NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Ft.)

CODE 606

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DEFINITION

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

PURPOSE

- Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
  - ◊ Regulating water table and ground water flows,
  - ◊ Intercepting and preventing water movement into a wet area,
  - ◊ Relieving artesian pressures,
  - ◊ Removing surface runoff,
  - ◊ Leaching of saline and sodic soils,
  - ◊ Serving as an outlet for other subsurface drains, and
  - ◊ Regulating subirrigated areas or waste disposal areas.
- Collect ground water for beneficial uses.
- Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.
- 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.

CRITERIA

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

Utilities and Permits. The landowner shall be responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

The landowner shall obtain all necessary permissions from regulatory agencies, including the Illinois Department of Agriculture, US Army Corps of Engineers, US Environmental Protection Agency, Illinois Environmental Protection Agency and Illinois Department of Natural Resources – Office of Water Resources, or document that no permits are required.

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

- 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.

- Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
- 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 of adverse weather and ground water conditions.
- 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:

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.

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 feet. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet 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.

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 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. NEH, Part 636, Chapter 52 "Structural Design of Flexible Conduits" may be used for the design.

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 (ft/s). If a sedimentation hazard exits, 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.

Maximum Velocity. The maximum velocity must not exceed the safe velocity for the conduit materials and installation (Table 1).

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Table 1. Corrugated Plastic Tubing Velocity, ft/s		
Soil Texture	Perforated	Non-Perforated
Sand and sandy loam	3.5	8.0
Silt and silt loam	5.0	10.0
Silty clay loam	6.0	12.0
Clay and clay loam	7.0	12.0
Coarse sand or gravel	9.0	12.0

On sites where topographic conditions require that perforated drain lines be placed on steep grades and design velocities will be greater than indicated in Table 1, a filter may be used to prevent movement of the surrounding soil material into the conduit.

Maximum Velocity for non-perforated Dual Wall Polyethylene pipe and joints is 20 ft/s. All joints and fittings shall be watertight, capable of withstanding 10.8 psi internal pressure.

Non-Perforated Polyvinyl Chloride (PVC), Smooth Steel or Corrugated Metal Pipe have no velocity restrictions if joints are watertight and pipe is aligned to prevent cavitation and water hammer.

Iron Ochre Control. If drains are to be installed in sites where iron ochre and manganese dioxide 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 and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their 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.

Where possible, use non-perforated 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 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 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 or perforated or watertight pipe having adequate strength to ensure 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 perforated 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:

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1. Local experience indicates 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.
5. Maximum expected flow velocity exceeds the value in Table 1 for perforated conduits.

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 may be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required. In all cases the resulting flow pattern through filter material shall be a minimum of 3 inches.

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

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

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

Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-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 should 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 must 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.

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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 compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 inches in diameter. Blinding should be carried to a minimum of 3 inches above the conduit.

All installations shall meet the minimum requirements of ASTM F449 Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control.

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 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 water head 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.

Pressure-relief wells may be used to allow excess flow to escape the conduit and flow over the ground surface. Only use pressure relief wells where there is a stable outlet for the flow from the relief well. Cover pressure relief wells with a grate or other appropriate covering to prevent the entry of small animals and debris. For relief wells used as outlets, the subsurface drain system shall have a positive hydraulic grade line to the relief well. Inline relief wells shall have a positive hydraulic grade line from the relief well to the outlet of the system.

Junction boxes, manholes, catch basins, and sand traps must 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 must be protected against velocities exceeding those given in Table 1 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 1.5 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.

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.

Outlet.
The outlet must be stable for anticipated design flow conditions from the subsurface drain. Design the outlet for water surface conditions at the outlet expected during the design flow conditions.

The outlet must consist of a continuous 10 foot section or longer of closed conduit or a headwall at the outlet. If a closed conduit is used, the material must be durable and strong enough to withstand anticipated loads,

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including those caused by ice. If the outlet is to a ditch or channel, at least two-thirds of the continuous section of closed conduit shall be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch.

Do not design outlets to be placed in areas of active erosion. Use fire resistant materials if fire is an expected hazard. All outlets must have animal guards to prevent the entry of rodents or other animals. Design animal guards to allow passage of debris while blocking the entry of animals that cannot easily escape from the conduit.

Stabilization. Reshape and regrade all disturbed areas so that they blend with the surrounding land features and conditions. Revegetate or otherwise protect from erosion, disturbed areas that will not be farmed, as soon as possible after construction.

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.

Consideration should be given to using subsurface drainage to control high water tables in areas where septic tanks and leach fields exist.

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

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

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under federal, state, or local laws. Consideration shall be given to maintaining or enhancing environmental values.

Pressure relief wells, if not properly covered, can present a safety hazard for people or animals stepping into the well. In addition, pressure relief wells can be easily damaged by field equipment. To prevent accidents, mark the location of pressure relief wells with a high visibility marker.

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.

REFERENCES

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapters 3, 6, 8, 14.

USDA-NRCS. National Engineering Handbook (NEH) Part 633, Chapter 26, “Gradation Design of Sand and Gravel Filters.”

USDA-NRCS. National Engineering Handbook (NEH), Part 636, Chapter 52, “Structural Design of Flexible Conduits.”

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NATURAL RESOURCES CONSERVATION SERVICE
ILLINIOS CONSTRUCTION SPECIFICATION
SUBSURFACE DRAIN

Scope
The work shall consist of furnishing and installing conduits and appurtenances for the subsurface drain system as shown on the drawings and specified herein.

Utilities
The landowner shall be responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

Inspection and Handling of Materials
Conduit and inlet materials shall be carefully inspected before installation. Where applicable, clay and concrete tile shall be checked for damage from freezing and thawing prior to installation. Bituminized fiber and plastic pipe and tubing shall be protected from hazards causing deformation or warping. Materials with physical imperfections shall not be installed. All material shall be satisfactory for its intended used and shall meet applicable specifications and requirements.

Materials
Materials for subsurface drains shall meet the requirements as shown in the plans and specifications. They shall be field inspected for any deficiencies such as thin spots or cracking prior to installation.

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

The following reference specifications pertain to products currently acceptable for use as subsurface drains:

REFERENCE SPECIFICATIONS FOR UNDERGROUND OUTLET MATERIALS	
Description	**ASTM**
Plastic	
Corrugated Polyethylene (PE) Pipe and Fittings	F405 F667
Poly Vinyl Chloride (PVC) Pipe and Fittings	F949 D1785
Styrene-Rubber (SR) Plastic Drain Pipe and Fittings	D2852
Dual Wall Polyethylene Pipe	
Corrugated Polyethylene (PE) Pipe and Fittings	F2306 F2648 F405 F667
Elastomeric Seals and Joints (Gaskets)	F477 D3212
Clay	
Clay Drain Tile and Pipe	C4 C700 C301
Concrete	
Concrete Drain Tile and Pipe	C412 C118 C14 C76 C444
Test Methods for Concrete Pipe	C497
Portland Cement	C150
Metal	
Corrugated Aluminum Pipe	B745
Corrugated Steel Pipe	A760

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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 over the top of the drain. No reversals in grade of the conduit shall be permitted. Material used for blinding shall contain no rocks greater than 1½ inches in diameter. The cover over all buried conduit lines shall be at least 2 feet deep.

All conduits shall be installed in accordance with ASTM F449 Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control.

Rigid conduits such as clay or concrete tile will not need the 90º V groove, but all other applicable placement and bedding requirements will be adhered to. Joints between drain tiles shall have the closest possible fit.

Backfill

Earth backfill material shall be placed in the trench in such a manner that displacement of the conduit will not occur and so that the filter and bedding material, after backfilling, will meet the requirements of the drawings and specifications. Backfill within 2 feet of conduit shall have no rock particles larger than 2 inches in diameter. All backfill shall contain no stones larger than 6 inches in diameter, frozen material, or large dry clods.

Outlet

A continuous section of non-perforated conduit shall be used at the outlet, unless a headwall is used. All outlets shall have an animal guard, hinged to allow passage of debris.

The continuous section of non-perforated conduit shall be long enough to satisfy all requirements of the standard:

- At least two-thirds of the pipe shall be buried in the ditch bank.
- The cantilever section must extend to the toe of the ditch side slope or to the side slope protected from erosion.
- The continuous section must be at least 10 feet long.

Acceptable materials for use at the outlet include the following:

- Corrugated metal pipe, galvanized or aluminum, 16-gauge, minimum thickness,
- Smooth steel pipe with 3/16 of an inch minimum thickness,
- Smooth plastic pipe, polyvinyl chloride (PVC), with a SDR of 35 or less or schedule 40 or heavier, and
- Dual wall corrugated polyethylene pipe.

All plastic and polyethylene pipe outlets shall include an ultra-violet stabilizer. Conduit ends shall be protected during installation.

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NATURAL RESOURCES CONSERVATION SERVICE

ILLINOIS OPERATION AND MAINTENANCE

SUBSURFACE DRAIN

Follow the operation and maintenance plan below to keep your subsurface drain system functioning as intended:

- Inspect after significant storm events and at least annually to identify repair and maintenance needs.
- Promptly repair or replace damaged components as necessary.
- Repair any settlement or erosion that occurs. If this problem persists, evaluate the drain for leakage and repair as necessary.
- Maintain design depth of cover on all pipelines and structures.
- Limit traffic over pipeline to designated sections that were designed for traffic loads.
- Check outlet pipe and animal guard to ensure proper functioning.
- Maintain erosion protection at outlets; repair any eroded areas at the outlet.
- Protect the components from damage by farm equipment and livestock.
- Follow OSHA trench safety requirements during repairs of the subsurface drain

Additional Details:

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