Considering the total weight of catfish taken, 36.6 percent was captured in the round basket, 30.4 percent in the horizontal "D" basket and 33.0 percent in the vertical "D" basket.

The vertical "D" and round baskets took a larger percentage of game fish than did the horizontal "D" baskets. Inasmuch as crappie dominate the game fish population in High Rock Reservoir, it was not surprising to find a fair number of them in the baskets. Of the total number of crappie captured in all baskets, 12.0 percent were taken in the horizontal "D" baskets, with 41.8 percent in the round and 46.2 percent in the vertical "D" baskets. The highest catch rate for any type of basket was less than 0.03 pounds of crappie per basket day in the vertical "D" baskets during 96-hour set periods. This catch rate is so low that it may be considered negligible in the study reservoir.

A comparison of the catch record data for all types of catfish baskets (Table III) shows that the yield of fish declined as the length of time set increased. It is logical to deduce that escapement from the baskets was responsible for the reduction in number of fish captured. For efficient operations, catfish baskets should be fished at least every 48 hours.

## CONCLUSIONS

1. The round type catfish basket with the slotted opening of the inner funnel positioned at random was slightly more effective for catching catfish than were the other two types tested.
2. Game fish catch was very low in all traps but the traps having a horizontally set opening captured fewer game fish than did the other types.
3. The yield of fish from catfish baskets was inversely proportional to the fishing time. Maximum catches were made from baskets set over a 48-hour period.
4. None of the baskets tested took game fish in a quantity considered detrimental to the game fish population in High Rock Reservoir.

# LOW-FLOW REGULATION AS A MEANS OF IMPROVING STREAM FISHING

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*U. S. Study Commission, Southeast River Basins*

## ABSTRACT

Studies by the U. S. Study Commission, Southeast River Basins, and cooperating agencies have disclosed that utilization of many streams in the study area is curtailed in part by excessively low stages and sometimes by excessively high stages during the fishing season. The U. S. Study Commission has considered the regulation of low flows by controlled discharge from upstream storage reservoirs as one means of improving such streams for fishing.

Concepts and methods employed in the determination of flow-storage relationships, flow-fishery relationships, storage required to regulate flows, and measurement of fishery benefits are described in this paper. Results of the study indicate that the utility of some streams may be increased from two to five times with low-flow regulation; however, a much better understanding is needed of flow-storage-fishing relationships on which to base more accurate determinations of desired stages and potential benefits.

## INTRODUCTION

An inventory of fishing waters in the Southeast River Basins area by the U. S. Study Commission, Southeast River Basins, revealed about 4,700 miles of warm water streams of particular significance with a surface area of over 124,000 acres. These streams have a potential capacity of sustaining around 2 million man-days of sport fishing—according to standards employed by the U. S. Study Commission, Southeast River Basins.

Present as well as potential utilization, however, is curtailed by excessively low stages and sometimes by excessively high stages during the fishing season.

While the streams afford excellent fishing when "conditions are right" long-range forecasting is difficult due to the vagaries of weather and stream sensitivity to uncontrolled runoff.

There is a wide variation in the regimen of stream flow in different sections of the study area as is reflected by the flow duration curves of the Chattooga River in the Blue Ridge Mountains, Apalachee River in the Piedmont, Suwannee River in the Coastal Plains, the Sante Fe River in north central Florida and the Escambia River in west Florida (Figure 1).

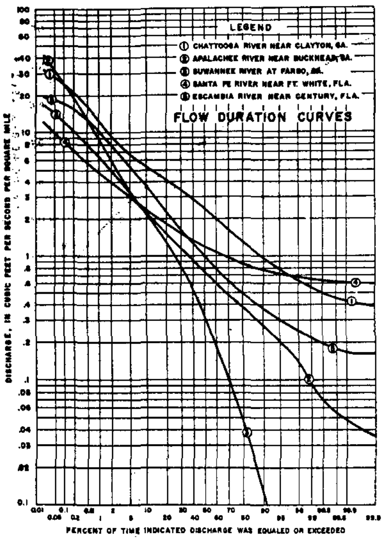
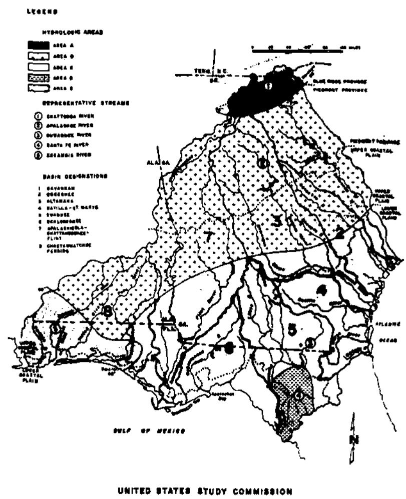



FIGURE 1




UNITED STATES STUDY COMMISSION
SOUTHEAST RIVER BASINS

FIGURE 2

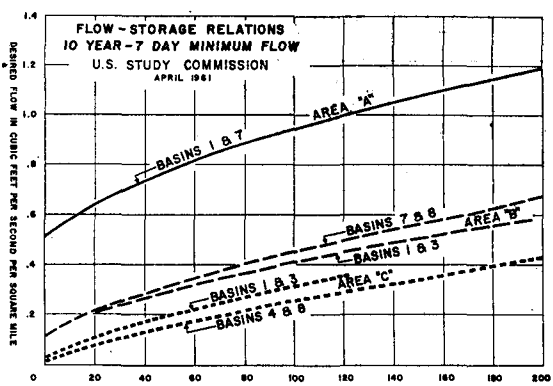



FIGURE 3

Regulation of low flows by controlled discharge from upstream storage reservoirs provides means of increasing the utility of streams for fishing. A number of reservoir projects with provision for low-flow regulation was considered by the U. S. Study Commission.

Formulation of specific project proposals for low-flow regulation involved the determination of:

(1) Flow-storage relationships,

(2) Flow-fishery relationships,

(3) Storage required to regulate low flows within a specified range, and
(4) Measurement of benefits.

## FLOW-STORAGE RELATIONSHIPS

The regulation of low flows in order to maintain more favorable conditions for fishing from May 1 to October 31 of each year would require: (1) Storage of water in upstream reservoirs to augment natural flows so as to maintain a stage equal to or exceeding a minimum desired stage and (2) additional storage capacity to impound enough of the runoff to prevent the occurrence of stages in excess of a maximum desired stage.

Studies revealed that while it would be practicable to achieve the first objective, the second would be partially obtained incidental to storing water to augment the low flow. Primary consideration, therefore, was given to determining storage requirements to overcome deficiencies in low flows.

Flow records from 61 United States Geological Survey gaging stations located at strategic points on streams throughout the study area were analyzed as the basis for determining flow-storage relationships. The gaging stations were selected to represent minimum flows from tributary drainages within generalized homogeneous areas and to provide data on several main river points. Values determined for a ten-year frequency-seven-day minimum flow in terms of both inches of runoff and cubic feet per second per square mile were employed in grouping watersheds into homogeneous areas (Figure 2).

Area A represents low-flow frequency conditions in the Blue Ridge mountains including the foothill sections southward to the isohyetal for the average annual rainfall of 56 inches. The relatively flat slope of the flow-duration curve of the Chattooga River and other streams of this area is believed to be due mainly to high rainfall and to ground water storage.

Area B represents the Piedmont Province plus the upper section of the Upper Coastal Plain. The water storage properties of the soils and underlying rocks of the Piedmont area are comparable to that of the Blue Ridge Mountains, but the yield of water is believed to be considerably reduced due to diminished rainfall and ground water recharge.

Area C represents the lower portion of the Upper Coastal Plain and the Lower Coastal Plain with the exception of those areas designated as Areas D and E. Sand deposits in Area C absorb much of the rainfall, but during dry periods in the late summer and fall, the water table falls below the beds of all but the largest sreams. Consequently many of the smaller streams in this area cease to flow.

Area D coincides with a region of limestone sinks, underground rivers, and high yielding springs in the lower Suwannee basin. Stream flow in this particular portion of the Upper Coastal Plains, is typified by the Santa Fe River, Florida.

Area E represents a region in Florida panhandle of rather high yield due to an average annual rainfall of more than 60 inches.

Upstream storage required to make up for deficiencies in low flows at each stream location was determined on the basis of a ten-year-low-flow frequency; that is, low flows would be permitted to drop below a design standard one year out of ten on the average. This design standard was based on the assumption that occasionally a year of extremely low water may benefit fishing. Also, costs of storage required to achieve stream control approaching 100 percent would be prohibitive.

The ten-year, seven-day, low-flow frequency values were obtained from low-flow frequency relations, which were constructed for each of the 61 selected stream gaging stations.

Since the ten-year frequency of seven-day minimum flow could be produced by a drought of either long or short duration, it was also necessary to estimate the average volume of runoff associated with the ten-year, seven-day minimum flow. Several annual discharge hydrographs were selected for each stream gaging station whose seven-day minimum flow value was about that of the ten-year frequency. Then the volume of runoff in inches was computed which would be needed in reservoir storage to increase the low flow to various selected flows during the fishing season. These relations of volumes of deficient runoff to various selected flows were averaged for each stream gaging station and then converted to units of acre-feet per square mile of drainage area for reservoir storage or volume of deficient runoff and to cubic feet per second per square mile (c.s.m.) for rate of flow or draft. These draft-storage curves were then averaged for all of the selected stations in hydrologic homogeneous areas A, B, and C (Figure 3). Streams in areas D and E were considered singularly because of the peculiar hydrologic characteristics of these areas.

## FLOW-FISHERY RELATIONSHIPS

The fish population inhabiting a particular stream is in itself an expression of the combined influence of environmental factors. Much diversity in habitat conditions was reflected by the species of fish which dominated the fish population of nineteen representative streams in the study area. There was also wide variation in the extent of fishing by streams due to a combination of many factors of which the regimen of stream flow is of particular significance.

Both fishermen and fishery biologists have observed that fishing conditions are more favorable at certain stages of a stream than at others. The most desirable range of water levels for fishing was estimated by relating the habitats of fish and the habits of fishermen to stream flow and topography.

Two extremes in topography were recognized: (1) streams having wide flood plains subjected to overflow of long duration, and (2) streams without flood plains or with narrow flood plains which are subject to overflow of short duration.

The Suwannee River near Fargo, Georgia (Figure 4), is an example of streams with a broad flood plain and flat gradient. In streams of this type, high water stages favor fish production; low water stages following periods of high water favor harvest and high angling success. Mean annual flow from May 1 to October 30 from water year 1950-51 to 1959-60 actually ranged from a maximum of 3,866 second feet to a minimum of 42 second feet. These flows are equivalent to 380% and 4% of the average annual flow, respectively.

For maximum fish production in the Suwannee River at Fargo, Georgia, a minimum stage of 7.1 feet was deemed desirable. When waters equal or exceed this stage a large portion of the fish population move into the backwaters to feed and to spawn but usually are so widely dispersed as to discourage sport fishing. The extent of production is influenced greatly by the time, extent, and duration of flooding. In general, the higher the stage and the longer the duration, the greater the production.

For maximum utilization by fishermen of the Suwannee River near Fargo, Georgia, a maximum stage of 7.1 feet and a minimum stage of about 3.4 feet was believed to be most desirable. When the waters subside to a stage of 7.1 feet in the Suwannee River, at which time the flow is equivalent to about 75% of the average flow of record, the standing crop of fish is concentrated in the main river channels, lakes and other permanent water bodies where the fishermen can find them. However, should the river subside to a stage of less than 3.4 feet, at which time the flow is equivalent to about 25% of the average flow of record, the fish are more prone to avoid the fishermen. Under these conditions poor fishing is usually experienced. Should the period of low flow be prolonged, natural mortality is high and the crop is diminished. While certain beneficial effects may result from very low stages, it is apparent that frequent periods of excessively low stages reduce fish populations and their utilization by fishermen.

Chattooga River near Clayton, Georgia (Figure 5), is an example of those streams with little flood plain and relatively steep gradients. For maximum production of fish and utilization by fishermen more uniform flows throughout the year would be necessary. On one hand the high water stages of the Chattooga and similar streams are of too short duration to be of much value for fish production, and flash floods sometimes damage the habitat by excessive sand and gravel deposition in the deep holes and shoal areas. On the other hand, excessively low stages reduce the acreage of productive waters and discourage use by fishermen.

From water year 1950-51 to water year 1959-60, the mean-annual minimum flow of the Chattooga was equivalent to 26 percent of the average annual flow or about six times the equivalent percentage flow of the Suwannee at Fargo, Georgia. Because of the relatively high base flow of the Chattooga and other streams within Area A and in Area D as well, the desired minimum is only slightly above the mean-annual minimum of record. Considerable reduction

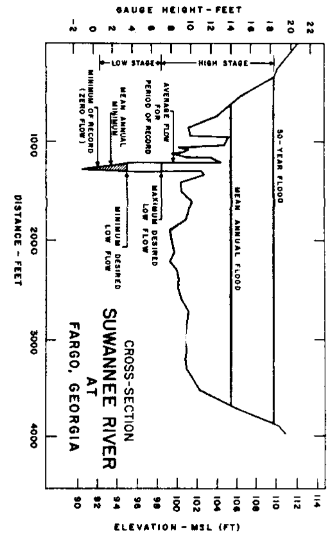


FIGURE 4

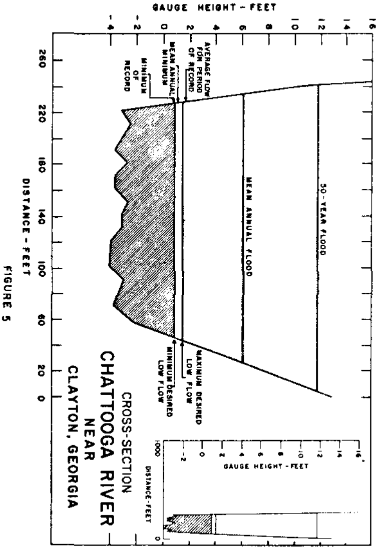


FIGURE 5

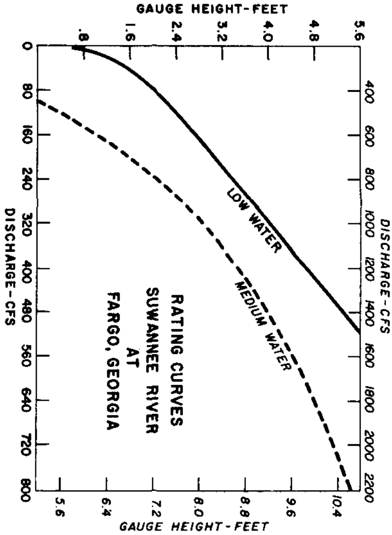


FIGURE 6

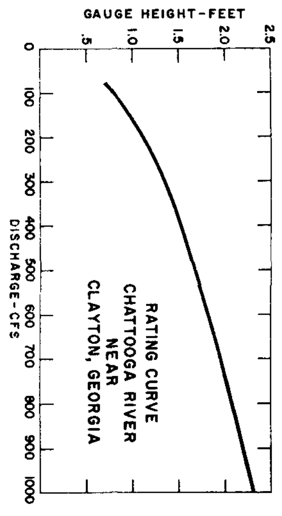


FIGURE 7

in the mean-annual maximum discharge from May 1 to October 30 would be necessary, however, to achieve optimum conditions for fishing due to the adverse affects of heavy runoff. A value of 75 percent of the average flow of record was employed as a standard maximum desired flow for all streams except as noted.

Guided by these assumed relationships, an optimum range of low water stages from the standpoint of fish conservation and utilization was estimated for each stream segment under consideration and related to the stream flow record at the nearest USGS gage for ten years of record (usually water years 1950-51 to 1959-60).

The optimum range of flows desired during the fishing season, May 1 to October 30, was then determined by converting stage as measured in feet on the U. S. Geological Survey gage to discharge as measured in cubic feet per second. These conversions were accomplished by using rating curves as exemplified by the Suwannee River rating curves and the Chattooga River rating curves (Figures 6 and 7) prepared from data provided by the United States Geological Survey.

In turn, the minimum flow desired was converted into percent of the average flow for the period as a means of establishing a common denominator for comparison of low-flow requirements between stream segments.

The actual range of flows during the period from May 1 to October 30 as compared to the desired range on 19 selected streams in the study area is summarized in Tables I and II.

## STORAGE REQUIREMENTS

Upstream storage requirements were measured in terms of acre feet of water required to maintain stages equal or exceeding the desired minimum flow. This was determined fo reach of the streams selected for study on the basis of the flow-storage relationships which had previously been determined for each of the hydrologic areas. For ready reference, stage-storage curves were prepared for each stream segment under consideration as, for example, the Suwannee River near Fargo, Georgia (Figure 8) and the Chattooga River near Clayton, Georgia (Figure 9).

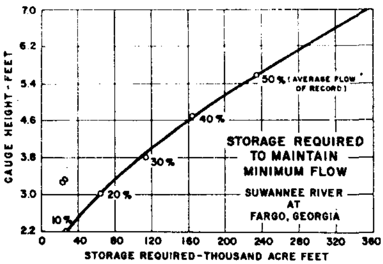



FIGURE 8

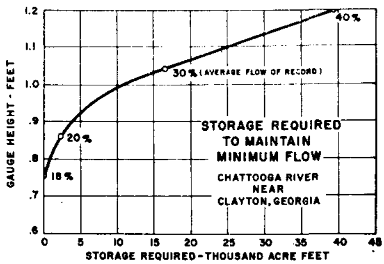



FIGURE 9

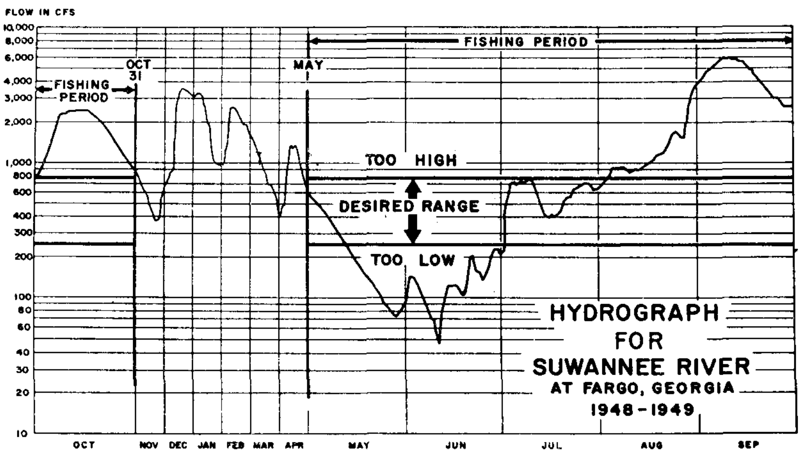



FIGURE 10

In using the Suwannee curve to estimate the amount of storage required to maintain a stage of 3.40 feet, nine years out of ten, the curve is entered from the left, and at the bottom 82,000 acre-feet of storage are indicated. For other stations other curves were prepared for reference use. For ungaged points, stage-storage curves were based on general regional relationships.

A comparison of minimum desired low flows, stages, and storage requirements is presented in Table III.

TABLE I

A COMPARISON OF THE MEAN ANNUAL MAXIMUM FLOW DURING MAY 1 TO OCTOBER 30 FOR THE PERIOD OF ANALYSIS WITH THE DESIRED MAXIMUM

| *Hydrologic Area* | *Name of Stream* | *Station* | *Stage in Feet* | *Actual Discharge in c.f.s.* | *% of Average Flow* | *Stage in Feet* | *Desired Discharge in c.f.s.* | *% of Average Flow* |
|---|---|---|---|---|---|---|---|---|
| A | Chattooga River | Clayton, Ga. | ... | 2,400 | 405 | 1.55 | 444 | 75 |
| B | Flint River | Griffin, Ga. | 10.0 | 1,571 | 495 | 5.30 | 238 | 75 |
| B | Flint River | Culloden, Ga. | 12.80 | 9,790 | 417 | 4.40 | 1,750 | 75 |
| B | Potato Creek | Thomaston, Ga. | ... | 1,001 | 460 | 3.40 | 164 | 75 |
| B | Chattahoochee River | West Point, Ga. | 10.40 | 15,950 | 288 | 4.40 | 4,149 | 75 |
| C | Pidgeon Creek | Thad, Ala. | ... | 1,399 | 329 | 5.0 | 318 | 75 |
| C | Patsaliga Creek | Luverne, Ala. | ... | 1,499 | 408 | 5.0 | 275 | 75 |
| C | Pea River | Sampson, Ala. | ... | .... | ... | ... | 1,290 | 75 |
| C | Ohoopee | Reidsville, Ga. | ... | 3,740 | 412 | 4.95 | 681 | 75 |
| C | St. Marys River | McClenny, Fla. | ... | 6,339 | 1,001 | 5.14 | 475 | 75 |
| C | Satilla River | Waycross, Ga. | ... | 5,480 | 632 | 7.30 | 649 | 75 |
| C | Satilla River | Atkinson, Ga. | ... | 14,270 | 738 | 8.10 | 1,449 | 75 |
| C | Alapaha River | Statenville, Ga. | 13.85 | 3,712 | 349 | 4.60 | 681 | 75 |
| C | Little River | Adel, Ga. | 13.70 | 2,338 | 505 | 5.60 | 355 | 75 |
| C | Suwannee River | Fargo, Ga. | ... | 3,866 | 380 | 7.10 | 760 | 75 |
| C | Ochlockonee River | Thomasville, Ga. | ... | 2,305 | 513 | 5.30 | 425 | 95 |
| C | Ochlockonee River | Havana, Fla. | ... | 2,498 | 267 | 16.6 | 1,100 | 118 |
| D | Ichawaynochaway Creek | Milford, Ga. | 4.55 | 2,028 | 258 | 1.81 | 590 | 75 |
| E | Escambia River | Century, Fla. | ... | 15,467 | 257 | 7.6 | 4,500 | 75 |

TABLE II

A COMPARISON OF THE MEAN ANNUAL MINIMUM FLOW DURING MAY 1 TO OCTOBER 30 FOR THE PERIOD OF RECORD WITH THE DESIRED MINIMUM FLOW

| *Hydrologic Area* | *Name of Stream* | *Station* | *Stage in Feet* | *Actual Discharge in c.f.s.* | *% of Average Flow* | *Stage in Feet* | *Desired Discharge in c.f.s.* | *% of Average Flow* |
|---|---|---|---|---|---|---|---|---|
| A | Chattooga River | Clayton, Ga. | 1.00 | 157 | 26 | 1.05 | 178 | 30 |
| B | Flint River | Griffin, Ga. | 2.30 | 29 | 9 | 4.50 | 175 | 55 |
| B | Flint River | Culloden, Ga. | 1.62 | 276 | 12 | 2.75 | 820 | 35 |
| B | Potato Creek | Thomaston, Ga. | 2.51 | 17 | 8 | 3.00 | 83 | 38 |
| B | Chattahoochee River | West Point, Ga. | 2.21 | 1,018 | 18 | 3.50 | 2,700 | 49 |
| C | Pidgeon Creek | Thad, Ala. | 2.20 | 28 | 7 | 3.50 | 150 | 35 |
| C | Patsaliga Creek | Luverne, Ala. | 1.42 | 17 | 5 | 3.60 | 147 | 40 |
| C | Pea River | Sampson, Ala. | ... | .. | .. | ... | ... | .. |
| C | Ohoopee | Reidsville, Ga. | 1.05 | 49 | 5 | 2.10 | 182 | 20 |
| C | St. Marys River | McClenny, Fla. | 1.50 | 46 | 7 | 2.40 | 114 | 18 |
| C | Satilla River | Waycross, Ga. | 4.42 | 28 | 3 | 4.60 | 160 | 18 |
| C | Satilla River | Atkinson, Ga. | ... | 133 | 7 | 4.20 | 330 | 18 |
| C | Alapaha River | Statenville, Ga. | 1.20 | 66 | 7 | 1.80 | 140 | 15 |
| C | Little River | Adel, Ga. | 1.56 | 5 | 1 | 3.00 | 80 | 17 |
| C | Suwannee River | Fargo, Ga. | 1.60 | 42 | 4 | 3.40 | 244 | 25 |
| C | Ochlockonee River | Thomasville, Ga. | .32 | 11 | 2 | 2.60 | 135 | 30 |
| D | Ichawaynochaway Creek | Milford, Ga. | .97 | 193 | 25 | 1.10 | 240 | 30 |
| E | Escambia River | Century, Fla. | 1.95 | 881 | 15 | 2.85 | 1,300 | 22 |

TABLE III

MINIMUM FLOWS DESIRED AND STORAGE REQUIREMENTS

| Hydrologic Area | Name of Stream | Station | Drainage Area (sq. mi.) | Minimum Desired Flow: Stage | Discharge c.f.s. | Discharge % of Avg. Flow | c.f.m. | Acre Feet of Storage Per Sq. Mi. | Acre Feet of Storage Total |
|---|---|---|---|---|---|---|---|---|---|
| A | Chattooga River | Clayton, Ga. | 207 | 1.05 | 178 | 30 | .859 | 20 | 4,140 |
| B | Flint River | Griffin, Ga. | 272 | 4.50 | 175 | 55 | .643 | 683 | 186,000 |
| B | Flint River | Culloden, Ga. | 1,850 | 2.75 | 820 | 35 | .443 | 97 | 180,000 |
| B | Potato Creek | Thomaston, Ga. | 186 | 3.00 | 83 | 38 | .446 | 102 | 19,000 |
| B | Chattahoochee River | West Point, Ga. | 3,550 | 3.50 | 2,700 | 49 | .760 | 13 | 46,000 |
| C | Pidgeon Creek | Thad, Ala. | 296 | 3.50 | 150 | 35 | .506 | 111 | 33,000 |
| C | Patsaliga Creek | Luverne, Ala. | 294 | 3.60 | 147 | 40 | .500 | 122 | 36,000 |
| C | Pea River | Sampson, Ala. | ... | ... | ... | .. | ... | .. | 74,000 |
| C | Ohoopee | Reidsville, Ga. | 1,110 | 2.10 | 182 | 20 | .163 | 50 | 55,000 |
| C | St. Marys River | McClenny, Fla. | 720 | 2.40 | 114 | 18 | .158 | 50 | 36,000 |
| C | Satilla River | Waycross, Ga. | 1,200 | 4.60 | 160 | 18 | .133 | 30 | 37,000 |
| C | Satilla River | Atkinson, Ga. | 2,790 | 4.20 | 330 | 18 | .118 | 32 | 89,000 |
| C | Alapaha River | Statenville, Ga. | 1,400 | 1.80 | 140 | 15 | .100 | 23 | 32,000 |
| C | Little River | Adel, Ga. | 547 | 3.00 | 80 | 17 | .146 | 63 | 35,000 |
| C | Suwannee River | Fargo, Ga. | 1,260 | 3.40 | 244 | 25 | .194 | 65 | 82,000 |
| C | Ochlockonee River | Thomasville, Ga. | 550 | 2.60 | 135 | 30 | .245 | 120 | 66,000 |
| C | Ochlockonee River | Havana, Ga. | 1,020 | 13.10 | 280 | 30 | .274 | 105 | 107,100 |
| D | Ichawaynochaway Creek | Milford, Ga. | 620 | 1.10 | 240 | 30 | .387 | * | * |
| E | Escambia River | Century, Fla. | 3,817 | 2.85 | 1,300 | 22 | .340 | 18 | 69,000 |

* Comparable to streams in Area D although located in Area C; storage requirements not determined.

## Table IV

Increased Utility of Streams Per Annum as Would Result from Low Flow Regulation from May 1 to October 30 for Period of Analysis (Water Years 1949-50 to 59-60)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Without Regulation* | | | | *With Regulation* | | | | |
| | | | | *Days Unfavorable* | | | | *Days Unfavorable* | | | | |
| *No.* | *Area* | *Name of Stream* | *Station* | *Below Range* | *Above Range* | *Total* | *Days Favorable* | *Below Range* | *Above Range* | *Total* | *Days Favorable* | *Benefit Index (Col. 12 ÷ Col. 8)* |
| 1 | A | Chattooga River | Clayton, Ga. | 21 | 75 | 96 | 88 | 0 | 75 | 75 | 109 | 1.23 |
| 2 | B | Flint River | Griffin, Ga. | 139 | 23 | 162 | 22 | 0 | 23 | 23 | 161 | 7.32 |
| 3 | B | Flint River | Culloden, Ga. | 96 | 27 | 123 | 61 | 0 | 27 | 27 | 157 | 2.57 |
| 4 | B | Potato Creek | Thomaston, Ga. | 95 | 28 | 123 | 61 | 0 | 28 | 28 | 161 | 7.32 |
| 5 | B | Chattahoochee River | West Point, Ga. | 100 | 35 | 135 | 49 | 0 | 35 | 35 | 149 | 3.04 |
| 6 | C | Ohoopee River | Reidsville, Ga. | 86 | 25 | 111 | 73 | 0 | 25 | 25 | 159 | 2.17 |
| 7 | C | St. Marys River | McClenny, Fla. | 86 | 43 | 129 | 55 | 0 | 43 | 43 | 141 | 3.90 |
| 8 | C | Satilla River | Atkinson, Ga. | 86 | 41 | 127 | 57 | 0 | 41 | 41 | 143 | 3.99 |
| 9 | C | Satilla River | Waycross, Ga. | 92 | 29 | 121 | 63 | 0 | 29 | 29 | 155 | 2.46 |
| 10 | C | Alapaha River | Statenville, Ga. | 60 | 42 | 102 | 82 | 0 | 42 | 42 | 142 | 1.73 |
| 11 | C | Little River | Adel, Ga. | 105 | 30 | 135 | 49 | 0 | 30 | 30 | 154 | 3.14 |
| 12 | C | Suwannee River | Fargo, Ga. | 101 | 41 | 142 | 42 | 0 | 41 | 41 | 143 | 3.40 |
| 13 | C | Ochlockonee River | Thomasville, Ga. | 86 | 35 | 121 | 63 | 0 | 35 | 35 | 149 | 2.36 |
| 14 | C | Ochlockonee River | Havanna, Ga. | 101 | 24 | 125 | 59 | 0 | 24 | 24 | 160 | 2.71 |
| 15 | C | Pidgeon Creek | Thad, Ala. | 136 | 17 | 153 | 31 | 0 | 17 | 17 | 167 | 5.39 |
| 16 | C | Patsaliga Creek | Luverne, Ala. | 123 | 26 | 149 | 35 | 0 | 26 | 126 | 158 | 4.51 |
| 17 | C | Pea River | Sampson, Ala. | 77 | 8 | 85 | 99 | 0 | 8 | 8 | 176 | 1.77 |
| 18 | D | Ichawaynochaway Crk. | Milford, Ga. | 45 | 44 | 89 | 95 | 0 | 44 | 44 | 140 | 1.47 |
| 19 | E | Escambia River | Century, Fla. | 38 | 59 | 97 | 87 | 0 | 59 | 59 | 135 | 1.43 |

## MEASUREMENT OF BENEFITS

Fishery benefits from low-flow regulation as proposed are expected to accrue in the form of increased carrying capacity of the stream habitat, increase in the percentage by weight of game fish in the population, and increase in the number of days per annum that the stream will be fishable. In the absence of specific data on which to predict changes in stream productivity and species composition, the U. S. Study Commission limited its analysis to determining the number of days each year during which the selected streams were suitable for sport fishing without flow regulation as compared to the number of days the streams would have been suitable with low-flow regulation.

This comparison was made by examining the annual hydrographs of record on which were drawn the desired minimum and maximum low-flow lines from May 1 to October 30, as illustrated by the Suwannee River hydrograph for the water year 1948-49 (Figure 10). Analysis of this and other hydrographs covering the period from November 1950 to November 1960 revealed that from May 1 to October 30 the water was too low on 101 days, too high on 41 days, and favorable on 42 days. With regulation of low flows to overcome deficiencies, river stages would have been favorable from May 1 to October 30 for an average of 143 days each year or 3.4 times the number of days without flow regulation.

Factors thus obtained were multiplied by the present use of the selected streams and stream segments to be benefited by low-flow regulation and the resulting figure compared with the present rated man-day capacity of that stream segment. Benefits were considered to be the difference between prospective use with low-flow regulation and prospective use without low-flow regulation.

For other stream segments studied, a similar analysis was made for each year of a ten-year period and averages calculated to reflect the potential increase in the utility of the stream as measured in terms of the increased number of days that water stages would be favorable. Results thus obtained were employed as an index to potential benefits that could be obtained by regulation of low flows for the respective streams studied (Table IV).

## DISCUSSION

Some correlation between acre-feet of storage required per square mile of drainage and the potential increase in the number of days suitable for fishing was anticipated in each of the homogeneous hydrologic areas. A diagram (Figure 11) depicting storage-benefit data for each of the streams studied, however, does not reflect a uniform relationship.

In explanation it may be that every stream must be considered individually. On the other hand, it appears that more uniform results and possibly a more reliable index to potential benefits could have been obtained by the use of a standard range of desired low flows for streams in each homogeneous area.

## ACKNOWLEDGMENTS

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Figure 1. Flow duration curves for selected streams in the Southeast River Basins, water years 1944-48.

Figure 2. Map of Southeast River Basins showing major hydrologic areas and location of typical streams.

Figure 3. Flow-storage relations of streams in the Southeast River Basins.

Figures 4 and 5. Stage and topography in relation to a desired range of low flows in the Suwannee River near Fargo, Georgia, and the Chattooga near Clayton, Georgia.

Figures 6 and 7. State-flow curve for the Suwannee River near Fargo, Georgia.

Figures 8 and 9. Stage-storage curve for the Suwannee River near Fargo, Georgia and the Chattooga River near Clayton, Georgia.

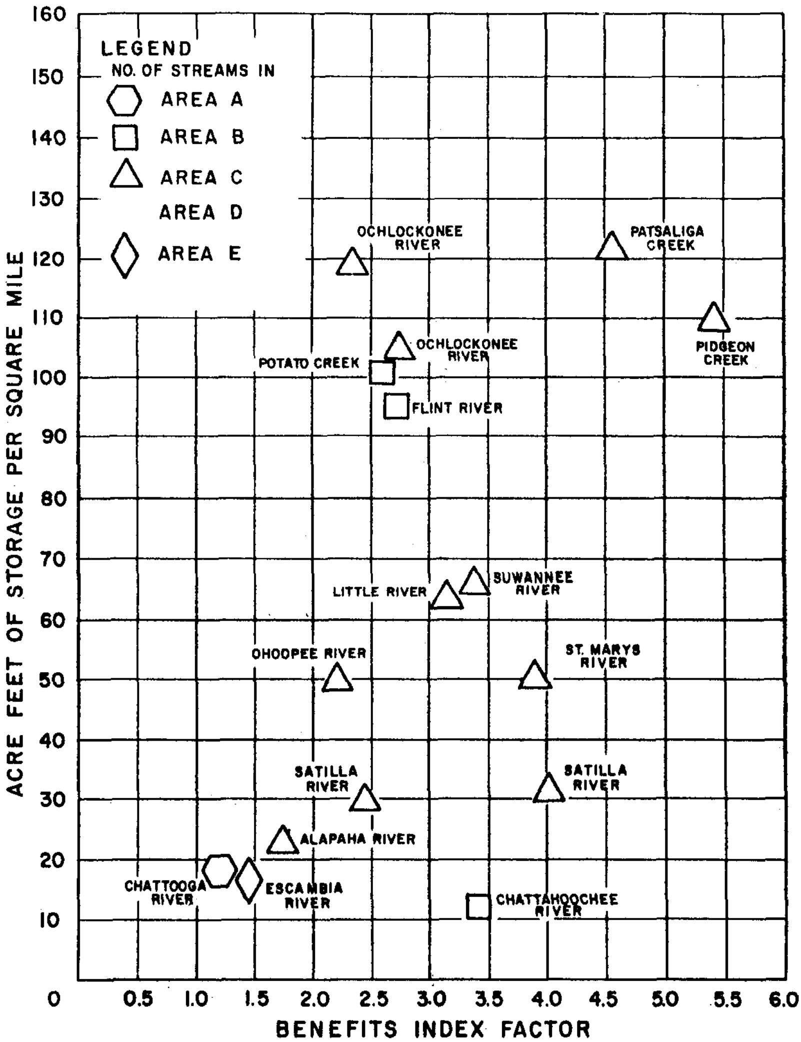


Figure 11

Figure 10. A comparison of the actual and desired range of flows in the Suwannee River near Fargo, Georgia, as shown on a hydrograph for the period May 1 to October 30, 1949. Benefits were based on the increased number of days that water levels would be favorable for fishing if flows were increased to equal or exceed the desired minimum from May 1 to October 30 for each year during the actual period of analysis (1950-1960).

Figure 11. Diagram depicting relationship between acre feet of storage required per square mile and potentials increase in stream utility for fishing for each stream segment studied.