CUYAHOGA COUNTY
DEPARTMENT OF PUBLIC WORKS

CUYAHOGA COUNTY ENGINEER
DRAINAGE MANUAL

Supplement to

O.D.O.T. Location and Design Manual

Volume 2 – Drainage Design

March 2021

Revisions to the June 2017 edition
are noted by a vertical line in the right page margin.

INTRODUCTION

Volume Two, Sections 1000 and 1100 of the O.D.O.T. Location and Design Manual, except as modified herein, together with this supplement, shall be applicable to all Cuyahoga County funded County Road or Bridge improvement projects. It is the objective of this manual to supplement O.D.O.T. drainage policy and also to indicate the differences between Cuyahoga County policy and O.D.O.T. policy. In order to facilitate cross-referencing, the topic headings and section numbers used in this manual correspond to those in the Location and Design Manual.

Where references are made to the State, the Administrator/Office of Hydraulic Engineering (OHE), or any other term designating any representative or employee of the State, or the Department of Transportation, as found in Sections 1000 and 1100 of the O.D.O.T. Location and Design Manual, such references shall alternately mean Cuyahoga County, The Cuyahoga County Department of Public Works, the Cuyahoga County Engineer, the Cuyahoga County Chief Section Engineer Highway Design and the Cuyahoga County Chief Section Engineer Bridge Design.

When a municipality has a written drainage policy, which the municipality desires to apply to a county funded County Road or Bridge improvement project, the Chief Section Engineer Highway Design or Chief Section Engineer Bridge Design shall review the municipality's policy and determine if such policy is appropriate for use on the project.

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(1001) HYDRAULIC DESIGN CRITERIA (Cuyahoga County)

1001.1 Responsibilities

Depending on which office manages the project, the Cuyahoga County Chief Section Engineer Highway Design or the Cuyahoga County Chief Section Engineer Bridge Design is responsible for the hydraulic and structural design approval of all prefabricated structures having a span of less than twenty feet (6.1 meters) and all standard headwalls or endwalls used in conjunction with these structures.

The Cuyahoga County Chief Section Engineer Bridge Design is responsible for the hydraulic and structural design approval of all prefabricated structures having a span of twenty feet (6.1 meters) or greater and all headwalls or endwalls used in conjunction with these structures. He/She also is responsible for the structural design approval of all non-standard headwalls or endwalls used in conjunction with prefabricated structures having a span of less than twenty feet (6.1 meters).

The Cuyahoga County Chief Section Engineer Bridge Design is responsible for the structural design approval of all cast-in-place structures regardless of structure size and for the hydraulic design approval of cast-in-place structures having a span of twenty feet (6.1 meters) or greater.

Depending on which office manages the project, the Cuyahoga County Chief Section Engineer Highway Design or the Cuyahoga County Chief Section Engineer Bridge Design is responsible for the hydraulic design approval for cast-in-place structures having a span of less than twenty feet (6.1 meters).

1001.2 Natural Streams

Channel designs and channel relocations of all natural streams passing through a proposed highway facility are the responsibility of the Chief Section Engineer (Bridge or Highway Design) who is responsible for the hydraulic review and approval for the highway structure.

(1002) PIPE CRITERIA (Cuyahoga County)

1002.3 Conduit Types

1002.3.1 Type A Conduits

For all local, non-federal aid projects, non-reinforced concrete pipe and clay pipe shall not be specified as Type A conduit. Subject to the approval of the maintaining agency, all other pipe materials listed under 611.02 (Type A Conduit) are acceptable. Specify Class III minimum for 706.02 and Class HE-III minimum for 706.04. Any special designs using alternate materials must be pre-approved by the County as well as the maintaining agency.

1002.3.2 Type B Conduits

Subject to the approval of the maintaining agency, all pipe materials listed under 611.02 (Type B Conduit) are acceptable. Specify Class III minimum for 706.02 and Class HE-III minimum for 706.04. Specify Class 3 for 706.01 – Maximum allowable size 21" (525 mm). Specify Extra Strength (ES) for 706.08 – Maximum allowable size 15" (375 mm). Provide 706.11 joints for all concrete pipe (706.01, 706.02, 706.04 and 706.05). Provide 706.12 joints for all clay pipe (706.08 ES).

1002.3.3 Type C Conduits

Subject to the approval of the maintaining agency, all pipe materials listed under 611.02 (Type C Conduit) are acceptable. Specify Class 3 for 706.01 – Maximum allowable size 21" (525 mm). Specify Extra Strength (ES) for 706.08 – Maximum allowable size 15" (375 mm). Provide 706.11 joints for all concrete pipe (706.01, 706.02, 706.04 and 706.05). Provide 706.12 joints for all clay pipe (706.08 ES).

1002.3.4 Type D Conduits

Subject to the approval of the maintaining agency, all pipe materials listed under 611.02 (Type D Conduit) are acceptable.

1002.3.5 Type E Conduits

Where used, all pipe materials listed under 611.02 (Type E Conduit) are acceptable subject to approval of the maintaining agency.

1002.3.6 Type F Conduits

Subject to the approval of the maintaining agency, all pipe materials listed under 611.02 (Type F Conduit) are acceptable.

B. Type F non-perforated underdrain outlet pipe material shall be the same as or compatible with the actually installed perforated underdrain pipe material. Subject to approval of the maintaining agency, all pipe materials listed under 611.02-Type F Conduit (underdrain outlets) are acceptable.

(1004) FLOOD CLEARANCE

1004.2 Design Year Frequency

County Roads (2000 ADT and Over)	25-Year
County Roads (Under 2000 ADT)	10-Year

(1006) ALLOWABLE HEADWATER

1006.1 Design Storm

As stated in Section 1004.2 of this supplement.

1006.2 Culvert Headwater Controls

1006.2.1 Design Storm Controls

A. Two (2) feet (0.6 meter) below the tree lawn grade break (berm) elevation typically located at the right-of-way for a curbed pavement. One (1) foot (0.3 meter) below the outer edge of graded shoulder (berm) elevation for an uncurbed pavement.

(1009) SUBSURFACE PAVEMENT DRAINAGE

1009.1 General

Subsurface pavement drainage is required on all projects except when located in an area having a granular subgrade. For County Roads, typically provide a single row of pipe underdrains (O.D.O.T. Pavement Design Manual, Section 205.1.1) on each side of the pavement regardless of the pavement width.

The size of all underdrain pipe shall be six (6) inch (150 mm) diameter unless project conditions make it necessary to specify four (4) inch (100 mm) diameter. For new construction, four (4) inch (100 mm) size underdrain may only be used upon approval of the Chief Section Engineer Highway Design and the maintaining agency. All underdrain shall be of the size specified in the plan/proposal even when the kind of pipe material is not specifically itemized.

Subject to the approval of the maintaining agency, the following six (6) inch (150 mm) perforated pipe material may be used:

706.06, 706.08, 707.31, 707.41, 707.42 (Perforated per 707.31) and
707.45 (Perforated per 707.31).

Subject to the approval of the maintaining agency, the following four (4) inch (100 mm) perforated pipe material may be used when permitted as specified above:

706.06, 706.08, 707.41, 707.42 (Perforated per 707.31) and
707.45 (Perforated per 707.31).

Nonwoven or Monofiliment woven filter fabric wrap per 605.03 shall be specified except when spot (contingency) replacement is called for. Where available outlets permit, a desirable underdrain depth of 30 inches (750 mm) below subgrade should be specified. Minimum depths of 18 inches (450 mm) below subgrade are acceptable. An absolute minimum depth of twelve (12) inches (300 mm) below subgrade may be permitted for rock cut installations or where warranted for special design conditions.

Designer Note: Reference is made to the Cuyahoga County Engineer's General Plan Note No. CUY- D12, "Item 605 – X" Shallow Pipe Underdrains with Geotextile Fabric, As Per Plan" and "Item 605 – X" Base Pipe Underdrains with Geotextile Fabric, As Per Plan".

(1101) ESTIMATING DESIGN DISCHARGE

1101.2 Procedures

1101.2.1 Statistical Methods

In addition, the SCS Method (TR-20) may be used, if approved by the County's Chief Section Engineer Bridge/Highway Design.

1101.2.4 Rainfall Intensity

Note: Figure 1101-2, Area A is used for Cuyahoga County.

(1102) OPEN WATER CARRIERS

1102.3 Ditch Design Criteria – Design Traffic Exceeding 2000 ADT (for County Roads)

1102.3.1 Design Frequency

For roadside ditches, whose primary function is pavement drainage, a 2-year frequency storm shall be used to determine the depth of flow, shear stress and width of ditch lining (if required). The design frequency criteria for all other ditches shall be as stated.

The depth of flow for any roadside ditch shall be limited to the elevation of the outside edge of the pavement shoulder. All other ditches shall not be overtopped for the design discharge.

1102.3.1.1 Estimating Design Discharge

Runoff will be estimated by the Rational Method for all roadside ditches.

The drainage area contributing to roadside ditches, whose primary function is pavement drainage, shall be determined per Section 1103.3 of this supplement.

The drainage area contributing to all other ditches shall be determined based upon suitable topographic mapping and site observation as required.

Drive pipe conduit types shall be in accordance with Section 1002.3.4 of this supplement. The headwater shall not exceed the limits in Section 1102.3.1 of this supplement.

1102.3.2 Ditch Protection

Ditch protection shall be in accordance with 1102.3.2 except that a 2-year frequency event shall be used for roadside ditches as defined in 1102.3.1 above.

1102.4 Ditch Design Criteria – Design Traffic of 2000 ADT or Less (Cuyahoga County)

1102.4.1 Design Frequency

As stated in Section 1102.3.1 of this supplement.

1102.4.1.1 Estimating Design Discharge

As stated in Section 1102.3.1.1 of this supplement.

1102.4.2 Shear Stress Protection

In accordance with 1102.3.1 above, a 2-year frequency event shall be used for roadside ditches. A 5-year frequency event shall be used for all other ditches.

(1103) PAVEMENT DRAINAGE

1103.1 General

The following are acceptable catch basins and inlets for curbed Cuyahoga County roads:

(a) Cuyahoga County No. CB-3C.

(b) Cuyahoga County No. CB-3C2 (twin 3C).

(c) Subject to Municipal Engineer approval, O.D.O.T. Pavement Inlets; No. 2A-6 (1.8m), No. 2A-8 (2.4m), and No. 2A-10 (3.0m).

(d) O.D.O.T. CB, No. 6 (for use with mountable curbs and/or at drives should catch basin locations at drives be necessary).

(e) Others may be considered upon request or approval of the maintaining agency.

1103.2 Design Frequency

A 2-year design frequency shall be used for all County Roads.

Pavement inlets or catch basins shall be spaced to limit the spread of flow such that a minimum of 4 feet (1.2 meters) of "dry" pavement remains in the curb lane.

The spread check for 25-year or 50-year storms for underpasses or other depressed roadways is NOT required.

1103.3 Estimating Design Discharge

Runoff will be estimated by the Rational Method.

The drainage area contributing to the pavement shall be generally considered as 150 feet (45 meters) taken on each side of the roadway centerline, except as follows:

(a) In fill areas where it is evident that there will be no future development, the contributing area shall be the area of the roadway cross section that drains toward the pavement.

(b) In highly developed or urbanized areas the actual area draining to the pavement may be used in lieu of the 150-foot (45 meter) strip, provided the actual area can be clearly determined from topographic maps and site inspection.

(c) Where the overland slope beyond the right-of-way is away from the roadway, but where it is likely that future development will cause portions of this area to slope towards the pavement, the contributing area shall be based on the designer's judgment. Generally, the 150-foot (45 meter) strip shall not be exceeded nor shall a strip less than the right-of-way width be used.

For contributing areas of 150 feet (45 meter) or less each side of the pavement centerline, the design storm shall be calculated using a rainfall duration of 15 minutes with an intensity of 2.95 inches/hour (75 mm/hour) for the 2-year storm. In existing commercial areas with mostly paved frontage, the duration time may be 10 minutes.

In the rare event the 150-foot (45 meter) strip is exceeded, the actual time of concentration shall be used to determine the rainfall intensity assuming it is more than the 15 minute/10 minute durations prescribed above.

1103.6 Bypass Charts for Continuous Pavement Grades

Companion bypass charts for Cuyahoga County 3-C catch basins on various pavement cross slopes are included in the "Supplements to Appendix A and the Drainage Design Aids". The Designer should note that the bypass charts as noted above take into account the local two (2) inch (50 mm) pavement depression as detailed on Cuyahoga County Construction Drawing No. CB-3C.

For metric units, use the English unit bypass charts and convert the resultant answers into metric units by using the following conversions:

Given: English Units	Multiply By	To Get: Metric Units
Feet	0.3048	Meters (m)
Inches Per Foot (in./ft.)	1/12	(decimal slope rate): (m/m)
Feet Per Foot (ft./ft.)	1.0	(decimal slope rate): (m/m)
Cubic Feet Per Second (cfs)	0.028317	Cubic Meters Per Second (m^3/s)

1103.7 Grate Catch Basins and Curb Opening Inlets in Pavement Sags

Cuyahoga County No. CB-3C2 (twin 3C) catch basins shall be provided at the low points of sag vertical curves. The 2-year design frequency spread of flow at the low point shall be limited per Section 1103.2 of this supplement. The next upstream Cuyahoga County No. CB-3C catch basins on each side of the low point shall be located to limit the flow reaching the sag catch basins such that the spread requirements are not exceeded.

Conservatively assuming the capacity of the Cuyahoga County No. CB-3C2 (twin 3C) catch basin to be equivalent to the State's standard No. CB-3 catch basin, the standard CB-3 capacity curves in Figures 1103-3 and 1103-4 of the Location and Design Manual may be used to determine the depth of ponding at the low point.

Evaluating the spread for a 25-year or 50-year event in a depressed sag is NOT necessary. It should be noted that although the depth of ponding based on grate capacity can be used to determine the 25-year or 50-year event spread, the hydraulic grade line is more of a controlling factor at low points of sag vertical curves. The hydraulic grade line requirement as explained in Section 1104.4.2 of this supplement should be checked for a 50 yr. storm at the low points.

1103.7.1 Data Presentation

Appropriate computer software may be used provided that all the information ordinarily furnished in the "No. 3C Catch Basin Spacing Form" is clearly presented for review by the Cuyahoga County Highway Design Office personnel.

(1104) STORM SEWERS

1104.1 General

As stated and as supplemented herein.

The drainage area contributing to the storm sewer system shall be determined from topographic mapping supplemented by:

(a) Field Observation.
(b) Data from the Municipal Engineer such as municipal sewer maps which may indicate contributory sewers from side streets, subdivisions, or commercial developments.

In no case shall the drainage area be less than the highway right-of-way.

When the local governmental agency, through whose jurisdiction the highway improvement passes, desires that runoff from areas in addition to those naturally contributing to the roadway storm sewer be included in the roadway storm sewer system, the Agreement for the improvement between Cuyahoga County and the local agency must contain provisions for the increase in contributory area.

1104.2 Design Considerations

1104.2.1 Storm Sewer Depth

(J) Where outfall conditions permit, depths shall be such that structure footer drains can outlet to the storm sewer by gravity flow.

(K) When applicable, storm sewers shall be at least as deep as those they replace to ensure an outlet for existing lateral connections.

Where proposed highway storm sewers or ditches will interfere with existing private drains carrying treated sanitary flow, the designer must obtain a list of all property owners authorized to discharge treated sanitary effluent into the storm sewer/ditch system.

This information including residential septic system site plans may be obtained from the County Board of Health and/or the City/Village Engineer.

1104.4 Storm Sewer Design Criteria

1104.4.2 Hydraulic Grade Line

As stated in the O.D.O.T. Location and Design Manual except that the resultant ponding based on the 50-year check shall be limited to the top of curb.

The friction slope (S_f) for conduits flowing under pressure may be determined by the following equation:

(English Units)	(Metric Units)
$S_f = 4.66n^2xQ^2/D^{16/3}$	$S_f = 10.29n^2Q^2/D^{16/3}$
Q (cfs) = Q_{25}	Q (m^3/s) = Q_{25}
D = conduit diameter (feet)	D = conduit diameter (meters)

1104.4.4 Time of Concentration

t_c = 15 min. to first ditch inlet/pavement catch basin or 10 min. for mostly paved commercial frontages. If the distance from the most remote point of the drainage area to the first inlet exceeds 150 feet (45 meters), use the actual time of concentration assuming it is more than the 15 minute/10 minute durations prescribed above.

1104.5 Hydraulic Design Procedure

As stated except that approved computer software may be used provided that all hydraulic calculation data ordinarily furnished on the "Cuyahoga County Storm Sewer Computation Form" is clearly presented for review by Cuyahoga County Highway Design Office personnel. If all hydraulic calculation data noted above is not satisfactorily presented with the computer software data, it will be necessary to additionally complete the "Cuyahoga County Storm Sewer Computation Form".

(1105) ROADWAY CULVERTS

1105.4 Design Procedure

1105.4.1 General

SCS Method (TR-20) may be used within limitations, if approved by the County Chief Section Engineer Highway/Bridge Design.

1105.4.2 Hydraulic Analysis

As stated except that all required hydraulic analysis/calculation data shall be additionally provided on the "Cuyahoga County Culvert Calculation Form" for review by Cuyahoga County Bridge/Highway Design Office personnel.

(1109) LONGITUDINAL SEWER LOCATION

1109.1 Under Pavement (County Roads)

The designer shall make every reasonable attempt to locate longitudinal sewers so that they are not under the pavement. Preferably, the storm sewer will be on the opposite side of the roadway from the sanitary sewer. A minimum of six (6) feet (1.8 meters) clear distance between storm and sanitary sewers should be maintained. Where this clearance cannot be obtained, all portions of both the longitudinal storm and sanitary sewers, excluding minor crossings; shall be constructed using premium jointed conduit for their full (manhole to manhole) runs.

Manholes should not be located in the pavement or sidewalk unless no practical alternative exists.

(1111) SANITARY SEWERS

1111.1 General

Sanitary sewers which are under the jurisdiction of the Cuyahoga County Sanitary Engineer shall be designed in accordance with policies and criteria of the Cuyahoga County Sanitary Engineer.

Sanitary sewers which are under the jurisdiction of the local municipality shall be designed in accordance with the policies and criteria of the local municipality.

SUPPLEMENTS TO APPENDIX A
AND
THE DRAINAGE DESIGN AIDS

CUYAHOGA COUNTY NO. 3C CATCH BASIN SPACING FORM INSTRUCTIONS

Column 1	Reference Number
Column 2	Station of inlet structure.
Column 3	Directional location of inlet structure.
Column 4	Runoff coefficient (See Section 1101.2.3 of the O.D.O.T. Location and Design Manual).
Column 5	Average Rainfall Intensity in inches per hour (millimeters per hour).
Column 6	Contributory drainage area in acres (hectares).
Column 7	Calculated inflow in cubic feet per second (cubic meters per second).
Column 8	Bypassed flow from adjacent upstream inlet.
Column 9	Total flow into inlet in cubic feet per second (cubic meters per second).
Column 10	Longitudinal slope, assumed parallel to centerline profile.
Column 11	Cross slope of pavement (from typical section).
Column 12	From Pavement Flow Charts (O.D.O.T. Location and Design Manual or Manning's Equation).
Column 13	Gutter flow depth equals Column 11 x Column 12.
Column 14	From attached bypass charts for Cuyahoga County No. 3C Catch Basins. If O.D.O.T. structure is otherwise used, from O.D.O.T. Location and Design Manual, Figures 1100-20 thru 1100-100E.

CUYAHOGA COUNTY ENGINEER'S STORM SEWER COMPUTATION FORM INSTRUCTIONS

Column 1	Structure type symbol.
Column 2	Station of pipe junctures.
Column 3	Directional location of structure.
Column 4	Incremental drainage areas in acres (hectares).
Column 5	Summation of drainage areas in acres (hectares).
Column 6	t = Time of flow in upstream pipe (minutes)
Column 7	t = Total time to this point (minutes).
Column 8	Rainfall intensity from rainfall intensity-frequency duration curves, area "A" (10-year storm).
Column 9	Rainfall intensity from rainfall intensity-frequency duration curves, area "A" (25-year storm).
Column 10	Runoff coefficient (See Section 1101.2.3 of the O.D.O.T. Location and Design Manual).
Column 11	Incremental CA (Column 4 x Column 10).
Column 12	Total CA (Column 11 + Column 12 from previous run within the same system).
Column 13	Discharge ($Q_{10} = i_{10}$ x CA)(cfs) or (m^3/s)
Column 14	Discharge ($Q_{25} = i_{25}$ x CA)(cfs) or (m^3/s)
Column 15	Size of pipe (Diameter in inches or millimeters based on Manning's equation and 10-year storm).
Column 16	Length of pipe section in feet (meters).

CUYAHOGA COUNTY ENGINEER'S STORM SEWER COMPUTATION FORM INSTRUCTIONS (CONT.)

Column 17	Slope of pipe (Ft./Ft.)or (m/m).
Column 18	F/L elevation of inlet into structure.
Column 19	F/L elevation of outlet leaving structure.
Column 20	Actual depth of flow in feet (meters).
Column 21	Velocity using Manning's equation (Ft./Sec.) or (m/s).
Column 22	Capacity using Manning's and continuity equations (cfs) or (m^3/s).
Column 23	Friction slope for Q_{25} using Manning's (Ft./Ft.) or (m/m).
Column 24	Head loss in pipe section (Column 23 x Column 16).
Column 25	Hydraulic grade line (25-year elevation).
Column 26	Inlet grate or manhole cover elevation.
Column 27	Reference remark(s) provided on back of form(s) or on separate sheet(s)