum height = 2.0').

Slope K	Discharge (Q) cfs	
	8" Pipe	12" Pipe
5	1.4	4.1
6	1.5	4.5
7	1.7	4.9
8	1.8	5.2
9	1.9	5.5
10	2.0	5.8
11	2.1	6.1
12	2.2	6.4
13	2.3	6.6
14	2.4	6.9
15	2.4	7.1
16	2.5	7.3
17	2.6	7.6
18	2.7	7.8
19	2.7	8.0
20	2.8	8.2
21	2.9	8.4
22	2.9	8.6
23	3.0	8.8
24	3.1	9.0
25	3.1	9.2
26	3.2	9.3
27	3.3	9.5
28	3.3	9.7
29	3.4	9.9
30	3.4	10.1

Head H Feet	CAPACITY TABLE FOR PIPE INLETS					
	8" Conduit-18" Riser			12" Conduit-18" Riser		
	For Pipe Lengths of:			For Pipe Lengths of:		
	50'	70'	90'	50'	70'	90'
5	1.8	1.6	1.4	5.0	4.4	4.0
6	2.0	1.7	1.5	5.5	4.9	4.4
7	2.1	1.9	1.7	6.0	5.3	4.7
8	2.3	2.0	1.8	6.4	5.6	5.1
9	2.4	2.1	1.9	6.8	6.0	5.4
10	2.6	2.2	2.0	7.1	6.3	5.7
11	2.7	2.3	2.1	7.5	6.6	6.0
12	2.8	2.4	2.2	7.8	6.9	6.2
13	2.9	2.5	2.3	8.1	7.2	6.4
14	3.0	2.6	2.3	8.4	7.4	6.7
15	3.1	2.7	2.4	8.7	7.7	6.9
16	3.2	2.8	2.5	9.0	7.9	7.2
17	3.3	2.9	2.6	9.3	8.2	7.4
18	3.4	3.0	2.7	9.6	8.4	7.6
19	3.5	3.1	2.7	9.8	8.7	7.8
20	3.6	3.1	2.8	10.1	8.9	8.0

Figure 6-24 Capacity chart for 8" and 12" C.M. pipe drop inlet spillway

PIPE FLOW CHART (Full flow assumed)

For Corrugated Metal Pipe Inlet $K_a + K_b = 1.0$ and 70 feet of Corrugated Metal Pipe Conduit $n = 0.025$. Note correction factors for other pipe lengths.

Dia. H	12"	15"	18"	21"	24"	30"	36"	42"
2	2.84	4.92	7.73	11.30	15.60	26.60	40.77	58.12
3	3.48	6.03	9.47	13.84	19.10	32.58	49.93	71.19
4	4.02	6.96	10.94	15.98	22.06	37.62	57.66	82.20
5	4.49	7.78	12.23	17.87	24.66	42.06	64.46	91.90
6	4.92	8.52	13.40	19.57	27.01	46.07	70.60	100.65
7	5.32	9.21	14.47	21.14	29.19	49.77	76.28	108.75
8	5.68	9.84	15.47	22.60	31.19	53.19	81.53	116.23
9	6.03	10.44	16.41	23.97	33.09	56.43	86.49	123.30
10	6.36	11.00	17.30	25.26	34.88	59.48	91.16	129.96
11	6.67	11.54	18.14	26.50	36.59	62.39	95.63	136.33
12	6.96	12.05	18.95	27.68	38.21	65.16	99.87	142.37
13	7.25	12.55	19.72	28.81	39.77	67.83	103.96	148.21
14	7.52	13.02	20.47	29.90	41.27	70.39	107.88	153.80
15	7.78	13.48	21.19	30.95	42.72	72.85	111.66	159.18
16	8.04	13.92	21.88	31.96	44.12	75.24	115.32	164.40
17	8.29	14.35	22.55	32.94	45.48	77.55	118.87	169.46
18	8.53	14.77	23.21	33.90	46.80	79.81	122.33	174.39
19	8.76	15.17	23.84	34.83	48.08	81.99	125.67	179.15
20	8.99	15.56	24.46	35.73	49.33	84.12	128.93	183.80
21	9.21	15.95	25.07	36.62	50.55	86.21	132.13	188.36
22	9.43	16.32	25.65	37.47	51.73	88.22	135.21	192.76
23	9.64	16.69	26.23	38.32	52.90	90.21	138.27	197.12
24	9.85	17.05	26.80	39.14	54.04	92.15	141.24	201.35
25	10.05	17.40	27.35	39.95	55.15	94.05	144.15	205.50
L	Correction Factors For Other Pipe Lengths							
40	1.23	1.22	1.20	1.19	1.16	1.14	1.13	1.11
50	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07
60	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97
90	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94
100	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.92

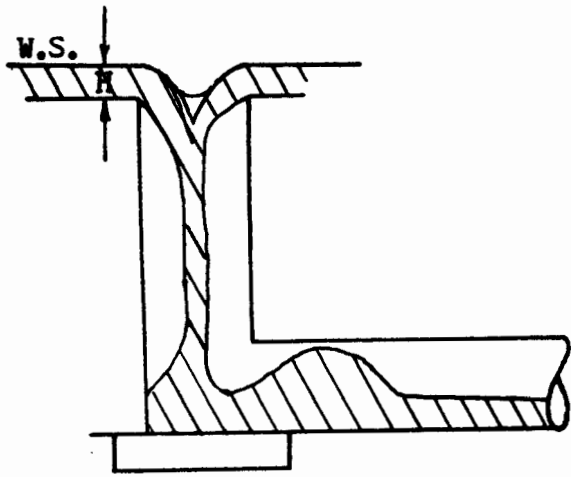
Figure 6-25 Pipe flow chart for corrugated metal pipe drop inlet spillway

PIPE FLOW CHART (Full Pipe flow assumed)

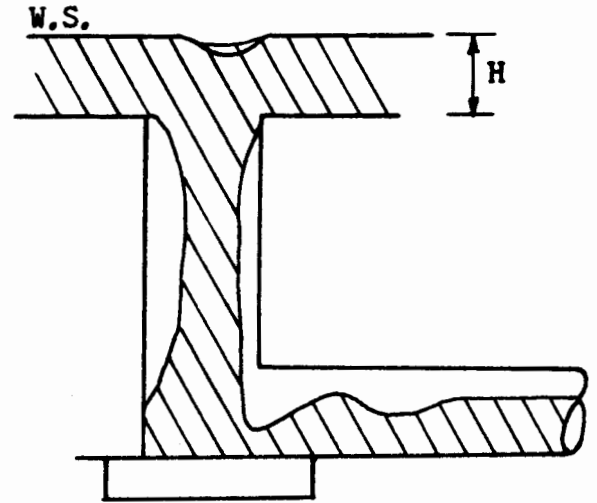
For R/C Drop Inlet, $K_e + K_b = 0.65$ with 70 feet of R/C conduit, $n = .013$. Note correction factors for other pipe lengths.

Dia. H	12"	15"	18"	21"	24"	30"	36"	42"
2	4.54	8.01	11.74	16.60	22.44	36.74	54.65	76.02
3	5.56	9.81	14.39	20.33	27.49	45.00	66.94	93.11
4	6.42	11.33	16.61	23.48	31.74	51.96	77.30	107.52
5	7.18	12.66	18.57	26.25	35.49	58.09	86.42	120.21
6	7.87	13.86	20.34	28.75	38.87	63.63	94.65	131.66
7	8.50	14.98	21.98	31.06	41.99	68.74	102.27	142.25
8	9.08	16.01	23.49	33.20	44.88	73.47	109.30	152.03
9	9.64	17.00	24.92	35.22	47.61	77.94	115.95	161.28
10	10.16	17.91	26.26	37.12	50.18	82.15	122.21	169.99
11	10.65	18.78	27.55	38.94	52.64	86.18	128.20	178.32
12	11.13	19.62	28.77	40.67	54.97	89.99	133.88	186.22
13	11.58	20.42	29.95	42.33	57.23	93.68	139.37	193.86
14	12.01	21.18	31.07	43.93	59.37	97.19	144.59	201.12
15	12.44	21.93	32.17	45.47	61.46	100.62	149.69	208.21
16	12.85	22.65	33.22	46.96	63.48	103.92	154.60	215.04
17	13.24	23.35	34.24	48.40	65.43	107.12	159.35	221.65
18	13.63	24.03	35.24	49.81	67.34	110.23	163.99	228.10
19	14.00	24.68	36.21	51.17	69.18	113.25	168.48	234.34
20	14.36	25.32	37.14	52.50	70.97	116.18	172.84	240.41
21	14.72	25.95	38.07	53.80	72.73	119.07	177.13	246.38
22	15.06	26.56	38.96	55.06	74.43	121.85	181.27	252.13
23	15.40	27.16	39.84	56.31	76.11	124.60	185.36	257.83
24	15.73	27.74	40.69	57.51	77.75	127.28	189.35	263.37
25	16.06	28.32	41.53	58.70	79.35	129.90	193.25	268.80
L	Correction Factors For Other Pipe Lengths							
40	1.15	1.13	1.11	1.09	1.08	1.06	1.06	1.05
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03
60	1.04	1.04	1.04	1.03	1.03	1.02	1.02	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.96	0.96	0.97	0.97	0.98	0.98	0.98	0.99
90	0.93	0.94	0.94	0.95	0.95	0.96	0.97	0.97
100	0.90	0.91	0.92	0.93	0.93	0.95	0.95	0.96

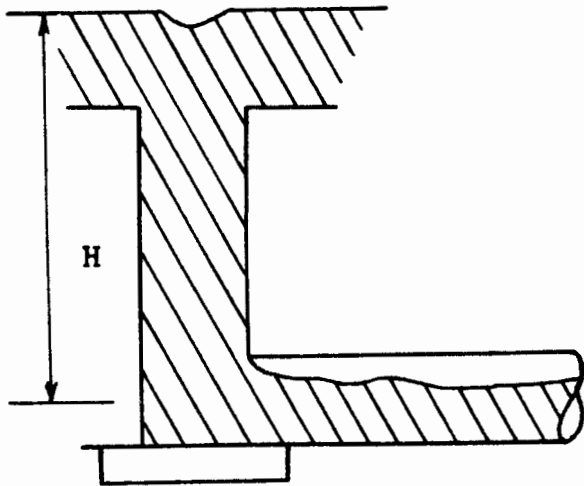
Figure 6-26 Pipe flow chart for concrete pipe drop inlet spillway



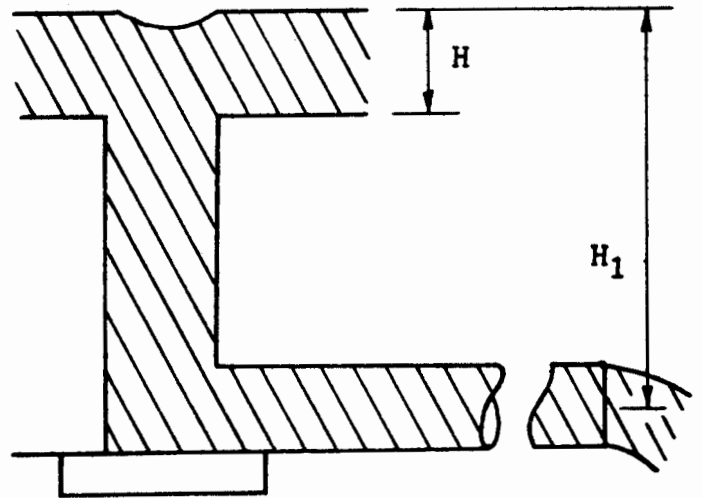
Weir Control at Entrance



Orifice Control at Entrance of Conduit



Orifice Control at Entrance of Barrel or Short Tube Control



Full Pipe Flow

Figure 6-27 Chart for determining inlet proportions and required head over inlet

**HEAD DISCHARGE TABLE FOR CORRUGATED METAL PIPE
DROP INLETS
(WEIR FLOW CONDITION)**

Riser Diameter Inches	Head in Feet													
	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	
15	2.7	3.8	4.9	6.3	ORIFICE									
18	3.2	4.5	5.9	7.6	9.3	10.9	FLOW							
21	3.8	5.3	7.0	8.8	10.7	12.8	15.0	CONDITIONS						
24	4.3	6.0	7.9	10.1	12.3	14.6	17.1	19.7	22.4	CONTROL				
30	5.4	7.5	9.8	12.6	15.4	18.2	21.4	24.6	28.0	31.7	35.5			
36	6.4	9.0	11.8	15.1	18.5	21.8	25.7	29.5	33.6	38.0	42.6	47.2	51.9	
42	7.5	10.5	13.8	17.7	21.6	25.5	30.0	34.5	39.3	44.4	49.8	55.1	60.5	
48	8.6	12.0	15.7	20.2	24.6	29.1	34.2	39.4	44.8	50.7	56.8	63.0	69.1	
54	9.6	13.5	17.7	22.7	27.7	32.8	38.5	44.3	50.5	57.0	64.0	70.9	77.8	
60	10.7	15.0	19.7	25.2	30.8	36.4	42.8	49.2	56.1	63.3	71.0	78.7	86.4	

Riser Diameter Inches	Head in Feet									
	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	
42	66.5	72.5	ORIFICE FLOW							
48	76.0	82.8	89.7	96.9	104.1	CONDITIONS CONTROL				
54	85.5	93.2	100.9	109.0	117.1	125.6	134.5	143.3		
60	95.0	103.6	112.1	121.1	130.1	139.5	149.3	159.2	169.0	

NOTES: (1) The discharge capacities shown in this table are based on the formula:

$$Q_2 = C_2 L H_2^{3/2}$$

Q_2 = discharge capacity of weir, in c.f.s.

C_2 = weir coefficient = 3.33

L = length of weir crest, in feet (for circular riser with headwall, $L = 2.57$ times diameter of riser).

H_2 = distance from crest of riser to water surface in reservoir, in feet.

(2) The diameter of the riser should be at least $1\frac{1}{2}$ times the diameter of barrel.

(3) Use this table in conjunction with orifice flow and full pipe flow conditions to determine capacity of the drop inlet.

Figure 6-27 Chart for determining inlet proportions and required head over inlet

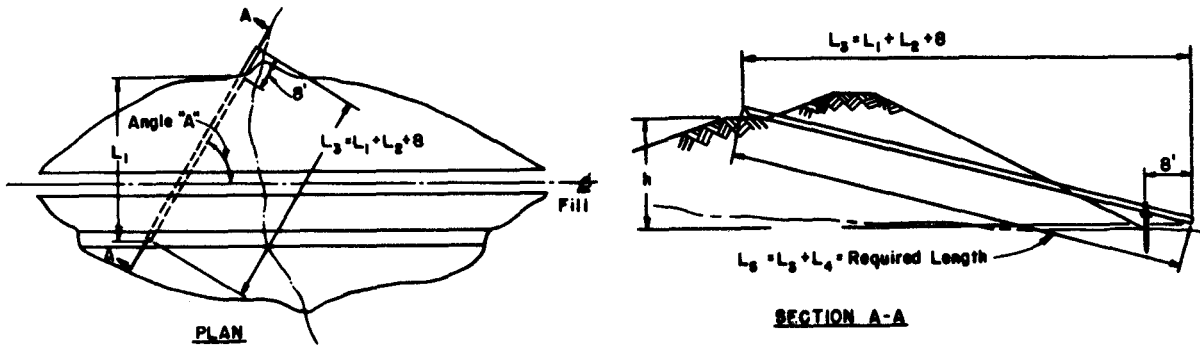
HEAD DISCHARGE TABLE FOR CORRUGATED METAL PIPE
DROP INLETS
(Orifice Control Conditions at Crest of Riser or Entrance to Barrel)

Dia. Inches	Head in Feet																
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
12	4.1	5.0	5.8	6.3	7.1	7.7	8.2	8.7	9.1	9.6	10.0	10.4	10.8	11.2	11.6	11.9	12.3
15	6.7	8.2	9.5	10.6	11.6	12.6	13.4	14.3	15.0	15.8	16.5	17.1	17.8	18.4	19.0	19.6	20.2
18	10.1	12.3	14.3	16.0	17.5	18.9	20.2	21.4	22.5	23.6	24.7	25.7	26.7	27.6	28.5	29.4	30.2
21	13.8	17.0	19.6	21.9	24.0	25.9	27.7	29.4	31.0	32.5	33.9	35.3	36.6	37.9	39.2	40.4	41.6
24	Weir Flow Controls	22.5	26.1	29.2	32.0	34.5	36.8	39.0	41.1	43.1	45.0	46.9	48.6	50.3	52.0	53.6	55.1
30		35.2	40.8	45.4	49.9	53.8	57.5	61.0	64.3	67.4	70.4	73.3	76.1	78.7	81.3	83.8	86.2
36		58.7	65.7	71.9	77.8	82.9	87.9	92.7	97.2	101.5	105.7	109.7	113.5	117.2	120.8	124.4	
42		79.8	88.2	97.7	105.5	112.6	119.5	125.9	132.1	137.9	143.6	149.0	154.2	159.3	164.2	169.0	
48		115.0	125.5	136.0	145.2	154.0	162.3	170.2	177.8	185.0	192.1	198.7	205.3	211.6	217.8		

6-43b

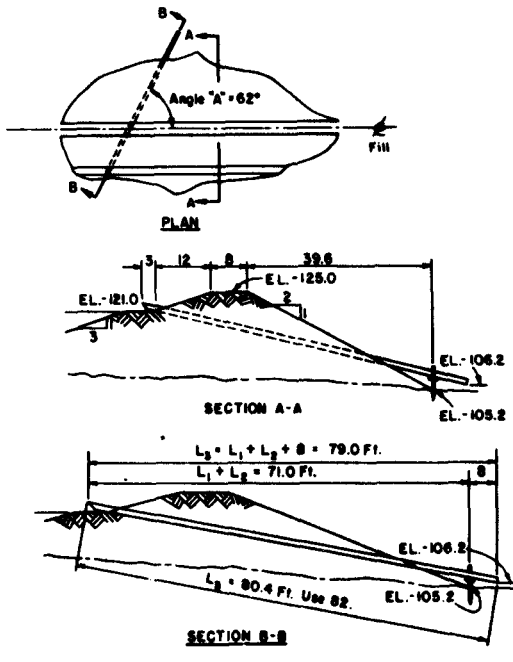
Figure 6-27 Chart for determining inlet proportions and required head over inlet

In many instances, particularly with small pipe drop inlets, the conduit is placed at an angle with the dam to obtain better downstream alignment, to provide a location on undisturbed ground, or to reduce the height of the riser. Figure 6-28 gives a procedure for determining the length of conduits placed at an angle.



- Step 1. From field survey determine L_1 in feet and Angle "A" in degrees.
2. Enter Table I with L_1 and Angle "A" to find L_2 , the increase in length due to the skew angle.
3. $L_1 + L_2 + 8 \text{ feet} = L_3$
4. Determine "h", the total fall in the pipe (in feet).
5. Enter Table II with L_3 and h to find L_4 , the increase in length due to slope.
6. $L_3 + L_4 = L_5$, which is the required length of pipe in feet. Round off to next higher even value.

SAMPLE PROBLEM



Step 1. From Section A-A, determine $L_1 = 3 + 12 + 8 = 39.6$
 $= 62.6 \text{ Ft.}$
 Angle "A" = 62°

Step 2. Enter Table I with 62.6 Ft. and 62°
 Interpolate to determine L_2

L_1 \ θ	60°	62°	63°
$62'$	9.6		6.4
62.6	9.7	8.4	6.5
$64'$	9.9		6.6

$L_2 = 8.4 \text{ Ft.}$ - Increase in length due to the skew angle.

Step 3. Add $L_1 + L_2 + 8 = L_3$
 $L_3 = 62.6 + 8.4 + 8 = 79.0 \text{ Ft.}$

Step 4. Total fall in pipe: $h = 121.0 - 106.2 = 14.8 \text{ Ft.}$

Step 5. Enter Table II with $h = 14.8$ and $L_3 = 79.0$
 Interpolate to determine L_4 :

L_3 \ h	14	14.8	16
78	1.2		1.6
79	1.2	1.4	1.6
80	1.2		1.6

$L_4 = 1.4 \text{ Ft.}$ - Increase in length due to slope.

Step 6. Add $L_3 + L_4 = L_5$
 $L_5 = 79.0 + 1.4 = 80.4$

Round off to next higher even Ft. Final length = **82 feet**

Figure 6-28 Procedure for determining length of conduit

TABLE II: VALUES OF L₄
(INCREASE IN LENGTH DUE TO SLOPE)

L ₃ Feet	Values of L ₄											
	h - Feet											
	4	6	8	10	12	14	16	18	20	22	24	26
40	0.2	0.5	0.8	1.2	1.8	2.4	3.1	3.9	4.7			
42	0.2	0.4	0.8	1.2	1.7	2.3	2.9	3.7	4.5			
44	0.2	0.4	0.7	1.1	1.6	2.2	2.8	3.5	4.3			
46	0.2	0.4	0.7	1.1	1.5	2.1	2.7	3.4	4.2	5.0		
48	0.2	0.4	0.7	1.0	1.5	2.0	2.6	3.3	4.0	4.8	5.7	
50	0.2	0.4	0.6	1.0	1.4	1.9	2.5	3.1	3.9	4.6	5.5	
52	0.2	0.3	0.6	1.0	1.4	1.9	2.4	3.0	3.7	4.5	5.3	6.1
54	0.1	0.3	0.6	0.9	1.3	1.8	2.3	2.9	3.6	4.3	5.1	5.9
56	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.5	4.2	4.9	5.7
58	0.1	0.3	0.5	0.9	1.2	1.7	2.2	2.7	3.4	4.0	4.8	5.6
60	0.1	0.3	0.5	0.8	1.2	1.6	2.1	2.6	3.2	3.9	4.6	5.4
62	0.1	0.3	0.5	0.8	1.2	1.6	2.0	2.6	3.1	3.8	4.5	5.3
64	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1	3.7	4.4	5.1
66	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	3.0	3.6	4.2	4.9
68	0.1	0.3	0.5	0.7	1.1	1.4	1.9	2.3	2.9	3.5	4.1	4.8
70	0.1	0.3	0.5	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.0	4.7
72	0.1	0.2	0.4	0.7	1.0	1.3	1.8	2.2	2.7	3.3	3.9	4.6
74	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.2	2.7	3.2	3.8	4.4
76	0.1	0.2	0.4	0.6	0.9	1.3	1.7	2.1	2.6	3.1	3.7	4.3
78	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.1	2.5	3.0	3.6	4.2
80	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.5	3.0	3.5	4.1
82	0.1	0.2	0.4	0.6	0.9	1.2	1.5	2.0	2.4	2.9	3.4	4.0
84	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9	2.3	2.8	3.4	3.9
86	0.1	0.2	0.4	0.6	0.8	1.1	1.5	1.9	2.3	2.8	3.3	3.8
88	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.2	2.7	3.2	3.8
90	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.2	2.6	3.1	3.7
92	0.1	0.2	0.3	0.5	0.8	1.1	1.4	1.7	2.1	2.6	3.1	3.6
94	0.1	0.2	0.3	0.5	0.8	1.0	1.4	1.7	2.1	2.5	3.0	3.5
96	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5
98	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0	2.4	2.9	3.4
100	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0	2.4	2.8	3.3
102	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.6	1.9	2.3	2.8	3.3
104	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.9	2.3	2.7	3.2
106	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.9	2.3	2.7	3.1
108	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.8	2.2	2.6	3.1
110	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.8	2.2	2.6	3.0
112	0.1	0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.8	2.1	2.5	3.0
114	0.1	0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.7	2.1	2.5	2.9
116	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.1	2.5	2.9
118	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.0	2.4	2.8
120	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.7	2.0	2.4	2.8
122	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.3	1.6	1.9	2.3	2.7
124	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.3	1.6	1.9	2.3	2.7
126	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.3	1.6	1.9	2.3	2.7
128	0.1	0.1	0.2	0.4	0.6	0.8	1.0	1.3	1.6	1.8	2.2	2.6
130	0.1	0.1	0.2	0.4	0.6	0.8	1.0	1.3	1.6	1.8	2.2	2.6
132	0.1	0.1	0.2	0.4	0.5	0.7	1.0	1.2	1.5	1.8	2.2	2.5
134	0.1	0.1	0.2	0.4	0.5	0.7	1.0	1.2	1.5	1.8	2.2	2.5
136	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.2	1.5	1.8	2.1	2.5
138	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.2	1.4	1.7	2.1	2.4
140	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.2	1.4	1.7	2.0	2.4
142	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.7	2.0	2.4
144	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.7	2.0	2.3
146	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.6	2.0	2.3
148	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.3
150	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.2

Computed from the relationship $L_4 = \sqrt{L_3^2 + h^2} - L_3$

TABLE I: VALUES OF L₂
(INCREASE IN LENGTH DUE TO SKEW)

L ₁ Feet	Value of L ₂ - Feet								
	Angle "A" - Degrees								
	45	50	55	60	65	70	75	80	85
40	16.6	12.2	8.8	6.2	4.1	2.6	1.4	0.6	0.2
42	17.4	12.8	9.3	6.5	4.3	2.7	1.5	0.6	0.2
44	18.2	13.4	9.7	6.8	4.5	2.8	1.6	0.7	0.2
46	19.1	14.0	10.2	7.1	4.8	3.0	1.6	0.7	0.2
48	19.9	14.7	10.6	7.4	5.0	3.1	1.7	0.7	0.2
50	20.7	15.3	11.0	7.7	5.2	3.2	1.8	0.8	0.2
52	21.5	15.9	11.5	8.0	5.4	3.3	1.8	0.8	0.2
54	22.4	16.5	11.9	8.4	5.6	3.5	1.9	0.8	0.2
56	23.2	17.1	12.4	8.7	5.8	3.6	2.0	0.9	0.2
58	24.0	17.7	12.8	9.0	6.0	3.7	2.0	0.9	0.2
60	24.9	18.3	13.2	9.3	6.2	3.9	2.1	0.9	0.2
62	25.7	18.9	13.7	9.6	6.4	4.0	2.2	1.0	0.2
64	26.5	19.5	14.1	9.9	6.6	4.1	2.3	1.0	0.2
66	27.3	20.2	14.6	10.2	6.8	4.2	2.3	1.0	0.3
68	28.0	20.8	15.0	10.5	7.0	4.4	2.4	1.0	0.3
70	29.2	21.4	15.5	10.8	7.2	4.5	2.5	1.1	0.3
72	29.8	22.0	15.9	11.1	7.4	4.6	2.5	1.1	0.3
74	30.7	22.6	16.3	11.4	7.7	4.8	2.6	1.1	0.3
76	31.5	23.2	16.8	11.8	7.9	4.9	2.7	1.2	0.3
78	32.3	23.8	17.2	12.1	8.1	5.0	2.8	1.2	0.3
80	33.1	24.4	17.7	12.4	8.3	5.1	2.8	1.2	0.3
82	34.0	25.0	18.1	12.7	8.5	5.3	2.9	1.3	0.3
84	34.8	25.7	18.5	13.0	8.7	5.4	3.0	1.3	0.3
86	35.6	26.3	19.0	13.3	8.9	5.5	3.0	1.3	0.3
88	36.4	26.9	19.4	13.6	9.1	5.6	3.1	1.4	0.3
90	37.3	27.5	19.9	13.9	9.3	5.8	3.2	1.4	0.3
92	38.1	28.1	20.3	14.2	9.5	5.9	3.2	1.4	0.3
94	38.9	28.7	20.8	14.5	9.7	6.0	3.3	1.4	0.4
96	39.8	29.3	21.2	14.9	9.9	6.2	3.4	1.5	0.4
98	40.6	29.9	21.6	15.2	10.1	6.3	3.5	1.5	0.4
100	41.4	30.5	22.1	15.5	10.3	6.4	3.5	1.5	0.4
102	42.2	31.2	22.5	15.8	10.5	6.5	3.6	1.6	0.4
104	43.1	31.8	23.0	16.1	10.8	6.7	3.7	1.6	0.4
106	43.9	32.4	23.4	16.4	11.0	6.8	3.7	1.6	0.4
108	44.7	33.0	23.8	16.7	11.2	6.9	3.8	1.7	0.4
110	45.6	33.6	24.3	17.0	11.4	7.1	3.9	1.7	0.4
112	46.4	34.2	24.7	17.3	11.6	7.2	4.0	1.7	0.4
114	47.2	34.8	25.2	17.6	11.8	7.3	4.0	1.8	0.4
116	48.0	35.4	25.6	17.9	12.0	7.4	4.1	1.8	0.4
118	48.9	36.0	26.1	18.3	12.2	7.6	4.2	1.8	0.4
120	49.7	36.6	26.5	18.6	12.4	7.7	4.2	1.8	0.5
122	50.5	37.3	26.9	18.9	12.6	7.8	4.3	1.9	0.5
124	51.4	37.9	27.4	19.2	12.8	7.9	4.4	1.9	0.5

Computed from the relationship $L_2 = L_1 [(cscA)-1]$

1. In most cases the values in the tables are so nearly the same that interpolation is not necessary. This must be decided according to the degree of accuracy required.
2. When these tables are used with drop inlet spillways, the values of h is not the total fall, but only the fall occurring within the pipe.

The outlet of the drop inlet spillway should be in line with the downstream channel. The layout providing the shortest conduit will exist when the conduit is straight and at a 90-degree angle with the centerline of the embankment.

MONOLITHIC BOX-TYPE DROP INLET DESIGN

This type must be designed by an engineer. Reinforced concrete has been used most extensively for locations requiring a 3' x 3' culvert or larger. Removal of forms is difficult on smaller culverts. The reinforced concrete monolithic drop inlet is generally recommended for the larger and more important spillways. See Figure 6-29.

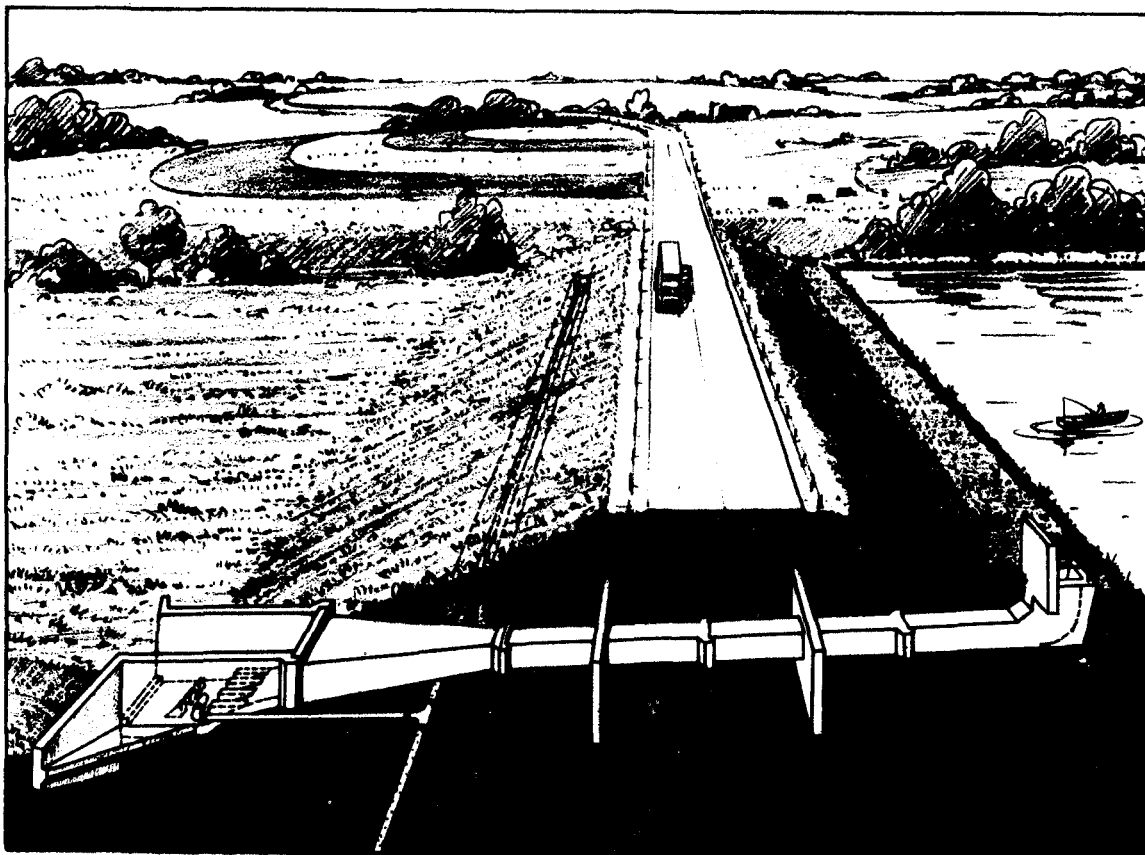
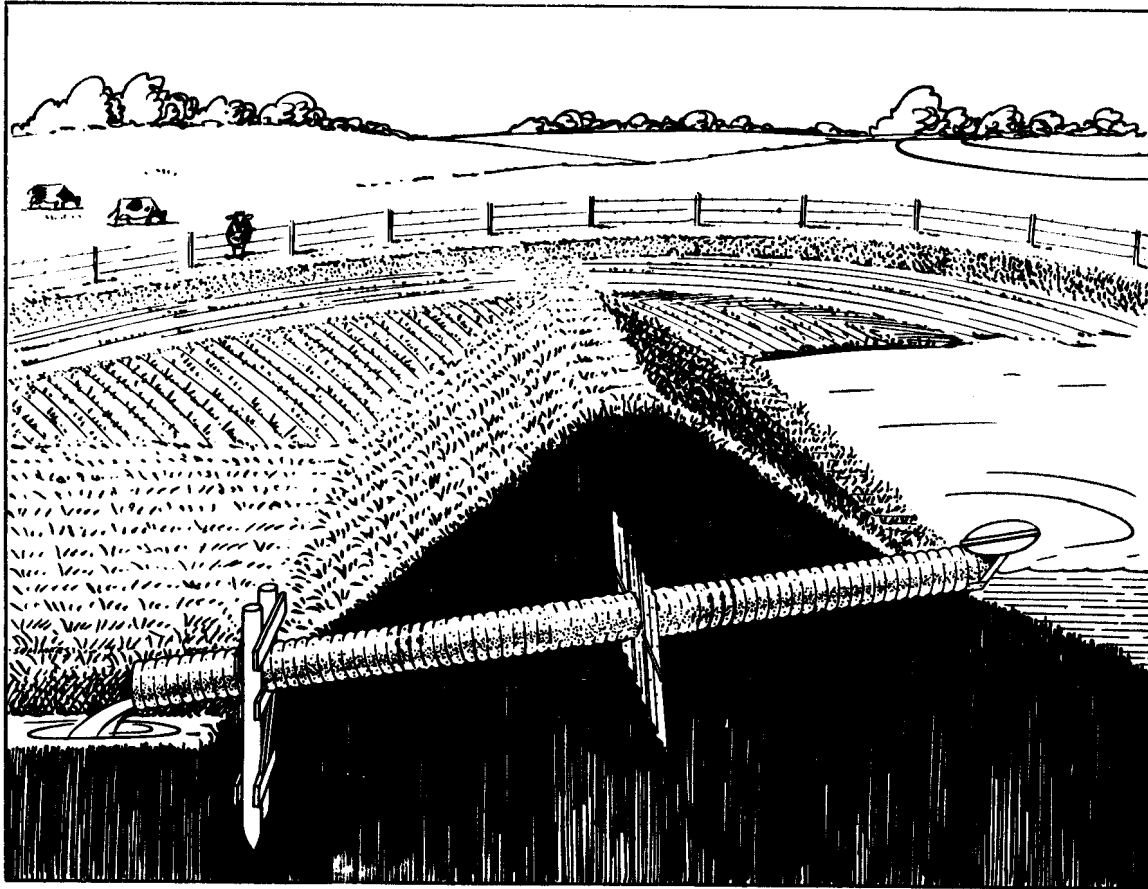


Figure 6-29 Reinforced concrete monolithic drop inlet spillway

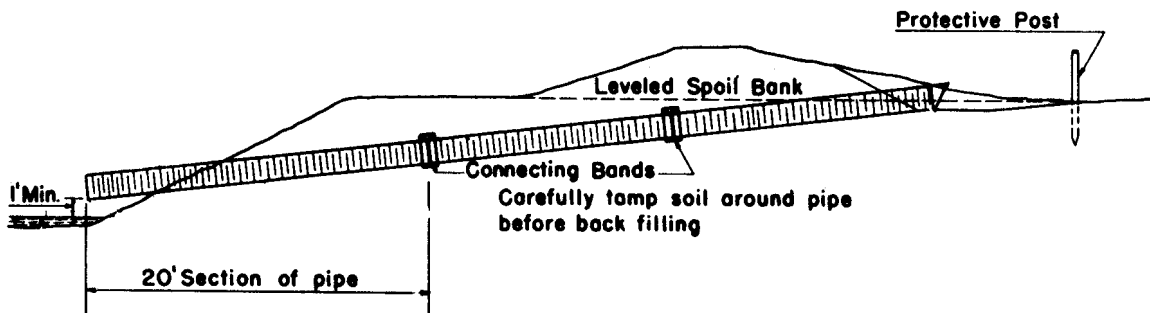
13. HOOD INLET SPILLWAY

DESCRIPTION

The hood inlet spillway consists of a pipe conduit with the inlet end formed by cutting the pipe at an angle. The long side of the cut is placed on top and figuratively forms a hood over the entrance. An anti-vortex wall or plate is located on the upper side of the pipe at the inlet. (Figure 6-30)



Metal pipe with hood inlet



Hood inlet used to lower surface water into a channel

Figure 6-30 Hood inlet spillways

MATERIALS

The hood inlet spillway can be built of corrugated metal, welded steel, concrete, asbestos cement, and possibly other types of pipe. Corrugated metal is the most commonly used pipe, especially on small structures.

FUNCTIONAL USE

Same as for pipe drop inlets.

ADAPTABILITY

It is best adapted for use at those sites where the pipe can be installed in the original ground. Construction is complicated when the pipe is placed in the embankment.

ADVANTAGES

The hood inlet spillway will flow completely full regardless of the slope of the conduit if the length of the hood is properly selected and the head on the inlet is adequate. As compared with the drop inlet, it has the advantage that no riser is required and there is less fill over the pipe. It is simple to fabricate and install and is comparatively low in cost.

LIMITATIONS

For the same crest elevation, hooded pipes over 24 inches in diameter require a greater depth of water over the inlet to obtain full pipe flow than a pipe drop inlet. Icing presents a problem in some areas. Both of these may be overcome with a box and hood combination similar to the one shown in Figure 6-31.

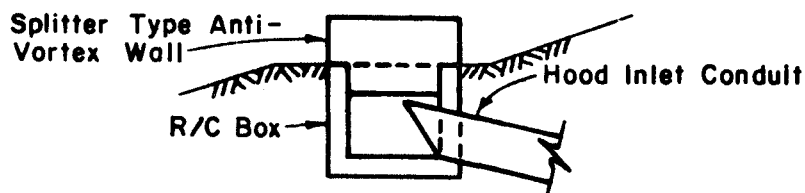
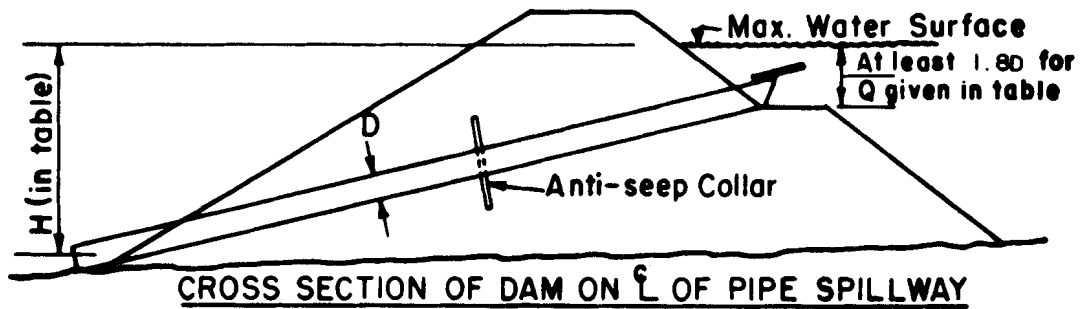


Figure 6-31 Box and hood inlet combination

DESIGN

The hydraulic design of a hood inlet spillway is based on the addition of a hood and anti-vortex device to the inlet of a culvert on a steep slope. These additions will make the culvert flow full when the water surface above the inlet (invert of the pipe) reaches about 1.8 times the diameter of the pipe. A capacity chart for 8- and 12-inch corrugated metal pipe, commonly used for farm ponds, can be found in Figure 6-32.



CAPACITY TABLE OF HOODED INLET IN C.F.S. FOR VARYING HEADS						
Head H	8" DIAMETER PIPE For Pipe Lengths of:			12" DIAMETER PIPE For Pipe Lengths of:		
	50'	70'	90'	50'	70'	90'
5	1.8	1.6	1.4	5.0	4.4	4.0
6	2.0	1.7	1.5	5.5	4.8	4.4
7	2.1	1.9	1.7	6.0	5.2	4.7
8	2.3	2.0	1.8	6.3	5.6	5.0
9	2.4	2.1	1.9	6.7	5.9	5.4
10	2.6	2.2	2.0	7.1	6.2	5.6
11	2.7	2.3	2.1	7.4	6.5	5.9
12	2.8	2.4	2.2	7.8	6.8	6.2
13	2.9	2.5	2.3	8.1	7.1	6.4
14	3.0	2.6	2.3	8.4	7.4	6.7
15	3.1	2.7	2.4	8.7	7.6	6.9
16	3.2	2.8	2.5	9.0	7.9	7.1
17	3.3	2.9	2.6	9.2	8.1	7.3
18	3.4	3.0	2.7	9.5	8.4	7.6
19	3.5	3.0	2.7	9.8	8.6	7.8
20	3.6	3.1	3.0	10.0	8.8	8.0

Figure 6-32 Capacity chart for 8- and 12-inch C.M.
pipe hood inlet spillway

Figure 6-33 provides capacities for larger corrugated metal pipe hood inlets. Capacities for smooth pipe can be found in Figure 6-34.

The use of some type of device to prevent vortex formation is necessary for developing maximum capacity shown in the previously mentioned figures. When the hood inlet is of corrugated metal pipe an anti-vortex device similar to the one shown in Figure 6-35 can be used.

PIPE FLOW CHART (Full flow assumed)

For Hooded Inlet $K_e = 1.08$ and 70 feet of Corrugated Metal Pipe Conduit, $n = 0.025$.
 Note corrections for other pipe lengths.

Dia. H	12"	15"	18"	21"	24"	30"	36"	42"
2	2.79	4.89	7.72	11.16	15.48	26.31	40.28	57.42
3	3.41	5.99	9.46	13.67	18.97	32.32	49.34	70.34
4	3.94	6.92	10.92	15.78	21.90	37.32	56.98	81.22
5	4.40	7.74	12.21	17.64	24.48	41.72	63.70	90.80
6	4.82	8.47	13.37	19.32	26.82	45.70	69.77	99.45
7	5.21	9.16	14.45	20.88	28.97	49.37	75.38	107.45
8	5.57	9.78	15.44	22.31	30.97	52.77	80.57	114.85
9	5.91	10.38	16.38	23.61	32.85	55.98	85.47	121.83
10	6.23	10.94	17.26	24.95	34.62	59.00	90.09	128.41
11	6.53	11.48	18.11	26.17	36.32	61.90	94.50	134.70
12	6.82	11.99	18.91	27.33	37.93	64.64	98.69	140.67
13	7.10	12.48	19.69	28.45	39.49	67.29	102.73	146.44
14	7.37	12.95	20.43	29.52	40.97	69.83	106.61	151.96
15	7.63	13.40	21.15	30.56	42.41	72.27	110.34	157.28
16	7.88	13.84	21.84	31.56	43.80	74.64	113.96	162.44
17	8.12	14.27	22.51	32.53	45.15	76.94	117.46	167.44
18	8.36	14.68	23.17	33.48	46.46	79.17	120.88	172.31
19	8.59	15.08	23.80	34.39	47.73	81.34	124.19	177.02
20	8.81	15.47	24.42	35.28	48.97	83.45	127.41	181.61
21	9.03	15.86	25.02	36.16	50.18	85.52	130.57	186.12
22	9.24	16.23	25.61	37.00	51.36	87.52	133.62	190.46
23	9.45	16.59	26.19	37.84	52.52	89.49	136.64	194.77
24	9.65	16.95	26.69	38.65	53.64	91.42	139.57	198.95
25	9.85	17.30	27.30	39.45	54.75	93.30	142.45	203.05
L	Correction Factors For Other Lengths							
40	1.23	1.21	1.19	1.18	1.16	1.13	1.12	1.10
50	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07
60	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97
90	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94
100	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.92

Figure 6-33 Pipe flow chart for corrugated metal pipe hood inlet spillway

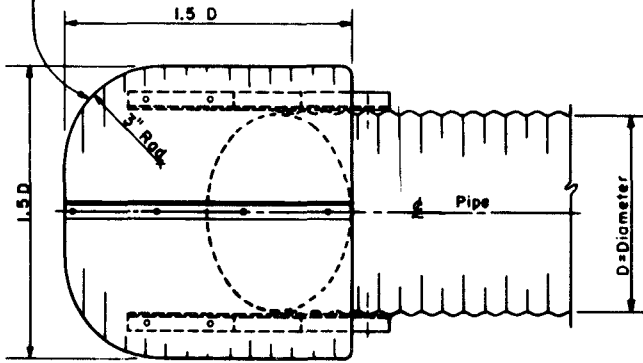
PIPE FLOW CHART (Full flow assumed)

For Hooded Inlet $K_e = 1.08$ and 70 feet of smooth pipe conduit, $n = 0.010$. Note corrections for other lengths.

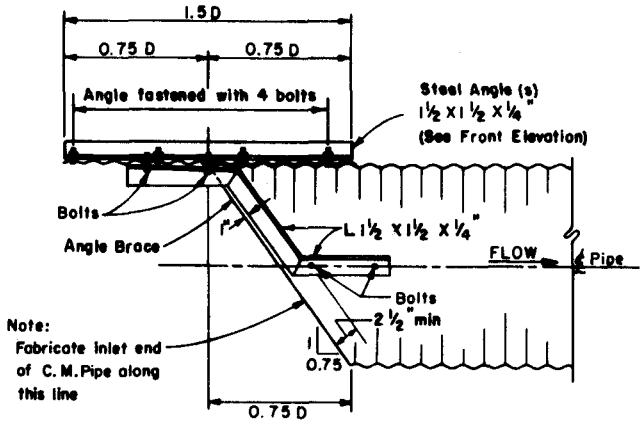
Dia. H	10"	12"	14"	15"	18"	21"
2	3.20	4.85	6.85	7.99	11.92	16.64
3	3.92	5.94	8.38	9.79	14.60	20.39
4	4.53	6.85	9.68	11.31	16.86	23.54
5	5.06	7.66	10.82	12.64	18.85	26.32
6	5.54	8.39	11.86	13.84	20.64	28.83
7	5.99	9.07	12.81	14.96	22.30	31.15
8	6.40	9.69	13.69	15.99	23.84	33.29
9	6.79	10.28	14.52	16.96	25.29	35.31
10	7.16	10.84	15.31	17.87	26.65	37.22
11	7.51	11.36	16.05	18.74	27.95	39.03
12	7.83	11.87	16.77	19.58	29.20	40.77
13	8.16	12.36	17.46	20.41	30.39	42.45
14	8.47	12.82	18.11	21.15	31.54	44.05
15	8.77	13.27	18.75	21.89	32.64	45.59
16	9.06	13.71	19.36	22.61	33.72	47.08
17	9.33	14.13	19.96	23.31	34.75	48.53
18	9.61	14.54	20.54	23.99	35.76	49.94
19	9.87	14.94	21.10	24.64	36.74	51.31
20	10.12	15.33	21.65	25.28	37.69	52.64
21	10.38	15.71	22.19	25.91	38.63	53.95
22	10.62	16.07	22.70	26.51	39.53	55.21
23	10.86	16.44	23.24	27.11	40.42	56.45
24	11.09	16.79	23.72	27.69	41.29	57.67
25	11.32	17.14	24.21	28.26	42.14	58.86
L	Correction Factors for Other Lengths					
40	1.11	1.09	1.08	1.08	1.06	1.05
50	1.07	1.06	1.05	1.05	1.04	1.03
60	1.03	1.03	1.02	1.02	1.02	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00
80	0.97	0.97	0.98	0.98	0.98	0.98
90	0.95	0.95	0.96	0.96	0.96	0.97
100	0.93	0.93	0.94	0.94	0.95	0.96

Figure 6-34 Pipe flow chart for smooth pipe hood inlet spillway

Metal Baffle shall have the same coating as the pipe to which it is attached. Where Metal Baffle is fabricated of more than one piece of metal, the separate pieces shall be securely fastened to each other. Sharp corners shall be removed. Metal Baffle may be made of corrugated or smooth sheet metal and shaped circular, square or as shown.



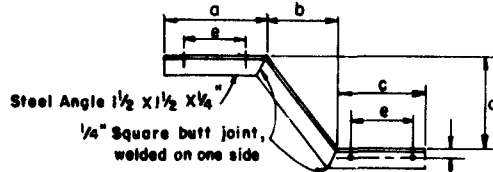
PLAN



SIDE ELEVATION

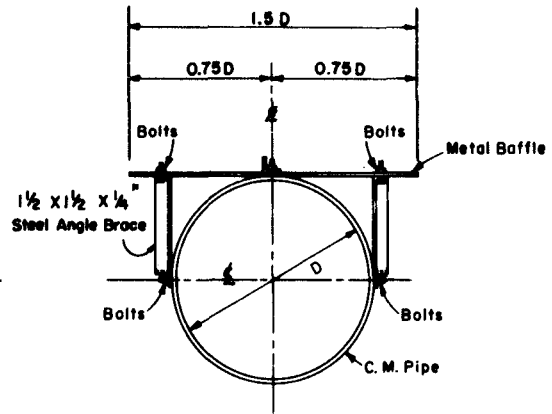
GAGE OF METAL BAFFLE AND DIMENSIONS OF ANGLE BRACE						
Diam. of Pipe D	Gage of Baffle	Angle Brace Dimensions in inches when used				
		a	b	c	d	e
6"	16					
8"	16					
10"	16					
12"	16	8	3 3/4	9	5	5 1/3
15"	16	9	4 7/8	9	6 1/2	5 1/3

Note: Angle Brace is optional



ANGLE BRACE DETAIL

(1 left and 1 right required for each baffle)



FRONT ELEVATION

- Notes:
- All bolts shall be 3/8" x 1 1/2" with nut and split washers.
 - All holes for bolts shall be drilled 7/16" diameter.
 - All nuts, bolts and washers shall be galvanized, cadmium plated, or stainless steel.
 - All cuts shall be saw or shear cuts.
 - Holes in the angle brace shall be spaced and located to match corrugations in pipe and baffle.
 - Steel angles shall be galvanized.
 - All galvanizing damaged by cutting, drilling or welding shall be repaired by painting with two (2) coats of zinc dust-zinc oxide primer.

Figure 6-35 Details of a typical hood inlet and baffle for 6- to 15-inch diameter corrugated metal pipe

Under full pipe flow conditions, high velocities exist near the pipe entrance, which generally causes a scour hole in the embankment face unless protected by paving or riprap. It is, therefore, desirable to provide protection to prevent the formation of a scour hole under the inlet. Paving is better than riprap in that it prevents the growth of vegetation near the

inlet where it is apt to impair the hydraulic efficiency of the spillway. Two typical paving layouts of inlets for farm pond spillways having barrel diameters of 12 inches or less are shown in Figure 6-36.

Where adequate riprap or paving is not available, or not apt to be installed, the lower two layouts can be used. These layouts should not be used where more than a thin film of ice might form around the inlet and be continuous with ice on the reservoir surface.

The inlet of the spillway must be located so that water can reach it from all sides. Some type of trash guard should be provided. Antiseep collars should be installed in the same manner as for drop inlet spillway.

14. EARTH SPILLWAYS

DESCRIPTION

An earth spillway (side or emergency spillway) is an open channel for conveying floodwater safely past an embankment from its reservoir to a point where its discharge will not damage the toe of the earth embankment. Refer to Chapter 11 of this manual for details of design, layout, and construction.

15. EARTH DAM

DESCRIPTION

The earth dam is an earth embankment constructed across a watercourse with adequate spillways to protect the dam from failure by overtopping from the design storm runoff. Because its construction involves use of natural, unprocessed materials, it is the most common type of dam. As its name implies, it is constructed of soil borrowed in the vicinity of the damsite. (Figure 6-37)

FUNCTIONAL USE

Earth dams with necessary spillways may be constructed to serve one or several intended purposes:

1. As a diversion dam to divert all or part of the water from a waterway or stream into a different watercourse, an irrigation canal, or a water-spreading system.
2. As a storage dam to store surface runoff for farm water supply, irrigation, municipal water supply, fish and wildlife or recreation, or to store sediment.
3. As a grade stabilization dam to drop water from one level to another.
4. As a retarding dam to store floodwater temporarily and protect land from flooding; or to reduce the outflow and permit the use of a more economical system of structures downstream.

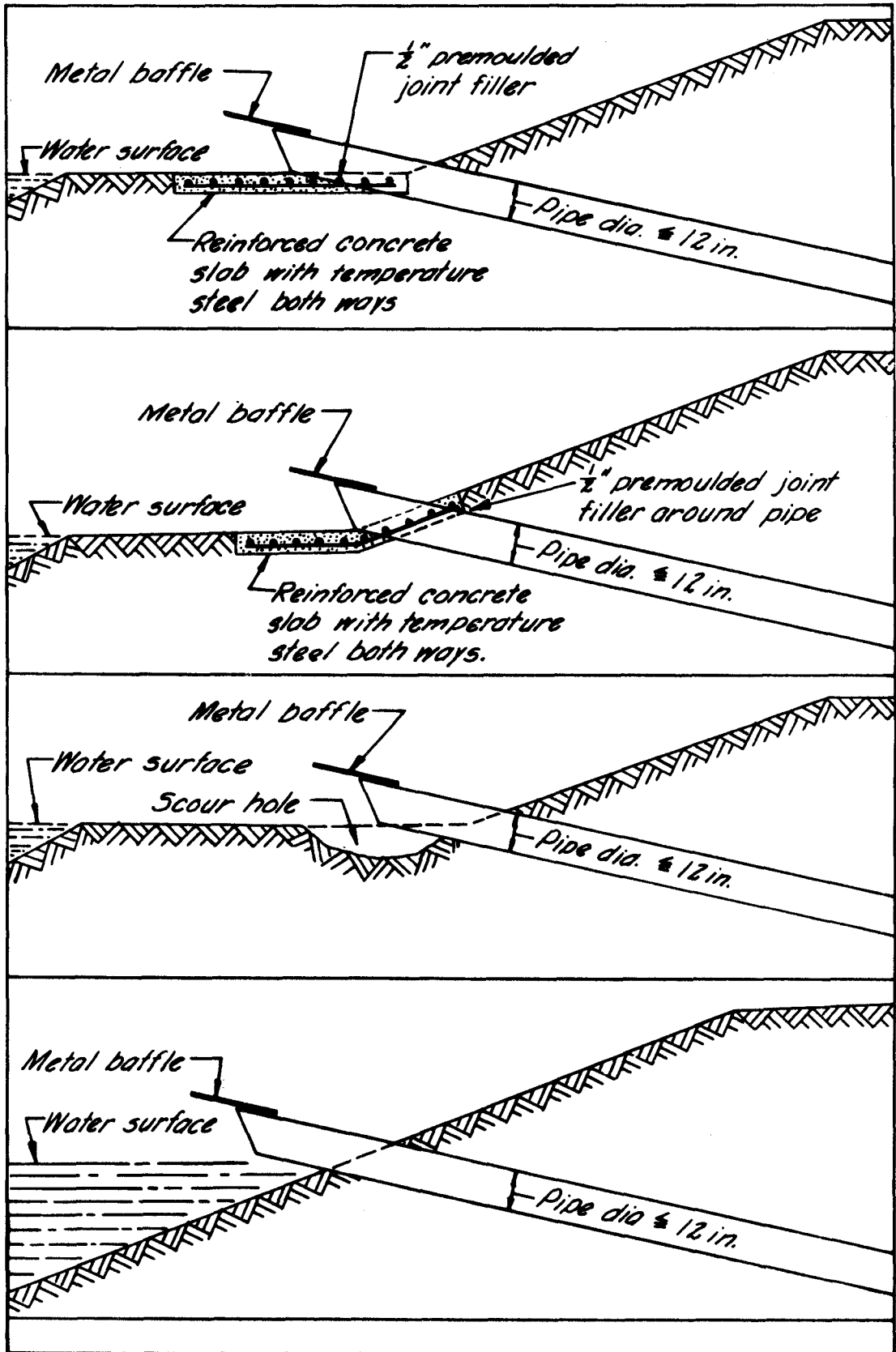


Figure 6-36 Typical layouts of inlets for 12-inch or less hood inlet spillways

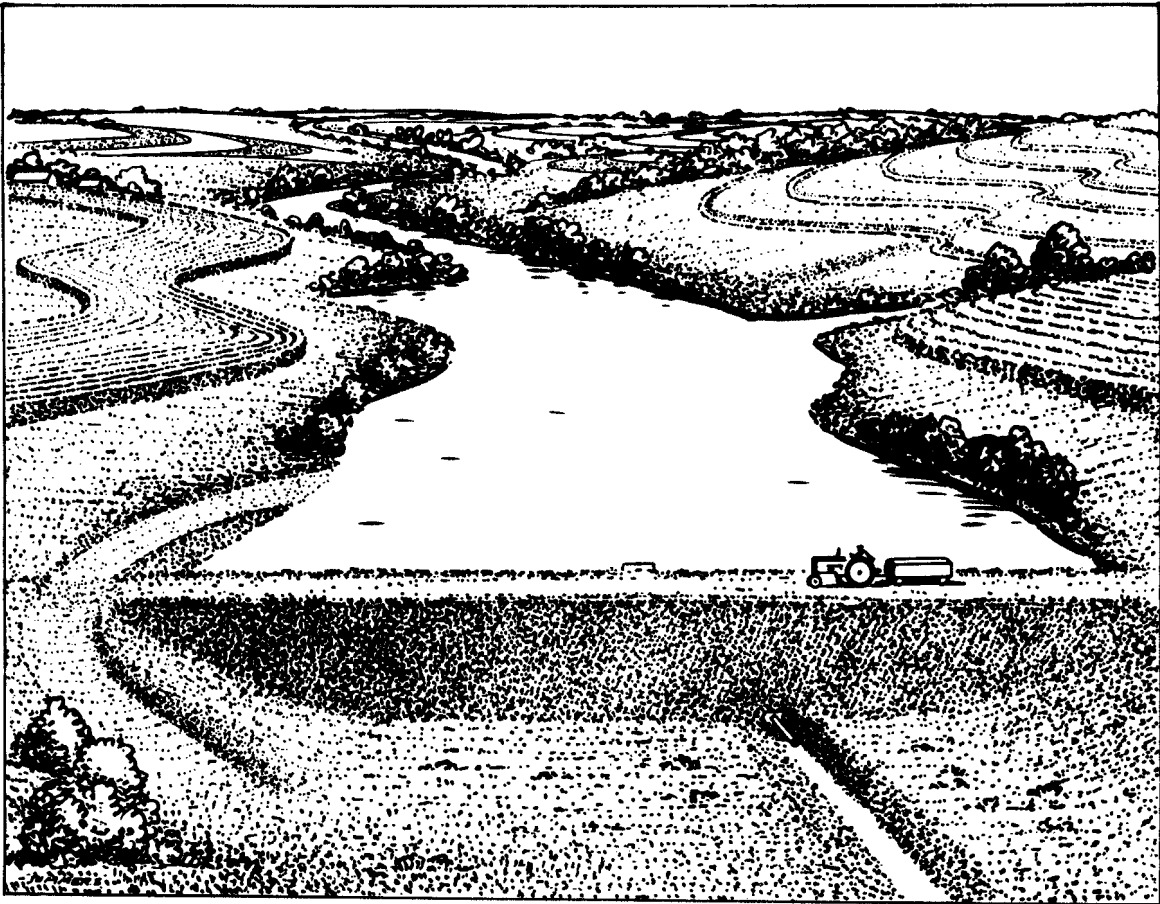


Figure 6-37 Earth dam
 Note outlet of principal spillway in foreground
 and vegetated earth spillway around embankment

ADAPTABILITY

Earth dams are adapted to any gully or valley site where the soils are suitable, the banks and valley side slopes are high enough to permit the construction of an earth embankment, and there is a safe spillway location.

ADVANTAGES

With proper design and construction, the earth dam is a reliable and dependable structure and for most sites the most economical structure for the intended purpose.

LIMITATIONS

It is limited only by topographic and foundation conditions and availability of suitable earthfill material.

DESIGN

The earth dam is an engineering structure requiring sound engineering procedures in both design and construction.

These procedures include:

1. Thorough predesign investigations of foundation conditions and materials of construction.
2. Application of engineering skill and techniques to design.
3. Application of known and definite principles of soil mechanics.
4. Carefully planned and controlled methods of construction.

Refer to Chapter 11 - Ponds and Reservoirs, and Chapter 17 - Construction and Construction Materials, for information and criteria on design, layout, and construction of earth dam embankments.

16. WATER CONTROL STRUCTURES

DESCRIPTION

Water level control structures are designed to regulate and maintain water levels for water table control, fish and wildlife management, or for flooding land surfaces. The control is accomplished by use of gates or stoplogs that can be fitted into several types of structures.

USES

1. Control drainage. To maintain a high water table consistent with the crop by reducing the depth of normal drainage. With uncontrolled drainage, the water table generally drops during the hot, dry weather toward the end of the season. Also, to control the water table in peat and muck to reduce subsidence.
2. Subirrigation. Subirrigation is similar to controlled drainage but differs in that water is supplied from an outside source to maintain or regulate the water table throughout the growing season.
3. Flooding. Flooding of the land surface is necessary in the production of some crops such as cranberries and rice. It is also used to create habitat for some species of wildlife.
4. Water level regulation. The manipulation of water levels for the management of fish spawning areas and water fowl habitat.

TYPES OF STRUCTURES

Drop Spillways with Gates or Stoplogs

The drop spillway generally is constructed of reinforced concrete, timber sheet piling, or corrugated steel sheet piling. Reinforced concrete is the most permanent and also the most expensive. It can be adapted to a bridge crossing and the height and width can be varied to accommodate any ordinary drainage channel. The highest position of the stoplogs determines the crest of the weir. The weir size is normally selected to pass the design storm. Figure 6-38 shows a straight drop spillway with stoplogs used as the headwall to control weir elevation.

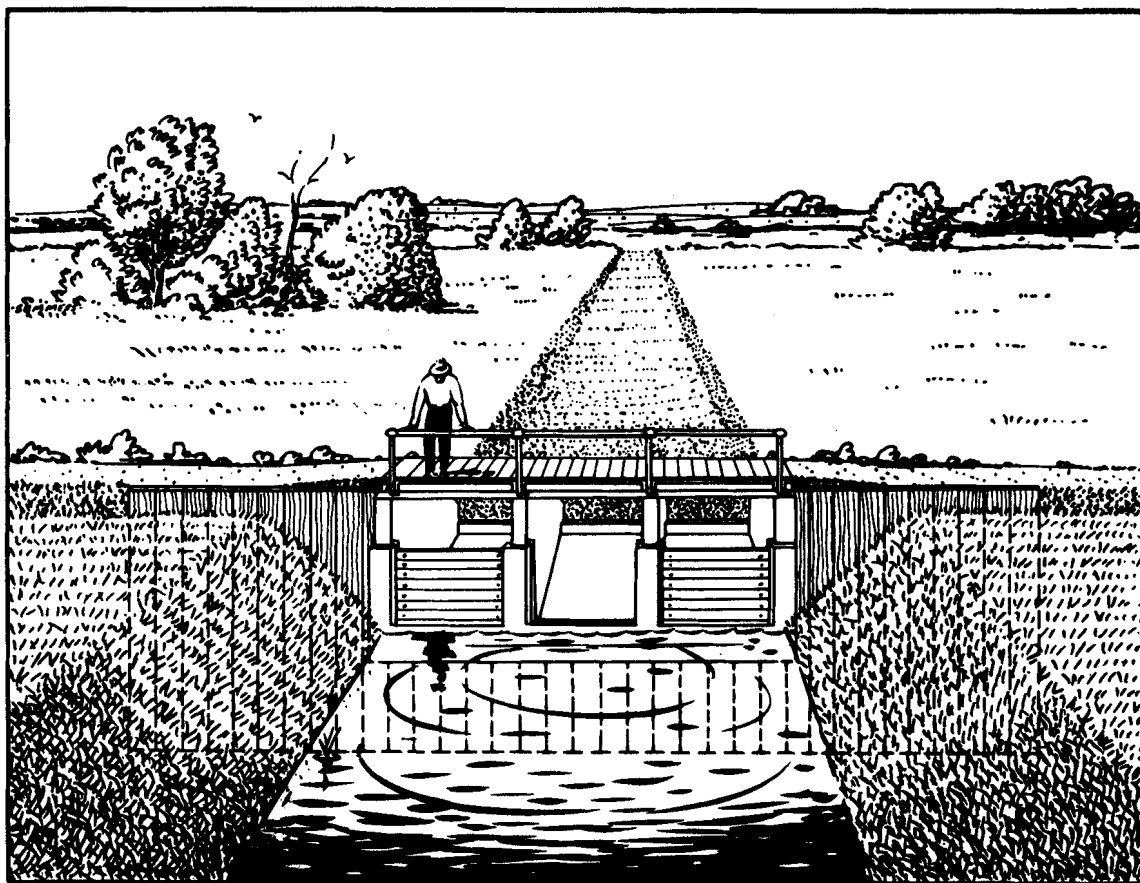


Figure 6-38 Straight drop spillway water control structure

Note: Headwall extensions and cutoff wall are of sheet piling

Sheet piling structures are often used for sites with poor foundation or extremely wet conditions. Sheet piling spillways require the use of special equipment to drive or jet the piling into place. Treated lumber is recommended for long life. In any event, only first-class lumber should

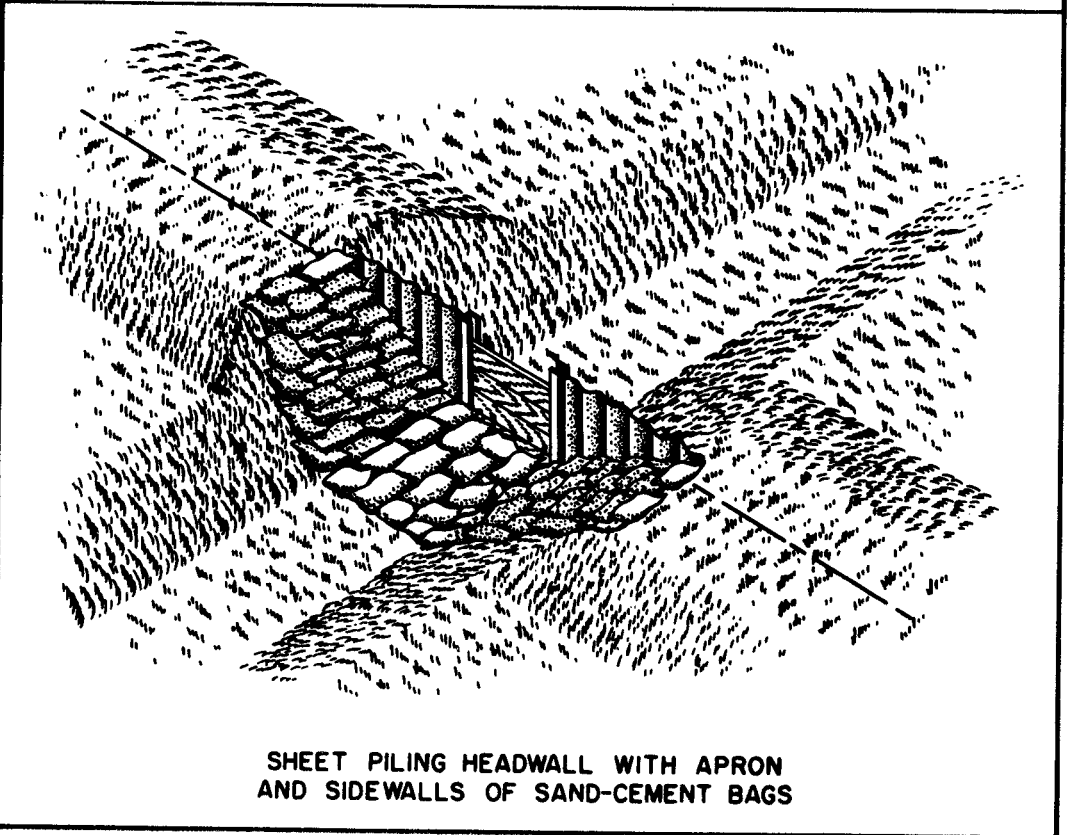
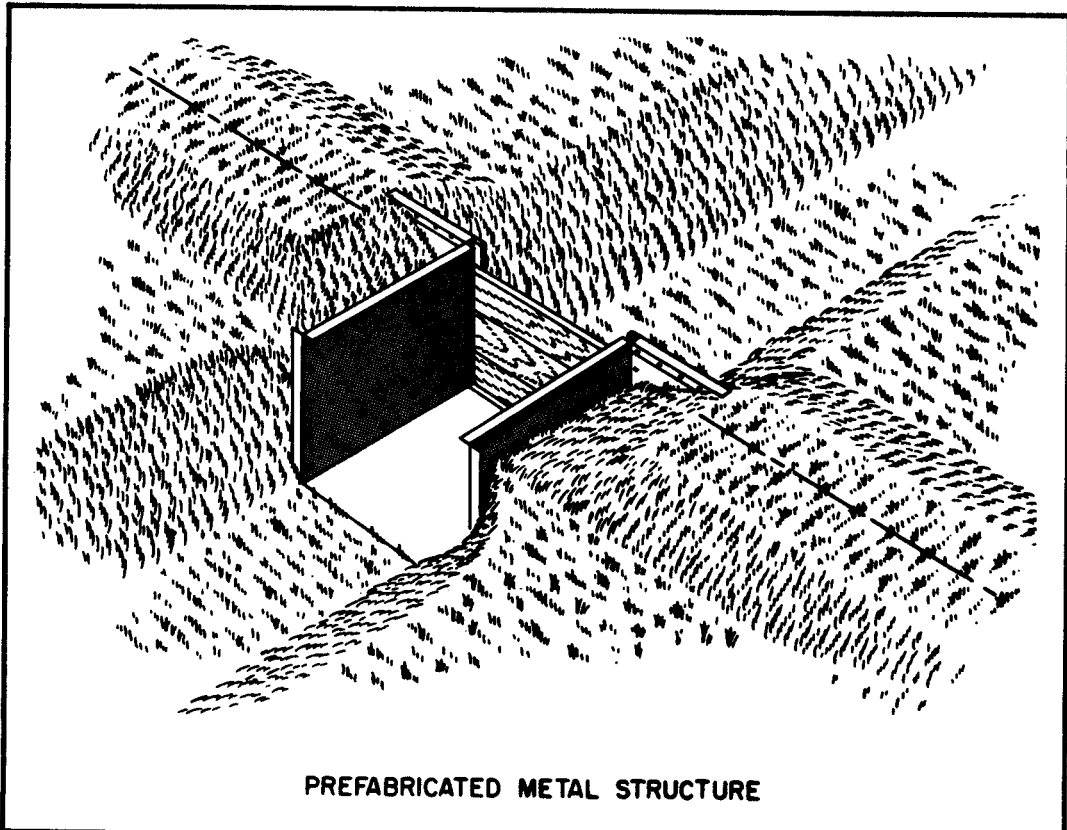


Figure 6-39 Small low cost water control structures

be used. Steel sheet piling makes a permanent structure if properly installed and protected. The cost is similar to reinforced concrete. A low-cost structure consisting of a sheet piling wall, an opening into which stoplogs are placed, and the apron and sidewalls built of sand-cement bags, is shown in Figure 6-39. This structure is well adapted to V-type ditches 1.5 to 2.0 feet deep or small trapezoidal ditches commonly used for sub-irrigation or in wildlife areas. Also shown in Figure 6-39 is one type of prefabricated sheet metal structure that is easy to install and can be moved.

Box Inlet on Culvert with Gate or Stoplogs

This structure combines a road culvert with a water control structure. The culvert may be of concrete, corrugated metal pipe or timber. The box inlet section is generally made of reinforced concrete, timber, or a half-section of metal pipe. An example of this type of structure is shown in Figure 6-40.

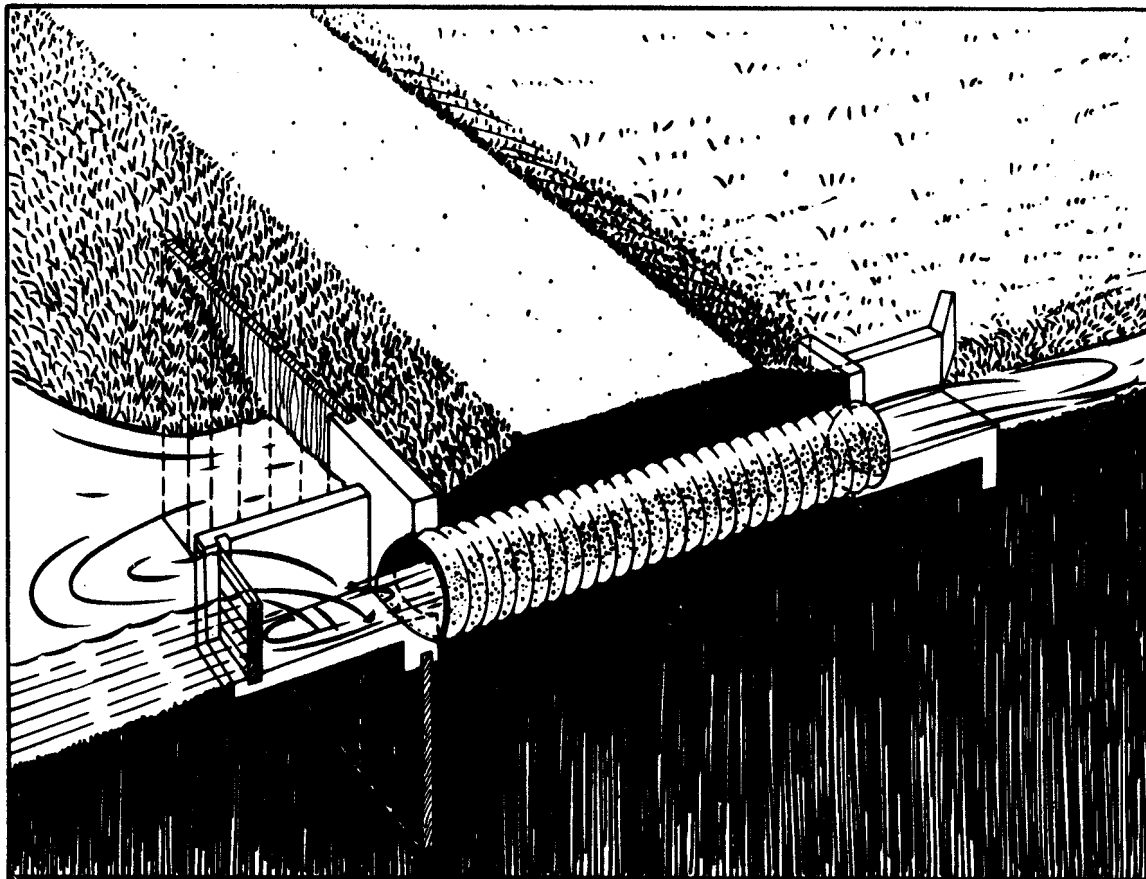


Figure 6-40 Corrugated metal culvert water control structures with concrete box inlet and stoplogs

Drop Inlet Spillway with Stoplogs

The pipe drop inlet spillway can be used with an earth dam embankment to impound and control the depth of water by use of stoplogs placed inside the drop inlet. Examples of a full section metal pipe riser and a half section metal pipe riser are shown in Figure 6-41.

Drop Inlet Spillways for Fish Management

By incorporating additional features in the drop inlet spillways, fish management can be provided. Figure 6-42 shows necessary provisions to permit migration of fish upstream through the structure, or provide for cool water release from a reservoir for fish below the structure.

Open Flumes

This is a box-type structure with the top side open and stoplogs or a gate installed at the upstream end for controlling the water level. It is generally constructed of concrete, timber or metal. See Figure 6-43.

17. FLOODGATES

DESCRIPTION

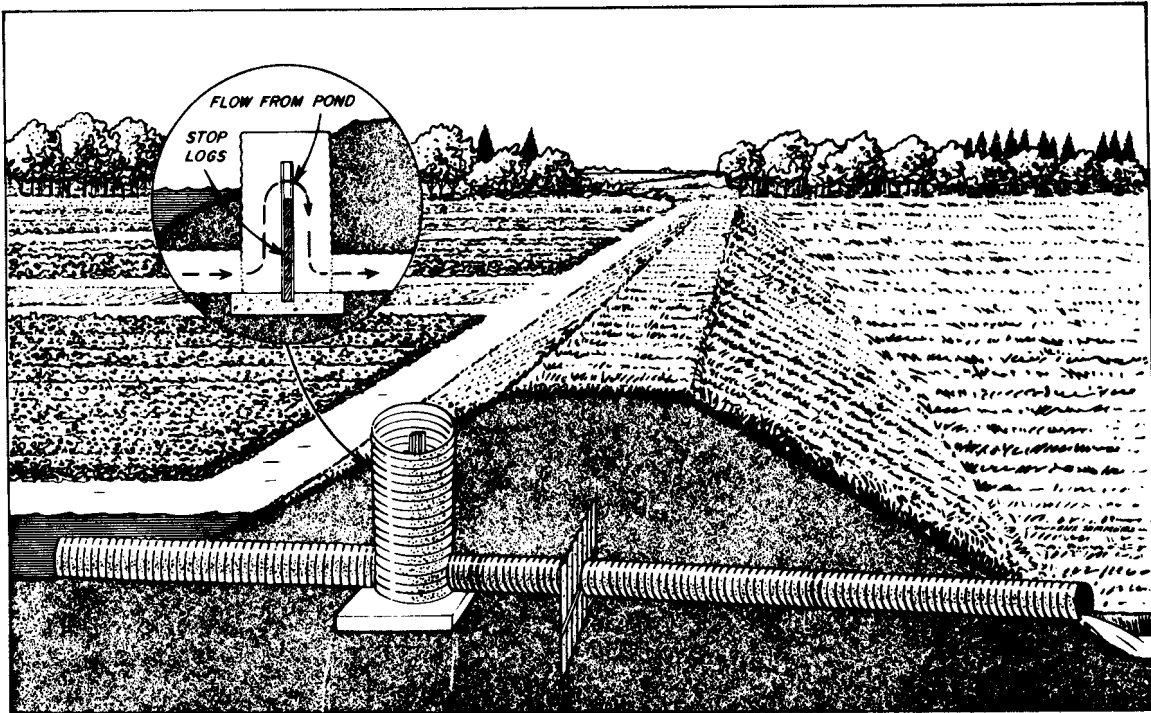
Floodgates are devices for regulating the flow of water. They may be either free-swinging gates that serve as automatic check valves or slide gates operated manually or by power. Usually they are installed at the end of a pipe, or made part of a concrete or wood structure, located in an earth embankment built as a dike or across a channel or drainage ditch. The automatic gate allows the water to flow in one direction only, thereby preventing the water from flowing back into the protected area. See Figure 6-44. Slide gates may be used to permit the flow of water in either direction as desired. When a floodgate structure outlets into an ocean estuary, it is referred to as a tide gate.

MATERIAL

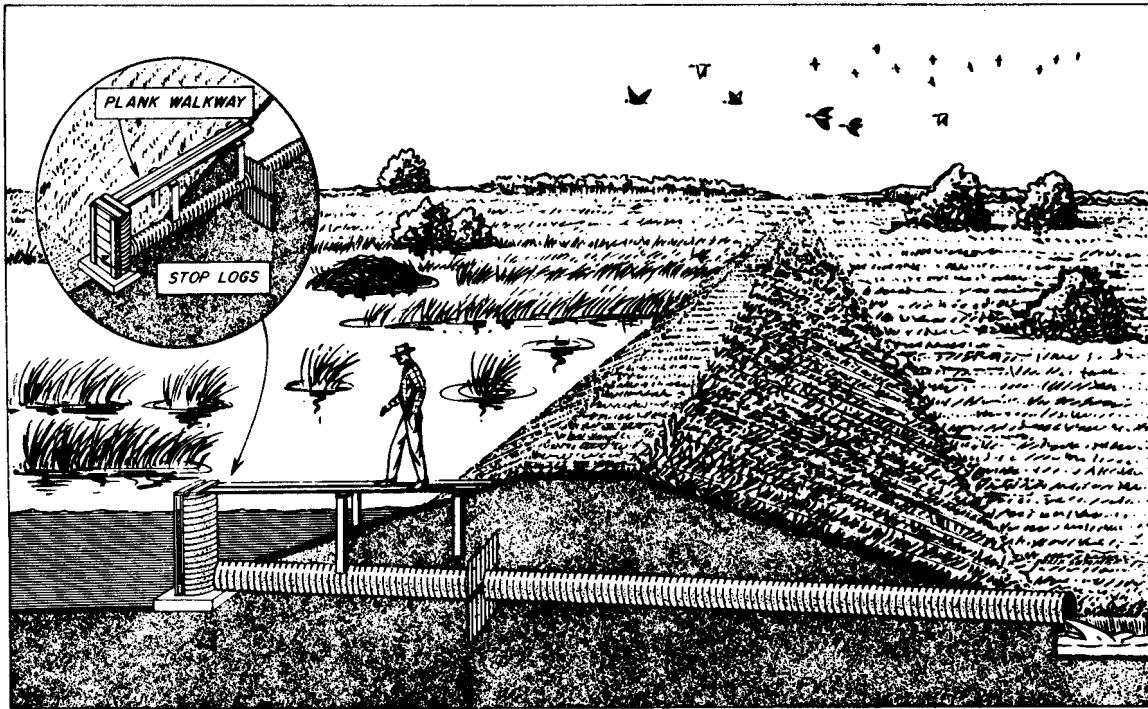
Manufactured gates made from metal and attached to corrugated metal pipes are the most widely used. Large metal or wood gates fabricated in both round and rectangular shapes are often used in locations where they can be installed as part of a wood or concrete structure.

FUNCTIONAL USES

1. At the end of a drainage ditch or flood channel where it outlets into a larger stream to prevent high stages on the large stream from backing up the ditch or channel.
2. In conjunction with pumped drainage outlets to allow gravity flow when water stages in the outlet are sufficiently low and to prevent high flow of the outlet channel from backing into the pump installation.

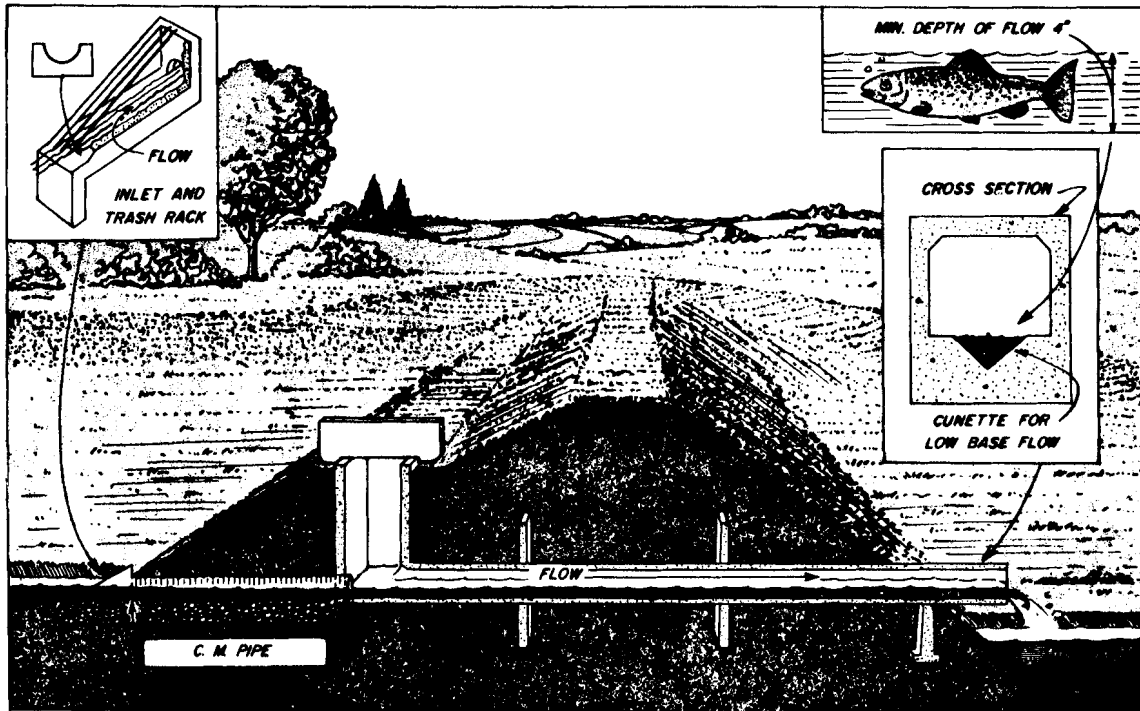


Full section of pipe riser with stoplogs

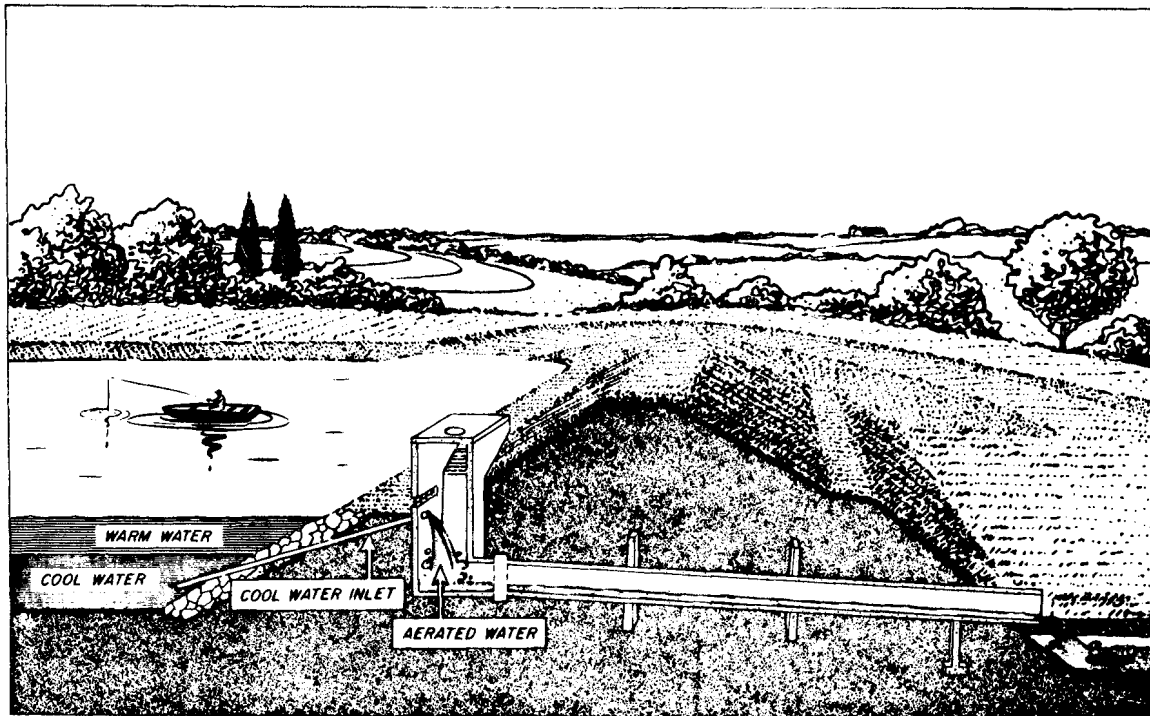


Half section of pipe riser with stoplogs

Figure 6-41 Corrugated metal pipe drop inlet spillways for water level control by use of stoplogs in the riser



Migration of fish upstream through structure



Cool water release for fish below structure

Figure 6-42 Monolithic reinforced concrete drop inlet with provisions for fish management

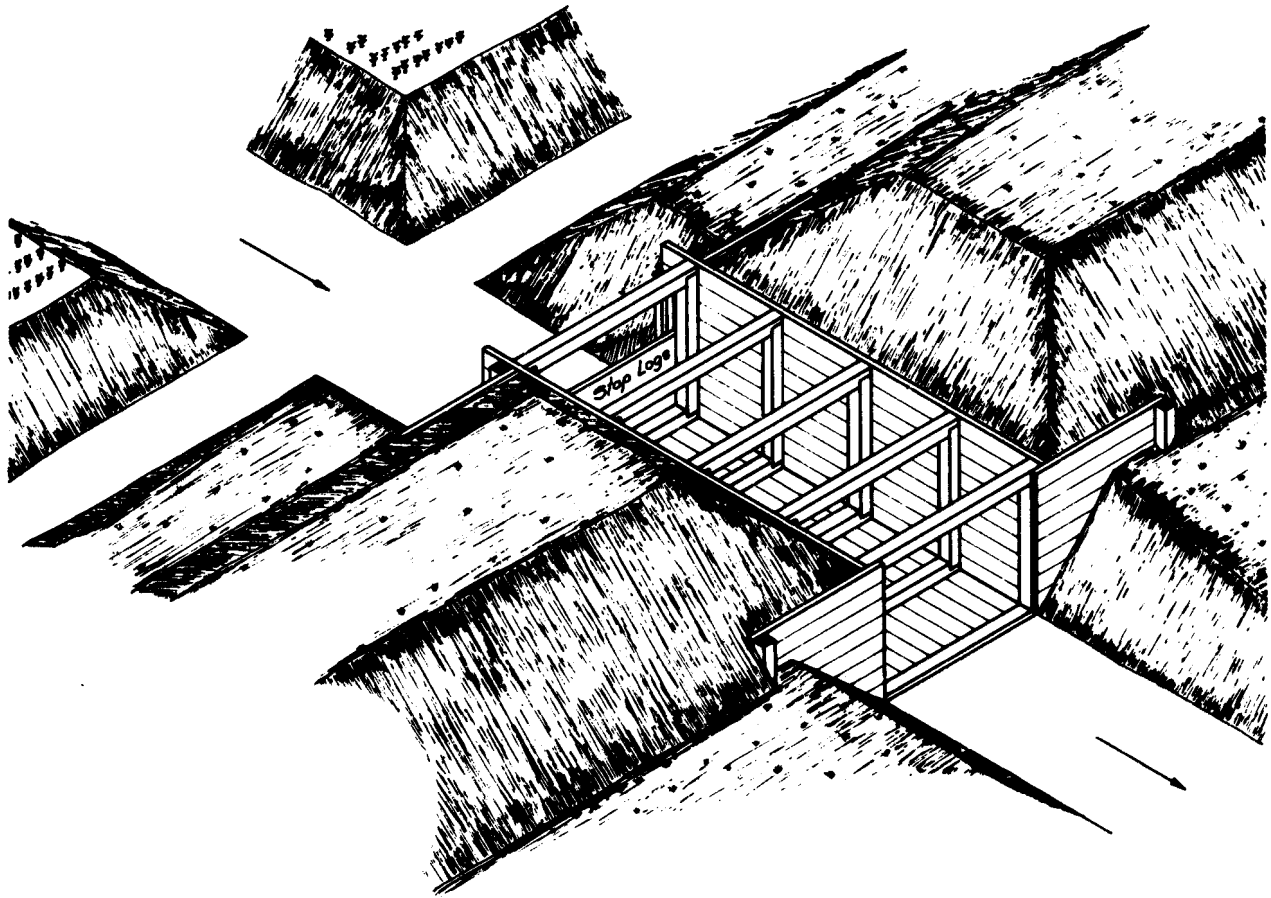


Figure 6-43 Open timber flume with stoplog water level control

3. In outlets through dikes in tidal areas to prevent inflow from the tides and to permit outflow from the interior area when the tide lowers. During high tide the interior water is stored.

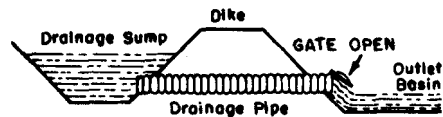
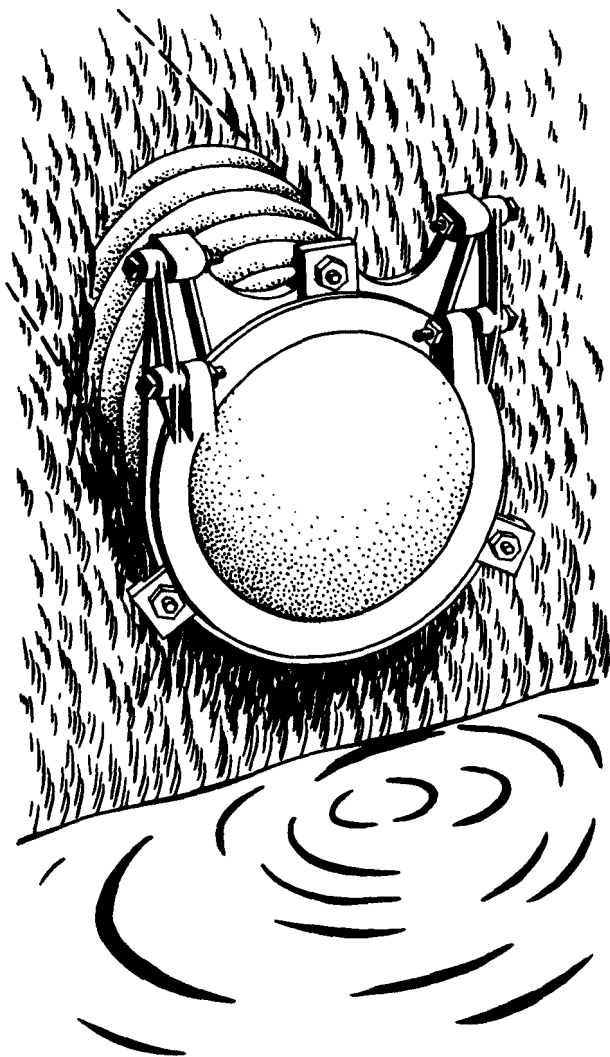
ADAPTABILITY

Floodgates are best adapted to locations where water stages on the outlet side periodically are low enough to permit gravity disposal of runoff water in a specified period of time. They also are used along with pumps where enough gravity flow will occur to reduce the size of the pumps required or the amount of time the pumps must be operated.

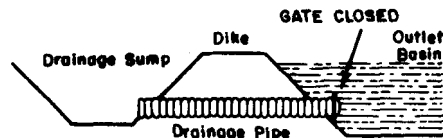
ADVANTAGES

The variety of sizes and types available permits fitting them to site requirements. Floodgates installed with pumping plants reduce the cost of operation of the plant. Floodgates may be used to prevent flooding of protected land and in some cases may eliminate the need for pumping.

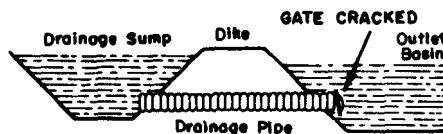
They can be installed with inlet controls to maintain a definite water elevation for subirrigation, reducing subsidence of organic soils, or for providing water areas for wildlife developments.



The water in drainage sump is free to flow through the drainage pipe and be discharged into outlet basin. The gate automatically stands open to whatever degree the drainage flow requires.



Drainage sump is empty and tide or flood head in outlet basin is above the drainage outlet so that the gate is either partially or wholly submerged. Under these conditions the gate automatically remains closed preventing any back flow into the drainage system.



High flood in outlet basin and an accumulation of drainage water in the drainage sump. Should the accumulation in drainage sump reach an elevation higher than the flood or tide in outlet basin the gate automatically becomes "cracked" sufficiently to permit the drainage flow to proceed until the drainage head equals the tide or flood head in outlet basin. The gate then automatically closes and remains closed until the drainage head again exceeds the tide or flood head in outlet basin.

Figure 6-44 Automatic swinging floodgate

LIMITATIONS

Floodgates must be protected from debris that could cause breakage or impair their use. They must be inspected frequently and maintained in good repair. Automatic gates especially require maintenance to insure that they open and close as required. In many cases, site conditions require extensive dewatering work if large wood or concrete structures are to be installed with gates. Riprap or concrete headwalls are frequently required to prevent erosion around the gate.

DESIGN

1. Normally, the design of the outlet system should be based on the same drainage coefficients as apply to adjoining nontidal lands. However, the effects of prolonged wind tides or river floodflows may require a high degree of protection from flooding in the

Observed Tide Stages			Height Above ^{1/} Mean Low Water	E ^{2/}	Head ^{3/} on Gate	Gate ^{4/} Discharge
Time	Gage Height					
<u>Hour</u>	<u>Minute</u>	<u>Feet</u>	<u>Feet</u>	<u>Feet</u>	<u>Feet</u>	<u>cfs</u>
AM	6	02	3.0	4.7	3.8	
	7	00	3.8	5.5 = R		
	8	00	3.5	5.2		
	9	00	2.8	4.5		
	10	00	1.5	3.2		0 @ 9H36M
	11	01	0.2	1.9	0.6	18.3
M	12	00	-1.0	0.7	1.9	32.5
	1	02	-1.7	0.0	3.1	41.6
	2	00	-1.6	0.1	4.0	47.2
	3	00	-1.3	0.4	3.9	46.6
	4	00	-0.5	1.2	3.4	43.6
	5	00	0.9	2.6	2.6	37.9
					1.2	25.9
					0	0 @ 5H36M
	5	58	2.2	3.9		
	7	00	3.5	5.2		
	8	00	3.7	5.4		
PM	9	00	3.2	4.9		

1/ Mean low water = elevation -1.7 R = tidal range

2/ Distance of design water elevation in gate forebay above mean low water (0.0 on tidal range)

3/ Head on gate = E less height above mean low water

4/ Discharge for selected 30" \emptyset gate from Figure 6-46

Figure 6-45 Tide gate design data

protected area. See the State Standards and Specifications for guidance.

2. The highest allowable water surface above the levee should be used as the basis for the hydraulic design.
3. The data may be determined by direct observation at the site or obtained from recorded data obtained nearby. This data may be recorded as shown in Figure 6-45, Tide gate design data.
4. By means of Figure 6-46, Capacity of circular gates, determine the gate discharges for the various heads on the gate.
5. Plot a time-gate discharge curve and determine the area under the curve. This represents the total discharge for the tidal cycle.
6. Divide the total discharge by the total time of the cycle to obtain the average rate of discharge for the gate size selected.
7. If the selected gate size does not meet the discharge requirements determined in item 1, recalculate for other gate sizes or use of multiple gates.

Complex or large installations require the assistance of an engineer.

18. IRRIGATION STRUCTURES

Structures play an important part in the use and management of irrigation water, whether by open ditch or pipeline. Various kinds of structures are used for the storage, diversion, distribution and conveyance of water, and for erosion and grade control. For more detailed information on irrigation structures refer to Chapter 3 - Planning Farm Irrigation Systems, Section 15, N.E.H. and Standard plans developed by the States. Most large storage, diversion, and conveyance structures require the assistance of an engineer.

STORAGE STRUCTURES

Structures for storing irrigation water are classified as reservoirs for runoff storage, offstream storage, seepage storage and regulating storage.

Runoff Storage

Reservoirs for storing runoff water generally are made by constructing an earth dam across a watercourse. (See Figure 6-37) They will vary in size from small excavated farm ponds to large impounding main stream reservoirs. Usually large reservoirs are built to furnish water to a group or groups of farmers through a legal organization, such as an irrigation or conservancy district. Small farm ponds usually are built for use on single farms or fields.

Gate Size - Inches	12	14	15	16	18	20	21	24	30	36	42	48	54
Gate Area - Sq. Ft.	.79	1.07	1.23	1.40	1.77	2.18	2.41	3.14	4.91	7.07	9.62	12.57	15.90
Hydr. Head - Feet													
.2	1.70	2.30	2.64	3.01	3.81	4.69	5.18	6.75	10.36	15.20	20.68	27.03	34.19
.4	2.40	3.25	3.74	4.26	5.38	6.63	7.33	9.55	14.95	21.54	29.32	38.31	48.47
.6	2.94	3.98	4.58	5.21	6.58	8.11	8.97	11.68	18.27	26.30	35.79	46.76	59.15
.8	3.40	4.60	5.29	6.02	7.61	9.37	10.36	13.50	21.11	30.40	41.37	54.05	68.37
1.0	3.80	5.15	5.92	6.73	8.51	10.49	11.59	15.10	23.62	34.01	46.27	60.46	76.48
1.2	4.16	5.64	6.48	7.38	9.34	11.49	12.70	16.55	25.88	37.26	50.70	66.24	83.79
1.4	4.49	6.08	6.99	7.95	10.05	12.38	13.69	17.84	27.89	40.16	54.64	71.40	90.31
1.6	4.65	6.30	7.24	8.25	10.43	12.84	14.19	18.49	28.92	41.64	56.66	74.04	93.65
1.8	5.10	6.91	7.95	9.04	11.43	14.08	15.57	20.28	31.72	45.67	62.15	81.20	102.71
2.0	5.37	7.28	8.36	9.52	12.04	14.82	16.39	21.35	33.39	48.08	65.41	85.48	108.12
2.2	5.64	7.64	8.78	10.00	12.64	15.57	17.21	22.42	35.06	50.48	68.69	89.75	113.53
2.4	5.89	7.98	9.18	10.44	13.20	16.26	17.98	23.42	36.63	52.74	71.77	93.77	118.61
2.6	6.13	8.30	9.53	10.84	13.69	16.85	18.62	24.24	37.87	54.50	74.13	96.85	122.49
2.8	6.36	8.61	9.90	11.27	14.25	17.55	19.40	25.28	39.53	56.91	77.44	101.19	128.00
3.0	6.58	8.91	10.25	11.66	14.74	18.16	20.08	26.16	40.90	58.89	80.13	104.71	132.45
3.2	6.80	9.21	10.59	12.05	15.24	18.77	20.75	27.04	42.28	60.87	82.83	108.23	136.90
3.4	7.01	9.49	10.91	12.42	15.70	19.34	21.38	27.85	43.55	62.71	85.33	111.50	141.03
3.6	7.21	9.77	11.23	12.78	16.16	19.90	22.00	28.67	44.83	64.55	87.83	114.76	145.17
3.8	7.41	10.04	11.54	13.13	16.60	20.45	22.61	29.45	46.06	66.32	90.24	117.92	149.14
4.0	7.60	10.29	11.83	13.47	17.03	20.97	23.18	30.21	47.23	68.01	92.54	120.93	152.96
4.2	7.79	10.55	12.13	13.80	17.45	21.49	23.76	30.96	48.41	69.71	94.85	123.95	156.77
4.4	7.97	10.88	12.41	14.13	17.86	22.00	24.32	31.68	49.54	71.34	97.07	126.83	160.43
4.6	8.15	11.04	12.69	14.45	18.27	22.50	24.87	32.40	50.67	72.96	99.28	129.72	164.09
4.8	8.33	11.28	12.96	14.76	18.66	22.98	25.40	33.10	51.75	74.52	101.39	132.49	167.59
5.0	8.50	11.51	13.23	15.06	19.05	23.46	25.93	33.79	52.83	76.07	103.51	135.25	171.08
5.2	8.67	11.74	13.49	15.36	19.42	23.91	26.44	34.45	53.86	77.56	105.53	137.89	174.42
5.4	8.83	11.96	13.75	15.65	19.79	24.37	26.94	35.11	54.89	79.04	107.55	140.53	177.76
5.6	9.00	12.19	14.01	15.95	20.16	24.83	27.45	35.76	55.92	80.53	109.57	143.17	181.10
5.8	9.16	12.40	14.26	16.23	20.51	25.27	27.93	36.39	56.91	81.94	111.50	145.69	184.28
6.0	9.31	12.60	14.49	16.49	20.85	25.68	28.39	36.99	57.84	83.28	113.32	148.07	187.30
6.2	9.46	12.82	14.74	16.77	21.20	26.12	28.87	37.62	58.82	84.70	115.25	150.59	190.48
6.4	9.61	13.02	14.97	17.04	21.54	26.53	29.33	38.21	59.75	86.04	117.08	152.98	193.50
6.6	9.76	13.23	15.20	17.30	21.88	26.94	29.79	38.81	60.69	87.39	118.90	155.37	196.52
6.8	9.91	13.43	15.44	17.57	22.21	27.36	30.25	39.41	61.62	88.73	120.73	157.75	199.55
7.0	10.06	13.62	15.66	17.82	22.53	27.75	30.68	39.97	62.50	90.00	122.46	160.02	202.41
7.2	10.20	13.81	15.88	18.07	22.85	28.14	31.11	40.54	63.39	91.27	124.19	162.28	205.27
7.4	10.34	14.01	16.10	18.33	23.17	28.54	31.55	41.10	64.27	92.55	125.93	164.54	208.13
7.6	10.48	14.20	16.32	18.58	23.49	28.93	31.98	41.67	65.16	93.82	127.66	166.80	210.99
7.8	10.62	14.38	16.53	18.82	23.79	29.30	32.39	42.20	65.99	95.02	129.29	168.94	213.70
8.0	10.75	14.56	16.74	19.05	24.09	29.67	32.80	42.74	66.83	96.22	130.93	171.08	216.40

Based on $Q = .6 A \sqrt{2gh}$ - Pipe Flowing Full with Outlet Submerged

Figure 6-46 Capacity of circular gates

Offstream Storage

Offstream storage should be considered if streamflow is not enough to provide the required amount of irrigation water or if damming a stream is not feasible. Floodflow in the stream may be diverted through a pipe or open ditch or pumped into an offstream reservoir. The reservoir is made by constructing an earth dam across a draw or small valley or by building a levee around an area of land.

Seepage Storage

Excavated reservoirs for intercepting and storing underground seepage water may be used in some localities as a water supply for irrigating small areas. The storage basin usually is excavated in a low-lying level area where the lateral movement of water underground replenishes the supply. A dependable excavated reservoir requires a high natural water table under adjacent lands and a highly pervious layer permitting the rapid lateral movement of water within practical excavated depths, usually 12 to 20 feet. The success of such a reservoir depends upon the rate of recharge because its capacity generally is small.

Regulating Storage

Regulating reservoirs are used where the stream is too small for continuous irrigation. They are built either by excavating a pit and using the spoil material to build a levee around it, or by building an earthen dam across a low area. Size is generally determined by the amount of water needed for one day's operation. The reservoir should be large enough to store all inflow while the irrigation system is not in operation. Irrigation water may be supplied by pumping from a low-producing well, diverting flow from a spring, or continuous small deliveries from canals and laterals. Often it is called an overnight-storage reservoir.

DIVERSION STRUCTURES

Where surface irrigation is practiced, the source of water is often the direct diversion of flow from a natural stream into a conveyance canal or ditch. Although temporary measures may be used to divert the water, a good system will use a permanent structure to raise the water level in the stream and force part of the flow into the irrigation ditch. Many types of structures are used for this purpose. The most common is one that uses stoplogs to adjust water levels and the diversion of flow.

Figure 6-47 shows a stoplog type of concrete structure used on creeks and small streams. Many states use various versions of standard plans for this type of structure. Some stoplog structures have provisions for a pump installation. These are used where water must be raised above the level of the stream or where the water is moved directly into a sprinkler system. Diversion structures used on wide stream subject to high floodflows may require provisions for the collapse of sections of the structure during the periods of high water to safely pass the floodflows.

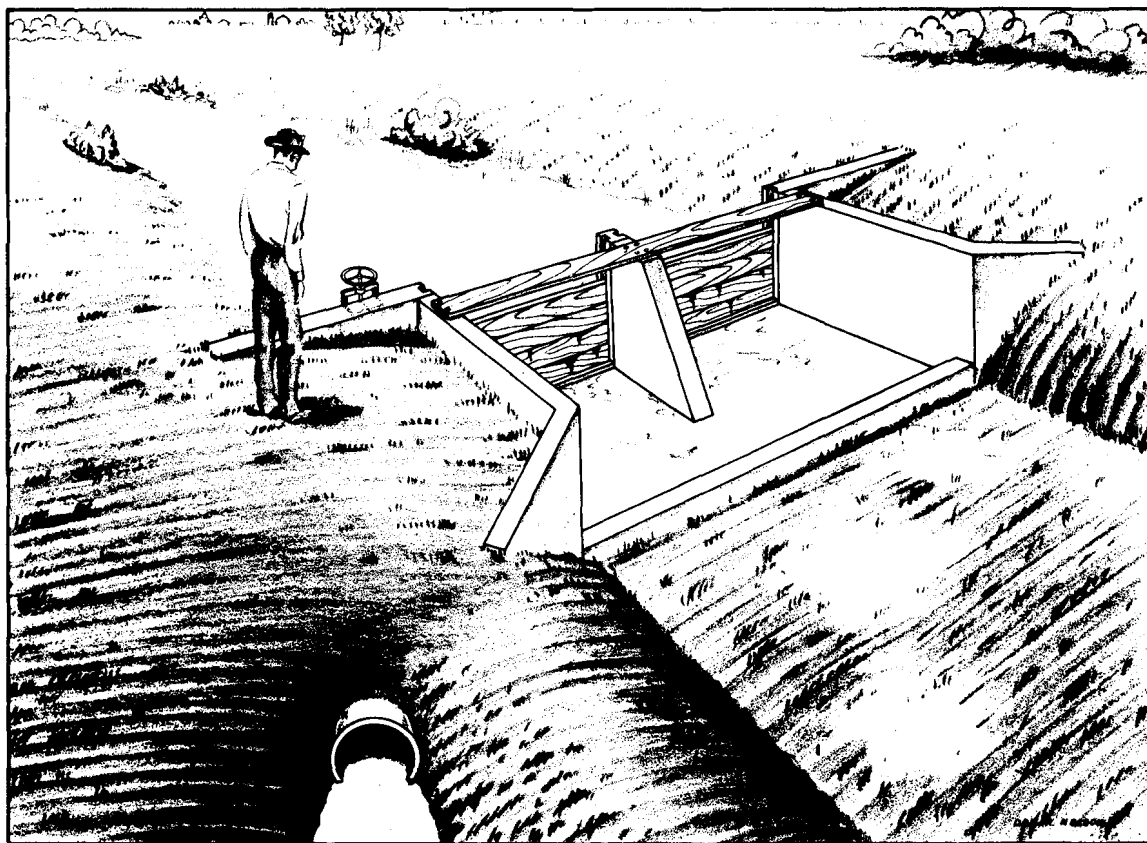


Figure 6-47 Stoplog type concrete diversion structure

DITCH CONVEYANCE STRUCTURES

Conveyance structures are used to transport water across or under obstructions, such as swales, draws, or roads, and to convey it along steep hillsides. They include flumes, inverted siphons, road culverts, and bridges.

Flumes

Flumes are artificial channels, supported by a substructure, for carrying water across areas where ditches are not practical. They are used to carry the water across draws or swales or to convey it along steep or rocky hillsides. These structures must have the capacity to carry the full discharge of the ditch, and the substructure must be strong enough to support the flume when flowing full. Timber, metal, or concrete are ordinarily the materials used for open flumes. Long span steel pipes may be used as a closed flume.

Inverted Siphons

An inverted siphon is a closed conduit with each end raised to form a U-shaped structure for carrying water under streams and drains or under roads and other obstructions. Inverted siphons usually are constructed of corrugated or smooth metal pipe, concrete pipe or reinforced concrete

poured in place. They are particularly adapted for conveying water under roads where the water level in the irrigation ditch is carried above the ground. The inverted siphon is different from a culvert in that the top of the pipe is lower than the water surface at either end, and the pipe always flows under pressure. See Figure 6-48

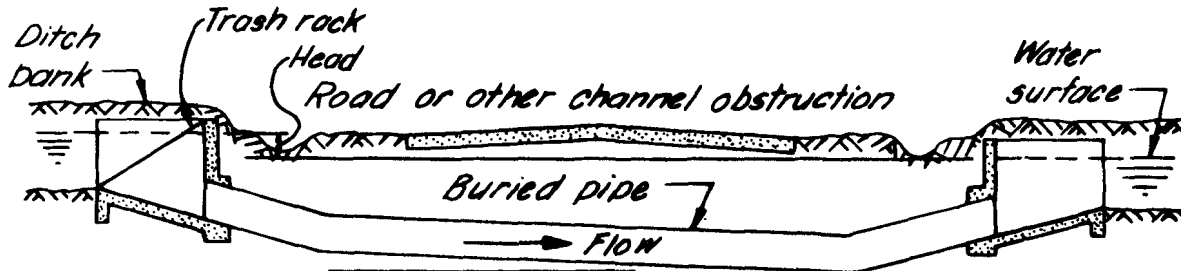


Figure 6-48 Cross section of an inverted siphon

Ditch Crossings

Ditch crossing structures for farm roads frequently are necessary for access to the fields. Culverts are most often used for this purpose. Corrugated metal, smooth metal or concrete are most commonly used for culverts. Inverted siphons are adapted for crossings where the water surface in the ditch is at a higher elevation than the road. Bridges are more often used on large ditches. They can be built so there is little or no head loss through the structure.

EROSION CONTROL STRUCTURES

Irrigation ditches are sometimes located where the ditch will have sufficient grade to produce erosive velocities. The eroded material will be deposited downstream, thereby reducing the ditch capacity. Drops, chutes, and pipelines are used to prevent such damages.

Drop Structures

The drop structure is used to control the ditch velocity by lowering the water abruptly from one level to another. This may be accomplished by using a drop spillway or a pipe drop structure. Figure 6-49 is an example of a standard plan for a concrete drop and Figure 6-50 shows a concrete block drop. Figure 6-51 is an example of a corrugated metal pipe drop.

Chutes

Chutes are paved or lined high-velocity open channels. They are adapted to short ditch sections on steep slopes or where drop structures would be so close together that a paved or lined ditch would be more practical. The paving or lining material for the chute must be able to withstand the high velocities. Chutes are most often constructed of concrete. They are complex in design and require the assistance of an engineer. A combination of a drop and chute, Figure 6-52, can sometimes be used where

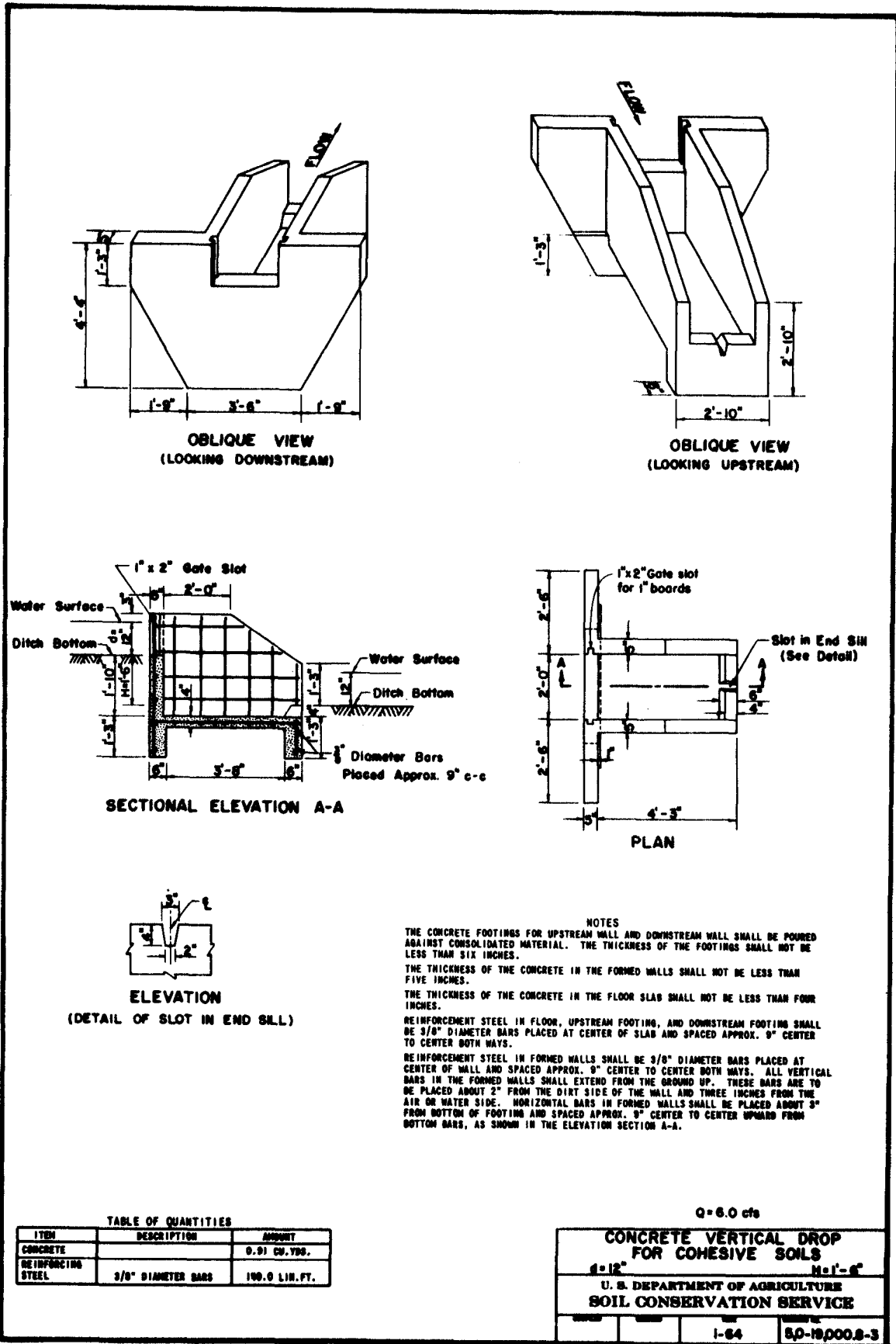


Figure 6-49 Plan for a concrete drop

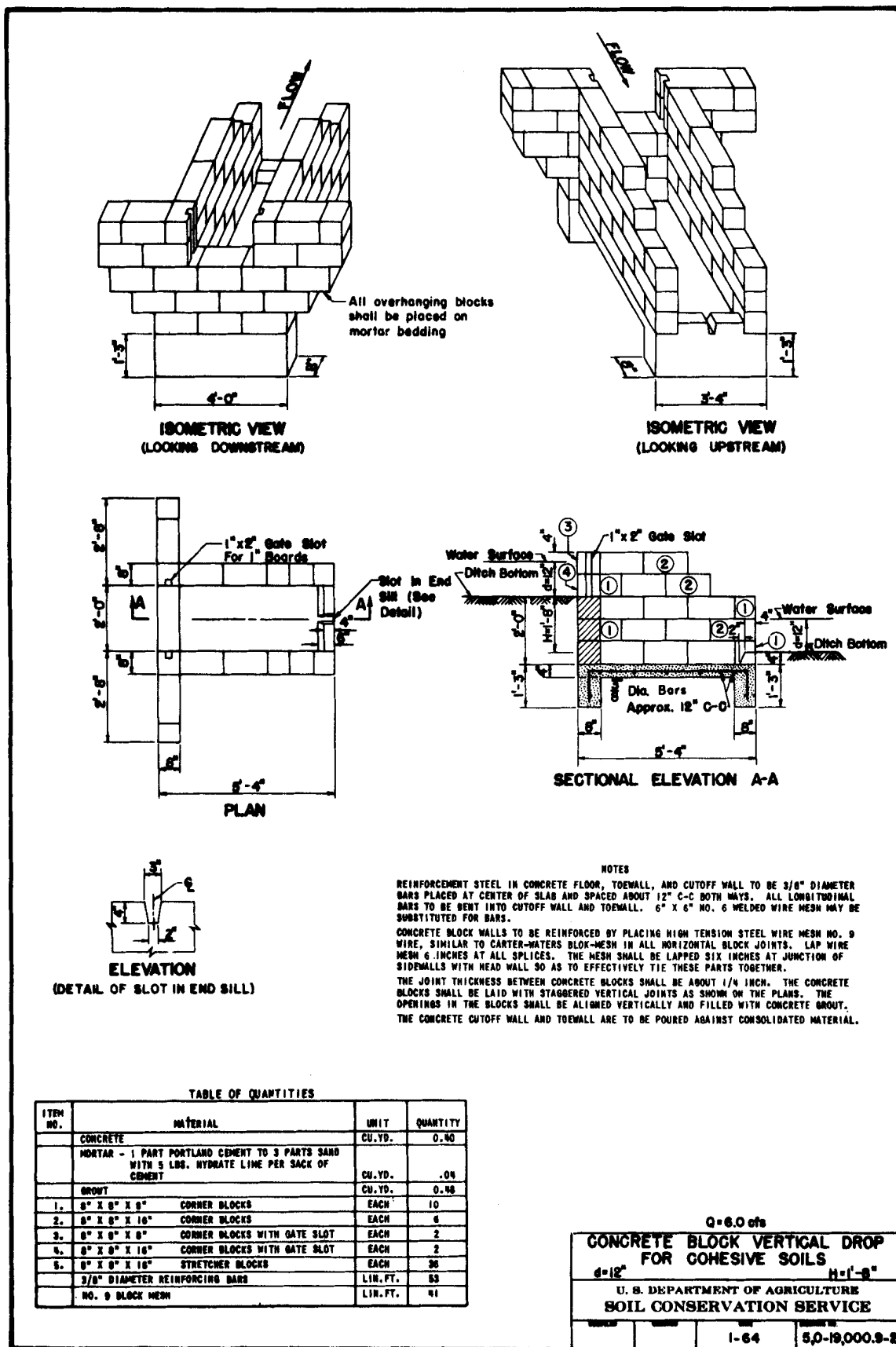


Figure 6-50 Plan for a concrete block drop

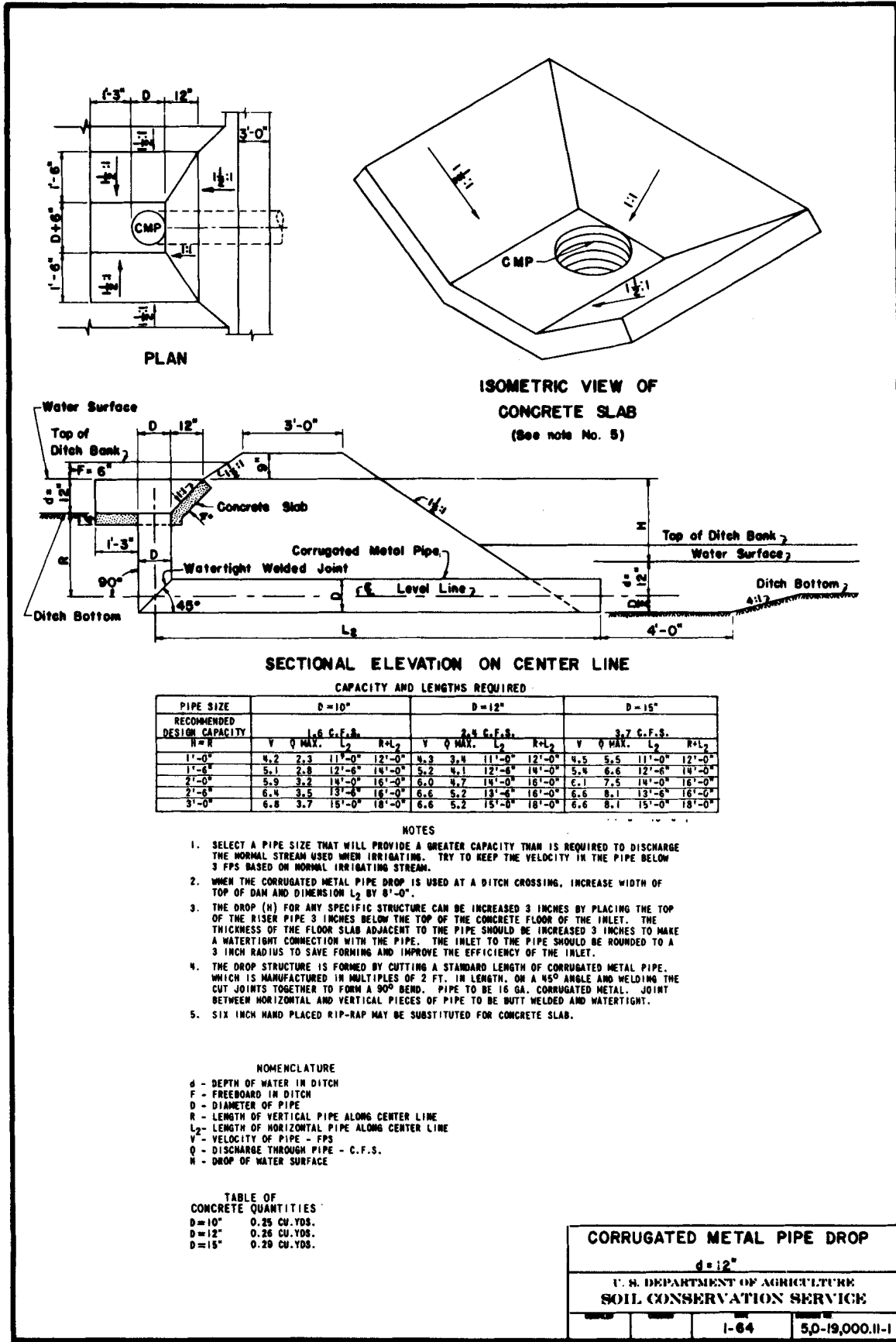


Figure 6-51 Plan for a corrugated metal pipe drop

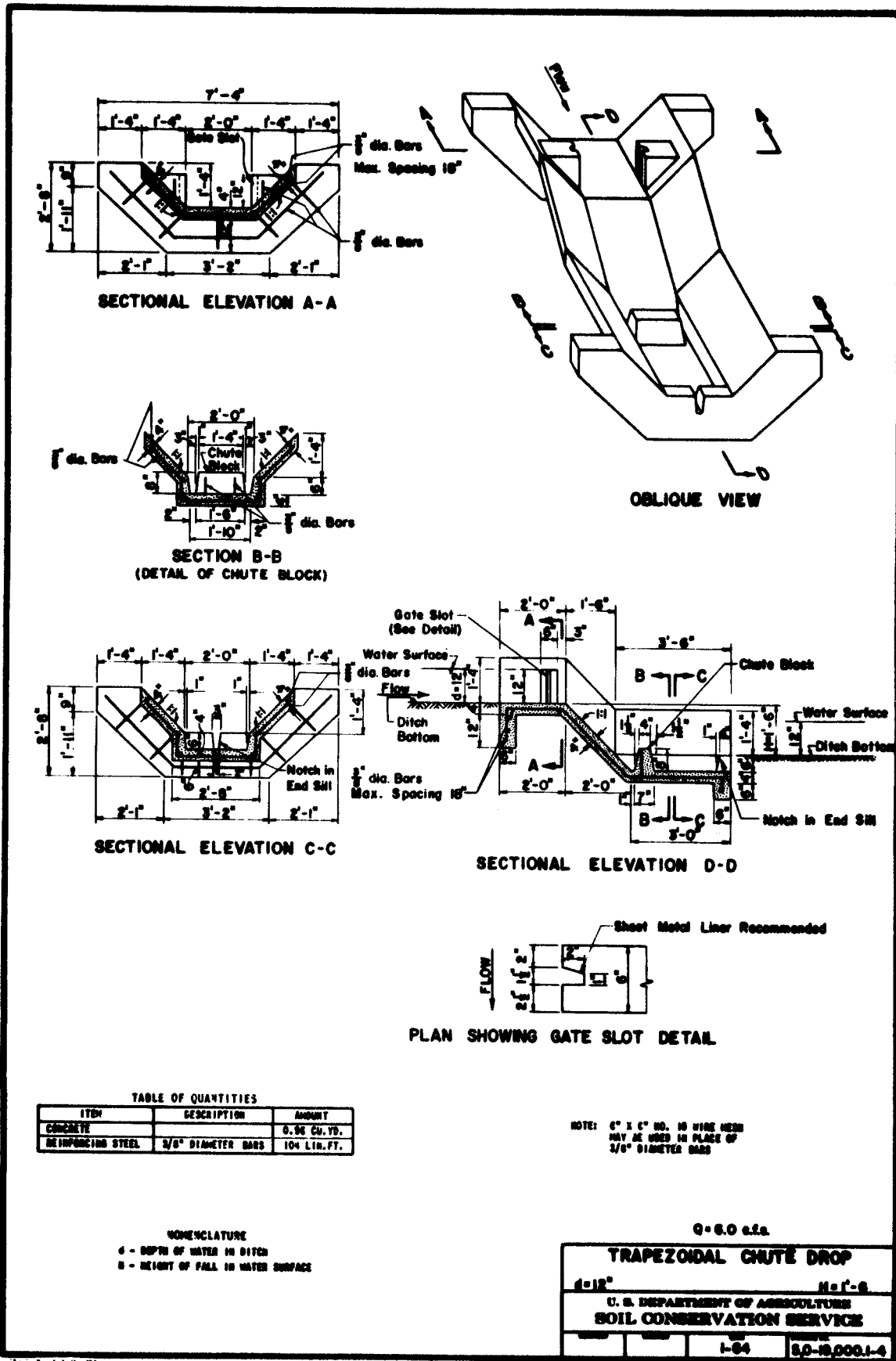


Figure 6-52 Plan for a trapezoidal chute drop

it is necessary to take up grade in a short distance like the drop between benches.

DISTRIBUTION CONTROL STRUCTURES

Distribution control structures are required for easy and accurate distribution of irrigation water to the various fields on the farm. Good control of the water permits efficient distribution and application and reduces the labor requirements. Distribution control structures include headgates, division boxes, checks, and turnouts.

Farm Headgates

The farm headgate is a gate-type structure used to divert the required amount of irrigation water from the farm source of supply into the farm field ditches. The headgate is generally equipped with some type of water-measuring device to determine the flow into the field ditch. Figure 6-53 is an example of a plan for a concrete headgate.

Division Boxes

A division box is a structure used to divide or direct the flow of water into two or more ditches. It is a box structure with the supply flow entering through an opening on one side. The other sides have openings equipped with gates of the required size to furnish the necessary flow to the field ditches. See Figure 6-54. Division boxes are used also with pump installations to control the flow from the pump into one of two or more field ditches. Figure 6-55 shows a combination pump outlet and division box.

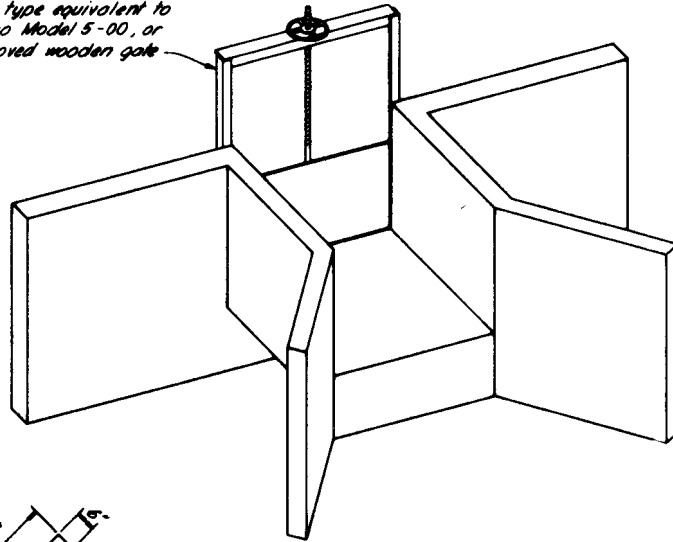
Checks

A check is a structure placed in a ditch to control the elevation of the water surface above the structure. The water level is raised as necessary so that it can be diverted from the ditch. Checks are either portable or permanent. Portable checks are removed after they have served their purpose for irrigating a given area and are reset for irrigating another area. The portable check is available commercially and is generally made of canvas, plastic, rubber, or metal. A permanent check is a headwall with a weir-type opening equipped with stoplogs or slide gates for adjusting the upstream elevation of the water surface. Figure 6-56 is a standard plan for one type of concrete check.

Turnouts

The turnout is a box or orifice-type structure located in the bank of the head ditch for controlling the flow of water from the head ditch into border strips, contour levee areas, and contour ditches. The structure is equipped with a simple slide gate for regulating the flow. Wooden or concrete boxes and concrete or metal pipe are generally used for turnouts. An example of a plan for a concrete turnout is shown in Figure 6-57.

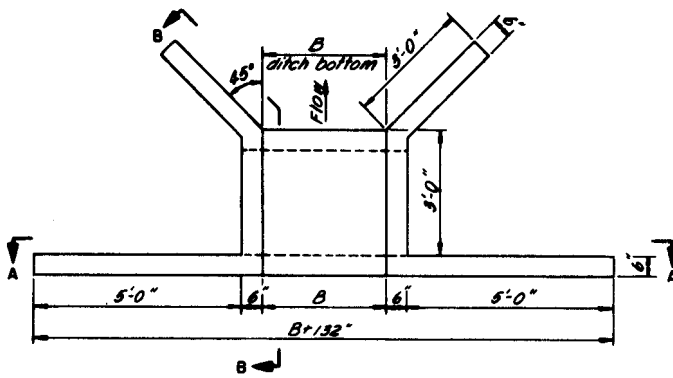
Headgate to be flat back steel type equivalent to Armco Model 5-00, or approved wooden gate.



ISOMETRIC VIEW

TABLE OF QUANTITIES

B	Concrete Cu. Yds.	Reinforcing steel Lbs.
3'-0"	2.24	154
4'-0"	2.37	163
6'-0"	2.58	180

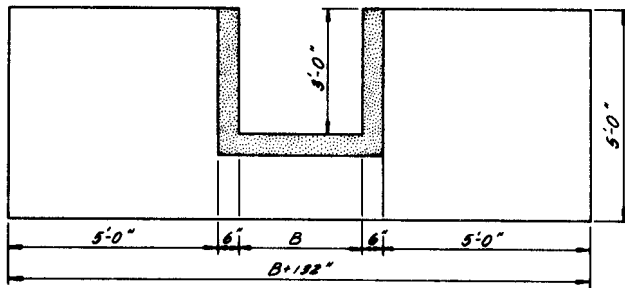


PLAN

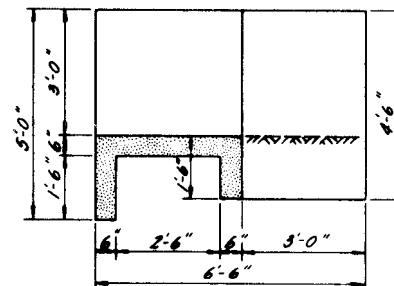
HEADGATE NOT SHOWN

Notes:

1. Reinforcing steel to be $\frac{1}{2}$ " diameter bars approximately 12" center to center, placed in center of slab.
2. Chamfer all exposed edges $\frac{3}{8}$ ".
3. B = bottom width of ditch.



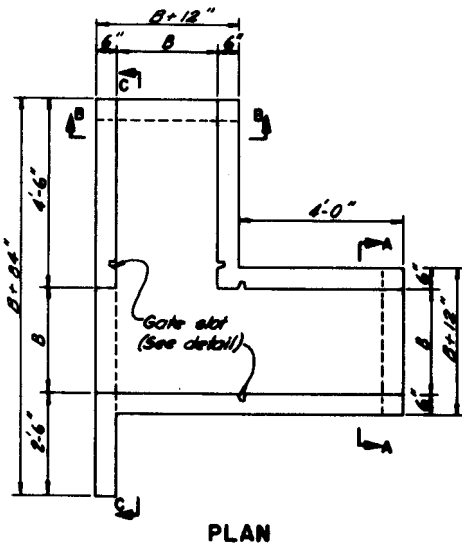
ELEVATION A-A
HEADGATE NOT SHOWN



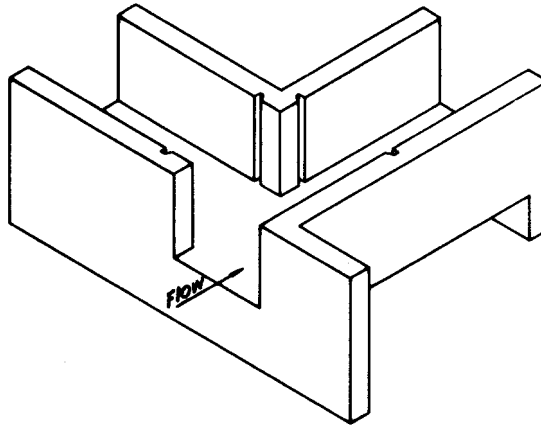
SECTIONAL ELEVATION B-B
HEADGATE NOT SHOWN

CONCRETE HEADGATE STRUCTURE	
B = 3'-0", 4'-0", 6'-0"	
U. S. DEPARTMENT OF AGRICULTURE	
SOIL CONSERVATION SERVICE	
1-64	50-19,000.34-1

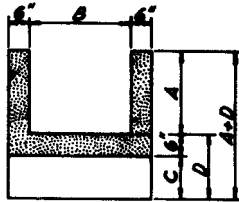
Figure 6-53 Plan for a concrete headgate



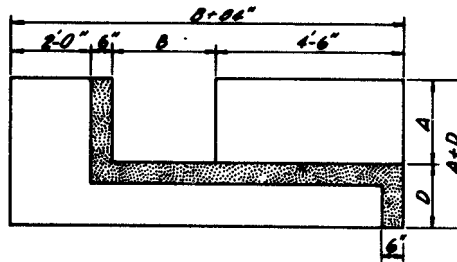
PLAN



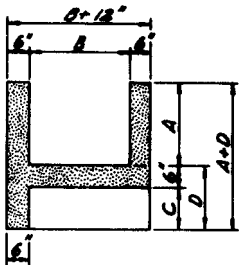
ISOMETRIC VIEW



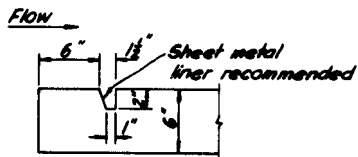
SECTIONAL ELEVATION A-A



SECTIONAL ELEVATION C-C



SECTIONAL ELEVATION B-B



DETAIL OF GATE SLOT

TABLE OF DIMENSIONS AND QUANTITIES

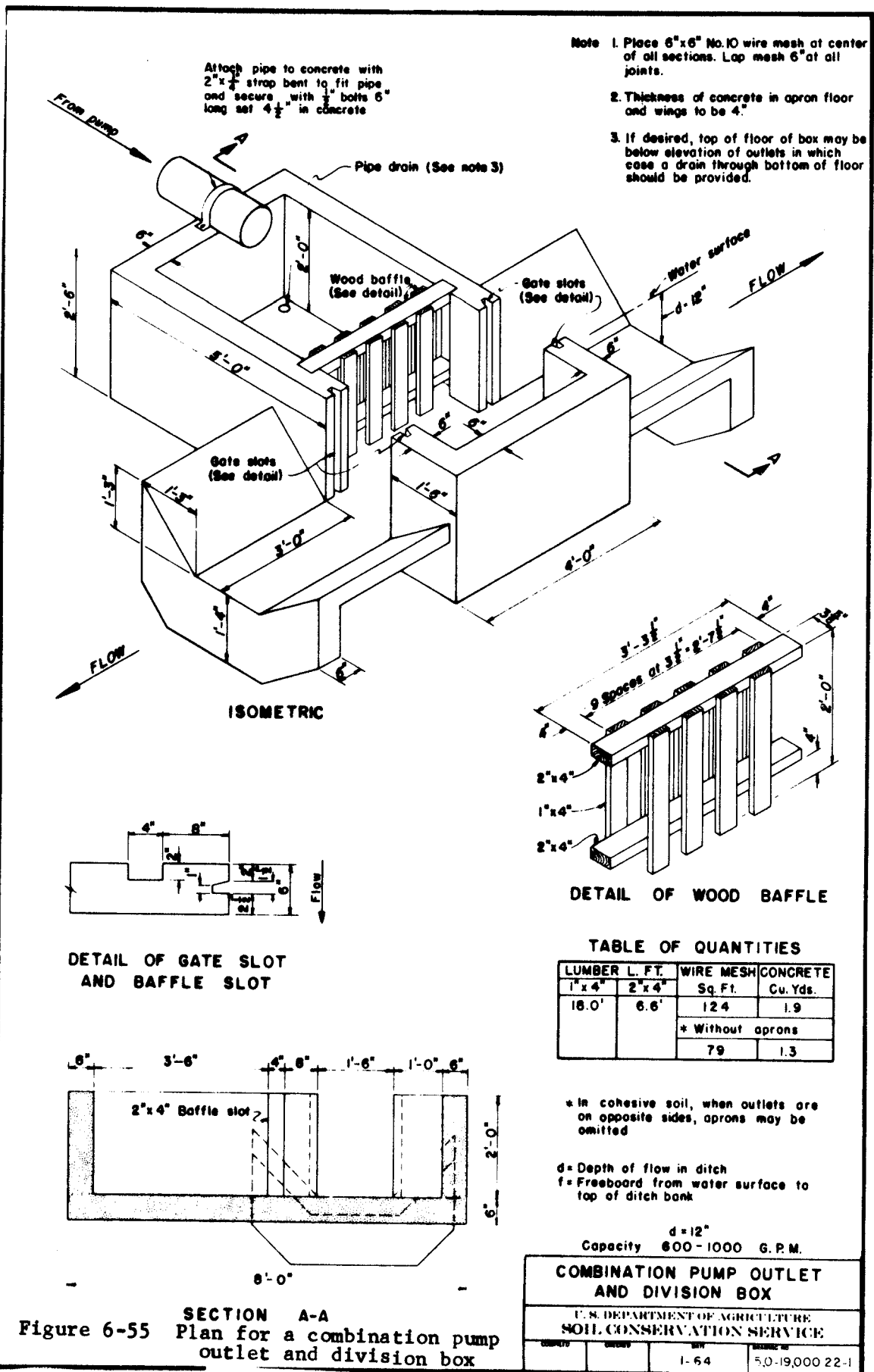
A	B	C	D	Concrete Cu. Yd.	Steel Lin. Ft.
2'-0"	2'-6"	1'-0"	1'-6"	1.87	224
2'-0"	3'-6"	1'-6"	2'-0"	2.46	276
2'-0"	4'-6"	1'-6"	2'-0"	2.91	324
3'-0"	2'-6"	1'-6"	2'-0"	2.46	285
3'-0"	3'-6"	1'-6"	2'-0"	2.89	332
3'-0"	4'-6"	1'-6"	2'-0"	3.37	382

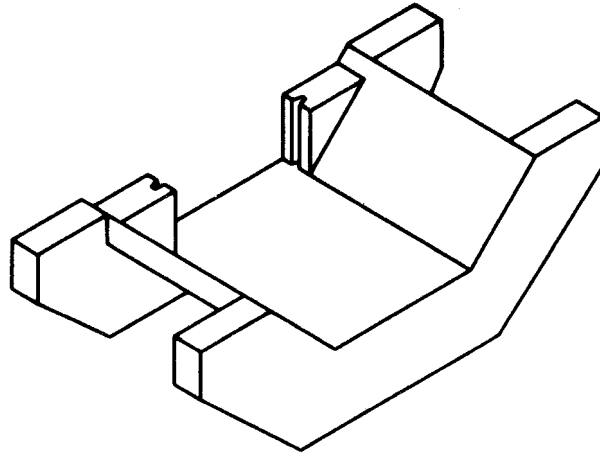
A - Height of sidewalls
 B - Width of flow pattern
 C - Depth of well below slab
 D - Depth of well including slab

Note:
 Reinforcement to be 3/8" dia. reinforcing bars on 12" c-c placed in center of concrete slab 6" x 6". No. 10 wire mesh may be used in place of 3/8" dia. reinforcing bars.

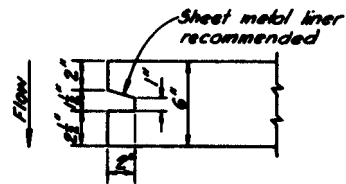
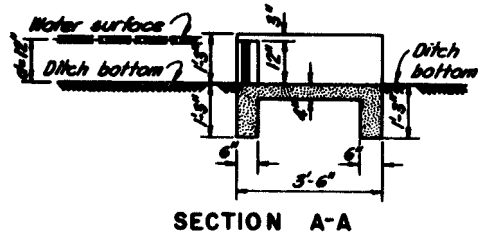
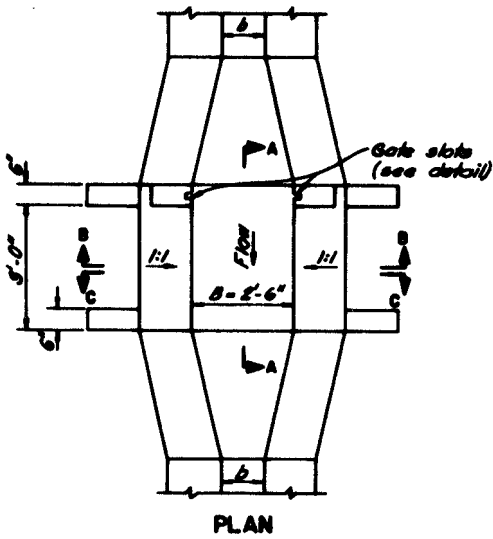
CONCRETE RECTANGULAR DIVISION BOX	
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	
1-64	5,0-19,000.13-1

Figure 6-54 Plan for a concrete rectangular division box





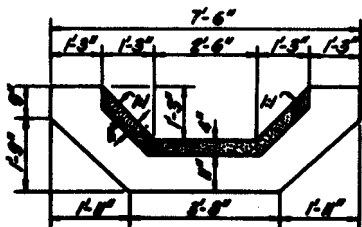
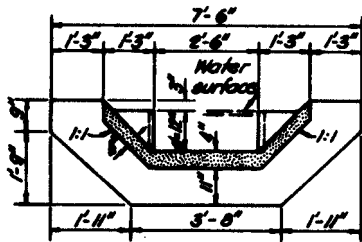
ISOMETRIC VIEW



Concrete quantity = 0.60 cu. yd.

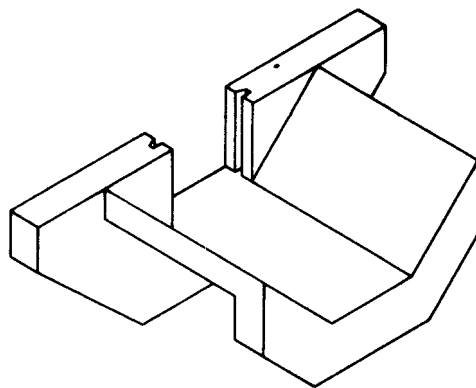
NOMENCLATURE

- B = Bottom width of structure
- b = Bottom width of ditch
- d = Depth of water in ditch

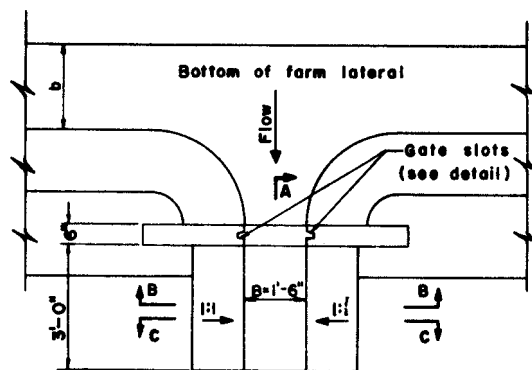


CONCRETE CHECK	
6'-12"	8'-2'-6"
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	
1-64	SO-2000B-1

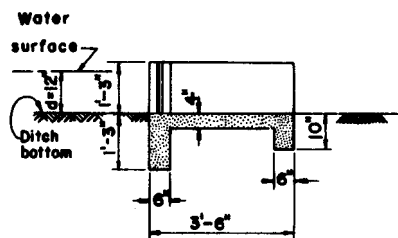
Figure 6-56 Plan for a concrete check



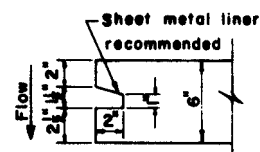
ISOMETRIC VIEW



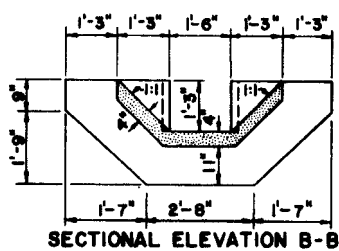
PLAN



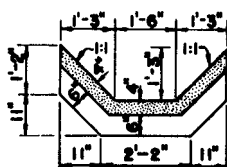
SECTION A-A



DETAIL OF GATE SLOT



SECTIONAL ELEVATION B-B



SECTIONAL ELEVATION C-C

Concrete quantity = 0.44 cu. yd.

NOMENCLATURE
 B = Bottom width of structure
 b = Bottom width of ditch
 d = Depth of water in ditch

CONCRETE TURNOUT	
$d = 12"$	$B = 1'-6"$
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Figure 6-57 Plan for a concrete turnout

PIPELINE STRUCTURES

The distribution of irrigation water by means of low-head underground pipelines has many advantages in conserving soil, water and labor. On sloping lands, erosion that could occur in open ditches is eliminated. In a properly designed system with sealed joints, the loss of water by seepage is reduced to minor amounts. Labor can be saved by means of the controls that are used to quickly turn water on and off or to shift the delivery to other points.

Some typical examples of the structures commonly used in pipeline systems are described in the following paragraphs.

Inlets

Inlets to move water from a supply source into the pipe are first structures in a system. Where water is obtained by pumping, a pump inlet stand such as in Figures 6-58 or 6-59 may be used. If clean water is to be taken directly from an irrigation ditch, a simple inlet such as that in Figure 6-60 can be used. Sometimes, water from an open ditch contains sediment, small debris, or weed seeds that could create problems. In this event, structures such as those in Figure 6-61 are used to settle and screen out the objectionable materials at the inlet. Or, in cases of sand only, a trap such as that in Figure 6-62 may be placed in the system.

Vents

Air trapped in pipelines can cause erratic flow conditions. To prevent this, vents are used at high points in the lines and where the line makes abrupt changes in grade. A simple type of vent is illustrated in Figure 6-63.

Outlets

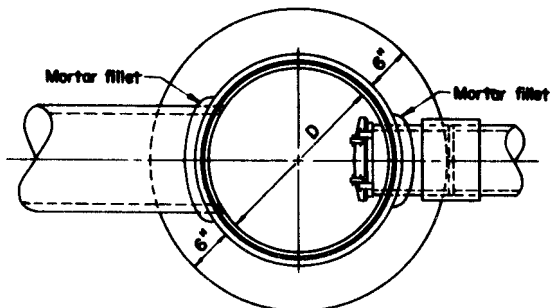
In any pipeline system, outlets are used to control the discharge of water at selected points in the area to be irrigated. The two most common valves are the Alfalfa Valve, Figure 6-64, and the Orchard Valve, Figure 6-65.

Further discussion and examples of pipeline structures can be found in Chapter 3, Section 15, N.E.H. Also, locally adopted standard plans may be available.

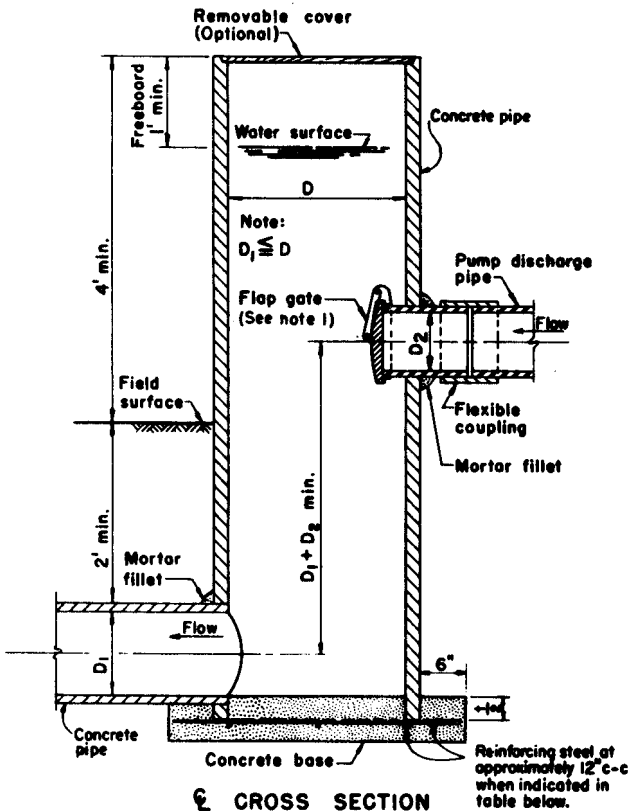
19. STRUCTURE DESIGN

After information needed for a structure design has been obtained by a field survey, it and other pertinent information should be recorded on a structure data sheet or plan. All recorded information, calculations, and design data should be checked for accuracy.

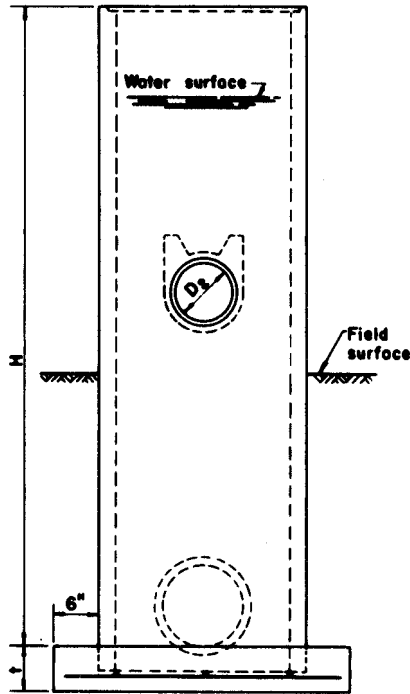
The detailed structure design develops the overall plan for the structure as indicated on the structure data sheet. Such items as dimensions of the various parts of the structure, spacing of steel reinforcing bars in



PLAN



CROSS SECTION



ELEVATION

Notes:

1. When $D \leq 27"$ or when D_2 is greater than $\frac{1}{2} D$ eliminate flap gate and use a check valve in pump discharge pipe.

NOMENCLATURE

- D - Diameter of vertical pipe
- D_1 - Diameter of underground pipe
- D_2 - Diameter of pump discharge pipe
- t - Thickness of concrete base
- H - Height of vertical pipe above top of concrete base
- Q - Discharge through structure in cfs. and g.p.m.

Max. Q	D	A.S.T.M. Spec.	Concrete Base				Reinforcing steel	
			H=10' or less	H=more than 10'	Size	Length		
c. f. s.	g. p. m.	inches	†	Cu. yd.	†	Cu. yd.		
0.79	355	12	4"	0.05	6"	0.07	—	—
1.07	480	14	4"	0.05	6"	0.08	—	—
1.23	550	15	4"	0.06	6"	0.09	—	—
1.40	630	16	4"	0.06	6"	0.10	—	—
1.77	795	18	4"	0.07	6"	0.11	—	—
2.18	960	20	6"	0.13	8"	0.17	—	—
2.41	1080	21	6"	0.14	8"	0.18	—	—
3.14	1410	24	6"	0.16	8"	0.22	—	—
3.98	1785	27	6"	0.20	8"	0.26	$\frac{3}{8}"$	19'
4.91	2208	30	6"	0.23	8"	0.30	$\frac{3}{8}"$	21'
5.94	2665	33	6"	0.35	8"	0.35	$\frac{3}{8}"$	22'
7.07	3175	36	8"	0.39	8"	0.39	$\frac{3}{8}"$	23'
9.62	4320	42	8"	0.50	8"	0.50	$\frac{3}{8}"$	38'
12.57	5640	48	8"	0.62	8"	0.62	$\frac{1}{2}"$	46'

Figure 6-58 Plan for high head non-tapered pump stand for concrete pipe

HIGH HEAD NON-TAPERED PUMP STAND FOR CONCRETE PIPE

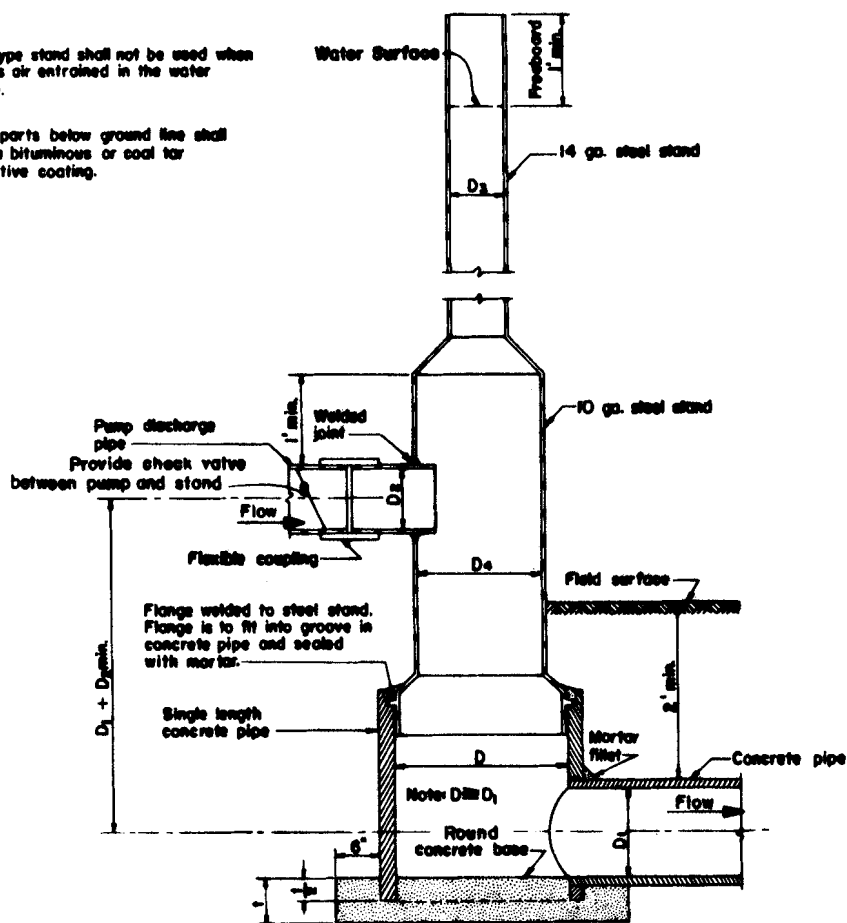
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Note: This type stand shall not be used when there is air entrained in the water source.

Metal parts below ground line shall have a bituminous or coal tar protective coating.



6 CROSS SECTION

NOMENCLATURE

- D - Diameter of vertical concrete pipe
- D₁ - Diameter of underground pipe
- D₂ - Diameter of pump discharge pipe
- D₃ - Diameter of upper steel stand pipe
- D₄ - Diameter of lower steel stand pipe
- t - Thickness of concrete base
- Q - Discharge through structure in c.f.s. and g.p.m.

Max. Q		Concrete Pipe			Steel Stand				Concrete Base	
c.f.s.	g.p.m.	D	A.S.T.M. Spec.	Type	D ₄ Min.	D ₃ Min.	t	Volume		
		Inches	No.		Inches Gage	Inches Gage	Inches	Cu. yd.		
0.79	355	12	C-118	Concrete Irrigation Pipe	8 1/2	10 3 7/8	14	4	0.05	
1.07	480	14	C-118		10	10 4 1/2	14	4	0.05	
1.23	550	15	C-118		10 5/8	10 4 3/4	14	4	0.06	
1.40	630	16	C-118		11 3/8	10 5 1/8	14	4	0.06	
1.77	795	18	C-118		12 3/4	10 5 3/4	14	4	0.07	
2.18	980	20	C-118		14 1/4	10 6 3/8	14	6	0.13	
2.41	1080	21	C-118		14 7/8	10 6 3/4	14	6	0.14	
3.14	1410	24	C-118		17	10 7 5/8	14	6	0.16	
3.98	1785	27	C-76		19 1/8	10 8 5/8	14	6	0.20	
4.91	2205	30	C-76		21 1/4	10 9 1/2	14	6	0.23	
5.94	2665	33	C-76	Reinforced Concrete Pipe	23 3/8	10 10 1/2	14	8	0.35	
7.07	3175	36	C-76		25 1/2	10 11 1/2	14	8	0.39	
9.62	4320	42	C-76		29 3/4	10 13 3/8	14	8	0.50	
12.57	5640	48	C-76		34	10 15 1/4	14	8	0.62	

Figure 6-59 Plan for a high head steel tapered pump stand for concrete pipe

HIGH HEAD STEEL TAPERED PUMP STAND FOR CONCRETE PIPE

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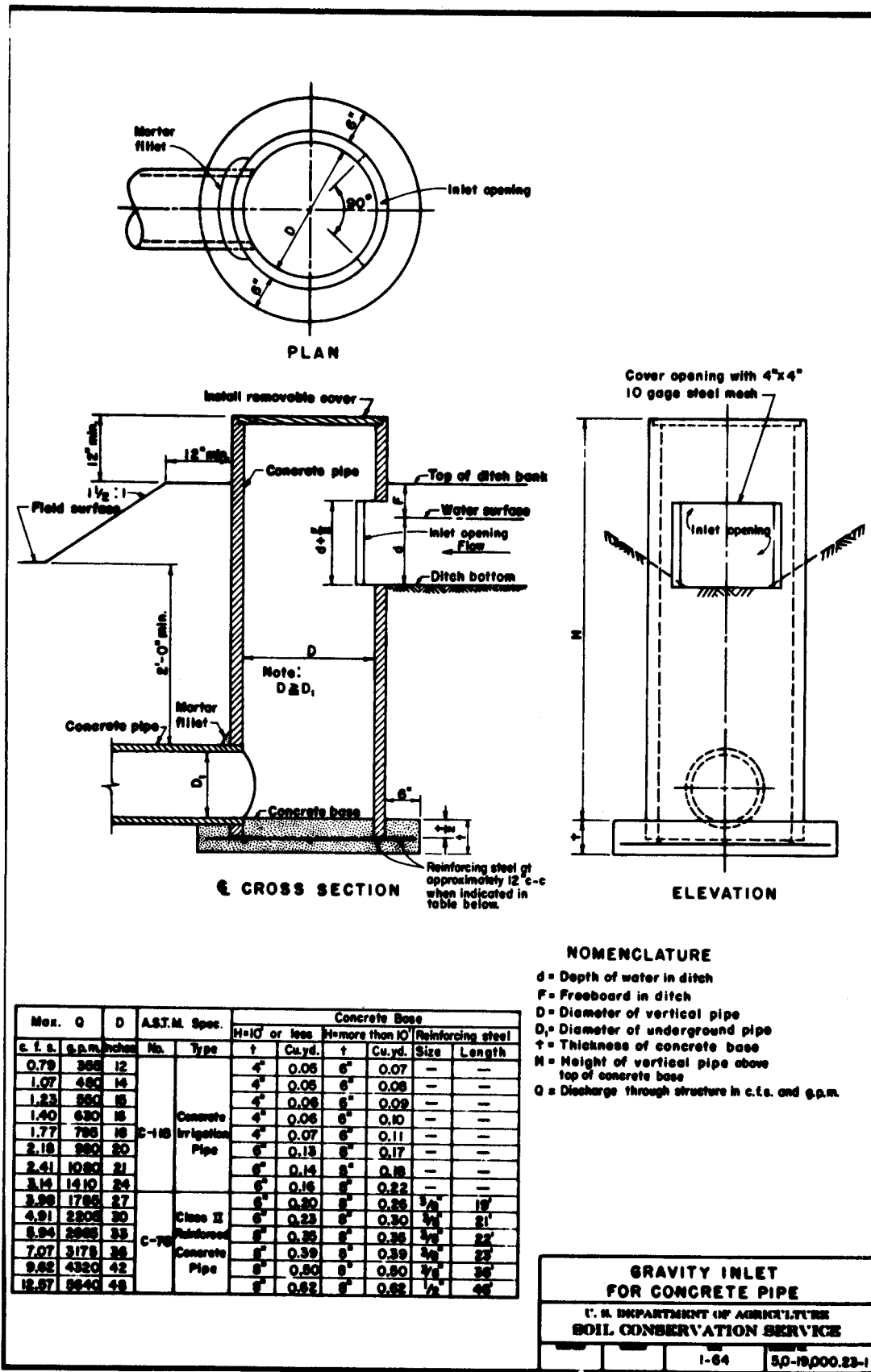


Figure 6-60 Plan for a gravity inlet for concrete pipe

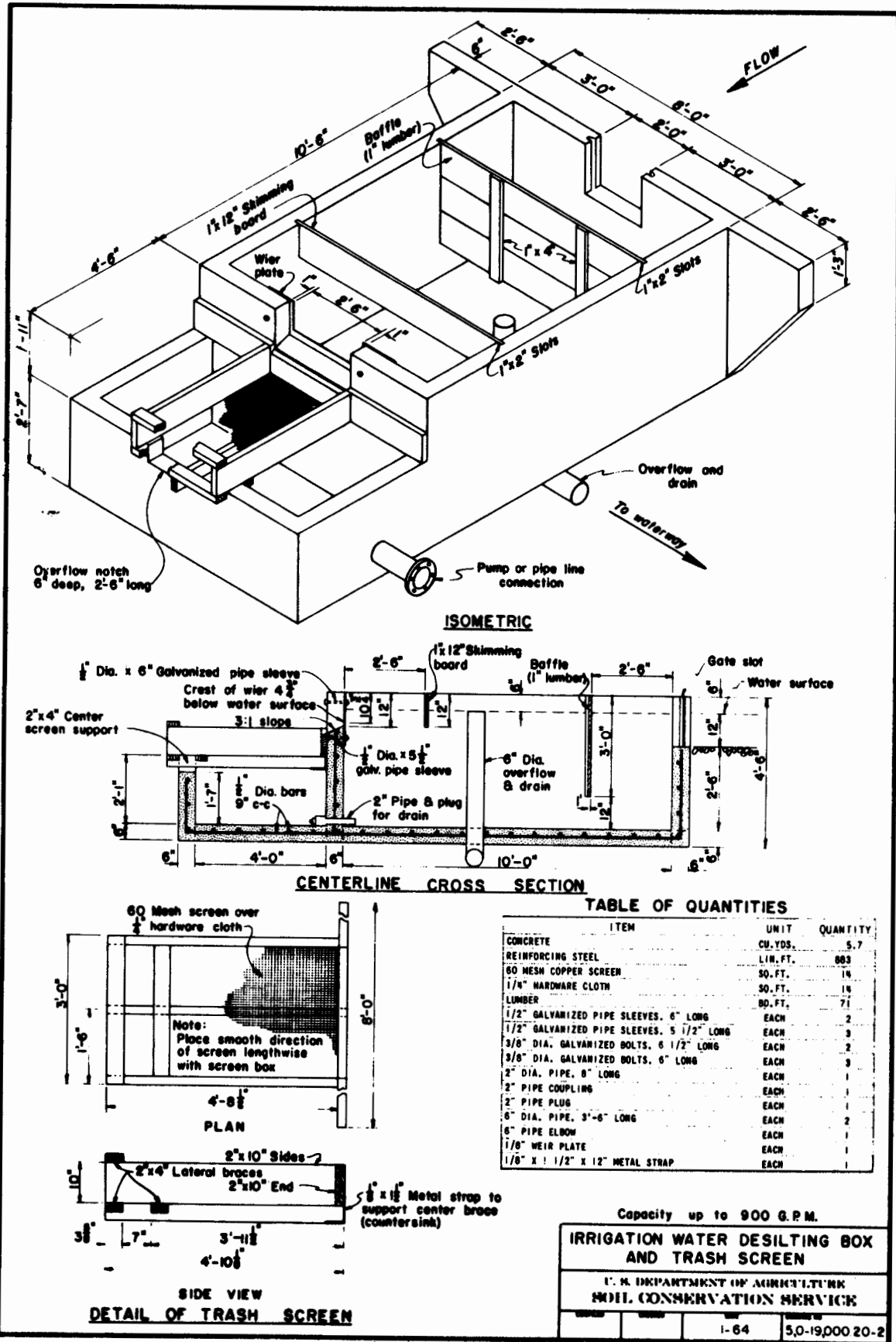
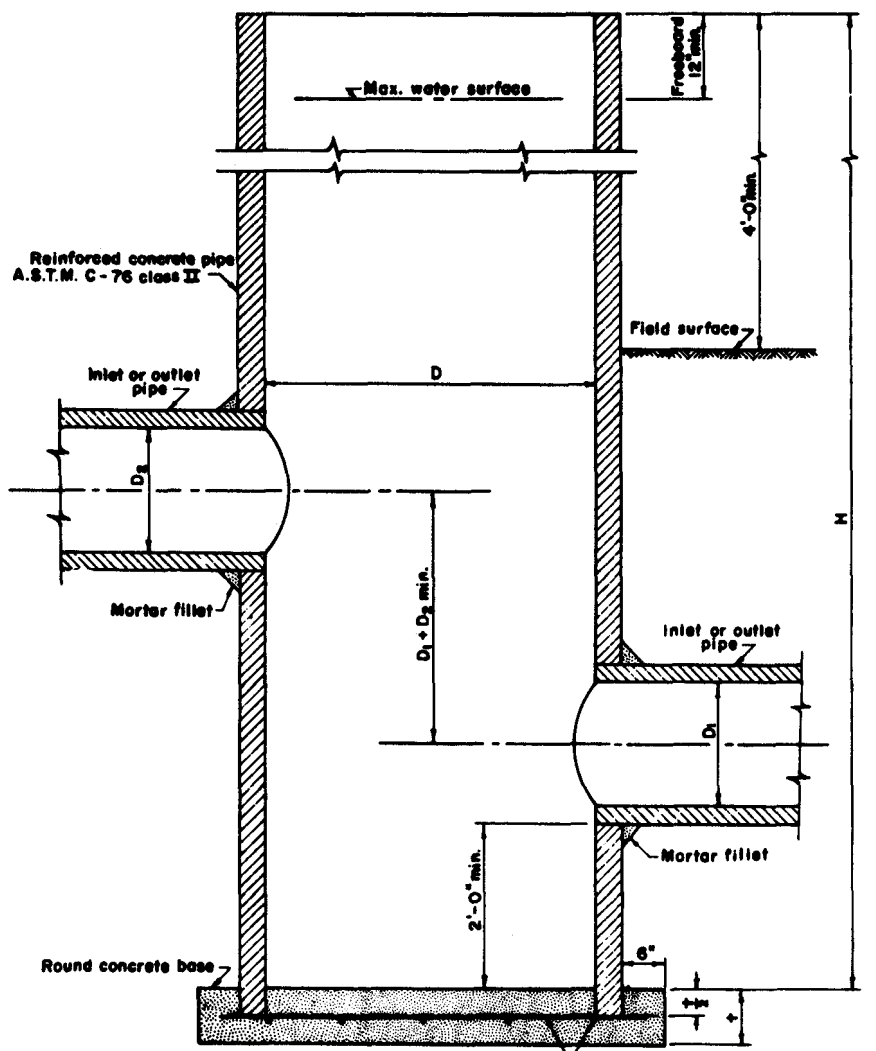


Figure 6-61 Plan for a water desilting box and trash screen



CROSS SECTION

Reinforcing steel at approximately 12" c-c both ways. Size as shown in table below.

NOMENCLATURE

- D = Diameter of vertical concrete pipe
- D₁ = Diameter of inlet or outlet pipe
- D₂ = Diameter of inlet or outlet pipe
- t = Thickness of concrete base
- H = Height of vertical concrete pipe above top of concrete base
- Q = Discharge through structure in c.f.s. and g.p.m.

Max. Q	D	Concrete Base							
		H=10' or less		H=more than 10'		Reinforcing steel		Size	Length
c.f.s.	s.p.m.	inches	t	cu. yd.	t	cu. yd.			
1.22	550	30	6"	.23	6"	.30	3/8"	21'	
1.49	670	33	6"	.35	6"	.36	3/8"	22'	
1.77	795	36	6"	.39	6"	.39	3/8"	23'	
2.40	1075	42	6"	.50	6"	.50	3/8"	30'	
3.14	1410	48	6"	.62	6"	.62	1/2"	46'	
3.99	1785	54	6"	.76	6"	.76	1/2"	53'	
4.90	2300	60	6"	.91	6"	.91	1/2"	71'	

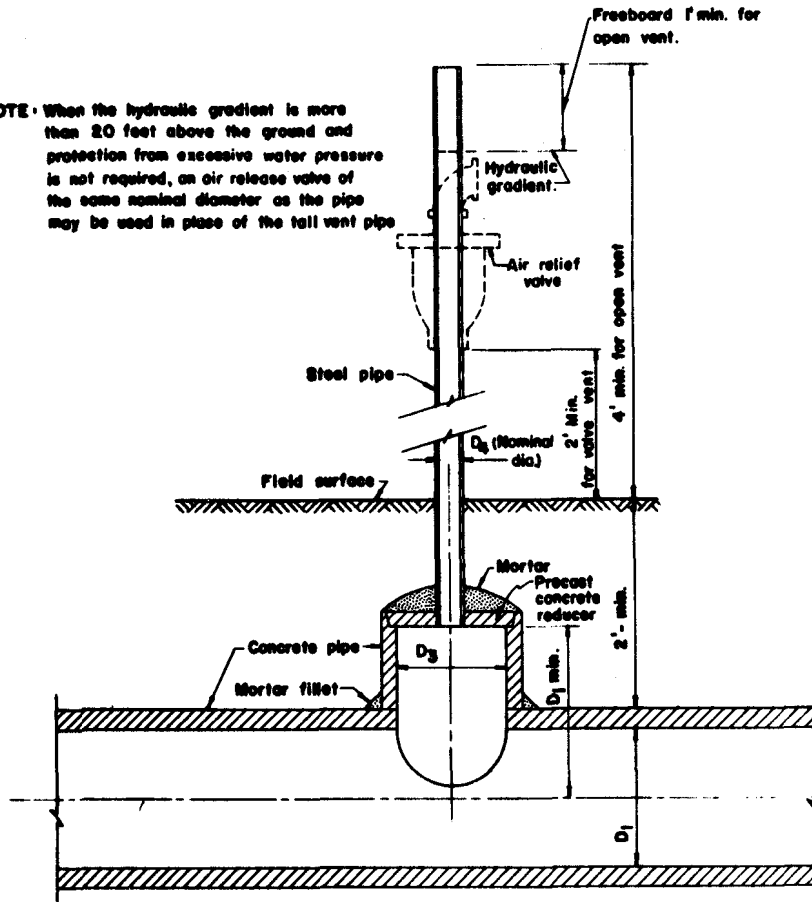
**CONCRETE PIPE SAND TRAP
FOR CONCRETE PIPE LINE**

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Figure 6-62 Plan for a concrete pipe sand trap for concrete pipe

NOTE: When the hydraulic gradient is more than 20 feet above the ground and protection from excessive water pressure is not required, an air release valve of the same nominal diameter as the pipe may be used in place of the tall vent pipe



§ CROSS SECTION

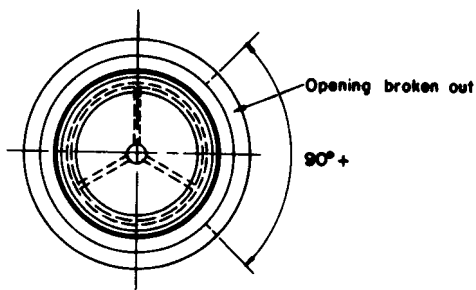
D ₁ Inches	D ₃ Min. Inches	D ₄ Min. Nominal Dia. Inches
8	6	2
10	8	2
12	10	2
14	10	2
16	12	2
16	12	2 1/2
18	14	2 1/2
20	16	3
21	16	3
24	18	3 1/2

NOMENCLATURE

- D₁ - Diameter of underground concrete pipe
- D₃ - Diameter of concrete vent pipe
- D₄ - Diameter (nominal) of steel vent pipe

VENT FOR CONCRETE PIPE LINES	
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Figure 6-63 Plan for a vent for concrete pipelines



PLAN

NOMENCLATURE

- D—Diameter of riser pipe and nominal diameter of alfalfa gate
- D₁—Diameter of underground concrete pipe

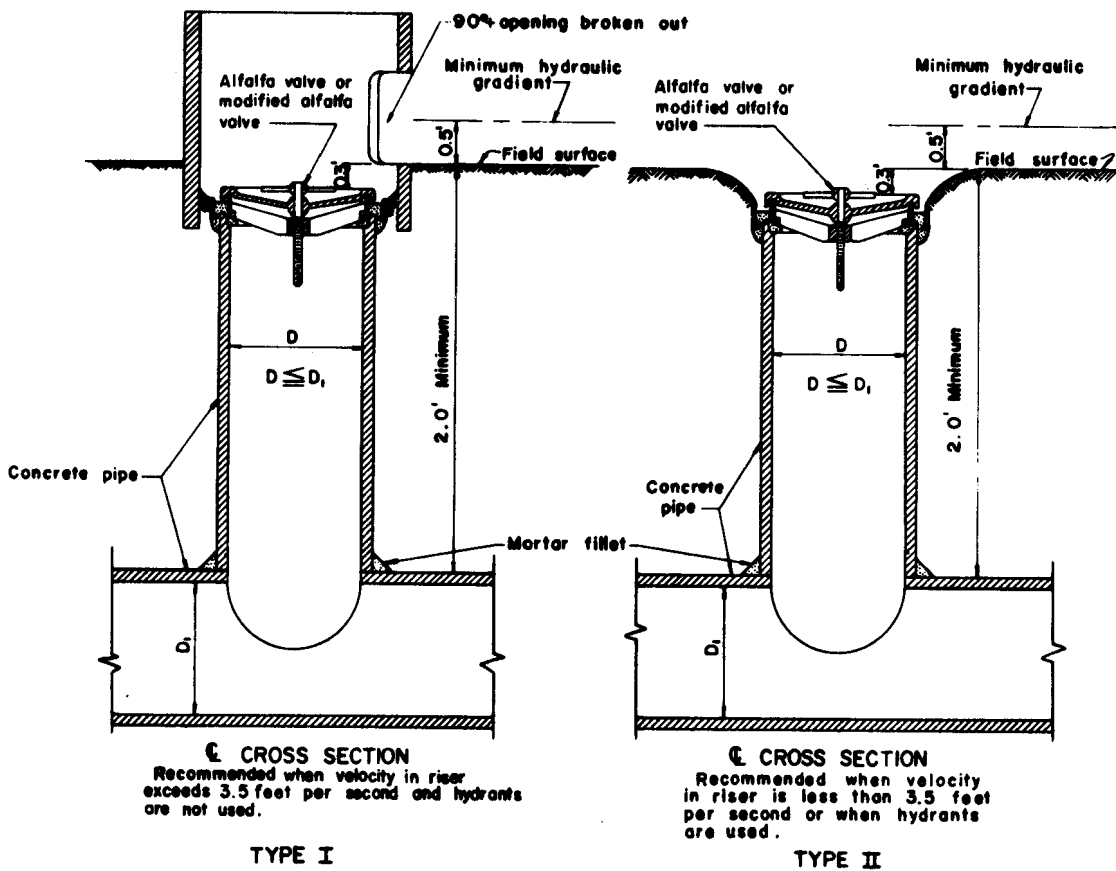
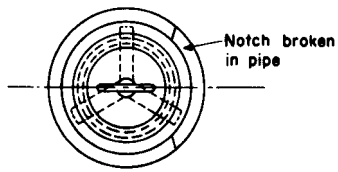


Figure 6-64 Plan for an alfalfa valve outlet on a concrete pipeline

ALFALFA VALVE or MODIFIED ALFALFA VALVE OUTLET for CONCRETE PIPE LINES
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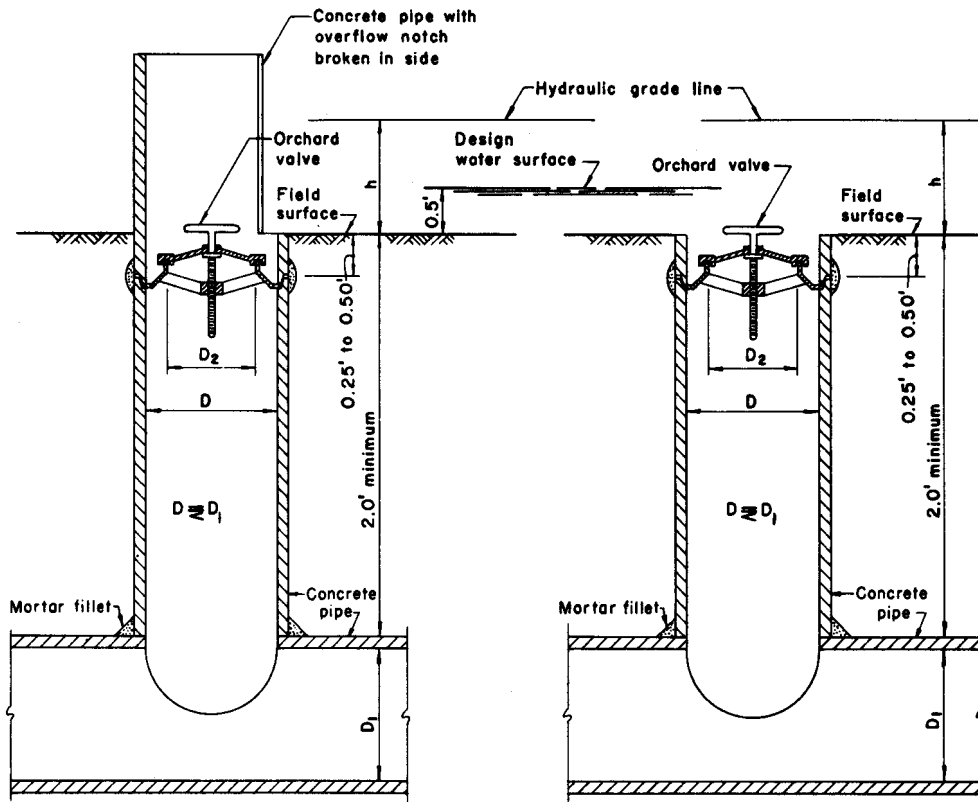
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PLAN

NOMENCLATURE

- D - Diameter of concrete riser pipe
- D_1 - Diameter of underground concrete pipe
- D_2 - Diameter of valve outlet
- h - Height of hydraulic grade line above field surface



TYPE I
 ⌀ CROSS SECTION

TYPE II
 ⌀ CROSS SECTION

Figure 6-65 Plan for an orchard valve outlet on a concrete pipeline

ORCHARD VALVE OUTLET FOR CONCRETE PIPE LINES			
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DRAWN BY	CHECKED	DATE	DRAWING NO.
		1-64	5,0-19,000.30-1

reinforced concrete, and location of construction joints are examples of required detail. Detailed designs are the responsibility of the engineer.

In the Soil Conservation Service two types of structure designs are used:

1. Standard designs. These are designs prepared in advance to fit various combinations of conditions. Some standard designs or plans have blank spaces for fill-in dimensions and quantities, thus they can be adapted to a given location. Modifications in standard structure designs should be made only by an engineer having that authority.
2. Special designs. These are prepared to fit the site when standard designs are not applicable. They are "tailor-made" designs, made after properly prepared and approved data sheets have been submitted to the design engineer.

20. CONSTRUCTION

Adequate structure designs and plans will not make a good structure unless sound construction techniques are used during its installation. Chapter 17 of this manual provides these techniques. It is also necessary to follow all specifications accompanying the structure plans.

Good quality construction can be promoted by laying the proper groundwork with the farmer. This involves:

1. Emphasizing the need for using construction materials of acceptable quality.
2. Emphasizing the importance of building the structure as planned and designed.

Timely technical assistance should be given both before and during the actual construction by:

1. Providing sufficient stakes for construction purposes, and checking the staking.
2. Explaining the stakes to the farmer and the contractor, making sure they understand their purpose and the need for protecting them.
3. Providing the farmer and contractor with plans and specifications prior to construction.
4. Explaining the construction details to the farmer or contractor.
5. Providing timely supervision and checking during the construction period.

21. MAINTENANCE

All structures need maintenance for satisfactory operation and to prolong their life, thereby reducing replacement cost. Owners should be urged to inspect structures at least once annually and at other opportune times. Cracks that develop should be sealed, protective coatings applied where needed, and modifications, riprap, or repairs made where and when they are necessary. Often a small repair job will prevent a large repair job, or even complete failure, later on. Debris or obstructions at the inlet or outlet of structures should be removed immediately. Check for destructive action of burrowing rodents under the structure and through adjacent earth embankments.

For preventative maintenance protect the structure from livestock. Maintain all earthfills and channels in good sod by mowing, reseeding and fertilizing.