NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(feet)
CODE 606

DEFINITION

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

PURPOSE

- To improve the soil environment for vegetative growth by regulating the water table and ground water flow;
- To intercept and prevent water movement into a wet area;
- To relieve artesian pressures;
- To remove surface runoff;
- To facilitate leaching of saline and alkali soils;
- To serve as an outlet for other subsurface drains;
- To regulate and control ground water for subirrigated areas or waste disposal areas;
- To collect ground water for beneficial uses;
- To remove water from around buildings, roads, airports, play areas, and other physical improvements; and
- To regulate water to control health hazards caused by liver fluke, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas having a high water table where benefits of lowering 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 drainability and treatment of saline and alkali 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 disposed. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under state laws.

Scope

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

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:

- Application of a locally tried and proven drainage coefficient to the acreage drained. Include added capacity required to dispose of surface water entering through inlets.
- Yield of ground water based on the expected deep percolation of irrigation

water from the overlying fields, including the leaching requirement.

- Survey and comparison of the site with other similar sites where subsurface drain yields have been measured.
- Measurement of the rate of subsurface flow at the site during a period having adverse weather and ground water conditions.
- The application of Darcy's law to lateral or artesian subsurface flow.
- 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:

- The hydraulic grade line parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.
- The conduit flowing part full where a steep grade or other condition requires excess capacity.
- Conduit flowing under pressure with hydraulic grade line 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 nominal diameter that equals or exceeds 3 inches (76mm).

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 alkaline conditions.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet (0.6m). 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 equipment travel.

The minimum depth of cover in organic soils shall be 2.5 feet (0.76m) 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.

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 feet per second (0.15 m/sec.). If a hazard exists, a velocity of not less than 1.4 feet per second (0.43 m/sec.) 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, as specified in the plans.

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 in Table 1, special measures shall be used to protect the conduit. These measures shall be specified for each job according to the particular conditions of the job site. The protective measures shall include one or more of the following:

- Selecting rigid, butt-end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.

- Wrapping open joints of the pipe or tile with tar-impregnated paper, burlap, or special fabric-type filter material.
- Placing the conduit in a sand and gravel envelope or blinding with least erodible soil available.
- Sealing joints or using a watertight pipe or nonperforated continuous tubing.
- Enclosing continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.

Table 1

Maximum Permissible Velocity Without Protective Measures

Soil Texture	Velocity (ft./sec.)	(meter/sec.)
sand and sandy loam	3.5	1.0
silt and silt loam	5.0	1.5
silty clay loam	6.0	1.8
clay and clay loam	7.0	2.1
coarse sand or gravel	9.0	2.7

Materials

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

The conduit shall meet strength and durability requirements of the site. Current specifications listed below or included in this standard shall be used in determining the quality of the conduit.

The following specifications pertain to products currently acceptable for use as subsurface drains or for use in determining the quality of materials used in drainage installations:

Type	Specification
Clay drain tile	ASTM[1/] C 4
Clay drain tile, perforated	ASTM C 498
Clay pipe, perforated, standard, and extra strength	ASTM C 700
Clay pipe, testing	ASTM C 301
Concrete drain tile	ASTM C 412
Concrete pipe for irrigation or drainage	ASTM C 118
Concrete pipe or tile, Determining physical properties of	ASTM C 497
Concrete sewer, storm drain, and culvert pipe	ASTM C 14
Reinforced concrete culvert, storm drain, and sewer pipe	ASTM C 76
Perforated concrete pipe	ASTM C 444
Portland cement	ASTM C 150
Asbestos cement storm drain pipe	ASTM C 663
Asbestos cement nonpressure sewer pipe	ASTM C 428
Asbestos cement perforated underdrain pipe	ASTM C 508
Asbestos cement pipe, testing	ASTM C 500
Pipe, bituminized fiber,	Federal Spec. [2/]
(and fittings)	SS-P-1540

[1/] American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

[2/] Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Type	Specification
Homogeneous perforated bituminized fiber pipe for general drainage	ASTM D 2311
Homogeneous bituminized fiber pipe, testing	ASTM D 2314
Laminated wall bituminized fiber perforated pipe for agricultural, land, and general drainage	ASTM D 2417
Laminated wall bituminized fiber pipe physical testing of	ASTM D 2315
Styrene rubber plastic drain and building sewer pipe and fittings	ASTM D 2852
Polyvinyl chloride (PVC) sewer pipe and fittings	ASTM D 2729
Corrugated Polyvinyl Chloride Tubing	See "Specifications for Corrugated Polyvinyl Chloride Drainage Tubing"
Perforations, if needed	ASTM D 2729
Corrugated Polyethylene Tubing and Fittings	ASTM F 405
Corrugated Polyethylene Tubing and Fittings, 10-15 inches	ASTM F 667
Pipe, corrugated, (aluminum alloy)	Federal specification WW-P-402
Pipe, corrugated, (iron or steel, zinc coated)	Federal specification WW-P-405

Drainage Conduit Perforations

If perforations are needed in smooth wall conduits, they shall be in compliance with ASTM-D-2729.

Perforations in corrugated plastic tubing shall be in compliance with paragraph 5.1.5 and 7.5 of specifications for "Corrugated Polyvinyl Chloride Drainage Tubing." Slot lengths for 15 inches (381mm) corrugated plastic tubing should not exceed 1-3/4 inches (44mm)

Round perforations greater than 5/16 inches (8mm) in diameter but equal to or less than 3/4 inch (19mm) shall be permitted on mineral soils if special requirements on blinding, envelopes, or filters are used. On organic soils, the fiber content shall govern the need for these special requirements on larger perforations.

The freezing and thawing and absorption test may be modified or waived for clay tiles.

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 title	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 water or soil at subsurface drain depth.

Sulfate soils:_____

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

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 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.

Corrugated Polyethylene Tubing Special Requirements

Corrugated polyethylene tubing meeting the requirements of ASTM-F-405 or ASTM-F-667 shall also meet the applicable perforation standards of this specification.

The following additional tests shall be performed on corrugated polyethylene tubing according to "Specifications for Corrugated Polyvinyl Chloride Drainage Tubing":

- Brittleness (paragraphs 5.6 and 7.10). A high temperature strength test shall be performed on PE tubing. The only modification in the test shall be the use of a temperature of 120 degrees + 5 degrees F to condition the samples. There shall be no fracture, cracking, rupture, splitting, or significant indentation of the tubing after the impact. Indentations shall be considered significant if the depression left by the falling tup creates a restriction of more than 1 inch in nominal inside diameter.

- Bending (paragraphs 5.7 and 7.11). This provision is applicable to continuously extruded tubing. Tubing molded in lengths that are less than 8 feet (2.4m) need not be subjected to this bending test.

Polyethylene tubing having a thin white exterior and a black interior that meets the performance tests for ASTM-F-405 and the above-mentioned additional test shall be acceptable under this specification:

Specifications for Corrugated Polyvinyl Chloride Drainage Tubing

1. Definition

1.1 This specification applies to corrugated polyvinyl chloride drainage tubing and fittings for subsurface drainage where soil support is given to its flexible walls. It pertains to tubing having a nominal diameter of 3, 4, and 5. 6, and 8 in.

2. Applicable Publications

2.1 The following publications are applicable to this standard:

2.1.1 American Society for Testing and Materials (ASTM) Standards:

D-618……Methods of Conditioning Plastics and Electrical Insulating Materials

D-883……Definitions of Terms Relating to Plastics

D-1248….Polyethylene Molding and Extrusion Materials

D-1784….Rigid Polyvinyl Chloride Compounds

D-2122….Methods of Determining Dimensions of Thermoplastic Pipe and Fittings

D-2152….Quality of Extruded Poly (Vinyl Chloride) Pipe by Acetone Immersion

D-2412….Method of Test for External Loading Properties of Plastic Pipe by Parallel-Plate Loading

D-2444….Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

2.2 The publications current on the date of invitation to tender are valid unless otherwise specified.

3. Materials

3.1 General - Compounds used in the manufacture of corrugated PVC drainage tubing and fittings shall have a minimum cell classification conforming with 12344-C in ASTM-D-1784. The compounds shall also contain an ultraviolet stabilizer that will provide protection against degradation due to sunlight for a minimum of 2 years.

3.1.1 Polyethylene Fittings - Polyethylene fittings may also be used on corrugated PVC tubing. Compounds used in the manufacture of polyethylene fittings shall conform with the requirements of Grades P-1 4, P-23, P-33, or P-34 and Class C (unless equivalent ultraviolet projection is uniformly included) according to ASTM-D-1248.

3.2 Rework Material - Clean rework material generated from the manufacturer's own tubing production may be blended with the same type of virgin tubing compound used by the same manufacturer, provided that the tubing meets the requirements of this standard.

4. General Requirements

4.1 Material - The material used in the manufacture of the drainage tubing and fittings shall be resistant to the chemicals normally present in subsoils and ground water.

4.2 Workmanship and Thickness - The tubing and fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other defects. The tubing wall shall have a thickness at any point in excess of 15 mills and shall be as uniform as commercially practicable to enable the tubing to meet the requirements of this standard. The tubing shall be round in cross section and corrugated over its entire length. The corrugations may be of any configuration but shall be uniform.

5. Detail Requirements

5.1 Dimensions

5.1.1 Nominal diameter - The nominal diameter for tubing description shall be the inside diameter.

5.1.2 Inside diameter - The tolerance on the specified inside diameter shall be -1.5 percent when measured according to instructions in paragraph 7.3.

5.1.3 Length - The tubing may be sold in any length agreeable to the user. The length shall not be less than 99 percent of the stated quantity when measured according to instructions in paragraph 7.4.

5.1.4 Perforations - If perforations are specified, the water inlet area shall be at least 1.0 $in.^2$/ ft of tubing length. The inlets shall be either circular perforations or slots about equally spaced along the length and circumference of the tubing in not less than three rows. Circular perforations shall not exceed 3/16 in. in diameter, and slots shall not be more than 1 /8 in. wide and 1-1 /4 in. long for 3- , 4-, and 5-in. diameter tubing, or l-1/2 in. for 6- and 8-in. diameter tubing and in the middle of the valley so that there is a shoulder on each side of the slot. Slots and circular perforations shall be cleanly cut. Perforations shall be measured according to instructions in paragraph 7.5.

5.2 Pipe Stiffness - The tubing shall have the minimum pipe stiffness given in table 1 when tested according to instructions in paragraph 7.6. The tubing shall not show evidence of cracking, rupture, or reverse curvature when tested according to instructions in paragraph 7.6.1. Tubing tested shall contain perforations if applicable.

5.3 Elongation - The tubing shall not elongate more than the specified maximum given in table 1 when tested according to instructions in paragraph 7.7. Tubing tested shall contain perforations if applicable.

5.4 Joint Separation Resistance - Joints made with couplings installed according to the manufacturer's instructions shall not separate when tested according to instructions in paragraph 7.8.

5.5 Quality of Extruded PVC - Tubing specimens shall not display flaking or disintegration when tested according to instructions in paragraph 7.9.

5.6 Brittleness - Tubing specimens shall not crack or split when tested according to instructions in paragraph 7.10.

5.7 Bending - There shall be no evidence of splitting or cracking when tested according to instructions in paragraph 7.11.

5.8 Straightening - There shall be no evidence of splitting or cracking when tested according to instructions in paragraph 7.12.

6. Sampling and Retest

6.1 Sampling - Samples of tubing and fittings sufficient to determine conformance with this specification shall be taken at random from stock by the testing agency. Samples must be representative of the product type under consideration.

6.2 Retest and Rejection - If any test failure occurs, the tubing or fittings shall be retested to establish conformity. The test shall be repeated on two additional samples from the same lot or shipment. If either of these two fails, the tubing or fitting does not comply with this specification.

7. Methods of Test

7.1 Conditioning Test Specimens - Before testing, specimen shall be conditioned at 73 degrees F ±2 degrees F for not less than 40 hours according to Procedure A in ASTM-D-618 for tests requiring conditioning, unless otherwise specified.

7.2 Test Conditions - Tests shall be conducted in a laboratory atmosphere of 73 degrees F ±2 degrees F, unless otherwise specified.

7.3 Inside Diameter - Measure the inside diameter of the tubing with a tapered plug according to guidelines in ASTM-D-2122.

7.4 Length - Measure tubing with any suitable device accurate to 1-1/4 in. in 10 ft (0.2 percent). Make all measurements on the tubing while it is resting on a relatively flat surface in a straight line. No external forces of tension or compression shall be exerted on the tubing.

7.5 Perforations - Measure dimensions of perforations on a straight specimen. No external forces shall be applied. Make linear measurements with instruments accurate to 0.01 in.

7.6 Pipe Stiffness - The tubing specimens shall be tested for pipe stiffness, F/ΔY, as described in ASTM-D-2412, except for the following conditions: (1) The test specimens shall be 12 plus or minus 1/8 in. long. (2) Locate the first specimen in the loading machine with the imaginary line between the two corrugator seams (end view) parallel to the loading plates. The specimen must lay flat on the plate within 1/8 in. and shall be straightened by hand bending at room temperature to accomplish this. Use the first location as a reference point for rotation and testing of the other two specimens. Each specimen shall be tested in only one position. (3) The deflection indicator shall be readable and accurate to plus or minus 0.001 in. (4) The parallel plates must exceed the samples in length.

7.6.1 Deflection - The pipe stiffness test described in paragraph 7.6 shall be continued until a deflection of 20 percent of the original inside diameter is reached. Visual examination shall be carried out immediately.

7.7 Elongation - A minimum of three test specimens, 5 ft in length, shall be tested for stretch resistance. Subject each test specimen to a longitudinal stretching force of the magnitude of five times the normal inside diameter in pounds, excluding tare weight. The specimens shall be hung vertically, and the test force shall be applied as a dead (hanging) weight to the bottom end of the tube. The gage length for determining percentage elongation shall be the middle 3-ft part of the specimen. A tare weight (one times the inside diameter) shall be applied before marking the 3-ft-gage length. The test weight shall be applied gently and shall be allowed to remain for 3 minutes; the gage length shall then be quickly measured to the nearest 0.125 in. to determine elongation. Elongation (E) shall be calculated as:

$$E = \frac{\text{(in. of stretch)}}{\text{36 in.}} \times 100 \text{ percent}$$

7.8 Joint Separation Test - The elongation test shall be repeated with a fitting in the center of a 3-ft-gage section. No external reinforcement, such as tape or wire shall be used unless supplied by the manufacturer with the fitting. Separation shall be considered a failure.

7.9 Quality of Extruded PVC - Sections of tubing shall be tested for quality of extrusion according to guidelines in ASTM-D-2152.

7.10 Brittleness - Tubing specimens shall be tested according to guidelines in ASTM-D-2444. A Tup B weighing 5.5 lb shall be used, and the height of

drop shall be 1.8 ft. A flat plate specimen holder shall be used. The specimens shall be conditioned for 24 hours at a temperature of 32 degrees F ±2 degrees F, and all tests shall be conducted within 60 seconds after removing the specimen from this atmosphere.

7.11 Bending - Select three tubing specimens of sufficient length to be bent half a revolution around a cylindrical mandrel with a radius of three times the nominal diameter of the tubing. Condition the specimens at 32 degrees F ±2 degrees F for a minimum of 24 hours. Remove the specimen from the cold chamber, and within 30 seconds bend the specimen by hand one-half revolution over the mandrel. Do not exert longitudinal forces on the specimen while bending. Keep the specimen in this position for 10 minutes and then immediately visually inspect the specimen in the bent position for splits and cracks.

7.12 Straightening - Select three tubing specimens of sufficient length to be bent half a revolution around a cylindrical mandrel with a radius of three times the nominal diameter of the tubing. Bend the specimen by hand one-half revolution over the mandrel and secure it in this position. Do not exert longitudinal forces on the specimen while bending. Place the mndrel, and the secured specimen in a cold chamber for a minimum of 24 hours at 32 degrees F ±2 degrees F. Within 30 seconds after removing the specimen from the cold chamber, straighten the specimen by hand and visually inspect it for splits or cracks. Inspect it again for splits and cracks 24 hours later.

8. Marking

8.1 Marking - Corrugated polyvinyl chloride drainage tubing complying with this specification shall be marked regularly at intervals not exceeding 10 ft with the manufacturer's identification symbol.

8.1.1 Dating - Each roll or bundle shall bear the day, month, and year of manufacture.

8.1.2 Declaration of compliance - The following statement shall appear on invoices, sales literature, and quotations: "This tubing complies with all applicable requirements of USDA, Soil Conservation Service, Specificationas for Corrugated Polyvinyl Chloride Drainage Tubing, dated October 1977."

9. Report

9.1 The test report shall include the following:

9.1.1 Date or dates of tests (uncoded).

9.1.2 Complete identification of product tested, including nomenclature, manufacturer, source, and previous history, if any.

9.1.3 Description of manufacturer's product marking.

9.1.4 Notation describing any retesting because of previous test failure.

9.1.5 Conditioning method.

9.1.6 Details of sampling.

9.1.7 Data in the report must include test results and weights of each test specimen, as well as averages of such tests and weights.

9.1.8 Description of any failures.

9.1.9 If tubing meets all requirements of this specification, the report shall contain the statement noted in paragraph 8.1.2.

Table I - Physical test requirements for corrugated polyvinyl chloride drainage tubing (heavy-duty)

Physical property specified	Tubing requirements
Stretch resistance (maximum)…..	5 pct
Pipe stiffness at 5 pct deflection (minimum)……..	30 lb/in.^{2}
Pipe stiffness at 10 pct deflection (minimum)……..	25 lb/in.^{2}

Foundation

If soft or yielding foundations are encountered, they shall be stabilized and the lines shall be protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a plank or other rigid support, or by using long sections of perforated or watertight pipe having adequate strength to insure satisfactory subsurface drain performance.

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.

Heavy-duty corrugated plastic drainage tubing shall be specified if the soil is rocky, if cover over the tubing is expected to exceed 10 feet (3 m), or trench widths are expected to exceed 2 feet (0.6 m). (This refers to trench widths in the area of the tubing and at least 1 foot (0.3 m) above the top of the tubing.)

Filters and Filter Material

Suitable filters shall be used around conduits if they are needed because of site conditions to prevent sediment accumulation in the conduit. 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.

Not less than three inches (76 mm) of filter material shall be used for sandgravel filters. 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 shall pass the No. 60 sieve.

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

Envelopes and Envelope Material

Envelopes shall be used around subsurface drains if they are required 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 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 sandgravel, 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. Where organic or other compressible materials are used, that 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

All subsurface drains, whether flexible conduit such as plastic or bituminized 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," except that:

- Rigid drainage conduits, such as clay or concrete drain tile, do not need the 90 degree V-groove in the trench bottom.
- The V-groove shall not be used for flexible conduits exceeding 8 inches (203 mm) in diameter, because the void under the conduit will create a potential path for soil erosion. A semicircular or trapezoidal groove shaped to fit the conduit shall be used for flexible conduits exceeding 8 inches (203 mm) in diameter.

An alternative method for placing and bedding all specified sizes of corrugated thermoplastic tubing is to place the tubing in accordance with ASTM-F-449, paragraph 8.6-Blinding, with the following additional requirements:

- Compact bedding material to the top of the tubing.
- Bedding material should be a minimum depth of 6 inches (152 mm) over the tubing.

Auxiliary Structures and Protection

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

If the drain system is to carry surface water flow, surface water inlets shall have a capacity of no less than that required to provide the maximum design flow in the drain line or lines.

The capacity of a relief well system shall be based on the flow from the aquifer, the well spacing, and other site conditions and shall be adequate to lower the artesian water head to the desired level.

Junction boxes, manholes, catch basins, and sand traps shall be accessible for maintenance. A clear opening of not less than 2 feet (0.6 m) shall be provided in either circular or rectangular structures.

The size of relief wells is generally based on the available equipment rather than on hydraulic consideration. Such wells shall not be less than 4 inches (100 m) in diameter.

The drain system shall be protected against velocities exceeding those provided under "Maximum Permissible Velocity Without Protective Measures" and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe shall be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed if more than two main drains join or if two main drains join at different elevations.

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 of flow. Auxiliary surface waterways shall be used where feasible.

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

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

Continuously submerged outlets shall be permitted for water table control in organic and sandy soils if planned and designed according to the standards for regulating water in drainage systems (554).

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

- Where there is a hazard of vegetation burning on the outlet ditch bank, the material from which the outlet pipe is fabricated shall be fire resistant. Where the hazard of burning is high, the outlet pipe shall be fireproof.
- Two-thirds of the pipe shall be buried in the ditch bank, and the cantilevered section shall extend to the toe of the ditch side slope or the side slope shall be protected from erosion. The minimum length of pipe shall be 8 feet (2.4 m).
- If 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.

- Headwalls used for subsurface drain outlets shall be adequate in strength and design to avoid washouts and other failures.

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

CONSTRUCTION PLANS

Plans 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 plans for subsurface drainage systems should include the location, size, spacing, depth, grade and material requirements of the drainage tubing. The plans should also include details on the filters, envelopes, placement, bedding, auxiliary structures, and protection.

PLANNING CONSIDERATIONS FOR WATER QUANITY AND QUALITY

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. Effects 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.