

Subsurface Drain (ft)

Definition

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

Scope

This standard applies to the design and installation of conduits placed beneath the surface of the ground to provide drainage.

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 and preventing water movement into a wet area,
 - b. intercepting and preventing water movement into a wet area,
 - c. relieving artesian pressures,
 - d. removing surface runoff,
 - e. leaching of saline and sodic soils,
 - f. serving as an outlet for other subsurface drains, and
 - g. 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 liver fluke, flies, or mosquitos.

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. The ability to drain and treat saline and sodic soils shall be considered where this is a problem.

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.

Planning considerations

Water Quantity

1. Effects on the water budget.
2. Effects on baseflow and runoff to water uses and users.
3. Effects on ground water recharge.
4. The volume of soil water needed to improve plant growth.

Water Quality

1. Effects on the delivery of sediment and dissolved and sediment-attached substances.
2. Effect of changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users.
3. In areas of ground water recharge, changes in the delivery of dissolved substances to the aquifer.
4. Effect on downstream water temperatures.
5. Effects on the visual quality of downstream water.

Design criteria

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

Capacity. The required capacity shall be determined by one of 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.
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.

All subsurface drains shall have a nominal diameter that equals or exceeds 3 in.

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, crops, land use, outlets, and saline or sodic conditions.

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 near 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 water table level in organic soils within the optimum range of depths.

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, provision 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.

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/s
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty 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 measures shall include one of more of the following:

1. Enclose continuous perforated pipe or tubing with fabric type filter material or properly 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 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 be 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 of 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 ridge supports, or by using long sections of 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 indicates 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 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-sieve; 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 placed 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 of corrugated plastic tubing 8 in. or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90° 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.

Auxiliary structure 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.

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 plates, 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 based 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 1-1/2 ft of soil cover.

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.

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 performance will be used at the outlet end of the line and must discharge above the normal elevations of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the 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 bank 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

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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:

10 in. and 12 in. in diameter, use 12 ft.

15 in. and 18 in. in diameter, use 16 ft.

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.

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.

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.

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 use and shall meet applicable specifications and requirements.

Materials

The following specifications 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:

Type	Specification
<i>Plastic</i>	
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
<i>Clay</i>	
Clay drain tile	ASTM-C-4 ¹
Clay drain tile, perforated	ASTM-C-498 ¹
Clay pipe, perforated, standard and extra strength	ASTM-C-700 ¹
Clay pipe, testing	ASTM-C-301 ¹
<i>Concrete</i>	
Concrete drain tile	ASTM-C-412 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, and sewer pipe	ASTM-C-76 ¹
Perforated concrete pipe	ASTM-C-444 ¹
Portland cement	ASTM-C-150 ¹

Other

Styrene rubber plastic drain pipe and fittings	ASTM-D-2852 ¹
Pipe, corrugated (aluminum alloy)	Federal Specification WW-P-402 ²
Pipe, corrugated (iron or steel, zinc coated)	Federal 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

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 in²/ft of conduit length. Round perforations shall not exceed 3/16-in diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of 1/2 in may be used. Slotted perforations shall not exceed 1/8 in. in width.

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 degree "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 1½ 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 1½ 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:

Class of tile	Lower permissible limits of pH values	
	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
		g/m
Title:	ASTM-C-412 Special quality C-14, C-118, C-444	7,000
Cement:	ASTM-C-150, Type V	
Title:	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	
Title:	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 1½ 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 1½ in. in diameter.

When a sand-gravel filter is specified, all openings in the conduit must be covered with at least 3 in of 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 flows 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.

NORTH CAROLINA SUPPLEMENT - 606-1

U.S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

Technical Guide
Section IV
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SUBSURFACE DRAIN (Feet)

Design Criteria

Capacity

Drains shall be designed as a minimum to remove 0.5 inch of water in 24 hours.

Size

All subsurface drains shall have a nominal diameter that equals or exceeds 4 inches. In the Coastal Plains area of North Carolina, due to flat grades and soil conditions, it is generally recommended that the minimum size of drain be 5 inches in diameter.

When selecting the size of drain that will provide the most satisfactory installation, the following design factors should be considered in addition to those shown in the Engineering Field Manual:

1. The optimum level of protection for the present and future land use of the area.
2. The total installation cost as compared to the difference in material cost of various size drains.
3. The expected length of system life, in terms of siltation, for various drain sizes.
4. The area for infiltration needed for optimum drainage based on the least permeable soil where the drain is to be located.

Minimum Velocity and Grade

Minimum grades shall be no less than shown in the following table. When using minimum grades, the length of the drain line shall not exceed 1,000 feet.

Fall in Feet per 100 Feet

Drain Diameter	Construction Minimum	Self-Cleaning $n=0.11^1$	Recommended Velocity = 1.4 fps	
			:	$n = 0.15^2$
4"	0.15	0.30		0.53
5"	0.12	0.21		0.40
6"	0.10	0.17		0.31
8"	0.08	0.12		0.21
10"	0.06	0.09		0.16
12"	0.05	0.08		0.13

¹ Using $V = 138R^{2/3} S^{1/2}$ (Smooth Tile)

² Using $V = 100R^{2/3} S^{1/2}$ (Corrugated Tubing)

The minimum grades for drain lines may be reduced for special or unusual problems only when approved by an engineer.

Loading

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Filters and Filter Material

The need for a filter shall be determined by the characteristics of the soil materials at drain depth and the velocity of flow in the conduit.

The filter shall be designed to prevent the material in which the installation is made from entering the conduit. Not more than 10 percent of the filter material shall pass the No. 60 sieve.

1. In soils with clay content exceeding 40%, no cover or filter is necessary. If there is a question concerning the clay content of these soils, a fabric filter cover or sand-gravel filter is to be used, but not a plastic cover.
2. Where unstable sandy soils or other soils known to have a stability problem are encountered, a complete filter is required and no plastic cover should be used. The filter material shall cover the drain, both top and bottom, and may be a sand-gravel filter or one of the fabric filters listed in item #5 below. In unstable soils that have a silt content above 40%, a complete fabric filter should not be used, as evidence indicates that a fabric filter may become clogged.
3. In soils where iron oxide problems are known to exist, a sand-gravel filter is to be used. More evaluations are needed for these conditions but evidence to date indicates that the fabric filter may become clogged as well as the slots or holes in the drains themselves.
4. In all other soils a fabric filter cover has been found to be very effective. A plastic sheet is not allowed as a cover on tubing in these soils. The fabric cover serves the same function as the plastic cover, plus affording a much larger area for water to enter the drain. This increased area makes the drain operate more efficiently and reduces potential silting in the line by decreasing the hydraulic head, and thus, decreasing the silt producing velocity of water entering through the slots or holes in the drain.
5. Fabric filters shall be one of the following materials:
 - a. Drainguard (Cerex Type F-11) 0.65 oz/sq.yd.
 - b. Reemay 0.8 oz/sq.yd.
 - c. Typar (Style 3351) 3.5 oz/sq.yd.
 - d. Bidim (Type C-22) 4.4 oz/sq.yd.
 - e. Mirafi (Type 140) 4.1 oz/sq.yd.

- f. Knitted polyester or nylon sleeves like those produced by Beane Machine and Filter Company when stretched and installed in accordance with manufacturer's recommendations.
- g. Others which meet or exceed the requirements of the above.

The minimum width of filter material used is to cover at least 50% of the tubing under field placement conditions with no maximum width specified. If a plastic sheet is used, the minimum thickness shall be 2 mil and the width shall cover not less than one-half or more than three-fourths of the tubing.

Envelopes and Envelope Material

Materials used for envelopes do not need to meet the gradation requirements of filters, but they shall 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, all of which shall pass a 1-1/2 inch sieve; 90 to 100 percent shall pass a 3/4 inch sieve; and not more than 10 percent shall pass a No. 60 sieve.

Placement and Bedding

All subsurface drains, whether flexible conduit such as plastic or bituminous fiber or rigid conduits such as clay or concrete, shall be laid to a neat line and grade. The conduit shall be placed and bedded as described in ASTM-F-449, "Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control." Rigid drainage conduits, such as clay or concrete drain tile, do not need the 90 degree V-groove in the trench bottom, but all other applicable placement and bedding requirements shall be adhered to.

Heavy-Duty Corrugated Plastic Drainage Tubing

Heavy-duty corrugated plastic drainage tubing shall be specified if the soil is rocky. This quality of tubing shall also be specified if cover over the tubing is expected to exceed 10 feet or trench widths are expected to exceed 24 inches. (This refers to trench width in the area of the tubing and at least 1 foot above the top of tubing.)

Auxiliary Structures and Protection

If surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity flow. Auxiliary surface waterways shall be used where feasible.

Special precautions shall be taken when drain lines are located in close proximity to trees. No drain line with openings shall be installed on agricultural land within 50 feet of trees, except outlets which are protected from tree roots by the outlet ditch and the upper end of laterals. Where drains must be placed through wooded areas, non-perforated tubing or pipe is to be used.

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SUBSURFACE DRAIN SPECIFICATIONS

Placement

All subsurface drains shall be laid to line and grade and covered with approved blinding, envelope, or filter material to a depth of not less than 3 inches. If an impervious sheet is used over the drain, at least 3 inches of blinding material must cover the sheet.

If the conduit is to be laid in a rock trench or if rock is exposed at the bottom of the trench, the rock shall be removed below grade so that the trench can be backfilled, compacted, and bedded. When completed, the conduit shall be not less than 2 inches from rock.

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

Flexible conduits, such as plastic pipe or tubing and bituminized fiber pipe, shall be installed according to the requirements of ASTM-F-449, "Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drains or Water Table Control."

Earth backfill material shall be placed in the trench in a manner to insure that the conduit does not become displaced and so that the filter and bedding material, after backfilling, meet the requirements of the plans and specifications.

If a filter is required, all openings in the subsurface drain shall be protected by the filter, or the bottom and sides of the conduit shall be protected by the filter and the top of the conduit. Part of the side filter material shall be covered by a sheet of impervious plastic. If a filter is needed, no part of the conduit containing openings shall be left exposed.

If sand-gravel filter material is used, it shall be a mixture of sand and gravel within the gradation required by the base material in the trench. The trench shall be over excavated 3 inches and backfilled to grade with filter material. After the conduit is placed on the filter material, additional filter material shall be placed over the conduit to fill the trench to a depth of 3 inches over the conduit. A plastic sheet and friable soil may be used as the backfill over the subsurface drain if specified.

General

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

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SUBSURFACE DRAINS ENGINEERING NOTEKEEPING

Design Survey, Design and Plans

- A. A plan-profile drawing will be prepared on all class II and larger jobs. The area conservationist on the recommendation of the area engineer and with the concurrence of the state conservation engineer may eliminate the requirement for plotting a profile for class II jobs for those persons having the capability and experience to make adequate designs without the profiles. When a profile drawing is not required, all supporting information for design will be recorded and signed in the engineering field book, and a construction drawing similar to Figure 14-23, sheet 1 of 2, Engineering Field Manual, would be prepared and furnished to the landowner. Engineering plans will be prepared on standard sheets or state approved forms and will show the following:
1. Location plan showing soil type and spacing of all lines.
 2. Profile of tile main when required showing grade and elevation of points where grade changes.
 3. Profile of any lateral when required if there is any deviation from the standard specifications; otherwise, give the minimum grade of the laterals.
 4. Length, size, type, minimum grade and depth of all lines.
 5. Length, size, and type of outlet pipe.
 6. Outlet requirements:
 - a. Size and depth of outlet channel.
 - b. Improvements needed if outlet channel is not adequate.
 - c. Vertical distance between invert of outlet pipe and normal water in outlet channel.
 - d. Diversion of surface water.
 7. Specifications for filters or covers where applicable.

Construction Check

The following information shall be recorded as supporting data when the job is completed.

1. Location map with sketch of lines installed.
2. Name of drain manufacturer.
3. Length, kind of material, and size of each drain line installed.
4. Length, kind of material, and size of outlet pipe.
5. Type of material used for filter or cover when applicable.
6. Vertical distance between invert of outlet pipe and normal water in outlet ditch or stream.
7. Adequacy of surface water control at the outlet.
8. Minimum depth of cover.
9. Type of animal guard installed on outlet pipe.
10. Sufficient grade checks or a certification statement signed by the contractor, stating that all lines were installed in accordance with grades shown on the plans.
11. Date and sign construction check notes.

The need for complete grade checks and the number of lines to check will vary depending upon the size and complexity of the system, the design grades, the type of equipment used, and the experience and skill of the contractor. A certification statement signed by a qualified contractor is acceptable as supporting data in place of recorded grade checks when accompanied by the information and measurements listed above to certify that the job was installed as designed and that all standards and specifications were met. Each year a complete construction and grade check shall be made, recorded, and filed on 5% of the jobs installed by each contractor making his own certification. Should any grade check show a deficiency, additional checks will be made of other jobs completed by the contractor to assure that satisfactory work is being done. All deficiencies must be corrected or other appropriate action taken.

Recording Data

Field survey and construction check data will be recorded in a standard engineering field book in accordance with Technical Release No. 62. Cross references to appropriate engineering field books will be made on drawings and plans. Recorded data and certifications provided by qualified contractors need not necessarily follow the format used by SCS, but must be legible and understandable. NC-ENG-7 may be used by contractors for recording supporting data and making a certification.