UNITED STATES DEPARTMENT OF THE INTERIOR
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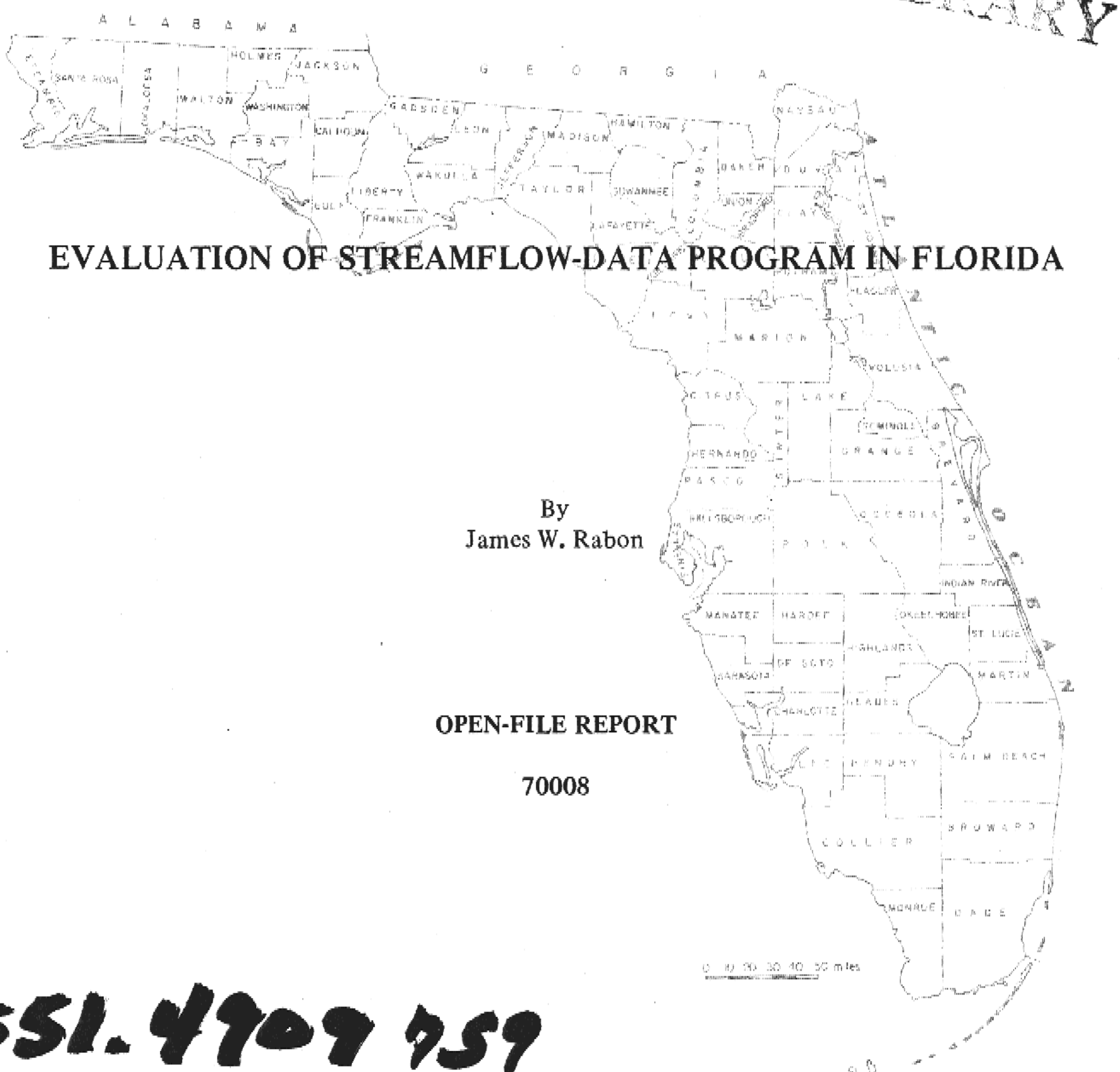
WATER RESOURCES DIVISION



EVALUATION OF STREAMFLOW-DATA PROGRAM IN FLORIDA

By
James W. Rabon

OPEN-FILE REPORT

70008

Tallahassee, Florida
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ABSTRACT

An evaluation was made of the streamflow data available for Florida to provide guidelines for planning future programs. The basic steps in the evaluation procedure were (1) definition of the long-term goals of the streamflow-data program in quantitative form, (2) examination and analysis of all available data to determine which goals have already been met, and (3) consideration of alternate programs and techniques to meet the remaining objectives. It was found that with few exceptions, the goals could not be met by generalization of the data for gaged basins by regression analysis. However, information was developed that can be merged and plans for the future data program were developed that eventually will attain as many of the goals as possible within the limits of available funds. Guidelines developed as part of the evaluation are presented for use in modifying the present streamflow-data program to meet future needs.

INTRODUCTION

Historically, surface-water data programs developed in the Geological Survey in response to local economic and hydrologic stimuli. Owing to their joint concern, other Federal agencies, the State, and many counties and municipalities have for more than 40 years contributed substantial funds to the Geological Survey to obtain data in Florida directed to specific problems and also to intensify the general inventory of water resources. Although the program has largely evolved in response to specific and local area needs rather than by broadscale national planning, a wealth of information on streamflow has been accumulated.

The Geological Survey began collecting records of streamflow in Florida in 1906 with the establishment of gaging stations on Silver Springs near Ocala and the Suwannee River at White Springs. Several discharge measurements were made at these and other locations in the Peace, Suwannee, and Withlacoochee River basins. Only fragmentary records were collected at these few sites and in 1907 or 1908 they were discontinued. During the following 20 years the only streamflow records collected were measurements of the Everglades Canals in 1913, flow of some of the larger springs in 1913, and daily stage and discharge at the gaging station on North Prong St. Marys River from 1921 to 1923.

The first systematic program was begun in 1926 and 1927 when continuous-record gaging stations were established on a few streams in northern Florida. From 1930 to 1940 the number of continuous-record stations increased from 23 to 97. Only 17 stations were established during the war years, bringing the total to 114 in 1945. By 1956 the number of active discharge stations had increased to 169. During the next several years the Geological Survey and the State of Florida together recognized the urgent need for a more systematic program to evaluate the water resources of the State. The scheme of classification of streamflow stations in a hydrologic network consisting of primary, secondary, and partial-record stations was instituted. The primary stations were long-term, and the secondary stations were short-term and intended to be moved after satisfactory correlation with a primary station had been attained. In 1957 the long-range plan was to double the primary streamflow network and at the end of about every 5 years of operation, determine statistically the size and distribution of the entire network. As a result of this Federal-State program, the number of active continuous-record stations increased steadily to 1966 when about 300 stations were in operation. About 20 discharge stations per year were discontinued during the following 4 years, reducing the total in operation on June 30, 1970, to 214.

The partial-record network in Florida includes essentially stations classified as crest-stage, low flow, and periodic streamflow, and lakes and ponds. After a modest beginning in 1953, the crest-stage program as of June 30, 1970, included about 100 stations, most of which are located in northern and northwestern Florida. The low-flow program, which was started in the mid-1960's, now consists of about 50 data-collection sites, also located mostly in northern and northwestern areas. Collection of stage records of lakes and ponds began in the mid-thirties. Stage data were obtained for about 15 lakes in 1940, 85 in 1950, 115 in 1960, and by June 30, 1970, the network included about 150 lake stations. In addition, considerable stage data on the larger streams and canals have been collected.

Since 1957, Florida's water resources program has grown rapidly in response to the increased demand for water information brought about by industrial expansion, increased population, flood and drought conditions, salt-water encroachment, and in recent years, problems associated with pollution and the hydrologic environment.

Total funds allocated for water-resources investigations in Florida for the 1970 fiscal year were about four times those for the 1958 fiscal year. In 1958 about 40 percent of the funds were derived from cooperating State, county, and city agencies, and about 60 percent from Federal sources. In 1970, because of the increased demand for water information by State and other local agencies, about 80 percent came from cooperative Federal-State sources and only about 20 percent from exclusively Federal sources.

The ever-increasing cost of operation, the restraint on funds and qualified manpower, and the need for a greater variety of hydrologic information, have brought about an urgent need for a more rational design of the streamflow data program. The purpose of this study is to evaluate the streamflow data program and to apply the results in the design of the future data program. The study provides justification for each element in the future program and allows for the weeding out of less productive elements.

The concepts and procedures used in this study are presented in detail by Carter and Benson (1970) and are summarized only briefly herein. The principal elements in the study are (1) establishing the objective and goals of the program, (2) examining and analyzing all available data to determine which of the goals have been met (3) considering alternate means of meeting the remaining goals, and (4) identifying elements that need to be included in the future program.

This report was prepared as part of the cooperative program between the Bureau of Geology, Division of Interior Resources, Florida Department of Natural Resources, Florida Department of Transportation, Florida Trustees of the Internal Improvement Trust Fund, the Central and Southern Florida Flood Control District, the Southwest Florida Water Management District, the Corps of Engineers, U. S. Army, and various other State, county, local, and Federal agencies, and the U. S. Geological Survey, Water Resources Division. Appreciation is expressed to the many individuals who contributed technical and other assistance to the report, especially R. W. Carter and M. A. Benson of the Surface-Water Branch, and to Carl J. Cash of the Ocala Subdistrict Office. The work was done under the general direction of C. S. Conover, District Chief and R. W. Pride, Assistant District Chief, Florida District, Tallahassee.

HYDROLOGY OF FLORIDA

Rainfall in Florida is quite varied both in annual amount and in seasonal distribution. Average annual rainfall, based on the 30-year period, 1931-1960, ranges from about 50 to 65 inches. The main areas of high annual rainfall are in the extreme northwestern area and at the southern end of the peninsula. Rainfall varies greatly from year to year; the rainfall in a wet year may be twice that of a dry year.

The distribution of rainfall within the year is quite uneven. The seasonal distribution changes somewhat from north to south. The climatological Regions referred to herein are composites of the U. S. Weather Bureau (USWB) Divisions as published in Climatological Data, Florida, and elsewhere. In the Northwest Region there are two wet seasons--March and April and again June through September. Rainfall during the 2-month period is about 18 percent of the average annual and during the 4-month period is about 45 percent. In the Peninsular Region except for the Lower East Coast Division the most striking features of the seasonal distribution are the rather abrupt start and end of the summer wet period in June and September, and the frequent rains during this period. Rainfall for the wet season ranges from about 52 percent of the average annual in the North Division to about 61 percent in the Everglades and Southwest Coast Division. The wet season in the Lower East Coast Division covers the 5-month period June to October and accounts for about 61 percent of the average annual rainfall--the same as for the Everglades and Southwest Divisions except for the additional month, October. In the Northwest Division, October and November are the driest months. On the peninsula, November, December, and January are the driest except in the Lower East Coast Division where December, January, and February tend to be the driest. Flood-producing rains generally are associated with broad cyclonic disturbances or tropical hurricanes. They usually occur between November and April in northern and northwestern Florida and June to September in most of the peninsula.

Streamflow, like rainfall, is highly variable in Florida, both in amount and seasonal distribution. Runoff is considerably greater in northwestern areas than in most of the peninsula. Year-to-year variations in streamflow generally are much greater in the peninsula, except for many streams in the peninsula that originate in large springs, lakes, or otherwise have substantial ground-water contribution which tends to maintain fairly uniform flow. Within-year variations in streamflow are greater in late fall and early winter in northwestern areas and in late spring in the peninsula.

In general, streamflow in northwestern Florida is greatest in spring and lowest in late summer and fall. Streamflow in the peninsula, consistently is greatest in August, September, and October and lowest in May, November, December, and January.

The probability of flooding is greatest in March and April in the northwestern area and in September in the peninsula. Tropical storms occurring in late summer or early fall occasionally produce heavy rainfalls over relatively large areas of the state usually resulting in excessive flooding as the soils are saturated from summer rains. High tides caused by winds associated with tropical storms produce flooding of coastal areas. Most of the tropical storms that move into Florida approach the state from the south or southwest, entering the Keys, the Miami area, or along the west coast.

Florida is not immune from droughts locally, even though annual rainfall is relatively great. Statewide droughts are rare. Several dry periods in the course of a year or two can lead to significant lowering of water tables and lake levels, particularly in the peninsula, where lakes and shallow wells are depended upon for water supply.

CONCEPTS AND PROCEDURES USED IN THIS STUDY

The main concept of this study is that streamflow information may be needed at any point on any stream in Florida, and that the streamflow data program must be designed to accommodate this need. The word "data" used here includes information on streamflow derived by correlation or synthesis as well as that obtained at gaged sites.

The goals of the program, including accuracy goals, is another important concept, and should be set in quantitative terms. This permits evaluation of existing data to determine which goals have been met and identification of the elements that should be included in future programs.

The procedures used in this study are presented with reference to the general framework described in table 1. Streamflow data are classified into four types: (1) data for current use, (2) data for planning and design, (3) data to define long-term trends, (4) data on the stream environment. For the second type of data, streams are classified as natural or regulated, and each of these two classifications is further subdivided into principal or minor, with separation of the two at a drainage of about 500 square miles, varying with terrain and hydrologic conditions.

Program goals for each type of data were established in the initial phase of the study. All available data were examined, analyzed, and then compared with the goals set; the comparison was essential in consideration of the elements to be included in the design of the future program.

The need for each of the four types of data and the methods of obtaining the data are described in the following sections.

Table 1.—*Framework for design of data collection program*

Type of data	Current use	Planning and Design				Long-term trends	Stream environment
		Natural Flow		Regulated Flow			
		Minor streams	Principal streams	Minor streams	Principal streams		
Goals	To provide current data on streamflow needed for day-by-day decisions on water management as required.	To provide information on statistical characteristics of flow at any site on any stream to the specified accuracy.				To provide a long-term data base of homogeneous records on natural-flow streams.	To describe the hydrologic environment of stream channels and drainage basins.
Drainage area limits	Full range	Less than 500 sq mi.	Greater than 500 sq mi.	Less than 500 sq mi.	Greater than 500 sq mi.	Full range	Full range
Accuracy goal	As required	Equivalent to 10 years of record.	Equivalent to 25 years of record.	Equivalent to 10 years of record.	Equivalent to 25 years of record.	Highest obtainable	As required
Approach	Operate gaging stations as required to provide specific information needed.	Relate flow characteristics to drainage basin characteristics using data for gaged basins.	Operate gaging stations to obtain 25 years of record (or the equivalent by correlation) at a network of points on principal streams; interpolate between points.	Develop generalized relations that account for the effect of storage, diversion or regulation on natural flow characteristics.	Utilize analytical model of stream system with observed data as input to compute homogeneous records for both natural flow conditions and present conditions of development.	Operate a number of carefully selected gaging stations indefinitely.	Observe and publish information on stream environment.
Evaluate available data	Identify stations where data is used currently and code the specific use of data.	Develop relationship for each flow characteristic and compare standard error with accuracy goal. Evaluate sample.	Lay out network of points on principal streams and compare data available at these points with goal.	Appraise type of regulation, data available, and areas where relationships are needed.	Identify stream systems that should be studied using model approach and determine data requirements.	Select two stations in each WRC subregion to operate indefinitely for this purpose.	Evaluate information available in relation to goals.
Design future program		Identify goals that have not been attained. Consider alternate means of attaining goals. Identify elements of future program.					

Data for Current Use

Many sites exist in Florida, particularly in central and southern Florida, where streamflow data are needed on a day-to-day basis for the management of water, for the assessment of current water availability, for the control of water quality, for the forecast of flow extremes, and for the surveillance necessary for legal requirements. This classification represents the need for information on the actual flow at any moment, or during any specified day, week, month, or year.

Streamflow data obtained for current use have a high payoff value, as a current knowledge of the rate of flow and storage at different points in the system provides a basis for water management decisions that govern the economic efficiency of the operation.

Data for current use are obtained by operating "current-purpose" gaging stations to obtain the data specifically required by water-management systems. Current-purpose stations are placed in a separate category because (1) justification can be related to specific needs and benefits, (2) the data may have little or no transfer value in a hydrologic sense, and (3) the location of the stations and the periods of operation are specified by the needs of the users of the data.

Data for Planning and Design

Designers and planners of water-control and water-related facilities increasingly utilize the statistical characteristics of streamflow rather than records of flow for specific periods. Although the probability is remote that the historical sequence of flow that has been observed at a given site will occur again, estimates of future flows needed in design and planning must consider all probable flows and sequences of flow. The need is to consider what may be expected to happen in the future, not in terms of specific events, but in terms of probability of occurrence over a span of years. For example, many highway bridges are designed on the basis of the flood that will be exceeded once in 50 years on the average; storage reservoirs can be designed on the basis of the probability of deficiency of storage for a given draft rate; the water available for irrigation, dilution of waste, or other purposes may be stated in terms of the mean flow, or probability of flow magnitudes for periods of a year, season, month, week, or day. In addition, a marked trend exists toward synthesis of streamflow data based on the statistical characteristics, such as the mean, standard deviation, and skew.

Generally, a record of streamflow of at least 25 years is necessary as a basis for defining the statistical characteristics. Although it is not feasible to collect long-term, continuous streamflow records at every site where information may be needed, a representative number of such stations is required to provide information that can be transferred to ungaged sites, or to sites where occasional or periodic observations of streamflow are available.

Natural-flow streams

For natural streams the transfer of streamflow information is accomplished by regression methods; either by relating flow characteristics to basin characteristics such as drainage area, topography and climate; by relating a short record to a longer one; or by interpolating between gaged points on the same stream channel. These methods are not usually applicable to streams where the flow is affected by regulation and diversion. Because different techniques are required to provide information on natural streams and regulated streams the two are considered separately in program design.

For the purpose of setting accuracy goals, streams are classified herein by size of drainage area as minor streams (less than 500 square miles), and as principal streams (greater than 500 square miles). The intent is to use size of drainage area as an index of importance of data. More costly water developments can be expected on principal streams, hence, a higher accuracy goal is justified for these than for minor streams.

Because of the large number of minor streams, definition of their flow characteristics must be by some method of regionalization. For natural streams this can be accomplished by gaging at sample locations and relating the observed flow characteristics to drainage basin parameters, thus providing definition for ungaged streams.

Techniques of regionalization cannot, in general, be used for principal streams because of higher accuracy requirements. Therefore the proposed approach is to operate a network of gaging stations at selected locations on principal streams and by interpolation or systems studies estimate the flow characteristics at locations between stations. Experience gained heretofore in hydrologic analysis justifies a procedure for defining the network of principal stream stations as follows: (1) select stations with drainage area of about 500 square miles on the most upstream segment of all streams, and (2) after the upstream stations are located select the next or following stations on each stream from the upstream station to the mouth at points where the drainage area has approximately doubled. The drainage area may be more than doubled if another principal stream enters between two principal stream stations.

Regulated-flow Streams

The natural flow regime of many streams is altered by the construction of storage reservoirs, by the diversion of water for consumptive use and by inflow from drainage and other water systems. These alterations increase the scope of both the data collection and the analysis that is required to provide information on the flow characteristics.

To be useful in statistical prediction, the factors that influence streamflow must be homogeneous in time. Frequently, however, it is not possible to obtain a long record under one condition of development before additional changes occur.

Definition of the flow characteristics at any point on any stream is also much more difficult under conditions of regulation. The procedures used for natural streams, for example, regression, correlation, and interpolation, cannot be applied.

For regulated streams a systems approach appears to be the most efficient way of providing meaningful information on the statistical characteristics of flow. This approach requires some sort of analytical model of the stream system. Such models are simple in concept and usually consist of water-budget equations and flow-storage equations. However, in many cases the use of the digital computer is required for complex relations, or to handle large volumes of data. A computer program tailored to the individual system must be prepared.

Development of such a model requires information on stage-capacity curves of reservoirs, stage-discharge curves at the outlets, operating rule curves for the release of water, losses due to evaporation and seepage, the geometry of the stream channel, and records of diversions and return flow. Information on streamflow at some point or points is also needed as input to the model and to verify the output. In some cases aquifer characteristics and ground-water pumpage should be taken into account.

The model and the associated data can be used to derive homogeneous data for either the natural or the regulated condition. All historical streamflow records for both natural and regulated flows could be utilized as input to the model. Furthermore, data could also be derived for ungaged sites in the stream system.

Data to Define Long-Term Trends

A long continuing series of consistent observations on streamflow is needed for (1) analysis of the statistical structure of the hydrologic time series, and (2) as a reference or comparative base for noting changes in the flow regime of streams that become increasingly modified or regulated over a period of time.

Statistical statements on flow characteristics are based on the assumption that the data series is stationary in a statistical sense, and that the observed record represents a sample of the population of flows. Long-term homogeneous streamflow data provide a basis for checking these assumptions, and a basis for adjusting flow characteristics from short records to more nearly represent the characteristics of the flow population.

For these purposes the gaging stations should be located on streams draining basins that have undergone no significant man-made changes, and which are expected to remain in a comparable condition in the future. The stations should be well distributed areally, and be located on basins of different physical characteristics.

Data on the Stream Environment

Stream discharge and use of water are intimately related to the environmental characteristics of the drainage basin. Environmental data include a wide variety of water-related information other than stream discharge. These data are necessary for hydrologic studies and for planning, designing, and operating systems for controlling water or pollution, and for appraising the effect of changes in land use on the flow regime. Examples are (1) data on drainage basin characteristics related to land use such as urban areas, irrigated lands, water storage, or areas with forest or vegetative cover, (2) data necessary in determining the hydrology of natural lakes, (3) information on aquifer characteristics essential in describing variability of low flow, or in planning the conjunctive use of surface water and ground water, (4) data on the geometry of a stream channel to appraise the use of a stream for recreation or to determine its capacity to assimilate waste, and (5) profiles of flood elevations to determine areas subject to inundation by floods.

GOALS OF THE FLORIDA STREAMFLOW DATA PROGRAM

The objective of the Florida streamflow data program is to provide information on flow characteristics at any point on any stream. The design of the program is based on specific goals that represent the four types of data and the accuracy of information that are needed. Acceptable accuracy levels are specified, because accuracy levels not only govern the cost and the techniques used in providing information, but also provide a quantitative measure of attainment of specific goals. The setting of goals for each of the four types of data is described below.

Data for Current Use

The program goal for this type of data is to provide the particular information needed at specific continuous-record sites for current use. Accuracy goals for a particular current-purpose site must fit the requirements for data on a current basis as specified by the users of the data. In general, a higher degree of stream-gaging accuracy is justified for current-purpose data used in the operation of water systems dealing with known volumes of water, than for data used in the planning and design of water-development projects. High accuracy goals at a given site can be met by intensified observations, or by more sophisticated instrumentation as needed.

Data for Planning and Design

The goal for this type of data is to define within the given accuracy the streamflow characteristics for each region as listed in table 2. The accuracies apply to estimates of flow made for all streams with natural flow, and also to those streams which are affected by regulation and diversion. For the latter streams, the goal includes definition of the flow characteristics for both natural conditions and present conditions of development.

Table 2.--Accuracy goals for planning and design

Streamflow characteristic	Error, in percent of mean, for indicated equivalent length of record, in years			
	Peninsular Region		Northwestern Region	
	10	25	10	25
Mean annual discharge.............	18	12	11	7
Standard deviation of mean annual discharge......................	22	14	22	14
Mean monthly discharge (average)..	34	21	22	14
Standard deviation of mean monthly discharge (average)............	22	14	22	14
50-year flood....................	43	26	36	23
2-year (median) 7-day low flow....	24	15	13	8
20-year 7-day low flow...........	37	23	20	13
50-year 7-day high flow..........	40	25	29	18

Previous studies of Florida hydrology have indicated that regional differences in the streamflow characteristics are to be expected because of the variable hydrologic conditions in the State. In the course of this study, marked differences appeared in meteorological, topographic, and most important, streamflow characteristics. In this report, "Peninsular Region," or "Northwestern Region" are used to describe the Florida study areas (figs. 1, 2). The Northwestern Region includes all basins west of the Aucilla River basin and the Peninsular Region includes the remaining area.

The methods used in this study for setting accuracy goals for planning and design data are presented in detail by Hardison (1969), and are summarized only briefly in this report.

Streamflow characteristics describe the flow to be expected at a given site. The 50-year peak flow, mean annual flow, mean monthly flow, 20-year low flow, and the standard deviations of each of these flow variables, are examples of such characteristics. Streamflow characteristics can only be estimated; their true value can never be determined because of the time-sampling error in every record of streamflow and a model error in every analytical method.

In this study the "standard error of estimate" is used to express the accuracy of estimates of streamflow characteristics that are made by using statistical multiple-regression techniques. This is compared with the "standard error," more exactly the standard error of the mean, that is based on stipulated record lengths and the regional variability of the streamflow as determined from gaging-station records. Either of these standard errors is expressed in percent as a single-valued index of accuracy. It should be understood that about 68 percent of the estimates are within one standard error, plus or minus, of the true value, about 95 percent within two standard errors, and that about 99.7 percent, or practically all of the estimates, are within three standard errors.

Accuracy goals in defining flow characteristics depend upon the flow variability. For example, accuracy goals for the Florida Northwestern Region are generally easier to attain than those for the Peninsular Region because flow variability is less in the Northwestern Region than in the Peninsular Region. These accuracies are based on the nature of the phenomena being observed in each region. They are the magnitudes of errors that occur in time sampling. Reduction of time-sampling errors by collection of records over a longer period of time is accomplished at progressively higher cost because the error varies inversely as the square root of the number of years of record. The improvement in accuracy becomes progressively less as the length of record is increased. For this reason, collection of continuous records at all gaging sites for indefinitely long periods is not generally justified, even though the accuracy goals may not have been met for their respective region of the State.

The accuracy goals shown in table 2 for each flow characteristic are equivalent to the accuracies that would be obtained at any location by an actual record of 10 years on minor streams and 25 years on principal streams. Accuracy goals were determined in terms of percent of the mean, using the methods described by Hardison (1969). In summary, the standard error of a flow characteristic for a given number of years of record depends on the variability of the annual events as defined by their coefficient of variation or by the standard deviation of their logarithms--called "variability indices." Average variability indices for the annual streamflow events in each of the two separate regions are used to obtain the accuracy goals in terms of standard error.

Data to Define Long-Term Trends

The goal for this type of data can be attained by operating indefinitely a relatively small but representative sample of gaging stations on natural streams in the State. Generally, gaging stations selected from the existing State network added to any already in the federal network of "benchmark" stations will provide an adequate network to meet this goal. The long-term trend network should include only those gages located on streams draining basins that have undergone no significant manmade changes during the period of record, and which are expected to remain in a comparable condition in the future. The gages should be well distributed areally and be located on basins of differing physical characteristics.

Data on the Stream Environment

The goal for this type of data is set in response to the need for information related to the hydrologic environment of each basin and stream channel in the State and should include the collection of the following types of data:

1. Drainage basin characteristics, including geometry, land use such as urban areas, irrigated lands, water storage, or areas with forest or vegetative cover; and climatic characteristics.
2. Aquifer characteristics, including location, extent, hydraulic connection to stream channel, and hydraulic characteristics.
3. Stream-channel geometry, including widths, depths, slopes, hydraulic roughness and description of bed and bank material.
4. Profiles of flood elevations and areas subject to inundation by floods.
5. Velocities and travel time of water and wastes in channels.
6. Lakes and ponds, including vegetative and nutrification characteristics, and ecological changes.

EVALUATION OF EXISTING DATA IN FLORIDA

Preliminary to the design of the streamflow data program, all available data were considered and analyzed in relation to the program goals. The deficiencies between present information and the goals formed the basis for the recommended future program. A separate evaluation is made for each of the four types of data previously described.

Data for Current Use

Identification of current-purpose gaging stations is a prerequisite to the appraisal of the total data program. About 55 percent of the continuous-record stations in Florida are operated to provide data for current use. It is assumed that the need for this type of data is being met, and that this part of the program can be modified as requirements change. The 117 continuous-record gaging stations operated in Florida to satisfy the need for current data are identified in table 4 and shown in figure 1. The principal uses of the data for each station are also shown in this table. About 90 percent of the current-purpose stations are located in the central and southern part of the State where the main users of the data are water-management and control districts and authorities.

Data for Planning and Design

An analysis of available data is necessary to determine which of the goals for this type of data have been met. Because the goal is to define flow characteristics at any point on any stream, techniques for generalizing the information at gaging stations, including regionalization, must be employed in the analysis. The following discussion of the evaluation of this type of data follows the general framework shown in table 1.

Natural-flow Streams

Minor streams.--the first question to be answered is how accurately can the statistical flow characteristics that are listed as goals be defined by regionalization of the data now available.

The most effective way known for defining statistical characteristics on a broad scale is to relate them to basin characteristics in equations developed by use of multiple-regression techniques applied to past data. Such an equation usually has the form

$$Y = aA^{b1}S^{b2}P^{b3}----,$$

where Y is a statistical streamflow characteristic, such as one of the eight listed in table 2, and A, S, and P are topographic or climatic characteristics such as drainage area, channel slope, and precipitation. The values of a, b_1, b_2, b_3, etc., are defined by multiple regression. This method was described by Benson (1962) and Thomas and Benson (1970).

Selection of streamflow records for analysis.--All continuous streamflow records available in each of the two study regions were examined to select records for use in the analysis. Streamflow records in Florida headwater basins located in the adjacent States of Georgia and Alabama were also examined. Records of the greatest possible length were desired because the characteristics of flow computed from such records can be expected to include less time-sampling error than characteristics computed from shorter records. Also desired was as large a group of records as possible because the increased range of basin characteristics usually found in a large sample improves the confidence in and utility of the defined multiple-regression relations.

Only those records or portions of records judged to represent essentially natural streamflow were selected for analysis. No attempt was made to select records so that they covered a common time period, to fill in missing years of record, or to adjust the streamflow characteristics to represent any selected time period. The use of records from whatever periods may be available is consistent with considering them as random sample data.

In the Peninsular Region, 105 streamflow records were selected for analysis. Included in this total were 5 continuous station records in Georgia and 3 crest-stage partial-record stations in Florida. In the Northwestern Region, 40 stations were selected, including 6 in Georgia and 12 in Alabama. Essentially all 145 stations had a minimum length of record of 10 years; the typical station for both study regions had about 20 years (geometric-mean) of record.

Streamflow characteristics.--The following streamflow characteristics are indices of all parts of the range of flows, from the lowest to the highest. They represent data required for planning and design:

a. Low-flow characteristics at each gaging site were represented by the minimum 7-day mean flows having recurrence intervals of 2 years ($M_{7,2}$), 10 years ($M_{7,10}$), and 20 years ($M_{7,20}$). They were, for the most part, determined by fitting a three-parameter Pearson Type III distribution to the logarithms of annual minimum flows. Mathematical fitting of the curves was done by a digital computer. To avoid difficulties associated with the use of zeros in the regression analysis, all flow values were increased by 0.001 cubic foot per second.

b. Flow-duration characteristics were represented by discharges equalled or exceeded 10 percent of the time (D_{10}), 50 percent of the time (D_{50}), 80 percent of the time (D_{80}), and 90 percent of the time (D_{90}). The flow-duration indices were taken (interpolated) from standard flow-duration summary tables for each station that show the percentage of days during the period of record that equalled or exceeded indicated discharges.

c. Annual peak flood discharges corresponding to five recurrence intervals were determined from each of the gaging-station records. They represent the annual maximum rate of stream discharge exceeded on the average of once each 2, 5, 10, 25, and 50 years. In this report these peak flow rates are respectively denoted by Q_2, Q_{10}, Q_{25}, and Q_{50}. The peak flow rates of selected recurrence intervals were for the most part determined by fitting a Pearson Type III distribution to the logarithms of observed peak flows. In order to avoid bias, it was preferable to use in the initial computations only those flood peaks that occurred during the time a gaging station was in operation. Historical flood information, where available, was incorporated into the period-of-record frequency relation to determine if the historical information significantly altered the upper part of the initial relation. Comparison of the two relations for each station with historical information included and omitted were used in defining the final frequency relation. Practically all calculations were performed by digital computer.

d. Annual maximum flood volumes were determined from each gaging record. These indices were the annual maximum 7-day mean flow that would be exceeded on the average of once each 2, 10, 25, and 50 years. The respective symbols for these flows are $V_{7,2}$, $V_{7,10}$, $V_{7,25}$, and $V_{7,50}$. These flow volume indices were also determined from a Pearson Type III distribution fitted to the logarithms of the observed flows for essentially all sites.

e. The mean of the annual flows and of each calendar month flow was computed for each gaging station and provided 13 indices of average streamflow. In this report the symbol Q_a represents the mean of the annual discharges and q_n (where the subscript n refers to the numerical order of the months with January as 1) represents the mean of the monthly discharges.

f. The standard deviations of annual flows and of flows for each calendar month were used as indices to evaluate the year-to-year variability of flows. Symbols representing the standard deviations of the annual and monthly flows are SD_a and SD_n, respectively (where the subscript n refers to the order of the months with January as 1).

Drainage-basin characteristics.--The physical characteristics of a drainage basin which might influence streamflow usually need to be expressed by some simplified representative indices. The problem in this study was to select numerical indices of the physical characteristics of each sample drainage basin upstream of a gaging site that could be related to the observed differences in streamflow characteristics. Indices investigated and selected for use in this study were evaluated from maps or tabular data. Practical limitations of time and of the statistical analytical procedures required the selection of a limited number of basin variables. Research in the area of improving basin indices is discussed later in this report. The basin variables evaluated in this study were selected on the basis of hydrologic principles, on the degree of success experienced in use of the variables in previous studies, and on the ease of enumeration. The basin characteristics selected for evaluation and the method of evaluation are as follows:

a. Size of drainage area, in square miles, shown in the latest Geological Survey streamflow reports were used in this study and are symbolically represented by A. Where appropriate, noncontributing areas of surface runoff were excluded and only contributing area used.

b. Main-channel slope, in feet per mile, was computed as the average slope of the main channel between points 10 and 85 percent of the distance upstream from the gaging site to the basin border. This simple index of slope was developed and used successfully by Benson (1962, 1964). The symbol S is used for main-channel slope in this study.

c. Main-channel length (L), in miles, was selected as a variable indicating basin shape in conjunction with A. Values of main-channel length (from gaging site to basin border) were available from the determination of main-channel slope.

d. Differences in surface storage capacities can be expected to be a measure of streamflow variability between basins and between regions of the State. Surface storage varies considerably between the Peninsular Region and the Northwestern Region. For both study regions, each basin's surface storage occupied by lakes, ponds, and swamps was computed as the percentage of total drainage area A. In the Peninsular Region, the total storage area computed for the basins sampled ranged from zero to about 84 percent; the typical storage area was about 18 percent (geometric mean). In the Northwestern Region, total storage ranged from zero to about 10 percent; for the typical basin, less than one percent of the drainage area was occupied by storage in lakes, ponds, and swamps. Before computations of the surface storage index was begun, it was considered advisable to delineate total surface storage by percent of drainage area in: (1) lakes <u>with</u> <u>no</u> forest cover, (S_{t_1}), (2) swamps <u>with</u> <u>no</u> forest cover, (S_{t_2}), (3) lakes <u>with</u> forest cover, (S_{t_3}), and (4) swamps <u>with</u> forest cover, (S_{t_4}). The reasoning was that these four storage indices may, taken individually, have greater significance in explaining flow variability in the study regions than if summed and used as total storage. To avoid difficulties associated with the use of zeros in the regression analysis, all values of percent of drainage area in lakes, ponds, and swamps were increased by a value of 0.01 percent.

e. Forests affect streamflow by transpiration, by precipitation interception, and possibly in other ways. The index of forest cover (F) used in this analysis is the percentage of total drainage area shown as forested on the topographic maps, with two exceptions; the surface storage indices S_{t3} and S_{t4} (under d, above) are not included in the F index in this analysis. Also, a constant was not added to the actual computed F values.

f. Mean annual precipitation (P) is a measure of the amount of water supplied to a drainage basin and of the potential runoff. It is a simple and comprehensive index that has proved useful in many previous studies. For each sample basin in the Peninsular and Northwestern study regions, mean annual precipitation, in inches, was determined from an isohyetal map prepared from U. S. Weather Bureau (1959, rev. 1962) precipitation records. Values determined were reduced by 40 inches for use in the regression analysis.

g. The precipitation intensity index selected for this study was the maximum 24-hour precipitation, in inches, expected to be exceeded on an average of once each 2 years ($I_{24,2}$). Values for this index were determined directly from a U. S. Weather Bureau publication (1958); the values so determined were adjusted for size of drainage area by methods suggested in this publication. The maximum 24-hour precipitation expected to be exceeded on an average of once each 100 years ($I_{24,100}$), was also investigated. The data used in the investigation were published by U. S. Weather Bureau (1958); the same publication used in determining $I_{24,2}$. The relationship between $I_{24,100}$ and $I_{24,2}$ was found to be

$$I_{24,100} = 2.35\ I_{24,2}.$$

It was concluded that $I_{24,100}$ varied as a uniform proportion of $I_{24,2}$, and $I_{24,100}$ was dropped from the analysis.

h. Infiltration capacity of the basin soils influence the amount of direct runoff from a storm and the amount of delayed subsurface runoff. The soils index represents values of potential maximum infiltration, in inches, during an annual flood, under average soil moisture conditions. Values of the soils index (S_i) were computed from a map provided by the Soil Conservation Service.

The following table shows the range of numerical values (constants excluded) of the variables in the sample basins for the two study regions. The ranges shown are only for basins whose gaging sites are located in Florida.

Characteristic	Peninsular Region			Northwestern Region		
	Maximum	Geometric Mean	Minimum	Maximum	Geometric Mean	Minimum
A	9,730	244	9.0	4,384	463	36
S	9.64	1.48	.15	11.9	4.88	1.61
L	258.1	33.1	4.35	199.9	48.6	11.89
St_1	32.86	1.84	0	2.20	.20	0
St_2	22.99	1.24	0	.29	.02	0
St_3	11.99	.06	0	.01	.01	0
St_4	84.07	4.46	0	10.2	.10	0
F	85.60	14.0	.16	96.8	65.0	36.8
P	60.5	52.6	50.9	66.7	56.0	50.0
$I_{24,2}$	5.54	4.36	3.61	5.31	4.44	3.98
S_i	6.23	3.06	1.60	8.04	4.47	2.99

Note.--Basin characteristics for Apalachicola River at Chattahoochee, Fla., are not included in the above.

Values of the basin characteristics above, excluding constants added for regression analysis, are listed in table A-1 (in appendix). The four surface storage indices (St_n) were dropped from regression equations for the Northwestern Region. They are included in the above table and in table A-1 (in appendix) for general information.

Analytical methods used in the analysis.--Statistical multiple-regression analysis was used to separately develop for each study region the relations between streamflow characteristics (dependent variables) and drainage-basin characteristics (independent variables). Briefly, multiple regression provides a mathematical equation of the relation between a single dependent variable and the independent variables. It also provides a measure of the accuracy of the defined relation (known as the standard error of estimate), and measures of the usefulness of each independent variable in the relation.

The standard error of estimate is a range of error such that the value estimated by the regression equation is within this range at about 2 out of 3 sites, and is within twice this range at about 19 out of 20 sites.

The usefulness of each independent variable to any relation is judged both on the basis of its statistical significance and on the basis of the reduction in the standard error that is brought about by including the variable. Those independent variables that had a 95 percent probability of effectiveness were classed as significant to the equation, and those variables that had a 99 percent probability of effectiveness were classed as highly significant.

Past experience in many hydrologic studies has shown that streamflow discharges are linearly related to most basin characteristics if the logarithms of each are used. Therefore, all streamflow and basin characteristics were transformed into logarithms before calculations were performed.

A high-speed digital computer performed the voluminous calculation required for regression analysis. The procedure involved entering into the computer, for each of the sample basins in each of the two study regions, a single streamflow variable along with several selected basin variables that might possibly explain the basin-to-basin streamflow variation. The computer calculated the regression equation, standard error of estimate, and effectiveness of each independent variable. Automatically then, the computer repeated the calculations omitting the least effective basin variable. This process of recalculation, omitting the least effective basin variable, was repeated until only the one most effective independent variable remained. After the relations for a given streamflow characteristic had all been evaluated, the entire computation process was repeated using another streamflow characteristic as the dependent variable along with a selected set of basin characteristics as independent variables.

The equation with the greatest number of independent variables, all of which are significant, would ordinarily be used for prediction purposes unless other considerations modify the choice. If an independent variable is significant, but has only a small effect on the standard error, it might be omitted. If a variable is not significant at the chosen level of significance, but is significant in other equations, for like streamflow characteristics, it might be included for consistency with other equations.

One of the practical requisites in multiple-regression analysis is that the various independent variables (in this analysis the basin characteristics) not be highly related among themselves. Violation of this criterion can lead to unstable values for the regression coefficients and to difficulties in interpreting the effectiveness of independent variables included in the equation. Although a set of topographic and climatic variables that are entirely independent of each other would be preferable, that is not possible because nearly all natural topographic and climatic variables exhibit some degree of interdependence. To investigate the amount of non-independence, a simple correlation matrix of the evaluated basin characteristics was obtained for each study region; the results are shown in table 3. In table 3 a value of 1.00 means perfect correlation, a value of 0 means complete independence, and a value of -1.00 means perfect inverse correlation. Correlation coefficients for total storage (sum of S_{t_1}, S_{t_2}, S_{t_3}, and S_{t_4}) are included in table 3 for reference purposes. Correlation coefficients for the Peninsular Region are tabulated next to those for the Northwestern Region (noted in parentheses), also for regional comparisons.

Table 3.--Simple correlation matrix for independent variables in Florida study regions.[1/]

	A	S	L	St_1	St_2	St_3	St_4	St(total)	F	P	$I_{24,2}$	Si
A	1.00 (1.00)											
S	-.49 (-.81)	1.00 (1.00)										
L	.96 (.98)	-.47 (-.83)	1.00 (1.00)									
St_1	.07 (.35)	-.25 (-.37)	.11 (.33)	1.00 (1.00)								
St_2	.06 (.20)	-.22 (-.47)	.05 (.27)	.19 (.28)	1.00 (1.00)							
St_3	.15 (.17)	-.45 (-.31)	.13 (.23)	.35 (.23)	.24 (.50)	1.00 (1.00)						
St_4	.09 (.01)	-.13 (-.37)	.07 (.04)	-.08 (.06)	.28 (.46)	.22 (.14)	1.00 (1.00)					
St(total)	-.02 (.15)	-.37 (-.36)	-.05 (.15)	*.60	*.66	*.40	*.81	(1.00)				
F	.31 (-.23)	.05 (.36)	.33 (.17)	-.15 (-.36)	-.53 (-.12)	-.40 (-.20)	.08 (-.26)	-.11 (-.32)	(1.00)			
P	-.45 (-.59)	.13 (.45)	-.44 (-.55)	-.07 (-.35)	.48 (-.16)	.01 (-.23)	.29 (.31)	.38 (.11)	-.25 (.53)	(1.00)		
$I_{24,2}$	-.68 (-.51)	.21 (.46)	-.63 (-.49)	.07 (-.27)	.33 (-.26)	-.14 (-.24)	.09 (.13)	.23 (-.01)	-.41 (.52)	.68 (.88)	(1.00)	
Si	.39 (-.06)	.02 (.01)	.37 (-.09)	.33 (.17)	-.30 (.02)	-.08 (.03)	-.04 (.13)	-.08 (.18)	.36 (-.14)	-.51 (.01)	-.50 (.08)	(1.00)

1/ Number in ( ) are for Northwestern Region.
* Peninsular and Northwestern Regions combined.

In both the Peninsular Region and the Northwestern Region, area (A) and length (L) showed high correlation. Area and slope showed relatively high correlation in the Northwestern Region and probably an insignificant amount of negative correlation in the Peninsular Region where slopes are relatively less than in the Northwestern Region. Slope and length, and precipitation and precipitation intensity showed relatively high correlation in both study regions. Combined total storage and the individual storage indices for all of the sample basins in the Florida study, showed enough independence to warrant entering the individual indices and omitting total storage in the regression analysis. Although all of these variables, except total storage, were tested in the analysis, their effects on computed relations were closely inspected. The process, in certain instances, involved some trial-and-error procedures to select the most useful combinations of variables.

Results of the regression analysis.--Table A-2 (in appendix) summarizes the results of the multiple-regression analyses. These analyses defined mathematical equations of the form:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 --- + b_n \log X_n$$

or its equivalent form:

$$Y = aX_1^{b_1} X_2^{b_2} --- X_n^{b_n}$$

where Y represents a streamflow characteristic, X_1 to X_n represent basin characteristics, a represents the regression constant, and b_1 to b_n represent regression coefficients. In table A-2, the first column indicates the streamflow characteristic studied. The next set of columns show the computed regression constant and regression coefficients for that streamflow characteristic. The last two columns show, respectively, the standard error of estimate in base 10 logarithmic units, and in appropriate equivalent percent. For the majority of the relations in table A-2, the regression coefficients are statistically significant to at least the 95 percent confidence level. A few relations are shown for which one regression coefficient is non-significant at the 95 percent level. These coefficients are included for consistency with other equations. All coefficients for drainage area (A) were significant at the 99 percent confidence level; actually, about 85 percent of the total number of coefficients were significant at the 99 percent confidence level.

In the course of the regression analysis, the regression relation for $V_{7,25}$ inadvertently was not included for the Peninsular Region; the standard error of estimate has been estimated to be probably no more than 40 percent for this flow index.

The relative accuracy of each of the regression relations shown in table A-2 are summarized as follows in the order in which they appear in the table.

The standard errors of the regression relations in the Northwestern Region appear to be somewhat less than those in the Peninsular Region. If the low-flow and flow-duration relations are not considered, the regression equations for the Northwestern Region average about 15 percent less error than those for the Peninsular Region, which is to be expected considering the greater flow variability in the Peninsular Region.

Annual mean-flow relations are more accurate in both study regions than for any of the other flow variables considered. Standard errors as shown in table A-2 indicate that in each of the study regions the defined relations are generally most accurate for flows nearest the mean, being least for extreme flows.

Monthly mean-flow relations were more accurate in each study region for months of high flow than for months of low flow. In the Peninsular Region they were most accurate for August and least accurate for May and December. In the Northwestern Region they were most accurate for April and least accurate for June, July, and October.

Accuracy of relations for estimating flow variability (standard deviations) were comparable to the accuracy of relations for estimating mean flows (actually about five percent less accurate).

The accuracy of peak-flow relations in both study regions appear to be greater for 50-year floods (Q_{50}) than for those having lower recurrence intervals. However, 50-year floods are based on a fewer number of stations and these are the longer records, which are generally on streams having larger drainage areas. Whether or not relations for Q_{50} are truly more accurate must remain a subject for future study. Accuracies of peak-flow relations for Q_{25} as an average, are used in this study for comparisons with goal requirements. Accuracy of Q_{25} relations for both study regions appear to be comparable with those for four widely separated pilot areas studied by Thomas and Benson (1970).

Low-flow relations are least accurate of all other relations, as was expected. Accuracy of the $M_{7,20}$ relations for basins in the Peninsular Region is particularly low. Only about one half of the basins in this study region had $M_{7,20}$ flows great enough to be considered significant for use in the regression analysis; that is, in about one half of the basins, $M_{7,20}$ flows were zero or nearly zero.

Accuracy of relations for estimating flood volumes in both study regions are comparable to the accuracies for estimating peak flows, including the accuracy comparison of $V_{7,50}$ with $V_{7,25}$.

Accuracy goals were not established for flow duration in this study. Flow durations were included as added variables in an attempt to define as much of the flow regime as possible. Regression analysis of the flow 80-percent of the time was included because of the sharp break of most flow-duration curves between D_{80} and D_{90}, particularly in the Peninsular Region. Peninsular basins sampled were the same as those for $M_{7,20}$. Regression relations for D_{80}, D_{50}, and D_{10} would perhaps have been more accurate had more gaging stations been included.

A more detailed comparison of the multiple-regression results with the goals established (table 2) will be made in a later section of this report. It appears, however, that with few exceptions, the goals established for natural-flow streams have not been attained. The regression results discussed above also indicate the relative amount of improvement needed to meet goals in the streamflow program of the future.

Principal streams.--In general, the accuracy goals for principal steams cannot be met by the results of multiple-regression studies; more intense gaging usually is required. The principal-stream system is established by selecting the headwater station where the drainage area is about 500 square miles, and then progressively selecting points at downstream locations where the drainage area has approximately doubled. The system of principal-stream gaging-points is established regardless of whether or not the stream now represents natural or regulated flow; these points represent sites at which it is considered desirable to define either natural flow or, if regulated, flow under current or other projected regulation schemes. Evaluation of existing data for natural-flow principal streams in Florida was accomplished by, first, determining the system of principal stream gaging points, second, identifying such of those points where 25 years of natural-flow record are already available or where records could be extended by regression to obtain the equivalent of 25 years of record, and third, identifying points where a station must be continued or a new station installed to obtain the equivalent of 25 years of record of natural flow.

Following identification of the Florida system of principal stream-gaging points it was found that seven qualified sites already had an average of 37 years of natural-flow record and one site, with 16 years of natural-flow record, would, by correlation with a downstream long-term trend site, have an equivalent of 25 years or more of record. These eight sites will be discussed later in this report. Also, of eight points where stations must be continued to obtain the equivalent of 25 years of natural-flow record, five serve also as current-purpose sites and one as a long-term trend site. Three of the eight sites have about 20 years of record, two average less than 13 years of record, and three have less than 10 years of record.

Regulated-flow streams.--As discussed earlier in this report, a systems approach is considered necessary, if meaningful information is to be provided on regulated streams. The goal for the Florida regulated-flow system is to define statistical flow characteristics for either the natural or regulated condition. Model studies will be required for most of Florida's regulated-flow systems.

Regulated flows in Florida are measured at 69 sites, most of which are located in central and southern Florida. The effect of regulation on natural flow at sites in the southernmost area of the peninsula is very difficult, if not impossible, to determine. Records needed to adjust regulated flow to natural flow are available for only a few sites. The regulated stream system in Florida, particularly in the central and southern area, would benefit by consideration of the model approach in program design. The model approach might also indicate deficiencies in the present data-collection scheme.

Data to Define Long-Term Trends

Currently, one station, Sopchoppy River near Sopchoppy (02-3271) is designated a hydrologic bench-mark and intended for indefinite operation to define long-term trends. Several other currently-operated gaging stations with drainage areas ranging from 30 to 7,700 square miles, with accurate flow records of as much as 43 years, located on basins which have undergone little or no man-made changes, and which are expected to remain in a virtually natural future condition, would qualify for designation as long-term trend stations.

Data on the Stream Environment

An abundance of information related to the stream environment is or can be made available easily. Examples are data on drainage area and aquifer characteristics, stream-channel geometry, flood profiles, velocities and travel time of water, and lakes and ponds. Many statewide projects and special studies, particularly those related to stream-channel geometry, flood profiles, and the hydrology of lakes and ponds, are already underway or completed.

DISCUSSION OF THE EVALUATION

The requirements for types of data other than planning and design are established in response to specific needs, or are defined by hydrologic judgment. The discussion of the evaluation which follows is limited to conclusions and implications drawn from the results of regression analyses that appear in table A-2 (in appendix) compared with the accuracy goals (standard errors) established for natural-flow streams as shown in table 2.

Application of the regression relations in table A-2 will not, in general, provide estimates of desired accuracy for any of the eight flow characteristics listed in table 2 for minor streams in either the Peninsular Region or the Northwestern Region. Therefore, data collection on minor streams must, in general, be continued until satisfactory methods of estimating flow characteristics can be developed. Exceptions are the stream-gaging stations whose records are long enough that continued operation will produce little additional information. This point is considered to have been reached with 20 years of record. There are 14 such streamflow gaging stations on minor streams located in the Peninsular Region, averaging about 26 years of record already collected, and one in the Northwestern Region that has about 20 years of record already collected. It is expected that regression relations of the required accuracy probably can be obtained by research of additional or improved basin characteristics (independent variables).

Low-flow characteristics ($M_{7,2}$, $M_{7,20}$) at ungaged sites on minor or principal streams cannot be estimated adequately by regression methods. Therefore, low-flow characteristics at a site will require a few measurements of low flow correlated with concurrent flows at a suitable continuous-record index station where similar hydrologic conditions prevail.

Regression relations are not defined for any of the eight streamflow characteristics for drainage areas of less than about 30 square miles in either of the study regions. In the Peninsular Region, streams having less than about 50 square miles of drainage may be expected to have significant 7-day low flows on the average of once about every two years. Continuous-record or partial-record gaging stations must otherwise be operated to define the streamflow characteristics for small drainage basins in both study regions.

The accuracy goal of 25 years of record, or equivalent, has been met for seven gaging stations on principal streams. Their records average about 37 years in length. One potential principal stream site with 16 years of record would, by correlation with a downstream long-term trend site, have an equivalent of 25 years of record or more. Eight principal stream sites have been selected that must be continued in operation until such time that 25 years of record, or equivalent, have been collected.

Records needs to be continued, for hydrologic purposes, on 68 natural-flow gaging sites in the state, of which 56 are in the Peninsular Region and 12 are in the Northwestern Region. Operation of these gaging stations should be continued until generalized flow characteristics are defined.

CONCLUSIONS

The information developed in the evaluation of existing data, (including that developed by regression analysis) and in other sections of this report can be merged and plans for the future surface-water data program developed that will eventually attain as many of the goals as possible within the limits of available funds. For the optimum program, a balance must be maintained between data collection and data analysis. Continuous interaction between the two is needed to gain a better understanding of the hydrologic system and to guide future evaluation of the adequacy of the program to meet ever-changing needs and technology. Users of water data will be asked to comment on the network analysis before the data collection system is modified. Financial support now expended on the operation of stations that may be proposed for discontinuance should be directed toward data analyses and reports thereon.

Where streamflow characteristics have been defined adequately, elimination or reduction in collection of that type of data is justified. If, on the other hand, the accuracy of definition of streamflow is deficient, or if developments are being made or are anticipated in a basin, the various remedial steps that can be taken should be considered in this planning. Alternatives to be considered are either continued and augmented collection of the specific type of data necessary to increase time or geographic coverage of the sampling, or research to improve the analytical methods. If the effect of operational patterns on regulated streams are to be predicted, there is probably no alternative to systems studies.

Stage records are collected at about 250 stations in Florida (including 18 flood-profile stations). Because of this large number of stations, it seems advisable to mention them, even though data on stage of streams, reservoirs, and lakes were not analyzed in this study. In general, it appears that a statistical approach would be useful in the analysis of stage records and in determining the need for new stations or discontinuance of old ones.

Categorization of the existing gaging stations based upon the statistical analysis and goals portrayed herein is given by table 4 and figure 1. Existing crest-stage partial-record stations as shown in table 5 and figure 2 are to be continued in the proposed network. The following summarizes the analysis in terms of the four types of data needed to attain the goals established.

Data for Current Use

Operation of 117 continuous-record stations, identified as presently meeting the needs for current-purpose data, should be continued. These stations are listed and coded "C" in table 4 and identified in figure 1. The changing needs for current-purpose data are assessed continuously, and the data-collection network is modified by adding or discontinuing stations as needs change. Also, for each site, a determination will be made as to whether a continuous record of discharge is required for current purposes or whether low-flow or peak-flow partial-record would suffice.

Because the system of classification used in this study has not been extended to stage stations, the current-purpose stage stations have not been identified in table 4. However, the stage stations operated in the regulated systems in central and southern Florida can be seen to fill a current need for data in water management. Likewise, the records obtained on reservoirs are useful in the determination of amounts of water to store or release. Analysis may indicate that stage records alone may suffice at many sites where discharge is being collected for current purpose.

Table 4.--Continuous-record gaging stations in operation and proposed for the network

Column 1: B, benchmark or long-term-trend station.

Column 2: C, current-purpose station.

Columns 3-5: Purposes for which current-purpose station is operated; 1, assessment; 2, operation; 3, forecasting; 4, disposal; 5, water quality; 6, compact or legal; 7, research or special study.

Column 6: P, principal-stream station; H, hydrologic station except when classified as P; R, regulated stream; U, station data need and use to be revaluated.

Column 7: Effect of regulation on low and monthly flow; blank, no appreciable effect; 1, no appreciable effect on daily flow (diurnal fluctuation only); 2, no appreciable effect on weekly low flow; 3, monthly flow not affected by more than 10 percent of natural conditions; 4, monthly flow affected, but published data available to adjust to natural conditions with an error of less than 10 percent; 5, effect of regulation has not been evaluated; 6, effect on daily flow is appreciable (more than 10 percent); 7, effect on weekly low flow is appreciable (more than 10 percent); 8, monthly flow affected by more than 10 percent, and data not available to adjust to natural conditions with an error of less than 10 percent.

Column 8: Effect of regulation on peak flow for station shown as C or R in columns 2, or 6, respectively; blank, no appreciable effect; 1, annual peak flow affected by less than 10 percent; 2, annual peak flow affected by more than 10 percent; 3, annual peak flow affected by undetermined amount.

Column 9: Financing of station; 1, Federal; 2, cooperative program; 3, other federal agency; 4, combination of 1 and 2; 5, combination of 1 and 3; 6, combination of 2 and 3; 7, combination of 1, 2, and 3.

Station number	Station name	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
02-2285	North Prong St. Marys River at Moniac, Ga.	B	-	-	-	-	-	-	-	2
2305	South Prong St. Marys River at Glen St. Marys, Fla.	-	-	-	-	-	U	-	-	2
2310	St. Marys near Macclenny, Fla.	B	-	-	-	-	-	-	-	1
2312.53	St. Marys River near Gross, Fla.	-	C	1	-	-	P	-	-	2
2312.8	Thomas Creek near Crawford, Fla.	-	-	-	-	-	H	-	-	2
2316	Jane Green Creek near Deer Park, Fla.	-	-	-	-	-	H	-	-	2
2320	St. Johns River near Melbourne, Fla.	-	-	-	-	-	U	-	-	3
2322	Wolf Creek near Deer Park, Fla.	-	-	-	-	-	H	-	-	2
2324	St. Johns River near Cocoa, Fla.	-	-	-	-	-	U	-	-	2
2325	St. Johns River near Christmas, Fla.	B	-	-	-	-	-	-	-	3
2332	Little Econlockhatchee River near Union Park, Fla.	-	-	-	-	-	H	-	-	2
2335	Econlockhatchee River near Chuluota, Fla.	-	-	-	-	-	U	-	-	3
2348.15	Lake Wekiva Outlet near Maitland, Fla.	-	-	-	-	-	H	-	-	2
2350	Wekiva River near Sanford, Fla.	-	-	-	-	-	U	-	-	2
2360	St. Johns River near De Land, Fla.	-	-	-	-	-	H	-	-	3
2365	Big Creek near Clermont, Fla.	-	-	-	-	-	H	-	-	2
2369	Palatlakaha River at Cherry Lake Outlet, near Groveland, Fla.	-	C	2	-	-	R	5	3	2
2372.93	Palatlakaha River at structure M-1, near Okahumpka, Fla.	-	C	2	-	-	R	5	3	2
2377	Apopka-Beauclair Canal near Astatula, Fla.	-	C	2	-	-	R	5	3	2
2380	Haines Creek at Lisbon, Fla.	-	C	2	-	-	R	5	3	2
2385	Oklawaha River at Moss Bluff, Fla.	-	C	2	-	-	P	2	1	2
2395	Silver Springs near Ocala, Fla.	-	C	1	-	-	H	-	-	2
2430	Orange Creek at Orange Springs, Fla.	-	-	-	-	-	U	-	-	2
2439.6	Oklawaha River at Rodman Dam near Orange Springs, Fla.	-	C	2	-	-	R	5	3	3
2440.32	Cross Florida Barge Canal at St. Johns Lock, near Palatka, Fla.	-	C	2	-	-	R	5	3	3
2444.2	Little Haw Creek near Seville, Fla.	B	-	-	-	-	-	-	-	2
2444.5	St. Johns River at Palatka, Fla.	-	-	-	-	-	P	-	-	3
2452	Rice Creek near Palatka, Fla.	-	C	4	-	-	-	-	-	2
2455	South Fork Black Creek near Penney Farms, Fla.	B	-	-	-	-	-	-	-	2
2460	North Fork Black Creek near Middleburg, Fla.	-	-	-	-	-	U	-	-	2
2463	Ortega River near Jacksonville, Fla.	-	-	-	-	-	H	-	-	2
2465	St. Johns River at Jacksonville, Fla.	-	C	1	4	5	H	-	-	2
2469	Moultrie Creek at State Highway 207, near St. Augustine, Fla.	-	C	1	-	-	H	-	-	2
2475.1	Tomoka River near Holly Hill, Fla.	-	-	-	-	-	H	-	-	2
2480	Spruce Creek near Samsula, Fla.	-	C	1	-	-	H	2	-	2
2525	North Canal near Vero Beach, Fla.	-	C	1	7	-	R	5	3	2
2530	Main Canal near Vero Beach, Fla.	-	C	1	7	-	R	5	3	2
2535	South Canal near Vero Beach, Fla.	-	C	1	7	-	R	5	3	2
2565	Fisheating Creek at Palmdale, Fla.	B	C	1	-	-	-	-	-	3
2578	Harney Pond Canal at S-71, near Lakeport, Fla.	-	C	2	-	-	R	5	3	2

Table 4.--Continuous-record gaging stations in operation and proposed for the network--Continued

Station number	Station name	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
02-2592	Indian Prairie Canal at S-72, near Okeechobee, Fla.	-	C	2	-	-	R	5	3	2
2629	Boggy Creek near Taft, Fla.	-	-	-	-	-	H	2	-	2
2638	Shingle Creek at airport, near Kissimmee, Fla.	-	-	-	-	-	H	-	-	2
2638.51	Bay Lake Outlet at S-105A, near Vineland, Fla.	-	C	2	-	-	R	5	3	2
2638.69	South Lake Outlet at S-15, near Vineland, Fla.	-	C	2	6	7	R	5	3	2
2640	Cypress Creek at Vineland, Fla.	B	-	-	-	-	-	5	3	2
2641	Bonnet Creek near Vineland, Fla.	-	C	2	-	-	R	5	3	2
2644.95	Shingle Creek at Campbell, Fla.	-	C	7	-	-	R	5	3	2
2660.25	Reedy Creek at S-46, near Vineland, Fla.	-	C	2	7	-	R	5	3	2
2662	Whittenhorse Creek near Vineland, Fla.	-	C	2	7	-	-	-	-	2
2662.91	Lateral 405 at S-405A, near Doctor Phillips, Fla.	-	C	2	7	-	R	5	3	2
2663	Reedy Creek near Vineland, Fla.	-	C	2	7	-	R	5	3	2
2664.8	Davenport Creek at Loughman, Fla.	-	C	2	7	-	-	-	-	2
2665	Reedy Creek near Loughman, Fla.	-	C	2	7	-	R	5	3	2
2670	Catfish Creek near Lake Wales, Fla.	-	-	-	-	-	U	-	-	2
2689.03	Kissimmee River at S-65, near Lake Wales, Fla.	-	C	2	-	-	R	5	3	2
2695	Reedy Creek near Frostproof, Fla.	-	-	-	-	-	U	-	-	2
2705	Arbuckle Creek near De Soto City, Fla.	-	-	-	-	-	H	2	-	2
2715	Josephine Creek near De Soto City, Fla.	B	-	-	-	-	-	2	-	2
2730	Kissimmee River at S-65E, near Okeechobee, Fla.	-	C	1	2	3	R	5	3	2
2732	Canal 41A at S-68, at Lake Istokpoga, near Lake Placid, Fla.	-	C	1	2	-	R	5	3	2
2733	Canal 41A at S-84, near Okeechobee, Fla.	-	C	2	-	-	R	5	3	2
2740	Taylor Creek near Bassinger, Fla.	-	C	7	-	-	R	2	-	2
2744.95	Williamson Ditch at S-7, near Okeechobee, Fla.	-	C	2	7	-	-	-	-	2
2745	Taylor Creek above Okeechobee, Fla.	-	C	2	7	-	R	5	3	2
2769.84	Monreve Ranch drainage canal near Stuart, Fla.	-	C	7	-	-	-	-	-	2
2770	St. Lucie Canal at lock, near Stuart, Fla.	-	C	1	2	-	R	5	3	3
2780	West Palm Beach Canal at HGS-5 at Canal Point, Fla.	-	C	2	-	-	R	5	3	2
2784	West Palm Beach Canal above S-5A, near Loxahatchee, Fla.	-	C	2	-	-	R	5	3	2
2785	Diversions to Conservation Area No. 1 at S-5A and S-5AS, near Loxahatchee, Fla.	-	C	2	-	-	R	5	3	2
2785.5	Levee 8 Canal at West Palm Beach Canal, near Loxahatchee, Fla.	-	C	2	-	-	R	5	3	2
2786	West Palm Beach Canal at S-5AE, near Loxahatchee, Fla.	-	C	2	-	-	R	5	3	2
2790	West Palm Beach Canal at West Palm Beach, Fla.	-	C	1	2	-	R	5	3	2
2805	Hillsboro Canal at HGS-4, near South Bay, Fla.	-	C	1	2	-	R	5	3	2
2815	Hillsboro Canal near Deerfield Beach, Fla.	-	C	1	2	-	R	5	3	2
2816.25	El Rio Canal at Boca Raton, Fla.	-	C	2	-	-	R	5	3	2
2820	Pompano Canal at Pompano Beach, Fla.	-	C	2	-	-	R	5	3	2
2821	Cypress Creek Canal at S-37A, near Pompano Beach, Fla.	-	C	2	-	-	R	5	3	2
2827	Middle River Canal at S-36, near Fort Lauderdale, Fla.	-	C	2	-	-	R	5	3	2
2832	Plantation Road Canal at S-33, near Fort Lauderdale, Fla.	-	C	2	-	-	R	5	3	2
2834.98	North New River Canal at S-2 and HGS-4, near South Bay, Fla.	-	C	2	-	-	R	5	3	2
2835	North New River Canal below HGS-4, near South Bay, Fla.	-	C	2	-	-	R	5	3	2
2850	North New River Canal near Fort Lauderdale, Fla.	-	C	1	2	-	R	5	3	2
2854	South New River Canal at S-9, near Davie, Fla.	-	C	2	-	-	R	5	3	2
2861	South New River Canal at S-13, at Davie, Fla.	-	C	1	2	-	R	5	3	2
2862	Snake Creek Canal at N. W. 67th Avenue, near Hialeah, Fla.	-	C	1	2	-	R	5	3	2
2863	Snake Creek Canal at S-29, at North Miami Beach, Fla.	-	C	2	-	-	R	5	3	2
2863.4	Biscayne Canal at S-28, near Miami, Fla.	-	C	1	2	-	R	5	3	2
2864	Miami Canal at HGS-3 and S-3, at Lake Harbor, Fla.	-	C	2	-	-	R	5	3	2
2873.95	Miami Canal east of levee 30, near Miami, Fla.	-	C	2	-	-	R	5	3	2
2882	Miami Canal at Palmetto Bypass, near Hialeah, Fla.	-	C	2	-	-	R	5	3	2

Table 4.--Continuous-record gaging stations in operation and proposed for the network--Continued

Station number	Station name	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
02-2886	Miami Canal at N.W. 36th Street, Miami, Fla.	-	C	1	2	-	R	5	3	2
2888	Tamiami Canal Outlets, Monroe to Carnestown, Fla.	-	C	1	6	7	-	-	-	3
2889	Tamiami Canal Outlets, 40-mile bend to Monroe, Fla.	B	C	1	6	7	-	-	-	3
2889.6	Big Cypress Swamp at Everglades Parkway, near Sunniland, Fla.	-	C	7	-	-	H	-	-	3
2890.3	Levee 3 Canal near Clewiston, Fla.	-	C	2	-	-	R	5	3	3
2890.4	Tamiami Canal Outlets, levee 67A to 40-mile bend, near Miami, Fla.	-	C	1	2	6	R	5	3	3
2890.6	Tamiami Canal Outlets, levee 30 to levee 67A, near Miami, Fla.	-	C	1	2	6	R	5	3	3
2895	Tamiami Canal near Coral Gables, Fla.	-	C	2	-	-	R	5	3	2
2906.1	Snapper Creek Canal at Miller Drive, near South Miami, Fla.	-	C	2	-	-	R	5	3	2
2907	Snapper Creek Canal at S-22 near South Miami, Fla.	-	C	2	-	-	R	5	3	2
2907.1	Black Creek Canal above S-21, near Goulds, Fla.	-	C	2	-	-	R	5	3	2
2907.25	Mowry Canal near Homestead, Fla.	-	C	2	-	-	R	5	3	2
2907.69	Canal 111 at S-18-C, near Florida City, Fla.	-	C	2	-	-	R	5	3	2
2908	Taylor Slough near Homestead, Fla.	-	-	-	-	-	H	5	3	3
2910	Barron River Canal near Everglades, Fla.	-	C	1	-	-	H	-	-	1
2910.47	Fakahatchee Slough at James Road, near Copeland, Fla.	-	C	7	-	-	H	-	-	3
2911.43	Faka Union Canal near Copeland, Fla.	-	C	7	-	-	H	-	-	3
2912.7	Henderson Creek Canal near Naples, Fla.	-	C	7	-	-	-	-	-	2
2913	Golden Gate Canal near Naples, Fla.	-	C	7	-	-	-	-	-	2
2913.93	Cocohatchee River Canal near Naples Park, Fla.	-	C	7	-	-	-	-	-	2
2920	Caloosahatchee Canal at Moore Haven, Fla.	-	C	2	-	-	R	5	3	3
2929	Caloosahatchee River at S-79, near Olga, Fla.	-	C	1	2	-	R	5	3	6
2939.86	Peace Creek drainage canal near Alturas, Fla.	-	-	-	-	-	U	-	-	2
2940.68	Lake Lulu Outlet at Eloise, Fla.	-	-	-	-	-	U	-	-	2
2944.91	Saddle Creek at structure P-11, near Bartow, Fla.	-	C	2	-	-	R	5	3	2
2946.5	Peace River at Bartow, Fla.	B	-	-	-	-	-	2	-	2
2956.37	Peace River at Zolfo Springs, Fla.	-	-	-	-	-	U	-	-	2
2962.23	Little Charley Bowlegs Creek near Sebring, Fla.	-	C	2	-	-	-	2	-	2
2965	Charlie Creek near Gardner, Fla.	-	-	-	-	-	U	-	-	2
2967.5	Peace River at Arcadia, Fla.	-	C	1	5	-	H	-	-	1
2971	Joshua Creek at Nocatee, Fla.	B	-	-	-	-	-	-	-	2
2973.1	Horse Creek near Arcadia, Fla.	-	-	-	-	-	H	-	-	2
2982.02	Shell Creek near Punta Gorda, Fla.	-	C	2	-	-	-	5	3	2
2988.3	Myakka River near Sarasota, Fla.	-	C	1	-	-	-	2	-	2
2994.7	Big Slough near Murdock, Fla.	-	-	-	-	-	H	-	-	2
2999.5	Manatee River near Myakka Head, Fla.	-	-	-	-	-	H	-	-	2
3001	Little Manatee River near Fort Lonesome, Fla.	-	-	-	-	-	H	-	-	2
3005	Little Manatee River near Wimauma, Fla.	B	-	-	-	-	-	-	-	2
3010	North Prong Alafia River at Keysville, Fla.	-	-	-	-	-	H	-	-	2
3013	South Prong Alafia River near Lithia, Fla.	-	-	-	-	-	H	-	-	2
3013.5	Little Alafia River near Hopewell, Fla.	-	-	-	-	-	H	-	-	2
3015	Alafia River at Lithia, Fla.	-	C	1	-	-	-	-	-	2
3017.8	Sixmile Creek at Buffalo Avenue, near Tampa, Fla.	-	-	-	-	-	H	-	-	2
3019	Fox Branch near Socrum, Fla.	-	-	-	-	-	H	-	-	2
3025	Blackwater Creek near Knights, Fla.	-	-	-	-	-	U	-	-	2
3030	Hillsborough River near Zephyrhills, Fla.	-	C	1	3	5	-	2	1	2
3031	New River near Zephyrhills, Fla.	-	-	-	-	-	H	-	-	2
3034	Cypress Creek near San Antonio, Fla.	-	-	-	-	-	H	-	-	2
3038	Cypress Creek near Sulphur Springs, Fla.	-	-	-	-	-	H	-	-	2
3045	Hillsborough River near Tampa, Fla.	-	C	1	2	-	R	4	1	2
3060	Sulphur Springs at Sulphur Springs, Fla.	-	-	-	-	-	H	5	3	2
3065	Sweetwater Creek near Sulphur Springs, Fla.	-	-	-	-	-	U	-	-	2
3070	Rocky Creek near Sulphur Springs, Fla.	-	-	-	-	-	H	-	-	2
3073.59	Brooker Creek near Tarpon Springs, Fla.	-	-	-	-	-	U	-	-	2
3076.97	Alligator Creek at Safety Harbor, Fla.	-	-	-	-	-	H	2	-	2
3088.89	Seminole Lake Outlet near Largo, Fla.	-	-	-	-	-	U	-	-	2

Table 4.--Continuous-record gaging stations in operation and proposed for the netowrk--Continued

Station number	Station name	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
02-3098.48	South Branch Anclote River near Odessa, Fla.	-	-	-	-	-	H	-	-	2
3100	Anclote River near Elfers, Fla.	B	-	-	-	-	-	-	-	2
3102.4	Jumping Gully at Loyce, Fla.	-	-	-	-	-	H	-	-	2
3103	Pithlachascotee River near New Port Richey, Fla.	-	-	-	-	-	H	-	-	2
3103.5	Bear Creek near Hudson, Fla.	-	-	-	-	-	H	-	-	2
3107.5	Crystal River near Crystal River, Fla.	-	-	-	-	-	H	-	-	2
3108	Withlacoochee River near Eva, Fla.	-	-	-	-	-	H	-	-	2
3109.47	Withlacoochee River near Compressco, Fla.	-	-	-	-	-	H	-	-	2
3110	Withlacoochee-Hillsborough overflow near Richland, Fla.	-	C	2	-	-	H	-	-	2
3120	Withlacoochee River at Trilby, Fla.	B	-	-	-	-	-	5	2	2
3121.8	Little Withlacoochee River near Tarrytown, Fla.	-	-	-	-	-	H	-	-	2
3122	Little Withlacoochee River at Rerdell, Fla.	-	-	-	-	-	H	-	-	2
3125	Withlacoochee River at Croom, Fla.	-	-	-	-	-	U	-	-	2
3126.4	Jumper Creek Canal near Bushnell, Fla.	-	-	-	-	-	H	-	-	2
3127	Outlet River at Panacoochee Retreats, Fla.	-	-	-	-	-	H	5	3	2
3127.2	Withlacoochee River at Wysong Dam, at Carlson, Fla.	-	C	2	-	-	H	2	1	2
3129.75	Tsala Apopka outfall canal at S-353, near Hernando, Fla.	-	C	2	-	-	R	-	-	2
3130	Withlacoochee River near Holder, Fla.	-	C	1	-	-	-	-	-	3
3131	Rainbow Springs near Dunnellon, Fla.	-	-	-	-	-	H	-	-	2
3132.3	Withlacoochee River at Inglis Dam, near Dunnellon, Fla.	-	C	2	-	-	R	5	3	3
3137	Waccasassa River near Gulf Hammock, Fla.	-	-	-	-	-	P	-	-	2
3142	Tenmile Creek at Lebanon Station	-	-	-	-	-	H	-	-	2
3155	Suwannee River at White Springs, Fla.	-	-	-	-	-	H	-	-	1
3190	Withlacoochee River near Pinetta, Fla.	-	C	4	-	-	-	-	-	2
3195	Suwannee River at Ellaville, Fla.	-	-	-	-	-	U	-	-	3
3205	Suwannee River at Branford, Fla.	B	C	1	5	-	-	-	-	2
3207	Santa Fe River near Graham, Fla.	-	-	-	-	-	H	2	-	2
3210	New River near Lake Butler, Fla.	-	-	-	-	-	U	-	-	2
3215	Santa Fe River at Worthington Springs, Fla.	B	-	-	-	-	-	2	-	2
3220	Santa Fe River near High Springs, Fla.	-	-	-	-	-	U	-	-	2
3225	Santa Fe River near Fort White, Fla.	-	-	-	-	-	U	-	-	2
3235	Suwannee River near Wilcox, Fla.	-	C	1	-	-	-	-	-	2
3240	Steinhatchee River near Cross City, Fla.	-	C	1	-	-	P	-	-	2
3244	Fenholloway River near Foley, Fla.	-	-	-	-	-	H	-	-	2
3245	Fenholloway River at Foley, Fla.	-	C	4	-	-	R	5	-	2
3260	Econfina River near Perry, Fla.	-	C	1	-	-	H	-	-	2
3265	Aucilla River at Lamont, Fla.	-	C	1	-	-	P	5	3	2
3269	St. Marks River near Newport, Fla.	-	C	1	-	-	P	-	-	2
3271	Sopchoppy River near Sopchoppy, Fla.	B	C	1	5	7	H	-	-	1
3290	Ocklockonee River near Havana, Fla.	-	C	1	2	5	-	-	-	2
3295	Little River near Quincy, Fla.	B	-	-	-	-	-	-	-	2
3300	Ocklockonee River near Bloxham, Fla.	-	C	1	2	-	R	4	2	2
3301	Telogia Creek near Bristol, Fla.	-	-	-	-	-	U	-	-	2
3303	New River near Wilma, Fla.	-	-	-	-	-	H	-	-	2
3580	Apalachicola River at Chattahoochee, Fla.	-	C	1	2	-	R	5	3	3
3587	Apalachicola River near Blountstown, Fla.	-	-	-	-	-	U	-	-	3
3590	Chipola River near Altha, Fla.	B	C	1	-	-	-	2	-	3
3594.5	Econfina Creek near Fountain, Fla.	-	-	-	-	-	H	-	-	2
3595	Econfina Creek near Bennett, Fla.	-	C	1	-	-	-	-	-	2
3655	Choctawhatchee River at Caryville, Fla.	-	C	1	5	-	-	1	-	1
3658	Seven Runs near Redbay, Fla.	-	-	-	-	-	H	-	-	2
3660	Holmes Creek at Vernon, Fla.	B	-	-	-	-	P	-	-	2
3665	Choctawhatchee River near Bruce, Fla.	-	C	1	-	-	-	-	-	2
3669	Magnolia Creek near Freeport, Fla.	-	-	-	-	-	H	-	-	2
3670	Alaqua Creek near De Funiak Springs, Fla.	B	-	-	-	-	-	-	-	2
3673.1	Juniper Creek at State Highway 85, near Niceville, Fla.	-	-	-	-	-	H	-	-	2
3680	Yellow River at Milligan, Fla.	-	C	1	-	-	-	-	-	2
3683	Baggett Creek near Milligan, Fla.	-	-	-	-	-	H	-	-	2
3685	Shoal River near Mossy Head, Fla.	-	-	-	-	-	H	-	-	2
3690	Shoal River near Crestview, Fla.	-	C	1	-	-	-	-	-	2
3700	Blackwater River near Baker, Fla.	-	C	1	-	-	H	-	-	2
3705	Big Coldwater Creek near Milton, Fla.	-	C	1	-	-	-	-	-	2
3707	Pond Creek near Milton, Fla.	-	-	-	-	-	H	-	-	2
3755	Escambia River near Century, Fla.	-	C	1	5	-	-	2	-	2
3760	Pine Barren Creek near Barth, Fla.	-	-	-	-	-	H	-	-	2
3763	Brushy Creek near Walnut Hill, Fla.	-	-	-	-	-	H	-	-	2
3765	Perdido River at Barrineau Park, Fla.	B	-	-	-	-	-	-	-	2

Table 5.--Crest-stage partial-record stations in proposed program

Station number	Station name	Drainage area (sq. mi.)
02-2300	Turkey Creek at Macclenny, Fla.	20.9
2311	St. Marys River near St. George, Ga.	900
2312.3	Pigeon Creek at Boulogne, Fla.	7.87
2312.5	Little St. Marys River near Hilliard, Fla.	20.8
2324.5	Jim Creek near Christmas, Fla.	22.7
2331.02	Econlockhatchee River tributary near Bithlo, Fla.	-
2352	Black Water Creek near Cassia, Fla.	135
2361.2	Deep Creek near Barberville, Fla.	23
2409.2	Fairfield Sink Drain at Fairfield, Fla.	Indeterminate
2409.5	Hogtown Creek near Gainesville, Fla.	18.5
2418	Lochloosa Creek near Melrose, Fla.	-
2419	Lochloosa Creek at Grove Park, Fla.	34.7
2435.3	Bruntbridge Brook at Kenwood, Fla.	4.63
2453	Clarkes Creek near Green Cove Springs, Fla.	8.81
2454	South Fork Black Creek near Camp Blanding, Fla.	34.8
2454.7	Greens Creek near Penney Farms, Fla.	14.9
2459	Yellow Water Creek near Maxville, Fla.	25.7
2461.5	Big Davis Creek at Bayard, Fla.	13.6
2462	Durbin Creek near Durbin, Fla.	36.7
2466	Trout River at Dinsmore, Fla.	19.9
2472	Fish Swamp Outlet near Summer Haven, Fla.	4.86
2476	Little Tomoka River near Ormond Beach, Fla.	10
2510	South Prong Sebastian Creek near Sebastian, Fla.	Indeterminate
2697.2	Morgan Hole Creek near Avon Park, Fla.	-
2916	Estero River at Estero, Fla.	Indeterminate
2930.5	Orange River at Buckingham near Fort Myers, Fla.	70
2933.9	North Prong Alligator Creek near Punta Gorda, Fla.	8.46
2934	Alligator Creek near Punta Gorda, Fla.	31.1
2954.35	Hog Branch near Wauchula, Fla.	-
2984.82	Johnson Creek near Myakka Head, Fla.	-

Table 5.--Crest-stage partial-record stations in proposed program--Continued

Station number	Station name	Drainage area (sq. mi.)
02-2998	Phillippi Creek at Sarasota, Fla.	45
3000.4	Braden River near Bradenton, Fla.	59
3000.44	Braden River near Elwood Park, Fla.	59
3002	South Fork Little Manatee River near Duette, Fla.	9.4
3007	Bull Frog Creek near Wimauma, Fla.	29.1
3013.14	Mizelle Creek near Keysville, Fla.	-
3032	Pemberton Creek near Dover, Fla.	24
3033.58	Cypress Creek near Darby, Fla.	-
3034.2	Cypress Creek at Worthington Gardens, Fla.	117
3102.12	Peck Sink Drain near Brooksville, Fla.	16.6
3103.55	Bear Creek below Bear Sink near Hudson, Fla.	29.7
3125.30	Blue Sink Drain near Brooksville, Fla.	29.2
3126.85	Walled Sink Drain near Coleman, Fla.	Indeterminate
3134	Waccasassa River near Bronson, Fla.	150
3155.34	Rocky Creek tributary near Wellborn, Fla.	-
3176.3	Alapaha River near Jasper, Fla.	1,720
3216	Olustee Creek near Lulu, Fla.	49.1
3217	Swift Creek near Lake Butler, Fla.	46.0
3218	Olustee Creek near Providence, Fla.	163
3218.94	Olustee Creek tributary near Providence, Fla.	-
3250	Fenholloway River near Perry, Fla.	160
3262.5	Aucilla River near Aucilla, Fla.	345
3262.61	Little Aucilla River near Cherry Lake, Fla.	-
3263	Little Aucilla River near Greenville, Fla.	90.7
3265.98	Caney Creek near Monticello, Fla.	2.54
3267	Lloyd Creek at Lloyd, Fla.	31.2
3268	Copeland Sink Drain at Lloyd, Fla.	285
3270.5	Sopchoppy River near Arran, Fla.	48.2
3296	Little River near Midway, Fla.	305
3300.5	Telogia Creek near Greensboro, Fla.	28.1
3302	New River at Vilas, Fla.	23.2
3304	New River near Sumatra, Fla.	157
3586	Flat Creek near Chattahoochee, Fla.	24.9
3588	Chipola River at Oakdale, Fla.	519
3589.98	Holliman Branch near Altha, Fla.	2.04

Table 5.--Crest-stage partial-record stations in proposed program--Continued

Station number	Station name	Drainage area (sq. mi.)
02-3593	Sandy Creek near Panama City, Fla.	25
3593.5	Econfina Creek near Compass Lake, Fla.	40.5
3595.5	Bear Creek near Youngstown, Fla.	67.2
3652.37	Fowler Branch near Leonia, Fla.	5.09
3657	Sandy Creek at Ponce de Leon, Fla.	115
3661.64	Reedy Branch at New Hope, Fla.	1.99
3668.59	Pate Branch near Freeport, Fla.	1.87
3672.42	Little Rocky Creek near Niceville, Fla.	3.70
3689	Shoal River at U. S. Highway 90 near Crestview, Fla.	365
3700.15	Muddy Branch near Beaver Creek, Fla.	1.45
3707.5	Hurricane Branch near Milton, Fla.	2.95
3765.51	Churchhouse Branch near Barrineau Park, Fla.	.92

Data for Planning and Design

Natural-flow Streams

Estimates by the regression relations for all flow characteristics will not in general meet the accuracy goals for either minor or principal streams. Operation of the 68 stations listed in table 4 and coded "H," or, "C" and "H," needs to be continued until such time as improved methods of estimating flow characteristics have been determined. The stations are also shown in figure 1. Research is needed to find additional or improved basin characteristics (independent variables) that would reduce standard errors of multiple-regression relations or to find other estimating techniques to attain the accuracy goals set for these stations on minor and principal streams.

The peak-flow partial-record stations shown in figure 2 are recommended for continued operation chiefly to define flood-flow characteristics on streams having drainage areas less than about 30 square miles. Data collected at these stations should be merged with data from continuous-record gaging stations on larger basins to define flood-flow characteristics for all ranges of drainage areas.

Because low-flow characteristics for most of the basins in Florida cannot be estimated satisfactorily by regression methods, flow measurements need to be continued at ungaged and discontinued natural-flow sites during periods of base flow. Research is proposed for developing analytical methods to be used for estimating low-flow characteristics within specified limits of accuracy for any area of the State. Data already available or being collected fill much of the data requirements for such research. However, additional data on the stream (or lake) environment is needed, particularly on aquifer characteristics that control low flows.

Flow characteristics have been defined from more than 20 years of record at 15 minor and 8 principal streamflow sites in Florida. An additional station on a regulated stream, Apalachicola River near Blountstown, Florida, has practically the same drainage area as a current-purpose and regulated station upstream. Each of these 24 stations (listed and coded "U" in table 4) is to be revaluated as to data need and use. If after revaluation, the objective for which it was operated is considered to have been met, the station could be discontinued or reclassified, as appropriate.

Regulated-flow Streams

The analysis of flow characteristics for stations on regulated-flow streams was limited to identifying the regulated-stream systems where future model studies are needed. The regulated streams in Florida, particularly in the central and southern parts, offer perhaps the greatest challenge in the future program. Regulated streams should be considered as a flow system and plans made to obtain the required data input for systems models. All regulated-flow stations included in the proposed program are identified and listed in table 4 and shown in figure 1. First priority should be given to model studies of those regulated-stream systems located mostly in central and southern Florida. Following is a listing of the basins in which these systems are located; the designation preceding each basin refers to the smaller map in figure 1.

09E2. Oklawaha River

09G. Withlacoochee River basin

10A. Turkey Creek and coastal area south to St. Lucie River

10B1. Lake Okeechobee inflow area

10B2. Lake Okeechobee and the Everglades

10D. Peace River basin

10F. Coastal area between Myakka River and Alafia River

10G. Alafia River basin

10H. Hillsborough River basin and coastal area north of Alafia River

10J. Coastal area between Hillsborough River and Withlacoochee River

Data to Define Long-Term Trends

Twenty-two existing stations in Florida, including one federal bench-mark station, were selected as long-term trend stations and should be operated indefinitely to meet the needs for this type of data. The stations are listed and coded "B" in table 4 and shown in figure 1. These stations were selected to provide a long-term representative sample of stations on streams which have undergone little or no man-made changes during the period of record and are expected to remain relatively unchanged in the future. Seven headwater stations proposed in the Georgia and Alabama programs supplement the Florida program and complete the network of 29 long-term trend stations. The network is well distributed areally in basins with a variety of physical characteristics.

Data on the Stream Environment

In Florida programs already in progress or completed will fill much of the need for data on the stream environment. Hydrologic data obtained at each of the stations listed in table 4 and such studies as those of the hydrology of lakes, floods in small basins, low-flow characteristics, flood-plain mapping, and flood profiles, will provide much valuable information related to the hydrologic environment. The following additional data need to be obtained for hydrologic studies and for planning, designing, operating systems for controlling water or pollution, and for appraising the effect of changes in land use on the flow regime.

1. Data on stream-channel geometry.

2. Data on use of land in drainage basins and adjacent to streams.

3. Data on time of travel of water and waste in channels.

4. Data on aquifer characteristics, particularly those related to low flows.

5. Data on use and development of water.

6. Data on quality characteristics of material and man affected waters.

7. Data on assimilative capacity and other organic and inorganic chemical and biological interreactions.

Data Analyses and Hydrologic Studies

The streamflow-data network operated through the years supplies a base for analyses and reports which should be started as soon as the proposed streamflow-data program can be implemented. Some aspects of data analyses are of a continuing nature, with the data-collection effort continuing, but reoriented as necessary to fill gaps or eliminate deficiencies, and to provide data for continuing future analyses.

The proposed program of data analyses for Florida streams may be classed in two phases--those based on data collected to date, and those for which additional data will be required.

Analyses which require no additional data collection should be implemented and considered as top priority:

1. This streamflow evaluation study indicated that most of the streamflow characteristics listed in Tables 2 and A-2 could not be predicted within the standards of accuracy specified. The reason for deficiencies in the multiple-regression method need to be examined. The method of prediction may have been deficient because the model was inadequate and because indices of all the important basin characteristics were not included or were not adequately defined. Research is needed for determining more suitable models and means of developing better indices of basin characteristics. A report presenting the results of this research should be prepared. Basically, the report will serve as an implementation or updating of the streamflow data evaluation.

2. Flood data obtained at 77 crest-stage partial-record stations (table 5, figure 2) should be merged with the results of regionalization from study 1, above, to obtain better areal definition of flood flows for any size drainage basin. Failure to obtain acceptable areal definition of flood flows, particularly for small-sized basins, may indicate the need for collection of data on storm rainfall and runoff to define model parameters, anticipating that flood records could be extended in time by use of the model and long-term rainfall records. Reports should be prepared which would update previous reports on magnitude and frequency of floods, and which would also include data on magnitude and frequency of flood volumes.

3. Results of multiple-regression methods used in the streamflow evaluation studies provide only rough estimates of low-flow characteristics at sites where little or no discharge information is available. Research is needed for defining and evaluating low-flow characteristics at gaged and ungaged sites in Florida. Data needed for analysis will be provided by low-flow records collected at short-term continuous-record sites, from discharge measurements made at sites during periods of base flow, and concurrent data collected at continuous-record sites. Additional information may be developed from a study of base-flow recession curves as related to ground-water outflow characteristics. Information may be developed on the lower end of the duration curve as an indication of the low-flow characteristics of a stream. A report entitled "Low-flow characteristics of Florida streams" should be prepared presenting the results of this investigation. Frequency characteristics at continuous-record stations should be given in detail. The low-flow characteristics reported should include those that could be tied to legal indices such as the legal index for pollution control. Examples are the lowest mean discharge for 7, 14, 30 days, and low-flow season. Information at each continuous-record station should include brief station descriptions and tables summarizing the lowest mean discharge for selected numbers of days and selected points on the duration curve (if meaningful). Drainage maps should be prepared showing every site at which base-flow measurements (or observations of no flow) were obtained. The report should show the estimated low-flow frequency characteristics and measured discharges at each site.

Occasional regions of appreciable size may be found to be homogeneous with respect to low-flow characteristics and to drainage basin and ground-water outflow characteristics. For such regions, relationships should be presented that would provide a method for approximating low-flow characteristics at unmeasured sites. The report should identify all diversions and sources of regulation and their relative effect on low-flow characteristics. Information on low-flow characteristics developed in this study will be useful as parameters in draft-storage analyses. Storage analyses should be the subject of a separate low-flow report.

4. The program should be continued for updating the determination of drainage areas of Florida streams and for the computation of other basin characteristics found to be significant in studies 1, 2, and 3, above, and including river mileage. The updating should be scheduled as new topographic maps and meteorologic information become available. The final objective of this program is publication of a gazeteer of streams in sections by basins, and beginning with basins where adequate 7½-minute maps are now available. The information presented would be used by investigators or water managers planning water projects or studying basin-aquifer systems.

5. The program of preparing and publishing atlas maps for supplementing interpretive reports on streamflow characteristics; lake hydrology; the quantities, intensities, areal distribution, magnitude, and frequency of rainfall should be continued. Many of the physical and environmental parameters related to streamflow and lakes would be presented in these reports. Preparation and publication of the lake atlas reports should be scheduled for selected important lakes in Florida for which long-term records are available and for which statistical analyses have shown independent variables, such as rainfall, to have significant effect in controlling lake levels.

6. The report, "Springs of Florida" by Ferguson and others, 1947, should be updated to include an inventory of available data on quantity and quality of spring flow. The updated report should present meaningful flow statistics of springs for which records of sufficient length are available.

7. Stage records currently collected at about 250 stations in Florida should be analyzed using a statistical approach which may produce results useful in determining an optimum stage network. The analysis should determine whether stage records alone will suffice at many sites where discharge and stage are being collected. Stage-frequency relations, particularly for flood stages, will be analyzed from available aerial photographs, maps, flood information, and gaging station data. A report should be prepared and published presenting the results of the study. The method of presentation should follow closely that of the streamflow evaluation study.

Utilizing available data to the extent possible, but depending primarily on the collection of additional data specifically required, the following studies should be initiated as a part of the proposed streamflow data program:

1. Time of travel and dispersion of solutes in selected streams.
2. Stochastic and deterministic modeling of stream systems with first emphasis on regulated-stream and canal systems, giving first priority to Lake Okeechobee and the Everglades system in southern Florida.
3. Modeling of stream-aquifer systems by basins.
4. Areas inundated by flood water and compilation of flood profiles on principal streams statewide.
5. Gains and losses of flows of selected streams.
6. Frequency of floods in urban and suburban areas. Elevation and frequency of floods should be investigated for critical areas.
7. Effects of small reservoirs, channel improvements, and land use on streamflow characteristics.
8. Flood histories on principal streams based on available data and field research.

Additional analyses and hydrologic studies should be included as they become important. Changing needs for streamflow information and changes in technology must be continually evaluated and coordinated into the streamflow-data program for Florida.

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Table A-1.--Basin characteristics at Gaging Stations.

Station number	Basin characteristics										
	Drainage area (square miles)	Slope (feet per mile)	Main channel length (miles)	Surface storage (area, in percent)				Forest cover (percent)	Annual precipitation (inches)	2-year, 24 hour rainfall (inches)	Soils index (inches)
				Lakes only	Swamps only	Lakes with forest cover	Swamps with forest cover				
Peninsular Region											
09C St. Marys River basin and coastal area											
02-2285	160	0.16	12.40	0.17	1.40	0	72.53	21.79	52.0	4.32	3.11
2290	45	2.12	12.20	0	0	0	15.05	77.43	53.1	4.20	2.45
2300	20.9	5.41	7.57	0	0	0	18.54	73.53	55.6	4.48	3.20
2305	130	2.69	24.72	.94	05	0	15.59	71.26	55.1	4.13	3.03
2310	700	2.56	34.10	.26	.66	0	31.68	60.36	53.3	4.07	2.81
09E1 St. Johns River above Oklawaha River											
2316	248	2.59	27.62	.33	3.37	9.24	6.07	1.61	54.4	4.59	2.05
2320	968	.15	50.93	1.45	22.99	2.45	5.49	4.39	58.0	4.44	1.74
2322	25.7	6.83	8.60	.19	1.44	5.95	3.54	.16	55.0	4.59	2.04
2324	1,331	.18	80.62	2.51	22.24	2.34	4.69	8.09	57.5	4.41	1.76
2325	1,512	.18	104.0	2.45	23.18	2.48	4.67	10.45	57.3	4.40	1.79
2332	27.1	3.73	6.02	1.77	.92	2.07	10.64	6.98	50.9	4.17	2.33
2335	241	2.00	39.12	1.51	1.39	6.96	8.30	8.87	52.1	4.05	2.21
2360	3,120	.18	170.7	4.29	13.78	1.78	8.45	18.02	55.2	4.24	2.48
09E2 Oklawaha River											
2365	68	.75	28.27	4.54	9.72	.10	27.55	2.19	52.5	4.70	2.52
2370	180	.93	49.44	10.83	5.73	1.03	14.77	5.23	51.7	4.43	2.66
2380	640	1.09	76.47	22.39	3.30	.45	8.21	8.06	51.2	4.09	4.14
2385	910	.95	95.97	20.29	2.97	.37	6.08	13.93	51.1	3.97	4.51
2390	1,070	.91	108.6	18.72	3.06	.32	6.03	17.68	51.3	3.93	4.56
2400	1,140	.91	111.0	17.55	2.87	.30	5.96	18.32	51.3	3.91	4.45
2405	1,480	.87	127.9	14.26	2.30	.23	5.88	23.24	51.6	3.89	4.48
2419	37.4	6.33	11.44	1.35	0	5.22	6.86	58.67	51.1	3.92	3.89
2430	440	2.00	52.42	11.35	1.59	1.73	8.38	40.95	51.5	3.77	4.12
2435	1,980	.85	139.2	13.67	2.10	.57	6.66	31.18	51.5	3.85	4.83
2440	2,160	.83	149.1	12.58	2.13	.55	7.30	30.24	51.8	3.85	4.88
09E3 St. Johns River below Oklawaha River											
2444.2	120	1.55	30.15	5.04	1.21	0	13.36	28.86	54.6	4.42	2.86
2455	134	7.98	16.40	.76	2.59	0	4.98	53.89	55.1	3.85	6.09
2459	25.7	7.55	4.35	.04	1.29	0	4.36	33.29	55.8	4.51	1.90
2460	174	5.22	24.68	1.47	1.24	0	6.57	54.87	55.6	4.15	6.23
09F Coastal area between St. Johns River and Turkey Creek											
2470	23.3	2.43	11.85	0	5.36	0	24.44	29.76	52.2	4.66	2.05
2480	32	.6	8.89	.22	0	.60	36.33	41.05	52.4	4.74	2.05
2495	12.6	.6	8.75	4.67	0	0	0	85.60	57.1	4.82	2.04
10A Turkey Creek and coastal area south to St. Lucie River											
2500	95.5	2.2	13.07	1.11	15.39	0	.35	24.13	57.6	4.68	1.81
2520	78.4	.8	12.55	.51	17.56	0	.10	4.44	60.5	4.70	1.60
10B1 Lake Okeechobee inflow area											
2560	188	1.32	28.25	.11	14.32	0	1.49	3.50	52.4	4.49	2.22
2565	311	1.33	50.24	.15	11.92	0	3.77	3.75	52.1	4.33	2.15
2615	111	.29	13.85	16.17	4.85	11.99	1.67	3.31	51.3	4.36	2.05
2629	83.6	2.04	14.20	6.46	.49	2.33	6.04	1.22	51.3	4.15	3.08
2635	308	.31	30.33	17.01	3.19	5.77	4.38	3.45	51.2	4.19	2.33
2638	89.2	1.78	20.81	6.03	.90	.69	8.91	3.36	51.9	4.25	2.28
2640	30.3	.41	12.02	26.73	.50	.82	6.99	5.34	52.1	4.38	5.31
2650	620	.29	44.83	15.89	2.66	3.53	6.68	3.78	51.6	4.20	2.15
2660	86.5	.75	20.99	4.82	1.84	9.15	11.82	2.35	51.2	4.63	2.05
2665	110	2.46	14.21	7.05	1.47	1.02	19.09	5.46	52.2	4.42	4.21
2670	58.9	1.66	9.61	12.82	2.62	.22	3.04	10.25	53.2	4.83	4.88
2690	1,607	.21	77.99	14.79	4.03	2.39	8.10	7.45	52.0	4.44	4.58
2695	60.9	3.12	17.84	26.76	2.59	0	1.21	13.46	54.0	4.43	4.21
2700	38.8	4.90	12.68	14.74	.49	0	.41	5.05	53.7	4.77	4.38
2705	379	1.40	47.16	8.98	3.98	.01	6.06	9.77	52.9	4.30	2.88
2710	44	6.21	12.60	26.72	.48	0	.07	5.78	51.5	4.95	5.10
2715	109	3.81	14.49	19.32	.74	0	3.12	4.65	52.4	4.86	5.14
2730	2,899	.26	152.8	12.16	6.82	1.33	5.56	6.47	52.3	4.44	2.53
2740	15.7	5.17	7.60	0	3.83	0	.06	1.60	56.2	4.43	2.05
2745	98.7	2.57	19.95	.14	6.00	.08	.25	3.92	57.4	4.48	2.05

Table A-1.--Basin characteristics at Gaging Stations--Continued

Station number	Basin characteristics										
				Surface storage (area, in percent)							
	Drainage area (square miles)	Slope (feet per mile)	Main channel length (miles)	Lakes only	Swamps only	Lakes with forest cover	Swamps with forest cover	Forest cover (percent)	Annual precipitation (inches)	2-year, 24 hour rainfall (inches)	Soils index (inches)
				Peninsular Region--Continued							
				10B2 Lake Okeechobee and the Everglades							
02-2930	60	1.64	11.62	2.62	5.83	0.02	0.10	1.76	52.4	4.75	2.01
				10D Peace River Basin							
2936.94	58	1.32	13.10	24.20	2.03	0	6.48	3.36	52.9	4.84	5.35
2939.86	160	1.26	26.55	12.79	5.93	0	4.76	4.46	53.3	4.55	3.88
2940.68	23	1.27	8.30	32.86	.78	0	.82	9.94	52.8	4.88	5.28
2946.5	390	1.25	35.67	13.26	3.50	02	7.31	12.72	52.8	4.45	4.05
2956.37	826	1.38	71.82	7.14	3.58	01	5.73	15.22	53.6	4.45	4.05
2962.23	41.9	1.25	10.15	.43	14.16	0	10.34	5.16	54.1	5.14	2.22
2965	330	1.68	35.03	.10	7.36	0	6.72	7.02	54.9	4.82	2.08
2967.5	1,367	1.30	104.0	4.34	4.85	01	5.47	13.49	54.1	4.56	3.04
2971	132	4.06	21.12	.14	5.76	0	1.03	3.64	53.6	4.15	2.03
2973.1	218	2.79	44.91	.12	5.98	0	3.60	9.22	55.1	4.77	2.05
				10E Myakka River basin							
2988.3	235	2.14	35.74	1.81	7.26	0	5.18	12.36	54.9	4.72	1.90
				10F Coastal area between Myakka River and Alafia River							
3000	80	4.93	24.16	.22	2.58	0	1.66	16.88	55.6	5.28	2.05
3005	149	5.03	27.89	.40	1.36	0	2.65	10.85	54.7	5.12	2.55
				10G Alafia River basin							
3010	135	4.96	19.65	3.09	2.57	0	4.94	22.26	52.8	4.16	2.70
3015	335	3.45	32.22	1.16	2.32	0	5.07	12.53	54.1	4.12	2.14
				10H Hillsborough River basin and coastal area north of Alafia River							
3025	110	3.52	19.40	2.57	3.35	.01	10.46	19.10	52.6	4.58	2.72
3030	220	3.87	26.71	1.81	2.31	0	12.75	15.56	53.6	4.65	2.77
3045	650	2.01	56.97	2.66	2.83	02	12.41	16.35	55.0	4.55	2.75
				10J Coastal area between Hillsborough River and Withlacoochee River							
3070	35	4.12	18.29	3.74	.74	0	9.21	18.50	54.7	4.84	2.23
3072.43	10	2.49	7.91	10.43	.30	0	12.44	58.98	55.1	5.09	2.05
3073.59	30	2.81	18.51	6.02	.74	0	21.95	62.92	55.0	5.00	2.05
3076.97	9.0	9.64	6.22	2.67	2.78	0	2.78	10.68	54.7	5.28	2.05
3088.89	14	1.71	7.80	4.33	1.85	0	1.14	4.62	55.1	5.54	2.05
3100	72.5	3.54	19.11	3.17	1.19	.03	15.51	55.81	56.2	4.91	2.42
				09G Withlacoochee River basin							
3108	130.0	1.09	20.55	4.32	7.15	04	31.59	5.02	52.0	4.67	2.52
3120	580.0	1.35	66.04	1.70	4.06	01	29.22	13.93	52.9	4.70	2.70
3122	160.0	1.75	24.99	4.15	2.12	.25	30.65	29.14	52.2	4.55	2.71
3125	880.0	1.24	81.67	2.35	3.18	.05	24.97	19.45	53.2	4.69	5.37
3130	1,710.0	.86	121.1	4.83	3.29	.12	17.32	34.30	54.1	4.53	3.89
				09J1 Suwannee River above Withlacoochee River							
3155	2,390	.57	119.7	.31	1.74	0	35.03	56.61	49.5	3.61	3.40
				09J3 Withlacoochee River							
3190	2,120	1.51	135.9	.23	.09	0	1.91	44.99	48.0	3.76	4.76
				09J5 Suwannee River below Withlacoochee River							
3195	6,850	.66	164.8	.27	.68	0	14.88	51.47	48.4	3.63	4.34
3200	7,280	.61	193.3	.27	.64	0	14.52	49.86	48.6	3.66	4.28
3205	7,740	.57	215.5	.30	.61	0	13.86	49.10	48.8	3.67	4.50
				09J6 Santa Fe River							
3207	94.9	1.54	16.6	12.62	.89	.64	23.16	34.91	52.5	3.95	4.80
3210	192	2.95	22.4	.01	.46	02	37.28	47.70	54.6	4.12	3.65
3215	582	3.12	33.3	2.20	.33	.44	22.61	37.54	52.4	4.03	3.88
3217	46.0	1.85	11.65	2.24	04	6.43	22.00	66.23	52.0	4.23	2.87
3220	950	2.33	57.8	1.63	.20	.27	18.15	41.29	51.9	4.00	4.97
3225	1,080	1.48	64.2	1.49	.18	.24	16.43	39.92	52.0	4.01	5.60
				09J5 Suwannee River below Withlacoochee River--Continued							
3230	9,490	.55	253.3	.46	.52	.03	13.76	45.53	49.4	3.73	4.78
3235	9,730	.51	258.1	.51	.50	.03	13.73	45.57	49.5	3.74	4.83
				09K Coastal area between Suwannee River and Aucilla River							
3240	350	2.42	37.21	.53	.17	0	62.08	31.36	55.3	4.46	2.48
3244	60	2.39	15.62	.04	.01	0	84.07	15.06	53.9	4.51	1.84
3245	110	3.10	21.83	.37	.16	0	73.80	23.12	55.0	4.45	1.74
3260	198	2.33	42.29	.85	.99	0	51.14	37.82	54.9	4.37	2.48

Table A-1.--Basin characteristics at Gaging Stations--Continued

Station number	Basin characteristics										
	Drainage area (square miles)	Slope (feet per mile)	Main channel length (miles)	Surface storage (area, in percent)				Forest cover (percent)	Annual precipitation (inches)	2-year, 24 hour rainfall (inches)	Soils index (inches)
				Lakes only	Swamps only	Lakes with forest cover	Swamps with forest cover				
				Northwestern Region							
				11B Coastal area between Aucilla River and Ochlockonee River							
02-3269	535	2.04	62.24	2.20	.29	0	3.55	56.44	55.2	4.28	3.69
				11C Ochlockonee River basin and coastal area							
3290	1,140	2.41	110.3	.97	.08	.01	.38	51.45	51.3	3.98	4.56
3295	237	6.20	29.53	.21	.03	0	.03	64.38	53.0	4.07	4.72
3300	1,720	1.95	140.1	1.84	.14	.01	.91	57.85	52.3	4.04	4.68
3301	126	5.07	29.36	.21	.10	0	10.18	62.03	54.3	4.19	6.84
				11E7 Apalachicola River							
3580	17200	3.00	434.0	.67	0	0	0	64.7	50.0	4.40	4.55
				11E8 Chipola River							
3590	781	1.61	54.09	.6	0	0	5.0	36.8	53.9	4.30	6.48
				12A4 Choctawhatchee River below Pea River							
3655	3,499	2.00	156.5	.5	.01	0	1.0	59.7	54.0	4.40	3.99
3660	386	3.80	41.45	.8	0	0	4.7	47.6	56.6	4.53	3.11
3665	4,384	1.72	199.9	1.0	.01	0	4.1	68.1	54.8	4.47	3.96
				12B Coastal area between Choctawhatchee River and Yellow River							
3670	65.6	11.1	15.00	0	0	0	0	96.8	66.7	5.31	7.35
				12C Yellow River basin							
3680	624	3.31	70.64	.03	.05	0	3.8	71.9	58.6	4.51	4.47
3685	123	8.55	17.91	.2	0	0	10.2	47.2	62.0	5.04	7.60
3690	474	4.04	45.03	.2	0	0	4.9	66.1	62.5	4.90	8.04
				12D Blackwater River basin and coastal area							
3700	205	3.59	26.00	0	0	0	1.7	84.4	61.2	4.63	4.05
3702	36	11.2	11.89	0	0	0	0	92.8	62.5	4.91	2.99
3705	237	6.03	29.44	0	0	0	2.1	68.6	62.8	4.74	3.33
3707	58.7	11.5	15.32	.2	0	0	1.0	81.3	63.4	5.04	4.83
				12E4 Escambia River							
3755	3,817	2.17	186.1	.2	.1	0	2.1	75.6	57.9	4.30	3.96
3760	75.3	11.9	19.51	0	0	0	1.1	53.3	63.3	4.67	3.04
				12F Perdido River basin and coastal area							
3763	49	11.0	15.06	0	0	0	0	75.9	63.2	4.68	3.45
3765	394	5.51	43.63	0	0	0	8.6	77.7	64.2	4.53	3.88

Table A-2.--Summary of regression relations (in Peninsular Region) in Florida:

$$Y = aA^{b_1} S^{b_2} L^{b_3} St_1^{b_4} St_2^{b_5} St_3^{b_6} St_4^{b_7} F^{b_8} (P-40)^{b_9} I_{24,2}^{b_{10}} Si^{b_{11}}$$

Flow Index Y	Regression Constant a	Regression Coeficients for											Standard Error	
		A	S	L	St_1	St_2	St_3	St_4	F	P-40	$I_{24,2}$	Si	logs	%
Qa	0.20	1.05	-	-	-0.06	-0.06	-	-	-	0.59	-	-0.19	0.108	25.1
SDa	.91	1.13	-	-0.27	- .07	- .06	-	-	-	-	-	- .32	.134	31.3
q_1	.05	1.13	-	-	-	- .15	-	-	-	.68	-	-	.183	43.4
q_2	.12	1.10	-	-	- .07	- .16	-	-	-	.51	-	-	.170	40.2
q_3	.99	1.04	-	-	- .10	- .13	-	-	-	-	-	-	.196	46.7
q_4	.18	1.15	-	-	-	- .11	-	-	0.15	-	-	-	.168	39.7
q_5	.46	1.16	-	-	-	- .18	-	-	-	1.35	-3.09	-	.231	55.7
q_6	.02	1.51	0.17	- .59	-1.14	- .09	-	-	-.10	1.11	-	-	.216	51.8
q_7	.10	1.31	.24	- .42	- .06	-	-	-	-	.90	-	- .35	.168	39.7
q_8	.02	1.07	.23	-	- .06	-	-	-	-	.80	1.53	- .32	.153	36.0
q_9	.05	.91	-	-	-	-	-	-	-	1.48	-	-	.183	43.4
q_{10}	.03	1.22	-	- .29	-	-	-	-	-	1.47	-	- .34	.169	39.9
q_{11}	.06	1.10	-.15	-	.06	-	0.06	-	-	.69	-	-	.210	50.3
q_{12}	.18	1.07	-	-	-	-	.10	-	.29	-	-	-	.248	60.3
SD_1	.62	.99	-	-	- .10	- .09	-	-	-	-	-	-	.162	38.2
SD_2	.77	1.03	-	-	- .11	- .12	-	-	-	-	-	- .32	.176	41.6
SD_3	1.75	1.00	-	-	- .13	- .13	-	-	-	-	-	- .44	.245	59.5
SD_4	.38	1.10	-	-	- .09	- .14	-	-	-	-	-	-	.210	50.3
SD_5	.27	1.08	-	-	- .15	- .11	-	-	-	-	-	-	.258	63.0
SD_6	2.01	1.43	.16	- .82	- .11	-	-	-	-	-	-	- .63	.233	56.3
SD_7	.04	1.32	.18	- .52	- .09	-	-	-	-	-	2.43	- .48	.184	43.6
SD_8	.02	.94	-	-	- .15	-	-	-	-	-	2.87	-	.190	45.2
SD_9	.93	1.15	-	- .49	- .07	-	-.05	0.07	-	.71	-	- .65	.168	39.8
SD_{10}	.33	1.26	-	- .51	- .08	-	-	-	-	.79	-	- .43	.199	47.4
SD_{11}	.40	1.08	-	-	-	-	.06	-.07	-	-	-	-	.231	55.7
SD_{12}	.23	1.10	-	-	-	- .20	-	.07	-	-	-	-	.262	64.1
Q_2	29.85	1.14	.32	- .50	- .21	-	-	-.05	-	-	-	- .59	.210	50.3
Q_5	61.66	1.11	.37	- .47	- .20	-	-	-	-	-	-	- .70	.223	53.6
Q_{10}	99.77	1.15	.40	- .51	- .18	- .06	-	-	-	-	-	- .94	.232	56.0
Q_{25}	90.57	.88	.46	-	- .23	-	-	-	-	-	-	- .89	.275	67.6
Q_{50}	335.6	1.29	.50	- .91	- .16	-	-	-	-	-	-	- .84	.194	46.2
$M_{7,2}$	.01	1.13	-	-	-	.28	-	-	-	-	-	1.26	.421	113
$M_{7,10}$	1.01×10^{-6}	-	1.83	3.34	-	.67	-	-	-	-	-	2.13	.929	419
$M_{7,20}$	2.23×10^{-7}	-	2.50	3.58	- .64	1.09	-	-	-	-	-	2.45	1.054	562
$V_{7,2}$	12.62	1.22	.24	- .47	- .14	-	-	-.05	-.08	-	-	- .80	.164	38.8
$V_{7,10}$	49.20	1.24	.27	- .57	- .13	- .07	-	-	-	-	-	- .94	.194	46.3
$V_{7,50}$	93.97	1.22	.37	- .58	- .11	-	-	-	-	-	-	- .79	.151	35.4
D_{10}	4.73	1.12		- .31	- .12	-	-	-.05	-	-	-	- .23	.111	25.8
D_{50}	.48	.95	-.21	-	-	-	-	-	-	-	-	.28	.168	39.7
D_{80}	.05	1.07	-	-	-	.21	-	-	-	-	-	.75	.295	73.3
D_{90}	.01	1.09	-	-	-	.27	-	-	-	-	-	1.13	.375	97.5
Mean monthly discharge (average)			-	-	-	-	-	-	-	-	-	-	-	45.6
Standard deviation of mean monthly discharge (average)						-	-	-	-	-	-	-	-	50.4

Table A-2.--Summary of regression relations (in Northwestern Region) in Florida:--Continued

$$Y = aA^{b_1} S^{b_2} L^{b_3} St_1^{b_4} St_2^{b_5} St_3^{b_6} St_4^{b_7} F^{b_8} (P-40)^{b_9} I_{24,2}^{b_{10}} Si^{b_{11}}$$

Flow Index Y	Regression Constant a	Regression Coeficients for											Standard Error	
		A	S	L	St_1	St_2	St_3	St_4	F	P-40	$I_{24,2}$	Si	logs	%
Q_a	0.19	1.02	-	-	-	-	-	-	-	0.70	-	-	0.066	15.2
SD_a	.31	1.16	-	-0.29	-	-	-	-	-	-	-	0.44	.078	18.1
q_1	2.88	.90	-	-	-	-	-	-	-	-	-	-	.102	23.7
q_2	.49	.99	-	-	-	-	-	-	-	-	1.05	-	.070	16.3
q_3	1.99	1.04	-	-	-	-	-	-	-	-	-	-	.083	19.3
q_4	.54	1.04	-	-	-	-	-	-	-	.45	-	-	.066	15.2
q_5	1.53	.97	-	-	-	-	-	-	-	-	-	-	.123	28.7
q_6	.05	1.05	-	-	-	-	-	-	-	1.04	-	-	.190	45.3
q_7	.09	.91	-	-	-	-	-	-	-	-	2.01	-	.198	47.2
q_8	.05	1.04	-	-	-	-	-	-	-	1.06	-	-	.103	24.0
q_9	.06	.99	-	-	-	-	-	-	-	1.06	-	-	.128	29.9
q_{10}	.06	1.00	-	-	-	-	-	-	-	.98	-	-	.195	46.4
q_{11}	.04	1.02	-	-	-	-	-	-	-	1.06	-	-	.130	30.4
q_{12}	.22	1.00	-	-	-	-	-	-	-	.69	-	-	.085	19.7
SD_1	.65	1.46	-	- .62	-	-	-	-	-	-	-	-	.149	35.0
SD_2	1.22	.96	-	-	-	-	-	-	-	-	-	-	.122	28.6
SD_3	.76	1.09	-	-	-	-	-	-	-	-	-	-	.154	36.4
SD_4	1.93	.96	-	-	-	-	-	-	-	-	-	-	.117	27.3
SD_5	.73	1.01	-	-	-	-	-	-	-	-	-	-	.115	26.9
SD_6	.26	.91	-	-	-	-	-	-	-	.53	-	-	.109	25.3
SD_7	.19	.98	-	-	-	-	-	-	-	.49	-	-	.117	27.2
SD_8	.03	1.63	-	- .91	-	-	-	-	-	.99	-	-	.135	31.5
SD_9	.10	.73	-0.64	-	-	-	-	-	-	-	2.61	.49	.140	32.9
SD_{10}	.80	.95	-	-	-	-	-	-	-	-	-	-	.229	55.3
SD_{11}	.64	1.01	-	-	-	-	-	-	-	-	-	-	.228	54.9
SD_{12}	.89	.92	-	-	-	-	-	-	-	-	-	.52	.150	35.2
Q_2	2.29	.91	.56	-	-	-	-	-	-	.53	-	-	.152	35.7
Q_5	4.87	.88	.66	-	-	-	-	-	-	.48	-	-	.120	28.0
Q_{10}	5.66	.87	.75	-	-	-	-	-	-	.50	-	-	.146	34.2
Q_{25}	7.26	.83	.76	-	-	-	-	-	-	.62	-	-	.146	34.2
Q_{50}	.32	.66	-	-	-	-	-	-	1.14	-	1.70	-	.103	24.0
$M_{7,2}$	.08	-	-	1.85	-	-	-	-	-1.62	2.56	-	-	.328	82.9
$M_{7,10}$	.01	-	-	2.08	-	-	-	-	-2.04	3.57	-	-	.424	114
$M_{7,20}$	1.29×10^{-3}	-	-	2.14	-	-	-	-	-2.04	4.04	-	-	.481	135
$V_{7,2}$	2.93	.95	-	-	-	-	-	-	-	.43	-	-	.117	27.3
$V_{7,10}$	26.12	.90	-	-	-	-	-	-	-	-	-	-	.138	32.3
$V_{7,25}$	12.76	.92	-	-	-	-	-	-	-	.30	-	-	.101	23.5
$V_{7,50}$	3.53	.86	-	-	-	-	-	-	-	-	1.84	-	.093	21.6
D_{10}	.29	1.01	-	-	-	-	-	-	-	-	1.26	.29	.068	15.7
D_{50}	9.08×10^{-3}	1.09	-	-	-	-	-	-	-	1.16	-	.60	.146	34.3
D_{80}	3.70×10^{-2}	1.16	-	-	-	-	-	-	-1.16	2.34	-	-	.253	61.6
D_{90}	1.22×10^{-1}	-	-	1.80	-	-	-	-	-1.40	2.21	-	-	.293	72.6
Mean monthly discharge (average)			-	-	-	-	-	-	-	-	-	-	-	28.8
Standard deviation of mean monthly discharge (average)						-	-	-	-	-	-	-	-	34.7

APPENDIX