NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Ft)

CODE 606

DEFINITION

A conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

PURPOSE

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
    a. regulating water table and ground water flows,
    b. intercepting and preventing water movement into a wet area,
    c. relieving artesian pressures,
    d. removing surface runoff,
    e. serving as an outlet for other subsurface drains, and
    f. regulating subirrigated areas or waste disposal areas.
2. Collect ground water for beneficial uses.

3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.

4. Regulate water to control health hazards caused by pests such as live fluke, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas having a high water table where the benefits of lowering the water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under state or local laws. Consideration shall be given to maintaining or enhancing environmental values.

DESIGN CRITERIA

The design and installation shall be based on adequate surveys and investigations.

Capacity. The required capacity shall be determined by one or more of the following:

1. Application of a locally tried and proven drainage coefficient to the acreage drained, including added capacity required to dispose of surface water entering through inlets.

    <u>The drainage coefficient is the rate at which excess water must be removed from cropland in order to provide the proper degree of protection for crops to be grown. Coefficients are expressed in inches of water to be removed in 24 hours. Minimum coefficients are as follows in subsurface drainage with no open surface inlets or with surface inlets to the drainage system:</u>

a. Subsurface Drainage Only (no open inlets)

Soil	Field Crops (inches)	Truck Crops (inches)
Mineral	3/8	1/2
Organic	1/2	3/4

This condition assumes that surface drainage is adequate. The selected drainage coefficient applies to the entire area being drained. If the runoff from an upland area spreads over the area to be drained and is likely to increase the drainage problem, the acres used in determining the drain (tile) size shall be proportionately increased.

b. Subsurface and Surface Drainage (surface inlets in subsurface drains)

Soil	Field Crops (inches)	Truck Crops (inches)
Mineral	1/2	1.0
Organic	3/4	2.0

The selected drainage coefficient will apply to the entire watershed contributing runoff to the surface inlet, except where only a small amount of runoff will be impounded at the location of the inlet with the remainder flowing away in a confined channel. For the latter case, the drain (tile) shall be large enough to remove the impounded water in 24 hours, plus providing additional capacity for the required internal drainage.

2. Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.

3. Comparison of the site with other similar sites where subsurface drain yields have been measured.

4. Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.

5. Application of Darcy's law to lateral or artesian subsurface flow.

6. Estimates of lateral or artesian subsurface flow.

Size. The size of subsurface drains shall be computed by applying Manning's formula. The size shall be based on the required capacity and computed by using one of the following assumptions:

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.

2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.

3. Conduit flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

Manning's Formula: $Q = A \times V$

$V = 1.486 \times R^{2}/_{3} \times s^{1}/_{2} / n$ $\quad R = A / WP$

Q = Discharge in cfs

A = Cross Sectional Area in Sq. Ft.

V = Velocity in Ft./Sec.

n = Manning's "n" Value

R = Hydraulic Radius

WP = Wetted Perimeter

s = Hydraulic Slope ~ slope of conduit

All subsurface drains shall have a nominal diameter that equals or exceeds 3 in. When 3-inch diameter drains are used, any single line shall not exceed 800 feet in length. Four-inch diameter drains shall not exceed 1320 feet in length.

Depth, spacing, and location. The depth, spacing, and location of the subsurface drain shall be based on site conditions, including soils, topography, ground water conditions, vegetation, land use, and outlets.

Typical Manning's "n" Value for Design

Pipe Type	"n"
Corrugated Polyethylene Pipe	
3 - 6 inch diameter	0.015
8 inch diameter	0.016
10 inch diameter	0.017
With smooth straight interior walls	0.012
Concrete Pipe	0.013
Corrugated Metal Pipe ($2^2/_3$" x $^1/_2$" corrugation)	
Annular	
Plain	0.024
Paved Invert	0.020
Fully Paved (smooth lined)	0.013
Helical	
Plain - 10 inch diameter	0.013
Spiral - Rib	0.012
Plastic Pipe (SDR, S&D, Etc)	0.011
Vitrified Clay	0.013

The minimum depth of cover over subsurface drains in mineral soils shall be 2 ft. This minimum depth shall apply to normal field levels and may exclude sections of line within 50 feet of the outlet or sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils shall be 2.5 ft for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table level in organic soils within the optimum range of depths.

The depth of laterals to intercept hillside seepage will vary according to the depth of the impervious layer. The drain line must be placed so that it intercepts the seepage flow.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 ft for trench widths of 2 ft or less (measured at tubing and to 1 ft above top of tubing). Heavy duty tubing shall be specified for depths greater than 10 ft, trench widths more than 2 ft, or in rocky soils.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. The design load on the conduit shall be based on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 ft. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Minimum velocity and grade. In areas where sedimentation is not a hazard, the minimum grades shall be based on site conditions and a velocity of not less than 0.5 ft/s. If a hazard exists, a velocity of not less than 1.4 ft/s shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions.

Minimum grades where no sediment hazard exists are as follows:

Drain size (inches)	Grade (percent)
3 and 4	0.1
5	0.07
6 to 8	0.05

Maximum velocity without protection.

Excessive flow velocity in the drain may induce piping of soil material into the drain line.

Maximum velocities by soil texture:

Soil texture	Velocity (ft/sec)
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silt clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

Maximum grade and protection

On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated under “Maximum velocity without protection,” special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site. The protective measure shall include one or more of the following:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or property graded sand and gravel.

2. Use nonperforated continuous tubing, a watertight pipe, or seal joints.

3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.

4. Select rigid butt end pipe or tile with straight smooth sections and square ends to obtain tight fitting joints.

5. Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.

6. Install open air risers for air release or entry.

Iron ochre considerations

If drains are to installed in sites where iron ochre problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron is in its insoluble form.

Where possible, in areas where the potential for ochre problems is high, protection against ochre development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection against root clogging

Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots or water-loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

The first consideration is to use nonperforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 ft on each side of the drain. A distance of 50 ft should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drains located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities may be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drainlines to prevent growth into the system.

Materials

Subsurface drains include conduits of plastic, clay, concrete, bituminized fiber, metal, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site. All conduits shall meet or exceed the minimum requirements indicated in the Materials section of the specifications.

Foundation

If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by using long sections or perforated or watertight pipe having adequate strength to insure satisfactory subsurface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing.

Filters and filter material

Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The

need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. A suitable filter should be specified if:

(1) local experience indicated a need,
(2) soil materials surrounding the conduit are dispersed clays, low plasticity silts, or fine sands (ML or SM with P.I. less than 7),
(3) where deep soil cracking is expected, or
(4) where the method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation will be based on the gradation of the base material surrounding the conduit within the following limits:

D_{15} size smaller than 7 times d_{85} size but not smaller than 0.6 mm,

D_{15} size larger than 4 times d_{15} size,

Less than 5% passing No. 200 sieve,

Maximum size smaller than 1.5 inches, where D represents the filter material and d represents the surrounding base material.

The number following each letter is the percent of the sample, by weight, that is finer than that size. For example, D_{15} size means that 15 percent of the filter material is finer than that size.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 in. of filter material except that the top of the conduit and side filter material may be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required.

Artificial fabric or mat-type filter materials may be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

Envelopes and envelope material

Envelopes shall be used around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

Envelope materials shall consist of sand-gravel, organic, or similar material, Sand-gravel envelope materials shall all pass a 1.5-in. sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM-C-33 fine aggregate for concrete has been satisfactorily used and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Placement and bedding

The conduit should not be placed on exposed rock or stones more than 1.5 in. in diameter. Where such conditions are present the trench must be overexcavated a minimum of 6 in. and refilled to grade with a suitable bedding material.

The conduit must be place on a firm foundation to insure proper alignment. If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or a silt slurry.

For trench installations or corrugated plastic tubing 8 in. or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90^{o} V-notch in the bottom of the trench for tubing support and alignment.

2. A sand-gravel envelope, at least 3 in. thick, to provide support

3. Compacted soil bedding material beside and to 3 in. above the tubing.

For trench installations of corrugated plastic tubing larger than 8 in., the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations should be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or a compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 in. in diameter. Blinder should be carried to a minimum of 3 in. above the conduit. The minimum trench width at the top of the drain should be adequate to permit installation and provide bedding conditions suitable to support the load on the tile.

Auxiliary structures and protection

Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

Manufactured connections of junctions for joining two tile lines should always be used when available. If manufactured connections are not available, the junction should be chipped and fitted and the cracks sealed with concrete mortar around the entire circumference of the fitted junction.

If the drain system is to carry surface water flow, the capacity of the surface water inlet shall not be greater than the maximum design flow in the drain line or lines. Covers, orifice plated, and/or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

The capacity of a relief well system will be base on the flow from the aquifer, the well spacing, and other site conditions and will be adequate to lower the artesian waterhead to the desired level.

The size of relief wells is generally based on the available materials rather than on hydraulic considerations. Such wells will not be less than 4 in. in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 ft will be provided in either circular or rectangular structures.

The drain system must be protected against velocities exceeding those provided under “Maximum velocity without protection” and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1 ½ ft of soil cover. The cross sectional area of the box shall be at least twice the area of the outlet drain, but not less than 4 square feet.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting cap of the same material as the conduit or other durable materials.

Outlets and Outlet Structures. An adequate outlet shall be available and shall meet the following requirements:

Open Channel. The outlet channel shall be large enough to remove surface runoff from the watershed in a period of time sufficient to prevent serious crop damage. Required capacity will be based on NRCS design criteria for open channels. The channel shall be deep enough to provide the minimum of one foot of clearance between the invert of the drain at its outlet and low-water stage in the channel. This clearance may be reduced: (1) where athe outlet channel is on such a grade that silting will not occur; (2) where the tile will flow freely within 24 hours after a storm; (3) where definite scheduled plans have been made for outlet improvement within the next 12 months.

Surface Drains. The area to be drained must have adequate surface drainage or provisions must be developed, if feasible and practical, for removing surface overland to the outlet channel. When it is not feasible or practical to remove impounded surface water by surface drains, surface inlets to subsurface drains may be used.

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the outlet section. Minimize the visual impact of projecting outlets.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to the standards for Regulating Water in Drainage Systems (554) or Water Table Control (641).

The outlet pipe and its installation will conform to the following requirements:

1. If burning vegetation on the outlet ditch band is likely to create a fire hazard, the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.
2. Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side slope protected from erosion. The minimum length of the pipe will normally be 8 ft. Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1:1 or less) with a narrow bottom width of 3 ft, commonly referred to as “minimum ditches,” for outletting individual subsurface drain laterals. For conduits 10 in. in diameter and greater, longer outlet sections should be considered, such as:
   a. 10 in. and 12 in. in diameter, use 12 ft.
   b. 15 in. and 18 in. in diameter, use 16 ft.
   c. Use 20-ft outlet pipe for all diameters larger than 18 in.
3. If ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered part of the pipe will be protected from the current in the ditch.
4. Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.
5. The minimum thickness for metal pipe shall be 0.064 inches.

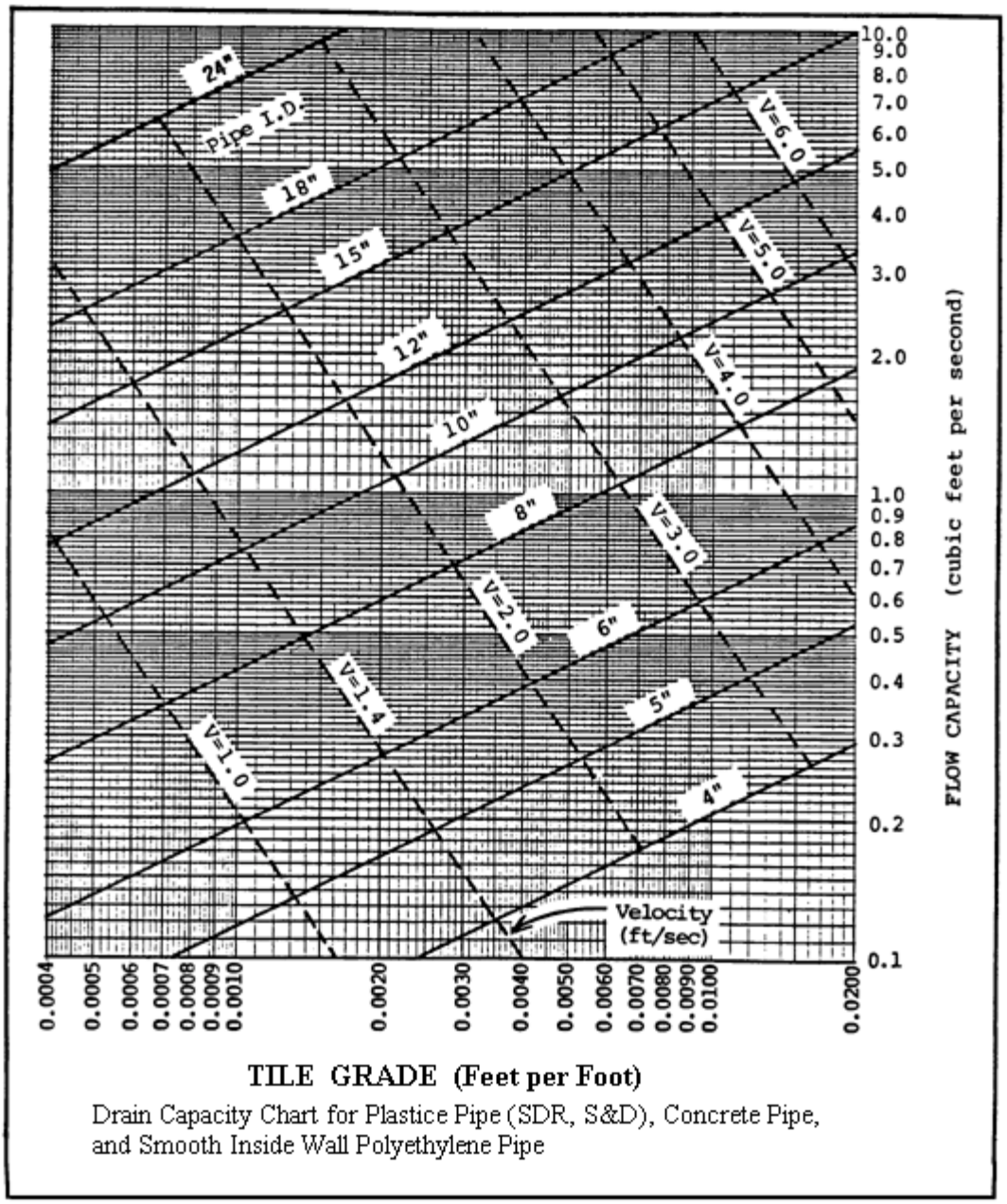
Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures. Conduits under roadways must be designed to withstand the expected loads. Shallow subsurface drains through depressed or low areas and near outlets must be protected from damage caused by farm machinery and other equipment and from freezing and thawing.

Alignment. The change in horizontal direction of the tile shall be made by one of the following methods:

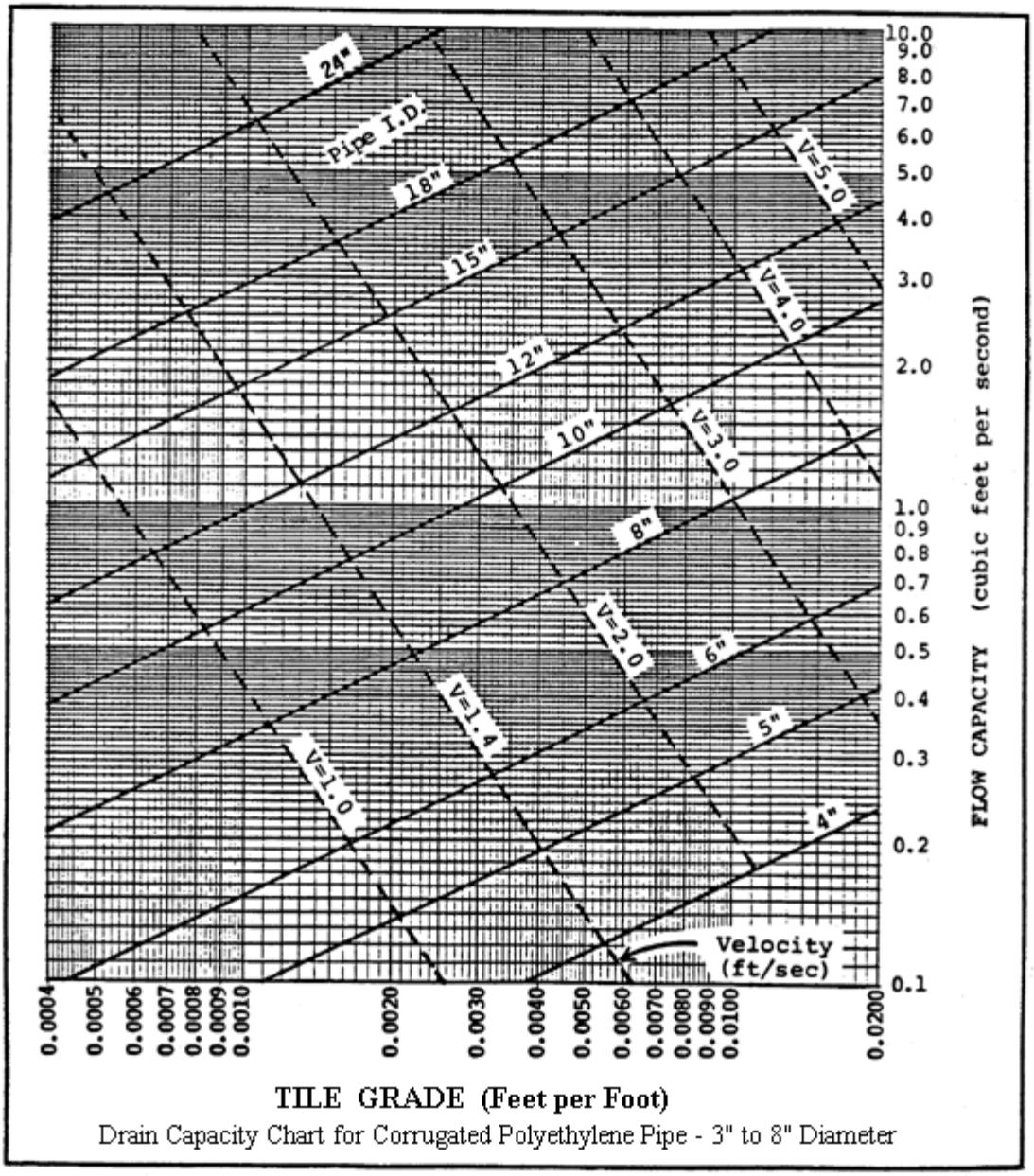
1. The use of manufactured fittings,
2. The use of junction boxes or manholes,
3. A gradual curve of the drain trench on a radius that can be followed by the trenching machine and maintain grade. A gradual curve may be made by hand shaping the inner side of the trench, but in no case shall the radius be less than 5 feet. In either case, rigid tile must then be shaped or chipped so that no crack between tile exceeds 1/8 inch, unless adequately covered.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.



Drain Capacity Chart for Plastice Pipe (SDR, S&D), Concrete Pipe, and Smooth Inside Wall Polyethylene Pipe



Drain Capacity Chart for Corrugated Polyethylene Pipe - 3" to 8" Diameter

Subsurface Drain Specifications

INSTALLATION

Inspecting and handling materials. Material for subsurface drains shall be carefully inspected before the drains are installed. Plastic pipe and tubing shall be protected from hazard-causing deformation or warping. Plastic pipe and tubing with physical imperfections shall not be installed. A damaged section shall be removed and a suitable joint made connecting the retained sections. Clay and concrete tile shall be checked for damage from freezing and thawing before it is installed. All material shall be satisfactory for its intended used and shall meet applicable specifications and requirements.

Materials

The following specifications in Table 1 pertain to products currently acceptable for use as subsurface drains. These specifications are also to be applied in determining the quality of materials referenced by other standards.

General

The installing contractor shall certify that the installation complies with the requirements of these specifications. The contractor shall also name the source of materials.

Conduit perforations special requirements

Where perforated conduit is required, the water inlet area shall be at least 1 $in.^2$/ft of conduit length. Round perforations shall not exceed 3/16-in. in diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of ½ in. may be used. Slotted perforations shall not exceed 1/8 in. in width.

Table 1

Type	Specification
Plastic	
Corrugated polyethylene (PE) tubing and fittings 3-6 in.	ASTM-F-405[1]
Corrugated polyethylene (PE) tubing and fittings 8-24 in.	ASTM-F-667[1]
Corrugated polyvinyl chloride (PVC) tubing and compatible fittings	ASTM-F-800[1]
Polyvinyl chloride (PVC) corrugated sewer pipe with a smooth interior and fittings 4-8 in.	ASTM-F-949[1]
Polyvinyl chloride (PVC) sewer pipe and fittings	ASTM-D-2729[1]
Polyvinyl chloride (PVC) pipe	ASTM-D-3033[1] or D-3034 type PSM or PSP
Clay	
Clay drain tile	ASTM-C-4[1]
Clay drain tile, perforated	ASTM-C-498[1]
Clay pipe, perforated, standard & extra strength	ASTM-C-700[1]
Clay pipe, testing	ASTM-C-301[1]
Concrete	
Concrete drain tile	ASTM-C-4[1]
Concrete pipe for irrigation or drainage	ASTM-C-118[1]
Concrete pipe or tile, determining physical properties of	ASTM-C-497[1]
Concrete sewer, storm drain, and culvert pipe	ASTM-C-14[1]
Reinforced concrete culvert, storm drain, & sewer pipe	ASTM-C-444[1]
Perforated concrete pipe	ASTM-C-76[1]
Portland cement	ASTM-C-150[1]
Other	
Styrene rubber plastic drain pipe and fittings	ASTM-D-2852[1]
Pipe, corrugated (aluminum alloy)	Fed. Spec. WW-P-402[2]
Pipe, corrugated (iron or steel, zinc Federal coated)	Specification WW-P-405[2]

[1] Specifications can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

[2] Specifications can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

SPECIFICATIONS—FLEXIBLE CONDUIT

I. General requirements

All conduits shall be laid to line and grade in such a way that the side walls are continuously and uniformly supported with suitable bedding material. Such material shall be properly placed and compacted to provide lateral restraint against deflection and to protect the conduit against collapse during backfilling.

II. Trenching

Trench widths must be adequate for proper installation of the conduit, allow proper joining of sections, and allow proper placement of filter, envelope, or blinding materials. The trench bottom shall be constructed to proper grade before placement of the conduit.

Where rock is encountered the trench will be overexcavated a minimum of 6 in. and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

III. Plow installation

Plow installation has been satisfactorily used in many situations. Special care needs to be exercised relative to grade control and bedding conditions.

IV. Bedding

The trench bottom shall be smooth and free of clods and loose or exposed rock. Where a gravel envelope is not specified, the bottom of the trench shall be shaped to conform to the pipe. The groove may be semi-circular, trapezoidal, or a 90 degrees “V”-shape (90 degree “V” suitable for 3-8 in. only) and shall be of such dimensions that the bottom quarter of the pipe is below the contact points of the groove.

In unstable soils a firm foundation shall be provided by overexcavation and backfilling with processed stone or gravel, suitably graded so as to act as a mat into which unstable soil will not penetrate.

V. Filters and envelopes

If a sand-gravel filter is specified, it shall be clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1 ½ in.

VI. Placement

Conduit will be placed in such a way that maximum stretch does not exceed 5 percent.

Fittings shall be installed in accordance with instructions furnished by the manufacturers. Couplers are recommended at all joints and fittings, at all changes in direction (where the centerline radius is less than three times tubing diameter), at changes in diameter, and at junction with another line.

Caps are needed at the ends of lines. All fittings shall be compatible with the tubing. Where certain fittings are not available, handcut holes are acceptable provided care is taken when making the connection not to create a means of obstructing flow, catching debris, or allowing soil to enter the line. Place selected bedding material, containing no hard object larger than 1 ½ in. in diameter in the trench to a minimum depth of 6 in. over the conduit. The conduit will be held in place mechanically until secured by blinding.

VII. Backfilling

Place backfill material so that displacement or deflection of the conduit will not occur. This is preferably on an angle, so the material flows down the front slope. Avoid large stones, frozen material, and dry clods that cause concentrated point loads on the tubing. The trench should be backfilled as soon as practical. When installing the tubing on a hot day, backfilling should be delayed until tubing temperature cools to the soil temperature.

SPECIFICATIONS—CLAY AND CONCRETE TILE

I. Clay and concrete drain tile special requirements

If clay tile will not be exposed to freezing and thawing before or during installation and if the average frost depth will be less than 18 in., the freezing and thawing and adsorption tests may be modified or waived.

The use of concrete tile in acid and sulfate soils shall be in accordance with the following limitations:

Acid soils:

	Lower permissible limits of pH values	
Class of tile	Organic and sandy soils	Medium and heavy-textured soils
ASTM-C-412		
Standard quality	6.5	6.0
Extra quality	6.0	5.5
Heavy duty extra quality	6.0	5.5
Special quality	5.5	5.0
ASTM-C-14, C-118, C-444	5.5	5.0

NOTE: Figures represent the lowest reading of pH values for soil or soil water at subsurface drain depth.

Sulfate soils:

Type of tile and cement (minimum)		Permissible maximum limit of sulfates, singly or in combination
		ppm
Tile:	ASTM-C-412 Special quality C-14, C-118, C-444	7,000
Cement:	ASTM-C-150, Type V	
Tile:	ASTM-C-412 Extra quality, Heavy-duty extra quality C-14, C-118, C-444	3,000
Cement:	ASTM-C-150, Type II or V	
Tile:	ASTM-C-412 Standard quality C-14, C-118, C-444	1,000
Cement:	ASTM-C-150, any type	

NOTE: Figures represent the highest reading of sulfates for soil or soil water at subsurface drain depth.

Bell and spigot, tongue and groove, and other types of pipe that meet the strength, absorption, and other requirements of clay or concrete tile as specified in the preceding paragraphs, except for minor imperfections in the bell, the spigot tongue, or the groove, and ordinarily classed by the industry as “seconds,” may be used for drainage conduits, provided that the pipe is otherwise adequate for the job.

II. Trenching

Trench widths must be adequate for proper installation of the conduit; must allow proper joining of sections; and must allow proper placement of filter, envelope, or blinding materials. The trench width will be a minimum of 3 to 6 in. on both sides of tubing. The trench bottom shall be constructed to proper grade and shape before placement of the conduit.

Where rock is encountered the trench will be overexcavated a minimum of 6 in. and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

III. Bedding

If unstable soil conditions are encountered, the trench bottom must be stabilized before placement of conduit. Where necessary the unstable material will be removed and replaced with sand-gravel or a similar suitable stabilizing material. Where an envelope is not specified, the bottom of the trench shall be shaped to ensure good alignment of the conduit.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be a minimum of 6 in. from rock.

IV. Filters and envelopes

If a sand-gravel filter is specified, it shall be of clean, hard durable material and of the gradation specified.

When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1 ½ in. ASTM-C-33 fine aggregate for concrete will meet these requirements.

V. Placement

All conduits shall be laid to line and grade and covered with the specified blinding, envelope, or filter material to a depth of not less than 3 in. around the drain. Blinding material shall contain no hard objects larger than 1 ½ in. in diameter.

When a sand-gravel filter is specified, all openings in the conduit must be covered with at least 3 in. or filter material except that the top of the conduit and the side filter material may be covered with a sheet of plastic or similar impervious material. The impervious sheet will be covered with at least 3 in. of blinding material.

Joints between drain tile shall not exceed 1/8 in. except in sandy soils, where the closest possible fit must be obtained, and in organic soils where some of the more fibrous types make it desirable to increase slightly the space between tile.

VI. Backfill

Backfill will be placed in such a manner as to avoid displacement of the conduit. Backfill should be moved into the trench at an angle so that material slows down the front slope of previously placed material. Backfill shall not contain frozen material, stones, clods, or objects large enough to damage the conduit. The trench should be backfilled as soon as possible after blinding.