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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

MANAGEMENT AND STORAGE OF SURFACE WATERS PERMIT INFORMATION MANUAL VOLUME IV

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

US 0039159

PERMITTING INFORMATION MANUAL

Volume IV, Management and Storage of Surface Waters

NOVEMBER 1981

Resource Control Department
South Florida Water Management District
P.O. Box V
West Palm Beach, Florida 33402

"This public document was promulgated at an annual cost of $523.81, or $.524 per copy to provide information on District regulatory requirements for potential permit applicants. RCD R1215 8C

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PREFACE

The South Florida Water Management District, formerly the Central and Southern Florida Flood Control District, is actively pursuing its duties as set forth in Chapter 373, Florida Statutes. Along with this above name change, which became effective January 1, 1977, were boundary changes designed to make the South Florida Water Management District more closely follow nature's watershed boundary lines (See Figure i). With these changes, The District has put into operation nearly all of the requirements of the Water Resources Act.

The regulatory procedures the Act mandates are well underway, with the District having the responsibility to issue permits for a variety of activities including water use (public water supply, irrigation, etc.), surface water management (generally referred to as drainage), artificial recharge (primarily deep well injection), and right-of-way use of District project works. In performing its regulatory duties, certain questions have arisen as to what the actual practice of these duties include, particularly as to how they supplement, complement, overlap, etc., the duties of local, regional and federal agencies. Therefore, the District has prepared for distribution a series of information manuals which capsulize the answers to the most commonly asked questions. This series is comprised of the following volumes (additional volumes may be necessary from time to time).

Volume I, General and Procedural Information

This volume provides a basic overview of the District's regulatory activities, including types of permits required, permit procedures, and references other volumes for detailed information.

Volume II, District Rules, Regulations, and Legislation

This volume contains a reprint of Chapter 373, Florida Statutes (Water Resources Act of 1972, as amended), and the pertinent rules (Chapter 40E, Florida Administrative Code) that are applicable to the District's regulatory operation.

Volume III, A through C, Permitting of Uses of Water

These volumes contain specific information and criteria for preparation and evaluation of water use permit applications as follows:

III-A Public Water Supply, including the basis of review and thresholds for specific levels of individual permitting and general permits.

III-B Mining (dewatering), including the basis of review and thresholds for water use and water discharge in conjunction with mining operations.

III-C Industrial, including the basis of review for water use and water discharge in conjunction with various industrial operations.

Volume IV, Management and Storage of Surface Waters

In this volume, specific information and criteria are presented for preparation and evaluation of permit applications for management and storage of surface waters, including basis of review, South Florida Water Management District project discharge limitations, and an example design.

Volume V, Criteria Manual for Utilization of Project Works and Lands

This manual provides specific criteria for preparation and evaluation of applications for use of project works and lands, including connection to drainage works, bridge design, permissable right-of-way uses, etc.

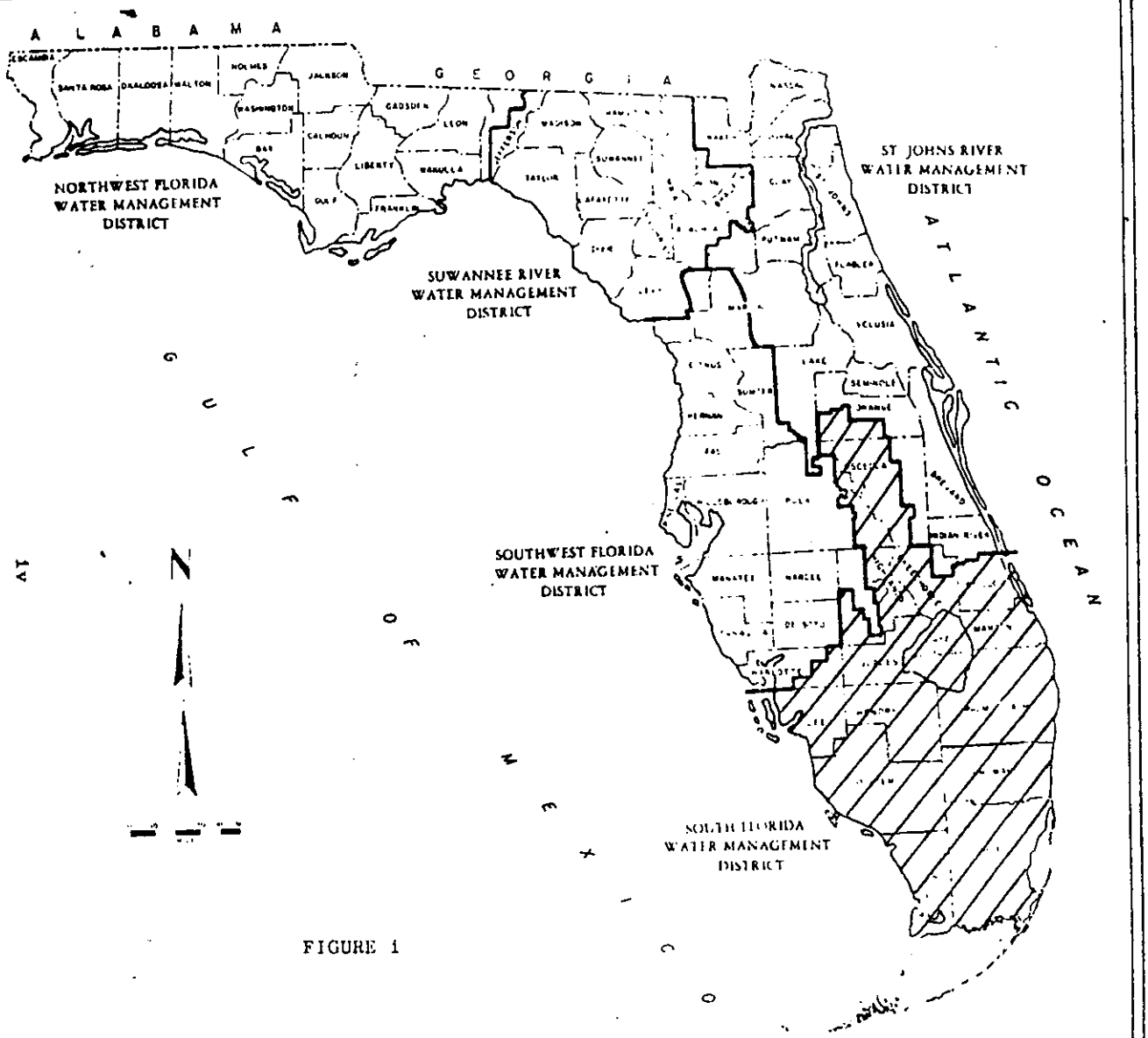


FIGURE 1

WATER MANAGEMENT DISTRICTS OF FLORIDA

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT
Route 1, Box 3100
Havana, FL 32333 1-904-487-1770

SUWANNEE RIVER WATER MANAGEMENT DISTRICT
Route 3, Box 64
Live Oak, Florida 32060 1-904-362-1001

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
Box 1429
Palatka, FL 32077 1-904-328-8321

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
5060 U.S. Highway 41 South
Brooksville, FL 33512 1-904-796-7211

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
P. O. Box V
West Palm Beach, FL 33402
Toll Free No. 1-800-432-2045
1-305-686-8800

BIG CYPRESS BASIN
P.O. Box 8325
Naples, FL 33941 1-813-775-3241

FIGURE 1

PART A

SURFACE WATER MANAGEMENT RULES

Part A - Surface Water Management Rules

I. General

A. South Florida Water Management District Authority

The Central and Southern Florida Flood Control District was created by Chapter 25270 Laws of Florida (1949) as a multicounty district for purposes of flood control and water conservation. In 1972 the Florida Legislature enacted Chapter 373, Florida Statutes, the Florida Water Resources Act of 1972 (Act), which greatly expanded the District's responsibilities from flood control to the full range of water management activities in addition to changing the name of the District.

The Act is intended to govern the regulation of all waters of the State, unless exempted by law, where waters of the state are defined to include all water on or beneath the surface of the ground or in the atmosphere.

Generally, the purposes for which the Act was adopted are to provide for management of water and related land resources, to promote the conservation, development and proper utilization of surface and groundwater, to provide water storage for beneficial purposes, to prevent damage from floods, soil erosion and excessive drainage, to preserve natural resources, fish and wildlife, and to promote recreational development.

The District is governed by a nine-member board which is responsible for the overall administration of District programs, the regulatory program implementing the Act and the development of a water use plan. The District is also divided into two basins (the Big Cypress Basin and Okeechobee Basin), which are governed by basin boards. The primary functions of the basin boards are to plan and approve construction of primary water resource development projects and to plan secondary water control facilities for guidance of local government and private local owners.

The Act provides for the establishment of permit programs for the regulation of consumptive use of water, well construction, surface water management systems, artificial recharge and utilization of works or land of the District. Except for artificial recharge, primary regulatory authority resides in the Department of Environmental Regulation with direction to delegate the authority to the water management districts to the maximum extent practicable.

Pursuant to the Administrative Procedures Act, the District has implemented all the permitting programs authorized by the Act except for Part III, the regulation of wells, by adopting rules which are published as Chapter 40E of the Florida Administrative Code.

B. Permitting Procedures

The District is governed by the Administrative Procedures Act, and Rule Chapter 40E. Together they provide an administrative framework for the resolution of conflicts between applicants, objectors and the District. Within this framework, if no objections are received and the applicant agrees with the staff's recommendations, the application can usually be disposed of informally before the Governing Board. If however, the applicant disagrees with the staff's recommendations, or someone whose substantial interest may be affected objects, a formal hearing may be held either before the Governing Board or before a hearing officer from the Department of Administrative Hearings. In either case, adequate safeguards are provided so that disputes can be resolved judiciously and expeditiously.

Upon receipt of an application for a permit, the District will request any necessary additional information from the applicant within 30 days. Upon receipt of a complete application the District will issue or deny the permit application within 90 days unless the matter has been scheduled for a public hearing.

C. Permitting of Surface Water Management Systems

1. Statutory Provisions (Part IV, Chapter 373 F.S.)

Part IV of the Act deals with surface water management. Generally permits may be required by the water management districts for construction, alteration, maintenance and operation of most real property improvements which are designed to control surface waters.

Permits issued pursuant to this part are permanent unless the surface water management system is abandoned, or the permit is otherwise revoked or modified. No permits are required under this part for a closed system as defined in F.S. 373.403(6). An applicant for a surface water management permit must show that the proposed project is consistent with the goals and policies expressed in F.S. 373.016, Declaration of Policy and F.S. 373.036, State Water Use Plan, and that the construction or alteration of the surface water management system will not be harmful to the water resources of the District, and that the operation and maintenance of the system will not be inconsistent with the overall objectives of the District or harmful to the water resources of the District.

2. Rules of the South Florida Water Management District (Chapter 40E, F.A.C.)

Chapter 40E-4 describes the permit requirements for construction, alteration, or operation of surface water management systems. Generally, all construction alteration or operation of dams, impoundments, reservoirs, appurtenant works or works as defined in the Act require a permit from the District. Closed systems and some projects in coastal areas may be exempt, however. To satisfy

the permit requirement an applicant must either receive an individual permit or qualify for a general permit. Individual permits are issued by the Governing Board upon application and compliance with Part IV of the Act and Chapter 40E, F.A.C. Specific criteria for evaluating urban projects are found in 40E-4.091. Further, additional criteria may be superimposed if the project is to be located within an area in which the District has adopted basin rules (see Chapter 40E-41 for additional criteria applicable in the Western Canal 9 Basin).

General permits have been issued by Rule for most small projects and certain types of highway construction District-wide, and for some larger projects which have received the approval of Dade County. To qualify for a general permit, an applicant needs to file the notice specified in the rules, a copy of the construction plans and some basic technical data about the project such as proposed minimum road and floor levels, proposed discharge rate, and retention/detention volume and facilities. Upon receipt of this information, the District will determine whether the project qualifies for a general permit, and/or if any additional information is needed, and respond to the applicant. Once the District has indicated in writing that a general permit is in effect for the project, no further application is required. Both individual and general permits are subject to revocation, suspension or modification in accordance with the provisions of Chapter 40E, F.A.C. and Chapter 373, F.S.

3. Permit Requirements

In terms of surface water management (generally referred to as drainage), the District currently issues individual permits for all drainage activities except the following:

(a) Certain tidal receiving water activities that are reviewed and/or permitted by numerous other agencies (reference Rule 40E-4.051, F.A.C.).

(b) Certain closed systems (reference Rule 373.406, Florida Statutes).

(c) Projects with less than forty acres of gross area which are designed in accordance with the District's "Basis of Review for Construction of Surface Water Management Systems . . . ." (reference Rule 40E-40.302(5), F.A.C.)

(d) Certain public highway projects (reference Rule 40E-40.302(6), F.A.C.)

(e) Certain projects in Dade County which have less than forty acres total land area with positive storm drainage, or have less than 320 acres total land area and less than 160 acres of impervious area with no positive storm drainage discharge outfall (reference Rule 40E-40.302(2), F.A.C.)

(f) Certain projects in Palm Beach and Collier Counties which have less than forty acres total land area (reference Rule 40E-40.302(3) and (4), F.A.C.).

Drainage activities identified in items (a) and (b) above are exempt from District permitting altogether, either by State statute or by District rule. However, the activities delineated in items (c), (d), (e) and (f) are permitted by District rule (General Permit Categories), provided such activities are conducted according to conditions specified in the appropriate rule. If these activities meet the applicable criteria, the permittee needs to file with the District a Notice of Intent to Construct Works pursuant to General Permit, a copy of the construction plans, and some basic technical data at least 60 days prior to commencement of construction. Generally, five review criteria are considered in evaluating surface water management permit applications. These include the following:

(1) Local subdivision protection criteria.
(2) Receiving water acceptance capability.
(3) One hundred year building floor protection.
(4) Potential water quality impacts.
(5) Environmental impacts.

Plans and calculations are required, sealed by a Florida Professional Engineer. When storage of surface water is proposed, stage-storage and stage-discharge calculations must be provided. In addition, when water management facilities such as lakes, pumps, etc. will not be in the public right-of-way and accepted by the local jurisdiction, evidence of a legal entity, which will be responsible for operation of the facilities, must be submitted. Some local agencies require the majority of the above information in their normal platting process.

II. Rule 40E-40

A. Justification for Rule

Sections 373.413 and 373.416 and Rule 40E-4.041 require that the District permit all surface water management systems which are encompassed within the definition of "works" as stated in 373.403(5) regardless of size or location. As a result, many small projects which, because of their size, nature or location, plus regulation by local government, and which were designed to meet District technical criteria still required an individual permit and had to be approved by the Governing Board at one of their monthly meetings. It was the District's desire to eliminate the need to await Governing Board scheduling in such situations which can be adequately handled by local government and routinely processed by District staff. To shorten the permit processing time, this rule automatically grants a permit for certian classes of small projects under specified conditions without the necessity for Governing Board scheduling.

B. Specifics of Rule

1. All works within the District which serve projects with less than 40 acres total land area, which are located on uplands and within local entities which have adopted subdivision regulations, are permitted by this rule subject to conditions.

2. All works within Dade County which have been approved by the Dade County Department of Environmental Resources Management, are permitted by this rule if they serve projects which have less than 40 acres total land area with a positive storm drainage outfall or if they serve projects which have less than 320 acres total land area and less than 160 acres of impervious area with no positive storm drainage discharge outfall.

3. All works within Palm Beach County which serve projects with less than 40 acres total land area and have been approved by Palm Beach County, are permitted by this rule.

4. All works within Collier County which serve projects with less than 40 acres total land area and have been approved by Collier County, are permitted by this rule.

5. All works within the District which serve public highway projects constructed or funded by state, federal or local government, are permitted by this rule subject to conditions and exceptions. The exceptions specified in the rule apply to projects which are likely to have an impact on the water resources of the District.

6. The applicant must notify the District 60 days in advance of construction to be permitted under this rule. Form No. RP 63, revised June 1981 Notice of Intent to Construct Works Pursuant to General Permit, (example form on next page) should be used for this purpose. Upon receipt of the notice, a set of the construction plans, and some basic technical data, the District will determine whether the project qualifies for a general permit and respond to the applicant.

NOTICE OF INTENT TO CONSTRUCT
*** WORKS PURSUANT TO GENERAL PERMIT ***
CHAPTER 40E-40

SUBMITTED TO: Governing Board of
South Florida Water Management District
Post Office Box "V"
West Palm Beach, Florida 33402

1. NAME & ADDRESS OF PERMITTEE/OWNER _____

_____

2. NAME OF THE PROPOSED PROJECT: _____

_____

3. LOCATION OF THE PROJECT (include location sketch with Section, Township and Range)

_____

4. BRIEF DESCRIPTION OF THE WORKS TO BE CONSTRUCTED OR ALTERED: _____

_____

_____

AND INCLUDE PAVING, GRADING & DRAINAGE PLANS, CALCULATIONS AND PERCOLATION TESTS IF USING EXFILTRATION SYSTEM.

5. BRIEF STATEMENT OF FACTS WHICH SHOW WHY THE PROPOSED WORKS QUALIFY FOR A GENERAL PERMIT: _____

_____

_____(Add extra sheet if necessary)

6. DATE CONSTRUCTION OR ALTERATION IS EXPECTED TO COMMENCE: _____

_____

I HEREBY CERTIFY THAT ALL NECESSARY FEDERAL, STATE, LOCAL AND SPECIAL DISTRICT AUTHORIZATIONS HAVE BEEN RECEIVED.

Permittee's Name (type or print) _____

Signature _____ Date _____

FORM RP-63
Rev. 6/81

FIGURE 2

RULES

OF THE

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

CHAPTER 40E-40

GENERAL SURFACE WATER MANAGEMENT PERMITS

40E-40.011	Policy and Purpose
40E-40.021	Definitions
40E-40.031	Implementation
40E-40.042	General Permit for Construction, Alteration or Operation of Surface Water Management Systems
40E-40.112	Notice of Intent
40E-40.141	Request for Additional Information
40E-40.302	Conditions for Issuance of Authorization
40E-40.321	Duration of Permit
40E-40.351	Revocation of Permits
40E-40.381	Limiting Conditions

40E-40.011 Policy and Purpose.

The rules in this chapter grant general permits for certain specified surface water management systems which have been determined to be not harmful to the water resources of the District and consistent with the objectives of the District. The purpose of this chapter is to set forth the requirements for qualifying for a general permit and the conditions under which it may be exercised. Non-exempt surface water management systems not qualifying for a general permit under this chapter are required to obtain individual permits. The District reserves the right to require an individual permit for any surface water management system which does not comply with the provisions of this chapter or which is harmful to the water resources of the District, interferes with the legal rights of others, is inconsistent with the overall objectives of the District, or is otherwise contrary to the public interest.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.103(4), 373.413(1), 373.416, 373.419, 373.429 F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1)(d), 16K-4.022(1)(e).

40E-40.021 Definitions.

As used in this chapter:
(1) "Public highway project" means a road and associated facilities located within a right of way dedicated to the public for highway purposes, which are constructed, altered, operated, maintained or funded by the United States, the State of Florida, a county, or municipality.
(2) "Total land area" means land holdings under common ownership which are contiguous or served by common surface water management facilities.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.103(1), 373.413, 373.416, 373.419 F.S.
History--New, 9-3-81.

40E-40.031 Implementation.

(1) This rule specifies the effective dates for the general surface water management permits granted in this chapter.
(2) If the surface water management system meets the conditions of rule 40E-40.302, the effective date is July 15, 1981.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.103(1), 373.416, 373.419 F.S.
History--New, 9-3-81.

40E-40.042 General Permit for Construction, Alteration or Operation of Surface Water Management Systems.

(1) All persons constructing, altering, operating or maintaining surface water management systems who are not exempt under rule 40E-4.051 and who meet the conditions specified in rule 40E-40.302, are authorized to construct, alter, operate or maintain the surface water management system subject to the requirements of this chapter.

(2) No construction, alteration, operation or maintenance shall be commenced until the permittee receives a written authorization to proceed from the District.

(3) The District shall issue the authorization to proceed within 60 days from the receipt of a complete Notice of Intent and all requested additional information.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 120.60(2), 373.103(4), 373.416, 373.419 F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1), 16K-4.022(1)

40E-40.112 Notice of Intent.

At least 60 days prior to the commencement of any construction or alteration of a surface water management system authorized in rule 40E-40.042, the permittee shall file with the District, a written Notice of Intent to Construct Works Pursuant to General Permit. The notice shall include the following information:

(1) the permittee's name and address;

(2) a description of the proposed project, including its location;

(3) a description of the surface water management system to be constructed or altered;

(4) a statement of facts which show why the proposed surface water management system qualifies for a general permit;

(5) a statement that all necessary Federal, State, local and special district criteria have been met and that the project is acceptable to the elected officials of the pertinent local jurisdiction as being in the public interest with respect to environmental and economic impacts;

(6) the date on which construction or alteration is expected to commence;

(7) a copy of the paving, grading and drainage plans,

(8) the name and address of the proposed operational entity, and;

(9) such other information as is reasonably necessary for the staff to determine that the surface water management system meets the conditions of this chapter including any information required in rule 40E-4.101.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.103(1), 373.416, 373.419 F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1)(c), 16K-4.022(1)(d)

40E-40.141 Request for Additional Information.

(1) If the information provided in the Notice of Intent required by rule 40E-40.112 is not sufficient to determine whether the construction, alteration, operation or maintenance of the surface water management system qualifies for a general permit under rule 40E-40.302, or meets the conditions in rule 40E-40.381, the District may request the permittee to submit additional information, including any information required in rule 40E-4.101.

(2) If additional information is required it shall be requested within 30 days of receipt of the Notice of Intent.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 120.60(2), 373.416, 373.419 F.S.
History--New, 9-3-81.

40E-40.302 Conditions for Issuance of Authorization.

In order to qualify for a general permit under this chapter, the permittee must give reasonable assurances that the surface water management system meets all conditions of subsection (1) and all thresholds and conditions of at least one other subsection.

(1) General Conditions.

(a) The surface water management system design plans must be signed and sealed by a Florida registered Professional Engineer, if required by chapter 471, Florida Statutes.

(b) The surface water management system must meet the criteria specified in rule 40E-4.301 and applicable local requirements.

(c) The project must not be located in natural water bodies or viable wetlands habitat.

(d) The project must not be located in an area governed by chapter 40E-41.

(e) The permittee must have obtained a right of way occupancy permit from the District if the project proposes to connect with, place structures in or across or otherwise make use of works of the District.

(2) Thresholds and Additional Conditions Within Dade County.

(a) The project must have less than 40 acres total land area with positive stormwater outfall or less than 320 acres total land area and less than 160 acres of impervious area with no positive stormwater outfall.

(b) The project and surface water management system must have been approved by the Dade County Department of Environmental Resources Management or its successor agency subsequent to October 2, 1977.

(3) Thresholds and Additional Conditions Within Palm Beach County.

(a) The project must have less than 40 acres total land area.

(b) The project and surface water management system must have been approved by Palm Beach County subsequent to October 2, 1977.

(4) Thresholds and Additional Conditions Within Collier County.

(a) The project must have less than 40 acres total land area.

(b) The project and surface water management system must have been approved by Collier County subsequent to September 17, 1980.

(5) Thresholds and Additional Conditions Within the Remainder of the District.

(a) The project must have less than 40 acres total land area.

(b) The project and surface water management system must have been approved by the appropriate unit of local government subsequent to the effective date of this rule.

(6) Additional Conditions for Surface Water Management Systems Associated with Public Highway Projects.

(a) The public highway project must be located within a right of way dedicated to the public for highway purposes.

(b) The public highway project must not:

1. Be exempt from Florida Department of Environmental Regulation jurisdiction;

2. Drain lands outside the jurisdiction of the constructing or funding public body;

3. Lower or have the potential for lowering the dry season groundwater table outside the project's design drainage area; and

4. Interfere with natural drainage patterns or flows.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.416, 373.419 F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1)(a),(2),
16K-4.022(1)(a),(b)

40E-40.321 Duration of Permit.

Unless revoked or otherwise modified, the duration of the general permit authorized in rule 40E-40.042 is:

(1) 3 years, for construction or alteration of a surface water management system;

(2) perpetual, for operation and maintenance of a surface water management system.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.416, 373.419(2) F.S.
History--New, 9-3-81.

40E-40.351 Revocation of Permits.

Violations of this chapter may result in the revocation or suspension of the authorization in whole or part in accordance with the provisions of section 373.429, and chapter 120, Florida Statutes, and rule 40E-1.609.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 120.60(6), 373.429 F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1)(e), 16K-4.022(1)(f)

40E-40.381 Limiting Conditions.

The general permits authorized in this chapter shall be subject to the following limiting conditions:

(1) The limiting conditions of rule 40E-4.381 shall apply.

(2) The general permit shall be subject to other reasonable conditions as are necessary to assure that the permitted works will not be inconsistent with the overall objectives of the District and will not be harmful to the water resources of the District.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.117, 373.416, 373.419, F.S.
History--New, 9-3-81.
Formerly 16K-4.021(1)(b), 16K-4.022(1)(c).

III. Rule 40E-41

A. Justification for Rule

The Western Canal 9 Basin has in the past been subject to periods of extensive flooding during moderate storm events and to severe over-drainage during dry seasons. The area has not been heavily developed to date, but development pressure is increasing and it is likely that any new development will create flooding problems in the eastern basin, as well as aggravating the overdrainage and flooding already existent in the western basin.

In addition to the criteria for surface water management systems already in effect throughout the District, additional restrictions are necessary in the Western Canal 9 Basin because of the unique water management regime in that area as described above. This rule will preserve the existing flood protection in the Eastern Canal 9 Basin, prevent over-drainage of the Western Basin, while giving a degree of flood protection to the western developments.

B. Specifics of Rule

1. The District's General Permit Rule 40E-40.042 is not applicable in the Western Canal 9 Basin.

2. This rule establishes for design purposes the 10-year, 25-year and 100-year flood frequency elevations as 6.5 feet, 6.8 feet, and 7.3 feet mean sea level, respectively, in the basin.

3. For diked and pumped systems, the allowable discharge is limited by this rule to three-fourths of an inch per twenty-four hours and no pumping is permitted when Canal 9 stages exceed elevation 6.8 feet mean sea level.

4. All direct connections to Canal 9 must be installed at a discharge elevation no lower than six inches below average existing ground for the project. However, discharge facilities designed to temporarily lower the groundwater table below these elevations immediately prior to the arrival of a major storm event are allowed by this rule.

5. This rule restricts the volume encroached by development between average existing ground surface and elevation 7.0 feet mean sea level to 2.0 feet times the total area of the property. The rule restricts diked areas such that the area diked must be less than this encroached volume divided by the difference between average existing ground elevation within the dike and elevation 5.75 feet mean sea level.

RULES

OF THE

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

CHAPTER 40E-41

SURFACE WATER MANAGEMENT BASIN CRITERIA

40E-41.011 Policy and Purpose
40E-41.023 Western Canal 9 Basin Boundary
40E-41.033 Implementation
40E-41.043 Application of Part
40E-41.053 Exemptions
40E-41.063 Conditions for Issuance of Permits in the Western Canal 9 Basin

40E-41.011 Policy and Purpose.

The rules in this part establish additional surface water management criteria for the Western Canal 9 Basin which insure that development within the basin incorporates the appropriate water quantity and water quality control measures necessary to protect the integrity of the public investments in the basin and which minimizes adverse impacts to the water resources of the District. Criteria delineated in this chapter are in addition to criteria specified in chapter 40E-4. The criteria, exemptions and additional requirements specified in this part are not intended to supercede or rescind the terms and conditions of any valid surface water management permit issued by the District prior to the effective date of this part. Chapter 40E-40 shall not be effective within the Western Canal 9 Basin.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416 F.S.
History--New, 9-3-81.
Formerly 16K-34.01

40E-41.023 Western Canal 9 Basin Boundary.

The Western Canal 9 Basin is generally depicted in Figure 41-1, and specifically shall include the area within the following boundaries: In Dade and Broward Counties, Florida, as follows:

BEGINNING at the Southeast corner of Section 12, Township 52 South, Range 40 East; Thence, bear Westerly along the Section Lines to the intersection thereof with State Road No. 25; Thence, Northwesterly and Northerly along State Road No. 25 to the intersection thereof with State Road No. 820; Thence, Easterly along State Road No. 820 to the intersection thereof with the East line of Section 14, Township 51 South, Range 40 East; Thence, Southerly along the Section Lines to the Northwest corner of Section 1, Township 52 South, Range 40 East; Thence, Easterly along the Section Line to the Northeast corner of said Section 1; Thence, Southerly along the Section Lines to the Southeast corner of said Section 12 to the POINT OF BEGINNING.

Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416 F.S.
History--New, 9-3-81.
Formerly 16K-34.02

40E-41.033 Implementation.

The effective date this part is October 2, 1977.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416 F.S.
History--New, 9-3-81.
Formerly 16K-34.03

40E-41.043 Application of Part.

All projects located within the Western Canal 9 Basin requiring permits pursuant to rule 40E-4.041 shall be constructed, altered, operated maintained and abandoned in accordance with the criteria specified in rules 40E-4.301 and 40E-41.063 unless specifically exempted in rules 40E-4.051 or 40E-41.053. The most restrictive criteria will be applicable unless the applicant can demonstrate to the District's satisfaction through accepted methodology that the purpose and

intent of this part will be fulfilled using alternate criteria.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416, 373.426 F.S.
History--New, 9-3-81.
Formerly 16K-34.04

40E-41.053 Exemptions.

Projects which have received final approval of construction plans, or equivalent approval, from local government prior to the effective date of this part are hereby exempt from the fill encroachment criteria specified in subsection 40E-41.063(4). All other criteria specified in rules 40E-4.301 and 40E-41.063 must be strictly met.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416 F.S.
History--New, 9-3-81.
Formerly 16K-34.05

40E-41.063 Conditions for Issuance of Permits in the Western Canal 9 Basin.

(1) For design purposes the 100-year, 25-year and 10-year flood frequency elevations are established as 7.3 feet, 6.8 feet and 6.5 feet mean sea level, respectively.

(2) For systems designed to be pumped from fully diked areas, discharge shall be limited to three-fourths of an inch per twenty-four hours, or the criteria in rule 40E-4.301 whichever is more restrictive. In addition, no pumping shall be permitted when Canal 9 stages at pump tailwater exceed the 25-year peak elevation of 6.8 feet mean sea level.

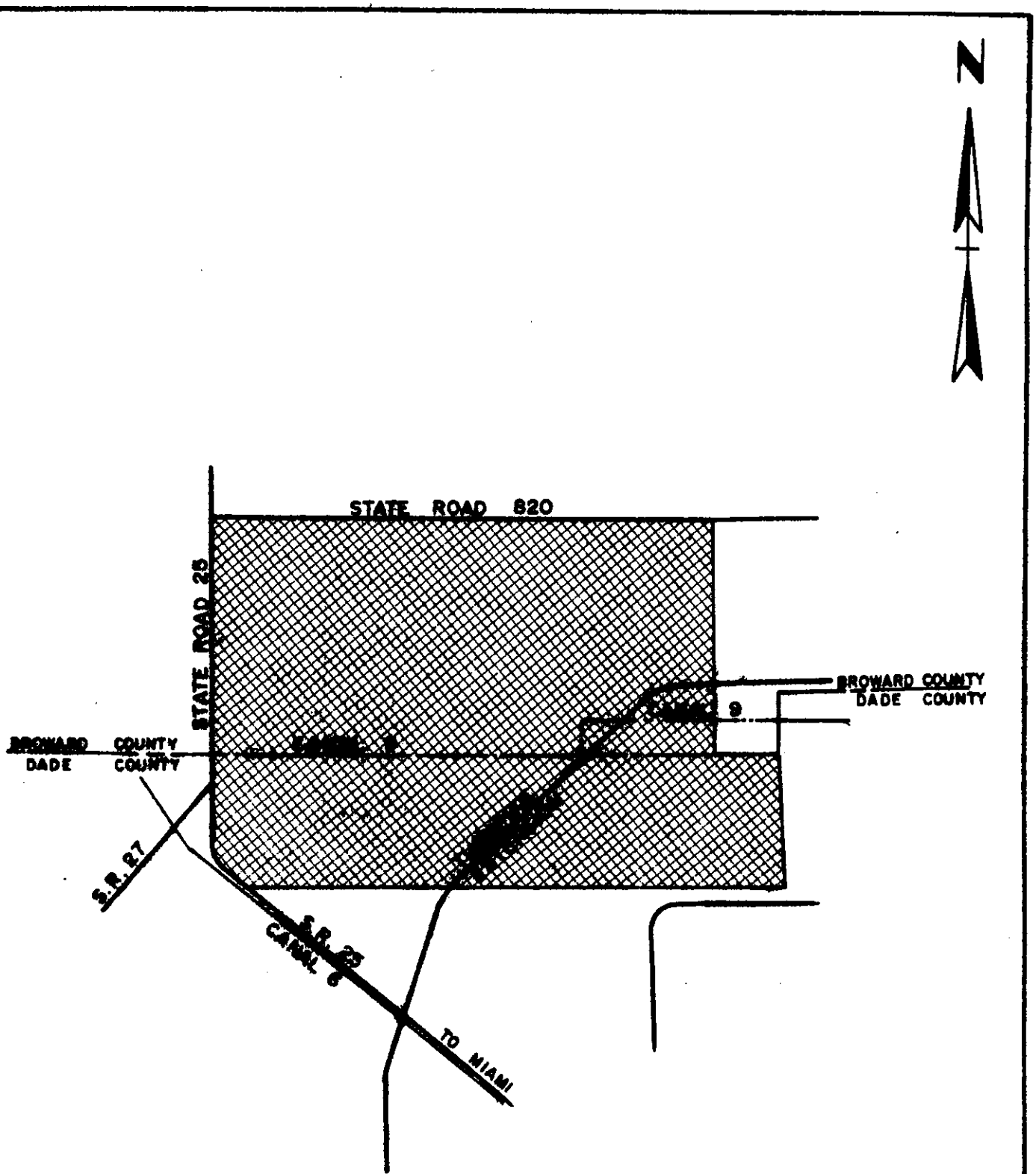
(3) All direct connections to Canal 9 shall be designed to prevent lowering of the groundwater table below elevation 2.5 feet mean sea level. All indirect connections to Canal 9 shall be designed toprevent lowering of the groundwater table by installing the discharge facilities at a discharge elevation no lower than six inches below average existing ground elevation for the project. Nothingin this subsection shall be construed to preclude the construction and operation of discharge facilities designed to temporarily lower the groundwater table below these elevations immediately prior to the arrival of a major storm event.

(4) Fill encroachment criteria

(a) The volume encroached by development between average existing ground surface and elevation 7.0 feet mean sea level shall not exceed 2.0 feet times the total area of the property.

(b) For diked areas with on-site retention of runoff, the area diked shall not exceed the encroachment volume specified in paragraph (a) divided by the difference between average existing ground elevation within the dike and elevation 5.75 feet mean sea level. This will require all such projects on land of average elevation less than 3.75 feet mean sea level to preserve some area outside of the dikes with no fill. The preserved area shall be located so as to preserve natural basin flow patterns for lands outside the dikes.

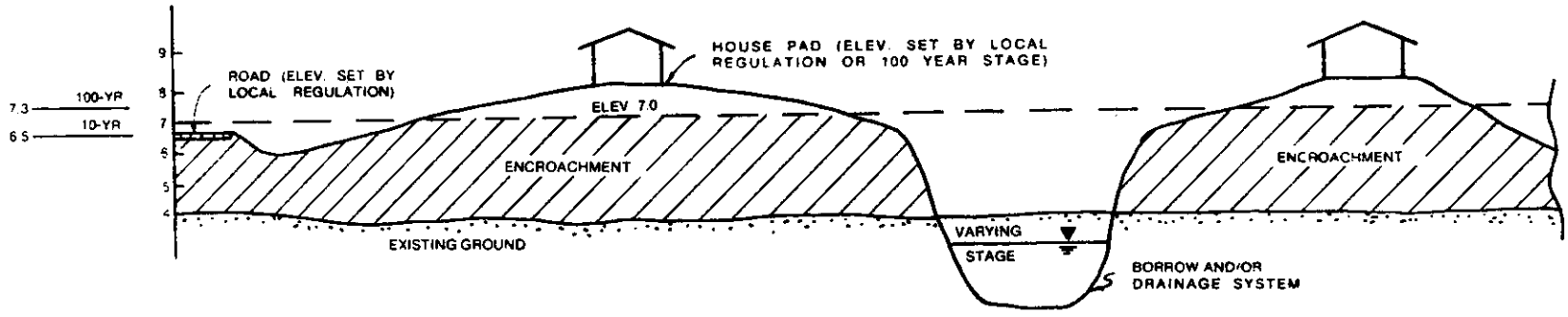
(c) Typical development schemes using these criteria are depicted in Figure 41-2.
Specific Authority 373.044, 373.113 F.S.
Law Implemented 373.413, 373.416 F.S.
History--New, 9-3-81.
Formerly 16K-34.06



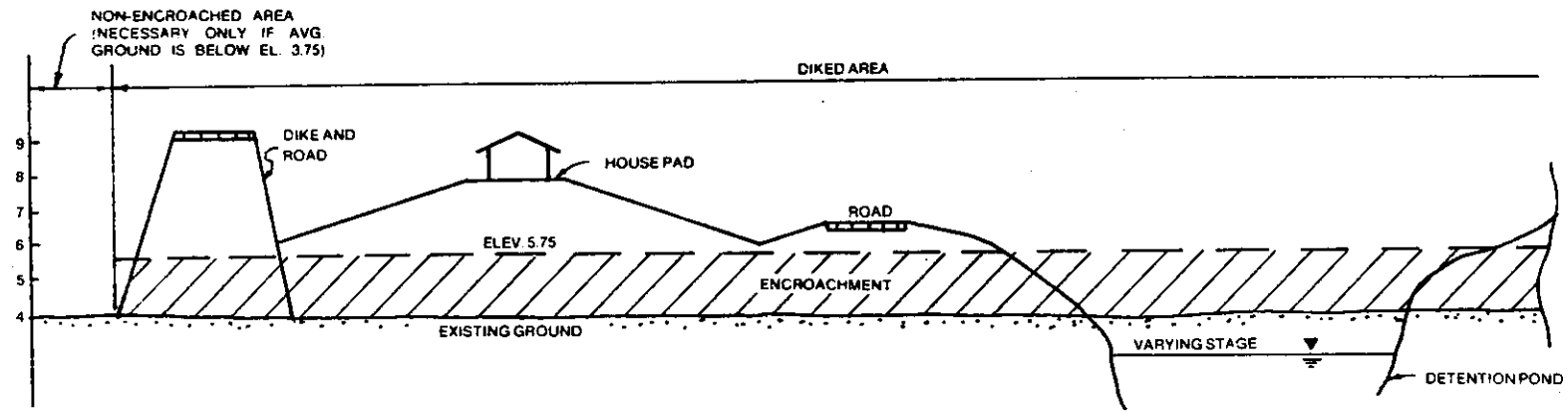
WESTERN CANAL 9 BASIN BOUNDARY

Figure (41-1)

FIGURE 3



GRAVITY DRAINAGE SYSTEM



PUMPED RETENTION SYSTEM

Figure 4 TYPICAL DEVELOPMENT SCHEMES

South Florida

Water Management District

BASIS OF REVIEW OF CONSTRUCTION OF SURFACE WATER MANAGEMENT SYSTEMS SERVING PROJECTS WITH TWO OR MORE ACRES OF IMPERVIOUS AREA WITHIN THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

FINAL - adopted by Governing Board
7/10/80

ADOPTED BY THE GOVERNING BOARD OF THE

SOUTH FLORIDA WATER MANAGEMENT DISTRICT ON DECEMBER 15, 1977

REVISED AUG., 1980

IV. Rule 40E-4.091

Section 373.413 F.S. and Rule 40E-4.041 F.A.C. require that the District permit the construction of all surface water management systems which are encompassed within the definition of "works" as stated in 373.403(5). The District may impose necessary reasonable conditions to the permits to assure that such construction will not be harmful to the water resources of the District. To implement this provision, the District has developed criteria and procedures for review of the design and construction of works serving projects which have two or more acres of impervious area. The general and specific criteria and procedures are designed to ensure that such projects are developed in accordance with the District's statutory obligations, and are contained in the District's "Basis of Review of Construction of Surface Water Management Systems Serving Projects With Two or More Acres of Impervious Area Within the South Florida Water Management District," which has been adopted by the Governing Board. This rule publishes the above titled document by reference and provides that pertinent projects will be reviewed in accordance therewith.

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OBJECTIVES

Under Part IV of Chapter 373, Florida Statutes, and Rule Chapter 40E-4 the District is responsible for the permitting of construction of surface water management systems within its jurisdictional boundaries. The intent of this document is to set forth in clear and understandable terms, the criteria and requirements that will be applied in reviewing applications for certain specific types of surface water management systems. An effort has been made to eliminate needless duplication and to take into account applicable local criteria to avoid unnecessary conflicts of jurisdiction.

The following information is presented as the basis of review for the construction of surface water management systems which serve projects with two or more acres of impervious area and for which either no more restrictive local criteria apply or for which no acceptable additional or conflicting information is available. If applicable local criteria are more restrictive than the District's criteria indicated herein, the local criteria shall be applied in the District's review. Although the content herein is specific in many instances, it is intended that the achievement of the stated objectives of proper water management are primary, with solutions not limited to those achieved by use of this document. Should the Applicant desire that his design be reviewed on a basis differing from that described herein, such desire shall be discussed with the Staff prior to submission of the Application. The Staff shall respond to such requests in writing within a reasonable time and may make recommendations to the Governing Board that it accept or reject the proposed alternate basis of review for a particular project when the application is presented to the Governing Board.

The basic objectives of the District are to insure that the Applicant's system will not be harmful to the water resources of the District and is consistent with the public interest. This means that the system should function consistently with the environment and fulfill its intended purpose. Means of satisfying these ends include maintenance of satisfactory water quality, flood protection, drainage and water conservation.

Because prevention of, rather than solutions to, problems is more feasibly and realistically handled, the District considers new projects primarily from the point of view of problem prevention. Contingencies in the state-of-the-art require that a mechanism exist for problem solution when prevention is not always possible. Thus, the District assumes that there will always be a Permittee who will be legally responsible for the system. Where the responsibility is not totally clear, a condition of the Permit will be the requirement for the establishment of a legally responsible entity. The District objective is therefore projected into the future in this manner.

Aside from purely technical aspects, legal and institutional factors must also be considered. Because of legal time constraints for processing permits, it is advisable for the Applicant to contact other interested agencies, organizations, and affected citizens prior to submitting a formal application to the District. Summaries of meetings and copies of responses from appropriate parties should be included in the Application.

It may be in the Applicant's best interest to seek concurrent approvals from all agencies with jurisdiction. Thus, this provision is not intended to preclude the submission of an application to this District prior to receiving other necessary approvals, but, the Application should contain at least a status report on other approvals being sought, with an indication that the surface water management portion of the project will be approved by other pertinent jurisdictions.

DEFINITIONS

"Conceptual Approval" - letter of approval of a surface water management system in concept, authorized for issuance by the District Board. No construction is authorized thereby, unless otherwise specifically permitted, and the approval becomes void after two years from date of authorization if no applications for permit are made for any portions of the project area.

"Construction Permit" - surface water management permit issued by the District to an applicant, who has the legal ability to perform, for construction of surface water management facilities in accordance with the Application, Staff Report and Permit Conditions.

"Control device" - element of a discharge structure which allows the gradual release of water under controlled conditions. The lowest elevation at which water can be released through the device is the control elevation.

"Control elevation" - design elevation of a discharge structure at which, or below which, water is contained behind the structure.

"Detention" - the delay of storm runoff prior to discharge into receiving waters.

"Detention volume" - the volume of water equal to the difference between the overflow elevation and control elevation of a discharge structure times the area of open surface storage (at the control elevation) behind the discharge structure.

"Discharge structure" - structural device, usually of concrete, metal, timber, etc., through which water is discharged from a project to the receiving water.

"Elevation" - height in feet above mean sea level according to National Geodetic Vertical Datum (NGVD).

"Impervious" - land surfaces which do not allow, or minimally allow, the penetration of water; included as examples are building roofs, normal concrete and asphalt pavements, and some fine grained soils such as clays.

"Operation Permit" - surface water management permit issued by the District to an entity, which has the legal ability to perform, for operation of surface water management facilities in accordance with the Application, Staff Report and Permit Conditions.

"Overflow elevation" - design elevation of a discharge structure at which, or below which, water is contained behind the structure, except for that which leaks out, or bleeds out, through a control device down to the control elevation.

"Retention" - the prevention of storm runoff from direct discharge into receiving waters; included as examples are systems which discharge through percolation, exfiltration, and evaporation processes.

"Retention/detention area (dry)" - water storage area with bottom elevation at least one foot above the control elevation of the area.

"Retention/detention area (wet)" - water storage area with bottom elevation lower than one foot above the control elevation of the area.

"Staff Report" - written report by the District Staff advising the Board of its conclusions and recommendations based on review of the Application. The description of the project in the Staff Report shall take precedence over application data in the District files, since numerous project changes are often made by applicants during application processing, the results of which may show up only in the staff report.

"Wetlands" - areas that are inundated by surface or ground water with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds [Ref: Executive Order 11990, 42 Fed. Reg. 26961 (1977)].

PLANNING AND DESIGN

I. Design Frequency

A. Definition - flood frequency will normally be assumed to result from rainfall of the same frequency. Areas subject to flooding from rising water as well as storm rainfall should be considered for the combination of events giving the more critical condition such as:

1. Design frequency rainfall with average wet season stage or spring tide stage, if applicable.
2. Mean year rainfall (2.33 year frequency) with design frequency flood stage in receiving waters, either tidal or non-tidal.

B. Local jurisdiction criteria - internal drainage systems will be reviewed on the basis of their ability to offer protection (usually of roads) in accordance with criteria of the local jurisdiction as normally published in subdivision regulations.

C. District criteria - drainage systems will be reviewed for the ability of the system to function in conjunction with receiving waters of the District at the respective design frequency of the District facilities.

D. Flood insurance criteria - building floor elevations will be reviewed on the basis of the 100 year frequency flood event, both tidal and from the occurrence of the 100 year, 3 day rainfall event. The Flood Insurance Rate Map (FIRM) will be utilized as one criterion for establishing floor elevations, except in Lee County until such time as the FIRM maps are adopted therein.

E. Receiving waters without discharge criteria will be reviewed on the basis of peak discharge and downstream peak flood stage and duration after development not exceeding peak discharge and downstream peak flood stage and duration before development consistent with maintenance of minimum flows if applicable, at the following frequency:

1. Areas less than one square mile - 10 year frequency.

2. Areas equal to or larger than one square mile - 25 year frequency.

F. Base flows and low flows from the developed site should be maintained equivalent to the historic conditions with a five year frequency drought condition being the most extreme event which must normally be considered. Base flows and low flows will usually cease for some more severe drought condition.

G. Flood plain encroachment - encroachment into the natural floodplain, resulting from the 100 year storm event, will be allowed only to the extent that existing construction will not be subjected to additional damaging flood impacts as a result of the encroachment. In riverine flood plains, where existing construction is not a consideration, the following shall apply:

(1) No net encroachment, which would adversely affect the rights of others, will be allowed in any cross section of the flood plain resulting from the 25 year rainfall event.

(2) Encroachment within any cross section of the flood plain, resulting from the 100 year rainfall event, will be allowed only to the extent that the stage not be increased by more than one foot.

(3) In areas affected by such encroachment, building floor elevations shall be set at or above the 100 year elevation resulting from the encroachment.

(4) The net retardance effect of existing features within the 100 year floodplain, except within the channel itself, shall not be reduced.

Other methods of achieving the above intent may be proposed and will be considered.

II. Rainfall

A. Frequency - depth and intensity reference sources include:

1. U.S. Weather Bureau Technical Paper No. 49, "Two-to-Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States" (1964); U.S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States for Duration from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years" (1961); or U.S. Department of Agriculture, Soil Conservation Service, "Rainfall Frequency Atlas of Alabama, Florida, Georgia and South Carolina for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years" (1973).

2. Florida State Road Department,"Drainage Manual" (Second Edition, revised 1978).

3. Actual gage data analyzed by accepted statistical methods.

(Note: Additional reference sources are in preparation both at the federal and District levels, so continuing announcements by the District may ensue.)

B. Duration - 3 Day Storm - design discharge and building floor
1 Day Storm - roads (if unspecified by local government)

If the Applicant is in doubt as to the duration storm he should use in his calculations for a particular project, for such reasons as conflicting jurisdictional requirements, he should contact the Staff of the District prior to submitting an application. The Staff will respond to the inquiry in writing within a reasonable time thereafter.

C. Distribution - the actual distribution of rainfall within a period should be consistent with the design duration. The arrangement of daily rainfall should be for a most critical response. The maximum one day event should be preceded by at least the second heaviest rainfall day. A uniform rainfall rate is not reasonable for the type of analysis seeking peak discharge.

A general distribution such as the SCS Type II (see U.S. Department of Agriculture, Soil Conservation Service Technical Paper No. 149, "A Method for Estimating Volume and Rate of Runoff in Small Watersheds"-1973), or a locally derived distribution is to be used.

A distribution may be used as follows:

Time (hours)	Cumulative Percentage of Peak One Day Rainfall	
0	0	
24	14.6	
48	35.9	
58	57.2	100% One Day Rainfall
59	62.8	
59.5	67.8	
59.75	82.8	
60	101.5	
60.5	108.8	
61	112.6	
62	117.7	
72	135.9	

III. Water Quantity Computations

A. Checklist for Drainage Projects - the attached checklist (Appendix 1), if complied with, will normally furnish the information required for review. Additionally, it is required that all engineering plans and calculations bear the seal of a State of Florida registered Professional Engineer, subject to the exemptions specified in Chapter 471, Florida Statutes.

B. Phased Projects - projects that are to be developed in phases will normally require the submission of a master plan of the Applicant's contiguous land holdings. The primary interest of the District is to insure continuity between phases, satisfactory completeness of individual phases should the project be incomplete as planned, and preservation of adjacent property owners' rights. This includes adjacent property owners created by the sale of incomplete phases.

Normally, an Application for Conceptual Approval of the total master plan must be submitted first. An Application for construction approval of the first phase may also be included as a part of the initial Application. As the Permittee desires to construct additional phases, these approvals would be included as modifications to the original Permit.

Applications for individual project phases, where no Conceptual Approval has been sought, may be considered only when the phases are totally independent of, or make sufficient provisions for, adjacent lands.

C. Antecedent Conditions - for groundwater and surface water stages antecedent to the design event, the average wet season water table and stage should be used. For artificially maintained on-site stages the Applicant should demonstrate the feasibility of creating a stage lower than the normal wet season water table. It will normally be necessary for the Applicant to demonstrate that soils or discharge structures possess the ability to draw storage stages down, preceding the design event, such that initial storage is available in the system.

D. Infiltration and Percolation

1. Ground surface - Ground surface infiltration will be reviewed on the basis of commonly accepted procedures such as those of Soil Conservation Service (see, U.S. Department of Agriculture, Soil Conservation Service Technical Paper No. 149, "A Method for Estimating Volume and Rate of Runoff in Small Watersheds" (1973), and U.S. Department of Agriculture, Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds" (1975); or Rational Method (see, Florida State Road Department, "Drainage Manual" (2nd Edition, rev. 1978)); or standard Civil Engineering textbooks),unless test data are submitted to justify other procedures.

2. Subsurface - Subsurface exfiltration will be reviewed only on the basis of representative or actual test data submitted by the Applicant. Tests should be consistent as to elevation, location, soils, etc. with the system design to which the test data will be applied. The Dade County Department of Environmental Resource Management and Florida Department of Transportation are suggested as reference sources to Applicants for test procedures and design and maintenance performance of subsurface exfiltration systems.

   The following procedure may be used in the design of surface water management systems utilizing underground exfiltration systems such as French Drains, etc.

   a. Systems should preferably have an overflow to a positive system with a control device, if necessary, between the exfiltration system and the outfall pipe. The overflow or control device should be sized for the allowable discharge. Based on the geometric properties of an exfiltration system, the length of the system may be determined as follows, unless other methods having scientific validity or local jurisdictional approval are utilized:

$$L = \frac{18{,}150\ C\ A}{W(10\ h + H)}$$

where, L = Length of system (feet)
C = Runoff coefficient (rational method)
A = Contributing area (acres)
W = Trench width (feet)
h = Average drop per minute in open hole exfiltration test data (inches)
H = Non-saturated trench depth (feet)

b. Based on the geometric properties, the length of exfiltration systems without overflows may be determined as follows, unless other methods having scientific validity or local jurisdictional approval are utilized:

$$L = \frac{7260CAR}{W(10\ h + H)}$$

where all terms are the same as in item "a" plus:

R = one hour rainfall to meet local jurisdictional frequency criteria (inches).

E. Evapotranspiration - amounts can be estimated as follows:

1. Groundwater depth 0 to 1' - 0.3" ET/day
2. Groundwater depth 1' to 2.5' - 0.2" ET/day
3. Groundwater depth 2.5' to 4' - 0.1" ET/day
4. Groundwater depth below 4' - 0"ET/day

F. Storage

1. Open surface storage - if open surface storage is to be considered in the review, the Applicant should submit stage storage computations. If open surface storage plus discharge is to be considered, the stage discharge computations should also be submitted. Actual rather than allowable discharges should be used in routing. Often for the more extreme events, such as 100 year frequency, discharge should be ignored because the high tail water stage in the receiving water effectively prevents any but a negligible discharge. In such cases a mass accounting of on-site water will suffice, if adjacent areas can safely be ignored.

2. Ground - the Soil Conservation Service has made the following estimate of soil storage capability for the normal sandy soils found within the District in their average natural state:

Depth to Water Table	Cumulative Water Storage
1'	0.6"
2'	2.5"
3'	6.6"
4'	10.9"

For the same sandy soils which have been compacted intentionally or incidental to earthwork operations, the cumulative storage should be reduced 25 percent.

Groundwater storage beneath impervious surfaces generally appears impractical to any great degree because of the trapped air which water cannot displace.

3. Side slopes - for purposes of public safety and maintenance, all wet retention/detention areas should have side slopes no steeper than 4:1 (horizontal:vertical) out to a depth of two feet below the control elevation.

4. Set-back requirements - all water bodies utilized as integral parts of the drainage system will be subject to the following setback requirements from District facilities (except for the actual connections to District canals). Requests for variances from these requirements should be submitted to the District when the application is filed. All such requests will be reviewed by the staff of all relevant departments within the District.

   a. For excavations adjacent to District canals, the top of the excavation shall be a minimum distance of 10d feet from the District canal right-of-way line, or (10d + 50) feet from the District canal top of cut, whichever produces the greater setback (d equals depth of excavation).

   b. For all excavations adjacent to Water Conservation Area levees the set-back from the adjacent right-of-way line of the District levee/borrow canal to the top of the excavation shall be computed as in "a" above, but shall not be less than 500 feet.

G. Runoff - the usual methods of computation are as follows:

1. Rainfall minus losses and storage.

2. Soil Conservation Service (see, U.S. Department of Agriculture, Soil Conservation Service, "National Engineering Handbook, Section 4, Hydrology" - 1972), with extra attention to hydrologic accounting of water table conditions.

3. Rational Method, for systems serving projects of less than 10 acres total land area. (see, Florida State Department of Transportation, "Drainage Manual" (2d Edition, revised 1978); or standard Civil Engineering texts.)

H. Receiving Water Stage

1. Regulated systems - design and maintained stage elevations should be available either from the local jurisdiction or the District. Stages for frequencies other than the design will be estimated by the District upon request from the Applicant.

2. Non-regulated systems - the Applicant should compute receiving water stages for such systems from the best available data and submit the results to the District for review and concurrence before utilizing such results in further computations.

3. Any system - variable tailwater stages should be considered if they have a significant influence on the design.

I. Discharge

1. Regulated systems - allowable discharges into District works and the Lake Worth Drainage District works are available from the District on request. Some flexibility exists in the values because of nonconcurrent peaks, but the preparation of the values has given consideration to some nonconcurrent peaks as well as areal reductions for non-uniform events, so the values should generally be adhered to in systems design.

2. Non-regulated systems - non-regulated systems are reviewed as discussed herein under design frequency for receiving waters without limiting criteria.

3. Allowable discharges - peak discharge, for purposes of meeting maximum allowable discharges, may normally be computed as the maximum average discharge over a time period equal to the time of concentration of the contributory area. Time of concentration, if not computed by more exact methods, may also be assumed as:

$$Tc = 2A^{\frac{1}{2}}$$

where, Tc = Time of concentration (hours)

A = Contributory area (square miles)

4. Minimums - systems shall possess the calculated ability to discharge by surface flow or subsurface percolation at least 3/8 inches per day during or subsequent to a storm of the design frequency, so that lowering of the ground water table to a depth of 2.5 feet below the ground surface will occur in 12 days or less.

5. Non-urban gravity systems - rural gravity systems are generally reviewed on the basis of the discharge culvert operating at a fixed head loss to meet the allowable discharge rate. This basis is justified by the estimate that the upstream headwater generated by rural runoff will be unable to collect at the upstream culvert end appreciably faster than the rate at which the receiving water rises. The fixed head loss amounts are 0.5' except in South Dade County (south of Canal C-2) where the value is 0.2'.

J. Discharge Structure Construction

1. All design discharges shall be made through structural discharge facilities. Earth berms shall be used only to disperse or collect sheet flows from or to ditches, swales, etc. served by discharge structures.

2. Discharge structures shall be fixed so that discharge cannot be made below the control elevation, except that emergency devices may be installed with secure locking devices. Either the District or an acceptable governmental agency shall keep the keys for any such devices.

3. Non-operable discharge structures shall be constructed so that they are just that.

4. Discharge structures should include gratings for safety and maintenance purposes. The use of trash collection screens is desirable.

K. Water Conservation - although drainage systems are usually designed primarily for the disposal of extreme event storm runoff, considerations for water conservation are necessary if these systems are to function as water management systems. Conservation is most critical where the primary canal system or other receiving water discharges directly into saline bodies of water making such discharges of fresh water irretrievable. Therefore, the surface water management facilities should be designed to operate so as to not hold groundwater levels lower than 6 feet below the highest natural ground elevation in the area served by the facility. For example, invert elevations of culverts and other works can be placed high enough so as not to facilitate groundwater drainage below the accepted level.

L. Models - the use of proven models in the design of surface water management systems is acceptable to the District. The choice of models utilized will be left to the Applicant; however, the Applicant will be required to provide data on model calibration and to substantiate that such data are transferable to the site in question.

IV. Water Quality - System Design Requirements

A. Retention/Detention Design Criteria - retention and/or detention in the overall system, including swales, lakes, canals, greenways, etc., shall be provided for one of the three following criteria or equivalent combinations thereof (Note: Appendix 2 may be utilized where appropriate.):

1. Wet detention volume shall be provided for the first inch of runoff from the developed project, or the total runoff from a 3-year, 1-hour rainfall event, whichever is greater.

2. Dry detention volume shall be provided equal to 75 percent of the above amounts computed for wet detention.

3. Retention volume shall be provided equal to 50 percent of the above amounts computed for wet detention.

B. Dry Retention/Detention Area Design Criteria (not applicable to natural wetland areas):

1. Dry retention/detention areas shall have mechanisms for returning the groundwater level in the area to the control elevation.

2. Mosquito control ditches or other appropriate features for such purpose, shall be incorporated into the design of dry retention/detention areas.

3. The design of dry retention/detention areas shall incorporate considerations for regular maintenance and vegetation harvesting procedures.

C. Wet Retention/Detention Area Support Facility Design Criteria:

1. Perimeter maintenance and operation easements of 20 feet (minimum preferable) width at slopes no steeper than 4 to 1 (horizontal to vertical) should be provided.

2. Control elevations should be no higher than 2.5 feet below the minimum road centerline elevation in the area served by the control device in order to protect the road subgrade.

3. Control devices should normally be sized based on a design discharge of 50 percent of the detention volume in one day. The devices should incorporate dimensions no smaller than 6 square inches of cross sectional area nor 1 inch minimum dimension.

D. Wet Retention/Detention Areas Dimensional Criteria (as measured at or from the control elevation):

1. Area - 0.5 acres minimum

2. Width - 100 feet minimum for linear areas in excess of 200 feet length. Irregular shaped areas may have narrower reaches but should average at least 100 feet.

3. Depth - 25 to 50 percent of the area shallower than 6 feet (including side slopes), and 25 to 50 percent of the area deeper than 12 feet.

E. Deep Water Bodies - water bodies shall meet both of the following criteria:

1. Entrapped salt water, resulting from inland migration of salt water during hurricane tide conditions or penetration of the freshwater/salt water interface, will not adversely impact on-site or adjacent water users.

2. The penetration of a water-bearing formation exhibiting poorer water quality, in terms of chloride concentrations, will not adversely impact on-site or adjacent water users.

F. Impervious Areas - runoff shall be discharged from impervious surfaces through retention areas, detention devices, filtering and cleansing devices, and/or subjected to some type of Best Management Practice (BMP) prior to discharge from the project site. For projects which include substantial paved areas, such as shopping centers, large highway intersections with frequent stopped traffic, and high density developments, provisions shall be made for the removal of oil, grease and sediment from storm water discharges.

G. Stagnant Water Conditions - configurations which create stagnant water conditions such as hydraulically dead end canals are to be avoided, regardless of the type of development.

H. Water Management Areas - areas to be utilized for the conveyance or storage of stormwater shall be legally reserved for that purpose by plat, dedication, etc., so that subsequent owners or others may not remove such areas from their intended use. Such areas shall be connected to a public road or other location from which operation and maintenance access is legally available.

I. Underground Exfiltration Systems

1. Design Criteria

a. Systems shall be designed for the retention volumes specified in Section A above for retention systems, exfiltrated over one hour for retention purposes, prior to overflow, and based on test data for the site. Systems may be designed in accordance with the procedure presented in Section III.D.2.

b. Safety factor - 2 minimum

2. Design and Construction

a. Pipe diameter - 12" minimum
b. Trench width - 3' minimum
c. Rock in trench must be enclosed in filter material, at least on the top and sides.
d. Maintenance sumps in inlets.

J. Florida Department of Environmental Regulation Requirements - Chapter 17-4 of the Florida Administrative Code, contains the permitting requirements of the Florida Department of Environmental Regulation (FDER). For projects which require FDER permits, the Applicant is advised that receipt of a Surface Water Management Permit from the South Florida Water Management District in no way relieves him of the necessity of complying with FDER permitting requirements. Copies of all applications submitted to the District are furnished to FDER.

K. Local Requirements - some counties and municipalities within the District have specific requirements regarding the design of surface water management systems. These are normally included in subdivision regulations, although this may vary from jurisdiction to jurisdiction. Therefore, Applicants would be well advised to contact the appropriate county or municipal office prior to finalizing the design of the systems.

L. Design Alternatives - the listing of design criteria is not intended to preclude the design engineer from utilizing other known state-of-the-art methods and available best management practices, and should not be construed in such a manner as to discourage innovative design concepts.

V. Water Quantity and Quality - Best Management Practices

A. Water Conservation - as discussed in Section III, K. above, water conservation is a desirable feature in design and operation of surface water management systems. Management practices utilized to reduce losses of fresh water also provide water quality benefits since total poundage loadings to off-site receiving waters would be reduced. In addition to those items enumerated in Section III, K., other best management practices for water conservation are encouraged. For example, maximum use of on-site retention is encouraged, consistent with maintenance of minimum flows, also, pump schedules should be determined so that over pumping does not occur subsequent to relatively minor storm events.

Voluntary conservation practices such as these will be useful in evaluating the need for mandatory measures.

B. Water Quality - separating design criteria from best management practices for water quality enhancement of storm water runoff does not follow any clear-cut guideline. Although there may be some duplication with previously listed design criteria, the following listing is presented to illustrate general management techniques available to the designer in the planning and design of surface water management systems.

1. Swales - drainage systems should utilize swales, greenways, etc. in lieu of storm drains and curb-and-gutter to the maximum extent possible, except in locations where their use would cause more problems than solutions such as unfeasible road maintenance, objectionable standing water, health or safety hazards, etc.

2. Littoral area - water bodies utilized as integral parts of the drainage system can include substantial littoral areas to provide for emergent vegetation for the improvement of nutrient uptake capabilities.

3. Percolation - infiltration and percolation is useful from a water quality standpoint where conditions are favorable. However, care must be exercised to ensure that such facilities do not create a hazard for potable water supplies by transferring surface water quality problems to unsuitable groundwater locations.

4. Catch Basins - the use of some type of baffled catch basin for oil, grease, and sediment removal is encouraged, along with a regular maintenance schedule. All catch basins should be located in swales or other pervious areas. In order to provide additional retention and percolation, catch basin lips should be raised 2 inches or more unless doing so would create long duration standing water or traffic safety problems.

5. Golf Courses - due to heavy fertilization and frequent irrigation, specialized use areas such as golf courses can create additional water quality problems. If major drainage system components (lakes, canals, etc.) are to be located in or adjacent to such areas, component design should include a low berm to induce percolation into the system instead of overland sheet flow. Such a design practice can also be of benefit for residential developments.

6. Recirculation - recirculating water as much as possible within a development can reduce off-site discharges, thus reducing pollutant poundage loadings to receiving streams.

7. Street sweeping/vacuuming programs - for large impervious areas (parking lots, shopping centers, etc.) a regular cleaning program should be implemented. From available information, regenerative air or vacuum type sweepers are recommended.

8. Pervious vehicular parking areas.

VI. Land Use Considerations

Before an Application will be considered for the issuance of a Surface Water Management Permit by the District, the proposed land use must be compatible with the applicable zoning for the area. Merely making application to the applicable local agency for rezoning of the land will not suffice; any necessary rezoning must be officially obtained prior to issuance of this District's Permit.

VII. Environmental Considerations

A. Impact assessment - all Surface Water Management Applications will be reviewed by the Staff for purposes of advising the District Governing Board as to anticipated impacts of the proposed work on (a) the water resources of the District and (b) natural upland systems.

The Staff shall identify the significant environmental features of the project which are directly related to the water resources of the District, evaluate the impact of the project on these water resource related environmental features and make specific recommendations as to the issuance or denial of the permit based upon the evaluation.

The Staff shall separately identify the environmental features of the project which are indirectly or not related to the water resources of the District and evaluate the impacts of the project on the non-water resource related environmental features. No recommendations as to the issuance or denial of the permit shall be given based upon non-water resource related environmental impacts.

The following paragraphs give general information concerning the evaluation of environmental impacts.

1. Information utilized in the review will include Application information such as aerial photographs, topographic maps and development plans, as well as relevant information from such other sources as site inspections, studies, meetings with the Applicant, etc.

2. Adverse impacts shall not be reported without a site inspection.

3. At the request of an Applicant or potential Applicant, the Staff will conduct a site inspection, at a mutually convenient time.

4. Pre-application meetings are encouraged, as are submissions of optional explanatory information, which may be useful to the Staff in its review.

5. The following categorization of environmental features shall be used by the Staff in evaluating impacts:

   a. Environmental features directly related to the water resources of the District, such as:

      (i) Viable wetlands habitat except those previously impacted by drainage, land clearing, earthwork, or those which have been invaded by exotic species and therefore are in a state of normal environmental decay.

      (ii) Natural waterbodies.

   b. Environmental features which may be indirectly related to the water resources of the District, such as:

      (i) Intermittent ponds.

      (ii) Significant habitat diversity support systems, usually consisting of highly productive mixed upland and wetland systems with appropriate buffer areas.

   c. Environmental features which are not related to the water resources of the District, such as:

      (i) Unique upland habitats, usually consisting of tropical hardwood tree hammocks and beach dunes.

   d. Preferred habitat for rare or endangered species of plants or animals shall be identified.

6. The actual impact resulting from changes to the natural site shall be predicted by considering the existing natural system as altered by the proposed project. It is recognized that the variety of actions associated with a project may result in both positive and negative environmental impacts. The Staff therefore, will balance both the positive and negative impacts of the project to achieve a reasonable degree of protection for significant environmental features consonant with the overall protection of the water resources of the District.

B. Design techniques - experience has shown that certain design techniques are worthy of attention in development of a water management plan and are thus presented for consideration by Applicants.

1. The use of joint water management/environmental preservation areas is encouraged. Care must be exercised though that the area is sufficiently buffered so that the good intention of preservation is not lost by the invasion of degradation elements. Perimeter waterways, outside the preservation area, can serve as a buffer as well as drainage element, aesthetic feature and source of fill material.

2. Preservation of a wetland area which will receive only rainfall on itself is usually an exercise in futility. The reason it has become a wetland is because it is lower than surrounding ground and receives runoff therefrom.

3. The replacement of a viable marsh type wetland by a water body is not normally an equitable environmental tradeoff.

4. Water management, environmental preservation, etc. areas should be legally reserved for the appropriate purpose to prevent future inappropriate development.

5. Water quality enhancement features such as continuous recirculation waterways, overflow rather than direct discharge devices, retention and containment berms and connecting water bodies for retention/detention plus seasonal habitat carryover should be utilized in designs.

6. It is recognized that, generally, small isolated environmentally sensitive areas are more susceptible to being adversely impacted by adjacent land use than larger ones. Thus, in appropriate situations, it may be desireable to combine or replace the smaller areas with a larger one.

VIII. Water and Wastewater Service

Potable water and wastewater facilities must be identified. The Applicant for a Surface Water Management Permit must provide information on how these services are to be provided. If wastewater disposal is accomplished on-site, additional information will normally be requested.

OPERATIONAL CONDITIONS

I. Inspection and Certification

A Florida registered Professional Engineer will be required to furnish the District with a certification stating that the subject surface water management system has been constructed in accordance with the Permit.

District personnel inspect water management systems to insure that the said systems have been constructed in accordance with the Permit.

II. Water Quality Monitoring

All new drainage projects will be evaluated based on the ability of the system to prevent degradation of receiving waters and the ability to conform to State water quality standards (see Chapter 17-3 Florida Administrative Code).

There are areas within the District where water quality considerations are extremely important, because of the sensitivity of the area. These areas include:

1. Lake Okeechobee and the Lower Kissimmee River.

2. Canals or streams designated as Class I or Class II waters by FDER.

3. Canals back-pumped to Lake Okeechobee or to the Conservation Areas, or proposed for back-pumping.

4. Sensitive areas, including but not limited to the Savannahs in St. Lucie and Martin Counties, the Six Mile Cypress strand and Estero Bay Aquatic Preserve in Lee County and the Big Cypress area of Collier County.

New developments which plan to utilize sensitive areas for disposal of stormwater may be given more detailed evaluation by the District Staff. In addition, new projects entailing a more intensified land use and planning to discharge to a sensitive receiving water, directly or indirectly, may be required to institute a water quality monitoring program. The following listing of land use intensity is in ascending order.

1. Wetlands (including transition zones adjacent thereto)
2. Forested lands
3. Rangeland
4. Agricultural
5. Urban and built-up land

Therefore, any proposed land use change causing a larger number in the above listing may require water quality monitoring if discharge is to go to sensitive receiving waters. In addition, some land use changes within the same category would also be considered as more intensified land use.

In general, there are two reasons for requiring water quality monitoring by permittees, as follows:

1. Such data can be used to determine if the pollution abatement practices incorporated into the design of the drainage system are functioning properly.

2. In some cases there may be a real and immediate concern regarding degradation of quality in the receiving waters, regardless of the pollutant removal efficiency of the drainage system.

The reason for the monitoring requirement will normally be stated in the Staff Report for each Permit, as will be the monitoring schedule and the parameters of interest. Although specifics may vary from project to project, samples will normally be collected at discharge locations. A typical sampling schedule will consist of samples collected once per month during the wet season, however this may also vary between projects. Rate of discharge at the time of sample collection and total monthly discharge each month for the duration of the permit will also be required. Parameters of interest will normally include nitrates as N, nitrites as N, total kjeldahl nitrogen as N, total nitrogen as N, ortho-phosphorus as P, total phosphorus as P, total suspended solids, BOD_5, turbidity, conductivity, D.O., and pH. In some cases, fecal and total coliform and fecal strep analyses will be required in addition to other parameters. Where feasible the District's water quality monitoring requirements will be coordinated with applicable FDER monitoring requirements.

As a general rule, monitoring required of permittees will be confined to points within their boundaries. If additional sampling is needed in order to assess off-site impacts of the projects, such sampling will normally be conducted by the District.

Staff Reports written and Permits issued for projects not requiring monitoring at this time will normally include a statement to the effect that water quality monitoring may be required in the future, along with a list of the parameters of interest. This should not be construed as an indication that the District is contemplating the implementation of a program of intensive water quality monitoring by all permittees. If water quality problems develop in specific areas, however, permittees are in this manner put on notice that they may have to determine the quality of the water which they are discharging.

APPENDIX 1

Checklist for Surface Water Management Permit Applications

I. Site Information including:

A. Detailed location sketch.

B. Topographic map of the site.

C. Overall map of the area showing where runoff presently goes and whether off-site areas drain through the project.

D. Identification of seasonal water table elevations. If the project is in the known flood-way of a natural stream, it should be identified and approximate flooding depths determined.

E. Description of vegetative cover. Wetland areas should be identified.

F. A recent aerial photograph of the project area with project boundaries delineated.

G. Paving, grading and drainage plans.

H. Percolation tests must be submitted if percolation or exfiltration systems are proposed. Percolation tests shall be representative of design conditions.

II. Master Drainage Plan showing:

A. Location of all water bodies with details of size, side slopes and depths.

B. Location and details of all major water control structures. Control elevations of the control structures should be included along with any seasonal water level regulation schedules.

C. Drainage basin boundaries showing direction of flow, taking into account off-site runoff being routed through or around the project.

D. Locations of roads and buildings along with their proposed elevations.

E. Right-of-way and easement locations for the drainage system including all areas to be dedicated for water management purposes.

F. Location and size of internal minor water management facilities.

G. Nearby existing offsite water management facilities such as wells, lakes, etc. which might be affected by the proposed construction or development. Owners of such facilities names and addresses should also be submitted.

H. Known temporary or construction techniques which might affect the surface water management system prior to completion of elements of the development.

III. Drainage Calculations including:

A. Design storms used including depth, duration and distribution.

B. Stage-storage computations for the project and stage-discharge computations for the major outfall structure(s).

C. Acreages and percentage of property proposed as:

1. Impervious surfaces
2. Pervious surfaces (green areas)
3. Lakes, canals, retention areas, and etc.
4. Total acreage of project
5. Other

D. Runoff routing calculations showing discharges, elevations, and volumes retained and/or detained during applicable storm event (see Rule 16K-4.035, "Basis of Review . . .", pages 3 and 4 for required design storm).

E. Calculations required for determination of minimum building floor and road elevations.

IV. Legal and Institutional Information including:

A. Identify entity responsible for operation and maintenance of the system.

B. If the operation and maintenance entity is to be a public body such as a city or drainage district, a letter of potential acceptance from the public body should be submitted. If the entity is a home-owners association, then documents verifying the existence of such an organization and its ability to accept operation and maintenance responsibility must be submitted prior to commencement of construction (assuming the permit is issued).

C. Indicate how water and wastewater service will be supplied. Letters of commitment from off-site suppliers should be included.

D. Identify agencies, organizations, etc. contacted. Include meeting summaries and/or responses. Give status of local approvals indicating if site plan and/or subdivision approval has been granted, final plats recorded and building or construction permits issued.

E. Present and proposed zoning, density and classification under the local land use plan should be submitted and verified by letter from the local government; including status under DRI process, if applicable.

F. Submit a copy of a boundary survey and a copy of the recorded warranty deed; if the Applicant is a contractual buyer then a copy of the executed contract should be provided.

G. Documentation of legal and/or physical availability of receiving water system to receive project discharge if such is not evident.

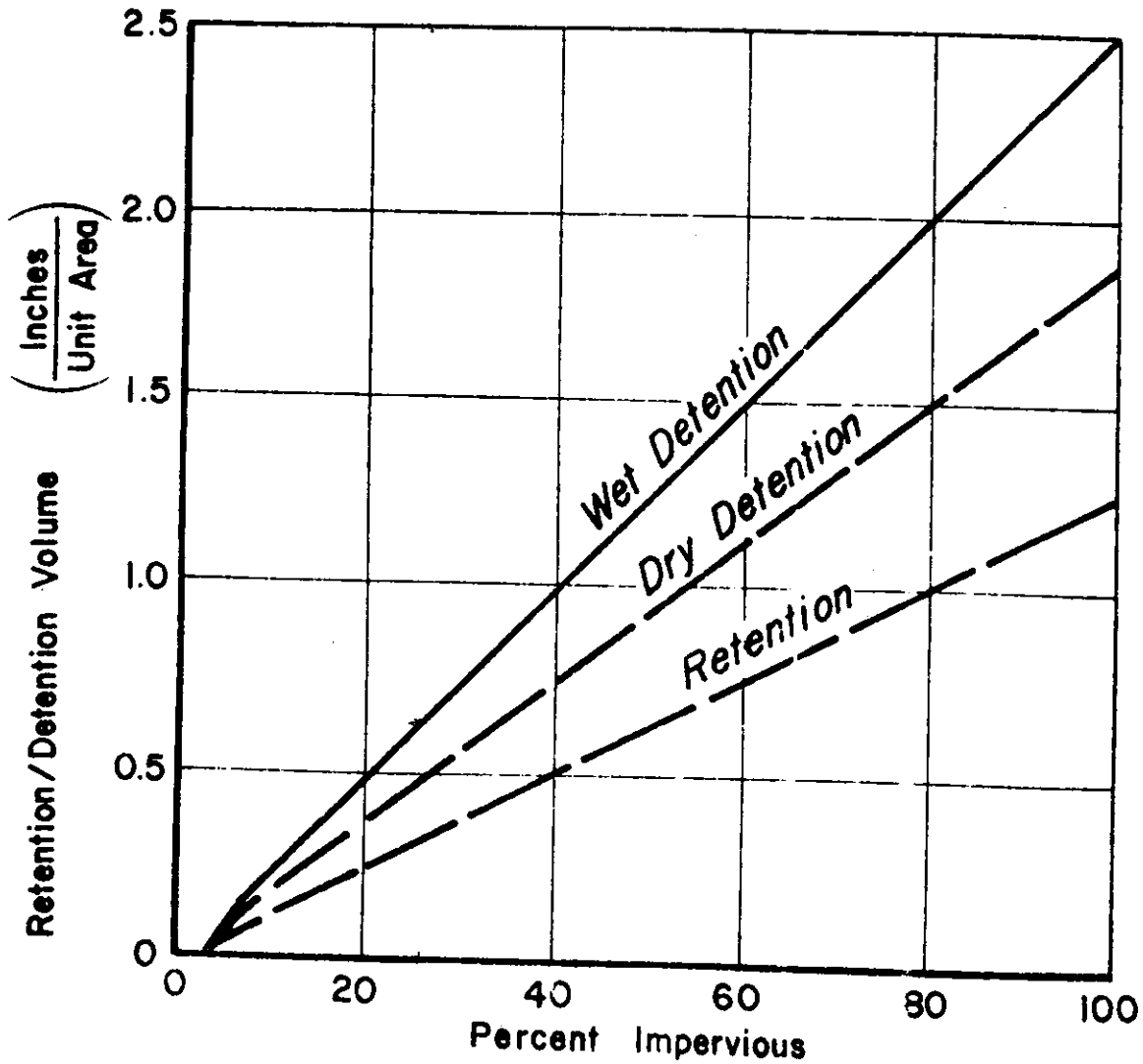
NOTES:

1. Include four copies of all information.

2. For a Conceptual Approval, Items I.G, II.E, II.F, II.G, II.H and IV.B will not be necessary.

APPENDIX 2

Note: Storage Req'd. Is In Addition To Normal Street & Lot Swales Which Have Already Been Accounted For In Preparation Of Curve.



Separate Storage Req'd. For Grass Swale Systems

BIBLIOGRAPHY

The following is a list of publications incorporated by reference in this document. A copy of Item 1 may be obtained by writing to the Florida Department of Transportation, Hayden Burns Building, Tallahassee, Florida 32301.

Copies of Items 2 through 7, published by the U.S. Government may be obtained by writing to: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Florida State Road Department, Drainage Manual. 2nd Ed., revised 1978.

2. U.S. Department of Agriculture, Soil Conservation Service, Technical Paper No. 149, A Method for Estimating Volume and Rate of Runoff in Small Watersheds. 1973.

3. U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds. 1975.

4. U.S. Department of Agriculture, Soil Conservation Service, NEH-4, National Engineering Handbook, Section 4 Hydrology. 1972.

5. U.S. Department of Agriculture, Soil Conservation Service, Rainfall Frequency Atlas of Alabama, Florida, Georgia and South Carolina for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. 1973.

6. U.S. Weather Bureau, Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Duration from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. 1961.

7. U.S. Weather Bureau, Technical Paper No. 49, Two-to-Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States. 1964.

P A R T B

SURFACE WATER MANAGEMENT DESIGN CRITERIA

Part B - Surface Water Management Design Criteria

I. General

Certain specific topics related to the District staff's position on the design of surface water management systems will be discussed in this section due either to their omission from other parts of this document or as a result of the need for clarification.

A. Marginal Drainage

A minimum discharge criteria has been established in the "Basis of Review" document which requires that drainage systems be capable of discharging at a minimum rate of 3/8 inches per day and be capable of lowering the on-site groundwater table to a depth of 2.5 feet below the ground surface in less than 12 days. This requirement was intended to prevent the development of projects which would have essentially no drainage ability or grossly inadequate drainage systems. Projects which normally would not be able to meet this requirement would be located in an area without local drainage facilities for the removal of storm runoff and the homes would be in essence isolated islands surrounded by water or soggy ground during the normal wet season. The most serious concerns for such a project, in addition to the physiological, would be the major health hazard due to exposure to water related disease.

B. Industrial Parks

When a parcel of land is developed into an industrial park and the individual lots will be sold to private owners, the surface water management system provided by the developer of the parcel must provide for: 1) the required retention for water quality enhancement for the entire parcel area; and 2) a stormwater collection and conveyance system to interconnect the retention area and outfall structure with the individual lots. This design requirement will ensure that a central maintainable water management system is installed which can be operated or modified in the future as needed.

C. General Permit-size Projects

One item which has been misconstrued since its inception is the design requirements for projects which fall under the General Permit threshold. The General Permit procedure provides a mechanism for the issuance of Permits for small projects within a few days. The projects are required to be designed in accordance with the procedures and requirements of the "Basis of Review," Rule 40E-4.091. This means that a small project must provide the required retention/detention, limit off-site discharges, and have roads and floors constructed at the proper elevations.

D. Construction Completion Certification

Upon completion of the construction of a system permitted by the District, it is a requirement of the issuance of the operation permit and hence transfer of operation and maintenance responsibility that an engineer certify that the system was indeed constructed as permitted. Suggested wording for this is as follows:

> I HEREBY CERTIFY THAT ALL FACILITIES FOR THE ABOVE REFERENCED PROJECT HAVE BEEN CONSTRUCTED IN ACCORDANCE WITH THE DESIGN APPROVED BY THE DISTRICT, AND HEREBY AFFIX MY SEAL THIS ____ DAY OF _____, 19___.

E. Legal/Operation Entity Requirements

The District considers the following entities acceptable to satisfy limiting condition #8:

1. Local governmental units including counties or municipalities

2. Active water control districts or drainage districts

3. Non-profit corporations including, homeowners associations, property owners associations, condominium owners associations or master associations

4. The property owner or developer as permittee is normally not acceptable as a responsible entity especially when the property is to be sold to various third parties. However, the property owner or developer may be acceptable under one of the following circumstances:

   a. The property is wholly owned by said permittee and is intended to be so retained. This would apply for a Farm, Corporate Office or Automobile Sales Center, for example.

   b. The ownership of the property is retained by the permittee and is either leased to third parties such as in some shopping centers or rented to third parties such as in some mobile home parks, for example.

To satisfy the requirement, the permittee must provide written documentation. If the entity is a governmental unit, the permittee must supply written proof in the appropriate form by either letter or resolution, that the governmental entity will accept the operation and maintenance of all of the surface water management system including lakes, easements, etc.

If a Homeowner or Property Owner's Association or Master Association is proposed, the permittee must submit the Articles of Incorporation for the Association, and Declaration of Protective Covenants or Deed

Restrictions, as well as a reference map if referred to in documents. After these are approved, the permittee must furnish the Certificate of Incorporation and the recording information (Official Book and page number) for the Declaration.

If a condominium association is proposed, the permittee must supply the Articles of Incorporation for the Condominium Association, and Declaration of Condominium. After the documents are approved, it will be necessary for the permittee to forward a copy of the letter from the Department of Business Regulations, Bureau of Condominium that the documents are proper for filing.

The Association, be it either a non-profit association or a condominium association, must comply with the applicable provisions of Florida laws, specifically Chapters 617 or 718, Florida Statutes.

The Association must have the following general powers which are reflected in the Articles of Incorporation:

1. Own and convey property

2. Operate and maintain common property specifically the surface water management system as permitted by the SFWMD including all lakes, retention areas, culverts and related appurtenances

3. Establish rules and regulations

4. Assess members and enforce said assessments

5. Sue and be sued

6. Contract for services (if the Association contemplates employing a maintenance company) to provide the services for operation and maintenance

7. The association must have as members all the homeowners, lot owners, property owners or unit owners

8. The association shall exist in perpetuity; however, if the association is dissolved, the Articles of Incorporation must provide that the property consisting of the surface water management system shall be conveyed to an appropriate agency of local government. If it is not accepted, then the surface water management system must be dedicated to a similar non-profit corporation

9. All other powers necessary for the purposes for which the association is organized.

The Declaration of Protective Covenants, Deed Restrictions or Declaration of Condominium must set forth the following:

1. That it is the responsibility of the Association to operate and maintain the surface water management system.

2. The surface water management system is owned by the Association or described therein as common property.

3. That there be a method of assessing and collecting the assessment for operation and maintenance of the surface water management system.

4. That any amendment which would affect the surface water management system, including the water management portions of the common areas, must have the prior approval of the South Florida Water Management District.

5. That the Declaration of Covenants be of effect for at least 25 years with automatic renewal periods thereafter.

If the documents are not submitted with the original application, they should be submitted during the application phase prior to the issuance of the staff report. It is advised that the documents be submitted prior to recording to allow comment by the District's Office of Counsel. Modification of these requirements can only be based upon

1. Intervening local government requirements of a more stringent nature such as the requirement of a maintenance agreement and posting of bond by the developer.

2. The uniqueness of the project requiring an alternative entity. Such alternative entity must be evaluated upon an individual basis with any and all necessary agreements or easements in effect before approval will be given.

Any questions concerning the particular requirements of a responsible entity should be addressed to the Office of Counsel.

II. Design Rainfall

A. Depth

1. Selection of Design Event

The depth of rainfall in inches for a specific return frequency and storm duration is the most basic parameter needed in the design and analysis of a storm water management system. The design event (return frequency storm) is determined either from local criteria or from the "Basis of Review" document.

2. Determination of Rainfall Amount

Once we have determined the design frequency and duration we can use Figures 5 through 12 for estimating the appropriate rainfall depth.

3. Use of Figures 5 through 12

Example 1:

Assume we know the following:

Frequency - 3-year
Duration - 1-hour
Location - West Palm Beach

From Figure 5 the 2-year, 1-hour depth is 2.6 inches and from Figure 6 the 5-year, 1-hour depth is 3.2 inches. Using linear interpolation we estimate the 3-year, 1-hour depth to be:

$$2.6 + \frac{3.2-2.6}{3} = \underline{2.8 \text{ inches Ans.}}$$

Example 2:

Assume we know the following:

Frequency - 10-year
Duration - 24-hour
Location - Jupiter

From Figure 9 we see that the 10-year, 24-hour depth is approximately 8.0 inches at Jupiter.

8.0 inches Ans.

Example 3:

Assume we know the following:

Frequency - 100-year
Duration - 3-day
Location - West Palm Beach

From Figure 12 the 100-year, 24-hour depth is 13.5 inches. From the "Basis of Review" we modify the 24-hour value by 135.9% to obtain a 72-hour (3-day) depth. Consequently, the 100-year, 3-day depth is:

$$13.5 \times 1.359 = \underline{18.3 \text{ inches Ans.}}$$

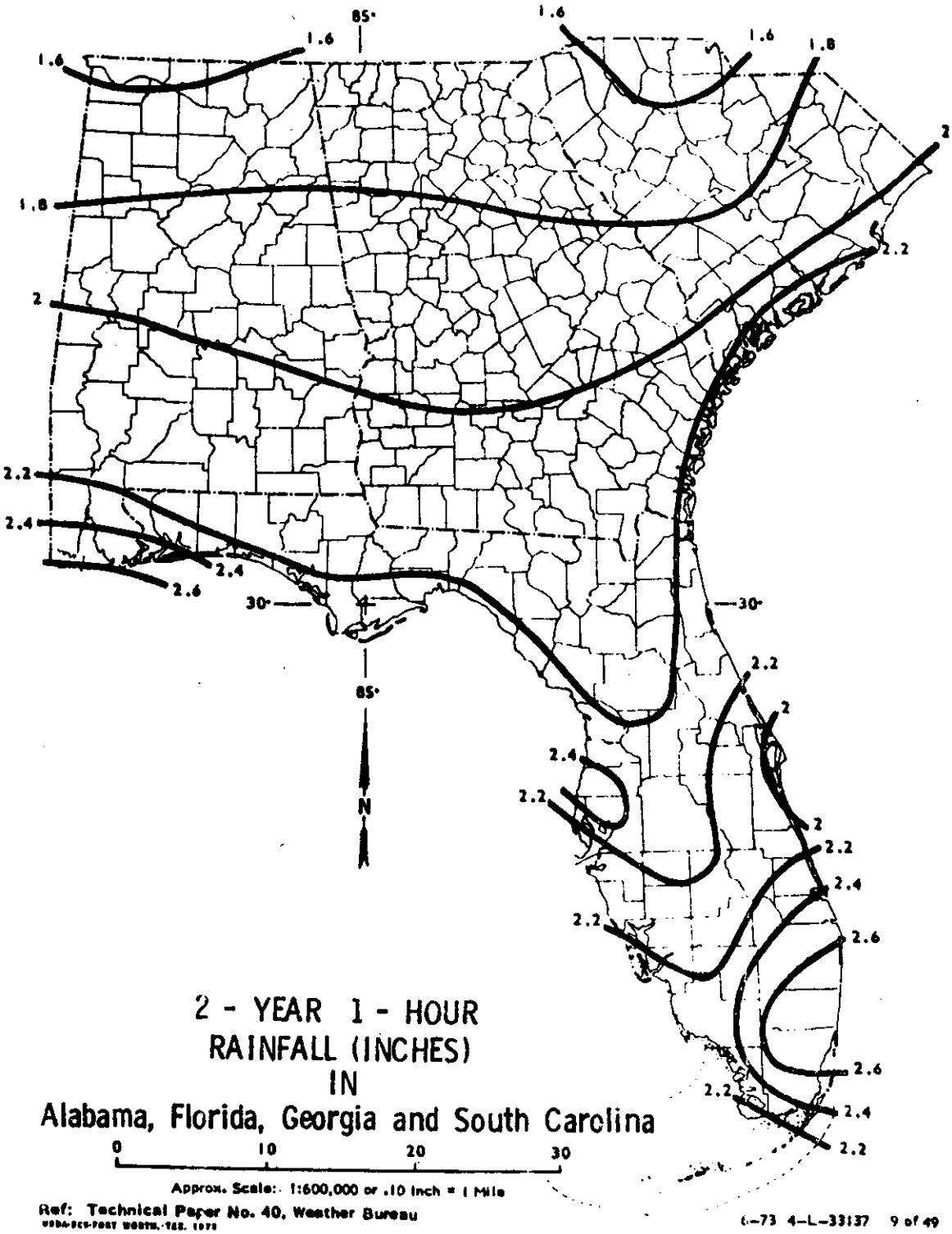

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FIGURE 5

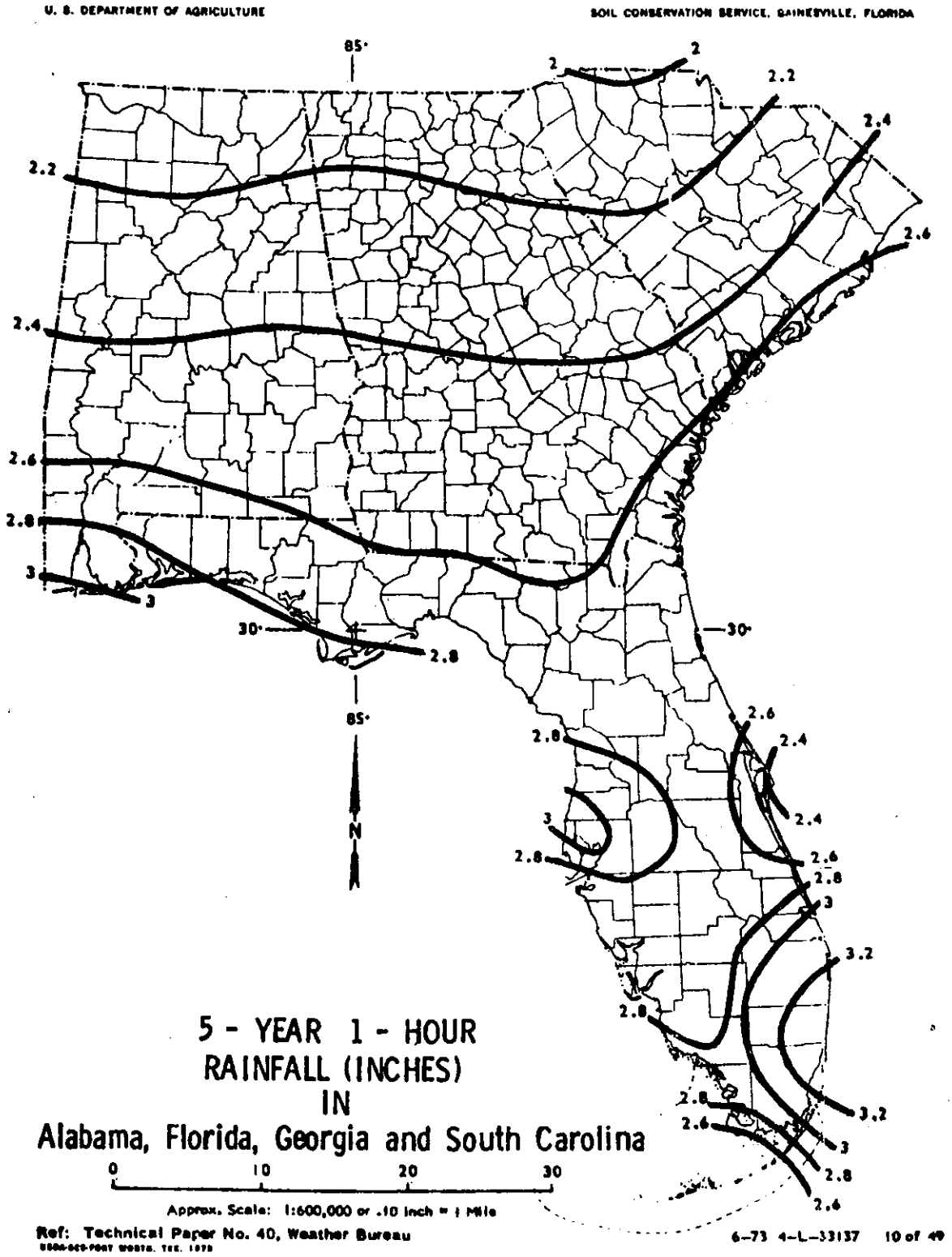
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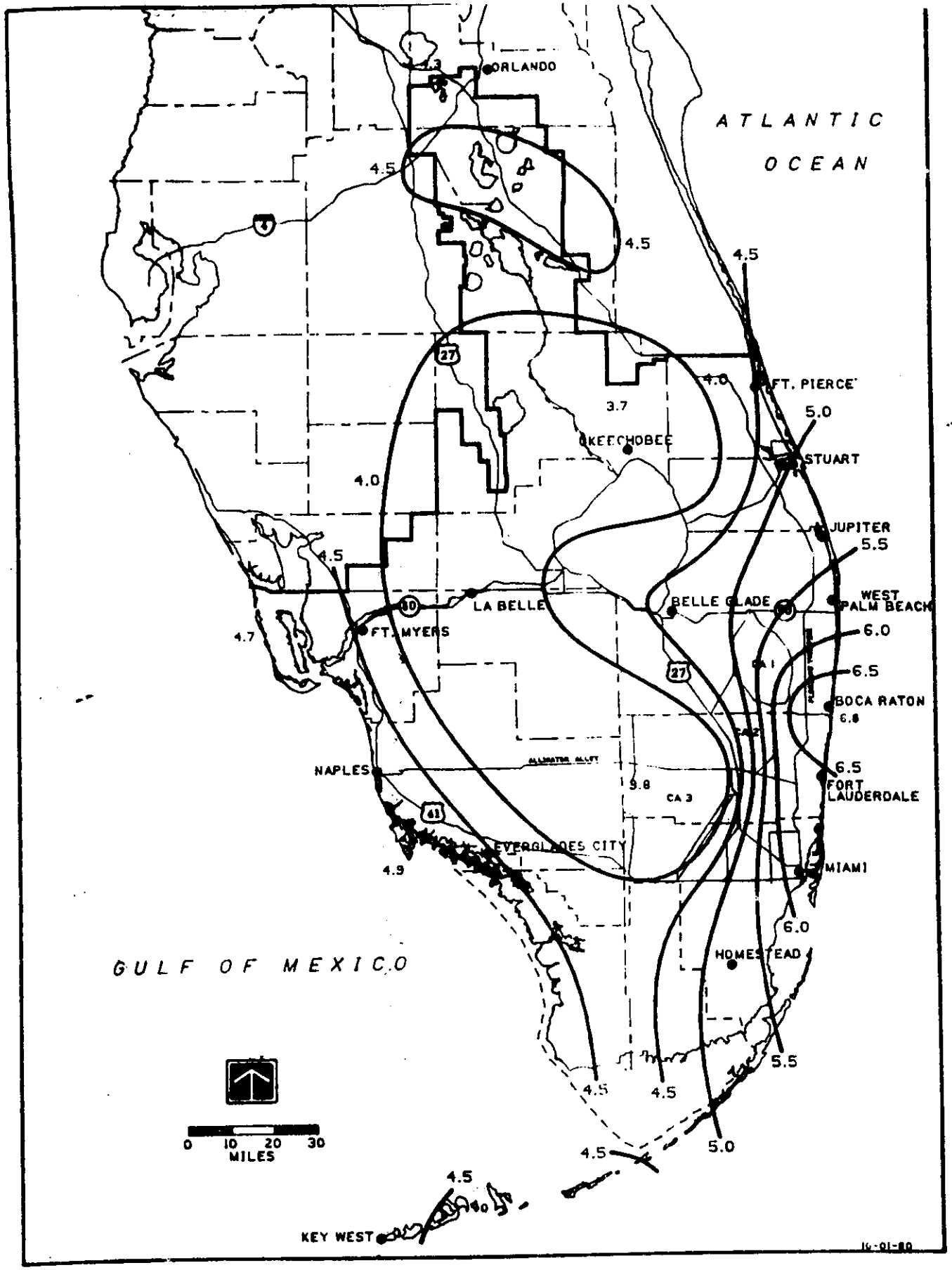
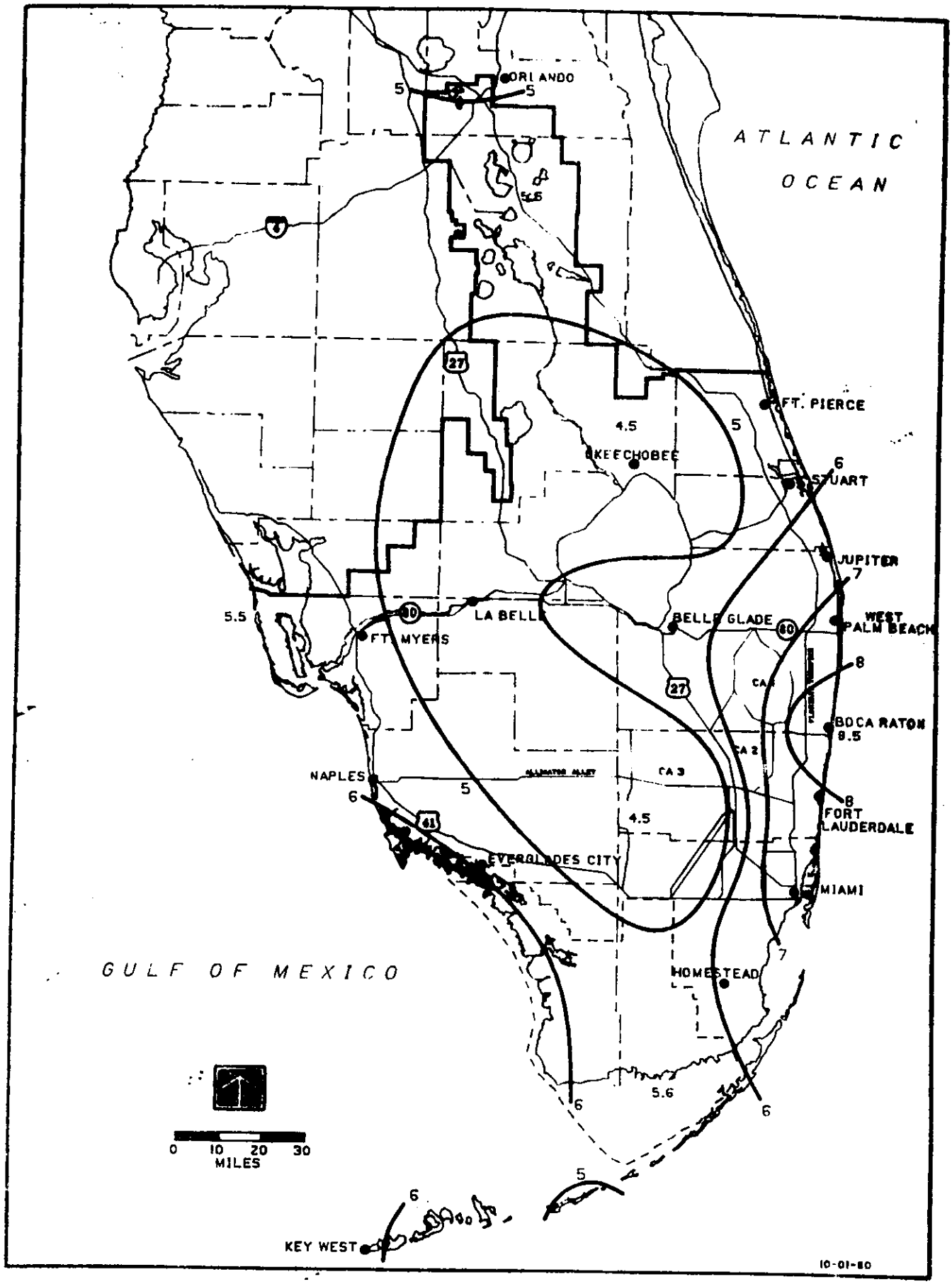
FIGURE 6



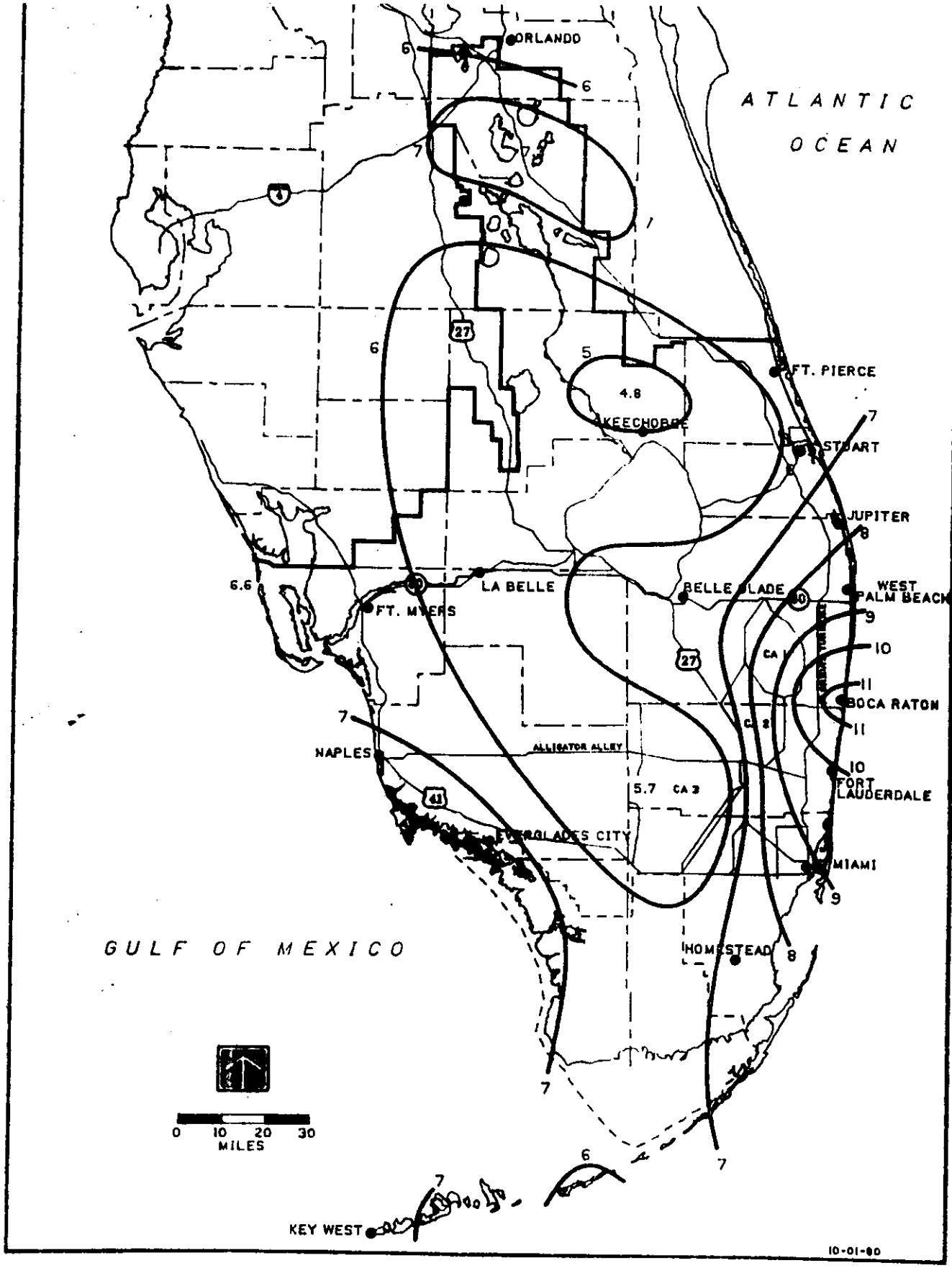
1 - DAY RAINFALL : 3 YEAR RETURN PERIOD

FIGURE 7



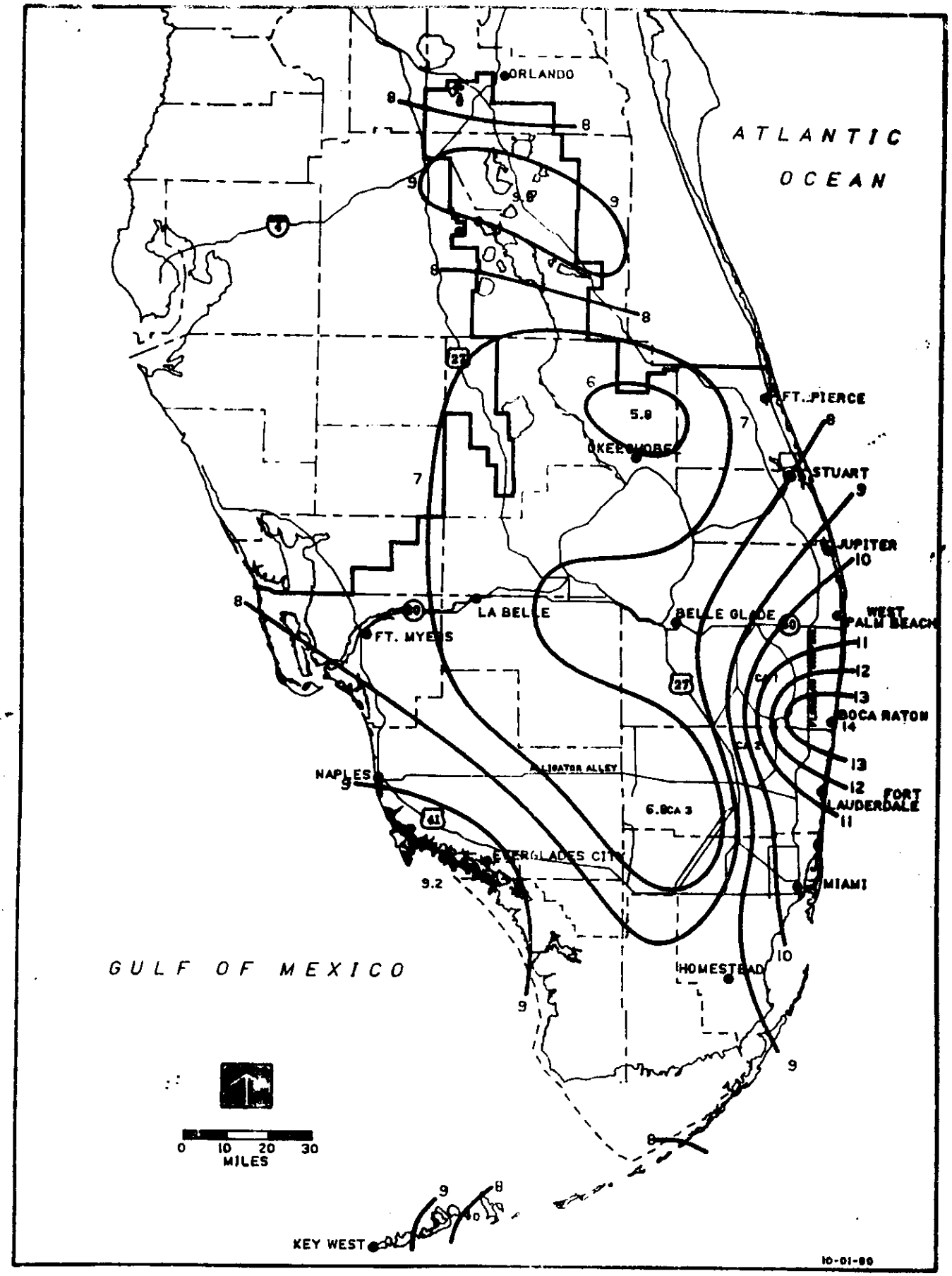
1-DAY RAINFALL : 5 YEAR RETURN PERIOD

FIGURE 8



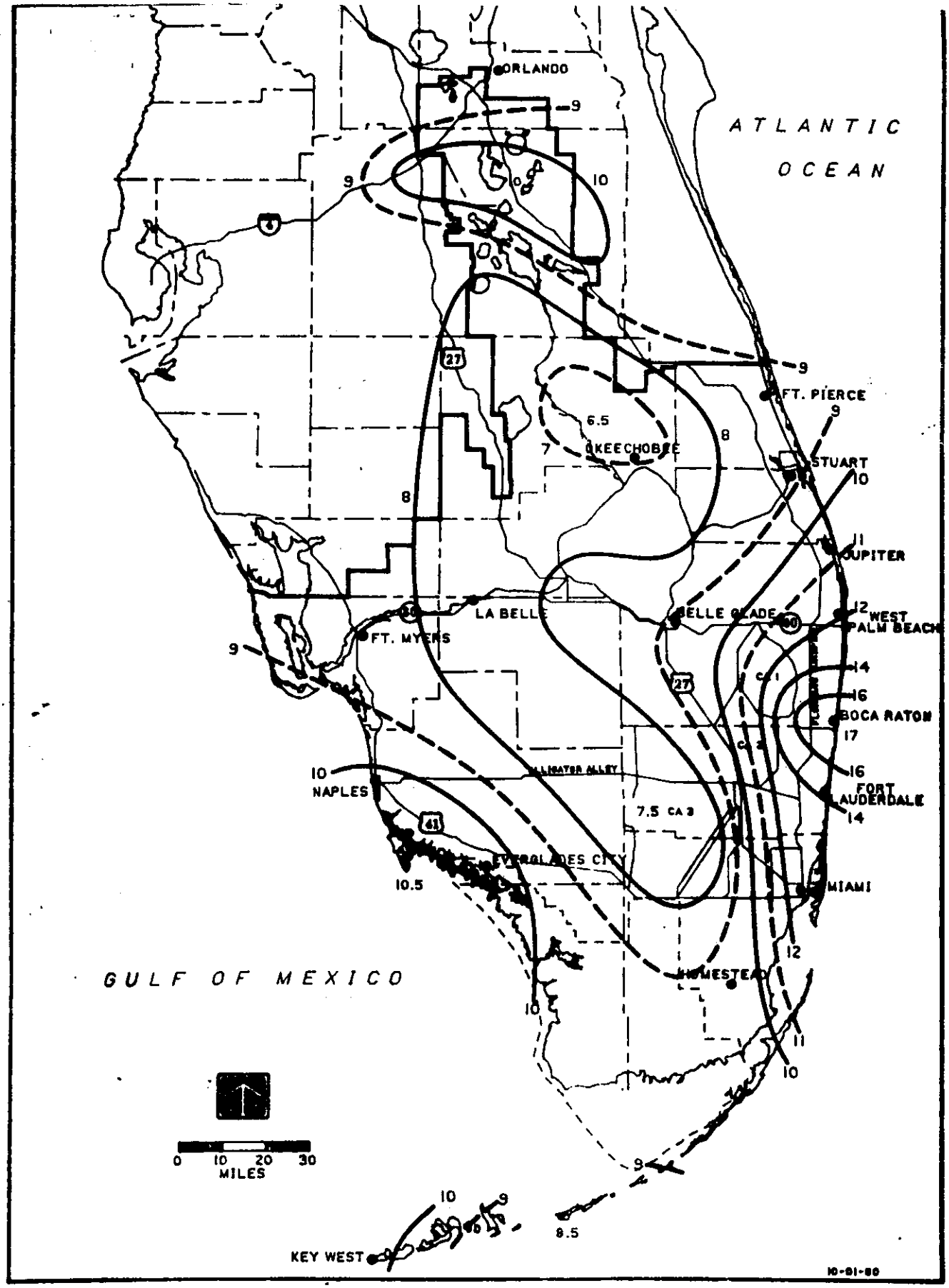
1-DAY RAINFALL: 10 YEAR RETURN PERIOD

FIGURE 9



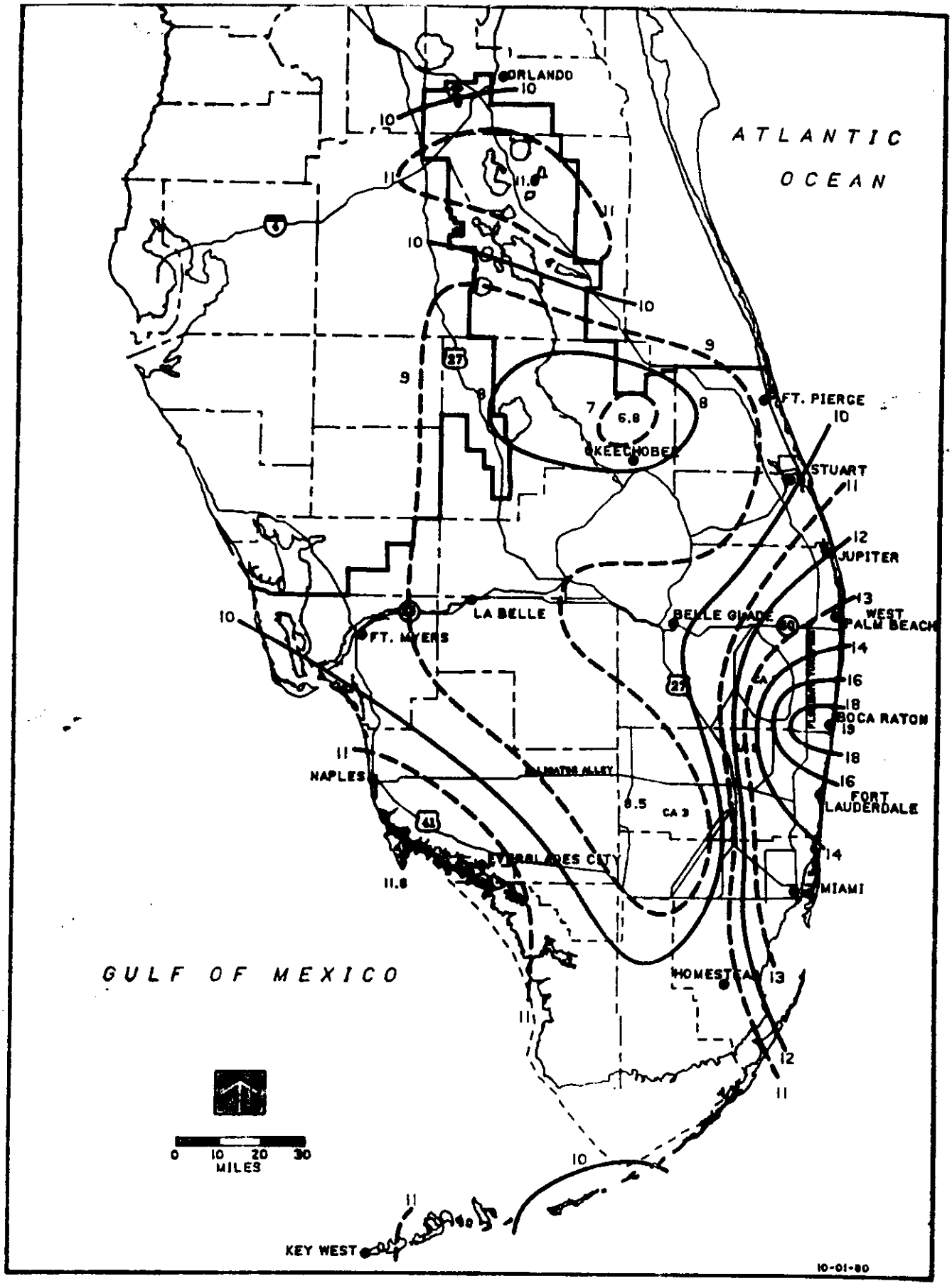
1 - DAY RAINFALL : 25 YEAR RETURN PERIOD

FIGURE 10



1 - DAY RAINFALL : 50 YEAR RETURN PERIOD

FIGURE 11



1 - DAY RAINFALL : 100 YEAR RETURN PERIOD

FIGURE 12

B. Distribution

1. SCS Type II 24-Hour

The distribution of rainfall versus time is an important consideration for determining the peak rates and stages which will occur during a design event. The table on the following page represents the SCS Type II 24-hour rainfall distribution in dimensionless form (P/P_{24}). The cumulative depth of rainfall versus time is represented as a ratio to the 24-hour total rainfall depth. An example of the use of this table for a 24-hour design rainfall depth of 10.0 inches is:

Time (hours)	Ratio (P/P_{24})	X	(P_{24}) 10.0 inches	=	Cumulative Rainfall (inches)	
0.0	.000	X	10.0	=	0.00	
4.0	.048	X	10.0	=	0.48	
8.0	.120	X	10.0	=	1.20	
10.0	.181	X	10.0	=	1.81	
11.0	.235	X	10.0	=	2.35	
11.5	.283	X	10.0	=	2.83	
12.0	.663	X	10.0	=	6.63	
13.0	.772	X	10.0	=	7.72	
16.0	.880	X	10.0	=	8.80	
20.0	.952	X	10.0	=	9.52	
24.0	1.000	X	10.0	=	10.00	24-hour Total RF

SCS RAINFALL DISTRIBUTIONS

The Type II distribution is representative for regions in which the high rates of runoff from small areas are usually generated from summer thunderstorms. The distribution is based on generalized rainfall depth-duration relationships obtained from Weather Bureau technical papers. The selection of the period of maximum intensity was based on design consideration rather than meteorological factors.

TYPE II

Time (hrs)	P/P_{24}	Time (hrs)	P/P_{24}
0.0	.000	12.5	.735
0.5	.005	13.0	.772
1.0	.011	13.5	.799
1.5	.017	14.0	.820
2.0	.022	14.5	.835
2.5	.029	15.0	.850
3.0	.035	15.5	.865
3.5	.042	16.0	.880
4.0	.048	16.5	.889
4.5	.056	17.0	.898
5.0	.064	17.5	.907
5.5	.072	18.0	.916
6.0	.080	18.5	.925
6.5	.090	19.0	.934
7.0	.100	19.5	.943
7.5	.110	20.0	.952
8.0	.120	20.5	.958
8.5	.134	21.0	.964
9.0	.147	21.5	.970
9.5	.163	22.0	.976
10.0	.181	22.5	.982
10.5	.204	23.0	.988
11.0	.235	23.5	.994
11.5	.283	24.0	1.000
12.0	.663		

Ref: A Method for Estimating Volume and Rate of Runoff in Small Watersheds, SCS-TP-149, April 1973.

2. SFWMD 24-Hour (See Table 1)

Figure 13 is a graphical representation of the 24-hour rainfall distribution presented in the "Basis of Review" document. The cumulative distribution of rainfall is given as a ratio to the total 24-hour rainfall depth. An example of the use of this figure for a 24-hour design rainfall depth of 10.0 inches is:

Time (hours)	Ratio (P/P_{24})	X	(P_{24}) 10.0 inches	=	Cumulative Rainfall (inches)	
0	.000	X	10.0	=	0.00	
10	.213	X	10.0	=	2.13	
11	.269	X	10.0	=	2.69	
11.5	.319	X	10.0	=	3.19	
11.75	.469	X	10.0	=	4.69	
12	.656	X	10.0	=	6.56	
12.5	.729	X	10.0	=	7.29	
13	.767	X	10.0	=	7.67	
14	.818	X	10.0	=	8.18	
24	1.000	X	10.0	=	10.00	24-hour Total RF

3. SFWMD 3-day (See Table 2)

Table 2 is a tabular representation of the 3-day rainfall distribution presented in the "Basis of Review" document. The cumulative distribution of rainfall is given as a ratio to the total 24-hour rainfall depth. An example of the use of this distribution for a 24-hour design rainfall depth of 10.0 inches is:

Time (days)	Time (hours)	Ratio (P/P_{24})	X	(P_{24}) 10.0 inches	=	Cumulative Rainfall (inches)	
0	0	.000	X	10.0	=	0.00	
1	24	.146	X	10.0	=	1.46	
2	48	.359	X	10.0	=	3.59	
2 + 10 hours	58	.572	X	10.0	=	5.72	
2 + 11 hours	59	.628	X	10.0	=	6.28	
2 + 12 hours	60	1.015	X	10.0	=	10.15	
2 + 13 hours	61	1.126	X	10.0	=	11.26	
3	72	1.359	X	10.0	=	13.59	3-day Total RF

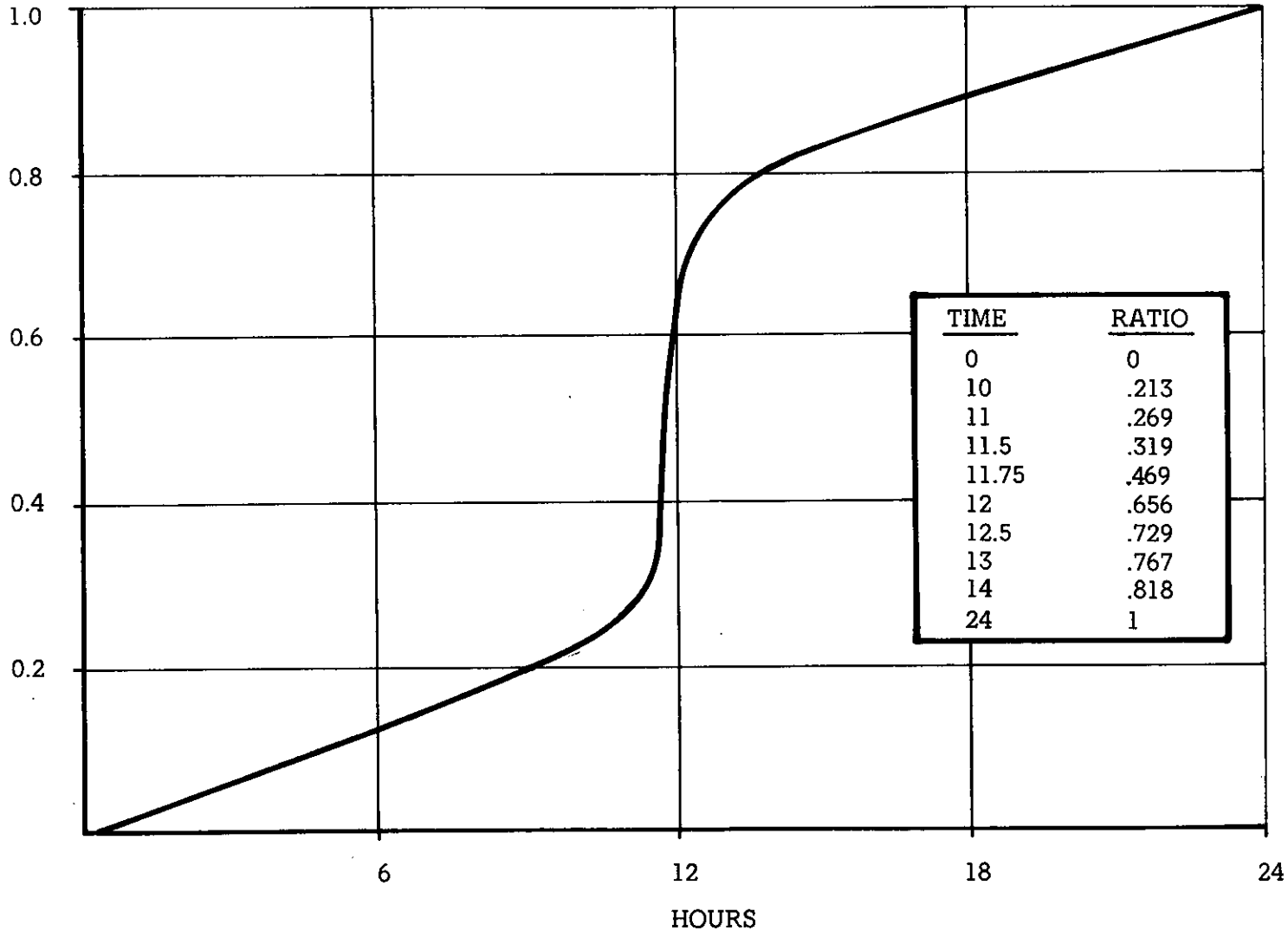


FIGURE 13

24 HOUR RAINFALL DISTRIBUTION

TABLE 1

DESIGN
24-HOUR EVENT RAINFALL DISTRIBUTION 15-MINUTE INCREMENTS

TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)	TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)
.00	.000	12.25	.692
.25	.002	12.50	.729
.50	.005	12.75	.748
.75	.008	13.00	.767
1.00	.010	13.25	.781
1.25	.013	13.50	.795
1.50	.015	13.75	.806
1.75	.018	14.00	.818
2.00	.020	14.25	.827
2.25	.023	14.50	.835
2.50	.026	14.75	.843
2.75	.029	15.00	.850
3.00	.032	15.25	.858
3.25	.035	15.50	.865
3.50	.038	15.75	.873
3.75	.042	16.00	.880
4.00	.045	16.25	.885
4.25	.049	16.50	.889
4.50	.053	16.75	.894
4.75	.058	17.00	.898
5.00	.062	17.25	.903
5.25	.067	17.50	.907
5.50	.072	17.75	.911
5.75	.078	18.00	.916
6.00	.083	18.25	.921
6.25	.089	18.50	.925
6.50	.095	18.75	.929
6.75	.102	19.00	.934
7.00	.108	19.25	.939
7.25	.115	19.50	.943
7.50	.122	19.75	.947
7.75	.130	20.00	.952
8.00	.137	20.25	.955
8.25	.145	20.50	.958
8.50	.153	20.75	.961
8.75	.162	21.00	.964
9.00	.171	21.25	.967
9.25	.181	21.50	.970
9.50	.191	21.75	.973
9.75	.202	22.00	.976
10.00	.213	22.25	.979
10.25	.225	22.50	.982
10.50	.237	22.75	.985
10.75	.253	23.00	.988
11.00	.269	23.25	.991
11.25	.294	23.50	.994
11.50	.319	23.75	.997
11.75	.488	24.00	1.00
12.00	.656		

TABLE 2

72-HOUR EVENT — DESIGN RAINFALL DISTRIBUTION — 15-MINUTE INCREMENTS

TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)	TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)	TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)
.00	.000	12.25	.075	24.25	.148
.25	.002	12.50	.076	24.50	.150
.50	.003	12.75	.078	24.75	.153
.75	.005	13.00	.079	25.00	.155
1.00	.006	13.25	.081	25.25	.157
1.25	.008	13.50	.082	25.50	.159
1.50	.009	13.75	.084	25.75	.162
1.75	.011	14.00	.085	26.00	.164
2.00	.012	14.25	.087	26.25	.166
2.25	.014	14.50	.088	26.50	.168
2.50	.015	14.75	.090	26.75	.170
2.75	.017	15.00	.091	27.00	.173
3.00	.018	15.25	.093	27.25	.175
3.25	.020	15.50	.094	27.50	.177
3.50	.021	15.75	.096	27.75	.179
3.75	.023	16.00	.097	28.00	.182
4.00	.024	16.25	.099	28.25	.184
4.25	.026	16.50	.100	28.50	.186
4.50	.027	16.75	.102	28.75	.188
4.75	.029	17.00	.103	29.00	.190
5.00	.030	17.25	.105	29.25	.193
5.25	.032	17.50	.106	29.50	.195
5.50	.033	17.75	.108	29.75	.197
5.75	.035	18.00	.110	30.00	.199
6.00	.036	18.25	.111	30.25	.201
6.25	.038	18.50	.113	30.50	.204
6.50	.040	18.75	.114	30.75	.206
6.75	.041	19.00	.116	31.00	.208
7.00	.043	19.25	.117	31.25	.210
7.25	.044	19.50	.119	31.50	.213
7.50	.046	19.75	.120	31.75	.215
7.75	.047	20.00	.122	32.00	.217
8.00	.049	20.25	.123	32.25	.219
8.25	.050	20.50	.125	32.50	.221
8.50	.052	20.75	.126	32.75	.224
8.75	.053	21.00	.128	33.00	.226
9.00	.055	21.25	.129	33.25	.228
9.25	.056	21.50	.131	33.50	.230
9.50	.058	21.75	.132	33.75	.233
9.75	.059	22.00	.134	34.00	.235
10.00	.061	22.25	.135	34.25	.237
10.25	.062	22.50	.137	34.50	.239
10.50	.064	22.75	.138	34.75	.241
10.75	.065	23.00	.140	35.00	.244
11.00	.067	23.25	.141	35.25	.246
11.25	.068	23.50	.143	35.50	.248
11.50	.070	23.75	.144	35.75	.250
11.75	.071	24.00	.146	36.00	.252
12.00	.073				

TABLE 2 (continued)

DESIGN RAINFALL DISTRIBUTION

72-HOUR EVENT		15-MINUTE INCREMENTS			
TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HOUR)	TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)	TIME (HOURS)	RAINFALL RATIO (TOTAL/24-HR)
36.25	.255	48.25	.362	60.25	1.052
36.50	.257	48.50	.364	60.50	1.088
36.75	.259	48.75	.367	60.75	1.107
37.00	.261	49.00	.369	61.00	1.126
37.25	.264	49.25	.372	61.25	1.140
37.50	.266	49.50	.374	61.50	1.154
37.75	.268	49.75	.377	61.75	1.166
38.00	.270	50.00	.379	62.00	1.177
38.25	.272	50.25	.382	62.25	1.186
38.50	.275	50.50	.385	62.50	1.194
38.75	.277	50.75	.388	62.75	1.202
39.00	.279	51.00	.391	63.00	1.209
39.25	.281	51.25	.394	63.25	1.217
39.50	.284	51.50	.397	63.50	1.224
39.75	.286	51.75	.400	63.75	1.232
40.00	.288	52.00	.404	64.00	1.239
40.25	.290	52.25	.408	64.25	1.243
40.50	.292	52.50	.412	64.50	1.248
40.75	.295	52.75	.417	64.75	1.253
41.00	.297	53.00	.421	65.00	1.257
41.25	.299	53.25	.426	65.25	1.262
41.50	.301	53.50	.431	65.50	1.266
41.75	.304	53.75	.437	65.75	1.271
42.00	.306	54.00	.442	66.00	1.275
42.25	.308	54.25	.448	66.25	1.280
42.50	.310	54.50	.454	66.50	1.284
42.75	.312	54.75	.461	66.75	1.289
43.00	.315	55.00	.467	67.00	1.293
43.25	.317	55.25	.474	67.25	1.298
43.50	.319	55.50	.481	67.50	1.302
43.75	.321	55.75	.488	67.75	1.307
44.00	.324	56.00	.496	68.00	1.311
44.25	.326	56.25	.504	68.25	1.314
44.50	.328	56.50	.512	68.50	1.317
44.75	.330	56.75	.521	68.75	1.320
45.00	.332	57.00	.530	69.00	1.323
45.25	.335	57.25	.540	69.25	1.326
45.50	.337	57.50	.550	69.50	1.329
45.75	.339	57.75	.561	69.75	1.332
46.00	.341	58.00	.572	70.00	1.335
46.25	.343	58.25	.584	70.25	1.338
46.50	.346	58.50	.596	70.50	1.341
46.75	.348	58.75	.612	70.75	1.344
47.00	.350	59.00	.628	71.00	1.347
47.25	.352	59.25	.653	71.25	1.350
47.50	.355	59.50	.678	71.50	1.353
47.75	.357	59.75	.847	71.75	1.356
48.00	.359	60.00	1.015	72.00	1.359

III. Runoff Estimation

A method for estimation of runoff from rainfall information has been developed by the United States Department of Agriculture's Soil Conservation Service (SCS).

The runoff equation used by SCS was developed by Victor Mockus and others and presented in the U.S. Soil Conservation Service's National Engineering Handbook, Section 4, Hydrology. The relationship between accumulated rainfall and accumulated runoff was derived from experimental data for numerous soils, vegetative cover and land treatment measures.

The equation is:

$$Q = \frac{(P-Ia)^2}{(P-Ia) + S}$$

where:

Q = accumulated direct runoff (inches)

P = accumulated rainfall (inches)

Ia = initial abstraction including surface storage, interception, and infiltration prior to runoff (inches)

S = potential maximum retention (inches)

This equation is particularly easy to use with the cumulative rainfall distributions which we introduced in the previous section. For purposes of developing project specific runoff generation relationships District staff applies this formula using a weighted soil moisture storage value for the maximum retention parameter, S. For example, if a project had the ability to store 6.0 inches of rainfall in the soil profile and it was 50% impervious, then for purposes of calculating the cumulative runoff volumes you would use an S value of:

$$6.0 \text{ inches } X \text{ } (1-0.50) = \underline{3.0 \text{ inches}}$$

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

$$Ia = 0.2S$$

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

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

To show the rainfall-runoff relationship graphically (see Figure14,) S values are transformed into curve numbers (CN) by the following equation:

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

Example:

Assume we have the following:

P_{24} = 10.0 inches rainfall
S_o = 10.0 inches storage in soil profile
I = 50% impervious
S = 10.0 (1-.50) = 5.0 inches
$CN = \frac{1000}{S+10} = 67$

Therefore,

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

$$Q = \frac{(10.0-0.2(5.0))^2}{10.0+0.8(5.0)} = 5.8 \text{ inches runoff in 24 hours}$$

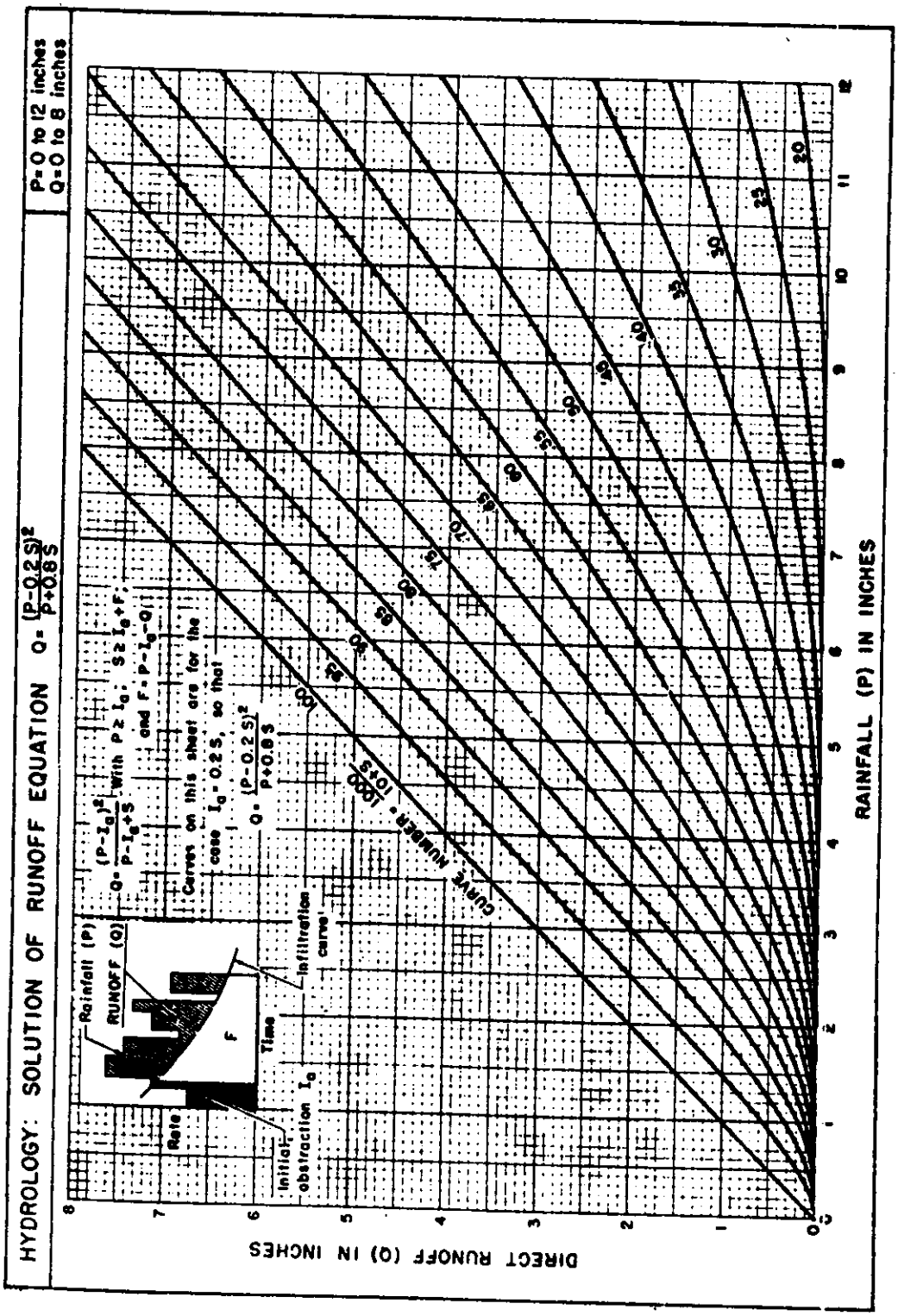
IV. Storage Calculation

A. Ground Storage

The moisture storage capability of the soil profile has been estimated by the Soil Conservation Service for the normal sandy soils found within the South Florida Water Management District boundaries. The total amount of water which can be stored in the soil profile expressed as a function of the depth to the water table for these soils is:

Depth To Water Table (Feet)	Cumulative Water Storage (Inches)	Compacted Water Storage (Inches)
1	0.60	0.45
2	2.50	1.88
3	6.60	4.95
4	10.90	8.18

The values in the third column represent the estimated amount of water which can be stored under pervious areas after development. These values represent the cumulative water storage values reduced by 25 percent to account for the reduction in void spaces due to the compaction which occurs incidental to earthwork operations. An example of the use of this information is:



Solution of the runoff equation, $Q = \frac{(P - 0.2S)^2}{P + 0.8S}$

FIGURE 14

Assume we have the following:

Average Finished Grade = 17.0 feet MSL
Average Ground Water Level = 14.0 feet MSL
Percent of Project in Lakes = 15%
Percent of Project Impervious = 35%

We wish to determine the project specific S-value to use for determining the runoff volume which will be generated after development. We see that the depth to the water table will be 3 feet (17.0-14.0=3.0) consequently the total amount of water which can be stored under pervious surfaces will be 4.95 inches. If 15% of the project will be in lakes and 35% will be covered by impervious surfaces, then the remainder, or 50%, will be pervious areas and the appropriate weighted S-value will be:

4.95 inches X (1.0-(.15+.35) =2.48 inches=S

Figure 15 is a graphical representation of the cumulative water storage capabilities of the soil profile for the developed and undisturbed conditions versus the depth to the water table for the typical sandy soils found within the South Florida Water Management District Boundaries.

B. Surface Storage

1. Storage in Lakes and Canals

For small projects the amount of water which can be stored within a developed project's lakes and canals can be assumed to store vertically without variation of surface area. For a project with 5 acres of lakes and canals and an average top of bank elevation 3 feet above the maintained water level within the project, we can estimate the "bank-full" storage capability as (5 acres X 3 feet) 15 acre-feet of water storage without overflowing the canal or lake banks. The actual storage volume will be somewhat different due to side slopes and the changing surface area versus elevation; however, it is not felt to be significant enough to substantially affect the calculated values for small projects. It should be noted that in certain projects that have a large number of lakes that compose the total lake acreage, thus creating a high ratio of shoreline to lake acreage, the side slopes may have to be considered when the volume of lake storage is computed.

2. Storage on the Land

The amount of water which can be stored above the land surface in the developed areas can be estimated as shown on Figure 16. The project used for Figure 16 has 360 acres of graded property below the house pad elevation of 17.5 feet MSL and above the top of bank of lake elevation of 14.5 feet MSL. The calculation is based upon the assumption that the total area with standing water varies linearly with the stage on-site. Based upon 360 acres of landscaped property with a 3 foot difference in grade, we see that the rate of submergence versus rising stage is 360 acres/3 feet or 120 acres of land submerged per foot of rise.

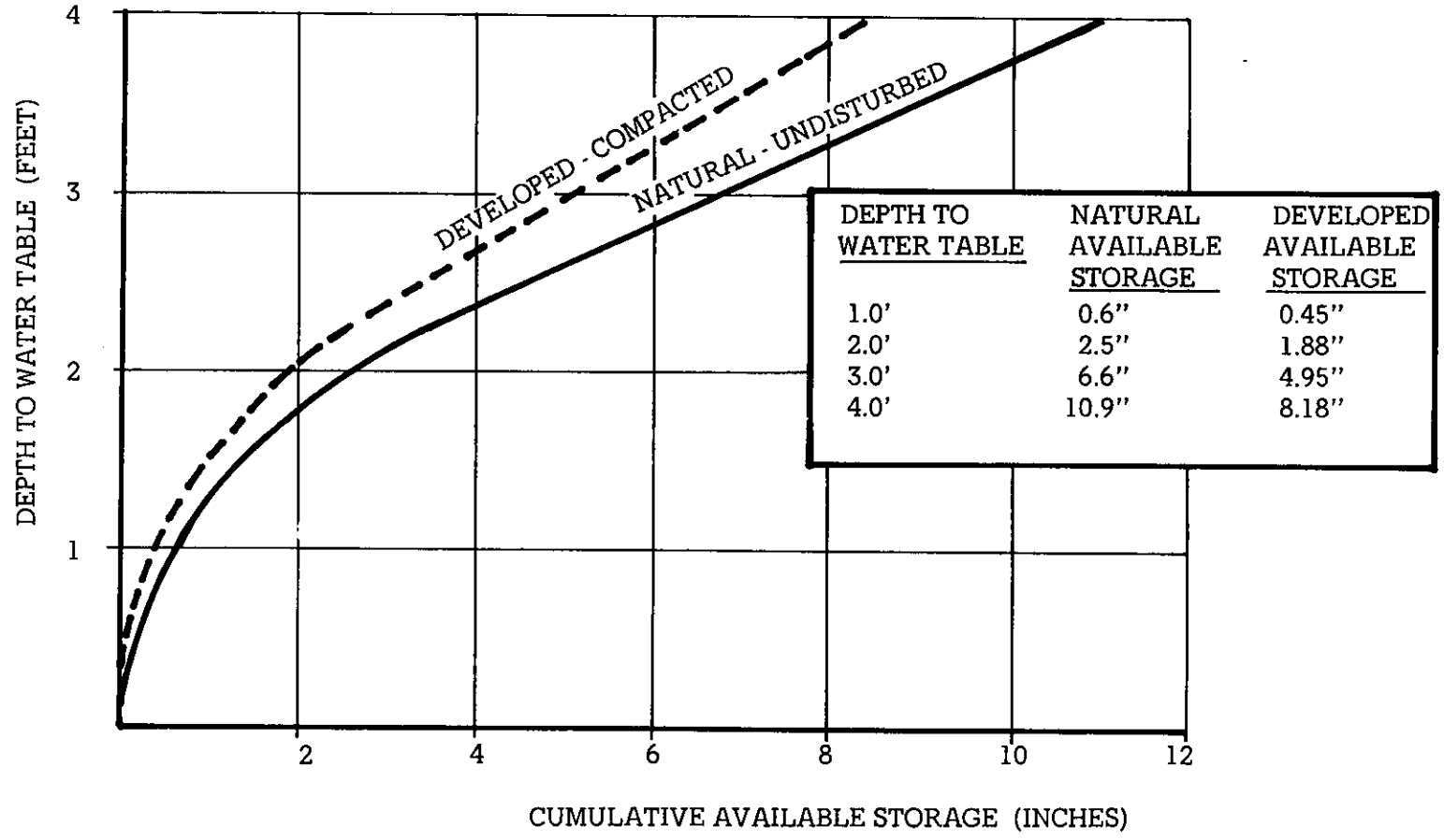


FIGURE 15

CUMULATIVE SOIL MOISTURE STORAGE

STAGE	STORAGE
14.5	0
16.0	0.75' X 180 = 135 AF
17.0	1.25' X 300 = 375 AF
17.5	1.50' X 360 = 540 AF

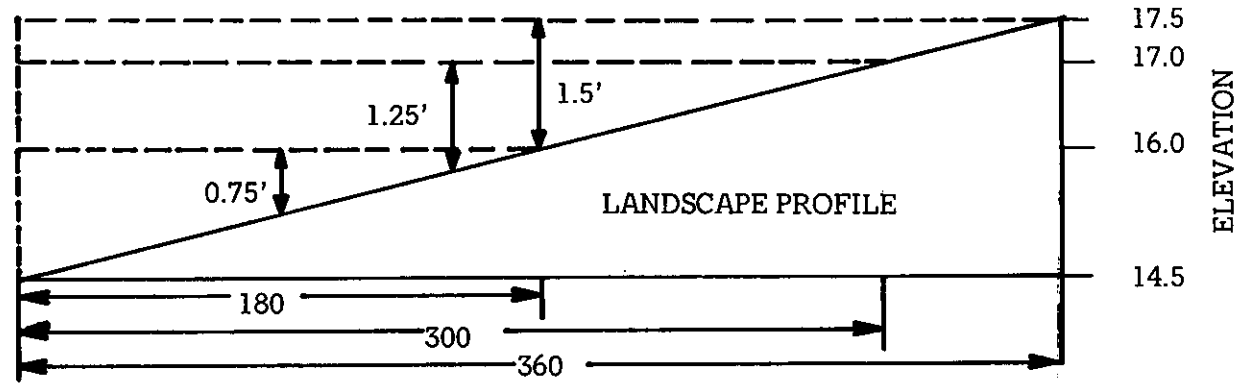


FIGURE 16

SURFACE STORAGE COMPUTATION SCHEME

As an example, we see from Figure 20 that at elevation 16.0 feet MSL, a total of 180 acres has some standing water on it and that the depth of standing water varies from 1.5 feet for property at 14.5 feet MSL to 0 feet depth for property at 16.0 feet MSL. Hence, the total volume of water stored on the land is equal to the total acreage with water on it times the average depth of standing water:

$$180 \text{ acres} \times \frac{1.5+0}{2} = \underline{\underline{135 \text{ acre-feet stored}}}$$

3. Stage-Storage Graph

Once we have performed the above calculation to determine the total volume of open surface storage available within the project as a function of the stage on-site, we can then represent the information visually by the construction of a Stage-Storage Curve as shown on Figure 17. On Figure 17 the total volume of water which can be stored within the developed project at a desired stage can be determined by moving across the graph horizontally to the right from the stage to the curve then from that point moving vertically downward to the bottom axis and reading the storage volume.

V. Discharge Considerations

A. Pumped Systems

For the design and analysis of surface water management systems the use of pumps is easy to account for in determination of discharge rates and peak stages. The peak discharge rate from the project is obviously the capacity of the pump or pumps. To determine the total volume discharged up to any particular time you just multiply the capacity of the pump times the elapsed time since the pump started pumping.

B. Gravity Systems

The design and analysis of gravity systems is relatively complex and requires a very good working knowledge of hydraulics and the performance of various structure types under variable head conditions. We will not go into great detail herein due to the large number of combinations of gravity discharge structures which are available and used in system designs.

As an example of one of the problems which occurs frequently the design of a culvert with flashboard riser will be discussed since it is the most common structure used within the District.

Figure 18 shows the schematic of a culvert with flashboard riser and also illustrates graphically the discharge characteristics of both the culvert and the flashboard riser. If the flashboard riser were not attached to the culvert, then the culvert would have discharge any time the headwater (elevation in the on-site lake) elevation rose above 10.0 feet MSL, the tailwater (elevation in receiving water) elevation, and its discharge capacity as a function of the lake stage is represented by Curve A. However, the flashboard riser is attached to the

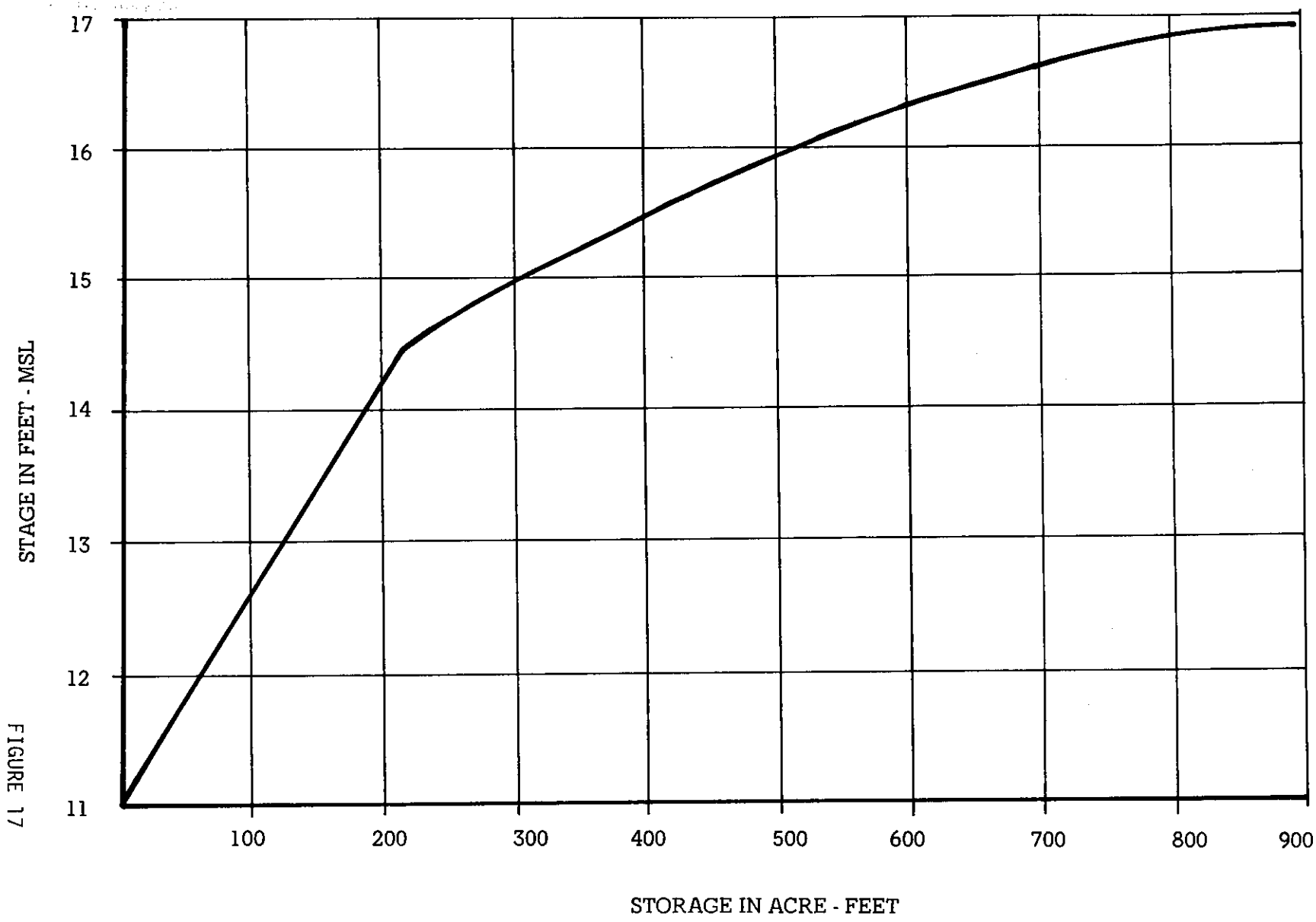


FIGURE 17

TYPICAL STAGE - STORAGE GRAPH

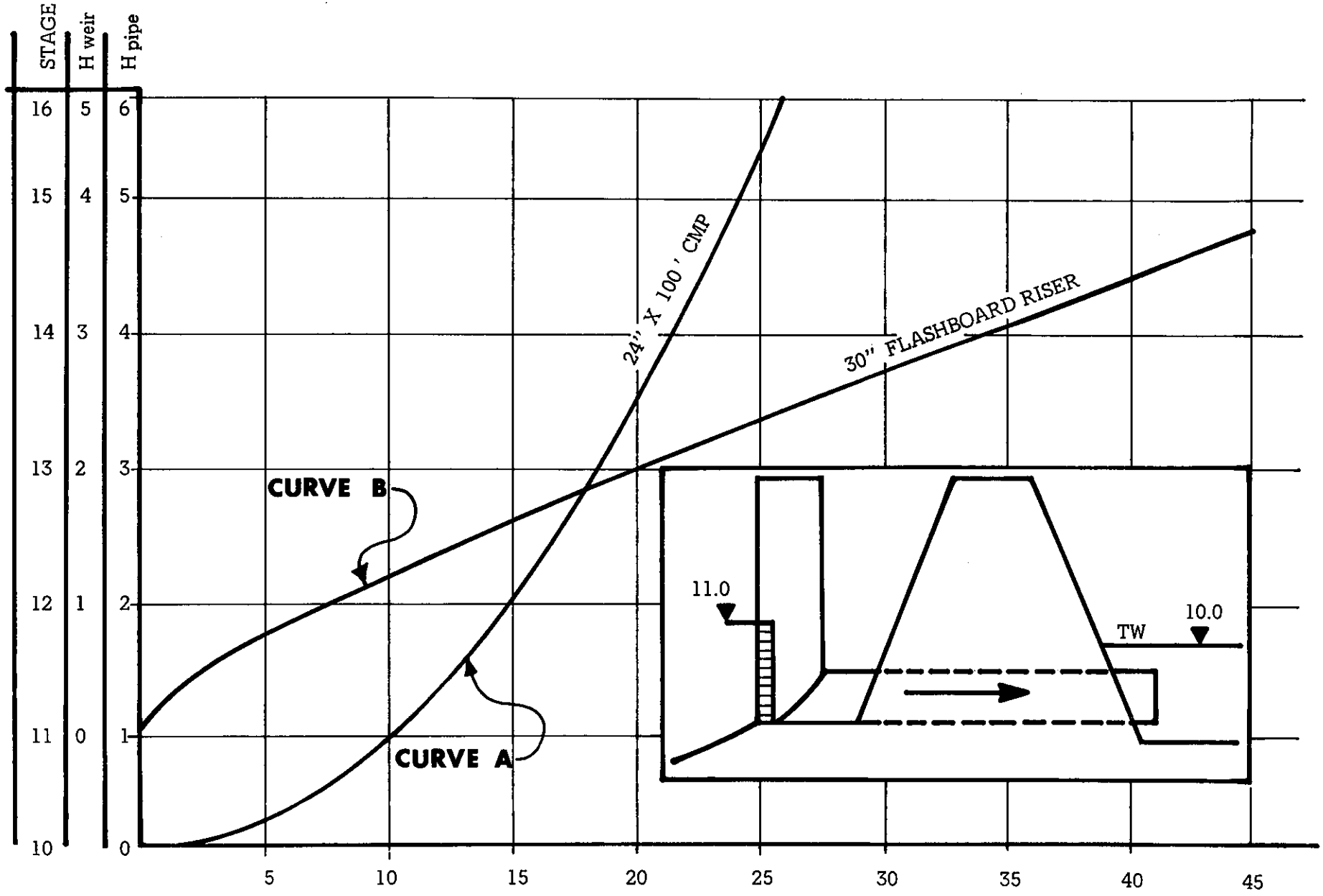


FIGURE 18

STAGE - DISCHARGE INTERSECTING CURVES GRAPH

upstream side of the culvert and acts as a sharp-crested weir which will not allow any discharges until the on-site lake level rises to elevation 11.0 feet MSL (the crest elevation of the top of the flashboards). When the lake stage rises above elevation 11.0 feet MSL the discharge capacity as a function of the lake stage is represented by Curve B.

The problem which we wish to point out in this example is the fact that the two discharge capacity curves cross when the on-site lake stage exceeds elevation 12.8 feet MSL. The question then is, which is the actual discharge rate of this structure as a function of the on-site lake stage? The answer is that whichever is more restrictive, i.e., whichever structure passes less at a specific stage, is the controlling structure. From elevation 10.0 feet to 12.8 feet MSL the discharges are controlled by the flashboard riser and the structure is said to be in "weir control." From elevation 12.8 feet MSL and up the discharges are limited by the hydraulic capacity of the culvert and the structure is said to be in "pipe control." Consequently, the actual Stage-Discharge Curve for this particular structure arrangement is that shown on Figure 19.

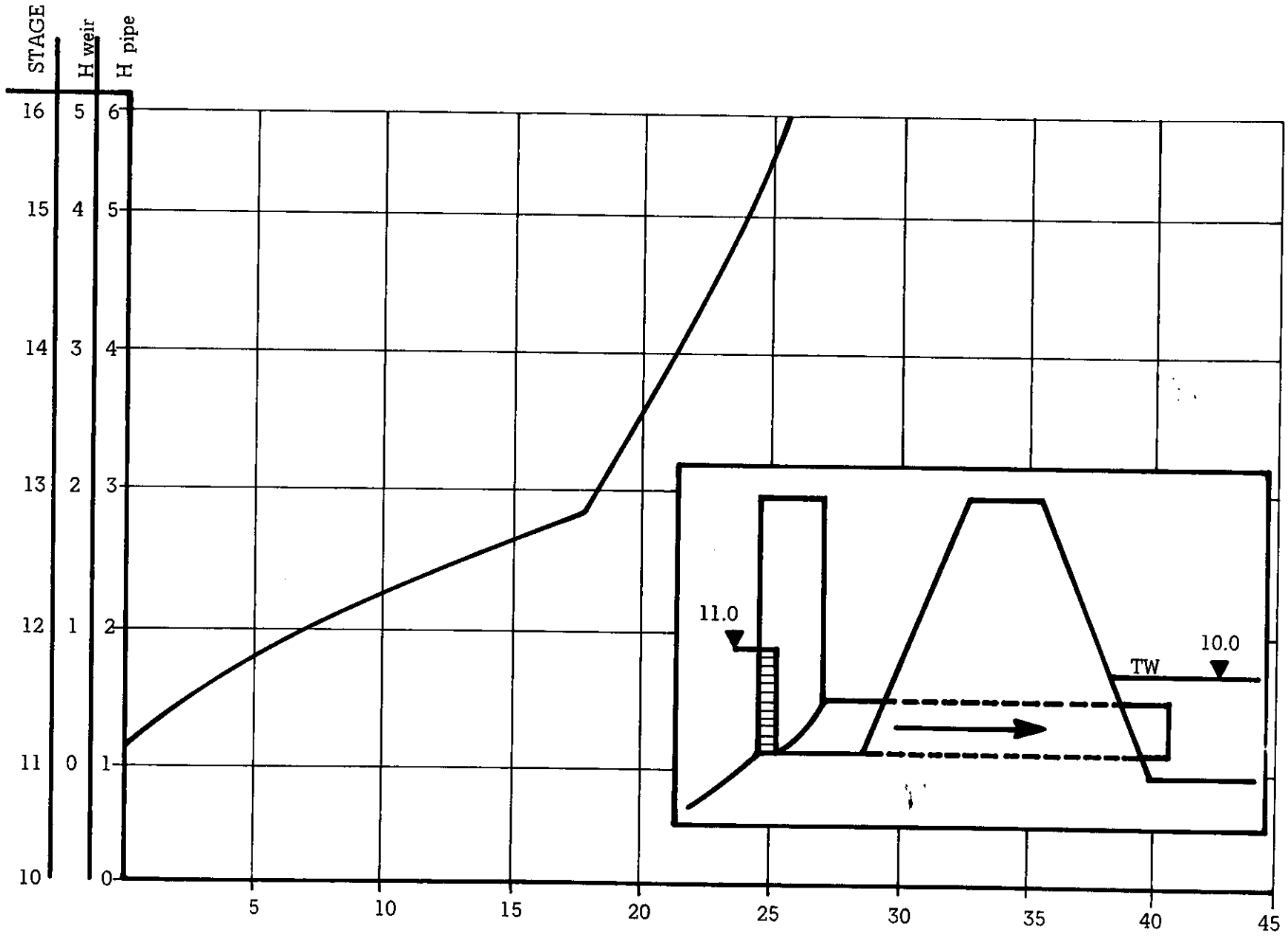


FIGURE 19

TYPICAL STAGE - DISCHARGE GRAPH

C. Overland Flow

The District staff have developed a procedure for estimating sheetflow runoff occurring from undeveloped watersheds in South Florida. The procedure is described in more detail in A Procedure for the Estimation of Sheetflow Runoff in the South Florida Water Management District. The method requires the use of the curves shown in Figures 20 through 35.

The appropriate set of curves Figures 20 through 34 are entered with the appropriate 24 hour rainfall (P), average wet season water table depth prior to the 5 day (or 3 day) design event (DWT), and the contributing sheetflow runoff length above the line or point under consideration. The value of discharge in cubic feet per second per square mile is then read using the appropriate slope curve for the average slope over the runoff length. The discharge value times the area of the watershed considered (in square miles) would give the discharge value for the watershed.

Since most Florida watersheds contain numerous "pockets" and depressions Figure 35 is included whereby the above computed discharge value is reduced to account for excess depression storage not included in the basic calculations. An average of 8" depth of depression was used in the preparation of these curves, which represents essentially initially dry storage above the water table. If depressions varied from this assumption a conversion can be made within the range of accuracy of the computations. For example, 10 percent depression storage area at an average depth of 24 inches could be converted to 30 percent in the curves [(24/8) x 10% = 30%]. For a 24 hour rainfall (P) of 9" this would indicate the value of discharge obtained from Figures 20 through 34 should be reduced to approximately 53 percent of that value.

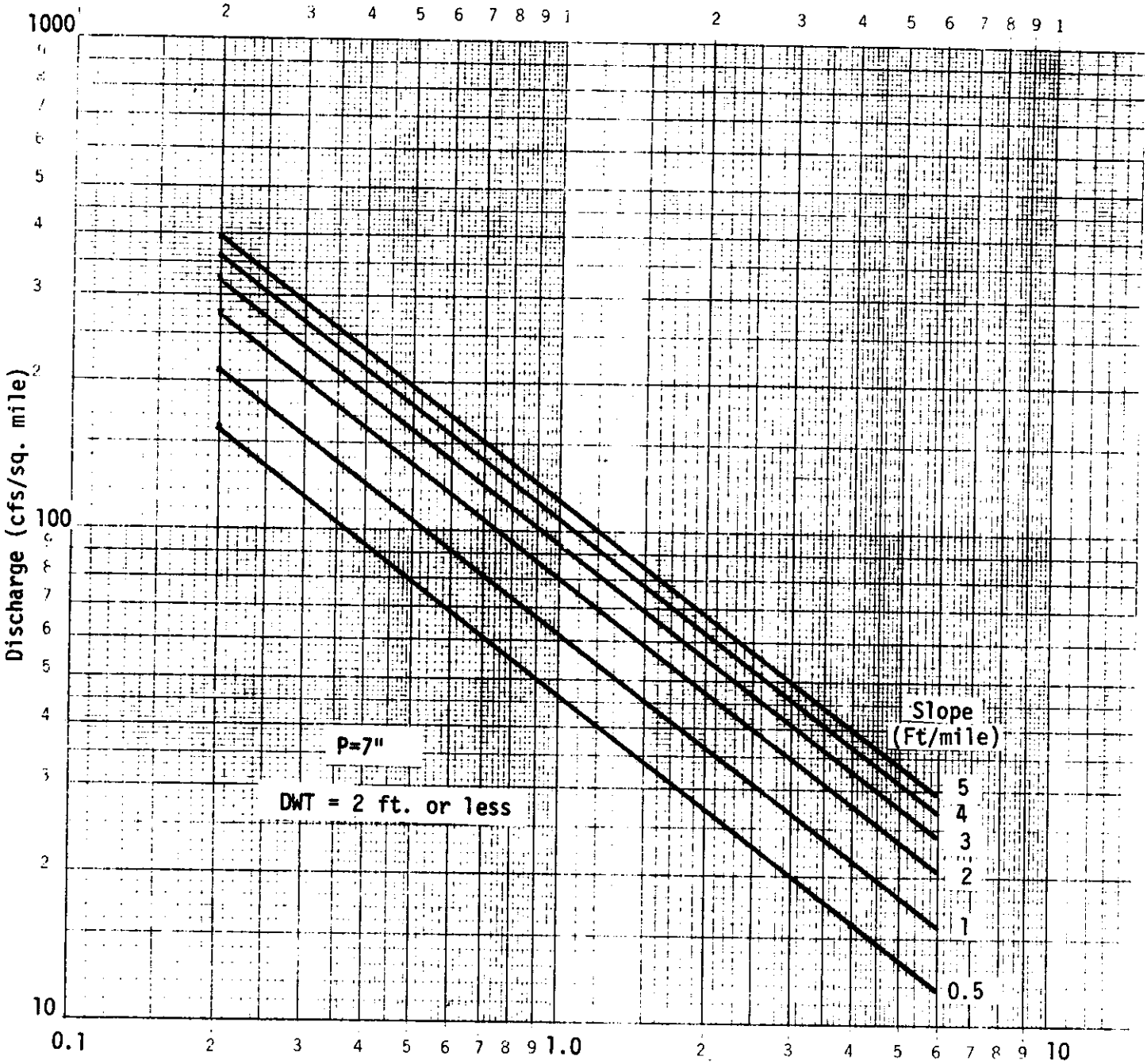

1000
100
10
Discharge (cfs/sq. mile)
0.1
1.0
10
Runoff Length (miles)
P=7"
DWT = 2 ft. or less
Slope
(Ft/mile)
5
4
3
2
1
0.5

Figure 20

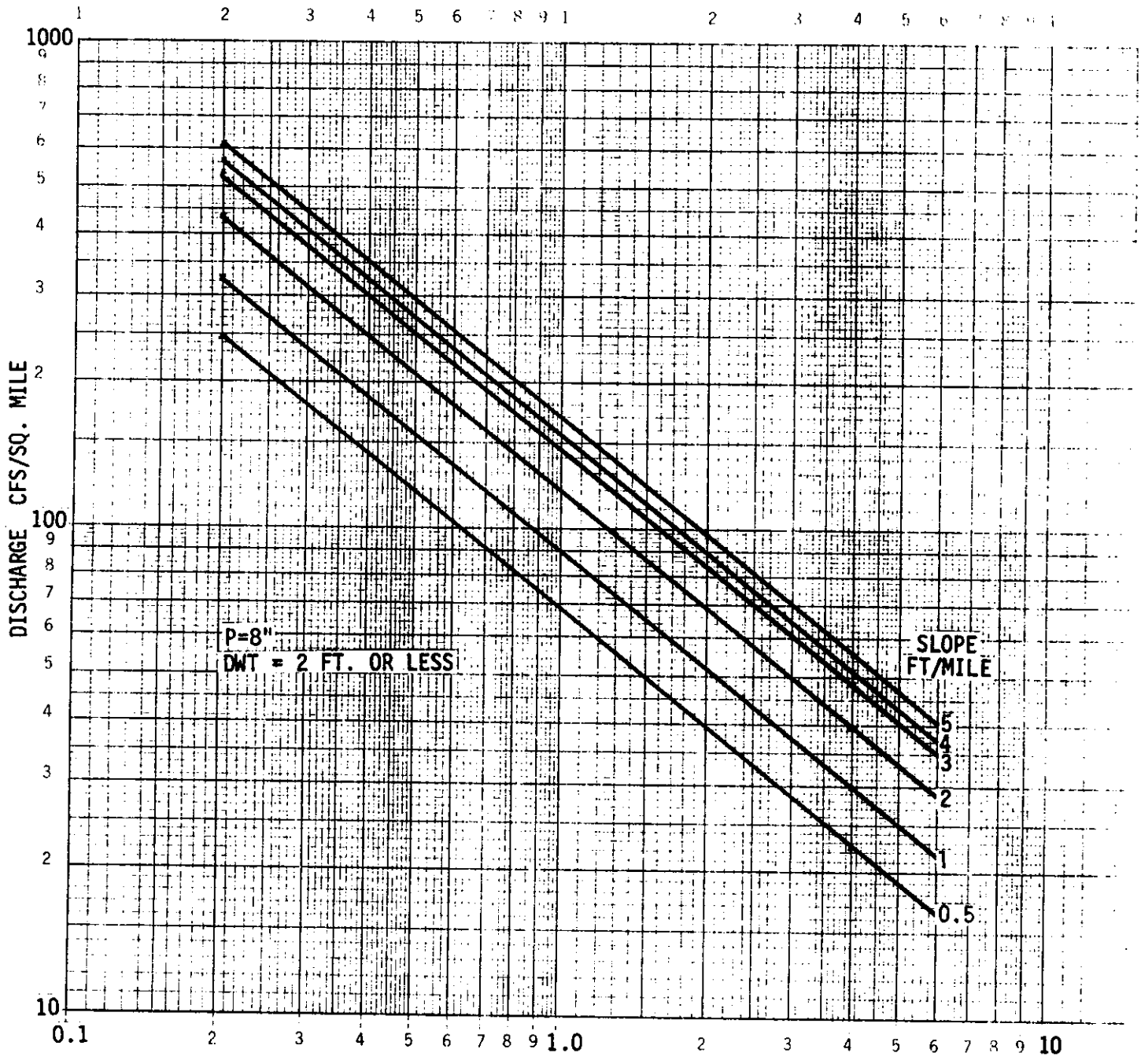

DISCHARGE CFS/SQ. MILE
1000
100
10
P=8"
DWT = 2 FT. OR LESS
SLOPE FT/MILE
5
4
3
2
1
0.5
0.1
1.0
10
RUNOFF LENGTH (MILES)

FIGURE 21

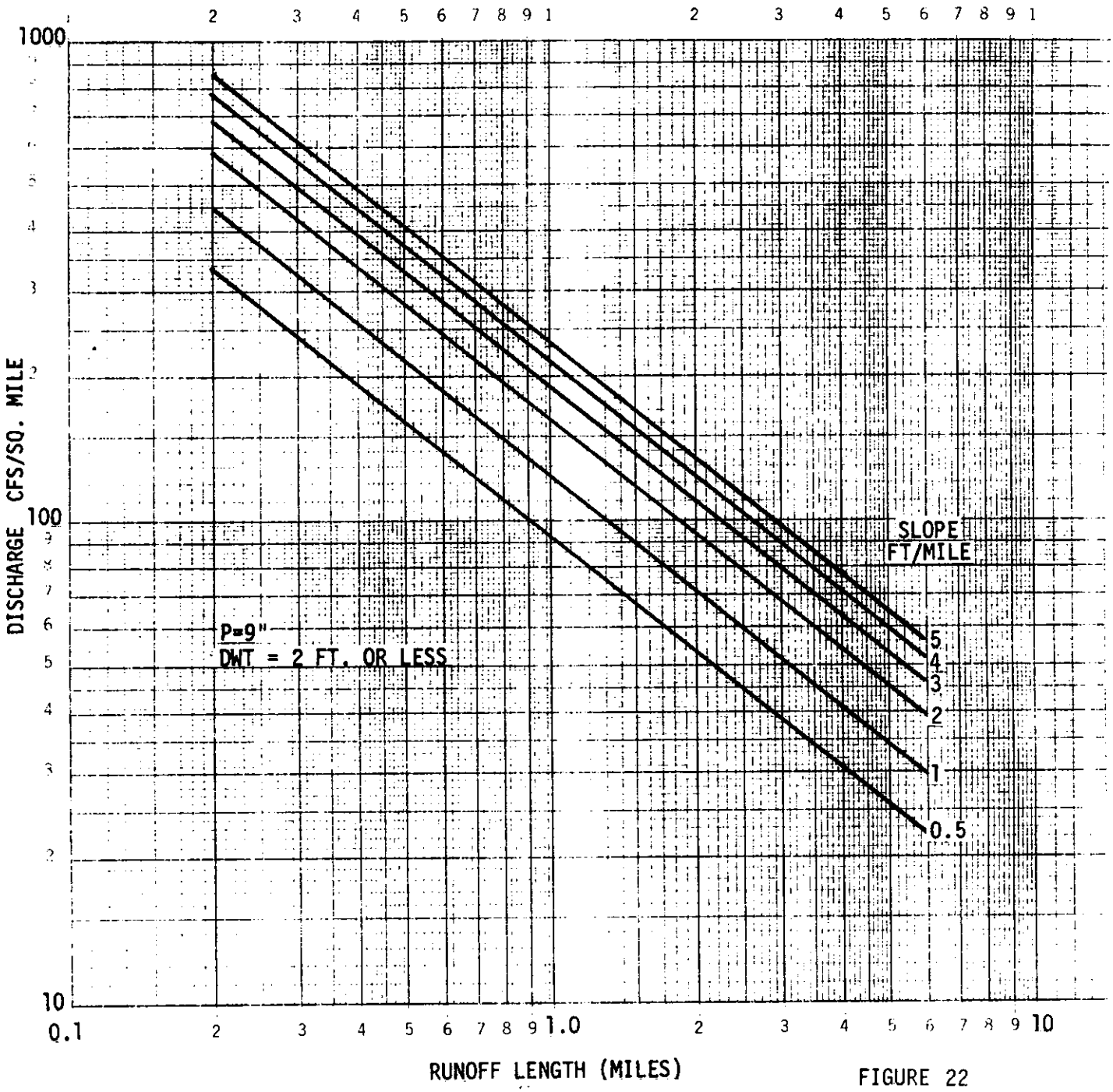

DISCHARGE CFS/SQ. MILE
1000
100
10
0.1
1.0
10
RUNOFF LENGTH (MILES)
P=9"
DWT = 2 FT. OR LESS
SLOPE FT/MILE
5
4
3
2
1
0.5

FIGURE 22

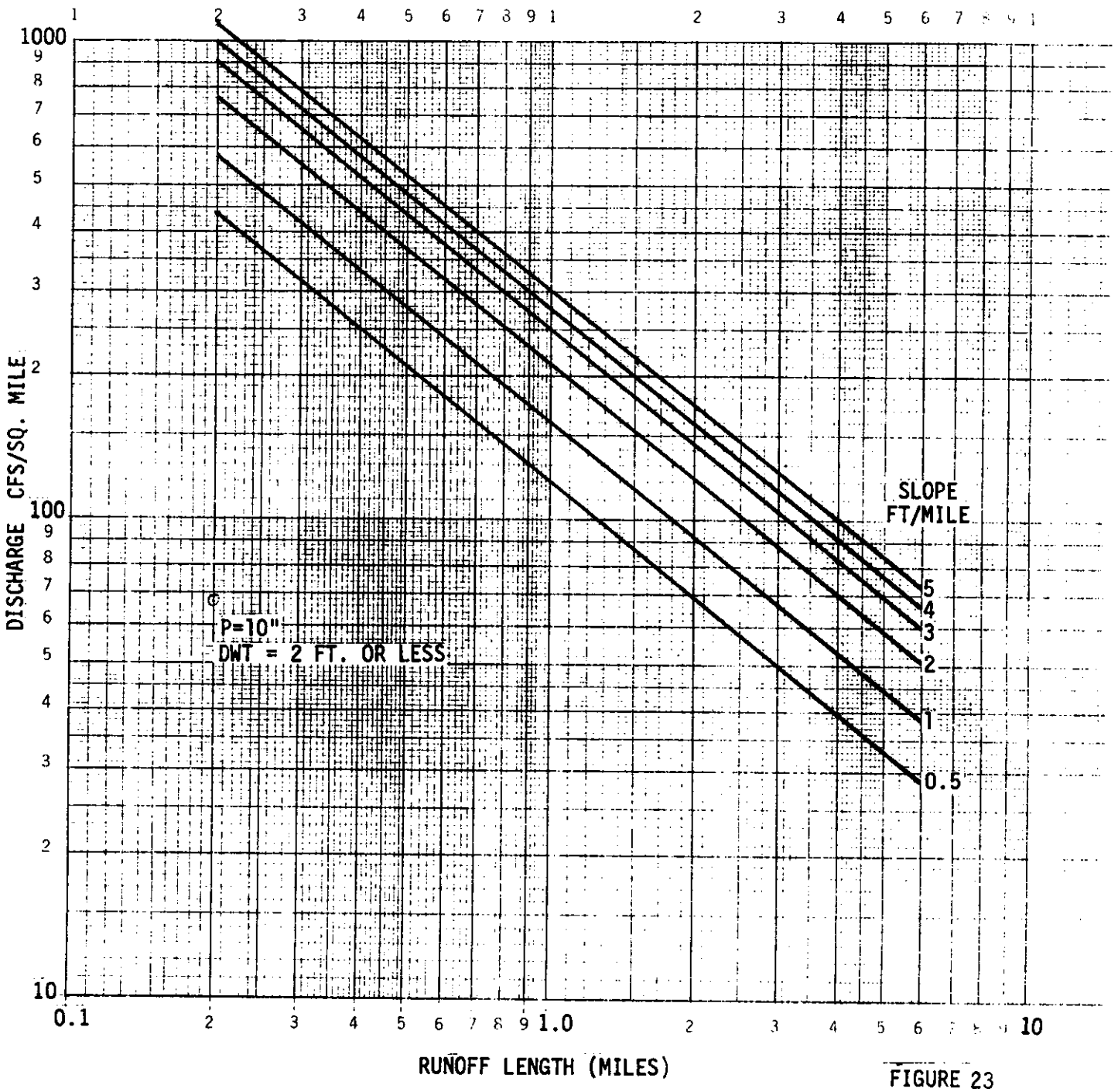

DISCHARGE CFS/SQ. MILE
1000
100
10
0.1
1.0
10
RUNOFF LENGTH (MILES)
SLOPE FT/MILE
5
4
3
2
1
0.5
P=10"
DWT = 2 FT. OR LESS

FIGURE 23

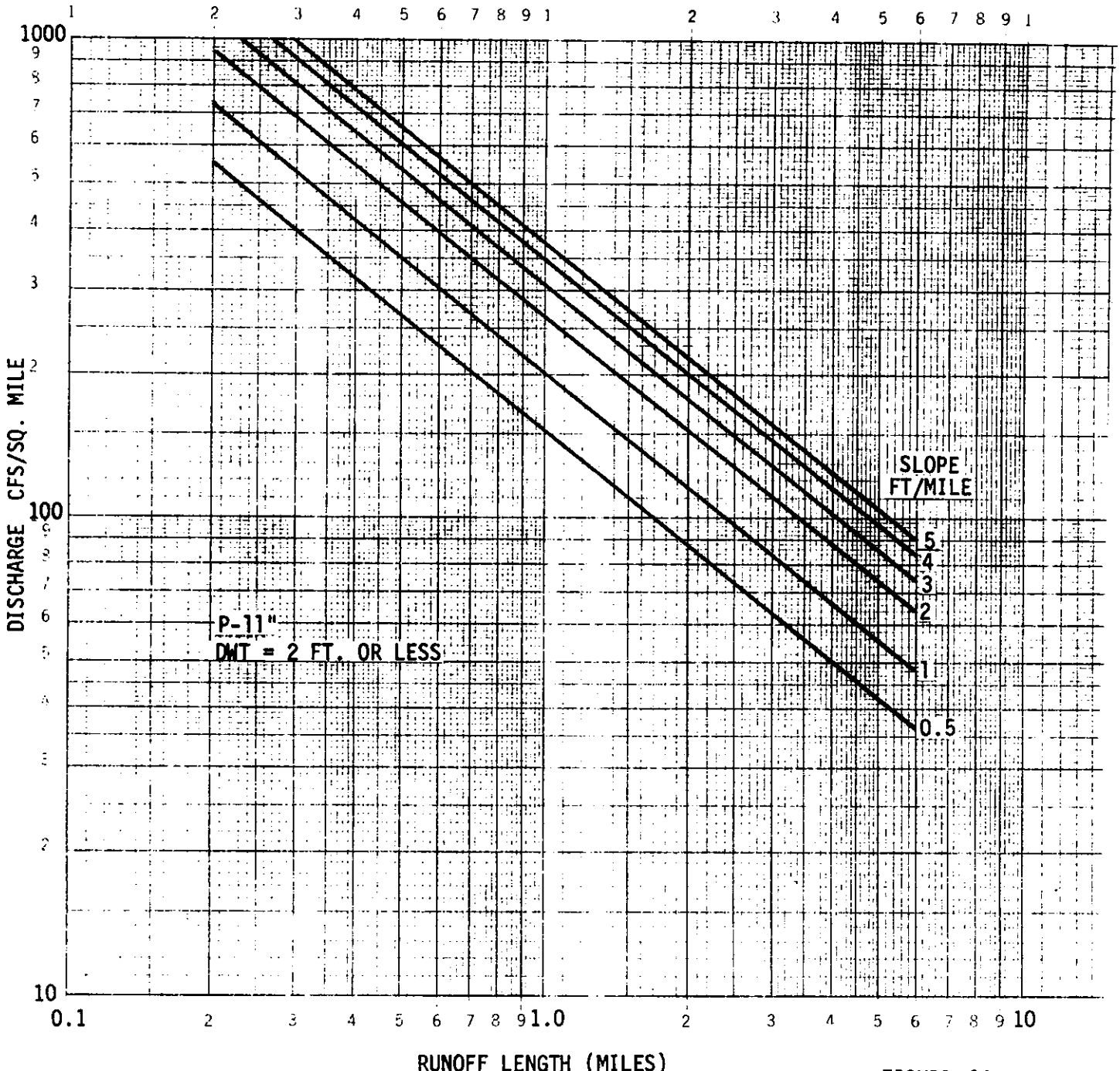

DISCHARGE CFS/SQ. MILE
1000
100
10
0.1
1.0
10
RUNOFF LENGTH (MILES)
P-11"
DWT = 2 FT. OR LESS
SLOPE FT/MILE
5
4
3
2
1
0.5

FIGURE 24

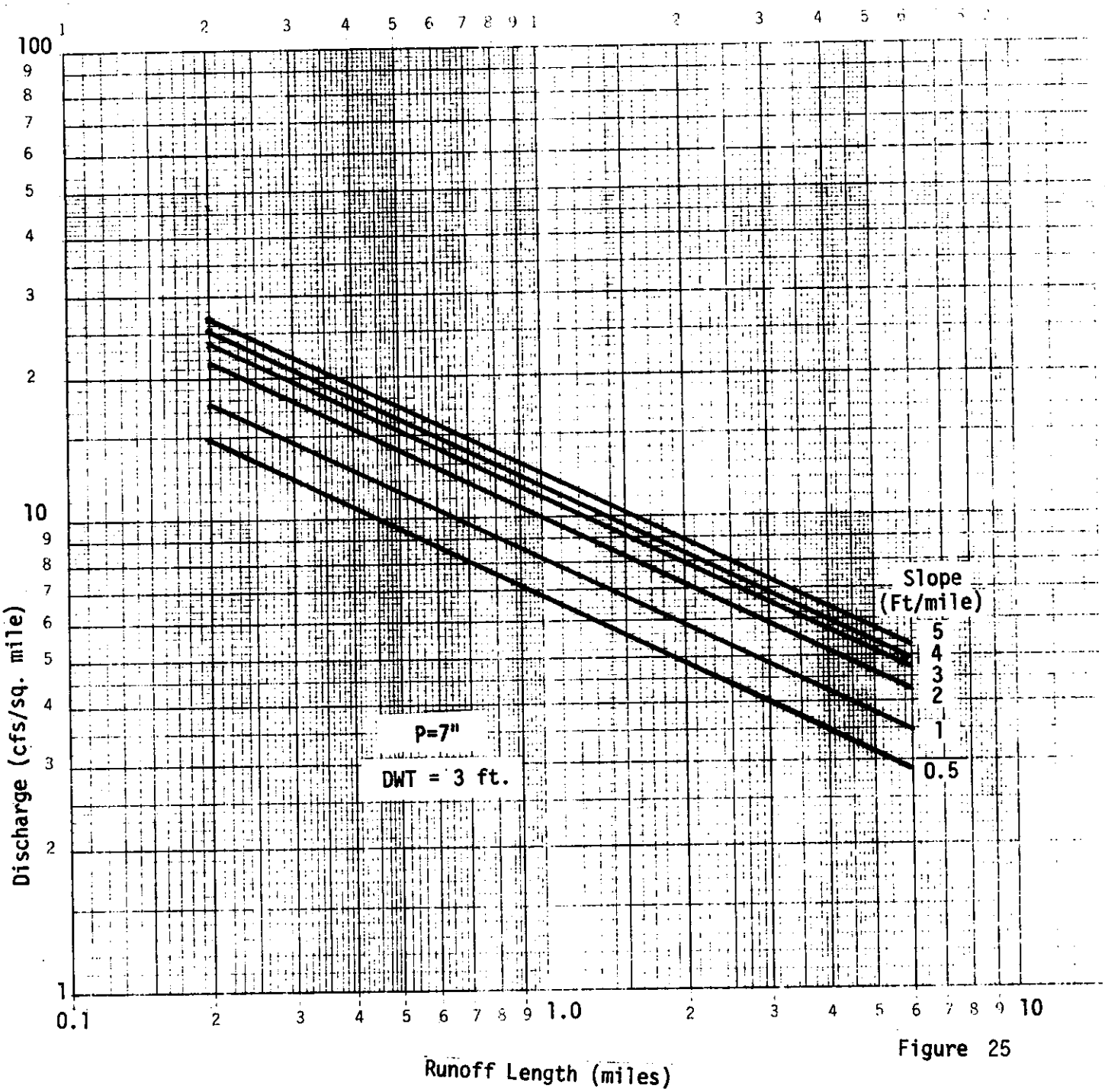

Discharge (cfs/sq. mile)
Runoff Length (miles)
Slope (Ft/mile)
5
4
3
2
1
0.5
P=7"
DWT = 3 ft.
100
10
1
0.1
1.0
10

Figure 25

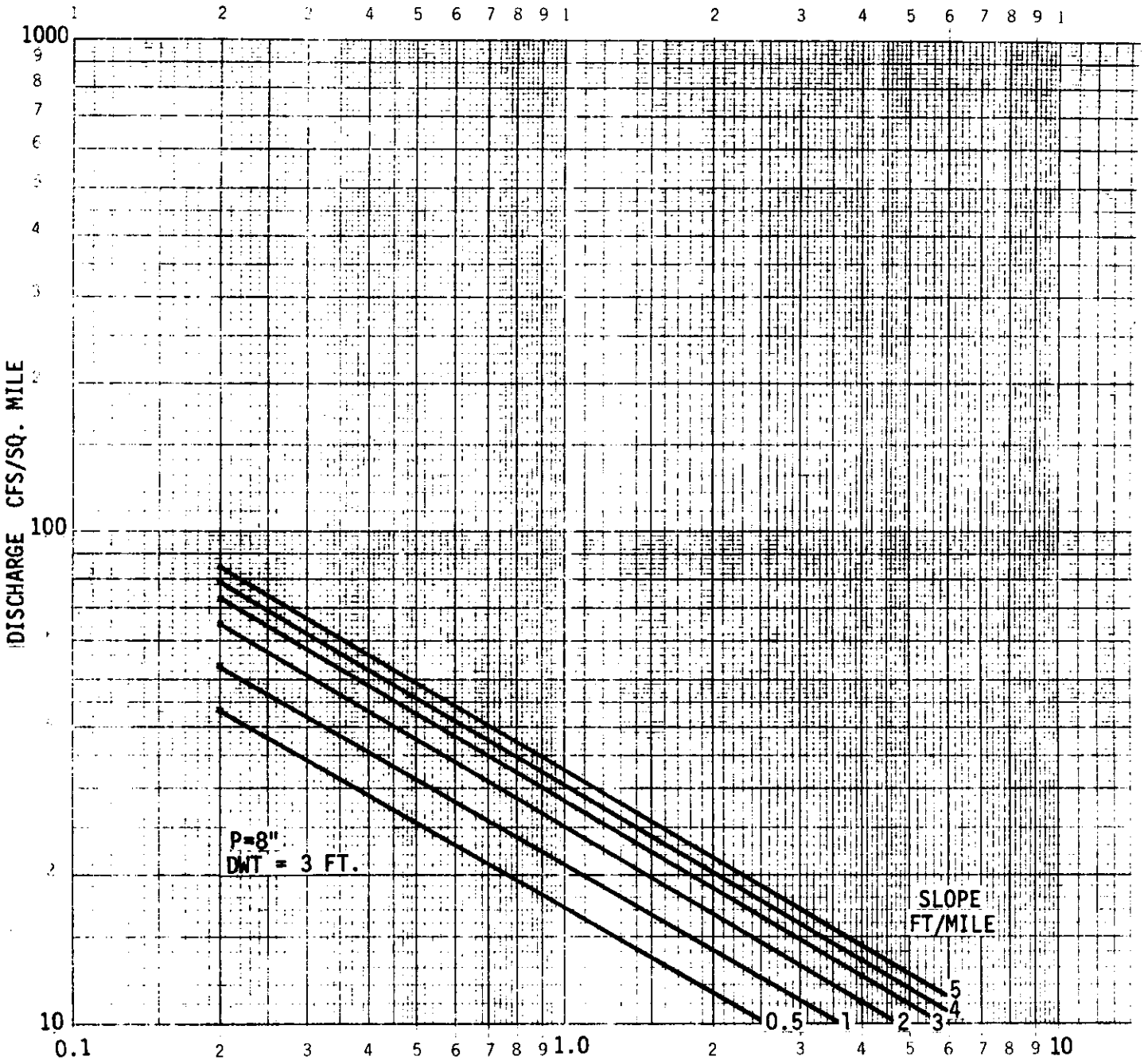

1000
100
10
DISCHARGE CFS/SQ. MILE
0.1
1.0
10
RUNOFF LENGTH (MILES)
P=8"
DWT = 3 FT.
SLOPE
FT/MILE
0.5
1
2
3
4
5

FIGURE 26

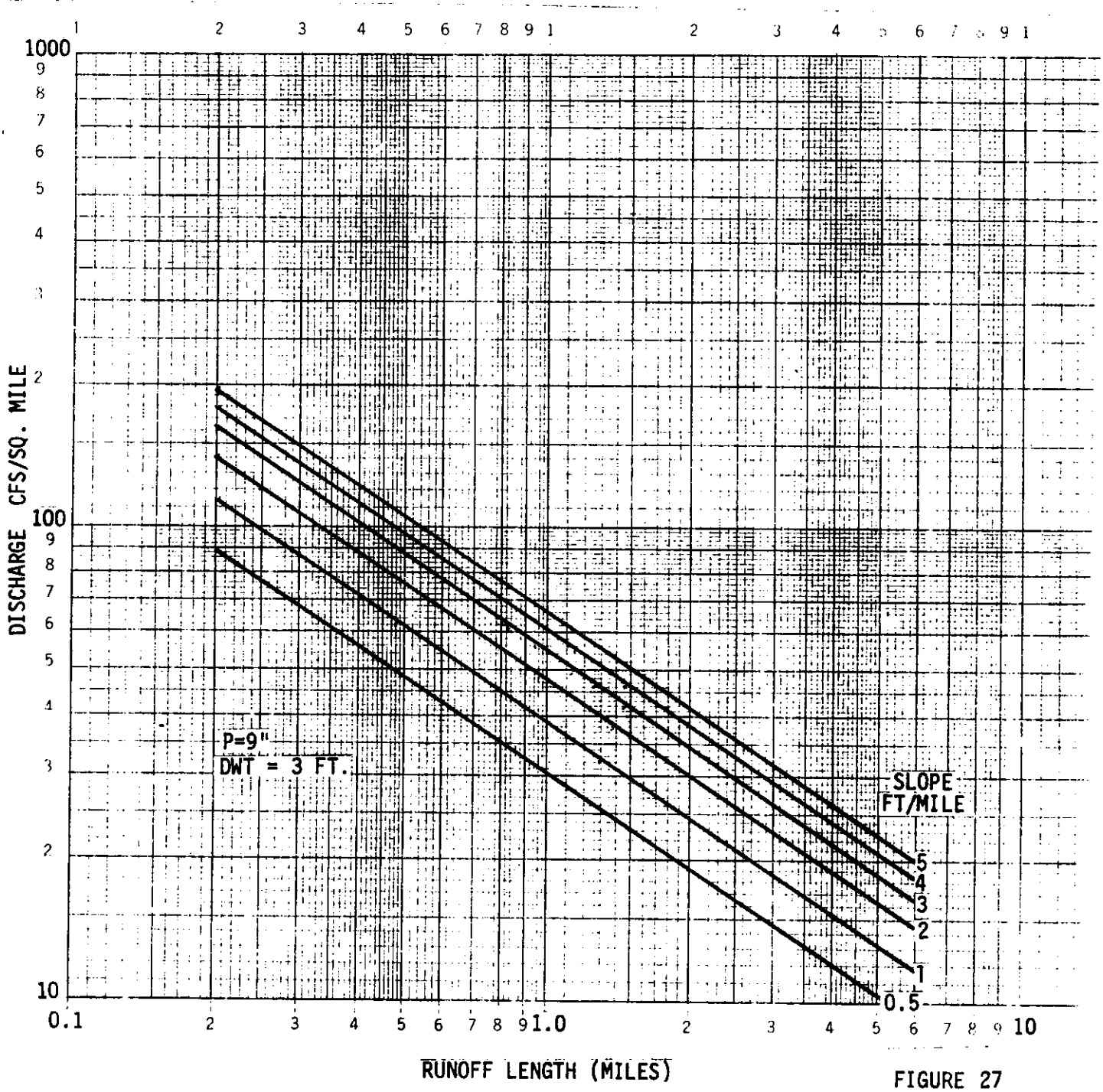

DISCHARGE CFS/SQ. MILE
1000
100
10
P=9"
DWT = 3 FT.
SLOPE FT/MILE
5
4
3
2
1
0.5
0.1
1.0
10
RUNOFF LENGTH (MILES)

FIGURE 27

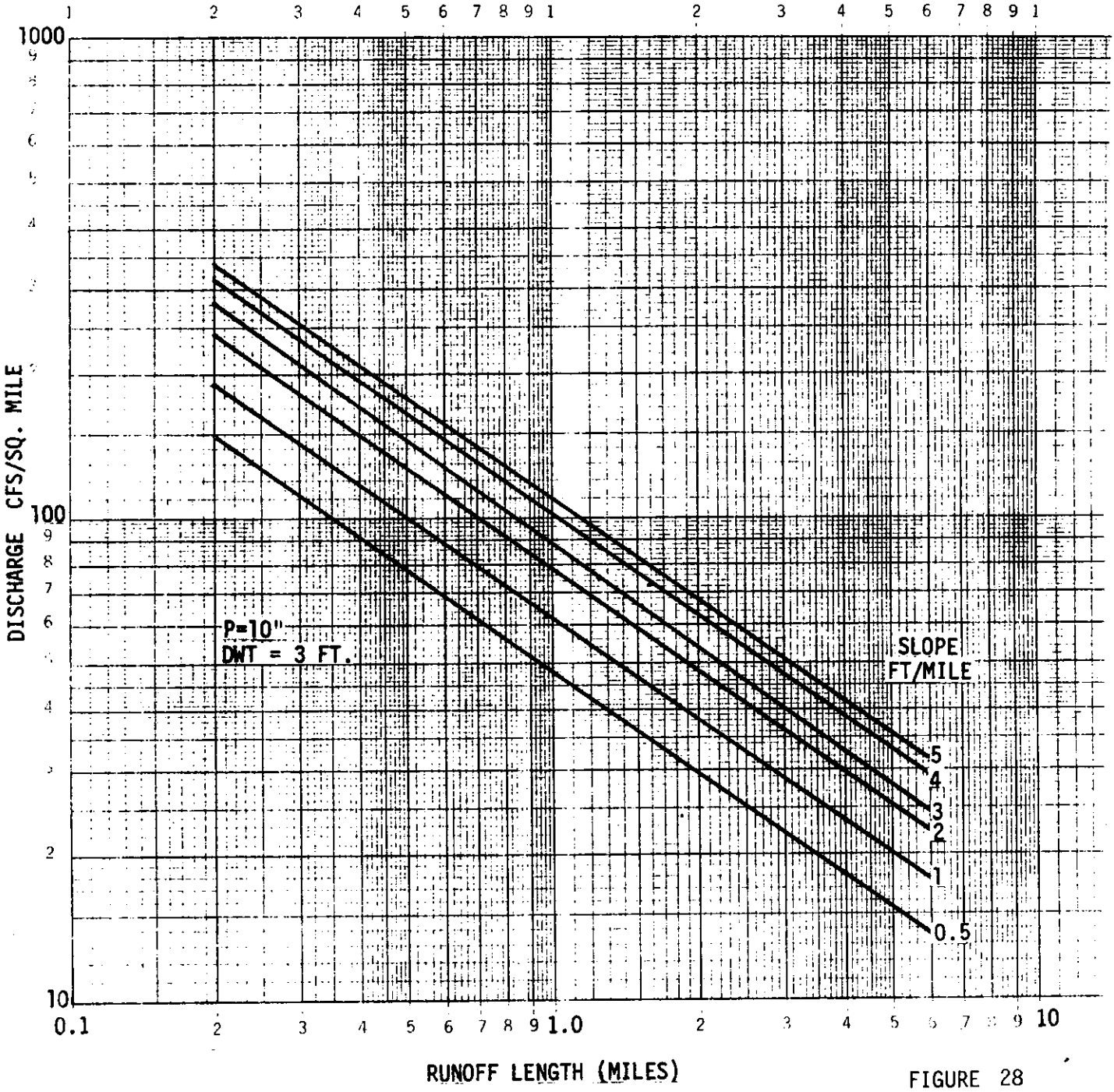

1000
100
10
DISCHARGE CFS/SQ. MILE
P=10"
DWT = 3 FT.
SLOPE
FT/MILE
5
4
3
2
1
0.5
0.1
1.0
10
RUNOFF LENGTH (MILES)

FIGURE 28

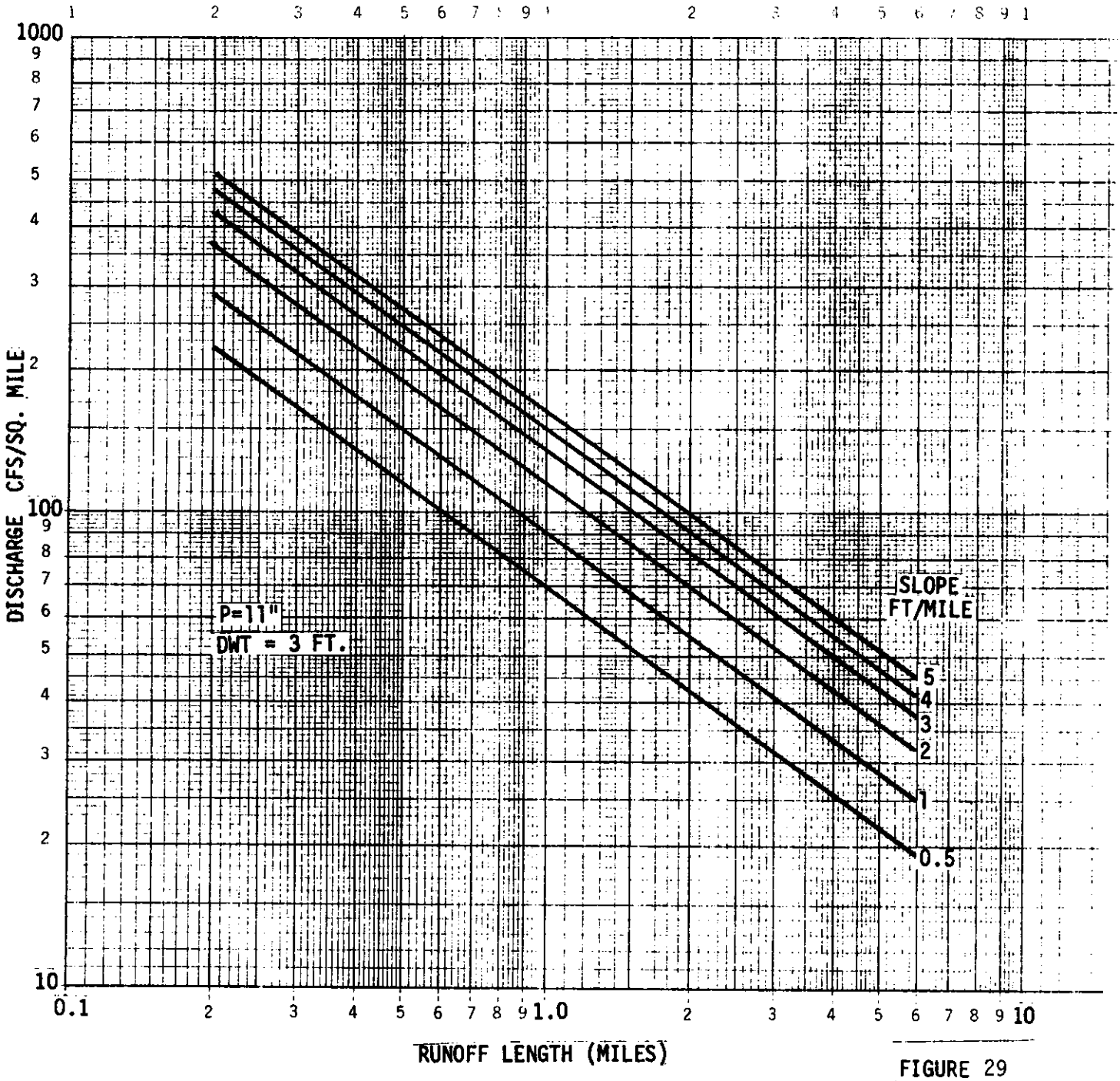

DISCHARGE CFS/SQ. MILE
1000
100
10
P=11"
DWT = 3 FT.
SLOPE FT/MILE
5
4
3
2
1
0.5
0.1
1.0
10
RUNOFF LENGTH (MILES)

FIGURE 29

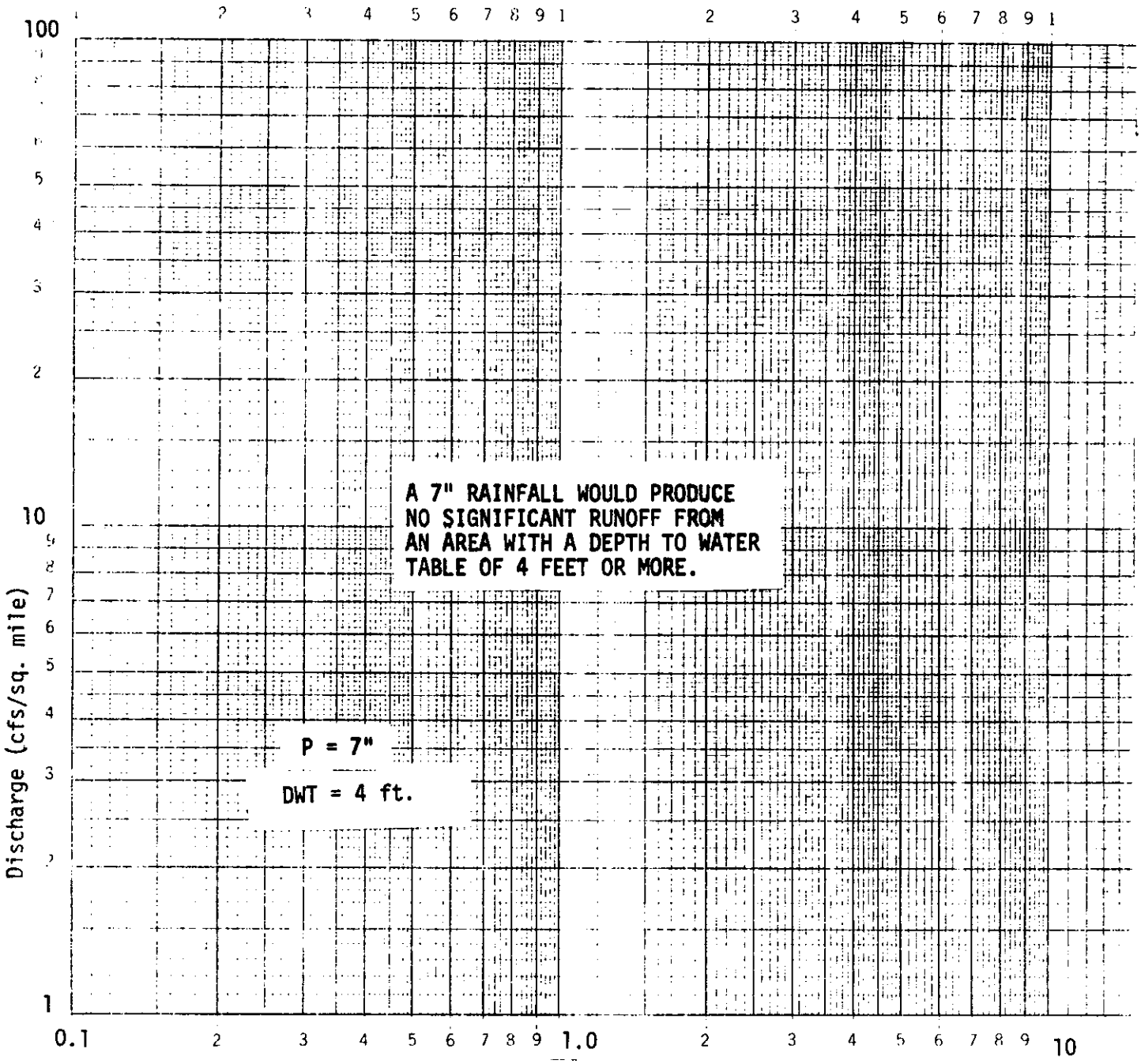

A 7" RAINFALL WOULD PRODUCE NO SIGNIFICANT RUNOFF FROM AN AREA WITH A DEPTH TO WATER TABLE OF 4 FEET OR MORE.
P = 7"
DWT = 4 ft.
Discharge (cfs/sq. mile)
Runoff Length (miles)
100
10
1
0.1
1.0
10

FIGURE 30

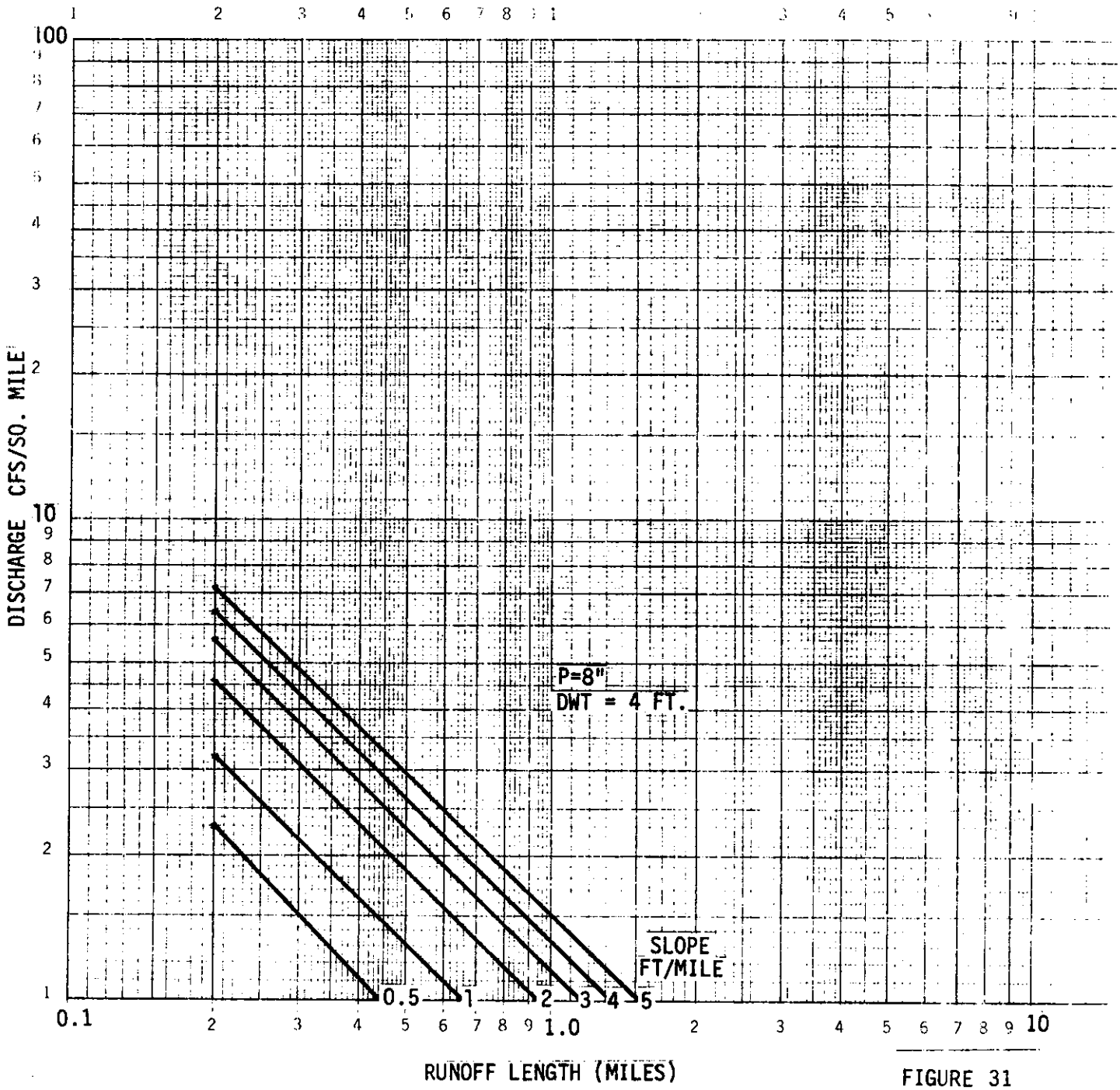

DISCHARGE CFS/SQ. MILE
RUNOFF LENGTH (MILES)
P=8"
DWT = 4 FT.
SLOPE
FT/MILE
0.5
1
2
3
4
5
0.1
1.0
10

FIGURE 31

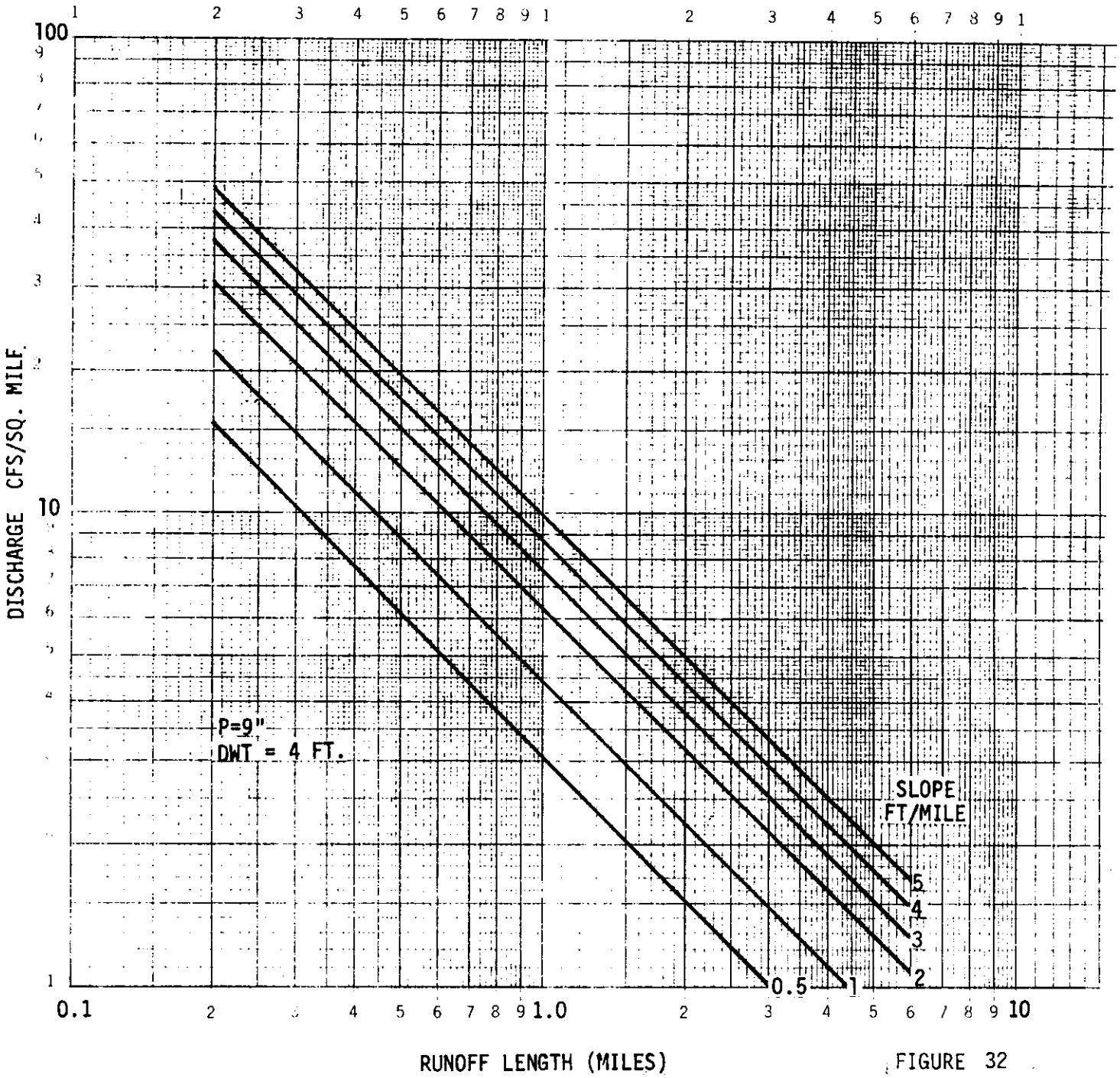

DISCHARGE CFS/SQ. MILE
100
10
1
0.1
1.0
10
P=9"
DWT = 4 FT.
SLOPE
FT/MILE
0.5
1
2
3
4
5
RUNOFF LENGTH (MILES)

FIGURE 32

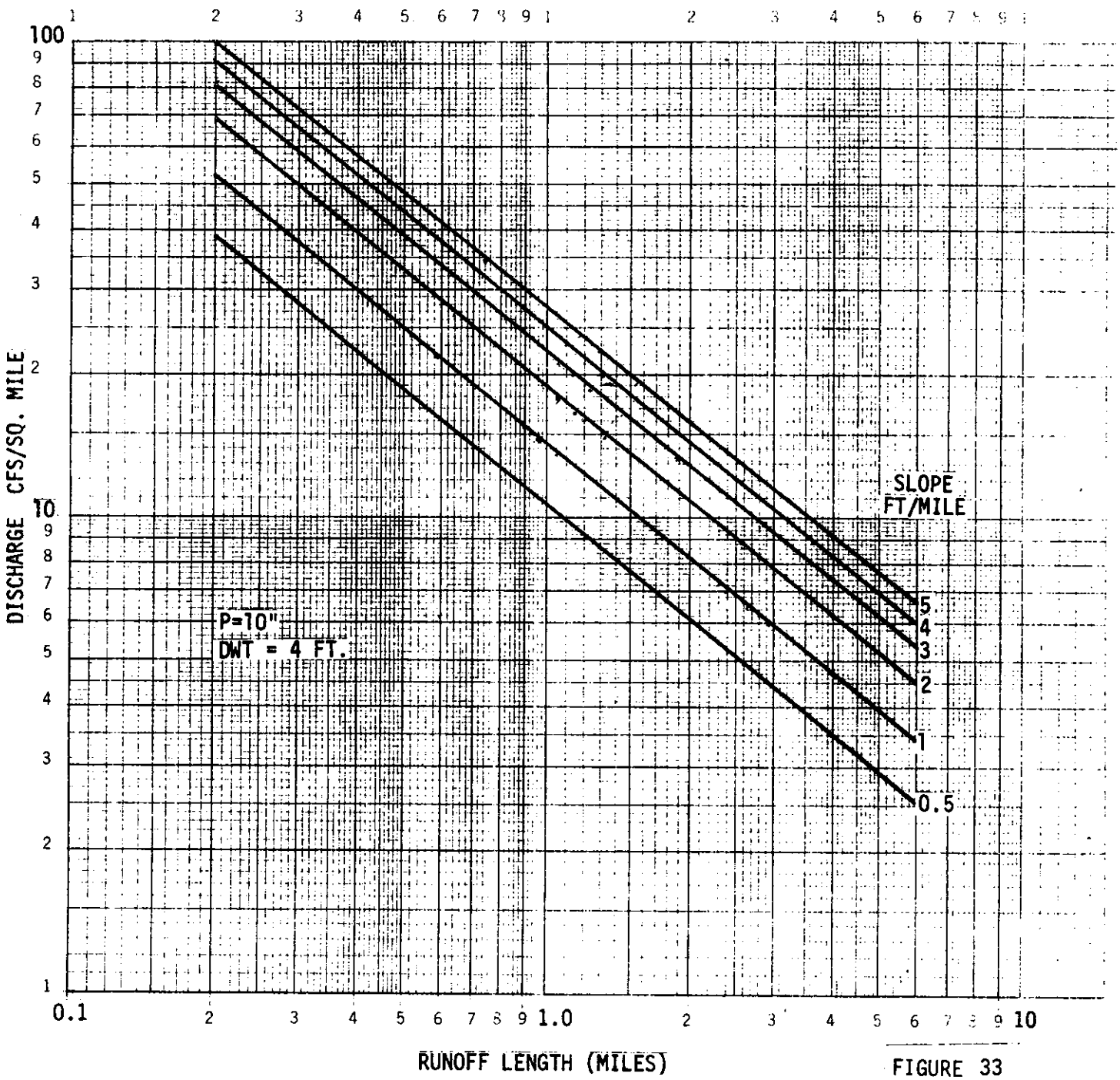

DISCHARGE CFS/SQ. MILE
RUNOFF LENGTH (MILES)
SLOPE FT/MILE
5
4
3
2
1
0.5
P=10"
DWT = 4 FT.
100
10
1
0.1
1.0
10

FIGURE 33

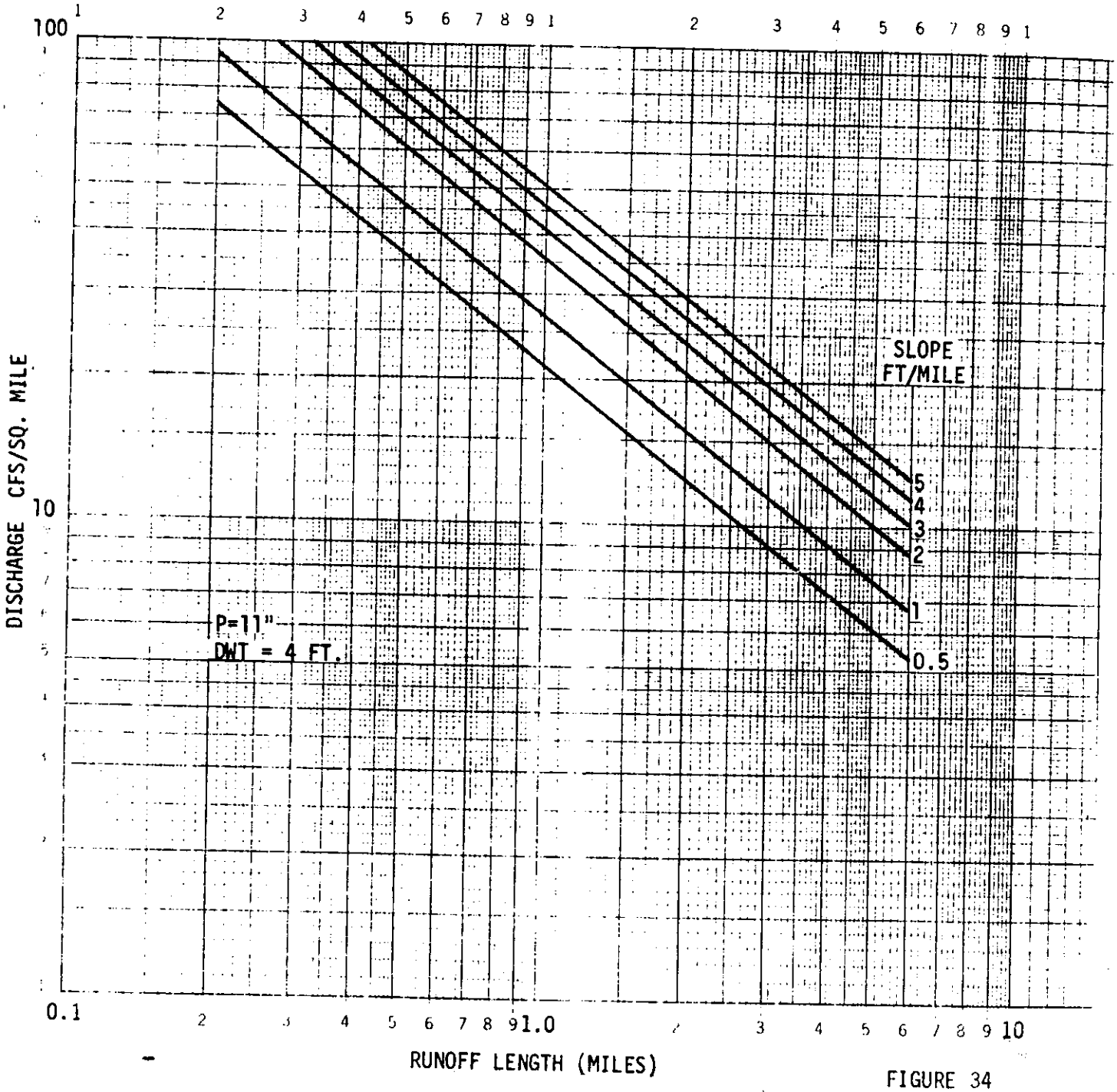

100
10
0.1
DISCHARGE CFS/SQ. MILE
SLOPE FT/MILE
5
4
3
2
1
0.5
P=11"
DWT = 4 FT.
1.0
10
RUNOFF LENGTH (MILES)

FIGURE 34

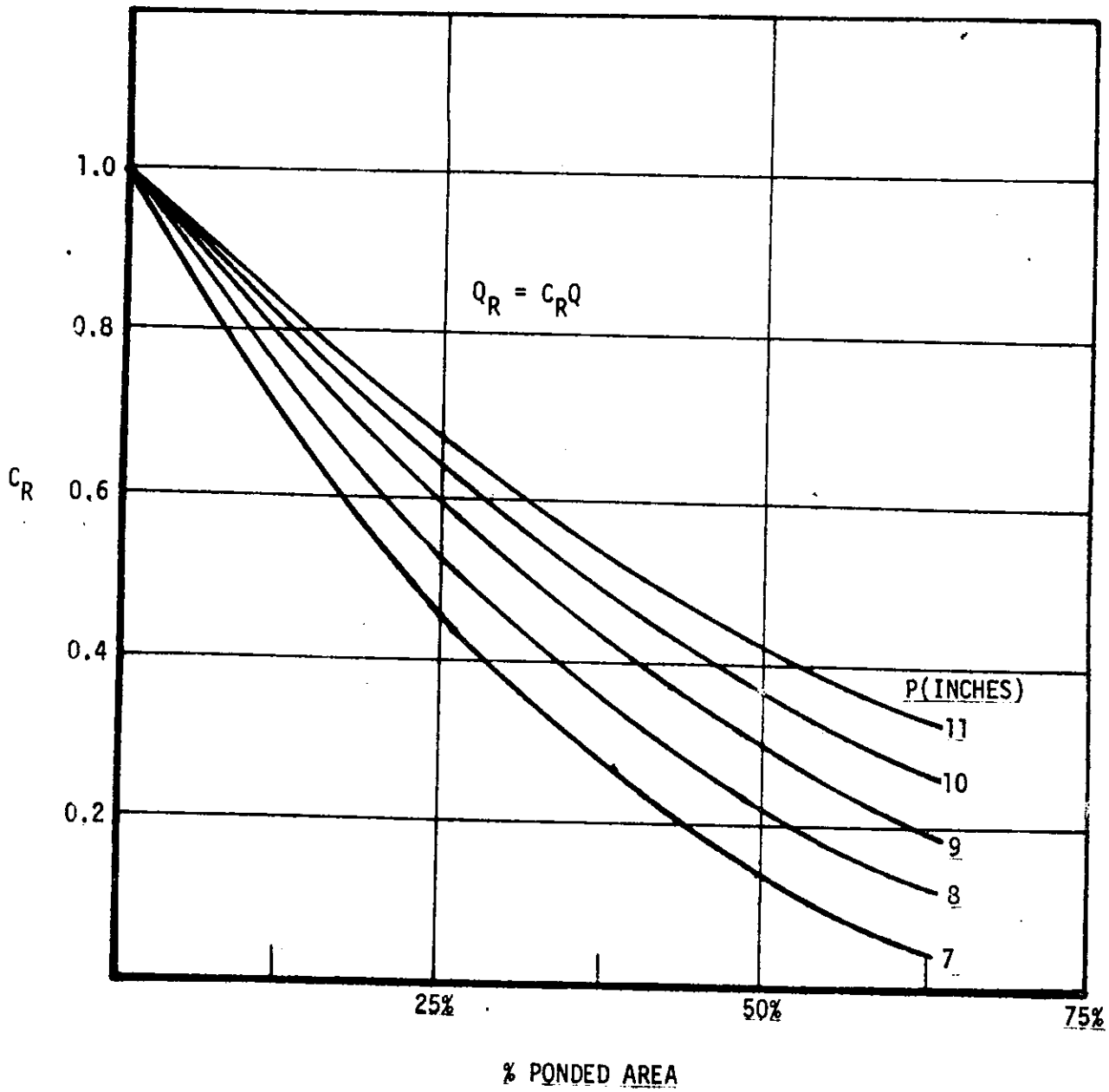


FIGURE 35

D. Allowable Discharge

The allowable discharge from a project is based upon the location of the project in relation to the receiving surface watercourse. Figures 36 through 57 show the major drainage basin boundaries within the District. The allowable discharge for District canals is based on the formulas, factors and curves shown in Appendix 3.

Maps of drainage basins

The following 22 maps show drainage basins for all counties in the South Florida Water Management District.

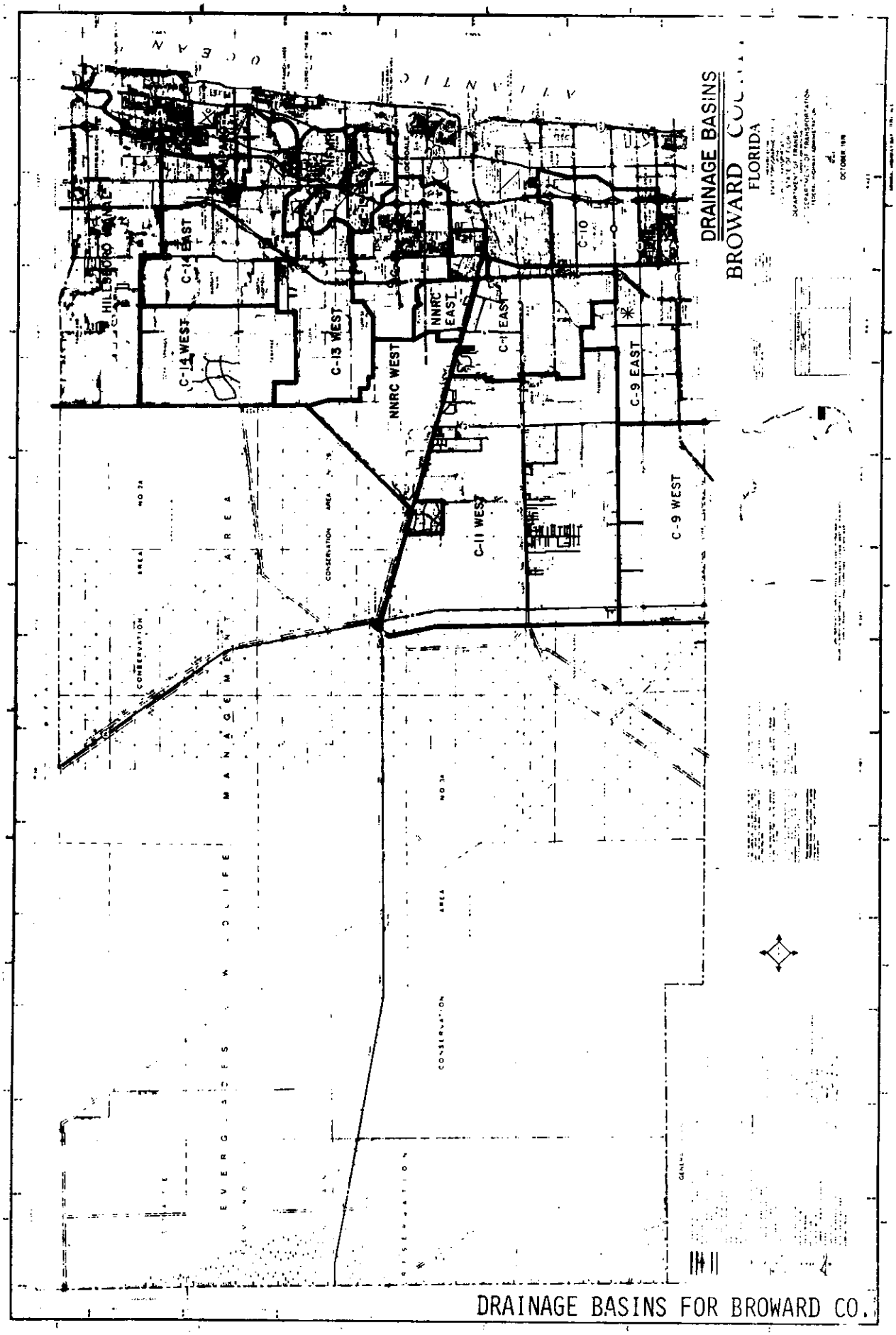

DRAINAGE BASINS
FLORIDA
C-14 EAST
C-14 WEST
C-13 WEST
NNRC WEST
NNRC EAST
C-11 EAST
C-10
C-9 EAST
C-11 WEST
C-9 WEST
DRAINAGE BASINS FOR BROWARD CO.

FIGURE 36

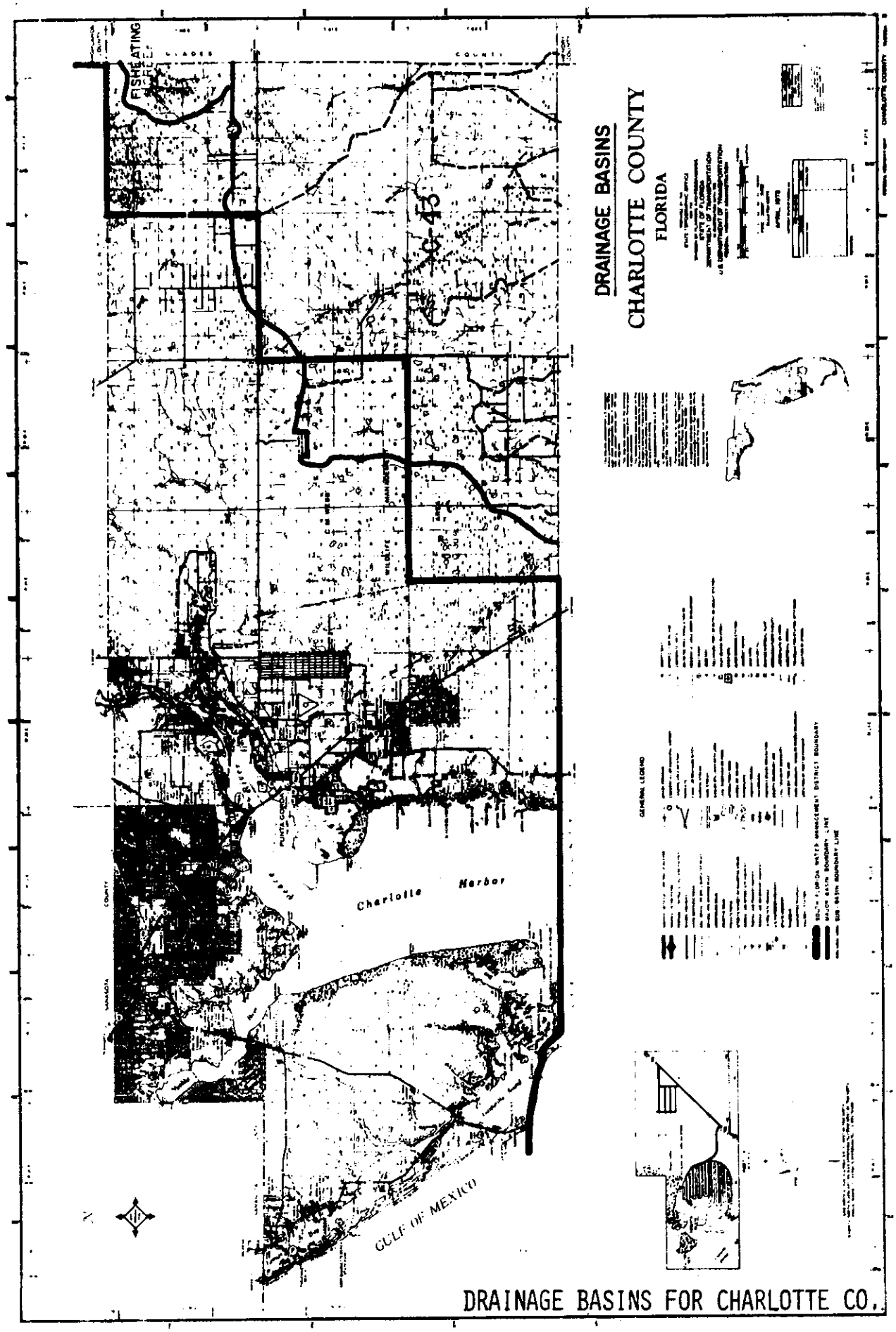

DRAINAGE BASINS
CHARLOTTE COUNTY
FLORIDA
Charlotte Harbor
GULF OF MEXICO
DRAINAGE BASINS FOR CHARLOTTE CO.

FIGURE 37
-94-

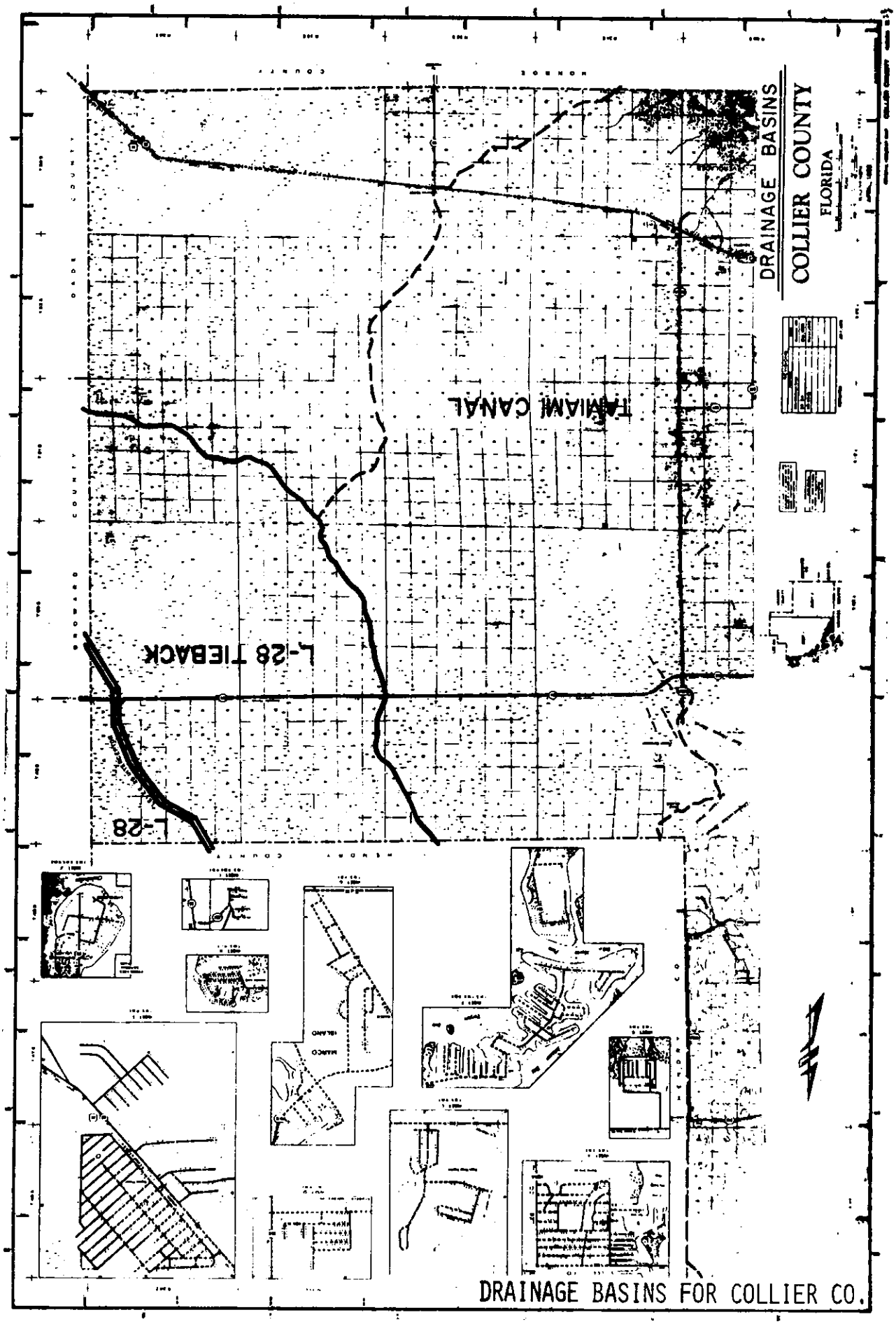

DRAINAGE BASINS
COLLIER COUNTY
FLORIDA
TAMIAMI CANAL
L-28 TIEBACK
L-28
DRAINAGE BASINS FOR COLLIER CO.

FIGURE 38

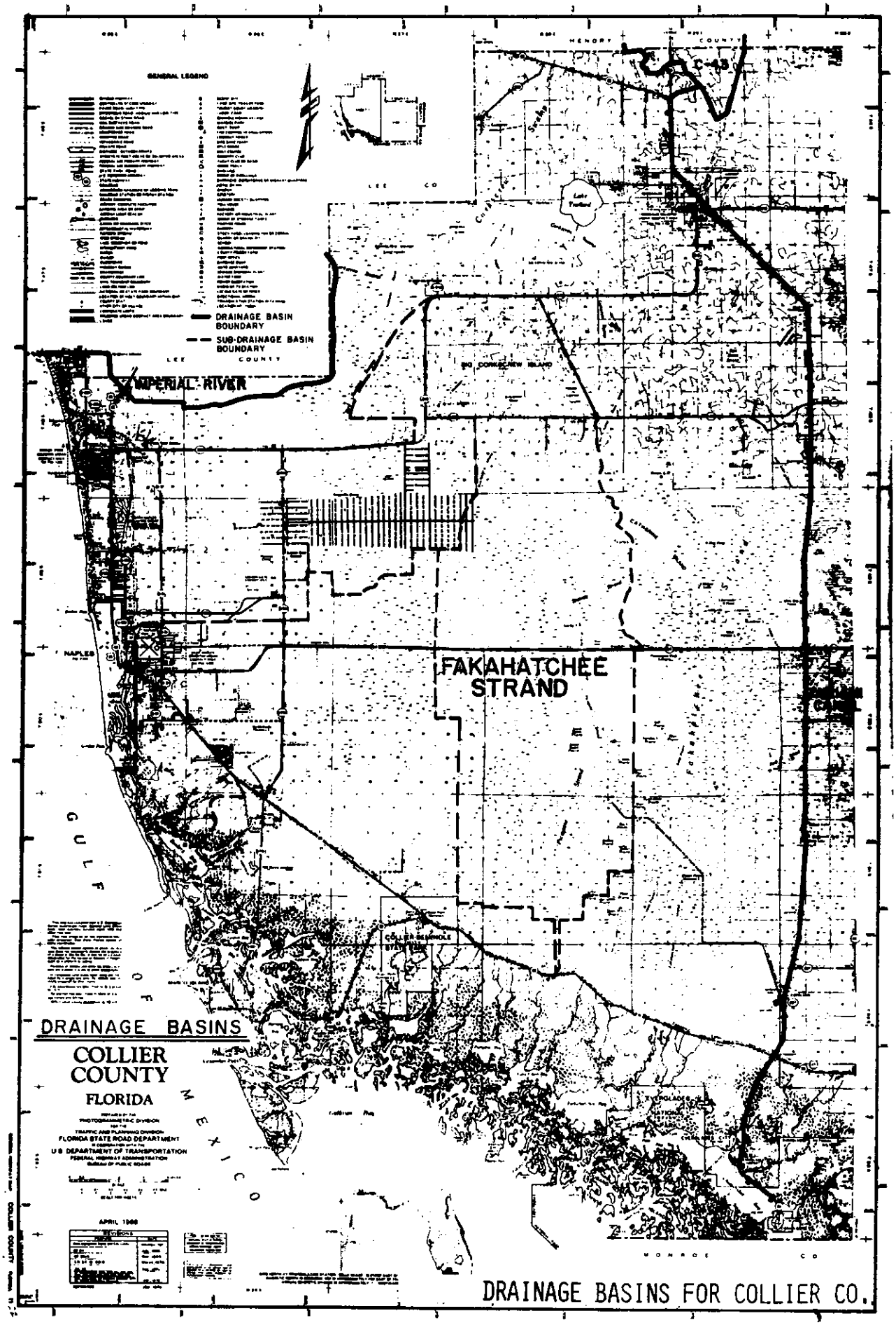

GENERAL LEGEND
DRAINAGE BASIN BOUNDARY
SUB-DRAINAGE BASIN BOUNDARY
IMPERIAL RIVER
FAKAHATCHEE STRAND
GULF OF MEXICO
DRAINAGE BASINS
COLLIER COUNTY
FLORIDA
DRAINAGE BASINS FOR COLLIER CO.

FIGURE 39

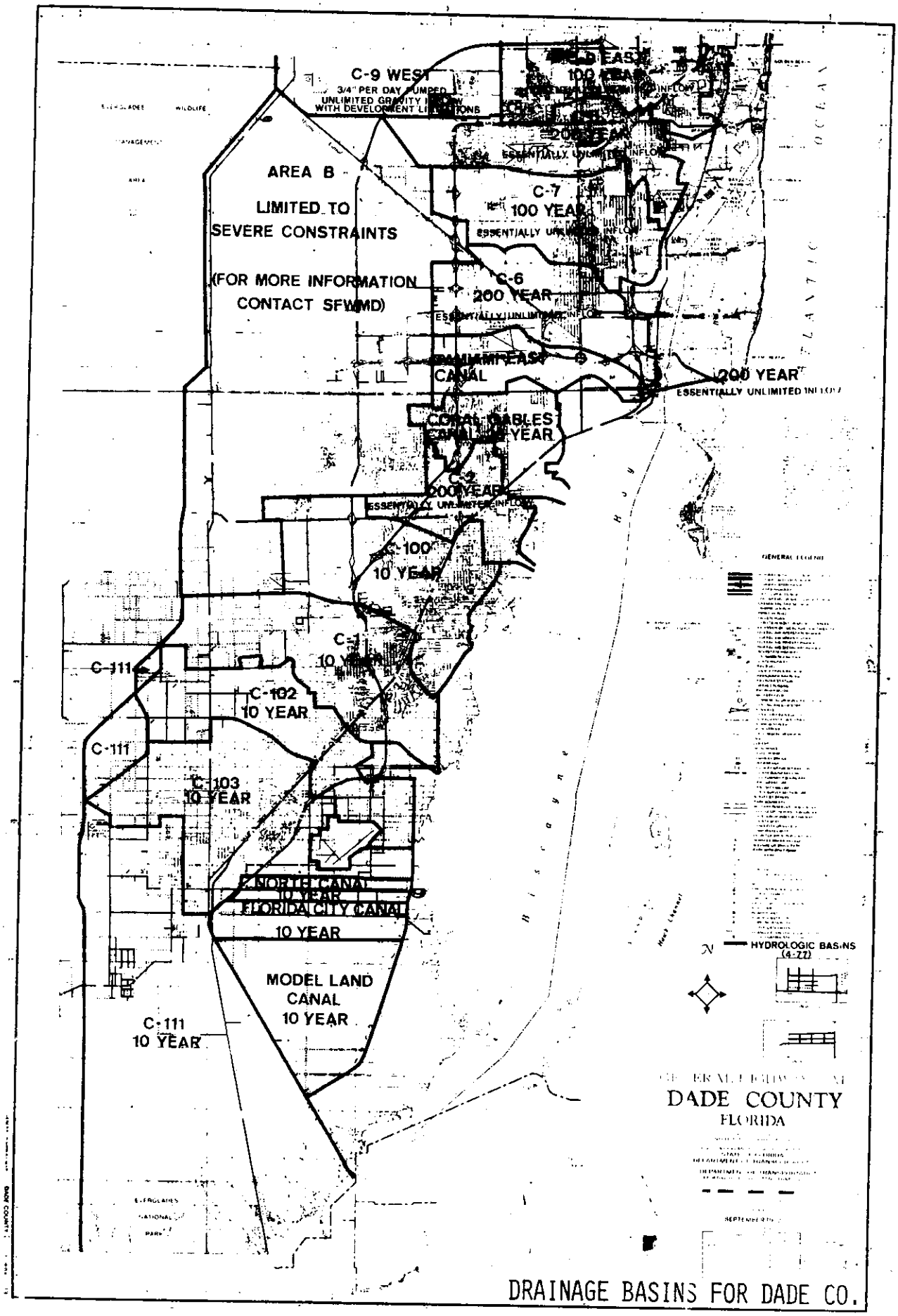

C-9 WEST
3/4" PER DAY PUMPED
UNLIMITED GRAVITY INFLOW
WITH DEVELOPMENT LIMITATIONS
AREA B
LIMITED TO
SEVERE CONSTRAINTS
(FOR MORE INFORMATION
CONTACT SFWMD)
C-7
100 YEAR
ESSENTIALLY UNLIMITED INFLOW
C-6
200 YEAR
ESSENTIALLY UNLIMITED INFLOW
CANAL
200 YEAR
ESSENTIALLY UNLIMITED INFLOW
CORAL GABLES
C-2
200 YEAR
ESSENTIALLY UNLIMITED INFLOW
C-100
10 YEAR
C-1
10 YEAR
C-111
C-102
10 YEAR
C-111
C-103
10 YEAR
NORTH CANAL
10 YEAR
FLORIDA CITY CANAL
10 YEAR
MODEL LAND
CANAL
10 YEAR
C-111
10 YEAR
HYDROLOGIC BASINS
(4-ZZ)
DADE COUNTY
FLORIDA
DRAINAGE BASINS FOR DADE CO.

FIGURE 40

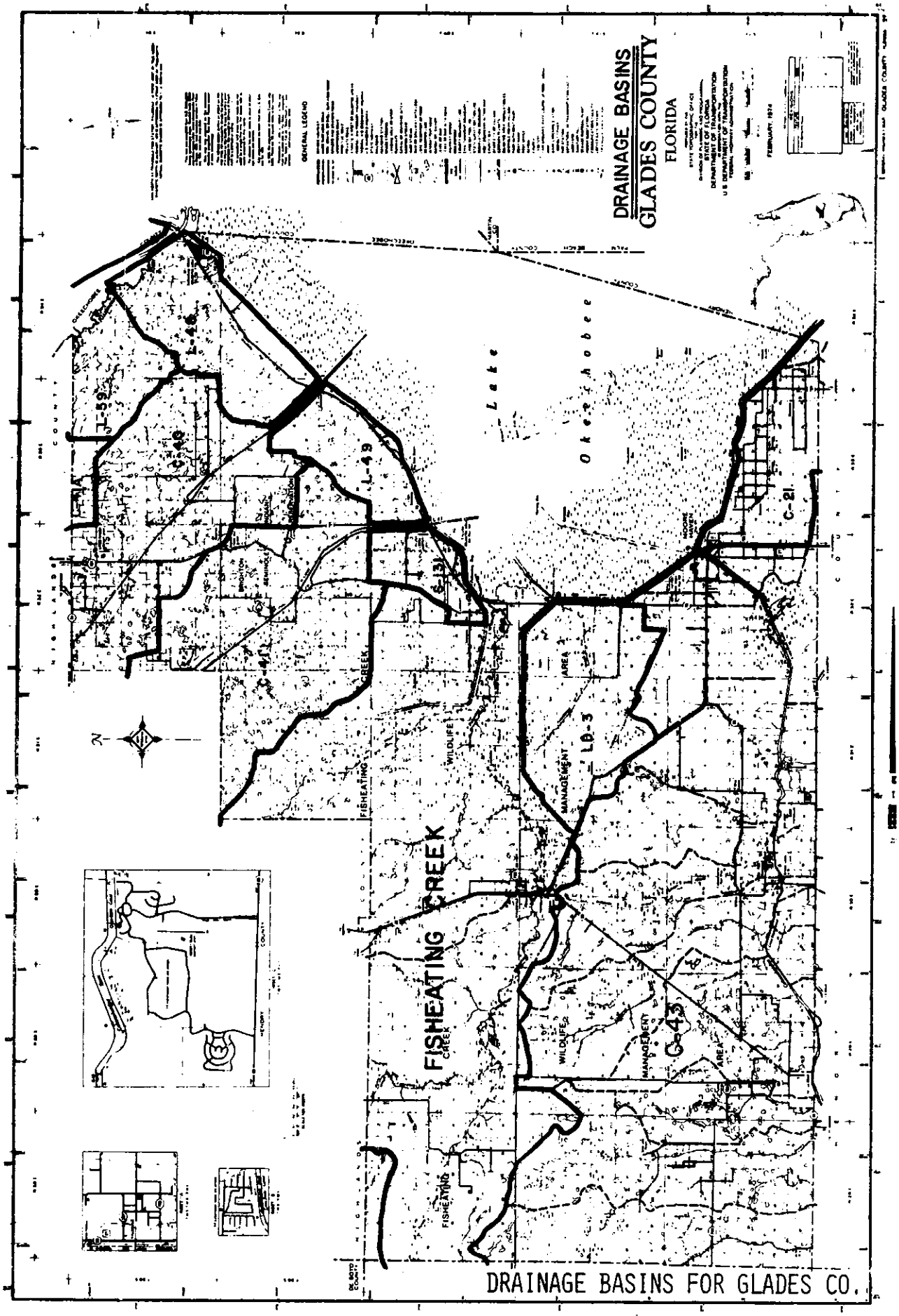

DRAINAGE BASINS
GLADES COUNTY
FLORIDA
Lake Okeechobee
FISHEATING CREEK
WILDLIFE MANAGEMENT AREA
L-59
L-49
L-48
L-47
C-21
C-43
LD-3
DRAINAGE BASINS FOR GLADES CO.

FIGURE 41

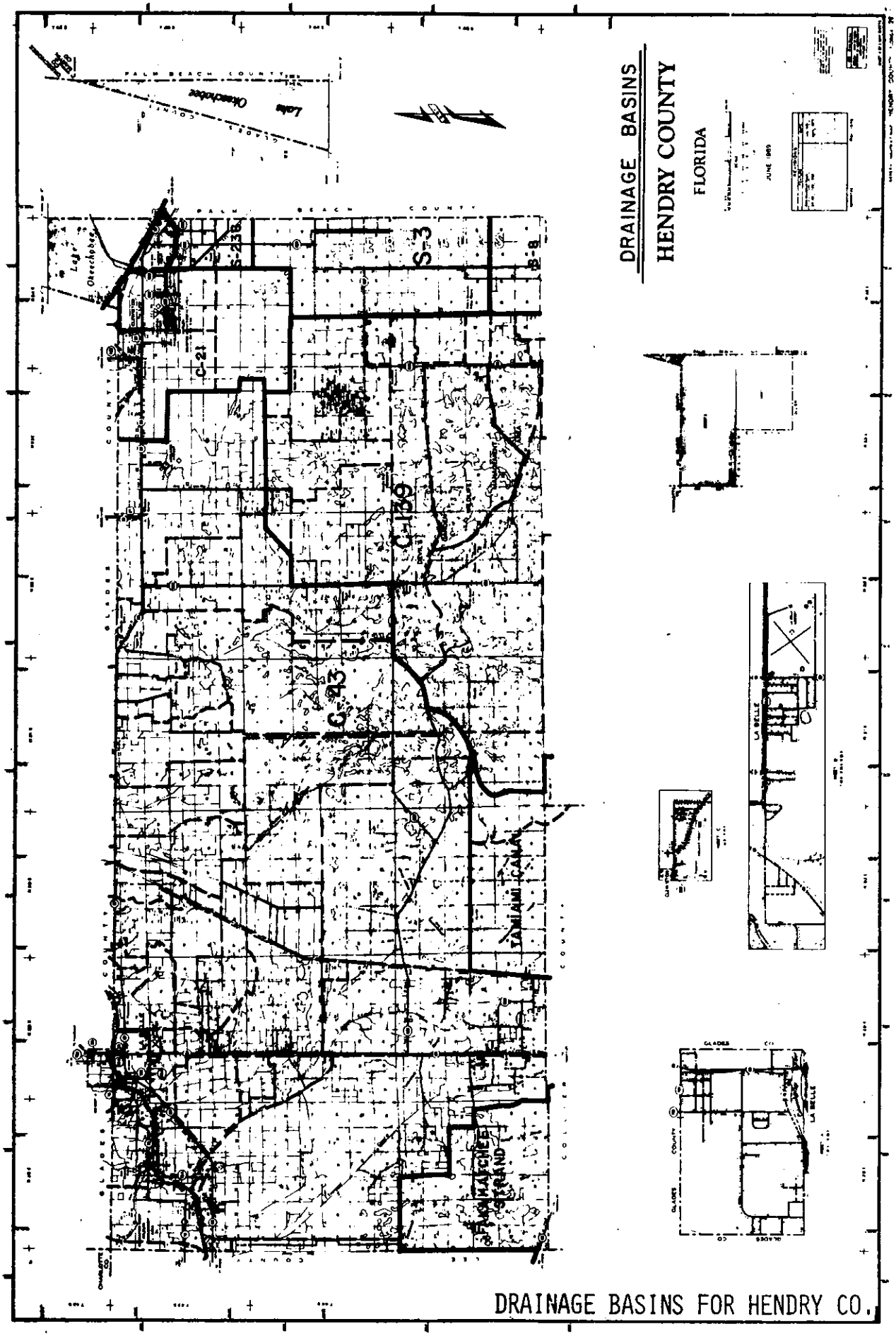
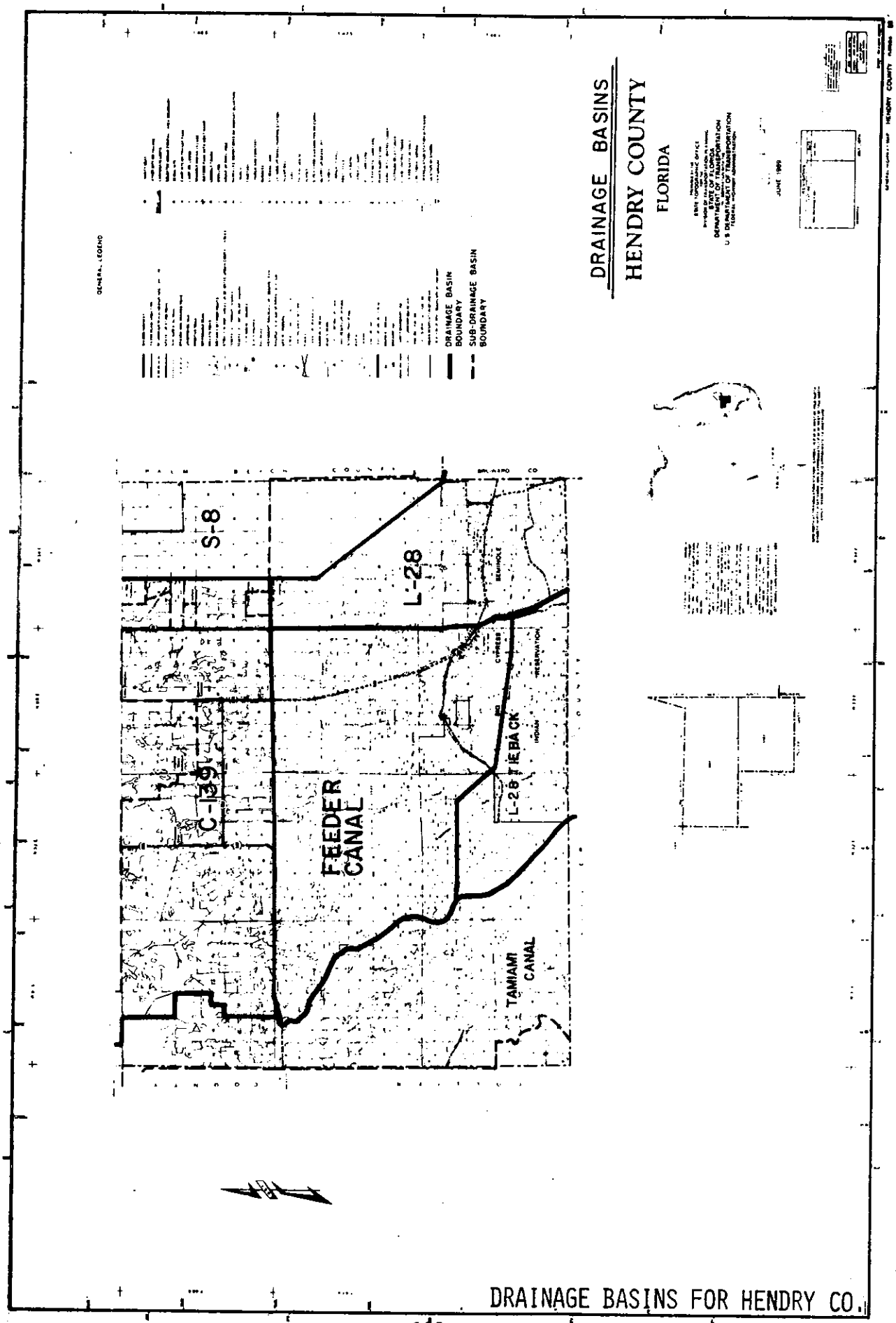
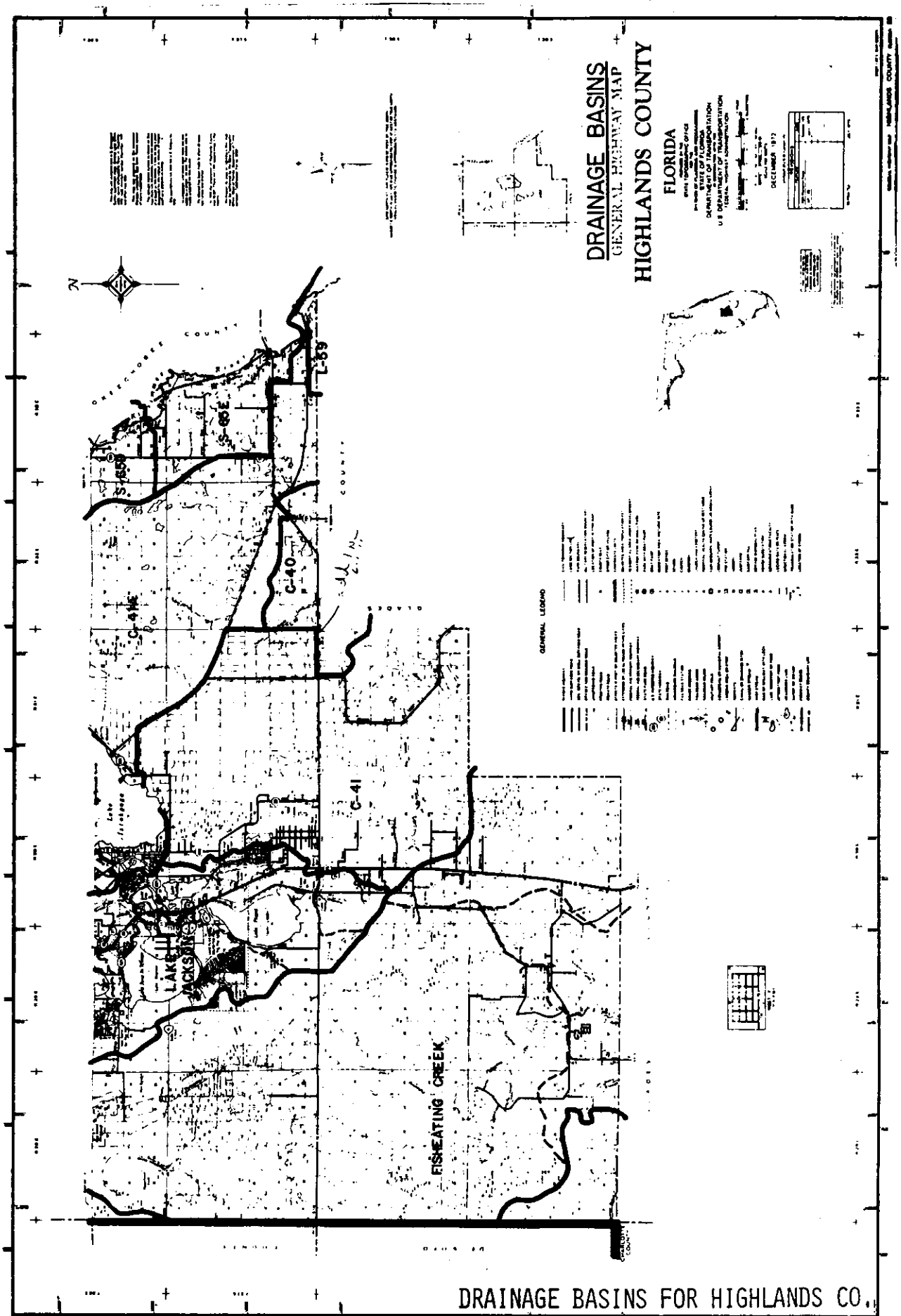

DRAINAGE BASINS
HENDRY COUNTY
FLORIDA
JUNE 1969
C-21
C-238
S-3
S-8
C-139
C-43
LA BELLE
FLAGHATCHEE STRAND
TAMIAMI CANAL
DRAINAGE BASINS FOR HENDRY CO.

FIGURE 42



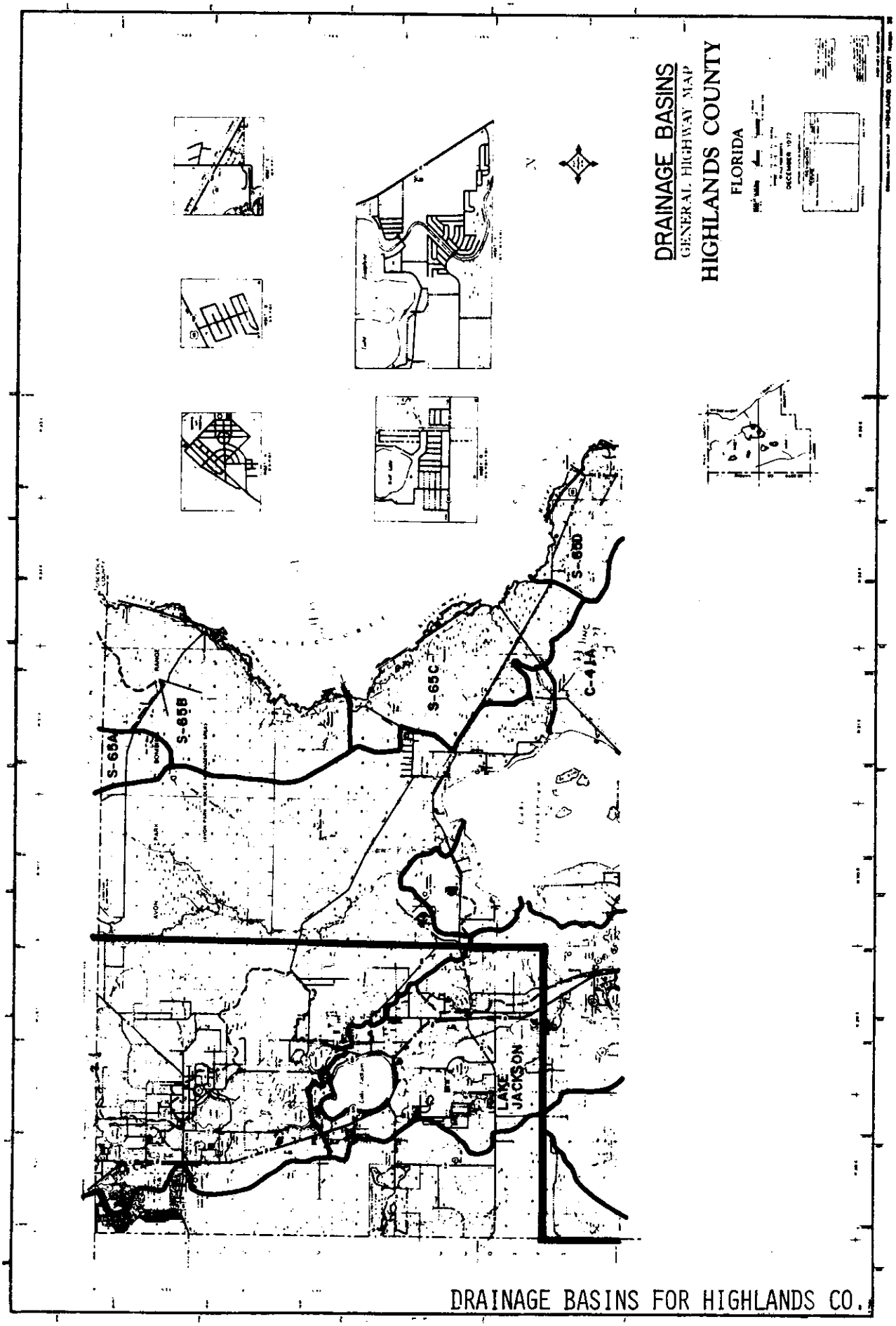
DRAINAGE BASINS FOR HENDRY CO.

FIGURE 43



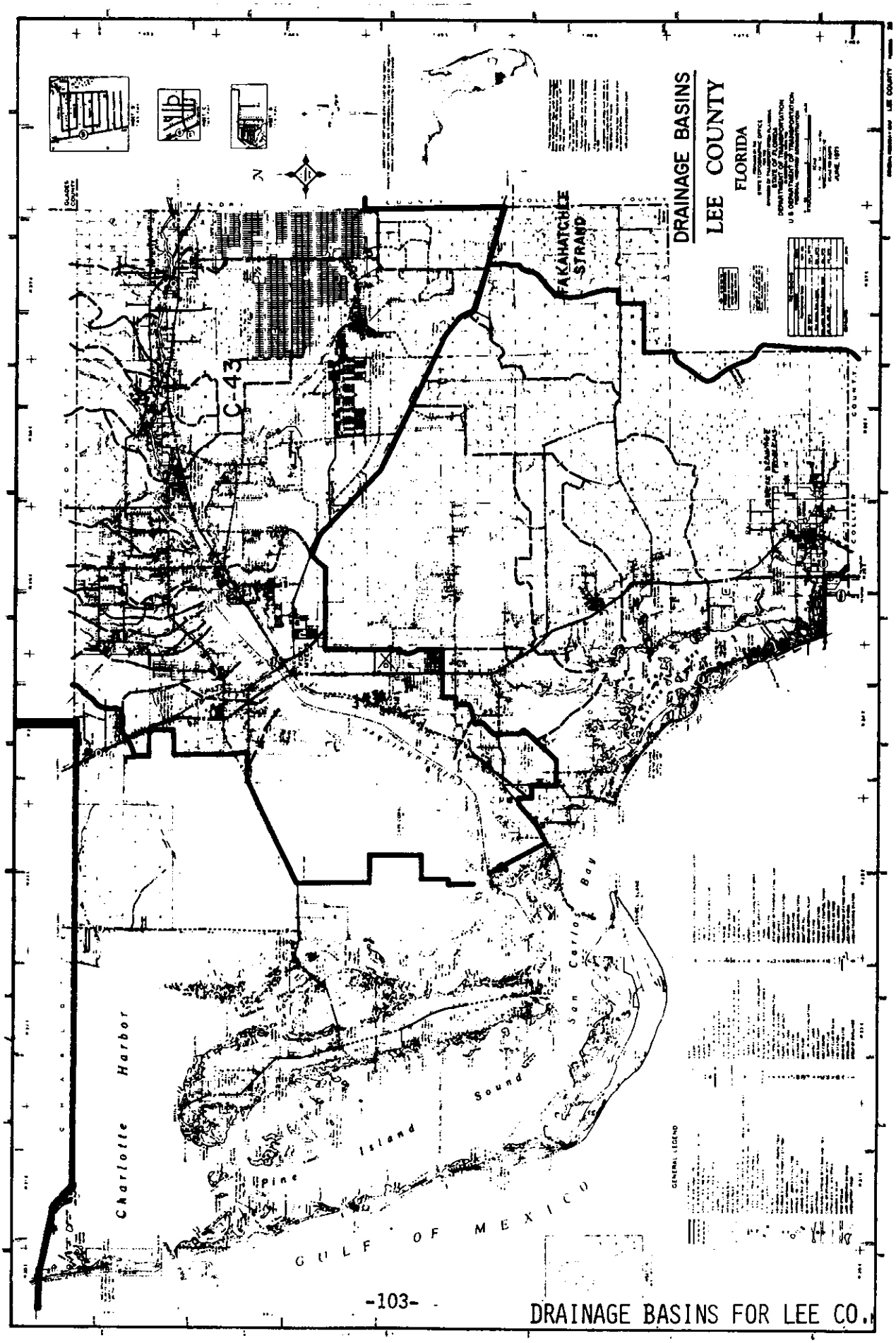
DRAINAGE BASINS FOR HIGHLANDS CO.

FIGURE 44



DRAINAGE BASINS FOR HIGHLANDS CO.

FIGURE 45



DRAINAGE BASINS FOR LEE CO.

FIGURE 46

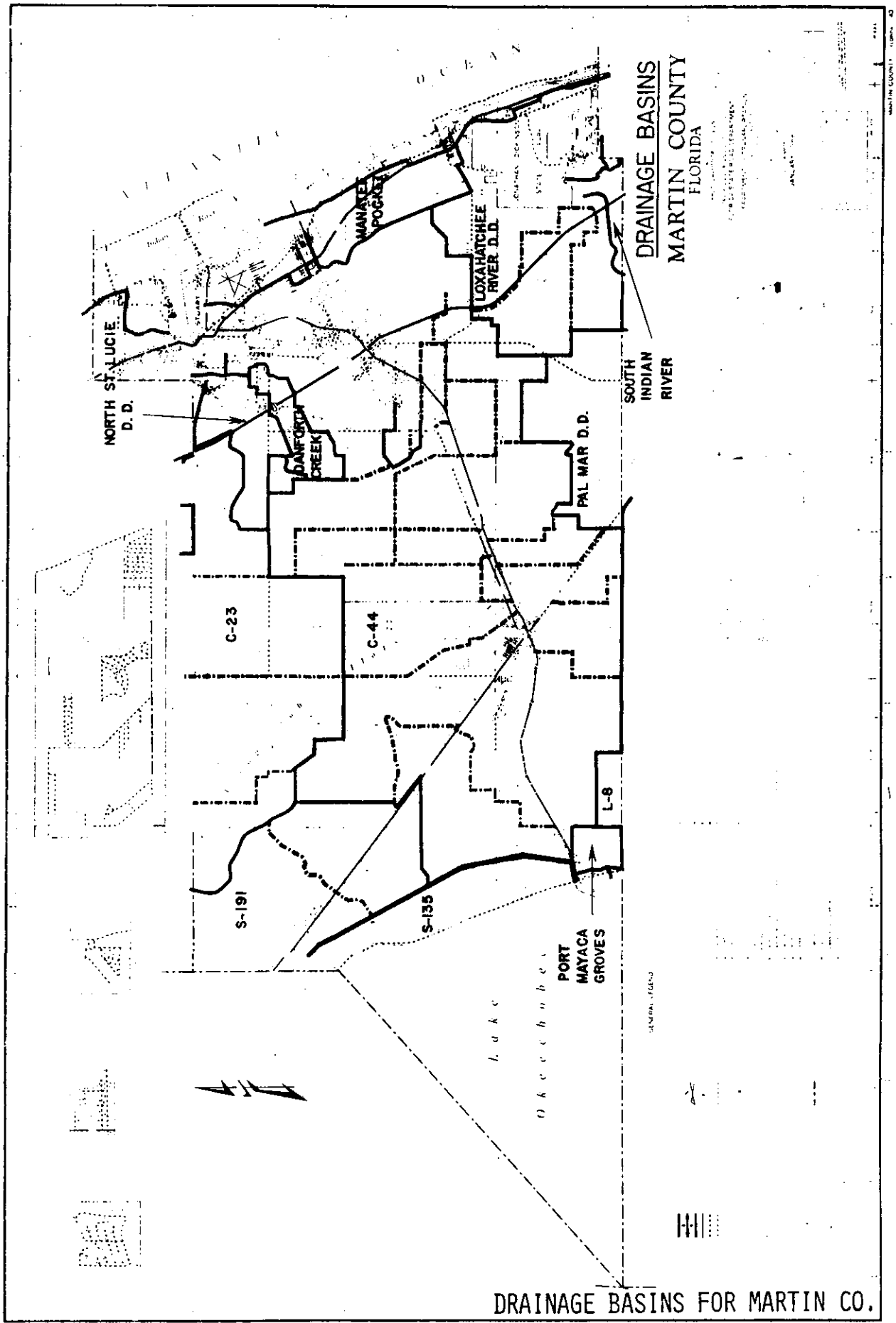

DRAINAGE BASINS
MARTIN COUNTY
FLORIDA
OCEAN
MANATEE POCKET
LOXAHATCHEE RIVER D.D.
SOUTH INDIAN RIVER
NORTH ST. LUCIE D. D.
DANFORTH CREEK
PAL MAR D.D.
C-23
C-44
L-8
S-191
S-135
PORT MAYACA GROVES
Lake Okeechobee
DRAINAGE BASINS FOR MARTIN CO.

FIGURE 47

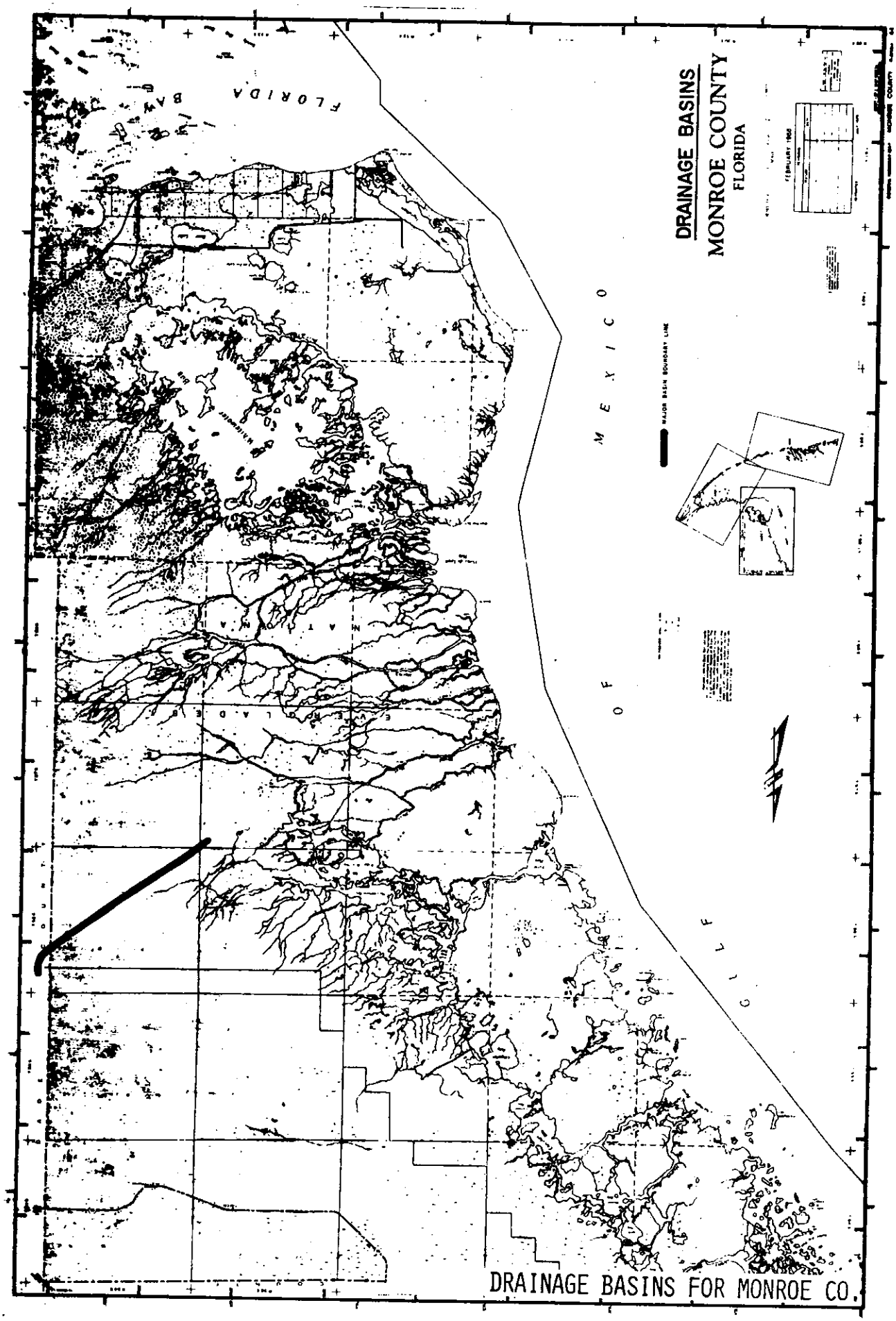

DRAINAGE BASINS
MONROE COUNTY
FLORIDA
FLORIDA BAY
GULF OF MEXICO
MAJOR BASIN BOUNDARY LINE
DRAINAGE BASINS FOR MONROE CO.

FIGURE 48

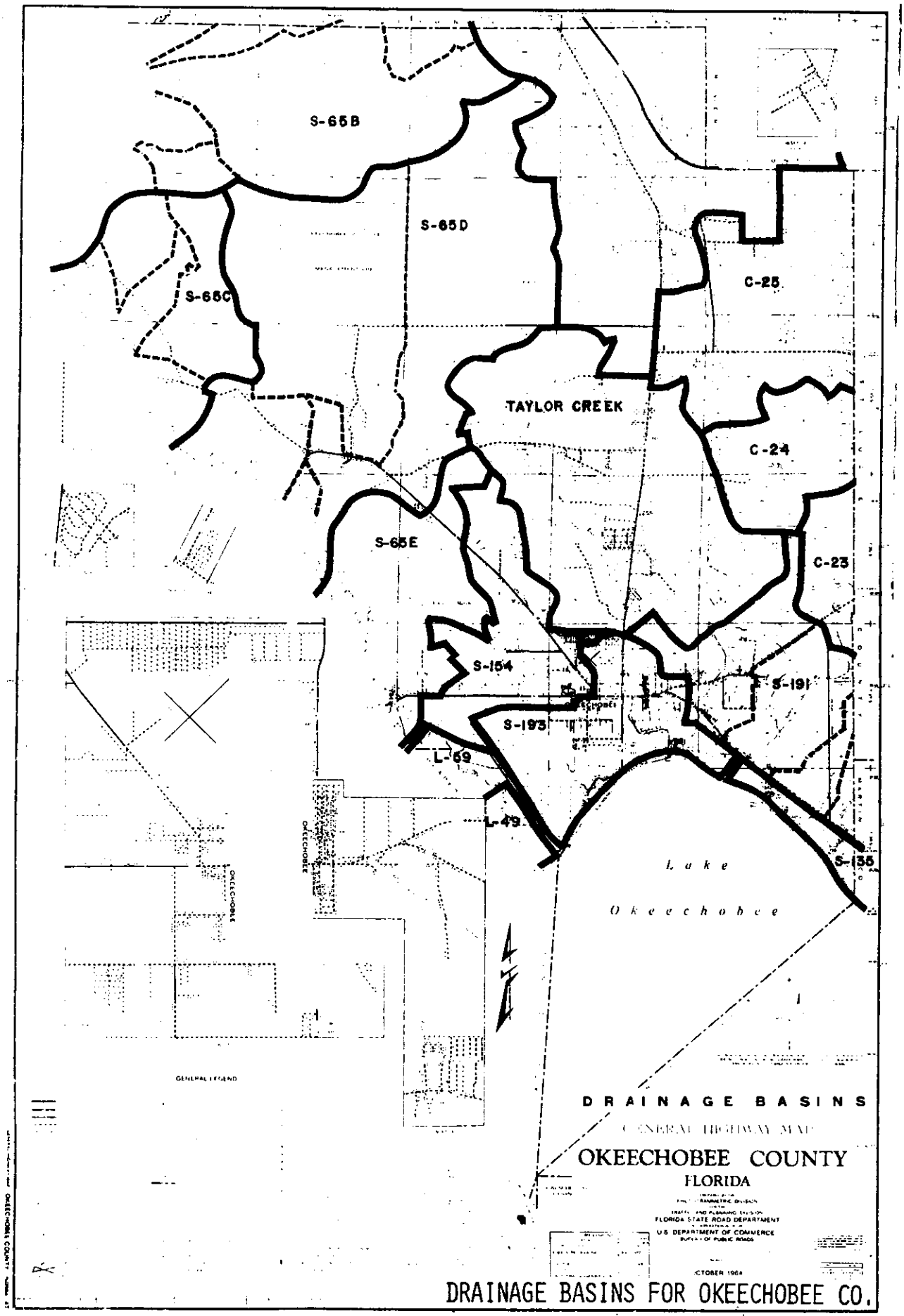
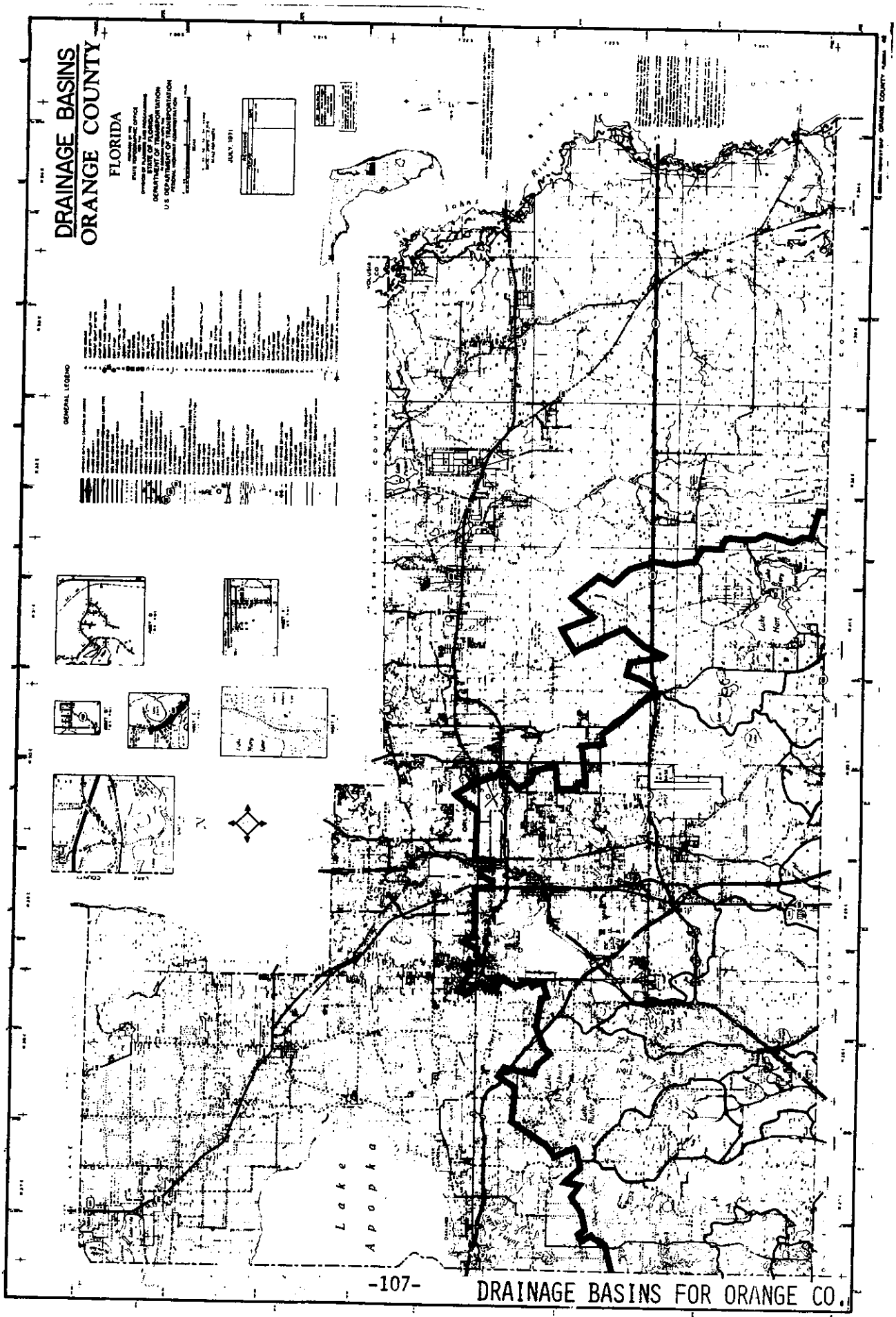

S-65B
S-65D
S-65C
C-25
TAYLOR CREEK
C-24
S-65E
C-23
S-154
S-191
S-193
L-69
L-49
S-135
Lake
Okeechobee
DRAINAGE BASINS
OKEECHOBEE COUNTY
FLORIDA
FLORIDA STATE ROAD DEPARTMENT
U.S. DEPARTMENT OF COMMERCE
OCTOBER 1964
DRAINAGE BASINS FOR OKEECHOBEE CO.

FIGURE 49



DRAINAGE BASINS FOR ORANGE CO.

FIGURE 50

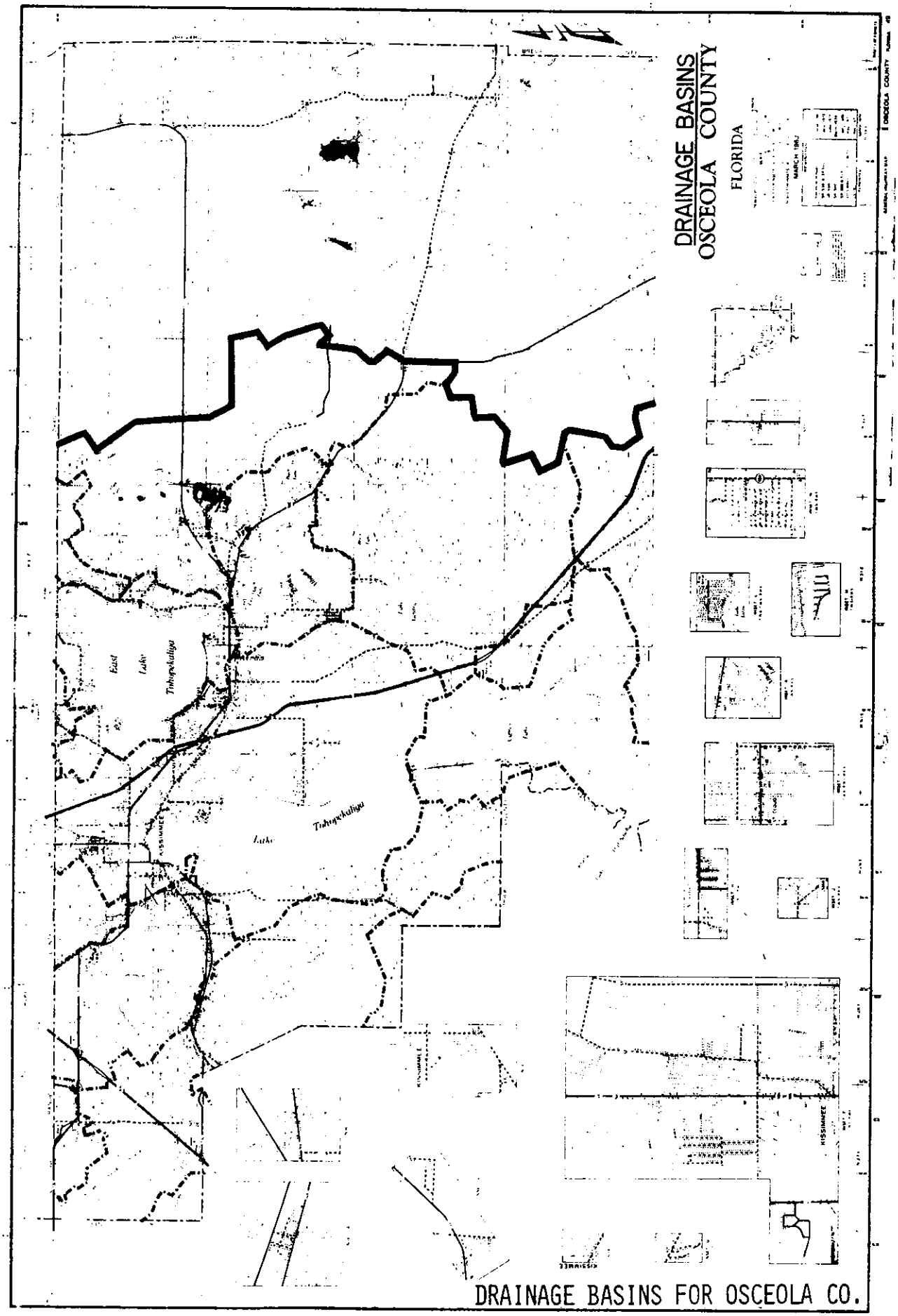
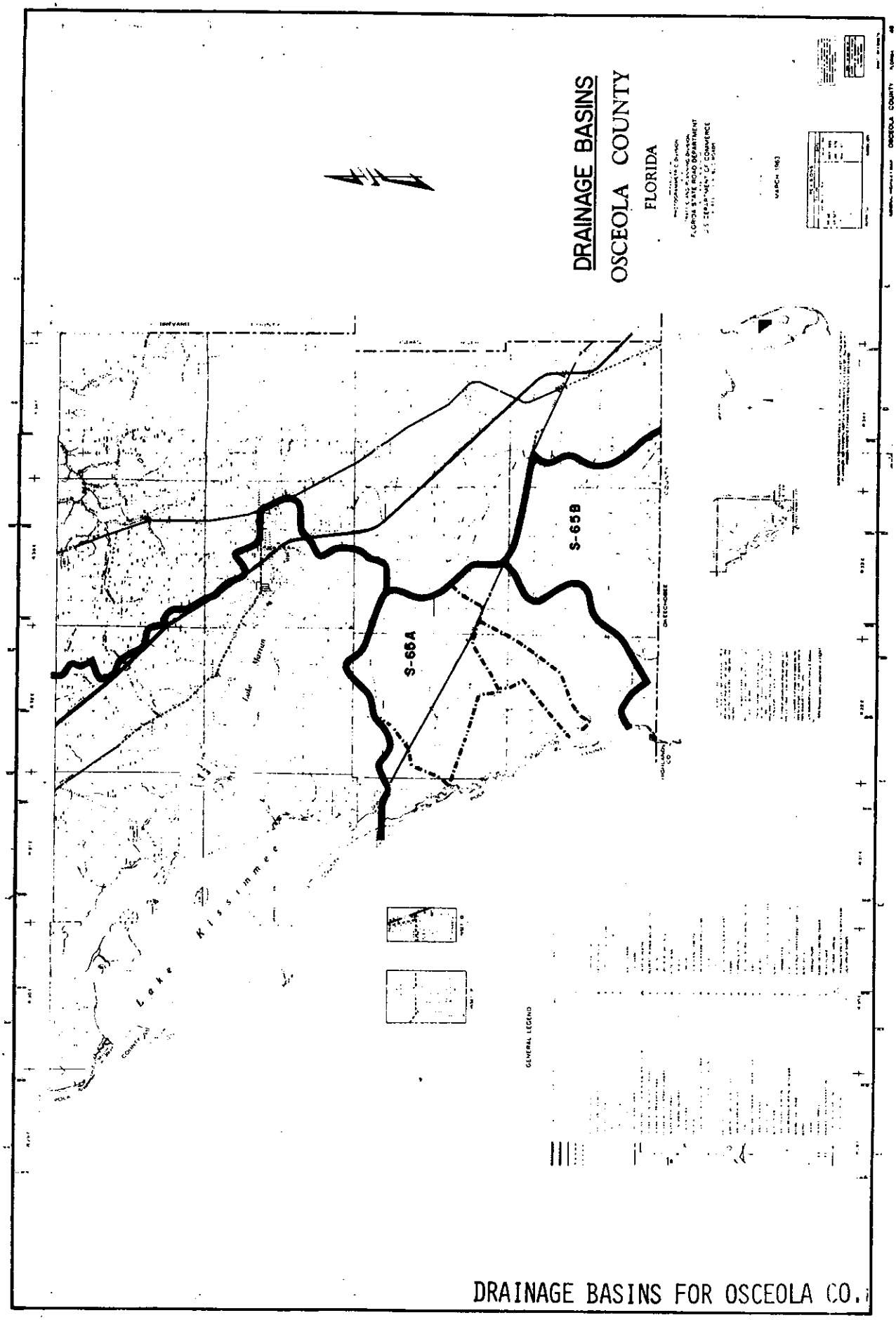


FIGURE 51
-108-



DRAINAGE BASINS FOR OSCEOLA CO.

FIGURE 52

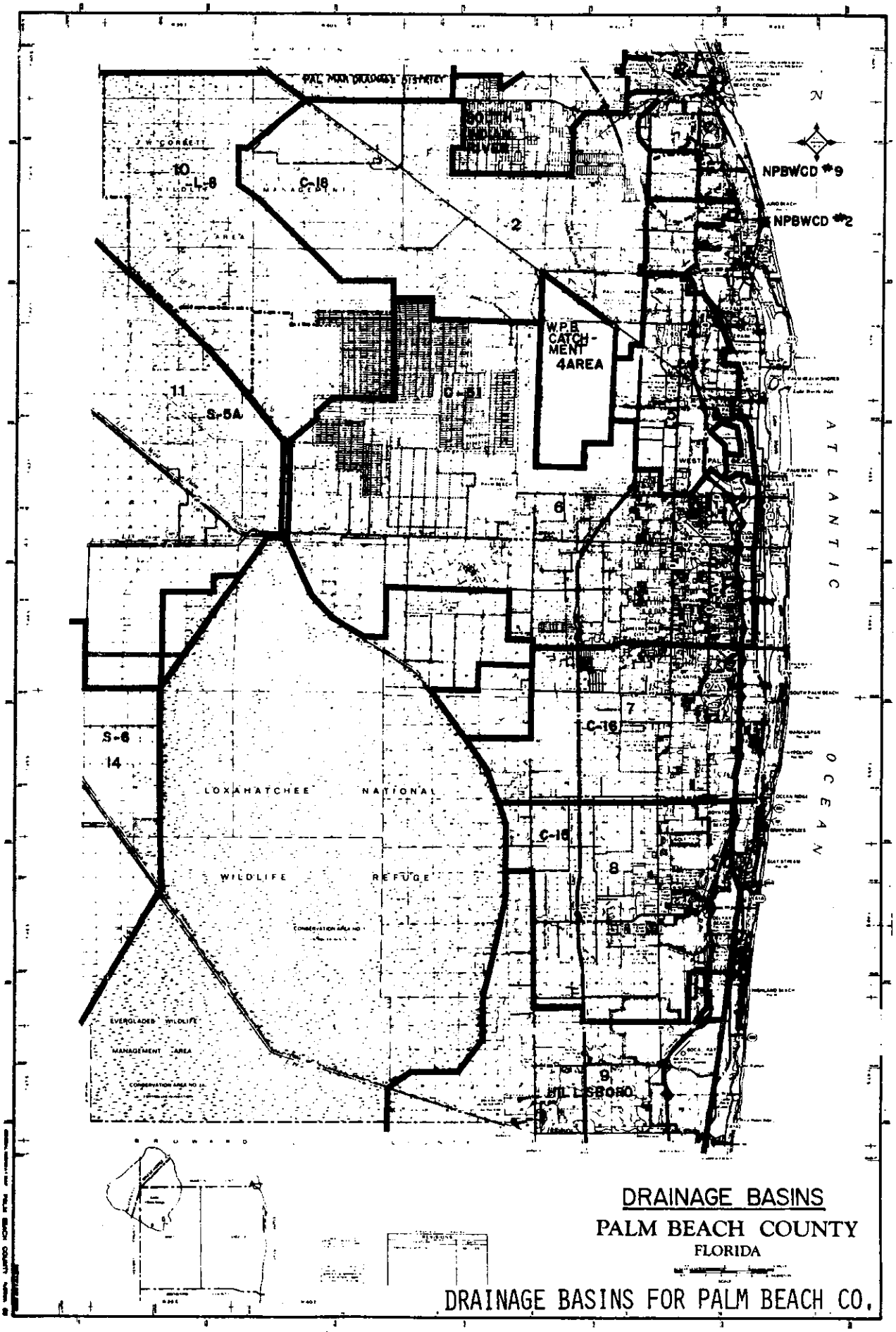

N
NPBWCD #9
NPBWCD #2
W.P.B. CATCH-MENT 4AREA
C-18
C-51
C-16
C-16
S-5A
S-6
10
11
14
2
6
7
8
9
LOXAHATCHEE NATIONAL WILDLIFE REFUGE
EVERGLADES WILDLIFE MANAGEMENT AREA
ATLANTIC OCEAN
DRAINAGE BASINS
PALM BEACH COUNTY
FLORIDA
DRAINAGE BASINS FOR PALM BEACH CO.

FIGURE 53

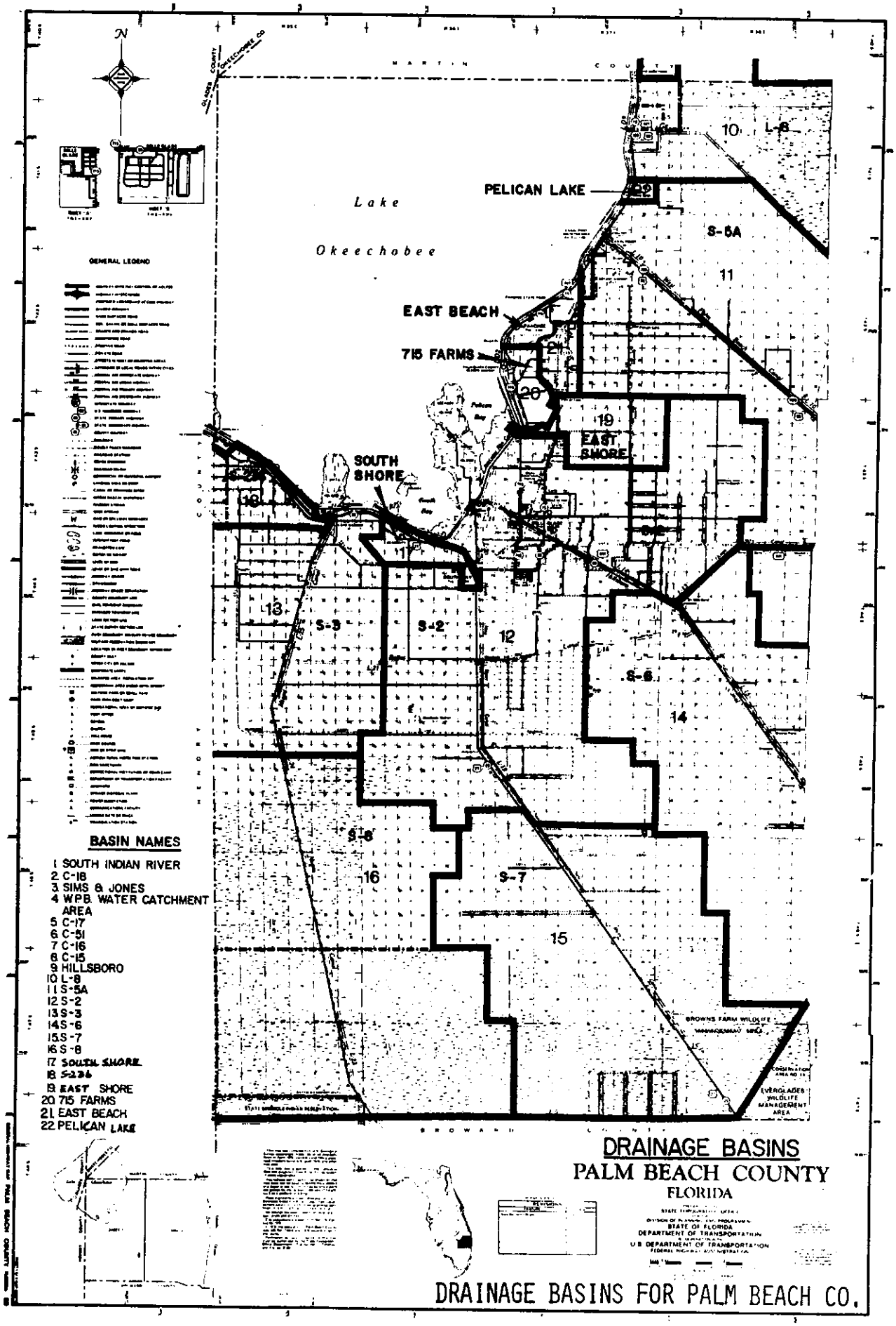

N
MARTIN COUNTY
OKEECHOBEE CO.
Lake
Okeechobee
PELICAN LAKE
EAST BEACH
715 FARMS
SOUTH SHORE
EAST SHORE
S-5A
S-2
S-3
S-4
S-6
S-7
S-8
10
11
12
13
14
15
16
19
20
21
L-8
BROWARD COUNTY
BROWNS FARM WILDLIFE MANAGEMENT AREA
EVERGLADES WILDLIFE MANAGEMENT AREA
BASIN NAMES
1 SOUTH INDIAN RIVER
2 C-18
3 SIMS & JONES
4 WPB WATER CATCHMENT AREA
5 C-17
6 C-51
7 C-16
8 C-15
9 HILLSBORO
10 L-8
11 S-5A
12 S-2
13 S-3
14 S-6
15 S-7
16 S-8
17 SOUTH SHORE
18 S-235
19 EAST SHORE
20 715 FARMS
21 EAST BEACH
22 PELICAN LAKE
DRAINAGE BASINS
PALM BEACH COUNTY
FLORIDA
STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION
DRAINAGE BASINS FOR PALM BEACH CO.

FIGURE 54

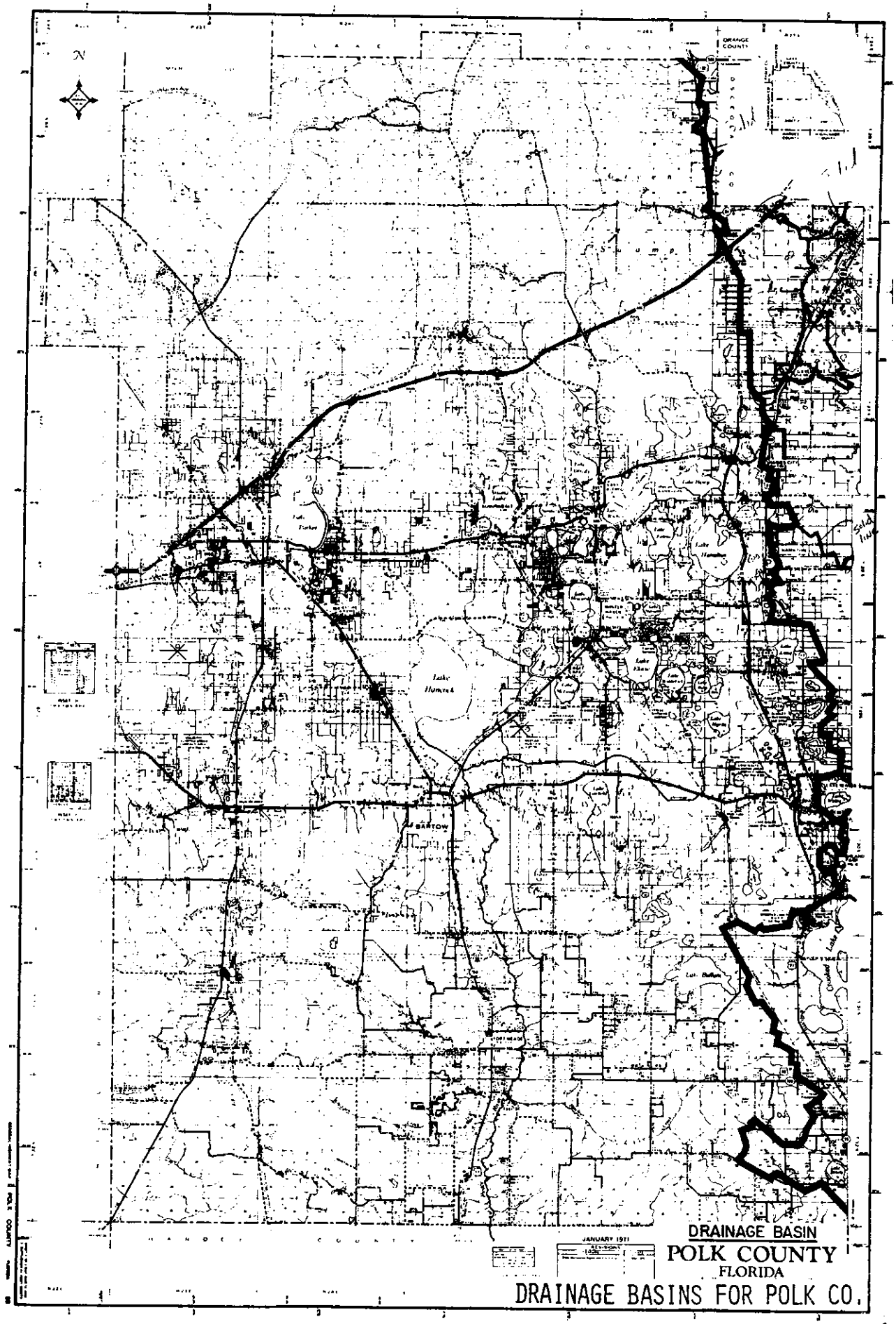


FIGURE 55
-112-

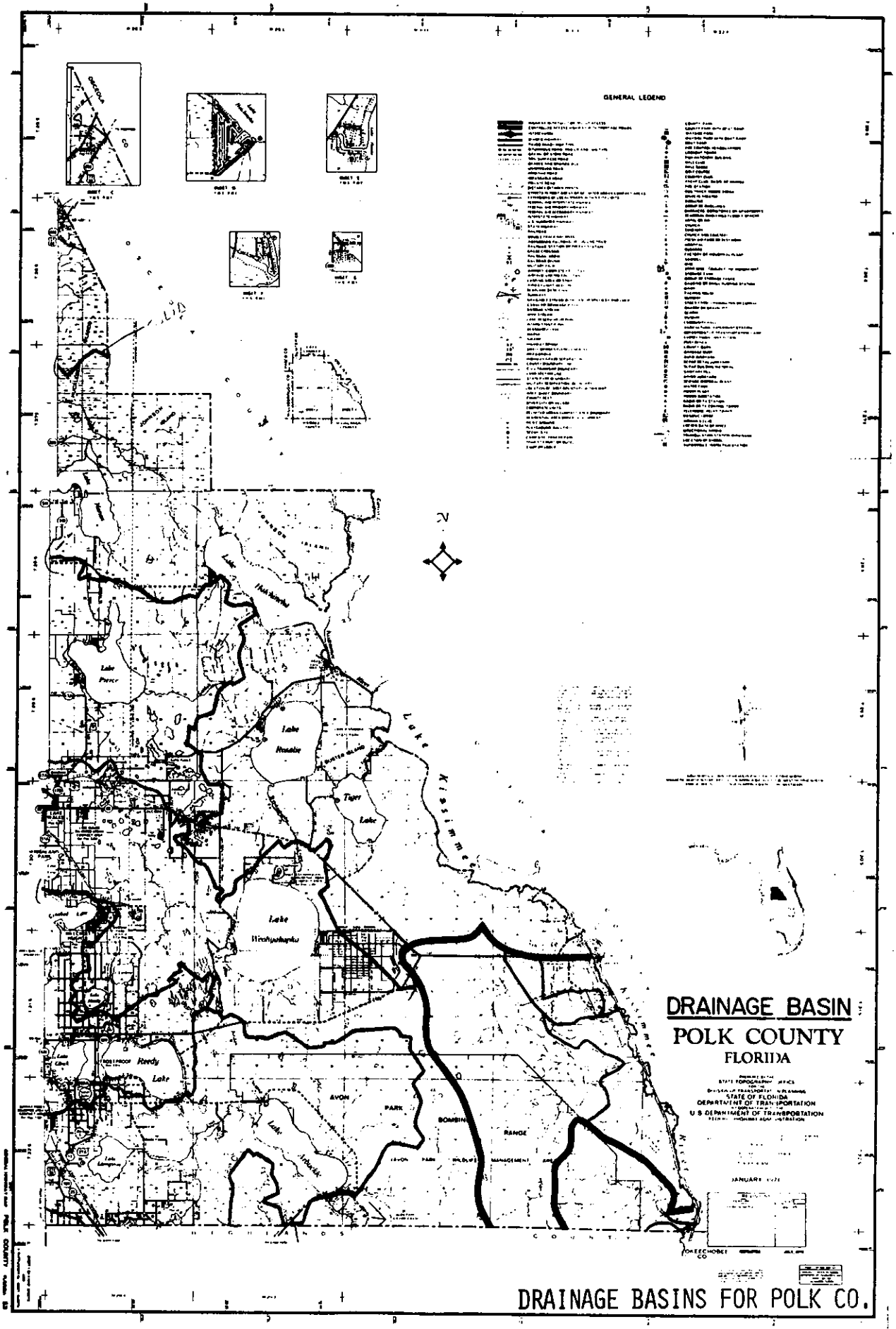
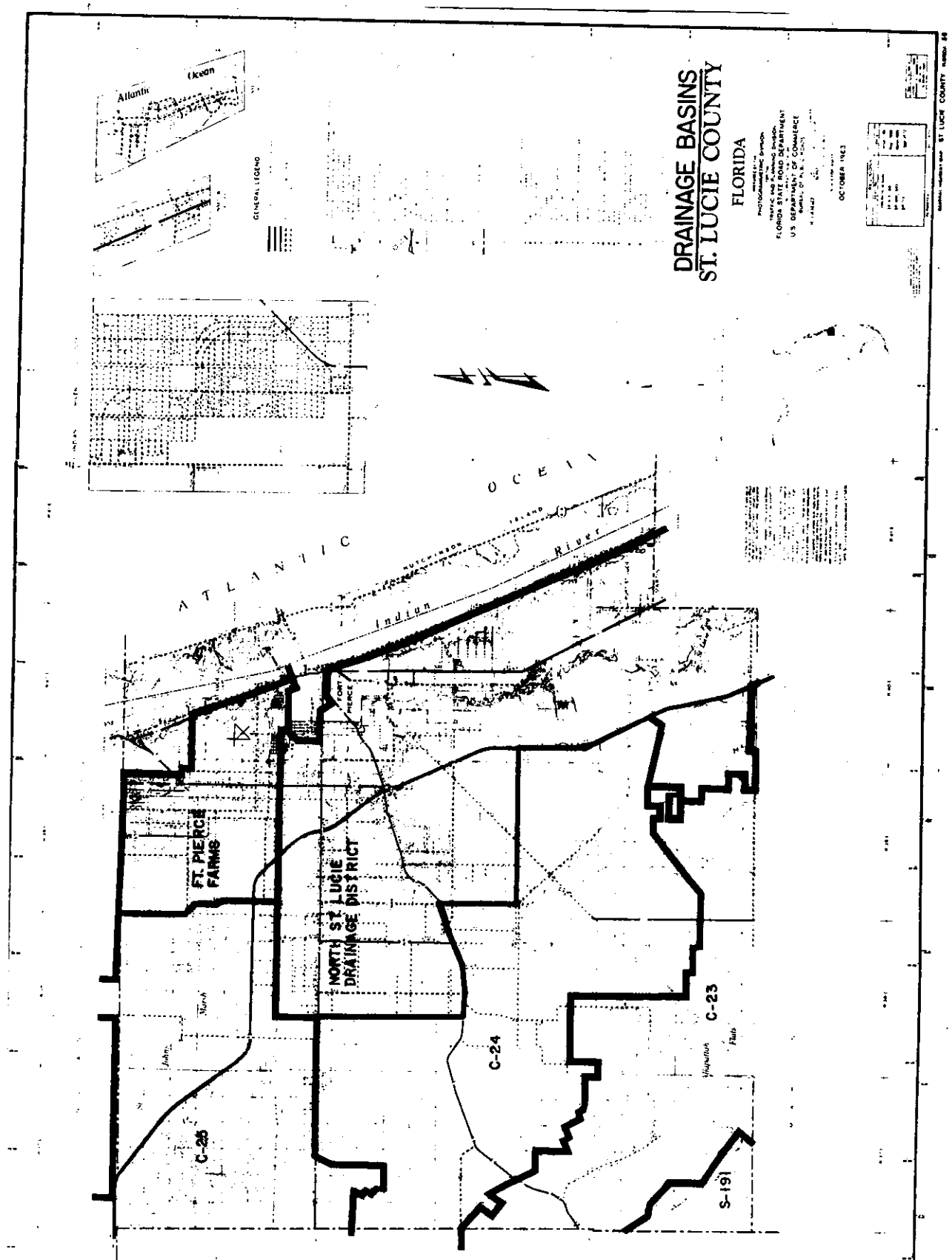

GENERAL LEGEND
DRAINAGE BASIN
POLK COUNTY
FLORIDA
STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION
JANUARY
Lake Kissimmee
Lake Hamilton
Lake Rosalie
Lake Hochjahnke
Reedy Lake
AVON PARK
BOMBING RANGE
DRAINAGE BASINS FOR POLK CO.

FIGURE 56



DRAINAGE BASINS FOR ST. LUCIE CO.

FIGURE 57

APPENDIX 3

SFWMD PROJECT DISCHARGE CRITERIA

Q = allowable discharge in cfs (cubic feet per second)

A = drainage area in square miles

CSM = cfs per square mile

CANAL	ALLOWABLE RUNOFF	DESIGN FREQUENCY
C-1	$Q = \left(\frac{112}{\sqrt{A}} + 31\right) A$	10 year
C-2	Essentially unlimited inflow by culverted connections southeast of Sunset Drive. 54 CSM northwest of Sunset Drive.	200 year +
C-4	Essentially unlimited inflow by culverted connections east of S.W. 87th Avenue. 54 CSM west of S.W. 87th Ave.	200 year +
C-6	Essentially unlimited inflow by culverted connections east of FEC Railroad. 54 CSM west of FEC Railroad.	200 year +
C-7	Essentially unlimited inflow by culverted connection.	100 year +
C-8	Essentially unlimited inflow by culverted connection.	200 year +
C-9	Essentially unlimited inflow by culverted connection east of Red Road. 20 CSM pumped, unlimited gravity with development limitations west of Red Road or Flamingo Blvd.	100 year +
C-10		200 year +
C-11	3/4" in 24 hours west of 13A 1.5" in 24 hours east of 13A	
C-12	$Q = \left(\frac{72}{\sqrt{A}} + 60\right) A$	25 year

CANAL	ALLOWABLE RUNOFF	DESIGN FREQUENCY
C-13	$Q = \left(\frac{72}{\sqrt{A}} + 60\right) A$	25 year
C-14	$Q = \left(\frac{78}{\sqrt{A}} + 54\right) A$	25 year
	$Q = \left(\frac{96}{\sqrt{A}} + 25\right) A$ (Western Reach)	10 year
C-15 C-16	$Q = \left(\frac{90}{\sqrt{A}} + 47\right) A$	25 year
C-17	$Q = \left(\frac{102}{\sqrt{A}} + 46\right) A$	25 year
C-18	$Q = \left(\frac{114}{\sqrt{A}} + 34\right) A$	25 year
	One inch in 24 hrs west of Bee Line Hwy.	Runoff quantity is restricted to any frequency storm.
C-19	$Q = \left(\frac{32}{\sqrt{A}} + 64\right) A$	
C-23	$Q = \left(\frac{47}{\sqrt{A}} + 28\right) A$	10 year
C-24	$Q = \left(\frac{47}{\sqrt{A}} + 28\right) A$	10 year
C-25	$Q = \left(\frac{47}{\sqrt{A}} + 28\right) A$	10 year
C-38	$Q = \left(\frac{109}{\sqrt{A}} + 26\right) A$	10 year
C-40 C-41 C-41A	Istokopoga Indian Prarie Area Canals $Q = \left(\frac{48}{\sqrt{A}} + 33\right) A$	10 year
Hillsboro Canal	35 CSM	Runoff quantity is restricted to any frequency storm.
North New River Canal	$Q = \left(\frac{116}{\sqrt{A}} + 32\right) A$	25 year

CANAL	ALLOWABLE RUNOFF		DESIGN FREQUENCY
Everglades Agricultural Area	Tributary to S-5A	L-8 $Q = 60.5\ A^{.8}$ L-10 L-12 L-13	5 year
	L-8 west of S-76	27 CSM	
	All other canals in Ag. Area	$Q = \left(\frac{81}{\sqrt{A}} + 13\right) A$	
L-28		$Q = \left(\frac{63}{\sqrt{A}} + 4\right) A$	
C-51	65 CSM east of Turnpike 27 CSM west of Turnpike (subject to change upon implementation of backpumping plan).		Runoff quantity is restricted to any frequency storm.
C-100 C-100A C-100B C-100C C-100D		$Q = \left(\frac{104}{\sqrt{A}} + 43\right) A$	10 year
C-102		$Q = \left(\frac{119}{\sqrt{A}} + 25\right) A$	10 year
C-103 north C-103 south		$Q = \left(\frac{107}{\sqrt{A}} + 39\right) A$	10 year
C-110		$Q = \left(\frac{137}{\sqrt{A}} + 9\right) A$	10 year
C-111		$Q = \left(\frac{117}{\sqrt{A}} + 29\right) A$	10 year
C-113		$Q = \left(\frac{142}{\sqrt{A}} + 3\right) A$	10 year

Allowable runoff curves to be used for the area within Lake Worth Drainage District are depicted on the following charts.

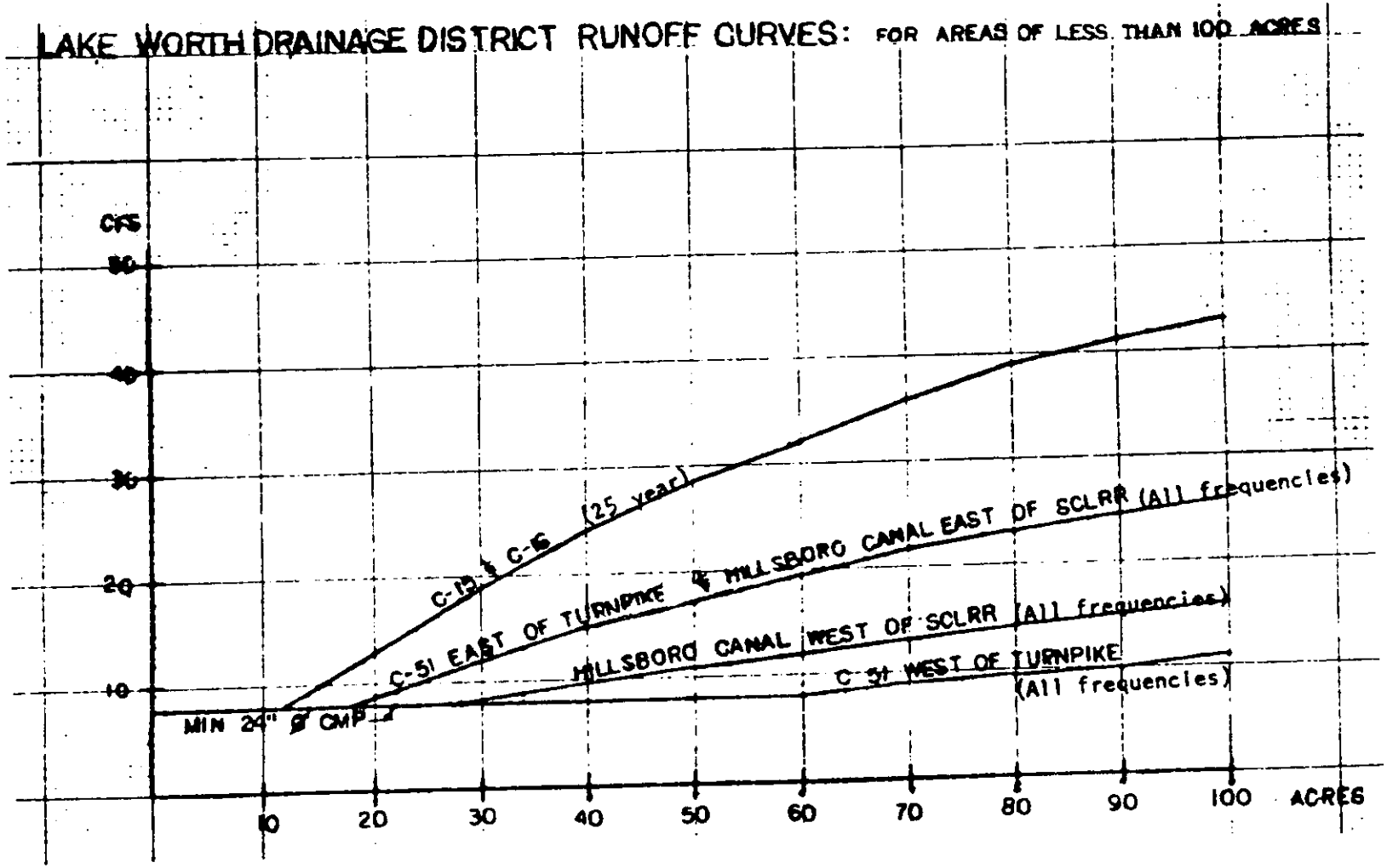

LAKE WORTH DRAINAGE DISTRICT RUNOFF CURVES: FOR AREAS OF LESS THAN 100 ACRES
CFS
40
30
20
10
C-51 EAST OF TURNPIKE & HILLSBORO CANAL EAST OF SCLRR (All frequencies)
HILLSBORO CANAL WEST OF SCLRR (All frequencies)
C 51 WEST OF TURNPIKE
(All frequencies)
MIN 24" Ø CMP
10
20
30
40
50
60
70
80
90
100
ACRES

FIGURE 58

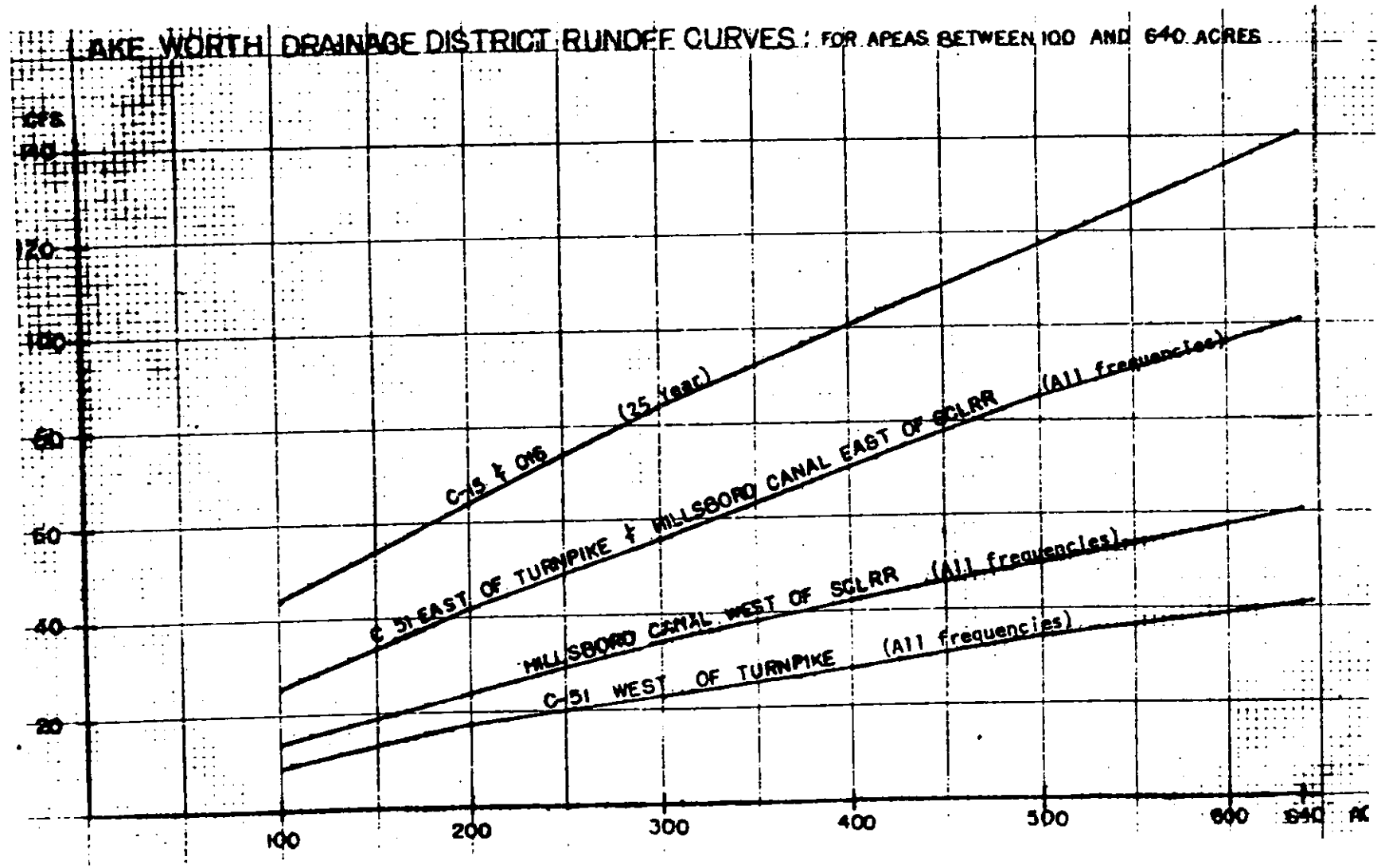
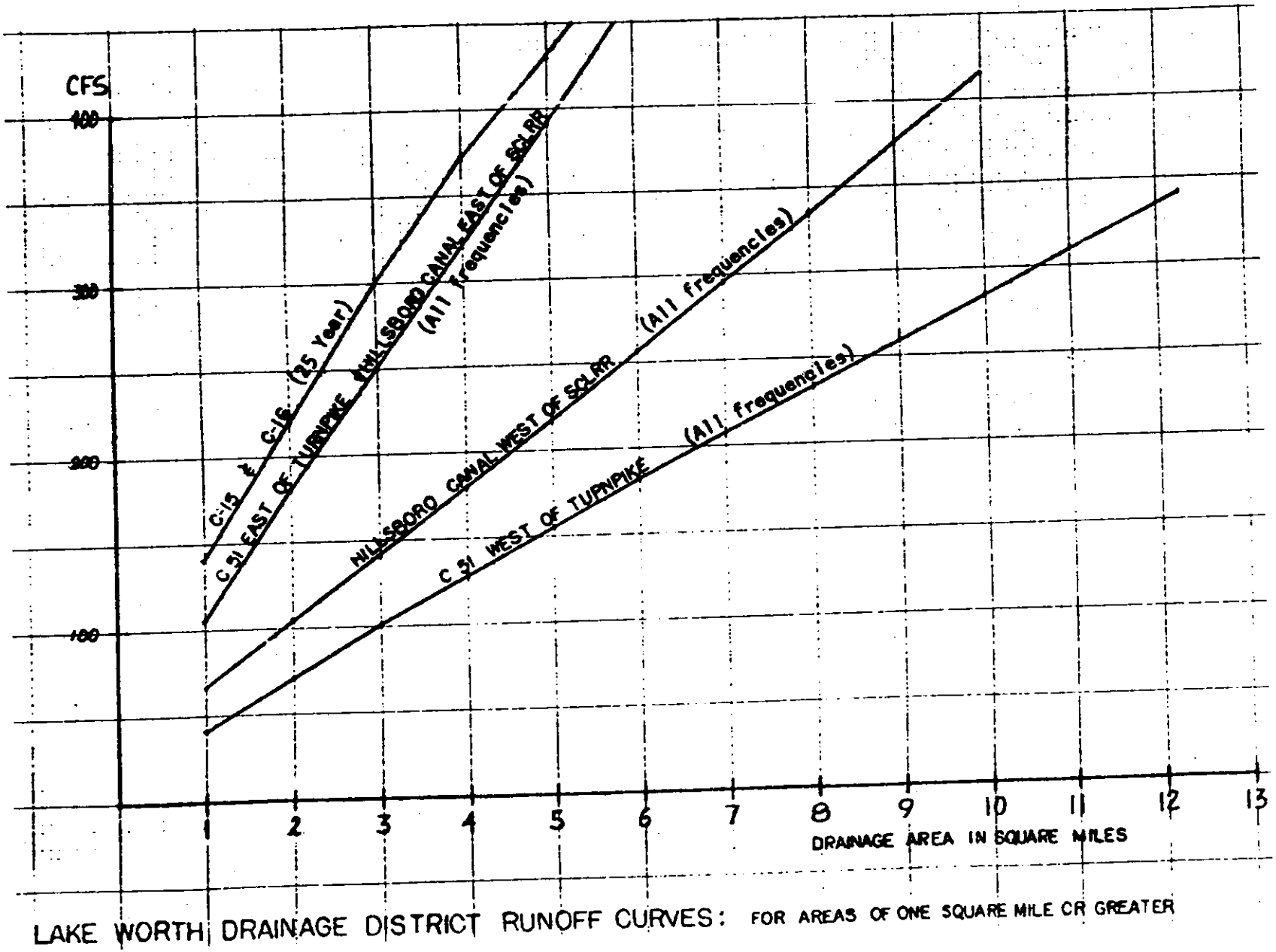

LAKE WORTH DRAINAGE DISTRICT RUNOFF CURVES : FOR APEAS BETWEEN 100 AND 640 ACRES
cfs
140
120
100
80
60
40
20
C-15 & C16 (25 Year)
C 51 EAST OF TURNPIKE & HILLSBORO CANAL EAST OF SCLRR (All frequencies)
HILLSBORO CANAL WEST OF SCLRR (All frequencies)
C-51 WEST OF TURNPIKE (All frequencies)
100
200
300
400
500
600
640
AC

FIGURE 59



LAKE WORTH DRAINAGE DISTRICT RUNOFF CURVES: FOR AREAS OF ONE SQUARE MILE OR GREATER

FIGURE 60

VI. Exfiltration Systems

Due to the high cost of land the use of exfiltration or seepage systems for design purposes has become economically more feasible in the last couple of years. Consequently, in an effort to provide the designer with a short-cut and simple method for sizing of such facilities the staff has proposed the use of a formula in the "Basis of Review" document which is based strictly on the geometry of the situation. This formula is shown on Figure 61 along with a typical trench section showing the terminology used in the formula. The derivation of this formula is as follows:

DERIVATION OF EQUATIONS - EXFILTRATION TRENCH LENGTH

Computations are based on a 1-hour storm and hence an exfiltration period of 1 hour also:

VOLUME IN = volume of runoff into the trench system

$$= A\ (\text{Acres}) \times \frac{43{,}560\ \text{ft.}^2}{\text{acre}} \times C \times R\ \left(\frac{\text{in}}{\text{hr}}\right) \times \left(\frac{1\ \text{ft}}{12\ \text{in}}\right)$$

$$= \underline{3630\ CAR\ \text{ft}^3/\text{hr.}} = \underline{3630\ CAR\ \text{ft}^3} \quad \text{based on 1-hour storm}$$

VOLUME STORED = volume of voids available in trench

$$= 0.5\ (\text{porosity}) \times W \times H \times L$$

$$= \underline{0.5\ WHL\ \text{ft}^3}$$

where W = trench width
H = height of trench above water table
L = trench length

VOLUME OUT = volume exfiltrated out of the trench.

$$= W \times L \times h\ \left(\frac{\text{in}}{\text{min}}\right) \times \frac{1\ \text{ft.}}{12\ \text{in.}} \times \frac{60\ \text{min.}}{1\ \text{hr.}}$$

$$= \underline{5WhL\ \text{ft}^3/\text{hr.}} = 5WhL\ \text{ft}^3 \quad \text{based on 1 hour}$$

Volume In = Volume Out + Volume Stored (Conservation of Mass)

$$3630\ CAR = 5WhL + 0.5WHL$$

$$3630\ CAR = 0.5WL\ (10h + H)$$

$$\frac{3630\ CAR}{0.5W\ (10h + H)} = L$$

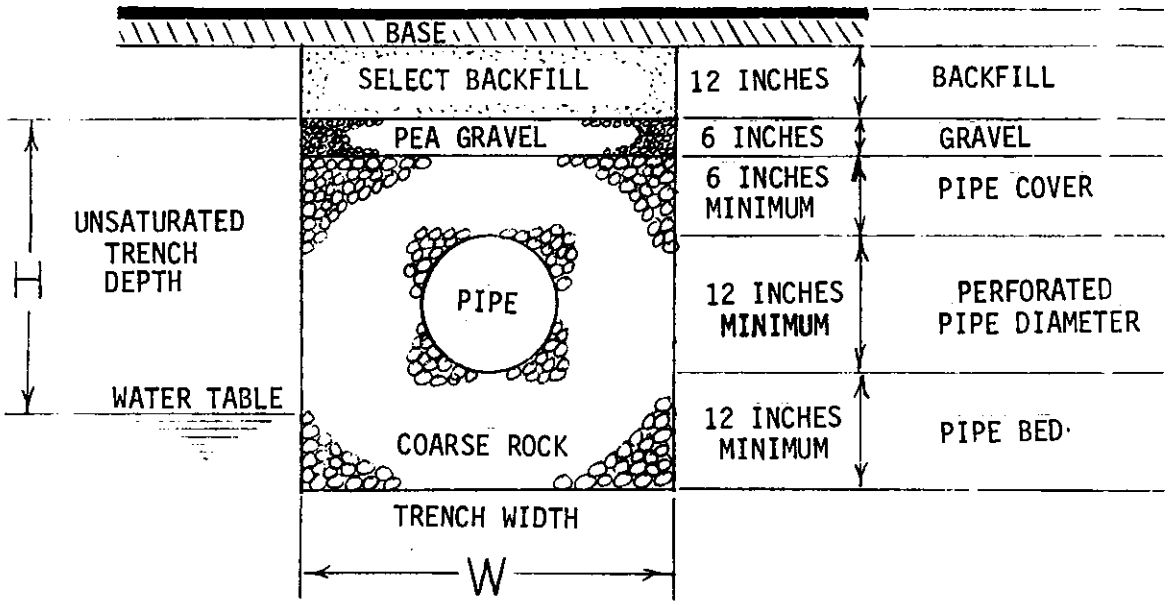
$$L = \frac{7260\ CAR}{W(10h + H)}$$

where R = one hour rainfall value

If R = 2.5 inches then you have:

$$L = \frac{18{,}150\ CA}{W(10h + H)}$$

TYPICAL EXFILTRATION TRENCH



$$L = \frac{18{,}150\ C\ A}{W(10h + H)}$$

L = LENGTH OF TRENCH REQUIRED (FEET)

C = RUNOFF COEFFICIENT (RATIONAL RUNOFF METHOD)

A = CONTRIBUTING AREA (ACRES)

W = TRENCH WIDTH (FEET)

h = AVERAGE DROP PER MINUTE IN OPEN HOLE TEST (INCHES)

H = NON-SATURATED TRENCH DEPTH (FEET)

FIGURE 61

As can be seen this formula is based on a rainfall event of one-hour duration. Consequently, the performance of systems sized with this formula will be unknown during longer duration events such as the 24-hour event.

VII. Hydrographs

There are numerous methods available to designers for estimating the shape of runoff hydrographs. A commonly used method is the Soil Conservation Services Unit Hydrograph technique. The Unit Hydrograph procedure is cumbersome to calculate by hand and is not normally used except with computer programs. It is the staff's desire to provide as many time-saving design techniques to the designers as possible. A relatively recent hydrograph development procedure known as the Santa Barbara Urban Hydrograph Method (SBUH) has been modified by the staff for consistent use with other procedures for stormwater system analysis presented herein. The SBUH has been found to produce results which correlate well with gaged watersheds in South Florida.

An example of the use of the SBUH procedure will serve as a description of the method much better than any discussion on its theoretical development.

SBUH EXAMPLE

In this problem we have a 640 acre project with a calculated S-value of 3.5 inches, an estimated Time of Concentration of 2.0 hours, and we desire to calculate the 10-year, 24-hour runoff hydrograph for a storm with a 24-hour rainfall depth of 8.5 inches.

In our procedure it is desireable to select a time interval, Δt, equivalent to one-half of the Time of Concentration. Therefore, Δt will be one hour.

We will define terminology as follows:

I_1 = instantaneous runoff rate at time t-1 cfs.

I_2 = instantaneous runoff rate at time t, cfs.

Q_1 = hydrograph rate at time t-1, cfs.

Q_2 = hydrograph rate at time t, cfs.

K = routing coefficient, dimensionless

Δt = routing intervals, hours

Tc = time of concentration, hours

In the SBUH method:

$$K = \frac{\Delta t}{2Tc + \Delta t}$$

and $Q_2 = Q_1 + K\ (I_1 + I_2 - 2Q_1)$

It is necessary to set up a table as shown on Table 3. The first four columns are calculated as described in Section III, Runoff Estimation. The fifth column represents the instantaneous runoff rate, I, ignoring the effect of the Time of Concentration on the attenuation of peaks. The conversion of the runoff, R, in inches to the instantaneous rate, I, in cfs is based on the following approximation:

$$I_2 = \frac{(R_2 - R_1)\ A}{T} \quad \text{(since 1 acre-inch/hr. = 1 cfs)}$$

By utilizing the relationships for K, Δt, Tc, I_1, I_2, Q_1 and Q_2 we can calculate the hydrograph points in the sixth column. A graphical plot of the computed hydrograph is shown on Figure 62.

TABLE 3

SBUH METHOD

Time (Hours) T	Rainfall Ratio P/P24	Rainfall (Inches) P	Runoff (Inches) R	Instant Runoff (cfs)	Runoff Hydrograph Q
0	.000	0	0	0	0
1	.010	.085	0	0	0
2	.020	.170	0	0	0
3	.032	.272	0	0	0
4	.045	.383	0	0	0
5	.062	.527	0	0	0
6	.083	.706	0	0	0
7	.108	.918	.013	8	2
8	.137	1.165	.054	26	8
9	.171	1.454	.134	51	20
10	.213	1.811	.268	86	39
11	.269	2.287	.495	145	70
12	.656	5.576	2.839	1500	371
13	.767	6.520	3.634	509	624
14	.818	6.953	4.009	240	524
15	.850	7.225	4.247	152	393
16	.880	7.480	4.472	144	295
17	.898	7.633	4.607	87	223
18	.916	7.786	4.743	87	169
19	.934	7.939	4.880	87	136
20	.952	8.092	5.017	87	116
21	.964	8.194	5.108	59	99
22	.976	8.296	5.200	59	83
23	.988	8.398	5.292	59	73
24	1.000	8.500	5.384	59	67

A = 640 Acres S = 3.5 inches Tc = 2.0 hours P_{24} = 8.5 inches

$$K = \frac{\Delta t}{2T_c + \Delta t} = 0.20$$

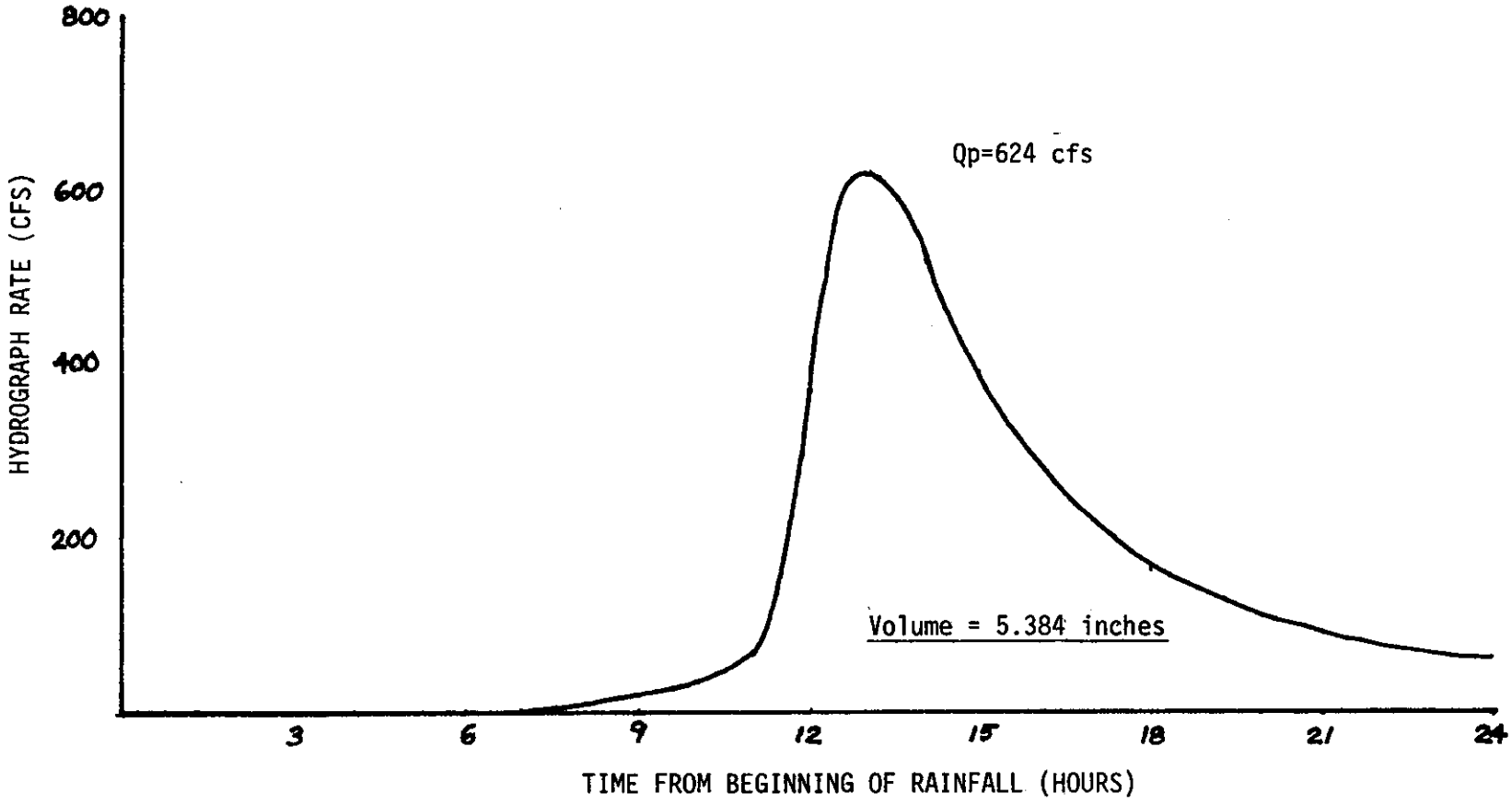

800
600
400
200
HYDROGRAPH RATE (CFS)
Qp=624 cfs
Volume = 5.384 inches
3
6
9
12
15
18
21
24
TIME FROM BEGINNING OF RAINFALL (HOURS)

FIGURE 62

VIII. Flood Routing

Flood routing is either a graphical or mathematical procedure for the determination of stages, flows and storage volumes at specific points in time during a storm event. A detailed flood routing method is used and explained in the Example Problem which follows this section. Figure 63 is a graphical example of exactly what a flood routing procedure will tell the designer. The solid line is the runoff or inflow hydrograph which can be calculated as described in the previous section. The dotted line is the outflow hydrograph and represents the time variation of discharge off-site through the control structure. The point where the inflow and outflow hydrographs cross is called the point of dynamic equilibrium. The dynamic variable that is in equilibrium, i.e., stopped, at this point is the on-site water level. To the left of this point the inflow rate is greater than the outflow rate and therefore the water level rises. To the right of this point the inflow rate is less than the outflow rate and the water level drops. Therefore, this is the point in time when the on-site water level ceases to rise and begins to drop and it is hence the peak stage coincident with the frequency of the storm event analyzed. It is interesting to note that it is at this point that the control structure is discharging at its peak rate also (assuming a gravity controlled structure). The area to the left of this point under the inflow hydrograph and above the outflow hydrograph is equivalent to the peak storage volume on-site. In order to calculate all of these quantities the reader should follow the procedures as they are applied in the next part, Surface Water Management Example problem.

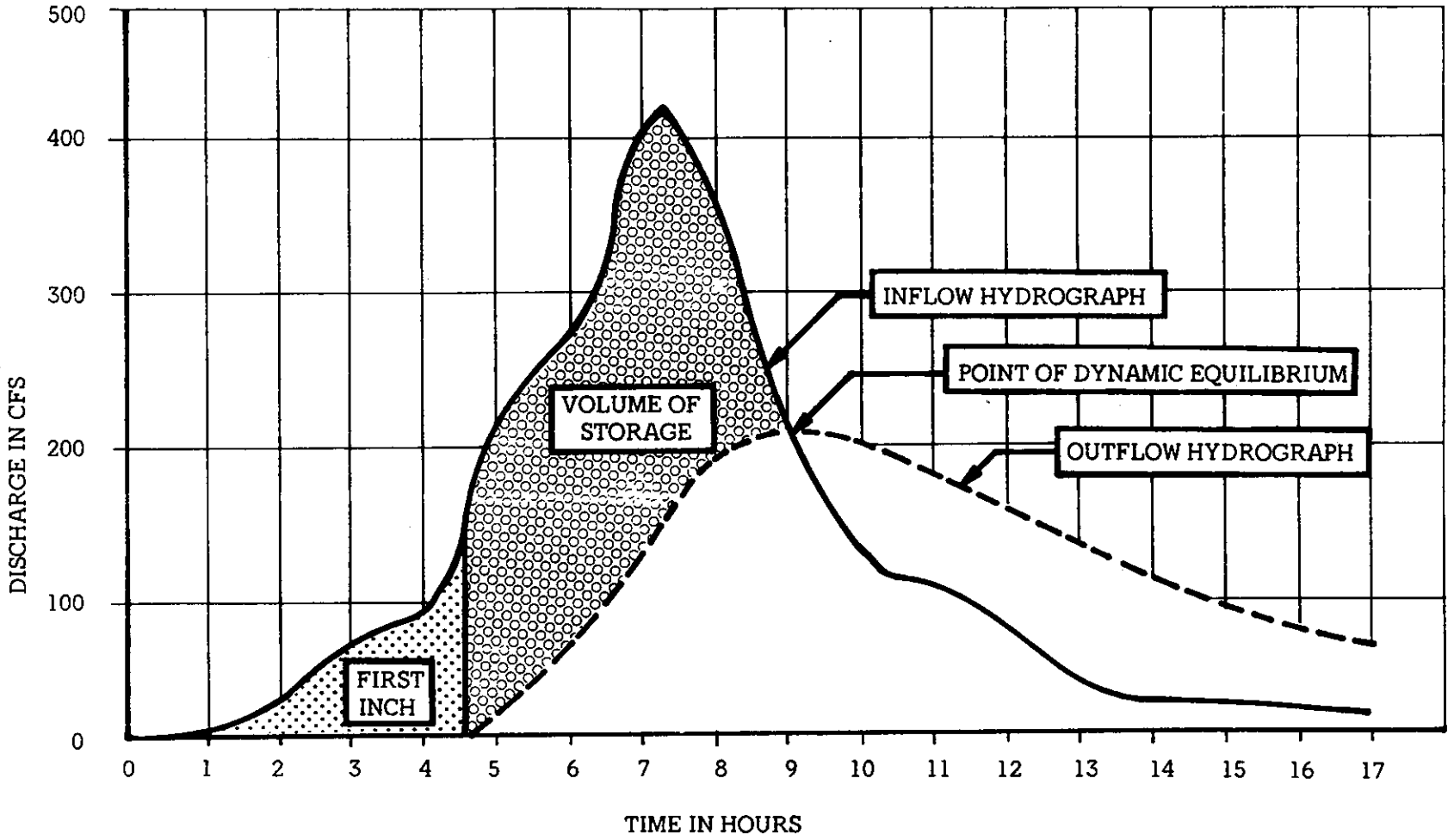


FIGURE 63

INFLOW AND OUTFLOW HYDROGRAPHS

Part C - Surface Water Management Example Problem

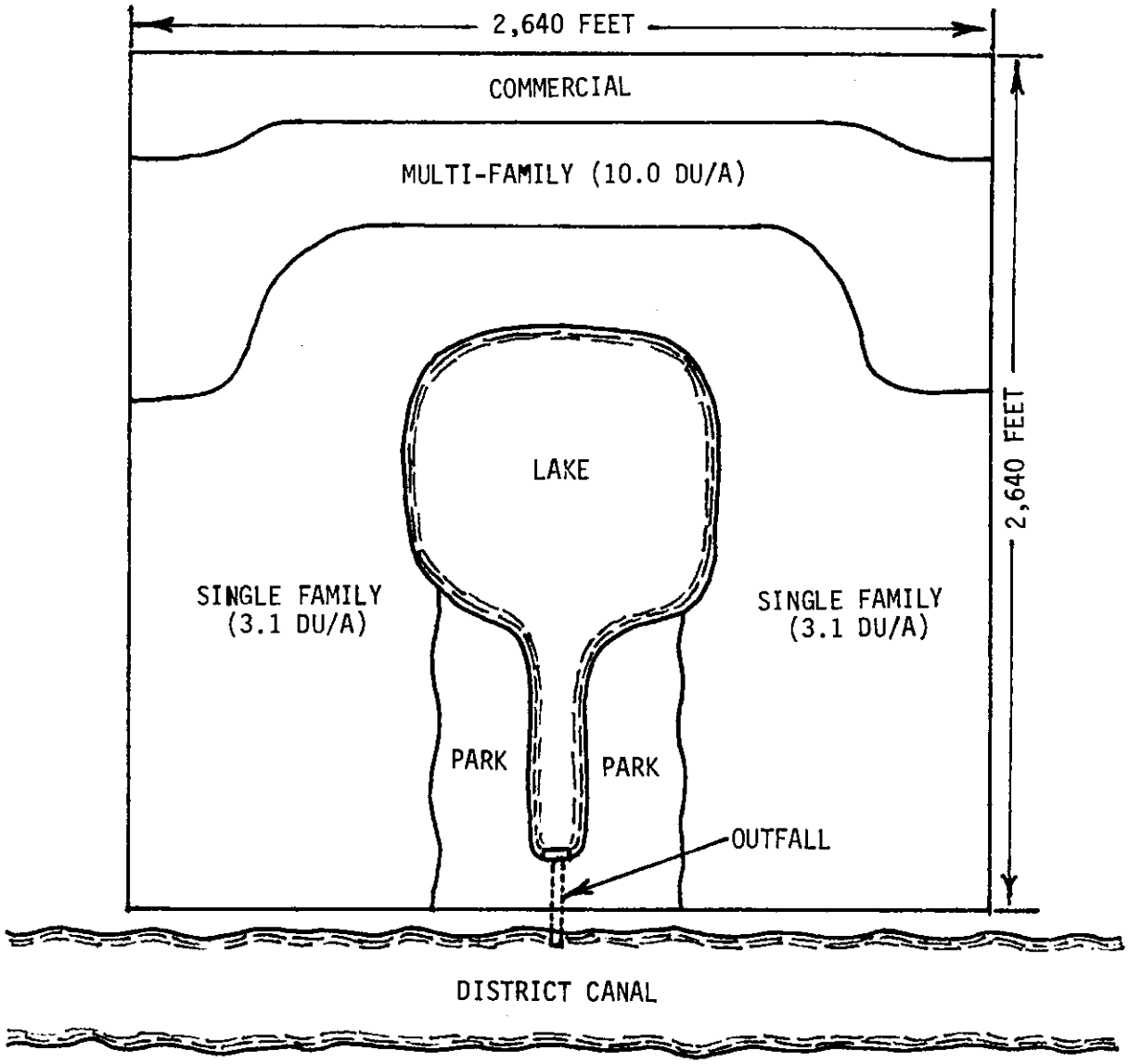
The example problem which follows incorporates all of the theories and principles of Part B of this volume to design a surface water management system which meets the criteria as delineated in Part A of this volume.

Any specific questions about any portion of this example problem can be answered personally through a visit with the staff.

P A R T C

SURFACE WATER MANAGEMENT EXAMPLE PROBLEM

EXAMPLE PROBLEM



Allowable 25-year peak discharge to canal based on

$$Q = \left(\frac{78}{\sqrt{A}} + 54\right)A$$

Where, A = project size in square miles
Q = allowable peak discharge in cfs

Lake Control Stage = 11.0
Maintained canal stage = 9.0
25-year design canal stage = 11.6
Proposed minimum road grade = 14.5
Proposed minimum floor level = 16.5
24-hour rainfall depths: 5-year = 7.5 inches
25-year = 10.0 inches
100-year = 13.0 inches

EXAMPLE DESIGN PROBLEM

PROPOSED LAND USE:

160 Acre Project

100 Acres Single-family Residential @3.1 DU/A

20 Acres Multi-family Residential @10.0 DU/A

10 Acres Commercial

14 Acres Neighborhood Park

16 Acres Lake

COMPUTATIONS:

I. Compute pervious/impervious acreages:

1. Lakes @ 100% "impervious" = 16.0 Acres
2. Commercial @ 90% impervious = 9.0 Acres
3. Multi-family @ 70% impervious = 14.0 Acres
4. Single-family @ 40% impervious = 40.0 Acres
5. Park @ 20% impervious (for parking) = 2.8 Acres
6. Total Impervious = 16.0 + 9.0 + 14.0 + 40.0 + 2.8 = 81.8 Acres

$$\% \text{ Impervious} = \frac{81.8 \text{ Acres}}{160 \text{ Acres}} \times 100\% = 51\%$$

7. Pervious = Total - Impervious = 78.2 Acres

II. Compute soil storage and SCS Curve Number:

1. Even though the control level is at elevation 11.0 FT. NGVD it is highly likely that the wet season water table will vary from 11.0 FT. NGVD (adjacent to the lake) to 13.0 FT. NGVD at the project boundaries. Consequently an average water table elevation of 12.0 FT. NGVD will be used.
2. Average finished grade will be at 15.5 FT. NGVD.
3. Therefore, the average depth to the wet season water table will be 3.5 feet.

4. From the soil storage table in the "Basis of Review" with an average depth to the water table of 3.5 feet and considering 25% compaction we can store up to 6.6 inches of moisture in the soil column beneath pervious areas.

5. Ground storage under pervious areas = $\frac{6.6 \text{ in.}}{12 \text{ in/ft.}}$ x 78.2 Acres = 43.01 Acre-feet

6. Equivalent Soil Storage, S = $\frac{43.01 \text{ Acre-feet}}{160 \text{ Acres}}$ x $\frac{12 \text{ in.}}{1 \text{ ft.}}$ = 3.23 inches

7. SCS Curve Number, CN = $\frac{1000}{S + 10} = \frac{1000}{3.23 + 10}$ = 76

III. Compute open surface stage-versus storage:

1. On-site control level at 11.0 FT. NGVD.

2. Lake stores vertically above elevation 11.0 FT. NGVD. (This is a valid assumption as long the lake side-slope area does not exceed 10% of the lake size.)

3. Developed site grading varies linearly from 14.0 to 17.0 FT. NGVD.

4. Building Coverage:

   a. Single-family

      Bldg. = (3.1 DU/A) x (100 Acres) x (3000 ft.^{2}/DU) = 930,000 ft.^{2} = 21.3 Acres

   b. Multi-family (2-story Townhouses)

      Bldg. = (10.0 DU/A) x (20 Acres) x (800 ft.^{2}/DU) = 160,000 ft.^{2} = 3.7 Acres

   c. Commercial (determined from plans, in this case, 30%).

      Bldg. = 10.0 Acres x 30% bldg. coverage = 3.0 Acres

   d. Total building coverage

      Bldg. = 21.3 + 3.7 + 3.0 = 28.0 Acres

5. Park area is graded from 13.5 to 14.5 FT. NGVD.

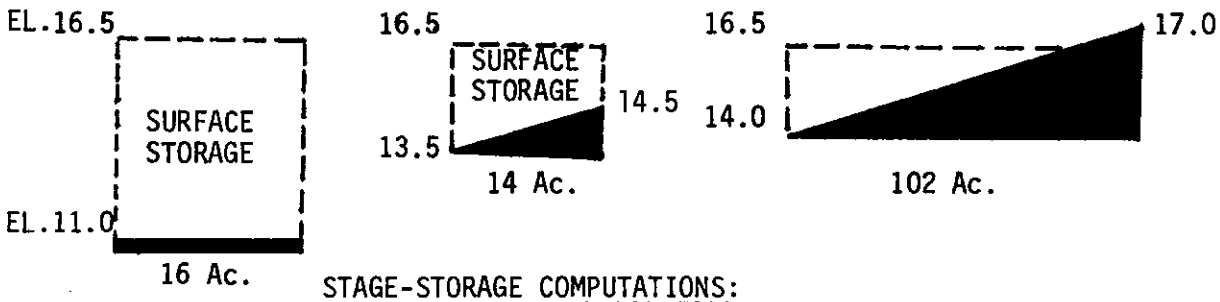
6. Area of developed site grading = Total area - Lakes - Bldgs. - Park

   Area Site Grading = 160.0 - 16.0 - 28.0 - 14.0 = 102.0 Acres

(Note: The Park area is deducted from the total site grading because surface storage in the Park will be computed separately.)

7. Calculations for developing stage-versus-storage curve:

STAGE-STORAGE SCHEMATIC DIAGRAMS:



STAGE-STORAGE COMPUTATIONS:

STAGE	LAKE	+	PARK	+	SITE GRADING	=	TOTAL
11.0	0		0		0		0
12.0	1' x 16 = 16 AF		0		0		16 AF
13.0	2' x 16 = 32 AF		0		0		32 AF
14.0	3' x 16 = 48 AF		$(\frac{1}{2})(14A)(\frac{0.5'}{2})$ = 1.75 AF		0		49.75 AF
15.0	4' x 16 = 64 AF		$(14A)(\frac{1}{2}')+(0.5')(14A)$ = 14AF		$(1/3)(102A)(\frac{1'}{2})$ = 17 AF		95 AF
16.0	5' x 16 = 80 AF		14 AF + (1'x14A) = 28 AF		$(2/3)(102A)(\frac{2'}{2})$ = 68 AF		176 AF
16.5	5.5' x 16 = 88 AF		28 AF + (0.5'x14A) = 35 AF		$(\frac{2.5}{3})(102A)(\frac{2.5'}{2})$=106.25AF		229.25 AF

8. The stage-versus-storage curve is shown in Figure 1.

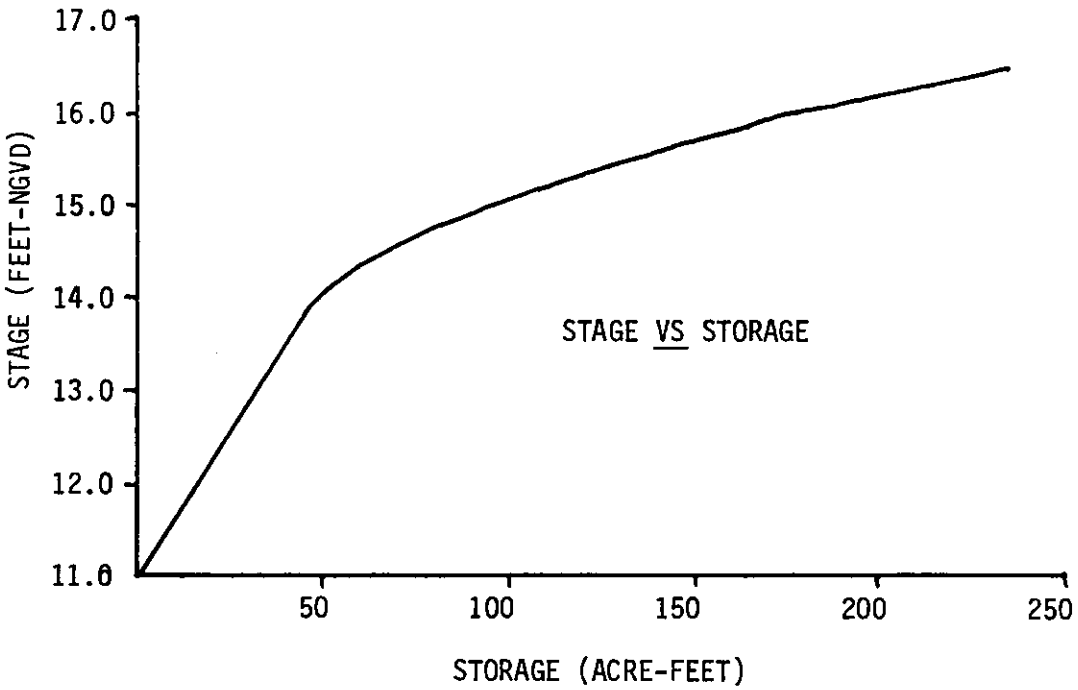


FIGURE 1

IV. Allowable discharge calculation:

$$Q = (\frac{78}{\sqrt{A}} + 54)A = (\frac{78}{\sqrt{.25}} + 54).25 = 52.5 \text{ cfs.}$$

V. Weir crest elevation required: (greater of the following):

1. First one inch of runoff

$$V \text{ one inch} = \frac{1 \text{ in.}}{12 \text{ in/ft.}} \times 160 \text{ Ac} = 13.3 \text{ Acre-feet}$$

2. Retention for wet retention/detention area from Appendix 2 of "Basis of Review" based on 51% impervious is 1.28 inches:

$$V \text{ RET} = \frac{1.28 \text{ in.}}{12 \text{ in/ft.}} \times 160 \text{ Ac} = 17.1 \text{ Acre-feet}$$ which is greater than one inch and therefore must be retained.

3. Based on stage-versus-storage curve set weir crest at elevation 12.1 FT. NGVD.

VI. Compute the weir length:

1. Runoff from the 25-year, 3-day storm event of 13.59 inches:

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} = \frac{(13.59-0.2(3.23))^2}{(13.59+0.8(3.23))} = 10.36 \text{ inches}$$

Volume of runoff = 10.36 in. x $\frac{1 \text{ ft.}}{12 \text{ in.}}$ x 160 Ac = 138.1 Acre-feet

2. The 25-year, zero discharge stage corresponding to 138.1 Acre-feet of runoff is 15.5 FT. NGVD.

3. The maximum design head is 15.5 - 12.1 = 3.4 feet based on zero discharge, therefore use a design head of 3.0 feet for sizing weir.

4. Using the formula for sharp-crested weirs with end contractions (for large weirs and small heads, end contractions can usually be neglected) solve for the weir length:

$$Q = 3.33\ (L-0.1nH)H^{1.5}$$

(REF: Handbook of Hydraulics by King and Brater, 1976, Sixth Edition, page 5-13)

where, Q = discharge over weir in cfs.
L = weir length in feet
n = number of end contractions (normally 2)
H = head on weir under free flow conditions, feet-head

solving for L yields:

$$L = \frac{Q + 3.33(0.1)nH^{2.5}}{3.33H^{1.5}}$$

Using Q = 52.5 cfs, n = 2, and H = 3.0

$$L = \frac{52.5 + 3.33(0.1)(2)(3.0)^{2.5}}{3.33(3.0)^{1.5}} = 3.63 \text{ feet}$$

use a weir length of 3.5 feet.

5. A bleed-down device must be incorporated into the structure design to return the lake system to the control water level. depending on the preference of the designer a small v-notch, a small diameter pipe, a slot, or a small hole may be used. In this example a vertical slot was used for the bleeder. Size the bleeder to discharge one-half of the retention volume (17.1÷2 = 8.55 AF) in 24 hours:

$$Q = \frac{2}{3} L \sqrt{2g}\, H^{1.5}$$

(REF: Handbook of Hydraulics by King and Brater, 1976, Sixth Edition, page 4-5)

where, Q = discharge for a rectangular orifice in cfs.
L = width of the orifice in feet.
g = acceleration due to gravity, feet per second squared.
H = head on invert of orifice in feet-head.

solving for L yields:

$$L = \frac{1.5Q}{\sqrt{2g}\, H^{1.5}}$$

Using Q = 4.31 cfs (based on discharging 8.55 AF in 24 hours)
g = 32.2 ft/sec.^{2}.
H = 1.1 feet (12.1 FT. NGVD - 11.0 FT. NGVD)

then:

$$L = \frac{1.5\ (4.31)}{\sqrt{2(32.2)}\ (1.1)^{1.5}} = 0.70 \text{ feet, use } \underline{0.7 \text{ feet}}.$$

6. In order to avoid "culvert control" of the discharge size the culvert leading from the weir to the receiving canal to pass the design flow at approximately one-half of the estimated design head. In this case the design head used was 3.0 feet so we will size the culvert to pass 50 cfs at 1.5 feet of head and assume full-flow conditions. From Figure 2 it can be seen that a 36" x 100' RCP should be sufficient.

7. The outfall structure consisting of a weir with vertical slot connected to a RCP culvert is shown in Figure 3.

8. Compute the stage-versus-discharge values for the outfall structure. It is important to take into account the hydraulics of the culvert, the weir, and the slot in deriving the discharge rates:

STAGE (FT. NGVD)	WEIR & SLOT (CFS)	PIPE (CFS)	CONTROL (CFS)	CONTROL (AF/HR)
11.0	0	0	0	0
12.0	3.7	32.0	3.7	.31
12.1	4.3	39.0	4.3	.36
13.0	9.4	55.0	9.4	.78
14.0	27.2	67.0	27.2	2.25

STAGE (FT. NGVD)	WEIR & SLOT (CFS)	PIPE (CFS)	CONTROL (CFS)	CONTROL (AF/HR)
15.0	48.0	77.0	48.0	3.97
16.0	69.8	86.0	69.8	5.77

The control structure discharge was converted to acre-feet per hour for the flood routing method which will be used.

VII. Check minimum building floor elevation:

1. The runoff from the 100-year, 3-day storm:

   13.0 in. x 1.359 = 17.67 inches of rainfall

   $Q = \frac{(P-0.2S)^2}{(P+0.8S)} = \frac{(17.67 - 0.2(3.23))^2}{(17.67 + 0.8(3.23))} = 14.44$ inches runoff

   Volume of Runoff = 14.44 in. x $\frac{1 \text{ ft}}{12 \text{ in}}$ x 160 Ac. = 192.5 Acre-feet

2. Based on the stage-versus-storage curve a storage level of 192.5 Acre-feet corresponds to a stage of 16.15.

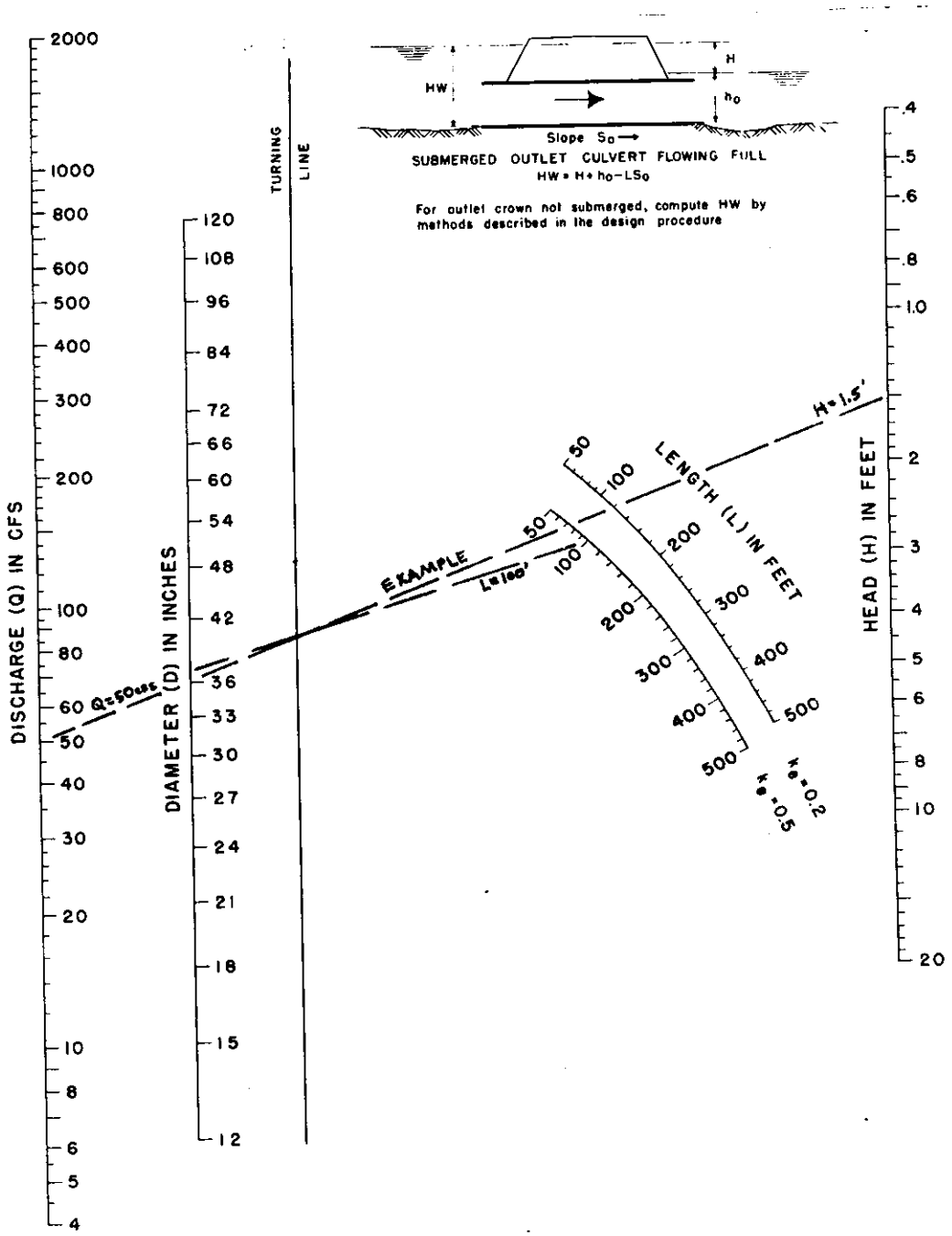
3. Since the minimum finished floor is set at 16.5 then it is adequate.

VIII. Check roads versus local criteria:

1. In this area the minimum road grade must be protected from the 5-year, 24-hour storm event. The rainfall for the 5-year, 24-hour event equals 7.5 inches in this location.

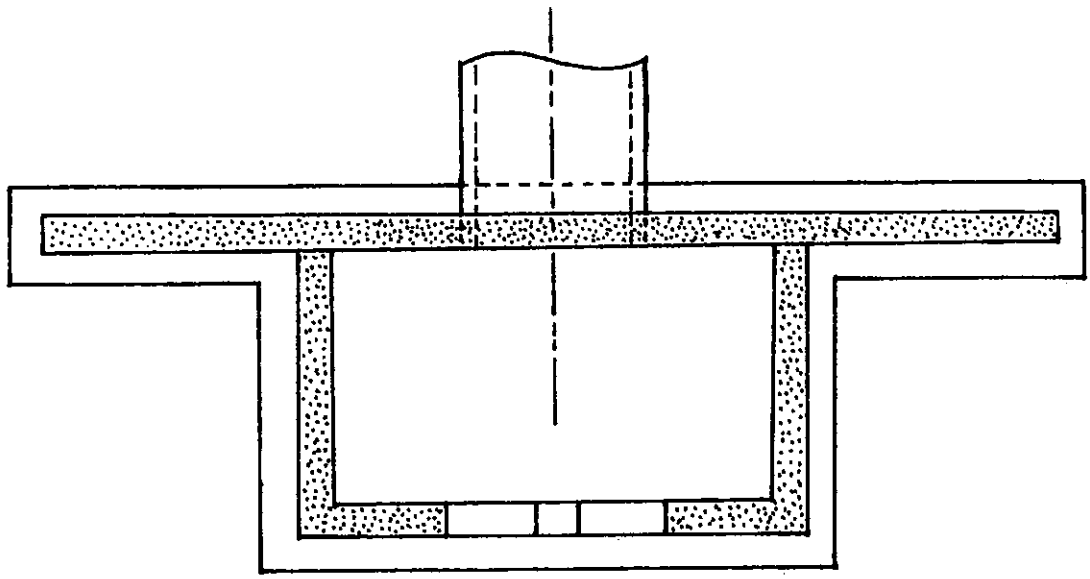
2. Computation of the peak stage is shown in the flood routing in Table 2 using the runoff information calculated in Table 1.

3. The peak stage for the 5 year, 24-hour storm is 13.71 and the minimum road grade is 14.5, therefore the road height is adequate.



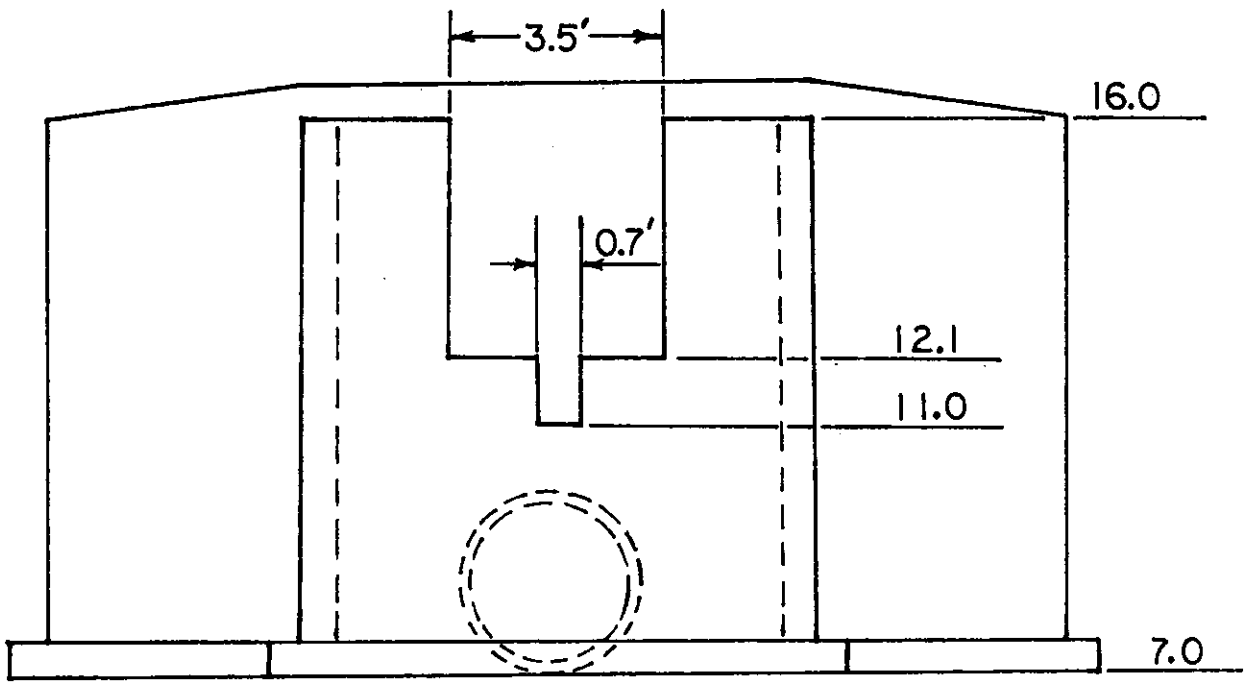
HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

FIGURE 2



PLAN VIEW

SCALE: 1"=3'



FRONT VIEW

SCALE: 1"=3'

FIGURE 3

INSTRUCTIONS FOR COMPUTATION SHEET NO. 1A OR 1B
(Runoff Volume)

Step 1. Columns 1, 2 and 3 are taken directly from the "Basis of Staff Review".

Step 2. Column 4 = Column 3 x 24 hour rainfall.

Step 3. Column 5 $=(\text{Column 4} - 0.2S)^2/(\text{Column 4} + 0.8S)$

Step 4. Column 6 = Column 5 x (total acreage ÷ 12)

(Note: Sheet No. 1A is for 72-hour event computations and
Sheet No. 1B is for 24-hour event computations.)

TABLE 1

COMPUTATION SHEET NO. 1B

RUNOFF VOLUME
24-HOUR EVENT

TIME (HOURS)		RAINFALL RATIO $\left(\frac{P}{P_{24}}\right)$	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	CUMULATIVE RUNOFF (ACRE-FT)
ACC.	ΔT				
(1)	(2)	(3)	(4)	(5)	(6)
0.0	0	0	0	0	0
10.0	10	0.213	1.598	0.217	2.89
11.0	1	0.269	2.018	0.409	5.45
11.5	0.5	0.319	2.393	0.613	8.17
12.0	0.5	0.656	4.920	2.434	32.45
12.5	0.5	0.729	5.468	2.888	38.51
13.0	0.5	0.767	5.753	3.128	41.71
14.0	1	0.818	6.135	3.456	46.08
15.0	1	0.850	6.375	3.664	48.85
16.0	1	0.880	6.600	3.860	51.47
17.0	1	0.898	6.735	3.979	53.05
18.0	1	0.916	6.870	4.098	54.64
24.0	6	1.000	7.500	4.659	62.12

Drainage area = 160 acres
Design storm = 5 year event
24-HR. rainfall = 7.5 inches
Weighted soil storage = 3.23 inches

INSTRUCTIONS FOR COMPUTATION SHEET NO. 2
(Flood Routing)

Step 1. Columns 1, 2 and 3 are taken from Computation Sheet No. 1A or 1B, Columns 1, 2 and 6 respectively.

Step 2. Enter stage-storage curve at volume from Column 3 to determine if the stage is below the wier (in this example bleeder weir is at 11.0).

a. If the stage is below the weir, then Columns 4, 6, 7, 8 and 9 are zero, and Column 5 = Column 3 (since no discharge has taken place yet).
b. If stage is above the weir, then estimate the cumulative discharge, and enter in Column 4, Col. 5 = Col. 3 - Col. 4.

Step 3. Determine stage for volume in Column 5, then use stage-discharge data for discharge rate and enter in Column 6.

Step 4. Column 7 = [Col. 6 + Col. 6 (previous row)] ÷ 2.

Step 5. Column 8 = Col. 2 x Col. 7.

Step 6. Col. 9 = Col. 8 + Col. 9 (previous row).

NOTE: You must now check to see that Col. 9 = Col. 4. If they are not equal, repeat Steps 2b, 3, 4, 5 and 6 until they are equal.

Step 7. Flood route entire event by performing Steps 2 → 6 for each time increment.

Step 8. Peak stage is determined by entering the stage-storage curve with the largest value from Column 5.

Step 9. Peak discharge is taken directly from Column 6.

TABLE 2

COMPUTATION SHEET NO. 2

FLOOD ROUTING

TIME (HOURS) ACC. (1)	TIME (HOURS) ΔT (2)	CUMULATIVE RUNOFF (AF) (3)	ESTIMATED CUMULATIVE DISCHARGE (AF) (4)	VOLUME STORED (AF) (5)	DISCHARGE (AF/HR) INST. (6)	DISCHARGE (AF/HR) AVG. (7)	DISCHARGE FOR ΔT (AF) (8)	CALCULATED CUMULATIVE DISCHARGE (AF) (9)	STAGE (FT. NGVD) (10)
0	0	0	0	0	0	0	0	0	11.0
10	10	2.89	TRY 0.25	2.64	.05	.025	0.25	0.25	11.17
11	1	5.45	TRY 0.32	5.13	.10	.075	.075	0.32	11.32
11.5	0.5	8.17	TRY 0.38	7.79	.15	.125	.06	0.38	11.49
12.0	0.5	32.45	TRY 0.60	31.85	.73	.44	.22	0.60	12.99
12.5	0.5	38.51	TRY 0.90 TRY 1.05 TRY 1.09	37.61 37.46 37.42	1.24 1.23 1.23	.98 .98 .98	0.49 0.49 0.49	1.09 1.09 1.09	13.31
13.0	0.5	41.71	TRY 1.50 TRY 1.75	40.21 39.96	1.46 1.44	1.35 1.33	0.67 0.66	1.76 1.75	13.45
14.0	1	46.08	TRY 3.00 TRY 3.30 TRY 3.31	43.08 42.78 42.77	1.70 1.67 1.67	1.57 1.56 1.56	1.57 1.56 1.56	3.32 3.31 3.31	13.61
15.0	1	48.85	TRY 5.00 TRY 5.03	43.85 43.82	1.76 1.76	1.72 1.72	1.72 1.72	5.03 5.03	13.67
16.0	1	51.47	TRY 6.80 TRY 6.83	44.67 44.64	1.83 1.83	1.80 1.80	1.80 1.80	6.83 6.83	13.71
17.0	1	53.05	TRY 8.70 TRY 8.65	44.35 44.40	1.80 1.81	1.81 1.82	1.81 1.82	8.64 8.65	13.70
18.0	1	54.64	TRY 10.45	44.19	1.79	1.80	1.80	10.45	13.69
24.0	6	62.12	TRY 20.00 TRY 20.60 TRY 20.53	42.12 41.52 41.59	1.62 1.57 1.57	1.70 1.68 1.68	10.20 10.08 10.08	20.65 20.53 20.53	13.54

Project name = Example Problem; Discharge = 1.83 AF/HR
x 12.1 = 22.1 CFS
Storm analyzed = 5 Year; Stage = 13.71 FT. NGVD

IX. Check discharge during design storm versus allowable discharge rate:

1. The design storm is the 25-year, 3-day storm with a total rainfall of:

   10.0 in. x 1.359 = 13.59 inches

2. Computation of the peak discharge is shown in the flood routing in Table 4 using the runoff information calculated in Table 3.

3. The peak discharge during the 25-year event is 48.0 cfs which is less than the allowable 52.5 cfs therefore the structure design is adequate.

TABLE 3

COMPUTATION SHEET NO. 1A

RUNOFF VOLUME
72-HOUR EVENT

TIME (HOURS)		RAINFALL RATIO $\frac{P}{P_{24}}$	CUMULATIVE RAINFALL (INCHES)	CUMULATIVE RUNOFF (INCHES)	CUMULATIVE RUNOFF (ACRE-FT)
ACC.	ΔT				
(1)	(2)	(3)	(4)	(5)	(6)
0	0	0	0	0	0
24.0	24	0.146	1.460	0.164	2.19
48.0	24	0.359	3.590	1.404	18.72
58.0	10	0.572	5.720	3.100	41.33
59.0	1	0.628	6.280	3.581	47.75
59.5	0.5	0.678	6.780	4.018	53.57
60.0	0.5	1.015	10.150	7.093	94.57
60.5	0.5	1.088	10.880	7.779	103.72
61.0	0.5	1.126	11.260	8.138	108.51
62.0	1	1.177	11.770	8.554	114.05
63.0	1	1.209	12.090	8.925	119.00
64.0	1	1.239	12.390	9.211	122.81
65.0	1	1.257	12.570	9.382	125.09
66.0	1	1.275	12.750	9.554	127.39
72.0	6	1.359	13.590	10.359	138.12

Drainage area = 160 acres
Design storm = 25 year event
24-HR. rainfall = 10.0 inches
Weighted soil storage = 3.23 inches

TABLE 4

COMPUTATION SHEET NO. 2

FLOOD ROUTING

TIME (HOURS) ACC. (1)	TIME (HOURS) ΔT (2)	CUMULATIVE RUNOFF (AF) (3)	ESTIMATED CUMULATIVE DISCHARGE (AF) (4)	VOLUME STORED (AF) (5)	DISCHARGE (AF/HR) INST. (6)	DISCHARGE (AF/HR) AVG. (7)	DISCHARGE FOR ΔT (AF) (8)	CALCULATED CUMULATIVE DISCHARGE (AF) (9)	STAGE (FT. NGVD) (10)
0	0	0	0	0	0	0	0	0	11.00
24.0	24	2.19	TRY 0.40 TRY 0.42	1.79 1.77	.035 .034	.017 .017	0.42 0.42	0.42 0.42	11.11
48.0	24	18.72	TRY 4.00 TRY 4.20	14.72 14.52	.285 .281	.160 .158	3.83 3.78	4.25 4.20	11.91
58.0	10	41.33	TRY 10.00 TRY 8.40 TRY 9.48	31.33 31.93 31.85	.760 .778 .776	.521 .530 .528	5.21 5.30 5.28	9.41 9.50 9.48	12.99
59.0	1	47.75	TRY 10.30 TRY 10.48	37.45 37.27	1.23 1.22	1.00 1.00	1.00 1.00	10.48 10.48	13.30
59.5	0.5	53.57	TRY 12.00 TRY 11.19	41.57 42.38	1.57 1.64	1.40 1.43	0.7 0.71	11.18 11.19	13.58
60.0	0.5	94.57	TRY 15.00 TRY 12.47	79.57 82.10	3.38 3.48	2.51 2.56	1.26 1.28	12.45 12.47	14.71
60.5	0.5	103.72	TRY 14.30 TRY 14.28	89.42 89.44	3.76 3.76	3.62 3.62	1.81 1.81	14.28 14.28	14.88
61.0	0.5	108.51	TRY 16.20 TRY 16.19	92.31 92.32	3.87 3.87	3.81 3.81	1.91 1.91	16.19 16.19	14.94
62.0	1	114.05	TRY 20.00 TRY 20.09	94.05 93.96	3.93 3.93	3.90 3.90	3.90 3.90	20.09 20.09	14.98
63.0	1	119.00	TRY 24.00 TRY 24.04	95.00 94.96	3.97 3.97	3.95 3.95	3.95 3.95	24.04 24.04	15.00

Project name = Example Problem; Discharge = 3.97 AF/HR
x 12.1 = 48.0 CFS
Storm analyzed = 25 Year; Stage = 15.0 FT. NGVD

Sheet 1 of 2

TABLE 4 (CONT'D.)

COMPUTATION SHEET NO. 2

FLOOD ROUTING

TIME (HOURS) ACC.	ΔT	CUMULATIVE RUNOFF (AF)	ESTIMATED CUMULATIVE DISCHARGE (AF)	VOLUME STORED (AF)	DISCHARGE (AF/HR) INST.	AVG.	DISCHARGE FOR ΔT (AF)	CALCULATED CUMULATIVE DISCHARGE (AF)	STAGE (FT. NGVD)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
63.0	1	119.00	24.04	94.96	3.97	3.95	3.95	24.04	15.00
64.0	1	122.81	TRY 28.00	94.81	3.95	3.96	3.96	28.00	15.00
65.0	1	125.09	TRY 31.94	93.15	3.90	3.92	3.92	31.92	
			TRY 31.92	93.17	3.90	3.92	3.92	31.92	14.96
66.0	1	127.39	TRY 35.80	91.59	3.84	3.87	3.87	35.79	
			TRY 35.79	91.60	3.84	3.87	3.87	35.79	14.92
72.0	6	138.12	TRY 56.00	82.12	3.48	3.66	21.96	57.75	
			TRY 57.50	80.62	3.42	3.63	21.78	57.57	
			TRY 57.57	80.55	3.42	3.63	21.78	57.57	14.68

Project name = Example Problem; Discharge = 3.97 AF/HR
x 12.1 = 48.0 CFS
Storm analyzed = 25 Year; Stage = 15.00 FT. NGVD