### 620-CPS-1



**United States Department of Agriculture**

**Natural Resources Conservation Service CONSERVATION PRACTICE STANDARD UNDERGROUND OUTLET**

CODE 620

(ft)

# DEFINITION

A conduit or system of conduits installed beneath the ground surface to convey surface water to a suitable outlet.

# PURPOSE

This practice is used to accomplish one or more of the following purposes:

* Prevent concentrated flow erosion.
* Manage flooding and ponding.
* Maintain water quality.

# CONDITIONS WHERE PRACTICE APPLIES

This practice applies where—

* Removal of surface water is necessary.
* An outlet is needed for a terrace, diversion, water and sediment control basin, or similar practices.
* Removal of stormwater collected by roof runoff structures or similar practices is necessary.
* A surface outlet is impractical because of stability problems, topography, climatic conditions, land use, or equipment traffic.

# CRITERIA

## General Criteria Applicable to All Purposes

Plan, design, and construct the underground outlet to meet all Federal, State, Tribal, and local regulations.

## Capacity

Base the design capacity of the underground outlet on the requirements of the structure or practice it serves. An underground outlet can function as the only outlet for a structure or in conjunction with other types of outlets.

Design the outlet so the water storage time does not exceed the inundation tolerance of the planned crops, vegetation, or works of improvement. Remove the design volume of surface water from natural or constructed basins within 48 hours or less for row and other commodity-type crops.

Design the underground outlet to account for anticipated water surface conditions at the outlet during design flow.

Flood routing techniques may be used to determine the relationship between flooding duration, underground release rate, and basin storage volume.

Underground outlets can be designed for either pressure or gravity flow. Design all pipes and joints in pressure systems to withstand the design pressure, including surges and vacuum. For gravity flow systems, use a flow-restricting device such as an orifice or weir to limit flow into the conduit or choose conduit sizes that are large enough to prevent pressure flow. Design the orifice to be compatible with the inlet. Size the orifice based on the inundation time and potential crop residue. Gravity flow systems must maintain a positive grade throughout the conduit length towards the outlet.

When used, orifice plates must be made of metal or durable plastic, fit tight against the seat of connectors, and have a smooth edge. Use NRCS Title 210, National Engineering Handbook, Part 650, Engineering Field Handbook (210 NEH Part 650), Chapter 8, “Terrace,” or other appropriate design tools to determine the capacity of orifices or other types of devices which restrict flow. Submergence of the orifice will reduce the orifice head pressure. Use the reduced head pressure to determine submerged orifice capacity.

If necessary, use pressure relief wells to allow excess flow to escape the conduit and flow over the ground surface. Use pressure relief wells only where there is a stable outlet for the discharge from the relief well. Extend the relief well to the ground surface but no more than 6 inches above the surrounding natural ground. Cover pressure relief wells with a grate or other appropriate covering to prevent injury to animals and entry of debris.

## Inlet

An inlet can be a collection box, blind inlet (gravel), perforated riser, perforated conduit, or other appropriate device. Design components of underground outlets, including inlet collection boxes and conduit junction boxes, with sufficient size to facilitate maintenance and cleaning operations.

Size the capacity of the inlet to be equal to or greater than the design discharge rate used to compute the basin storage volume. Calculate the inlet capacity with the water surface at 70 percent of the design ridge height.

Open inlets must have a trash guard. Design the inlet so any trash or debris entering the inlet will pass through the flow-restricting device and conduit without plugging. Screen openings must not be larger than one-half the orifice diameter on inlets with orifices.

Inlet caps or screens must be removable on inlets with orifice plates.

Minimum inside diameter of inlet is 4 inches.

Perforated riser inlets must be durable, structurally sound, and resistant to damage by rodents or other animals. Perforations must be smooth, free of burrs, and have adequate capacity to prevent the riser from restricting flow in the underground outlet. Calculate inlet capacity assuming 50 percent of the openings on the side of the inlet are plugged.

Blind inlets may be used where the installation of an open or above ground structure is impractical. Design the blind inlet to prevent soil particle movement into the conduit. Design the blind inlet with a graded granular filter around the conduit. Design the filter based on the particle size of the surrounding soil and the desired flow rate. Refer to NRCS 210 NEH Part 650, Chapter 14 “Water Management (Drainage)” (210 NEH Part 650 Ch 14) for the design of blind inlets.

## Conduit

The minimum allowable diameter of conduits is 4 inches, except the offset pipe between the surface intake riser and underground outlet may be 3 inches. Conduit joints must be hydraulically smooth and consistent with the manufacturer’s recommendation for the conduit material and installation.

An offset pipe is required between the inlet and the underground outlet conduit unless the inlet is the top inlet in a terrace/basin system. ~~Outlet conduit does not extend upstream from the inlet.~~ The minimum length of the offset pipe is 8 feet.

If the top most inlet in a terrace/basin system is placed directly on the main conduit, the conduit must be non-perforated from the inlet to the toe of the embankment backslope.

If the offset pipe is used to restrict flow, use pipe and joints rated to withstand the anticipated pressure.

The fittings used to connect the inlet pipe to the underground outlet conduit must be watertight. Fittings will comply with the underground outlet manufacturer’s recommendations and be of equivalent strength and pressure rating. Fittings must not reduce or impair the overall integrity or function of the underground outlet system.

Design the underground outlet to ensure that maximum allowable loads on the conduit are not exceeded for the type and size of conduit. Assess the depth of cover requirements to prevent damage to the underground outlet from traffic, tillage operations, and frost action. Design perforated components of underground outlets to prevent soil particle movement into the underground outlet. In absence of manufacturer’s data, use Iowa NRCS Conservation Practice Standard (CPS) Subsurface Drain (Code 606) criteria for filters, design loading, placement, and bedding requirements.

Provide thrust blocking or anchoring where needed to prevent undesired movement of the conduit. Evaluate placement, bedding, and backfill requirements for the conduit to ensure integrity of the installation. In absence of manufacturer’s data, design thrust blocks in accordance with NRCS 210 NEH Part 636, Chapter 52, “Structural Design of Flexible Conduits” (210 NEH Part 636 Ch 52).

Minimum velocity and grade

In areas where sedimentation of fine sands and silts is not a hazard, design the minimum grade based on site conditions and a velocity of not less than 0.8 feet per second. If a sedimentation potential exists, either use a velocity of not less than 1.4 feet per second to establish the minimum grade or include provisions for preventing sedimentation. Use filters, collect and periodically remove sediment from installed traps, or periodically clean the lines with high-pressure jetting systems or cleaning solutions to address sedimentation. Prior to using high-pressure jetting systems, verify that the jetting system will not damage the pipe or the pipe embedment.

Maximum velocity

Limit the design velocities in perforated, high-density polyethylene (HDPE) pipe under open channel flow to 12 feet per second or the manufacturer’s recommended limit. Limit design velocities for nonperforated pipe to manufacturer’s recommended limits applicable to the pipe diameter, material and joint type, and site condition.

## Materials

Underground outlet materials include flexible conduits of plastic, metal, or other materials of acceptable quality. Materials must meet applicable site-specific design requirements for leakage, external loading, and internal pressure including vacuum conditions. All materials specified in Iowa NRCS CPS Subsurface Drain (Code 606) may be used for underground outlets.

All conduits must 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 Transportation Officials (AASHTO), or the American Water Works Association (AWWA).

Underground outlet conduits may be continuous tubing, tile, or pipe sections and may be perforated or nonperforated. Ensure any couplers joining pipe sections are compatible with the pipe and will withstand all required loads.

Use an appropriately designed filter fabric wrap (sock) or granular filter if migration of soil particles into the conduit is anticipated. Design the filter based on the particle size of the surrounding soil to prevent rapid clogging of the filter. Refer to Iowa CPS Subsurface Drain (Code 606) for the design criteria of filter media.

Use fire-resistant materials for underground outlet components if fire is an expected hazard. All plastics must be UV resistant or protected from exposure to sunlight.

The fill height over the underground outlet conduit or pipe must not exceed the values shown in Table 1 or Table 2, depending on the type of conduit material. Meet the following conditions for the use of different pipes and/or pipe cover parameters:

* The pipe must be a type listed in 210 NEH Part 650 Ch 14, Section 650.1413 “Materials.”
* An engineering load analysis is completed in accordance with the parameters and procedures defined in 210 NEH Part 636 Ch 52.
* Develop installation specifications for the specific site conditions and pipe material used.

**Table 1. ALLOWABLE COVER ON METAL PIPE (STEEL AND ALUMINUM)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Material Type | Diameter Inches | Minimum Pipe Cover  Feet | Non - Trench Maximum Earth Fill Pipe Cover  Feet | Maximum Pipe Cover for Pipes Installed in a Trench Condition  Feet |
| Helical Corrugated Metal Pipe \* (Steel) | 6 - 18 | 1.0 | 20.0 | 20.0 |
| Annular Corrugated or Helical Corrugated  Metal Pipe # (Aluminum) | 6 – 10 | 1.0 | 20.0 | 20.0 |
| Annular Corrugated or Helical Corrugated  Metal Pipe $ (Aluminum) | 12 - 18 | 1.0 | 20.0 | 20.0 |
| Smooth Steel Pipe & | 4 - 16 | 1.0 | 20.0 | 20.0 |

\* ASTM’s A760, A762, and A929 with a minimum wall thickness of 16 gauge (either 1-½ inch by ¼ inch corrugations or 2-2/3 inch by ½ inch corrugation)

# ASTM B745 with 1-½ inch by ¼ inch corrugations and a minimum wall thickness of 16 gauge

$ ASTM B745 with 2-2/3 inch by ½ inch corrugations and a minimum wall thickness of 16 gauge

& Minimum wall thickness is ¼ inch

**Table 2. ALLOWABLE COVER ON PVC AND PE PIPE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Material Type | Diameter Inches | Minimum Pipe Cover  Feet \* | Non - Trench Maximum Earth Fill Pipe Cover  Feet # | Maximum Pipe Cover for Pipes Installed in a Trench Condition  Feet $ |
| PVC SDR 41 \*\* | 4 – 12 | 2.7 | 5.8 | 12.2 |
| PVC SDR 32.5 \*\* | 4 – 12 | 2.2 | 8.4 | 14.2 |
| PVC SDR 26 \*\* | 4 – 12 | 2.1 | 12.4 | 17.9 |
| PVC SDR 21 \*\* | 4 – 12 | 2.0 | 19.7 | 20.0 |
| PVC Schedule 40 ## | 4 | 2.0 | 20.0 | 20.0 |
| PVC Schedule 40 ## | 6 | 2.0 | 15.0 | 20.0 |
| PVC Schedule 40 ## | 8 | 2.1 | 11.7 | 19.1 |
| PVC Schedule 40 ## | 10 | 2.1 | 9.6 | 16.8 |
| PVC Schedule 40 ## | 12 | 2.1 | 8.9 | 15.5 |
| PVC Schedule 80 ## | 4 – 12 | 2.0 | 20.0 | 20.0 |
| HD Corrugated Plastic PE $$ | 3 – 15 | 2.4 | 7.3 | 11.6 |
| Dual Wall PE && (corrugated exterior w/ a smooth wall interior) | 4 - 15 | 2.2 | 7.0 | 11.2 |

* PVC and PE pipes were analyzed with a modulus of soil reaction, E’ = 400 psi and a H20 Live Load Classification (PL = 16000 lbs)

# PVC and PE pipes were analyzed with a modulus of soil reaction, E’ = 200 psi

$ PVC and PE pipes were analyzed with a modulus of soil reaction, E’ = 400 psi; however, the width of the pipe trench from the bottom to at least 6 inches above the pipe shall not exceed the pipe diameter plus 24 inches or else the “Non-Trench Maximum Earth Fill Pipe Cover” shall be used as the limiting control factor.

\*\* ASTM D2241 Designation 1120 (12454-B), 1220 (12454-C), and 2120 (12454-D)

## ASTM D1785 Designation 1120 (12454-B), 1220 (12454-C), and 2120 (12454-D)

$$ ASTM F405 or F667 depending on pipe diameter; AASHTO M252 and M294

&& ASTM F 2648 or D3350; AASHTO M252 and M294

## Outlet

Stabilize the outlet and protect it against erosion and undermining for the range of design flow conditions.

An underground outlet may discharge into a structure that is designed to accommodate the additional inflow.

For discharge to streams or channels, locate the outlet invert above the elevation of normal flow and at least 1 foot above the channel bottom.

Specify a continuous section of pipe for the outlet section, minimum 20 feet in length, without open joints or perforations, and with stiffness necessary to withstand expected loads, including those caused by ice.



A shorter section of closed conduit may be used if a headwall is used at the outlet of the conduit. The use and installation of outlet pipe must conform to the following requirements:

* Bury at least two-thirds of the rigid outlet pipe section in the ditch bank and project the cantilever section past the toe of the ditch side slope; or protect the side slope from erosion below the outlet pipe.
* If ice or floating debris may damage the outlet pipe, protect the pipe by recessing the cantilevered part of the pipe to protect it from the current of flow in the ditch or channel.
* Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.

Specify animal guards on all outlets to prevent the entry of rodents or other animals. Design animal guards to allow passage of debris while blocking the entry of animals large enough to restrict the flow in the conduit.

Use a vertical outlet to discharge water to the ground surface where topography does not allow adequate conduit cover using a horizontal outlet, or where it is practical to discharge over a vegetated filter strip.

Design the vertical outlet to allow the system to drain during periods when not in use.

Pressure relief wells and vertical outlets, if not properly identified, can present a safety hazard for people or animals and may be damaged by field equipment. Identify pressure relief wells and vertical outlet locations with a high visibility marker.

## Stabilization

Reshape and regrade all disturbed areas so they blend with the surrounding land features and conditions. For areas that will not be farmed, refer to Iowa NRCS CPS Critical Area Planting (Code 342) for establishment of vegetation criteria. Establish permanent vegetation on all noncrop disturbed areas as soon as possible after construction.

**ADDITIONAL CRITERIA SPECIFIC FOR DIRECTIONAL DRILLED CONDUITS IN WAUBONSIE CREEK WATERSHED**

Directional drilled conduit may be used as the outlet for water and sediment control basins ONLY in Waubonsie Creek Watershed when:

* The outlet needs to be downstream of the headcut in order to stabilize the channel grade.
* An outlet is needed for a water and sediment control basin to keep the loess soil as dry as possible.
* It is not practical to get construction equipment to the bottom of the gully.

Design the water and sediment control basin according to with Iowa NRCS CPS Water and Sediment Control Basin (Code 638). It should be designed a safe distance above the top of the headcut. The back toe of the water and sediment control basin will be no closer to the gully banks than a distance equal to the depth of the gully if practical. However, in no case will it be closer to the gully banks than 20 feet.

Design the basin to store 100% of the runoff from a 10 yr. – 24 hr. storm event plus the projected sediment accumulation during the life of the basin. Design the underground outlet to drain the stored water within 24 hours. The minimum pipe size for the conduit is 6 inches diameter and the maximum pipe size is 8 inches diameter.

The conduit must be one continuous piece of pipe. Any joints of the main conduit must be of a heat fusion joining system. Pipe joints and fittings must be connected by thermal butt fusion, saddle fusion, or socket fusion in accordance with manufacturer recommended procedures.

The top of the inlet must be open and equipped with a trash rack.

An offset pipe is required between the surface inlet and the directional drilled conduit. The minimum length of offset is 8 feet.

In lieu of an offset pipe, a soil-bentonite cutoff collar can be installed. The bottom of the cutoff must be a minimum of four feet below the low point in the basin. Collar minimum dimensions are 3 feet by 3 feet by 12 inches thick and centered around the pipe at the inlet. The following criteria will apply:

* Bentonite must be a sodium bentonite with a free swell of at least 22 milliliters as measured by ASTM Standard Test Method D5890, unless laboratory tests using other bentonite types are used for design.
* Bentonite will be mixed with soil prior to placing in the 12 inch wide cutoff trench. For silts with a Unified Soil Classification of ML or CL-ML, 6 pounds of bentonite will be mixed with each cubic foot of soil material. For silty sands with a Unified Soil Classification of SM, SC-SM, or SP-SM, 8 pounds of bentonite will be mixed with each cubic foot of soil material.
* The soil-bentonite mixture will be placed in the cutoff trench and hand tamped. Impact type compaction equipment may be used; however, plate type or vibratory plate tampers are not allowed. The final thickness of each layer must be 6 inches or less after compaction.

If livestock are present at the site, a permanent 3 barb fence must be installed around the embankment and any upstream borrow areas in accordance with Iowa Implementation Requirement 382, Fence.

Directionally drilled conduits in Waubonsie Creek Watershed must be installed in accordance with Practice Specification IA-620A Underground Outlet, Waubonsie Creek Watershed.

# CONSIDERATIONS

Consider climate change impact on determining outlets capacity.

Consider impacts on downstream source water due to erosion and sediment load and impacts on important fish and wildlife habitats such as streams, creeks, riparian areas, groundwater, and wetlands.

Consider the effects of the underground outlet on the hydrology of adjacent lands, especially potential or delineated wetlands and existing wetland easements. Where wetlands may be affected, advise the cooperator that current USDA wetland policy will apply.

Consider adding additional subsurface drain pipe as an extension to the inlet to improve farmability along the channel. This subsurface drain will meet the requirements of Iowa CPS Subsurface Drain (Code 606) and be a minimum of 10 feet in length. Use manufacturer approved end caps or concrete to cap the open end of the subsurface drain.

Directionally drilled conduits in Waubonsie Creek Watershed are best suited for sites where there is very little or no groundwater flow through the base of the headcut. Since level terraces can increase the amount of groundwater flow, sites with level terraces are not recommended for this practice application.

Seasonal water sources can be beneficial for migratory waterfowl and other wildlife. Consider the use of a water control structure at the inlet of an underground outlet to provide water for wildlife during noncropping periods. Use Iowa NRCS CPS Shallow Water Development and Management (Code 646) to manage seasonal water sources for wildlife and Iowa NRCS CPS Structure for Water Control (Code 587) for the structure.

Underground outlets may provide a direct conduit to receiving waters for contaminated runoff. Install underground outlets and the accompanying structures or practices as part of a conservation system that addresses issues such as nutrient and pest management, residue management, and filter areas. Consider providing an increased level of designed treatment for sites with high priority areas for source water protection or are upstream of community drinking water withdrawal sites.

The construction of an underground outlet in a riparian corridor can have an adverse effect on the visual resources of the corridor. Consider the visual quality of the riparian area when designing the underground outlet.

Consider potential effects of soil physical and chemical properties on areas where a conduit or system of conduits are installed to convey surface water. Refer to soil survey data as a preliminary planning tool for assessment of areas. Consult the Web Soil Survey to obtain soil properties and qualities information.

When revegetation is needed, consider using species or diverse mixes that are native or adapted to the site and have multiple benefits. In addition, where appropriate, consider a diverse mixture of forbs and wildflowers to support pollinator and other wildlife habitat. if project is for USDA certified-organic and transitioning-to-organic operations, all materials need to comply with the USDA National Organic Program (NOP) Standards, including all seeds, planting stock, fertilizers, and other production inputs.

# PLANS AND SPECIFICATIONS

Prepare plans and specifications for underground outlets that describe the requirements for applying this practice according to this standard. The plans and specifications for an underground outlet may be incorporated into the plans and specifications for the structure or practice it serves. As a minimum include—

* A plan view of the layout of the underground outlet.
* Typical cross sections and bedding requirements for the underground outlet.
* Profile of the underground outlet.
* Details of the inlet, pipe, and outlet.
* Seeding requirements if needed.
* Iowa Standard Drawing IA-1501 (Underground Outlet) or equivalent drawing(s)

Prepare construction specifications describing site-specific installation requirements of the underground outlet. The following list of Construction and Practice Specifications is intended as a guide to selecting the appropriate specifications for a specific project. The list includes most, but may not contain all, of the specifications needed:

IA-5 Pollution Control

IA-6 Seeding and Mulching for Protective Cover

IA-620 or 620A Underground Outlets

# OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are—

* Periodic inspections, especially immediately following significant runoff events, to keep inlets, trash guards, and collection boxes and structures clean and free of materials that can reduce flow.
* Prompt repair or replacement of damaged components.
* Repair or replacement of inlets damaged by farm equipment.
* Repair of leaks and broken or crushed lines to ensure proper functioning of the conduit.
* Periodic inspection of the outlet and animal guards to ensure proper functioning.
* Repair eroded areas at the pipe outlet.
* Maintenance of adequate backfill over the conduit.
* Maintenance of the permeability of surface materials of blind inlets by periodic scouring or removal and replacement of the surface soil layer.

# REFERENCES

USDA NRCS. 2021. National Engineering Handbook (Title 210), Part 650, Chapter 6, Structures. Washington, D.C. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=46256.wba

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