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.

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 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. 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 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. 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.

DESIGN CRITERIA

The design and installation shall be based on adequate surveys and investigations. *Subsurface drainage design information and guidelines are found in Chapter 14 of the Engineering Field Manual, Section, 16 of the National Engineering Handbook and Subsurface Drainage Guides filed in Appendix B of the Engineering Field Manual.*

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.

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 installation for subsurface drain shall be 5.0 feet where the primary purpose of drains is to maintain a favorable salinity balance in the soil. Subsurface drains should not be installed in very slowly permeable strata unless backfilled with well-graded gravel; the gravel backfill should extend up to more permeable strata. This should be done only where it is necessary to grade through a very slowly permeable strata for a short distance.

Subsurface interceptor drains may be placed at depths less than 5.0 feet where the depth of water-bearing strata so dictates.

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 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.

Grade in lines should not be less than 0.1 foot per 100 feet

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
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 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. Drains located close to the fruit trees can often drain orchards.

Where corps 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.

Concrete pipe used for subsurface drains shall be constructed with ASTM C 150 Type II or Type V Portland cement. Concrete pipe shall meet or exceed either ASTM C 412 specifications for extra quality drain tile or ASTM C 118 specifications for standard drainage pipe.

When requested, pipe constructed of fiber and plastic materials shall be certified by the manufacturer for compliance with the applicable 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.

All subsurface drains shall be installed with a suitable filter material to prevent excessive amounts of sediment from entering the conduit and to facilitate the collection of ground water and its passage into the drain.

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.

The design of any sand-gravel filter gradation shall also meet the criteria of Chapter 26, Part 633, National Engineering Handbook (Gradation Design of Sand and Gravel Filters).

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 in. on 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.

Sand-gravel filters shall be installed according to criteria in Chapter 4, Section 16, NRCS National Engineering Handbook, or as approved by the responsible technician.

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.

Fiberglass filter material shall have a minimum nominal thickness of 1 inch and density of one pound per cubic foot. When used on subsurface concrete drain tile, the fiberglass material shall be wrapped, at least, around each tile joint and overlapped and secured in a manner which will prohibit filter from being displaced during backfill operations. As a minimum, sides of the filter material shall extend on each side of tile joint approximately 3 inches.

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.

The trenchless method for installation of subsurface drains will not be permitted in the Lower Rio Grande Valleyof Texas. The NRCS will not render technical assistance upon or certify the technical adequacy for federal cost sharing on subsurface drains installed by the trenchless method in this designated area.

For trench installations where a sand-gravel or 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 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.

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.

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 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:

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.

CERTIFICATION AND GUARANTEE.

All materials shall conform to these minimum requirements and to the tests prescribed in the applicable ASTM Specification.

The acceptance of materials used will be by one of the following methods:

a. Onsite approval based on properly marked material showing compliance with the applicable ASTM Specification.

b. When conditions warrant, the State Conservation Engineer may elect to request the manufacturer to furnish material test data and written certification of compliance with applicable ASTM Specifications, including a description of the method to be used in identifying the certified material.

The installing contractor shall certify to the purchaser that the materials and installation comply with the requirements of these specifications. He/she shall furnish the purchaser a written guarantee against defective workmanship and materials to cover a period of not less than one year. He/she shall record on the guarantee the manufacturer's name and markings of the pipe material used.

The installing contractor shall furnish the Natural Resources Conservation Service a copy of his/her certification and guarantee, which will be made a part of the supporting records of the subsurface drain.

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.

Construction specifications describing the requirements for applying this practice shall be developed from the generalized Construction Specifications (Texas) for conservation Practices. The Construction Details section shall be used to describe site specific job requirements.

PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

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.

Research has shown that subsurface drainage reduces total seasonal surface runoff by 17 to 60 percent. Without site specific data, a reduction estimate of about 30 percent may be used. Storm peak discharge will normally be reduced by 15 to 30 percent.

The duration of interflow and base flow discharge time may lengthen and provide environmental benefits by making water in streams more dependable.

Drainage removes excess water from the soil, lowers the water table, and increases the depth of the root zone, allowing an increase in plant transpiration and crop growth.

Quality

1. Effects on the delivery of sediment and dissolved and sediment-attached

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.

Sediment: Reduction of surface runoff will result in a similar reduction of sediment detachment, transport, and deposition. The reductions vary from site to site, but without specific data, an estimate of a 30-50 percent reduction may be used.

Pesticides: Research indicates a very low level of pesticides lost in drainage water. Pesticides that are lost, however, may be concentrated at discharge points. The loss of sediment-attached pesticides will be reduced in proportion to sediment yield reductions.

Nutrients: The loss of sediment-attached nutrients is reduced proportionate to sediment reduction. Phosphorous reductions may be in the range of 40 to 50 percent.

Excess soil water collected by a drainage system may contain dissolved nutrients, which may be discharged in surface water. These nutrients may be concentrated at discharge points. Because of the reduction in surface runoff, however, the total mass load may be reduced.

Nitrogen loss to ground water may be reduced as a result of increased rooting depth in the drained soil. Some reduction of nitrogen loss to ground water may be attributed to the interception and discharge into surface waters of excess soil water containing soluble chemicals. Subsurface drainage will generally increase plant use of soil moisture and nutrients.

Salinity: Subsurface drainage reduces soil and ground water salinity by removing excess dissolved salts. In some cases, it may be difficult to find a discharge location for saline water to avoid polluting surface water. Subsurface drainage can also help correct saline seep problems by intercepting infiltration in the recharge area.

APPROVAL AND CERTIFICATION

SUBSURFACE DRAIN

(Ft.)

CODE 606

PRACTICE STANDARD APPROVED:

/s/ JOHN W. MUELLER	06/13/02
State Conservation Engineer	**Date**