Appendix G:
Storm Conveyance Design Parameters

STORM DRAINAGE DESIGN CRITERIA

A. STORM SEWERS

1. The required discharge capacity shall be determined by the Rational Method:

$$Q = ACI$$

a. The 10 year design storm of I=175/(t + 25) shall be used. The minimum value of time of concentration (t) shall be 15 minutes.

b. The run-off coefficient C shall be as recommended on Pg. 51 of ASCE Manual 37 Design and Construction of Sanitary and Storm Sewers, 1969. (See Annex 1.) Where a weighted coefficient is employed, the computations shall be attached to project plans.

2. Sewer design, velocities, capacity, and friction losses shall be based on Manning's formula, generally with n = 0.013 for concrete pipe and 0.021 for corrugated metal pipe.

$$Q = \left(\frac{1.486}{n}\right) r^{2/3} s^{1/2}$$

3. The following are permissible slopes for each pipe size (n = 0.013). Maximum velocities for outlet pipes shall be non-erosive.

Pipe Size	**Minimum % of Grade** 2.5ft/sec	**Desirable Range % of Grade** 4 ft/sec	8 ft/sec	**Maximum% of Grade** 10 ft/sec
10"	0.4	1	3.98	6.22
12"	0.32	0.78	3.12	4.88
15"	0.24	0.58	2.32	3.62
18"	0.2	0.46	1.82	2.84
21"	0.16	0.38	1.48	2.3
24"	0.14	0.3	1.24	1.94
27"	0.12	0.26	1.06	1.66
30"	0.1	0.22	0.92	1.44
36"	0.08	0.18	0.72	1.12
42"	0.06	0.14	0.58	0.92
48"	0.06	0.12	0.5	0.76
54"	0.04	0.1	0.38	0.6
60"	0.04	0.1	0.34	0.54
66"	0.04	0.08	0.32	0.48

4. A complete set of storm sewer design computations shall accompany every set of final plans submitted for review.

5. Hydraulic gradients shall be shown as a part of all storm sewer profiles. In no case shall the elevation of hydraulic gradient exceed the elevation of a point lying one (1) foot below the rim elevation of a manhole, catch basin, or inlet. For storm sewers, the future extension of which is anticipated surcharging out of the pipe will not be permitted.

6. The storm sewer pipe shall have a minimum diameter of 12 inches when constructed in a public right-of-way or easement.

7. The storm sewer plan and profile drawing shall show the following data:

a.	Identification and numbering of manholes, catch basins, and inlets.
b.	Invert and casting elevations for all structures.
c.	Pipe length (c - c of structures).
d.	Pipe diameter.
e.	Pipe slope.
f.	Pipe class.
g.	Pipe joints (modified rubber groove joint).
h.	Porous backfill and special bedding where required.

8. Generally, manholes shall be placed not more than 400 feet apart for sewers less than 30 inches diameter, and 600 feet apart for larger sewers.

9. The minimum inside diameter of all manholes, catch basins, and inlet structures shall be 48 inches, with the following exception:

   Inlet structures from which water will be discharged directly into a catch basin may be 24 inches inside diameter. The depth of such inlets shall be no greater than 5.0 and no less than 3.5 feet from top of frame and cover to invert.

10. Manholes and inlet structures may be constructed of brick, manhole block, pre-cast concrete (ASTM C478), or cast-in-place concrete.

11. All manhole block or brick structures shall be plastered on the outside with 1 to 2.5 mix of Portland cement mortar, 1/2 inch thick. No lime shall be added.

12. Inlet structures in the public street right-of-way shall be spaced a maximum of 400 feet apart of a maximum of 400 feet each way from high points. The spacing and/or number of inlet structures required to accommodate the design flows in streets and in private drives and parking areas shall be based on a maximum of 1 cfs per 90 square inches of opening in an inlet or catch basin cover.

13. Inlet Capacity

Designation*	Curb	Capacity (cfs) Ditch	Sump Condition
C	1.2		
D-4	0.9		
E		1.0	3.4
G		0.5	2.1
K	2.0		
H	2.5		
* MDOT			

MDOT cover K is the accepted standard in public streets. Other covers, having equivalent cross-sectional area of opening, are acceptable at other locations.

14. Generally, drops of over 2.0 feet at manholes, from invert of higher pipes to lower pipe, shall be avoided.

15. Unless otherwise permitted by the Livingston County Road Commission, all storm sewer pipe within the public road right-of-way shall be of reinforced concrete and conform to the specifications for reinforced concrete sewer pipe ASTM C-76. All piped components of drainage systems in new developments proposed to be public shall be of reinforced concrete conforming to ASTM C-76.

16. Concrete pipe joints shall have rubber gaskets conforming with ASTM 443. Joints in concrete pipe having a diameter of 30 inches and larger shall be pointed up on inside with mortar after backfilling has been completed.

17. Where drainage is outletted to County drains or natural water courses, such outlets shall be so designed as to enter the drain or water course at an angle of 90 degrees or less, as determined by the upstream centerline. Headwall, pre-formed end sections, grouted rip-rap, or specially designed outlet structures will be required.

18. All catch basins and inlets shall be as specified by the Michigan Department of Transportation Detail I-5C.

    All manholes for pipes 42 inches in diameter and under shall be specified by the Michigan Department of Transportation Detail I-1C.

    Special details will be required for manholes placed on pipe 48 inches in diameter and larger.

    Outlet velocities and elevation: Outlets located such that they are in a non-erosive position, generally with an elevation no more than two feet above the toe of slope.

B. OPEN CHANNELS

1. The required discharge capacity shall be determined by Rational Method (see STORM SEWERS).

C. CULVERTS

1. The required discharge capacity of all culverts except drive culverts shall be determined by Rational Formula (see STORM SEWERS).
2. All culverts other than driveway culverts shall be designed in accordance with procedures specified in the Hydraulic Engineering Circular No. 5 (Hydraulic Charts for the Section of Highway Culverts) U.S. Department of Commerce, Bureau of Public Roads. Computations for all culverts thus designed shall accompany the final plans and shall include both designs for inlet and outlet-controlled flows.
3. All culverts other than drive culverts shall be equipped with headwalls and/or preformed end sections.
4. The following is data which shall be provided in the final plans for all culverts other than driveway culverts:

a.	Length
b.	Diameter
c.	Invert Elevations
d.	Type
e.	Protection

5. Minimum size of a drive culvert shall be 12 inches.
6. Minimum size of a cross road culvert shall be 15 inches or equivalent pipe arch.
7. The pipe used in culverts may be reinforced concrete culvert pipe or corrugated metal pipe and pipe arch. The pipe furnished shall conform to the Current Specifications for Reinforced Concrete, Storm Drain and Sewer Pipe, ASTM Designation: C-76 or to the Current Specifications for Corrugated Metal Culvert Pipe AASHTO Designation: M-36.

AVERAGE VALUES OF THE MANNING ROUGHNESS FACTOR FOR VARIOUS BOUNDARY MATERIALS

Boundary Material	Manning n
HDPE pipe	0.011
Finished concrete	0.012
Planed wood	0.012
Concrete pipe	0.013
Unplaned wood	0.013
Unfinished concrete	0.014
Cast Iron	0.015
Brick	0.016
Riveted steel	0.018
Corrugated metal	0.022
Rubble	0.025
Earth	0.025
Gravel	0.029
Earth, with stones and weeds	0.035

Reference: Fluids Mechanics, 5th Edition, by V. L. Streeter, McGraw Hill 1971, N.Y., N.Y., page 279

VALUES OF RELATIVE IMPERVIOUSNESS

Type of Surface	C Factor
Water Surfaces	1.00
Roofs	.90 to 1.00
Asphalt or concrete pavements	.90 to 1.00
Gravel, brick, or macadam surfaces	.60 to .80
Impervious soils	.60 to .80
Impervious soils with turf	.40 to .60
Slightly pervious soils	.30 to .50
Slightly pervious soils with turf	.20 to .40
Moderately pervious soils	.20 to .30
Moderately pervious soils with turf	.15 to .25
Completely undeveloped pervious soils	.10 to .20
Playgrounds	.20 to .35
Unimproved	

These values are for slopes from 1 % to 4 %; steeper slopes will be higher.