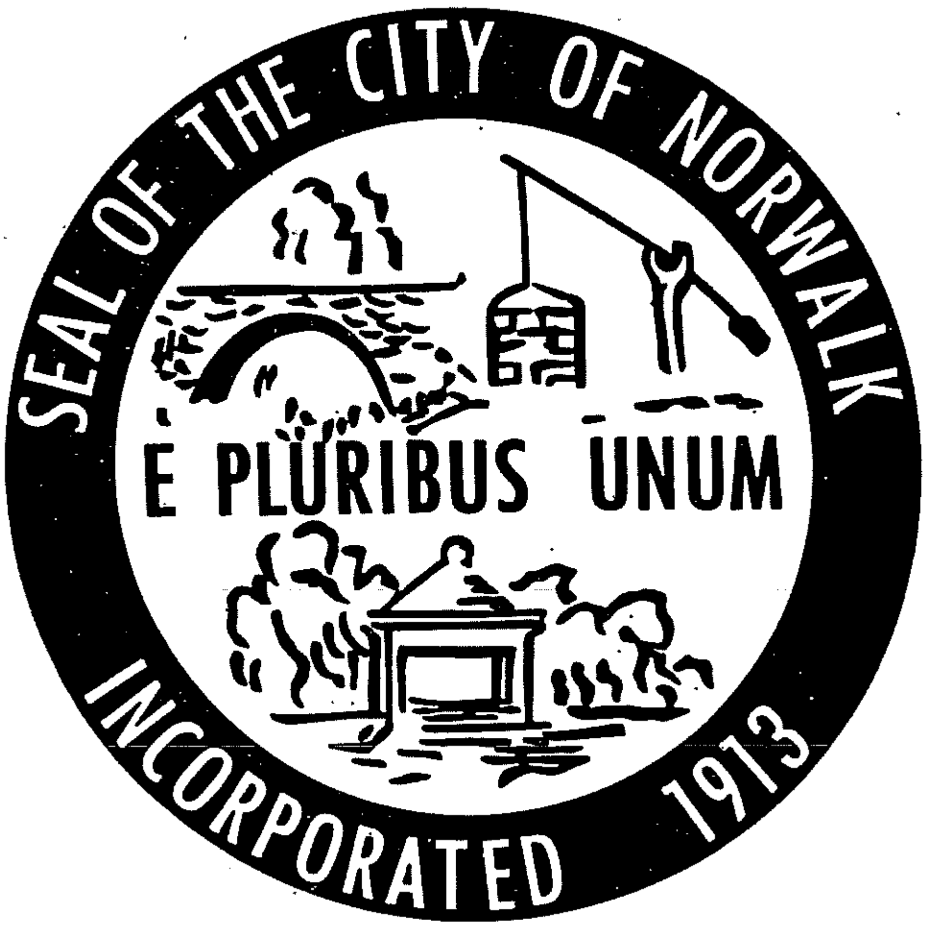
CITY OF NORWALK

CONNECTICUT

DEPARTMENT OF PUBLIC WORKS



DRAINAGE MANUAL

MAY 1983

Norwalk
THE RIGHT PLACE • THE RIGHT TIME

DEPARTMENT OF PUBLIC WORKS

Water Quality Subcommittee on Oil & Grit Separators

ADOPTED BY THE COMMON COUNCIL, CITY OF NORWALK, CONNECTICUT MAY 8, 2001

Standards for Removal of Oil, Grit and Other Material from Stormwater

The following requirements shall apply to any new or substantially modified drainage system including those that discharge to the City drainage system or to any wetland or watercourse within the City.

1. The system shall include equipment designed and certified by its manufacturer to remove 80% or more of the total suspended solids and floatable debris for all anticipated flow rates up to the flow rate calculated for a 25 year storm event.

   If it is not practical to retrofit an existing system to meet the 25 year storm requirement an alternative system designed to provide first flush only treatment may be approved. The design flow for the first flush shall be calculated by taking a 1/2-inch rainfall and dividing it by the Time of Concentration (Tc) for the site in hours (not minutes). Use this (0.5/Tc) as "i" (inches/hour) in the rational method formula (Q=CiA) to get the design flow for the first flush. In this formula Q is the required design flow rate in c.f.s., C is the runoff coefficient calculated in accordance with Chapter III of the Norwalk Drainage Manual and A is the site area in acres.

   The manufacturer shall furnish documentation which supports all product performance claims and features, storage capacities and maintenance requirements. Systems shall be designed to avoid scouring out or release of previously trapped material in the event of higher than designed flow rates.

2. Any system that provides drainage for automobile/truck service facilities, gas stations, or other facilities likely to generate storm water containing oil or other petroleum products shall also include equipment designed and certified by its manufacturer to remove 90% or more of such oil and petroleum products for all anticipated flow rates up to the flow rate calculated for a 25 year storm event. Systems shall be designed to avoid scouring out or release of previously trapped material in the event of higher flow rates.

125 EAST AVENUE • P.O. BOX 5125, NORWALK, CT 06856-5125 • TELEPHONE 203-854-7791 • FAX 203-857-0143

3. The owner of any system installed to meet the requirements of 1 and 2 above shall complete and file with the City a form listing all installed equipment. This form shall included the as-built location of each piece of equipment, with coordinates tied to the Connecticut Coordinate Grid System, its manufacturer and model number and other information necessary to define its performance characteristics. This information shall be in a form that may be readily incorporated into the City of Norwalk GIS system.

4. A written Inspection and Maintenance Plan for each piece of equipment installed to meet the requirements of 1 and 2 above shall be approved by the Public Works Department. As a minimum such Inspection and Maintenance Plan shall require periodic on site inspection of each unit, the removal of accumulated material as recommended by the manufacturer, and proper disposal thereof. A written Inspection and Maintenance Log showing inspection dates and the amount and type of materials removed and disposal location shall be maintained for each unit installed. Copies of the Inspection and Maintenance Logs shall be submitted to the Department of Public Works annually. Logs for the previous 3 years shall be kept available on site for inspection by the City at any time.

CITY OF

NORWALK, CONNECTICUT

DEPARTMENT OF PUBLIC WORKS

DRAINAGE MANUAL

MAY 1983

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CHAPTER I

PREFACE

This manual has been prepared to establish guidelines for the design of drainage facilities within the City of Norwalk. Its purpose is to present the best available methods, guidelines and criteria for drainage design. The Connecticut Department of Transportation "Drainage Manual" served as a basis for this Norwalk manual.

The objectives of good drainage design are to:

1. Provide for the safety of the public and adjacent property owners.

2. Eliminate or minimize undesirable upstream or downstream flooding effects which may result from the construction and maintenance of the drainage facilities.

3. Balance the risk of flood damage related to the drainage facility and the cost of its construction.

4. Produce reliable and long-lasting drainage structures and facilities, capable of being satisfactorily operated and maintained.

It is the responsibility of the design engineer to develop the required hydrologic and hydraulic data for a project. Field investigations, data collection, data analysis and sound judgement are all fundamentals of good drainage design and must be used by the engineer while employing the criteria set forth in this manual.

A complete hydraulic report documenting the basis for the hydrology and hydraulic design is a requirement for any work to be reviewed for approval by the Norwalk Department of Public Works.

The criteria set forth herein shall be used in the design of drainage facilities generally encountered in Public Works projects carried out by the Department of Public Works, as well as in subdivisions, site developments and other projects designed by Consulting Engineers over which the City has a responsibility for review and approval. Projects over which the Connecticut Department of Transportation has responsibility for review and approval shall be designed in accordance with their "Drainage Manual".

New and improved drainage design concepts are continually being developed. Accordingly, when feasible, this manual will be kept current by including improved design procedures which have been proven to be sound and effective. The Norwalk Department of Public Works would appreciate receiving constructive suggestions or comments which would improve the contents of this manual.

CHAPTER II

GENERAL DESIGN POLICIES

A. STORM WATER RETENTION AND DETENTION

Where it is anticipated that additional runoff incident to development or upstream drainage improvements will overload the existing downstream drainage facilities, or where downstream facilities are likely to become substandard in the future, then retention or detention of the runoff should be given consideration as a means of providing hydrologic stability.

B. DOWNSTREAM PROPERTY

Possible adverse effects of increased runoff upon downstream property shall be investigated and appropriate preventative measures taken, if necessary, to avoid possible damage.

C. CHANNELS, NON-STRUCTURAL IMPROVEMENTS

Except within the street right-of-way, open channels, ditches or swales should be used in lieu of pipes. In general, a non-structural approach to drainage improvements should be given preference, primarily through good land use planning and management.

D. QUALITY OF DRAINAGE WATERS

Discharges of industrial wastes and/or effluent from sanitary sewers, cesspools, septic tanks, etc., into the city drainage system will not be permitted.

E. DIVERSION OF DRAINAGE

The diversion of drainage from one watershed or watercourse to another may be permitted only after study of the hydraulic and hydrological impacts by a registered professional engineer and approval by the Director, Department of Public Works and other affected agencies having jurisdictional control.

F. GROUND WATER DISCHARGE

The discharge of ground water from sump pumps, subdrains, etc., onto sidewalks and roadways is prohibited.

G. TIDAL CONSIDERATIONS

1. Drainage Systems - In areas affected by tides, due consideration must be given to the effects of tidal flooding.

For design purposes, unless otherwise approved by the Director, Department of Public Works, design elevations of tidal waters shall be equal to the elevation midway between mean high water, and the elevation of tidal flooding for the storm frequency of the facility being designed. Design elevations for common design frequencies are as follows:

Design Storm Frequency	Design Elevation of Tidal Waters*
10 years	6.5
25 years	6.9
50 years	7.2
100 years	7.5

* Mean sea level datum in feet

2. Buildings - The City of Norwalk Building Zone Regulations require that:

"All new construction and substantial improvements of residential and non-residential structures shall have the lowest floor (including basement) elevated to or above the base flood level or, together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is flood-proofed to or above that level." (Article 110, Norwalk Building Zone Regulations).

The "Base Flood" level is defined as the flood having a one percent chance of being equalled or exceeded in any given year (100 year storm).

In locations immediately along the shoreline where a building is subject to wave action, floor elevations shall be a minimum of 17 feet above mean sea level unless the building has been designed as a "Floodproof Building". In addition, permanent mechanical and electrical equipment shall be above the base flood elevation.

H. EASEMENTS

Where drainage facilities are located within private property, city maintenance easements shall be provided and registered on a plan filed with the City Clerk. Easements shall generally be at least 20 feet in width. A swale, channel or ditch which passes drainage runoff from adjacent upstream public or private property shall be considered a drainage facility requiring an easement.

In subdivisions, where roadway drainage discharges into private property, a note designating the private property owner as being responsible for properly passing drainage through his property shall be shown on the record plan.

I. PERMITS - JURISDICTIONAL CONTROL

Permits to construct drainage facilities shall be obtained from all Agencies which have jurisdictional control. The following may be used as a guide.

Area of Control	Agency
Fresh Water Streams	1. Norwalk Inland Wetlands & Water Courses Agency
	2. U.S. Army, Corps of Engineers
	3. Connecticut Department of Environmental Protection, when Stream Encroachment Lines are Involved or the watershed area falls under the CT Water Diversion Policy Act P.A. 82-402.

Inland Wetland Areas	1.	Norwalk Inland Wetland & Water Courses Agency
	2.	U.S. Army, Corps of Engineers
Coastal Area	1.	Connecticut Department of Environmental Protection
	2.	Planning and Zoning Commission
	3.	U.S. Army, Corps of Engineers
	4.	U.S. Coast Guard, when work is in Navigable Waters
City Highways, Sidewalks and/or Drainage Facilities	1.	Department of Public Works (street opening permit, drain connection permit)
	2.	Connecticut Department of Transportation - Approval to Construct on or Near Railroad
State Maintained Highways & Drainage Facilities	1.	Connecticut Department of Transportation
Archaelogically and/or Historically Important Sites	1.	State Archaeologist
	2.	State Historic Preservation Officer
	3.	Norwalk Historical Society

CHAPTER III

RUNOFF DETERMINATION

A. DESIGN STORM FREQUENCIES

The average frequency of rainfall occurrence used for design largely determines the degree of protection afforded by a given storm drainage system. This protection should be consistent with the amount of damage potential at full development of the watershed and the level of design required to protect the safety and convenience of the public. Other factors which may affect the choice of design frequencies rest on economic analysis and policy decisions of the Department of Public Works.

The design storm frequencies listed in Table III-1 shall be complied with. Under exceptional circumstances, with the written approval of the Director, Department of Public Works, the rainfall intensity may be reduced, on the basis of an engineering study.

B. RATIONAL METHOD

Application - The Rational Method of determining runoff is based on the premise that the peak rate of discharge from an area will be proportional to the rate of rainfall, modified by the size and characteristics of the area. The use of the Rational Method shall be limited to watersheds smaller than 200 acres.

Procedure - In the Rational Method, runoff is related to rainfall intensity by the formula, Q=AIR, where Q is the flow rate in c.f.s.; "I" is the runoff coefficient, depending on characteristics of the drainage area; "R" is the average rainfall intensity in in./hr.; and "A" is the drainage area in acres. (1.008 c.f.s. = 1 in. depth of rainfall applied at a uniform rate in one hour to an area of one acre).

TABLE III-1

DESIGN STORM FREQUENCIES (YEARS)

Business Districts

	Area Drainage Normal	Area Drainage Sags*	Culverts
Local Streets & Parking Lots	25	25	50**
Collector & Arterial Streets	25	50	100
Detention & Retention Facilities		50	

Residential Districts

	Area Drainage Normal	Area Drainage Sags*	Culverts
Local Streets & Parking Lots	25	25	50**
Collector & Arterial Streets	25	50	100
Detention & Retention Facilities		25	

* Sags include any low point without a reliable means of overland flood relief, where ponding will occur if the drainage system cannot carry off storm flows.

** Crossings of the following rivers and streams will require 100 year design frequency: Norwalk River, Betts Pond Brook, Silvermine River, Five Mile River, Keelers Brook, Stony Brook, Noroton River, Indian River.

Area - Boundaries of the drainage area may be established by field surveys, or City topographic maps. City topographic maps at a scale of one inch equals 100 feet and one inch equals 400 feet are available from the Department of Public Works.

Time of Concentration - The time of concentration is the time it takes rainwater, falling on the most distant part of the watershed, to reach the location of the drainage facility being designed. A field investigation of the drainage basin should be made in all cases to verify assumed runoff patterns.

The time of concentration shall be determined by using the nomographs included as Figures III-1 and III-2. Total time of concentration shall be computed by adding together overland flow time, and appropriate allowances for ditch, channel and/or pipe time, and for travel time through reservoirs, lakes and swamps. In general, Figure III-1 shall be used for overland flow in the upper reaches of watersheds, and Figure III-2 for lower reaches, where the flow has concentrated into a channel.

The minimum time of concentration to be used for a mostly paved or impervious area shall be five minutes. For mostly unpaved areas the minimum time of concentration shall be ten minutes.

Intensity - The rainfall intensity for the storm having the appropriate frequency and of duration equal to time of concentration should be selected from Figure III-3.

Runoff Coefficients - The runoff coefficient shall be based on ultimate development of the watershed in accordance with the Building Zone Map, a copy of which may be obtained from the Planning and Zoning Commission. For watersheds in Norwalk, Table III-2 may be used to select runoff coefficients for areas not yet developed.

TABLE III-2

RUNOFF COEFFICIENTS
NORWALK, CONNECTICUT

(For Use in the Rational Method)

	Zone	Steep Slope	Average Slope	Flat Slope
AAA	Residence	0.40	0.30	0.25
AA	Residence	0.45	0.35	0.30
A	Residence	0.50	0.40	0.35
B	Residence	0.55	0.50	0.45
C	Residence	0.57	0.52	0.47

In other zones a composite runoff coefficient based on the percentage of different types of surface in the drainage area may be developed utilizing the following coefficients:

Character of Surface	Runoff Coefficients
Streets:	
Asphaltic	0.70 to 0.95
Concrete	0.80 to 0.95
Brick	0.70 to 0.85
Drives & Walks	0.75 to 0.85
Roofs	0.75 to 0.95
Lawns: Sandy Soil:	
Flat, 2%	0.05 to 0.10
Average, 2% to 7%	0.10 to 0.15
Steep, 7%	0.15 to 0.20
Lawns: Heavy Soil:	
Flat, 2%	0.13 to 0.17
Average, 2% to 7%	0.18 to 0.22
Steep, 7%	0.25 to 0.35

Ref: ASCE Manual No. 37

The coefficients in Table III-2 are applicable for storms of 5-year to 100-year frequencies. Higher intensity storms require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff. In general, not less than the larger value tabulated for each condition shall be used for design against 25-year, 50-year or 100-year frequency storms.

C. SOIL CONSERVATION SERVICE METHODS

Application - Runoff may be determined by methods outlined in SCS National Engineering Handbook, Section 4, "Hydrology" (NEH-4) for all watershed areas. A simplified SCS Method is described in SCS Technical Release No. 55, "Urban Hydrology for Small Watersheds." Use of this method shall be limited to watersheds of less than 20 square miles having a 24-hour duration and a storm pattern with a "Type II" distribution, as defined by the Soil Conversvation Service.

Procedure - The design procedures described in the above referenced publications shall be followed.

D. U.S.G.S. METHOD

Application - The U.S.G.S. Method for determing peak rates of runoff is described in "Flood Flow Formulas for Urbanized and Non-Urbanized Areas of Connecticut" by L. A. Weiss. Use of this method shall be limited to watersheds greater than one square mile.

Procedure - The design procedure described in the above referenced publication shall be followed.

E. FHWA METHOD

Application - The FHWA Method for determining runoff is described in Report No. FHWA-RD-77-159 "Runoff Estimates for Small Rural Watersheds" October 1977, Vol. II. Use of this method shall be limited to watersheds smaller than 50 square miles.

Procedure - The design procedure for this method described in the above referenced publication shall be followed.

CHAPTER IV

DESIGN OF DRAINAGE FACILITIES

A. DRAINAGE SYSTEMS - GENERAL

The storm drainage system shall be designed to effectively transport storm water for the required frequency, assuring a minimum self-cleansing velocity of 3 feet per second, yet not attaining destructive velocities over 15 feet per second.

Storm drainage systems shall be designed on the basis of ultimate development of the tributary watershed. The latest edition of the Planning and Zoning Commission's "Building Zone Map" shall be used as the basis for the future development to be expected.

Drainage systems shall be carried to a suitable outlet, preferably an existing river, stream, or street drainage system. Where a suitable outlet is not available within a developer's property or the adjacent street right-of-way, it will be necessary to obtrain appropriate drainage easements and to construct new and/or improve existing drainage facilities.

Where there is no suitable outlet, with the written approval of the Director, Department of Public Works, dry wells may be used for drainage from very small areas or, for small sites which have frontage along City streets, drainage may be permitted to discharge into roadway gutters. The design of drywells and the discharge into roadway gutters shall be subject to the review and approval of the Director, Department of Public Works.

B. CATCH BASINS

General - Catch basins are the means by which runoff enters the storm drainage system. Proper inlet analysis and design are required to define the hydraulic design capacity of the drainage system.

Location - Along roadways having curbs or shoulders raised above the roadway, catch basins shall be located to prevent gutter and/or catch basin and gutter capacities from being exceeded and to prevent ice from building up in the gutter.

On roadways which do not have curbs or shoulders raised above the edge of pavement, no provision will ordinarily be required to provide drainage of the pavement other than the cross slopes of the pavement and shoulder, except at low points which shall be drained by catch basins located within the area normally clear after snow removal. In such cases, the curb head of the catch basin shall be set back two and one-half feet (2.5') from the normal edge of pavement.

In residential areas, where the design flow across a roadway intersection is 1 c.f.s. or more, a catch basin shall be provided upstream of the intersection to intercept the flow. In business districts, catch basins shall be provided upstream of all intersections, irrespective of design flow.

At the downgrade end of all curbed or cut sections, catch basins shall be provided to prevent erosion of the adjacent shoulder or slope.

Within parking lots, catch basins shall be located (a) at low points, (b) to prevent gutter and/or catch basin capacities from being exceeded, and (c) to drain gutters located along the high side of parking lots to prevent hazardous freezing of snow melt.

In business districts, catch basins shall be provided at driveway entrances where the design flow would significantly inconvenience pedestrians or where existing gutter capacity along the road is already exceeded or would become exceeded. Catch basins at driveway entrances shall be located outside the street right-of-way.

Selection of Inlet Type - At all locations within public or private roadways, parking lots or driveway entrances, catch basins having sumps shall be provided, except that, at the upstream end of a drainage system, an inlet with a pipe draining into a catch basin, having a sump, will be acceptable and inlets without sumps, may be constructed over culverts at roadway low points.

Inlet Capacity - The amount of flow intercepted by a catch basin is dependent upon many factors including the type of grate, the amount of depression, potential for clogging, and velocity of flow. The primary factor is the type of grate which is used. Experience indicates that the portion of the flow within the width of the grate will usually be intercepted. Lateral flow over the side of the grate is negligible and should not be considered on normal installations. The remainder of the flow, outside the grate width, will bypass to the next catch basin.

Inlet Flow - The flow entering a catch basin shall be determined by gutter flow analysis based on the following design limits for the extent of flooding or ponding on streets and highways:

1. The shoulders of all roads may be flooded.

2. Two-lane bi-directional roads may have one-half of a lane in each direction flooded; or if superelevated; one-half of the lane on the low side of superelevation.

3. Four-lane undivided roads may have a lane in each direction, or one lane on the low side of a superelevation flooded.

4. Depressed roads shall have a minimum of 12 feet of travelled way free of flooding.

Gutter flow analysis shall be carried out using the following procedure.

Procedure for Gutter Flow Analysis (See Figure IV-1)

1. Inlet Station - Identify inlet by station and offset from centerline or baseline.

2. Time to Inlet - Time required for surface flow to concentrate at the inlet in minutes.

3. Area (A) - Enter all areas of each surface type contributing runoff to the inlet in separate rows, in acres.

4. Runoff Coefficient (I) - Runoff coefficient for each area of each surface type contributing to the inlet.

5. AI - The product of the areas and the runoff coefficients, (#3 x #4).

6. Sum of AI - The sum of the AI for the inlet.

7. Total AI - The AI bypassing the previous inlet and the AI for the inlet, (#6 + #15) from the upstream inlet)).

8. Rainfall Intensity (R) - The intensity determined by the Time to Inlet (#2), from Figure III-3, in inches per hour.

9. Q to Inlet - The product of the Total AI, (#7), and the Rainfall Intensity, (#8), (Q=AIR), in cubic feet per second.

10. Grade of Gutter - Grade to be expressed in feet per foot.

11. Cross Slope of Shoulder - Slope to be expressed in feet per foot.

12. Depth of Flow - Depth of water at gutter, from Figures IV-2 and IV-3, in feet.

13. Width of Flow - The width of water from the face of curb, from Figure IV-2, in feet. When the width of flow exceeds the shoulder width and the shoulder cross slope changes from the pavement cross slope the depth and total width of flow shall be determined by following Instruction 4 on Figure IV-3.

14. Q Bypassing Inlet - The portion of flow that is beyond the width of the grate will be used to determine the bypass Q. No consideration will be given to the minimal flow that enters along the longitudinal edge of the grate.

15. AI Bypassing Inlet - Determined by dividing Q Bypassing Inlet, (#14), by Rainfall Intensity, (#8).

16. AI Entering System - The Total AI, (#7), minus the AI Bypassing Inlet, (#15).

Computerization of gutter flow analysis is acceptable. The computer printout shall contain the same information as is shown on the Gutter Flow Analysis Form (Figure IV-1). A detailed explanation of the method of analysis employed by the program shall be provided.

Sag Inlet Flow - The capacity of a catch basin in a sag or low point location shall be determined by the following method.

A grate inlet in a sag operates first as a weir having a crest length roughly equal to the outside perimeter along which the flow enters. Bars are disregarded and the side against the curb is not included in computing the perimeter. Weir operation continues to a depth of about 0.4 foot above the top of grate and the flow entering the grate is:

$Q_i = 3.0\ P(d)^{1.5}$ (ConnDOT Drainage Manual)

Where Q_i = flow entering the grate, in cubic feet per second

P = perimeter of grate opening, in feet, disregarding bars and neglecting the side against the curb

d = depth of water at grate, in feet

When the depth at the grate exceeds about 1.4 feet, the grate begins to operate as an orifice and the flow entering the grate is:

$Q_i = 0.67A\ (2gd)^{0.5} = 5.37A(d)^{0.5}$ (ConnDOT Drainage Manual)

Where Q_i = flow entering the grate, in cubic feet per second

A = clear opening of the grate, in square feet

g = acceleration of gravity, 32.2 feet per second per second

d = depth of ponded water above top of grate, in feet

For depths over the grate between about 0.4 and 1.4 feet the operation of the grate inlet is indefinite due to vortices and other disturbances. The capacity of the grate is somewhere between that given by weir analysis and orifice analysis. For the purpose of analyzing the extent of flooding, the lesser flow condition shall be used. For the purpose of analyzing the pipe system, the greater flow shall be used.

Because the capacity of catch basins in sags is frequently restricted by litter and leaves, a clogging factor should be used with the above equations in determining inlet flows. In depressed roadways and parking lots a clogging factor of 0.5 should be used. Where danger of clogging is less likely to occur, a smaller clogging factor may be used.

C. SLOTTED DRAINS

Slotted drains may be used to clear utilities where a standard catch basin cannot be installed, or to intercept sheet flow.

A method for determining the flow interception and length of slotted drains is found in the State of Connecticut, Department of Transportation "Drainage Manual" pages 141 through 144B.

D. MANHOLES

Manholes shall be provided where a change in horizontal and/or vertical alignment of conduits is required. Manholes shall be located at not greater than 350 foot intervals for pipes up to 48" diameter and at not greater than 700 foot intervals for pipes larger than 48" diameter.

Conduits shall not pass directly from catch basin to catch basin, but shall pass from catch basin to manhole, or manhole to manhole. However, within a building site, under conditions of limited flow, (less than 2.0 c.f.s.) catch basins may be used as manholes, provided that a catch basin having a sump is installed prior to the discharge entering the City's drainage system.

In general, catch basins shall be precast. Concrete block may be used for the construction of catch basins with the written approval of the Director, Department of Public Works.

Connections to the City drainage system shall be by means of a manhole. However, an isolated catch basin, within a building site, may discharge into an existing City catch basin. Direct connection to existing pipes shall not be permitted.

E. STORM SEWERS

Pipe Selection - Circular conduits of less than 12 inches nominal diameter shall not be used for the transportation of surface drainage, except that roof leader drains may be of smaller size. Elliptical pipe of equal hydraulic characteristics to the circular conduit may be substituted.

Reinforced concrete pipe, Class IV, shall be used except when otherwise approved in writing by the Director, Department of Public Works.

Pipe Installation - Pipe backfill and support conditions shall be in accordance with Standard Construction Details and Specifications, Department of Public Works. All trenches on slopes greater than 6 percent shall have cutoff walls.

Where drainage pipes cross sanitary sewers, water mains, gas mains or other utilities, minimum clearance shall be twelve inches (12"), properly cushioned. Where it is not possible to provide the minimum twelve inches (12") of clearance, provision shall be made for the protection of the pipes in accordance with the requirements of the utility company and subject to the written approval of the Director, Department of Public Works.

Conduits, except for underdrains, shall be installed on straight alignments, both horizontally and vertically, with manholes providing access to all deflection points and to all junctions of two or more lines. In special cases, with the approval in writing of the Director, Department of Public Works, conduits may be placed on curved alignments. Such curvature shall not exceed the pipe manufacturer's recommendations. The minimum radii (in feet) for reinforced concrete pipe to be installed on curves are shown in Table IV-1.

TABLE IV-1

Size	4' Lengths	8' Lengths
15"	108	216
18"	128	256
21"	148	296
24"	168	336
30"	210	420
36"	250	500
42"	288	276
48"	326	652
54"	365	730
60"	405	810
72"	442	884

Ref: ConnDOT Drainage Manual

Hydraulic Design - Storm sewers shall be designed as open channels, where there is a free water surface (just full or less than full), or for pressure or pipe flow under surcharged conditions. The hydraulic design of a storm sewer system shall take into account the effect of backwater and shall allow for all energy losses in the system.

A hydraulic analysis shall be performed to determine whether the pipe will operate as an open channel or as a pressure system. Backwater calculations shall be made for each run of conduit or pipe. Friction losses as well as form losses shall be calculated. Form losses include losses due to manholes, bends, contractions, enlargements and transitions.

The Manning Formula shall be used for computing flow characteristics of conduits operating as open channels or under pressure:

$$V = \frac{1.486}{n} (R)^{2/3}(S)^{1/2}$$

$$Q = \frac{1.486}{n} A(R)^{2/3}(S)^{1/2}$$

Where:

V = Average velocity, ft./sec.
Q = Flow, cu.ft./sec.
R = Hydraulic radius, ft.
A = Cross sectional area, sq. ft.
S = Slope of hydraulic gradeline for open channel flow and slope of energy grade line for pressure flow
n = Roughness coefficient

Figure IV-4 provides an acceptable graphic solution of the Manning Formula for pipes flowing full.

Flow characteristics at inlets and other restrictions should be calculated by the use of appropriate variations of the Bernoulli Equation which is:

$$\frac{(V_1)^2}{2g} + \frac{P_1}{\gamma} + Z_1 = \frac{(V_2)^2}{2g} + \frac{P_2}{\gamma} + Z_2 + H_T$$

Where:

V_1 & V_2 are the velocities at locations 1 & 2

P_1 & P_2 are the pressures at locations 1 & 2

γ is the specific weight of fluid

Z_1 & Z_2 are the heights above datum at locations 1 & 2

H_T is the total head loss which includes both friction losses and form losses. H_T = Friction head loss (hf) + Transition head loss (ht) + manhole loss (hm) + junction loss (hj) + entrance loss (he) + bend loss (hb). These head losses are defined in King's "Handbook of Hydraulics" and "Modern Sewer Design."

Storm sewers should be designed to flow as open channels. Headwaters in structures shall not be higher than one foot below the top of frame or grate, taking into consideration the possible effect of headwater in the next downstream structure. The "Backwater Curve" procedure shall be used by the design engineer to determine the hydraulic grade in each structure.

<u>Procedure for Storm Sewer System Design (See Figure IV-5)</u>

1. <u>Line Segment</u> - Identification of line, usually between inlets or manholes.

2. <u>Time to Inlet</u> - Time for surface flow to concentrate at inlet to the segment, in minutes. If the area is such that it takes less than the minimum time of 5 minutes then 5 minutes shall be used until the accumulated time exceeds 5 minutes.

3. Time in Pipe - time required to pass through line segment, in minutes.

4. Accumulated Time - Time of concentration at the design location in minutes. The longest time is to be used. This may be overland flow to an inlet; accumulation of time in the mainline pipe; or the accumulation of time along a branch line entering a system.

5. AI entering Catch Basin - AI determined by "Gutter Flow Analysis" (See Figure IV-1).

6. Sum of AI in System - sum of the AI's entering inlets effective at location.

7. Rainfall Intensity - The intensity determined by the Accumulated Time (#4), inches/hour.

8. 'Q' in System - The product of Sum of AI in System (#6), and the Rainfall Intensity (#7), in cubic feet per second.

9. Pipe Size - Inside diameter in inches.

10. Length of Pipe - In feet, measured between inside faces of structures.

11. Slope - In feet per foot.

12. Average Velocity - The velocity which will occur in pipe of size, type and slope specified at design flow, in feet per second from Figure IV-4.

13. Full Capacity - Flow which would be carried by pipe of size and type specified, flowing full, in cubic feet per second from Figure IV-4.

14. Headwater - Height water will reach above the flowline that will develop at the design discharge in the structure. Headwater shall be determined by backwater analysis and shall include losses from friction, bends, junctions, manholes and transitions.

15. 'n' - Roughness Coefficient: n = .012 for R.C.P.; n = .019 for C.C.M.P. with paved invert. Values for 'n' for other materials are available from King's "Handbook of Hydraulics".

Outlets - All outlets shall be designed to prevent erosion. They shall be carried down steep slopes to lesser slopes where outlet erosion will not occur. Riprap or modified riprap shall be used at all outlets not flowing over exposed rock or directly into watercourses or ponds.

Where pipes are installed on steep grades and it is necessary to provide for energy dissipation at the outlet, the methods described in Hydraulic Engineering Circular No. 14 shall be used.

F. CULVERTS

Culverts shall be designed to carry discharges resulting from the storm frequencies defined in Table III-1. The water surface used at the inlet to determine the culvert size shall generally be based on the allowable headwater (AHW) minus one foot for freeboard. The AHW shall be indicated on the culvert computation forms. (Figures IV-6 and IV-7) The AHW is determined or limited by the elevation of the roadway, parking lot or building sills for present as well as future development. Each culvert design must be considered individually based on the AHW and the topography adjacent to its inlet.

Consideration shall be given to the effect of the selected design water surface on abutting private property. In general, the backwater effects should be contained within the street right-of-way or drainage easement. Engineering judgment shall be exercised to ensure that the headwater level selected is reasonable.

At all culvert inlets, the approximate limits of the flooded area covered by the headwater shall be shown on the plans submitted for review.

Where a culvert will carry a discharge reduced by detention the Department of Public Works reserves the right to require that the design be based on zero storage. In that case, the culvert will be designed as if the detention facility or facilities did not exist.

The location and alignment of culverts should be consistent with the flow tendency of existing streams.

Culverts should be designed with the aid of the "Hydraulic Charts for the Selection of Highway

Culverts" as found in Hydraulic Engineering Circulars Nos. 5 and 10 and should be checked for inlet and outlet control.

Where successive culverts are utilized and the flow in upper culverts is affected by headwaters in the lower culverts, a water surface profile and appropriate computations shall be submitted for review.

The effects of tidal action shall be investigated to insure that scour or erosion resulting from high velocities due to the movement of the tidal prism will not endanger the structure, roadway or adjacent property.

The need for energy dissipation at all outlets shall be investigated. Outlet dissipation methods are outlined in Hydraulic Engineering Circular No. 14.

Design calculations shall be submitted in a clear, neat and understandable manner. The sample computation sheets and/or information provided on Figures IV-6 and IV-7 may be used as a guide. Where other forms are used, they shall contain all of the information shown in Figures IV-6 and IV-7.

G. HEADWALLS, ENDWALLS AND END SECTIONS

A headwall, or other approved protection, shall be provided wherever an open drainage system discharges into or receives discharge from an enclosed system. An increase in culvert efficiency can be realized by the design of "Improved Inlets." An outline for the hydraulic design of improved inlets is detailed in Hydraulic Engineering Circular No. 13.

Safety of the structure loction must be considered in relation to pedestrian and vehicular traffic. Culvert ends are preferred to endwalls. Safe recovery areas shall be provided where vehciles may impact the structure, if guide rail is not used.

The need for trash racks shall be established by field investigation. If used, they shall be designed so as to allow for overflow when clogged. Access for maintenance of trash racks should be considered.

Headwalls shall conform to City of Norwalk Roadway and Drainage Standard Details.

H. CHANNELS

Hydraulic Design - Channels shall be designed with a section and grade which will carry the design discharge, in its flattest section, under the controlling conditions, providing freeboard as needed, and with channel lining protection to prevent erosion. A change in the type of channel lining, with all other conditions unchanged, may require a change in channel dimensions unless the two linings have the same roughness coefficient. Open channels shall be designed to carry runoff consistent with the storm frequencies defined in Table III-1. Hydraulic Design Series Nos. 3 & 4 and Hydraulic Engineering Circular No. 15 shall be used for the design of channels. The form shown in Figure IV-8 may be used in the design of all channels. Calculations made in other formats shall include all of the information shown in Figure IV-8.

Channels shall be designed to convey the design discharge within their banks unless an engineering study is submitted and approved by the Director, Department of Public Works, which demonstrates that the proposed solution is acceptable.

Location, linings and cross slope of banks are important safety considerations. Along streets and highways, motorists' safety generally improves with increasing distance between the travelled way and the channel.

All channels shall be designed so as to minimize erosion. Erosive velocities, as defined in SCS-TP-61, may be reduced by flattening channel grades, where uniform flow conditions exist, otherwise an appropriate channel lining shall be used. To prevent erosion all channels, ditches or swales shall be lined, in accordance with their design, as soon as they are excavated.

Consideration should be given in the design to maintenance requirements. The design should reduce maintenance to a minimum.

Freeboard should be provided where overflow would cause considerable damage by providing extra height of lining above the design depth of flow.

Superelevation of the flow surface will occur at channel bends or curves and will require an additional height of lining. Subcritical flow around a curve causes the water to rise on the outside of the curve. Supercritical flow around a curve will cause the water to rise alternatively on the outside and inside of the curve requiring additional height throughout the curve length. The height of the water surface can be computed by the formula provided in Hydraulic Engineering Circular No. 15.

In large watercourses wave action may occur and will require additional height of lining. Where channel slopes are between 0.7 Sc and 1.3 Sc it is recommended that an allowance for waves be added to the normal depth of flow based on the following formula:

$$Hw = 0.25\ dc\ [1-(11.1)(\frac{S}{Sc} - 1)^2]$$

Where: Hw = height of wave in feet
dc = critical depth in feet
S = slope of channel in feet per foot
Sc = critical slope in feet per foot

Ref.: SCS-TR-25

Rigid Linings - The hydraulic design of rigid linings is described in Hydraulic Design Series Number 3. Coefficients of roughness, 'n', for rigid linings shall be as follows:

Material	'n'
Bituminous Concrete	.015
Portland Cement Concrete	.015
Concrete Pipe Ditch Liner	.015
Metal Pipe Ditch Liner	.024
Slope Paving	.015-.025*

*For cast-in-place concrete .015; for stone .025

The following design features should be considered in the design of rigid channel linings:

1. A riprap pad or energy dissipater at the outlet end of the rigid lining to reduce scour and undermining. An energy dissipater may be needed in the channel itself.

2. The use of back drainage where ground water is intercepted.

3. A cut-off wall at the outlet end to reduce undermining.

4. The channel should be kept below existing ground, if possible.

5. The use of sod, one foot wide, adjacent to the top of the lining to prevent surface water infiltration behind the lining material.

Flexible Linings - A flexible lining is generally more economical and is aesthetically preferable since it blends in with the landscape. There are several types of flexible linings. These include grass, riprap, keyed riprap and gabions. Design procedures for flexible linings are described in Hydraulic Engineering Circular No. 15.

I. ENERGY DISSIPATERS

Energy dissipaters serve to reduce the kinetic energy of flowing water to minimize scour and erosion in channels and at the outlets of structures. There are several types, including check dams, drop structures, baffles, stilling basins, scour holes and structures designed to create a hydraulic jump.

In some situations, channel lining requirements may be reduced downstream of an energy dissipater, because of the reduced water velocity, providing an economic benefit.

Energy dissipaters shall be designed to prevent overtopping and causing damage, when carrying the design flow.

The design procedure for energy dissipaters is found in Hydraulic Engineering Circular No. 14.

J. STRUCTURAL DESIGN OF PIPES AND CULVERTS

It shall be the responsibility of the engineer to obtain all data concerning the structural design of pipes and culverts to be installed in the City of Norwalk. This data shall include, but shall not be limited to, height of overfill, probable future changes in roadway grade, foundation conditions, permissible or expected live loads during and after construction, and the expectable corrosive or erosive characteristics of the discharge.

The gauges of metal of pipes or of pipe-arches fabricated from corrugated steel shall be not less than those shown in the Gauge and Fill Height Tables shown in Tables IV-2 through IV-4 for the types of pipes and with the depths of fill described. For different types of corrugations or metals the manufacturer's recommendations shall be followed.

Reinforced concrete pipe and reinforced concrete eliptical pipe, shall meet load-strength criteria as shown in the "Design Manual-Concrete Pipe" published by the American Concrete Pipe Association.

Except where indicated by an engineering study submitted to and approved in writing by the Director, Department of Public Works, all reinforced concrete pipe shall be Class IV. A unit weight of 125 lbs./C.F. for fill or backfill shall be used to determine the loading.

All pipes shall be installed in accordance with the City of Norwalk Roadway and Drainage Standards and Specifications. Class 'C' bedding (Ref: ASCE Manual No. 37) will be used unless otherwise detailed and specified.

Conduits placed under railroad roadbeds shall be designed to conform to the pertinent provisions of the current American Railway Engineering Association Specifications for the type of conduit provided.

TABLE IV - 2

GAUGE AND FILL HEIGHT TABLES

The gauge and fill height tables to follow can be converted from gauge thickness as below:

Conversion of Nominal Gauge to Thickness

Gauge No.	22	20	18	16	14	12
Galvanized* Thickness - In.	0.034	0.040	.052	.064	.079	.109

Gauge No.	10	8	7	5	3	1
Galvanized* Thickness - In.	.138	.168	.188	.218	.249	.280

*Also referred to as "specified thickness" for corrugated steel pipe products.

Ref.: Conn. DOT Drainage Manual.

Table IV-3

STRUCTURAL DESIGN
OF
PIPES & CULVERTS

CORRUGATED GALVANIZED STEEL PIPE ($2\frac{2}{3}''$ x $\frac{1}{2}''$ CORRUGATIONS)

Recommended Gages

DIAM. (IN.) \ FILL HEIGHT (FT) ①	Min.-10	11-15	16-20	21-25	26-30	31-35
15	16	16	16	16	16	16
18	16	16	16	16	16	16
21	16	16	16	16	16	16
24	16	16	16	14	14	14
30	14	14	14	14	12	12
36	14	14	12	12	10	10
42	12	12	12	10	10	10
48	12	12	12	10	8	8
54	10	10	8	8	10	10
60	8	10	10	10	8	8
66	10	10	10	8	8	8
72	8	8	8	8	8	8

NOTES:

① Fill height above top of pipe in feet.
② All pipe below heavy line to be shop strutted or elongated in accordance with Conn DOT Specs.
③ For pipe or fill height larger than shown in this table use Structural Plate.
④ Minimum cover of 18" is the distance from the top of pipe to the finished grade of the road.
⑤ Unit weight dead load is 125#/cu. ft.
⑥ Ref: Conn DOT Drainage Manual

Table IV-4

STRUCTURAL DESIGN
OF
PIPES & CULVERTS

ASPHALT COATED CORRUGATED GALVANIZED STEEL PIPE ($2\frac{2}{3}$" x $\frac{1}{2}$" CORRUGATION)

Recommended Gages

SPAN (IN)	RISE (IN) / FILL HEIGHT (FT) ①	1½ - 3	4 - 5	6 - 10	11 - 15
	18" Minimum Cover				
18	11	16	16	16	16
22	13	16	16	16	16
29	18	14	14	14	14
36	22	14	14	14	14
43	27	12	12	12	12
50	31	12	12	12	12
58	36	10	12	12	10
65	40	10	10	10	8
72	44	8	8	8	

NOTES:

① Fill height above top of pipe in feet.
② For larger structures use Structural Plate.
③ Fill limited to 15 ft. in order to hold corner bearing pressures to 4 ton maximum.
④ Unit weight dead load is 125#/cu. ft.
⑤ Minimum Cover is the distance from the top of the pipe arch to the finish grade of the road.
⑥ Ref: Conn DOT Drainage Manual

CHAPTER V

SUBSURFACE DRAINAGE

Subsurface drainage relates to the control of ground water, in contrast to surface water or storm drainage.

Subsurface drainage is a practical, economical way of maintaining firm, stable subgrades and foundations while eliminating frost heaving, sloughing of fill and cut slopes and reducing saturation of backfill behind retaining walls and abutments.

Adequate provision for subsurface drainage shall be included in all designs. The location and size of subsurface drainage facilities shall be determined by analysis and design by a registered professional engineer. A report documenting the hydraulic design of the subsurface drainage system shall be submitted to the Director, Department of Public Works for approval. The hydraulic report shall present the subsurface runoff calculations.

Underdrains shall consist of a trench cut below the elevation of the bottom of the subbase or base, containing a suitable perforated or slotted pipe and backfilled with a pervious material in accordance with the Roadway and Drainage Standards of the City of Norwalk and/or the recommendations of the Department of Public Works.

The pipe size shall be determined by engineering analysis but shall be not less than eight inches nominal diameter. Underdrains may be designed to carry surface drainage. Where underdrains carry surface drainage in addition to subsurface drainage, the size shall be not less than 12 inches. At locations where the combined flow exceeds the capacity of the largest underdrain pipes of the appropriate type, the subsurface water and the surface drainage shall be carried in separate pipes.

Outlets for underdrain pipe shall be connected directly to drainage structures. Where no drainage structure is available, the outlet pipe may be terminated with an underdrain outlet endwall. Uphill ends of underdrains carrying only subsurface drainage shall be extended into a drainage structure, if one if available within 25 feet, and plugged. Where no upstream drainage facility is available the underdrain may be terminated within the pervious backfill.

The location of lateral foundation underdrains crossing a street or highway and of slope underdrains shall be approved by the Director, Department of Public Works. Maintenance of the subsurface drainage system shall remain the responsibility of the owner.

CHAPTER VI

DETENTION/RETENTION FACILITIES

General - Detention refers to a storm water storage facility that is normally dry but is designed to temporarily hold (detain) water during and immediately after a runoff event. Examples of detention facilities are, natural swale's with berms, subsurface tanks, pipes or reservoirs, rooftop storage and parking lots.

In contrast, a retention facility always contains (retains) a substantial volume of water to serve recreational, aesthetic, water supply or other functions. Storm water is temporarily stored above the normal water surface elevation (stage) during and immediately after runoff events. Examples of retention facilities include ponds, lakes, streams and rivers.

Hydrological Study - A hydrological study of the impact of proposed changes in runoff on the entire watershed shall be prepared by a registered professional engineer. The study should include:

1. An investigation of the adequacy of the existing downstream drainage system,
2. A review of existing flooding problems,
3. An estimate of the impact of additional runoff from development,
4. A review of the probability and impact of further development within the watershed which may cause increased runoff,
5. An analysis of the effect of time lag between drainage systems of developments and the surrounding watershed at critical points.

The study should be based on various storm durations and frequencies to ensure that the retention or detention facility will function properly and prevent increased downstream flooding for the design storm as well as more frequent storms.

Hydrological Study - A hydrological study of the impact of proposed changes in runoff on the entire watershed shall be prepared by a registered professional engineer. The study should include:

1. An investigation of the adequacy of the existing downstream drainage system,
2. A review of existing flooding problems,
3. An estimate of the impact of additional runoff from development,
4. A review of the probability and impact of further development within the watershed which may cause increased runoff,
5. An analysis of the effect of time lag between drainage systems of developments and the surrounding watershed at critical points.

The study should be based on various storm durations and frequencies to ensure that the retention or detention facility will function properly and prevent increased downstream flooding for the design storm as well as more frequent storms.

Detailed engineering computations should be made although, with the approval of the Director, Department of Public Works, qualitative judgments will be accepted where conclusions are obvious or where an inordinate amount of computations would be required to demonstrate impacts known to be insignificant and not accumulative in the watershed under consideration. A report of the results shall be submitted to and approved by the Director, Department of Public Works.

Retention and detention facilities shall not be provided where discharge is directly into Long Island Sound or in areas where the engineering study indicates retention or detention is not required such as in the lower reaches of large streams or rivers.

The design engineer shall make provision for safety and for the maintenance of the proposed facility.

Design Procedure - Detention and retention facilities shall be designed in accordance with the following procedures:

1. Develop an In-flow Hydrograph for the detention or retention facility for the design storm using one of the following methods:

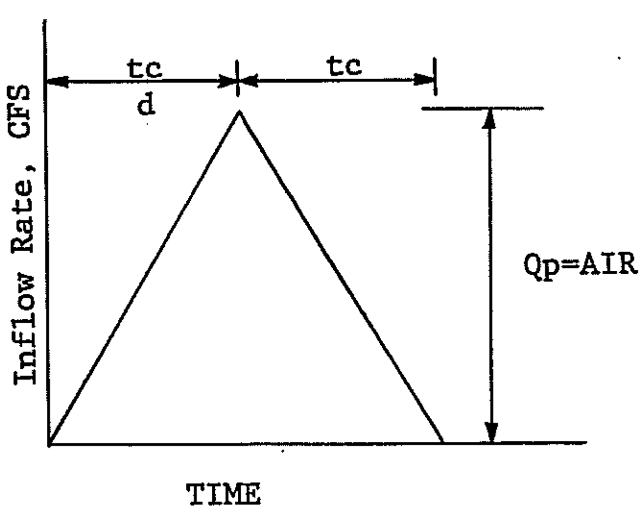
   a. Modified Rational Method

   Application - The Modified Rational Method may be used to develop an in-flow hydrograph and is based on the Rational Method of estimating peak rates of runoff. The use of this method shall be limited to watersheds smaller than 50 acres. The basic assumption inherent in the Rational Method is that the rainfall occurs at a uniform rate throughout the entire rainfall period. This is a highly improbable assumption and therefore the method should be applied only to relatively small drainage areas.

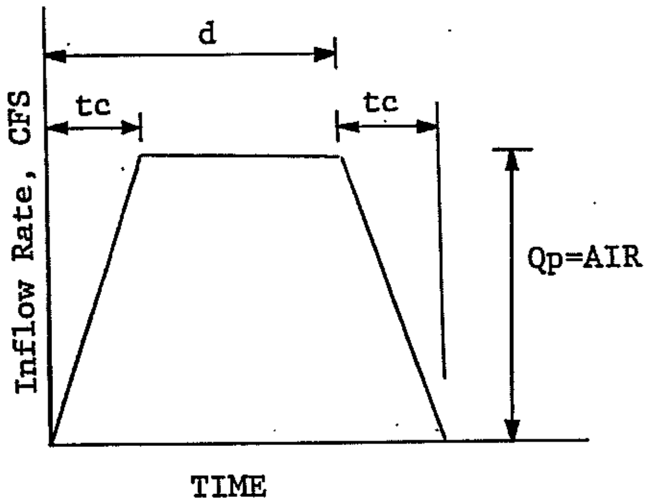
   Procedure - In the Rational Method, the peak rate of runoff is determined by the formula Q=AIR (See Chapter III - Rational Method, for application and procedure).

   The in-flow hydrograph shall fall into one of the following cases:

   Case 1. The duration of the storm (d) is equal to or less than the time of concentration (tc) and the peak discharge (Qp) is equal to AIR. This hydrograph shape is shown below.



Case 2. The duration of the storm (d) is greater than the time of concentration (tc) and the peak discharge Qp is equal to AIR. This hydrograph shape is shown below.



b. Soil Conservation Service Tabular Hydrograph Method

Application - An in-flow hydrograph may be determined by methods outlined in SCS Technical Release No. 55 "Urban Hydrology for Small Watersheds". Use of this method shall be limited to watersheds of less than 20 square miles having a 24-hour duration and a storm pattern with a Type II distribution.

Procedure - The design procedure described in the above referenced publication shall be followed.

c. Soil Conservation Service Unit Hydrograph Method

Application - The Soil Conservation Service has developed a method of hydrograph synthesis which may be used to determine an in-flow hydrograph. Use of this method shall be limited to watersheds of less than 20 square miles and is outlined in SCS National Engineering Handbook, Section 4, "Hydrology" (NEH-4).

Procedure - The design procedure described in the above referenced publication shall be followed.

d. Unit Hydrograph Method

Application - The unit hydrograph method may be used when observed rainfall runoff data during a rainfall event is available for the drainage area. This method is outlined in Ven Te Chow's "Handbook of Applied Hydrology".

Procedure - The design procedure described in the above referenced publication shall be followed.

2. Determine the allowable discharge rate. This shall be not greater than the undeveloped discharge rate.

3. Compute the Storage/Stage Curve for the proposed detention or retention facility indicating the volume of storage at various water surface elevations.

4. Select a specific outlet control structure, and compute the outflow discharge rates for various water surface elevations to produce the Outflow/Stage Curve.

5. The time interval selected shall be no greater than five minutes for a time of concentration less than one hour and no less than 10 minutes for a time of concentration equal to or greater than one hour.

6. Route the design In-flow Hydrograph through the detention or retention facility, utilizing the Storage-Indication Working Curve Method or Modified Puls Method. This routing is accomplished by the use of the standard flood routing equation.

$$\frac{[I_1 + I_2]}{2} \Delta T - \frac{[Q_1 + Q_2]}{2} \Delta T = S_2 - S_1 = \Delta S$$

Where:

Q_1 & Q_2	= Outflow rates at times 1 and 2
I_1 & I_2	= Inflow rates at times 1 and 2
S_1 & S_2	= Storage values at times 1 and 2
T	= $time_2 - time_1$ (Time Interval)

The standard flood routing equation can be rewritten in the Storage-Indication Working Curve format:

$$I_1 + I_2 + [\frac{2S}{\Delta T}1 - Q_1] = [\frac{2S}{\Delta T}2 + Q_2]$$

At the beginning of the rainfall event I_1, S_1 & Q_1 are equal to zero, so that $I_2 = \frac{2S}{\Delta T}2 + Q_2$.

The maximum outflow shall not exceed the allowable discharge rate and the freeboard at the peak water surface elevation shall be not less than one foot.

7. Once the detention or retention facility has been designed to offset peak runoff from the design frequency storm, storms of other durations and frequencies should be checked to ensure that downstream flooding does not occur for these storm events.

8. The Hydrological Report shall document the method of generating the in-flow hydrograph and all assumptions for the routing. The routing curves and tables shall be included. The routing output shall provide, but not be limited to, the time, the in-flow rate, the out-flow rate and the maximum storage volume.

CHAPTER VII

EROSION AND SEDIMENTATION CONTROL

All projects to be reviewed and approved by the Department of Public Works, City of Norwalk shall include methods to adequately minimize erosion or contamination in streams, ponds, rivers and reservoirs. The design engineer shall submit with his drainage plans, the proposed erosion and sedimentation control measures. Methods of erosion and sediment control include:

1. Temporary sedimentation pools.

2. Baled hay, straw or permeable fabric erosion check.

3. Diversion of streams.

4. Log, hay erosion check dam.

5. Stream bank protection through the use of rip-rap jetties, revetments or fencing.

6. Interceptor or diversion dikes.

7. Tree planting.

8. Temporary fertilizing, seeding and mulching.

All erosion and sedimentation controls are to be constructed in accordance with standards and specifications of the "Erosion and Sediment Control Handbook" for Connecticut by the U. S. Department of Agriculture Soil Conservation Service.

A method for designing sedimentation pools is found in the State of Connecticut Department of Transportation "Drainage Manual" pages 58 through 68.

Erosion and sedimentation controls are to be installed prior to construction, where possible. Land disturbances are to be kept to a minimum. Restabilization is to be scheduled as soon as possible.

All control measures are to be maintained in effective condition throughout the construction period and until all disturbed areas are thoroughly stabilized. Sediment removed from control structures is to be disposed of in a manner approved by the Department of Public Works.

NOTES

N O T E S

N O T E S

NOTES

NOTES

NOTES

FIGURES

TIME OF CONCENTRATION

(OVERLAND FLOW ONLY)

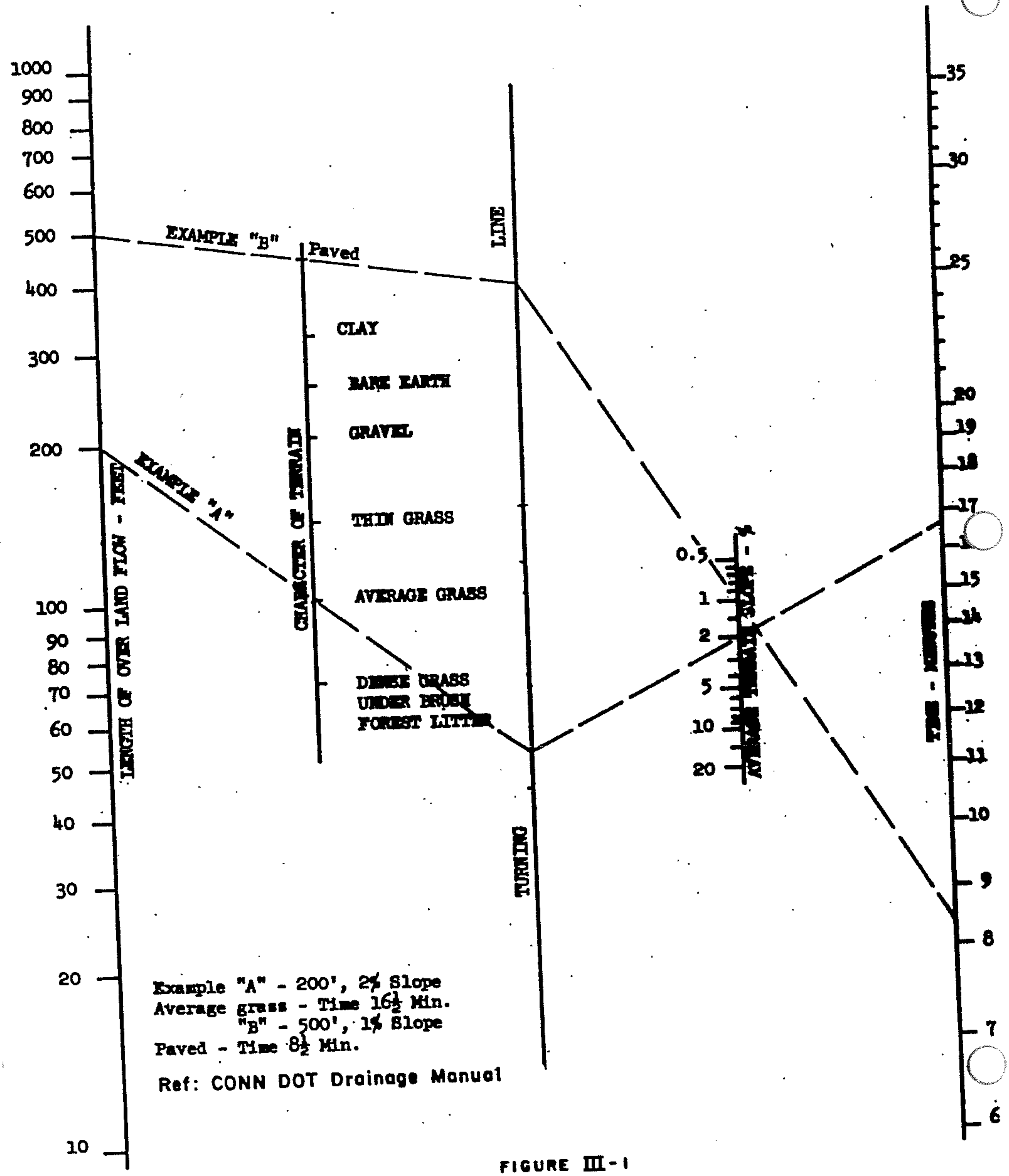
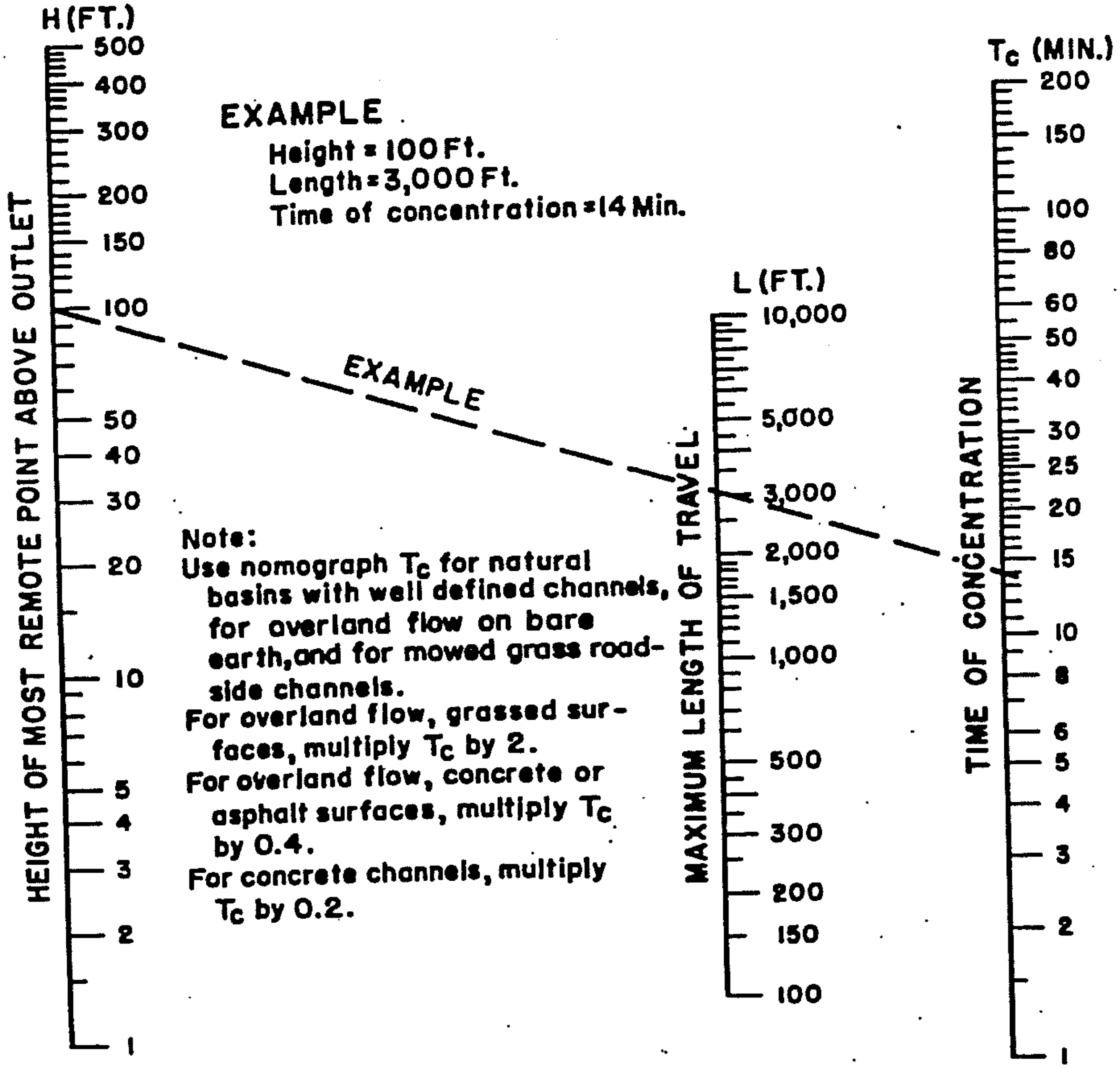


FIGURE III-1



Based on study by P. Z. Kirpich,
Civil Engineering, Vol. 10, No. 6, June 1940, p. 362

TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

FIGURE III - 2

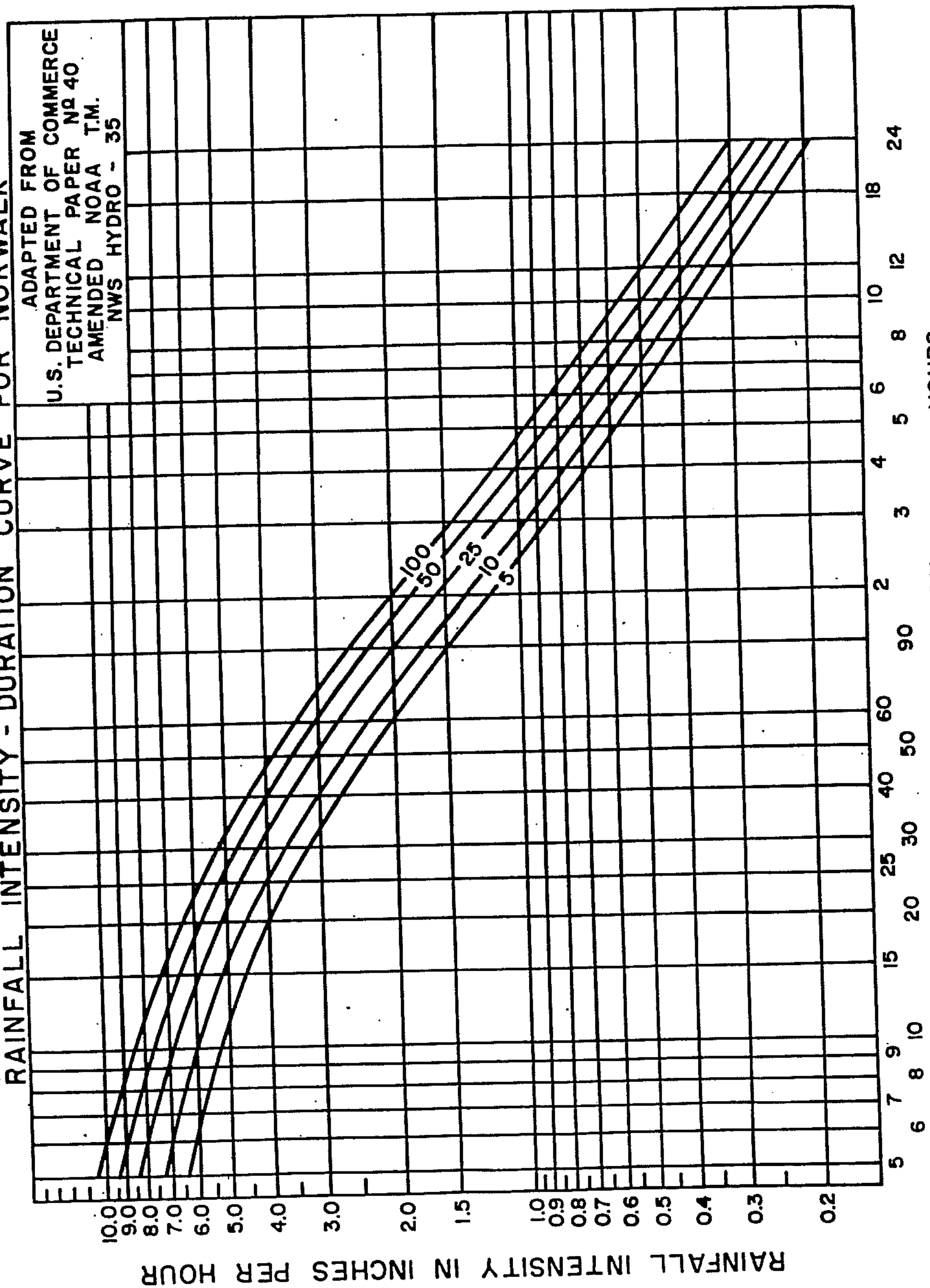

RAINFALL INTENSITY - DURATION CURVE FOR NORWALK
ADAPTED FROM
U.S. DEPARTMENT OF COMMERCE
TECHNICAL PAPER Nº 40
AMENDED NOAA T.M.
NWS HYDRO - 35
100
50
25
10
5
RAINFALL INTENSITY IN INCHES PER HOUR
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.5
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
5
6
7
8
9
10
15
20
25
30
40
50
60
90
2
3
4
5
6
8
10
12
18
24
MINUTES
DURATION
HOURS

FIGURE III -3

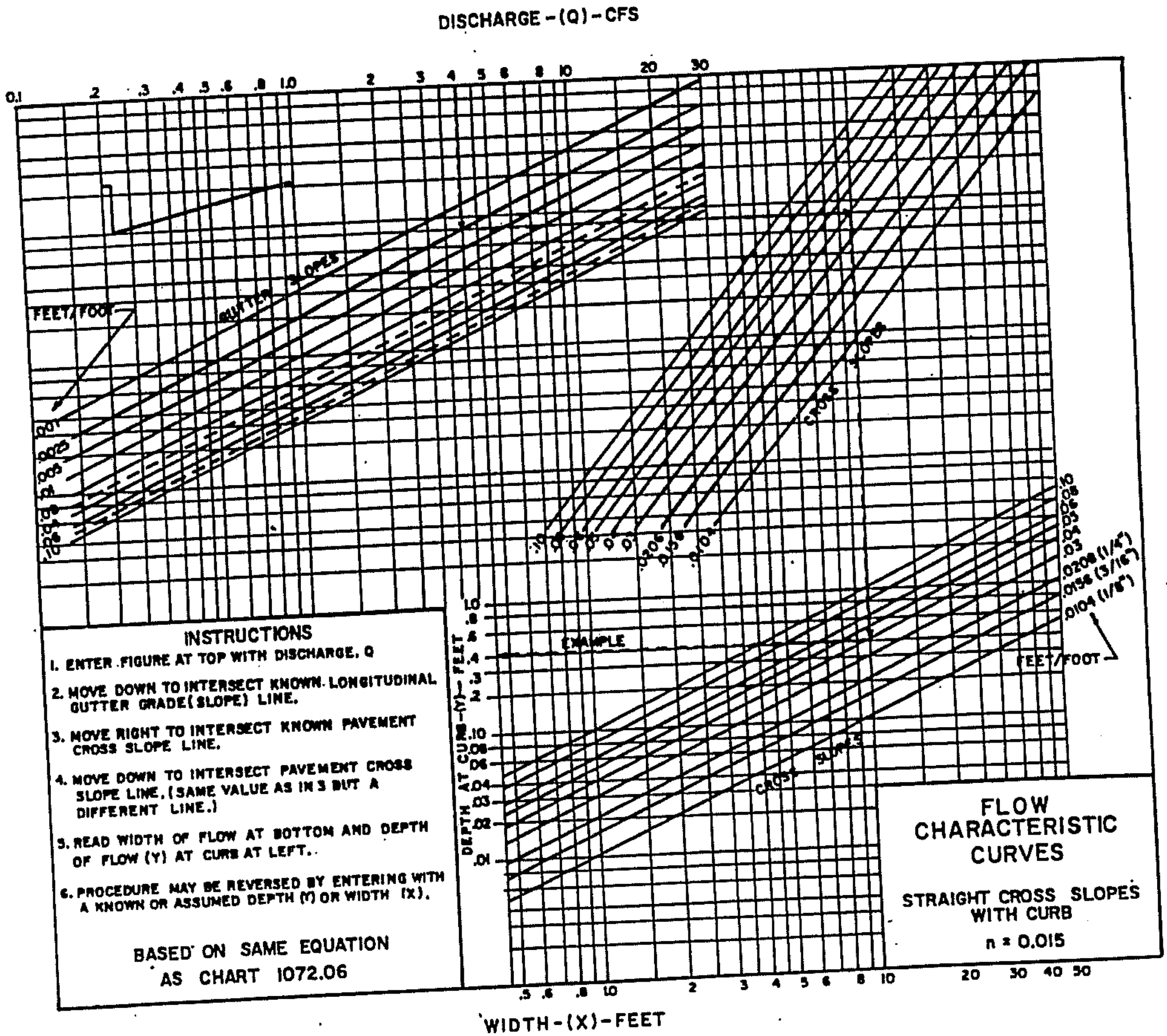
Project: ______________________ Designed by: ______________________

Street: ______________________ Checked by: ______________________

Sheet No.

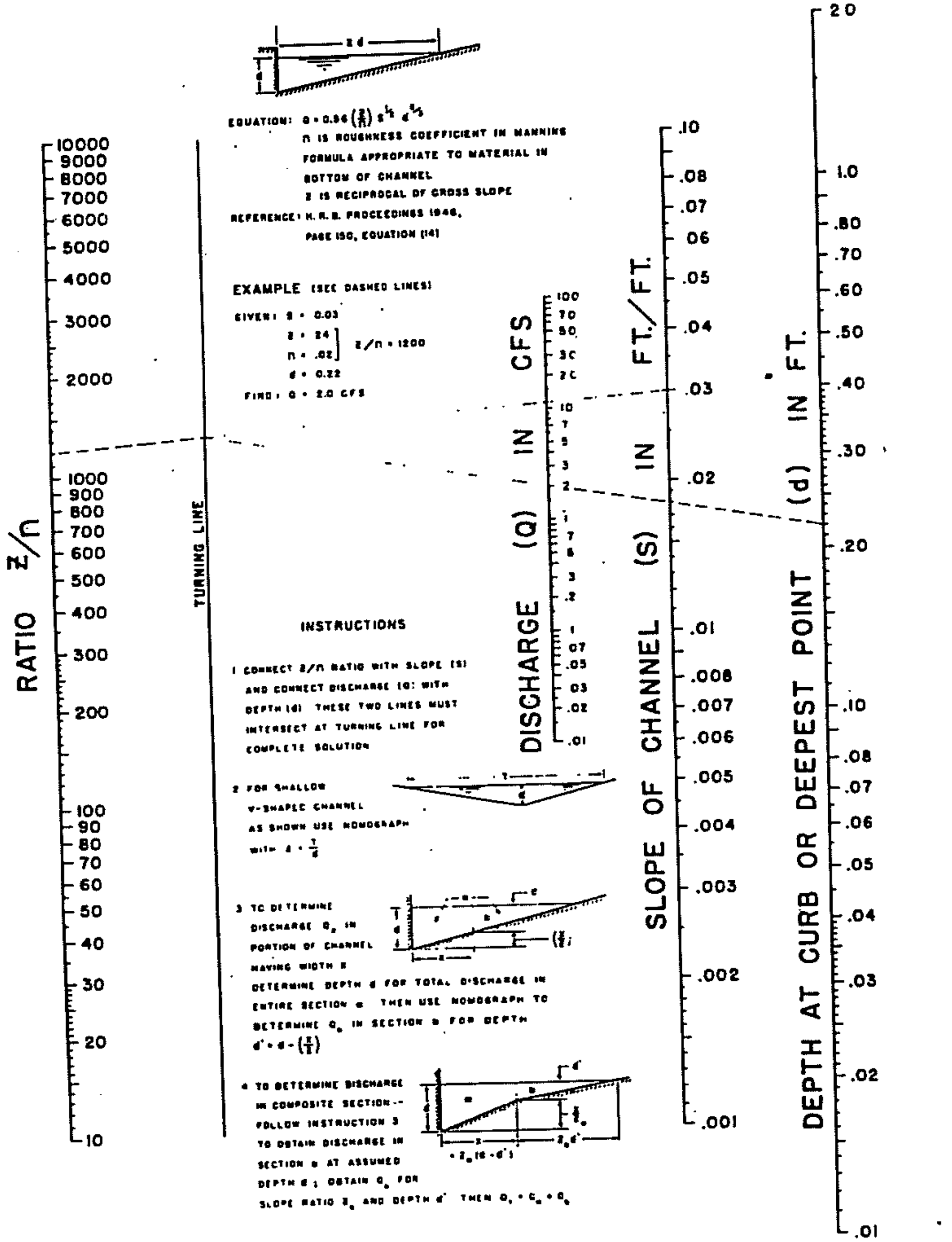
GUTTER FLOW ANALYSIS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
INLET STATION AND OFFSET	TIME TO INLET (Min.)	AREA (A) (Acres)	RUNOFF COEFFICIENT (I)	AI	SUM OF AI	TOTAL AI	RAINFALL INTENSITY (R) (In./Hr.)	Q TO INLET (c.f.s.)	GRADE OF GUTTER (FT./FT.)	CROSS SLOPE OF SHOULDER (FT./FT.)	DEPTH OF FLOW AT GUTTER (FT.)	WIDTH OF FLOW (FT.)	Q BYPASSING INLET (c.f.s.)	AI BYPASSING INLET	AI ENTERING CATCH BASIN



DISCHARGE - (Q) - CFS
GUTTER SLOPES
FEET/FOOT
CROSS SLOPES
EXAMPLE
DEPTH AT CURB - (Y) - FEET
WIDTH - (X) - FEET
INSTRUCTIONS
1. ENTER FIGURE AT TOP WITH DISCHARGE, Q
2. MOVE DOWN TO INTERSECT KNOWN LONGITUDINAL GUTTER GRADE (SLOPE) LINE.
3. MOVE RIGHT TO INTERSECT KNOWN PAVEMENT CROSS SLOPE LINE.
4. MOVE DOWN TO INTERSECT PAVEMENT CROSS SLOPE LINE. (SAME VALUE AS IN 3 BUT A DIFFERENT LINE.)
5. READ WIDTH OF FLOW AT BOTTOM AND DEPTH OF FLOW (Y) AT CURB AT LEFT.
6. PROCEDURE MAY BE REVERSED BY ENTERING WITH A KNOWN OR ASSUMED DEPTH (Y) OR WIDTH (X).
BASED ON SAME EQUATION AS CHART 1072.06
FLOW CHARACTERISTIC CURVES
STRAIGHT CROSS SLOPES WITH CURB
n = 0.015
.10 .08 .06 .05 .04 .03 .0208 (1/4") .0156 (3/16") .0104 (1/8")

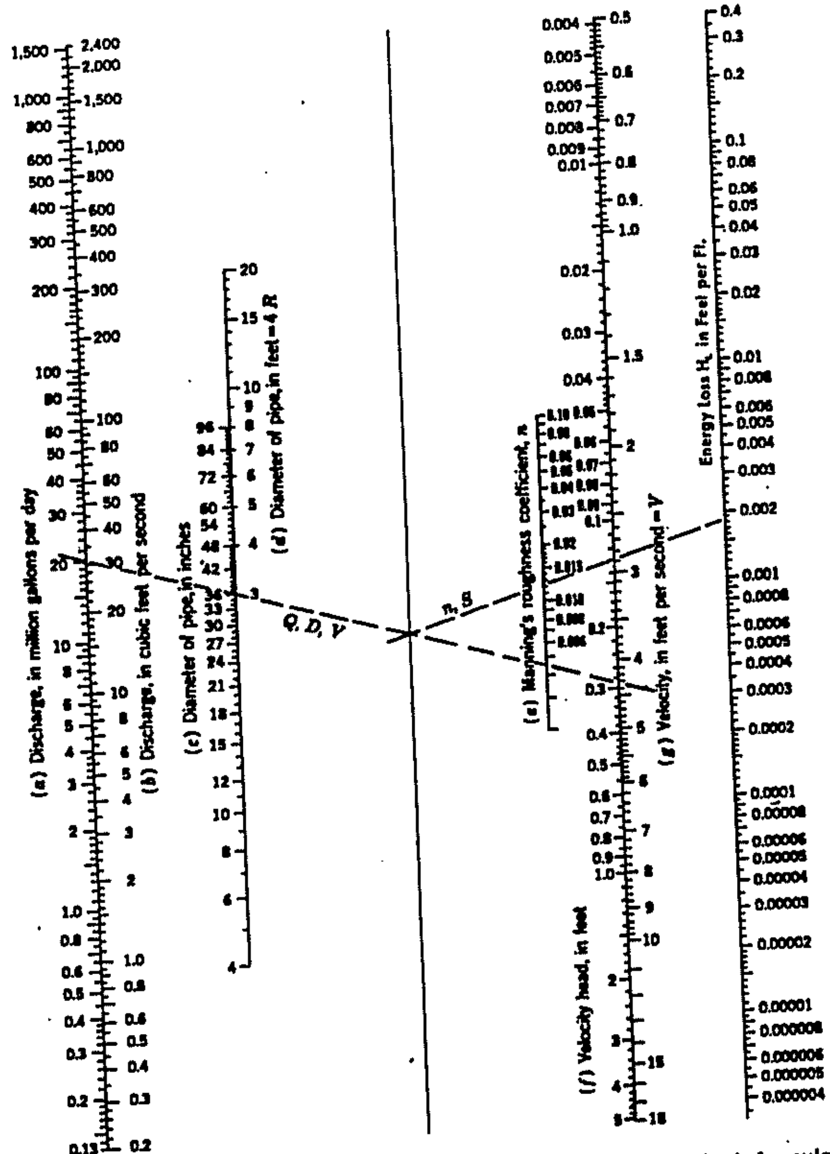
FIGURE IV - 2



NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

REF. "Hydraulic Design Series No. 3"

FIGURE IV-3



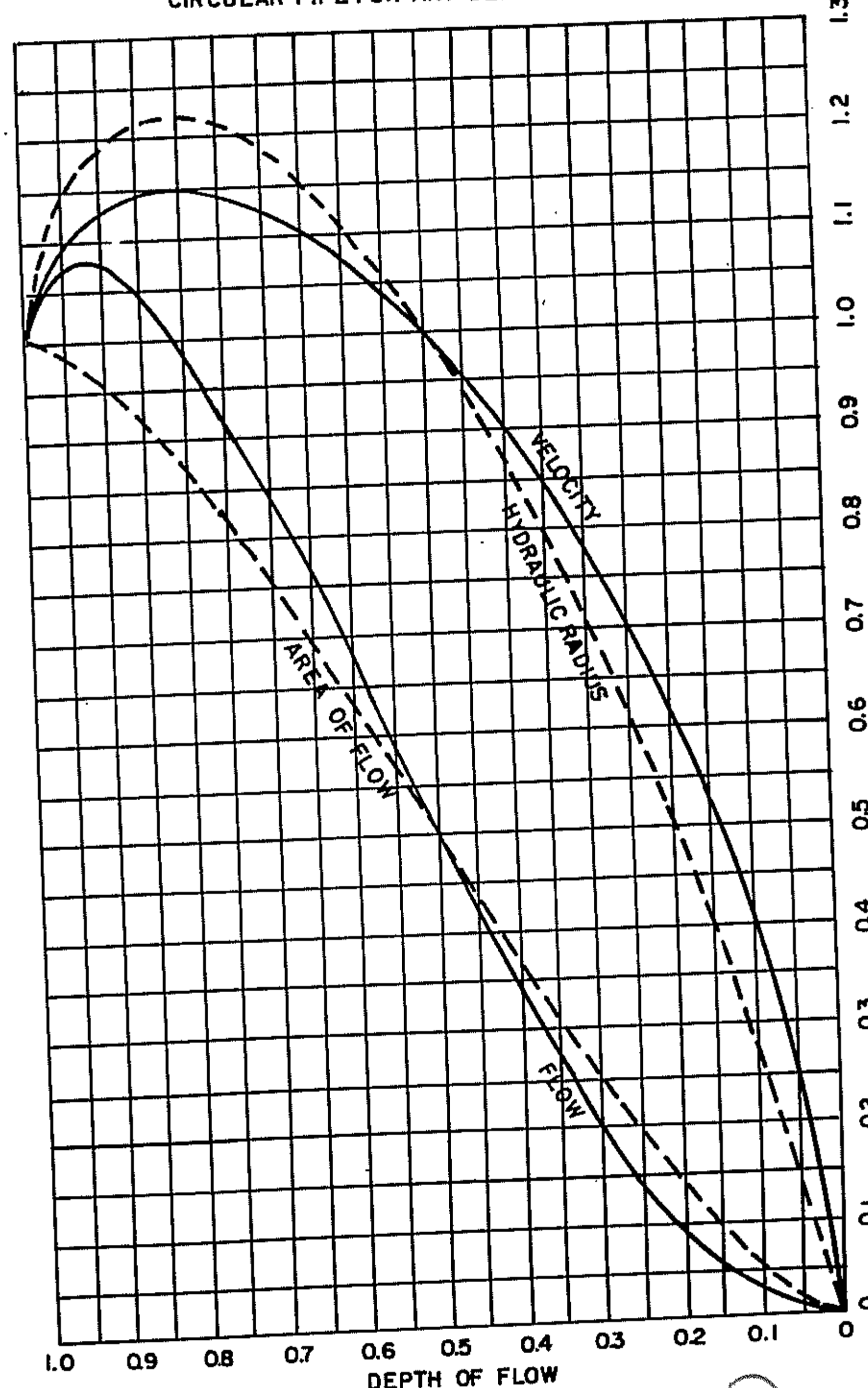
Alignment chart for energy loss in pipes, for Manning's formula.
Note: Use chart for flow computations, $H_L = S$

Nomograph for solution of Manning's formula.
For Pipes Flowing Full

FIGURE IV-4

Ref.
Modern Sewer Design
1980

RELATIVE VELOCITY AND FLOW IN
CIRCULAR PIPE FOR ANY DEPTH OF FLOW



STORM SEWER SYSTEM DESIGN

Project: ______________________ Designed by: ______________________

Street: ______________________ Checked by: ______________________

Sheet No.

1 LINE SEGMENT	2 TIME TO INLET (Min.)	3 TIME IN PIPE (Min.)	4 ACCUMULATED TIME (Min.)	5 AI ENTERING CATCH BASIN	6 SUM OF AI IN SYSTEM	7 RAINFALL INTENSITY (R) (in./hr.)	8 Q IN SYSTEM (c.f.s.)	9 PIPE SIZE (in.)	10 LENGTH OF PIPE (ft.)	11 SLOPE FT./FT.	12 AVERAGE VELOCITY (f.p.s.)	13 FULL CAPACITY (c.f.s.)	14 HEADWATER (ft.)	15 'N'

FIGURE IV - 5

CULVERT DATA

Prep. by:
Date:

Checked:
Date:

Project No.
Town
Route
Location

---

1. DRAINAGE AREA
   (a) Total area________________Acres
   (b) Above storage________________Acres
   (c) Effective area________________Acres
   (d) Special considerations________________
   (e) Existing Culverts________________

2. DESIGN DISCHARGE________C.F.S. for________Year frequency
   (a) Rational Formula, Time of Concentration________Minutes
   (b) Other Methods used with data________________
   (c) Remarks________________

3. HYDRAULIC DATA
   (a) Size________Type________
   (b) Maximum permissible headwater elevation and description________
   (c) Elevation of channel bed at outlet________
   (d) Length________Ft. and Slope________Ft./Ft. of Culvert____
   (e) Entrance invert elevation________
   (f) Type and Location of Hydraulic Control________

4. MISCELLANEOUS DATA
   (a) Height of Overfill________________Ft.
   (b) Strength Requirements________Gage Metal Pipe or________ Class RCP (submit computations)
   (c) End treatment________________
   (d) Entrance Channel Protection (submit design)________
   (e) Outlet Channel Protection (submit design)________
   (f) Bank protection (submit design)________
   (g) Bedload (heavy, medium, or light)________

CULVERT COMPUTATIONS

PROJECT: ____________
TOWN: ____________
ROUTE: ____________

PREPARED BY: ____________
CHECKED BY: ____________
DATE: ____________

HYDROLOGIC AND CHANNEL INFORMATION

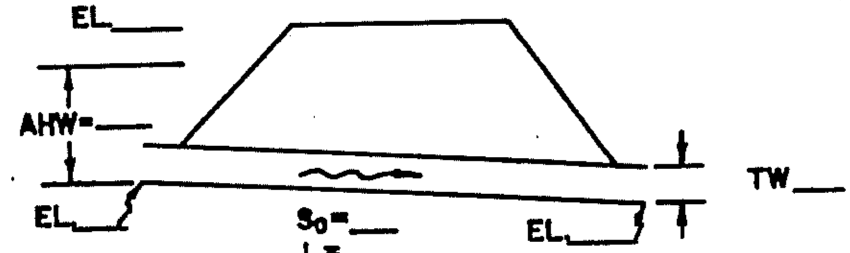
Q_1 = ______
Q_2 = ______

TW_1 = ______
TW_2 = ______

Q_1 = DESIGN DISCHARGE, FREQ. = ____ YR.
Q_2 = CHECK DISCHARGE, FREQ. = ____ YR.

SKETCH

STATION: ____________



MEAN STREAM VELOCITY = ______
MAX. STREAM VELOCITY = ______

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$							CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	HW				

SUMMARY & RECOMMENDATIONS:

FIGURE IV-7

DRAINAGE CHANNEL LINING DESIGN

DATE: ____________

PROJECT: ________________________________ DESIGNER: ____________

STATION ______________ TO STATION ______________ DATE: ____________

DRAINAGE AREA = ______________ ACRES CHECKED BY: ____________

HYDROLOGIC COMPUTATIONS:

DESIGN FLOW: Q ______ = ______________ cfs

DESIGN FLOW FOR TEMPORARY LINING: Q_2 ______ = ______________ cfs

SOIL ERODIBILITY: ______________________

CHANNEL DESCRIPTION: MAX. TOP WIDTH = ______________ ft.

S_o = ______________

AVAILABLE LININGS:

LINING	d_{max}	B	$\frac{d_{max}}{B}$	$\frac{A}{Bd}$	A	$\frac{R}{d}$	R	V	Q=AV	T	REMARKS

FIGURE IV-8

Norwalk
THE RIGHT PLACE • THE RIGHT TIME

DEPARTMENT OF PUBLIC WORKS

Water Quality Subcommittee on Oil & Grit Separators

ADOPTED BY THE COMMON COUNCIL, CITY OF NORWALK, CONNECTICUT
MAY 8, 2001

Standards for Removal of Oil, Grit and Other Material from Stormwater

The following requirements shall apply to any new or substantially modified drainage system including those that discharge to the City drainage system or to any wetland or watercourse within the City.

1. The system shall include equipment designed and certified by its manufacturer to remove 80% or more of the total suspended solids and floatable debris for all anticipated flow rates up to the flow rate calculated for a 25 year storm event.

   If it is not practical to retrofit an existing system to meet the 25 year storm requirement an alternative system designed to provide first flush only treatment may be approved. The design flow for the first flush shall be calculated by taking a 1/2-inch rainfall and dividing it by the Time of Concentration (Tc) for the site in hours (not minutes). Use this (0.5/Tc) as "i" (inches/hour) in the rational method formula (Q=CiA) to get the design flow for the first flush. In this formula Q is the required design flow rate in c.f.s., C is the runoff coefficient calculated in accordance with Chapter III of the Norwalk Drainage Manual and A is the site area in acres.

   The manufacturer shall furnish documentation which supports all product performance claims and features, storage capacities and maintenance requirements. Systems shall be designed to avoid scouring out or release of previously trapped material in the event of higher than designed flow rates.

2. Any system that provides drainage for automobile/truck service facilities, gas stations, or other facilities likely to generate storm water containing oil or other petroleum products shall also include equipment designed and certified by its manufacturer to remove 90% or more of such oil and petroleum products for all anticipated flow rates up to the flow rate calculated for a 25 year storm event. Systems shall be designed to avoid scouring out or release of previously trapped material in the event of higher flow rates.

125 EAST AVENUE • P.O. BOX 5125, NORWALK, CT 06856-5125 • TELEPHONE 203-854-7791 • FAX 203-857-0143

3. The owner of any system installed to meet the requirements of 1 and 2 above shall complete and file with the City a form listing all installed equipment. This form shall included the as-built location of each piece of equipment, with coordinates tied to the Connecticut Coordinate Grid System, its manufacturer and model number and other information necessary to define its performance characteristics. This information shall be in a form that may be readily incorporated into the City of Norwalk GIS system.

4. A written Inspection and Maintenance Plan for each piece of equipment installed to meet the requirements of 1 and 2 above shall be approved by the Public Works Department. As a minimum such Inspection and Maintenance Plan shall require periodic on site inspection of each unit, the removal of accumulated material as recommended by the manufacturer, and proper disposal thereof. A written Inspection and Maintenance Log showing inspection dates and the amount and type of materials removed and disposal location shall be maintained for each unit installed. Copies of the Inspection and Maintenance Logs shall be submitted to the Department of Public Works annually. Logs for the previous 3 years shall be kept available on site for inspection by the City at any time.