NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Feet)

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.

PURPOSES

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 flukes, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

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

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

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged. Septic tanks and other waste disposal systems shall not be connected directly to subsurface drain systems.

CRITERIA

General Criteria Applicable To All Purposes

The design and installation shall be based on adequate surveys and investigations. This practice shall comply with all Federal, State, and Local laws and regulations.

Capacity. One or more of the following shall determine the required capacity:

1. Application of drainage coefficients, as recommended by the Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001 or Chapter 14, Water Management (Drainage), Subchapter C, Subsurface Drainage of the Engineering Field Handbook (EFH) 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 inches. Unless special bedding arrangements are provided, the minimum diameters used in organic soils shall be five inches for plastic tubing and six inches for rigid tile. Rigid tile used in organic soils shall have a minimum length of two feet.

Existing subsurface drains used for outlets.

When an existing subsurface drain is to be used for an outlet, the following shall apply:

Case I – For areas to be drained that are five (5) acres or less.

This will apply principally to small systems and random lines where complete extensive systems are not needed.

An investigation shall be made of the existing subsurface drain to determine that:

1. It is in good physical condition based on observations at the junction point with the new system.
2. It has adequate capacity based on general observations made in the field. A survey or instrument check of the subsurface drain main downstream a distance of 200 to 300 feet from the junction is advisable to determine grade. It will not be necessary to continue this check to the outlet unless observations indicate the advisability of such survey.
3. It has sufficient depth to provide minimum cover for all new lines to be installed.

Case II – For areas to be drained in excess of five (5) acres.

The investigation shall include the following:

1. A physical inspection of the existing subsurface drain to determine that it is operative, free from breakdowns, and has an adequate outlet. The physical inspection will constitute observing the physical condition of the subsurface drain for the following conditions:

    a. Breakdowns which are usually accompanied by holes in the land over and along the line.

    b. Fractured tile, such as quartering (fractures on the quarter points, which result in an egg-shape cross-section).

    c. Deposition of soil. If excessive deposition appears, make a further study to determine the cause and correct the situation.

    d. Physical material deterioration that would seriously subject it to failure, due to high absorption rate, soil acidity, or alkalinity, etc.

1. Determine the capacity of the existing tile by checking the grades and sizes in the critical areas, particularly the flat reaches.

2. The existing subsurface drain outlet will be considered adequate if the capacity of the subsurface drain, as determined in Step 2, is greater than 80% of the required capacity, and if the existing tile is not deteriorated because of holes, quartering, roots or submergence of the outlet, except where such damages are repaired, and/or corrected.

If the surface drain is a drain of record or legal drain, all of the information available from the record, shall be used in making the determination as to the adequacy of the tile outlet.

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, and outlets.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet. 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 feet 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 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Heavy-duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

Depth of mains shall be designed so that the laterals can be joined to the main with a center-to-center or higher connection. A minimum difference in elevation of 0.3 foot between the flow lines of the main and of the lateral is desirable. Flowline-to-flowline connection is permissible when unavoidable.

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 are not a concern when the depth of cover exceeds 6 feet. 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.

Criteria for depth, spacing, and location are provided in the Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001 and Chapter 14, Water Management (Drainage), Subchapter C, Subsurface Drainage of the EFH.

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 (feet per second). 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 acceptable cleaning solutions.

Velocities based upon drain material sizes and grades are shown on the applicable nomographs in both the Indiana Drainage Guide and Chapter 14 of the EFH.

Maximum Velocity Without Protection. Excessive flow velocity in the drain may induce piping of soil material into the drain line.

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

TABLE 1 Maximum Velocities by Soil Texture

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 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 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 with tar impregnated paper, burlap, or special fabric-type filter material.
6. Install open-air risers for air release or entry.

Iron Ochre Control. If drains are to be installed in sites where iron ochre and manganese dioxide problems are likely to occur, provisions shall be made to provide access for cleaning the lines. Each drain line shall outlet directly into an open ditch and/or shall have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions shall 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 shall be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their development shall 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 vegatation 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 feet on each side of the drain. A distance of 50

feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities shall 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 drain lines 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 for the site. All conduits shall meet or exceed the minimum requirements of the appropriate specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

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 of perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance. A flat treated plank shall not be used 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 shall be specified if:

1. Local experience indicated a need.
2. Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7.
3. Deep soil cracking is expected, or
4. The method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with National Engineering Handbook (NEH) Part 633, Chapter 26, 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 inches of filter material except that the top of the conduit and side filter material shall 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 shall be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

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

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

Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch 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 shall not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger tile and stones no more than ¾ inch diameter for tile less than 6 inches. Where such conditions are present the trench must be over-excavated, a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit shall be placed on a firm foundation to ensure proper alignment. Prevent runoff and surface water from entering the trench.

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 inches 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 inches thick, to provide support.
3. Compacted soil bedding material beside

and to 3 inches above the tubing

For trench installations of corrugated plastic tubing larger than 8 inches, 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 shall 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 compacted bedding is not specified, the conduit shall be covered with selected material containing no hard objects larger than 1.5 inches in diameter. Conduit shall be covered to a minimum of 3 inches above the top of the conduit.

All installations shall meet the minimum requirements of the appropriate ASTM specification.

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 or trash racks shall 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 inches in diameter.

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

The drain system shall be protected against velocities exceeding those provided in Table 1 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 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 shall be used, and the junction box shall have a minimum of 1 ½ feet of soil cover.

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

Outlet

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. Standard 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 Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) Standard (554) Drainage Water Management.

The outlet pipe and its installation will conform to the NRCS FOTG Standard (620) Underground Outlet.

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures.

CONSIDERATIONS

When designing subsurface drainage systems, consider the effects the system will have on water quantity and quality.

Effects on quantity to consider include: water budget, base flow and runoff to water uses and users, groundwater recharge, and volume of soil water needed to improve plant growth.

Water quality effects that should be considered include: delivery of sediment, changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users, changes in delivery of dissolved substances to the aquifer, downstream water temperatures, and the effects on the visual quality of downstream water.

If a concern exists of tile lines picking up polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow blocking devices.

Consider adding collector mains to minimize the visual impact, potential fear from ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions.

Consideration shall be given to maintaining or enhancing environmental values.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

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.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain the

functional capacity of the subsurface drain. Items to consider are:

1. Keep inlets, trash guards, collection boxes and structures clean and free of materials that can reduce the flow.

2. Repair all broken or crushed lines to insure proper functioning of the drain.

3. Repair or replace broken or damaged inlets and breathers damaged by livestock or machinery.

4. Periodically, or at a minimum of annually, inspect the outlet conduit and animal guards for proper functioning.

REFERENCES

NEH Part 650, Engineering Field Handbook, Chapter 14, Water Management (Drainage)

NEH Part 633, Soil Engineering, Chapter 26, Gradation Design of Sand and Gravel Filters

Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001