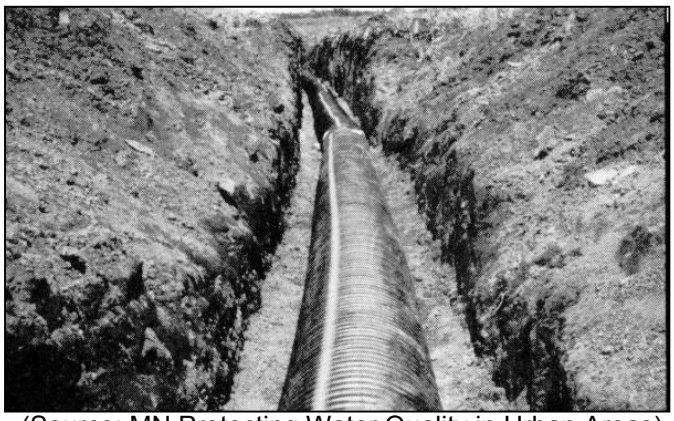
NATURAL RESOURCES CONSERVATION SERVICE
ILLINOIS URBAN MANUAL
PRACTICE STANDARD

SUBSURFACE DRAIN

(ft.)
CODE 945



(Source: MN Protecting Water Quality in Urban Areas)

DEFINITION

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

PURPOSE

The purposes of this practice are to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
   a. Regulating the 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 liver 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.

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:

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.

The minimum required drainage coefficient shall be determined from the Illinois Drainage Guide, for the kinds of crop grown and degree of existing drainage.

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 evaluations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

All subsurface drains shall have 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 ft. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet or sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils shall be 2.5 ft. for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control 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. 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 equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be negated 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 use 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 not less than 0.5 ft/sec. If a sedimentation hazard exists, a velocity of not less than 1.4 ft/sec shall be used to establish the minimum grades. 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 without protection. Excessive flow velocity in the drain may induce piping of soil material into the drain line.

TABLE 1
Maximum Velocities by Soil Texture

Soil Texture	Velocity (ft./sec.)
Sand & sandy loam	3.5
Silt & silt loam	5.0
Silty clay loam	6.0
Clay & 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 site.

The protective measures 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 considerations - If drains are to be installed in sites where iron ochre problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron is in its insoluble form. Where possible, in areas where the potential for ochre problems is high, protection against ochre development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection against root clogging - Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water-loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

The first consideration is to use nonperforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100-ft on each side of the drain. A distance of 50 ft should be maintained from other species of trees except for fruit trees. Orchards can often drained by drains located close to the fruit trees.

Where crops and grasses may cause trouble to 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.

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 non-perforated 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 characteristic of the surrounding soil material, site conditions, and velocity of flow in the conduit. A suitable filter should be specified if:

1. Local experience indicates a need,
2. Soil materials surrounding the conduit are dispersed clays, low plasticity silts, or fine sands (ML or SM with P.I less than 7),
3. Where deep soil cracking is expected, or
4. Where the method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation will be based on the gradation of the base material surrounding the conduit within the following limits:

D15 size smaller than 7 times d85 size but not smaller than 0.6 mm.

D15 size larger than 4 times d15 size, less than 5% passing No. 200 sieve, maximum size smaller than 1.5 inches.

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, D15 size means that 15 percent of the filter material is finer than that size.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 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. 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 or 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. Where such conditions are present the trench must be overexcavated a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to insure proper alignment. If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or a silt slurry. For trench installations of corrugated plastic tubing 8 inches or

less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90 degree V-notch in the bottom of the trench for tubing support and alignment.
2. As 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 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. Blinder should be carried to a minimum of 3 inches 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 plates, and/or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

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

The size of relief wells is generally based on the available material rather than on hydraulic consideration. Such wells will not be less than 4 inches in diameter.

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 proved under "Maximum velocity without protection" and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1 1/2 foot of soil cover.

If not connected to a structure, the open 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.

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

1. If burning vegetation on the outlet ditch bank is likely to create a fire hazard; the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.
2. Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side protected from erosion. The minimum length of the pipe will normally be 8 feet. 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 feet, commonly referred to as "minimum ditches," for outletting individual subsurface drain laterals. For conduits 10 inches in diameter and greater, longer outlet sections should be considered, such as:

   10 inches and 12 inches in diameter, use 12 feet.

   15 inches and 18 inches in diameter, use 16 feet.

   Use 20-feet outlet pipe for all diameters larger than 18 inches.
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.

CONSIDERATIONS

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.

Septic tanks and other waste disposal systems shall not be connected to subsurface drain systems.

Where wetlands will be affected, the cooperator will be advised and USDA-NRCS wetland policy shall apply.

PLANS AND SPECIFICATIONS

Plans and specification for installing subsurface drains shall be in keeping with this standard and include the following:

1. Drain location and alignment.
2. Drain depth and grade.
3. Filter and envelope requirements (if used).
4. Material requirements.
5. Backfilling requirements.

OPERATION AND MAINTENANCE

A properly designed and installed subsurface drain requires little maintenance. However, check drains periodically and especially after heavy rains to see that they are operating properly. Keep the outlet free of sediment and other debris, and keep the animal guard in place and functional. Investigate any wet areas along the line for possible cave-in due to vehicle traffic, blockage by roots, or other problems. Make all needed repairs promptly.

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