CITY OF BELLEVUE
DEPARTMENT OF PUBLIC WORKS
STORM AND SURFACE WATER UTILITY

GUIDELINES FOR STORMWATER RUNOFF DETENTION FACILITIES

DECEMBER 1975

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A. Allowable Rate of Release

The release rate is based upon a City-wide average of natural runoff from a 10-year storm. This average was determined by the Utility's consultants through the use of precipitation and stream flow data. The allowable rate of release is 0.2 cfs/acre (which equals to 0.2 inches per hour) for the portion of the subject site tributary to the point of release.

The Utility's performance criteria for allowable rate of release requires that runoff under developed conditions shall not exceed the natural rate of runoff from a 10-year storm, i.e. .2 cfs/acre.

By restricting the rate of release, it is obvious that storage must be provided for the water which is not released.

B. Storage Requirements

The storage requirement performance criteria of the Utility is based on a rainfall intensity/duration curve developed by the consultants in conjunction with the RIBCO Urban Drainage Study (See Graph Section D. page 2.), and the allowable rate of release indicated above.

1. Impervious Area

The storage requirement for impervious area is based on the 100-year storm of 1.8 inches of rain in 4 hours (See Graph Section D. page 2.). During the same period .8 inches is allowed to be released (4 hours x .2 inches/hour). Therefore 1" coverage of water (1.8 inches minus .8 inches) is required to be stored for the area which is impervious. This is easily calculated by dividing the square footage of impervious area by 12, which expresses the cubic footage of water storage required for the impervious area.

1.8 inches rainfall (4 hours)
\- .8 inches allowed release (4 hours x .2 inches/hour)
1.0 inches storage required

2. Pervious Area

Because of poor infiltration conditions which predominate in the City, storage may be required for pervious as well as impervious areas. Unless it can be otherwise demonstrated by an infiltration (perc) test, it is assumed that individual properties allow infiltration at a sustained rate of .2 inches per hour on the pervious surface. The sustained rate is that which occurs after 2 hours of continuous infiltration and is maintained thereafter. Storage is required for the pervious area whenever the infiltration rate is less than .5 inches per hour.

The storage requirement for pervious surfaces is based on an assumed rate of infiltration of .2 inches/hour, and upon the 100-year storm of 1.3 inches rain in 2 hours (See Graph Section D.

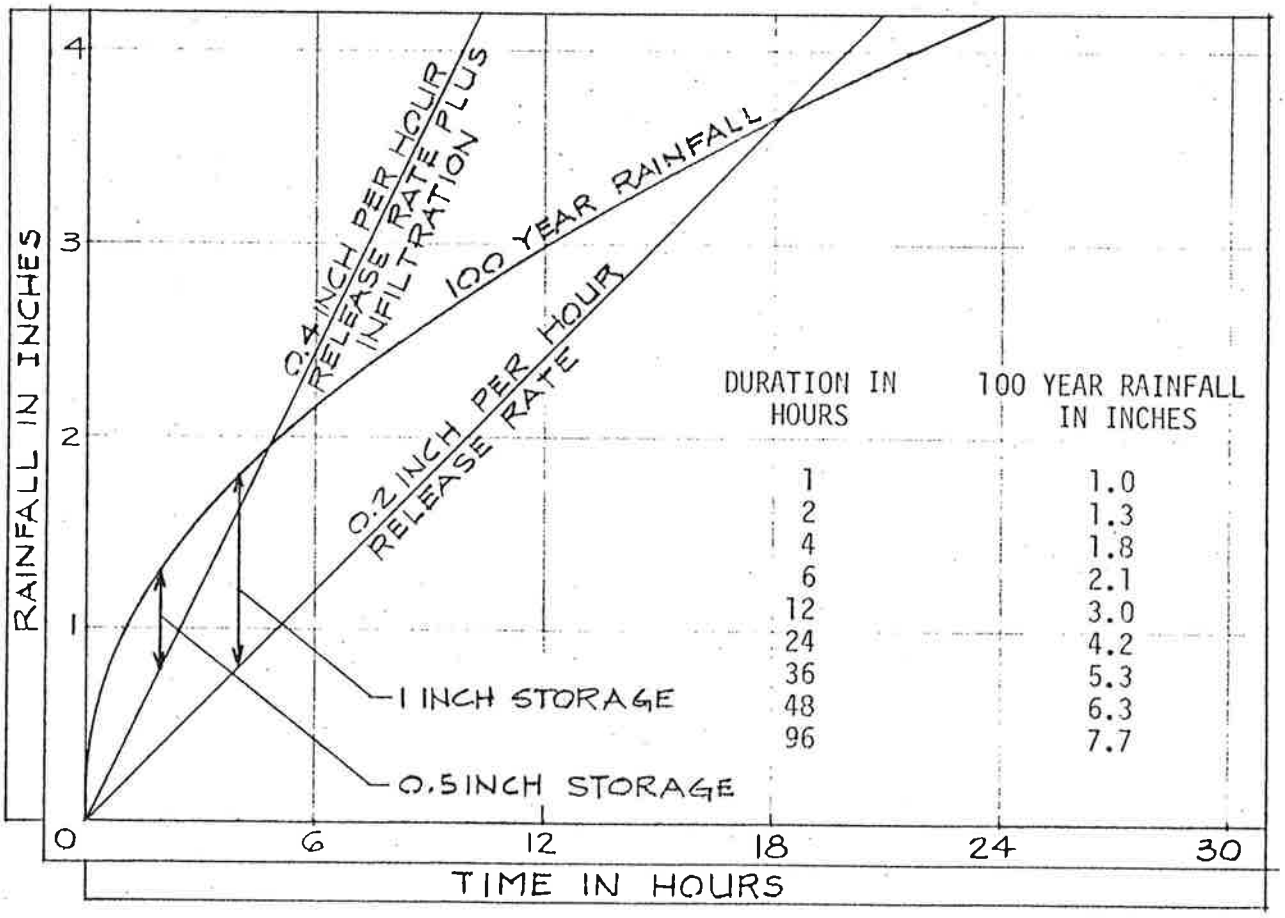
page 2.). On these assumptions, the storage required is 0.5 inches coverage of water for the pervious surface area. This is calculated by dividing the square footage of pervious area by 24, which expresses the cubic footage of water storage required for the pervious area.

1.3 inches rainfall (2 hours)
- .4 inches allowed release (.2 inches/hour x 2 hours)
- .4 inches infiltration (.2 inches/hour x 2 hours)
0.5 inches storage required

C. Controlled Overflow Requirements

All detention storage facilities shall include provision for and control of overflow, and suitable data shall be provided to support design.

D. Rainfall Intensity/Duration Curve



E. Calculating Effective Infiltration to Reduce Storage Requirement

Under certain conditions a gravel-filled trench or sump may be used to infiltrate water into the ground as an alternative to storing the water on the surface, on roofs, or in pipes. In such a case the volume of the voids between the gravel is calculated as storage area, and the amount of water infiltrated is also calculated as effective storage since it reduces the required storage in the rest of the system. Infiltration may be used to eliminate the need for storage of runoff from pervious surfaces (if the rate is 0.5 inches/hour or greater no storage is needed for the pervious surfaces), and to reduce the storage for the impervious areas.

The total quantity of water infiltrated during the 4 hours is calculated by multiplying the total square footage of the bottom of the trench or sump plus one half the square footage of the sidewalls times the total infiltration for the 4-hour time period (sustained rate), and dividing by 12 to obtain the cubic footage of water infiltrated.

F. Examples of Storage Requirement Calculations for Various Combinations of Storage and Infiltration

Example 1.

A 20 acre parcel is proposed for residential development.

20 acres = 871,200 sq. ft.
Proposed Impervious Area = 261,360 sq. ft. (30%)
Proposed Pervious Area = 609,840 sq. ft. (70%)
Assumed Infiltration Rate = .2 inches per hour

a. Impervious Area Storage Required

$$\frac{1.0 \text{ inch} \times 261{,}360 \text{ sq. ft.}}{12} = 21{,}780 \text{ cubic feet storage}$$

b. Pervious Area Storage Required

$$\frac{0.5 \text{ inch} \times 609{,}840 \text{ sq. ft.}}{12} = 25{,}410 \text{ cubic feet storage}$$

Total Storage Required = 47,190 cubic feet

Example 2.

A 20 acre parcel is proposed for residential development.
A sustained infiltration rate of .4 inches per hour is determined, and is used instead of the assumed .2 inches per hour.

20 acres = 871,200 sq. ft.
Proposed Impervious Area = 261,360 sq. ft. (30%)
Proposed Pervious Area = 609,840 sq. ft. (70%)
Sustained Infiltration Rate = .4 inches per hour

a. Impervious Area Storage Required

$$\frac{261{,}360 \text{ sq. ft.}}{12} = 21{,}780 \text{ cubic feet storage}$$

Example 2. (Cont'd)

b. Pervious Area Storage Required

Total Rain	1.3 inches	(2 hours)
Less Released	.4 inches	(2 hours x 0.2 in./hr.)
Less Infiltrated	.8 inches	(2 hours x 0.4 in./hr.)
	0.1 inches	

$$\frac{0.1 \text{ inches} \times 609{,}840 \text{ sq. ft.}}{12} = 5{,}082 \text{ cubic feet}$$

Total Storage Required = 26,862 cubic feet

Example 3.

A 20 acre parcel is proposed for residential development. A sustained rate of infiltration of .6 inches per hour is determined, and a trench with 12" perforated pipe is used to store and re-charge runoff from the impervious area to reduce the total storage required in other elements of the system.

20 acres = 871,200 sq. ft.
Proposed Impervious Area = 261,360 sq. ft. (30%)
Proposed Pervious Area = 609,840 sq. ft. (70%)
Sustained Infiltration Rate = .6 inches per hour
Dimensions of Trench: 3' deep x 2' wide x 1000' long
Size of Pipe: 12" diam. (Storage = .78 cu. ft./lin. ft.)

a. Impervious Area Storage

$$\frac{261{,}360 \text{ sq. ft.}}{12} = 21{,}780 \text{ cubic feet storage}$$

Storage in Pipe = .78 cu. ft./lin. ft. x 1,000 lin. ft. = = 780 cubic feet

Volume consumed by pipe = 1,000 cu. ft. (outside diam.)

Storage in Trench = Trench storage volume x % of voids - Volume consumed by pipe = (1000' x 3' x 2') x 0.25 - 1,000 cu. ft. = 1,250 cubic feet

Effective Storage: 780 cu. ft. + 1,250 cu. ft. = 2,030 cubic feet

Infiltration from Trench = .6 inches per hour x 4 hours x 1/12 x x 5,000 sq. ft. = 1,000 cubic feet

Impervious Area Storage Required =	21,780 cu. ft.
less pipe storage	780 cu. ft.
less storage in trench	1,250 cu. ft.
less infiltration	1,000 cu. ft.
Remainder to be stored	18,750 cu. ft.

b. Pervious Area Storage is not required because infiltration rate exceeds .5 inches per hour.

Example 4.

A 20 acre parcel is proposed for residential development. A sustained rate of infiltration of 6 inches per hour is determined, and a trench with 12" perforated pipe is used to store and re-charge runoff from the pervious area to reduce the total storage required in other elements of the system.

20 acres = 871,200 sq. ft.
Proposed Impervious Area = 261,360 sq. ft. (30%)
Proposed Pervious Area = 609,840 sq. ft. (70%)
Sustained Infiltration Rate = 6 inches per hour
Dimensions of Trench: 3' deep x 2' wide x 1000' long
Size of Pipe: 12" diam. (Storage = .78 cu. ft./lin. ft.)

a. Impervious Area Storage

$\frac{261,360 \text{ sq. ft.}}{12}$ = 21,780 cubic feet storage

Storage in Pipe = .78 cu. ft./lin. ft. x 1,000 lin. ft. = = 780 cu. ft.

Volume consumed by pipe = 1,000 cu. ft. (outside diam.)

Storage in Trench = Trench storage volume x % of voids - Volume consumed by pipe = (1,000' x 3' x 2') x 0.25 - 1,000 cu. ft. = 1,250 cubic feet

Effective Storage: 780 cu. ft. + 1,250 cu. ft. = 2,030 cubic feet

Infiltration from Trench = 6 inches per hour x 4 hours x 1/12 x 5,000 sq. ft. = 10,000 cubic feet

Impervious Area Storage Required =	21,780 cu. ft.
less effective storage	2,030 cu. ft.
less infiltration	10,000 cu. ft.
Remainder to be stored	9,750 cubic feet

b. Pervious Area Storage is not required because infiltration rate exceeds .5 inches per hour.

G. Site, Soil and Infiltration Data Requirements for Construction of Recharge System

1. General Data Requirements:

a. Proposed site must have favorable topography to satisfy functional requirements for construction of a recharge system.

b. Required data must be tabulated and submitted in accordance with guidelines below.

c. A log of the soils and data of infiltration tests must be submitted to reveal the soil conditions and infiltration rates.

d. An adequate number of test holes shall be located over the proposed site to substantiate representative conditions for design of recharge systems, and as minimum condition test holes shall be located in each area proposed for infiltration.

e. Minimum depth to groundwater should be greater than four feet.

f. Impervious strata should be at a depth greater than two feet below the bottom of the proposed trench.

2. Soil Log Data Requirement:

The log must describe soil type and depth of each type and the location shall be indicated on a site map. Classification may be in general terms such as loose sand, sandy silt, silt, clay hardpan, rock, etc. or classification may be in specific terms as described in U.S. Department of Agriculture.

3. Soil Log Data Form:

Log of Soils (to include ground water height):

Height in Feet	Log of Soils	Soil Classification

4. Infiltration Test Data Requirement

a. Test Hole Size:

Horizontal dimension: 4 to 12 inches

Vertical sides to the depth of the proposed trench.

b. Test Procedure:

Carefully clean the bottom and sides of the hole and add 2" of coarse sand or fine gravel to the bottom of the hole.

Fill the hole with clean water to a minimum depth of 12" above the gravel or sand. Keep water in the hole at least 2 hours but preferably longer. In most soils it will be necessary to augment the water as time progresses.

5. The Infiltration Rate Measurements:

   a. If water remains in the test hole after an established period of time (minimum 2 hours), adjust the water depth to approximately 6" above the gravel and measure the drop in water level over a 30-minute period. This drop is used to calculate the infiltration rate.

   b. If no water remains in the hole after 2 hours, add clean water to bring the depth to approximately 6" over the gravel and measure the drop in water level at approximately 30-minute intervals for 4 hours, refilling to 6" over the gravel as necessary. The drop in water level that occurs during the final 30-minute period is used to calculate the infiltration rate.

   c. In sandy soils (or other soils where the first 6" of water seeps away in less than 30 minutes) the time interval between measurements shall be 10 minutes and the test run for 1 hour, refilling to 6" over the gravel as necessary. The drop in water level that occurs during the final 10 minutes is used to calculate the infiltration rate.

6. Infiltration Test Data Form:

   a. Test Hole Size:

      Horizontal Dimension:

      Vertical Dimension (at least two (2) feet below the depth of the proposed trench):

   b. Infiltration Rate Data:

      State which procedure identified in section 5. above is used in this case and state results in following table:

Time in Minutes	Drop in Water Level in Inches

H. Sizing of the Control Orifice for the Allowable Rate of Release (0.2 cfs/acre)

1. Allowable Release Rate and Storage Requirement for Rooftop Detention Facilities:

ROOF AREA (S.F.)	STORAGE REQ'D (CF)	ALLOWABLE RELEASE RATE (CFS)
1,000	83	.0046
2,000	166	.0092
3,000	250	.0138
4,000	333	.0184
6,000	500	.0275
8,000	667	.0367
10,000	833	.0459
14,000	1167	.0643
18,000	1500	.0826
22,000	1833	.1010
26,000	2167	.1190
30,000	2500	.1377
36,000	3000	.1653
42,000	3500	.1928
50,000	4167	.2297

TABLE H-1

2. Example of Detention Ring(s) Discharge Capacities for Rooftop Detention Facilities
(Ref.: American Public Work Association, Special Report No. 43, Practices in Detention of Urban Storm Water Runoff)

a. General Information Data:

Roof drain ring is placed around standard roof drain installation.

Roof drain ring shall be furnished with set(s) of holes as per requirements.

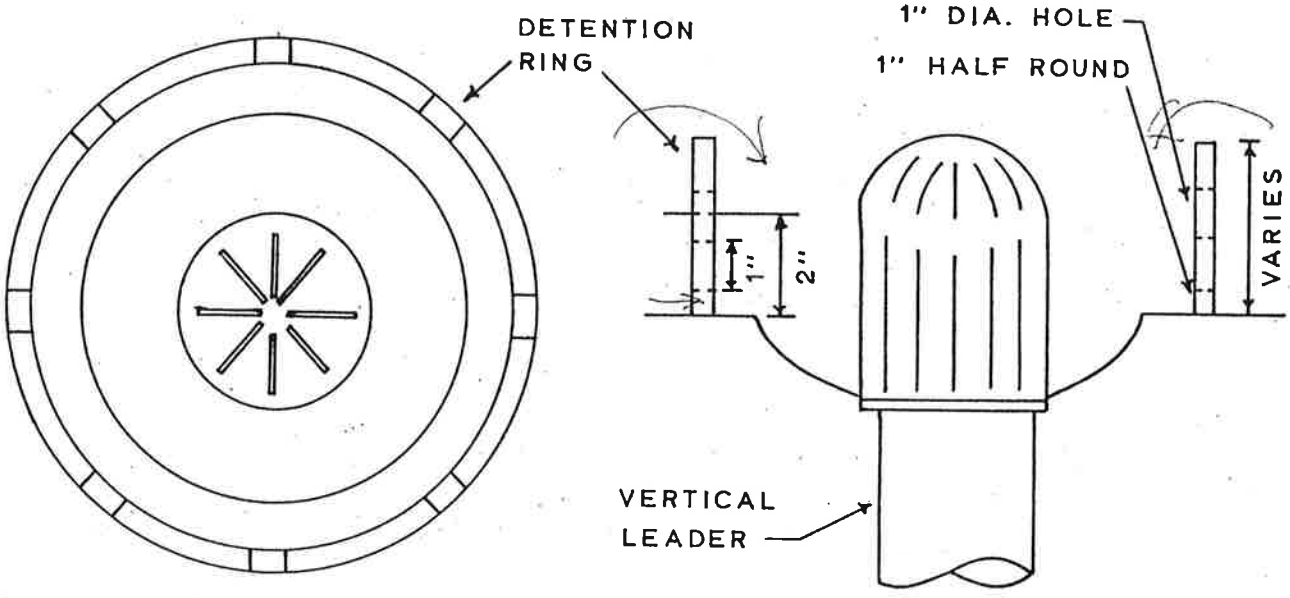
Number of holes sets to be based on storage requirement, allowable rate of release and water depth at inlet.

Minimum spacing between holes to be 2 inches c.c..

Height of ring to be determined by roof slope and storage required.

A set of holes refers to a one-half round and full round over it as depicted in Fig. H-1.

b. Rooftop Detention Device:



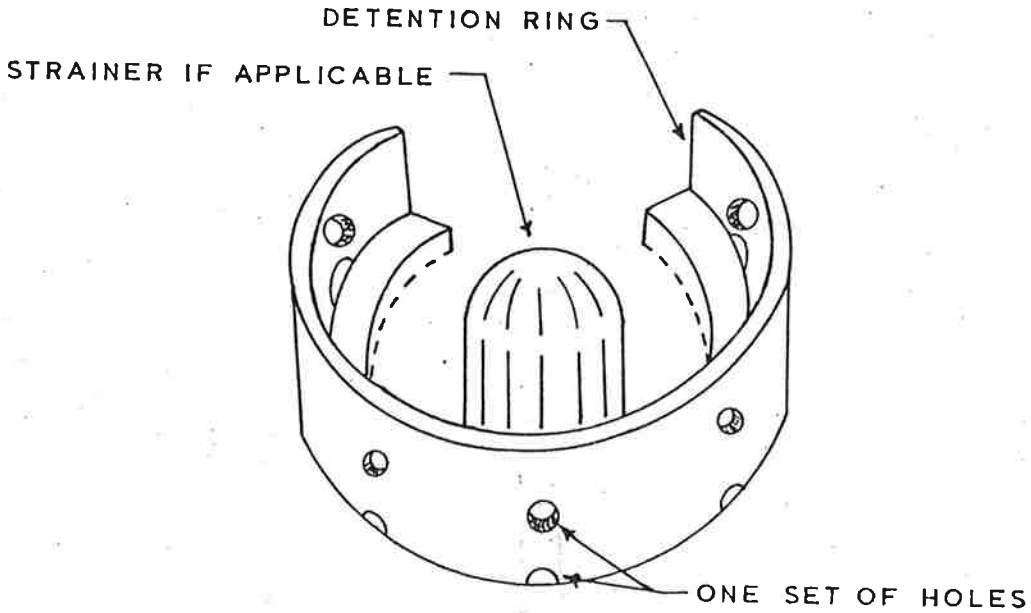


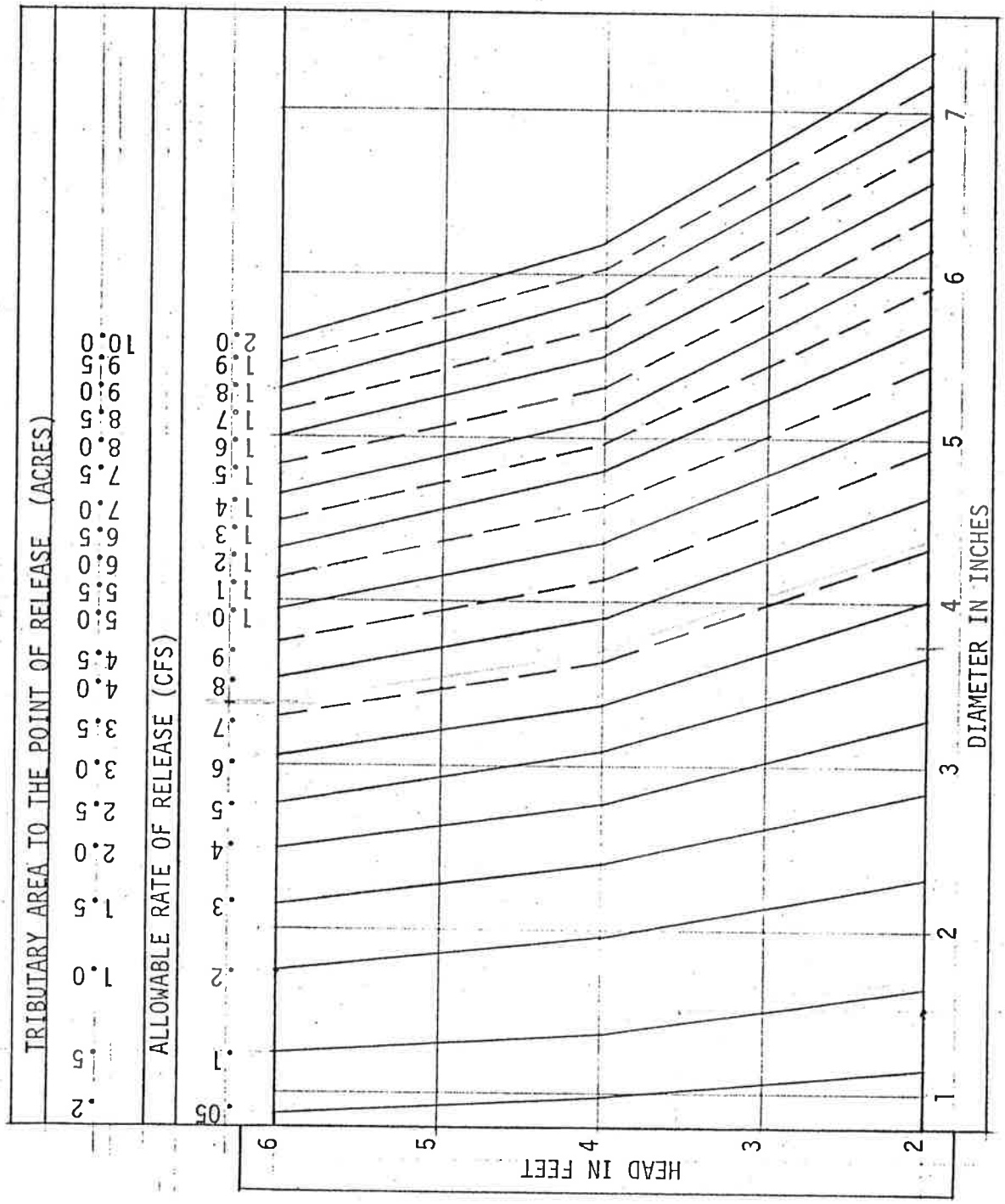
FIG. H-1

c. Detention Ring(s) Discharge Capacity for Various Sets of Control Openings:
(Ref. to H. 1., 2.)

WATER DEPTH AT INLET (INCHES)	DISCHARGE CAPACITY THRU SET OF HOLES (CFS)							
	1	2	4	6	8	10	12	14
1.5	.0022	.0044	.0088	.0132	.0176	.022	.0264	.0308
2.0	.0046	.0092	.0018	.0276	.0368	.046	.0552	.0644
2.5	.0114	.0228	.0456	.0684	.0912	.114	.1368	.1596
3.0	.0137	.0274	.0548	.0822	.1096	.137	.1644	.1918

TABLE H-2

3. Sizing of the Control Orifice for other Means of Storage than Rooftop Facilities
(Ref.: Handbook of Hydraulics; H.W. King, E.F. Brater)



RELATIONSHIP BETWEEN THE HEAD AND THE ORIFICE OPENING FOR VARIOUS ALLOWABLE RATES OF RELEASE

FIGURE H-2

I. Design Data Checklist for Complete Design of Storm Water Detention Facilities

1. Site, soil and infiltration data
2. Total site area
3. Impervious and pervious area of each portion of total site area requiring storage
4. Total tributary area to the point of each release
5. Total storage required
6. Portion of total storage required for each design area
7. Storage provided for each design area
8. Allowable release rate and size of control orifice for each tributary area and its storage facilities at the point of release
9. Detailed drawings of all storage facilities and their appurtenances with all pertinent design data required to satisfy functional requirements

J. Example of On-Site Storm Water Detention Methods and Devices

1. Open Basins or Ponds
2. Rooftops
3. Parking Lot Ponding
4. Underground Storage
   a. Pipe
   b. Chamber
5. Gravel-Filled Storage and Infiltration Trenches
6. Typical Orifice and Overflow Controls

Note: Graphical examples will be added progressively along with utility evaluation of experience with installation and performance of various storm water runoff detention facility designs.