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3.301 DESIGN OF STORM SEWERS

A. General Information

These guidelines apply to storm sewers in the public right-of-way. Storm sewers on private property fall under the jurisdiction of the municipal engineer where work is being performed. Storm drainage shall be designed for conveyance in a separate gravity system at such depths that all structures within the tributary area may be served to full foundation footer drain depths and no violations of a natural drainage area are generated.

B. Investigations and Surveys

1. Information Required

   Each project shall be identified by name, municipality within which it is to be constructed and original lot number and tract. A general description of the project shall be included indicating approximate project size, zoning, general description of discharge points, off site tributary area drainage area maps, and any special factors to be considered in the design.

2. Investigations

   Information on all existing conditions shall be listed. This information shall include capacity of receiving sewers or downstream culverts and the ability of receiving waterways to provide an adequate outlet with respect to both depth and capacity in vicinity of storm outlet. Special analysis will be required for known flooding areas.

C. Special Projects

Variation from a separate gravity storm sewerage system of normal depth shall be considered a special project. The approving governmental agency shall review and approve the proposed variation in concept prior to final design. Variations requiring review and approval will include shallow depth, materials of construction, methods of construction, controlled discharge systems, combination conduit-overland flow system, and others.

3.302 DESIGN CRITERIA FOR STORM SEWERS

A. General Information

In general, all sewers shall be designed using the following criteria. Variation from such would constitute special projects.

B. Design Storm Frequency

Residential	5 Year Frequency
Multifamily	10 Year Frequency
Schools	10 Year Frequency
Industrial/Commercial	10 Year Frequency
Major Urban Business Area	25 Year Frequency

Additional Minimum Criteria

Flow between	0 cfs - 150 cfs	5 Year Frequency
Flow between	150 cfs - 500 cfs	10 Year Frequency
Flow between	500 cfs - 1500 cfs	25 Year Frequency
Flow between	1500 cfs - and over	50 Year Frequency

C. Rainfall Intensity - Duration

5 - Year Storm	i = 1.50 Inches/Hr.
10 - Year Storm	i = 1.80 Inches/Hr.
25 - Year Storm	i = 2.00 Inches/Hr.
50 - Year Storm	i = 2.25 Inches/Hr.
100 - Year Storm	i = 2.50 Inches/Hr.

D. Runoff Coefficient

Zoning	Lot Area (ft^2)	c =
Residential	0 - 5000	0.7
	5,000 - 10,000	0.6
	10,000 - 25,000	0.5
	25,000 - and over	0.4

Multifamily and Schools	0.75
Industrial/Commercial	0.90
Shopping Centers	0.90
Major Urban	0.90
Business Area	0.90

The above runoff coefficients assume typical ground cover and average slope.

E. Concentration Times

1. Residential Areas.

   The concentration times to the critical inlet varies between 12 and 20 minutes with 15 minutes to be used as the average case based upon full development of the land.

2. Industrial - Multifamily - School Areas.

   The concentration time to the critical inlet varies between 10 and 15 minutes with 12.5 minutes to be used as the average case based upon full development of the land.

3. Major Urban Business Areas and Shopping Centers.

   The concentration time to the critical inlet varies between 5 and 12 minutes with 10 minutes used as the average case based upon full development of the land.

F. Standard Rainfall Intensity-Duration Tables

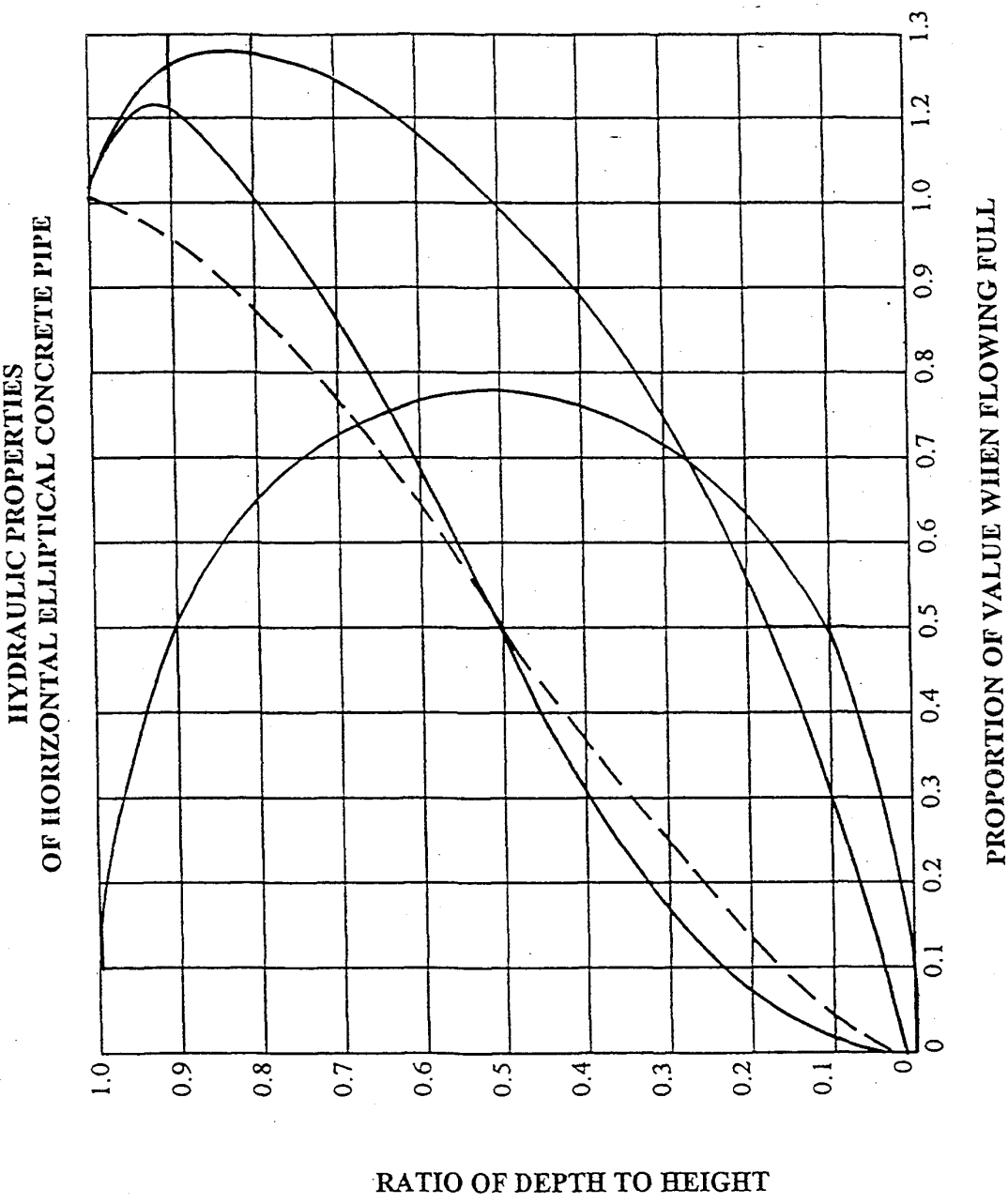
The Standard Rainfall Intensity-Duration Tables shall be used to determine the rainfall intensity occurring at the time of concentration to the inlet under consideration.

STANDARD RAINFALL INTENSITY-DURATION TABLES

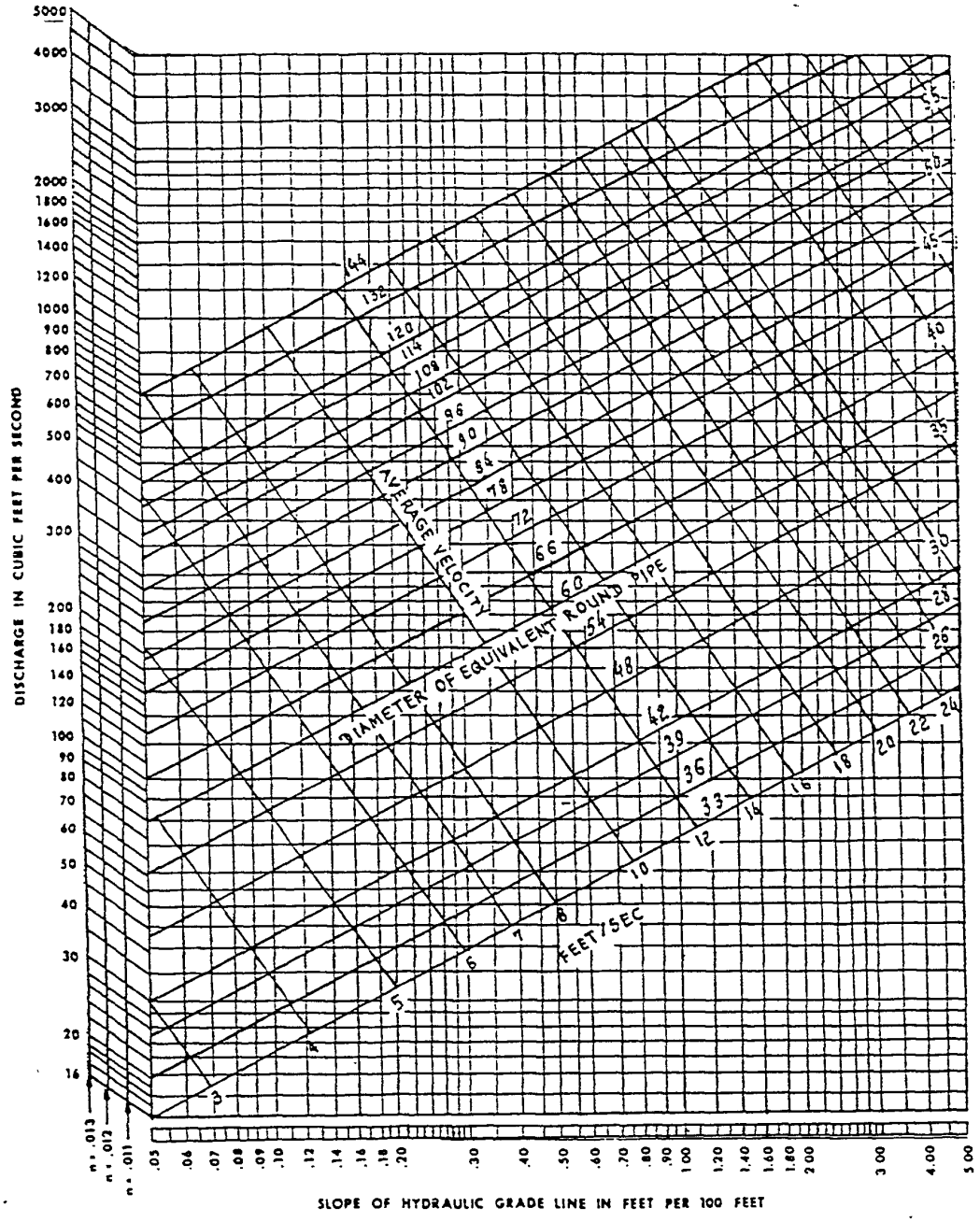
Rainfall Intensity in Inches Per Hour

Time of Concentration In Minutes	5 Yr. 1.50"/Hr.	10 Yr. Design 1.80"/Hr.	25 Yr. Storm 2.00"/Hr.	50 Yr. Frequency 2.25"/Hr.	100 Yr. 2.50"/Hr.
10	4.30	4.95	5.20	5.75	6.15
11	4.14	4.78	5.04	5.58	5.98
12	4.00	4.63	4.89	5.41	5.81
13	3.87	4.48	4.74	5.26	5.65
14	3.74	4.34	4.61	5.11	5.51
15	3.62	4.21	4.48	4.98	5.37
16	3.51	4.09	4.36	4.85	5.23
17	3.41	3.98	4.25	4.72	5.11
18	3.31	3.87	4.14	4.60	4.99
19	3.22	3.76	4.04	4.49	4.87
20	3.13	3.67	3.94	4.39	4.76
21	3.05	3.57	3.85	4.28	4.65
22	2.97	3.49	3.76	4.19	4.55
23	2.89	3.40	3.67	4.09	4.46
24	2.82	3.32	3.59	4.01	4.37
25	2.76	3.25	3.51	3.92	4.28
26	2.69	3.17	3.44	3.84	4.19
27	2.63	3.10	3.37	3.76	4.11
28	2.57	3.04	3.30	3.69	4.03
29	2.52	2.97	3.23	3.61	3.96
30	2.46	2.91	3.17	3.54	3.88
35	2.22	2.64	2.89	3.23	3.28
40	2.03	2.41	2.65	2.97	3.28
45	1.86	2.22	2.45	2.75	3.04
50	1.72	2.06	2.28	2.56	2.84
55	1.60	1.92	2.13	2.40	2.66
60	1.50	1.80	2.00	2.25	2.50
70	1.33	1.60	1.78	2.01	2.23
80	1.19	1.43	1.60	1.81	2.02
90	1.08	1.30	1.46	1.65	1.84
100	0.99	1.19	1.34	1.51	1.70
110	0.91	1.10	1.24	1.40	1.57
120	0.84	1.02	1.15	1.30	1.46

G-HYDRAULIC PROPERTIES
OF HORIZONTAL ELLIPTICAL CONCRETE PIPE



H. HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE FLOWING FULL



I. Flow Formulas

1. Quantity of Runoff by Rational Method.

   a. Areas up to 500 Acres

   Q = CIA in cubic feet per second where A is the area to be drained in acres, C is the runoff coefficient for the area under consideration and I is the rainfall intensity derived from the Standard Rainfall Intensity-Duration Tables for the concentration time to the inlet under consideration.

   b. Areas Greater Than 500 Acres

   Ohio Department of Natural Resources Bulletin No. 45 with urbanization correction in accordance with the following table shall be used as a guideline for computing runoff quantities.

URBANIZATION MULTIPLYING FACTOR

PERCENT URBANIZATION	10 YEAR STORM	25 YEAR STORM	50 YEAR STORM	100 YEAR STORM
10	1.25	1.25	1.25	1.25
20	1.39	1.36	1.34	1.33
30	1.52	1.47	1.44	1.42
40	1.67	1.58	1.53	1.50
50	1.81	1.69	1.63	1.58
60	1.94	1.81	1.72	1.67
70	2.08	1.92	1.82	1.75
80	2.22	2.03	1.91	1.83
90	2.36	2.14	2.01	1.92
100	2.50	2.25	2.10	2.00

2. Manning's Formula

   $V = \frac{1.486}{n} (R)^{2/3} (S)^{1/2}$ where S is slope in feet per foot; R is hydraulic radius; and n is the roughness coefficient. The roughness coefficient shall be n = 0.015 for sizes up to and including 27 inches; n = 0.013 for sizes including 30 inches through 84 inches and n = 0.011 for 90 inches and larger. Graphs for the Manning Formula are provided in Table 3.3. This Table is based on Quantity of flow Q = Av where A is the cross-sectional area

of the conduit developed by the nominal conduit diameter. Where other than circular pipe is proposed, the actual cross-sectional area developed may be used.

3. Hydraulic Radius

The formula for the hydraulic radius is R = A/p where p is wetted perimeter developed by the nominal pipe diameter. Where other than circular pipe is proposed, the actual wetted perimeter developed may be used.

3.303 LAYOUT OF SEWERS

A. General Information

The layout of the storm system shall place the storm and sanitary sewers on opposite sides of roadways and within the tree lawn areas where practical. Where opposite side construction is not practical, every effort shall be made to separate the storm and sanitary sewers by six feet (6') barrel to barrel. Vertical and horizontal alignment of storm sewers shall be in general conformance with Section 3.206. Manhole spacing shall be also as described in Section 3.206. Catch basins shall be used prior to the connection of inlets into the main storm sewer system. Consideration shall be given to installing traps or other methods to control the release of floatable debris into the sewer system.

B. Minimum Size

The minimum size of all storm sewers, excluding connections and yard drains, shall be 12 inches in diameter. The minimum yard drain size shall be 8" in diameter.

C. Types of Conduits

In addition to conduits recommended for sanitary sewers, the following conduits may be utilized for public storm sewers:

1. Reinforced Concrete Arch Culvert ASTM C-507
2. Reinforced Concrete Elliptical Pipe ASTM C-597
3. Reinforced Concrete Box Culvert ASTM C-789
4. Reinforced Concrete Box Culvert ASTM C-850

5. Uncased bored sewer conduit under 14 inches shall be Ductile Iron Pipe ANSI A-21.51 Class 2. Pipe over 14 inches through 24 inches shall be Ductile Iron Culvert Pipe ANSI A-716, and pipe 30 inches and over may be Ductile Iron Culvert Pipe ANSI A-716 or Reinforced Concrete Pipe ASTM C-76.

6. Polyvinyl Chloride (PVC) ASTM F-794, AASHTO M-304-91. Pipe cell classification must be stamped on pipe. When required by the engineer, certification of long term properties of design shall be provided.

Pipe shall be installed in accordance with Uniform Standard Sewer Details. Only wye branch fittings will be accepted for service connections for sewers up to and including 21" diameter. For sewers 24 inches and larger, tee connections are permitted.

Deflection test is required on all plastic pipe with a pipe stiffness less than 200 PSI. Air testing is not required for storm sewers.

For projects, where such pipe is applicable and approved by the municipal engineer, aluminized steel Type II pipe, 46 PSI minimum pipe stiffness conforming to ASTM A-819 and AASHTO M-274 is acceptable for installation where soils pH are in the range of 5-9. In cases where aluminized or galvanized pipe is encased in concrete, the pipe shall be coated with a bituminous substance. Sections of pipe which fits into a concrete manhole or concrete headwall shall also be coated.

All storm sewer pipes between manholes increments shall be one type and class of pipe. In case of lateral connections, transition connections of different materials may be permitted.

D. Lateral Connections

Lateral connections to building sites shall be a minimum of six inches (6") in diameter and of the materials listed above.

E. Storm Sewer Joints

Storm sewers in the right-of-way, easements, private property under pavement, driveways and sidewalks, and any other storm sewer tributary to public storm sewers shall have premium joints conforming to ASTM D-3212 for plastic pipes, ASTM C-425 for clay pipes, ASTM C-443 for concrete pipes, ASTM A-798 for aluminized steel pipes (where pipe is approved by municipal engineer). Exceptions may be allowed upon approval of the Municipal Engineer where work is being performed.

F. Depths of Sewers

In general, the storm sewer crown shall be at least 8 1/2 feet below the finished grade at the building line in residential districts and 10 1/2 feet below the finished grade at the building line in all other areas, measured to the crown of the conduit. Conduits shallower than this requirement shall be considered as a special project.

G. Velocities

Storm sewers should have a minimum flowing full velocity of three feet (3') per second and a maximum velocity of 15 feet per second.

H. Open Channel and Culvert Design

Open channels shall be designed using the energy concept and Mannings Formula using care in selection of the proper roughness coefficient "n". The following are suggested "n" factors for several typical open channel materials:

n = 0.014 for concrete lined

n = 0.017 for smooth rock bottoms with rock or concrete sides

n = 0.023 for well constructed waterways in firm earth.

Other channel materials may be considered as special projects. Other suitable "n" factors and velocities can be obtained from the Bureau of Public Roads Publication, Hydraulic Engineering Circular No. 5.

I. Concrete Anchorage

Unless otherwise specified, concrete anchorage will be utilized when sewer slopes fall within the following limits:

20% to 35% slope-anchorage shall be 36 feet center to center (maximum)

35% to 50% slope-anchorage shall be 24 feet center to center (maximum)

over 50% slope-anchorage shall be 16 feet center to center (maximum)

Concrete anchorage will be installed on the down side of each bell.

3.304 WATER MANAGEMENT AND SEDIMENT CONTROL

In order to prevent flooding of other land and stream channel erosion and to protect water resources from degradation resulting from accelerated storm water flows caused by construction activities, the owner, or the owner's representative shall be responsible for developing an erosion and sediment control plan. This plan shall meet the standards and specifications in the current edition of "Rain Water and Land Development" prepared by the Natural Resource Conservation Services, Ohio Environmental Protection Agency.

This requirement applies to development of one (1) acre or more. The Erosion and Sediment Control Plan shall be submitted to and approved by the city/village/township engineer prior to any earth disturbing activity for the development area.

The city/village/township engineer may submit the plan to the Cuyahoga County Soil and Water Conservation District for their review and comments prior to approval. Development disturbing five (5) or more acres or part of a larger common plan of development must have a National Pollutant Discharge Elimination System (NPDES) permit from Ohio Environmental Protection Agency.

3.305 DETENTION/RETENTION BASINS

In general, storage basins are considered to be special projects with the design criteria to be that

of the local city/village/township ordinances and as recommended by the Cuyahoga County Soil and Water Conservation District Model Ordinance.

Maximum storm water discharge from any project may be established by the responsible agency for the purpose of minimizing downstream flooding, erosion control or protection of downstream structures.

3.306 CULVERTS

Culverts under all roads with minimum traffic volumes of 2000 vehicles per day shall be designed for a 25 year storm flow with headwater of one (1) foot below the edge of the roadway. Consideration shall be given to the headwater elevation with respect to adjacent buildings.

3.307 HEADWALLS

The design engineer shall consider the earth pressure and surcharge pressures exerted behind the headwall during design. The headwalls shall be designed to resist overturning.

In areas with steep backslopes, the use of an ODOT HW-3 headwall shall be considered. In areas with gradual backslopes, an ODOT HW-1 or HW-4 headwall shall be considered. Outlet channel protection, consisting of dumped rock limestone and sized per ODOT requirements shall be placed in areas with erodible soils. A filter fabric shall be used below the limestone.

3.308 ORGANIZATION OF COMPUTATIONS

The Standard Computation Sheet contained in Part 6, shall be filled out for each project and submitted to the approving governmental agency along with a drainage design map of such scale as to reasonably relate both on and off site areas incorporated within the design.

Any special treatment, such as stilling basins, energy dissipator, downstream channel improvements, erosion control or other treatment shall be taken into consideration by the design engineer.