PART C

SURFACE WATER MANAGEMENT SYSTEM DESIGN AIDS

TABLE C-V-1

BROWARD COUNTY - USUAL OPEN-HOLE TEST

Elapsed Time (Minutes)	Begin Meter Reading	End Meter Reading	Flow Gallons	Q (G.P.M.)
1	0.0	5.5	5.5	5.5
2	5.5	11.0	5.5	5.5
3	11.0	16.0	5.0	5.0
4	16.0	19.0	3.0	3.0
5	19.0	22.5	3.5	3.5
6	22.5	26.5	4.0	4.0
7	26.5	30.0	3.5	3.5
8	30.0	33.5	3.5	3.5
9	33.5	37.5	4.0	4.0
10	37.5	40.5	3.0	3.0
11	40.5	44.5	4.0	4.0
12	44.5	48.5	4.0	4.0
13	48.5	51.5	3.0	3.0
14	51.5	55.5	4.0	4.0
15	55.5	59.5	4.0	4.0
16	59.5	63.0	3.5	3.5
17	63.0	67.0	4.0	4.0
18	67.0	70.0	3.0	3.0
19	70.0	73.5	3.5	3.5
20	73.5	77.5	4.0	4.0
25	77.5	96.0	18.5	3.7
30	96.0	114.5	18.5	3.7
35	114.5	132.0	17.5	3.5
40	132.0	154.0	22.0	4.4
45	154.0	172.5	18.5	3.7
50	172.5	190.5	18.0	3.6
55	190.5	208.5	18.0	3.6
60	208.5	220.0	11.5	2.3
65	220.0	235.0	15.0	3.0
70	235.0	247.0	12.0	2.4
75	247.0	259.5	12.5	2.5

4. Design of Trenches

Since the first publication of Volume IV, Permit Information Manual additional consideration has been given to the derivation of an acceptable exfiltration trench design formula. The latest development is shown on Figure C-V-3 along with the description of the appropriate parameters. The derivation of this trench sizing formula is given in the Appendix along with the derivations of the formulae used for use with the field testing procedures.

An example of the use of this formula with the data from the Broward County test site follows:

$$L = \frac{V}{K(H_2W + 2H_2Du - Du^2 + 2H_2D_s) + (1.39 \times 10^{-4})WDu}$$

V = 15 Ac-In.

$K = 1.75 \times 10^{-4}$ CFS/FT.^{2}-FT.HEAD

H_2 = 5.0 Feet (Design Condition)

W = 4.0 Feet

D_u = 2.5 Feet

D_s = 1.5 Feet

$H = D_u + D_s$ = 4.0 Feet

Solving for L gives,

L = 1389 feet of 4' x 4' exfiltration trench.

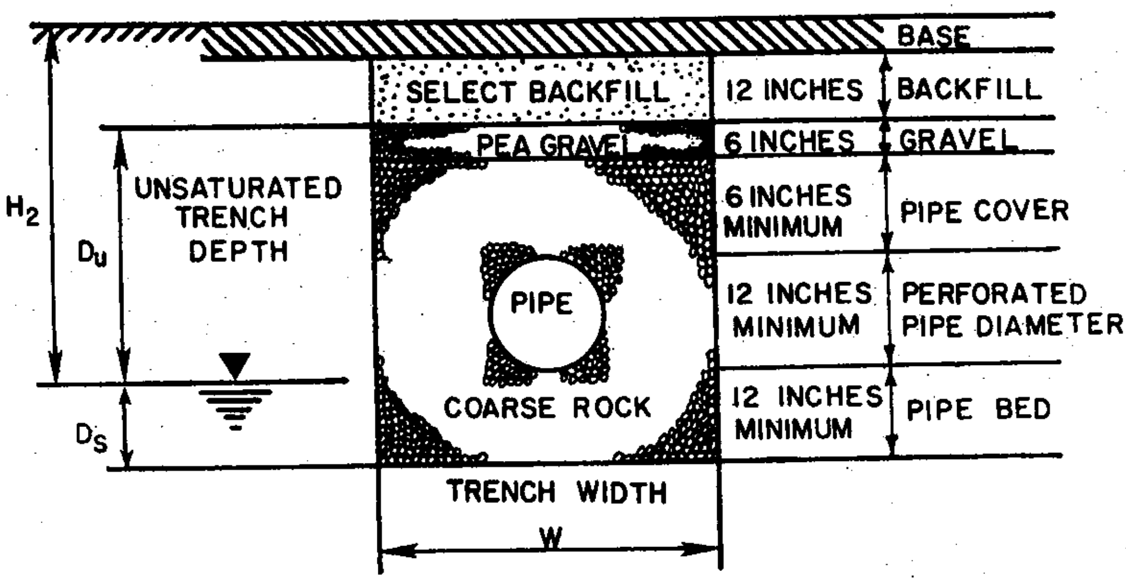
This formula can be used for sizing exfiltration trenches to meet SFWMD criteria as it is since it already takes into consideration both a Safety Factor of 2 and the 50% credit for retention systems as opposed to detention systems.

For those situations when either: (1) the saturated depth of trench is greater than the non-saturated depth of trench; or (2) the trench width is greater than two times the total trench depth, the proportional assumptions for flow out the trench bottom are probably not valid. A conservative design formula for use in these cases would be:

$$L = \frac{V}{K(2H_2Du - Du^2 + 2H_2Ds) + (1.39 \times 10^{-4})WDu}$$

As with any design method a good amount of engineering judgement must be applied for use on site-specific cases.

TYPICAL EXFILTRATION TRENCH



$$L = \frac{V}{K(H_2W + 2H_2Du - Du^2 + 2H_2D_S) + (1.39 \times 10^{-4})WDu}$$

L = LENGTH OF TRENCH REQUIRED (FEET)

V = VOLUME TREATED (ACRE-INCHES)

W = TRENCH WIDTH (FEET)

K = HYDRAULIC CONDUCTIVITY ($CFS/FT.^2$-FT.HEAD)

H_2 = DEPTH TO WATER TABLE (FEET)

Du = NON-SATURATED TRENCH DEPTH (FEET)

D_S = SATURATED TRENCH DEPTH (FEET)

Figure C-V-3

APPENDIX

DERIVATION OF EQUATIONS

I. USUAL OPEN-HOLE TEST

$$K = \frac{Q}{S_1 H_1 + S_2 H_2} \qquad \text{(EQ. 1)}$$

FROM FIGURE C-V-1:

H_2 = DEPTH TO WATER TABLE (FT.)
D_S = SATURATED DEPTH OF HOLE (FT.)
d = DIAMETER OF HOLE (FT.)
$S_1 = H_2 \pi d$ (EQ. 2)
$S_2 = D_S \pi d + \frac{1}{4} \pi d^2$ (EQ. 3)
$H_1 = \frac{1}{2} H_2$ (EQ. 4)

SUBSTITUTING INTO EQUATION 1:

$$K = \frac{Q}{\left[(H_2 \pi d)(\frac{1}{2} H_2) + (D_S \pi d + \frac{1}{4} \pi d^2)(H_2)\right]}$$

$$K = \frac{4Q}{\pi d (2H_2^2 + 4H_2 D_S + H_2 d)} \qquad \text{(EQ. 5)}$$

II. FALLING-HEAD OPEN-HOLE TEST

$$Q = KSH \qquad \text{(EQ. 1)}$$

WHERE, Q = AVERAGE FLOW RATE (CFS)
K = HYDRAULIC CONDUCTIVITY (CFS/FT.^{2} - FT. HEAD)
S = SURFACE AREA OF HOLE (FT.^{2})
H = HEAD ON SURFACE AREA OF HOLE (FT. HEAD)

AND

$$Q = -\frac{\pi d^2}{4}\frac{dH}{dt} \qquad \text{(EQ. 2)}$$

Q = AVERAGE FLOW RATE (CFS)
d = DIAMETER OF HOLE (FEET)
dH = CHANGE IN HEAD (FT. HEAD)
dt = CHANGE IN TIME (SECONDS)

EQUATING EQ. 1 AND EQ. 2:

$$KSH = -\frac{\pi d^2}{4}\frac{dH}{dt} \qquad \text{(EQ. 3)}$$

$$\frac{4KS}{\pi d^2}\, dt = -\frac{dH}{H}$$

$$\int_{t_1}^{t_2} \frac{4KS}{\pi d^2}\, dt = \int_{H_1}^{H_2} -\frac{dH}{H}$$

$$\frac{4KS}{\pi d^2}(t_2 - t_1) = \ln(H_1/H_2)$$

$$K = \frac{\pi d^2 \ln(H_1/H_2)}{4S(t_2 - t_1)} \qquad \text{(EQ. 4)}$$

S = SURFACE AREA OF HOLE, EFFECTIVE (FT.^{2})

$$S = \pi d L + \frac{1}{4}\pi d^2$$

$$L = \frac{(H_1 + H_2)}{2} + Ds \qquad \text{(SEE FIGURE C-V-2)}$$

$$S = \pi d\left[\frac{H_1 + H_2}{2} + Ds\right] + \frac{1}{4}\pi d^2$$

$$K = \frac{\pi d^2 \ln(H_1/H_2)}{4\left[\pi d\left[\frac{(H_1+H_2)}{2} + D_S\right] + \frac{1}{4}\pi d^2\right](t_2 - t_1)}$$

$$K = \frac{d \ln(H_1/H_2)}{(2H_1 + 2H_2 + 4D_S + d)(t_2 - t_1)} \qquad \text{(EQ. 5)}$$

III. TRENCH LENGTH EQUATION

A. <u>VOLUME OF RUNOFF:</u>

$$Q = V\left(\frac{43560}{12}\right) = 3630\ V\ (FT.^3) \qquad \text{(EQ. 1)}$$

WHERE,

V = VOLUME TREATED (ACRE-INCHES)

B. <u>VOLUME OF STORAGE IN TRENCH:</u>

BASED ON 50% VOIDS:

$$V_{STOR} = 0.50\ WDuL\ \ (FT.^3) \qquad \text{(EQ. 2)}$$

WHERE,

W = TRENCH WIDTH (FT.)
Du = UNSATURATED TRENCH DEPTH (FT.)
L = TRENCH LENGTH (FT.)

C. <u>VOLUME EXFILTRATED:</u>

$$V_{BOT} = KH_2WL(3600) \qquad \text{(EQ. 3)}$$

WHERE,

V_{BOT} = VOLUME EXFILTRATED OUT BOTTOM IN 1 HOUR ($FT.^3$)
K = HYDRAULIC CONDUCTIVITY ($CFS/FT.^2$ - FT. HEAD)
H_2 = HEAD ON SATURATED SURFACE (FT. HEAD)

AND:

$$V_{SIDE} = L(KS_1H_1 + KS_2H_2)\ 3600 \qquad \text{(EQ. 4)}$$

WHERE,

V_{SIDE} = VOLUME EXFILTRATED OUT A SIDE IN 1 HOUR ($FT.^3$)
S_1 = UNSATURATED TRENCH SURFACE ($FT.^2$)
S_2 = SATURATED TRENCH SURFACE ($FT.^2$)
H_1 = AVERAGE HEAD ON UNSATURATED SURFACE (FT. HEAD)
H_2 = HEAD ON SATURATED SURFACE (FT. HEAD)

FROM FIGURE C-V-3

$S_1 = D_u L$

$S_2 = D_S L$

$H_1 = H_2 - \frac{1}{2} D_u$

THEN:

$$V_{SIDE} = \left[K D_u L (H_2 - \tfrac{1}{2} D_u) + K D_S L H_2 \right] 3600$$

$$V_{SIDE} = 3600 KL (H_2 D_u - \tfrac{1}{2} D_u^2 + H_2 D_S) \qquad \text{(EQ. 5)}$$

SETTING THE VOLUME OF RUNOFF EQUAL TO THE VOLUME EXFILTRATED: $Q = V_{STOR} + V_{BOT} + 2V_{SIDE}$

$$3630\ V = 0.50 W D_u L + 3600 K H_2 W L + 2\left[3600 KL (H_2 D_u - \tfrac{1}{2} D_u^2 + H_2 D_S) \right]$$

SOLVING THIS EQUATION FOR L:

$$L = \frac{1.00834\ V}{K(H_2 W + 2H_2 D_u - D_u^2 + 2H_2 D_S) + 0.000139\ W D_u} \qquad \text{(EQ. 6)}$$

HOWEVER, CONSIDERING THE EFFECT ON THE ANSWER AND THE NORMAL VARIATIONS IN ESTIMATION SIMPLIFY THE EQUATION:

$$L = \frac{V}{K(H_2 W + 2H_2 D_u - D_u^2 + 2H_2 D_S) + (1.39 \times 10^{-4}) W D_u} \qquad \text{(EQ. 7)}$$

WHERE,

L = LENGTH OF TRENCH REQUIRED (FT.)
V = VOLUME TREATED (ACRE-INCHES)
H_2 = DEPTH TO WATER TABLE (FT.)
W = TRENCH WIDTH (FT.)
D_u = UNSATURATED TRENCH DEPTH (FT.)
D_S = SATURATED TRENCH DEPTH (FT.)

VI. 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

The given data are: a 640-acre project with a calculated S-value of 3.5 inches, and an estimated Time of Concentration of 2.0 hours. The desired end product is to calculate the 10-year, 24-hour runoff hydrograph for a storm with a 24-hour rainfall depth of 8.5 inches.

It is desirable to select a time interval, Δt, equivalent to one-half of the Time of Concentration. Therefore, Δt will be one hour.

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 C-VI-1. The first four columns are calculated as described in Section II, 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 calculate the hydrograph points in the sixth column.

A graphical plot of the computed hydrograph is shown on Figure C-VI-1.

TABLE C-VI-1

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

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

EXAMPLE HYDROGRAPH

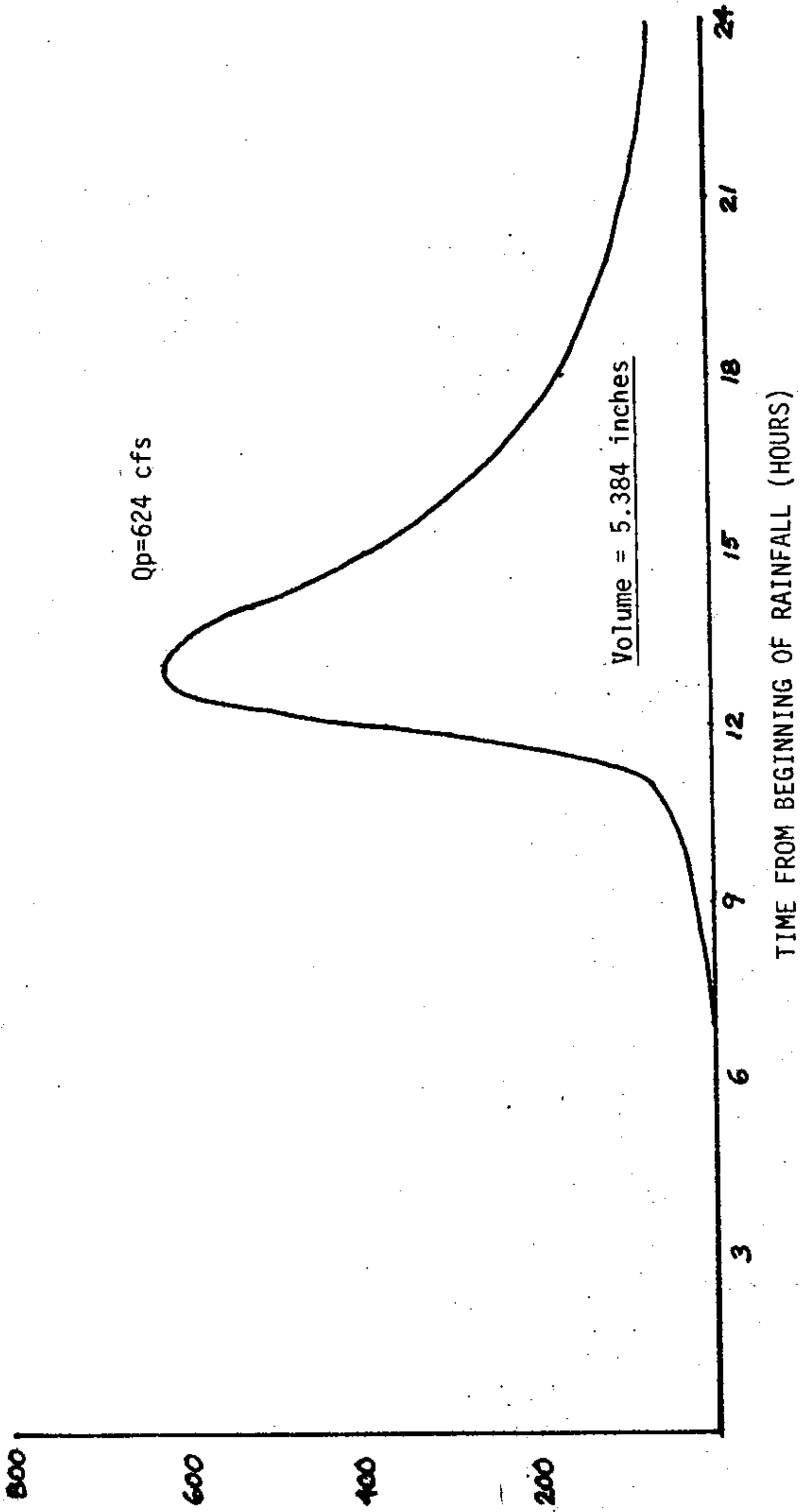


Figure C-VI-1

VII. 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. Figure C-VII-1 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.

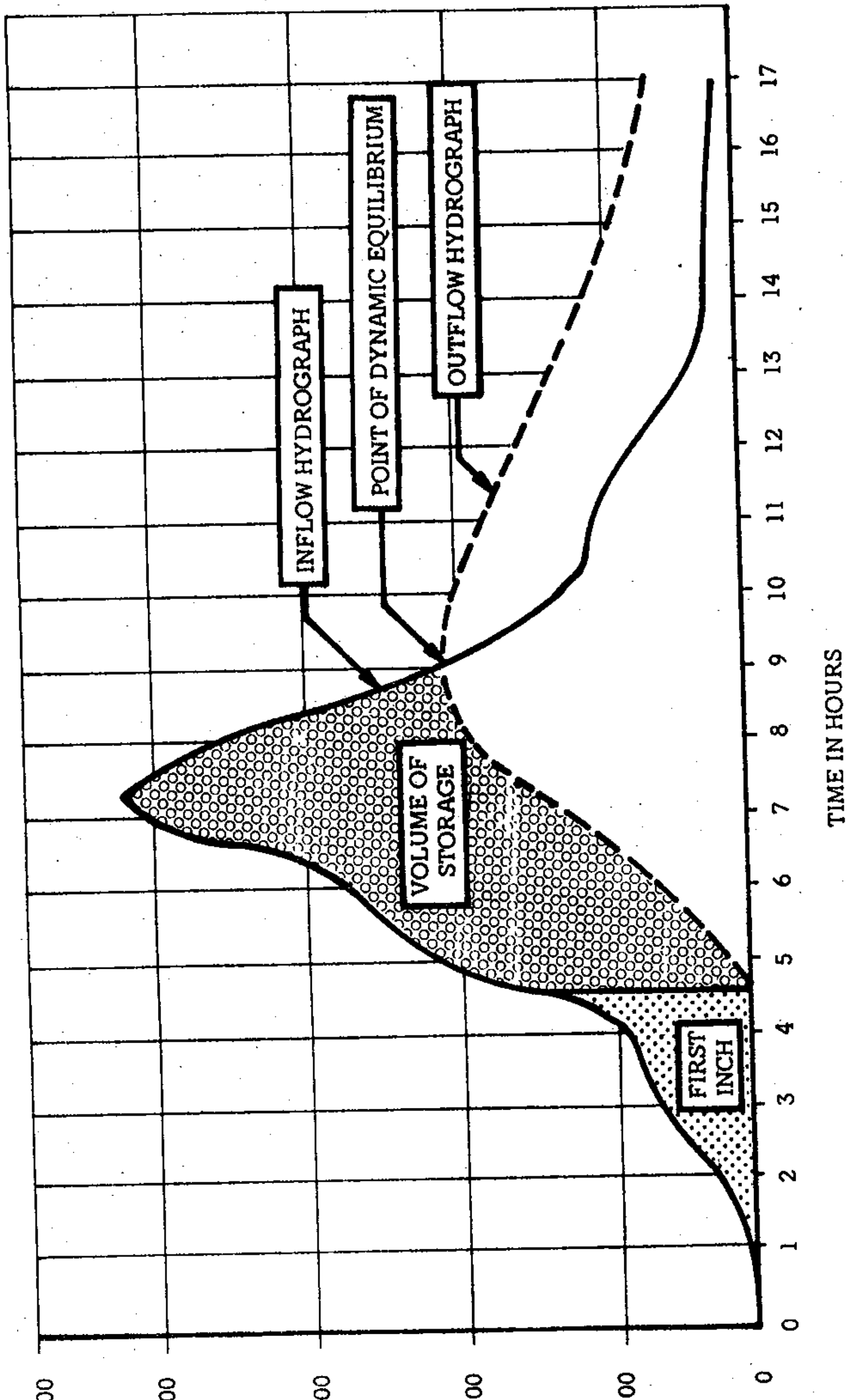
The point where the inflow and outflow hydrographs cross is called the point of dynamic equilibrium. The dynamic variable that is in equilibrium, i.e., stopped, at this point is the on-site water level. To the left of this point the inflow rate is greater than the outflow rate and therefore the water 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.

The question of how much larger a flood-routed peak discharge may be, compared to the allowable value, arises frequently. As an example, small (say, 20 acres or less) sites which were formerly undeveloped but are proposed to be highly impervious often can meet design requirements only by utilizing a water quality control structure with near-minimum dimensions, because the total volume of water to be stored and then discharged to meet the "2.5 inches times percent impervious" is rather small.

However, if the project is in a basin where an extremely restrictive allowable discharge equation (say, a peak of 1 cfs or less), is in effect, the only way that criteria can be met would be to devote a very sizeable portion of the project site to water management.

The District is willing to consider waiving the allowable design discharge criteria in certain cases. Projects which might qualify for consideration include, but are not necessarily limited to, those where: the project is small enough so that even if the actual design storm discharge is slightly larger than the allowable, the effect on the receiving body is negligible; or cases where the computed discharge is so small (in the range of a few tenths of a cfs), that even slight differences in the selection of design parameters can yield peak discharge values which are substantially different, based on a percentage of the true amount, but still give very small values.



INFLOW AND OUTFLOW HYDROGRAPHS

Figure C-VII-1

VIII. Agricultural Projects

The next six pages are a reprint of a discussion of the District's general philosophy on reviewing agricultural surface water permit applications. Following that are a few brief comments intended to provide additional guidance on what usually needs to be included in an agricultural project surface water management system.

Surface Water Management Permitting for
New Agricultural Construction
by the South Florida Water Management District
Dick Rogers - 1979 (Revised 1982)

Introduction

The construction of new agricultural projects in central and south Florida, particularly within the boundaries of the South Florida Water Management District (SFWMD), is becoming increasingly difficult because of the increasing intensity of development plus the need to use the more marginal and poorly drained lands. It is becoming harder to construct projects which don't have a domino effect on other projects, just as it is becoming harder to drain onto "unused" lands. The value of land allows little to be considered unuseable by its owners.

Certain laws are in existence which consider development, and this paper has been prepared to address in particular new agricultural development as permitted by the SFWMD under Chapter 373 of the Florida Statutes and Chapter 40E of the Florida Administrative Code. More specifically this paper is directed to 373, Part IV and 40E-4, Surface Water Management. Subsequent papers will address 373, Part II and III, and 40E-2 and 3, Water Use and Wells. (Water use permits for proposed systems are normally not issued without concurrent surface water management permit issuance.)

The SFWMD has the responsibility for the regulation of storm water within its boundaries, both quantity and quality, by virtue of its authority under 373, plus additional delegation from the Florida Department of Environmental Regulation (DER) for storm water quality (effective February 1, 1982). DER and the U.S. Army Corps of Engineers still retain jurisdiction over dredge and fill permitting, which may be applicable to some agricultural projects. Determination of assertion of jurisdiction by those agencies must be requested directly from them.

This paper has been prepared to provide a narrative discussion of the technical review process utilized by the SFWMD in the consideration of permit applications for new agricultural projects. The administration process is described in 40E and the technical hydrologic and numerical information is presented in the reference to 40E-4 as published (with example problems, etc.) in the SFWMD publication "Permit Information Manual, Volume IV".

Basic Review Concepts

Although the regulatory process is often blamed for the difficulties in constructing new agricultural projects, it is more likely that the real culprit is increased competition for land as discussed in the first paragraph above. The regulatory process has been established as the means of attempting to maintain equity such that each owner gets the fair use of his land through the management of the water resource. Therefore the basic review concepts are directed toward maintaining a reasonable interface between new projects and the rest of the world. This interface essentially shows up in two ways: one at the boundaries of the applicant's land; the second through joint use facilities available to all, such as internal environmental values. The concept associated with the boundaries are essentially the maintenance of the "status quo" insofar as impacts to adjacent lands. For example upstream flows should continue to be passed and not blocked. Downstream flows should continue to be no more damaging after development than before. Downstream water quality should not be degraded. Floodplains should not be encroached, either by volume or flow interruption, without compensating construction. These are essentially "good neighbor" policies, which must be observed.

Onsite environmental preservation, protection or whatever name used is also a "good neighbor" policy, though somewhat more nebulous. The general public collectively enjoy the benefits of wetlands for example, thus their protection through proper water resource management has become a requirement of many regulatory programs, including the SFWMD.

The following discussion is intended to elaborate on the above concepts for purposes of attempting to guide a project designer though the technical review process in the most logical manner. The order of discussion is not necessarily intended to prioritize subject importance, but is intended to sequence subjects according to the designer difficulties encountered based on the SFWMD staff experience.

Soils and Vegetation

On a new agricultural project it is usually worthwhile to initially review the site from the perspective of both the agronomist and environmentalist. In all probability the soils and vegetation will clearly indicate certain areas which are feasibly unfarmable because of excessive drainage requirements, and these areas will usually coincide with wetland areas considered as viable and preservation candidates by environmentalists. Since onsite storage of water will probably be necessary in the final design, such areas can obviously serve dual purposes. Some areas may be in contention as farmable but worthy of preservation for environmental water resource reasons. In general the SFWMD would prefer to see larger areas of perservation (also jointly used for water storage) than pockets of small areas. This is particularly true where it is doubtful that the small areas will survive when surrounded by intense farming with the drainage necessary to support it. The staff is therefore perfectly willing to consider the "tradeoff" of small pockets for larger areas which may be comprised naturally of uplands and wetlands. Obviously the control elevations in such areas should be above the ground level, if the areas are to serve as mitigation to the destruction of other wetlands.

Floodplain Encroachment

The floodplain encroachment subject is difficult to discuss, particularly in south Florida, which is said by some to all be a floodplain. Floodplain extents are related to the severity of the event being considered. The SFWMD considers 25 year-3 day events as being major and for which the "status quo" need be maintained. It also considers 100 year-3 day events for which building floors must be protected. It is therefore safe to say that the 100 year event is the order of magnitude of event which must be considered. District rules require that event be considered, but it is recognized that such delineation is difficult to establish in remote agricultural areas. In many cases considerable engineering judgement will be needed.

Encroachment must be considered from two aspects: storage reduction and flow interference. This means that not only must a volume between the water table and flood elevation be preserved, but a continuous flow cross-section must be maintained. A water storage or detention area may partially serve this purpose, but in addition it may be necessary for land outside diked and farmed areas to remain. Obviously the specific location for the site determines the severity of its floodplain encroachment problems. One solution may include low farm dikes which could be overtopped by 100 year flood stages, since that amount of rainfall would wipe out many crops anyway or might occur when no crop was planted. The design refinements and review concerns associated with this subject are very much related to the site location both with respect to topography and local development intensity. Land ownership is also a consideration, since a small farm in the middle of a large holding is unlikely to create impacts felt off the property.

Offsite Discharge

As noted above, the SFWMD criteria for which offsite discharge is considered is normally the 25 year-3 day event. This may vary occasionally in locations where physical works have been constructed to a different criteria. In most new farm areas of the District where preconstructed works do not exist it is necessary to accept upstream flows generated by such a design event and pass them through or around the proposed project. Added discharge from the project would add its historic flow such that final discharge from the site would be limited to that which did not cause additional adverse downstream impacts. This delicate balancing act to make post-development impacts meet pre-development impacts is normally accomplished by matching pre- and post-development peak discharges, under the assumption that resulting stages will also match. Occasionally duration of high stages also becomes a concern, but usually if duration is involved the issue is discharge into an environmentally sensitive area, such as a natural park, and duration is more related to continuous rather than peak discharge. Such analyses may be a necessary consideration by a project designer in such situations.

There are two ways offsite discharge can be routed across a new project: around it or through it. In most cases it will not be economical to attempt to mix the project storage area with the offsite flows as they enter the project site. The problems created by such designs include the backwater effects of the project on upstream lands, which may cause new upstream flooding. Significant onsite storage area is therefore necessary because of the shallow storage depths which might be allowed.

In flat areas where sheetflow of unknown direction predominates, the SFWMD usually requires that the toe of new farm dikes be kept away from property boundaries in order to allow water to move freely among the outside farm fields. The minimum distance is usually 50 feet, but may be more if it appears necessary. The construction of conveyance facilities may or may not be necessary in this setback area.

In areas where pre-constructed facilities exist, discharges greater than natural may be allowed if the secondary facilities exist or can be constructed to deliver the project discharge to the primary system. This would be true in locations served by SFWMD project, local drainage district, county, etc. works. The amount may be either a prorated amount based on project area and basin area or predominately pumped basins or a basin formula amount for predominately gravity basins.

Onsite Storage

The above discussion should by now have lead the reader to the obvious conclusion that onsite storage is usually necessary; if not for quantity management then for quality management, as will be discussed hereinafter. The storage may serve an additional purpose of irrigation supply, but this is usually only likely for deeper storage areas such as lakes. Above ground storage areas usually go dry just as other surface areas during winter months when irrigation water is most needed.

The SFWMD preference for storage areas is for separately contained areas fed by pumps, or gravity if topography allows, and which discharge by gravity. Offsite pumped discharges have become a monumental enforcement problem in some areas, because of complaints which are extremely difficult to reconcile. Gravity discharges, although still subject to artificial heads created in storage areas, are still more easily considered "self-regulating" than pumps which can be operated manually. Automatic stage controls on pumps have been used on occasion, but are "one more thing which can break down". Field protection is still afforded under the preferred scheme, since fields can be pumped into the storage area. If all fields in a basin were constructed to the same criteria, all would receive equal protection (or greater if they chose to exceed SFWMD storage requirement criteria).

In general it is preferred that external storage area levees be more substantial than interior ones, so that any failure would be internal rather than offsite.

It is also likely that an internal emergency overflow discharge would be required and useful not only for that purpose but also for on-farm irrigation purposes.

Water Quality

The SFWMD has adopted certain criteria, which, if met, offer the presumption that offsite water quality discharge will be satisfactory. It is still a permittee's responsibility to meet State water quality performance standards as required by law, and an applicant or permittee may submit test data, etc. which show that he doesn't have to meet SFWMD design standards in order to meet State water quality performance standards. No such evidence or test case has thus far been presented.

The basic criteria applicable to projects is the detention of the first inch of runoff (not rainfall) or the runoff from a 2.5 inch rainfall, whichever is greater. The 1 inch is obviously applicable to agriculture. This first inch must be detained and allowed to release within about 5 days. This means that if the release is by gravity, the discharge structure would be designed to discharge about 1/2 inch the first day. As the upstream head declined, subsequent day releases would decline and the full inch would get out in about 5 days. Certain refinements to this criteria are possible, as can be reviewed in Volume IV. Actual retention (as opposed to detention) is usually difficult to accomplish, because a guaranteed seepage system is necessary. Most farms are not in a location nor construction, operation, and maintenance situation to feasibly accomplish this.

Although internal canals, ditches, swales, etc. are often desired by project designers to be used for detention, this is usually impractical. Waterway surface must be at least 100 feet wide and the detention requirement is not usually compatible with on-farm flood protection. All calculations are based on average wet season water table elevations, and farm field detention under such circumstances usually causes a significant decrease in protection and increase in risk.

Low Flows and Groundwater Maintenance

This subject has not usually been a problem with agriculture but is worthy of some discussion. It is obviously illegal to trap all water and not maintain low flows and base flows. Very few projects propose to do this, since the passage of offsite upstream runoff usually allows low flows to continue. The SFWMD does require that projects not alter water tables that would cause offsite problems and requires that projects not control internal water levels deeper than 6 feet below ground level. In more hilly terrain this requires internal "step down" control structures, but in most cases the farmer desires this anyway in order to irrigate efficiently.

Review Details

Basically the system design is a responsibility of the design engineer, thus the requirement for engineering certification of plans by a Florida registered professional engineer for engineering designs. Certification of above ground storage area dikes upon completion of construction and semi-annually is a further permit requirement. The SFWMD engineering staff does review the project for basic compliance with its criteria and normal agricultural and engineering practices. Sizes and dimensions are normally reviewed. Structural adequacy is not, except for obvious inadequacies. Particular items of review include:

A. Discharge structures - usually weirs and culverts; reviewed for dimensions to meet hydraulic criteria; typical check includes weir width and elevation, control mechanism (V-notch bleeder device) size and elevation, culvert size and elevation.

B. Exterior levees - location, sizes, and elevations to allow passage of offsite flows, containment of project water, floodplain encroachment help or hinderance, and need for designer calculations for stability, wave runup, etc.

C. Bypass and flow-through conveyance - location, elevation, hydraulic capacity, and interaction between project and adjacent lands.

D. Floodplain encroachment - consideration of floodplain location and elevation, activity in area or basin, and project dimensions and elevations.

E. Internal Facilities

1. Pumps into storage area
2. Control structures to maintain groundwater elevations

F. Environmental - projects are reviewed from aerial photographs to determine the need for a site inspection.

Summary

If an agricultural project designer follows the basic list herein:

Soils and vegetation review
Floodplain encroachment consideration
Offsite discharge analysis and design, upstream/downstream
Onsite storage, quality/quantity
Low flows and groundwater maintenance considerations,

he will normally address all the issues necessary for surface water management permit consideration by the South Florida Water Management District.

Additional Guidance on Agricultural Construction

A "typical" agricultural project is likely to be a "minor" impoundment, featuring a pumped discharge into one or more storage areas (which often are also preserved wetlands), with gravity discharge to an off-site receiving body and an overflow back into the property. Pumps can create situations which are technically different from a "typical" residential or commercial/industrial project, which would not utilize pumps.

In a non-pump system, a certain amount of soil storage is available at the beginning of the rainfall. The storage becomes filled by infiltration, and no appreciable reuse of soil storage is assumed to occur during the storm. Likewise, once runoff reaches the open storage area(s) the water stays there, until it flows into the receiving body. Water levels in the storage areas will be equal to or lower than those elsewhere on the site. In a pumped system, one or both of these situations might not occur.

For example, a citrus project drainage system might be designed to provide both continuous pumping starting at the beginning of rainfall, and accompanying oversized storage areas, to keep the water table in the grove areas down at or near the control elevation (and, obviously, to allow as little moisture as possible to remain in the soil above the control elevation). But, a typical vegetable project might be designed with oversized pumps and a carefully-designed system to return storage area overflow back to the pumps, to keep near-surface and surface water away from the plants. The District recognizes that such systems may be desirable and will review proposed works accordingly, if proper explanation and justification are provided.

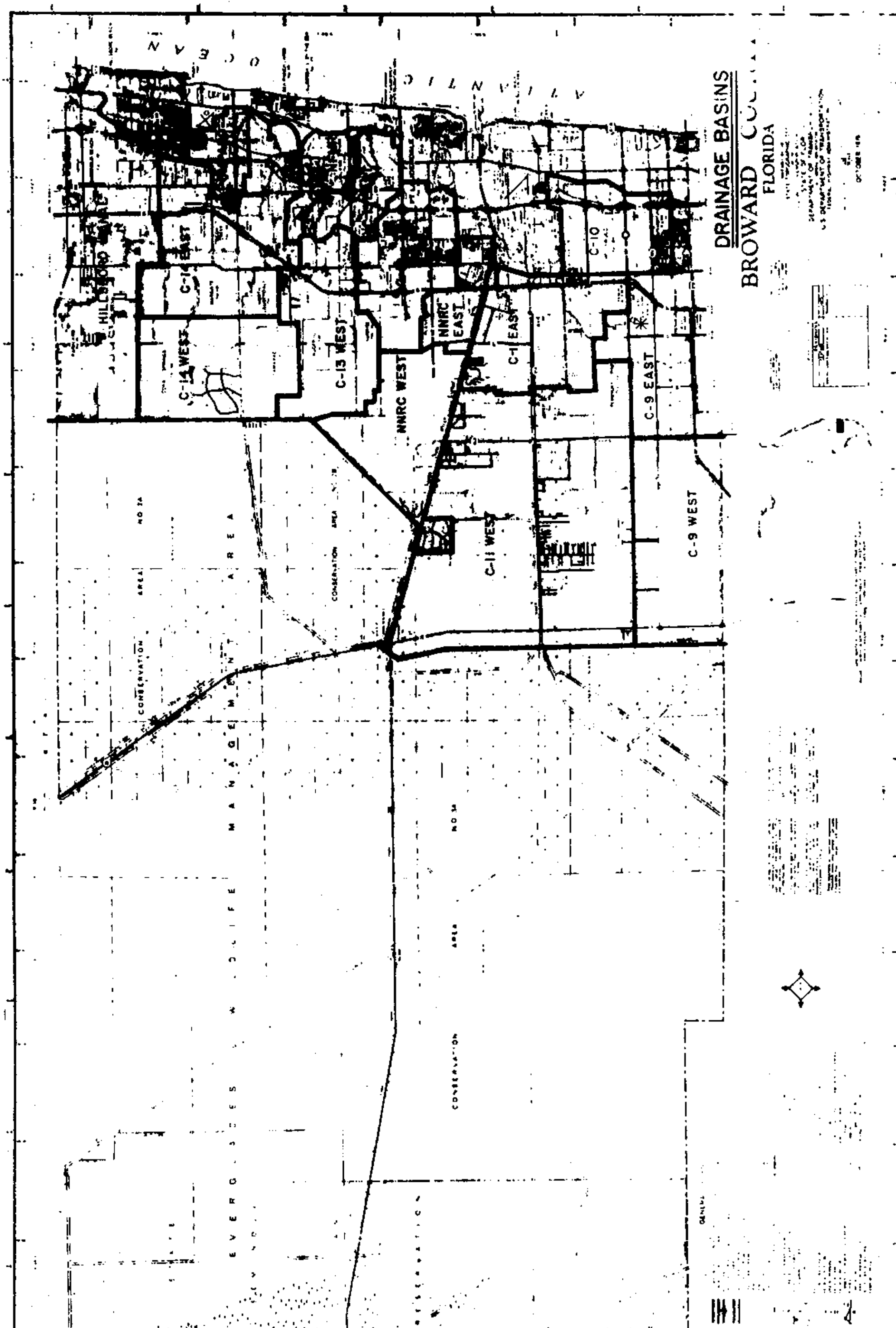
In the absence of a detailed dam structural safety analysis of above-ground dikes, the maximum above-grade water depth which can be stored is 4.0 feet. Freeboard shall be equal to the water depth but no less than 2.0 feet, and not more than 3.0 feet above the depth of the stored routed design storm. Certain project-specific factors might affect these recommended criteria: project or reservoir size, configuration, or location of the project with regard to neighboring areas which could be subject to flooding if the proposed system failed to operate properly. All perimeter and storage area dike tops shall be wide enough for typical operation and maintenance equipment.

The recommended style of overflow structure is either a non-adjustable riser with a weir crest at the proper elevation, attached to an outfall pipe which conducts flows back into the property; or a non-adjustable broad- or sharp-crested weir at the proper elevation, at a place in the dike where flow can go back onto the property. A simple outfall pipe with an invert at the proper elevation will not suffice because of anticipated erosion problems. Recommended criteria for the overflow structure are that the weir crest shall be at the elevation of the peak of the routed design storm, and the length be such that the weir will return to the property the difference between the routed (if any) pumped inflow hydrograph (using the same pump system as was used for designing the reservoir control structure), plus the 100-year 3-day rainfall on the reservoir, minus the routed outflow through the control structure; with not more than 6 inches of head on the overflow structure weir.

IX. Design Drainage Basins

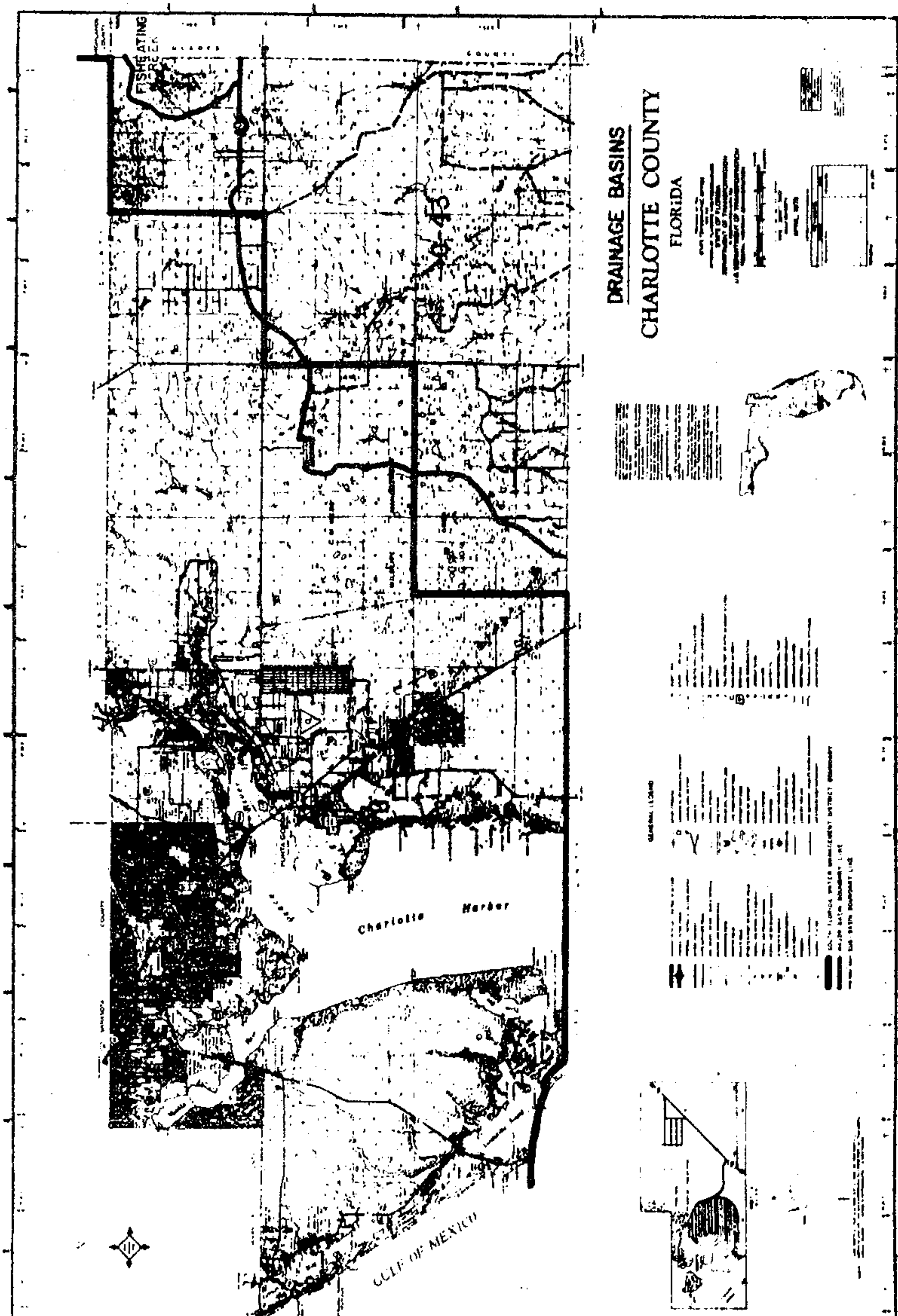
The allowable discharge from a project is based upon the location of the project in relation to the receiving surface watercourse. Figures C-IX-1 through C-IX-22 show the major drainage basin boundaries within the District.

The allowable discharge for District canals is based on the formulas, factors and curves shown in Appendix 2 of the Basis of Review document.



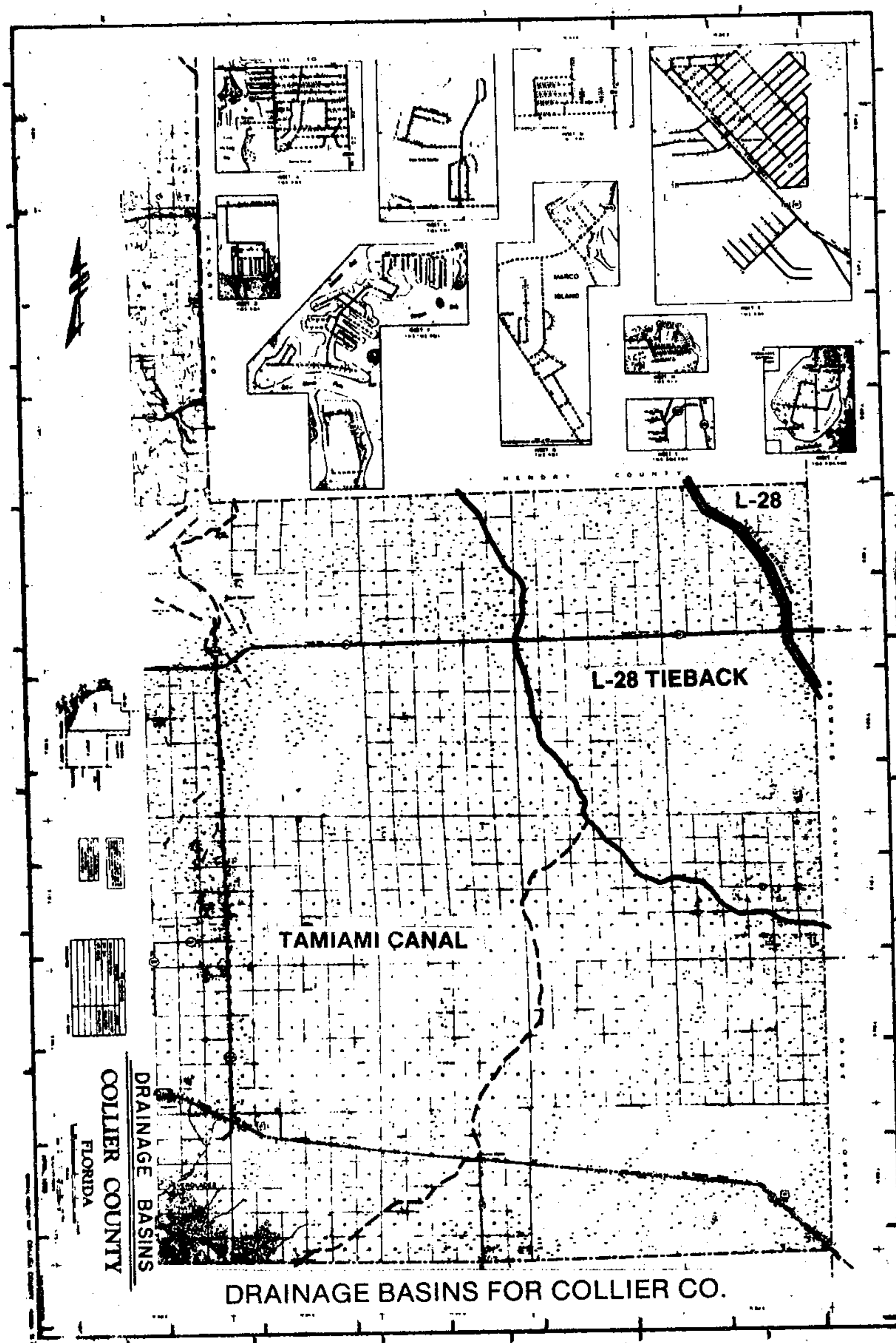
DRAINAGE BASINS FOR BROWARD CO.

Figure C-IX-1



DRAINAGE BASINS FOR CHARLOTTE CO.

Figure C-IX-2



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

Figure C-IX-3

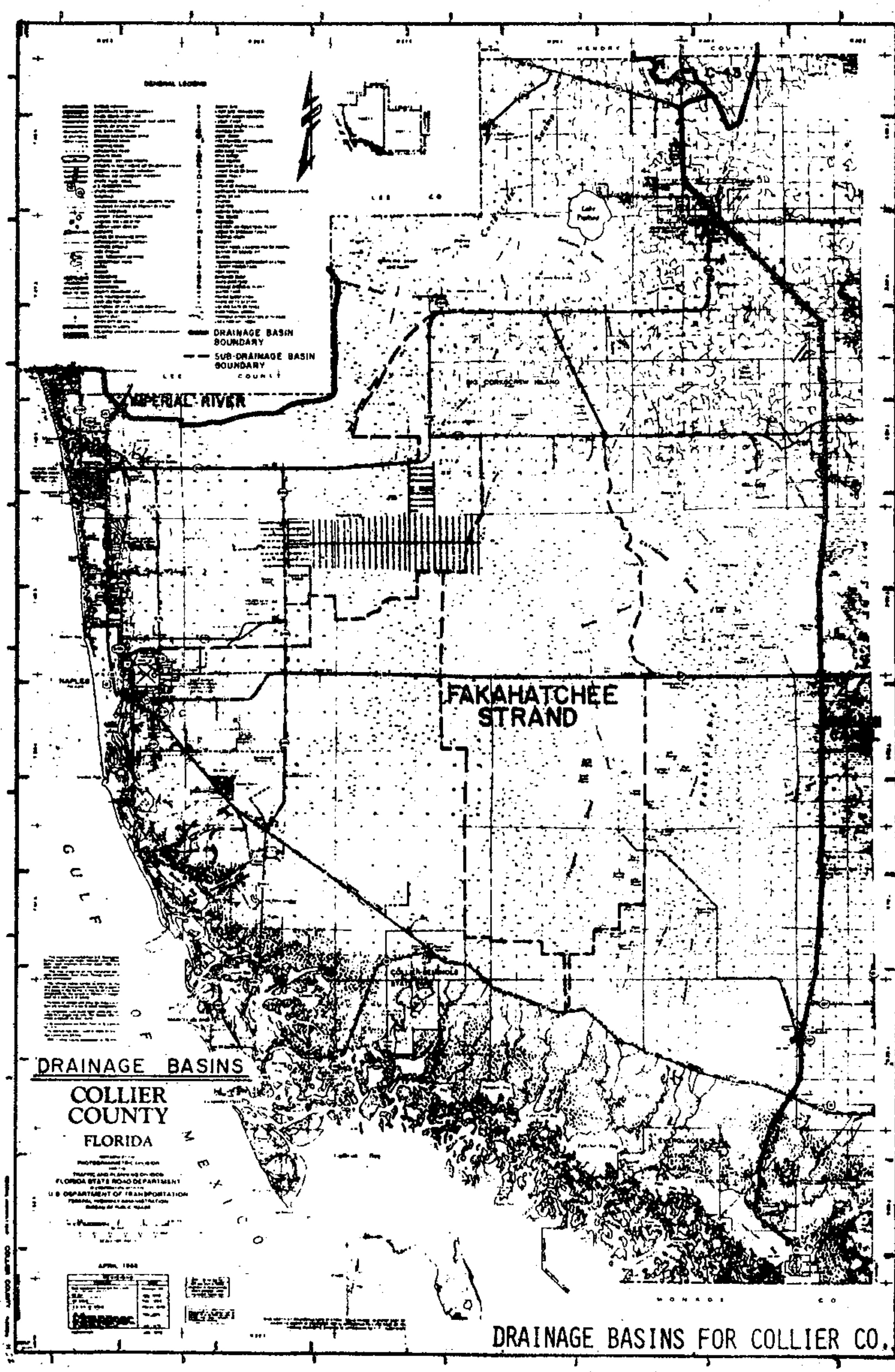
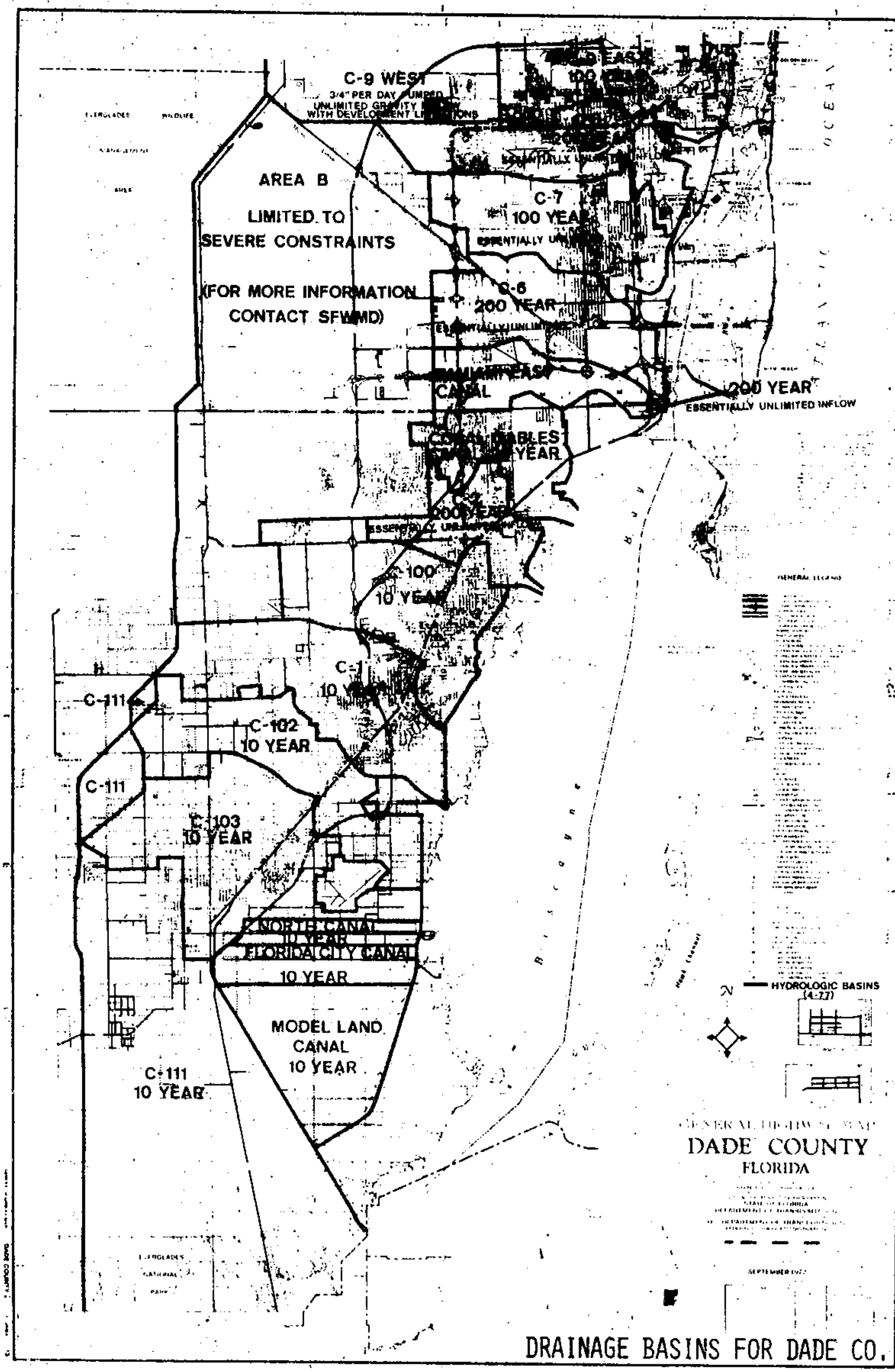
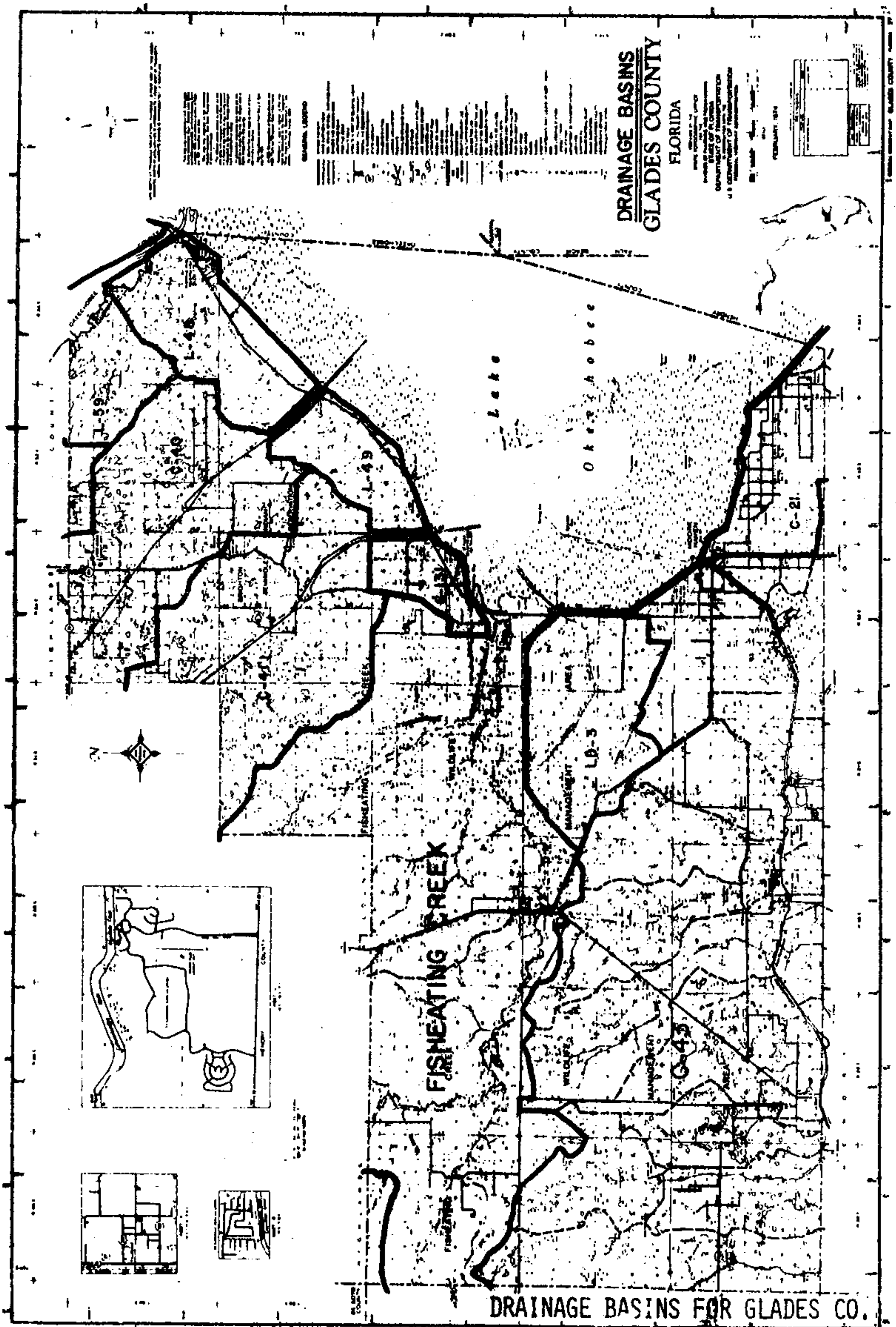

DRAINAGE BASIN BOUNDARY
SUB-DRAINAGE BASIN BOUNDARY
IMPERIAL RIVER
FAKAHATCHEE STRAND
NAPLES
GULF OF MEXICO
DRAINAGE BASINS
COLLIER COUNTY
FLORIDA
DRAINAGE BASINS FOR COLLIER CO.

Figure C-IX-4



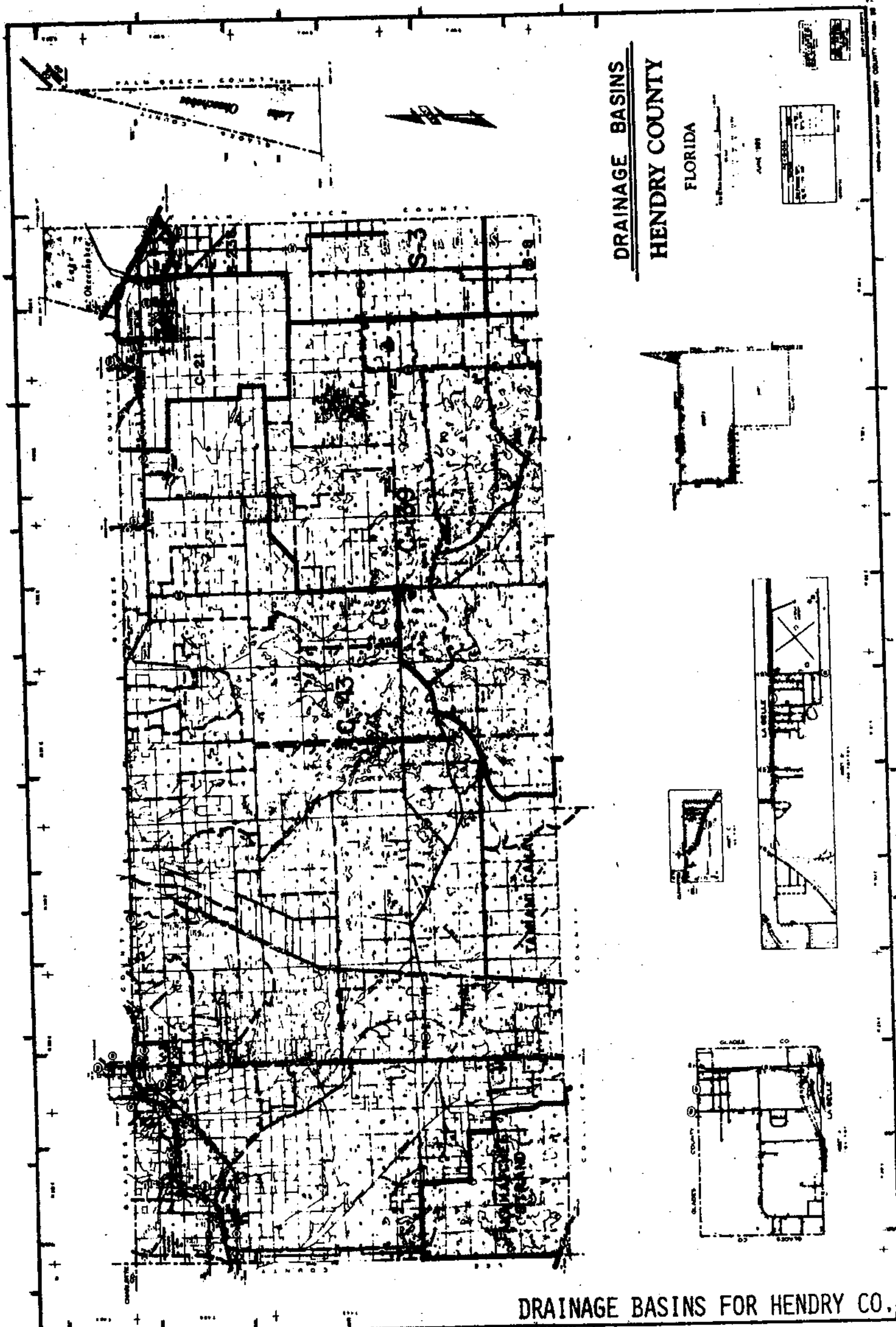
DRAINAGE BASINS FOR DADE CO.

Figure C-IX-5



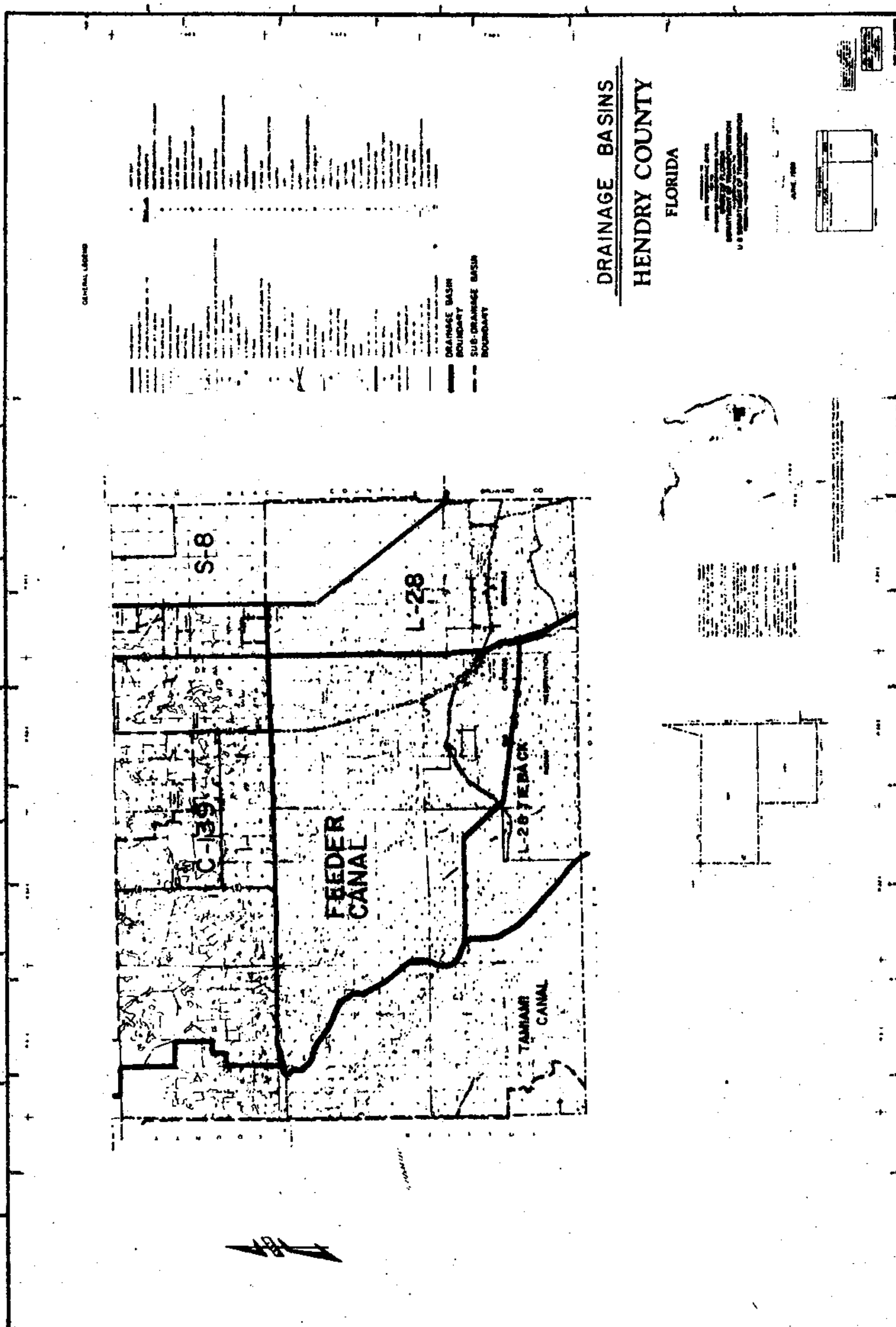
DRAINAGE BASINS FOR GLADES CO.

Figure C-IX-6



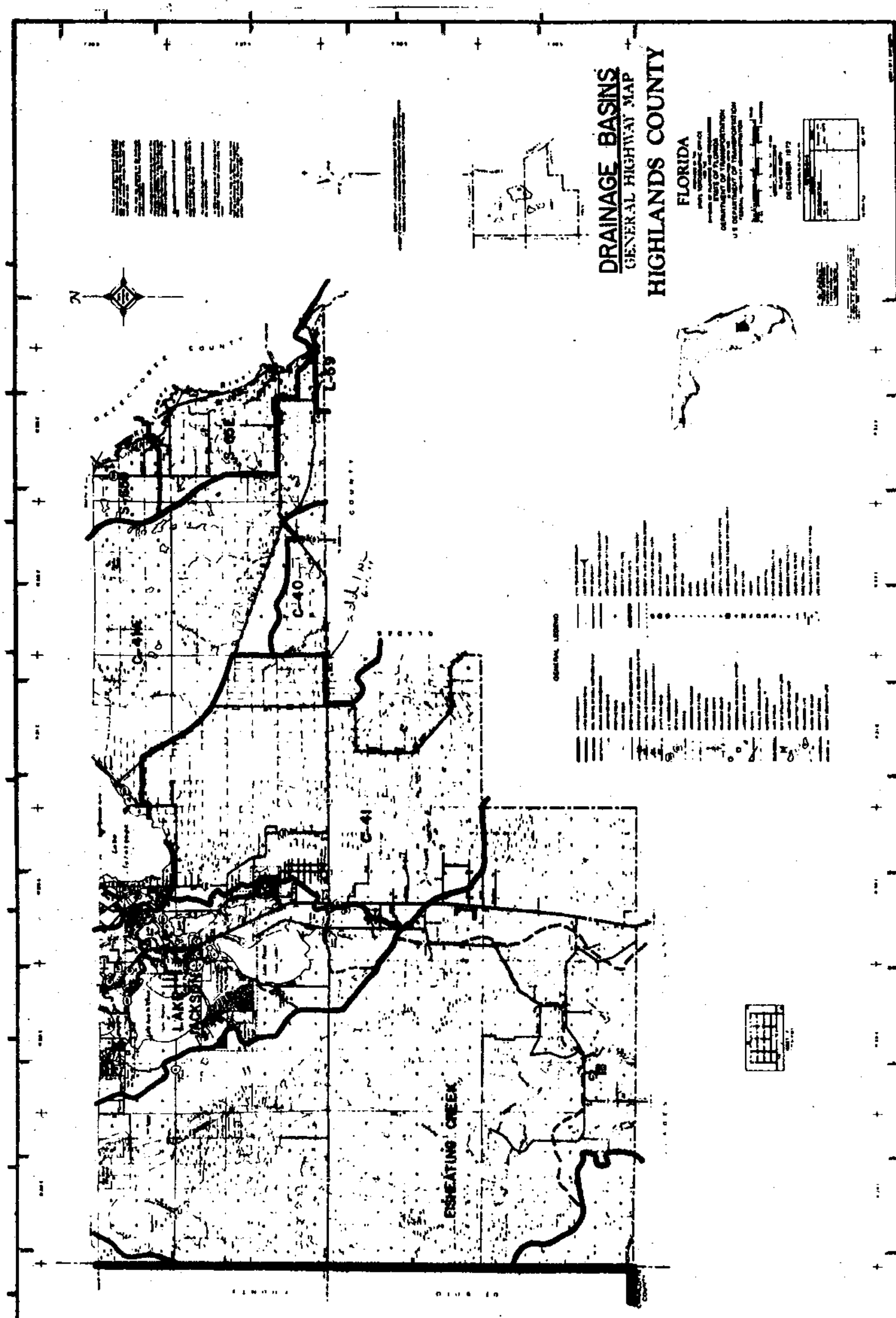
DRAINAGE BASINS FOR HENDRY CO.

Figure C-IX-7



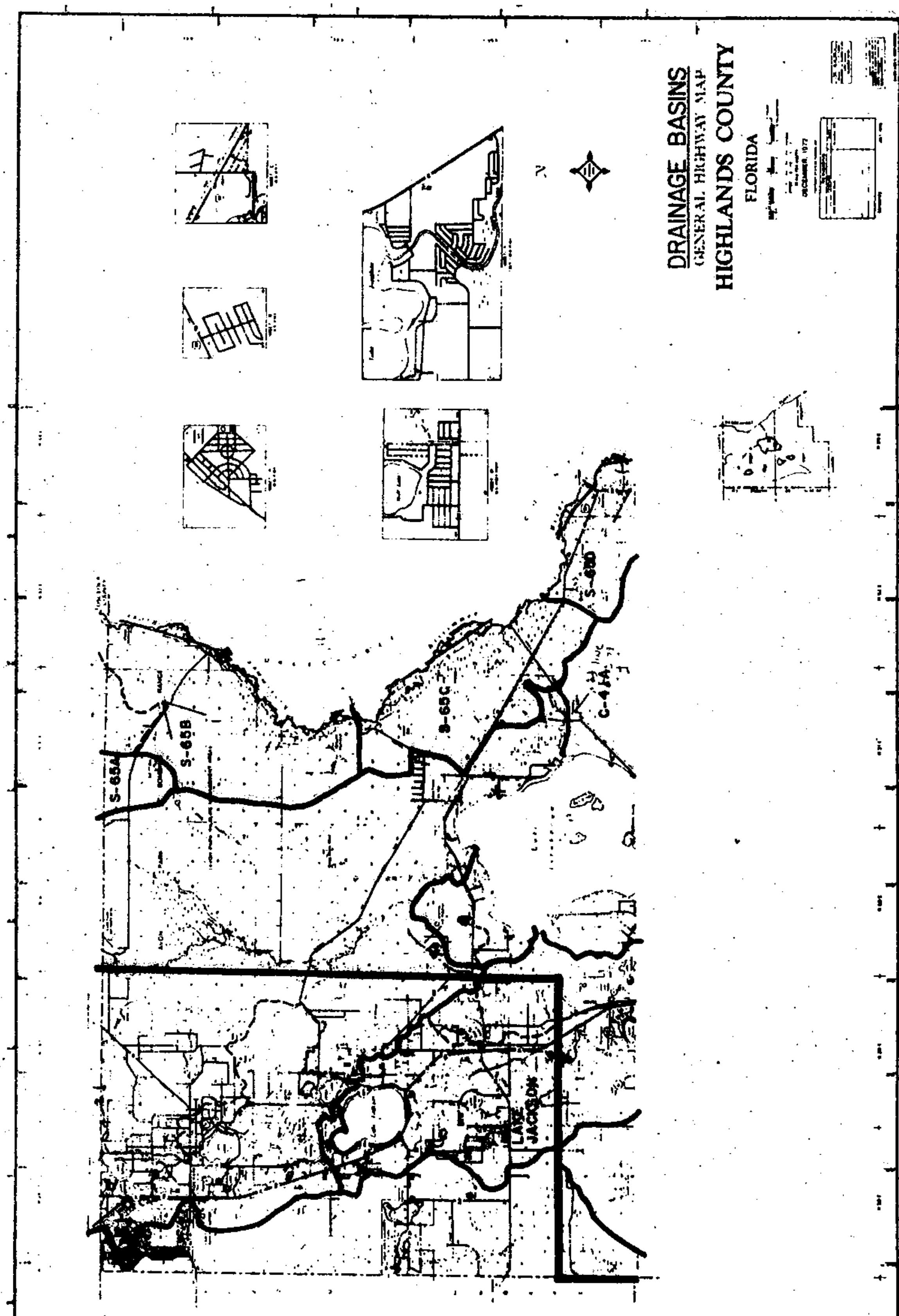
DRAINAGE BASINS FOR HENDRY CO.

Figure C-IX-8



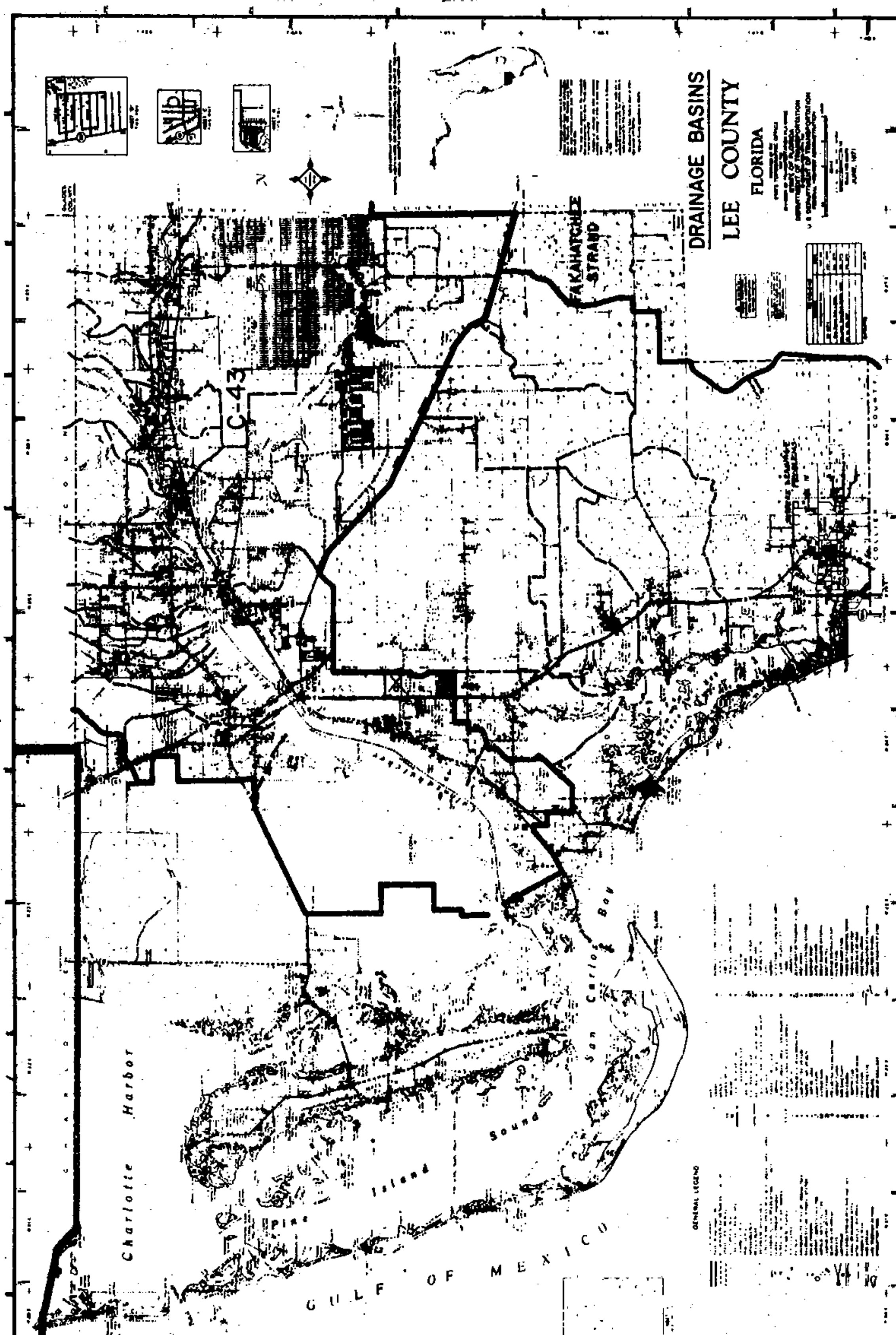
DRAINAGE BASINS FOR HIGHLANDS CO.

Figure C-IX-9



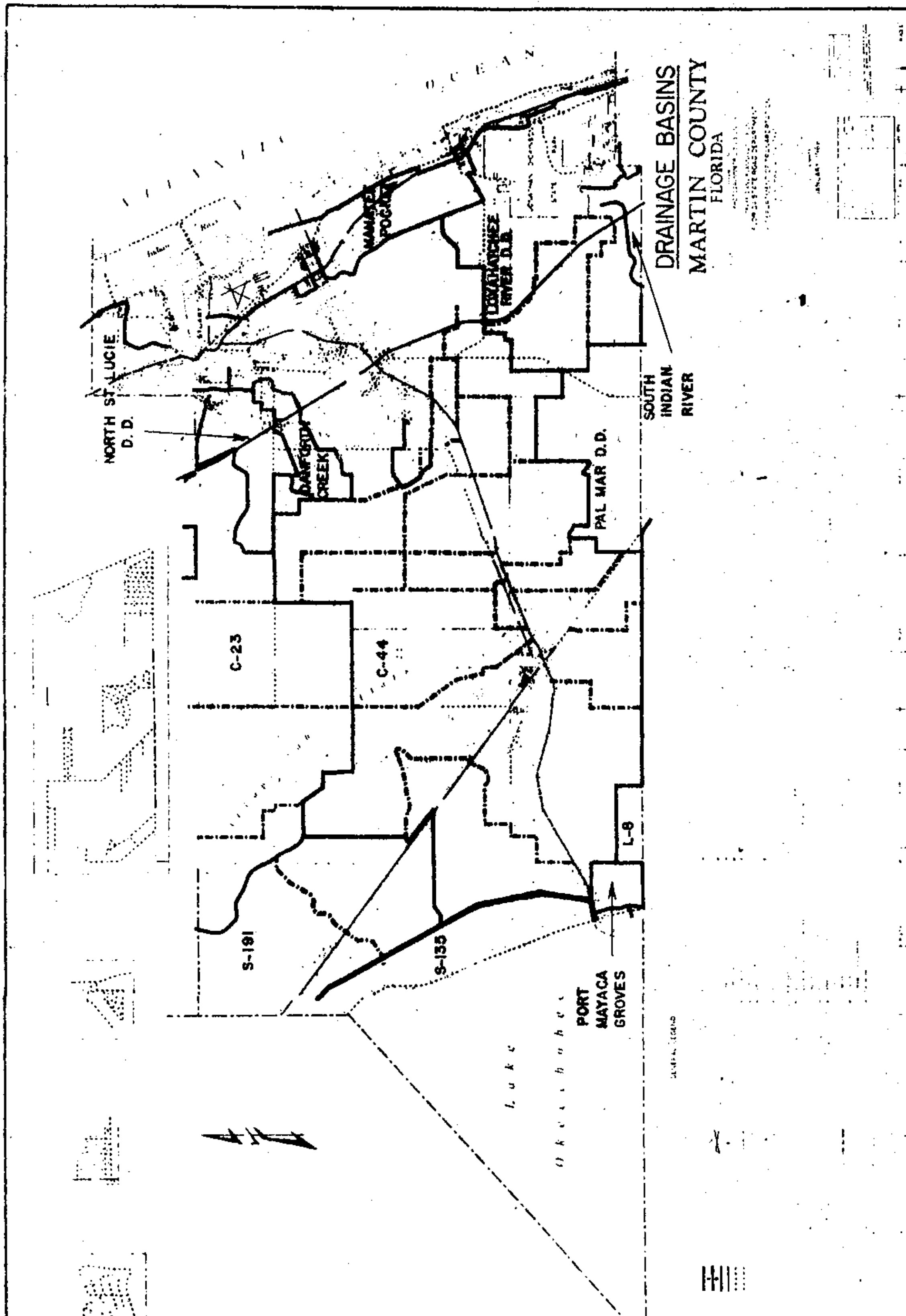
DRAINAGE BASINS FOR HIGHLANDS CO.

Figure C-IX-10



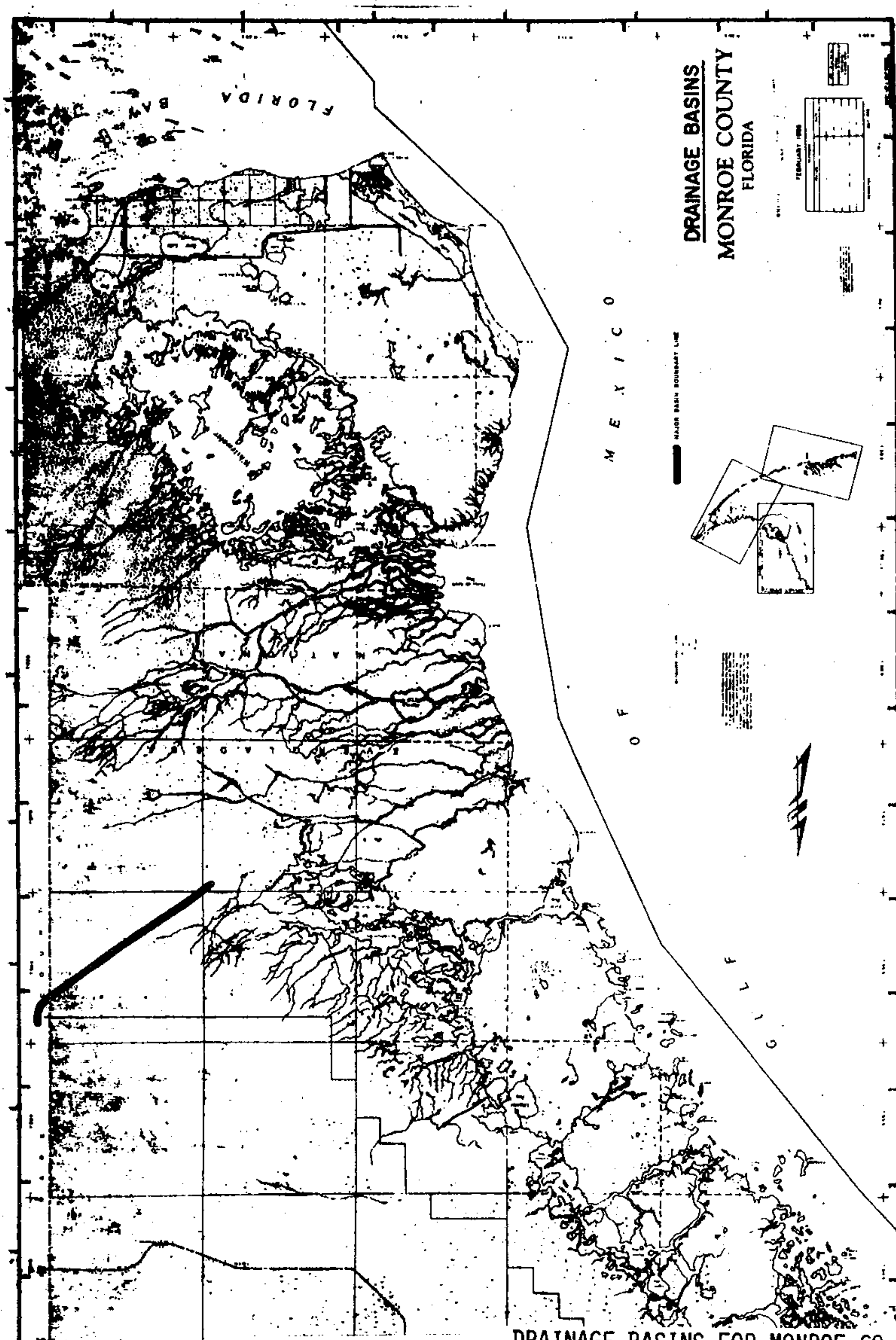
DRAINAGE BASINS FOR LEE CO.

Figure C-IX-11



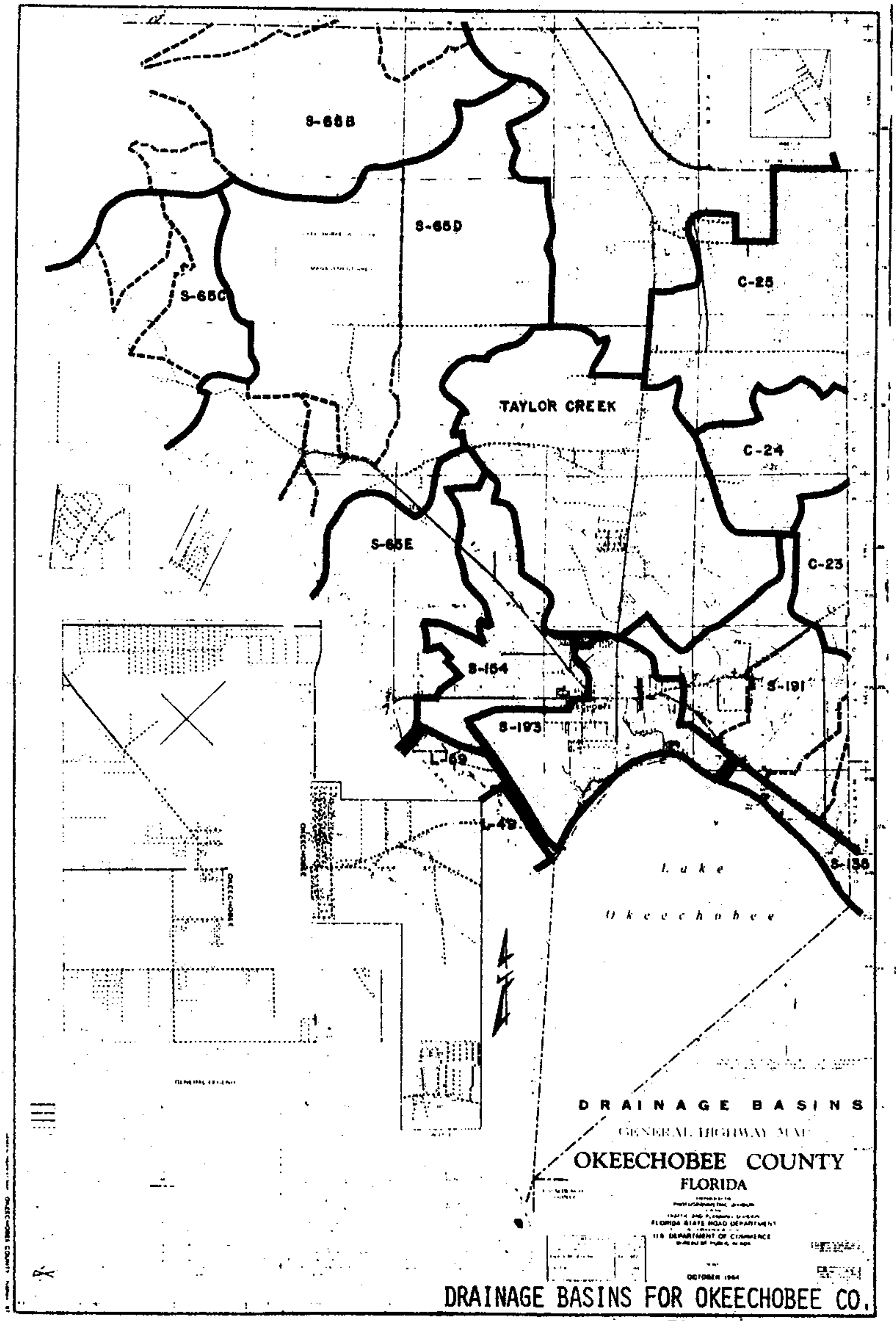
DRAINAGE BASINS FOR MARTIN CO.

Figure C-IX-12



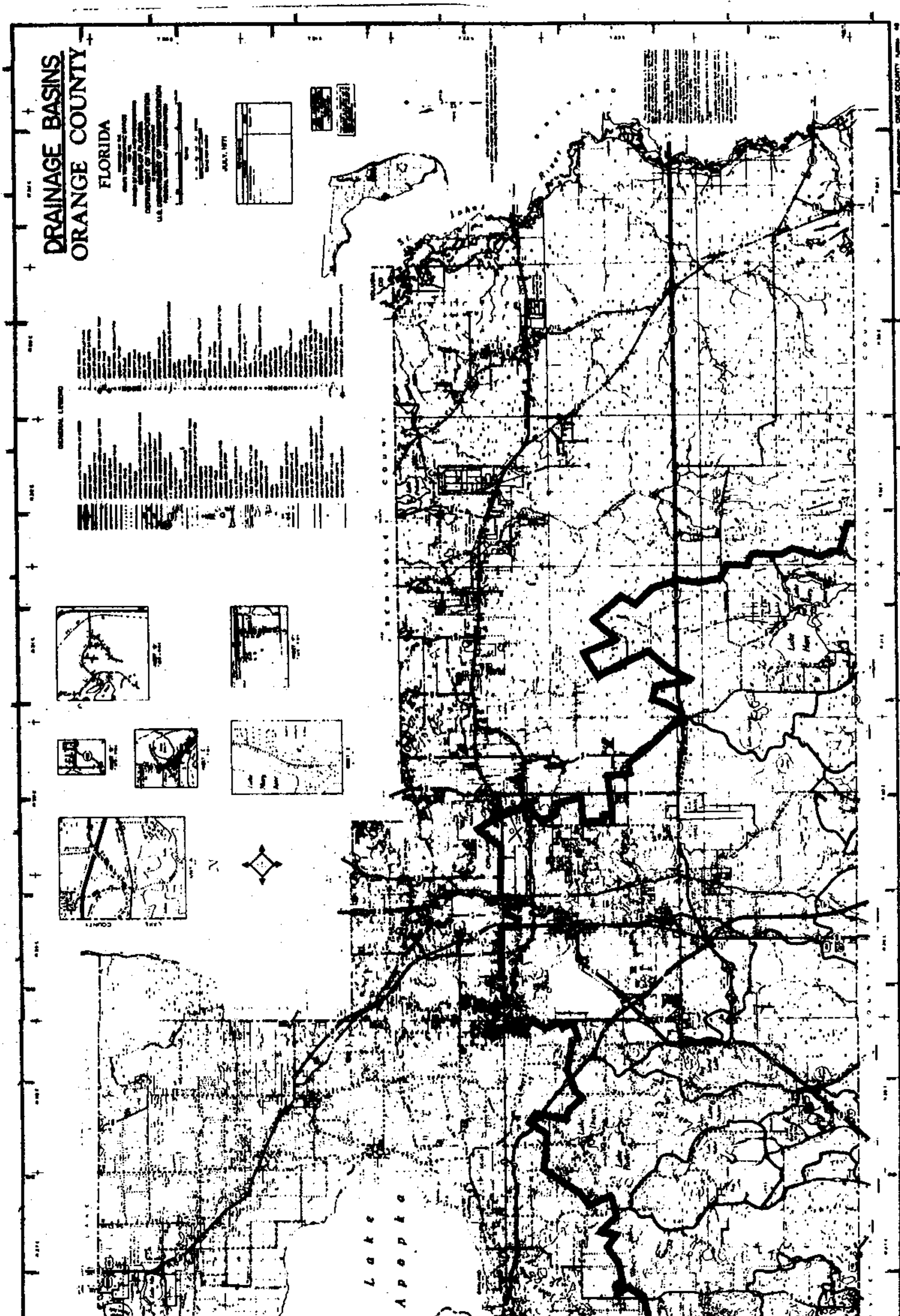
DRAINAGE BASINS FOR MONROE CO.

Figure C-IX-13



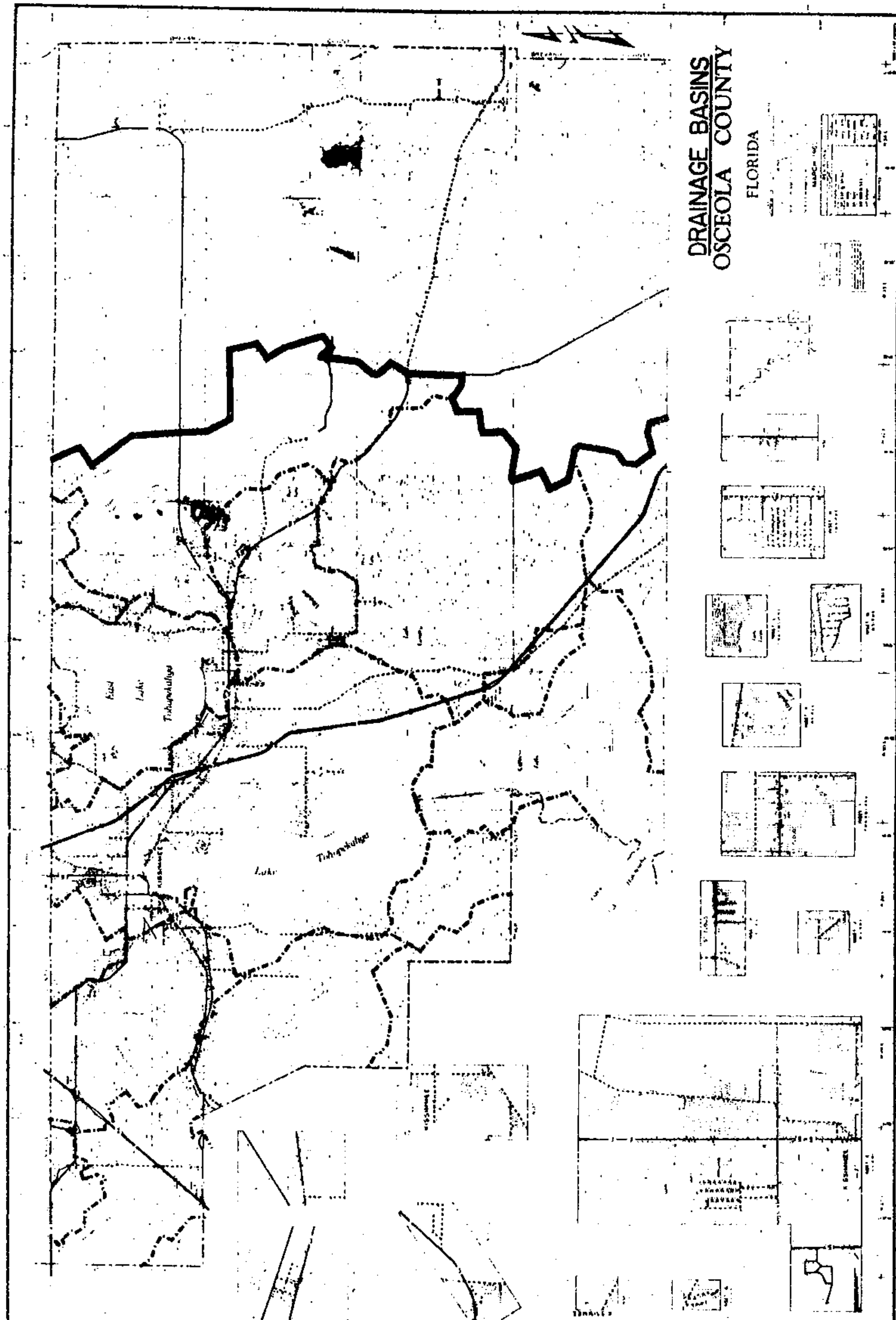
DRAINAGE BASINS FOR OKEECHOBEE CO.

Figure C-IX-14



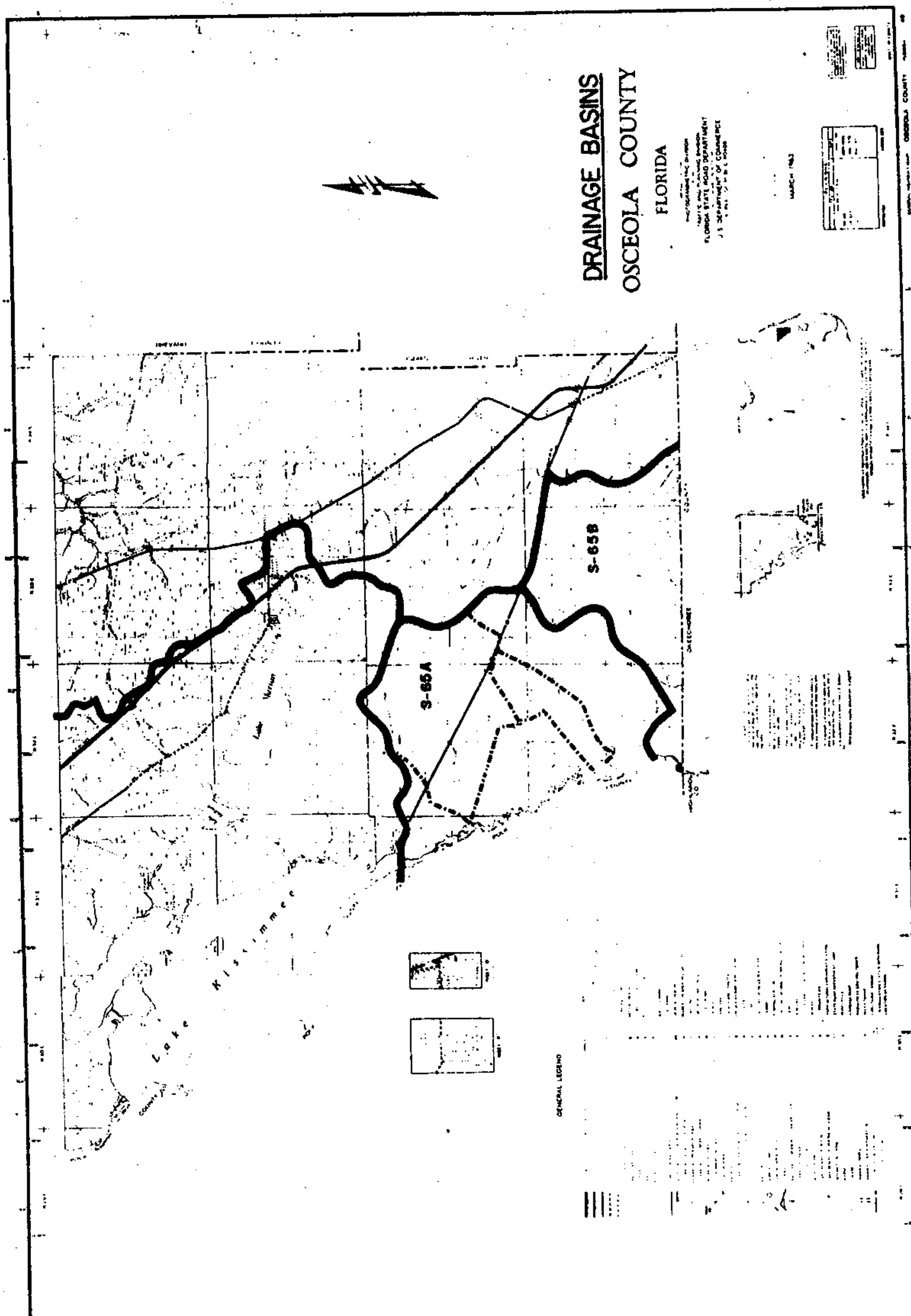
DRAINAGE BASINS FOR ORANGE CO.

Figure C-IX-15



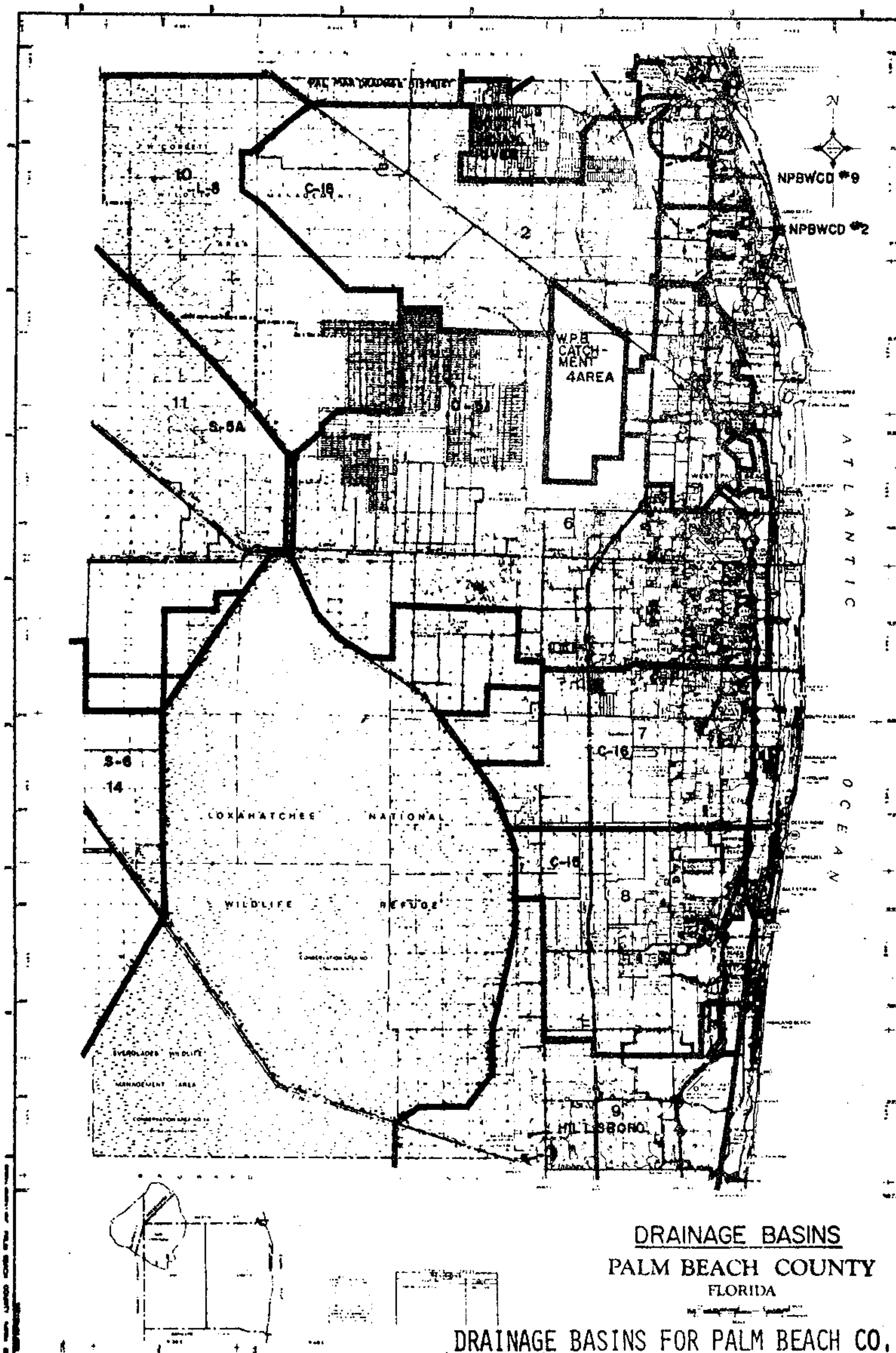
DRAINAGE BASINS FOR OSCEOLA CO.

Figure C-IX-16



DRAINAGE BASINS FOR OSCEOLA CO.

Figure C-IX-17



DRAINAGE BASINS FOR PALM BEACH CO.

Figure C-IX-18

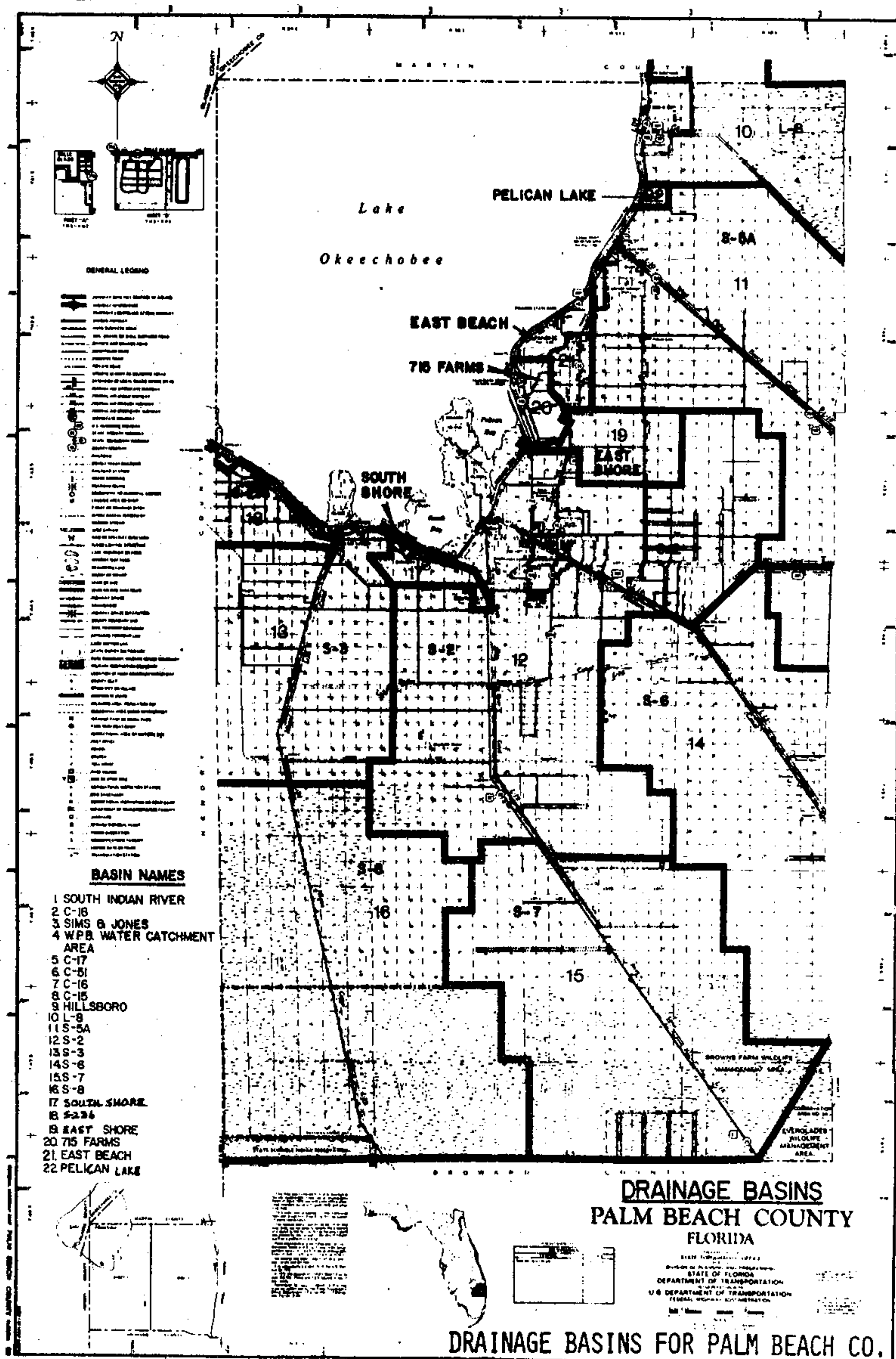


Figure C-IX-19

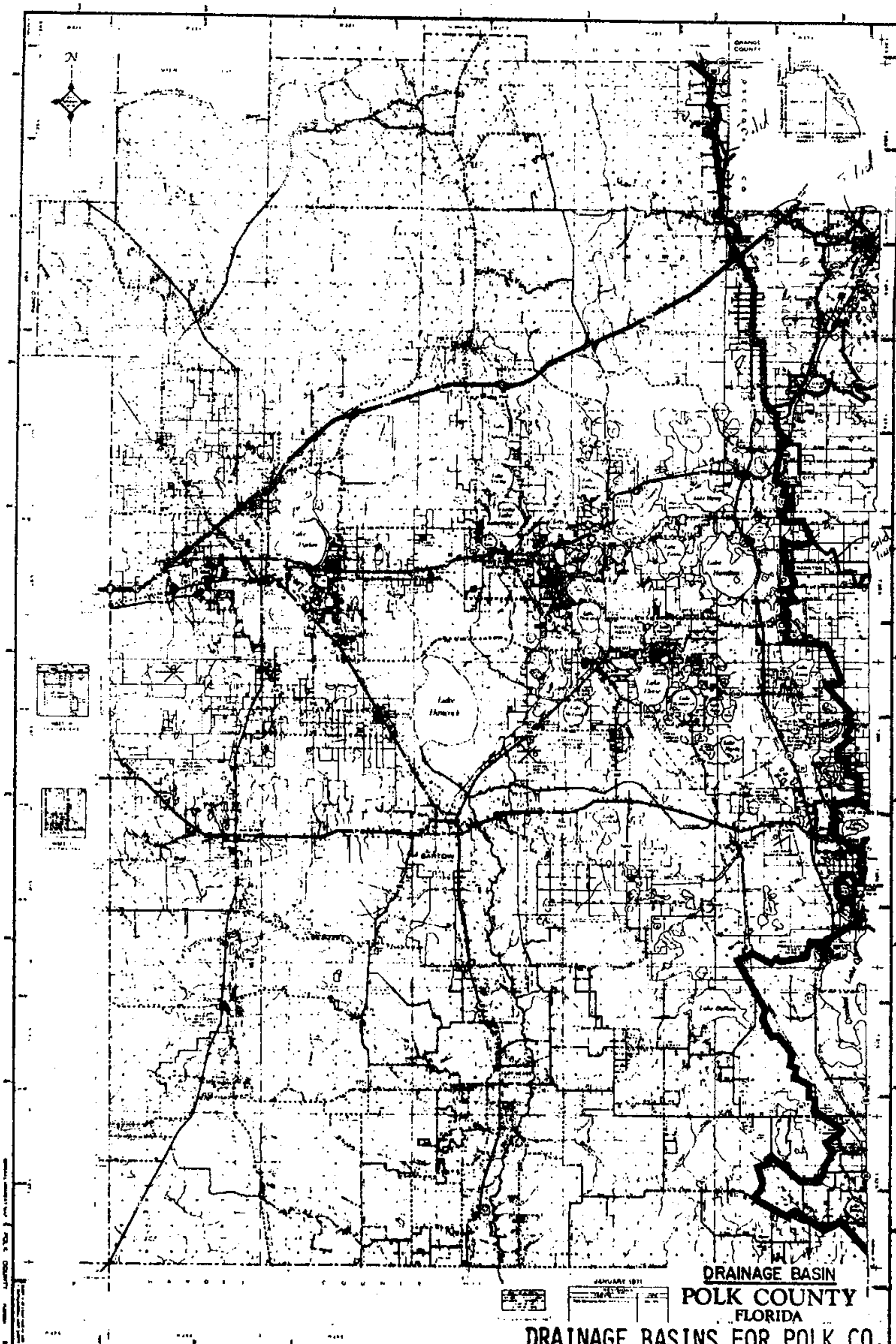
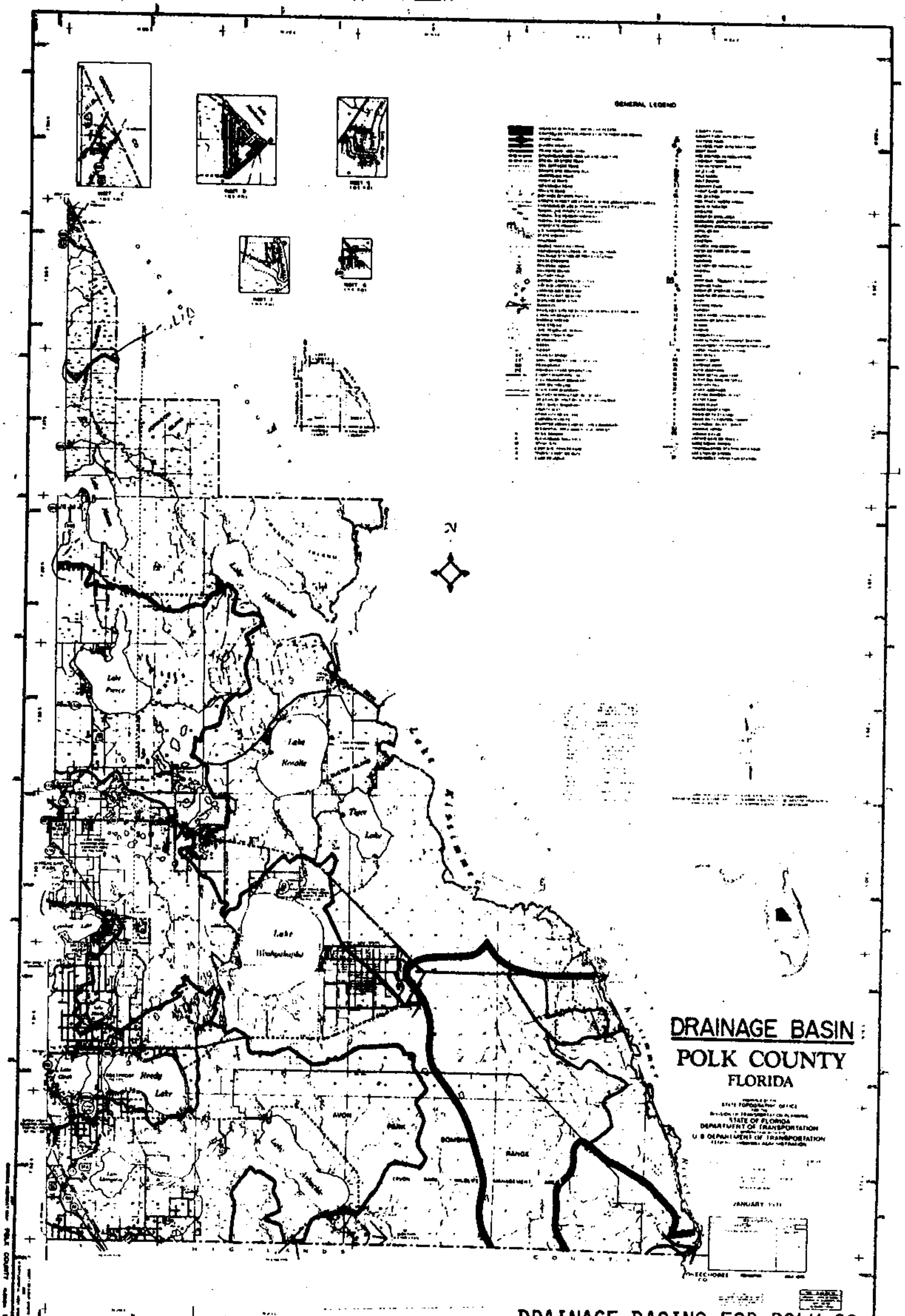
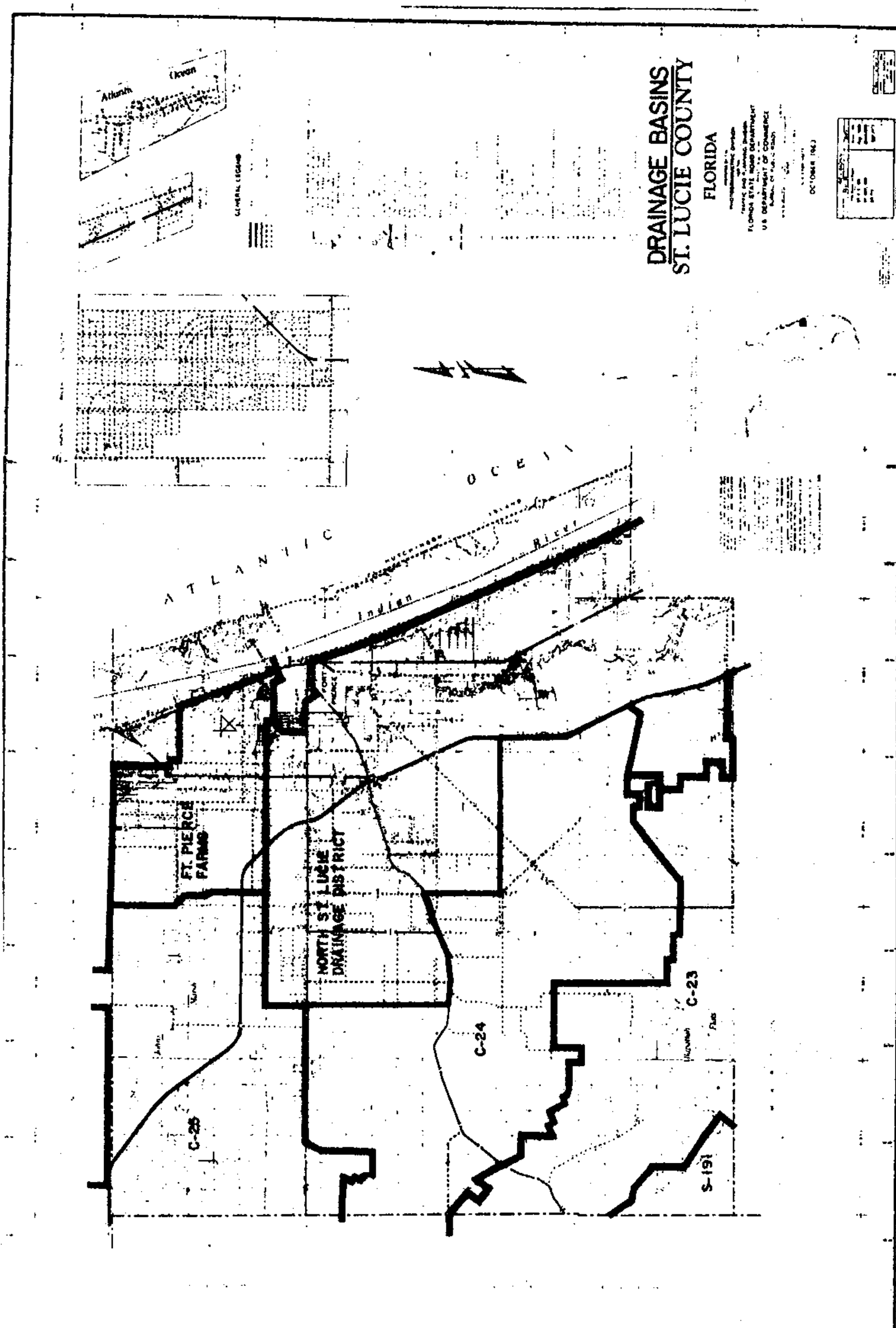


Figure C-IX-20



DRAINAGE BASINS FOR POLK CO.

Figure C-IX-21



DRAINAGE BASINS FOR ST. LUCIE CO.

Figure C-IX-22

X. Application Review Elements Lists

The next seven pages are reprints of two lists which District staff have developed and used to organize the review of each application for a surface water management permit. The first four pages - "SWM Reviewer Checklist" - are a list of subjects to consider during the review of an application for a typical proposed project. The reviewer does not use the checklist to judge the correctness of the items; the list is to serve as a reminder of what needs to be considered.

The remaining three pages - "Information Receipt" - are a list of what needs to be considered or done in the course of reviewing the technical aspects of a typical proposed project. By determining if each item is either "Unnecessary", "Short" (inadequate or flawed), or "OK", the reviewer can easily keep track of the progress of an application through the review process. (Notice that this "Information Receipt Form" is one item in the "SWM Reviewer Checklist.")

The application review elements lists are expansions of the "Checklist for Surface Water Management Permit Applications" included Rule 40E-4 and the "Basis of Review"; and may be used to assist applicants in the orderly assembly of a complete and technically adequate permit application package.

SWM Reviewer Checklist	N/A	Check
I. Application		
A. Brief look-all information		
B. Initial review		
1. Type project		
a. Single basin		
b. Multiple basins		
2. Off-site contributing areas		
3. Adjacent problem areas		
4. Average elevations		
a. Existing ground		
b. Existing wet season water table		
c. Finished grades		
d. Control elevation		
e. Wetland elevations		
5. Percentages land cover		
a. Impervious		
b. Water management		
6. Discharge governed by:		
a. Pre/Post		
b. Formula		
c. Other		
C. Design intent understood		
D. Inform environmental reviewer of priority		
II. Record check		
A. Quads		
1. Land elevation		
2. Surface water features		
a. Slopes		
b. Streams, canals, etc.		
c. Wetlands		
d. Regional conveyance trend noted		
3. Related permits		
4. Rezonings, D.R.I., exemptions, etc.		
B. Related permit check		
1. Elevations		

	N/A	Check
a. Site		
b. Control		
c. Roads		
d. Buildings		
2. Unit discharge		
3. Regional basin definition		
4. Other		
5. Use permits		
a. Wellfield cone of depression		
C. Floodplain maps		
D. Other District action-read		
1. Rezoning		
2. D.R.I.		
3. Exemption		
4. DER/COE letters and permit notice		
5. Other		
E. Groundwater maps		
F. Use of District works		
1. Check DDM		
a. Stages		
b. Allowable discharges		
G. Use of other entity works		
a. Stages		
b. Allowable discharge		
c. Other		
H. Information adequacy understood		
III. Determine informational adequacy		
A. Complete information receipt form		
1. Applicant supplied information		
2. In-house information		
B. Information adequate to begin review?		
1. Yes		
2. No - send 30 day letter		
a. Prepare draft		
b. review with superior		
c. Phone applicant's engineer		
d. Send letter		

SWM Reviewer Checklist	N/A	Check
IV. Review		
A. Existing site computations		
1. Off-site contributing areas		
a. Stage		
b. Discharge		
c. Constraints		
2. Receiving water		
a. Stage		
b. Allowable discharge		
c. Constraints		
B. Project computations		
1. Pervious/impervious		
2. Soil storage		
3. Stage/storage		
4. Floor elevations		
5. Control elevation		
6. Overflow elevation		
7. Discharge structure		
a. Stage/discharge		
b. Bleeder		
8. Discharge routing		
9. Road routing		
10. Multiple basin addition		
a. On-site basins		
b. Off-site plus on-site basins		
11. Exfiltration system length		
C. Basin design confirmation		
1. Floor elevations		
2. Discharge structure dimensions		
3. Road elevations		
4. Exfiltration trench length		
D. Technical review		
1. Perimeter and off-site		
a. Contributing areas		
b. Receiving water		
c. Sheetflow preservation		

SWM Reviewer Checklist	N/A	Check
d. Variable and submerged tailwaters		
e. Design event handled by perimeter grades		
f. Basin storage replaced		
g. Off-site effects		
1. Water bodies		
2. Wetlands		
3. Overdrainage		
4. Wells		
5. Other		
2. On-site		
a. Conveyance system		
b. Water management area criteria		
c. Retention/detention (40% impervious)		
d. Grading		
e. Overdrainage		
f. Wetland control elevations		
g. Flood plain encroachment		
h. Exfiltration system		
i. Other		
E. Procedural, legal, institutional		
1. Ownership		
2. Operation entity		
3. Zoning, D.R.I., comp. plans, etc.		
4. Number units, square feet commercial, etc.		
5. On-site easements, right-of-way, etc.		
6. Off-site easements, right-of-way, etc.		
7. Receiving water legality		
8. Water supply		
9. Wastewater		
10. Use of District works		
11. Other entity approval		
12. Staff report distribution list		

Information Receipt	Unnecessary	Short	OK
I. Site information			
A. Location sketch			
B. Topo			
1. Site			
2. Adjacent related areas			
3. Bench marks			
C. Adjacent areas			
1. Upstream			
2. Downstream			
3. Unrelated			
4. Land use			
D. Existing water resources			
1. Water table elevations			
2. Flood plain			
3. Streams			
4. Water bodies			
E. Land cover			
1. Vegetation			
2. Wetlands			
3. Other			
F. Aerial photo			
1. Site boundaries			
G. Paving, grading, and drainage plans			
1. Elevations			
a. Site			
b. Perimeter			
2. Conveyance system			
a. Sizes			
b. Elevations			
c. Off-site interception			
3. Storage areas			
a. Sizes			
b. Elevations			
c. Side slopes			
4. Exfiltration system			
a. Overflow			

Information Receipt	Unnecessary	Short	OK
5. Discharge structures			
a. Size			
b. Elevation			
c. Bleed down			
d. Baffle			
e. Dispersion			
H. Percolation tests			
I. Construction procedures (optional)			
II. Master drainage plan			
A. Water bodies			
1. Size			
2. Elevation			
3. Depths			
4. Side slopes			
B. Control structures			
1. Size			
2. Elevation			
C. Drainage basins			
1. Off-site contributing			
2. On-site subbasins			
3. Conveyance system			
4. Receiving waters			
D. Physical features and elevations			
1. Roads			
2. Buildings			
3. Other			
E. Water management plans			
1. On-site			
2. Off-site easements and rights-of-way			
F. Minor on-site systems			
G. Off-site facilities affected			
III. Calculations			
A. Design events			
1. Discharge rainfall			
a. Depth			

Information Receipt	Unnecessary	Short	OK
b. Distribution			
2. Road design rainfall			
a. Depth			
b. Distribution			
3. Building floor rainfall			
a. Depth			
b. Distribution			
4. Retention/detention			
a. 3-year, 1-hour			
b. One inch			
B. Off-site inflows			
1. Peak			
2. Location			
3. Stage			
C. Stage relationships			
1. Stage/storage			
2. Stage/discharge			
D. Land cover areas			
1. Impervious			
2. Pervious			
3. Water bodies			
4. Total			
E. Routing-discharge			
1. Runoff			
2. Subbasin addition			
3. Retention/detention			
4. Basin storage preservation			
5. Discharge			
a. Pre-development			
b. Post-development			