MANATEE COUNTY PUBLIC WORKS DEPARTMENT ENGINEERING DIVISION

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STORMWATER MANAGEMENT DESIGN MANUAL

STORMWATER DESIGN SYSTEM MANUAL

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STORMWATER DESIGN PROCEDURES MANUAL

SECTION I

OVERVIEW

The purpose of this Stormwater Design Procedure Manual is to ensure that an effective management system for an area to be developed or redeveloped is provided. This criteria will provide the basis on which a stormwater management plan will be evaluated by the County prior to approval and ultimate construction. The criteria is a minimum and in certain cases the County may require higher criteria to ensure a properly functioning system to safegaurd adjacent or downstream properties, public roadway and drainage systems, and the general public.

In order to aid in understanding the criteria presented in this Manual, a full explanation of the various procedures required for implementation of this criteria is presented.

It is suggested that, prior to the start of the detailed engineering on any project, the proposed preliminary drainage design and procedures be reviewed in detail with the Public Works Department.

The limitation of run-off will require the construction of retention or detention basins. Detention or retention basins will provide the necessary reservoir storage to insure predevelopment flow rates are not exceeded. Manatee County requires that, when possible, large natural conveyance systems in an area to be developed or redeveloped should be preserved (kept in their natural state and without reduction in conveyance capacity), to provide for the passage of stormwater run-off from adjacent and/or upstream areas.

In all cases, attenuated discharge from detentions basins must be to a County approved positive outfall.

The treatment of the the appropriate volume of run-off, or in accordance with SWFWMD 40D-4 and 40D-40/45 from the contributary area of a development will be required. Development within certain watershed boundaries may require additional stormwater treatment. Also, sediment and erosion control measures will be required to control and minimize damage to downstream property, and the conveyance system and to preserve water quality. Stormwater designs including sediment and erosion control measures shall be submitted to and approved by the Public Works Department prior to construction.

For purposes of system evaluation, a stormwater management system will be considered to have two parts, the interior drainage system and the primary drainage system.

The interior drainage system shall consist of swales and or storm sewers adjacent to or in the streets to carry stormwater run-off from the lots adjacent to these streets to culverts or through lot lines directly to the detention or retention basins or to the interior drainage system and convey it directly to the detention or retention basins. (All commercial, residential, industrial sites).

The primary drainage system shall consist of the principal conveyance channels, detention or retention basins and outflow channels leading to the principal receiving water course.

NOTE: This manual will be updated or modified from time-to-time as the County deems necessary.

SECTION II

PRIMARY DRAINAGE SYSTEM

GENERAL

The selection of detention/retention basin for the purposes of peak flow attenuation will depend on the hydrologic soil group and site specific conditions of the soils in the area to be developed or redeveloped.

The purpose of detention/retention ponds is to serve as a buffer to attenuate peak flows and/or excess runoff volume from urbanized area. In addition to attenuation, it provides treatment of the first flush, which will cover the water quality aspect of stormwater runoff. In general, water quality designs should be based on the minimum performance standard described in chapter 17-25 FAC, SWFWMD 40D-4, 40D-40 and Manatee County Comprehensive plan.

In general, retention refers to stormwater storage without access to a positive outlet, while detention facilitates offer temporary storage accompanied by controlled release of the stored water. Wet detention has a pool of water below the outlet elevation; dry detention is typically placed with the basin bottom above the seasonal high water table. Retention and detention can be used separately or together in storage basins as site conditions and management objectives require.

A key element to proper planning of retention/detention facilities is the selection of potential sites that will provide control of both flooding and stormwater quality. Other important considerations include:

1. Stormwater Management Master Plan.
2. Conveyance of drainage to the site.
3. Suitability of site for water storage.
4. Availability of suitable outlet point.
5. Adjacent land use.
6. Roadway control elevation.
7. Soil infiltration capability.
8. Water table fluctuations.
9. Outfall high water elevation.
10. Type of facilities proposed.
11. Safety and maintenance requirements.
12. Other regulatory agencies requirements.

For the design of detention ponds the instantaneous peak discharge expected for the undeveloped site due to 25 year rainfall shall not be exceeded by the instantaneous peak discharge from the developed site due to a 25 year rainfall. Calculation of instantaneous peak discharge from the undeveloped site shall consider the affect of existing storage in attenuating this peak. Off site runoff must be routed around or through the project without combining with on site runoff unless the pond and discharge structure are designed to accept this off site runoff.

HYDROLOGY

DESIGN STORM

In most cases, the primary drainage system (detention or retention basins principal conveyance channels of an area to be developed or redeveloped) shall be designed so as to control the runoff from a 25 year - 24 hour Duration Design Rainfall (DDR) as determined from Appendix B-4 without causing flooding of the area. The actual design storm required will be dependent on existing outfall conditions. To provide consistency in the parameters used by the County staff in their review process, the soil conservation service (SCS) Type II modified rainfall distribution is recommended and will be used. (See appendix A-1)

The 25 year - 24 hour DDR will be applicable where either a more than adequate or an adequate outfall condition exists.

In areas of known drainage problems, a peak sensitive outfall condition shall prevail and require a reduction of up to 50% of the allowable pre-development flow from the 25 year - 24 hour DDR or that adequate off-site improvements be installed to provide for an adequate outfall condition.

Where no positive outfall exists, alternate solutions shall be required. These solutions include:

1. Capacity for retention of the 100 year - 24 hour duration design rainfall, with one foot of freeboard,

2. The upgrading of downstream facilities to provide positive outfall.

In areas of direct discharge to coastal waters or those with proven tidal influence, the attenuation of stormwater runoff as required may be waived by the County, however, the water quality needs to be addressed prior to direct discharge.

HYDROGRAPH COMPUTATION

Design flood hydrographs (pre-development hydrographs or post-development inflow hydrographs to detention or retention basins) resulting from the 25 year - 24 hour DDR may be computed by the TR-20 Model and TR-55 (SCS's unit hydrograph model); the HEC-1 Model (Corps or Engineer's unit hydrograph model); or, for basins 10 acres or less, by the Rational Method, or other equivalent and widely accepted method; however, the flow rates should be compatible with the flow rates computed through software available to the County staff.

TIME OF CONCENTRATION

The time of concentration is the longest travel time it takes a particle of water to reach a discharge point in a watershed. There are three common ways that waters are transported:

1. Overland flow.
2. Pipe flow (storm sewer).
3. Channel flow, including gutter flow.

The velocity method is a segmental approach that can be used to account for each of these types of flow by considering the average velocity for each flow segment being evaluated, and by calculating a travel time using the equation

$$t_i = \frac{L_i}{60 (V_i)}$$

Where:

t_i = Travel time for velocity segment i, (min)
L_i = Length of the flow path for segment i (Ft)
V_i = Average velocity for segment i (Ft/Sec)

The time of concentration is then calculated expressed as

$$T_c = t_1 + t_2 + t_3 + \ldots . t_i$$

Where:

T_c = time of concentration, (Minutes)
t_1 = overland flow travel time (Minutes)
t_2 = channel flow travel time (Gutter Flow) Min.
t_3 = pipe flow time (storm sewer) Min.
t_i = travel time for Th i Th segment (Min.)

An alternative procedure for evaluating overland flow travel time involves the use of figures in appendix A-2,3 to obtain an estimate of the average velocity for overland flow and consequently calculating the travel time.

Time of concentration* can also be obtained from the following methods:

1. Kinematic Wave Equation:

The Kinematic Wave Equation (RAGAN, 1971; Flemming 1975) can be used to estimate time of concentration when there exist a Kinematic wave (velocity not changing with distance but changing @ a point). The time of concentration equation for these conditions is

$$t_c = \frac{0.93\ [L^{0.6}\ N^{0.6}]}{I^{0.4}\ S^{0.3}}$$

Where:

T_c = time of concentration (Min.)
L = overland flow length (Ft.)
N = mannings roughness co-efficient for overland flow
I = rainfall intensity (In/Hr)
S = Average slope of overland flow path Ft/Ft

* Other accepted and widely used methods are allowed for computation of the time to concentration.

Following overland flow manning's N values should be used with the above Kinematic wave eq.

Overland Flow Manning's N Values

	Recommended Value	Range of Values
Concrete	0.011	0.01-0.013
Asphalt	0.012	0.01-0.015
Bare sand	0.010	0.010-0.016
Graveled surface	0.012	0.012-0.030
Bare clay-loam (eroded)	0.012	0.012-0.033
Fallow (no residue)	0.05	0.006-0.16
Plow	0.06	0.02-0.10
Range (natural)	0.13	0.01-0.32
Range (clipped)	0.08	0.02-0.24
Grass (bluegrass sod)	0.45	0.39-0.63
Short grass praire	0.15	0.10-0.20
Dense grass	0.24	0.17-0.30
Bermuda grass	0.41	0.30-0.48
Woods	0.45	-- --

Note: These values were determined specifically for overland flow conditions and are not appropriate for conventional open channel flow calculations.

Values are from Engman(1983), with additions from the Florida Department of Transportation Drainage Manual (1986).

Kinematic wave equation generally involves a cumbersome trial and error process using the following steps:

1. Assume a trial value of rainfall intensity (i).
2. Find the overland travel time (T_c) using the above equation on page 7.
3. Find the actual rainfall intensity for a storm duration of T_c from the appropriate intensity duration frequency (IDF) curve for zone 6. Also record the intensity for T_c.
4. Compare rainfall intensities, if they are not the same, select a new trial rainfall intensity and repeat step 1.

An alternative to the above equation is the nomograph presented in Appendix A-4

2. Soil Conservation Service

The soil conservation service (SCS) (USDA, 1975 or updated version) related the time of concentration to the watershed lag time as follow:

$$T_c = 1.67\ t_1$$

Where:

t_1 = watershed lag time in hours (from the center of mass of rainfall excess to the time peak runoff) and:

$$t_1 = \frac{L^{0.8}\ (S + 1)^{0.7}}{1900\ Y^{0.5}}$$

Where:

L = Watershed hydraulic length (Ft.)
S = Potential watershed storage (In.)
Y = Average watershed slope (Percentage)

To aid in calculating overland flow velocities, the Soil Conservation Service nomograph (SCS 1975) is inserted in Appendix A-3. This alternate SCS method requires an estimate of overland slope and a description of the cover crop or land use. Thus, some engineering judgment must be exercised. Generally, estimates are made for each relatively constant slope and ditches should be divided into smaller homogeneous areas with regard to slope and cover type.

3. Manning's Equation

In storm sewer, gutter and open channels, manning's equation (CHOW, 1959) to calculate average velocities could be used.

$$V = \frac{1.48}{n} (R^{2/3}) (S^{1/2})$$

Where:

V = Velocity (Ft/Sec)
R = Hydraulic Radius, Ft = D/4 for pipe flowing full
S = Slope Ft/Ft
N = Roughness Coefficient

SCS TR-55 METHOD

The SCS has developed an empirical relationship for estimating rainfall excess that accounts for infiltration losses and initial abstraction by using a site-specific runoff parameter called the curve number (CN). The watershed CN is a dimensionless coefficient that reflects watershed cover conditions, Hydrologic Soil group, Land uses and antecedent moisture conditions. In all cases, Manatee County selects only antecedent moisture condition II for design purposes.

A composite curve number (CN) for a watershed having more than one land use, treatment, or soil type can be found by weighting each curve number according to it's area. A table showing the runoff curver number is present in appendix A-9,10.

The maximum soil storage and a CN value for a watershed can be related by the following expression

$$S = \frac{1000}{CN} - 10$$

Where:

S = Maximum soil storage, in inches
CN = Watershed curve number, dimensionless

When the maximum soil storage is known, the rainfall excess can be calculated using the following SCS Relationship

$$R = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where:

R = Accumulated rainfall excess (or runoff) in inches
P = Accumulated rainfall, in inches
S = Maximum soil storage, in inches
I_a = Initial abstraction including surface storage interception, & infiltration prior to runoff(inches)

The relationship between I_a and S was developed from experimental watershed data. The empirical relationship used in the SCS runoff equation is:

$$I_a = 0.2\ S$$

Substituting 0.2 S for I_a in the runoff equation, above, yields:

$$R = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

For directly connected impervious areas, an initial abstraction (I_a) of equal to 0.05S will be allowed.

Additional information on the SCS relationship can be found in USDA Technical Release No. 55 publication.

RATIONAL METHOD

According to the Rational Method, the peak runoff rate can be estimated as the product of a runoff coefficient, a rainfall intensity, and the drainage area. The Rational Method is expressed mathematically as:

$$Q = CIA$$

Where:

- Q = Peak runoff rate in Ft^3/Sec
- C = Rational Method runoff coefficient, dimensionless
- I = Average rainfall intensity for the design, inches/hour
- A = Watershed drainage area in acres (Basins must be 10 acres or less to use Rational Method for its hydrograph computation

Assumption

1. The time of concentration of the drainage basin refers to the travel time required for the runoff to flow along the representative basin flow, which is typically defined to be from the most hydraulically remote point of the design. Overland flow, storm sewer or gutter flow, and channel flow are commonly used in computing travel time.

2. The storm duration equals the time of concentration of the basin.

Rational coefficients should be estimated by using the values in Appendix A-12 for the two to ten (2 - 10) year design frequency storm. For the 25 - 100 year frequency storm a correction factor shown in Appendix A-8 is to be applied to the previous areas unless flood routing computations are appropriate for the basin. When using these tables one should consider the following conditions:

a) Land use
b) surface types and percentages
c) soil type
d) slope

For basins with varying cover, a weighted rational coefficient can be determined for the basin by the following equation:

$$\text{Weighted } C = \frac{C_i\ A_i}{A_i}$$

Where:

C_i = Rational coefficient for A_i (dimensionless)
A_i = Portion of basin with a relatively uniform land cover, soil type, and slope, in acres

Rainfall intensity, (I) is the average rate of rainfall in inches per hour. Critical storm duration equals the time of concentration of the drainage basin for Rational Method. Refer to Appendix B for storm frequency and rainfall intensity curve for this area (Zone 6).

ROUTING CALCULATION

To develop an estimate of the storage volume required to meet allowable discharge requirements, the following need to be calculated:

1. Inflow Hydrograph for 25 year storm
2. Stage storage data for proposed retention/detention
3. Allowable peak outflow rate, which should not exceed the existing condition flow rate.
4. Perform filtration, and ex-filtration calculations to comply with appropriate stormwater treatment regulations.
5. Evaluate the downstream effects of detention outflow, as necessary determined by staff, to ensure that the outflow hydrograph does not cause downstream flooding problems.

An acceptable and widely used (state and federal agencies) computer procedure is useful for conducting final routing computations (ie: HEC-1, ICPR, ...). County will also accept analysis based on the following method:

Storage indication method or modified plus

A flood wave passing through a storage reservoir is both delayed and attenuated as it enters and spreads over the pool surface. Water stored in the reservoir is gradually released through outlet control structure.

$$I - O = \frac{ds}{dt}$$

Where:

I = Inflow C.F.S.
O = Outflow C.F.S.

$\frac{ds}{dt}$ = Rate of change of storage within the reach

FILTRATION AND UNDERDRAIN CALCULATION

In cases where soil and groundwater flow conditions will not permit recovery of the stormwater treatment volume within the regulated duration, stormwater filtration system may be required. The minimum of 6" underdrain pipe is to be used. A filter fabric envelope shall be used with underdrains and shall be an approved strong, porous nylon, polyester, polypropylen or other fabric approved by the County, which completely covers the underdrain surface in such a way to prevent infiltration of surrounding material. A drawdown worksheet for underdrain calculation is present in Appendix "C" which may be utilized for draw down calculations. Clean outs are to be spaced no greater than every 250 feet and at the ends of the underdrain pipes.

OUTLET CONTROL STRUCTURES

Outlet controls selected for retention/detention facilities should accomplish the necessary functions of the facility. Outlet control can take the form of drop inlets with pipes, weirs, filtration underdrain piping, and orifices. The sizing of a particular outlet control should be based on results of hydrologic routing calculations, and as appropriate subsurface filtration calculations. All control structures shall be designed to prohibit the entrance of floating debris into the structure. The bottom of the skimming device should be at least 2-6" below the weir elevation, and the top no lower than the design high-water elevation. The top of the control structure should be at the elevation of the design high water.

WEIR FLOW CALCULATIONS:

1. Free discharge:

   The equation in computing discharge over a rectangular sharp-crested weir is:

$$Q = CLH^{1.5}$$

Where:

Q = discharge, C.F.S.
C = Weir coefficient
L = Weir length, Ft.
H = Head on weir, Ft.

Detailed information for determining specific values of the weir coefficient for various weir configuration is presented by Brater and King (1976).

2. Submerged discharge:

When tailwater rises above the weir crest elevation the actual discharge over the weir is inhibited by the backwater conditions. The above calculated "Free" discharge value is multiplied by the following reduction factor to account for the submerged effect:

$$Q_s = Q_f \, (1 - H_2/H_1)^{1.5})^{0.385}$$

Where:

Q_s = Submerged flow, CFS
Q_f = Free flow, CFS
H_1 = Upstream head above crest (feet)
H_2 = Downstream head above crest (feet)

3. V Notch Flow

The discharge through a V notch sharp crested weir is given by

$$Q = CH^{5/2} \tan (O/2)$$

Where:

O = Notch angle, degree
H = Measured head, ft
C = Coefficient of discharge

The head H is measured from the notch elevation to the water surface elevation. The water surface should be measured at least 2.5 H up stream from weir, to be beyond the drop in the water surface near the weir. Values of C, Coefficient of discharge can be taken from nomograph in appendix A-11.

4. Orifice Flow

When stages exceed the crest elevation of the weir, discharges though the bleeder notch should be calculated using the orifice equation.

$$Q = 4.8 \, AH^{1/2}$$

Where:

Q = Flow, CFS
A = Area of the notch, Sq. Ft.
H = Head above notch centroid, ft.

DETENTION BASINS

Detention basins may be of either the shallow dry type or may be artificial lakes specifically constructed for the purposes of flow attenuation.

Proposed detention basins and their outlet pipe control structures shall be analyzed by the computation of inflow hydrographs to the detention basins resulting from the applicable Design Rainfall on the contributary area to each basin. The determination of the resulting water level in the basins and outflow hydrograph peaks from these basins shall be determined by flood routing.

Hydraulically, outlet structures shall be weir/orifice controlled. Flashboard risers are not acceptable.

The seasonal high groundwater elevation shall be estimated from existing soil conditions and profiles, and existing water level for the location(s) proposed to be utilized as detention ponds. No storage credit will be given below the seasonal high water table elevation (or adjusted S.A.W. elevation). The outlet of detention ponds shall have a water level control structure that enables the pond to function as indicated in the hydraulic calculations. All detentions requirement shall comply with State of Florida regulations. (FAC 17-25; FAC 40D-4; FAC 40D-40; Chapters 120 and 373 F.S.)

RETENTION BASINS

Retention basins constructed for flow attenuation purposes must have sufficient volume to contain the volume of post development runoff from the design storm rainfall, or shall have sufficient volume to contain said runoff volume with a minimum of one (1) foot of freeboard. Exfiltration out of the basin shall not be considered in determining this theoretical basin size.

The storage volume in any retention basin occupied by runoff from the design rainfall, shall again be available within a 36-hour period after the design rainfall ceases; stormwater stored in these basins shall be removed in this 36-hour period by infiltration or underdrain drawdown. If infiltration (percolation) rates are used, in excess of the SCS soil book for Manatee County, in the design of retention basins, the rate shall be determined by the performance of double ring infiltrometer test (ASTM standard method D3385-75), which shall be performed at the proposed bottom of the retention basins by a qualified soil engineer or scientist.

It is desirable for the bottom of any retention basin to be a minimum of two (2) feet above the estimated seasonal high water table (SHWT) when percolation is the primary outlet of retention. If the above specified clearance cannot be met, the site engineer must demonstrate by calculations that the retention ponds will function according to County criteria and the intended design. These calculations must take into consideration the effects of groundwater mounding on percolation both during the rainfall event and in the recovery of the design storage volume. However, a minimum of one (1) foot of clearance is required from the seasonal high groundwater table to the proposed pond bottom.

The seasonal high groundwater table shall be determined or estimated by a qualified soil engineer or scientist (or use the SCS book for Manatee County).

A suitable emergency overflow outlet, and path shall be provided for retention ponds. This flow path shall conduct overflow away from the area without minimizing flooding of adjacent property, either public or private.

DETENTION AND RETENTION SYSTEM DESIGN CRITERIA

Dry Type Systems

Dry, shallow type detention or retention system shall be required to meet the following design criteria:

1. These systems shall maintain dry conditions except for a 36 hour period following the design storm rainfall. There should be a minimum of a one (1) foot clearance between the seasonal high water table (SHWT) to the bottom of the pond.

2. These areas shall have a food stand of grass or other acceptable coverage.

3. The maximum allowable sideslope is that of 4:1 (4 feet horizontally for every 1 foot vertical).

4. Inlets to these systems shall be provided, for controlling erosion. This may be done by incorporating mitered ends, flumes with riprap, or other accepted methods.

5. Adequate clearance shall be provided between these systems and the adjacent property.

6. A minimum of one (1) foot of freeboard for systems within subdivisions and six (6) inches of freeboard for all other systems shall be required unless the 100 Year - 24 Hour Storm Design is required. In those cases, a minimum of one (1) foot of freeboard shall be required on all developments. (100 Year 24 Hour Storm Design)

Artificial Lake Systems

All systems which intend to incorporate wet detention facilities shall be required to meet the following criteria:

1. There shall be a minimum depth of six (6) feet over at least 5% or a minimum of 500 ft., or whichever is larger, of the lake. This will allow for the required littoral zones needed for mitigation or water quality treatment.

2. The maximum allowable sideslope is that of 4:1 (4 feet horizontally for every 1 foot vertical), and is to be maintained for a minimum of three (3) feet vertically below the normal water level.

3. All sideslopes, as well as a two feet band around the entire perimeter of the top of bank shall be sodded.

4. Provide adequate clearance between the top of bank and adjacent property to provide for a minimum of a 4:1 sideslope from the top of bank to the existing ground elevation and a property line swale, when necessary.

5. A minimum of one (1) foot of freeboard will be required, regardless of the design storm or the type of development.

WATER QUALITY TREATMENT DESIGN

The design requirements for water quality treatment shall, in general, be reviewed under SWFWMD criteria. However, Manatee County has criteria which exceeds those required by SWFWMD, which sets the minimum size of underdrain to be of a six (6) inch diameter.

GENERAL STORMWATER MANAGEMENT DESIGN CRITERIA

For all developments, property line swales shall be required and shall conform to, at a minimum, Manatee County Standards. If the development is occurring within an approved subdivision, the perimeter and property line swales shall conform to that approved ~~per the~~ typical lot grading plan. Should no typical lot grading plan be available, then the grading for the swales shall meet Manatee County Standards for property line swales.

Developments occurring within existing subdivisions where no Master Drainage System exists, shall be required to provide their own stormwater management systems.

Detailed information regarding the area of influence shall be provided when drawing down the SHWT or where filling of the site under development may influence the existing groundwater table on adjacent properties.

Easements shall be provided for all property line swales. The site engineer shall field investigate drainage patterns immediately upstream and within at least 1,000 feet downstream of the site. It shall be demonstrated that design tailwater conditions are appropriate and there are no downstream restrictions to conveyance which may necessitate the use of peak sensitive outfall criteria.

OFFSITE DRAINAGE

Offsite surface waters which flow across or to a site proposed for development must be accommodated in the stormwater management plans for the development. The stormwater management system for the development must be capable of transporting existing offsite flows through or around the site development. THe estimation of the offsite flows must be calculated separately from the estimation on-site post-development flows (i.e., separate offsite and on-site hydrographs must be computed due to the typically significant differences in land use characteristics).

ENVIRONMENTAL REQUIREMENTS

Water quality standards as established by the State of Florida (FAC 17-25), the Southwest Florida Water Management District, and the Manatee County Comprehensive Plan shall be required by Manatee County. The latest standards or revisions of these agencies shall be adhered to in the design, construction, operation and maintenance of Stormwater Management facilities in Manatee County, Florida.

Water quality treatment shall be reviewed jointly between the Manatee County Public Works and Pollution Control Departments.

An additional 50% treatment or volume is required by the Manatee County Comprehensive Plan within the County's watersheds (Evers Reservoir and Lake Manatee Watersheds). Otherwise, the treatment volumes shall be equal to those required by the State of florida and/or SWFWMD, whichever is more restrictive.

SECTION III

INTERNAL DRAINAGE SYSTEM DESIGN

GENERAL

The type of interior drainage system of an area to be developed or redeveloped will depend on its typical roadway cross section. Where the proposed roadway system is to have curbs and gutters, the interior drainage system shall consist of storm sewers with sufficient drop inlets to insure runoff entry thereto (closed system).

Where no curb and gutter is proposed, the collection system shall consist of shallow grassed swales on both sides of the roadway (open system).

Public roadway drainage conveyed from the roadway between side or near lot lines shall be piped.

MINIMUM GROUNDWATER AND HIGH-WATER CLEARANCES

All roadways shall be designed to provide a minimum of one (1) foot between the bottom of the base course of the roadway and the seasonal high groundwater table. Roadside underdrains may be used in lieu of meeting this criteria, provided that the underdrains will result in the seasonal high water table under the roadway being lowered to the above cited level.

In all situations, the crown of proposed roadways shall be no lower than 18 inches below the elevation of the adjacent ground after development.

HYDROLOGY

The interior drainage systems of an area are to be developed or redeveloped shall be designed to carry runoff from a 10 Year Frequency Rainfall. Drainage systems from improvements to or for roadways which are designated part of the Major Thoroughfare Plan shall be designed for the 25 Year Frequency event.

In all cases, the interior drainage system of developments shall be laid out so that if a more intense rainfall (greater that 10 Year Frequency event) overtaxes the system, an unobstructed flow path to lower ground will be provided. The purpose of this path shall be to ensure that no damage to properties located in the lower areas of development will occur and that no extensive ponding of water results.

AREAS DRAINED BY CLOSED SYSTEMS

Storm sewer systems shall be designed to flow full, but not under pressure at the computed peak design discharge.

In all cases, a self-cleaning system will be designed utilizing drop inlets. Longitudinal connecting pipes will run from inlet to inlet. No manholes shall be utilized unless absolutely necessary. Where possible, to insure self-cleansing, pipes will be placed on a minimum grade of 0.2 percent and provide a minimum velocity of 2.5 - feet per second when flowing full or half-full. Minimum pipe sizes for closed systems shall be as follows:

1. For longitudinal pipes - 15 inches
2. For runs 75-feet or less - 15 inches
3. For low points on roadways (Bucket) - 18 inches

Inlet Spacing

Pavement inlets shall be so spaced as to limit the spread of water from a 10 Year Frequency Rainfall to five-feet measured longitudinally on a continuous grade. Spacing shall be based on a maximum of 400 feet gutter flow. If slopes exceed 2% at low points, two pavement inlets on each side of the roadway shall be provided if deemed necessary by hydraulic analysis. Special care shall be taken in the placing of inlets so as to prevent water from flowing across the pavement. For purposes of maintenance, a spacing of 400 feet between junction boxes shall be required.

Headwalls and/or erosion protection devices (i.e., riprap, mitered ends) shall be installed at the ends (outlet pipes) of all closed systems to reduce erosion in the receiving water course.

Tailwater Effect

The affect of tailwater level in the receiving water shall be fully considered in the design of all storm sewer systems, such that when the outlet of the storm sewer system is below the tailwater level in the receiving water, the hydraulic grade line for the proposed storm sewer system shall be computed.

In all cases, the computed Hydraulic grade line elevation shall not be higher than 0.25 feet below the gutter line elevation at any drainage structure.

Where the receiving stormwater facility is a detention basin, the design tailwater level can be computed by routing a hydrograph resulting from a 10 Year Frequency storm of a duration equal to that used in designing the pond through the basin.

In the computation of the hydraulic grade line, all energy losses (entrance, exit, friction, structure, etc.) must be considered.

AREAS DRAINED BY OPEN SYSTEMS (INTERIOR SYSTEM)

Swale drainage systems shall be designed as open channels in a manner similar to the closed system.

The minimum slope of swales adjacent to roadways and other swales constituting the interior drainage system shall be to FDOT and Green Book Standards. The maximum velocity of flow in swales shall be as follows (upon project completion):

1. Seeded and mulched - 0 to 2-feet per second
2. Sodded (no staking) - 2 to 4-feet per second
3. Paved - 4-feet per second or greater
4. Existing ground cover:
    a. Good condition - 0 to 4-feet per second
    b. Fair condition - 0 to 2.5-feet per second
    c. Poor condition - 0 to 1.5 feet per second

Flow in roadway swales shall be routed to culverts carrying the primary drainage system through the area to be developed or to flow channels (swales) in dedicated public easements between lots which will convey runoff to the primary drainage system.

The hydraulic engineering circular no. 5, hydraulic charts for the selection of highway culverts, published by the U.S. Department of Transportation, Federal Highway Administration should be used for all culvert design under the roadway.

ACCEPTABLE STORMSEWER PIPES

The following are acceptable materials for the construction of storm sewer systems which must meet County standards:

1. Storm sewer running across a public roadway - RCP or structural plate only*
2. Storm sewer running parallel to a public roadway and between lots - RCP, Polyethylene, corrugated metal*
3. Corrugated metal pipe is not permitted under any roadway.

    * **Metal pipe will only be allowed if surrounding soils are of proper PH ranges conducive to metal pipe.**

EROSION AND SEDIMENT CONTROL

Erosion and sediment control must be submitted with the construction or immediately following (same day) of any land disturbing activities. In no case shall silt or debris be allowed to enter a public right of way in such a manner as to create a traffic hazard, a public nuisance or a threat to exiting drainage.

In accordance with best engineering practices, erosion and sediment control measures must be provided on all sites to be developed or redeveloped where existing vegetation or impervious surfaces shall be removed so that bare soil remains. These measures shall be provided not only in areas of the proposed stormwater system (i.e., inlets, ponds, outfalls, etc.), but in all areas disturbed. This includes providing silt screens or haybales along property lines where the existing ground cover has been removed.

Erosion and sediment controls must be in place prior to construction or immediately following (same day) of any land disturbing activities.

Plans for erosion and sediment control must be submitted with the construction plan submittal and be approved prior to the commencement of any work on site. The following items shall be included in the erosion and sediment control plans:

1. A description of the siltation control program and siltation control practices.
2. Details of erosion and sediment controls.
3. A plan for temporary and permanent vegetative and structural erosion and siltation control measures.
4. A description of the maintenance program for siltation control facilities including inspection programs, re-vegetation of exposed soils, method and frequency of removal and disposal of solid waste material from control facilities and disposition of temporary structural measures.

PROTECTION AND STABILIZATION OF SOIL STOCKPILES

Soil stockpiles shall be protected at all times by on-site drainage controls which prevent erosion of the stockpiled material. Control of dust from such stockpiles shall be required.

In no case shall any unstabilized stockpile remain in place, longer than thirty (30) calendar days.

Stockpiling of material may not occur unless a minimum of thirty (30) feet of clearance between to the toe of slope of the stockpile and the adjacent property is available.

MAINTENANCE

All erosion control devices shall be checked regularly. Devices shall be cleaned or repaired as required.

Maintenance of all soil erosion and siltation control devices, whether temporary or permanent, shall be at all times the responsibility of the Owner.

Rights of Way, Easement, and Maintenance Access Requirements

Open drainage channels and piped systems shall have unobstructed maintenance access areas as shown on the drawings following this section (Appendix A). Detention and retention basins shall have an unobstructed access route at least 20-feet wide from the nearest street and shall have an unobstructed maintenance access area a minimum of 20-feet from the top of bank completely around their perimeter.

All rights of way, easements, and maintenance access areas shall be sodded, or have a good stand of grass or other acceptable coverage per County approval. In all cases there shall be a minimum of 2 foot strip of sod placed at the edge of pavement or back of curbs.

SECTION IV

SUBMITTAL REQUIREMENTS
FOR
STORMWATER MANAGEMENT SYSTEMS

All construction plan submittals are to include the following information for the review of the proposed stormwater management systems:

1. Vicinity sketch and legal description

2. Basin and sub-basin boundaries, including all on-site and offsite areas contributing to the proposed development site. This is to include both pre- and post-development conditions.

3. Existing one foot contours and spot elevations for a minimum of 100 feet offsite. (Not including Right of Way).

4. Proposed elevations, specifically those for the perimeter and property line swales and for finished grades at the property lines. (Minimum elevations are to be provided at the property lines, lot lines and at the beginning and end of all swales).

5. Flow paths used to determine the basin and sub-basin times of concentration for both pre-development and post-development conditions.

6. Existing drainage features (ditches, ponds, easements, etc.). Existing features are to be shown downstream of the proposed development. The downstream distance shall be determined from the following, whichever is applicable:

   A. The Site Designer shall field investigate drainage patterns immediately upstream and a minimum of 1000 feet downstream of the site and provide documentation of field conditions.

   B. The Site Designer shall demonstrate that design tailwater conditions are appropriate and that there are no downstream restrictions of conveyance which may necessitate the use of <u>Peak Sensitive Outfall conditions.</u>

7. Highwater data upstream and downstream of the proposed development when available.

8. Proposed layout with horizontal and vertical controls.

9. Proposed drainage features, including the location of inlets, swales, ponds, easements, conveyance systems, etc.

10. Notes pertaining to standing water, springs, areas of seepage or sources of highwater data.

11. Specific soils information as determined from a geotechnical report or soils analysis. (SHWT data shall be included).

12. Soils report indicating infiltration rates, soil type and profile, etc...

13. Flood zone delineation.

14. Existing land uses and ground cover.

15. Scaled no smaller than 1" = 60'.

16. Signed and sealed boundary survey (by a Florida registered land surveyor).

17. Calculations for all of the following must be signed and sealed by the Engineer of Record (Registered in the state of Florida):

    A. Pre- and Post-development times of concentration.

    B. Average Runoff Coefficients or Curve Numbers for both pre- and post-development stormwater facilities.

    C. Volume capacities of existing site storage and post-development stormwater facilities.

    D. Pre- and Post-development flows.

    E. Internal pipe calculations (include basin delineation).

    F. Offsite flow contributions.

    G. Cut and fill calculations for mitigation within the 100 year floodplain.

    H. Stage storage discharge

17. Computer generated reports (Include all input as well as all output.)

18. Water quality treatment and drawdown calculations.

19. Typical Lot Cross Section.

20. Typical Road Cross sections.

21. Plan and Profiles for all roadways.

22. Jurisdictional Survey.

23. Minimum building elevations.

24. Location, elevation and detail of all stormwater system components (i.e., swales, inlets, ponds, control structures, etc.).

25. Erosion and sediment control plans.

26. Design reference material shall be documented and made available upon request.

27. Drainage and access easements.

28. Location and elevations of all utilities.

29. Construction specifications.

SOURCES

SWFWMD "Management and Storage of Surface Waters - Permit Information manual; Volume I", March 1988

City of Sarasota, "Engineering Design Criteria Manual", 17 January 1989

Hillsborough County, "Stormwater Management Technical Manual", May 1988

Snyder, F.F., "Synthetic Flood Frequency", Paper 1908, Journal of the Hydraulics Division, Proceedings ASCE, October 1958

USDA "Urban Hydrology for Small Watersheds", Technical Release 55 (TR-55), 2nd Edition, June 1986

Briley, Wild & Associates, Inc.

Wright-McLaughlin Engineers (1969)

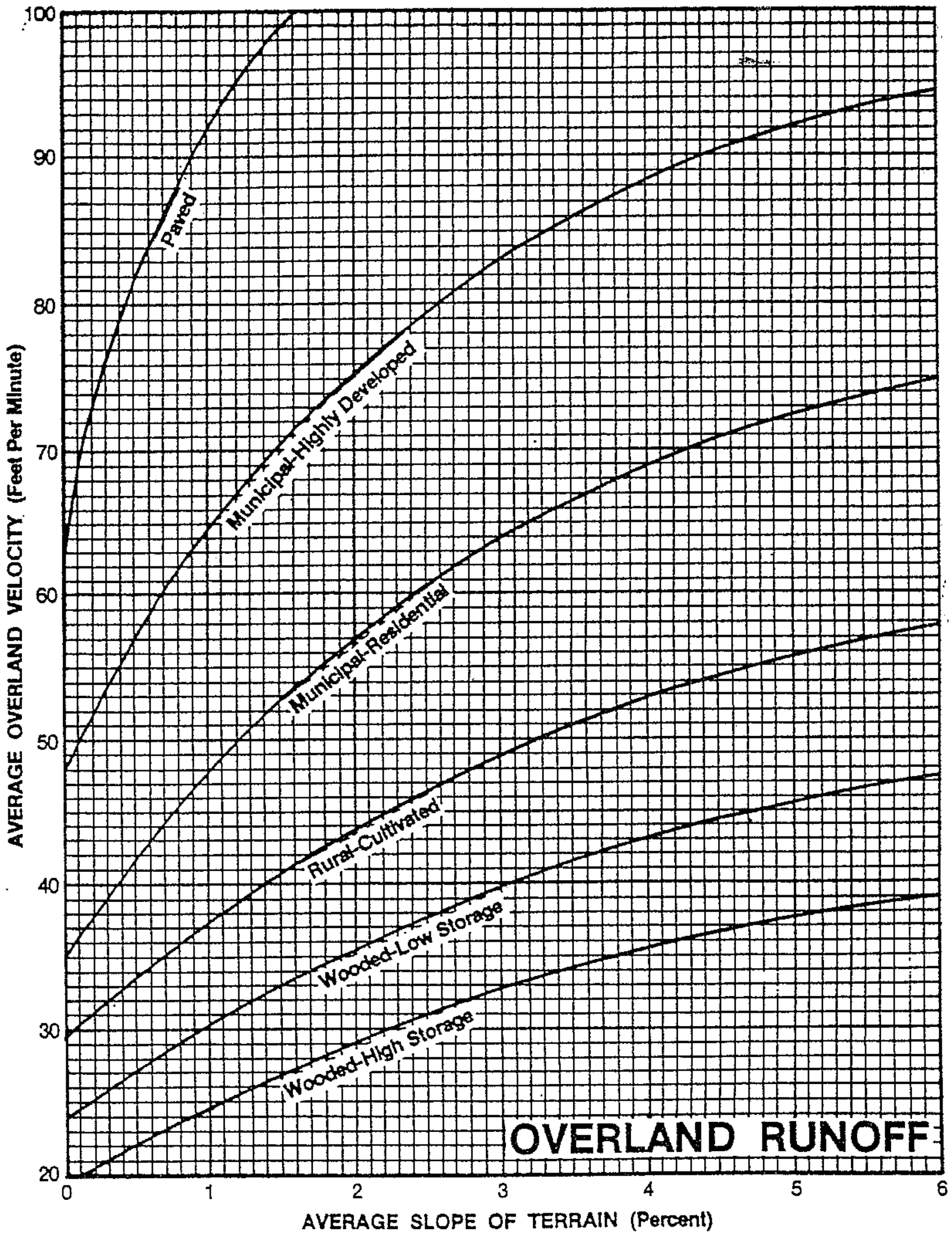
Hydrology and Water Quantity Control
By: M.P. Wanielista, 1990, Wiley Publication

Introduction to Hydrology, 2nd Edition, 1977
By: W. Viessman, Jr., J.W. Knapp, G.L. Lewis, T.E. Harbaugh

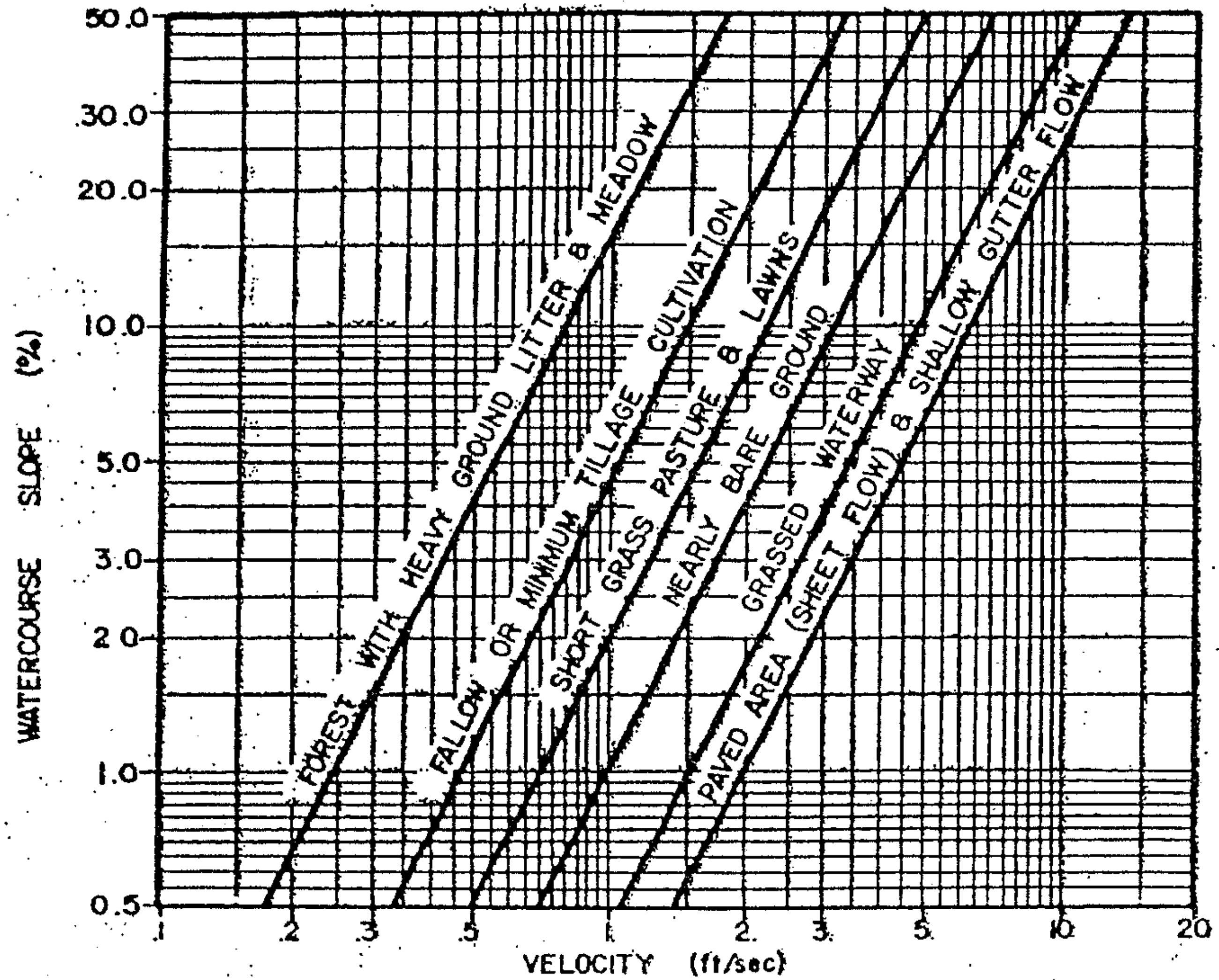
APPENDIX "A"

RAINFALL RATIOS (ACCUMULATED TOTAL 24-HOUR TOTAL)

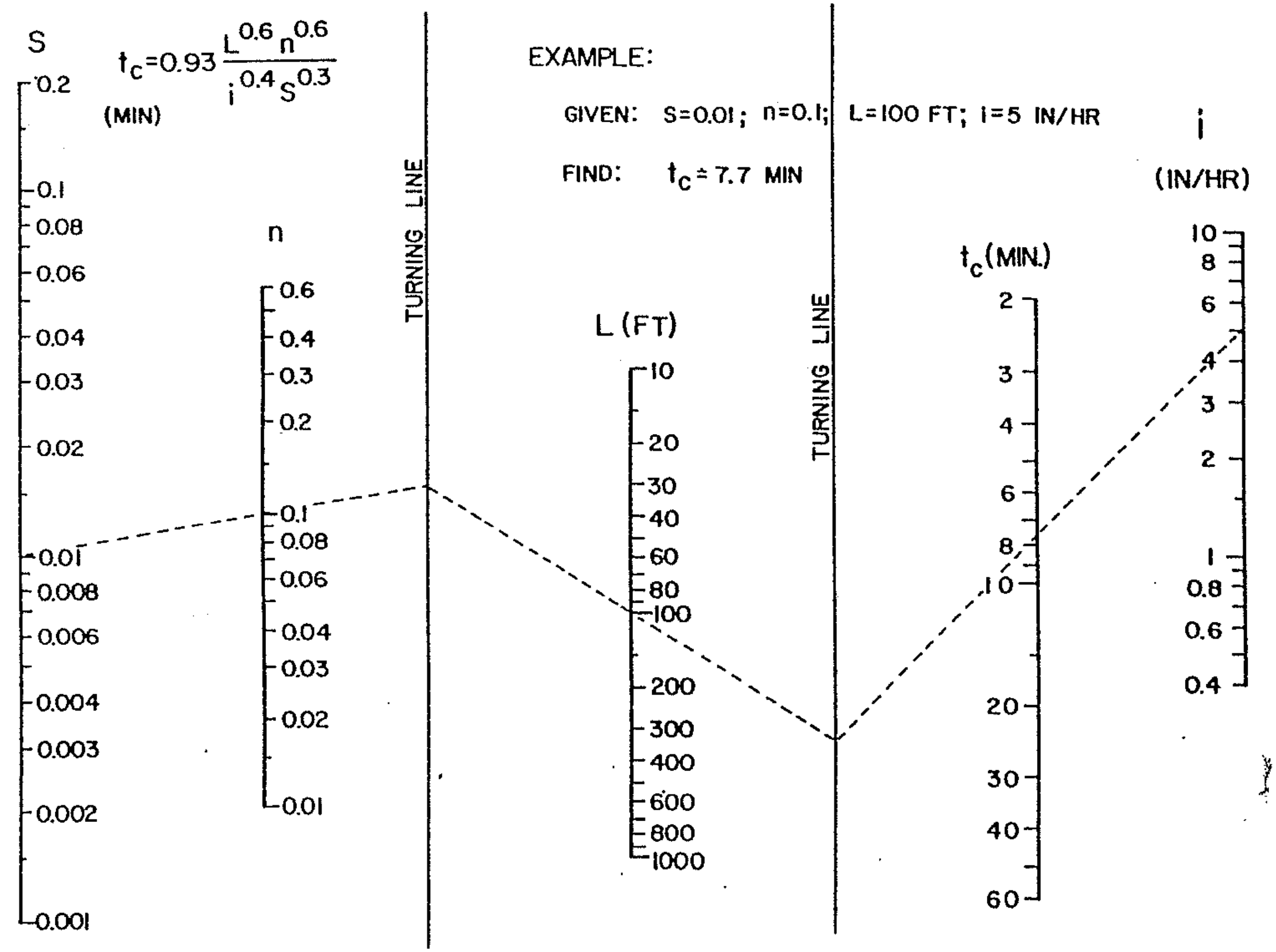
TIME (HR.)	SCS TYPE II FL. MODIFIED
0.0	.000
0.5	.006
1.0	.012
1.5	.019
2.0	.025
2.5	.032
3.0	.039
3.5	.047
4.0	.054
4.5	.062
5.0	.071
5.5	.080
6.0	.089
6.5	.099
7.0	.110
7.5	.122
8.0	.134
8.5	.148
9.0	.164
9.5	.181
10.0	.201
10.5	.226
11.0	.258
11.5	.308
12.0	.607
12.5	.719
13.0	.757
13.5	.785
14.0	.807
14.5	.826
15.0	.842
15.5	.857
16.0	.870
16.5	.882
17.0	.893
17.5	.904
18.0	.913
18.5	.923
19.0	.931
19.5	.940
20.0	.948
20.5	.955
21.0	.962
21.5	.969
22.0	.976
22.5	.983
23.0	.989
23.5	.995
24.0	1.000



Overland Flow Velocities for Various Land Use Types



The average velocities for estimating travel time for overland flow (SCS method). (*Source*: SCS, 1975.)



Reference: USDOT, FHWA, HEC-12 (1984).

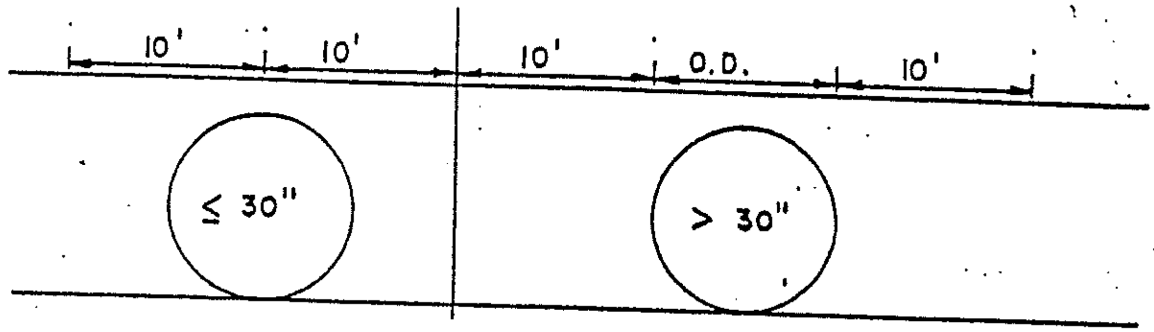
Kinematic Wave Formulation for Determining Overland Flow Travel Time

EASEMENT GUIDELINES FOR PIPE SYSTEMS

I. LESS THAN FIVE FEET OF COVER OVER THE PIPE

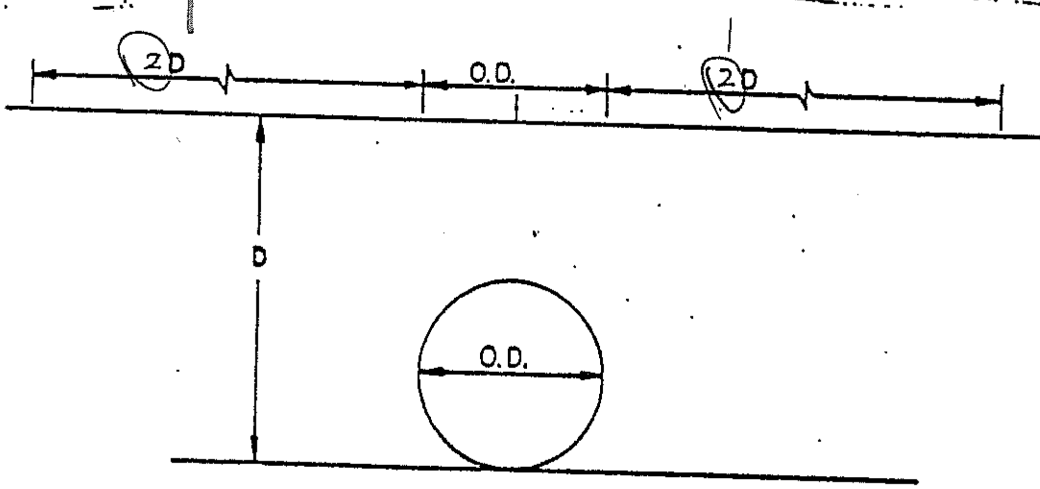
A. Diameter equal to or less than 30" round or equivalent: easement shall be 10 feet either side of the centerline of the pipe.

B. Diameter greater than 30" round or equivalent: easement shall be 20 feet plus the outside diameter of the pipe in width (rounded up to the nearest 5 foot increment) and centered on the centerline of the pipe.

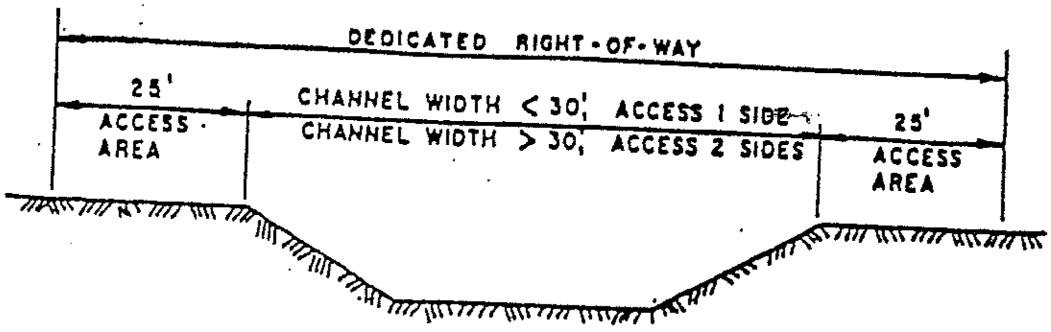


II. EQUAL TO OR GREATER THAN FIVE FEET OF COVER OVER THE PIPE

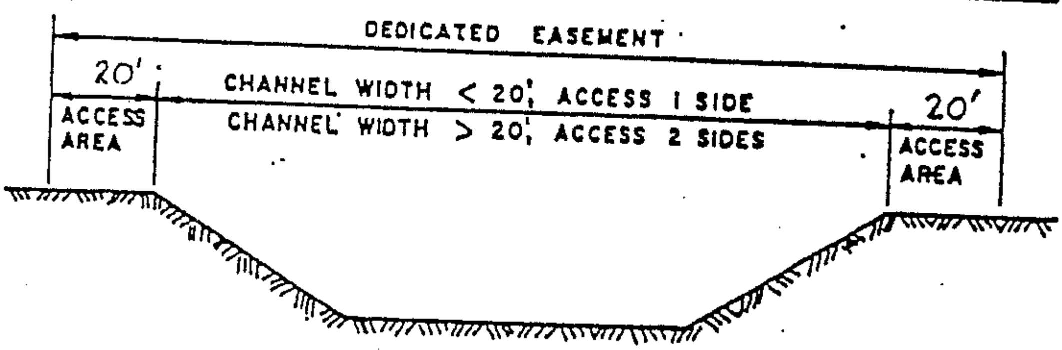
Easement will be equal to the outside diameter of the pipe plus twice the distance from the ground surface to the trench bottom measured at the deepest point along the path of the proposed easement (rounded up to the nearest five foot increment), and centered on the centerline of the pipe. Minimum easement width is 20 feet.



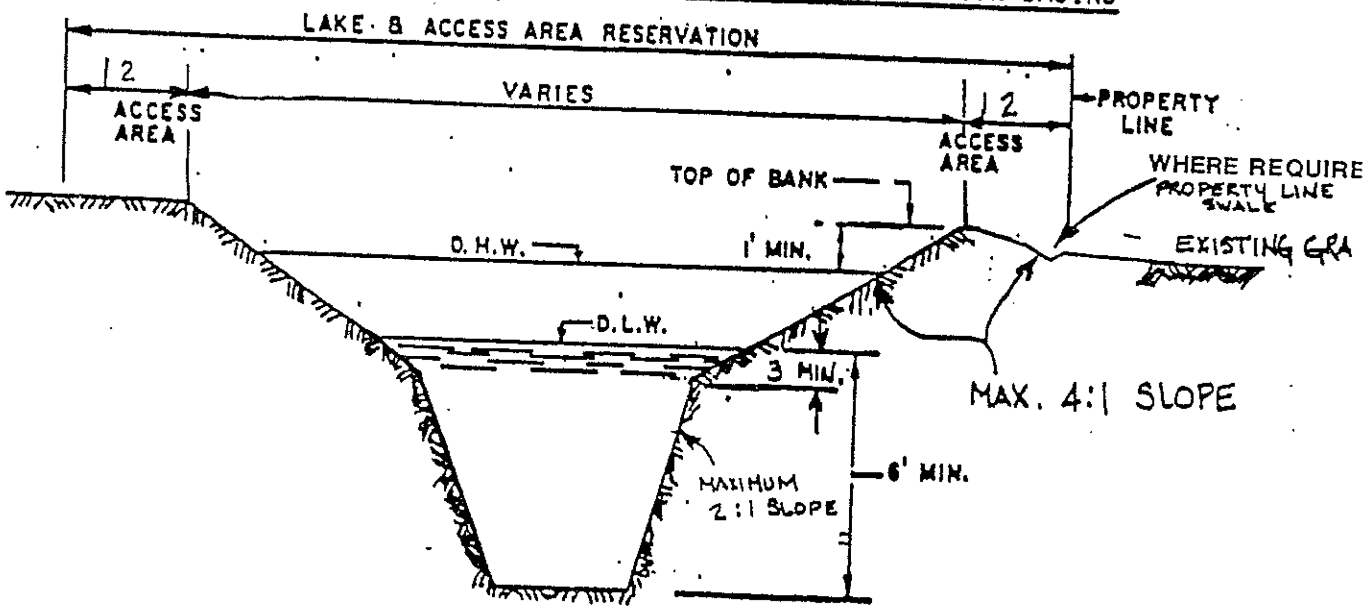
DRAINAGE R/W GUIDELINES FOR MAJOR OPEN DRAINAGE CHANNELS



DRAINAGE EASEMENT GUIDELINES FOR MINOR OPEN DRAINAGE CHANNELS.



LAKE RESERVATION GUIDELINES FOR DETENTION AND RETENTION BASINS



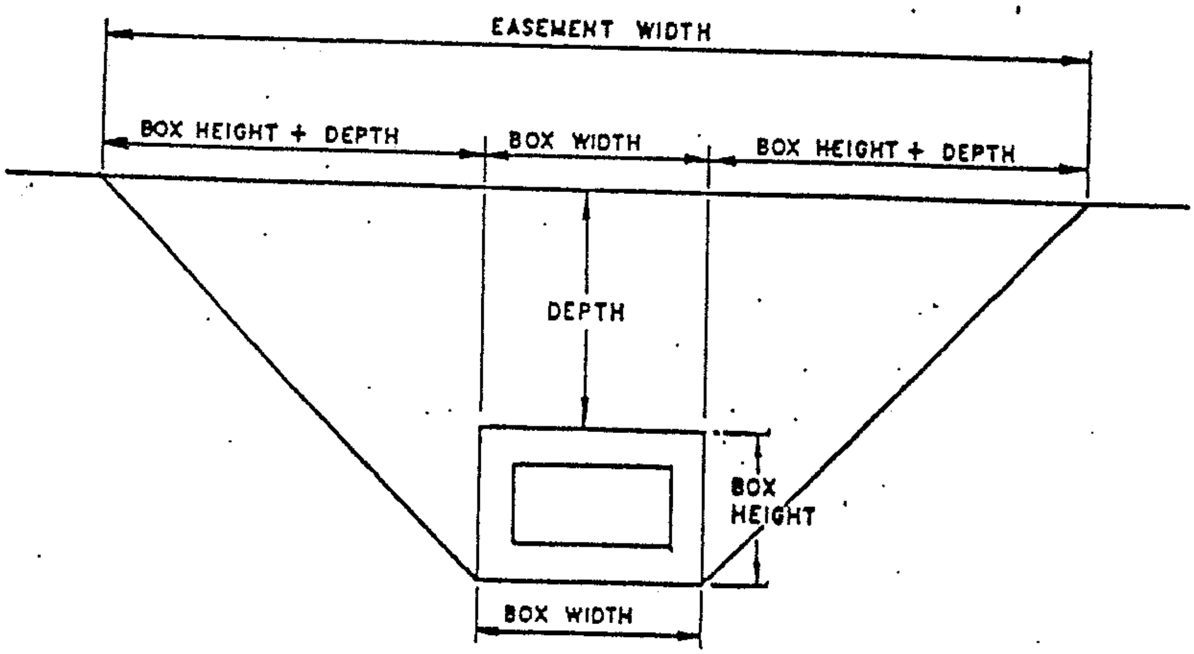
EASEMENT GUIDELINES FOR BOX SYSTEMS

1. All dimensions shown are external dimensions.

2. Depth of cover is measured from the ground surface to the top of the box.

3. Easement Width = [(2) x (Depth of Cover + Box Height)] + Box Width. All calculations are to be rounded up to the nearest five foot increment for easement purposes.

4. Minimum easement width is 20 feet.



DESIGN STORM FREQUENCY FACTORS
FOR PERVIOUS AREA RUNOFF COEFFICIENTS

Design Storm Return Period (years)	Frequency Factor, X_T
2 to 10	1.0
25	1.1
50	1.2
100	1.25

Reference: Wright-McLaughlin Engineers (1969).

SCS RUNOFF CURVE NUMBERS FOR SELECTED AGRICULTURAL, SUBURBAN, AND URBAN LAND USE

Land Use Description		Hydrologic Soil Group A	B	C	D
Cultivated Land[a]:					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture or range land:					
Poor condition		68	79	86	89
Good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest Land:					
Thin stand, poor cover, no mulch		45	66	77	83
Good cover[b]		25	55	70	77
Open Spaces, Lawns, Parks, Golf Courses, Cemeteries:					
Good condition: grass cover on 75% or more of the area		39	61	74	80
Fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Poor condition: grass cover on 50% or less of the area		68	79	86	89
Commercial and Business Areas (85% impervious)		89	92	94	95
Industrial Districts (72% impervious)		81	88	91	93
Residential[c]:					
Average lot size	Average % Impervious[d]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved Parking Lots, Roofs, Driveways[e]:		98	98	98	98
Streets and Roads:					
Paved with curbs and storm sewers[e]		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Newly graded area (no vegetation established)[f]		77	86	91	94

[a]For a more detailed description of agricultural land use curve numbers, refer to Table 5-9.

[b]Good cover is protected from grazing and litter and brush cover soil.

[c]Curve numbers are computed assuming the runoff from the house and driveway is directed toward the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[d]The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[e]In some warmer climates of the country, a curve number of 96 may be used.

[f]Use for temporary conditions during grading and construction.

Note: These values are for Antecedent Moisture Condition II, and $I_a = 0.2S$.

Reference: USDA, SCS, TR-55 (1984).

SCS RUNOFF CURVE NUMBERS FOR AGRICULTURAL LAND USES

Land Use	Cover Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	and terraced	Poor	66	74	80	82
	and terraced	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured	Good	55	69	78	83
	and terraced	Poor	61	72	79	82
	and terraced	Good	59	70	78	81
Close seeded legumes[a] or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	and terraced	Good	55	69	78	83
	Contoured	Poor	63	73	80	83
	and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt)[b]		----	72	82	87	89
(hard surface)[b]		----	74	84	90	92

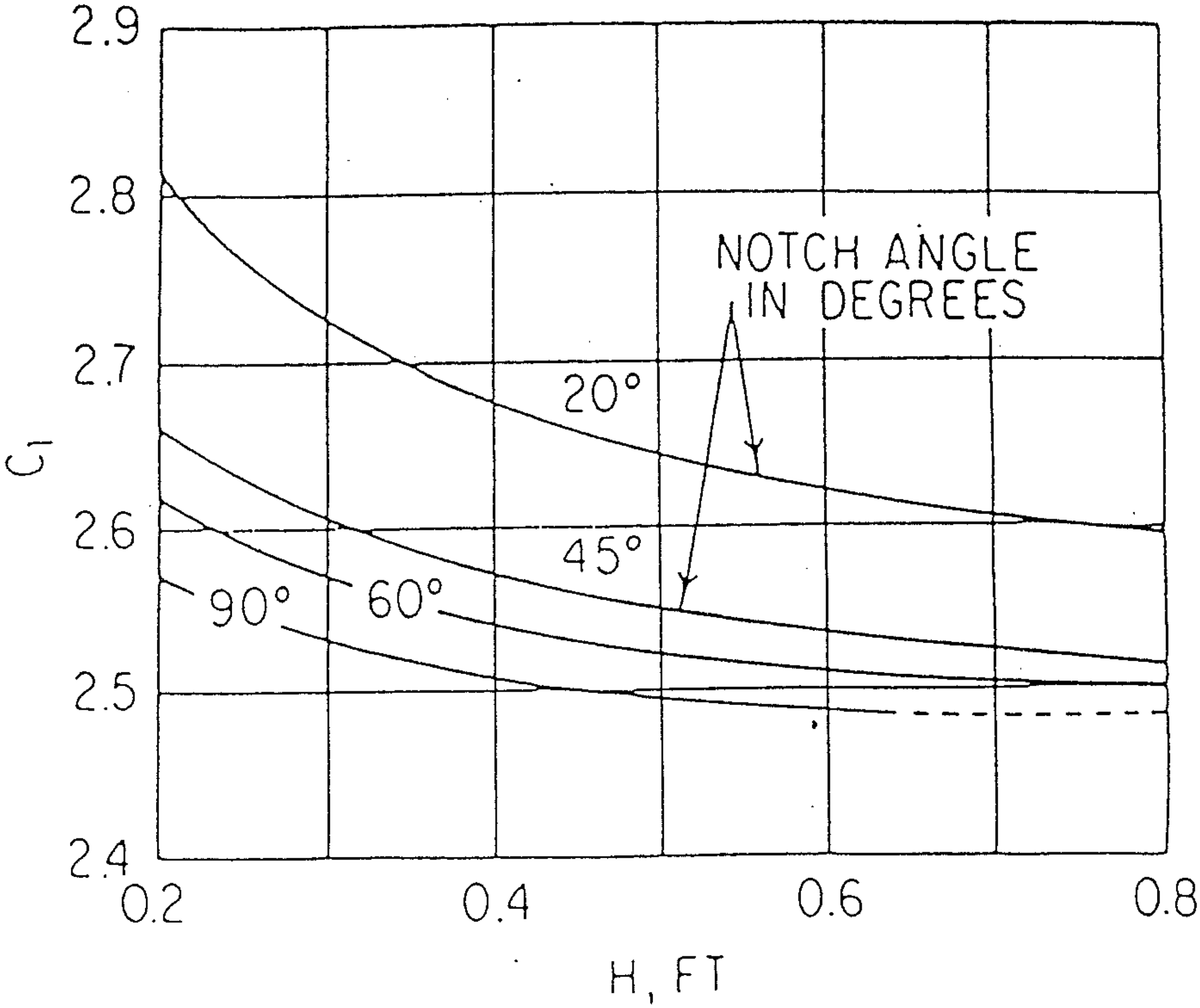
[a]Close-drilled or broadcast.

[b]Including right-of-way.

Note: These values are for Antecedent Moisture Condition II, and $I_a = 0.2S$.

Reference: USDA, SCS, NEH-4 (1972).

DISCHARGE COEFFICIENTS FOR SHARP-CRESTED V-NOTCH WEIRS



RUNOFF COEFFICIENTS [a] FOR A DESIGN STORM RETURN PERIOD OF 10 YEARS OR LESS

Slope	Land Use	Sandy Soils		Clay Soils	
		Min.	Max.	Min.	Max.
Flat (0-2%)	Woodlands	0.10	0.15	0.15	0.20
	Pasture, grass, and farmland[b]	0.15	0.20	0.20	0.25
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.75	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.30	0.35	0.35	0.45
	Smaller lots	0.35	0.45	0.40	0.50
	Duplexes	0.35	0.45	0.40	0.50
	MFR: Apartments, townhouses, and condominiums	0.45	0.60	0.50	0.70
	Commercial and Industrial	0.50	0.95	0.50	0.95
Rolling (2-7%)	Woodlands 0.15	0.20	0.20	0.25	
	Pasture, grass, and farmland [b]	0.20	0.25	0.25	0.30
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.80	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.35	0.50	0.40	0.55
	Smaller lots	0.40	0.55	0.45	0.60
	Duplexes	0.40	0.55	0.45	0.60
	MFR: Apartments, townhouses, and condominiums	0.50	0.70	0.60	0.80
	Commercial and Industrial	0.50	0.95	0.60	0.95
Steep (7%+)	Woodlands 0.20	0.25	0.25	0.30	
	Pasture, grass and farmland [b]	0.25	0.35	0.30	0.40
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.85	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.40	0.55	0.50	0.65
	Smaller lots	0.45	0.60	0.55	0.70
	Duplexes	0.45	0.60	0.55	0.70
	MFR: Apartments, townhouses, and condominiums	0.60	0.75	0.65	0.85
	Commercial and Industrial	0.60	0.95	0.65	0.95

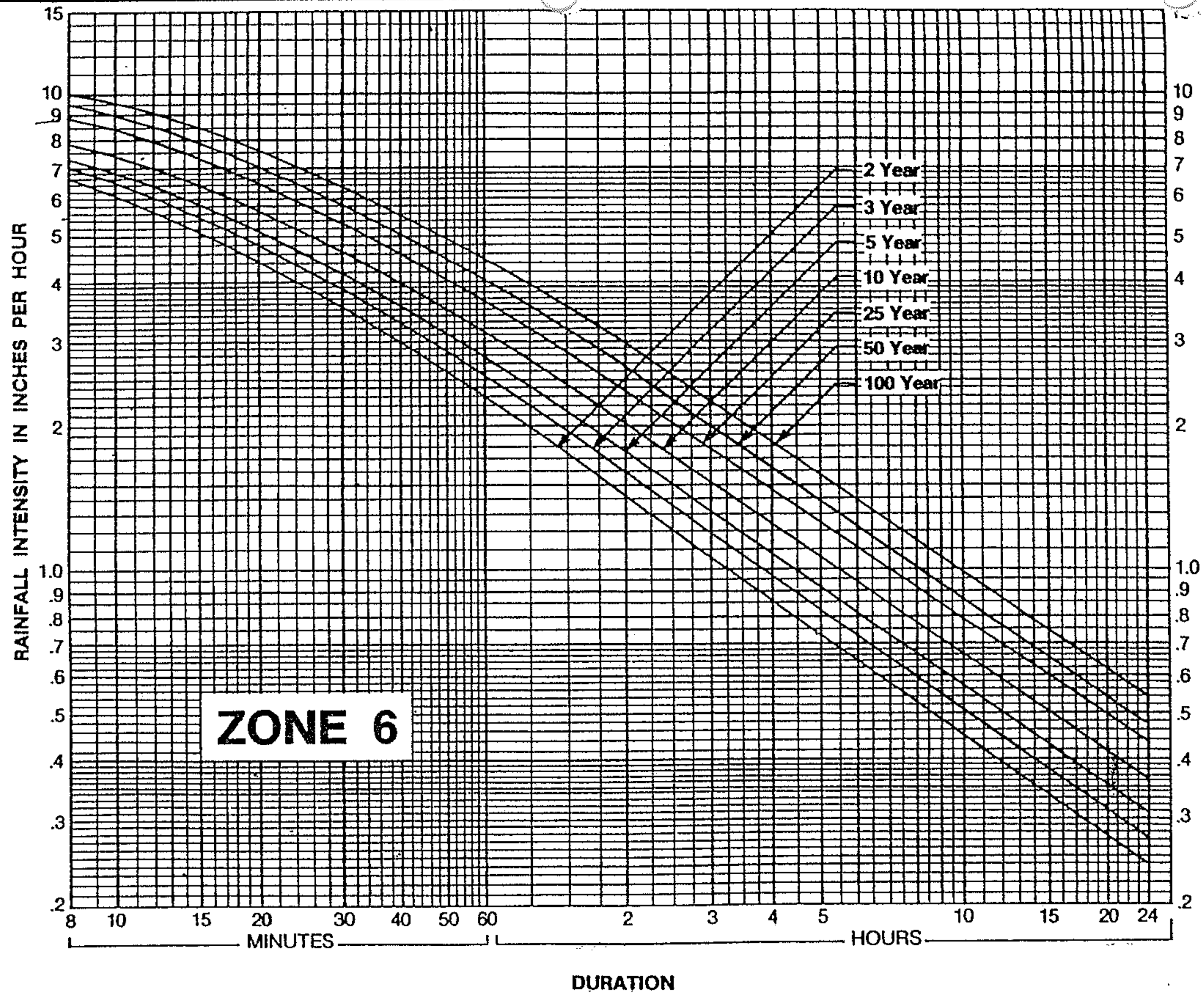
[a]Weighted coefficient based on percentage of impervious surfaces and green areas must be selected for each site.

[b]Coefficients assume good ground cover and conservation treatment.

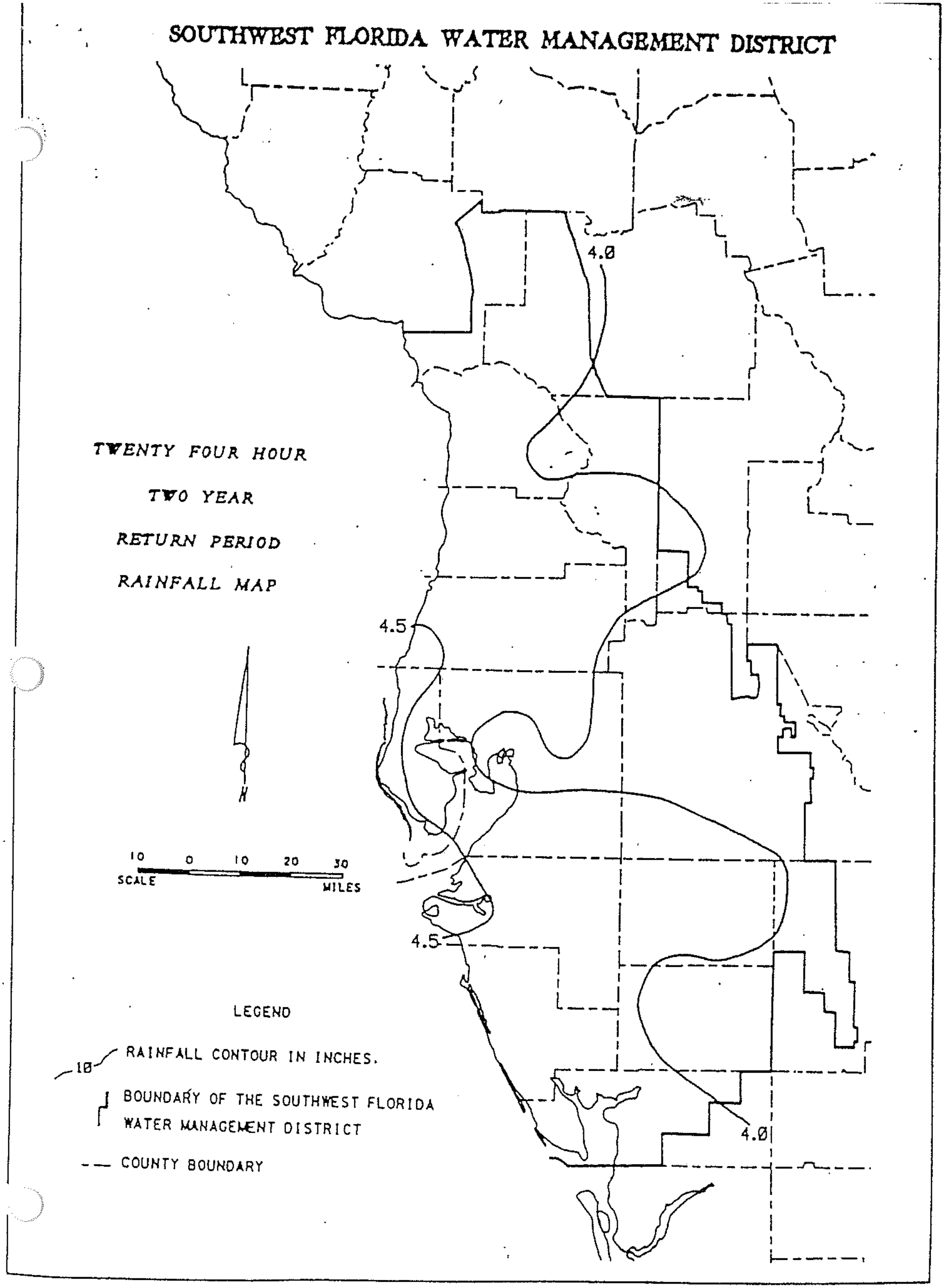
[c]Depends on depth and degree of permeability of underlying strata.

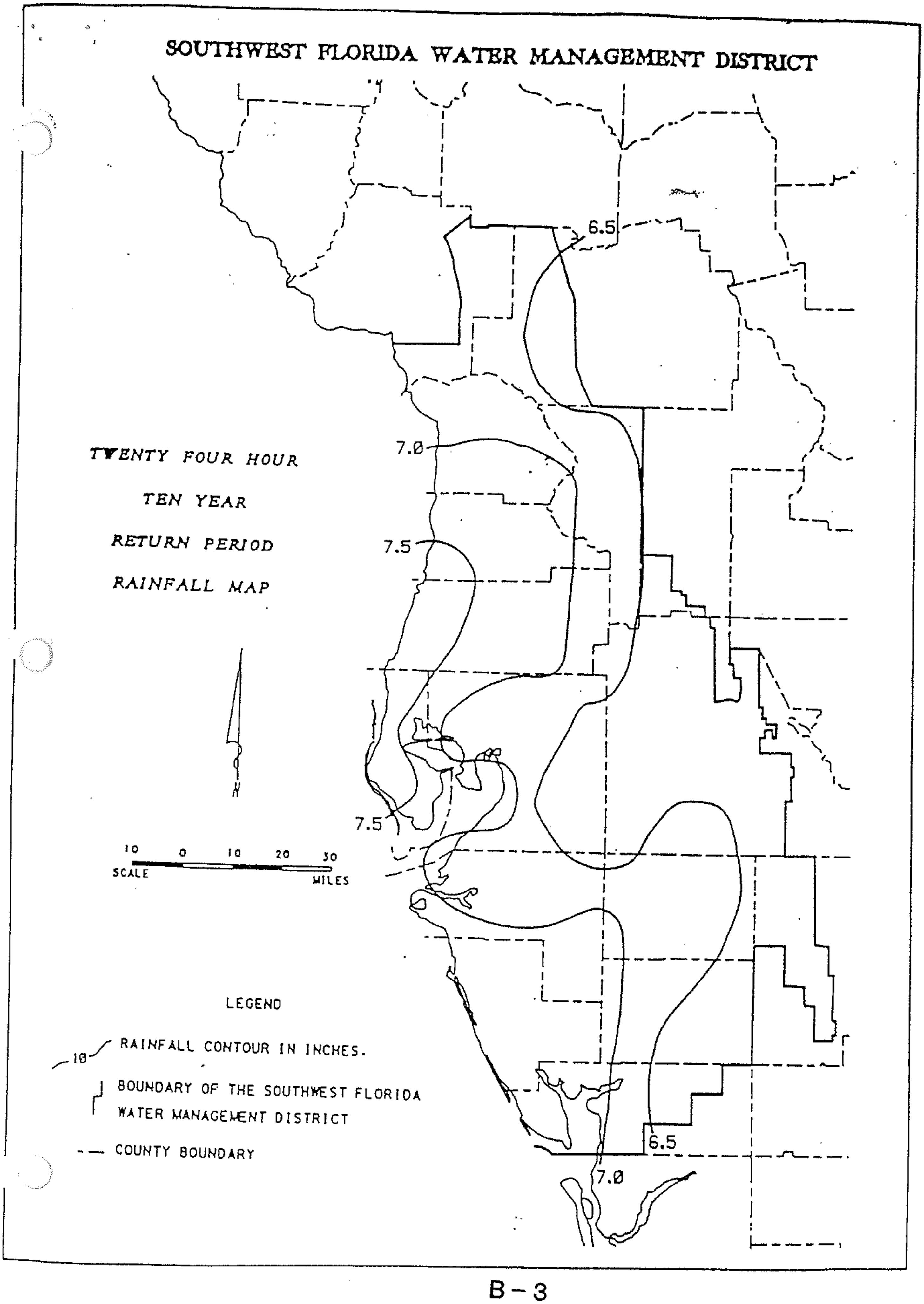
Note: SFR - Single Family Residential
MFR - Multi-Family Residential

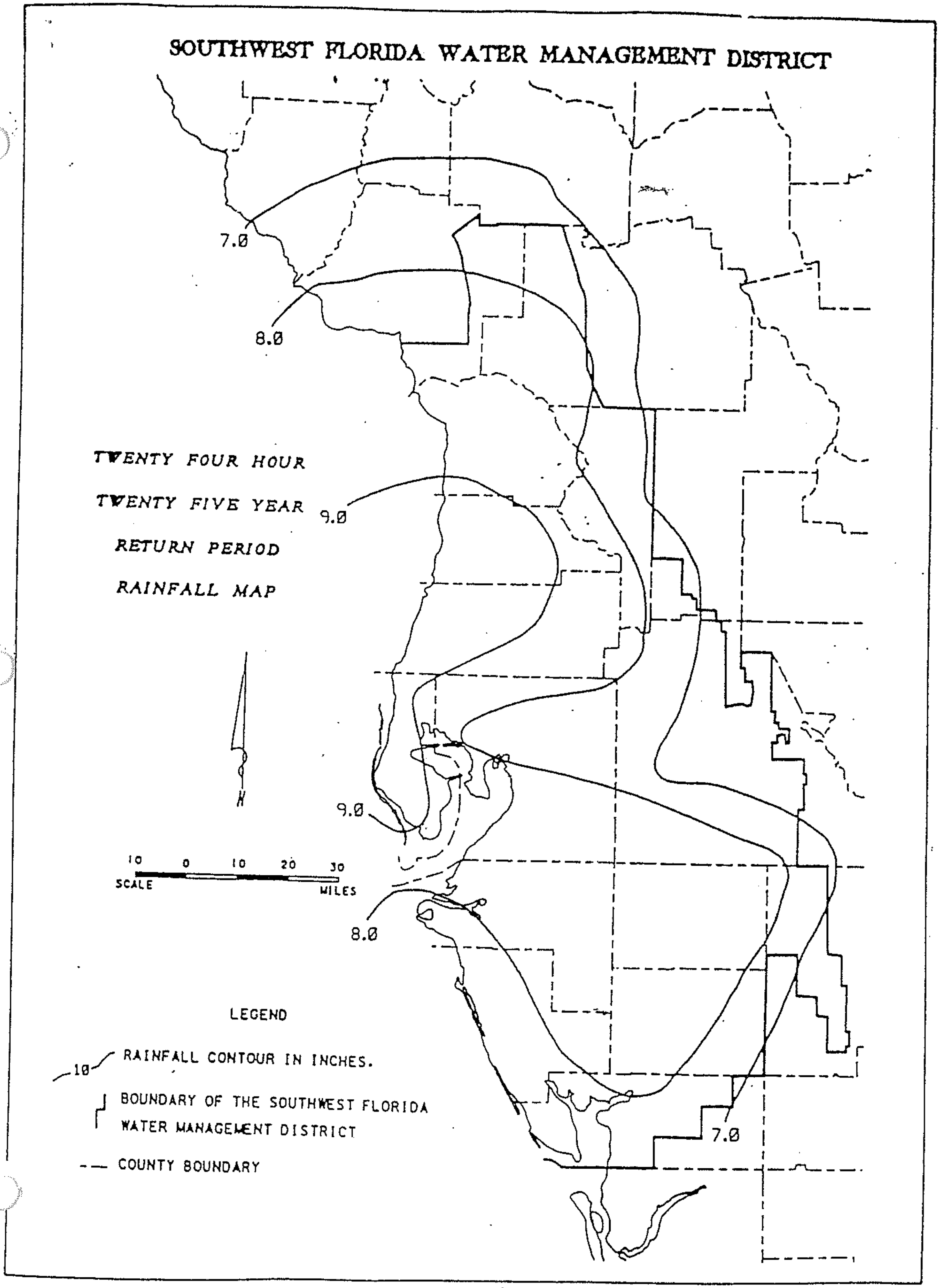
APPENDIX "B"

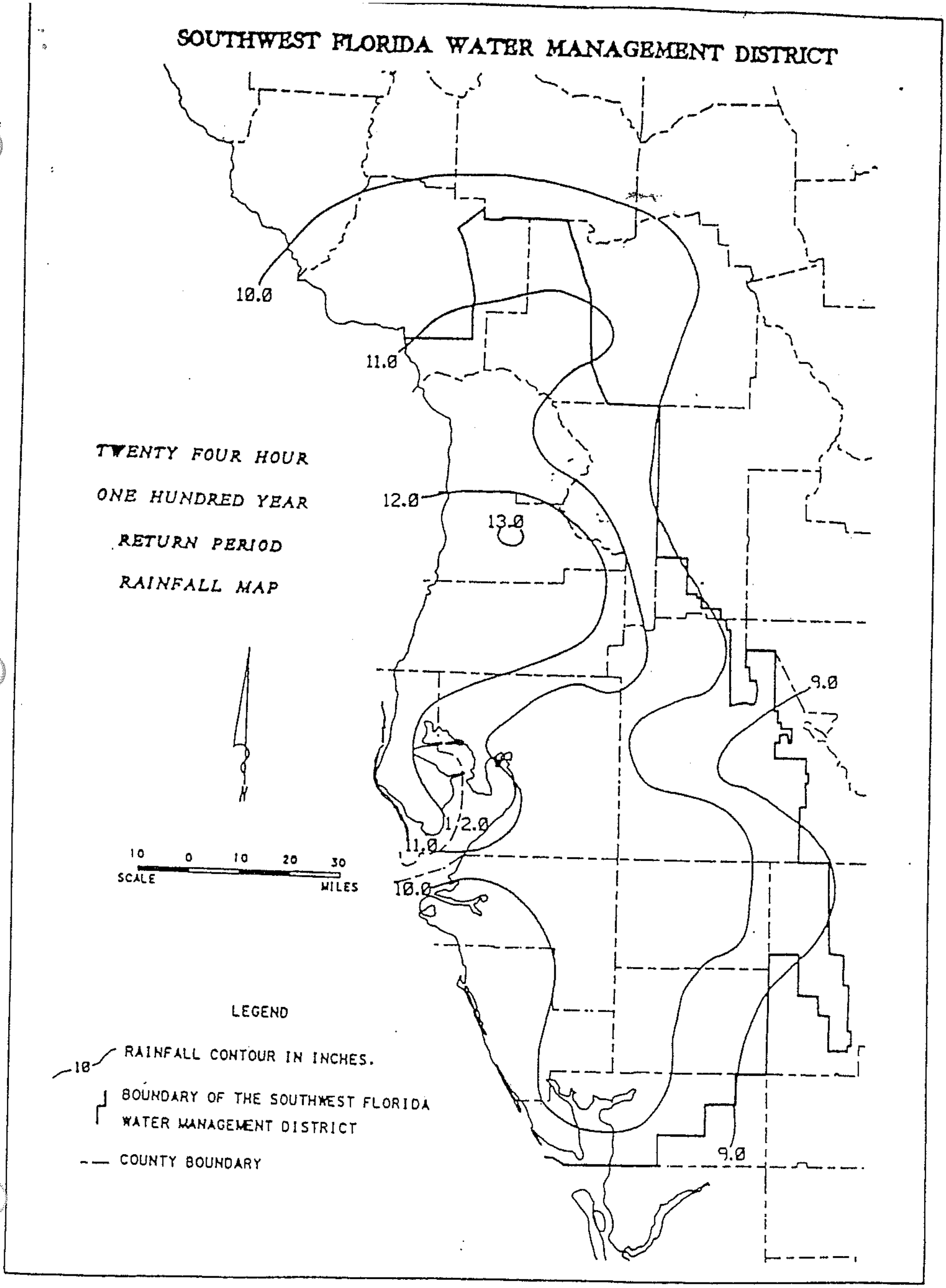


Rainfall Intensity-Duration-Frequency Curves for Zone 6


SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
TWENTY FOUR HOUR
TWO YEAR
RETURN PERIOD
RAINFALL MAP
4.0
4.5
4.5
4.0
N
10 0 10 20 30
SCALE
MILES
LEGEND
10 RAINFALL CONTOUR IN INCHES.
BOUNDARY OF THE SOUTHWEST FLORIDA
WATER MANAGEMENT DISTRICT
COUNTY BOUNDARY


SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
TWENTY FOUR HOUR
TEN YEAR
RETURN PERIOD
RAINFALL MAP
6.5
7.0
7.5
7.5
6.5
7.0
N
10 0 10 20 30
SCALE MILES
LEGEND
10 RAINFALL CONTOUR IN INCHES.
BOUNDARY OF THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
COUNTY BOUNDARY


SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
TWENTY FOUR HOUR
TWENTY FIVE YEAR
RETURN PERIOD
RAINFALL MAP
7.0
8.0
9.0
9.0
8.0
7.0
N
10 0 10 20 30
SCALE
MILES
LEGEND
10 RAINFALL CONTOUR IN INCHES.
BOUNDARY OF THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
COUNTY BOUNDARY


SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
TWENTY FOUR HOUR
ONE HUNDRED YEAR
RETURN PERIOD
RAINFALL MAP
10.0
11.0
12.0
13.0
12.0
11.0
10.0
9.0
9.0
10 0 10 20 30
SCALE MILES
N
LEGEND
10 RAINFALL CONTOUR IN INCHES.
BOUNDARY OF THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
COUNTY BOUNDARY

APPENDIX "C"

DRAWDOWN WORKSHEET FOR TYPE V (a) UNDERDRAIN

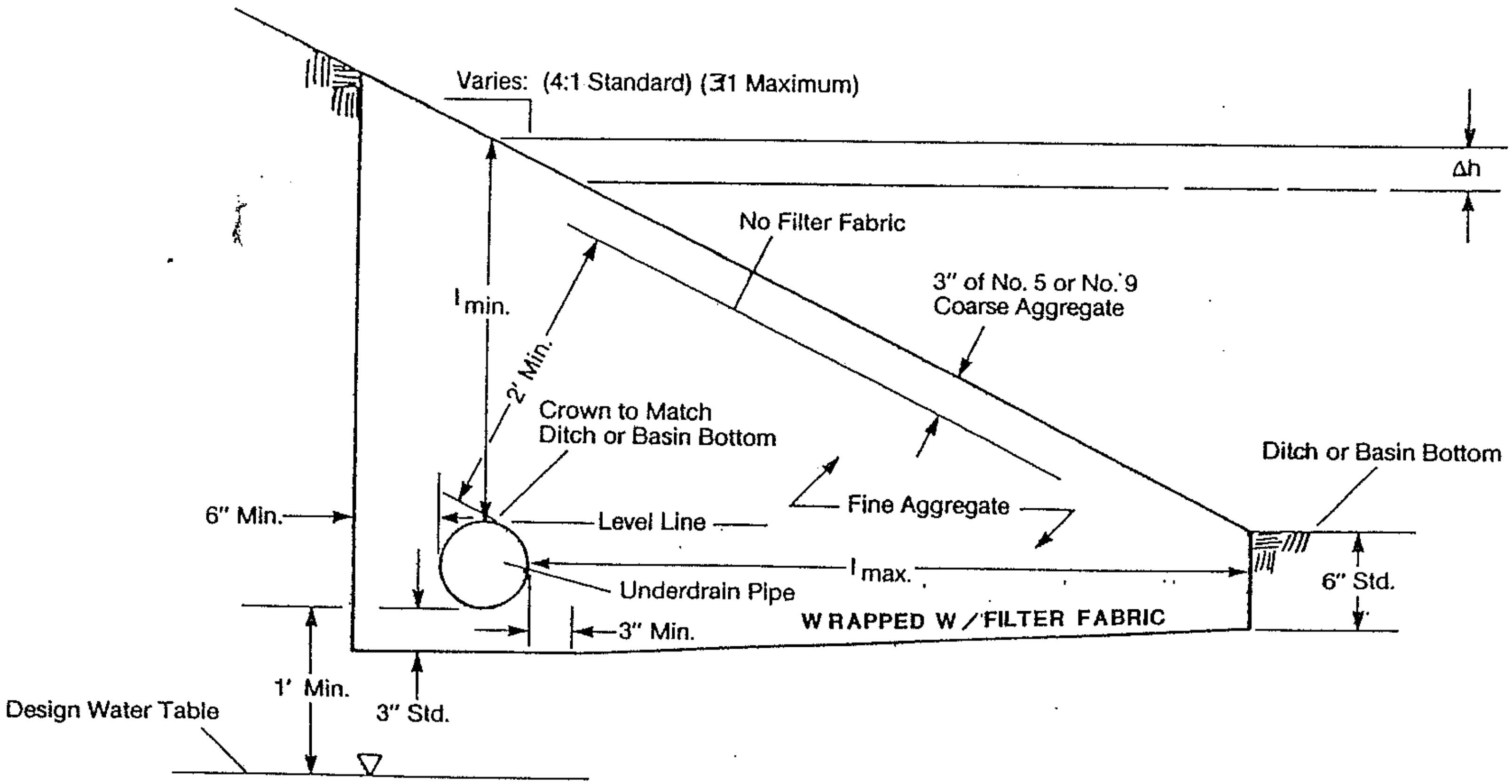
(Using Darcy's Law for Flow-Through Porous Material)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
E Elevation (NGVD)	h Total Head (ft)	Δh Incr. Head (ft)	V Total Volume (ft^3)	ΔV Incr. Volume (ft^3)	l max Maximum Flow Length Through Filter (ft)	l min Minimum Flow Length Through Filter (ft)	l avg Avg. Flow Length Through Filter (ft)	Hydraulic Gradient $i = h/la$	Area of Filter $A = Lxh$ (ft^2)	Darcy Flow $Q = KIA$ (ft^3/hr)	Avg. Flow $\frac{Q_1 + Q_2}{2}$ (ft^3/hr)	ΔT Incr. Time (hr)	ΣT Total Time (hr)

Assumed Length L = ______________ Hydraulic Conductivity K = ____________ ft/hr

See Figure 13-4 for Typical Section Details

Drawdown Worksheet for Type V (a) Underdrain



Typical Section for the Type V (a) Underdrain