EFFECTS OF THE OPERATION OF HUNGRY HORSE DAM ON THE KOKANEE FISHERY IN THE FLATHEAD RIVER SYSTEM

Annual Progress Report FY 1983

By

John J. Fraley, Project Biologist
and
Steve L. McMullin, Project Coordinator

Fisheries Research and Special Projects Bureau
Montana Department of Fish, Wildlife and Parks
Kalispell, Montana 59901

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EXECUTIVE SUMMARY

This study was undertaken to assess the effects of the operation of Hungry Horse Dam on the kokanee fishery in the Flathead River system. Studies concerning operation of the dam on Flathead River fisheries began in 1979 and continued to 1982 under Bureau of Reclamation funding. Studies concerned specifically with kokanee salmon continued under Bonneville Power Administration funding in 1982. This annual report covers the 1982-1983 field season concerning the effects of Hungry Horse operations on kokanee abundance, migration, spawning, egg incubation and fry emergence in the Flathead River system. This report aiso addresses the expected recovery of the mainstem kokanee population under the flow regime recommended by the Department of Fish, Wildlife and Parks in 1982.

An estimated 5,000 kokanee salmon constructed 1,528 redds in the mainstem Flathead River below Hungry Horse Dam in 1982. Estimates of kokanee abundance in the mainstem during 1982 were lower than in 1979 and 1981, but greater than in 1980. An estimated 35,000 kokanee spawned in McDonald Creek during 1982, compared with an average of 55,000 over the 1979-82 period. Numbers of spawners in 1982 were also lower in Heaver and Deerlick creeks and in the Middle and South Forks of the Flathead River. Numbers of kokanee were higher than in previous years in the Whitefish River. Based on direct observation of spawners and redd counts, an estimated 45,000 kokanee reached spawning grounds in the Flathead River system in 1982. This compares with estimates of 74,000, 48,000 and 138,000 kokanee in 1979, 1980 and 1981, respectively.

Aerial counts of kokanee spawners indicated kokanee moved into McDonald Creek after little or no holding in the upper mainstem. Counts in the Middle Fork of the Flathead River were low throughout the August-October sampling period. Electrofishing catch rates indicated there was no substantial "late run" of fish in 1982. Fishermen returned 61 (13.3%) of the 460 kokanee tagged on their spawning migration in 1982.

Anglers harvested an estimated 12,402 kokanee on the mainstem Flathead River during the fall, 1982 season. The harvest was composed almost entirely of "early run" fish, as only 500 kokanee were harvested on the mainstem after 1 October. Mainstem anglers caught kokanee at a rate of 0.45 fish/hour. An estimated total of approximately 7,767 man-days of fishing pressure was expended on the mainstem in 1982. Anglers harvested an estimated 18,047 kokanee on the Middle Fork of the Flathead River during the 1982 fall. snag season. The catch rate was 0.93 fish per hour. An estimated total of 5,006 man-days of fishing pressure was expended, concentrated mainly in the area near the mouth of McDonald Creek. The total harvest of 30,449 kokanee in the Flathead River system in 1982 was much lower than the estimated 152,117 kokanee harvested in 1981. Anglers focused almost entirely on the early. run of kokanee bound for McDonald Creek in both the 1981 and 1982

seasons. This represents a shift from 1975 when anglers focused mainly on the late run of kokanee bound for mainstem spawning areas.

Comparison of kokanee numbers and redd counts in Brenneman's Slough and Beaver Creek indicated approximately three kokanee spawners per completed redd. The majority of spawning occurred during the dark hours in dielexperiments conducted in mainstem spawning Area 39. In Brenneman's Slough, spawning activities such as redd maintenance and behavioral interactions were observed throughout the daylight hours.

A total of 648,465 m^2 of suitable spawning gravel for kokanee was measured in the mainstem Flathead River below the South Fork. This total represents approximately seven times the quantity of suitable gravel which is present in McDonald Creek. Kokanee have utilized a total of 44 mainstem areas comprising 107,946 m^2 of gravel area during the past four years of study.

Flows of 3500-4000 cfs were maintained in the mainstem Flathead River during both the spawning and incubation periods. Hungry Horse operations resulted in negligible dewatering mortality in mainstem spawning beds during the 1982-83 period, Survival of eggs in late December ranged from 37 to 75 percent in mainstem redds and 23 to 78 percent in redds sampled in other river system spawning areas.

Kokanee year class strength as measured by spawner length and flows in the mainstem Flathead River from 1966 to 1982 were closely correlated, indicating Hungry Horse discharges had impacted kokanee populations. Strong relationships existed between kokanee year class strength and spawning and incubation gauge height difference ($r = -0.93$, $p<.001$) and average number of hours/day kokanee eggs were dewatered ($r = 0.94$, $p<.001$).

Timing and abundance of kokanee fry emergence was studied to help assess the relative contribution of river system spawning areas to Flathead Lake. An estimated 12.4 million fry emerged from McDonald Creek from February through June of 1983, representing a 68 percent survival rate from potential egg deposition. An estimated 6,734 fry, 4.5 percent of the estimated potential egg deposition, emigrated from the Whitefish River in 1983. An estimated 31,500 fry emigrated from Brenneman's Slough in 1983, representing a 13.7 percent egg to fry survival rate. Estimates of 3,700 and 3,500 emigrating fry were obtained for Beaver and Deerlick creeks which represented 15.7 and 22.7 percent egg to fry survival.

Experiments conducted with marked fry emigrating from McDonald Creek indicated fry moved as fast or faster than the current speed. Marked fry left McDonald Creek in a large group and traveled 34 km down the Flathead River to Columbia Falls in five hours. The fry required 12 hours of night travel to reach Kalispell, 55 km downstream from McDonald Creek. Chironomid larvae were the dominant item in the diet of kokanee fry in Flathead River system spawning areas. Fry length and water temperature were positively related in the various spawning areas.

The mainstem kokanee run presently contributes less than 20 percent of the recruitment to Flathead Lake, largely due to the effects of Hungry Horse discharges on kokanee reproductive success. The mainstem run has declined from well over 100,000 post-harvest spawners in 1975 to an average of only 10,000 post-harvest spawners during the past four years. Implementation of the recommended spawning (3500-4500 cfs) and incubation (3500 cfs minimum) flows in the mainstem would increase kokanee egg survival and should result in the recovery of the mainstem kokanee run. The recovery period could vary, depending on natural fluctuations in the survival rates of kokanee eggs and fry. Average conditions of 20 percent egg to fry survival and two percent fry to adult survival with no angler harvest would bring about recovery to the level of the 1975 run after approximately five kokanee generations, or by the year 2003. The mainstem kokanee run would reach complete recovery after approximately six generations (2008) with a harvest rate varying between 10 and 50 percent after the population reached a minimum fishery level of 50,000 kokanee.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

INTRODUCTION

Kokanee salmon (Oncorhynchus nerka) were first introduced to the Flathead system in 1916 (Montana Fish and Game Commission 1918) and a thriving kokanee fishery had developed by the early 1930's in Flathead Lake. Kokanee have become the most popular gamefish in the drainage, supporting a summer trolling fishery in Flathead Lake and an intense fall snagging fishery in the Flathead River system. Kokanee comprised about 90 percent of the total harvest of 719,000 fish in the Flathead Lake--River system during the 1981-82 season (Graham and Fredenberg 1982, Fredenberg and Graham 1982a, 1982b). Over 80 percent of the gamefish harvested in 1975 were kokanee salmon (Hanzel 1977). Anglers from most of the western United States, Alberta and British Columbia have taken part in the Flathead Lake trolling and river snagging fisheries.

Hungry Horse Dam was constructed on the South Fork of the Flathead River from 1948-1953. At the time of completion, Hungry Horse was the fourth largest concrete dam in the world, measuring 172 m in height and impounding 2 reservoir which is 66 km long and contains 3,461,000 acre-feet of water at full capacity.

Located 8 km upstream from the mouth of the South Fork, the Hungry Horse project is part of the Bonneville Power Administration electrical energy grid. The dam is operated primarily for flood control and hydroelectric energy production. Penstocks are located 75 m below the crest. At present peak capacity, the powerhouse produces 328 Mw at a rated flow capacity of 11,417 cfs. Operation of Hungry Horse is determined in concert with the complex network of electrical energy producing systems, consumption needs, and flood control requirements throughout the Pacific Northwest. Water leaving Hungry Horse passes through 19 dams before reaching the Pacific Ocean. Operation of Hungry Horse altered natural flow and temperature regimes in the South Fork and in the mainstem Flathead River below the South Fork. The effects of the altered discharges and temperature on the mainstem are ameliorated by natural flows from the unregulated North and Middle Forks.

Kokanee spawning in the South Fork and mainstem have been affected by operation of Hungry Horse Dam. Kokanee prefer to spawn in shallow areas with moderate water velocities. In large rivers like the Flathead, kokanee spawn primarily along stream margins and in side channels. Vertical water level fluctuations of over two meters in the South Fork and up to 1.4 m in the mainstem have resulted in alternate wetting and dewatering of eggs when flows were high during the spawning season and low during the incubation season. Eggs deposited in spawning gravels which are dewatered are subject to freezing mortality. Heavy incubation mortality resulting from dewatering has probably been the most important factor affecting year class strength in Flathead kokanee (Graham et al. 1980, McMullin and Graham 1981, Fraley and Graham

1982). The mainstem kokanee spawning run has declined from a post-harvest level of over 100,000 fish in 1975 to an average of 14,000 fish during the last four years (Fraley and Graham 1982, Hanzel 1977).

Studies conducted by Department of Fish, Wildlife and Parks from 1979 to 1982 under Bureau of Reclamation funding, have resulted in flow recommendations for the mainstem of 3500-4500 cfs during the kokanee spawning period (15 October-15 December) and 3500 cfs or more during the remainder of the year (Fraley and Graham 1982). Studies conducted by the Bureau of Reclamation are ongoing concerning effects of the flow recommendations on power production from Hungry Horse Dam and the economic feasibility of a reregulating dam on the South Fork below Hungry Horse Dam (Richard Prange, Bureau of Reclamation pers. comm.).

Montana Department of Fish, Wildlife and Parks studies continued under Bonneville Power Administration funding in 1982 with major emphasis on fine tuning the flow recommendations in the mainstem Flathead River, monitoring their effect on kokanee reproduction and recommending management strategies to enhance the mainstem kokanee fishery. Major objectives of the study are:

1. Continue to develop the stock recruitment relationship for kokanee in the river system begun in 1979 (Graham et al. 1980b).

2. Quantify effects of the amount and timing of controlled flows on distribution and reproductive success of kokanee in the reregulated portion of the Flathead River. Determine the relative contributions of day and nighttime spawning.

3. Determine relative contributions of major river system spawning areas to total kokanee population.

4. Identify timing and destination of successive runs of kokanee spawners in the Flathead River and their use by fishermen, and determine if timing is affected by discharge from Hungry Horse Dam.

DESCRIPTION OF STUDY AREA

The Flathead River which drains 21,876 km^2 of southeast British Columbia and northwest Montana is the northeastern most drainage in the Columbia River basin (Figure 1). Three forks of approximately equal size drain the west slope of the Continental Divide.

The North Fork of the Flathead flows south out of British Columbia forming the western boundary of Giacier National Park. The North Fork was classified as a scenic river under the National Wild and Scenic Rivers Act, from the Canadian border to Camas

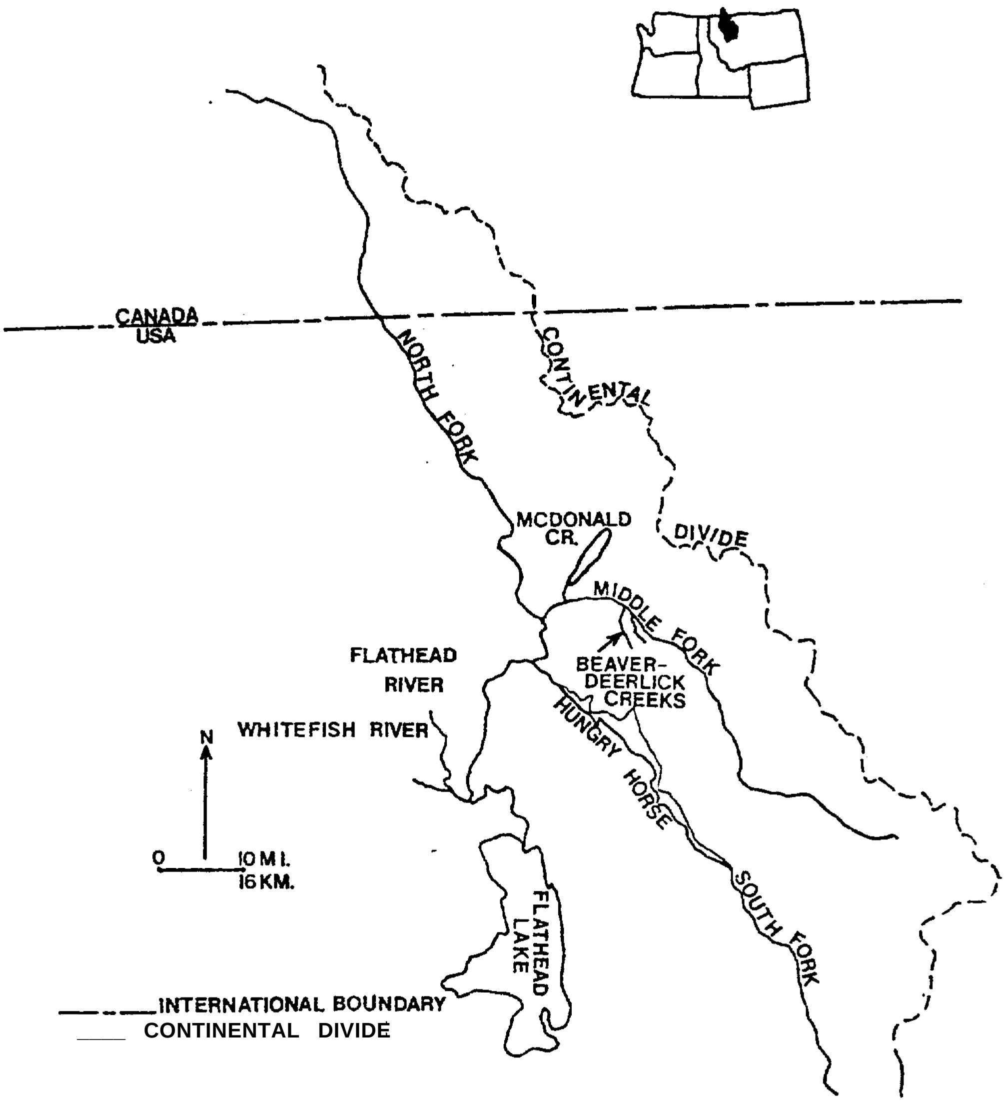

Figure 1. The upper Flathead drainage.

Creek, a distance of 68 km. The lower 24 km of the North Fork was classified as a recreational river.

The Middle Fork of the Flathead was classified as a wild river from its source in the Bob Marshall Wilderness area to its confluence with Hear Creek near Essex, Montana. Below Dear Creek, the Middle Fork was designated a recreational river. The Middle Fork forms the southwestern boundary of Glacier National Park.

The upper South Fork of the Flathead River was also classified as a wild river from its headwaters in the Bob Marshall Wilderness to Hungry Horse Reservoir. A short stretch of the South Fork, from the headwaters of Hungry Horse Reservoir upstream to Spotted Hear was classified recreational. The lower South Fork is regulated by flows from Hungry Horse powerhouse. Vertical water level fluctuations in the lower South Fork have been as much as 2.5 m daily due to peak hydroelectric energy production (Figure 2) .

The mainstem Flathead River was classified a recreational river from the confluence of the North and Middle forks to the confluence of the South Fork. Streamflows in the Flathead River are subject to fluctuation due to the operation of Hungry Horse powerhouse downstream from its confluence with the South Fork.

Peak flows in the mainstem normally occurred in late May or early June, coinciding with peak runoff in the North and Middle Fork drainages (Figure 3). During fall and winter, the mainstem hydrograph mirrored that of the South Fork. Daily vertical water level fluctuations in the mainstem varied up to 1.4 m due to Hungry Horse operation (Figure 2).

Water temperature in the mainstem was also partially regulated by discharge from Hungry Horse Dam. Hypolimnial water releases from Hungry Horse Dam lowered summer water temperatures and elevated winter water temperatures in the mainstem (Figure 4).

Kokanee salmon, westslope cutthroat (*Salmo clarki*) and bull trout (*Salvelinus confluentus*) are the three major sport fish in the Flathead River (Hanzel 1977). Cutthroat and bull trout are native to the Flathead, but kokanee were introduced. In 1916, 500,000 chinook salmon eggs obtained from the Oregon Fish Commission were reared in the Flathead Lake Hatchery and the fry were stocked in several area lakes (Montana Fish and Game Commission 1918). In subsequent years, mature kokanee salmon or "redfish" were netted in Lake Mary Ronan and Flathead Lake; apparently they had been mixed in with the chinook salmon eggs. Kokanee populations became established in Flathead Lake and continued to grow. By 1933, a kokanee trolling fishery was underway on Flathead Lake. That fall an estimated catch of 100 tons of kokanee was canned for the Montana Relief Commission. Thousands of kokanee were spawning along the shores of Flathead

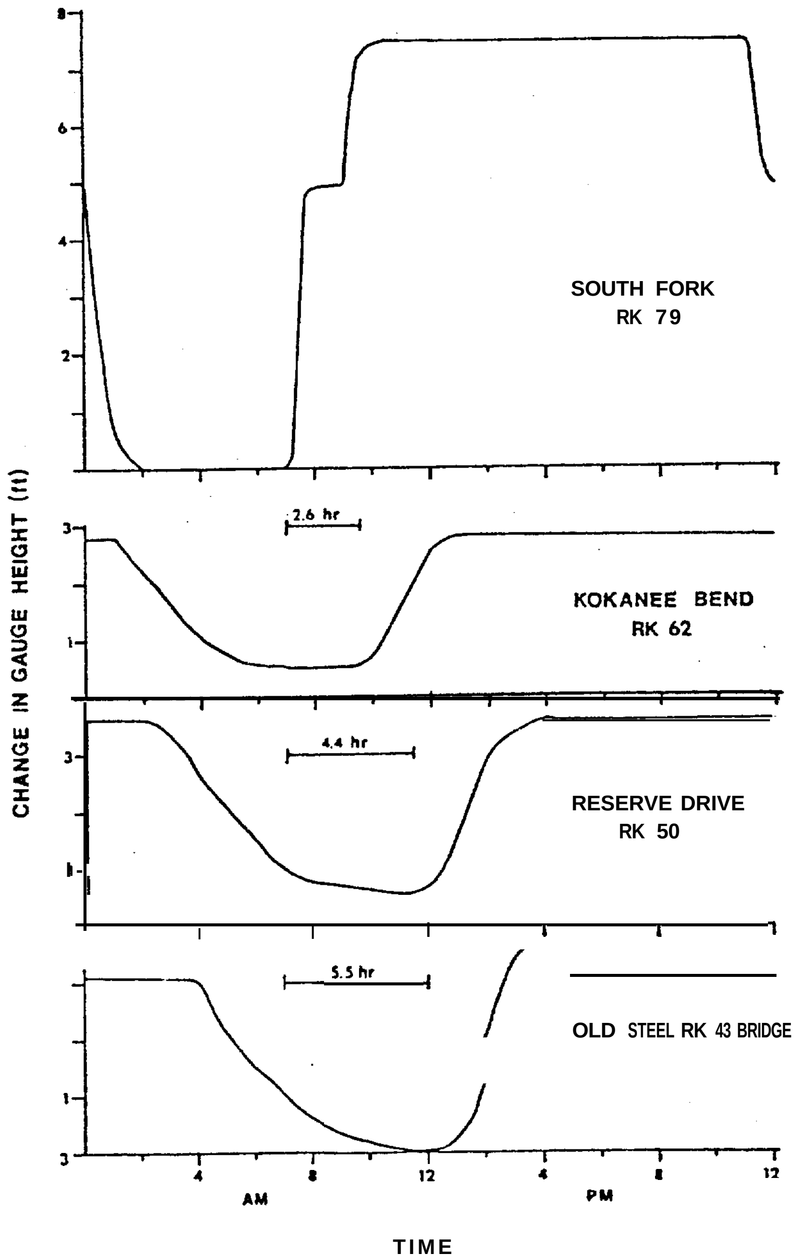

Figure 2. Vertical water level changes in the South Fork and three areas of the mainstem Flathead River as a result of generation at Hungry Horse Dam, August 2, 1979. Range of flows is 164 cfs to 9,100 cfs in the South Fork and 3,210 cfs to 12,100 cfs in the mainstem (from McMullin and Graham 1981).

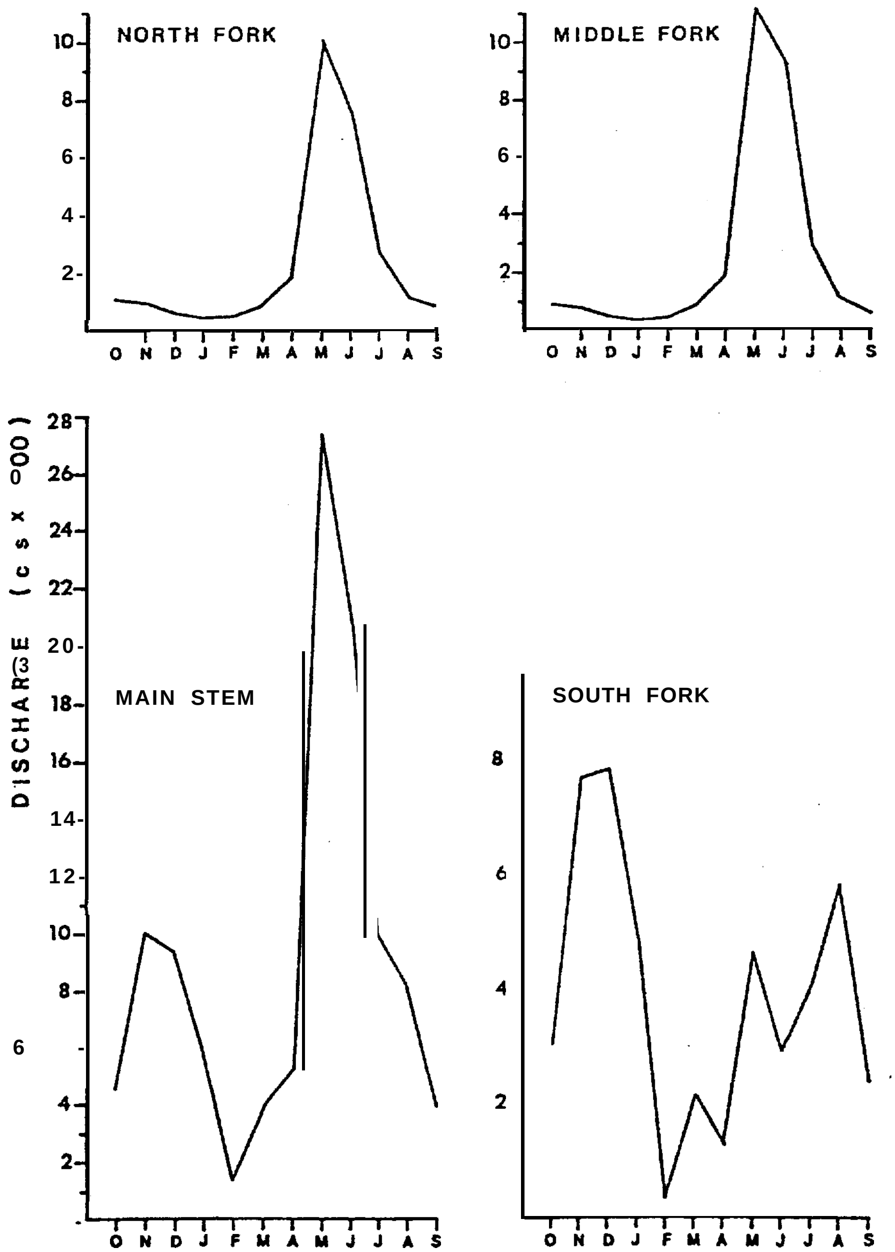

Figure 3. 1979 hydrographs for the North Fork near Canyon Creek, Middle Fork near West Glacier, South Fork near Hungry Horse and Flathead River at Columbia Falls (from McMullin and Graham 1981).

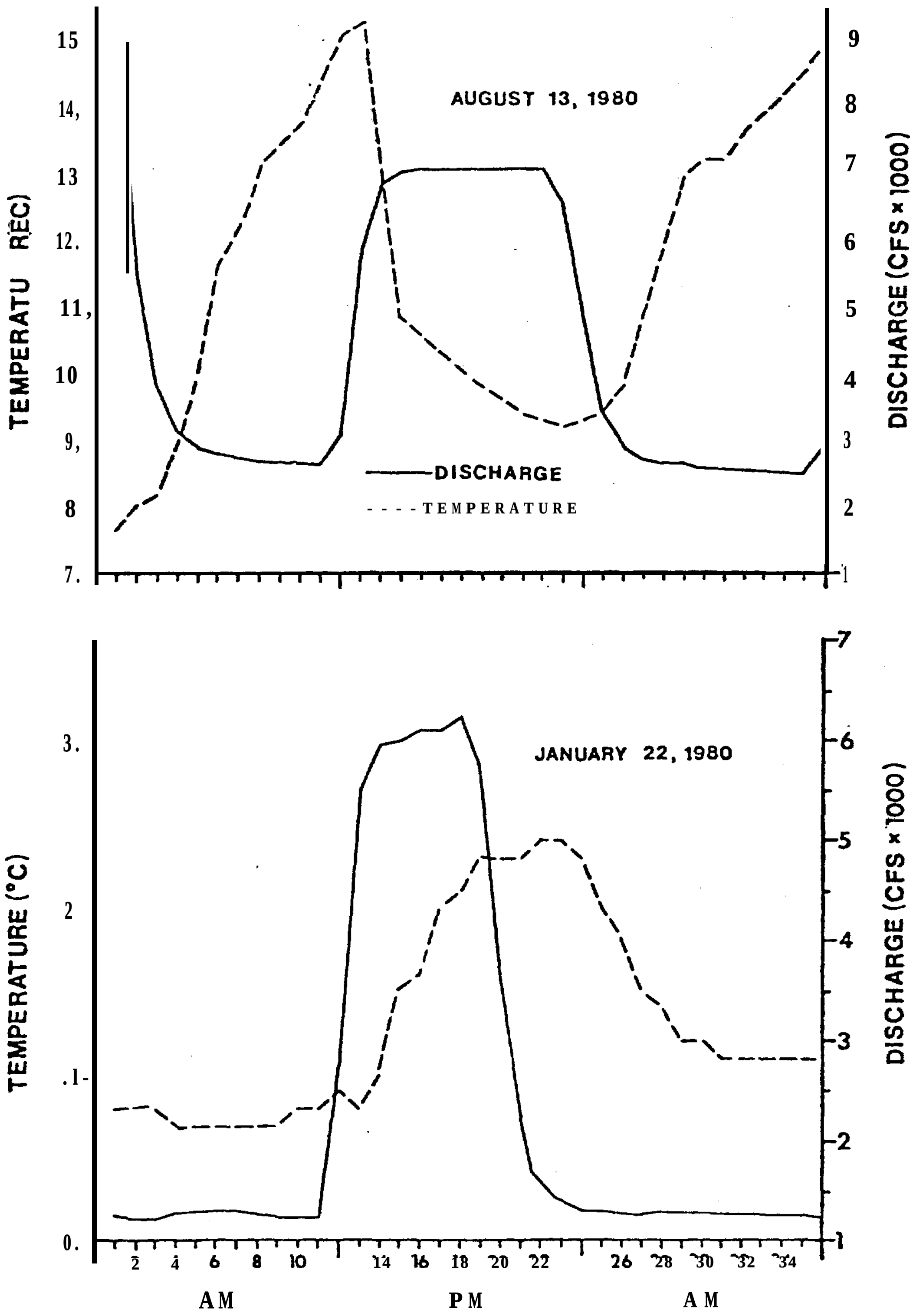

Figure 4. Flow-related temperature fluctuations in the mainstem Flathead River at Columbia Falls on a winter day and a summer day (from McMullin and Graham 1981).

Lake and runs were ascending the Flathead River system (Montana Fish and Came Commission 1934, Alvord 1975).

By the late 1930's, a run of kokanee had become established in McDonald Creek (Fish and Wildlife Service 1968) and probably in the Whitefish River and spring areas in the mainstem Flathead River. The kokanee population in the mainstem continued to grow in size from the 1960's through the early 1970's. This was partly associated with flow patterns and modified temperatures of water discharged from Hungry Horse Dam. During the mid-1960's, local residents first noticed large numbers of kokanee in Beaver and Deerlick creeks in the Middle Fork drainage. Department personnel first observed kokanee spawning in the Middle Fork of the Flathead River from McDonald Creek upstream to the mouth of Deerlick Creek in 1981.

Other fish species commonly found in the Flathead River include rainbow trout (Salmo gairdneri), mountain whitefish (Prosopium williamsoni) and largescale sucker (Catostomus macrocheilus) Several other species encountered less frequently include brook'trout (Salvelinus fontinalis), Yellowstone cutthroat trout (Salmo clarki bouvieri), lake trout (Salvelinus namaycush), lake whitefish (Coregonus clupeaformis), pygmy whitefish (Prosopium coulteri) northern squawfish (Ptychocheilus oregonensis) Several more species are known to be present in the drainage, but are rarely encountered in the Flathead River.

METHODS

ADULT KOKANEE MIGRATION AND ABUNDANCE

Migration and abundance of kokanee spawners was monitored by snorkeling, aerial census, fisherman tag returns of marked fish, and redd counts. Kokanee were observed by snorkeling in the North and Middle Fork drainages. Aerial census was the major method used in determining distribution in the mainstem Flathead and lower Middle Fork. Tag return information was utilized to assess distribution and harvest throughout the drainage.

Snorkeling surveys were conducted in selected areas of the Middle Fork above McDonald Creek in late September and the North Fork from Kintla Creek to Canyon Creek in early October, 1982. Snorkeling counts were made on the entire length of McDonald Creek four times between mid-September and mid-November, 1982.

Aerial counts of kokanee spawners were made as part of a fisherman census on the Flathead River from the mouth of the Stillwater River to the confluence of the North and Middle Forks. These aerial counts were also made on the Middle Fork below West Glacier. A small plane carried the observer at an elevation of approximately 150 m over the river channel and counts were made by estimating the size of schools of adult spawners. The counts were made approximately three times weekly from 28 August to 15 October, 1982. Aerial counts were terminated after 1 October on the Middle Fork to avoid conflicts with soaring eagles. Gibson 1973) Neilson and Geen (1981) and Church and Nelson (1963) successfully used aerial counting methods to enumerate salmon.

Kokanee spawner abundance was estimated from redd counts in all segments of the river system except McDonald Creek, where redds were too dense to be enumerated individually. Abundance was estimated by multiplying redd counts by an average figure of three spawners per completed redd. This ratio was determined by comparisons of trap counts of spawners and redd counts in confined areas.

CENSUS OF THE RIVER SYSTEM KOKANEE FISHERY

A survey of the kokanee fishery was conducted on sections MSl-MS4 of the mainstem Flathead River and section MFl of the Middle Fork of the Flathead River from 28 August through 15 October, 1982 (Table 1). The purpose of the survey was to determine catch rates, fishing pressure, harvest, and other information concerning the 19-day lure fishery for kokanee salmon in the lower mainstem from 28 August to 15 September, and the 31-day snag fishery for kokanee in the mainstem and Middle Fork from 15 September through 15 October.

The fishery or creel census design was a modification of the method described by Neuhold and Lu (1957) and used by Fredenberg

Table 1. Description of angler survey sections on the mainstem Flathead and Middle Pork of the Flathead River.

Description	River section	Section length km	Section length Miles
Flathead River - Flathead Lake to confluence of Stillwater River	MS1	36.0	22.4
Flathead River - Mouth of Stillwater River to Pressentine Fishing Access	MS2	19.0	11.8
Flathead River - Pressentine Access to Highway 40 Bridge at Columbia Falls	MS3	10.6	6.6
Flathead River - State Highway 40 Bridge to confluence of North and Middle Forks	MS4	23.3	14.5
Middle Fork of Flathead - Confluence of North Fork to coaflueace of Harrison Creek	MF1	21.7	13.5

and Graham (1982a). In river sections MS1 through MS4 (the mainstem Flathead River), aerial counts of anglers from a fixed-wing aircraft were made twice a day on all scheduled sample days, weather permitting, from 28 August through 15 October. The time of the flight each day was randomly chosen from 7:30 a.m. to 1:00 p.m., with the other flight of the day beginning six hours after the start of the first flight. Starting times were chosen at random with non-replacement within two-week intervals so that counts and interviews were conducted during all the daylight hours. As the season progressed, starting and ending times were adjusted to compensate for fewer hours of daylight.

Weekdays were treated separately from weekend days in setting up the sampling schedule. Four weekdays and three weekend days were chosen at random during each two-week period.

All flights originated from Kalispell and counts were conducted in upstream order. The counts required less than fifteen minutes per section and thus were considered as instantaneous in analysis of data. Only those individuals seen actually fishing or with rods nearby were counted as fishermen. Anglers associated with boats were considered to be boat fishermen if they were fishing from the shore when counted.

Creel clerks interviewed fishermen on a party basis. Party representatives were asked questions about the number of anglers, where they were from, whether they fished from shore or used a boat, what type of terminal tackle they used, how many hours they had fished, and whether or not they were done fishing for that particular day. At least two creel clerks (one on the Middle Fork and one on the mainstem) conducted interviews on all sample days. Clerks recorded lengths of the kokanee harvested as time allowed.

Angler count interview data were recorded directly on coding forms and keypunched for computer analysis. Analysis was done following the procedures of Neuhold and Lu (1957) using a computer program developed by the Department. Estimates were formulated on a weekly basis with weekdays and weekends lumped together. Pressure estimates were based on the average number of daylight hours available during each two week period (one-half hour before sunrise to one-half hour after sunset).

Catch rates were calculated as the number of fish caught divided by the total number of hours fished for the sample of anglers interviewed. Harvest rate was the catch rate for only those fish kept by anglers. The harvest was estimated by multiplying pressure by harvest rate for each two-week period and then summing them.

The snag fishery season for kokanee in the Flathead River system during 1982 was shorter than in 1981 or 1975. During 1981 and 1975, the opening date was 1 September. The closing date in 1981 was 23 October on the mainstem and 30 November on the Middlw

Fork. During 1975, the snag season extended from 1 September through January.

SPAWNING SITE INVENTORY

An inventory of spawning sites or redds was conducted in five major spawning areas in the Flathead River system, including the mainstem Flathead, Middle Fork of the Flathead, Beaver-Deerlick Creeks, Whitefish River and South Fork of the Flathead. The inventories were made when spawning was considered approximately 90 percent completed in each area.

Spawning and incubation flows in the Flathead River below the South Fork were provided during the 1982 water year through agreement with the Bureau of Reclamation and the Bonneville Power Administration, as recommended to the Northwest Power Planning Council by the Department of Fish, Wildlife and Parks. Spawning flows of 3500 to 4500 cfs (at Columbia Falls) were maintained from 15 October to 15 December. A minimum flow of 3500 cfs was maintained from 16 December to 30 April.

Kokanee redd counts were made in early October and early and late November in the Flathead River below the South Fork. All areas which had suitable spawning gravel were checked from a jet boat or by wading.

Surveys of spawning activity in McDonald Creek were made while snorkeling from September to November, 1982. Actual counts of redds were not made due to the density of spawners and redd superimposition.

Kokanee redd counts were made in the Middle Fork of the Flathead River above McDonald Creek on 24 and 25 October, 1982. The Middle Fork below McDonald Creek was surveyed on 26 October. Redd counts were made in both Beaver and Deerlick creeks in the Middle Fork drainage above McDonald Creek on 8 December. The Whitefish River and South Fork of the Flathead were surveyed for kokanee redds on 22 October and 12 November, respectively.

Substrate samples of kokanee redds were collected from spawning areas in McDonald Creek, Whitefish River, Middle Fork of the Flathead River and the mainstem Flathead River. The samples were analyzed as described in Fraley and Graham (1982).

Fish traps to enumerate kokanee spawners were placed in Brenneman's Slough (mainstem area 1), Columbia Falls Slough (mainstem area 36), Beaver Creek and Deerlick Creek. Numbers of spawners entering these areas were compared with the numbers of redds constructed.

Areas of gravel in four mainstem kokanee spawning areas, McDonald Creek and Beaver Creek were selected for diel spawning studies in September, 1982. In areas where sufficient spawners were present, areas of gravel were alternately covered and uncovered during day and night periods. Redd construction and egg deposition were compared in areas available for daytime and nighttime kokanee spawning. Behavioral observations were also made throughout the spawning period in these areas.

The channels of the Flathead River from the mouth of the South Fork to the Salmon Hole (37 km) were traced from aerial photographs (1:2300) provided by USDI, Bureau of Reclamation. The aerial photos were taken on flights made in October, 1978. The wetted substrate of the mainstem was surveyed from a jet boat or by wading and classified as spawnable or unspawnable based on substrate composition, compaction, and velocity criteria. The criteria used were based on observations in kokanee spawning areas in the Flathead River system from 1979-1982. Gravel areas with water velocities greater than three feet per second, high compaction or large amounts of very fine or very coarse material were classified unspawnable. The areas of spawnable and unspawnable substrate were drawn in on the aerial photos using landmarks or survey equipment.

The gravel area survey was conducted from 29 July through September at flows of 3500-4000 cfs. If flows were not in this range, an allowance was made to correct all measurements to the wetted area at these flows. A few areas of the mainstem were mapped during the late winter and spring of 1983.

Completed gravel area maps were planimetered using a 2400 Digitablet Menu Planimeter (Numonics Corp.) provided by the Flathead National Forest. All area measurements were rounded to the nearest tenth of a square meter and were summarized by river section Approximately two percent of the river was too deep to be classified during the survey. These areas were included in the tinspawnable area totals and will be classified using SCUBA gear during the summer of 1983. Spawning gravel maps of the mainstem Flathead River are not attached to this report but are available from the Montana Department of Fish, Wildlife and Parks, Box 67, Kalispell, Montana, 59901.

EGG INCUBATION AND ALEVIN DEVELOPMENT

Survival and development of kokanee eggs and sac-fry alevins was monitored in natural redds throughout the winter in the Flathead River to evaluate the effects of the requested spawning and incubation flows. A hydraulic egg sampler (Graham et al. 1980, McNeil 1963) and kick net were used to sample natural redds.

Incubation and-development in the lower Flathead River were also evaluated with experimental egg plants. Eggs were put in fiberglass bags and buried in gravel in a deep area (4 m) and a shallow area (0.5 m) near Columbia Falls.

Survival and development of eggs and alevins in natural redds was also monitored at spawning areas in the Middle Fork Flathead River, McDonald Creek and the Whitefish River. Two areas of the Middle Fork, one below and one above McDonald Creek, were sampled with the hydraulic egg sampler and kick net. A 2 km portion of McDonald Creek was sampled with the hydraulic egg sampler and kick net to estimate the density of live eyed eggs and sac fry alevins in the gravel. Total production and survival were estimated from 34 samples taken at randomly selected points using methods described by McNeil (1964).

Incubation and development in the Middle Fork of the Flathead River was also monitored with experimental egg plants. Eggs were placed in fiberglass screen bags and buried in gravel in a deep area (7 m) and a shallow area (0.5 m) in the river above West Glacier.

B-KOKANEE LENGTH RELATIONSHIPS

Relationships between year class strength of kokanee spawners and flows during the spawning and incubation seasons which produced them were analyzed (Graham et al. 1980, McMullin and Graham 1981, Fraley and Graham 1982). Length of kokanee spawners was used as the measure of year class strength, assuming fish size was inversely related to fish numbers in Flathead Lake. Other workers have reported this density dependent relationship in sockeye salmon populations (Foerster 1944, Johnson 1965, Goodlad 1974, Stober etal. 1978).

The majority of kokanee spawners entering the river system in a particular year were of one age class (Hanzel 1976). However, interactions with other year classes of kokanee can affect their growth. To account for year class interactions, a three-year moving average of flow conditions was used in the calculations (Graham et al. 1980, McMullin and Graham 1981).

FRY EMERGENCE AND MIGRATION

Timing and abundance of emerging fry was evaluated using 0.5 m^2 drift nets suspended in the water column and fry emergence traps placed over the spawning gravel.

Drift nets were used in all river system spawning areas to filter swimming fry from the water column Net sets were made weekly in McDonald Creek, Brenneman's Slough and Beaver Creek during February and early March and twice weekly from mid-March through early June. Nets were set generally weekly from March through May in the Middle Fork of the Flathead River near West Glacier, the mainstem Flathead River near Kalispell, the Whitefish River near Rose Crossing and Deerlick Creek at the Highway 2 crossing. Drift nets were suspended in the water column overnight at each area. Fry were counted, the volume of water filtered by the net was calculated and a total estimate of fry emigration from each area was obtained. These data were used to estimate production and egg to fry survival rates from each area. Distribution of fry in the water column was evaluated in overnight experiments using drift nets distributed laterally and vertically in the water column in McDonald Creek.

Three experiments were conducted to monitor fry movements in the river system. Three groups of fry were captured in McDonald Creek and dyed with Bismark Brown stain at a concentration of 1:30,000 (Ward and Ver Hoeven 1963). Movements of these fry were followed by setting drift nets at the junction of the Middle and North Forks of the Flathead River near Blankenship Bridge (8 km downstream), the mainstem Flathead River at the County Bridge 'below Columbia Falls (34 km downstream) and at the Old Steel Bridge near Kalispell (55 km downstream).

Flows during the first experiment averaged 1100 cfs in the Middle Fork, 2300 cfs in the mainstem above the South Fork, and 7400 cfs in the mainstem below the South Fork. Flows during the second experiment averaged 2100 cfs in the Middle Fork, 4600 cfs in the mainstem above the South Fork, and 8200 cfs in the mainstem below the South Fork. During the third experiment, flows averaged 3850, 4830 and 17300 cfs in the Middle Fork, North Fork and mainstem,respectively.

Fry emergence traps (0.12 m^2) were placed in river system spawning areas to help determine emergence timing and abundance of kokanee fry (Fraley and Graham 1982). Phillips and Koski (1969) used similar traps in Oregon river systems to capture salmonid fry. The traps consisted of a nylon net and metal frame with a nylon sock and screen fyke to capture emerging fry. Frames were attached to the stream bottom with rebar. Eight traps were placed in mainstem spawning areas, four were placed in McDonald Creek and four were placed in Beaver and Deerlick creeks.

One hundred fifty eyed kokanee eggs were planted in each of five additional traps placed in McDonald Creek containing five different sediment mixtures to determine potential egg to fry survival rates in various sediment mixtures.

Kokanee fry were collected for food habit analysis from four Flathead River system spawning areas; Brenneman Slough (Mainstem Area 1), McDonald Creek, Beaver Creek and the Middle Fork of the FlatheadRiver.

Kokanee fry were measured and the stomachs removed. Each stomach was sectioned from the base of the esophagus to the pylorus. The stomach was emptied and the contents identified and counted. Head capsules were counted to determine numbers and body parts noted Aquatic insects and zooplankton were identified to order and terrestrial insects were enumerated. Zooplankton were classified into Cladocera and Copepoda.

Stomach contents were expressed in percent number of organisms in the sample, frequency of occurrence, percent weight (mg), and Index of Relative Importance (IRI). IRI combines the other three values into an arithmetic mean which can range from 1 to 100. An IRI value of 100 indicates exclusive use of that food type (George and Hadley 1979). Zooplankton and aquatic macro-invertebrates were assigned mean wet weights (mg) following methods in Leathe and Graham (1981).

RECOVERY OF THE MAINSTEM KOKANEE POPULATION

To protect the recovery of the mainstem kokanee population, an egg to fry survival rate of 20 percent and various fry to adult survival rates were assumed. A 20 percent overlap of the previous kokanee year class was assumed and the number of retaining kokanee spawners was projected for each year from 1983 to 2033. A computer program which incorporated the above assumptions was written by Roger Larson of the Bureau of Reclamation in cooperation with the Department of Fish, Wildlife and Parks.

RESULTS AND DISCUSSION

KOKANEE ABUNDANCE AND MIGRATION

Kokanee Abundance

An assessment of the relative contributions of various segments of the river system to kokanee recruitment to Flathead Lake is required to evaluate the recommended study flows in the Flathead River below Hungry Horse Dam. Determining the abundance of kokanee in areas unaffected by Hungry Horse discharges such as McDonald Creek, the Middle Fork of the Flathead River, Heaver Creek, Deerlick Creek, the Whitefish River and mainstem spring areas provides a reference to monitor natural fluctuations in the kokanee populations.

Approximately 5,000 kokanee spawned in the mainstem Flathead River in 1982, assuming approximately three kokanee spawners per completed redd (Table 2). This compares to 24,000, 2,000 and 12,000 post-harvest spawners estimated for 1981, 1980 and 1979, respectively. These total estimates were adjusted based on redds located after the November redd count. An estimated 165,000 kokanee were present after harvest in the mainstem in 1975. Discharge patterns from Hungry Horse Reservoir have contributed to these relatively weak year classes of kokanee in recent years.

A mean trend count of 30,984 kokanee (this count includes 5,719 dead fish) was obtained in McDonald Creek by snorkeling on 27 October, 1982 (Table 3). It is probable that some kokanee had spawned and died and some kokanee entered the creek after the count. The actual number of kokanee using McDonald Creek in 1982 was probably nearer to the upper range of the estimate of 35,000 fish. Counts of spawners made at about three-week intervals indicated live kokanee spawner numbers peaked during the month of October (Table 4). Spawning had begun by 20 September when 11,516 live kokanee were counted and was virtually completed by 17 November when only 1,366 live kokanee were present.

The number of kokanee in McDonald Creek in 1982 was lower than in the three previous years of the study (Table 3). Numbers of spawners were also generally lower than in previous years of the study in the Middle Fork of the Flathead River above and below McDonald Creek (Table 3).

Although fishermen reported catching a few kokanee in the North Fork of the Flathead, none were seen during a snorkel survey on 4 October, 1982. Water temperature or some other factor appears to limit kokanee spawning success in the North Fork.

Approximately 300 kokanee spawned in the South Fork of the Flathead River based on the 1982 redd count (Table 2 and Appendix A). Releases from Hungry Horse Dam during the spawning and incubation periods provided continuous watering of the redds

Table 2. Number of redds observed in the Flathead River system in late November 1979, 1980, 1981 and 1982.

	Year			
	1982	**1981**	1980	1979
Flathead River below the South Fork				
Total	1,422 1/	6,952	467	2,802
Non-spring	1,199 2/	5,961	77	1,861
Spring	223	991	390	941
South Fork Flathead River	100	300	--3/	--3/
Middle Fork Flathead River	751	2,300	--3/	--3/
Beaver Creek	18	516	--3/	0
Deerlick Creek	24	202	--3/	--3/
Whitefish River	765	416	426	--3/

1/ An additional 106 redds were located during December and January, bringing the total count to 1,528.

2/ 620 of these redds may have been partially influenced by springs.

3/ Spawning probably occurred but no redd surveys were conducted.

Table 3. Trend snorkel counts of kokanee salmon adults in the Flathead River system above the confluence of the North and Middle Fork, 1979-1982.

	Kokanee counts			
Date	McDonald Creek	Middle Fork below McDonald Creek	Middle Fork above McDonald Creek	North Fork from Kintla Creek to Canyon Creek
September				
9/20-9/21/82	9,942-13,090	2,060-2,620	87-132	0[1/]
9/23-9/25/81	12,434-15,834	19,917-24,297	2,785-3,350	0
9/23-9/25/80	28,700-43,300	350-550	0	0
9/19-9/21/79	1,200-1,500	7,000-12,000	0	175-225
October				
10/27/82	21,525-29,005 (+5,100-6,300 dead kokanee)	1,046-1,441[2/]	---	---
10/21/81	84,000-111,000 (+5,000-7,000 dead kokanee)	11,000-15,000	---	---
10/22/80	37,000-54,000 (+4,000 dead kokanee)	450-500	---	---
10/17/79	60,000-70,000	6,500-9,500	--[3/]	--[3/]

1/ Counted on 10-4-82.
2/ Counted on 10-6-82.
3/ Counts were not made in the North or Middle Fork drainages in October of 1979.

Table 4. Snorkel counts of kokanee in McDonald Creek during 1982.

Date	Number of kokanee				Total mean
	Low count	High count	Mean (live)	Dead kokanee	
9/20/82	9,942	13,090	11,516	7	11,516
10/6/82	22,200	29,421	25,810	258	26,068
10/27/82	21,525	29,005	25,265	5,719	30,984
11/17/82	1,224	1,507	1,366	1 1/	-- 1/

1/ No count was made due to decomposition.

constructed and a much higher rate of survival is expected than in previous years when large fluctuations in flows dewatered redds.

Approximately 2,250 kokanee spawned in the Middle Fork of the Flathead River, based on 1982 redd counts (Table 2 and Appendix A). Approximately 93 percent of these fish spawned above the mouth of McDonald Creek

Totals of only 54 and 72 kokanee spawned in Beaver Creek and Deerlick Creek, respectively, based on 1982 stream trapping and redd counts. Spawning appeared to be later than in previous years in these streams, peaking in mid to late November in both streams.

The Whitefish River supported a relatively large run in 1982 with 2,300 spawners estimated from the 22 October redd count. However, additional spawning was observed through mid-November and it is probable that nearly 3,000 kokanee spawned in the Whitefish River in 1982. This represents about twice as many kokanee than were in the 1981 or 1980 runs. The Whitefish River appeared to be the only segment of the river system that supported a larger run of kokanee than the average over the previous years of the study.

An estimated 45,000 kokanee reached Flathead River system spawning areas during 1982, based on direct observation, redd counts and trap counts. An estimated 140,000, 60,000 and 100,000 kokanee reached spawning grounds in 1981, 1980 and 1979, respectively.

Although depressed well below natural levels, spawner abundance in the Flathead River below the South Fork from 1979-1982 followed the same general pattern recorded for McDonald Creek, indicating natural environmental fluctuations affecting survival as well as Hungry Horse discharge have influenced kokanee abundance. This demonstrates the critical importance of monitoring portions of the river system unaffected by Hungry Horse operations.

Kokanee Migration

The rate of migration and distribution of kokanee spawners may be influenced by river discharge and temperature and may affect the recreation potential of the fishery. Aerial counts of kokanee and tag return information aided in the assessment of the migration patterns in the river system.

The first concentration of kokanee spawners during 1982 in the Flathead River near Kalispell was recorded in an aerial count on 5 September. Small schools of salmon had been sighted as far upstream as McDonald Creek by this date by U.S. Park Service personnel. This timing of the migration of the first wave of kokanee spawners in 1982 is similar to that which occurred in 1979 and 1981. During 1980, large numbers of spawners did not appear in the river near Kalispell until mid-September (McMullin and Graham 1981, Fraley and Graham 1982).

An estimated 11,000 kokanee spawners had reached McDonald Creek spawning grounds by 20 September, 1982. Snorkeling counts, aerial counts and catch rate data near the mouth of McDonald Creek indicated that kokanee moved quickly into McDonald Creek during 1982, and did not hold for significant periods of time in the Middle Fork of the Flathead River. Water temperatures in McDonald Creek during early to mid-September averaged near or below the 16°C temperature level that appears to limit kokanee movement into the creek (Fraley and Graham 1982).

Aerial counts of kokanee spawners in Flathead River Section MS2 indicated a mid-September peak of numbers (Figure 5). No large concentrations of spawners were recorded after 22 September in this section. A small peak of spawners was observed during the second week of October. Electrofishing catch of kokanee in the mainstem near Kalispell also peaked in mid-September but was very low in late September and October (Figure 6).

Aerial counts of spawners in Flathead River Sections MS3 and MS4 peaked during early to mid-October (Figure 5). The majority of these kokanee were probably staging to move upstream into McDonald Creek. Aerial counts in the Middle Fork of the Flathead River indicated that kokanee were moving from staging areas of the upper Flathead River into McDonald Creek without holding in the Middle Fork (Appendix B).

Fishermen returned 61 of the 460 kokanee (13.3%) tagged in the Flathead River near Kalispell in 1982. Tag return information collected from anglers in 1982 indicated an average rate of movement of 2.1 km/day for the 27 kokanee caught which exhibited movement from the tagging site. The maximum rate of movement was 5.3 km/day. Thirty-four tagged kokanee were caught near the tag site.

CENSUS OF THE RIVER SYSTEM KOKANEE FISHERY

Fishery Characteristics and Catch Rates

Mainstem Flathead River

The kokanee fishery on the mainstem Flathead River during 1982 began in late August when kokanee spawners moved from Flathead Lake into the "Salmon Hole" area of the river below Kalispell (sections MS1 and MS2). Kokanee were vulnerable to lure fisherman (mainly boat anglers) prior to the opening of the snagging season on 15 September. Lure fishing for kokanee (including some illegal snagging with lures) also took place in sections MS3 and MS4 before the opening of the snagging season. A total of 128 party interviews were conducted on the mainstem before 15 September.

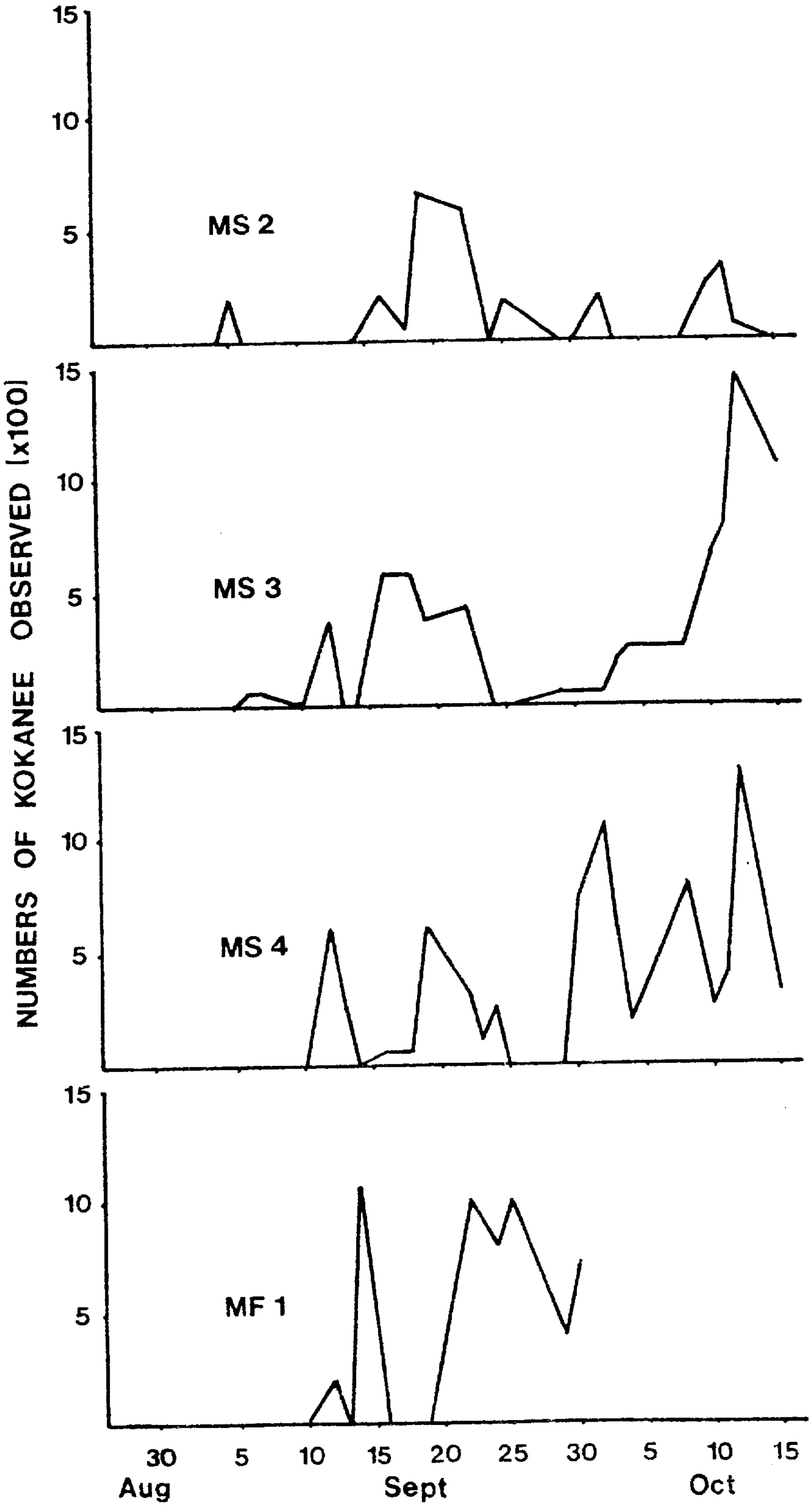

Figure 5. Aerial counts of kokanee spawners in sections of the mainstem Flathead River.

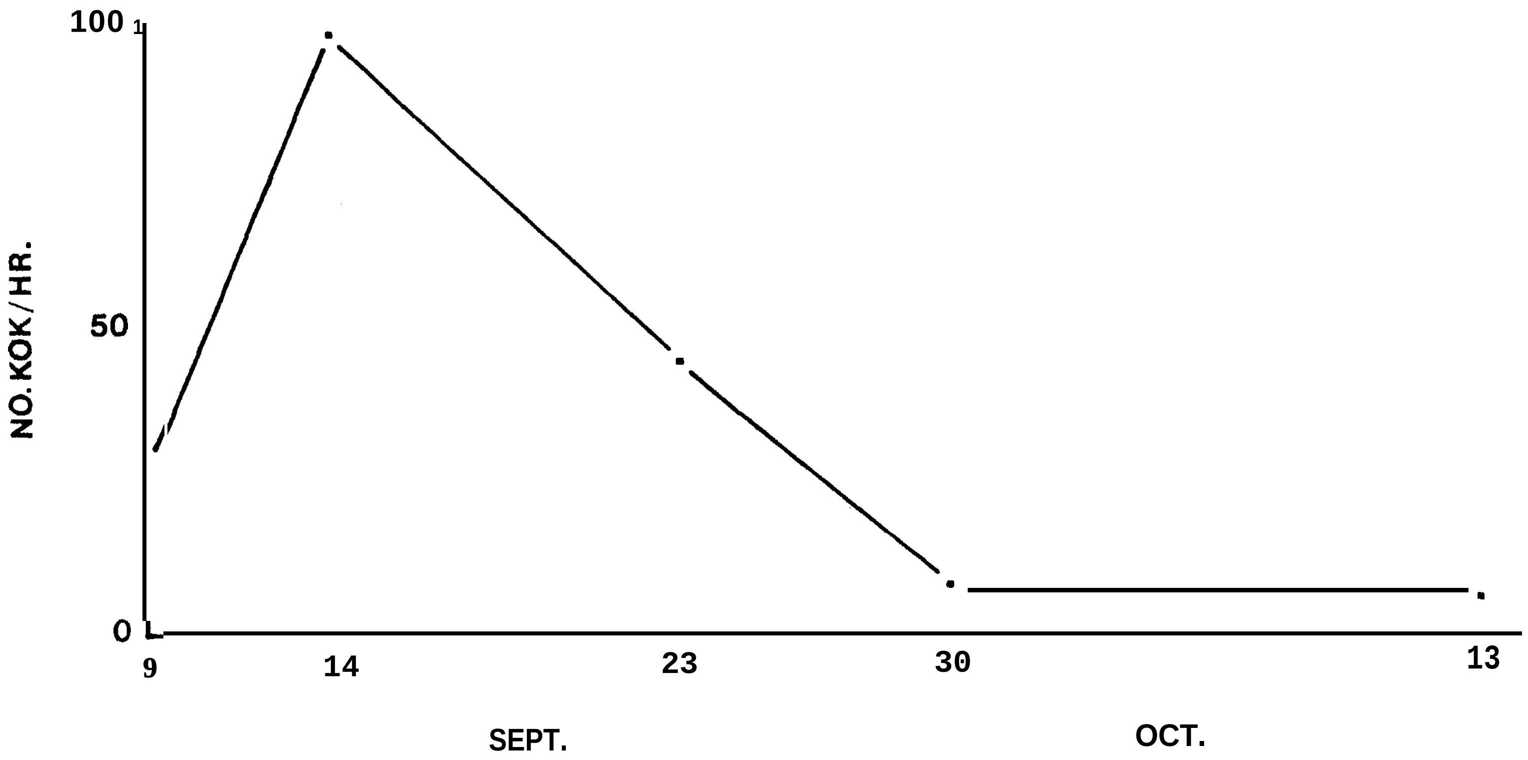

Figure 6. Kokanee catch per hour of electrofishing effort in the Flathead River near Kalispell, 1982.

The snagging season began on 15 September. The opening of the season was delayed from the traditional 1 September opening to allow part of the early run of kokanee to pass up river to the Middle Fork drainage without being exposed'to snagging. Clerks interviewed a total of 196 parties from 15 September through 15 October.

Of the 324 party interviews conducted during the 28 August-15 October mainstem kokanee fishery, 196 (60%) were conducted with chore angler parties and 128 (40%) with boat angler parties (Appendix B). Forty-two percent of the anglers interviewed (comprising 52% of the hours fished) had completed their trips. Anglers averaged 3.3 hours fished in 137 completed trips (Appendix B).

Prior to the opening of the snagging season, the majority of the anglers used lures and combinations of lures and corn Appendix B). After the snagging season began, 87 percent of all anglers on the mainstem used snag hooks (Appendix B). During the entire census on the mainstem, 92 percent of all anglers interviewed were fishing for kokanee. Only two percent fished with flies, while six percent of the anglers used bait. Anglers in section MS1 used the highest percentage of non-snagging terminal tackle (Appendix- B).

Most mainstem anglers interviewed (83%) listed their residence as Flathead County (Appendix B). Only 11 percent of the anglers were from outside Montana.

Catch rates averaged 0.15 kokanee per hour in the mainstem during the early season lure fishery (Appendix B). During the first two weeks of the snag season, mainstem catch rates averaged 0.70 kokanee per hour. Catch rates dropped to 0.18 fish per hour during the last two weeks of the snag season on the mainstem. Overall, mainstem catch rates for kokanee averaged 0.45 fish/hour from 28 August to 15 November. Anglers in sections MS2 and MS4 had the highest average catch rates. Catch rates for shore anglers on the mainstem average 0.62 kokanee per hour while boat anglers caught kokanee at a rate of 0.24 fish/hour (Appendix B).

Middle Fork Flathead River

The kokanee fishery on the Middle Fork of the Flathead River consisted of a concentrated snag fishery, mainly on the lower five miles of the river (below McDonald Creek) from 15 September through 15 October. A total of 411 interviews comprising 3,107 hours fished were conducted with shore fishermen and 25 interviews comprising 184 hours fished were conducted with boat fishermen (Appendix B). About one-third of the parties interviewed had completed their fishing for the day. Most anglers interview& (94%) used snag hooks followed by combinations (3%), lures (2%) bait (1%) and flies (less than 1%). Over 97 percent of all anglers interviewed were fishing for kokanee.

Almost 75 percent of the parties interviewed on the Middle Fork were from Montana, with 36 percent from Flathead County, 25 percent from counties in Eastern Montana, and 13 percent from other counties in Western Montana. Fifteen percent of the angler parties were from Canada and the remaining 11 percent were from other states in the U.S.

Party size, length of completed fishing trip and catch rates varied between the different angler residence groups (Appendix B). Anglers from Flathead County had the highest catch rates for kokanee, 1.28 fish per hour, and the shortest average length of completed fishing trip, 2.7 hours per trip. Canadians and residents of the U.S. other than Montana had the lowest catch rates and longest average length of completed trip.

Catch rates for kokanee on the Middle Fork were higher for the first two weeks of the season than for the second two weeks (Appendix B). The average catch rate for kokanee on the Middle Fork for 1982 was 0.97 fish per hour. Boat anglers had higher catch rates than shore anglers on the Middle Fork, probably because they were better able to locate and reach concentrated schools of kokanee. Boat anglers averaged 1.60 kokanee per hour while shore anglers caught 0.89 kokanee per hour (Appendix B).

Fishing Pressure

Mainstem Flathead River

Fishing pressure estimates made from aerial counts included kokanee anglers as well as anglers fishing for other species. However, kokanee fishermen dominated the fishery during the 28 August through 15 October census period. Over 90 percent of the anglers interviewed on the mainstem during this period were fishing for kokanee.

During the census period, anglers fished an estimated 25,630 hours on the 89 km mainstem Flathead River (Appendix B). This is equivalent to 288 fisherman hours per km of stream. Section MS2 supported the highest total fishing pressure and the highest pressure per km of stream. Section MS1 had the second highest total fishing pressure, but the lowest pressure per km. Section MS3 supported the lowest total pressure, but the second highest pressure per km. About six percent of the total estimated fisherman hours were interviewed during the census.

In terms of man-days of fishing pressure, the total mainstem pressure of 25,630 hours (with an average of 3.3 hours per completed trip) represented 7,767 man-days. This is equivalent to 87.3 man-days of pressure per km of stream.

Almost70 percent of the total fishing pressure during the census period on the mainstem occurred during the first two weeks of the snag season, from 15 September through 30 September iAppendix B). Approximately 21 percent of the total pressure occurred during the lure early season fishery. Nine percent occurred during the last two weeks of the snag season (1 October-15 October).

Shore fishermen comprised 52 percent of the total mainstem fishing pressure during the census period (Appendix B), while boat fishermen made up 48 percent (Appendix B). Sections MS2 and MS4 had the heaviest shore fishing pressure, while section MS1 supported the most boat fishing pressure.

Middle Fork Flathead River

Kokanee anglers comprised over 97 percent of anglers fishing the Middle Fork during the 28 August to 15 October period. An estimated totai of 17,019 fisherman hours were expended on the 22 km of the lower Middle Fork (Appendix B). Completed trip length averaged 3.4, translating to a total of 5,006 man-day of pressure or 228 man-days per km. Only one percent of the pressure occurred before the opening of the snag season. Approximately 71 percent of the total pressure occurred during the first two weeks of the snag season (15 September-30 September), while 29 percent occurred during the last two weeks of the snag season. Most of the fishing pressure (88%) on the Middle Fork was by shore fishermen. Almost 19 percent of the total estimated fishermen hours were interviewed.

Kokanee Harvest

Mainstem Flathead River

Anglers harvested an estimated 12,402 kokanee on the four sections of the Flathead River during the 28 August-15 October census period (Appendix B). The majority (87%) of the harvest occurred during the first two weeks of the snag season. Approximately nine percent of the harvest occurred during the early season lure fishery. Approximately one-half of the harvest occurred in Section MS2, while Sections MSl, MS3 and MS4 contributed 12%, 7% and 30%, respectively.

Shore anglers accounted for approximately 70 percent of the kokanee harvest on the mainstem. Boat anglers harvested 30 percent of the total, mainly in Sections MS1 and MS2 (Appendix B). Creeled kokanee on the mainstem averaged 367 mm in totai length (n = 107). Males averaged 374 mm, while females averaged 360 mm.

Middle Fork Flathead River

Anglers harvested an estimated 18,047 kokanee on the Middle Fork of the Flathead River during the 1982 census period (Appendix B). Approximately 78 percent of the harvest occurred from 15 September-30 September. Twenty-two percent of the harvest occurred during the first two weeks of October. Almost all of the harvest occurred in the lower five miles of the Middle Fork, from McDonald Creek downstream. Shore anglers accounted for the majority of the harvest (77%). Creeled kokanee measured on the Middle Fork averaged 378 mm in total length (n = 875). Males averaged 387 mm (n = 400) and females averaged 368 mm (n = 475).

Comparison of 1982, 1981 and 1975 Kokanee Fisheries

Surveys of the Flathead River system kokanee fishery were conducted in 1975 by Hanzel (19771, in 1981 by Fredenberg and Graham (1982) and for the 1982 spawning run. The 1982 fishery for kokanee in the river system was much reduced from 1981, reflecting the weaker 1982 year class of spawners (Table 5). Catch rates during 1982 were about one-half of the 1981 levels on the Middle Fork of the Flathead and one-fifth of the 1981 level on the main- stem.

Fishing pressure during 1982 was 45 percent of 1981 levels on both the Middle Fork and the mainstem. Due to low numbers of kokanee in the river system, catch rates and fishing pressure were well below 1981 levels. The 1982 kokanee harvest was 16 percent of the 1981 level on the mainstem and 24 percent of the 1981 level on the Middle Fork.

During both 1981 and 1982, the majority of the kokanee harvest was borne by the "early runs" of fish bound for the Middle Fork drainage (Table 6). In 1975, however, the majority of the harvest was from the "late runs" of mainstem spawners present in the mainstem after 1 October. This shift of the harvest from the late runs to the early runs of kokanee reflects the population change in the mainstem spawning run during the late 1970's.

During the 1981 season, anglers harvested an estimated 53 percent of the Middle Fork spawner population bound for McDonald Creek, the Middle Fork of the Flathead River and Beaver and Deerlick creeks (Table 6). During 1982, 44 percent of the Middle Fork population was harvested. Part of the reason for this decline in percent harvest was the regulation changes from a 1 September opening of the snag season in 1981 to a 15 September opening in 1982 and an early closure of the 1982 snag season on 15 October. Harvest rate on the mainstem declined from 44 percent in 1981 to 10 percent in 1982. The 15 October closure of the snag season and the low level of the mainstem population contributed to this decline. Total angler pressure on the mainstem during the 1 October-15 October period was only 12.8 man-days per km and catch rates were extremely low.

Table 5. Comparison of characteristics of the 1982, 1975 and 1981 river system kokanee fisheries. The 1975 fishery data is for the mainstem only. During the fall of 1975 very little fishing occurred on the Middle Fork.

	Middle Fork		Mainstem		
	1982	1981	1982	1981	1975
Catch rate (kokanee/hour)	0.93	2.0	0.45	2.0	2.0
Fishing pressure (hours)	17,019	37,870	25,630	56,602 1/	69,276
Number of hours per completed trip	3.4	4.7	3.3	3.2	3.6
Fishing pressure (man-days)	5,006	8,040	7,767	17,688 1/	19,223
Kokanee harvest	18,047	75,117	12,402	77,000	150,243
Percent of harvest by shore anglers	77%	79%	70%	73%	---
Percent of fisherman hours interviewed	19%	6.8%	6%	4.8%	1.6%
Total number of party interviews	436	237	324	207 2/	---

1/ Pressure from September and October.

2/ Interviews from September and October only.

Table 6. Estimated distribution of harvest between the Middle Fork "early" runs and the mainstem "late" runs during 1982, 1981 and 1975. The percent of the estimated population which was harvested is in parentheses.

Year	Middle Fork runs 1/	Mainstem runs 2/
1982	29,999(44) 3/	450(10)
1981	133,385(53)	18,562(44)
1975	18,450(--) 5/	131,793(40) 4/

1/ Kokanee harvested in the mainstem before 1 October and in the Middle Fork itseif.
2/ Kokanee harvested in the mainstem after 1 October
3/ Percent harvest was calculated by dividing the total estimated harvest by the total estimated preharvest population based on snorkel counts, redd counts and harvest estimates.
4/ Estimated (Fraley and Graham 1982).
5/ No estimate.

SPAWNING SITE INVENTORY

Flathead River Redd Counts

Kokanee spawning in the mainstem Flathead River below the South Fork was first observed on 8 October, 1982 when redds and actively spawning fish were observed in the river near Columbia Falls. From l-9 November, 296 redds were counted and by 3 December, 1,422 redds had been constructed (Table 7). An additional 106 redds were located after 3 December (Appendix A). Spawning continued into January in Brenneman's Slough (mainstem spawning area number 1). Approximately 90 percent of all spawning on the mainstem took place between 15 October and 15 December. Approximately four percent occurred before 15 October and six percent occurred after 15 December.

The timing of mainstem spawning appeared to be later in 1982 than in 1979 or 1981. Only 21 percent of the total redds had been constructed by the end of the early November count in 1982. During 1979 and 1981, 33 percent and 50 percent of the total redds had been constructed by the end of the early redd count.

Kokanee spawners utilized fewer mainstem spawning areas during the weak even-year runs (1982, 1980) than in the strong odd-year runs (1981, 1979). Only 12 mainstem spawning areas were utilized by kokanee during 1982. In 1981, kokanee used 35 mainstem spawning areas and in 1979, 27 spawning areas were utilized. During the poor 1980 mainstem spawning run, kokanee utilized 13 mainstemareas. A total of 44 mainstem spawning areas have been identified from 1979-1982.

Relationship of Redd Counts and Spawner Counts

Kokanee salmon entering the Beaver Creek and Brenneman's Slough spawning areas were monitored by stream trapping for the purpose of comparing spawner numbers and redd counts. Total kokanee numbers can be estimated from redd counts by determining the ratio between numbers of spawners and numbers of redds.

A total of 45 spawners entered Beaver Creek from 29 September through 28 November (Figure 7, Table 8). The majority entered the stream in mid-November. By 10 November, five kokanee redds had been constructed by seven females and 10 males, yielding a ratio of 3.4 kokanee per redd. By 29 November, 24 male kokanee and 21 female kokanee had entered Beaver Creek. These fish constructed 14 redds, which yielded a ratio of 3.2 spawners per completed redd.

In Brenneman's Slough (mainstem area 1), 160 males and 216 females had constructed 127 redds by 1 December, yielding a ratio of 2.8 spawners per redd (Figure 8,Table 8). By 5 January, a total of 241 male and 230 female spawners had entered Brenneman's Slough and 156 redds had been constructed. The ratio had

Table 7. Numbers of redds counted in early and late November in spawning areas utilized by kokanee salmon on the Flathead River below the South Fork in 1982.

Area number 1/	Date	
	November l-9	November 30-December 3
1	0	134
4	9	9
7	6	16
8	36	47
13	30	60
22	5	17
30	14	22
32A	50	413
34	0	67
39	135	560
41	1	65
41A	10	12
TOTAL	296	1,422

1/ See Appendix E for location of spawning areas.

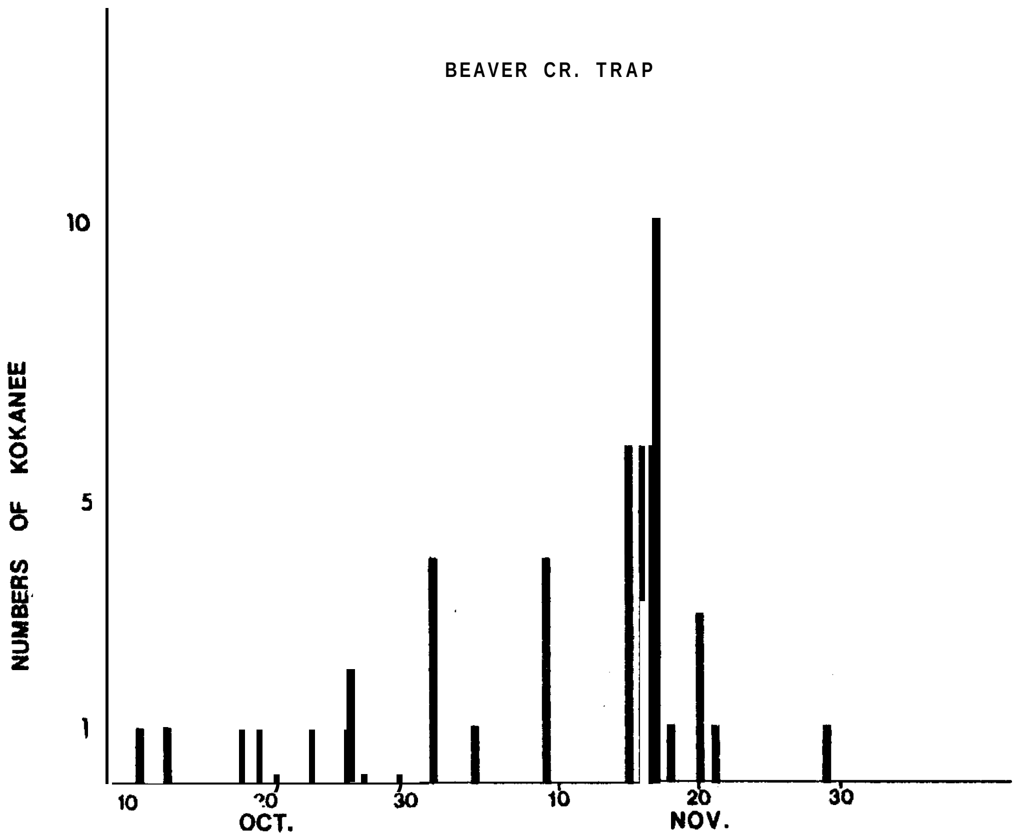

Figure 7. Number of kokanee spawners which entered Beaver Creek in the Middle Fork of the Flathead drainage during 1982.

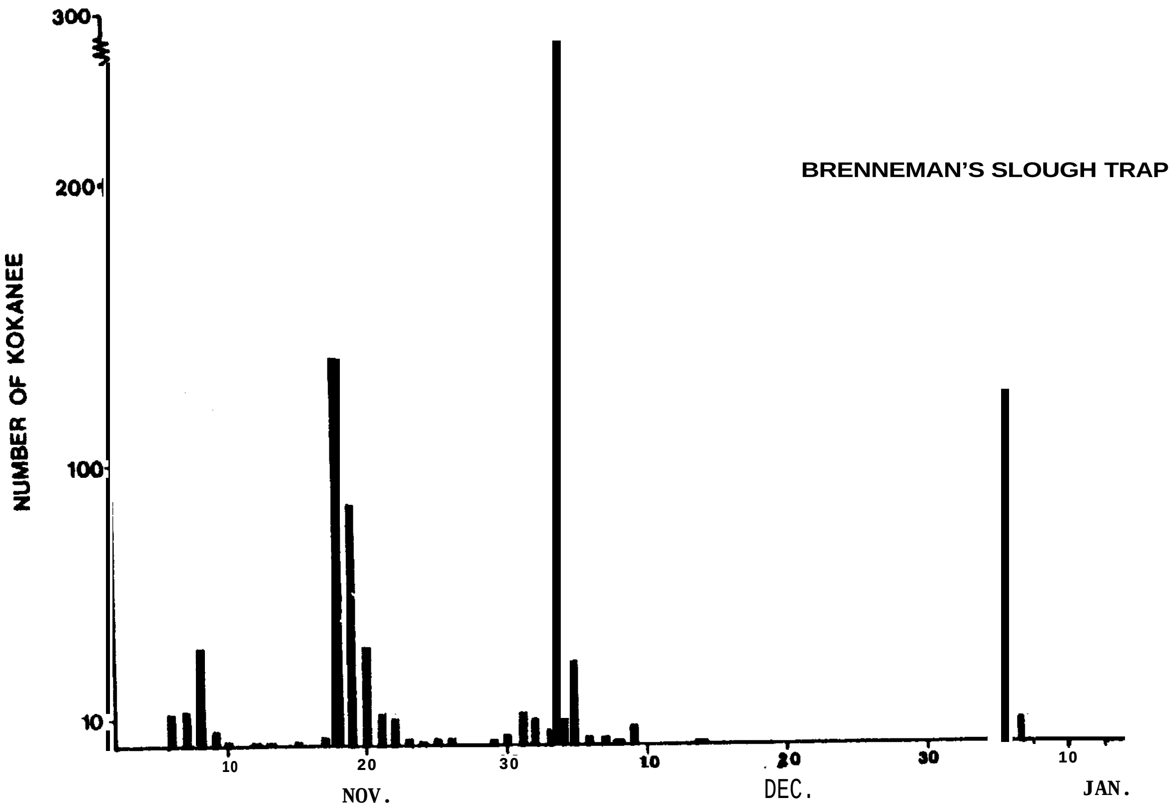

Figure 8. Number of kokanee spawners entering Brenneman's Slough (Mainstem Area 1) on the lower Flathead River during 1982-83.

Table 8. Summary of upstream trap catches for Flathead River system kokanee spawning areas in 1982 and 1983.

Area	Dates	Number of fish: Kokanee Male	Kokanee Female	Mountain whitefish	Brook trout	Cutthroat trout	Juvenile Bull trout	Rainbow trout	Peamouth chub
Beaver Creek	9/29 - 11/29/82	24	21	215	38	9	5	1	0
Brenneman's Slough	11/4/82-1/30/83	293[1/]	311[2/]	6	0	0	0	0	1
Deerlick Creek	9/27 - 11/9/82	0	0	175	12	0	0	-	0

1/ Count does not include 107 males (27% of the run) taken by hatchery personnel.

2/ Count does not include 186 females (37% of the run) taken by hatchery personnel.

increased to 3.0 spawners per redd, and some superimposition probably had taken place. Superimposition probably increased the ratio due to use of previously constructed redds by new spawners. There were large daily fluctuations in the numbers of spawners entering Brenneman's Slough. Lorz and Northcote (1965) reported a similar migration pattern for kokanee entering Moose Creek, British Columbia.

Attempts were made to obtain similar information in Deerlick Creek and Columbia Falls Slough (mainstem area 36). No kokanee entered Columbia Falls Slough, and kokanee entered Deerlick Creek after the trap was removed.

Day-Night Spawning Studies

In mainstem area 1 (Brenneman's Slough) a sufficient number of kokanee spawners did not enter the area where day and night gravel sections had been prepared. However, kokanee were observed over redds in other portions of the slough throughout the daylight period.

It appeared through our observations that kokanee spawning activity consisted of four major elements: 1) behavioral interactions, 2) redd construction, 3) egg deposition, and 4) redd maintenance. All four of these activities appear to be important in the spawning process. Behavioral interactions and redd maintenance activities were observed in mainstem spawning area 1 throughout the daylight hours from 9 November through mid-December. Behavioral interactions consisted of chasing and other social actions by male and female kokanee. Redd maintenance involved fanning and removal of debris and rocks from the redd.

Many kokanee redds observed in area 1 were multiple or "community" redds. Observations indicated up to four pairs of fish on one large community redd area. The gregarious behavior of kokanee spawners probably contributes to the spawner:redd ratio of three kokanee per classified redd. However, a similar ratio was present in Beaver Creek which had a low density of spawners.

The redd construction period in day and night areas at the House of Mystery spawning area (area 39) extended from 25 October through 16 November. A total of five recognizable redds were constructed by kokanee in the gravel area made available to nighttime spawning (Figure 9). One excavation or partial redd was built in the night area. Three excavations were built in the area available for daytime spawning.

Kokanee eggs were deposited in both day and night areas. A total of 1,444 eggs (94%) were deposited in the night area and 96 eggs (6%) were deposited in the day area.

Kokanee were present on the spawning area mainly during the dark hours (Figure 10). Numbers of kokanee spawners present on a

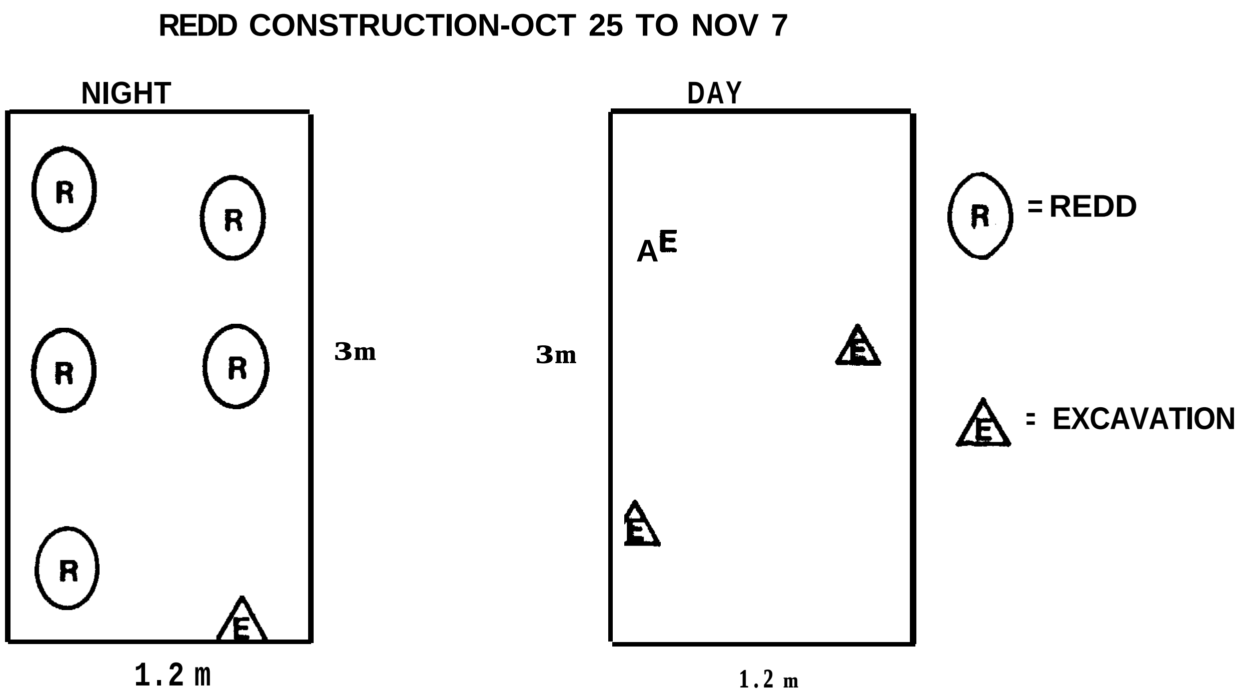

Figure 9. Redd construction by kokanee salmon in day and night spawning areas during 1982.

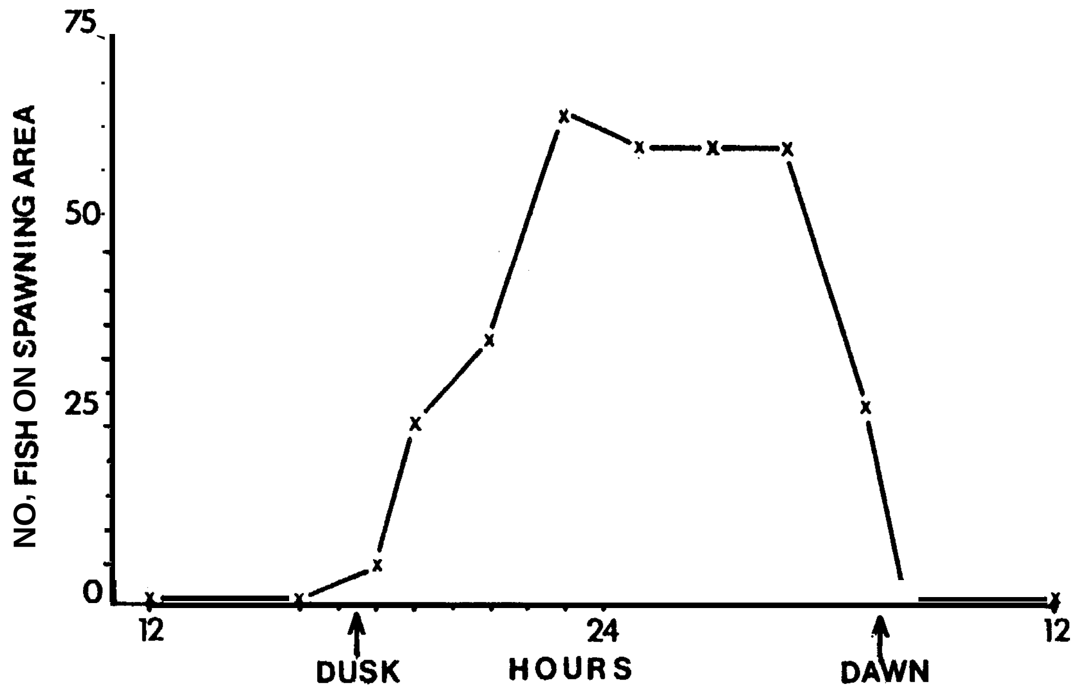

Figure 10 Number of kokanee spawners present in a section of mainstem spawning area 39 on 3-4 November, 1982.

portion of the spawning area surveyed on 3 November peaked from 2200 to 0500 hours. Some kokanee spawners were present on the area at dusk and numbers quickly increased through the first four hours of darkness. Although a number of spawners were still present on the area at dawn, numbers quickly fell to zero as full daylight was reached. Kokanee were found to be holding in a deeper area just off shore from the spawning area during daylight hours. Further observation later in the spawning period indicating daytime kokanee use of the area increased as the spawning period progressed.

Insufficient numbers of kokanee spawners entered five other areas planned for day-night spawning studies in 1982. These preliminary data concerning day-night kokanee spawning activities in mainstem area 1 and 39 are limited and study in more areas during different portions of the spawning period are needed. During the 1983 spawning period, eight additional areas are planned for study. These sites include five mainstem areas, McDonald Creek, Deerlick Creek and Beaver Creek.

Spawning Gravel Survey

Gravel Area Measurements

A total of 3,264,169 m^2 of wetted area was measured in the mainstem Flathead River between the mouth of the South Fork and the mouth of the Stillwater River at a flow of 3,500-4,000 cfs (Table 9). A total of 20 percent of this area, or 648,465 m^2 was classified as suitable for kokanee spawning based on substrate size and compaction, and water velocity. The downstream river section between Pressentine access and the Stillwater River (MS2) was about twice as long and contained about twice as much spawnable area as sections MS3 and MS4. A total of 107,946 m^2 of gravel area, or 17 percent of the total spawnable area in all three sections, was utilized by spawning kokanee during at least one year in the 1979-1982 period. This utilized gravel area is greater than the total spawnable area of 82,500 m available in McDonald Creek (Fraley and Graham 1982).

The uppermost section (MS4) contained the least amount of total spawnable area, but a relatively large proportion of the area (33%) was utilized by kokanee during the last four years (Table 10). About nine percent and 13 percent of sections MS3 and MS2, respectively, were utilized by spawning kokanee during the past four years.

Potential Spawning Gravel at Various Flows

Spawning gravel available at various water elevations was mapped in three major spawning areas in 1981 (Fraley and Graham 1982). Based on the mapping of these three areas only, estimated spawnable area and utilized spawning area in the mainstem Flathead River were calculated for various flows (Table 11). The large

Table 9. Gravel area measurements (percent) in the Flathead River between the mouths of the South Pork and the Stillwater Rivers.

River section	Section length(km)	Spawnable area(m^2)	Nonspawnable area (m^2)	Total
MS-2	19	321,381(19)	1,346,055(81)	1,667,436(100)
MS-3	10	176,489(19)	751,627(81)	928,116(100)
MS-4	8	150,595(23)	518,022(77)	668,617(100)
TOTAL	37	648,465(20)	2,615,704(80)	3,264,169(100)

Table 10. Total spawnable area and utilized area in sections of the Flathead River at a flow of 3500-4000 cfs. Utilized area is the sum of all the mainstem spawning areas which were actually used by kokanee from 1979-1982.

River section	Total spawnable area (m^2)	Number of utilized spawning areas	Area utilized(m^2)	Percent utilized
MS-2	321,381	23	42,866	13
MS-3	176,489	10	15,845	9
MS-4	150,595	11	49,235	33
TOTAL	648,465	44	107,946	17

Table 11. Estimated total spawnable area and utilized spawning area at various flows in the mainstem Flathead River. The relationship is based on measurements of total gravel area made in 1982 and measurements of three spawning areas during 1981 (Fraley and Graham 1982).

Flow (cfs)	4000	3500	3000	2500	2000
% area	100	82	65	41	20
Total spawnable area (m^2)	648,465	531,741	421,502	265,871	129,693
Area of utilized spawning areas (m^2)	107,946	88,516	70,165	44,258	21.589

reduction of spawnable gravel at lower flows occurred because the major spawning areas measured consisted of gently sloping gravels along the margins of the mainstem. A small drop in water elevation resulted in a large loss of spawnable area. The estimate of actual utilized area was probably high because all the area available in each spawning area was not utilized.

Using the surveys of three major spawning sites, with the mainstem at 4000 cfs, the estimated production potential in mainstem gravels was calculated based on the number of redds per m^2 in these three heavily used sites (Table 12). The average number of redds/m^2 (.35) multiplied by the total utilized spawnable area (107,946 m^2) yields an estimated potential capacity of 37,781 redds in mainstem gravels that have been utilized by kokanee during the past four years.

Assuming a 20 percent egg to fry survival, the potential production of the utilized areas of the mainstem was 7,556,200 kokanee fry. This would represent 151,124 returning adult spawners at a two percent fry to adult survival rate.

Substrate Composition in Kokanee Redds

Size distribution of substrate material was determined for kokanee redds in three mainstem Flathead River spawning sites, the Whitefish River, McDonald Creek and the Middle Fork of the Flathead River (Figure 11). Fine materials less than 6.35 mm comprised 20.1 percent of Middle Fork substrate and 29.2 percent of McDonald Creek substrate. Mainstem redds ranged from 20.3 to 26.0 percent fines. Whitefish River redds averaged 24.5 percent fines.

EGG INCUBATION AND AIEVIN DEVELOPMENT

Egg and Alevin Survival

Natural Redds

Kokanee redds were sampled during December in various river system spawning areas to monitor survival during the green and the early eyed stage. Survival in mainstem redds in late December ranged from 37-75 percent and averaged 59 percent in areas 1, 8, and 39 (Table 13). Egg survival in redds sampled in McDonald Creek, the Middle Fork of the Flathead and the Whitefish River averaged 78, 77, and 23 percent, respectively.

Mean dissolved oxygen levels in the sampled redds at gravel depths of 5-20 cm were above 8.5 ppm at all areas except area 1 (Brenneman's Slough) where oxygen levels averaged only 4 ppm due to high levels of organics resulting from agricuiture. Egg survival in redds at area 1 averaged 65 percent. Reiser and Bjornn 1979), Wickett 1954), Hayes et al. (1951) and Decker-Hess

Table 12. Spawning area measurements and redd counts at Areas 10, 27, 32 and 39 in the mainstem Flathead River, 1981.

Spawning area #	Spawning gravel area (m^2)	Number of redds in 1981	Number of redds per m^2
10	809	245	.3
27	1,133	201	.2
32	1,644	735	.4
39	1,402	702	.5

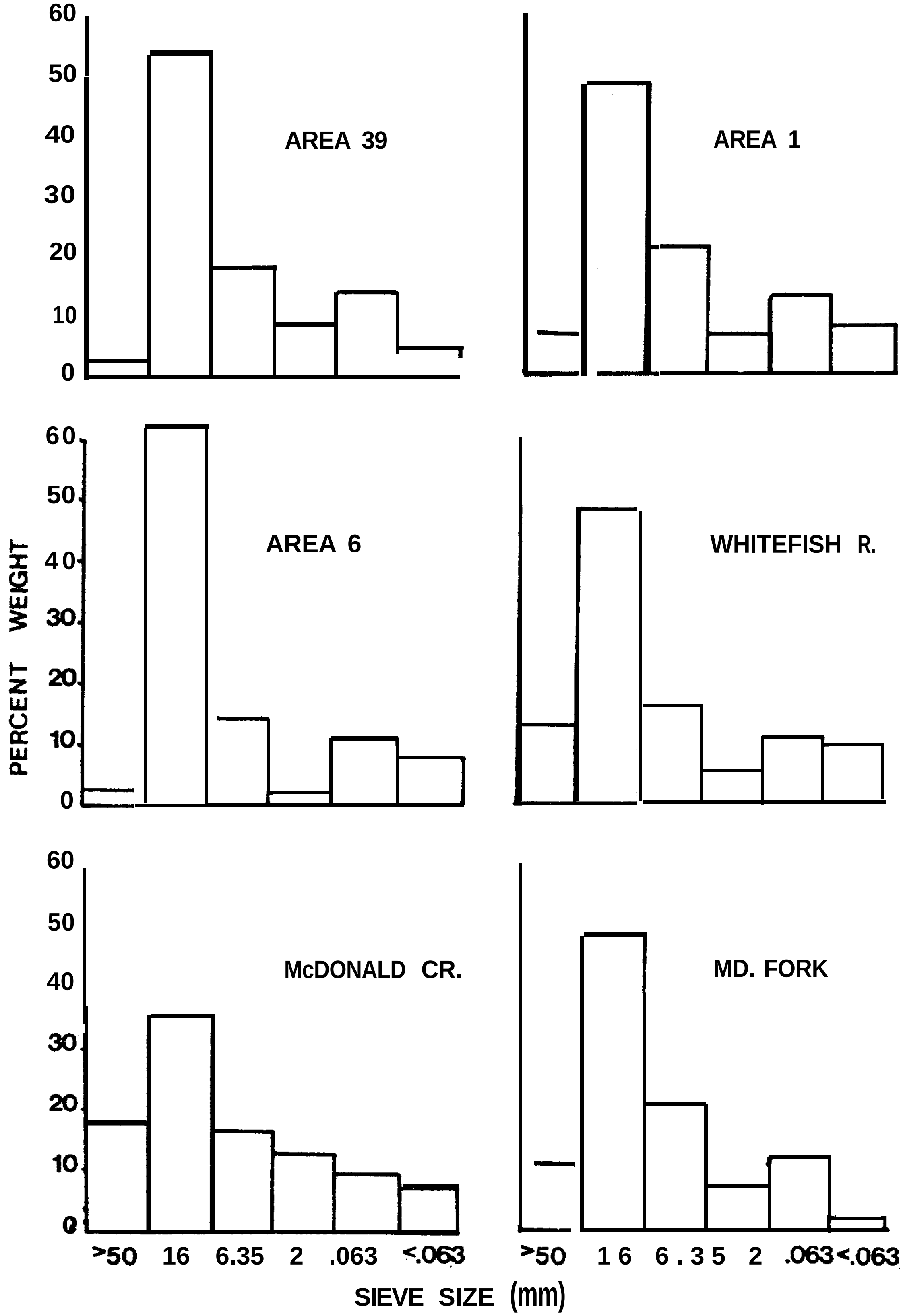

Figure 11. Substrate composition of kokanee redds in six Flathead River drainage spawning areas.

Table 13. Analysis of green to early eyed kokanee egg samples taken from kokanee redds with a 0.11 m^2 hydraulic sampler in areas of the mainstem Flathead River, Middle Fork Flathead River, McDonald Creek and Whitefish River during December, 1982.

Location	Date	Total number eggs	Percent survival	Percent eyed	Mean intergravel dissolved oxygen (ppm)	Water temperature
Mainstem Flathead River						
Brenneman's Slough (Area 1)	12/17/82	396	65	0	4.0	---
Wagoners Gravel (Area 8)	12/29/82	153	37	0	8.5	37°F
House of Mystery (Area 39)	12/28/82	548	75	63.5	10.9	36°F
Middle Fork Flathead River	12/16/82	284	77	<1	11.4	33°F
McDonald Creek	12/20/82	908	78	74	10.6	39°F
Whitefish River	12/14/82	622	23	10.5	9.4	34°F

and Graham (1982) reported critical oxygen levels for eyed salmon eggs averaging 3-4 ppm.

Experimental Egg Plants

Kokanee eggs were planted in deep and shallow gravel areas in both the mainstem Flathead River and the Middle Fork to monitor egg survival and development. Survival was generally above 90 percent through the green stage at all areas (Figure 12). Survival remained above 90 percent to the eyed stage in the shallow areas in both the mainstem and the Middle Fork areas. Survival dropped to 62 and 36 percent respectively by the mid-eyed stage in deep areas in the mainstem and Middle Fork areas.

Hatching success was low at all areas, averaging 15 percent in the Middle Fork and five percent in the mainstem. Survival to hatching was higher in shallow areas than in deep areas (Figure 12). Dissolved oxygen levels ranged from 9.3 to 13.7 ppm in the gravel throughout the incubation period and should not have a factor in the low survival to hatching. Much higher survival to hatching (averaging 70%) was recorded in experimental egg plants made in the mainstem during the 1981-1982 incubation period. The experiments will be repeated during the 1983-1984 incubation season in these and other areas of the river system.

Egg and Alevin Densities

Live kokanee egg and alevin (sac fry) densities average 485/m^2 in McDonald Creek spawning gravels in February 1983 (Table 14). The densities of eggs and sac fry in McDonald Creek gravels averaged 16 percent lower in 1983 than in 1982. Twice as many embryos had hatched during the 1983 sampling and survival was 20 percent higher than in 1982. The higher survival rate in 1982-1983 was probably due to lower densities of kokanee spawners and iess superimposition than occurred in 1981-1982.

Egg samples collected over the past four years in McDonald Creek gravels near Apgar show no relationship between live egg and alevin densities and numbers of kokanee spawners. There was very little difference between egg and alevin densities during the year of highest spawner numbers (1981-1982) and the year of the lowest number of spawners (1982-1983). Merrel (1960) and Neave (1953) reported that salmon spawner densities and egg survival were inversely related.

Although the accuracy of estimating egg densities with this method is limited, it does indicate substantially higher egg densities in the 1979-1980 and 1980-1981 incubation years. These egg densities resulted from estimated kokanee spawner numbers of 65,000 and 20,000, respectively. If the mean redd density of 0.35 redds per m^2, measured in four concentrated mainstem spawning areas, is applied to the total spawnable area of McDonald Creek (82,476 m^2) a capacity of 28,867 redds is indicated. This would

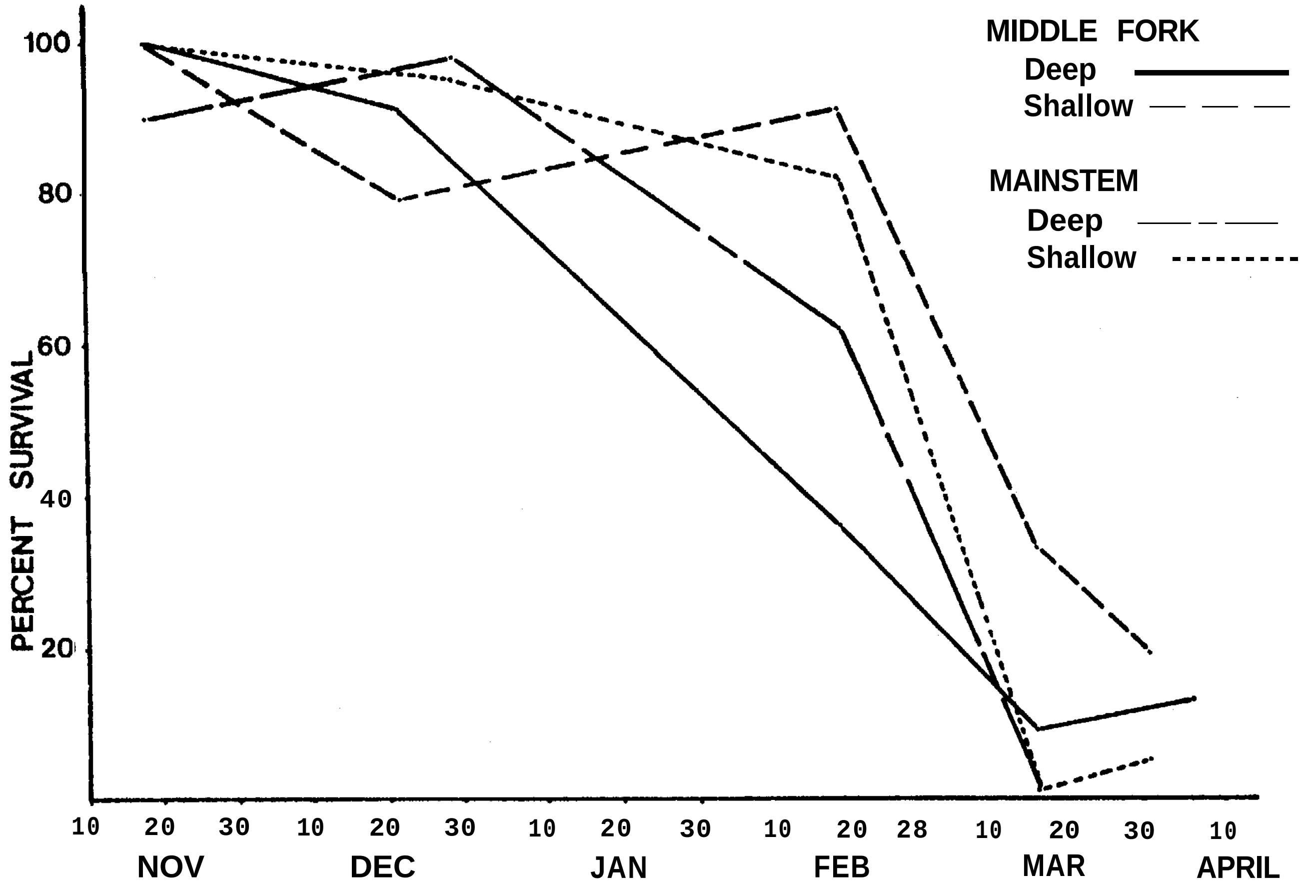

Figure 12. Percent survival of kokanee eggs and alevins planted in deep and shallow areas of the Mainstem Flathead River and Middle Fork on 15 October, 1982.

Table 14. Egg densities, survival and percent sac fry in McDonald Creek gravels sampled in 1982 and 1983.

			Live egg and alevin density (no./m^2)					
Year	Date	Number samples	Good gravel	Medium gravel	Poor gravel	All gravel	Percent sac fry	Percent survival
1981-82	2/3/82- 2/11/82	36	965	470	14	563	21	72
1982-83	2/1/83- 2/8/83	34	725	438	8	485	41	86

indicate that, at two to three kokanee per redd, 57,000 to 86,000 kokanee would be sufficient to utilize McDonald Creek spawning gravels to capacity. The lower egg densities in 1981-1982 and 1982-1983 indicate that 35,000 spawners may be too few and 98,000 spawners may be too many for the most efficient utilization of McDonald Creek gravels.

Egg and Alevin Development

Kokanee eggs planted in bags in the Middle Fork of the Flathead River required fewer temperature units to reach the eyed and hatching stages than eggs in the mainstem Flathead River (Figure 13). However, the eggs planted in the Middle Fork required a much longer incubation time to reach each developmental stage, because of the slow accumulation of temperature units in the colder water. Temperature unit requirements for developmental stages of kokanee eggs in the Middle Fork were the lowest of any values reported for the Flathead drainage or other areas of the western United States and Canada (Table 14). Stober et al. (1978), Hunter (1973), Graham et al.. (1980), and Alderdice and Velson (1978) reported fewer temperature units were required for development of kokanee or sockeye salmon eggs at lower incubation temperatures. Gunnes (1979) reported that more temperature units were required for development of Atlantic salmon eggs at lower incubation temperatures.

Egg deposited in McDonald Creek accumulated temperature units more rapidly than eggs deposited in three other spawning areas (Figure 14). Temperature units accumulated slowly after the spawning period in the Middle Fork of the Flathead River and the WhitefishRiver. Estimated dates of first emergence (from temperature unit accumulation rates) in the Middle Fork of the Flathead River and mainstem Flathead River were 10 May and 1 May, respectively (Figure 15).

STREAMFLOW - KOKANEE LENGTH RELATIONSHIPS

Several models were developed using weighted three year moving average flow conditions to explain the variations in kokanee year class strength from the 1966 through 1981 spawning years (Graham et al. 1980, McMullin and Graham 1981, Fraley and Graham 1982). Kokanee spawner length (male and female combined) was assumed to be inversely related to population density and was used as the measure of year class strength.

There were strong relationships between kokanee spawner length and flow conditions from 1966 through 1981 (Table 15, Figures 16 and 17). The correlation between kokanee lengths and spawning and incubation gauge height difference was highly significant ($r = -0.93$, $p < .001$), indicating that a large proportion (87%) of the variation in spawner length could be attributed to differences in spawning and incubation gauge heights. The relationship between kokanee spawner lengths and the average

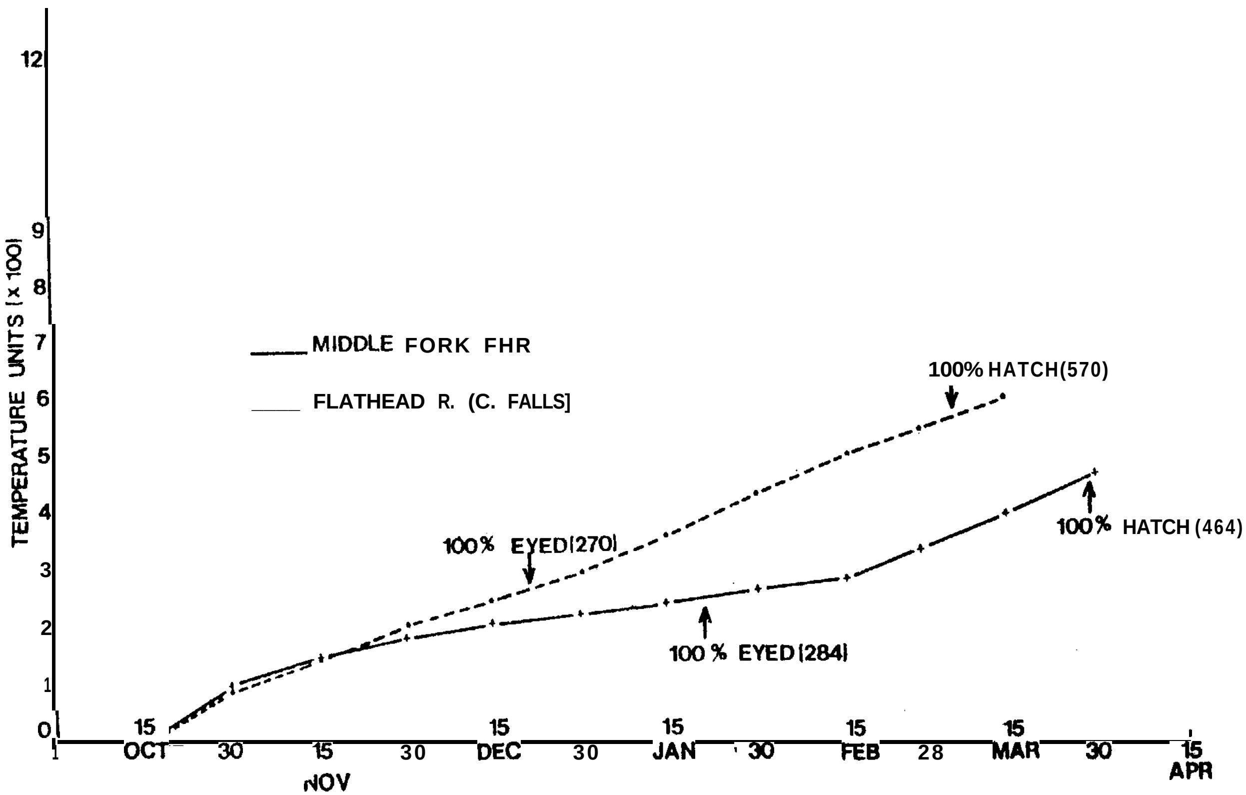

Figure 13. Temperature unit (°C), accumulation and developmental requirements of kokanee eggs planted in the Flathead River near Columbia Falls and the Middle Fork of the Flathead River above McDonald Creek.

Table 15. Calculated number of temperature units (°C) and days required for developmental stages of kokanee salmon eggs.

Area	Stage of development					
	Eye up		Hatching		Yolk sac absorption	
	Unite	Days	Units	Days	units	Days
Flathead River						
Non-spring (1982-83)	270	69	570	144	---	---
Non-spring (1981-82)	200	66	400	138	700	195
Spring	300	45	540	104	850	154
MF Flathead River (1982-83)	252	100	464	168	---	---
Beaver Creek. (Graham et al. 1980)	260	46	525	101	700	145
Flathead Lake[1/]	331	82	526	143	---	---
Flathead Lake Hatchery[2/]	300	41	580	110	800	145
Sand Point. Idaho Hatchery (Jeppson 1960)	---	---	555	100	805	136
Odell Lake	---	---	643	204	800	251
Average (sockeye salmon) (Foerster 1968)	286	55	590	107	760	138
Cedar River. Washington (sockeye salmon) (Stober et al. 1978)	263	38	620	90	95	140

1/ Decker-Hess and Graham (1982)
2/ Montana Fish, Wildlife and Parks (unpublished date)

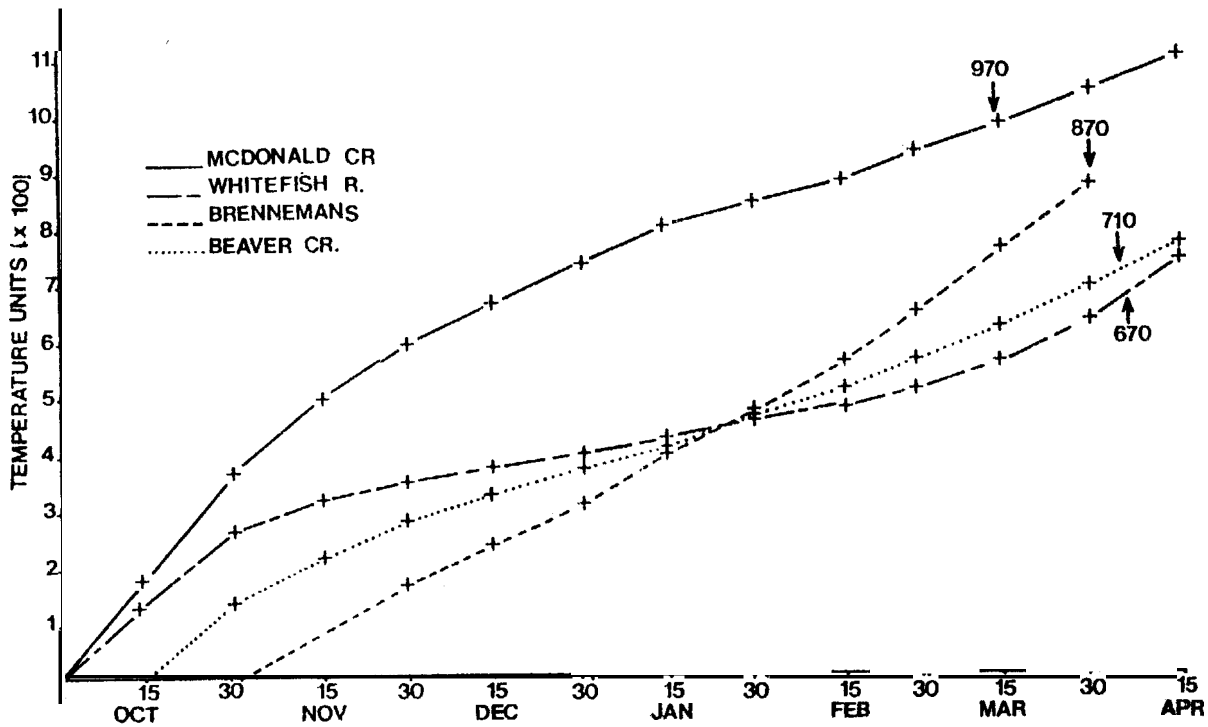

Figure 14. Temperature unit (°C) accumulation from deposition to emigration in Flathead River system spawning areas during 1982-83.

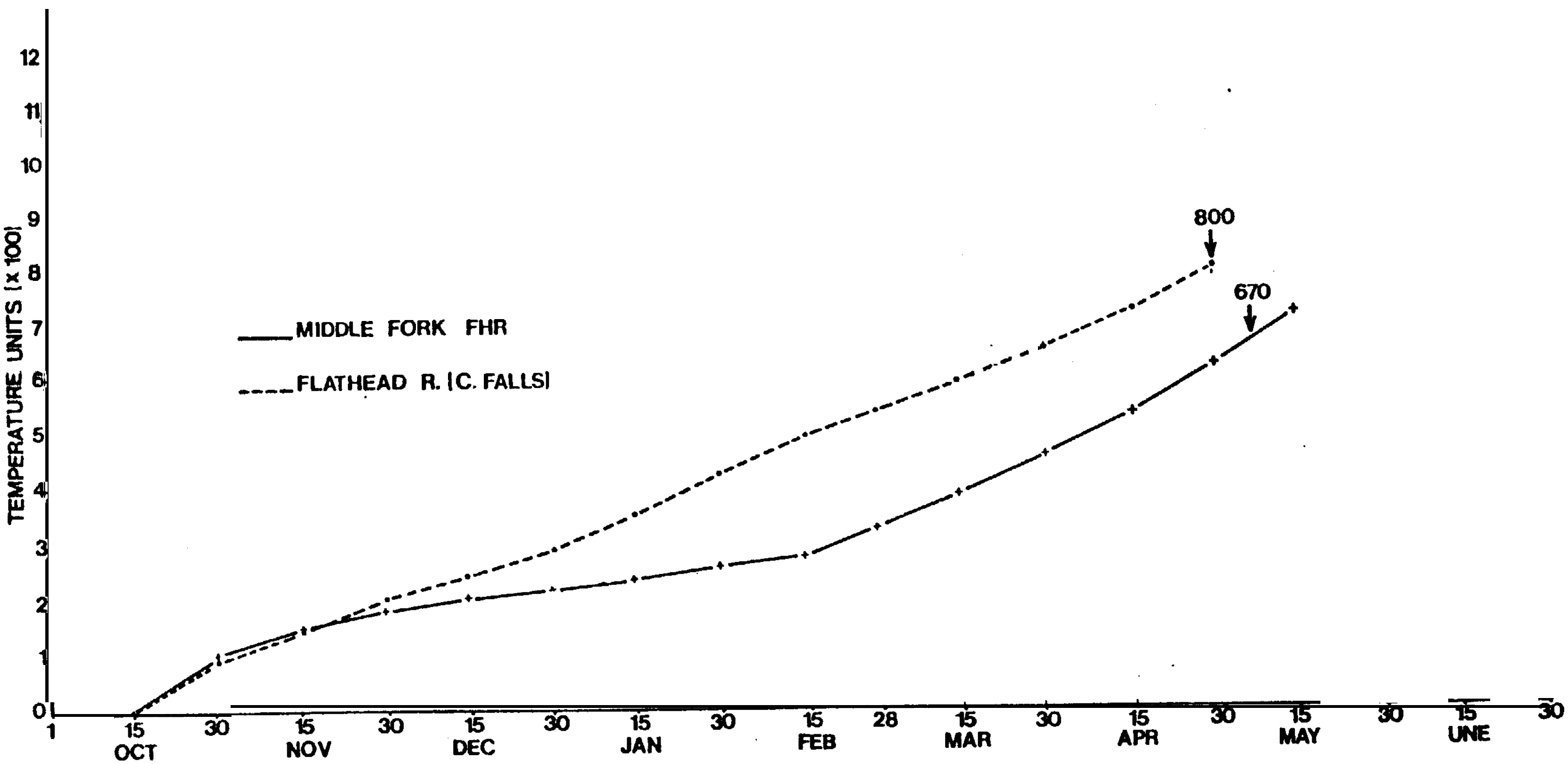

Figure 15. Temperature unit (°C) accumulation and estimate time of first emergence in the Middle Fork of the Flathead River and Flathead River near Columbia Falls °uring 1982-83.

Table 16. Mainstem Flathead River flow variables and Flathead system combined male and female kokanee lengths from 1954-1983.

Spawn year	Kokanee total length (mm)	Water used in 3-year mean	Water years	Incubation-spawning gauge height difference (ft)	Weighted 3-year moving average (ft)	Hours/day dewatered	Weighted 3-year moving average
1957	**294**	1954	---	-0.68	----	**12.43**	----
1958	---	1955	1954-56	1.21	0.56	**2.29**	**5.69**
1959	312	1956	1955-57	0.94	1.03	3.47	4.47
1960	348	1957	1956-58	0.96	-0.30	7.97	10.41
1961	339	1958	1957-59	-3.22	-0.96	20.59	12.36
1962	330	1959	1958-60	0.15	-1.22	5.76	12.62
1963	338	1960	1959-61	-1.06	-0.42	13.78	7.24
1964	347	1961	1960-62	-0.15	0.13	0	4.27
1965	326	1962	1961-63	1.68	1.09	0.44	0.18
1966	287	1963	1962-64	1.53	2.06	0	0.13
1967	272	1964	1963-65	3.16	2.44	0	0.10
1968	286	1965	1964-66	2.39	2.20	0.33	2.45
1969	313	1966	1965-67	0.99	0.65	7.74	7.49
1970	323	1967	1966-68	-1.54	-0.36	14.31	11.73
1971	334	1968	1967-69	-0.14	-0.29	12.28	11.01
1972	338	1969	1968-70	0.76	-0.14	6.03	11.66
1973	308	1970	1969-71	-1.35	0.22	18.55	9.24
1974	320	1971	1970-72	1.78	0.23	0.03	8.31
1975	324	1972	1971-73	-0.27	0.41	9.12	7.43
1976	316	1973	1972-74	-0.04	0.06	12.58	9.99
1977	327	1974	1973-75	0.52	-0.43	7.39	12.26
1978	341	1975	1974-76	-2.07	-0.97	**18.44**	13.00
1979	353	1976	1975-77	-0.97	-0.87	11.34	13.80
1980	367	1977	1976-78	0.46	-0.48	12.45	13.22
1981	371	1978	1977-79	-1.22	-0.94	16.12	14.52
1982	380	1979	1978- 80	-1.97	-2.31	14.45	17.29
1983	---	1980	1979-81	-3.86	-2.06	22.25	13.63
1984	---	1981	1980-81	0.25	-0.91	1.31	7.24
1985	---	1982	1981-82	0.49	----	0.15	.45
1986	---	1983	1982-83	---	---	<0.1	----

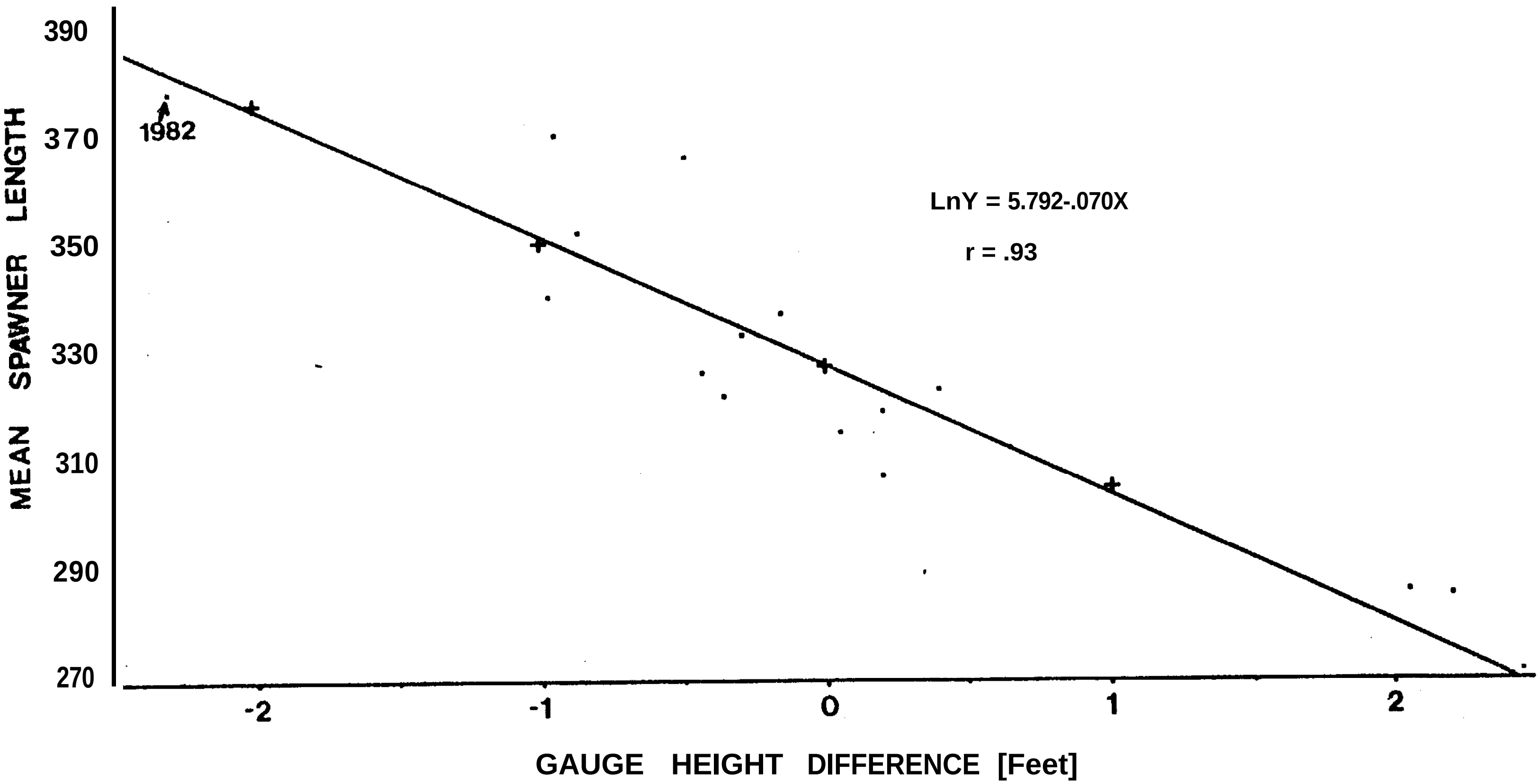

Figure 16. Relationship between mean kokanee spawner length (male and female combined) and the spawning and incubation gauge height difference in the years that produced them from 1966-1982.

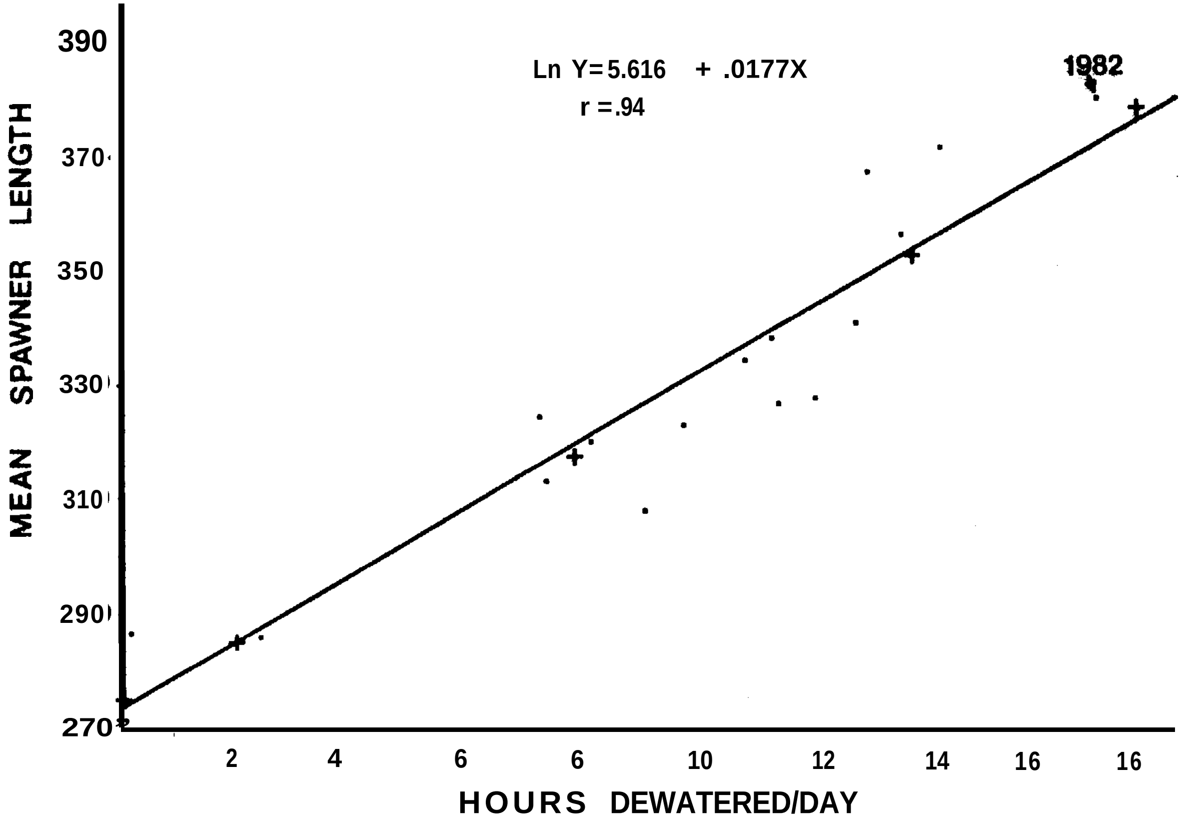

Figure 17. Relationship between mean kokanee spawner length (male and female combined) and the average number of hours/day that kokanee eggs were dewatered from 1966-1982.

number of hours per day that kokanee spawning beds were dewatered was also very strong ($r=0.94$, $p<.001$). This indicates that 88 percent of the variation in kokanee length could be attributed to the amount of time spawning beds were dewatered during their incubation period

Mean minimum air temperature was added to the models as a second independent variable because of its effect on incubation mortality (Tables 17 and 18). The addition of minimum air temperature as a variable improved the fit of the models and their predictive capabilities slightly. McMullin and Graham (1981) suggested that winter air temperatures were always cold enough to cause significant incubation mortality during periods of dewatering.

These streamflow-kokanee length relationships indicated that kokanee year class strength from 1966-1982 was dependent upon incubation success in the mainstem as affected by discharge from Hungry Horse Reservoir. Length of 1982 kokanee spawners averaged 376 mm in the Flathead River (Table 19) and 384 mm in Flathead Lake spawning areas, yielding an overall mean of 380 mm. Predicted lengths of kokanee spawners from the flow models ranged from 371-390 mm and averaged 381 mm (Fraley and Graham 1982).

Unexplained variation in kokanee year class strength may be related to other factors not included in the models. Other factors may affect incubation success (Wickett 1962), growth of kokanee in the Flathead Lake (Goodlad et al. 1974), or differential recruitment from other spawning areas to the lake population.

Age composition of the river system kokanee spawning run averaged 75 percent age III+ fish and 25 percent age IV+ fish from 1973 through 1982 (Figure 18). Age composition of males and females in the run was generally similar during the period. Differences in age structure in the river system and Flathead Lake kokanee spawning runs does not appear to have affected spawner lengths from 1970-1982 (Figure 19). Kokanee spawners in the river system were the largest recorded since consistent records have been kept (early 1950's); yet only 15 percent of the run was composed of the older age class (IV+) fish (Table 19). Collins (1971) and Lorz and Northcote (1965) reported the maturity was reached during the third year of life in kokanee populations in Ontario, British Columbia.

Flow conditions during the water years that will affect the 1983 mainstem kokanee run were poor. Predicted lengths for the 1983 fish by the four models ranged from 350-376 mm and averaged 363 mm.

Quadrennial or cyclic dominance in the four year cycle of kokanee populations may also be a factor in year class variation (Killick and Clemens 1963). Relationships between spawning and incubation gauge height differences and kokanee lengths within

Table 17. Incubation-spawning gauge height difference (weighted three year moving average), mean minimum temperature on days when dewatering occurred (three year moving average), predicted kokanee lengths, actual lengths and residual errors for the model Ln Y = 5.784 - 0.07066 X_1 - 0.001 X_2. Y = kokanee length, X_1 = gauge height difference, X_2 = temperature, R^2 = 0.869, n = 17.

Spawn year	Gauge height difference	Mean minimum air temperature(°C)	Actual kokanee length	Predicted kokanee length	Residual error
1966	2.06	-23.02	287	288	- 1
1967	2.44	- 4.25	272	275	- 3
1968	2.20	- 6.69	286	280	6
1969	0.65	- 5.54	313	312	1
1970	-0.36	- 5.26	323	335	-12
1971	-0.29	- 5.55	334	334	0
1972	-0.14	- 7.85	338	331	7
1973	0.22	- 9.15	308	323	-15
1974	0.23	- 8.93	320	323	- 3
1975	0.41	- 6.18	324	318	6
1976	0.06	- 5.46	316	325	- 9
1977	-0.43	- 6.71	327	337	-10
1978	-0.97	- 7.83	341	351	-10
1979	-0.88	- 7.42	353	349	4
1980	-0.48	- 6.64	367	339	28
1981	-0.94	- 9.08	371	351	20
1982	-2.31	-10.26	380	387	- 7
1983	-2.06	- 7.30	---	379	---

Table 18. Mean hours per day kokanee redds were dewatered (weighted three year moving average), mean minimum temperature on days when dewatering occurred (three year moving average), predicted kokanee lengths, actual lengths and residual errors for the model LN Y = 5.583 + 0.0184 X_1 - 0.00324 X_2. Y = kokanee length, X_1 = hours per day dewatered, X_2 = temperature, R^2 = 0.902, n = 17.

Spawn year	Hours/day dewatered	Air temperature	Actual kokanee length	Predicted kokanee length	Residual error
1966	.13	-23.02	287	287	0
1967	.10	- 4.25	272	270	2
1968	2.45	- 6.69	286	284	2
1969	7.49	- 5.54	313	311	2
1970	11.73	- 5.26	323	336	-13
1971	11.01	- 5.55	334	332	2
1972	11.66	- 7.85	338	338	0
1973	9.23	- 9.15	308	325	-17
1974	8.31	- 8.93	320	319	1
1975	7.44	- 6.18	324	311	13
1976	9.99	- 5.46	316	325	- 9
1977	12.26	- 6.71	327	341	-14
1978	13.00	- 7.83	341	347	- 6
1979	13.80	- 7.42	353	351	2
1980	13.22	- 6.69	367	347	20
1981	14.52	- 9.08	371	358	13
1982	17.29	-10.26	380	378	2
1983	13.63	- 7.30	---	350	---

Table 19. Combined male and female kokanee spawner lengths and age compositions in Flathead River system spawning areas during 1982. Age data is from Hanzel and Rumsey (unpublished).

Area	Mean length	Number of fish measured	Age composition III+	Age composition IV+	Number of fish aged
Brenneman's Slough (Mainstem Area 1)	378	393	90 1/	6	68
House of Mystery (Mainstem Area 39)	369	66	92	8	51
McDonald Creek	379	50	64	36	47
Whitefish River	373	45	85	15	27
Beaver Creek	379	30	--	--	--

1/ Four percent were age II+

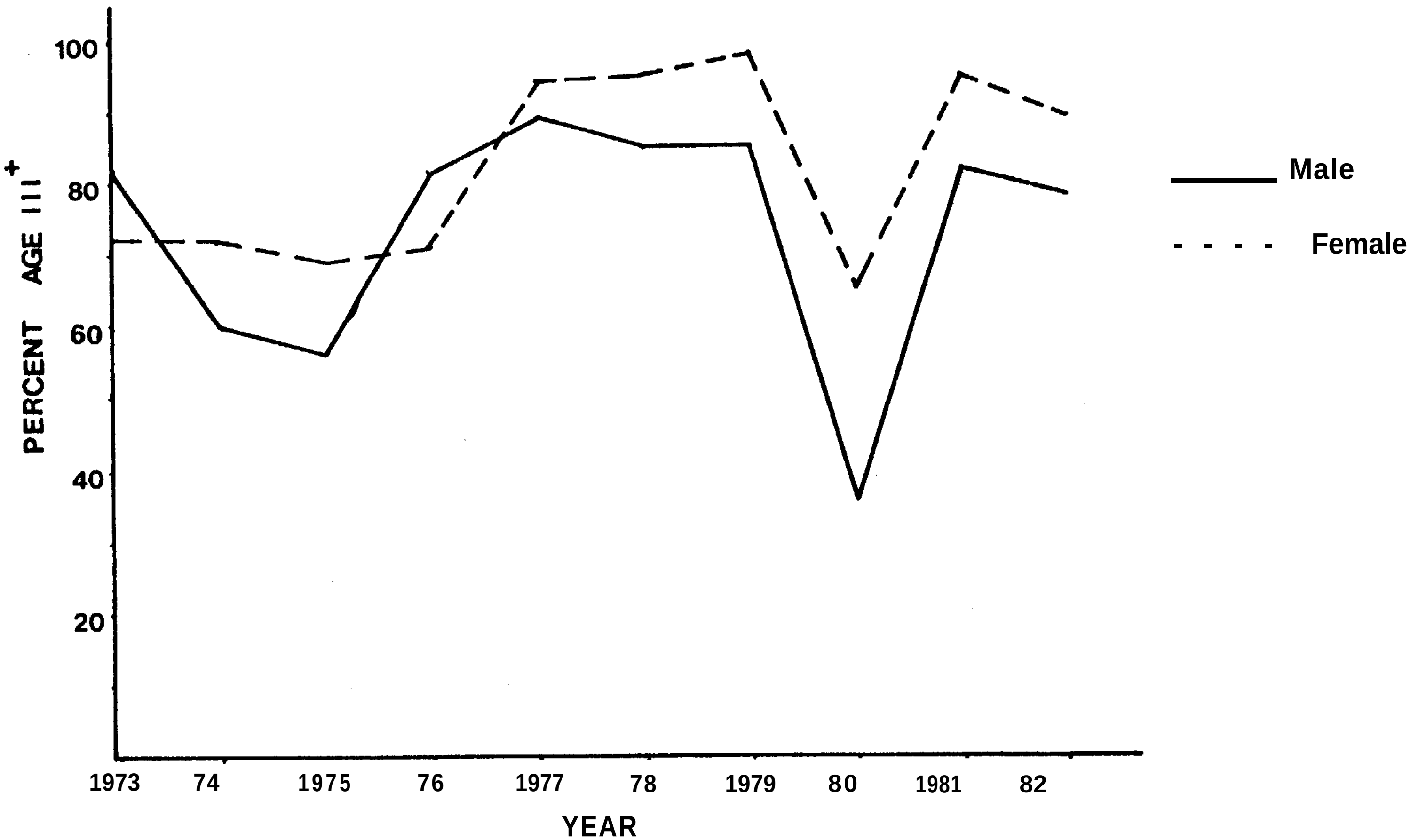

Figure 18. Percent of age III+ kokanee spawning in the Flathead River system from 1973-1982.

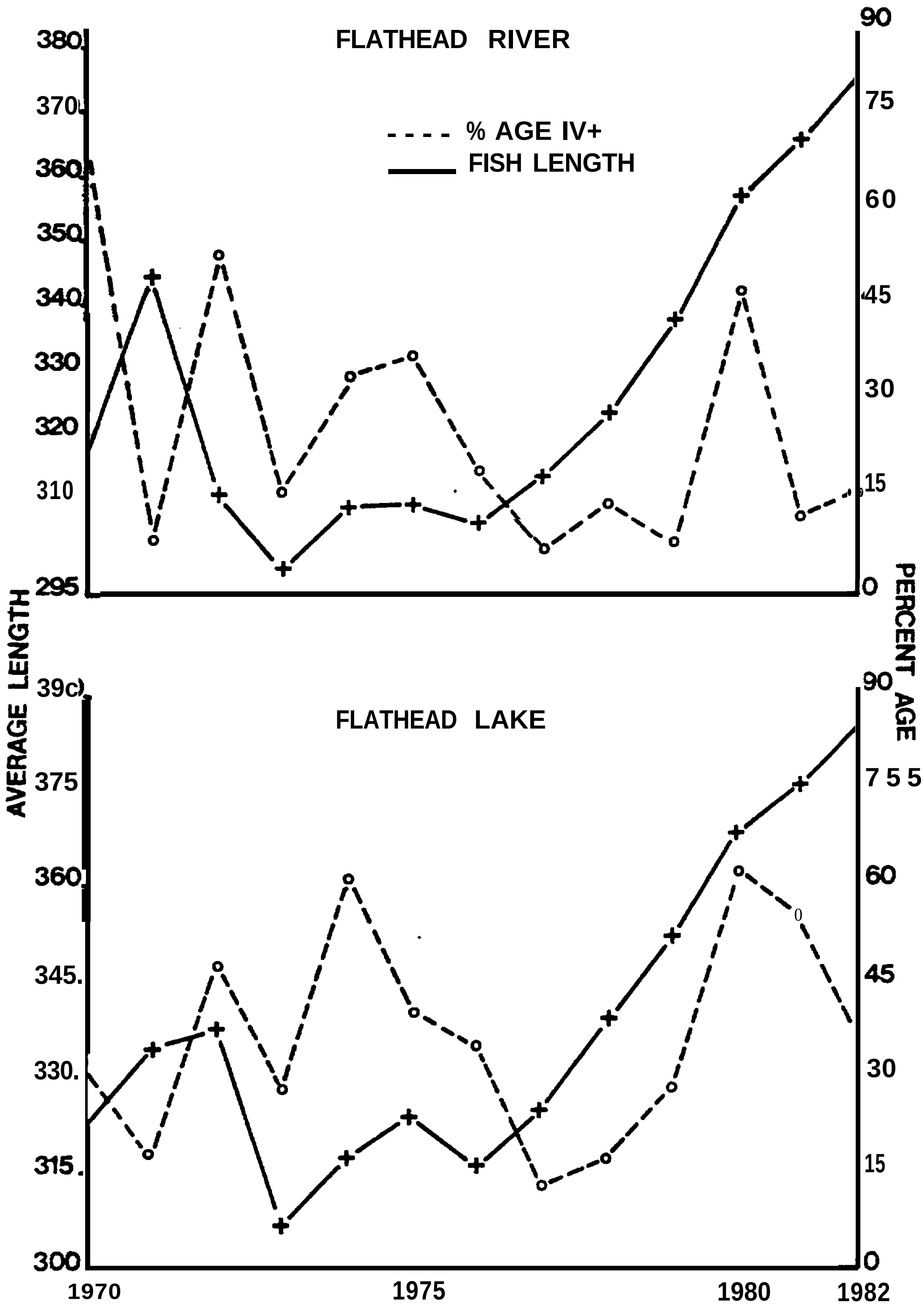

Figure 19. Average length of kokanee spawners and percent of older fish (Age IV+) in the Flathead River and Lake populations from 1970 to 1982. Average lengths are male and female combined.

four year cycles indicated that effects of quadrennial dominance may be occurring in the Flathead system kokanee population (Figure 20). Correlations within the four-year cycles are generally higher than in all cycles combined. Additional years of study will add to the data base for analyzing the quadrennial dominance effect in the Flathead system.

Merrel (1960) and McNeil (1968) suggested population cycling was a controlling factor in year class strength fluctuations in pink salmon. They reported that fish in odd year runs spawned earlier than fish in even year runs and their progeny experienced better incubation and emergence success. Ward and Larkin (1964) presented conclusive evidence of year class strength variations resulting from quadrennial dominance in sockeye populations of the Adams River, British Columbia. They suggested that competition between age 0 and age I sockeye may result in alternate year cycling within a four year cycle.

FRY EMERGENCE AND EMIGRATION

Fry Abundance and Emergence Timing

The timing of kokanee fry emergence and kokanee fry abundance is critical in the determination of the relative importance of Flathead River system spawning areas. Kokanee fry emigration was intensively monitored in five river system spawning areas. Fry emigration was monitored on a limited basis in the Fiddle Fork of the Flathead River and at several points on the mainstem Flathead River.

McDonald Creek

Emergence and emigration of kokanee fry in McDonald Creek during 1983 extended from early February to June and peaked during the first week of May (Figure 21). Emigration peaked in late May and early June in 1978 and 1982. Feak emigration occurred in early May during 1977 and 1981 (Hanzel and Rumsey, unpublished data, McMullin and Graham 1981). There appeared to be a pattern of early emigration during the odd years (1983, 1981, 1977) and late emigration during the even years (1982, 1978).

Peak emigration during 1983 occurred well before peak flows and were reached (Figure 21). An estimated 12.4 million fry emigrated from McDonald Creek in 1983. The range of the estimate was 9.3-15.9 million fry, based on the high and low catches of all nets. During 1982 and 1978, estimates of total fry emigration were 12,000,000 and 15,000,000 respectively. The total number of kokanee fry emigrating from McDonald Creek in 1983 was 68.9 percent (52% to 89%) of the total estimated potential egg deposition based on spawner and fecundity counts.

High egg to fry survival rate for kokanee during 1983 may have resulted from very warm winter incubation temperatures. The

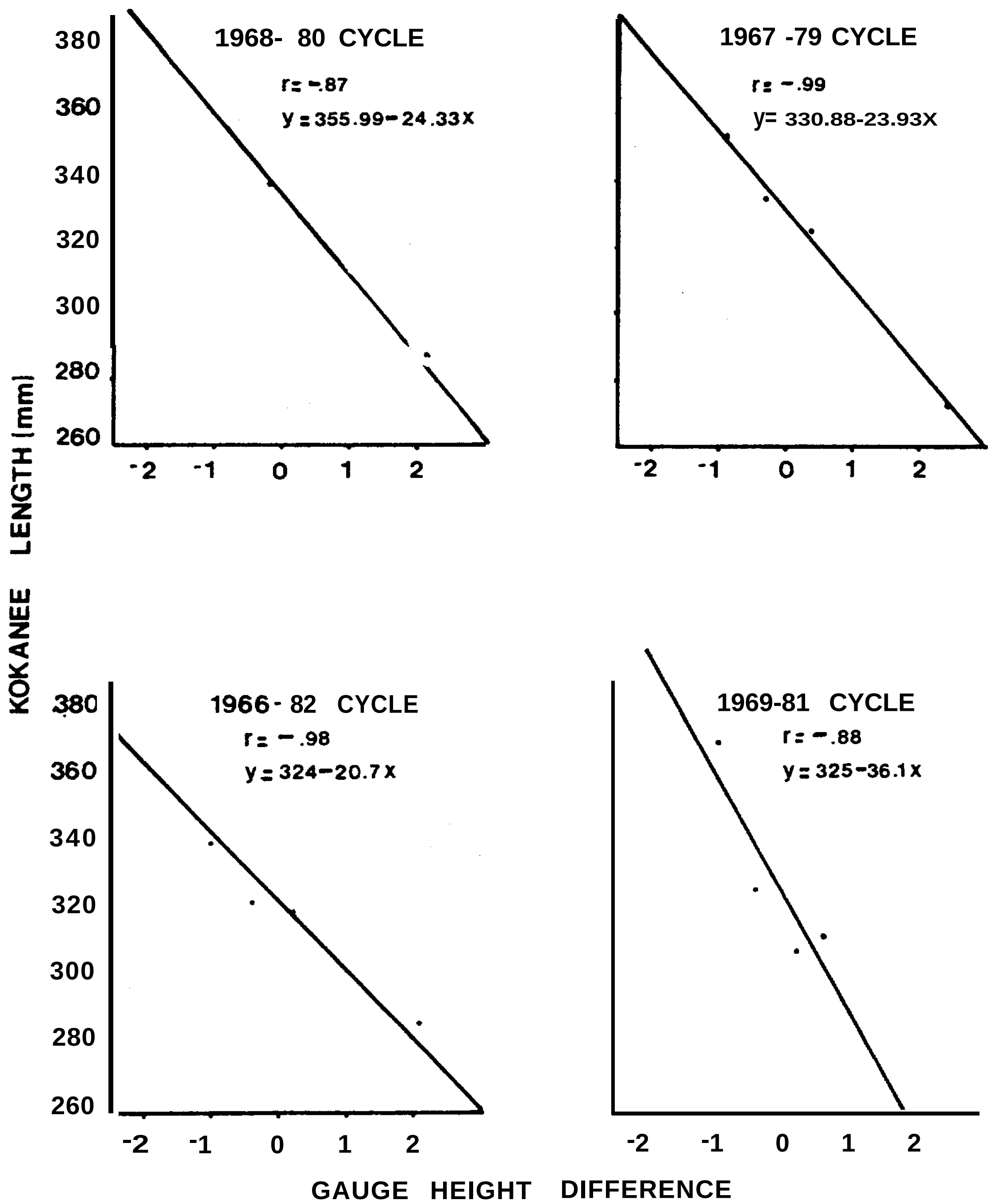

Figure 20. Relationships between mean kokanee spawner length and weighted three year moving average spawning-incubation gauge height difference for each of four kokanee spawning cycles.

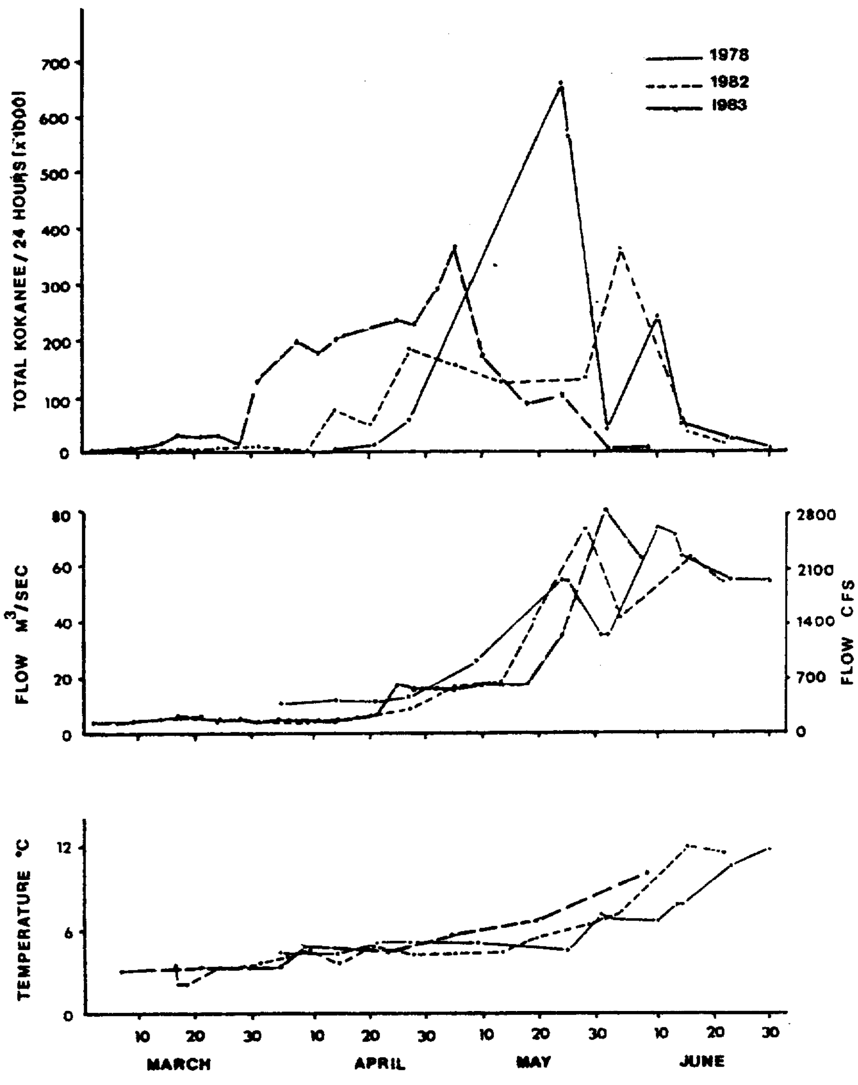

Figure 21. Estimated number of kokanee fry emigrating, flow and water temperature in McDonald Creek during 1982 and 1983. 1978 comparison data are from Hanzel and Rumsey (unpublished).

survival rate may have been inflated due to an underestimate of potential egg deposition. The snorkel counts of adult spawners used to estimate potential egg deposition are point estimates and may not represent the total number of spawners which entered McDonald Creek during the 1982 spawning period. An egg to fry survival rate nearer the lower end of the estimated range (50%) may be more realistic for 1983. Egg to emigrating fry survival in McDonald Creek was 22 percent in 1982 (Fraley and Graham 1982). Survival in McDonald Creek was high when compared to other natural salmon spawning areas (Table 20). Jeppson (1960) reported a seven percent egg to fry survival rate in Sullivan Spring Creek, Idaho which was considered a high quality kokanee spawning ground. Survival rates comparable to the 1983 McDonald Creek figures have been reported for salmon in several spawning channels in Japan and the U.S.S.R., in a salmon spawning channel located in Washington (Bakkala 1970) and in kokanee spawning channels in British Columbia (R.A. Lindsay, British Columbia Ministry of Environment, pers. comm). Royce (1959) reported a 75 percent egg to fry survival for silver salmon in a coastal California stream.

Whitefish River

An estimated 67,340 (35,888 to 98,762) kokanee fry emigrated from the Whitefish River in 1983. The major emigration peak occurred during late March and early April, with a smaller peak in mid-May (Figure 22). Estimated egg to fry survival was 4.5 percent (2.4 to 6.6%). Low egg to fry survival maybe due, in part, to low winter incubation temperatures, high percentages of fine sediments, and high compaction of spawning bed materials.

Brenneman's Slough

Fry emigration in Brenneman's Slough (mainstem area 1) occurred in a series of peaks (Figure 23), which corresponded roughly to the series of peaks which occurred during the spawner migration the previous fall (Figure 8). An estimated 31,511 fry emigrated from this area during 1983, which represented 13.7 percent of the total egg deposition. Low dissolved oxygen and a high percentage of fines in the spawning bed material may limit egg to fry survival in Brenneman's Slough.

Fry emigration occurred in a series of peaks in Beaver Creek in 1983 and was generally later than in 1982 (Figure 24). Late timing of the adult spawning run the previous fall was probably responsible for the delayed fry emergence in 1983. An estimated total of 3,791 (1,853 to 5,656) fry emigrated from Beaver Creek which represented 15.7 percent (7.7 to 23.6%) of the estimated potential egg deposition.

An estimated 3,448 naturally propagated fry (22.9% of the estimated potential egg deposition) emigrated from Deerlick Creek in 1983 (Figure 25). An additional 50,000 hatchery reared fry were planted in upper Deerlick Creek on 20 April. No estimate was

Table 20. Egg to fry survival of kokanee and sockeye salmon in various waters.

Area	Species	% egg to fry survival	Study
Flathead System, 1983			
McDonald Creek	Kokanee	69	This study
Deerlick Creek	Kokanee	23	
Beaver Creek	Kokanee	16	
Brenneman's Slough	Kokanee	14	
Whitefish River	Kokanee	5	
McDonald Creek, 1982	Kokanee	22	This study
Sullivan springs, Idaho	Kokanee	7	Jeppson 1960
O'dell Lake, Oregon	Kokanee	20	Lewis 1974
Cedar River, Washington	Sockeye	1-8	Stober and Hamalainen 1980
Sashin Creek, Alaska	Sockeye	7	McNeil 1968
Pitt River, Weaver Creek, British Columbia	Sockeye	11-19	Mead and Woodahl 1968
Average, several areas	Sockeye	11	Foerster 1968

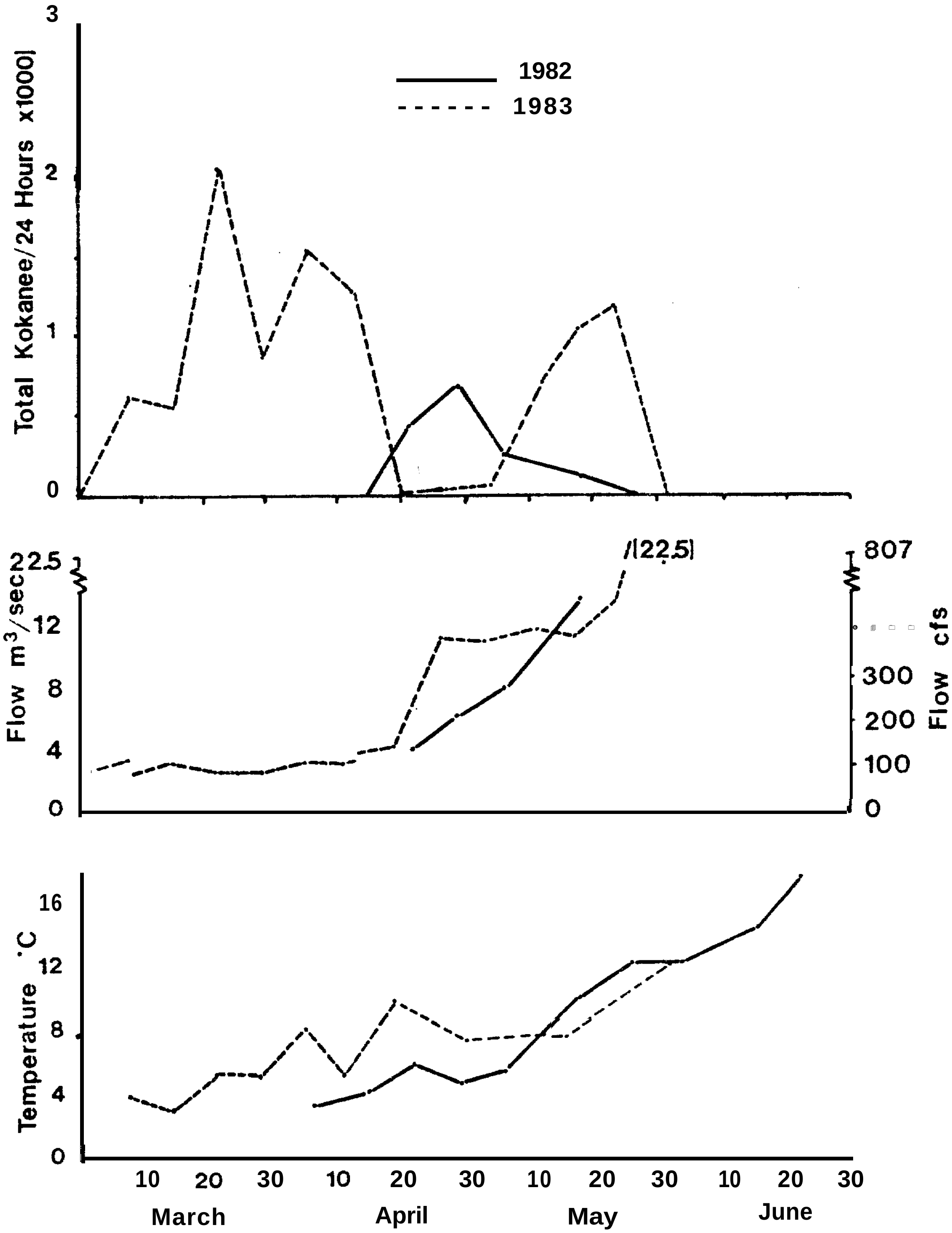

Figure 22. Number of kokanee fry emigrating, flow and water temperatures in the Whitefish Iiiver near Kalispell, 1982 and 1983.

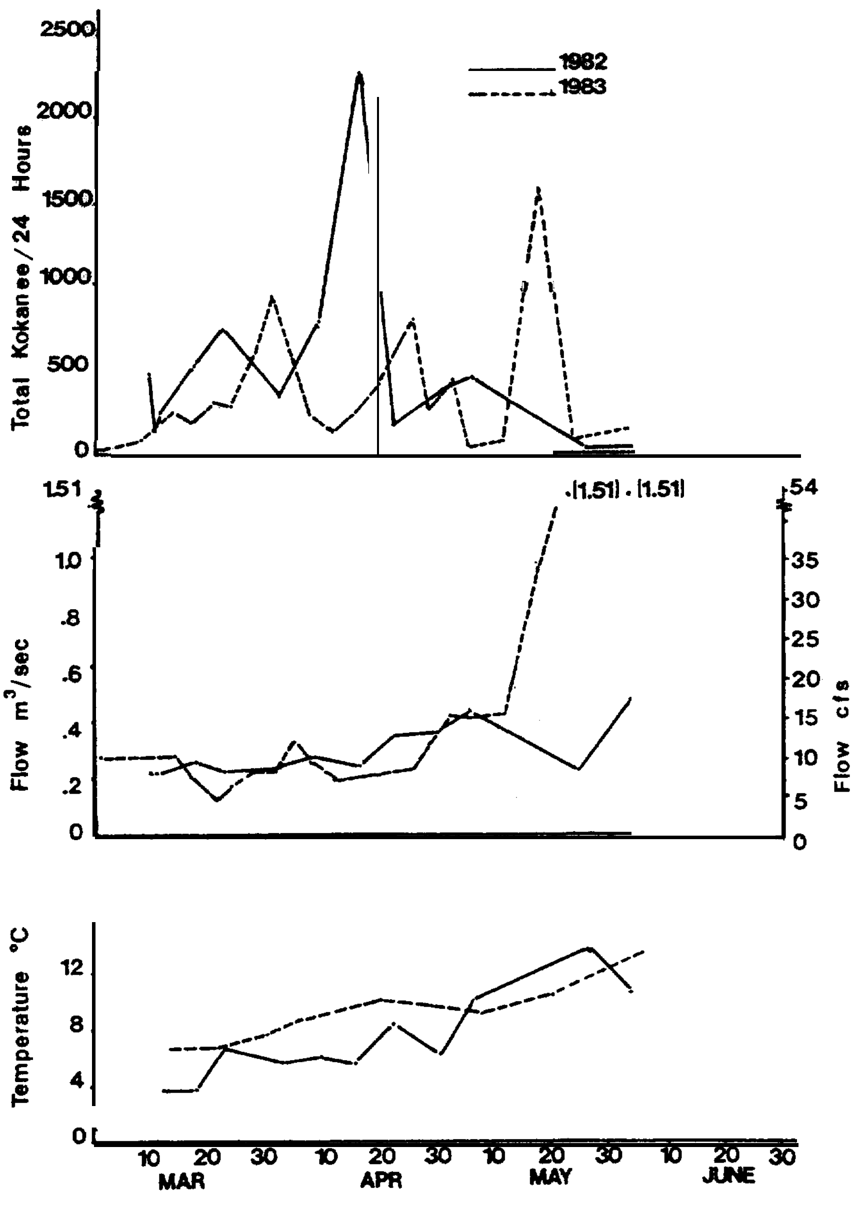

Figure 23. Number of kokanee fry emigrating, flow and water temperatures in Brenneman's Slough in the lower Flathead River, 1982 and 1983.

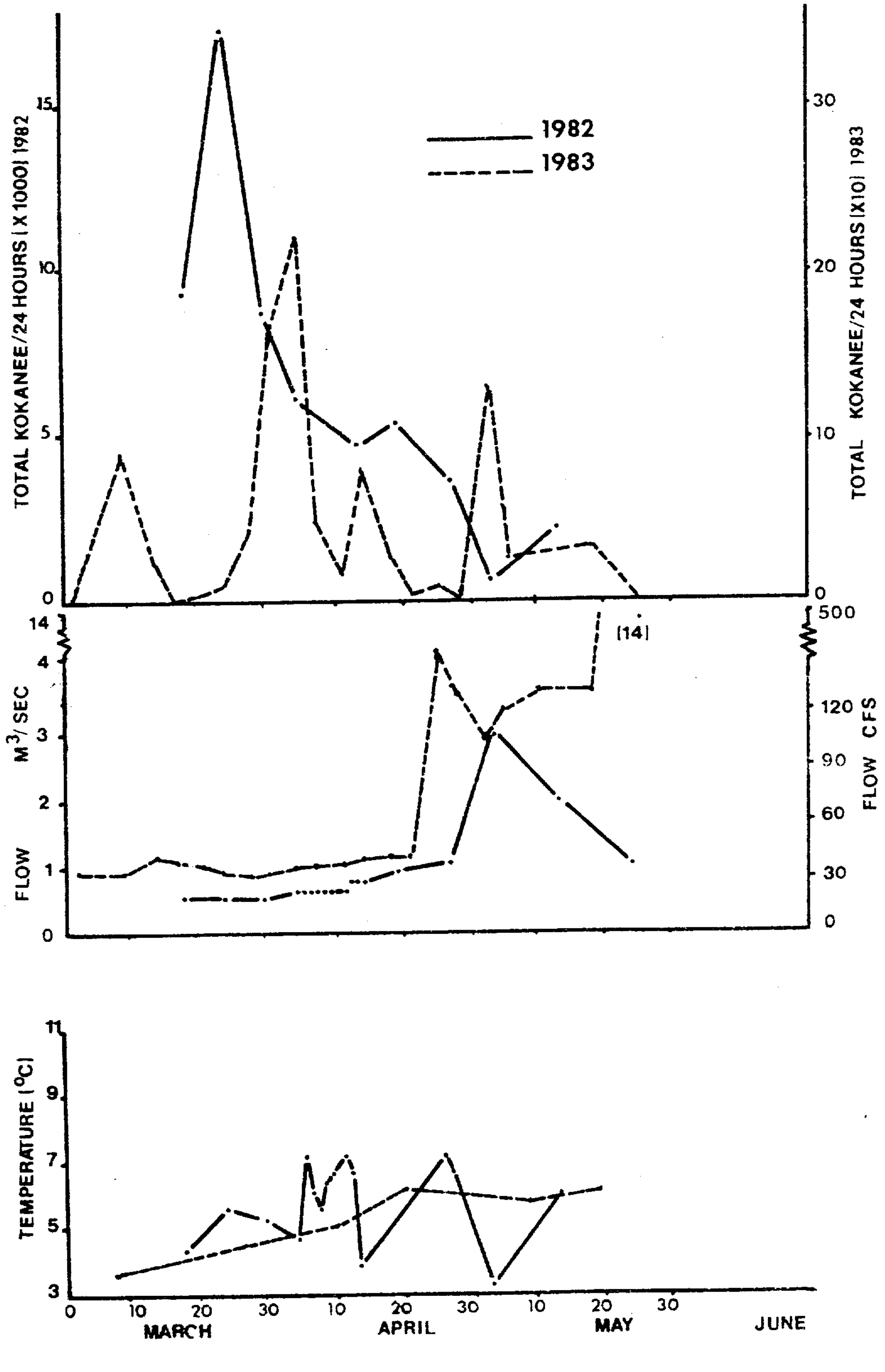

Figure 24. Number of kokanee fry emigrating, flow and water temperatures in Beaver Creek, 1982 and 1983.

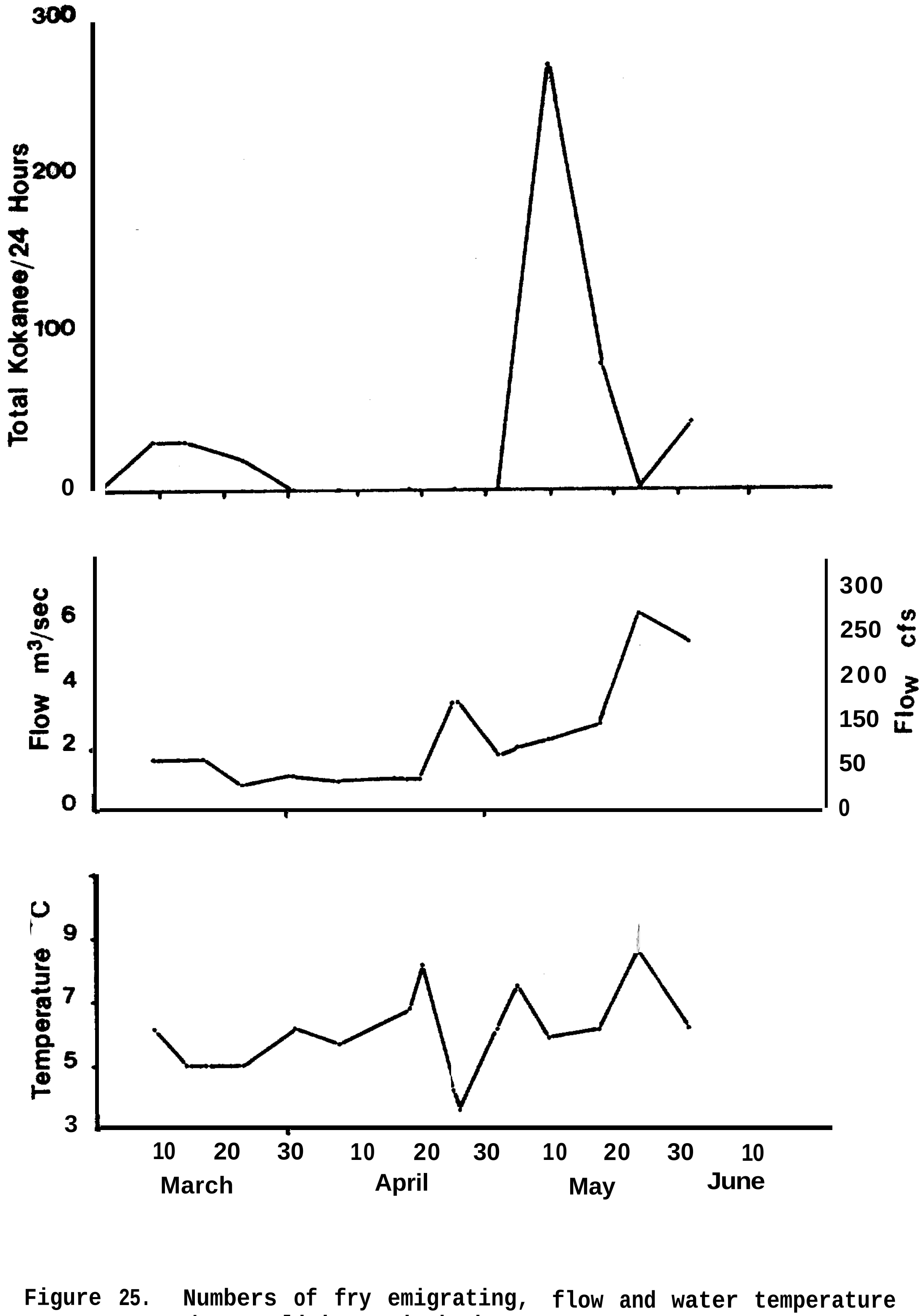

Figure 25. Numbers of fry emigrating, flow and water temperature in Deerlick Creek during 1983.

made of the total number of these fry which survived to emigrate downstream into the Flathead River system.

Mainstem Flathead River

Fry emigration monitored in the Flathead River near Kalispell peaked during roughly the same time period as in McDonald Creek during 1983 (Figure 26). No estimate of total numbers of emigrating fry were made. The majority of fry sampled in the mainstem were probably emigrants from McDonald Creek, as peak emigration in the mainstem itself probably occurred in late May or early June (Figure 15). High flows and debris made sampling impossible in the mainstem after mid-May.

Fry Emergence Traps

A total of 549 kokanee fry were captured in fry emergence traps placed over gravels in Flathead River system spawning areas. Emergence trap catches closely followed emergence timing indicated by drift net sampling in the various river system spawning areas (Figures 27 and 28).

Fry emergence traps were placed in McDonald Creek containing various substrate mixtures and 150 eyed kokanee eggs. Survival to emergence was negatively correlated with percent fines in the substrate (Figure 29). Survival to emergence was lower than predicted, based on substrate quality (Figure 30). Estimates of survival to emergence in McDonald Creek may be low due to trap efficiency. It is possible that some emerging fry had escaped the trap and were not enumerated.

Fry Distribution in the Water Column

Experiments conducted in McDonald Creek during 1983 indicated no consistent vertical distribution pattern for kokanee fry in the water column. Drift nets placed near the top of the water column captured more fry/100 m^2 of water filtered during three of the sampling periods, while nets set in the middle or bottom of the water column captured more fry during four of the sampling periods. Drift net sampling to estimate emigrating fry numbers in McDonald Creek was conducted throughout the water column after 10 May to account for possible differences in vertical distribution of fry. The distribution of kokanee fry in the water column appeared to be proportional to volume of flow, which is the major assumption made when calculating emigrating fry numbers in river system spawning areas. Data collected in McDonald Creek during 1982 (Fraley and Graham 1982) supported the assumption. Tagmaz'yan (1971) and Hartman et al. (1962) presented evidence that migrating salmon were distributed equally across the stream.

Peak numbers of fry were captured at about 0300 hours during die1 experiments conducted during a 48-hour period in 1983 at the junction of the North and Middle Forks of the Flathead River

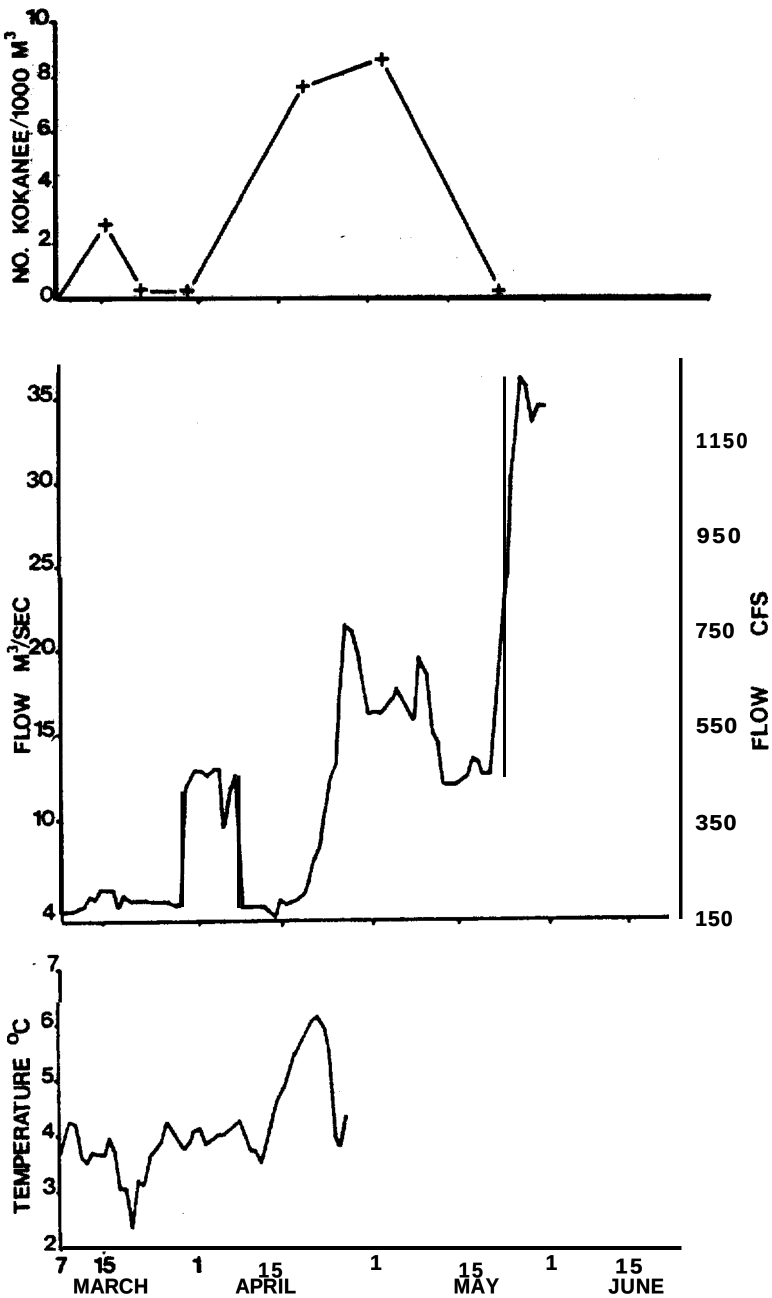

Figure 26. Number of kokanee fry/1000 m^3 of water filtered, flow and water temperature in the Flathead River near Kalispell during 1983.

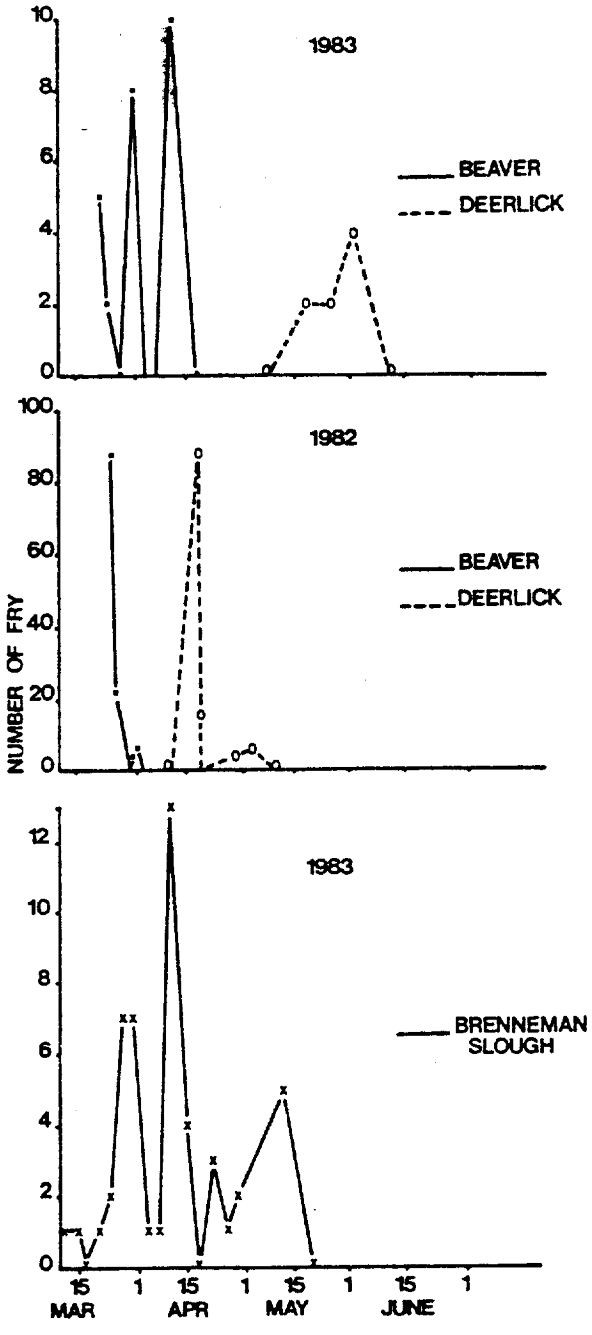

Figure 27. Number of fry captured in emergence traps in Beaver and Deerlick creeks during 1982 and 1983 and in Brenneman's Slough during 1983. Fry numbers represent totals for two traps in each of Beaver and Deerlick creeks and four traps in Brenneman's Slough.

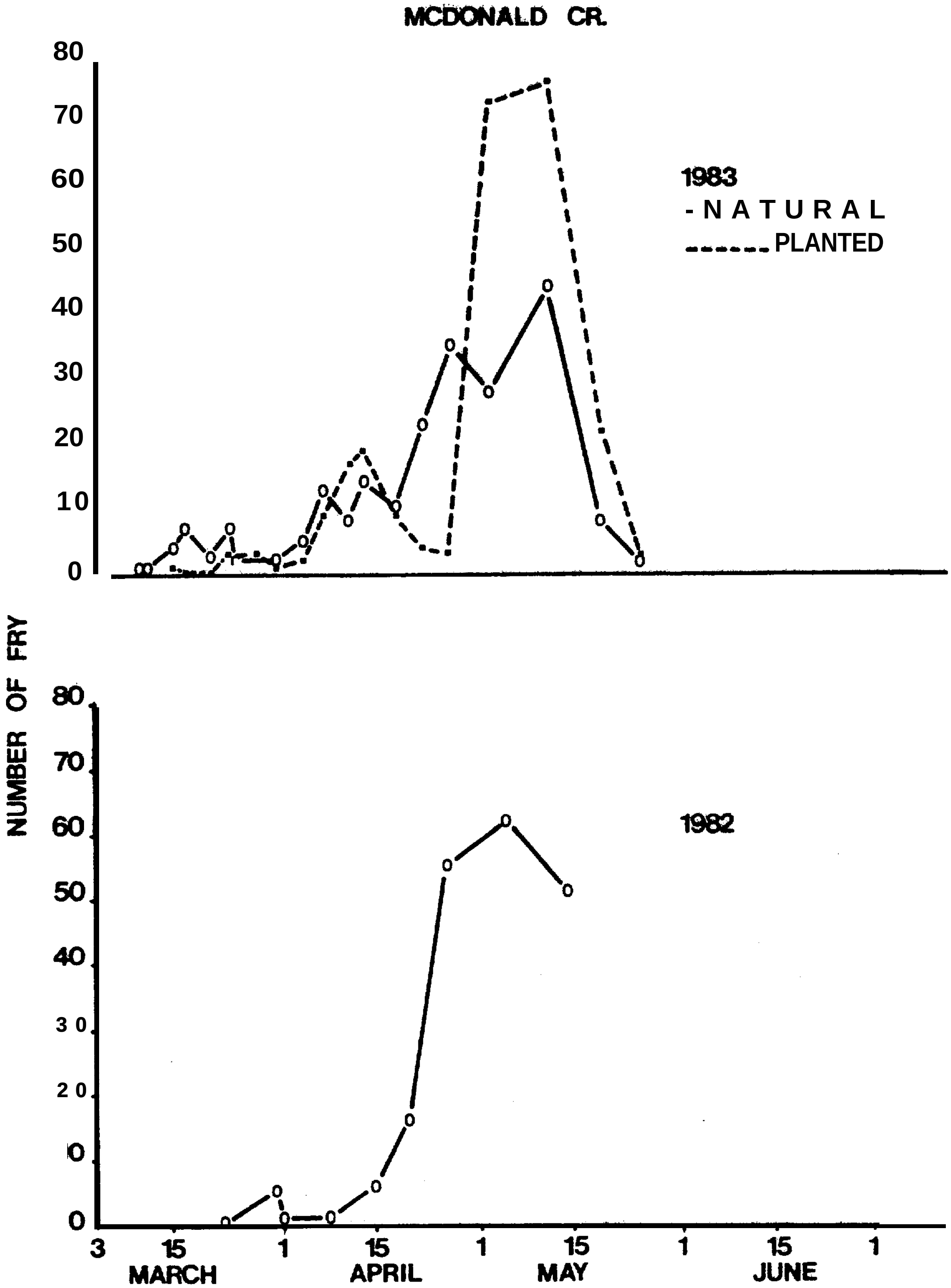

Figure 28. Number of fry captured in emergence traps placed over the gravel in McDonald Creek during 1982 and 1983. Fry numbers represent totals for nine traps in 1983 and eight traps in 1982.

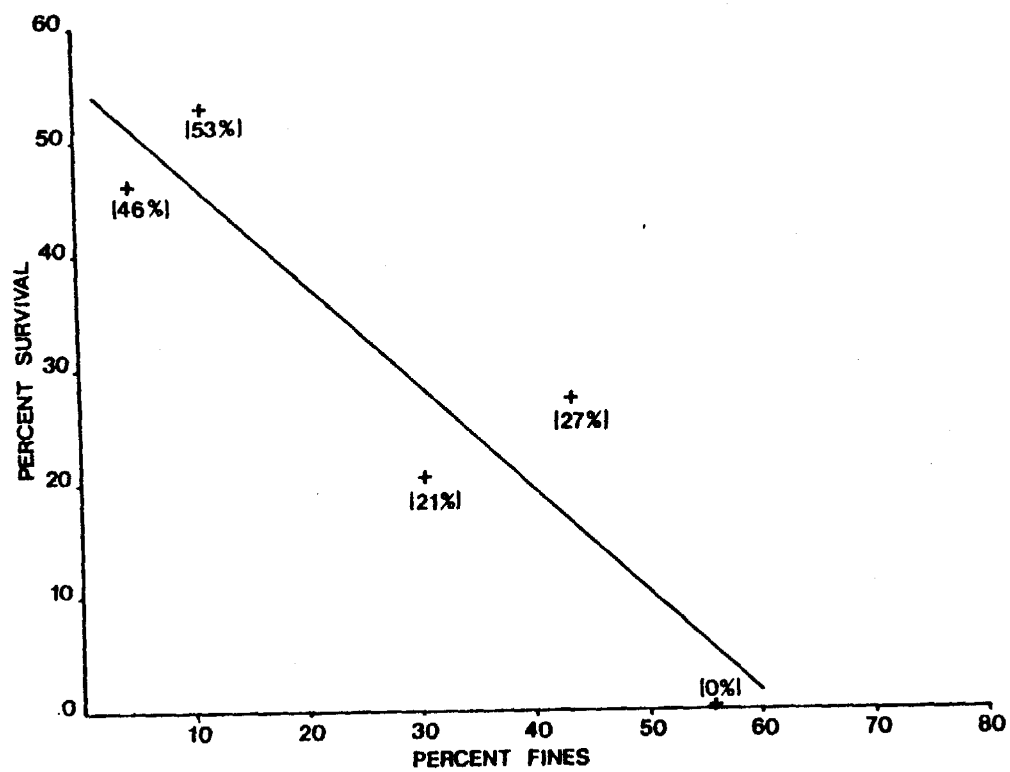

Figure 29. Relationship between percent survival to emergence of kokanee fry and percent fines in the substrate material for five emergence traps planted with eyed eggs in McDonald Creek during 1983 ($\hat{y}$ = 55.7 x = 0.90, r = -0.91).

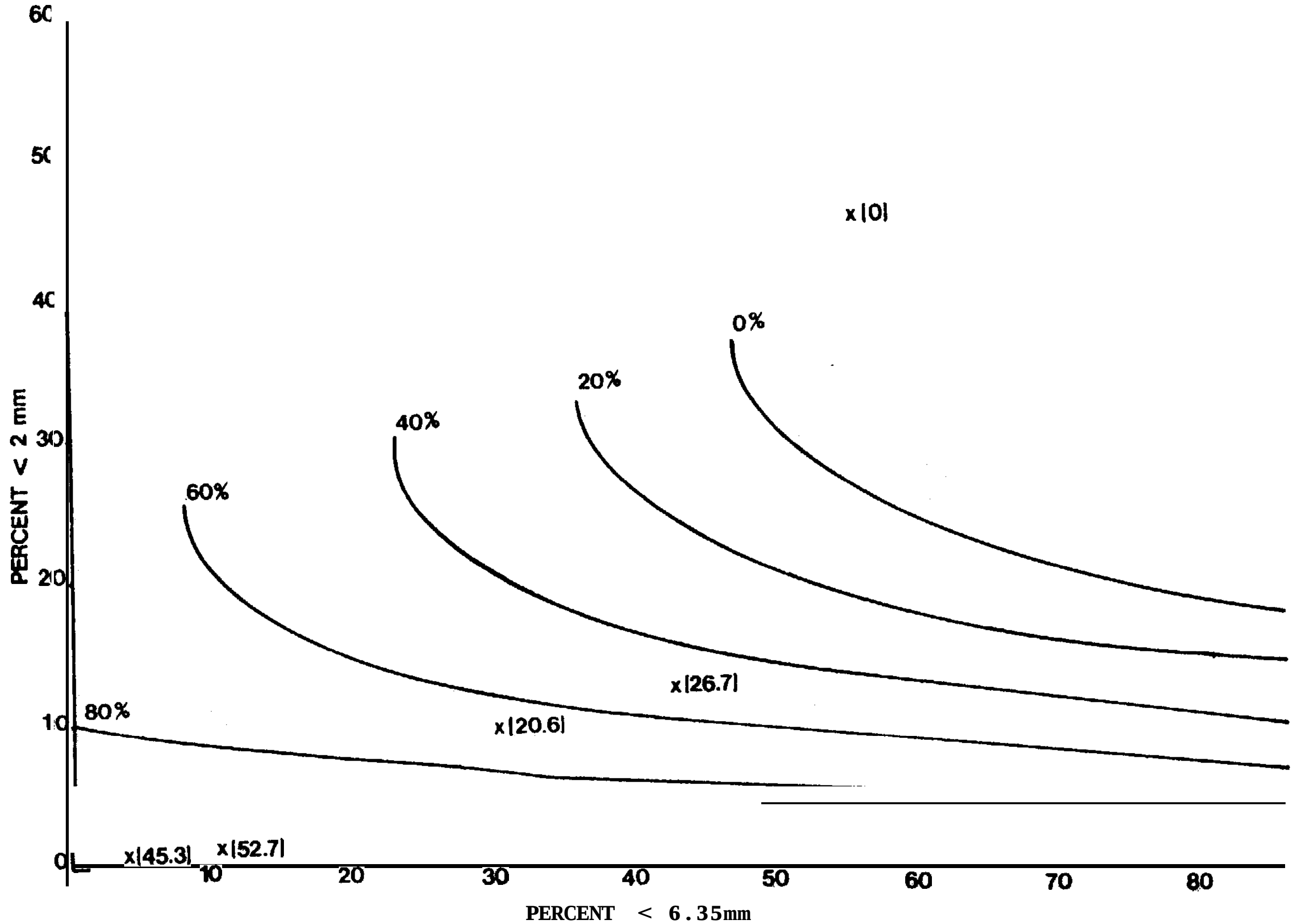

Figure 30. Predicted survival to emergence for kokanee eggs planted in emergence traps in McDonald Creek, based on substrate quality analysis. Survival bands were based on kokanee studies conducted by the Idaho Cooperative Fisheries Research Unit (unpublished).

(Figure 31). During the same 48-hour time period, peak numbers of fry were captured near dawn (0600) in the Flathead River near Columbia Falls. Fry emigration in McDonald Creek peaked from 2300 to 0200 hours during experiments conducted in 1982 and 1978 (Hanzel and Rumsey, unpublished, Fraley and Graham 1982). The delayed emigration peaks in the mainstem at the junction of the Middle-North Forks and at Columbia Falls were probably related to travel time of fry from McDonald Creek downstream through the river system.

Fry sampling in the mainstem Flathead River 2.0 km above Flathead Lake indicated fry emigration occurred during the dark hours through the lower section of the river. During a nine-day period (May 5-13) an average of 24 kokanee per net were captured during dark hours, while an average of only one kokanee per net was captured during the daylight period. It is possible that the die1 catch rate may change during the latter portion of the emergence period when the river becomes more turbid. Tagmaz'yan (1971) reported nocturnal migration of salmon fry. Hartman et al. (1962) reported that 98 percent of the stream migration of sockeye fry occurred at night, with the fry holding along stream margins during the light hours.

Fry Movements

Stained Fry Experiments

Stained fry movements

Kokanee fry emigration from McDonald Creek downstream through the Flathead River system was monitored during three fry staining experiments. A total of 5,120 fry captured in McDonald Creek were stained and released on 12 April and their movements were monitored at sampling sites downstream. Two fry were recaptured 8 km below McDonald Creek after one night of travel. After two nights of travel, one fry was recaptured 34 km downstream from McDonald Creek. It was assumed that the fry moved during the 10.5 hour dark period only. Assuming nocturnal fry movement, the fry recaptured at Columbia Falls moved approximately 1.6 km per hour. The sampling sites were monitored for four more days, but no additional stained fry were captured. No stained fry were captured in the mainstem site 55 km downstream, although this site was monitored for only one day (three days after release). A total of 1,905 fry were captured at the downstream sampling sites during the experiment, including the three stained fry.

On 19 April, 2,905 kokanee fry were captured, stained and released in McDonald Creek. One stained fry was recaptured 34 km downstream after one night of travel. This represents a movement rate of 3.4 km/hour assuming the fry traveled during the 10 hours of darkness. A total of 1,605 fry were captured at the downstream sampling sites, including the one stained fry. Sampling was

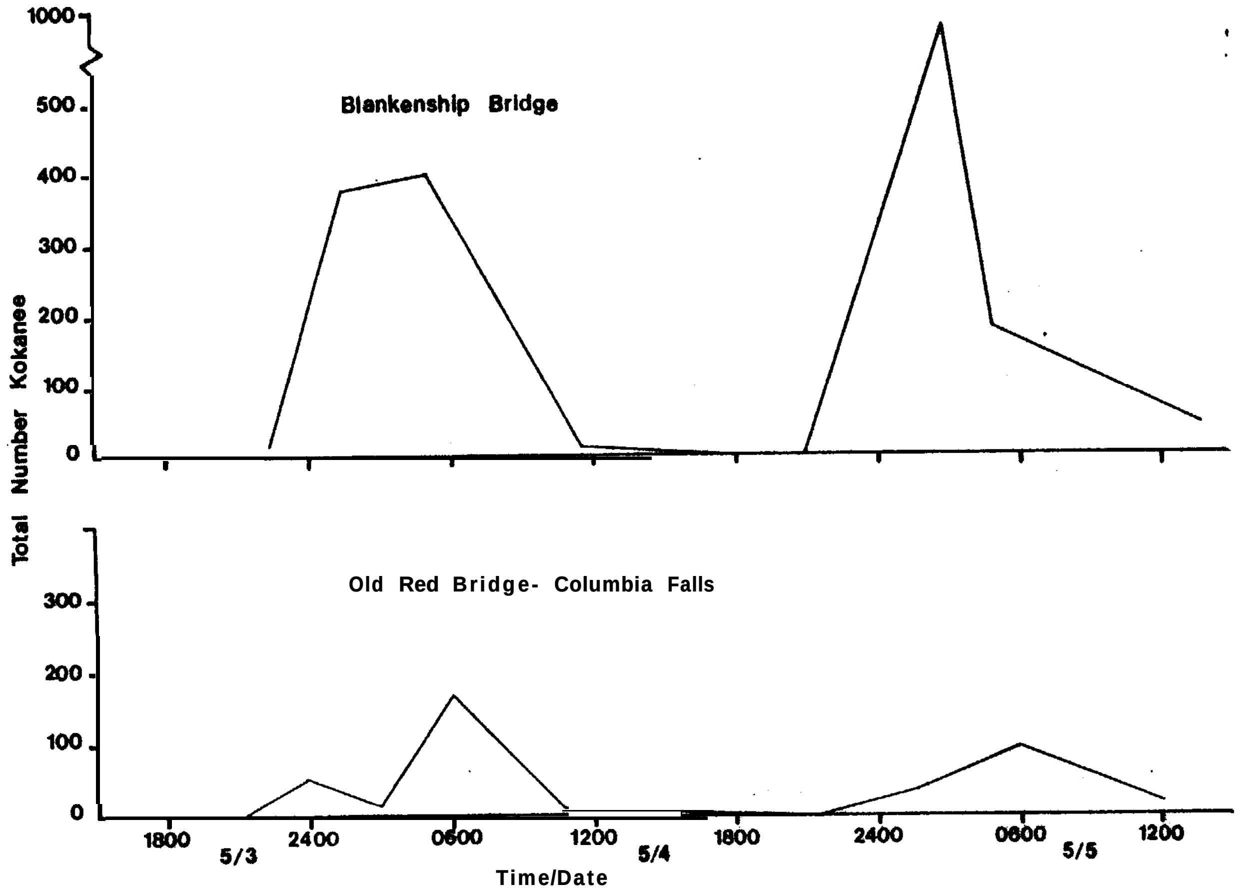

Figure 31. Numbers of kokanee fry captured in drift nets during a 48 hour period in the Flathead River near Blankenship Bridge and Columbia Falls, 3-4 May, 1983.

terminated two to three days after fry release at the downstream monitoring points due to a sudden increase in flows.

A total of 10,664 fry were captured, dyed and released on 3 May. Drift nets set at the first two sampling sites (8 km and 34 km downstream) were checked approximately every three hours after the release of the fry in McDonald Creek. The fry appeared to move out of McDonald Creek and downstream through the river system in a large group or wave (Figure 32). At 0130 hours, approximately 4.5 hours after dusk (the estimated time the fry left McDonald Creek) they had reached the sampling point 8 km downstream. A total of 371 fry were captured and 31 or 8.5 percent were stained. Movement rate of the fry down the Middle Fork of the Flathead to the sampling site was approximately 1.8 km/hour. Only four stained fry were captured during the next 60 hours of sampling at the 8 km point. At 0600 hours after approximately 9.0 hours of travel, the fry had reached Columbia Falls, 34 km downstream from McDonald Creek. A total of 164 fry were sampled at that time and 18, or 11 percent, were stained. The fry appeared to have moved 5.8 km/hour between the 8 km and 34 km points or 3.8 km/hour overall for the 34 km. By 0030 hours the following night, or approximately 12.0 hours of total travel time, the fry had reached Kalispell, 55 km downstream. A total of 52 fry were captured and five, or 9.6 percent, were stained. The fry appeared to have moved from the 34 to the 55 km point at a rate of 6.0 km/hour. The estimated overall movement rate of the stained fry group over the 55 km of stream from McDonald Creek to Kalispell was 4.4 km/hour. A sampling site just above Flathead lake at the Sportsmen's Bridge (95 km downstream from McDonald Creek) was established and monitored for 10 days after the fry passed Kalispell. A total of 671 fry were captured, but none were stained.

Movement rates of kokanee fry appeared to be as rapid or more rapid than estimated flow rates in the sections of the river between the South Fork and Columbia Falls and between Columbia Falls and Kalispell (Table 21). This would indicate that the fry were actively maintaining position in the flow and possibly swimming slightly faster than the flow. To travel as fast or faster than the flow the fry probably actively swam through eddies and back currents when they were encountered. Hartman et al. (1962) reported that sockeye fry actively migrated downstream in a river system swimming faster than the current.

Flow rates appeared to be somewhat related to gradient (Table 21), although bed roughness was probably also a factor. Stream gradient from Kalispell to Flathead Lake (0.14 m/km) is only 12.6 percent as great as the gradient between the mouth of the South Fork and Kalispell. If flow rates were proportional to gradient and kokanee fry swimming rates were similar to flow rates, an estimated 55 hours would be required for fry to travel the 42 km from Kalispall to Flathead Lake. Assuming only night travel, this would translate to approximately six days. Under this assumption,

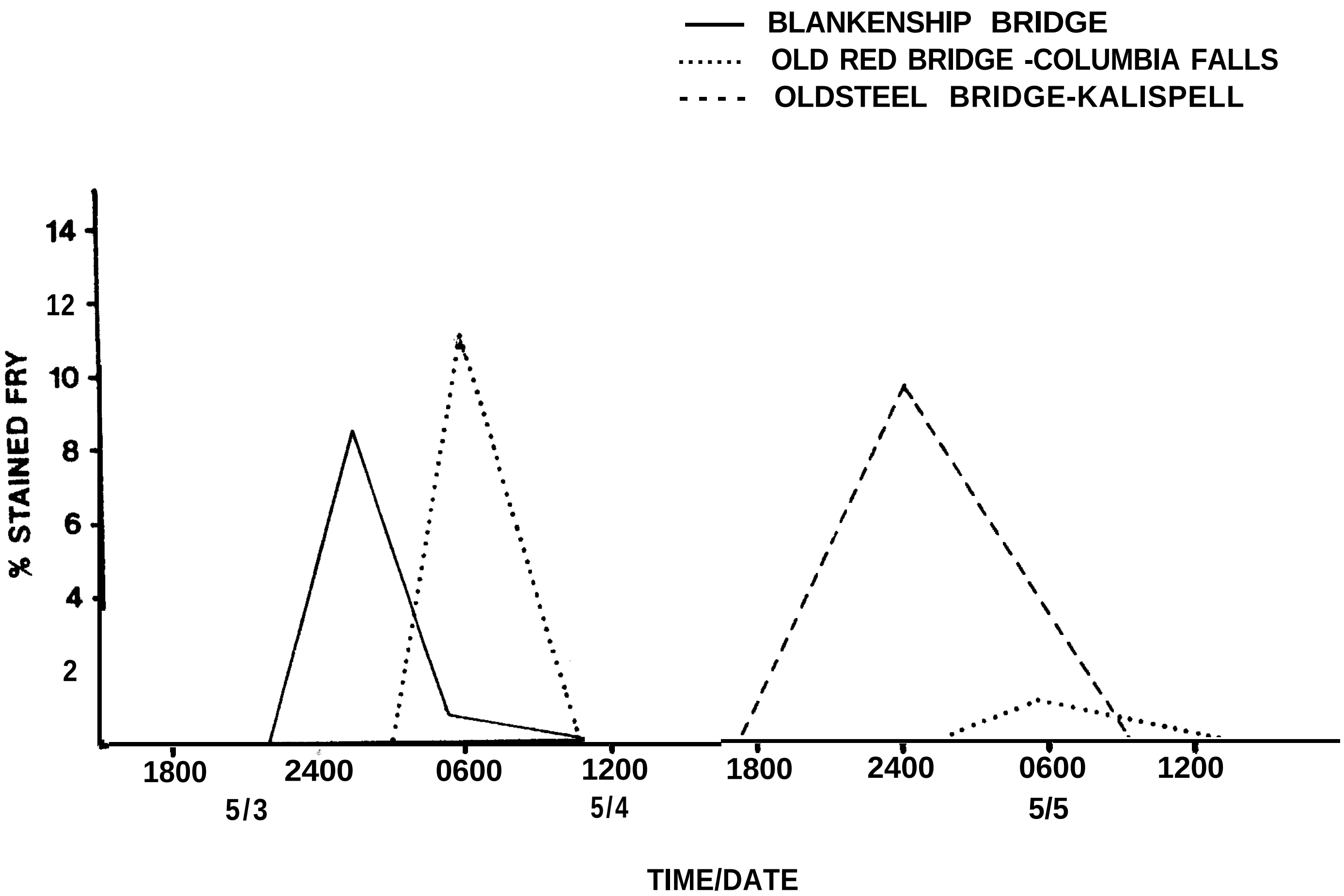

Figure 32. The percent of fry captured that were stained at sample sites 8 km (Blankenship), 34 km (Columbia Falls) and 55 km (Kalispell) below McDonald Creek on 3-4 May, 1983. Successive peaks show the downstream movement rate of the group of stained fry.

Table 21. Distances, flow times and flow rates in the Flathead River between the mouth of the South Fork and Kalispell.

River section	Section length (km)	Gradient (m/km)	Flow time (hours)	Flow rate (km/hr)	Movement rate of stained fry (km/hr)
Mouth of South Fork to Columbia Falls	9.2	1.33	1.5	6.1	5.8 1/
Columbia Falls to Kalispell	21	1.02	3.5	6.0	7.0
Total	30.2	1.11	5.0	6.0	6.3

1/ Represents movement rate of stained fry between Blankenship Bridge and Colunbia Falls.

fry could potentiaUy travel from McDonald Creek to Flathead Lake in approximately eight days under the flow conditions experienced in early May, 1983. However, it is possible that many kokanee fry remain in the slower "estuary" portion of the river from below Kalispell to Flathead Lake and may take much longer to reach Flathead Lake.

Substantial variation in kokanee fry movement patterns has been observed during the last two years of study. Fry movement experiments conducted during 1983 indicated that fry from McDonald Creek emigrated downstream through the river system with little or no residence time in McDonald Creek. However, the large size of some kokanee fry collected from McDonald Creek in mid-May indicated a substantial residence time in the stream before emigration Extended residence time, indicated by large fry size, was also noted in Brenneman's Slough. Extended residence time of kokanee fry in Beaver Creek and Brenneman's Slough was reported in 1982 (Fraley and Graham 1982). Spring influenced areas, such as Brenneman's Slough, appeared to produce larger fry which experienced longer residence times after emergence. Fry in non-spring influenced spawning areas appeared to emigrate shortly after emergence from the gravel. Stober and Hamalainen (1980) reported most stained sockeye fry released in the Cedar River, Washington emigrated in only one to three days after emergence from the gravel.

Mortality of stained fry

Control groups of stained and unstained kokanee fry kept in net cages in McDonald Creek during the three movement experiments suffered similar mortality rates. The mortality rates of fry held in McDonald Creek for seven days averaged 7.3 percent in the stained group and 6.2 percent in the unstained group. After 15 days, during experiment number three, stained and unstained fry suffered 16 and 18 percent mortality, respectively.

Fry stained for 50 minutes in a 1:30,000 solution of Bismark Brown were easily recognized for one week after staining. Fin and mouth areas retained stain for up to 22 days. Fry dyed for 45 minutes in a 1:20,000 solution of Bismark Brown retained the stain for less than one week (experiment number one).

Movements of Hatchery Fry

A total of 50,000 hatchery-reared kokanee fry were planted in upper Deerlick Creek on 20 April, completing a four year planting cycle. The movements of the hatchery fry were monitored at points 1 and 3 km downstream using fry drift nets. Fry were released in early afternoon and it was assumed that movement began at dusk. Large numbers of fry first passed the 1 km site at 2300 hours, approximately three hours after dark. Small numbers of fry had already reached the 1 km site by that time. At 0210 hours a large wave of fry had reached the 3 km point. This point is 0.8 km upstream from the mouth of Deerlick Creek on the Middle Fork of the Flathead River. The majority of the hatchery fry moved out of Deerlick Creek during the first several nights after release. However, a few fry were captured one km below the release point up to 15 days after planting. A control group of hatchery fry kept in a net holding box in Deerlick Creek suffered heavy mortality. Percent survival after 2, 6, 7 and 9 days were 80, 50, 30 and 0 percent, respectively. Poor survival of hatchery fry was also noted in Deerlick Creek in the spring of 1982 (Fraley and Graham 1982). Mead and Woodall (1968) suggested that hatchery fry were inferior to naturally propagated fry in characteristics important in survival, such as photonegative behavior. Bans (1969) found that hatchery fry were inferior to naturally propagated fry in swimming ability and in avoidance of predation.

Fry Food Habits and Fry Quality

Analysis of Kokanee Fry Stomachs

Stomach contents from 379 kokanee fry collected in 1982 were examined to determine food habits. Data was organized by month for each sample site. The number and wet weight (mg) of organisms, frequency of occurrence, and Relative Importance (RI) for all stomach contents were calculated.

Diptera larvae was the major item in the diet of kokanee fry in Beaver Creek, Middle Fork Flathead River, and Brenneman's Slough, while Copepoda and Cladocera had a small representation. Trichoptera, Ephemeroptera, and terrestrial insects were represented in small numbers during May and June in Brenneman's Slough only. Copepoda were present in the Middle Fork Flathead River and Brenneman's Slough, while Cladocera was present in Brenneman's slough only. Stomachs of 90 of the fry collected from McDonald Creek were empty. Copepods were present in one fry. Loftus and Lenon (1977) found that chironomidae were the most important food organisms for chum salmon fry and chinook salmon fry in the Salcha River, Alaska. Becker (1973) reported that juvenile chinook fed mainly on chironomid adults and larvae in the Columbia River, Washington. Salmon fry fed mainly on chironomid larvae in rivers of Japan and Norway (Kaeriyama et al. 1978, Lillehammer 19731.

Fry Quality

There was a relationship between kokanee fry length and water temperatures in Flathead River system spawning areas. Emigrating kokanee fry ranged from 25-51 mm in Brenneman's Slough during and after peak emergence. The warmer water temperatures in the spring fed slough coupled with the apparent longer residence time after emergence from the gravel was reflected in the relatively large length of the majority of kokanee fry emigrating from the slough. Peak time of emergence in Brenneman's Slough during 1982 was 30 March through 7 April. The mean temperature during this time was 8.9°C. The larger fry emigrating from the slough may experience greater survival traveling to Flathead Lake. Larger fry may also experience greater survival during the early residence period after reaching Flathead Iake.

Peak time of fry emigration in McDonald Creek during 1982 was between 20 May and 30 May. Fry collected ranged from 23-27 mm in length. The mean temperature during this period was 4°C. Mean temperature in Beaver Creek was 5°C during peak emergence (20 March through 30 March) and fry collected ranged from 22-30 mm in length. Fry emigration in the Middle Fork Flathead River peaked between 10 April and 30 April. The mean water temperature during this period was 6°C. Kokanee fry collected in the Middle Fork of the Flathead during peak emergence ranged from 23-28 mm in length but it was assumed that the majority of these fry originated from Beaver Creek. Kaeriyama et al. (1978) reported that chum salmon fry were longer during years of warmer stream temperatures in the Takachi River system, Japan.

RECOVERY OF THE MAINSTEM KOKANEE POPULATION

Timing of the Kokanee Recovery

Timing of the mainstem kokanee population recovery could vary substantially depending on the level of natural reproductive success for each year class of fish (Figure 33). Recovery of the kokanee population from its present depressed level to the level outlined in the management goal could not occur at a 20 percent egg to fry survival rate and a one percent fry to adult return rate. At a two percent fry to adult return, a fishable mainstem population would be reached by 1993 and nearly 200,000 spawners would return by 1997. A fry to returning adult survival rate of three percent would result in a fishable population by 1989. By 1993, the population would reach an assigned maximum level of over 300,000 spawners.

The mainstem kokanee population is expected to recover with an average of 20 percent egg to fry survival and two percent fry to adult survival, resulting in a doubling of numbers in each successive four year cycle of spawners. An egg to fry survival rate of 20 percent is based on the 1981-82 estimates for McDonald Creek (22%) and various studies of other salmon populations in the western United States and Canada (Table 20).

Egg to fry survival rates in Flathead River system spawning areas in the 1982-83 season averaged 25.1 percent and ranged from 4.5 to 68.9 percent (Table 22). The high egg to fry survival rate in McDonald Creek was probably due to low densities of spawners and warmer than average water temperatures resulting in ideal incubation conditions. Merrel (1962) and McNeil (1968) reported higher survival rates of sockeye and pink salmon eggs incubated in warmer water. Survival in McDonald Creek was probably inflated due to an underestimate of potential egg deposition. The range of 4.5 to 22.9 percent egg to fry survival in other river system

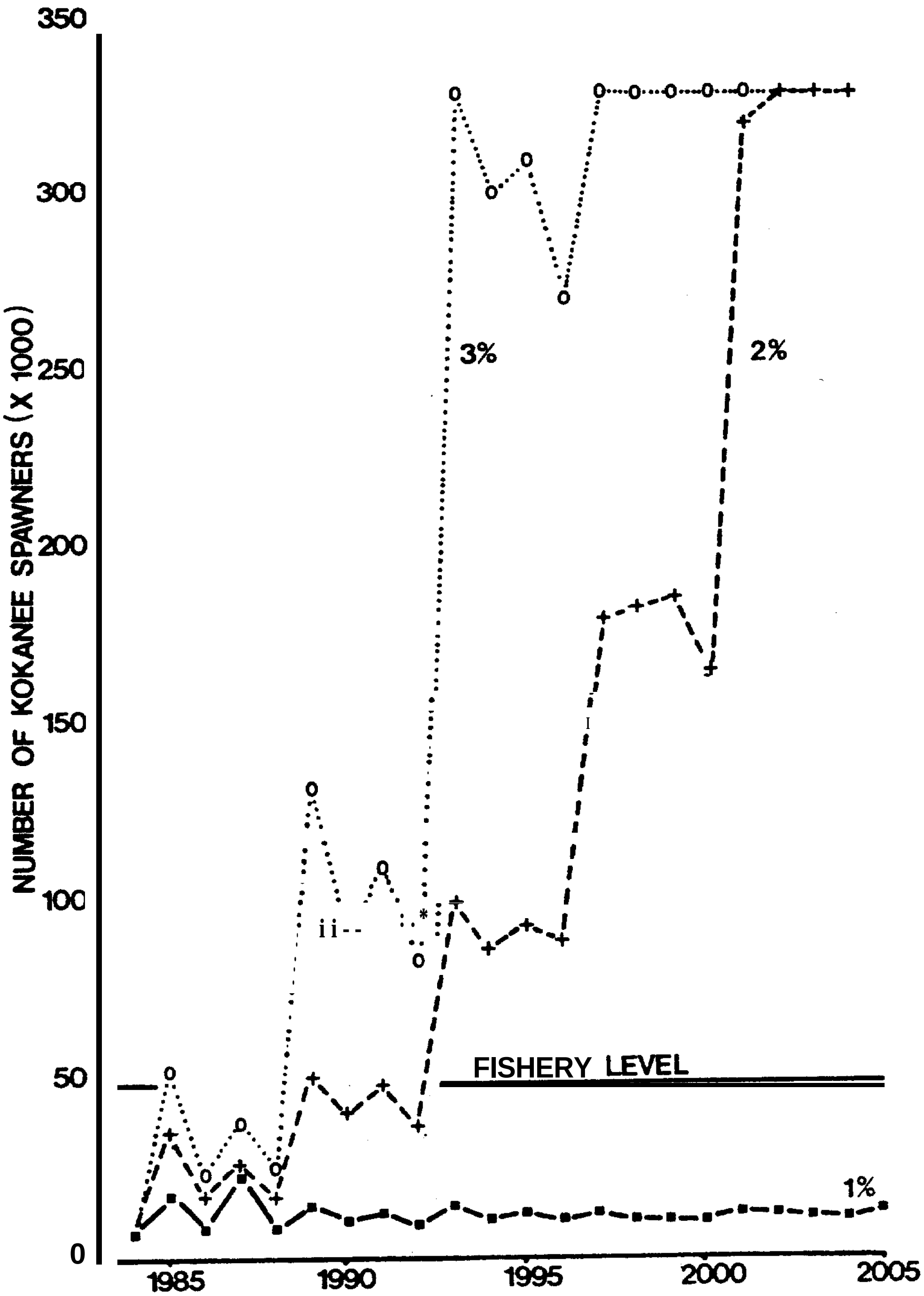

Figure 33. Projected growth of the mainstem kokanee population at 20 percent egg to fry survival, and one, two, and three percent fry to adult returns (no angler harvest).

Table 22. Kokanee egg to fry survival rate in Flathead River system spawning areas for 1982-1983.

Area	Estimated potential egg deposition	Estimated number of emigrating fry	Percent egg to fry survival
McDonald Creek	18,000,000	12,404,568	68.9
Whitefish River	1,500,000	67,340	4.5
Brenneman's Slough (Mainstem Area 1)	230,000	31,511	13.7
Beaver Creek	24,000	3,771	15.7
Deerlick Creek	15,000	3,448	22.9

spawning areas is probably more typical of expected survival rates in the mainstem Flathead River. Egg to fry survival may be higher during the first portion of the recovery due to low densities of spawners, Egg to fry survival rates are expected to fluctuate through the kokanee recovery period, but a 20 percent rate was selected as our best estimate of an average figure. Larkin (1971) developed a model to predict population cycling on sockeye populations of Alaska. He added a random environmental fluctuation factor to simulate a possible natural Occurrence of population cycling.

The estimate of two percent fry to adult return was largely based on our studies in McDonald Creek and survival figures reported for salmon in the literature. A rough estimate of 15 million fry emigrated from McDonald Creek in spring, 1978, based on unpublished Department netting data (Hanzel and Rumsey, unpublished, Fraley and Graham 1982). An estimated 250,000 kokanee would have returned to McDonald Creek in 1981 if no harvest had occurred (over 50 percent were harvested before they reached the creek), yielding a fry to adult return rate of 1.7 percent. McNeil et al. (1969) reported a two percent fry to adult return in Sashin Creek, Alaska for pink salmon in 1966. Fry to adult return rates in Sashin Creek from 1940 to 1965 ranged from 0.3 to 18 percent and averaged three percent. Bakkala (1970) reported fry to adult return rates for anadromous chum salmon ranging from 1.5 to 3.2 percent and averaging 2.5 percent in five tributaries to the Amur River, U.S.S.R.

A 20 percent egg to fry survival rate and a two percent fry to adult return rate would constitute an overall return rate of 2.0 returning adults per spawner, or a doubling of the population in each successive four year cycle. Mean estimates of returning adults per spawner reported for seagoing chum salmon in streams of Alaska and British Columbia ranged from 1.7 to 3.0 and averaged 2.3 over a 40 year period (Bakkala 1970).

Effect of Harvest Rate on Kokanee Recovery

A spawning run of 50,000 kokanee spawners in the mainstem run was estimated as the minimum population that could support a harvest. Allowing harvest of the mainstem kokanee spawners at population levels below 50,000 spawners would seriously impair the recovery rate of the population. With no harvest rate, the population should be safely above the 50,000 fish level by 1993, when harvest of the population could begin. The rate at which mainstem kokanee are harvested from that point would greatly affect the rate of population growth and recovery (Figure 34). A 50 percent harvest rate would remove the additional spawners which could potentially return, resulting in a return rate of 1.0 returning adult per spawner. Very slow growth of the mainstem kokanee population would occur at a 40 percent harvest rate. An estimated 130,000 pre-harvest spawners would be present in the year 2003, after five generations (five four-year cycles). At a

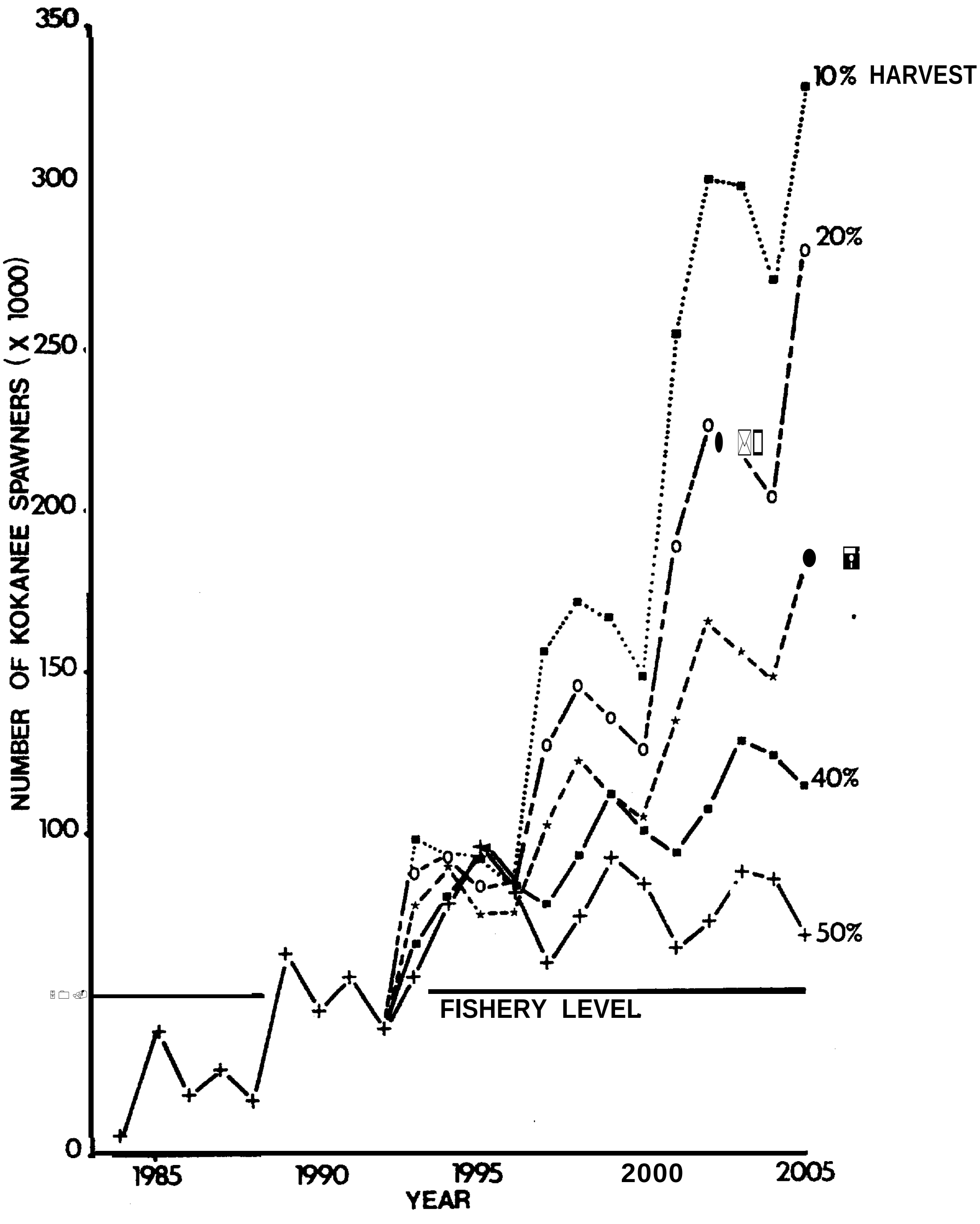

Figure 34. Projected growth of the mainstem kokanee run at 20% egg to fry survival, 2% fry to adult survival and 10-20%, 30%, 40% and 50% harvest rates.

30 percent harvest, an estimated 160,000 pre-harvest spawners would be present after five generations. At 20 and 10 percent harvest rates, 220,000 and 300,000 pre-harvest spawners, respectively, would be present in the mainstem run after five generations.

A desirable harvest rate for management of the mainstem kokanee population would be one that could be adjusted based on the number of spawners that return each year. This shifting harvest rate could begin at 10 percent after the minimum fishery level of 50,000 fish is reached and increased to 50 percent at the assumed maximum population level of 330,000 spawners (Table 23, Figure 35). The mainstem kokanee run would increase to 231,000 spawners after five generations and would reach the maximum level of 330,000 spawners by 2008.

Effects of Planting to Supplement Kokanee Recovery

Planting of 500,000 kokanee fry in even years (which appear to support the weak runs) from 1984-1996 was considered to supplement the recovery of the mainstem kokanee population. Benefits to kokanee recovery would not justify the expenditures involved in a fry or egg planting operation in the river system (Figure 36). Planting of 500,000 additional fry during the even years from 1984-1996 would yield a run of 240,000 kokanee after four generations with no harvest (2000), while a run of 170,000 kokanee would be present after four generations without supplemental plantings. The maximum level of 330,000 spawners would be reached after five generations with or without planting. Benefits of the planting operation are limited by the low expected adult return from the artificial plants. In addition, planted fish may exhibit a poor homing response as adults. Royce (1959) reported that planting of eggs in the stream gravels was a more successful method of increasing salmon populations than the introduction of hatchery fry.

An experimental plant of approximately 100,000 eyed eggs will be made in a mainstem spawning area during the 1983-84 season to test egg survival and fry production in artificial planting boxes.

Table 23. Hypothetical harvest management plan for the mainstem kokanee run.

Pre-harvest population level	Estimated time period	Mean harvest rate	Mean number of kokanee harvested
0-50,000	Present-1992	0	
50,000-100,000	1993-1996	14%	10,500
100,000-200,000	1997-2000	24%	36,000
200,000-329,000	2001-2008	41%	108,240
330,000 1/	2008-	50%	165,000

1/ Assumed maximum return

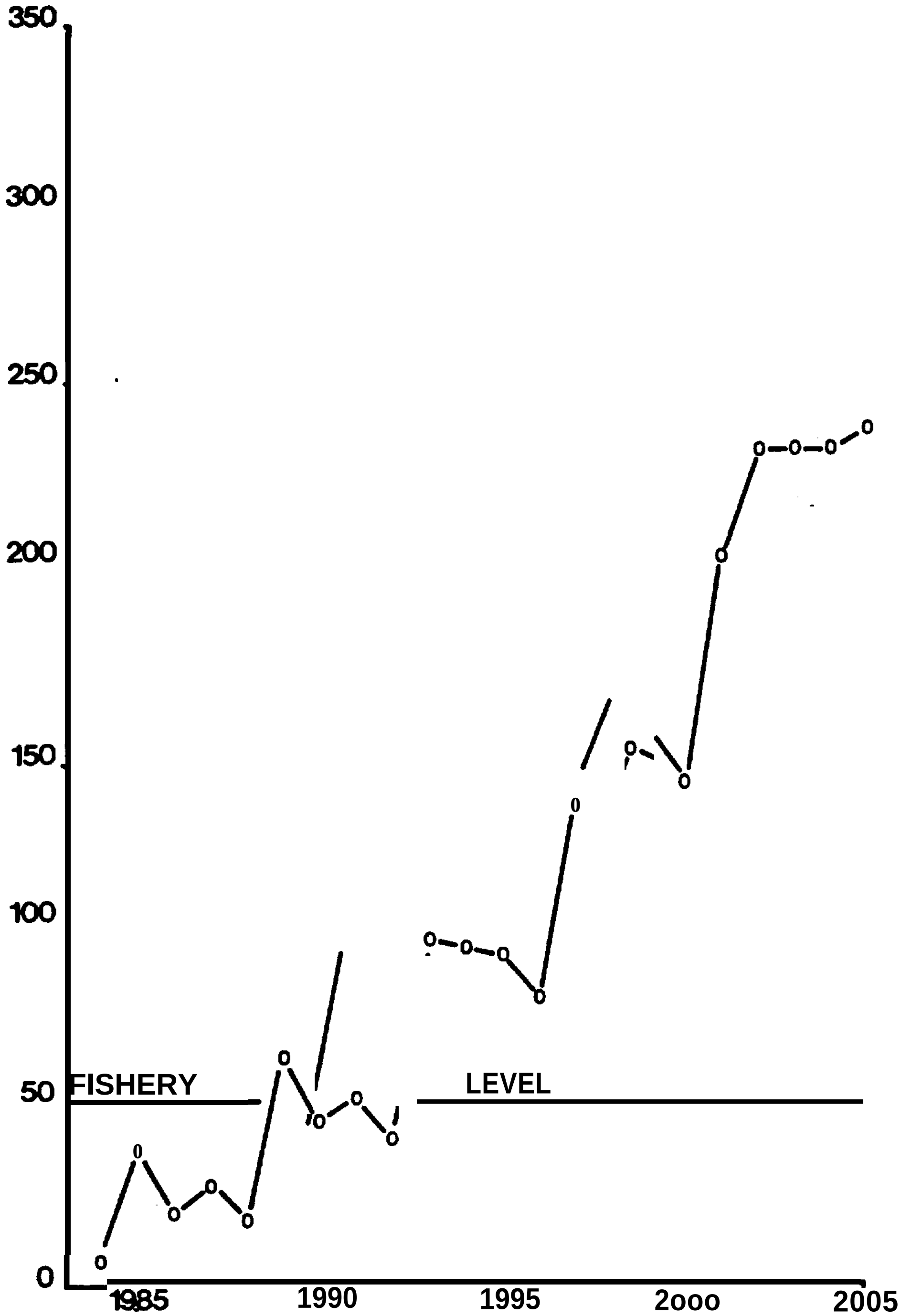

Figure 35. Projected growth of the mainstem kokanee run at 20% egg to fry survival, 2% fry to adult survival and a 10-50% shifting harvest rate from 50,000-330,000 spawners.

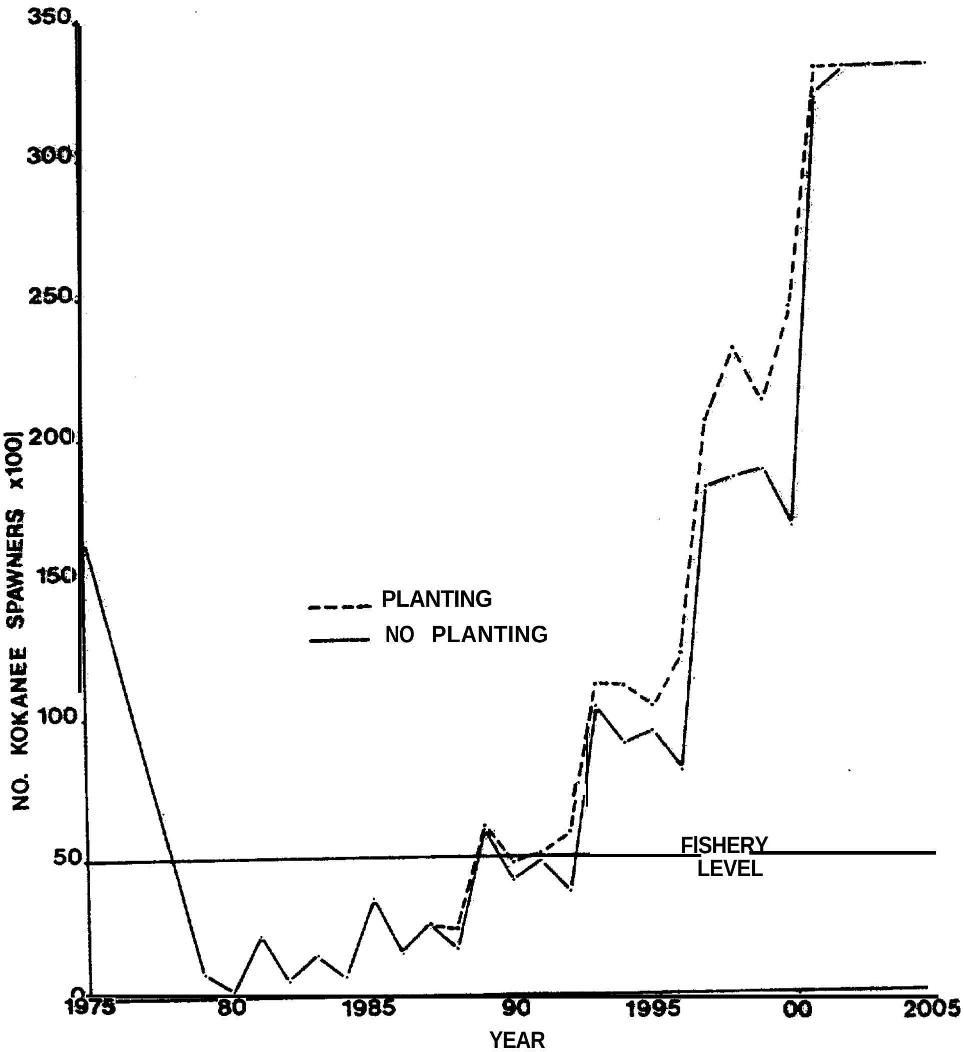

Figure 36. Projected growth of the mainstem kokanee run at 20% egg to fry survival, 2% fry to adult survival, and no angler harvest. Growth is projected with and without a plant of 500,000 fry during the even years from 1984-1996.

CONCLUSIONS AND RECOMMENDATIONS

PRESENT STATUS OF THE KOKANEE FISHERY

Kokanee reproduction in the mainstem Flathead River presently contributes less than 20 percent of the recruitment to Flathead Lake (Table 24). McDonald Creek is the major spawning ground for Flathead kokanee, while the Middle Fork of the Flathead River, Whitefish River, Beaver-Deerlick creeks and the Flathead lakeshore also contribute to total recruitment. From the late 1950's through the mid-1970's, the mainstem kokanee run was probably equal to or greater than the McDonald Creek run in terms of total recruitment to Flathead Lake (Fraley and Graham 1982). Hanzel (1964) reported that the mainste "late run" was larger than the early run during the early 1960's. During the late 1970's, the mainstem Flathead River spawning run declined dramatically. The post-harvest population of the mainstem "late run" spawners declined from an estimated level of over 150,000 12.9 inch fish in 1975 to an average of only 10,000 14.5 inch fish during the past four years (Figure 36). The McDonald Creek spawning run has recently dominated the river system kokanee population, averaging 55,500 spawners over the past four years (Table 24, Figure 37).

The decline in the mainstem spawning run was precipitated by a change in the discharge pattern of Hungry Horse Reservoir on the South Fork of the Flathead River in the late 1960's. Reservoir operations shifted to a fall drafting pattern for provisional energy deliveries which resulted in high flows during the kokanee spawning period (Fraley and Graham 1982). These high flows caused kokanee salmon to build redds high on the river bank which were later subject to dewatering at lower flows during the winter egg incubation period. Heavy incubation mortality resulted, and the mainstem spawning run declined to its present level.

Angler harvest during the fall kokanee snag fishery in the river system reflected these population changes, as anglers have completely changed the focus of their fishery from 1975 to 1982. During the mid-1970's, angling pressure was concentrated on the "late run" of fish which spawned in the mainstem below the South Fork during October, November and December (Hanzel 1977). With the decline of the mainstem run, angler effort and harvest shifted almost entirely to the early run of fish bound for spawning runs in McDonald Creek and the Middle Fork drainage (Fraley and Graham 1982, Fredenberg and Graham 1982A). During the 1975 fishery, the mainstem "late run" contributed 88 percent of the total kokanee harvest in the river system, while the early run contributed 12 percent (Hanzel 1977). During 1981 and 1982, only 12 and two percent of the kokanee harvest in the river system was from the mainstem run. Kokanee harvest was concentrated on the early run bound for McDonald Creek and the Middle Fork which comprised 88 and 98 percent of the total harvest in 1981 and 1982, respectively. Early closures of the 1981 and 1982 snagging seasons may have

Table 24. Estimated numbers of post-harvest kokanee spawners in Flathead River system spawning areas. Numbers are estimated from snorkel counts in McDonald Creek and redd counts in the other areas. Percent of total river system count for each area is in parentheses.

Area	Year 1979	1980	1981	1982
McDonald Creek	65,000 (84)	45,000 (94)	104,000 (75)	35,000 (77)
Mainstem Flathead River	12,000 (16)	1 ,500 (3)	24,000 (17)	5,000 (11)
Middle Fork Flathead River	--- 1/	--- 1/	7,000 (5)	2,200 (5)
Whitefish River	---	1,300 (3)	1,300 (1)	3,000 (7)
Beaver-Deerlick Creeks	0	--- 1/	1,500 (2)	125 (<I)
TOTAL River System	77,000	47,800	137,800	45,325

1/ No count.

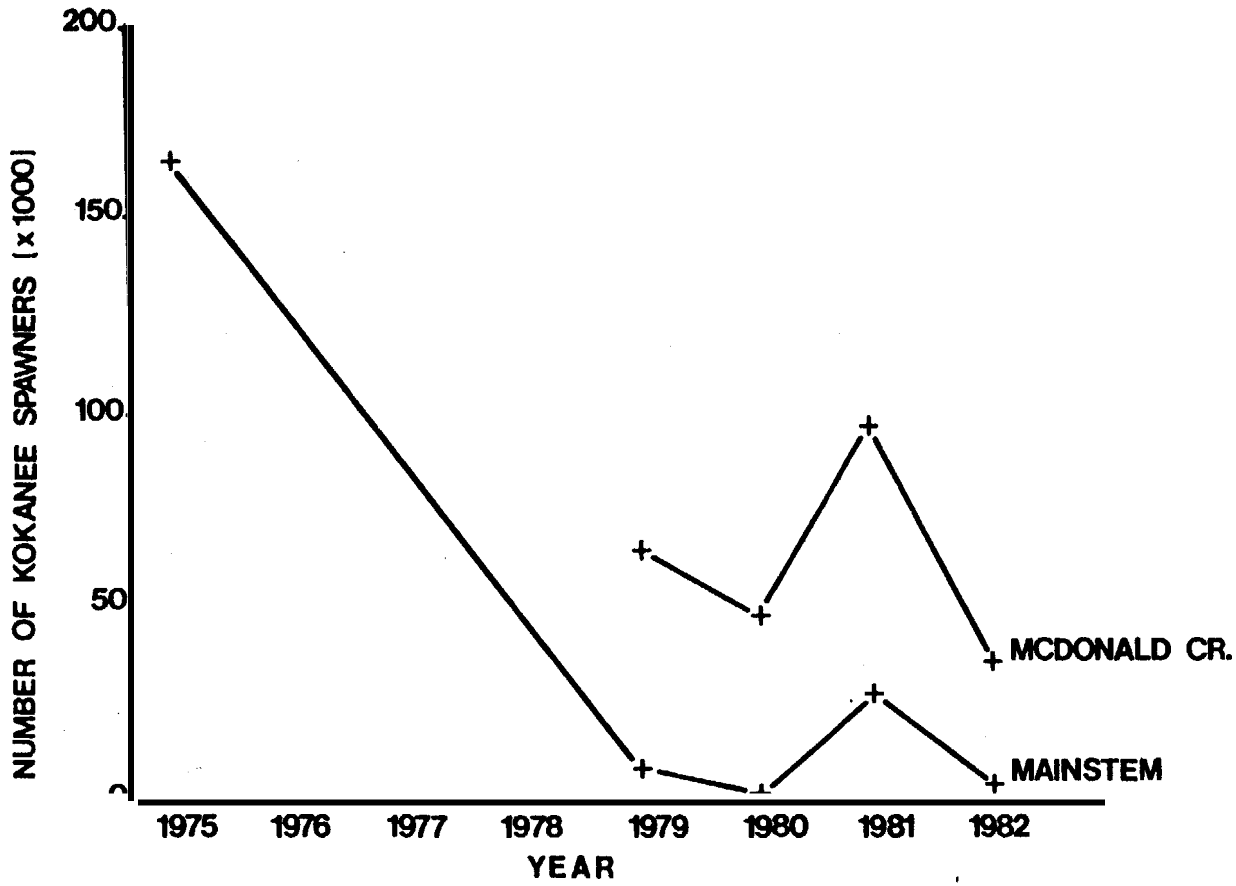

Figure 37. Numbers of kokanee spawners in the McDonald Creek and mainstem spawning runs from 1975-1982.

contributed to the shift of pressure to the early run.

RECOMMENDATIONS FOR THE RECOVERY OF THE MAINSTEM KOKANEE RUN

The goal for the management of the Flathead drainage kokanee fishery is to provide a balanced number of fish approximately 13 inches (330 mm) in length (Graham et al. 1980). Recovery of the run will enhance recruitment to the Flathead Lake fishery and provide a dependable fishery for adult kokanee in the river system.

Management of seasonal and daily flow levels in the Flathead River below the South Fork is critical to recovery of the mainstem Flathead River kokanee run. Similar flow levels during the fall spawning period (15 October to 15 December) and the winter incubation period (15 December to 30 April) will result in favorable conditions for kokanee reproduction with little egg mortality due to dewatering of spawning beds. Recommended flows in the mainstem at Columbia Falls of 3500-4500 cfs during the spawning period and a minimum of 3500 cfs for the incubation period were submitted to the Northwest Power Planning Council in 1981 (Graham et al. 1981, Fraley and Graham 1982). Monitoring the effects of these flows on kokanee reproduction began in 1982 and future studies will include continued monitoring and refinement of the flow recommendations. The recommended flows will reduce dewatering mortality in kokanee spawning beds and should result in the recovery of the mainstem run from the present condition to one similar to the estimated run of 1975. Increased kokanee production in the mainstem would greatly enhance recreational benefit to anglers in both the lake and river system. A strong mainstem run would provide an estimated 100,000+ kokanee to anglers in the river system, representing more than a ten fold increase in harvest over the 1981 and 1982 mainstem fisheries (Fraley and Graham 1982). An additional 100,000 post-harvest spawners would utilize mainstem spawning areas, resulting in an approximate doubling of recruitment to Flathead Lake.

The recovery of the mainstem kokanee run to a minimum fishery level of 50,000 spawners is expected by the late 1980's. By the late 1990's, full recovery of the population is expected, with kokanee numbers comparing favorably to 1975 levels. Management of angler harvest of kokanee as well as river flow management will be critical to the timing of the recovery. Harvest levels in the river system must be kept below 10 percent until the population reaches the minimum fishery level. The harvest could then be linearly increased to 50 percent as the population recovers to the assumed maximum level of approximately 300,000 pre-harvest spawners. These rates would allow a reasonable rate of growth of the mainstem run while supporting a substantial harvest of spawners, providing a balance of recreational and biological benefit. Under these harvest management recommendations, the mainstem kokanee run would increase to about 200,000 pre-harvest spawners by the year 2000. Harvest rates could be adjusted by regulating opening dates, limits and length of the kokanee fishery season in the river system. The snag season in the river system should be closed during the 1983 and 1984 kokanee runs with only a limited lure fishery allowed. Harvest of kokanee in Flathead Lake should also be closely regulated.

A regular planting program involving large numbers of fry or eggs to supplement the recovery of the mainstem kokanee run is not recommended at this time because of the large expense, limited availability of planting stock, and the low expected return from planted fry. A limited program of supplementing specific, high quality spawning areas which are not utilized in a particular year may be implemented if the 1983-84 experimental eyed egg plant appears successful.

Evaluation of the effects of the recommended flows on the kokanee salmon population in the Flathead River will continue through the 1983-84 study period. A monitoring program will be designed, evaluated and implemented by the beginning of the 1984-85 field season.

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APPENDIX A

Kokanee spawning areas and redd counts where redds were observed on the mainstem Flathead River below the South Fork from 1979-1982.

Redd counts and descriptions for other spawning areas in the river system.

Tables l-6, Figures l-5

Table 1. Numbers of kokanee redds counted in late November of 1979, 1980, 1981 and 1982 in areas of the Flathead River below the South Fork. See Appendix E and Fraley and Graham (1982) for locations and descriptions of spawning areas.

Area number	River km	Number of kokanee redds observed			
		1979	1980	1981	1982
1[1/]	37.0	425	136	341	180[4/]
1A	37.0	---	---	---	60
2	41.42	5	0	12	0
3	42.0	7	1	0	
4	42.2	0	25	67	9
5	42.5	0	0	14	0
6[1/]	43.4	60	11	0	0
7	44.3	0	6	30	16
8	45.0	0	0	133	47
9	45.5	0	15	218	0
10	46.7	0	0	517	0
11	47.9	0	0	165	0
12	48.0	0	0	254	0
13	48.3	22	0	0	60
14	48.8	0	0	151[4/]	0
15	49.0	0	0	9	0
16	49.4	119	12	106	0
17	50.0	359	0	118	0
18	50.5	10	0	0	0
19	52.0	0	3	174	0
20	52.2	55	0	604	0
21	52.4	0	13	226	0
22	54.4	100	0	179	17
23	55.3	100	7	31	0
24	55.5	200	1	13	0
25	59.8	290	5	363	0
26	60.2	0	0	3	0
27	60.3	150	0	494	0
28	60.7	0	1	51	0
29[2/]	60.8	250	0	375	0
30	61.0	25	0	94	22
31	61.5	25	0	23	0
32	65.0	0	0	735[4/]	0
32A	65.5	0	0	413	0
33	66.0	0	0	11	0
34[1/]	66.5	20	0	160	67
35	67.6	50	0	146	0
36[1/]	68.5	330	231	0[3/]	0
37	67.7	100	0	495	0
38[1/]	68.5	100	0	288	0
39[2/]	69.5	0	0	1,083	560
40	70.6	0	0	76	0
41	70.9	0	0	92	65
41A	72.0	0	0	0	12
42	73.7	0	0	2	0
TOTAL		2,802	467	7,853	1,528

1/ Spring influenced.
2/ Limited groundwater or spring influence.
3/ Beaver dammed during 1981.
4/ Redds found after late November redd count.

Table 2. Number of kokanee redds in the South Fork of the Flathead River on 29 October, 1981 and 12 November, 1982.

Spawning area description	Area	River km	Number of redds 1981	Number of redds 1982
3-400 m above Hwy 2 Bridge	1	1.5	45	0
200 m below Whelp Creek	2	2.6	90	0
Left bank of Big Bend (Gravel Bar) across from Whelp Creek	3	3.2	140	25
Left bank just downstream from USGS gauge	4	5.5	2	43
Devils elbow	5	6.3	- - 1/	32
TOTAL			227	100

1/ No count for 1981.

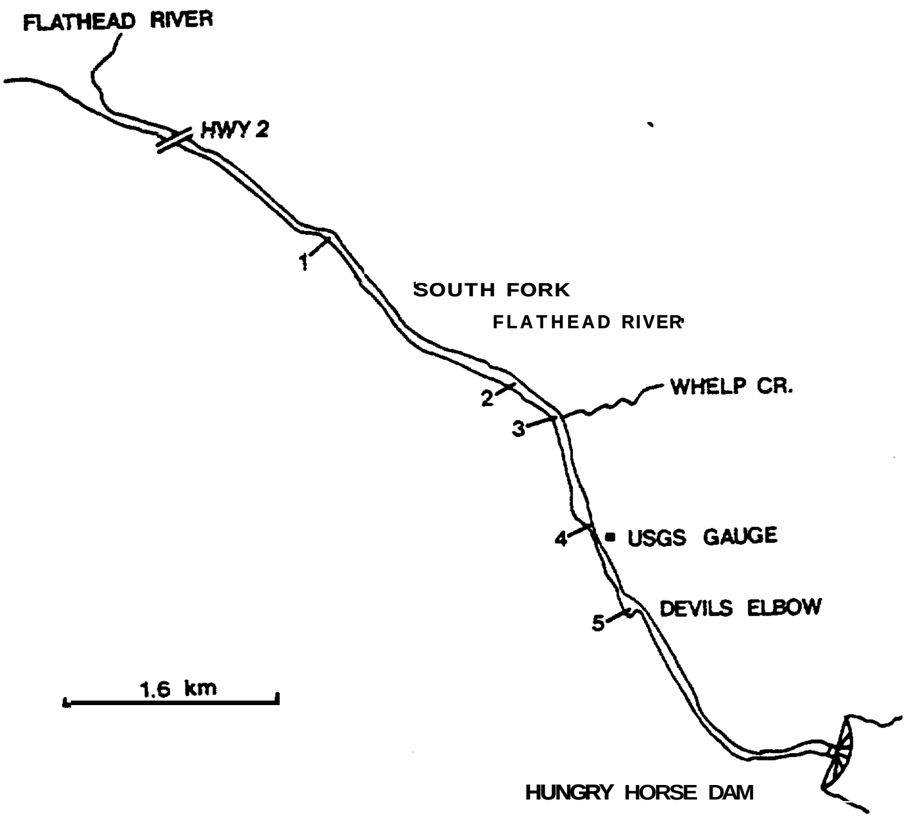


Figure 1. Kokanee spawning area locations on the South Fork of the Flathead River below Hungry Horse Reservoir.

Table 3. Number of kokanee redds counted in the upper Middle Fork of the Flathead River on 20 and 22 October, 1981 and 25 October, 1982.

Spawning area description	Area	River km	Number of redds 1981	Number of redds 1982
Run above golf course	13	8.6	25	0
Run below new W. Glacier bridge	14	9.1	35	0
New W. Glacier bridge	15	9.6	51	0
Run below Old W. Glacier bridge	16	10.7	307	0
First run below canoe dump rapids	17	12.0	360	0
Last tunnel	I8	12.8	95	0
Second hole below Lincoln Cr.	19	16.0	10	0
	19A	0	0	9
Between Deerlick and Harrison Cr.	20	21.9	7	0
Mouth Deerlick Creek	21	22.4	66	44
		TOTAL	956	53

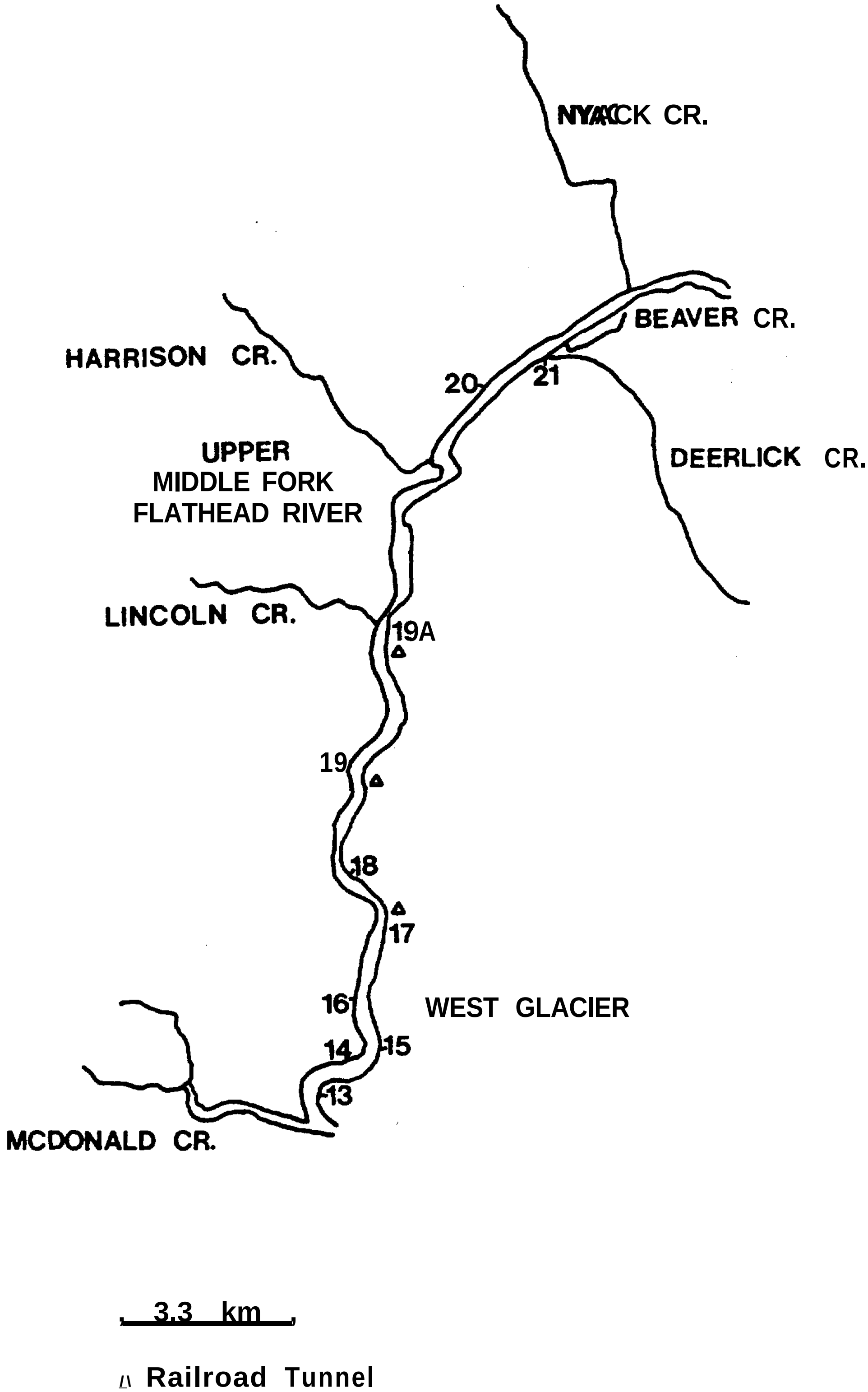


Figure 2. Kokanee spawning area locations on the Middle Fork of the Flathead River above McDonald Creek.

Table 4. Number of kokanee redds counted lo the lower Middle Fork of the Flathead River on 20 and 22 October, 1981 and 26 October, 1982.

Spawning area description	Area	River km	Number of redds 1981	Number of redds 1982
First run and pool of canyon	1	2.2	140	244
Second run/pool	2	2.6	230	122
Third run	3	2.9	246	0
Fourth run	4	3.2	170	40
Fifth run	5	3.5	62	0
First hole in canyon	6	3.8	62	46
Sixth run	7	4.5	23	0
Second hole of canyon	8	4.8	250	0
Third hole of canyon	9	5.1	14	57
Role at tall of USGS cable	10	5.9	40	4
Below first house on hill	11	6.9	119	60
Below McDonald Creek	12	7.4	4	125
TOTAL			1,360	698

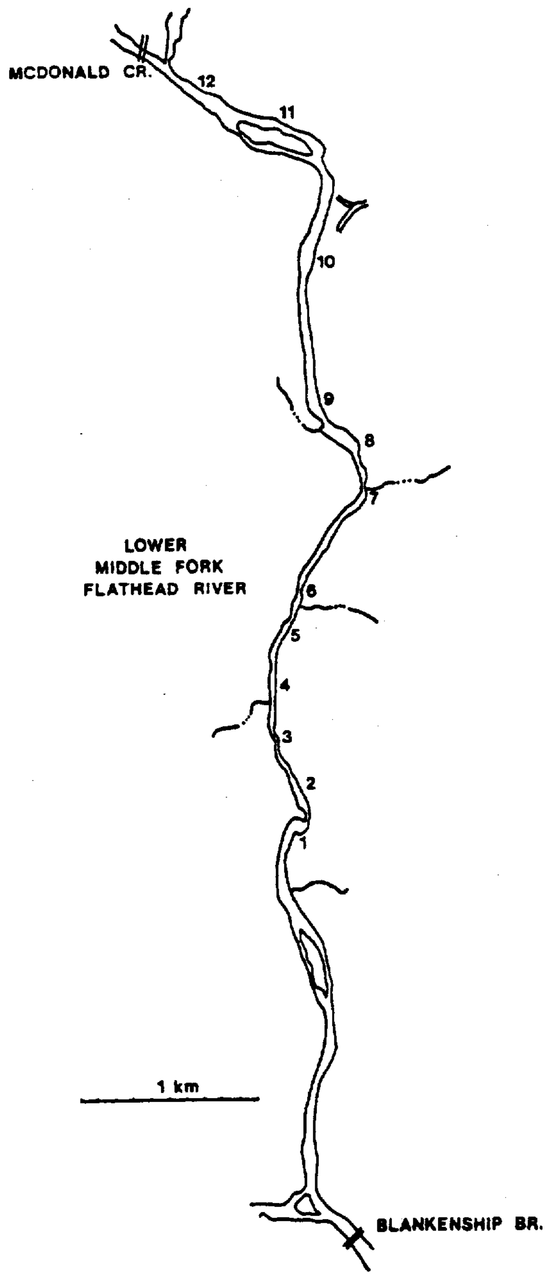


Figure 3. Kokanee spawning area locations on the lower Middle Fork of the Flathead River.

Table 5. Number of redds counted in Beaver and Deerllck creeks on 4 December. 1981 and 8 December, 1982.

Spawning area description	Area	Creek km	Number of redds 1981	1982
Deerlick Creek				
Mouth of Deerlick Creek to Moccasin Creek river access	1	0-.5	48	9
Hwy 2 bridge to Dalimata Bridge	2	1.0-1.5	11	1
Gas line crossing to Hwy. Dept. shed	3	2.0-3.0	143	14
Beaver Creek				
Run below ford crossing to beginning of creek (Including side channel by ford)	1	3.0-4.0	516	18
TOTAL			718	42

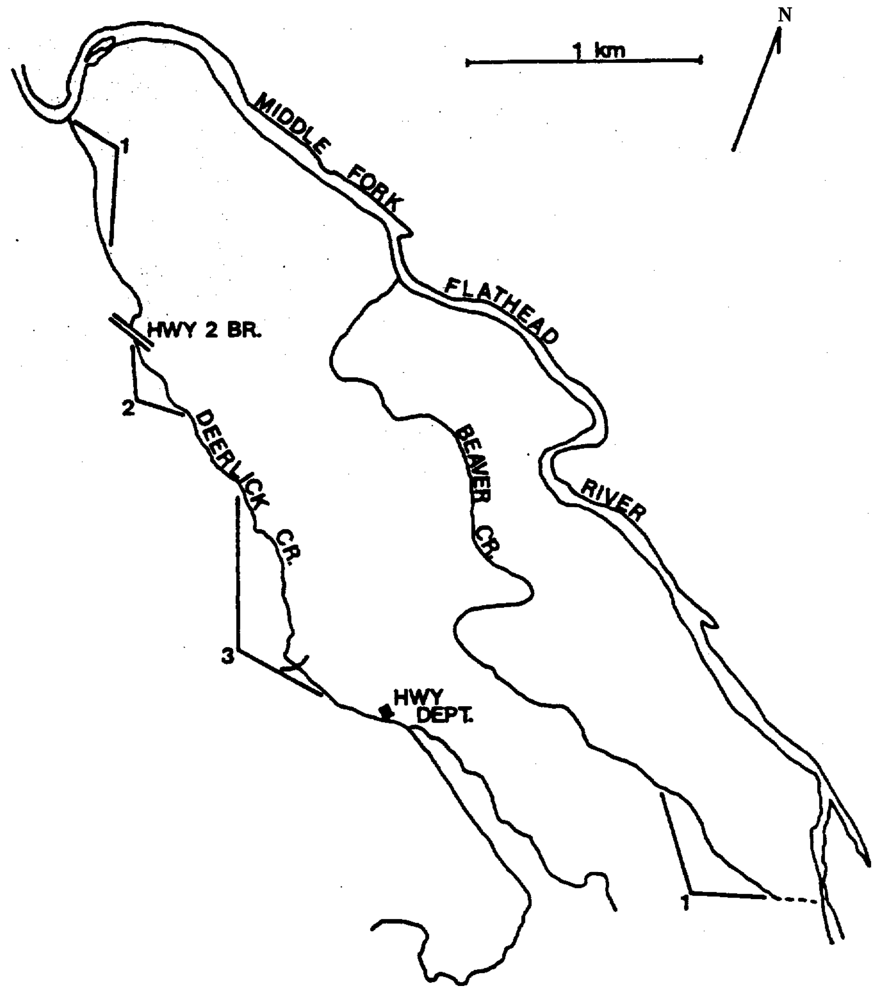


Figure 4. Spawning area locations on Beaver and Deerlick creeks.

Table 6. Number of kokanee redds counted in the Whitefish River on 19 October, 1981 and 22 October. 1982.

Spawning area description	Area	River km	Number of redds 1981	Number of redds 1982
Rose Crossing to Birch Grove Bridge	1	6.0-9.5	265	289
Birch Grove Bridge to Tetrault Bridge	2	9.5-13.0	48	421
Tetrault Bridge to Hodgson Crossing	3	13.0-15.0	41	127
Above Hodgson Crossing	4	15.0-15.5	59	36
TOTAL			413	873

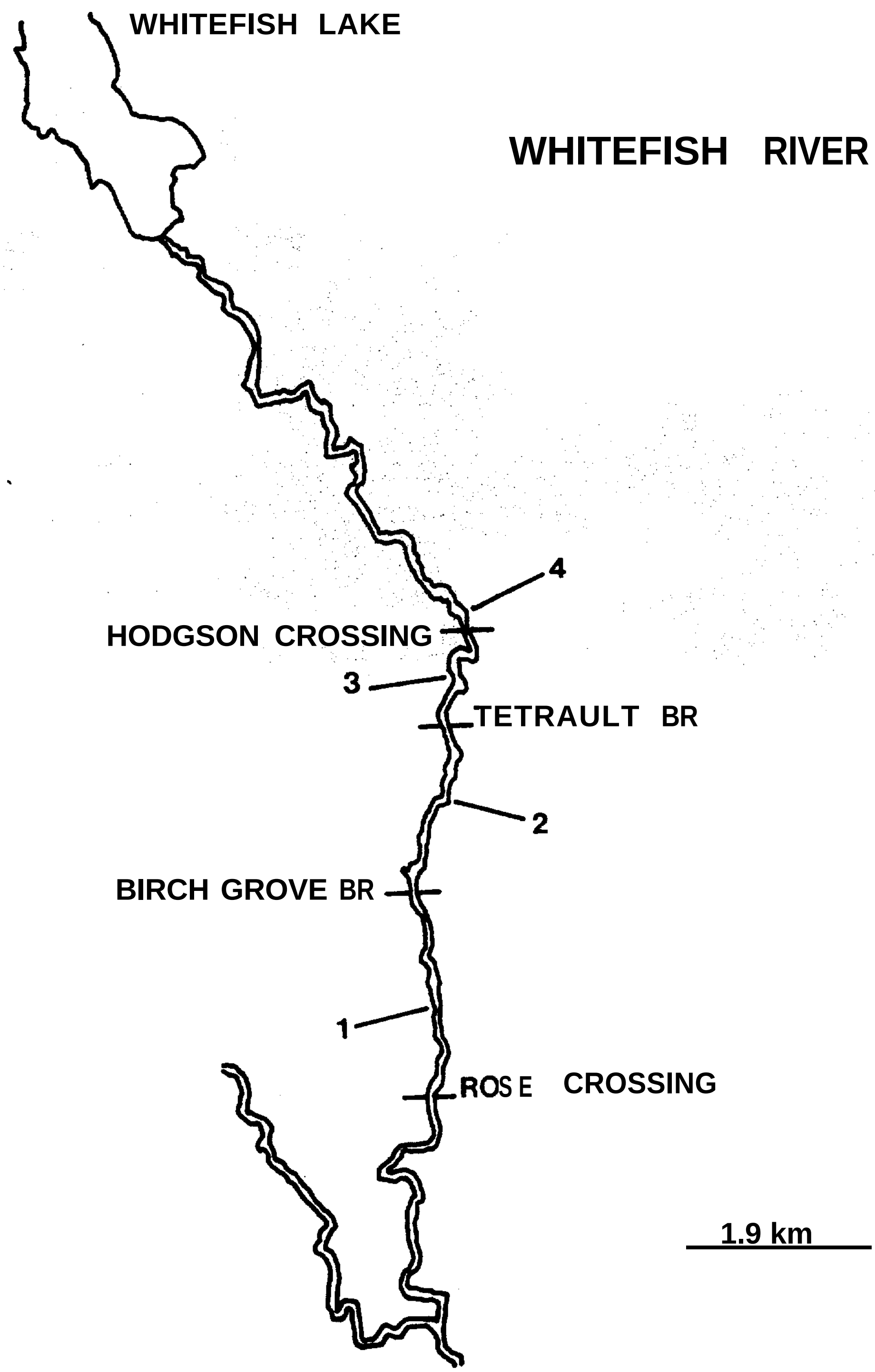


Figure 5. Kokanee spawning area locations on the Whitefish River.

APPENDIX B

Characteristics of the fall kokanee fishery
in the Flathead River system.

Table 1-18

Table 1. Mean number of hours per completed angler trip by time period on Sections MSl-MS4 on the mainstem Flathead River and Section MF1 on the Middle Fork of the Flathead River, 28 August to 15 October, 1982.

	Mean hours/completed angler trip					
	Mainstem					Middle Fork
Time period	MS1	MS2	MS3	MS4	Total	MFl
8/28 - 9/14						
shore	5.3	2.1	4.5	0.33	4.0	—
boat	2.0	3.4	5.5	- -	3.2	—
combined	3.1	3.0	5.0	0.33	3.3	---
9/15 - 9/30						
shore	- -	3.3	4.7	2.9	3.4	3.4
boat	3.5	4.1	7.1	2.5	4.3	3.3
combined	3.5	3.5	5.6	2.8	3.9	3.4
10/l - 10/15						
shore	- -	2.2	- -	1.2	1.9	2.9
boat	3.5	3.0	---	4.0	3.5	4.0
combined	3.5	2.4	---	3.0	3.0	3.1
TOTAL						
shore	3.7	2.9	4.5	2.4	3.0	3.3
boat	3.1	3.4	6.4	3.0	3.5	3.5
combined	3.3	3.1	5.2	2.6	3.3	3.3

Table 2. Number of parties using each terminal tackle type on Sections MSl-MS4 on the Flathead River, 28 August through 15 October, 1982.

	River section				
	MS1	MS2	MS3	MS4	Total(X)
Bait	8	10	2	0	20(6)
Fly	1	3	0	1	5(2)
Lure	16	23	3	1	43(14)
Snag hook	13	85	16	51	165(53)
Combination	57	21	1	1	80(25)
TOTAL	95	142	22	55	314(100)

Table 3. Number of angler parties using each terminal tackle type before and after 15 September on Sections MSl-MS4 on the Flathead River. Percentages are in parentheses.

	Number of parties using each tackle type		
	Before 9/15	After 9/15	Total
Bait	12(9)	8(4)	20(6)
Fly	2(2)	3(2)	5(2)
Lure	41(33)	2(l)	43(14)
Snag hook	0(0)	165(87)	165(53)
Combination	69(56)	11(6)	80(25)
TOTAL	124(39)	189(61)	314(100)

Table 4. Total number of angler party interviews and completed trip party interviews on Sections MSI-MS4 of the Flathead River from 28 August to 15 October, 1982.

	River section				
	MS1	MS2	MS3	MS4	Total
Number of Interviews					
Shore	25	105	17	50	196
Boat	81	40	5	5	128
Total	106	145	22	55	324
Number of hours	514	695	204	225	1638
Number of Completed Trips					
Shore	2	27	4	14	47
Boat	50	33	3	4	90
Total	52	60	7	18	137
Number of hours	363	343	72	a7	865
Percent Completed Trips	50	43	32	32	42
Percent Hours	71	49	32	39	52

Table 5. Angler residence from party interviews conducted on Sections MSl-MS4 of the mainstem Flathead River from 28 August through 15 October, 1982.

Angler residence	Number of parties	Percent of parties
Kalispell	194	60
Other Flathead County	76	23
Lake County	3	1
Missoula County	4	1
Other Western Montana	3	1
Eastern Montana	10	3
USA Non-resident	21	7
Foreign (Canada)	13	4

Table 6. Catch rates (number of kokanee per hour) for all anglers interviewed on the mainstem Flathead River from 28 August - 15 October, 1982. The number of kokanee creeled is in parentheses.

Date	Catch rate (no. kokanee/hour)				
	MS1	MS2	MS3	MS4	Total
8/28-9/14	0.12 (63)	0.16 (82)	0	1 (8)	0.15 (153)
9/14-9/30	0.45 (50)	1.00 (325)	0.28 (47)	0.69 (130)	0.70 (552)
10/1-10/15	0	0.25 (17)	—	.ll (8)	.18 (25)
TOTAL	0.22 (113)	0.61 (424)	0.23 (47)	0.65 (146)	0.45 (730)

1/ Illegal snagging of kokanee with lures.

Table 7.. Catch rates per number of kokanee creeled and number of interview hours by time period on Section MF1 of the Middle Fork of the Flathead River from 15 September - 15 October, 1982.

Time period	Number of kokanee	Number of hours	Catch rate
9/15 - 9/30	1,920	1,794	1.07
10/l - 10/15	1,145	1,363	0.84
TOTAL	3,065	3,157	0.97

Table 8. Total number of angler party interviews and number of completed trip angler party interviews on Section MFl of the Middle Fork of the Flathead River from 28 August to 15 October, 1982.

	Shore	Boat	Combined
Number of interviews	411	25	436
Number of hours	3,107	184	3,296
Number of completed trip interviews	115	16	131
Number of hours	907	126	1,033
Percent completed trips	28	64	30
Percent hours	29	66	31

Table 9. Interview data by angler residence on Section MFl of the Middle Fork of the Flathead River from 15 September - 15 October, 1982.

Angler resident	Number of interviews(percent)	Number anglers	Anglers/ party	Number hours fished per completed trip	Catch rate
Flathead County	156(36)	368	2.36	2.7	1.28
Other Montana	167(38)	358	2.15	3.8	0.92
Nonresident U.S.	48(11)	102	2.13	3.9	0.77
Canadian	65(15)	206	3.17	4.0	0.71
TOTAL	436(100)	1034	2.37	3.31	0.93

Table 10. Total estimated fishing pressure (hours) by time period on Sections MSl-MS4 of the Flathead River. The 95% confidence limits are in parentheses.

Time period	Days	Total daylight hours	Estimated fishing pressure (hours) by section				
			Mainstem Flathead River				
			MS1	MS2	MS3	MS4	Total
8/28 - 9/14	18	243	2,504 (2920)	1,819 (±865)	614 (±314)	435 (±305)	5,372 (±2041)
9/15 - 9/30	16	195	3,786 (±1497)	5,498 (±2161)	3,599 (±1823)	5,014 (±1877)	17,897 (±3579)
10/l - 10/15	15	168	701 (±331)	924 (±431)	147 (±119)	588 (±272)	2,360 (±890)
Total Pressure	45	552	6,992 (±1703)	8,241 (±2254)	4,360 (±1765)	6,037 (±1829)	25,630 (±3801)
Percent Pressure			27%	32%	17%	24%	100%
Pressure (hours) per km			194	434	411	259	288

Table 11. Estimated shore fishing pressure by time period on Sections MSl-MS4 of the Flathead River, The 95% confidence limits are in parentheses.

Time period	Days	Total daylight hours	Estimated shore fishing pressure by section Mainstem Flathead River MS1	MS2	MS3	MS4	Total
9/l - 9/14	18	243	293 (±244)	586	331 (±216)	435 (±305)	1,400
9/15 - 9/30	16	195	464 (±249)	4,124 (±1814)	2,233 (±1004)	3,745 (±1815)	10,566
10/l - 10/15	15	168	63 (±71)	714 (±284)	147 (±119)	210 (±118)	1,134
TOTAL	45	552	820 (±356)	5,423 (±1857)	2,710 (±1034)	4,390 (±1844)	13,343 (±2701)

Table 12. **Estimated boat fishing pressure by time period on Sections MS1-MS4 of the Flathead River. The 95% confidence limits are in parentheses.**

Time period	Days	Total daylight hours	Estimated boat fishing pressure by section: Mainstem Flathead River MS1	MS2	MS3	MS4	Total
8/28 - 9/14	18	243	2,211 (± 887)	1,233 (± 818)	284 (± 228)	0	3,728
9/15 - 9/30	16	195	3,323 (±1,476)	1,375 (±1,175)	1,366 (±1,521)	1,269 (±480)	7,333
10/1 - 10/15	15	168	638 (± 323)	210 (± 310)	0	378 (±235)	1,226
TOTAL	45	552	6,173 (±1,753)	2,817 (±1,398)	1,650 (±1,464)	1,647 (±706)	12,287 (±2,673)

Table 13. Total estimated fisherman pressure in hours exerted by kokanee snaggers from shore and in boats on the lower Middle Fork of the Flathead River from 28 August to 15 October, 1982.

Time period	Days	Total daylight hours	Estimated fishing pressure (hours)1/ Shore	Boat	Total
8/28 - 9/14	18	243	170 (±118)	0	170 (±118)
9/14 - 9/30	16	195	10,687 (±1,692)	1,342 (±680)	12,029 (±1,823)
10/l - 10/15	15	168	4,161 (±1,026)	660 (±309)	4,820 (±1,071)
TOTAL	45	552	15,018 (±1,982)	2,002 (±747)	17,019 (±2,118)

1/ 95% confidence intervals in parentheses.

Table 14. Estimated monthly kokanee harvest by all anglers on the four sections of the mainstem Flathead River during 1982. The 95% confidence limits are in parentheses.

Time period	Estimated numbers of kokanee harvested MS1	MS2	MS3	MS4	Total
8/28 - 9/14	344	322	0	476	1,142
9/15 - 9/30	1,147	5,773	868	3,021	10,809
10/l - 10/15	0	198	0	253	450
TOTAL	1,491 (±870)	6,293 (±3,188)	868 (±573)	3,750 (±1,844)	12,402 (±4,072)

Table 15. Estimated monthly kokanee harvest by shore anglers only on the four sections of the mainstem Flathead River during 1982. The 95% confidence limits are in parentheses.

Time period	Estimated numbers of kokanee harvested				
	MS1	MS2	MS3	MS4	Total
8/20 - 9/14	22	0	0	476	496
9/15 - 9/30	490	3,915	769	2,767	7,945
10/l - 10/15	0	198	0	0	198
TOTAL	512	4,113	769	3,244	8,639 (_+3,049)

Table 16. Estimated monthly kokanee harvest by boat anglers only on the four sections of the mainstem Flathead River during 1982. The 95% confidence limits are in parentheses.

Time period	Estimated numbers of kokanee harvested				
	MS1	MS2	MS3	MS4	Total
8/28 - 9/14	321	322	0	0	643
9/15 - 9/30	657	1,858	99	254	2,868
10/l - 10/15	0	0	0	252	252
TOTAL	979	2,180	99	506	3,763 (±2,812)

Table 17. Estimated kokanee harvest by shore and boat snag fishermen on the lower Middle Fork of the Flathead River during 1982. The 95% confidence limits are in parentheses for totals.

Time period	Estimated numbers of kokanee harvested		
	Shore	Boat	Total
9/15 - 9/30	10,512	3,542	14,055 (±3,392)
10/l - 10/15	3,392	601	3,992 (±1.089)
TOTAL	13,904 (±2,592)	4,143 (±2,515)	18,047 (±3,557)

Table 18. Catch rates (number of kokanee per hour) for shore and boat fishermen on Sections MSl-MS4 on the mainstem Flathead River and Section MFl on the Middle Fork of the Flathead from 28 August to 15 October, 1982.

	Catch rates (kokanee/hour)											
	Mainstem Flathead River										Middle Fork	
	MS1		MS2		MS3		MS4		All sections		MFl	
Date	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat	Shore	Boat
8/28-9/14	0.08	0.14	0	0.27	--	--	1.10	--	--	--	--	--
9/15-9/30	1.06	1.46	0.95	1.46	0.29	0.07	0.74	0.16	--		.98	2.64
10/l-10/15	0	0	0.28	0	--	--	0	0.67	--	--	.82	0.91
TOTAL	0.48	0.14	0.66	0.48	0.29	0.06	0.69	0.27	0.62	0.24	.89	1.60

Montana Waters Referred to:

Flathead Lake	l-07-6400-03
Flathead River	l-07-1560-01
South Fork	l-08-5100-01
North Fork	l-08-6660-01
Middle Fork	l-08-4740-01
McDonald Creek	l-08-4630-01
Deerlick Creek	l-08-2080-01
Beaver Creek	l-08-0580-10
Whitefish River	l-07-4980-01

MAPS OF GRAVEL AREAS SUITABLE FOR KOKANEE SPAWNING IN THE FLATHEAD RIVER FROM THE MOUTH OF THE SOUTH FORK TO THE MOUTH OF THE STILLWATER RIVER

Supplement to
Annual Progress Report FY 1983
Effects of the Operation of Hungry Horse Dam on the
Kokanee Fishery in the Flathead River System

Compiled By

John Fraley - Project Biologist
Mark Gaub - Field Person
John Cavigli - Field Person
Steve McMullin - Project Coordinator

Fisheries Research and Special Projects Bureau
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
Kalispell, Montana 59901

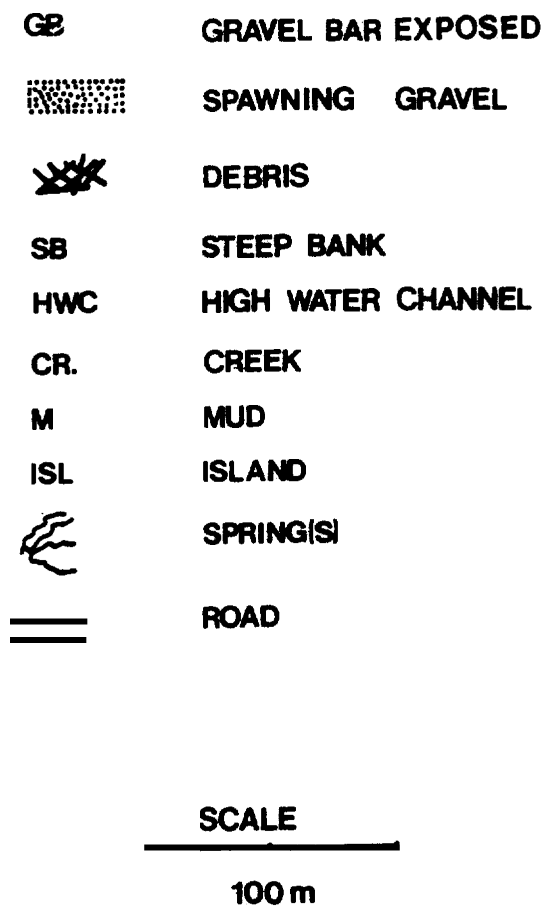
Sponsored By

Bonneville Power Administration
Agreement No. DE-AI79-83BP39641
Project No. 81S-5
Effect of Operation of Kerr and Hungry Horse Dam
on reproductive success of kokanee in the
Flathead System.

November 1983

The channels of the Flathead River from the mouth of the South Fork to the mouth of the Stillwater River (37 km) were traced from aerial photographs (1:2300) provided by USDI, Bureau of Reclamation. The aerial photos were taken on flights made in October, 1978. Wetted substrate of the mainstem was surveyed from a jet boat or by wading and classified as suitable or unsuitable for kokanee spawning based on composition, compaction and water velocity criteria The criteria used were based on observations in kokanee spawning areas in the Flathead River System from 1979-1982. Gravel areas with water velocities greater than three feet per second, high compaction or large amounts of very fine (<6 mm diameter) or very coarse (>lOO mm) material were classified unsuitable. The areas of suitable and unsuitable substrate were drawn in on the aerial photos using landmarks or survey equipment.

The gravel area survey was conducted from 27 July through September at flows of 3500-4000 cfs. If flows were not in this range, an allowance was made to correct all measurements to the wetted area at these flows. A few areas were mapped during the late winter and spring of 1983. A total of 20 percent (648,465 m^2) of the wetted area of the river at 4000 cfs was classified suitable for kokanee spawning.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DEBRIS
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HWC
HIGH WATER CHANNEL
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MUD
ISL
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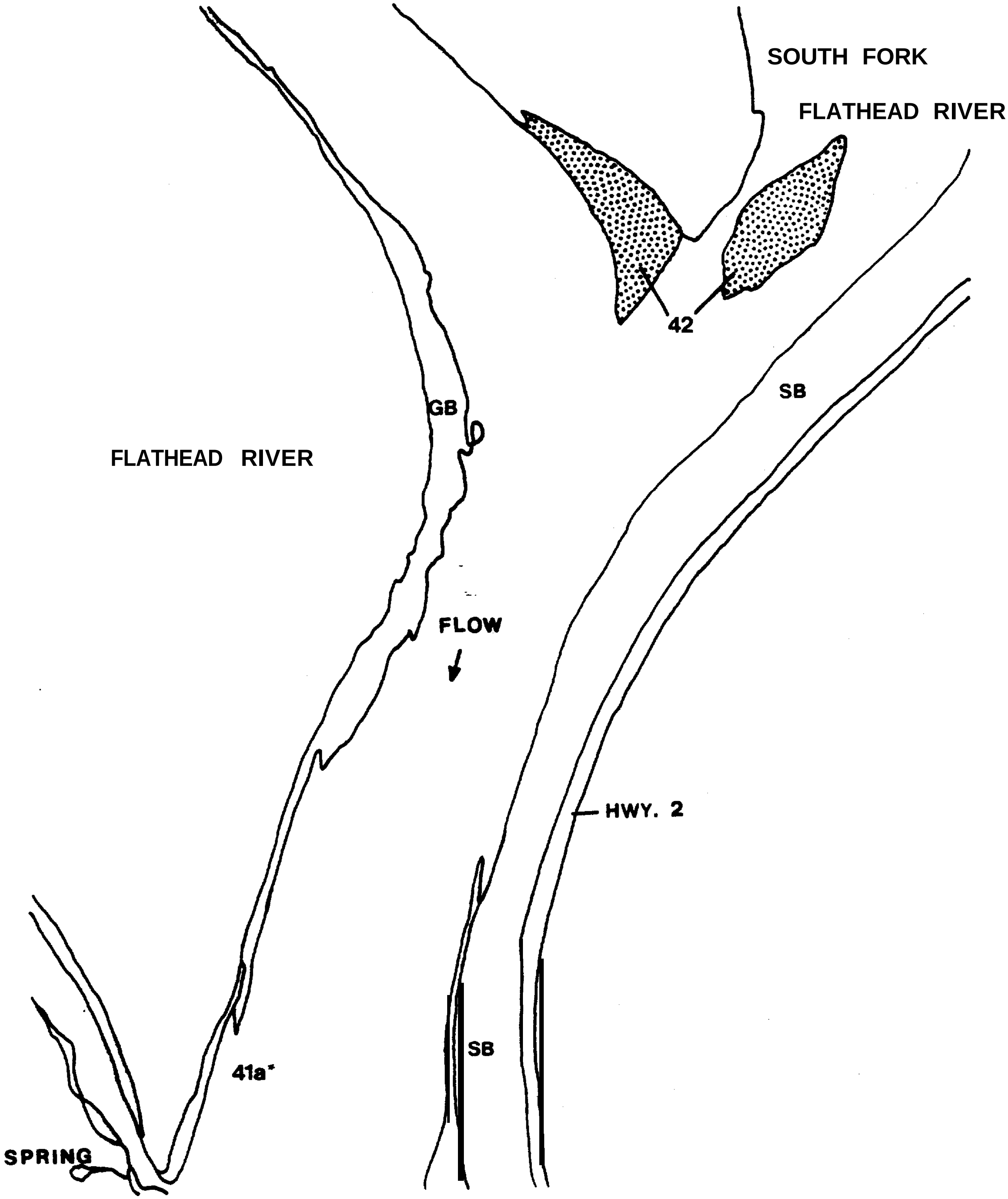
ROAD
SCALE
100 m

Key to maps.

River Section MS-4

(Columbia Falls to Mouth of South Fork)

pages 4-17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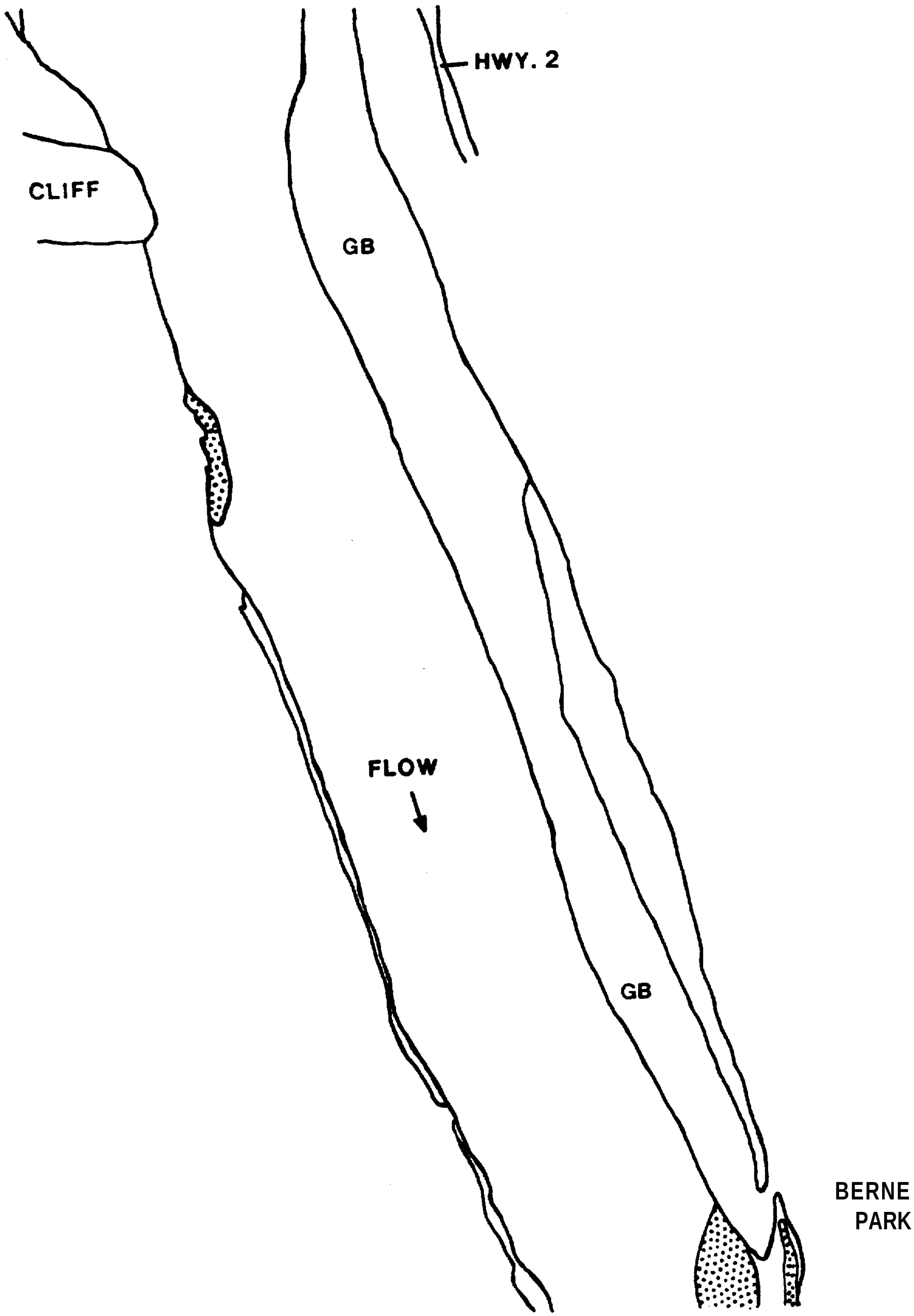
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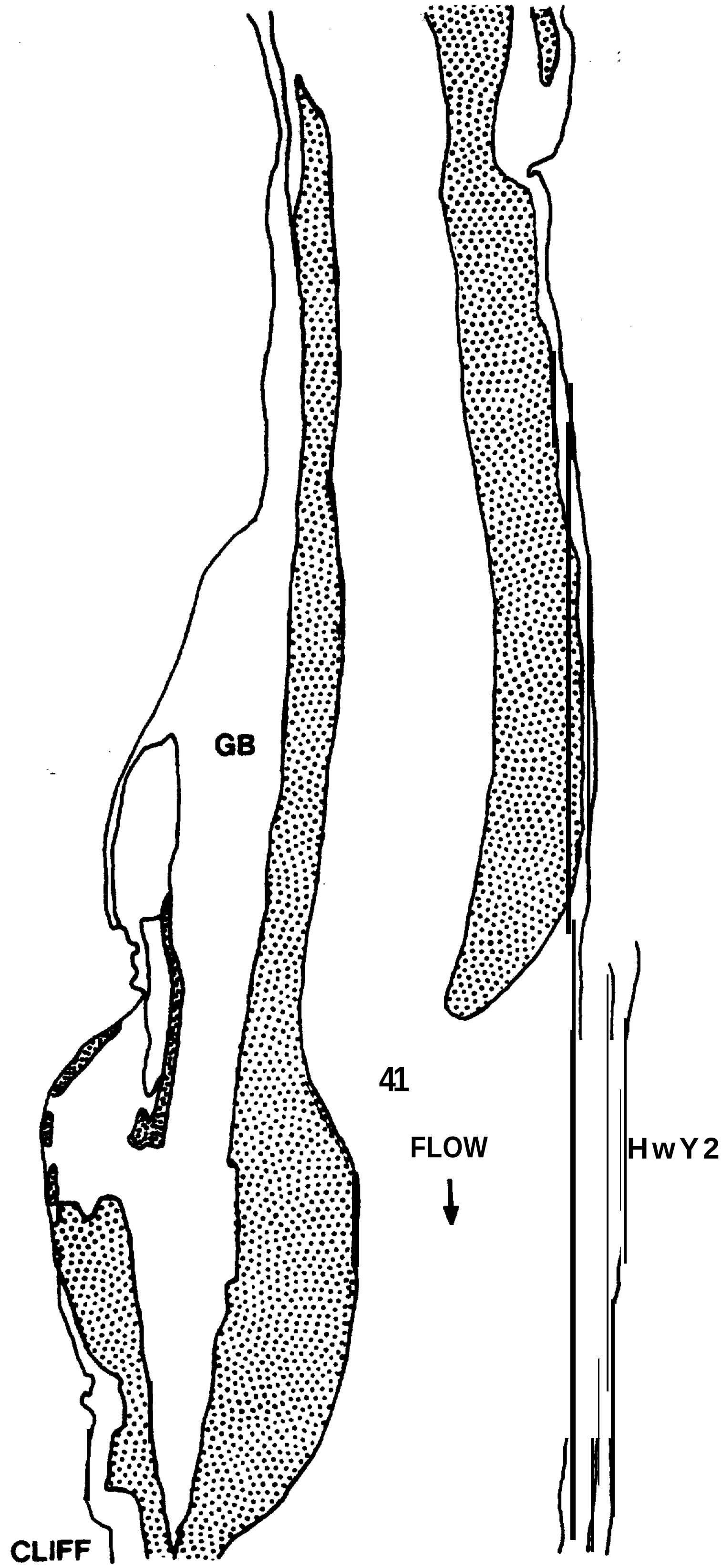
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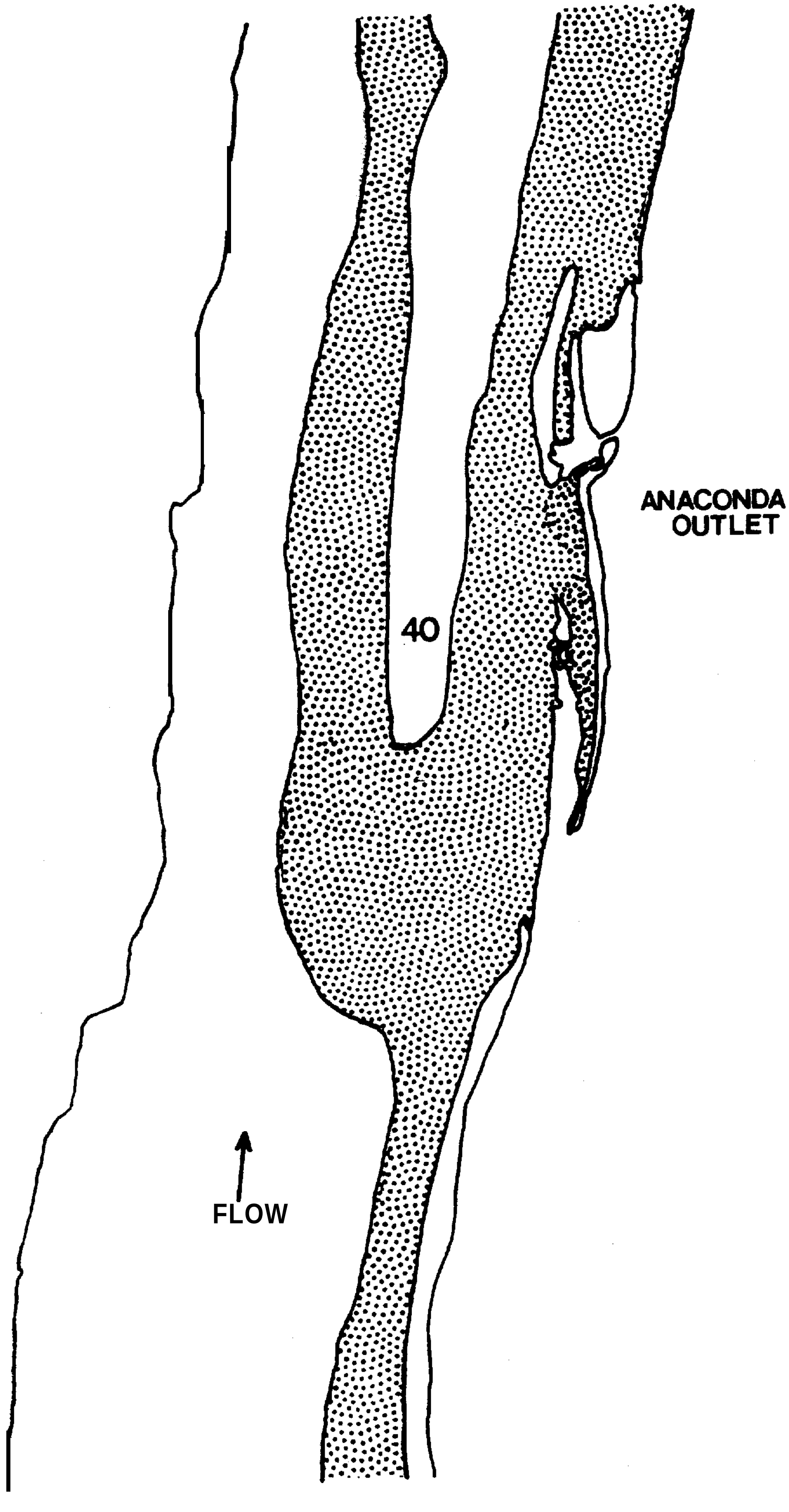
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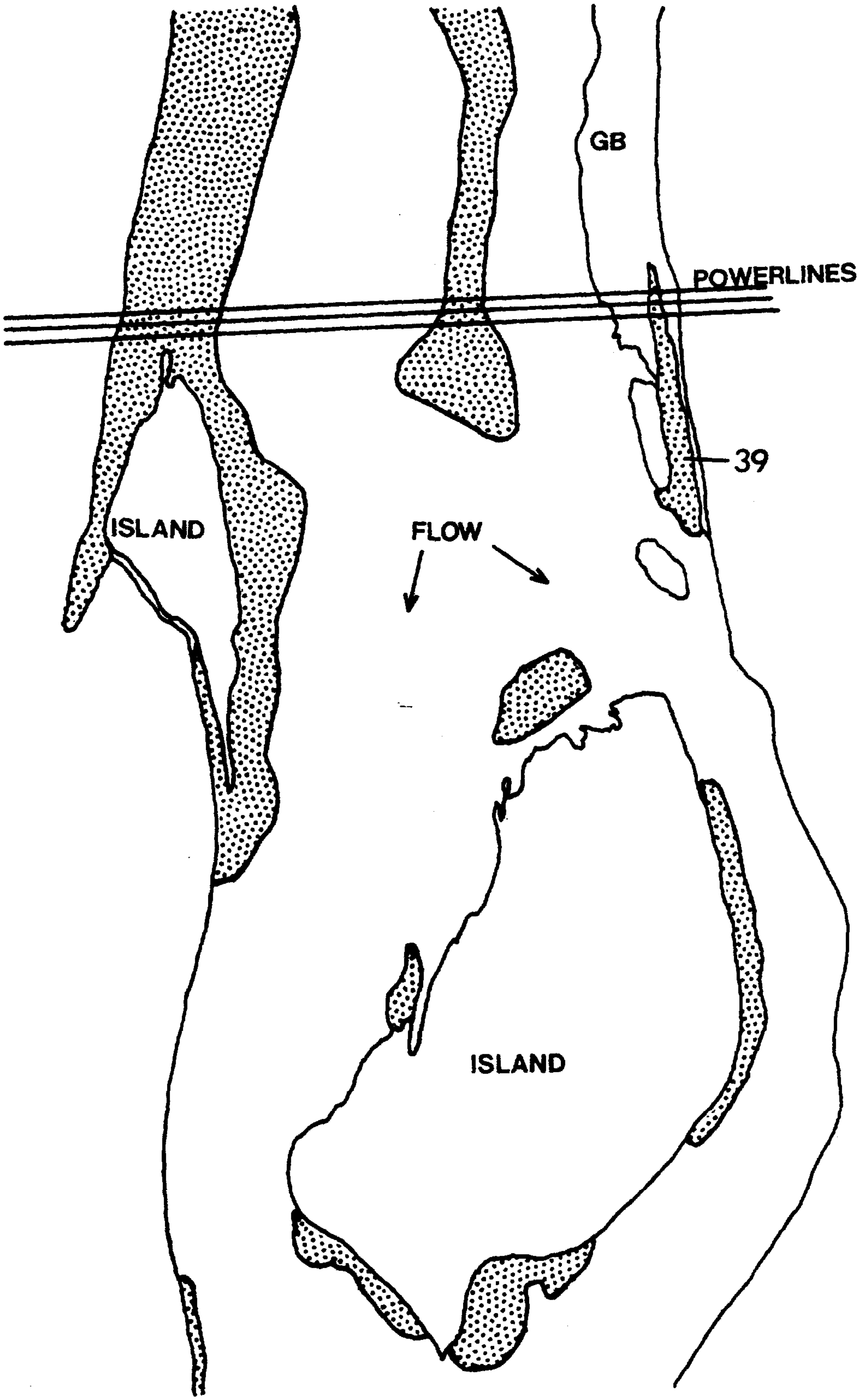

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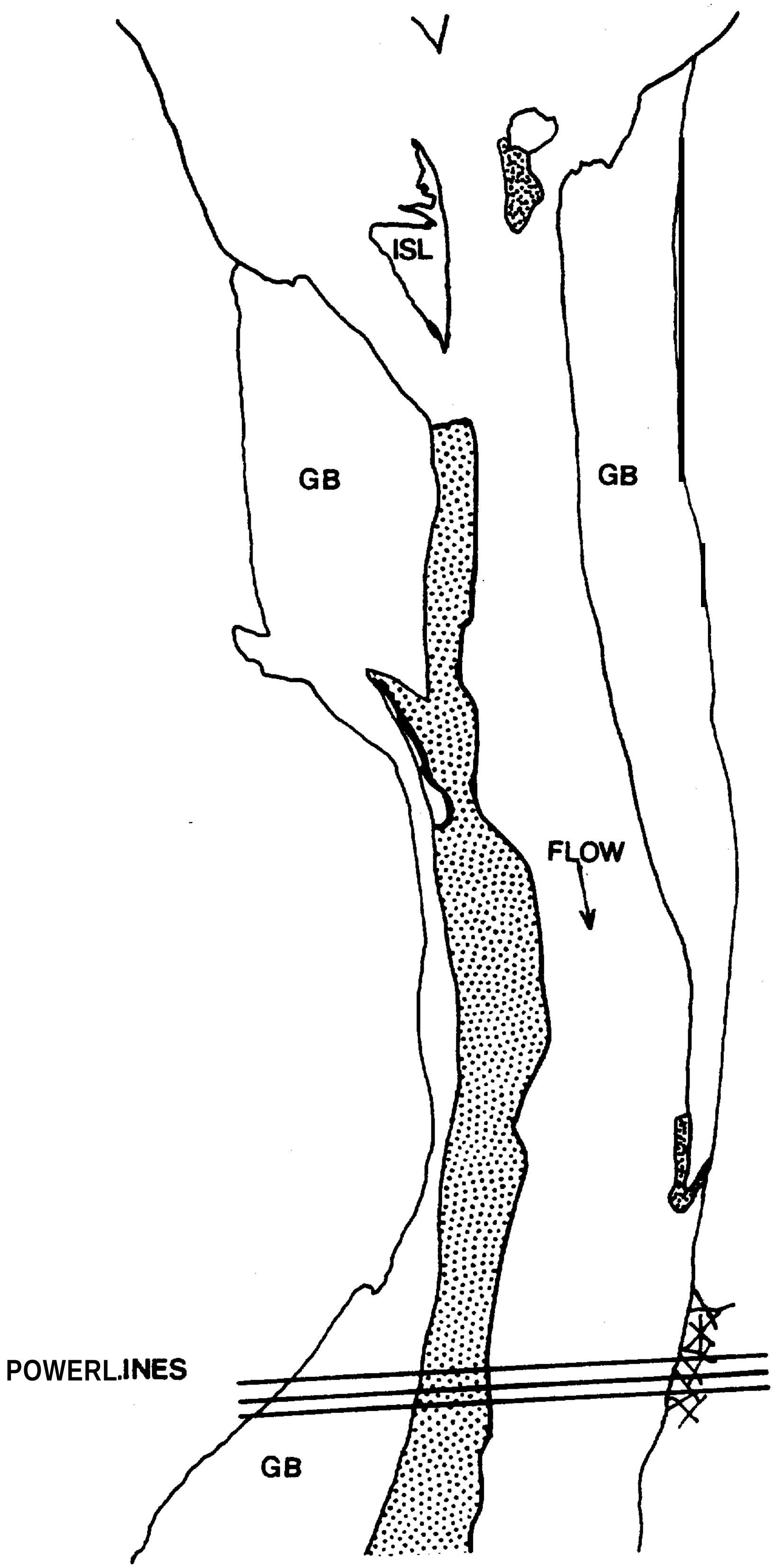
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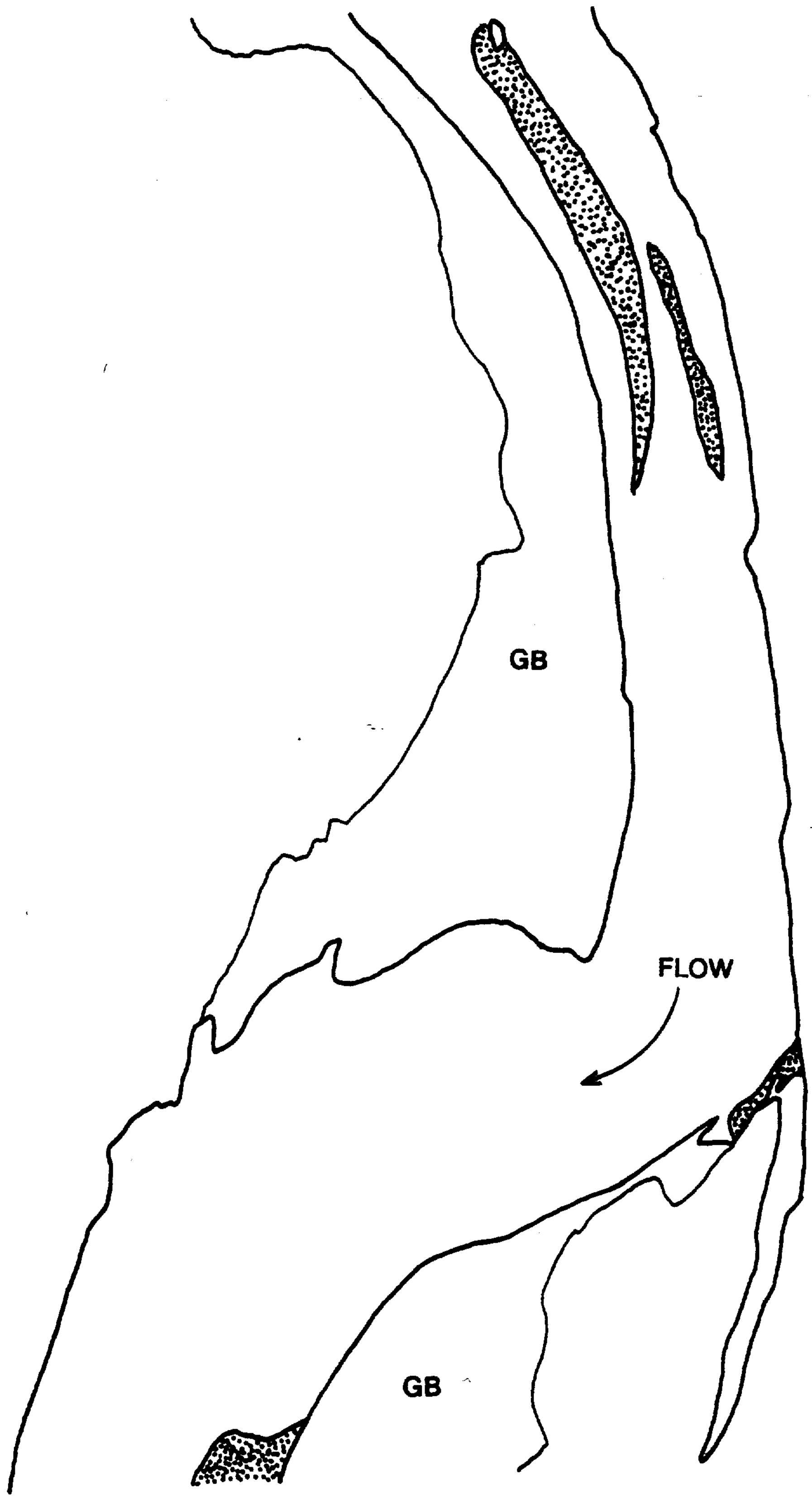
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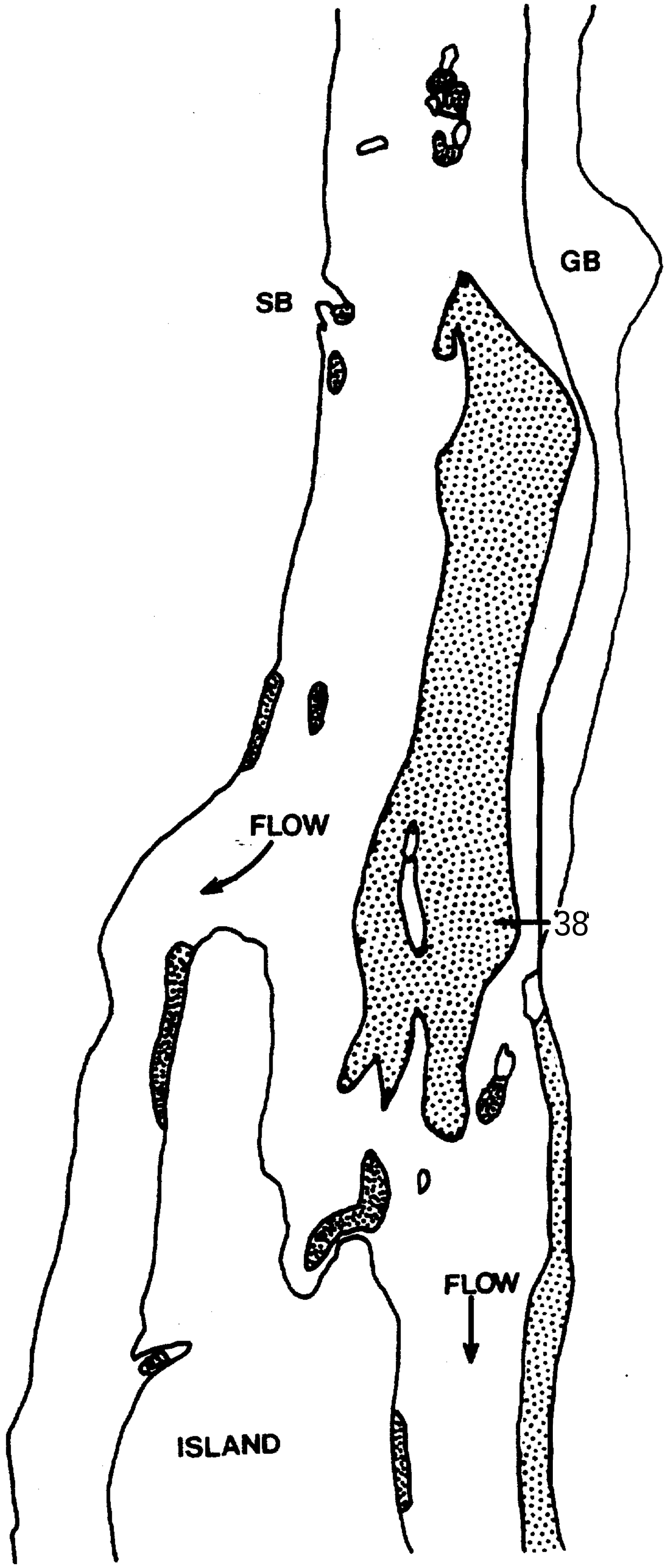
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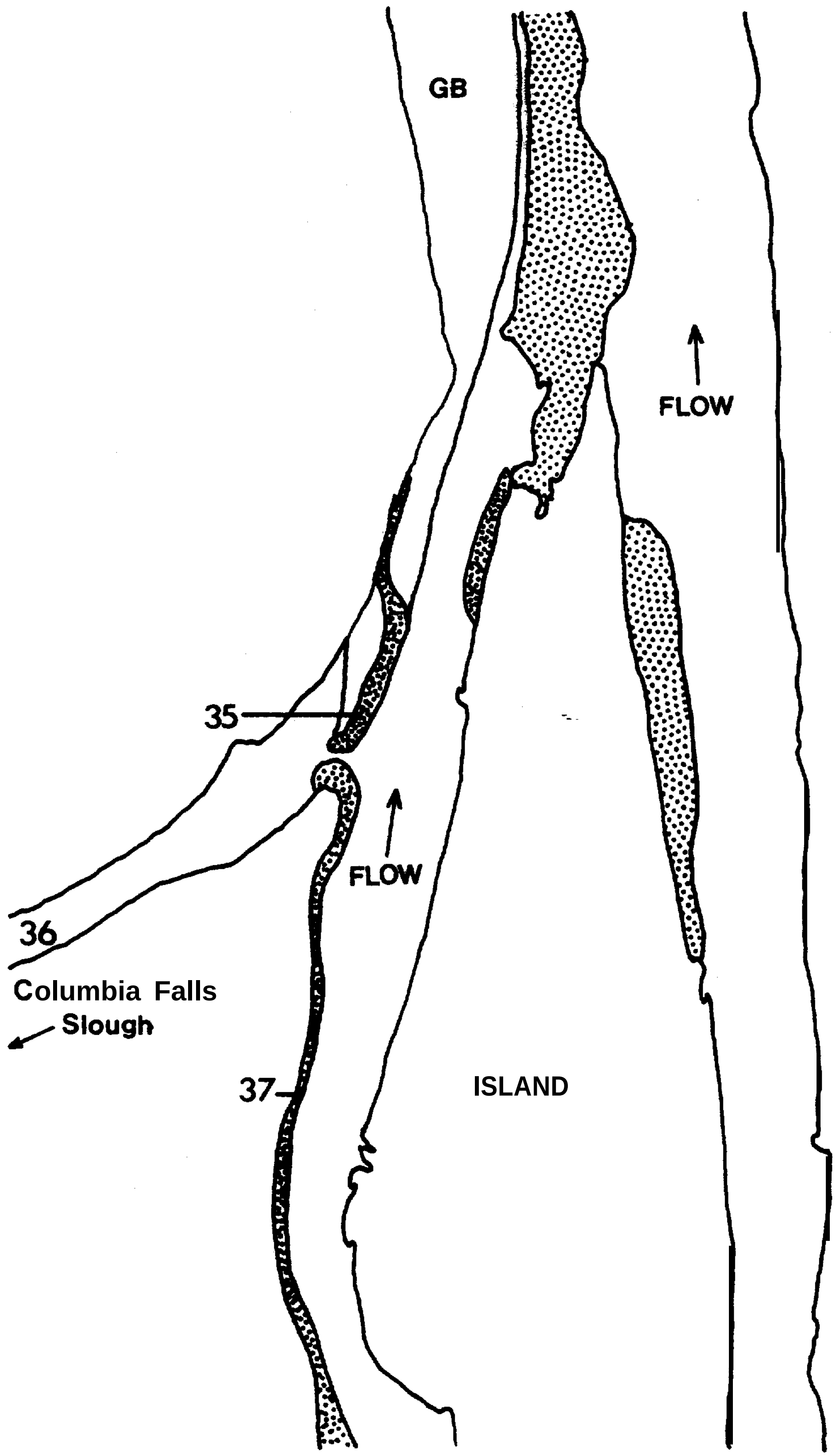
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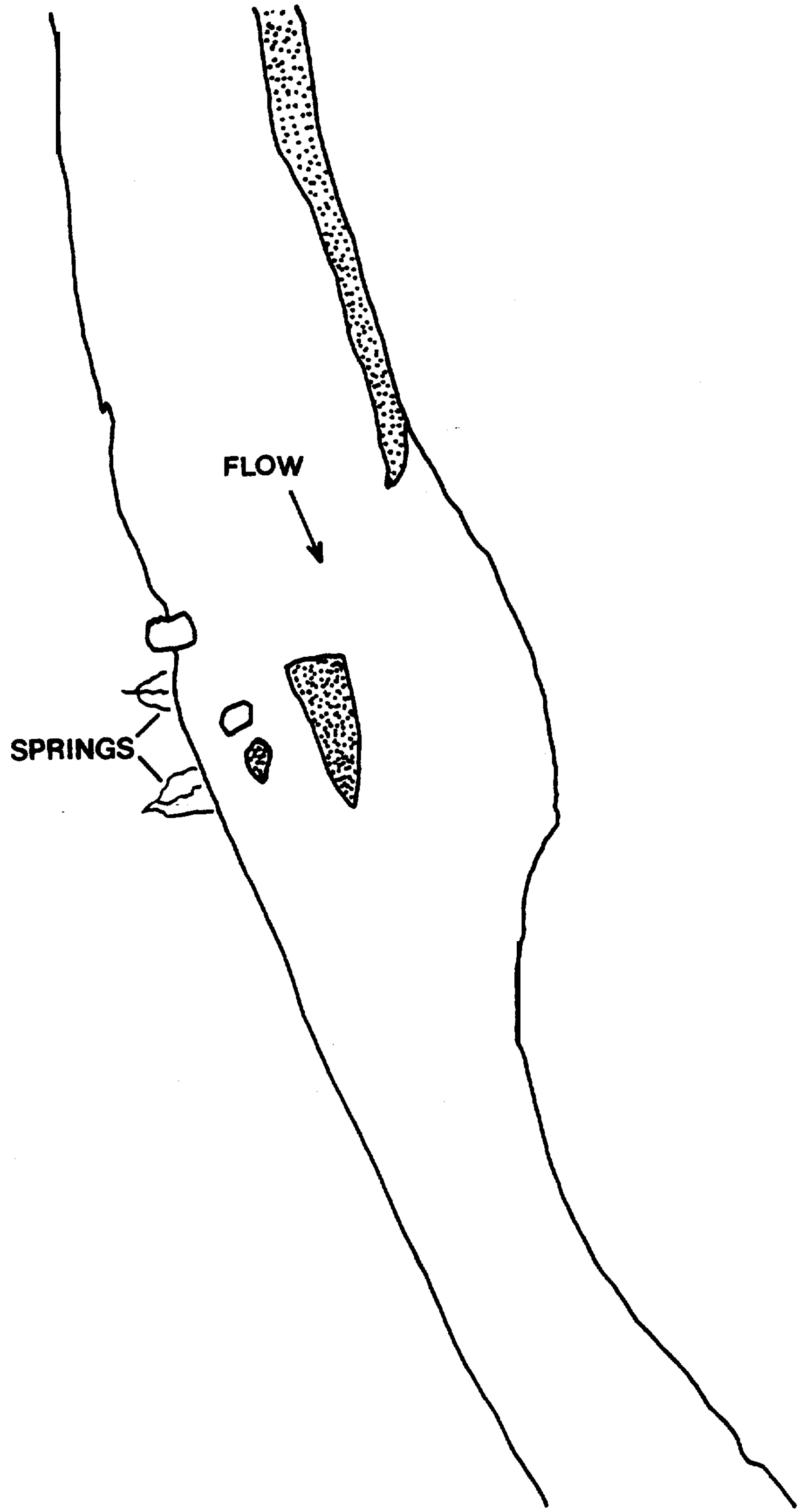
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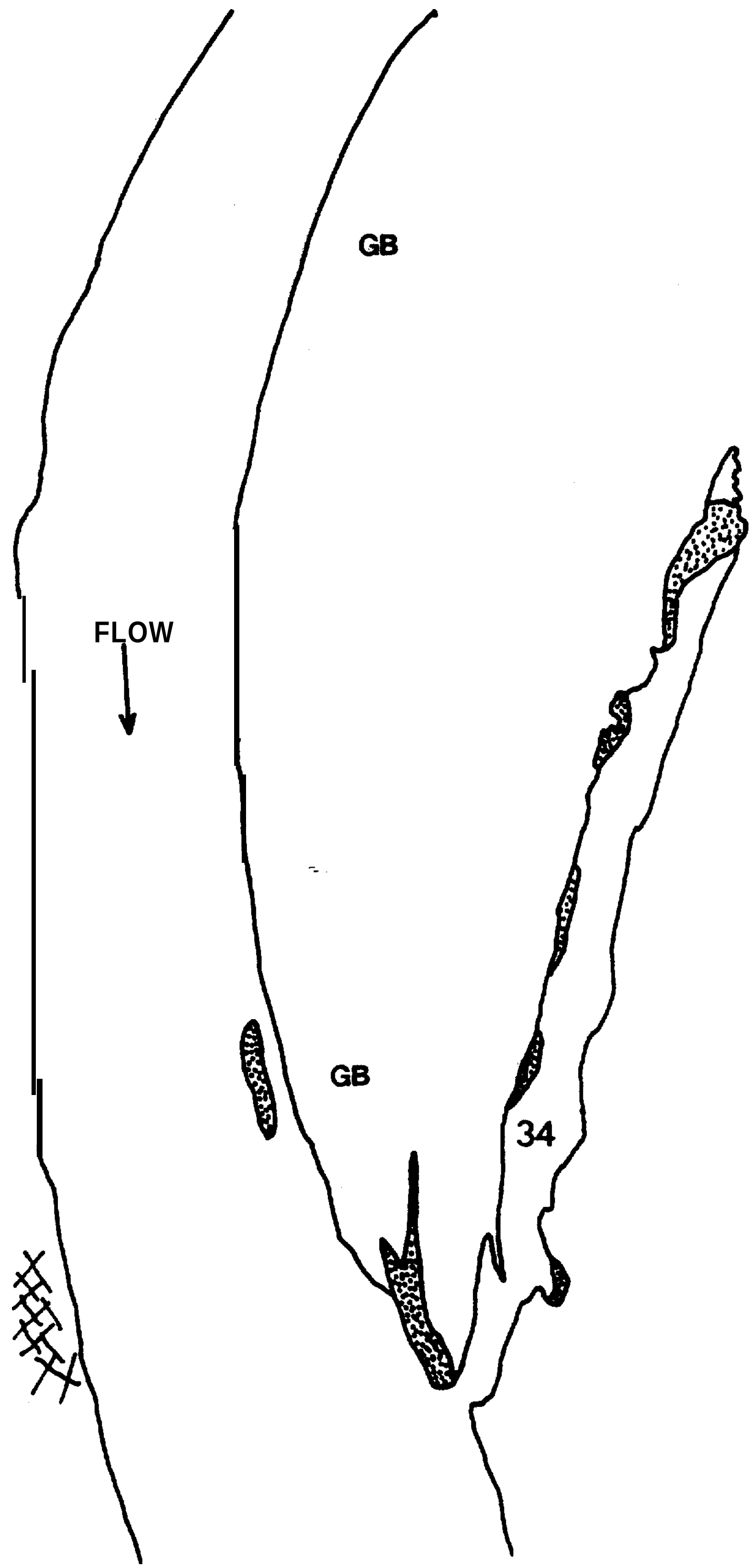
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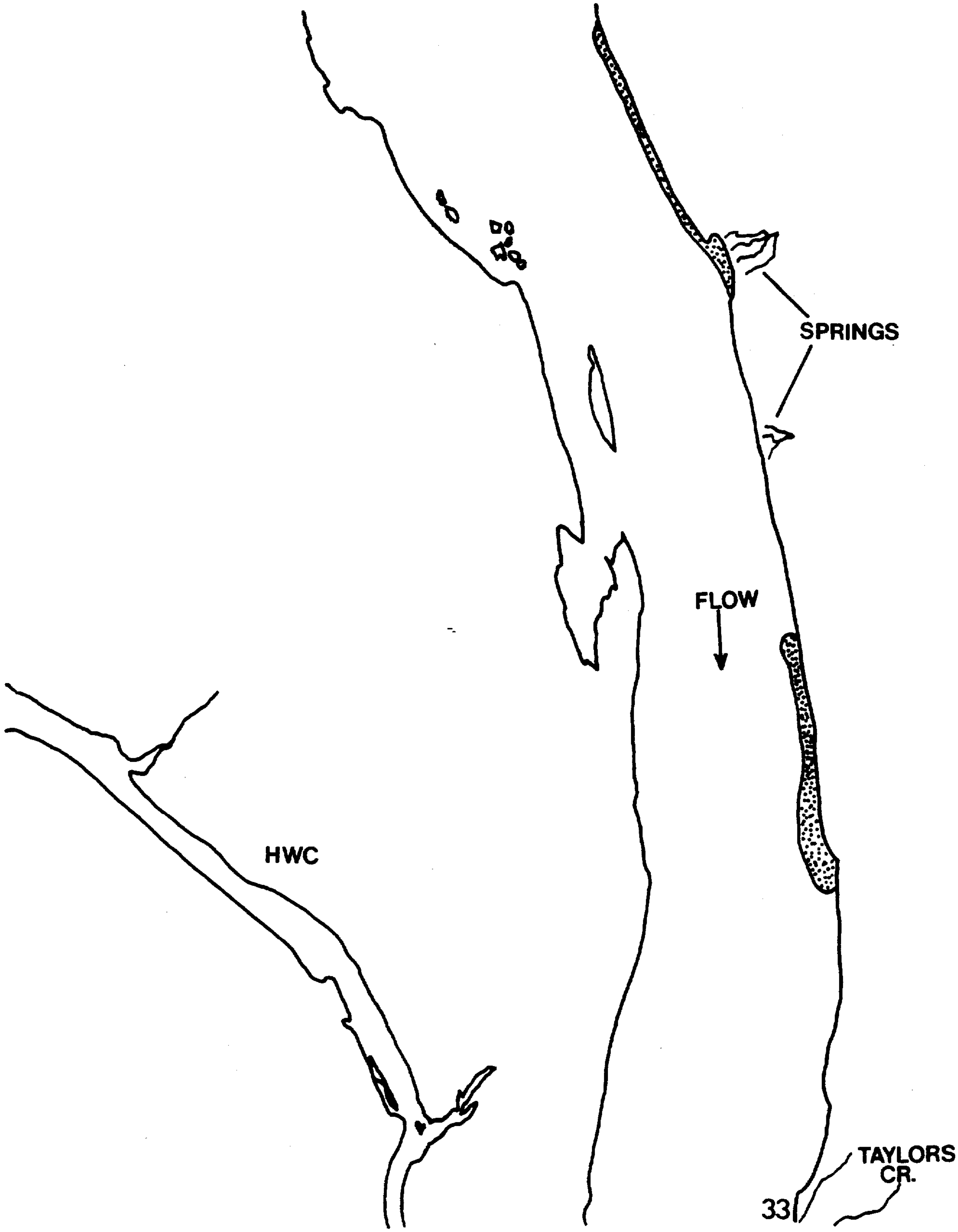
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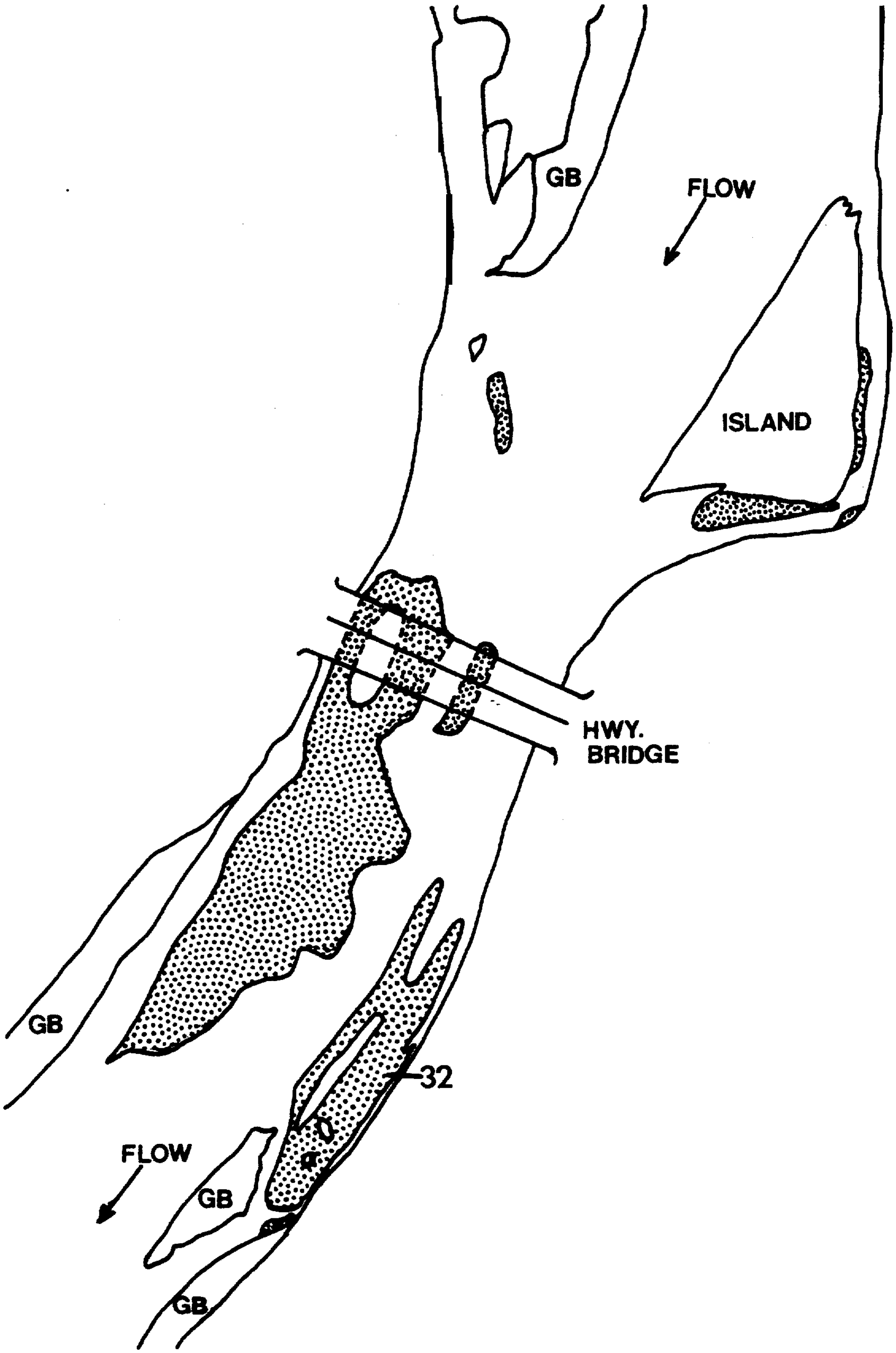
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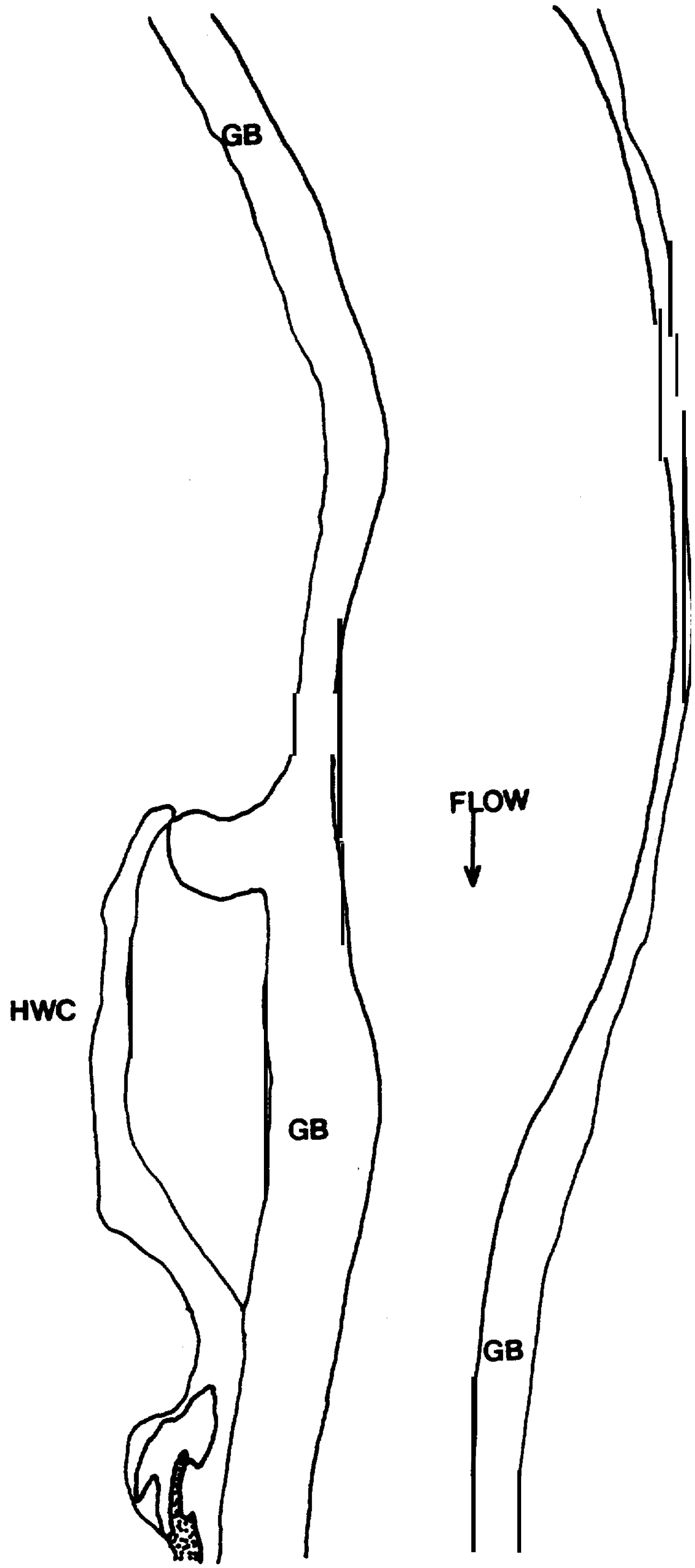
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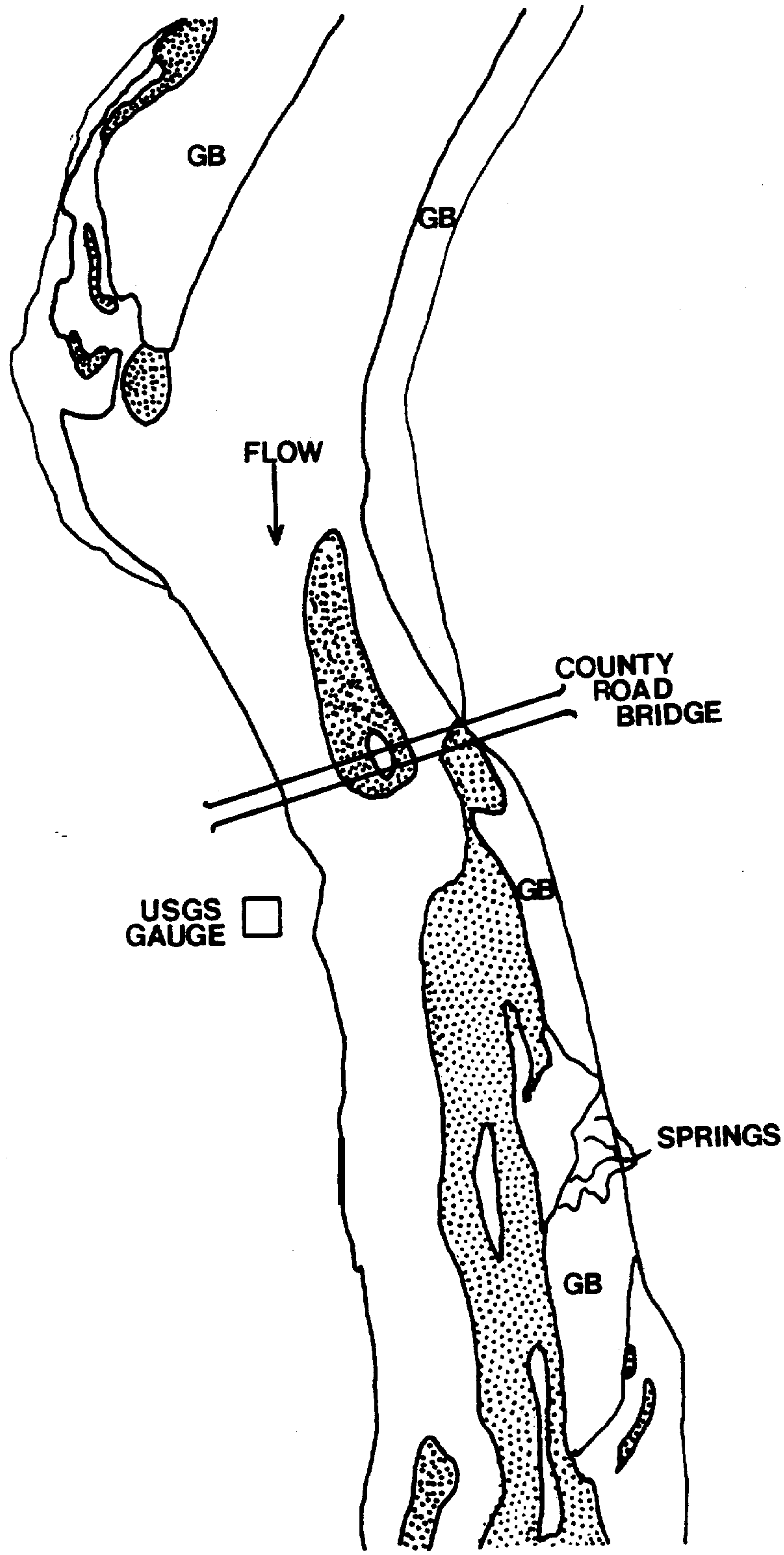
River Section MS-3

(Presentine to Columbia Falls)

pages 19-38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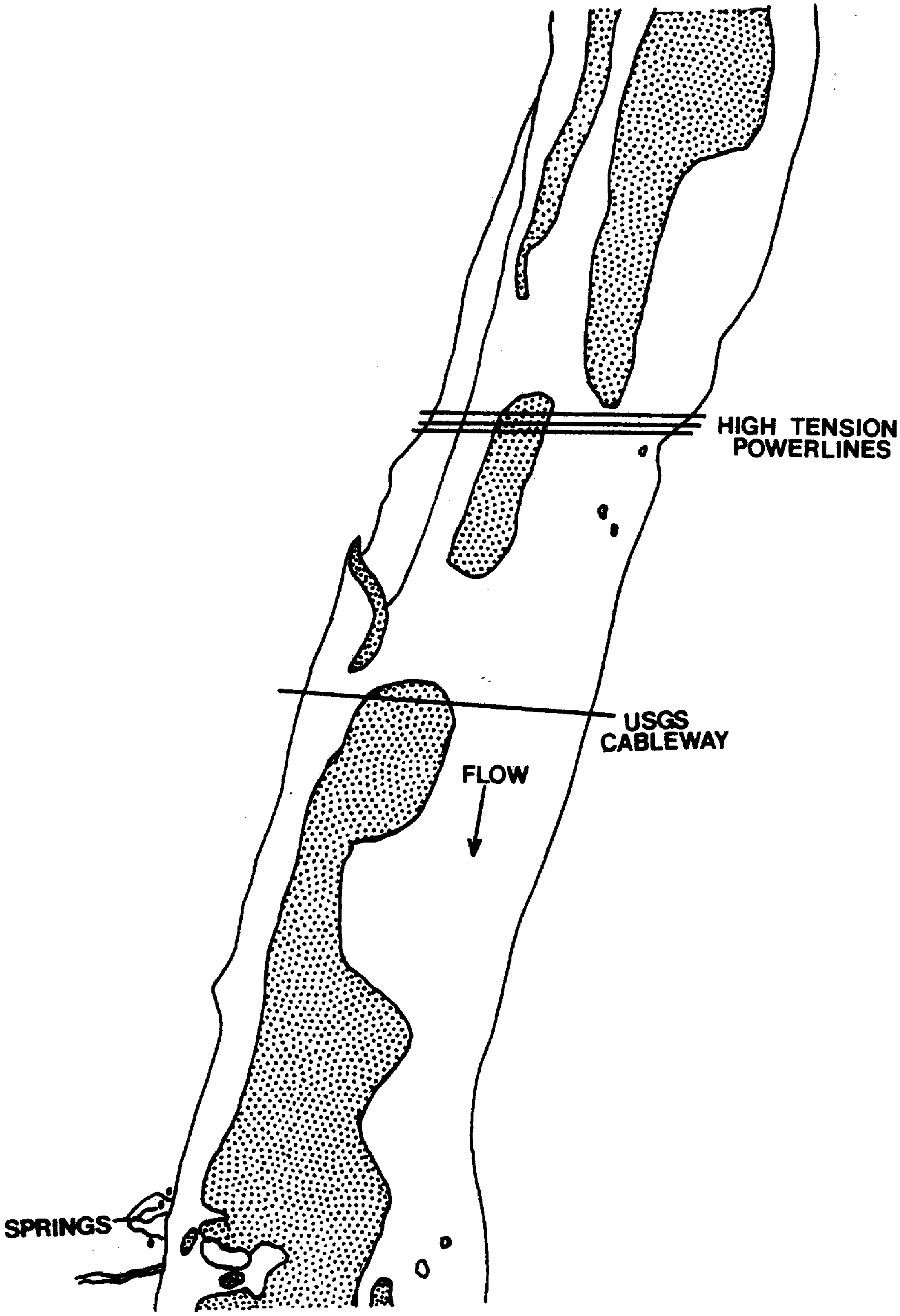
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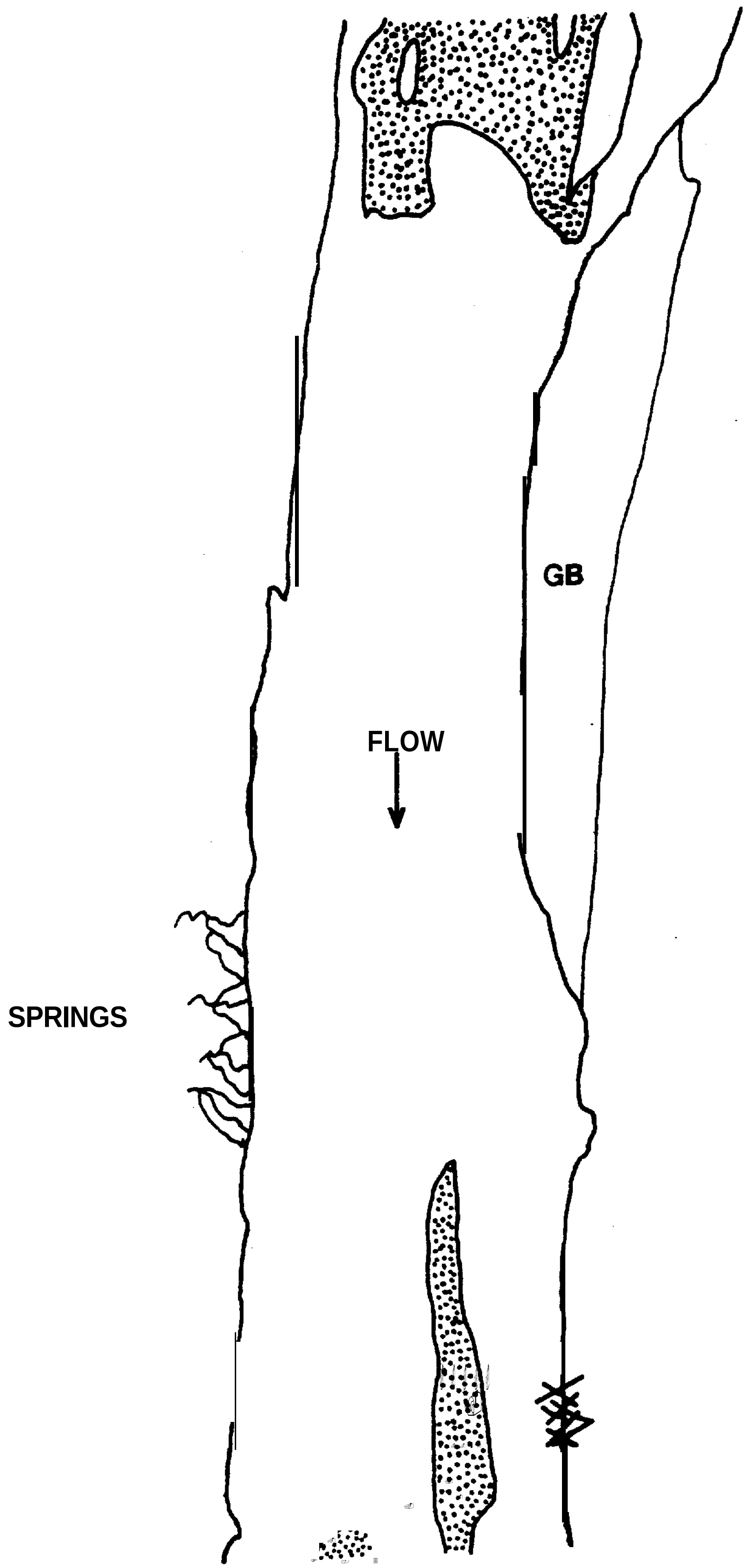
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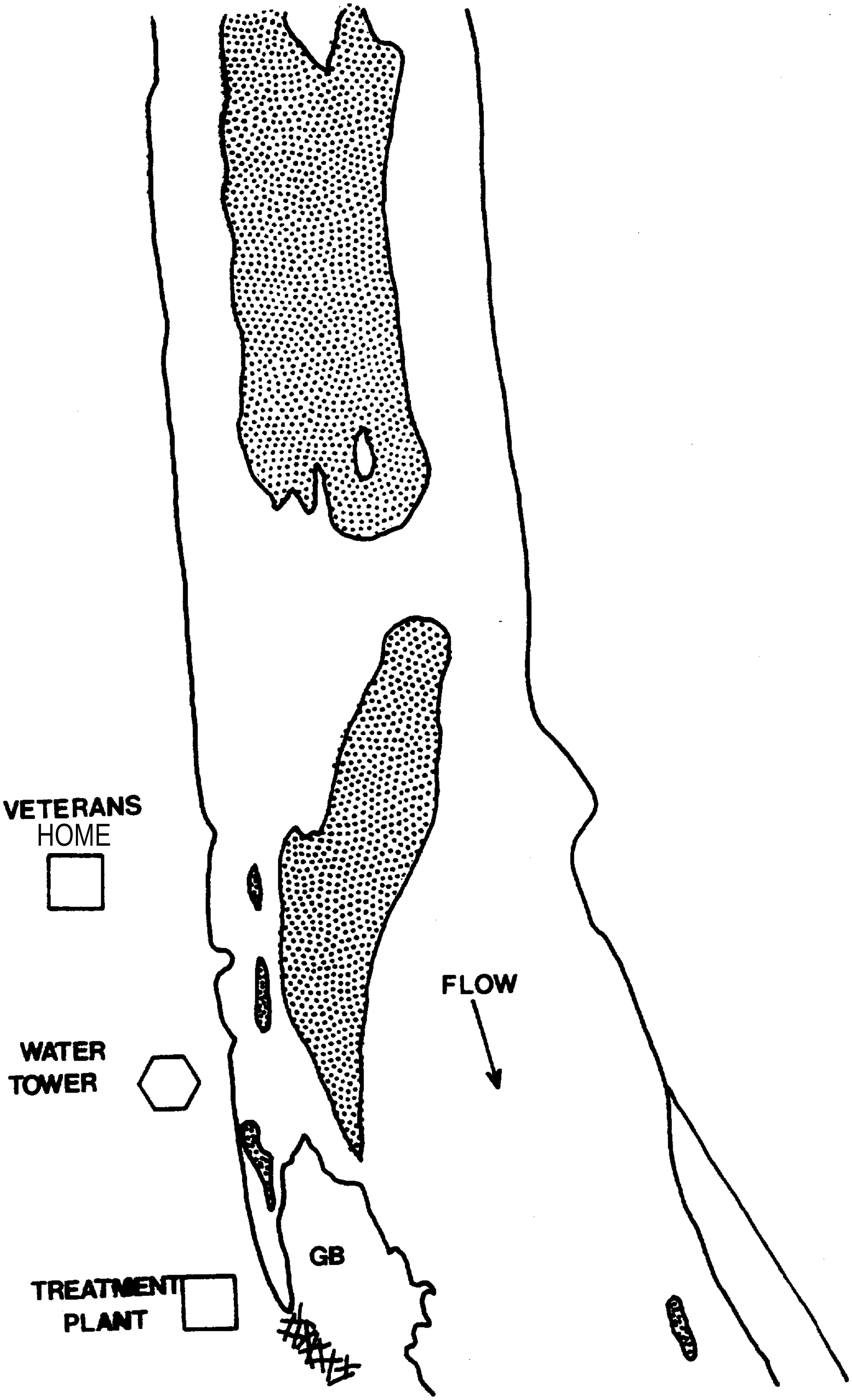
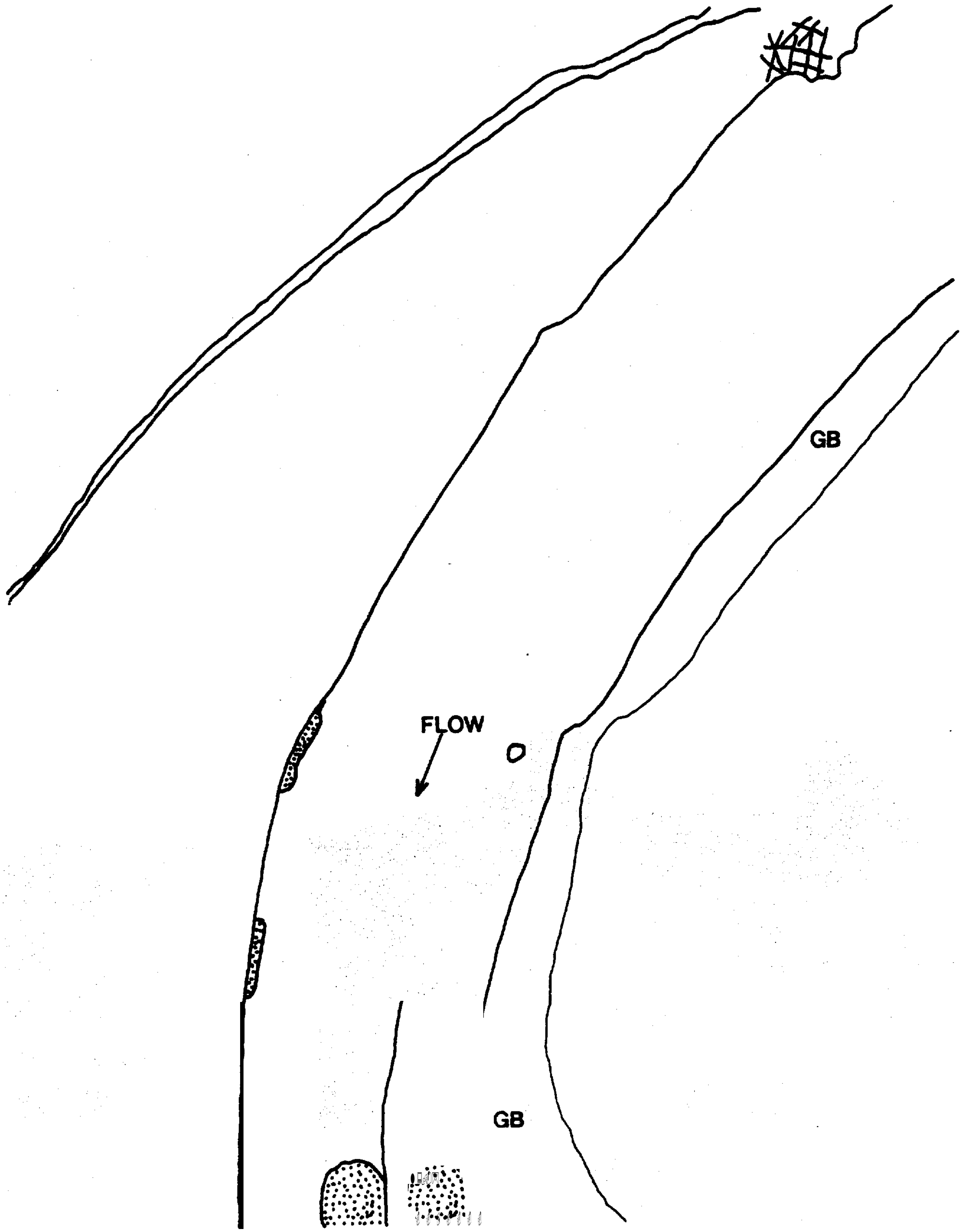
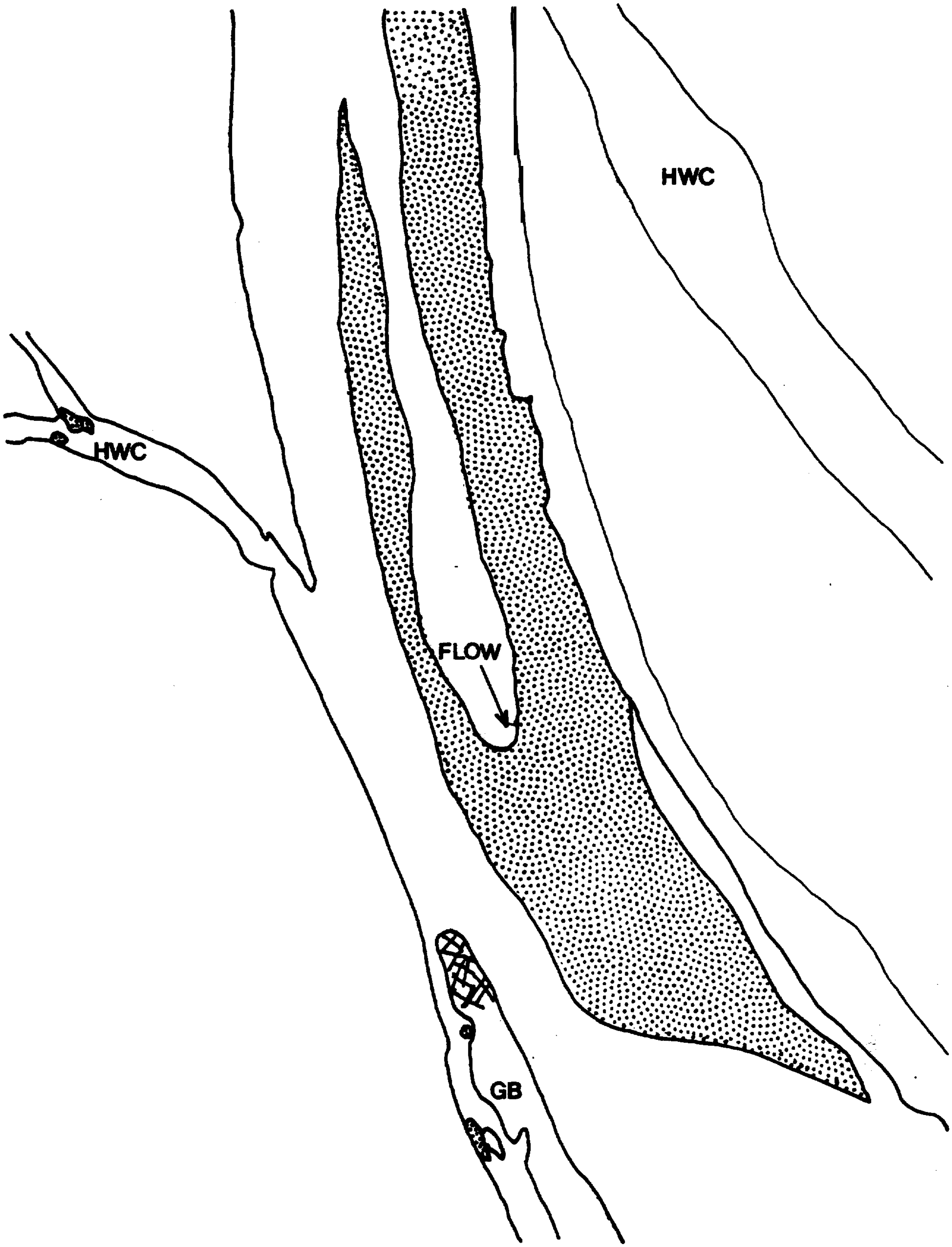
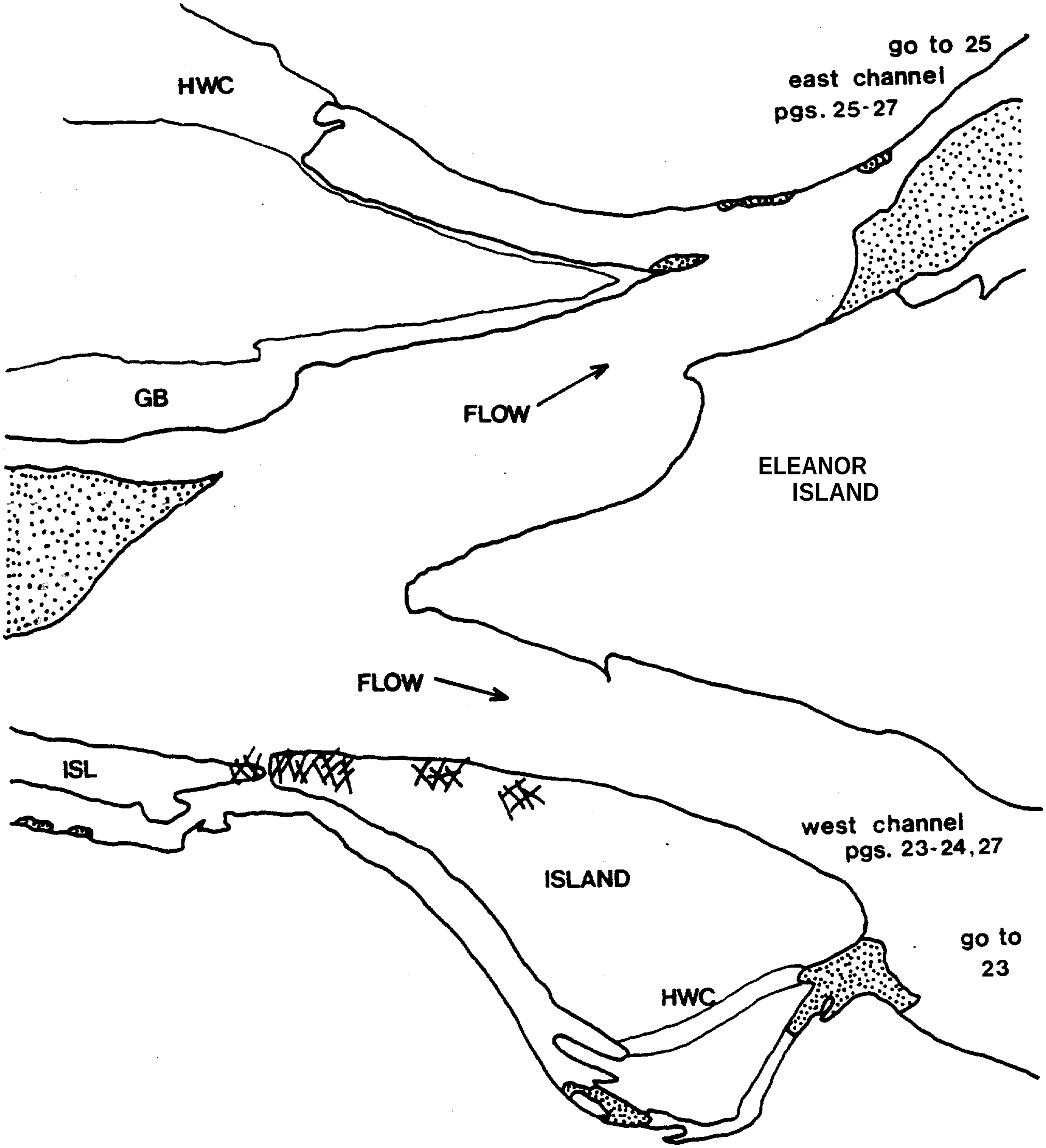
FLOW
SPRINGS

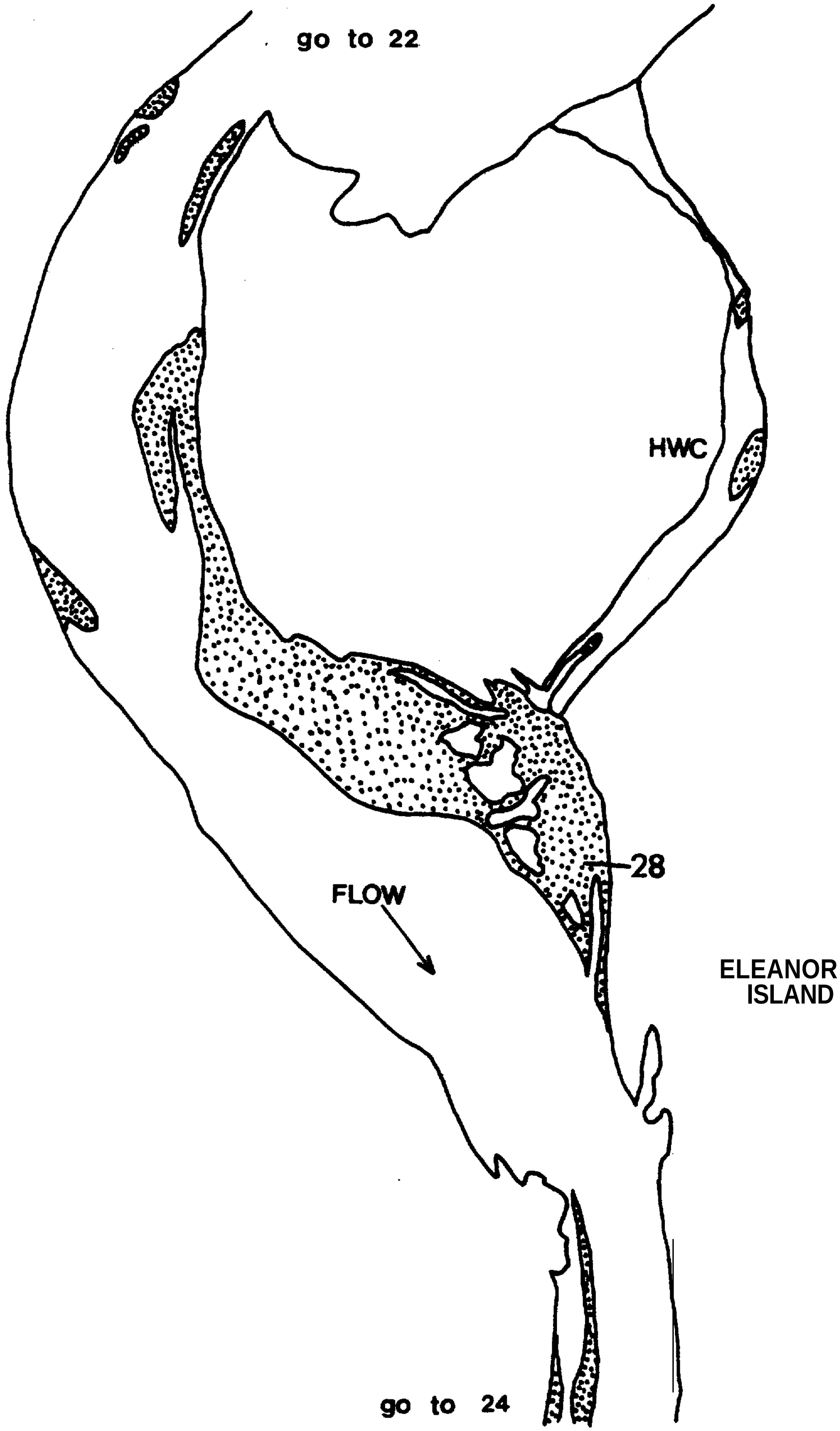

VETERANS
HOME
WATER
TOWER
FLOW
GB
TREATMENT
PLANT

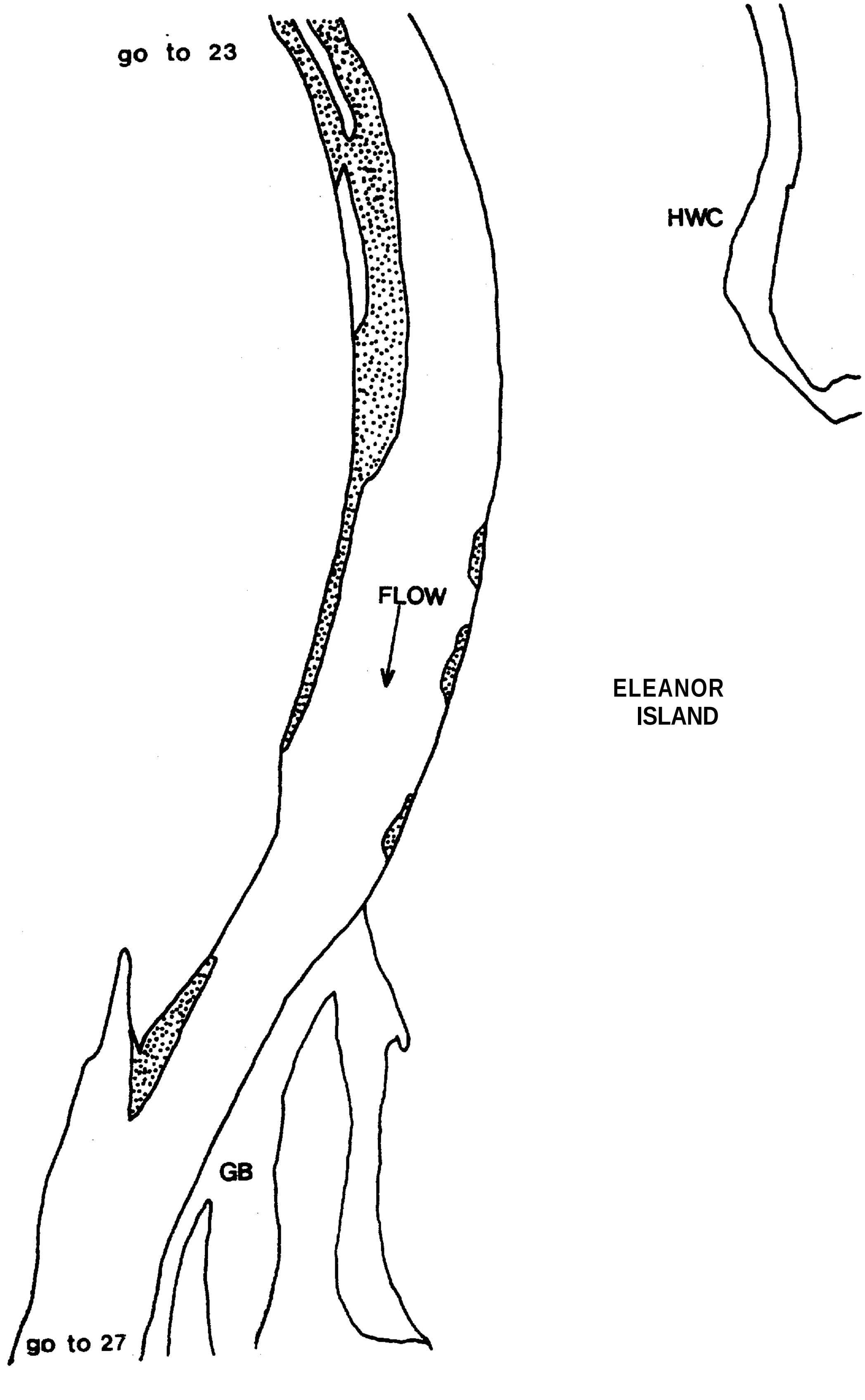

GB
FLOW
GB

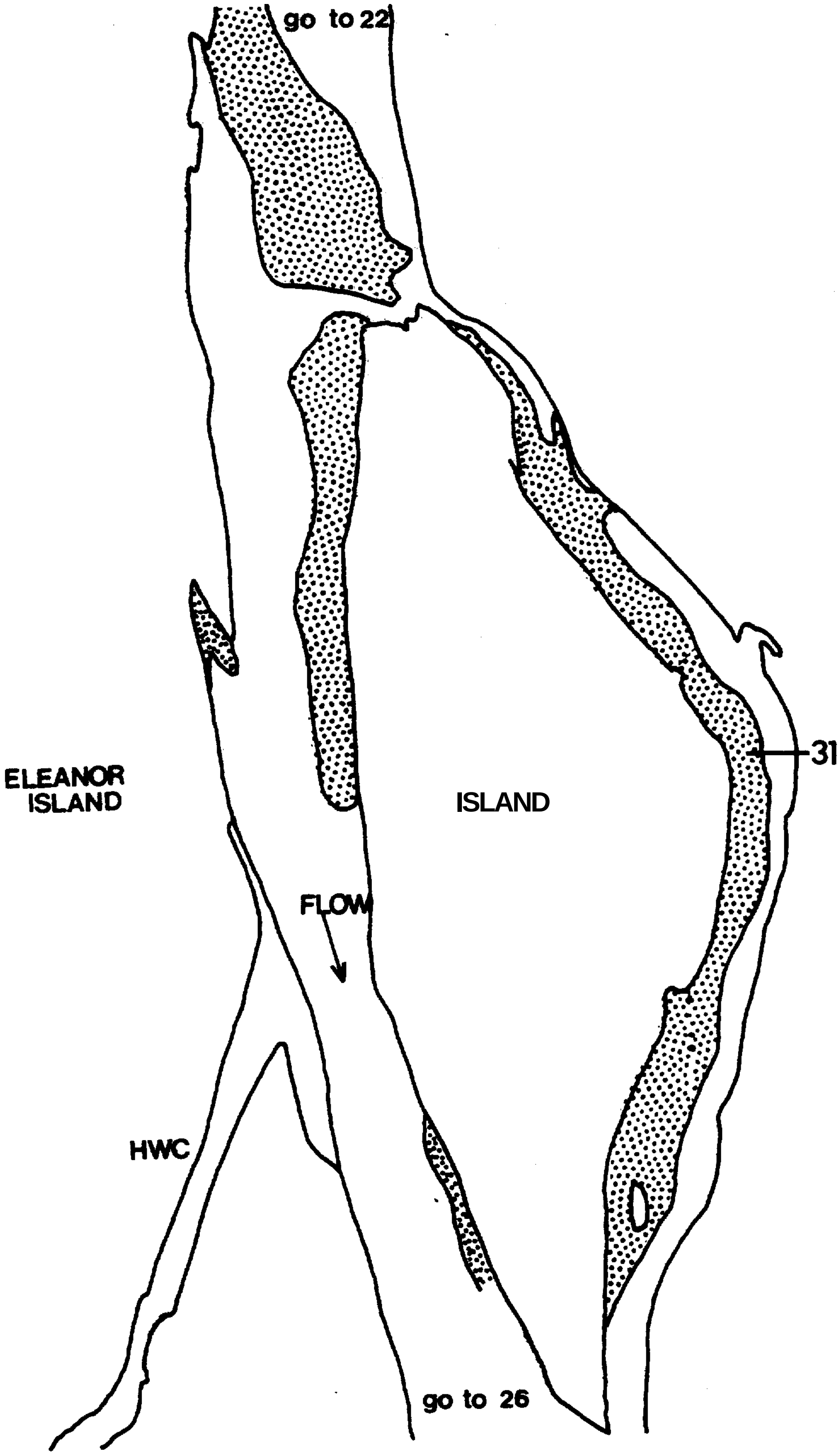

HWC
HWC
FLOW
GB

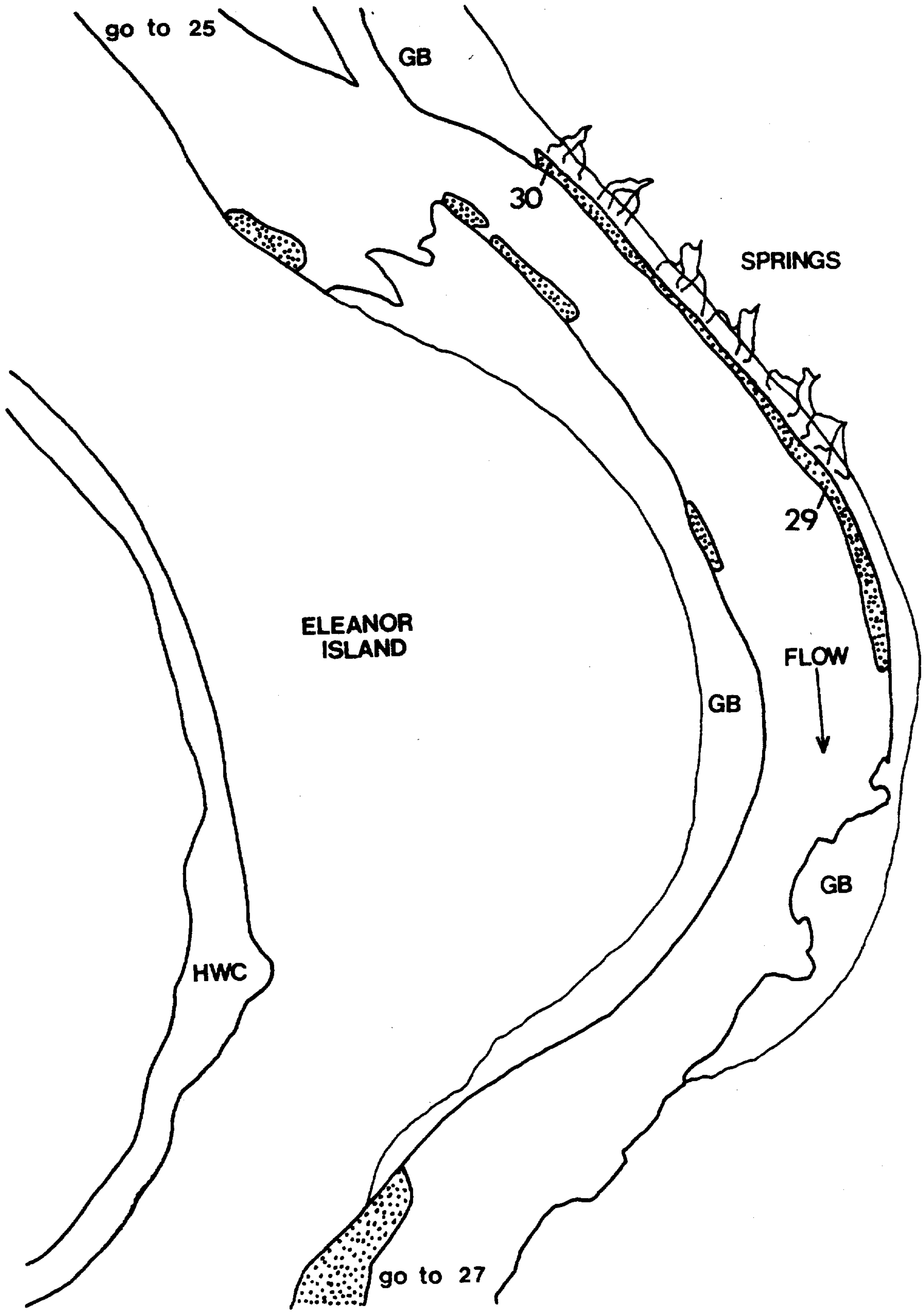


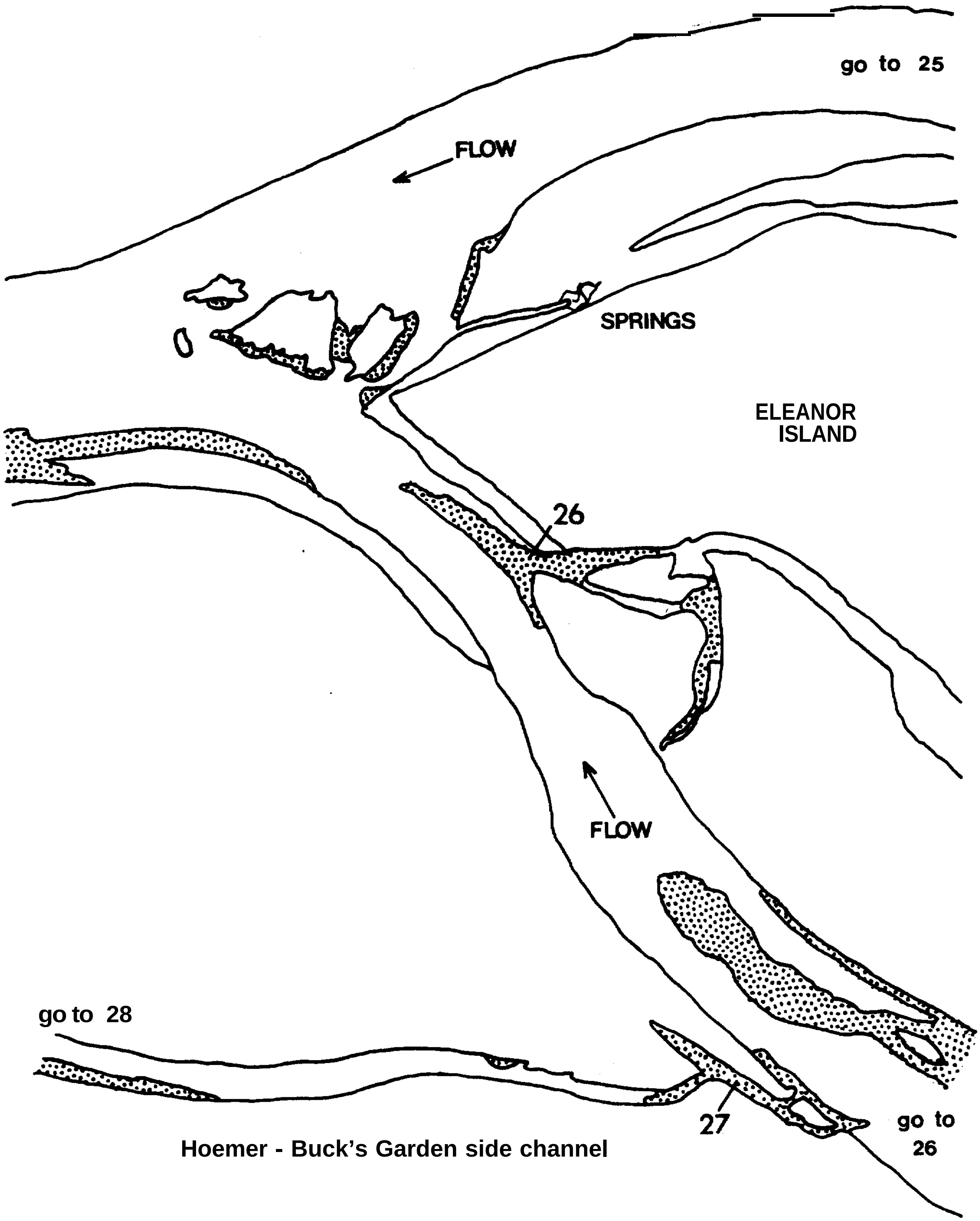
go to 25
east channel
pgs. 25-27
HWC
GB
FLOW
ELEANOR
ISLAND
FLOW
ISL
west channel
pgs. 23-24, 27
ISLAND
go to
23
HWC


go to 22
HWC
28
FLOW
ELEANOR
ISLAND
go to 24

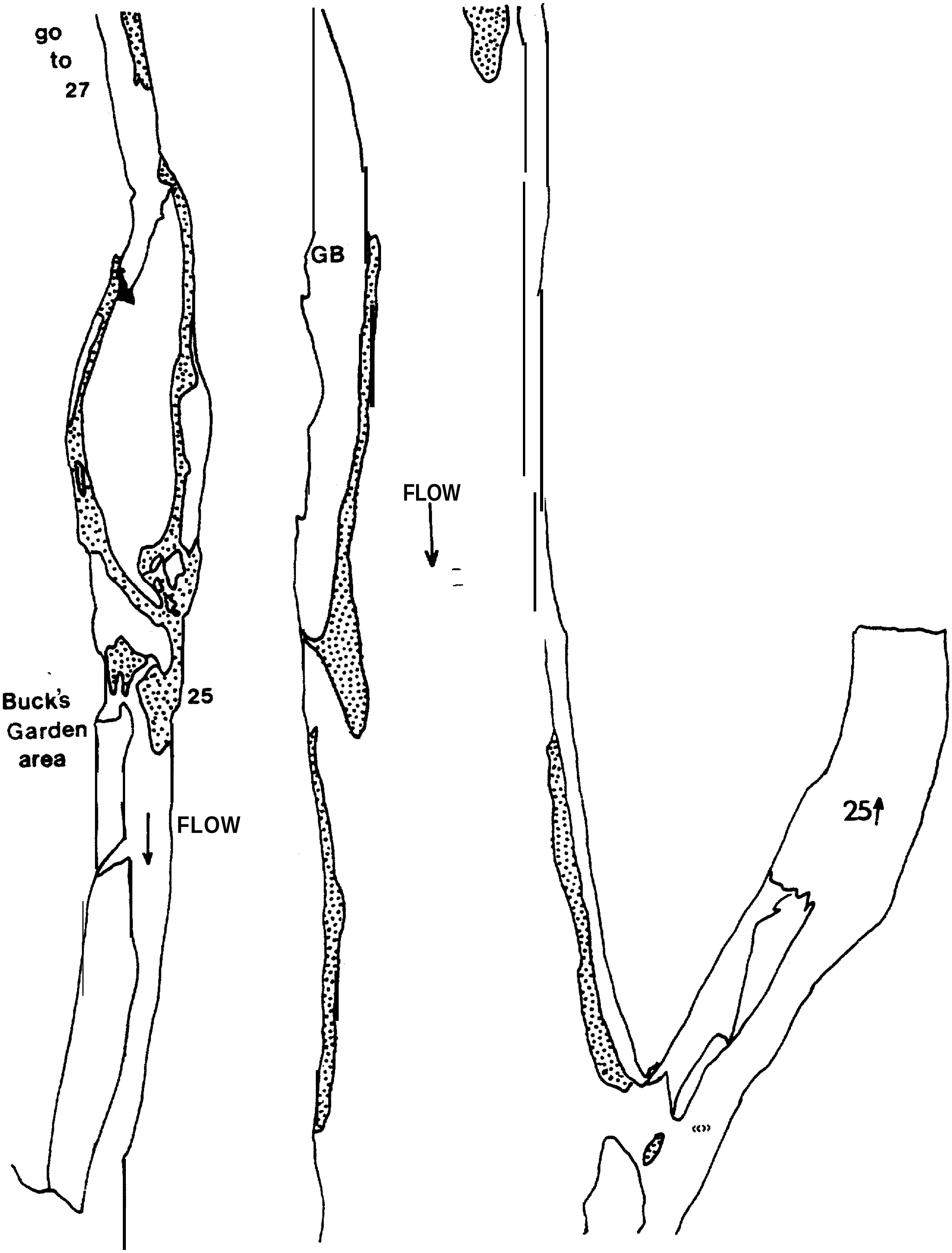

go to 23
HWC
FLOW
ELEANOR
ISLAND
GB
go to 27

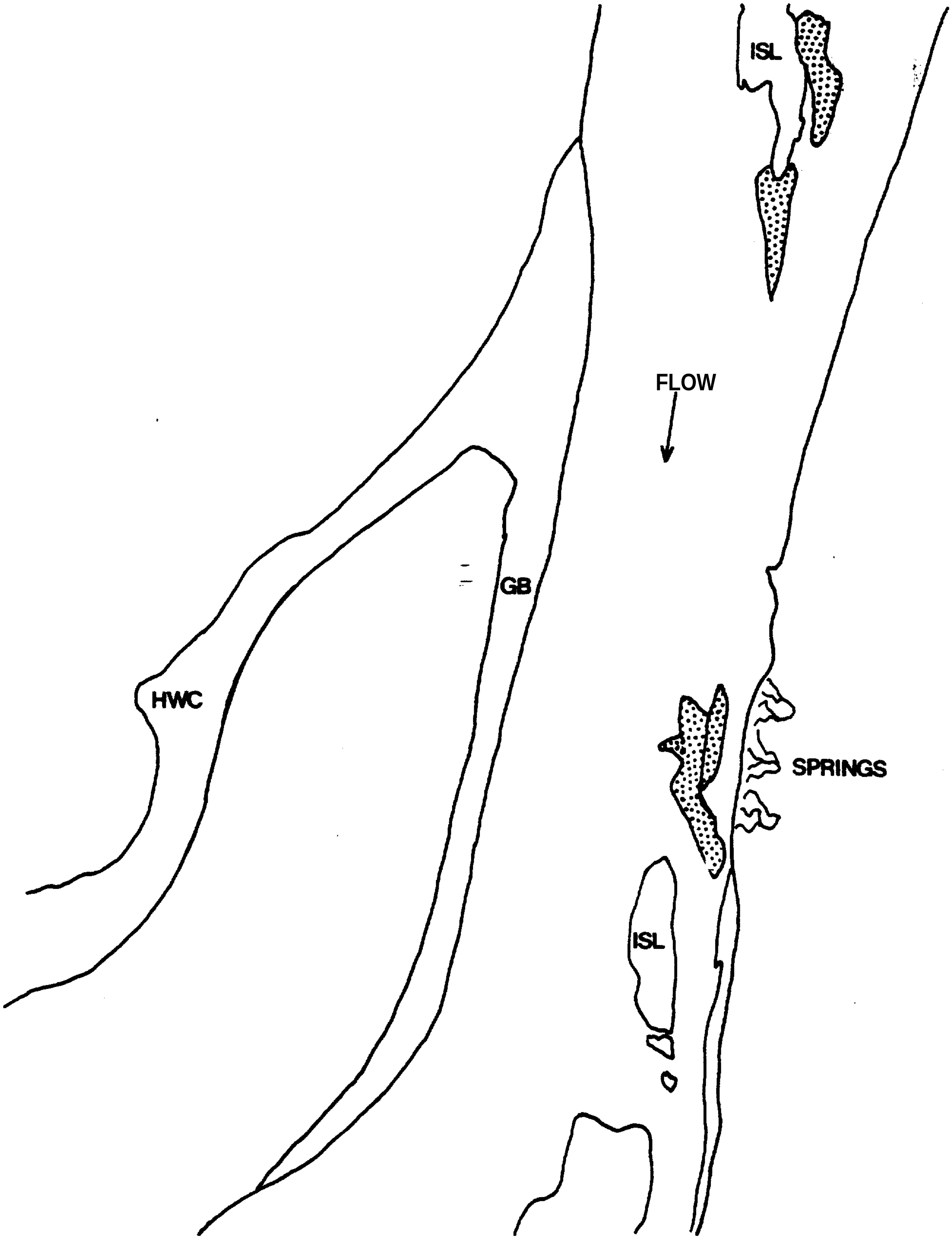

go to 22
31
ELEANOR
ISLAND
ISLAND
FLOW
HWC
go to 26

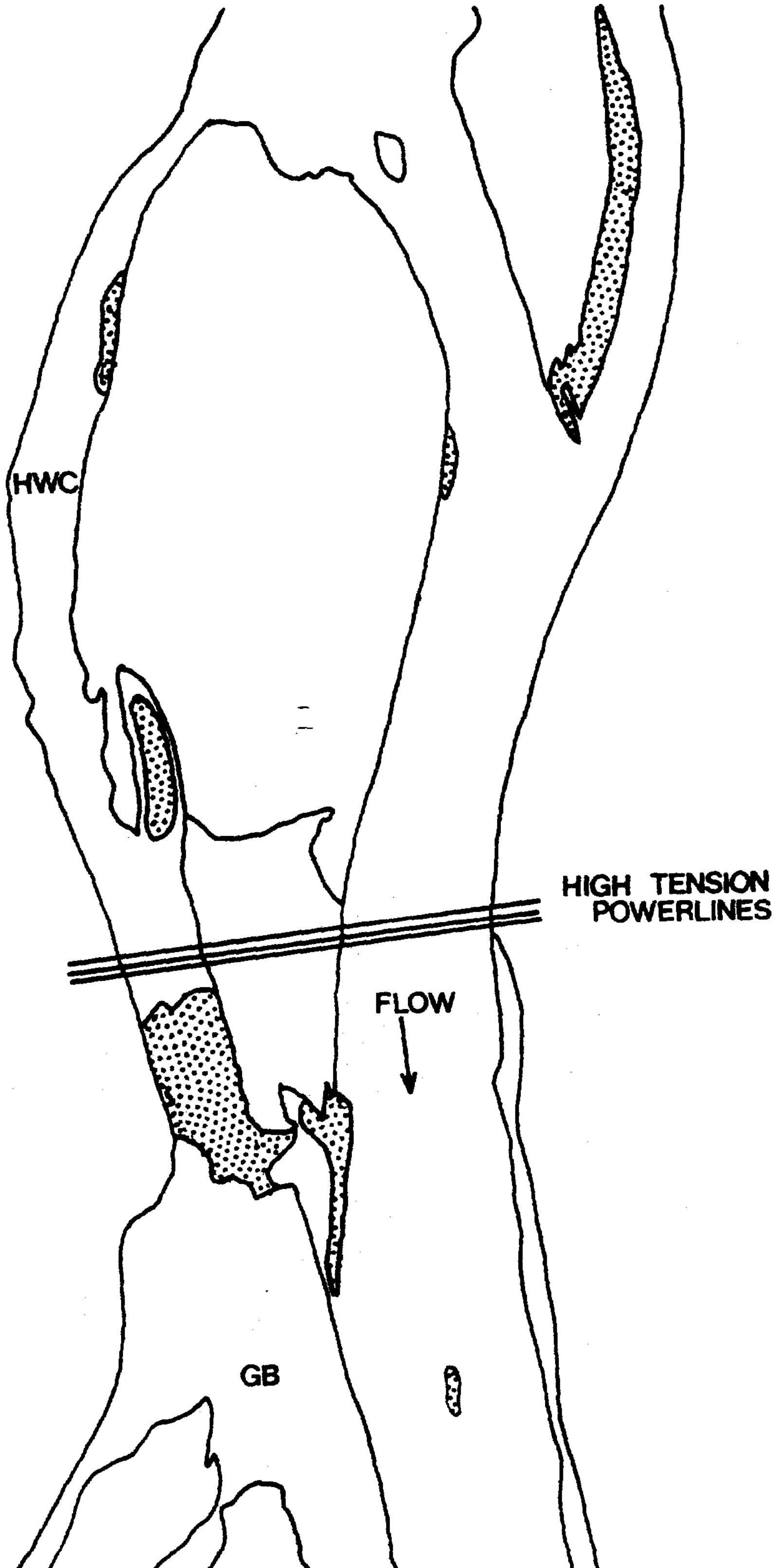

go to 25
GB
30
SPRINGS
29
ELEANOR ISLAND
FLOW
GB
GB
HWC
go to 27

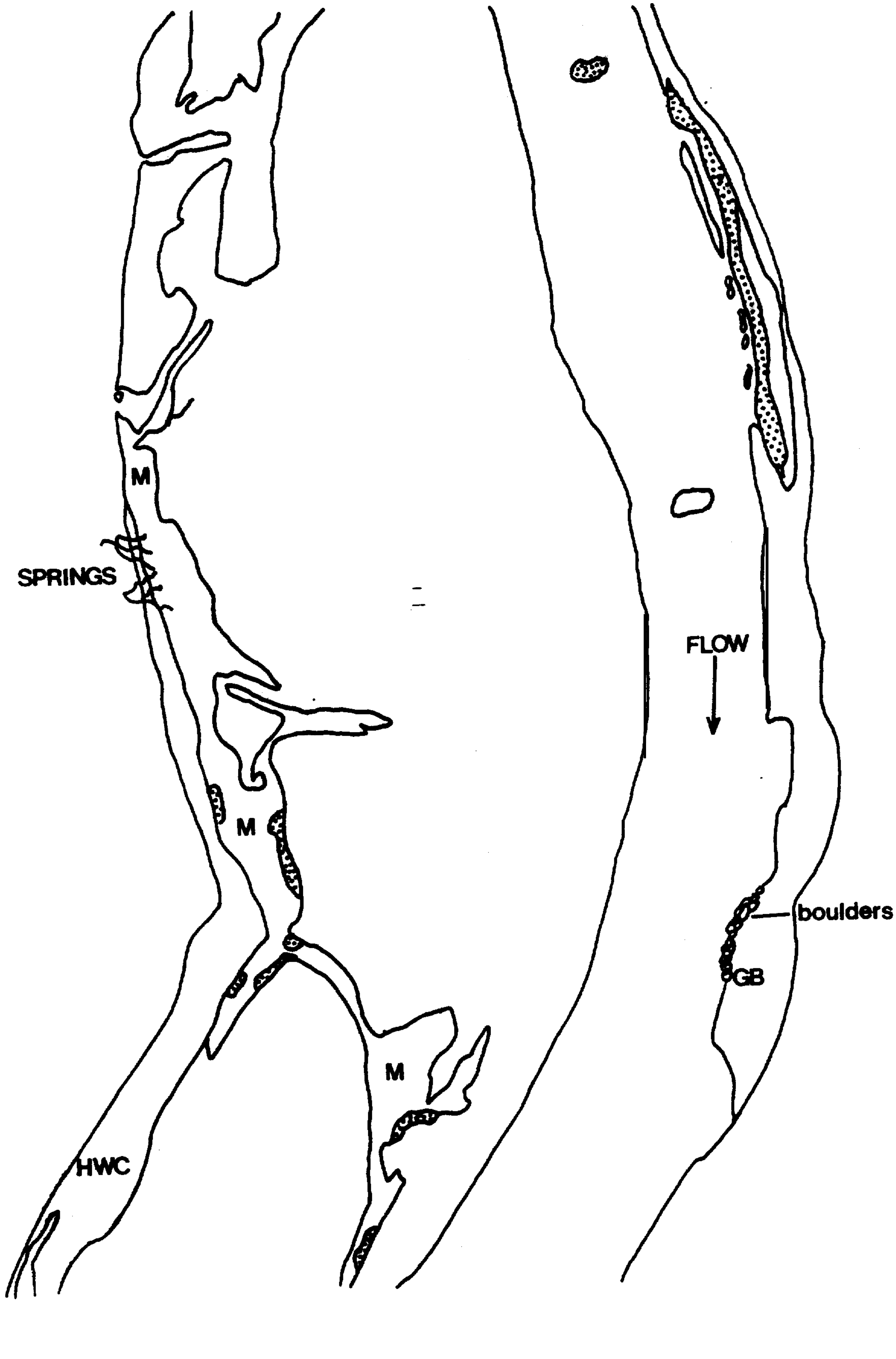


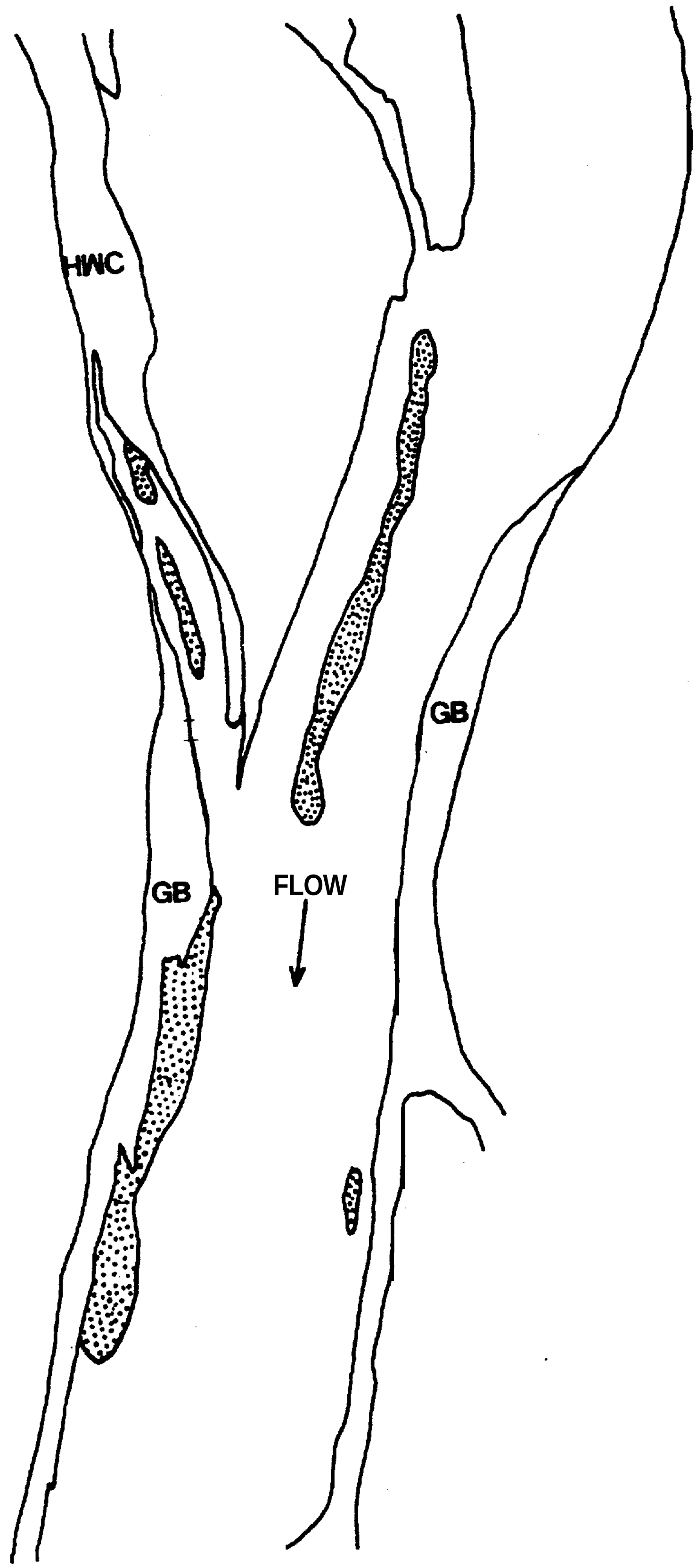
Hoemer - Buck’s Garden side channel

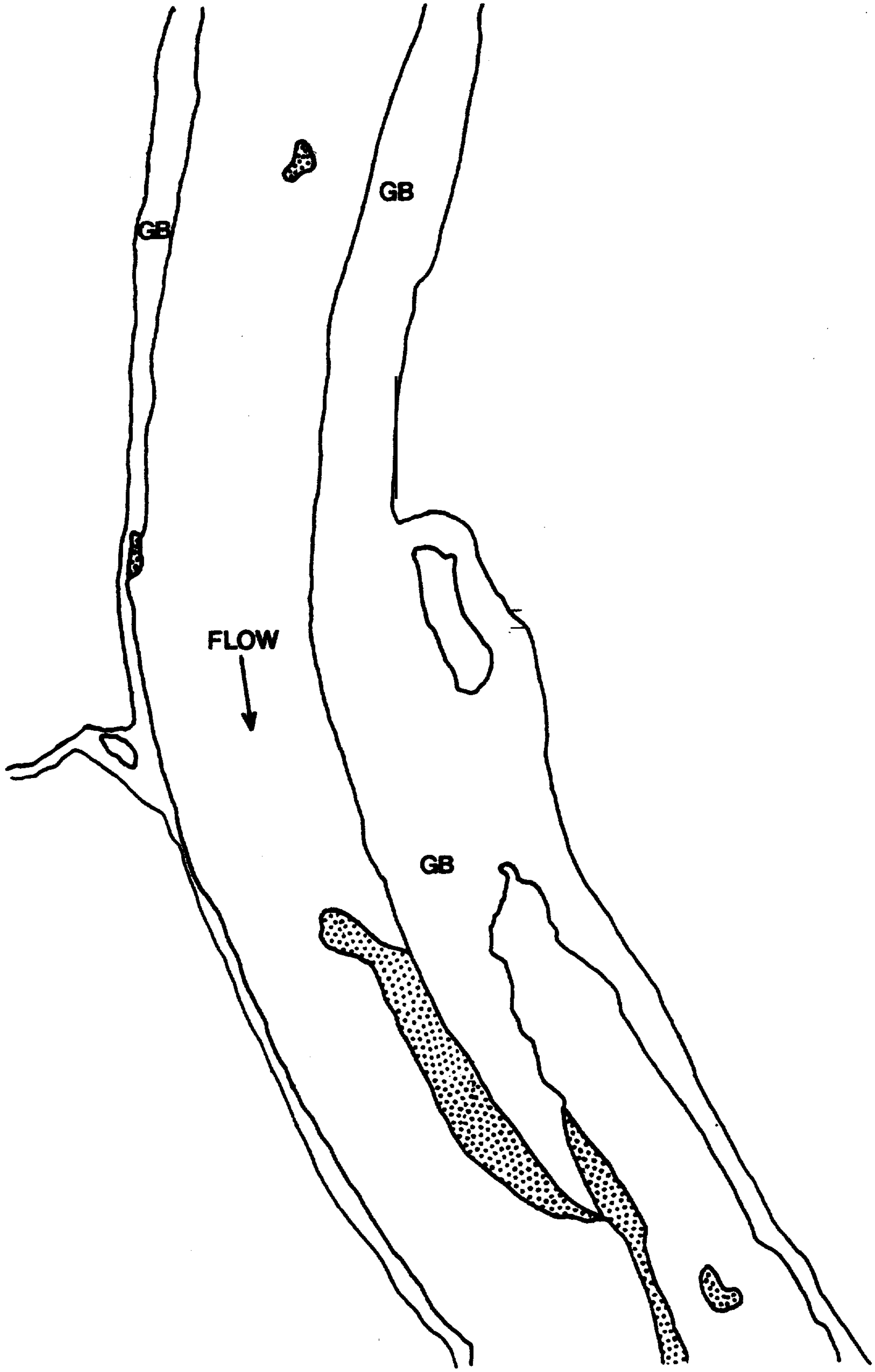

go
to
27
GB
FLOW
Buck's
Garden
area
25
FLOW
25

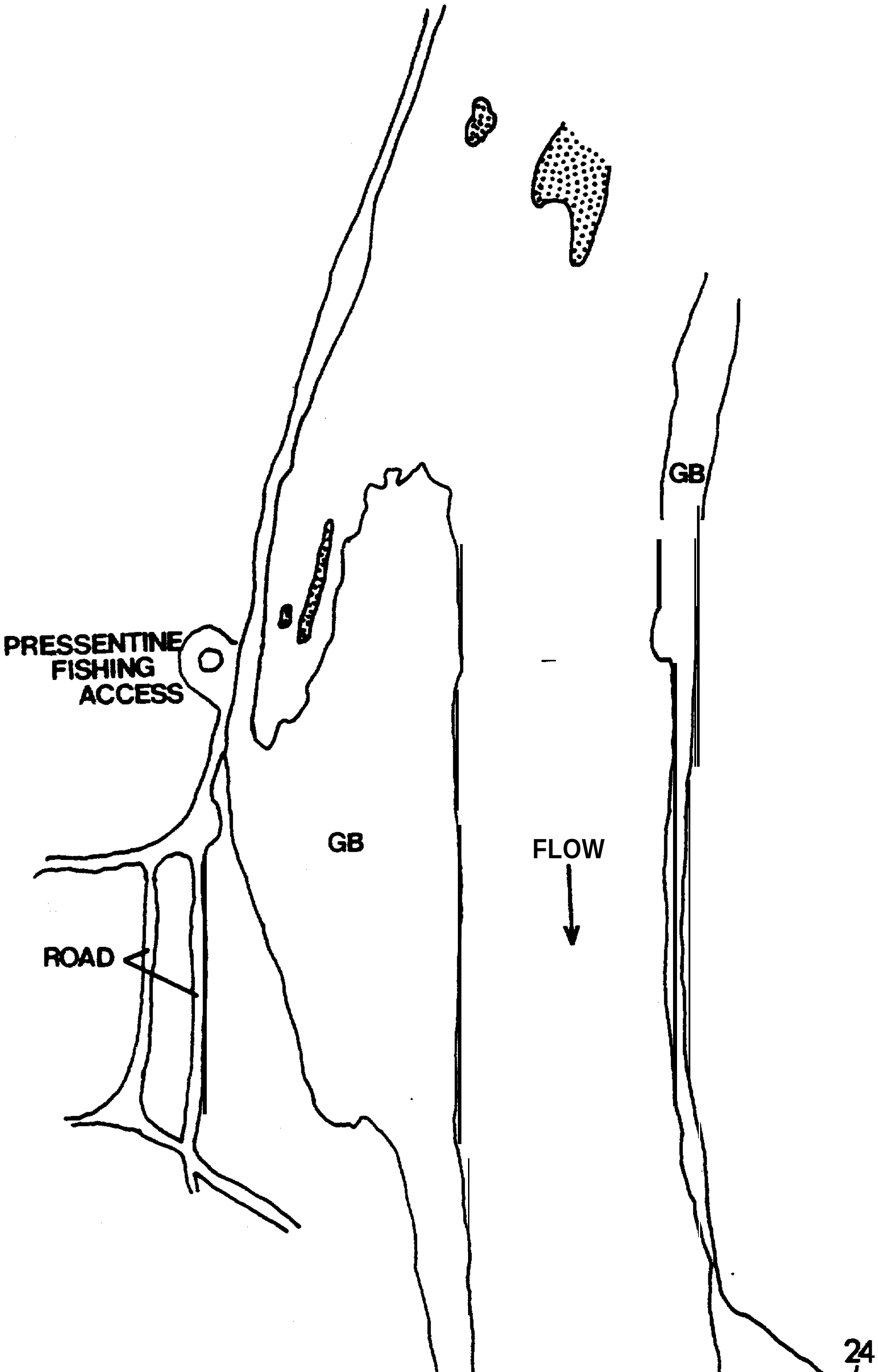

ISL
FLOW
GB
HWC
SPRINGS
ISL

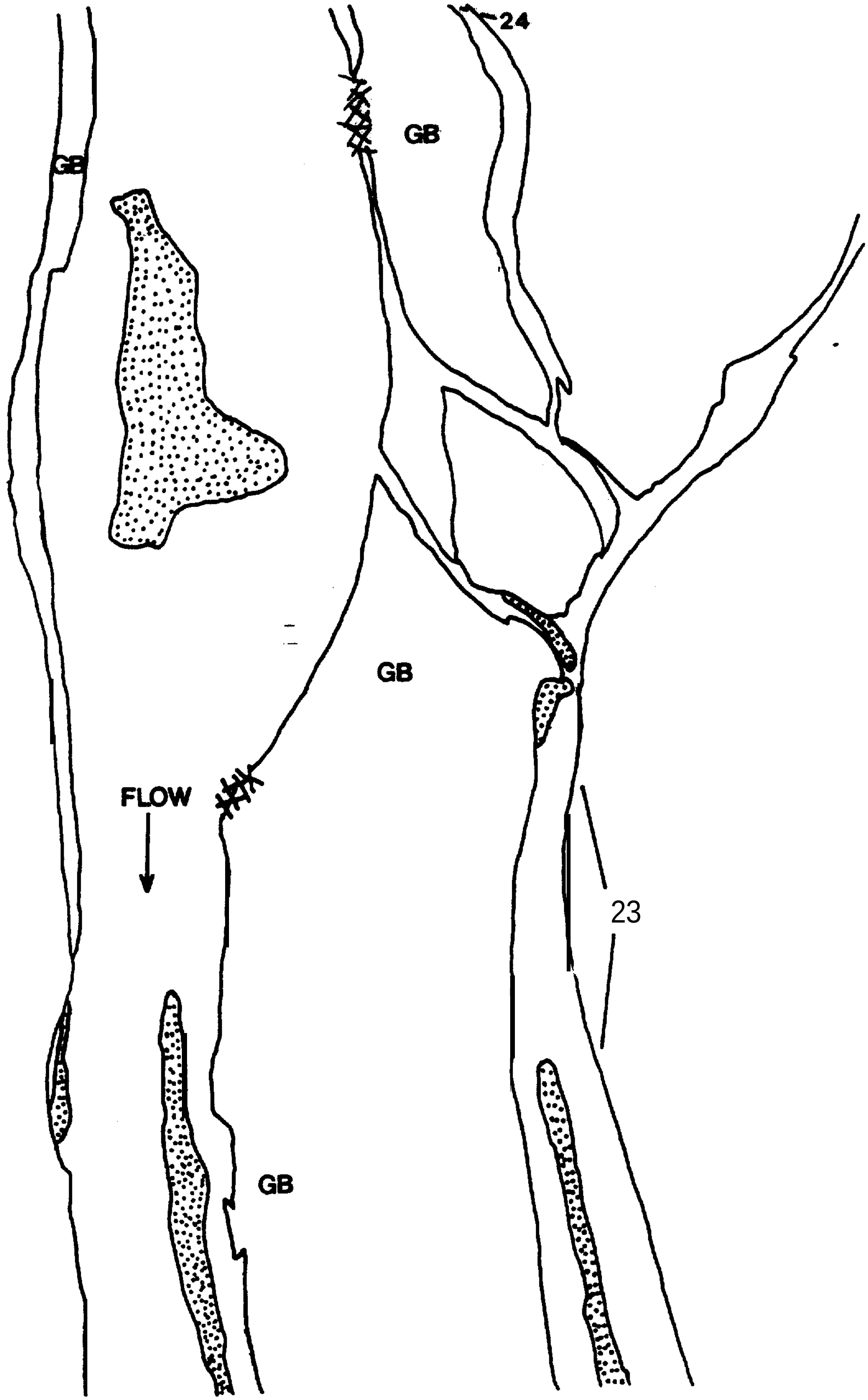

HWC
HIGH TENSION POWERLINES
FLOW
GB


M
SPRINGS
FLOW
M
boulders
GB
M
HWC


HWC
GB
GB
FLOW


GB
GB
FLOW
GB

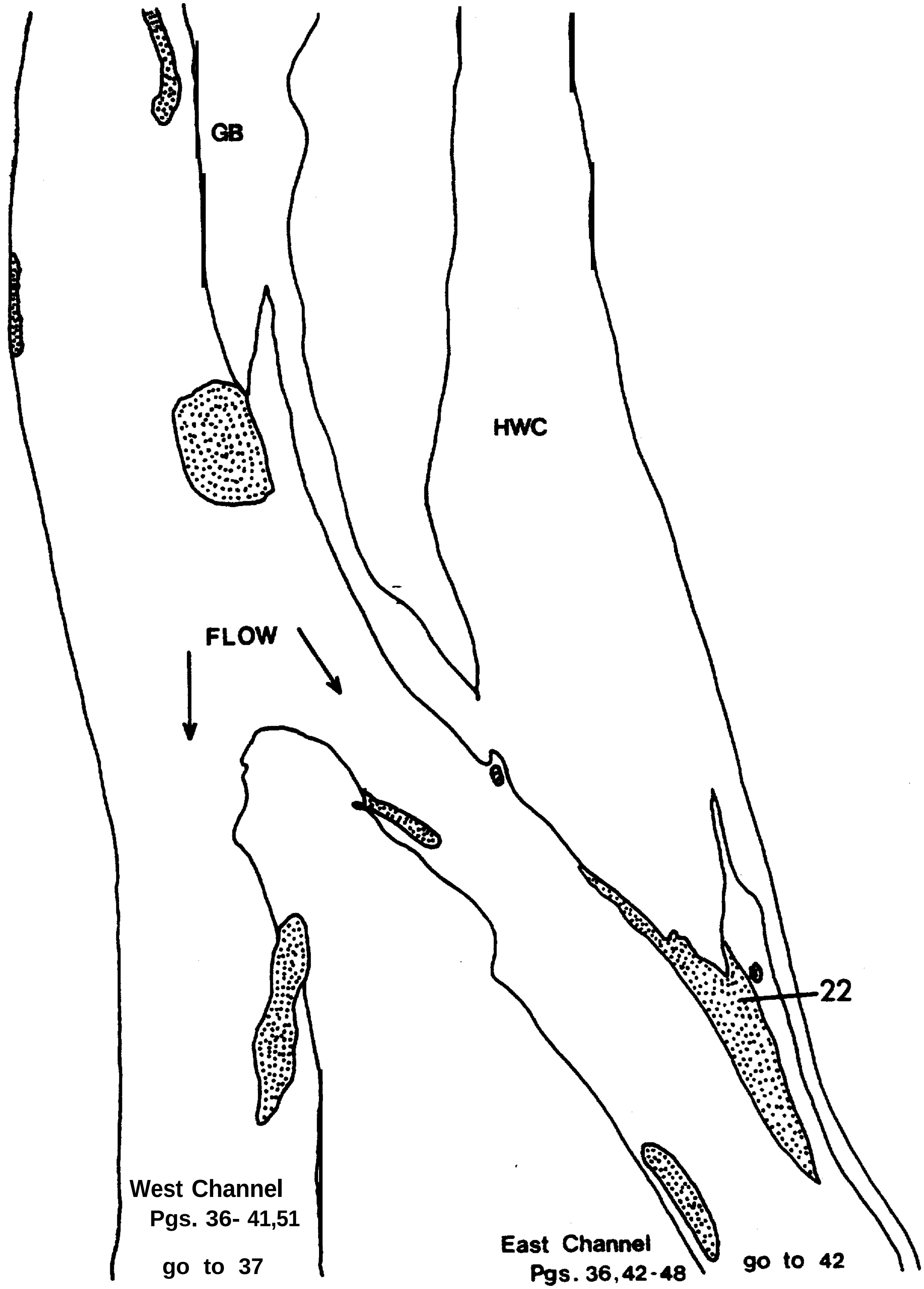

GB
PRESSENTINE
FISHING
ACCESS
GB
FLOW
ROAD
24


24
GB
GB
GB
FLOW
23
GB

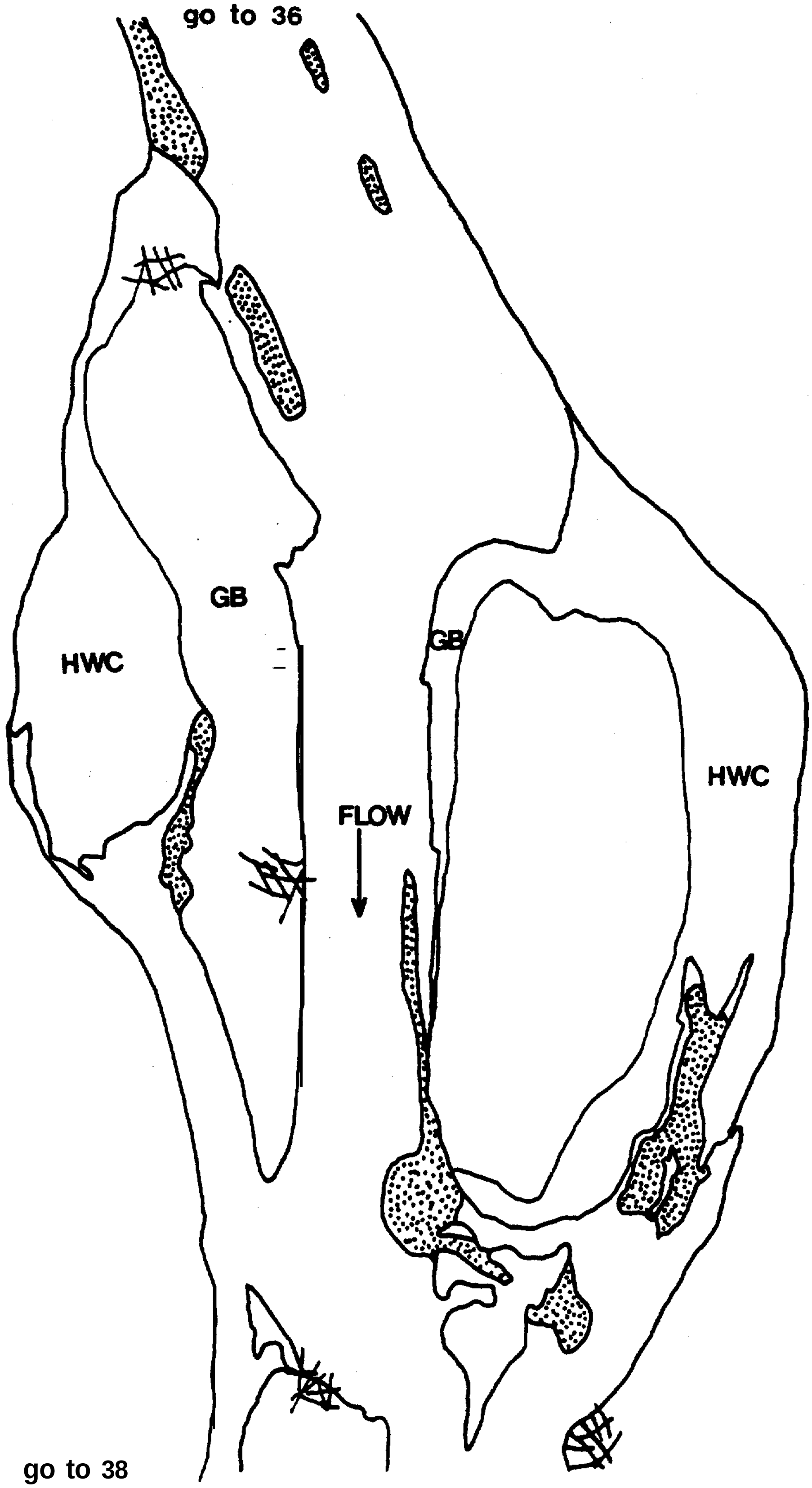
River Section MS-2

(Mouth of Stillwater to Presentine)

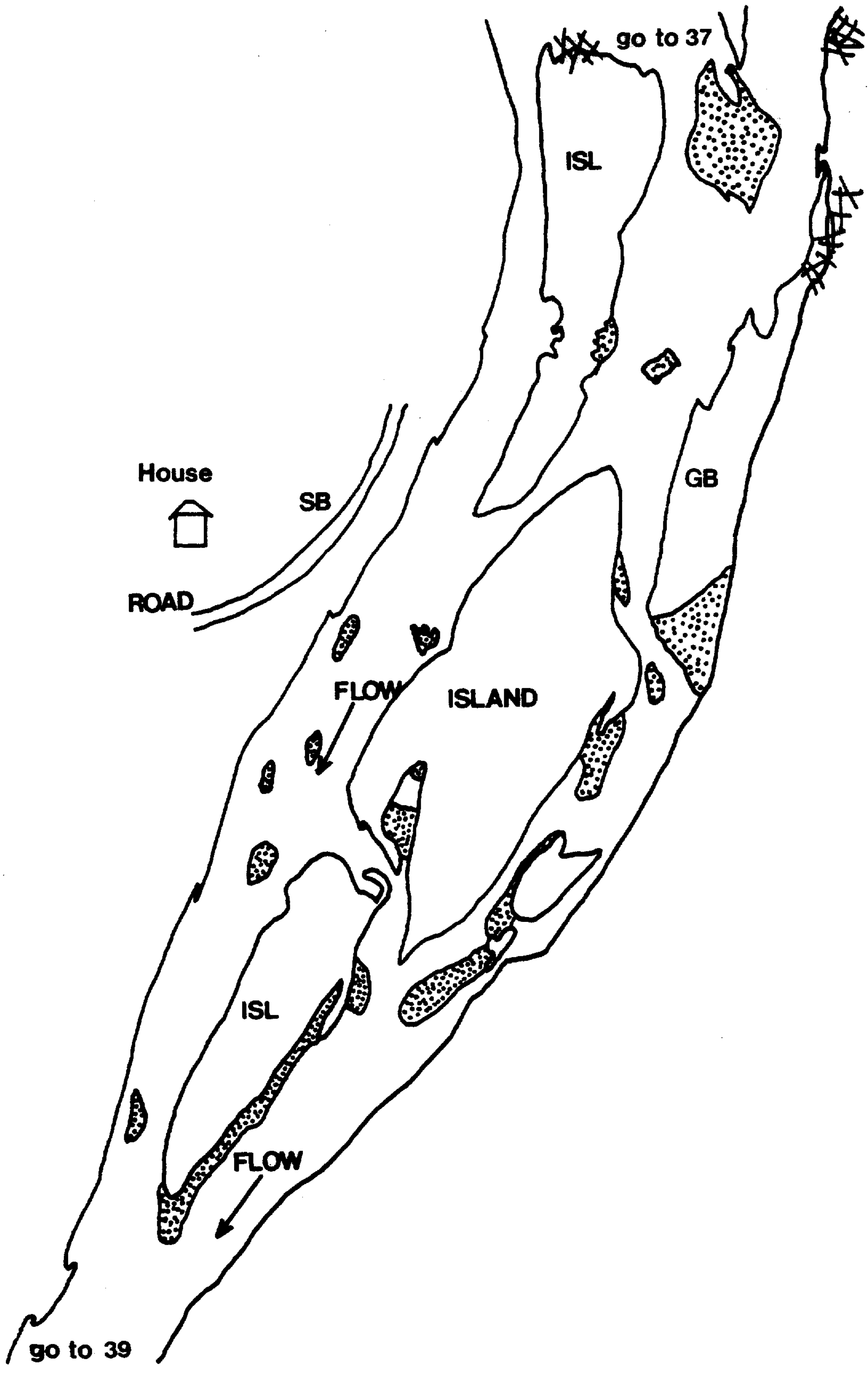
pages 40-79

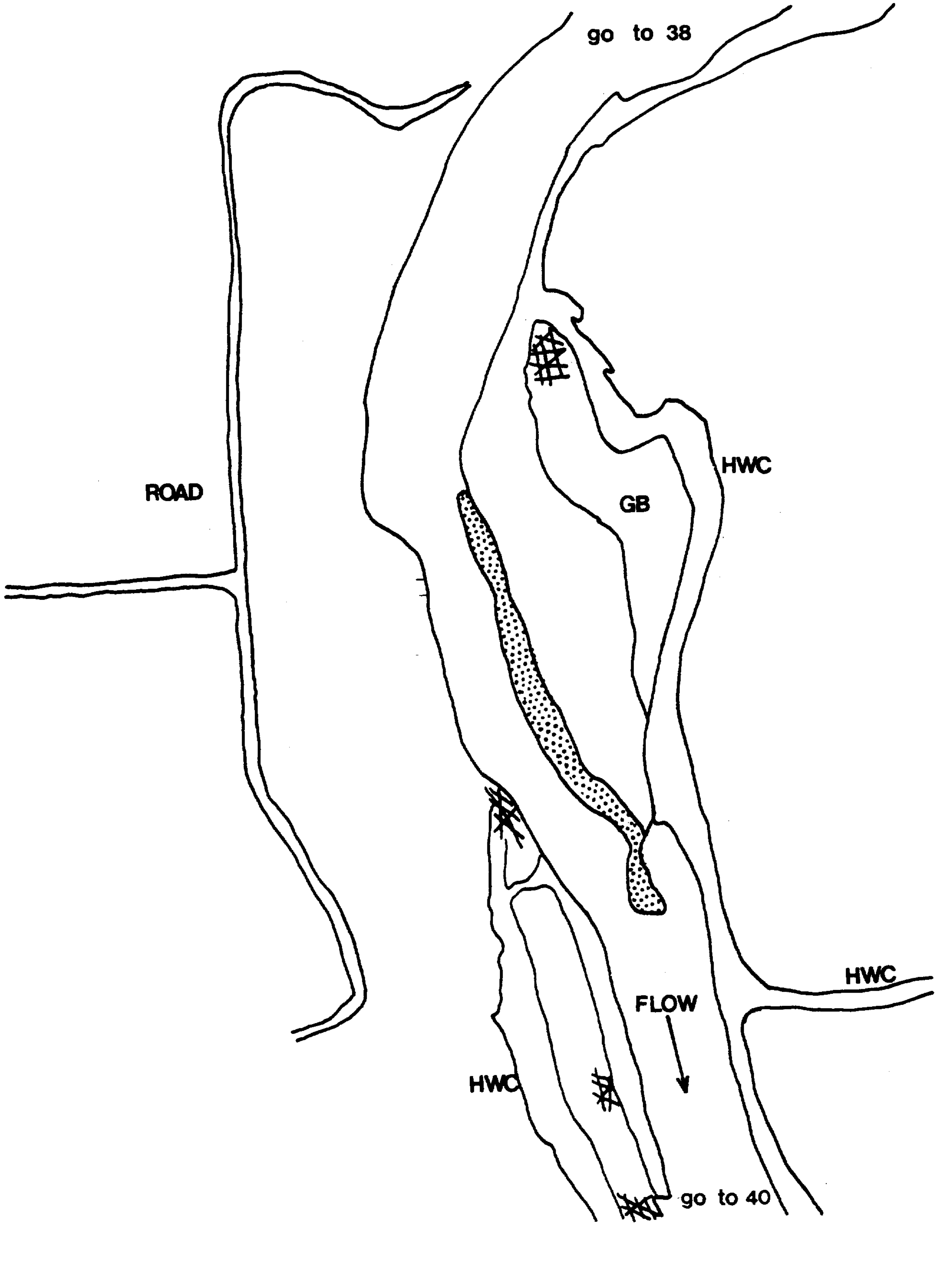

GB
HWC
FLOW
22
West Channel
Pgs. 36- 41,51
go to 37
East Channel
Pgs. 36,42-48
go to 42

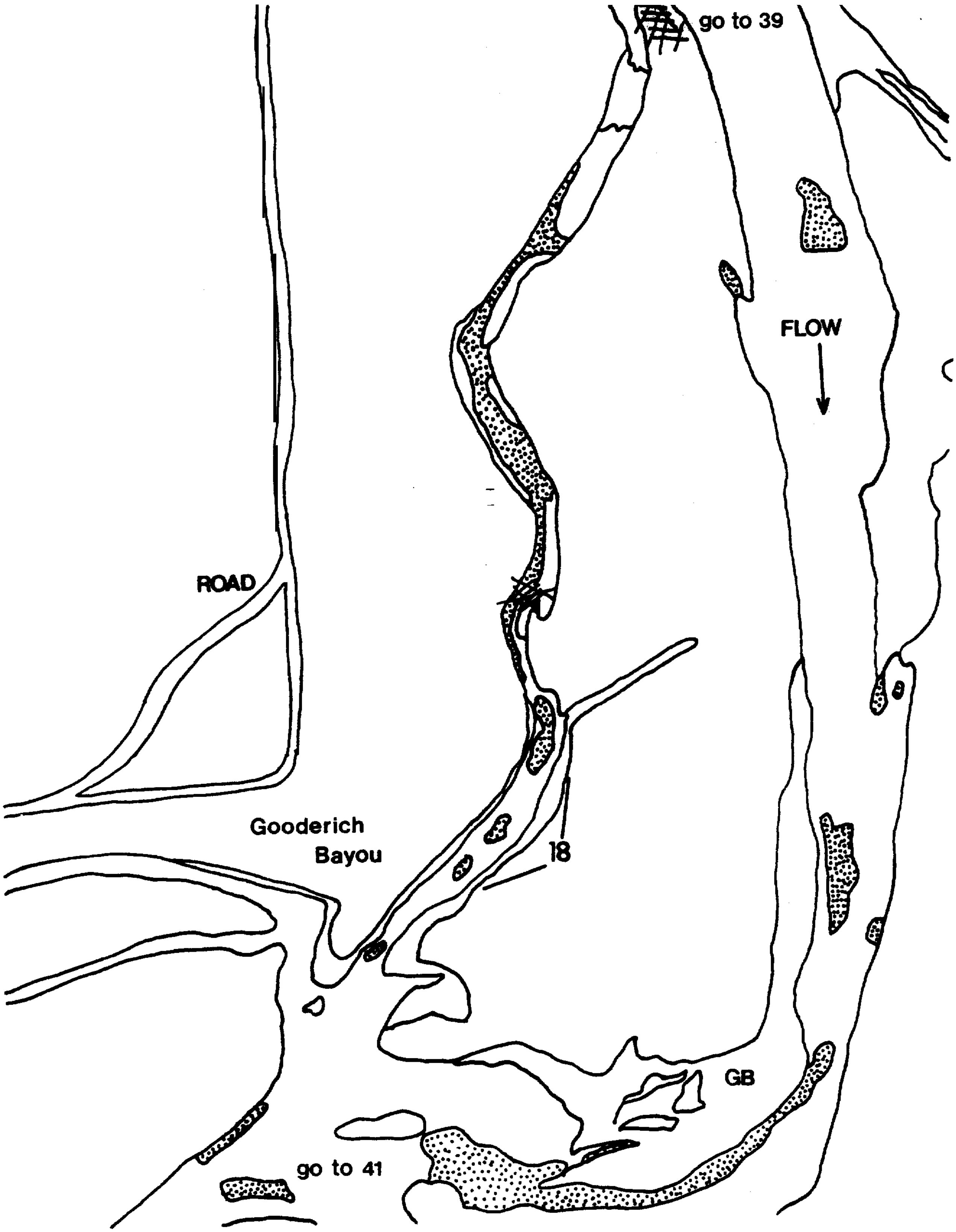
go to 36

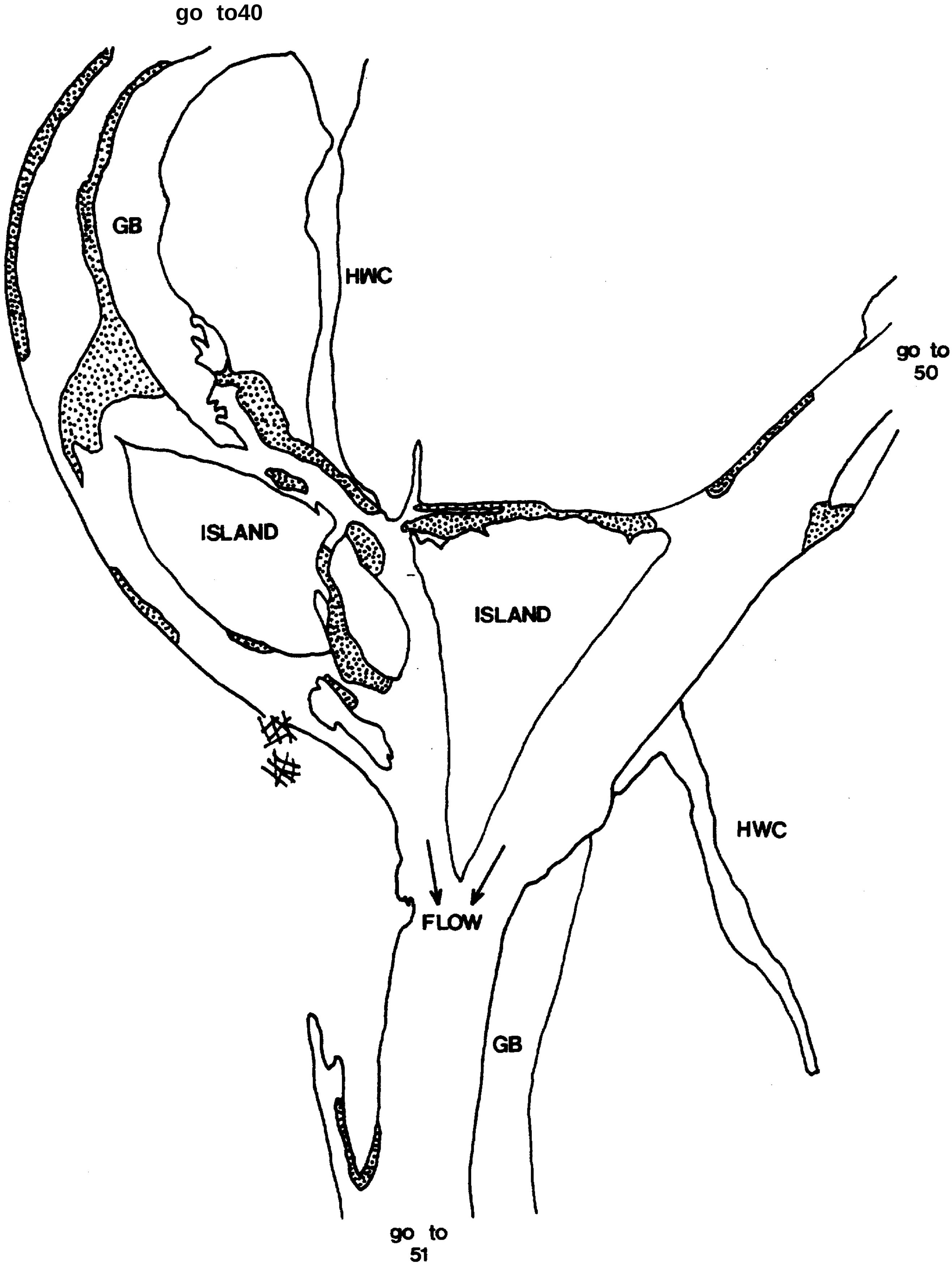


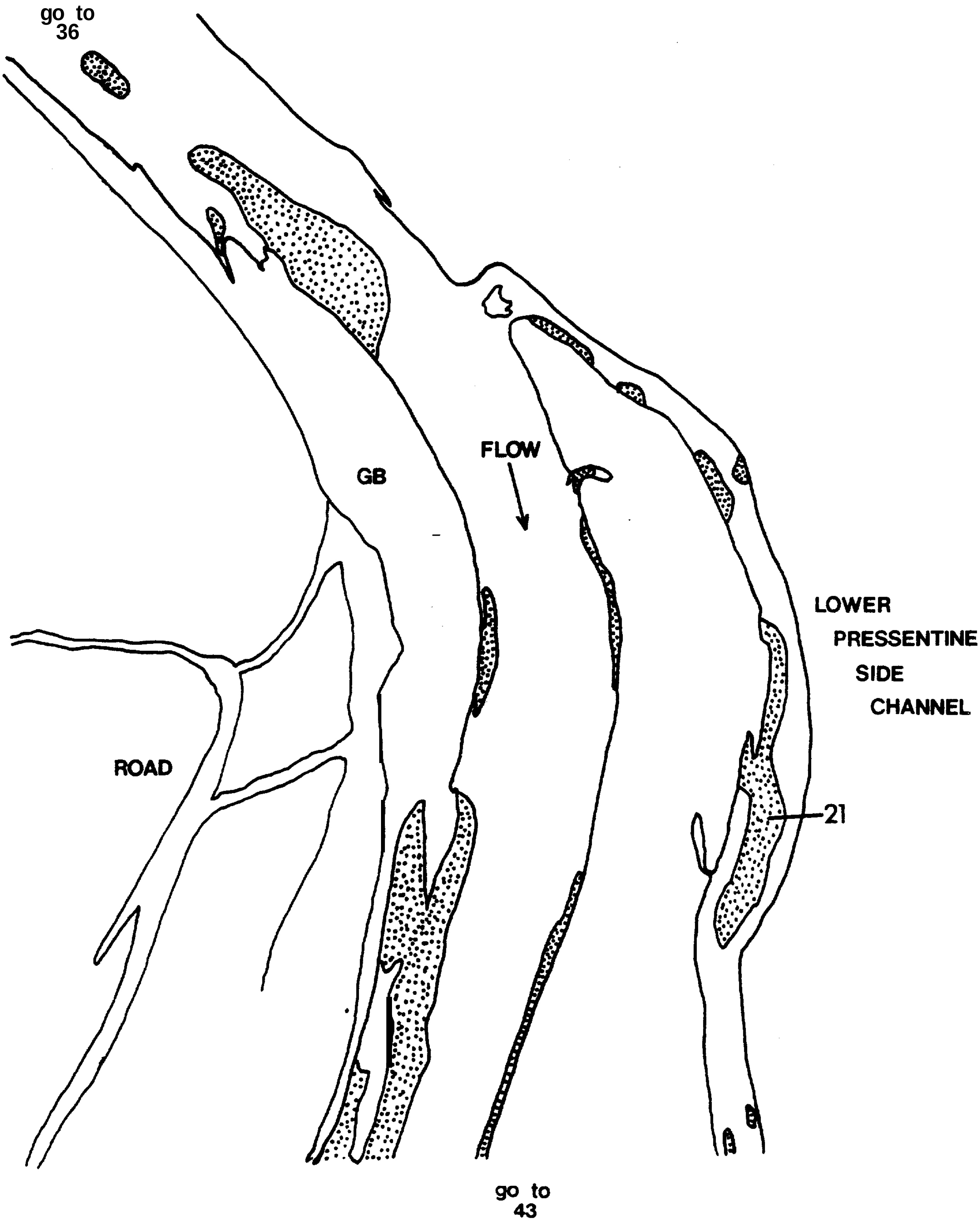
go to 38

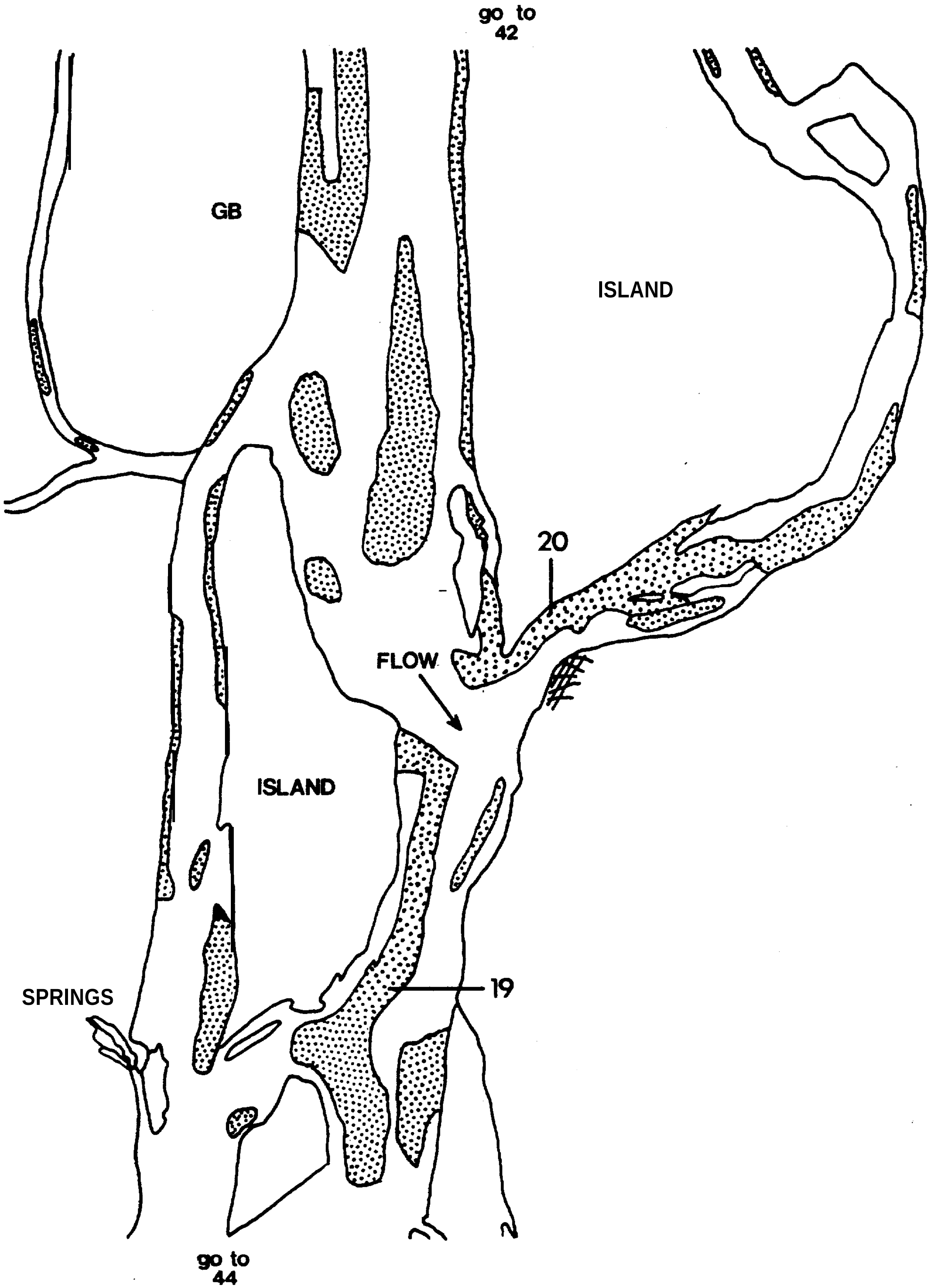

go to 37
ISL
House
SB
GB
ROAD
FLOW
ISLAND
ISL
FLOW
go to 39

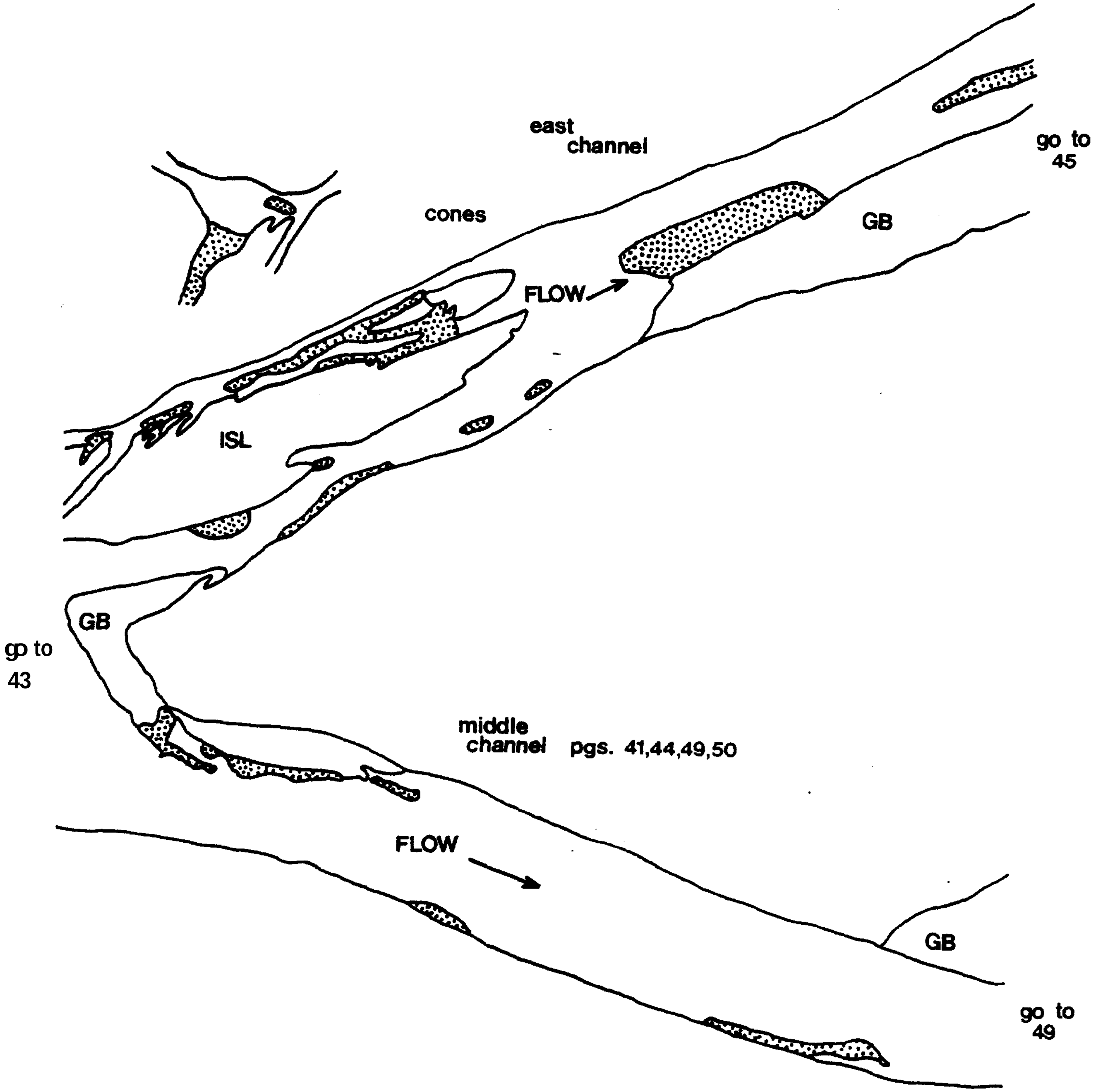

go to 38
ROAD
HWC
GB
HWC
FLOW
HWC
go to 40


go to 39
FLOW
ROAD
Gooderich
Bayou
18
GB
go to 41

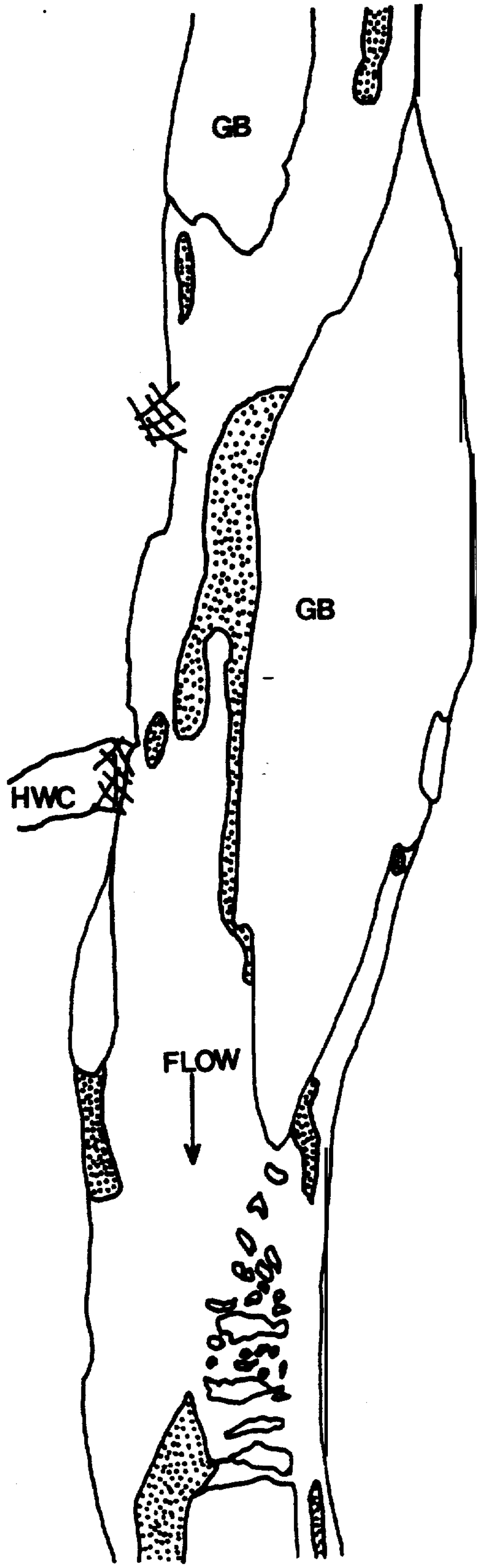

go to40
GB
HWC
go to
50
ISLAND
ISLAND
HWC
FLOW
GB
go to
51


go to
36
GB
FLOW
ROAD
LOWER
PRESSENTINE
SIDE
CHANNEL
21
go to
43

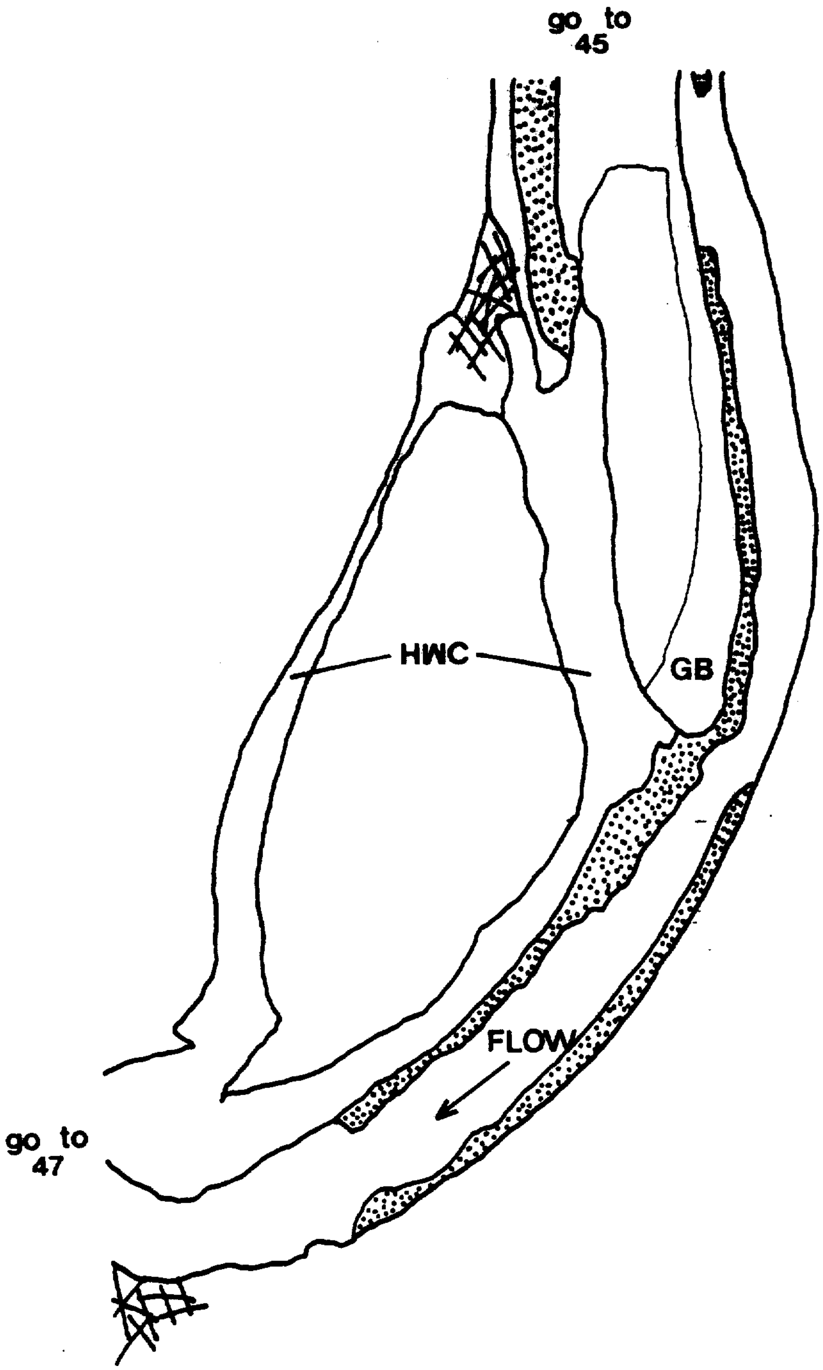

go to
42
GB
ISLAND
20
FLOW
ISLAND
SPRINGS
19
go to
44

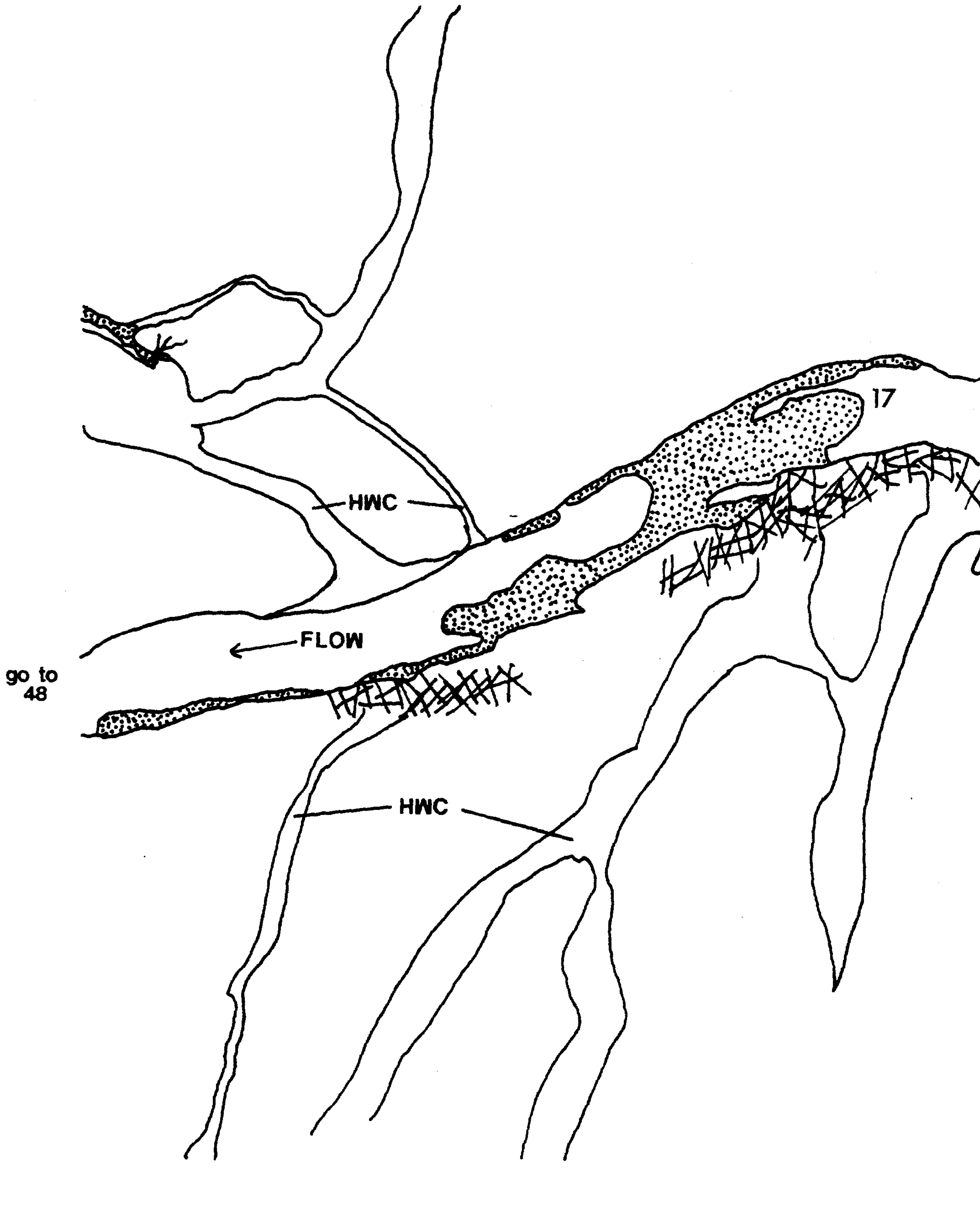

east
channel
cones
go to
45
GB
FLOW
ISL
GB
go to
43
middle
channel
pgs. 41,44,49,50
FLOW
GB
go to
49

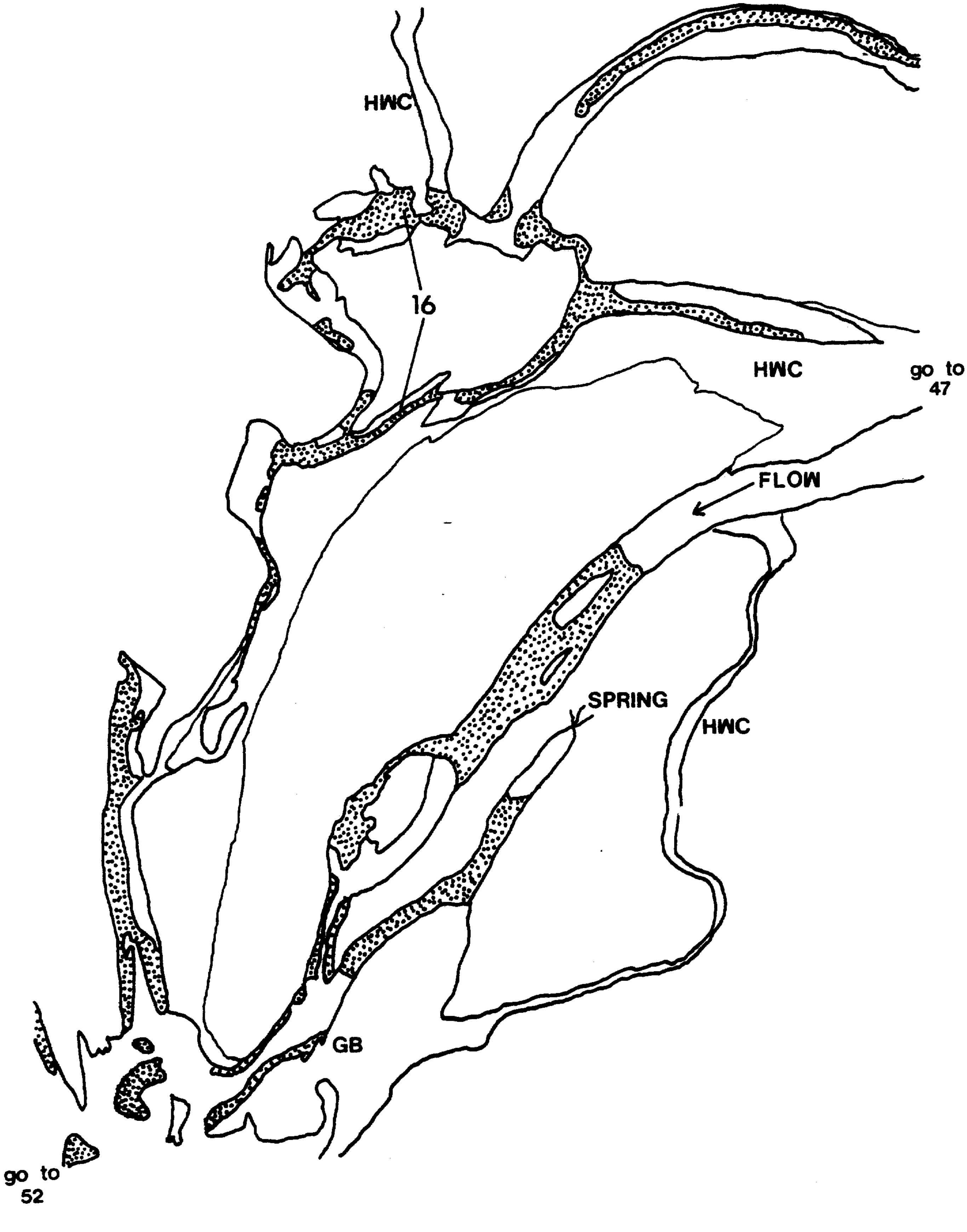
go to
44

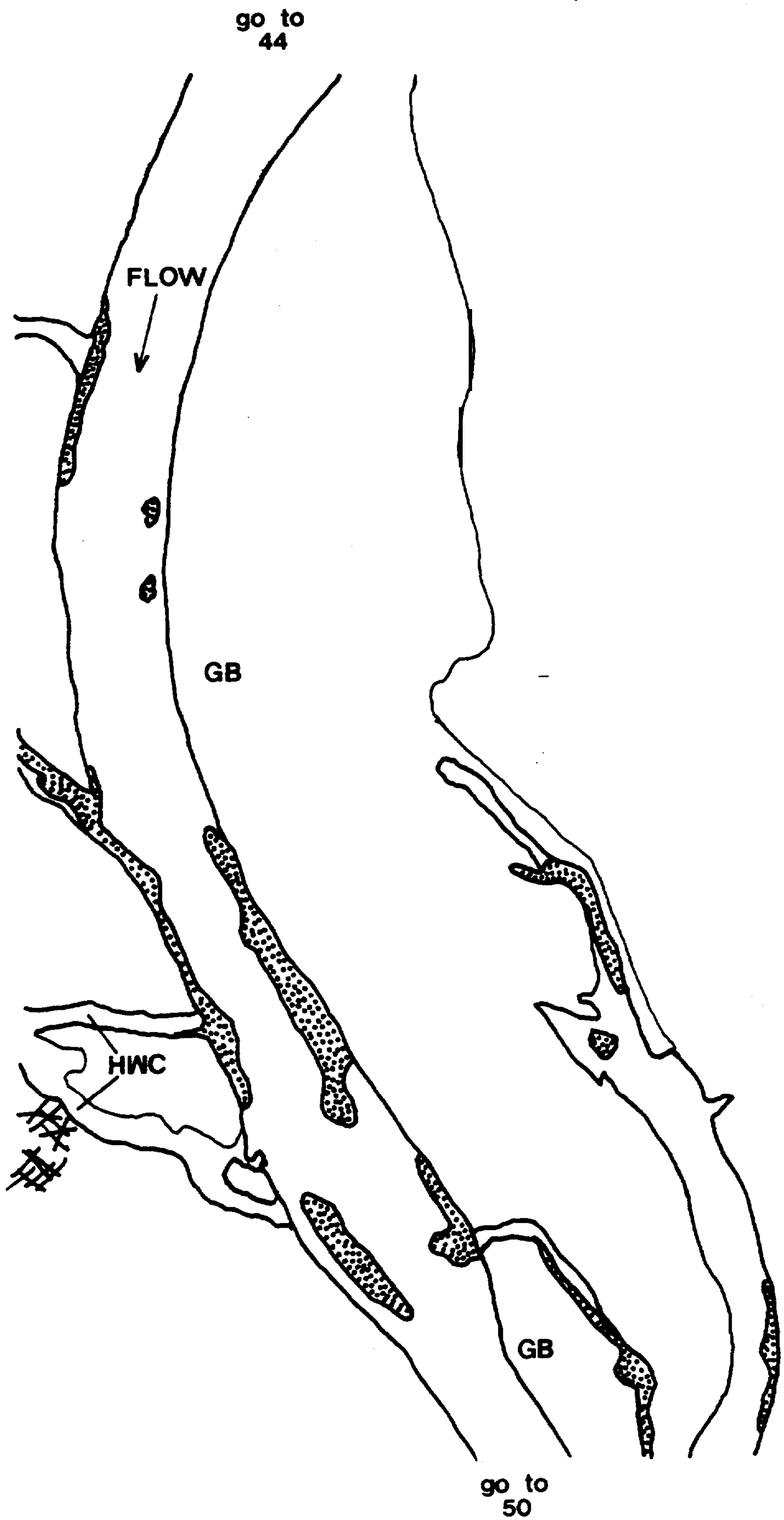


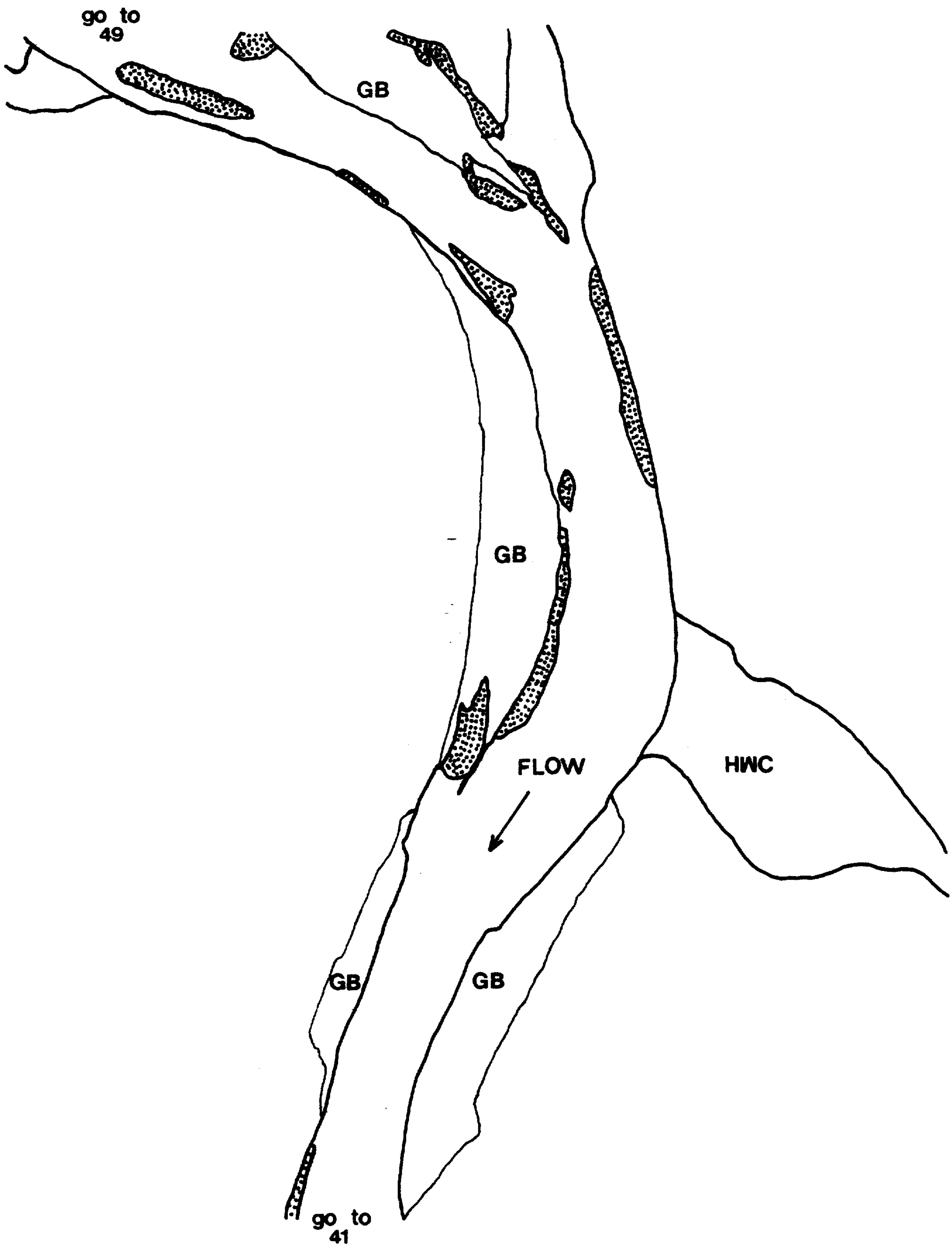
go to
46

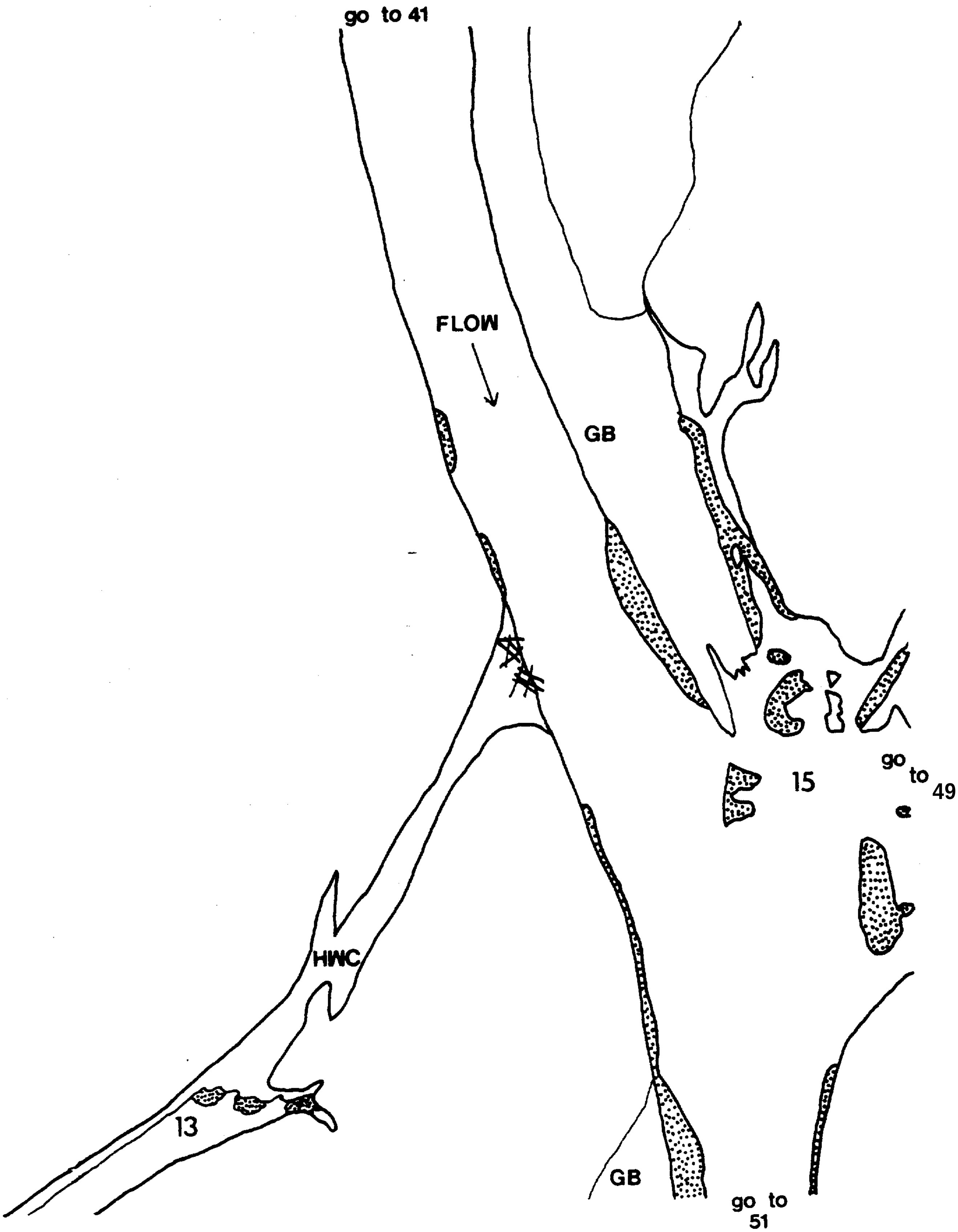

go to 45
HWC
GB
FLOW
go to 47

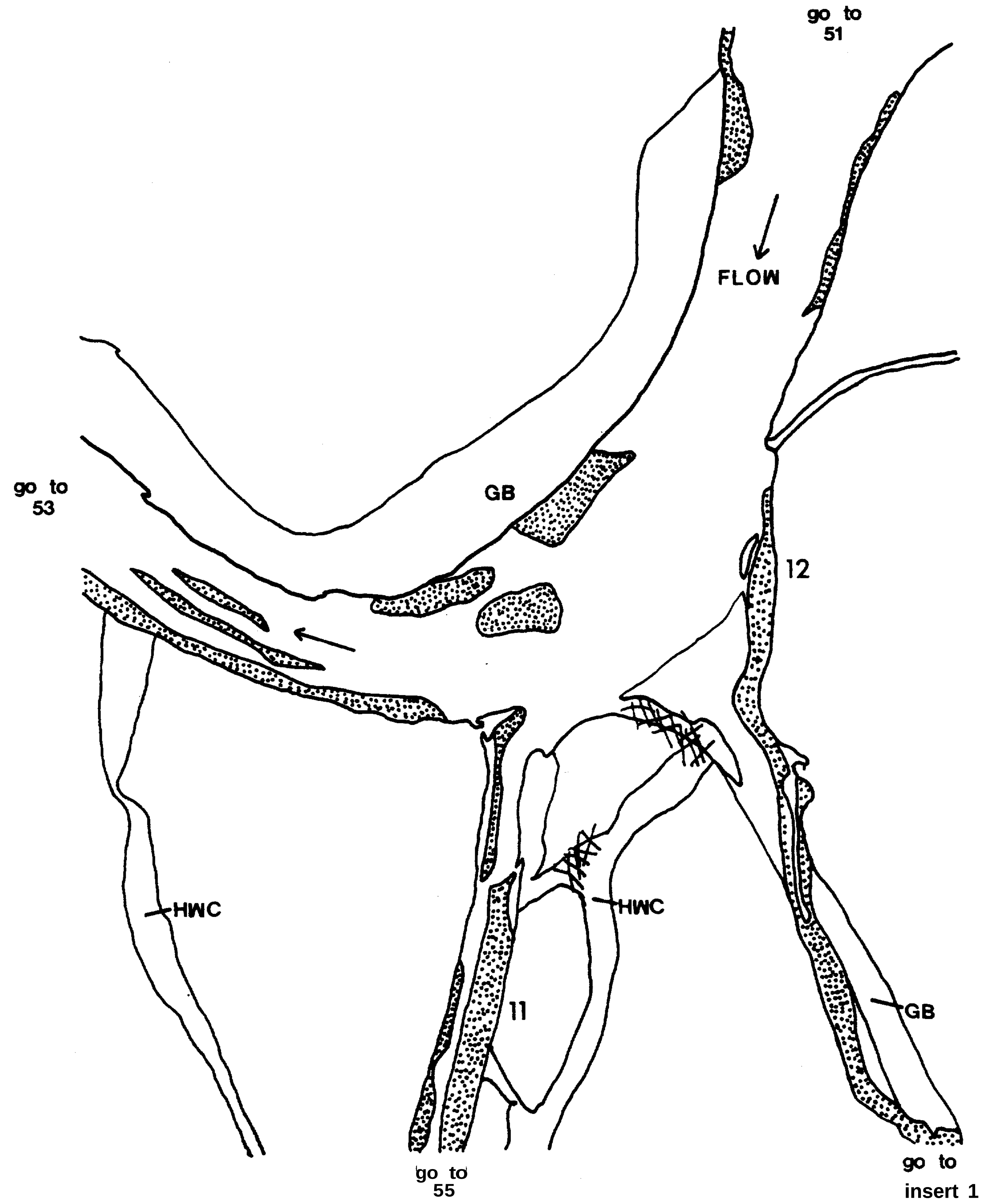

HWC
FLOW
go to
48
17
go to
46
HWC


HWC
16
HWC
go to
47
FLOW
SPRING
HWC
GB
go to
52

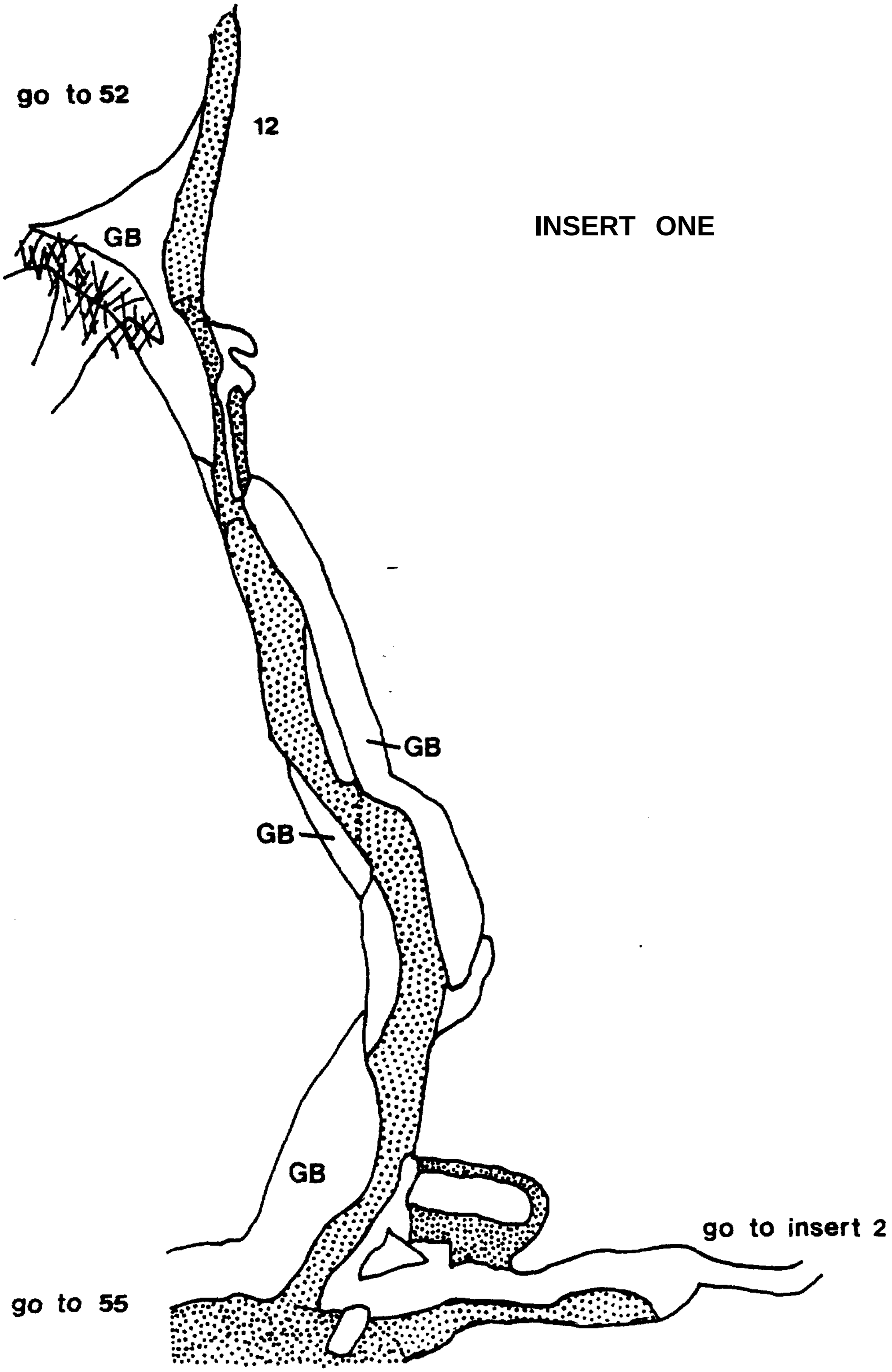

go to
44
FLOW
GB
HWC
GB
go to
50


go to 49
GB
GB
FLOW
HWC
GB
GB
go to 41

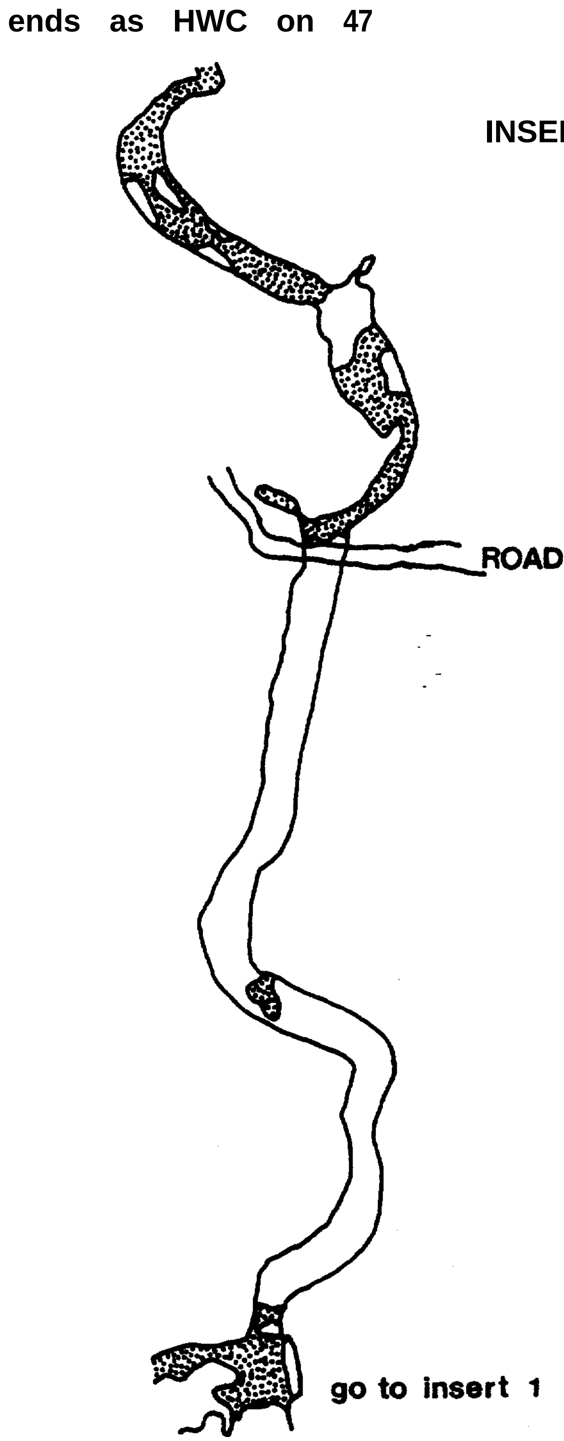

go to 41
FLOW
GB
15
go to 49
HWC
13
GB
go to 51

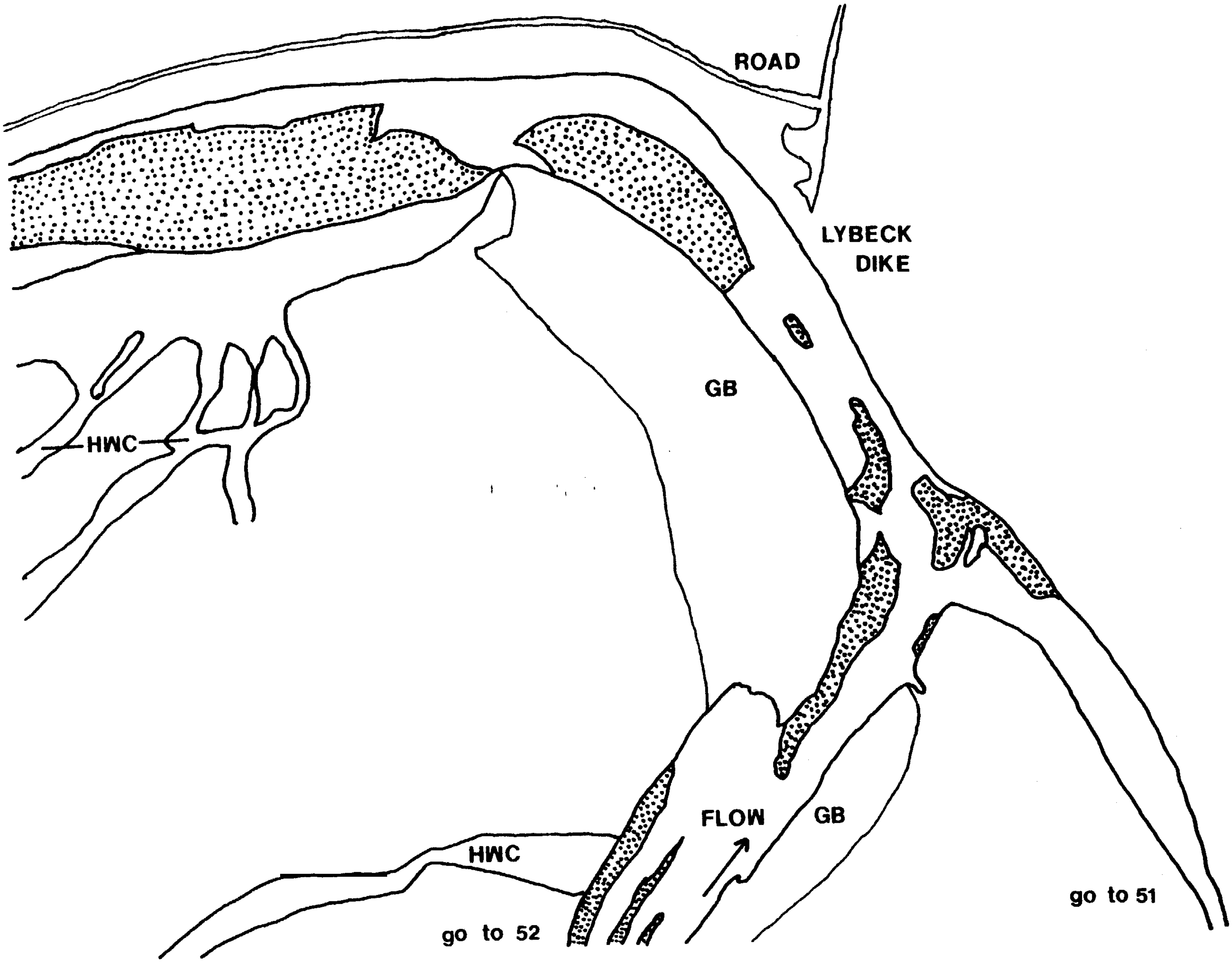


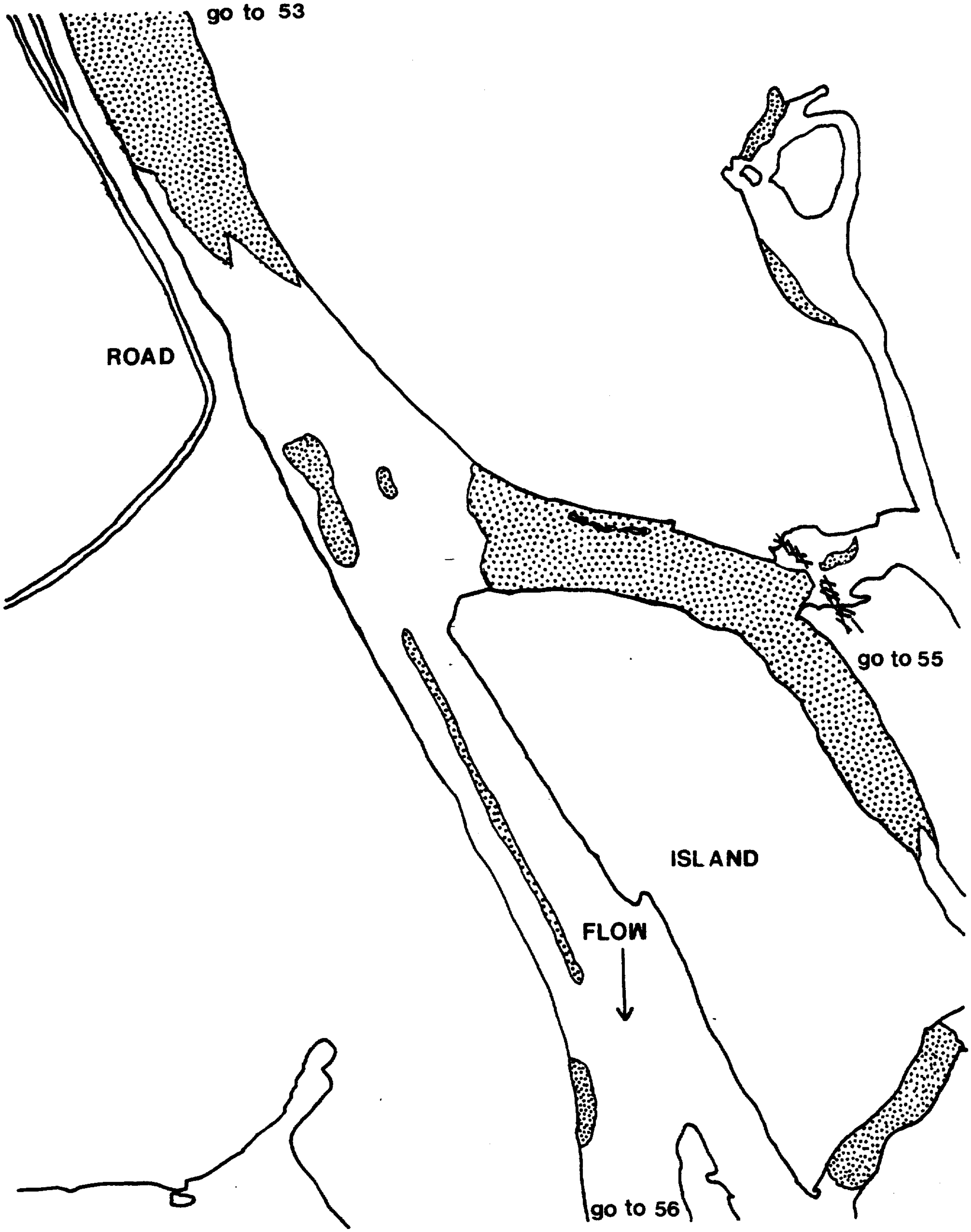
go to
51
FLOW
go to
53
GB
12
HWC
HWC
11
GB
go to
55
go to
insert 1

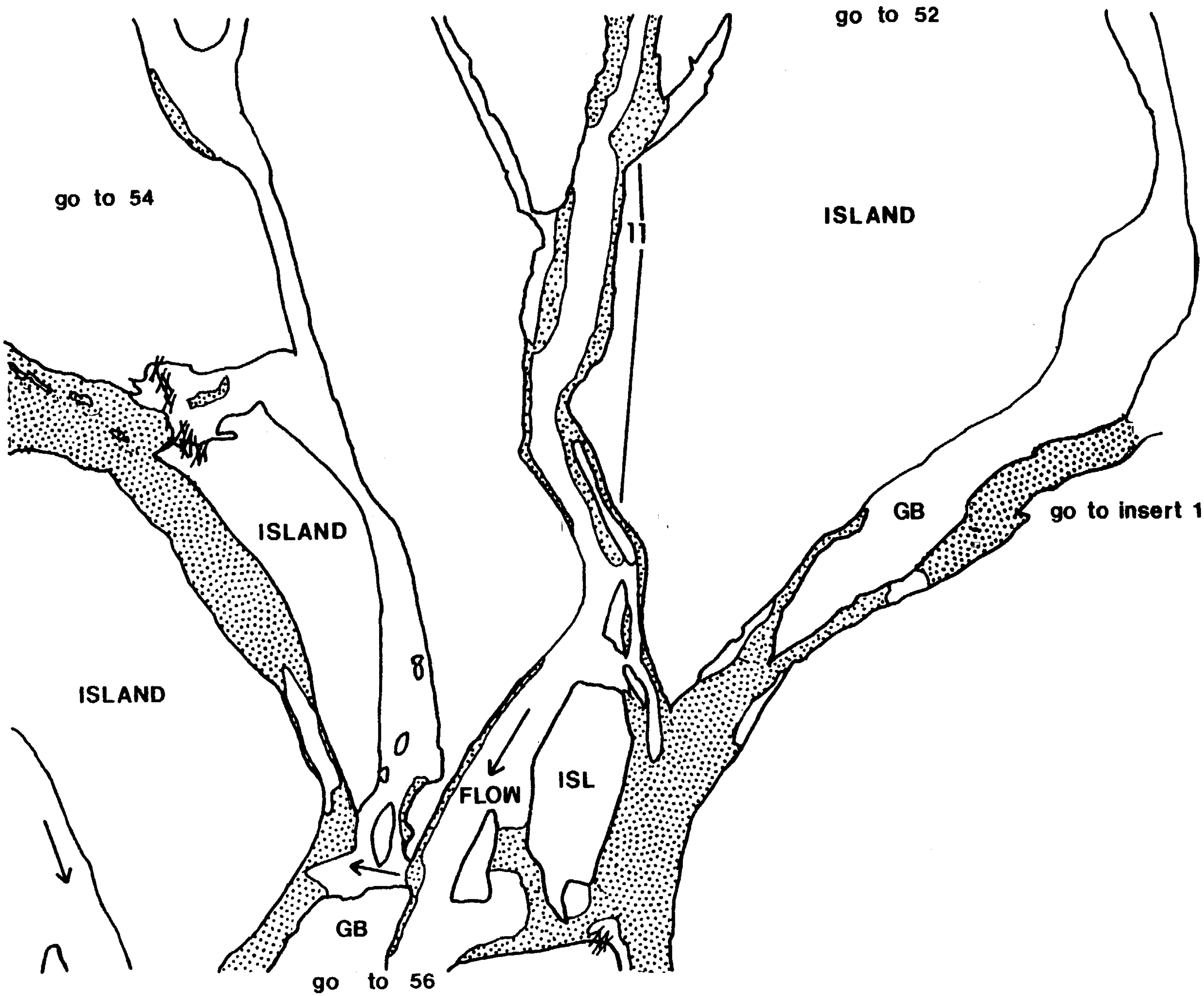

go to 52
12
INSERT ONE
GB
GB
GB
GB
go to insert 2
go to 55

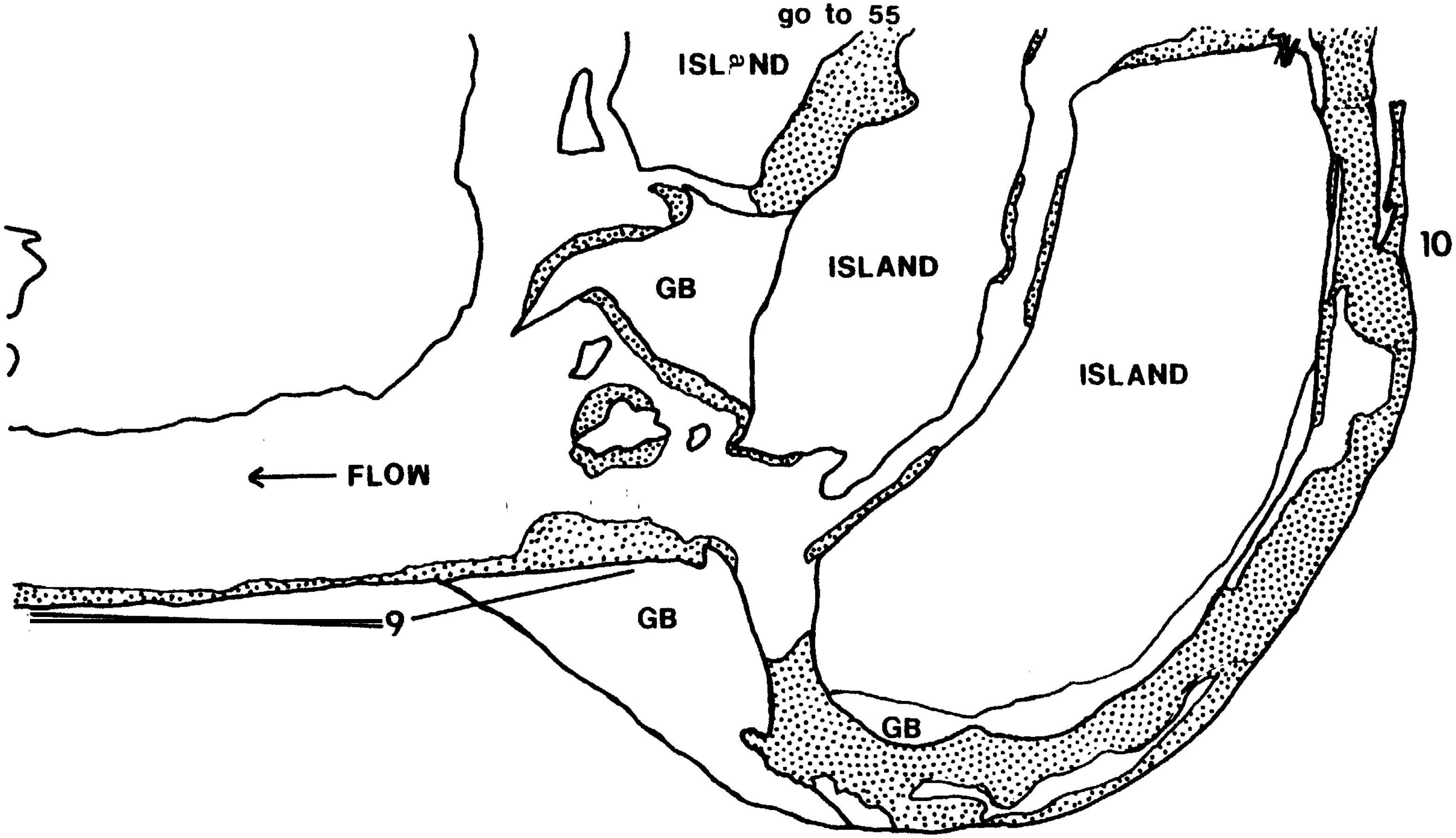
INSERT TWO

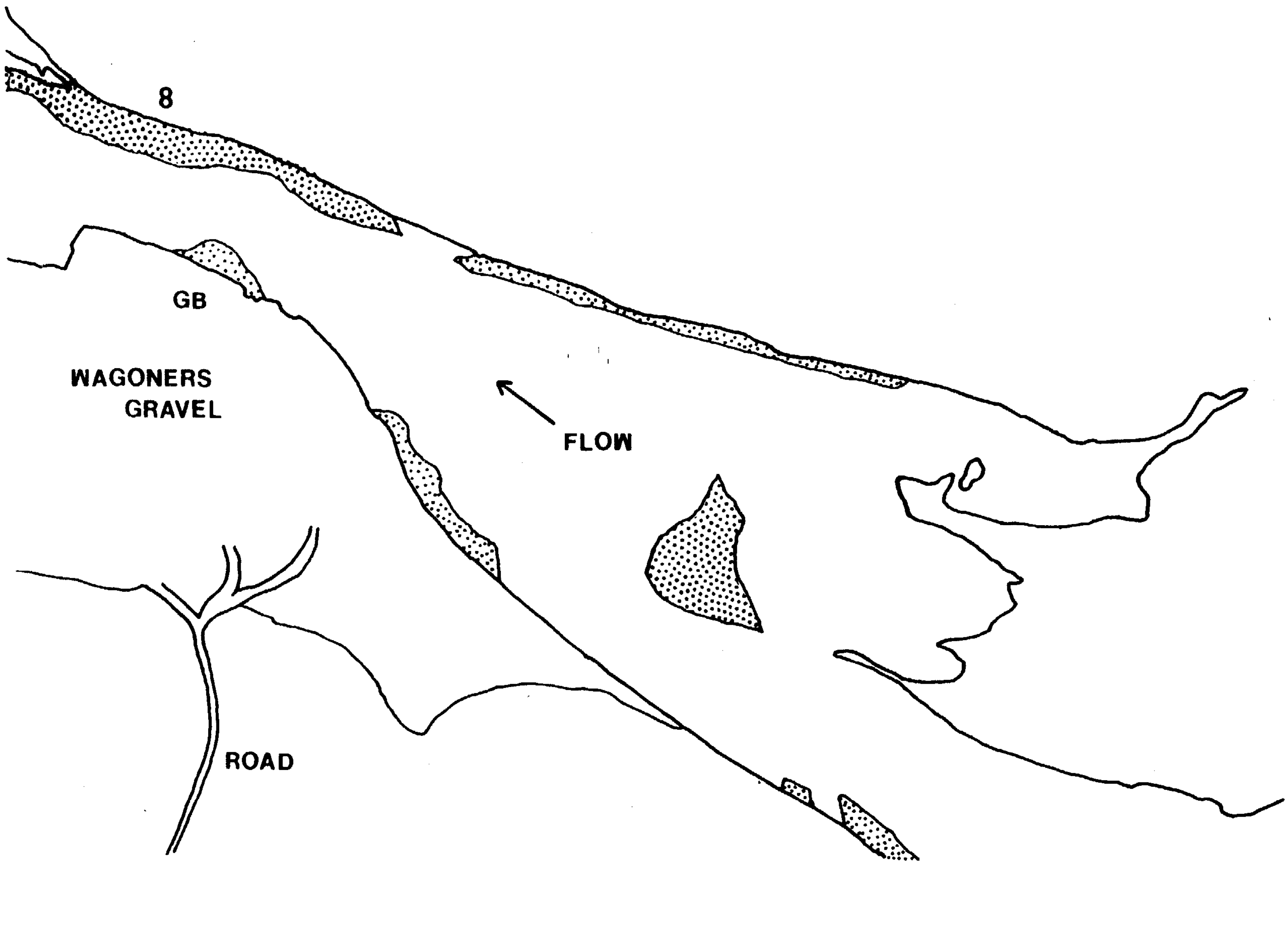


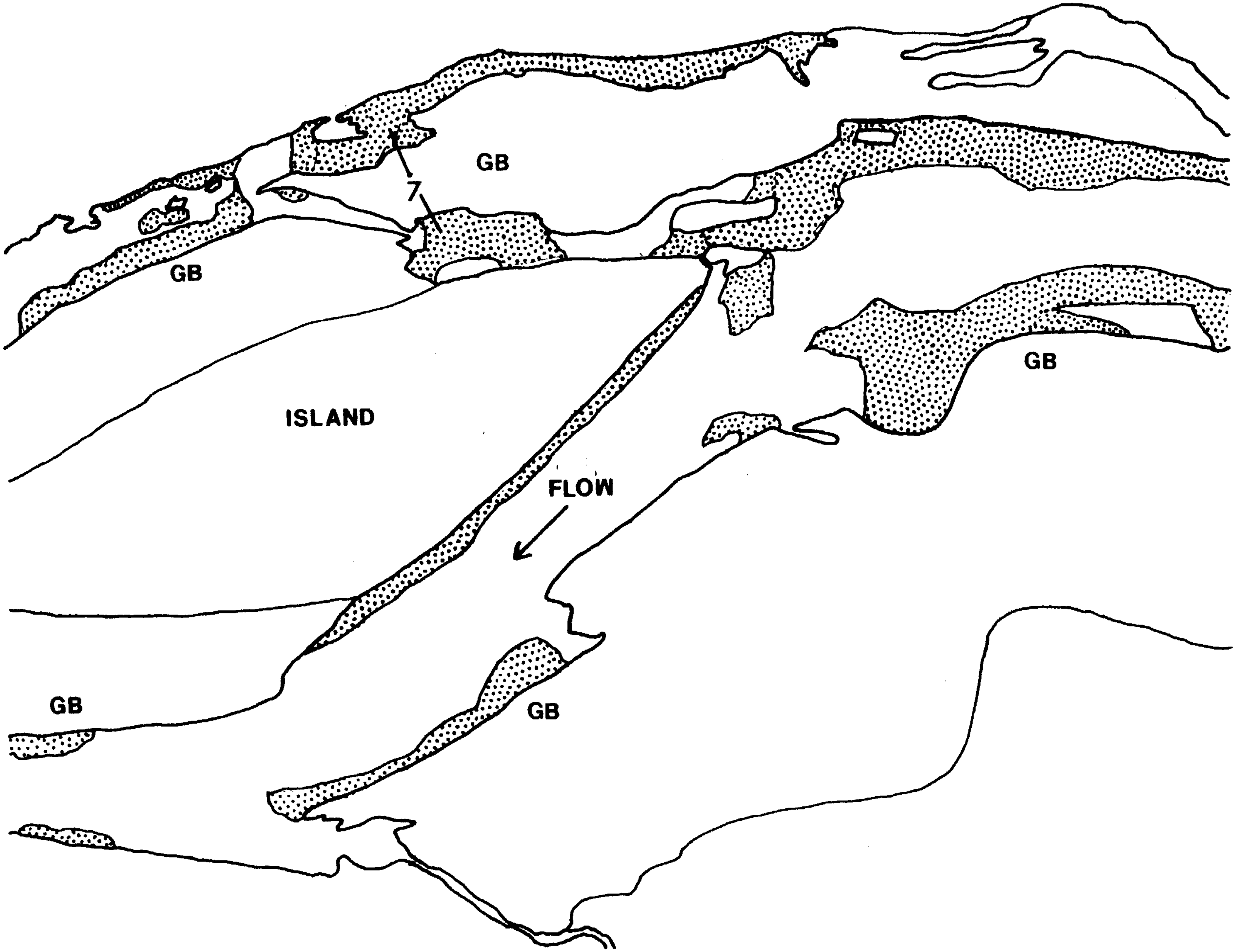

ROAD
LYBECK DIKE
GB
HWC
FLOW
GB
HWC
go to 52
go to 51

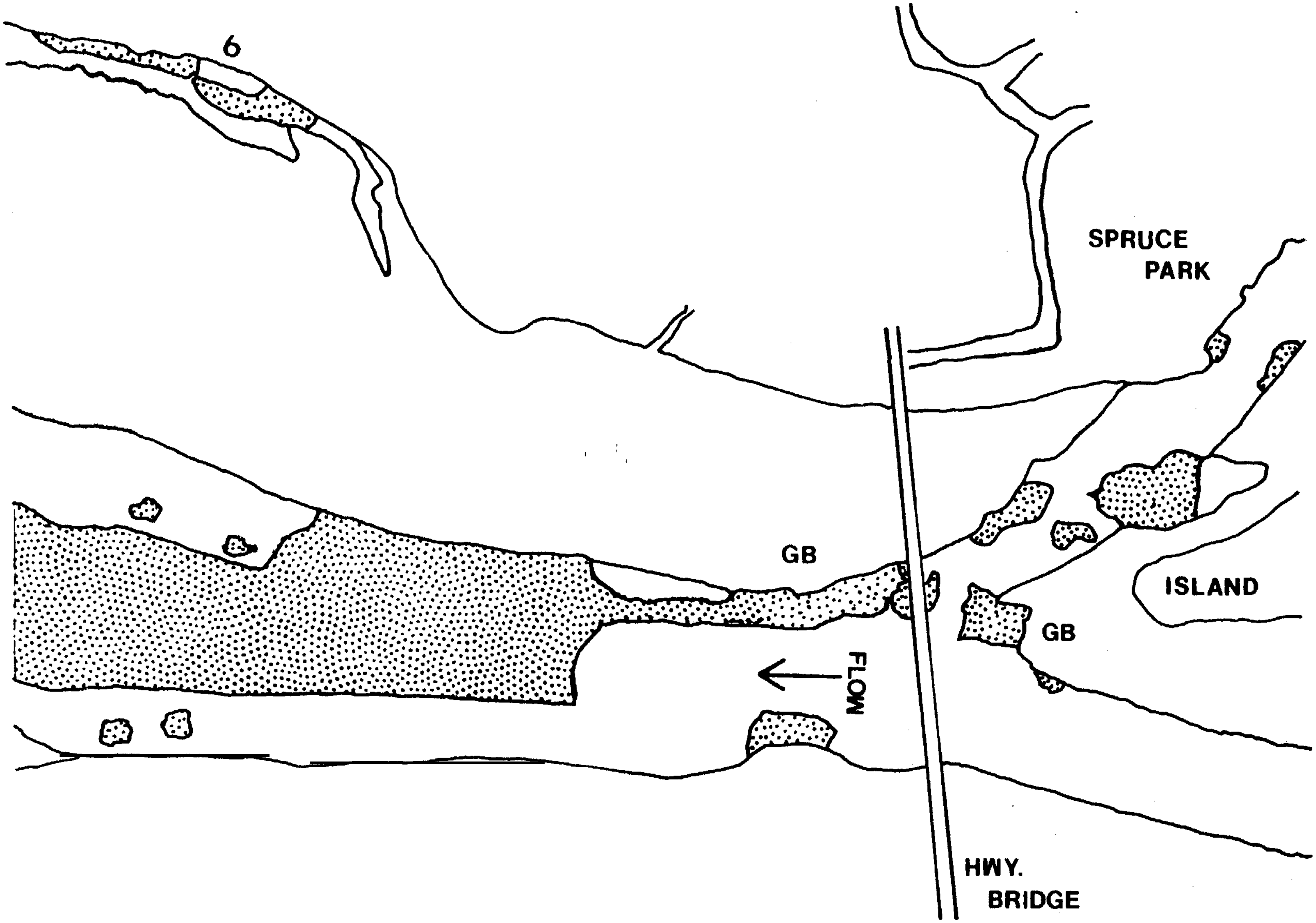

go to 53
ROAD
go to 55
ISLAND
FLOW
go to 56

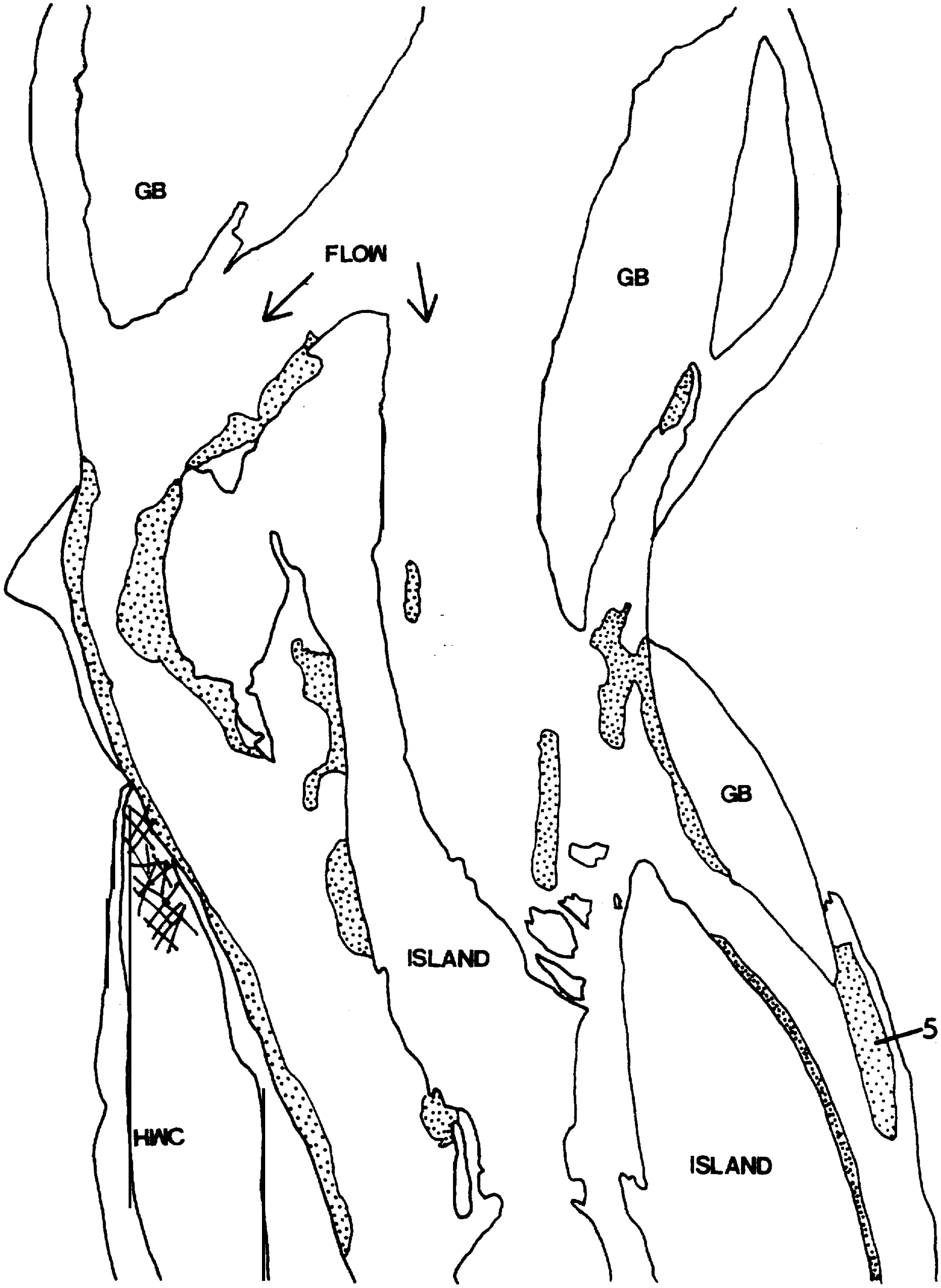

go to 52
go to 54
ISLAND
11
ISLAND
GB
go to insert 1
8
ISLAND
FLOW
ISL
GB
go to 56

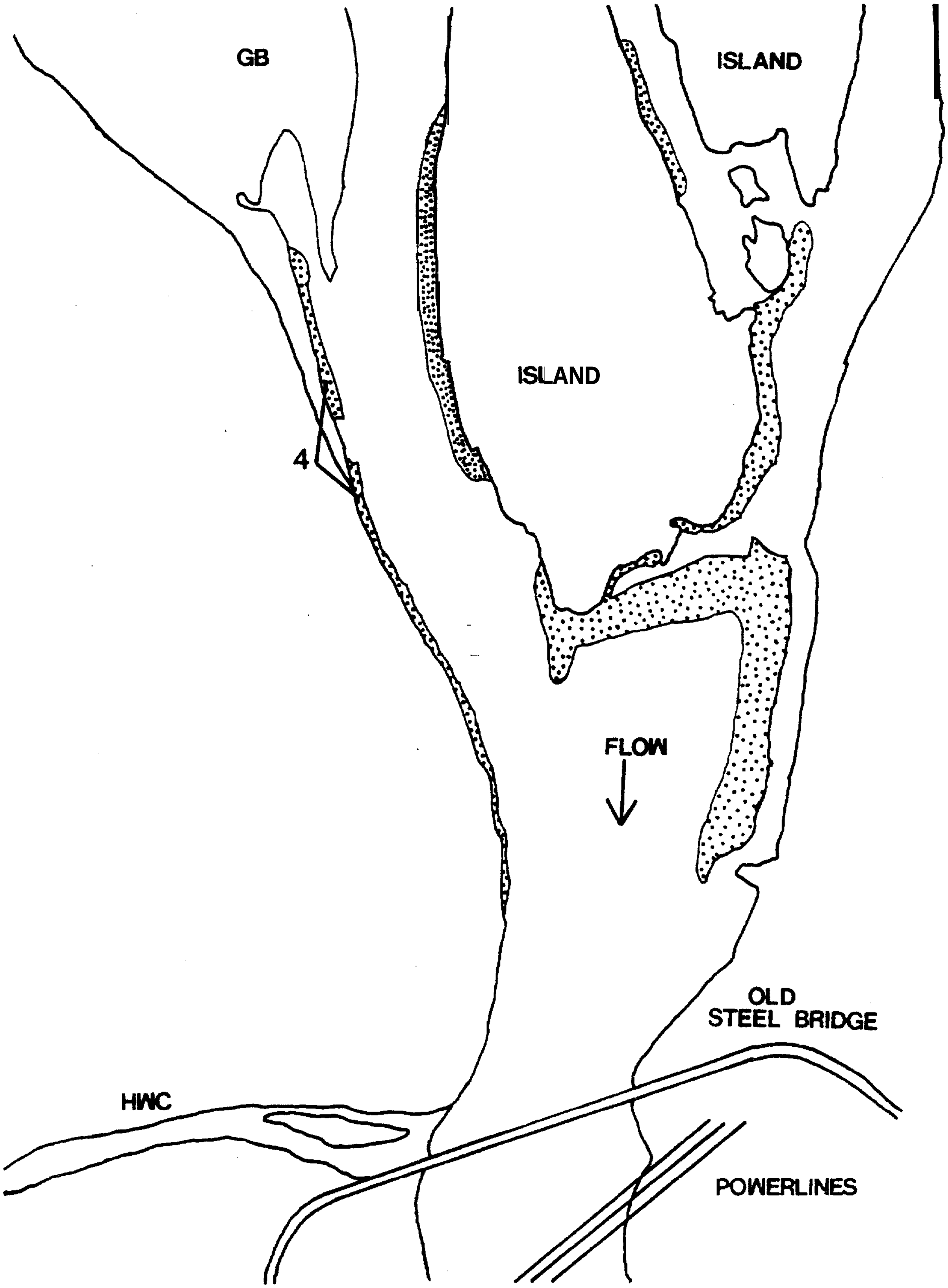

go to 55
ISLAND
ISLAND
ISLAND
GB
FLOW
GB
GB
9
10

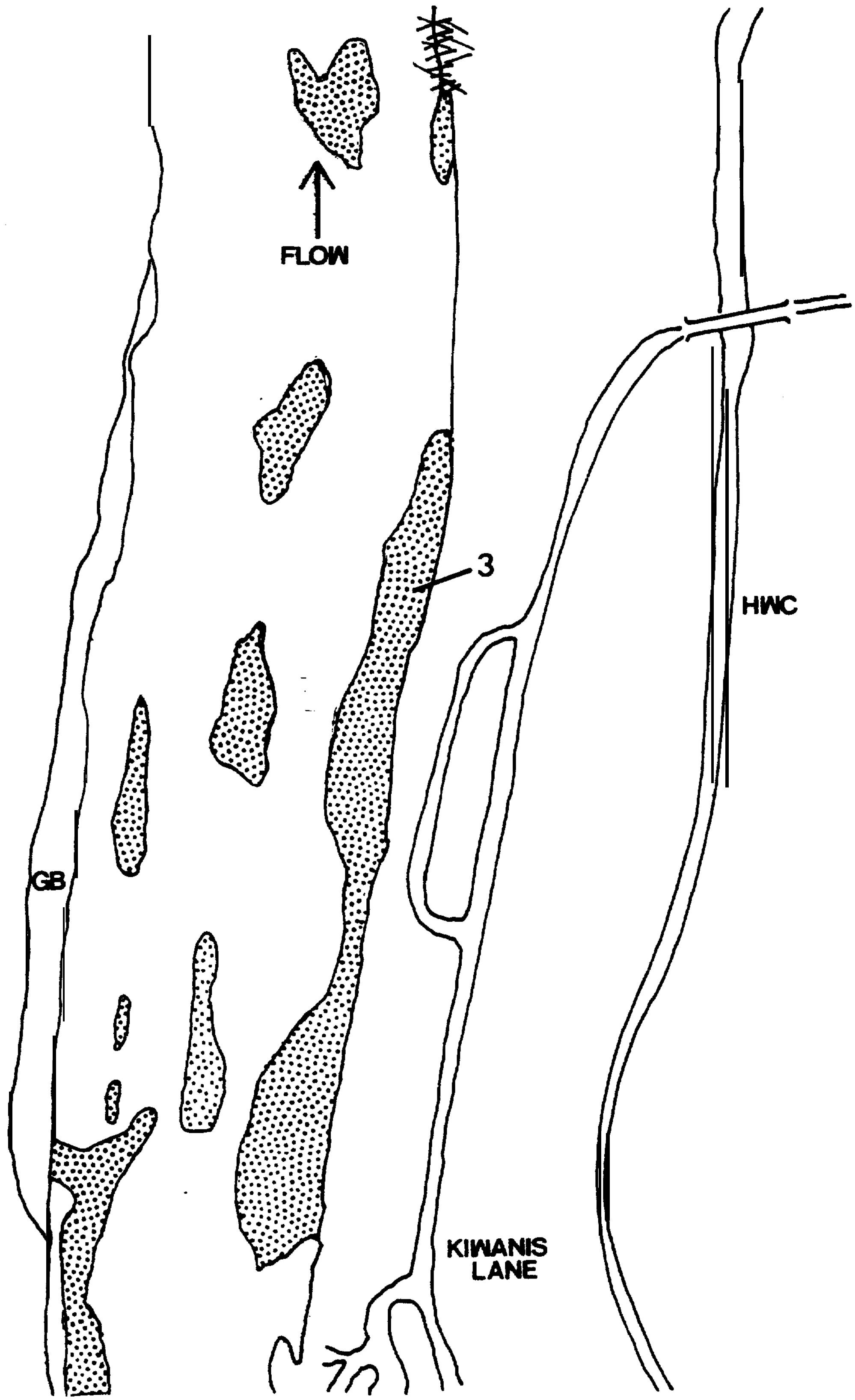

8
GB
WAGONERS
GRAVEL
FLOW
ROAD

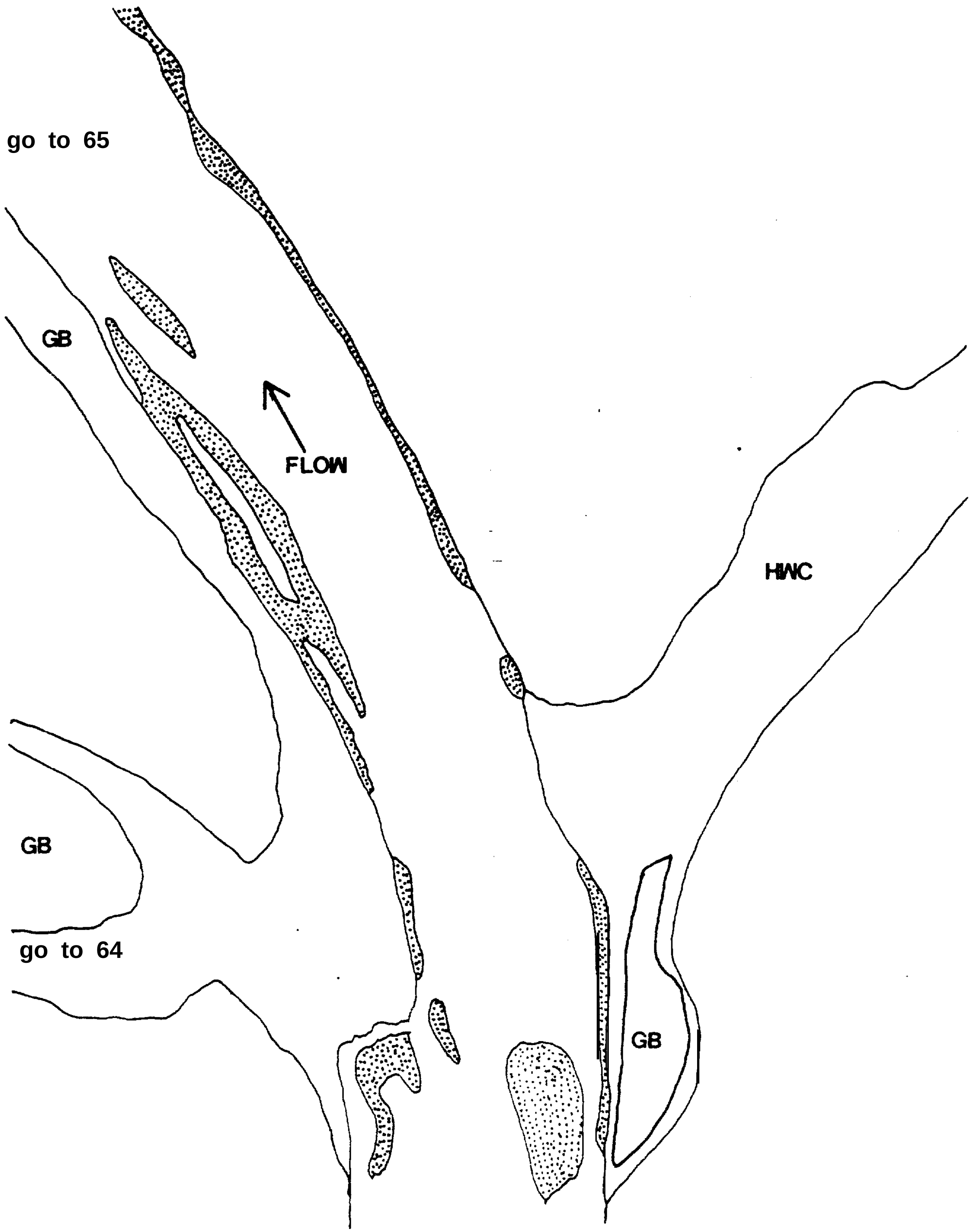

GB
7
GB
ISLAND
GB
FLOW
GB
GB


6
SPRUCE PARK
GB
ISLAND
GB
FLOW
HWY. BRIDGE

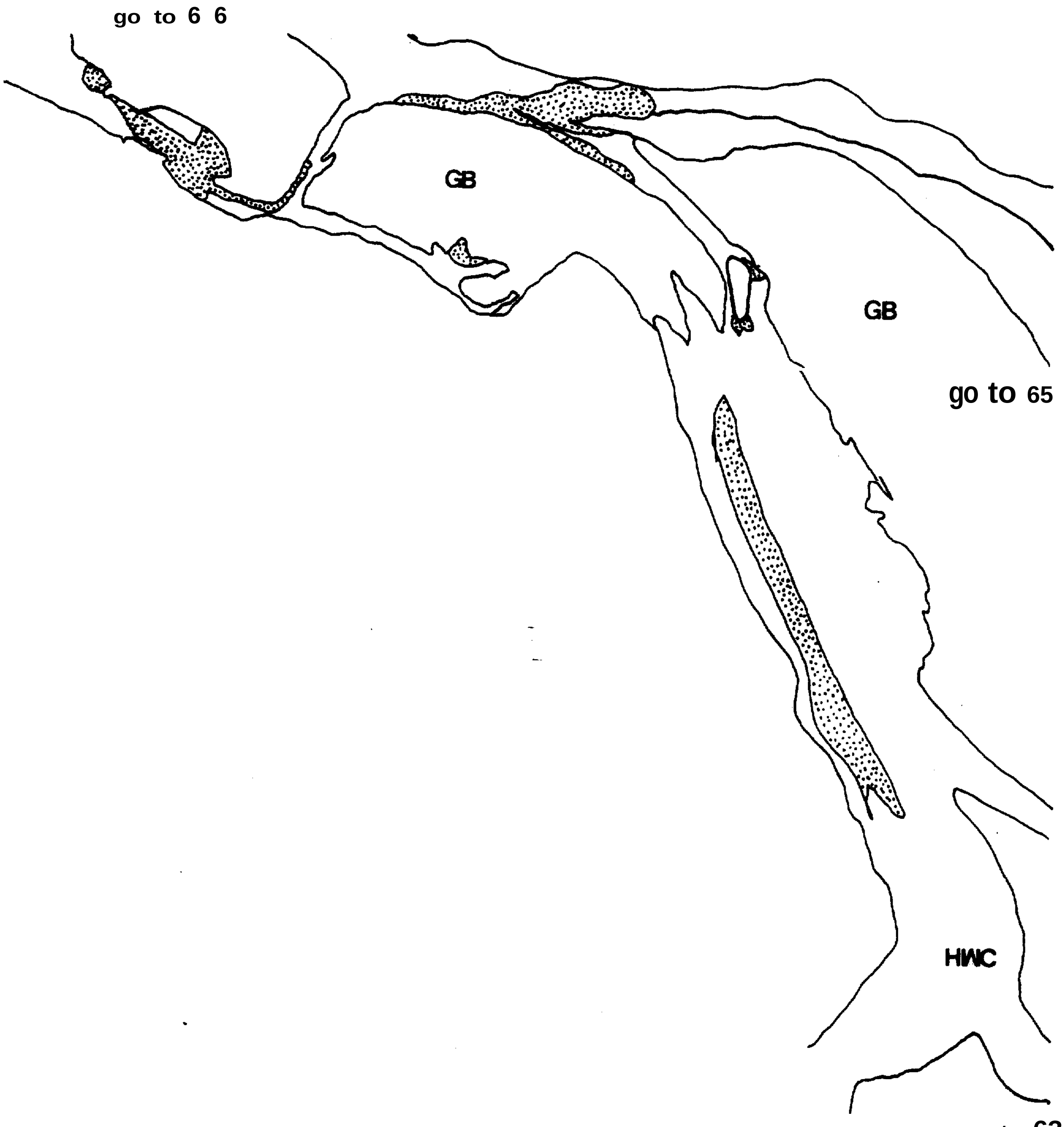

GB
FLOW
GB
GB
ISLAND
5
HWC
ISLAND


GB
ISLAND
ISLAND
4
FLOW
OLD
STEEL BRIDGE
HWC
POWERLINES

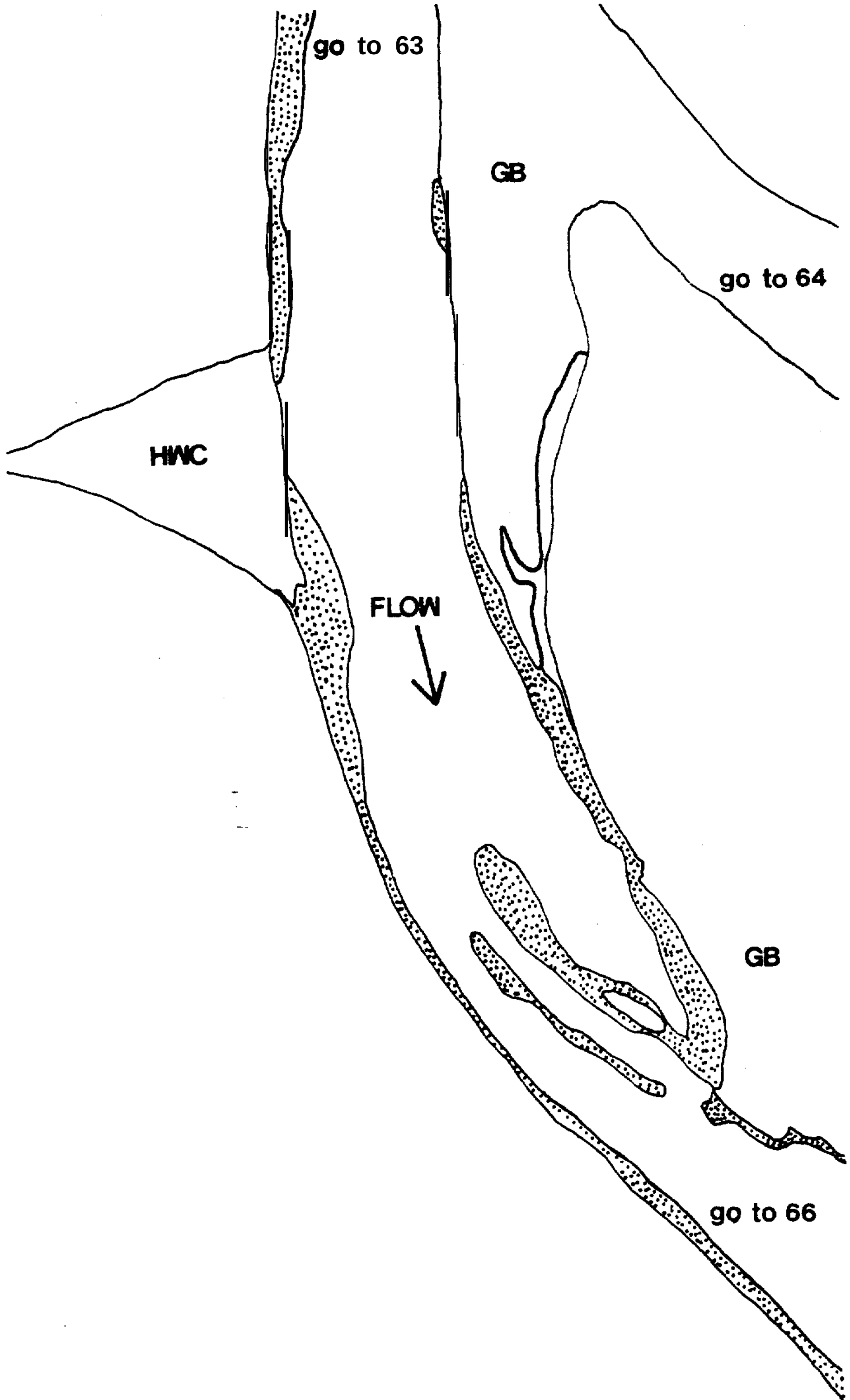

FLOW
3
HWC
GB
KIWANIS
LANE

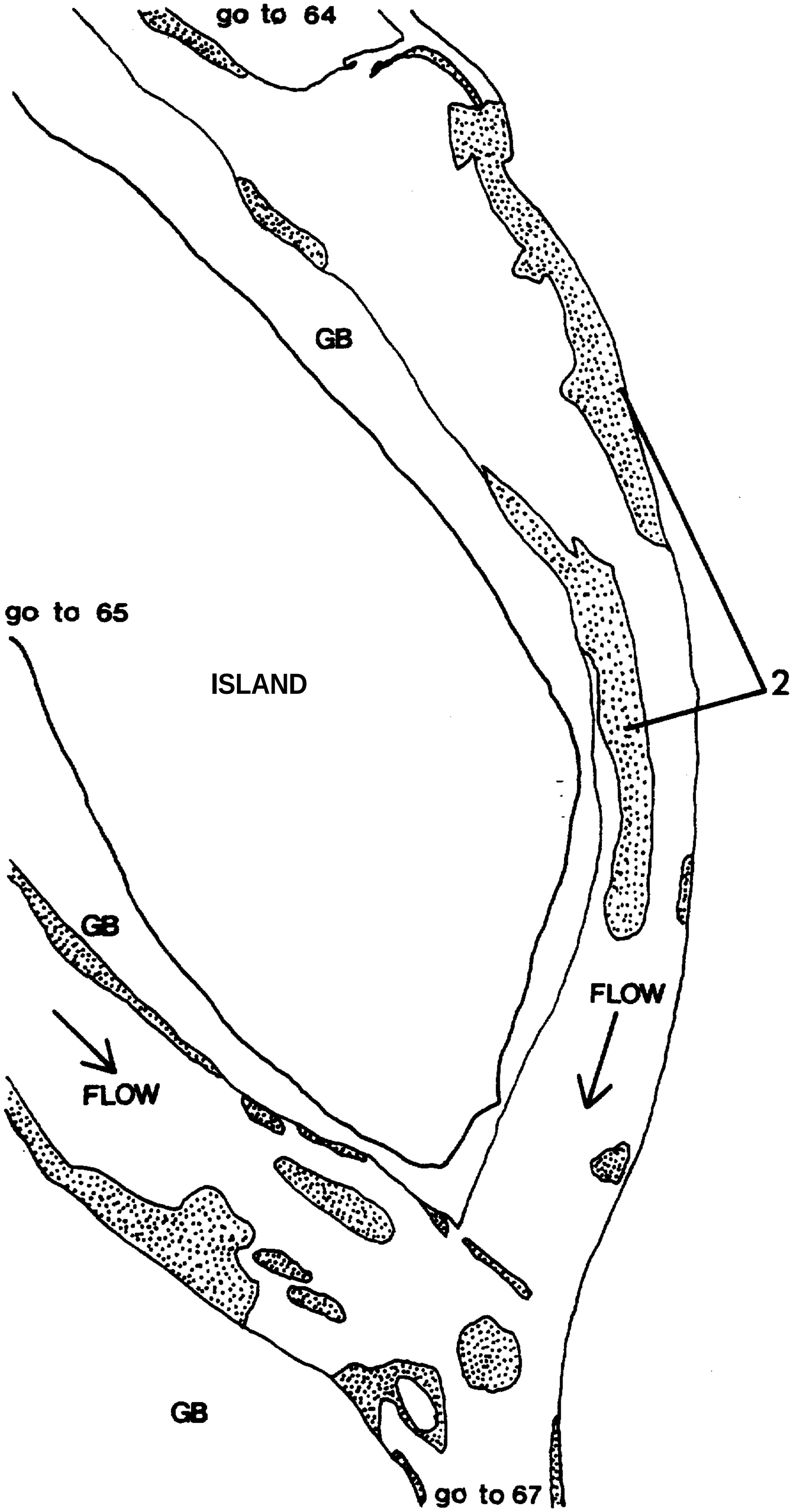


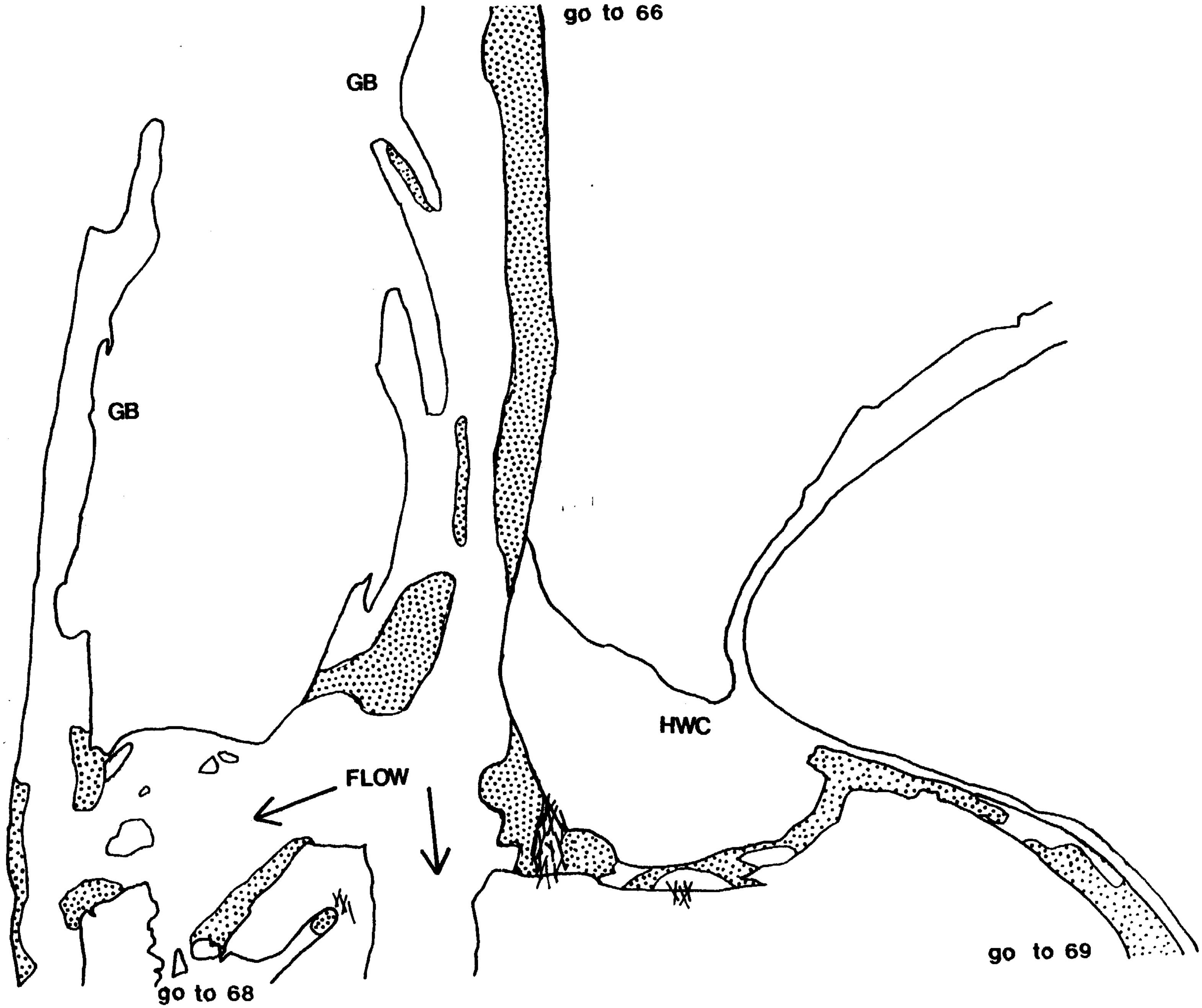
go to 65
GB
FLOW
HWC
GB
go to 64
GB

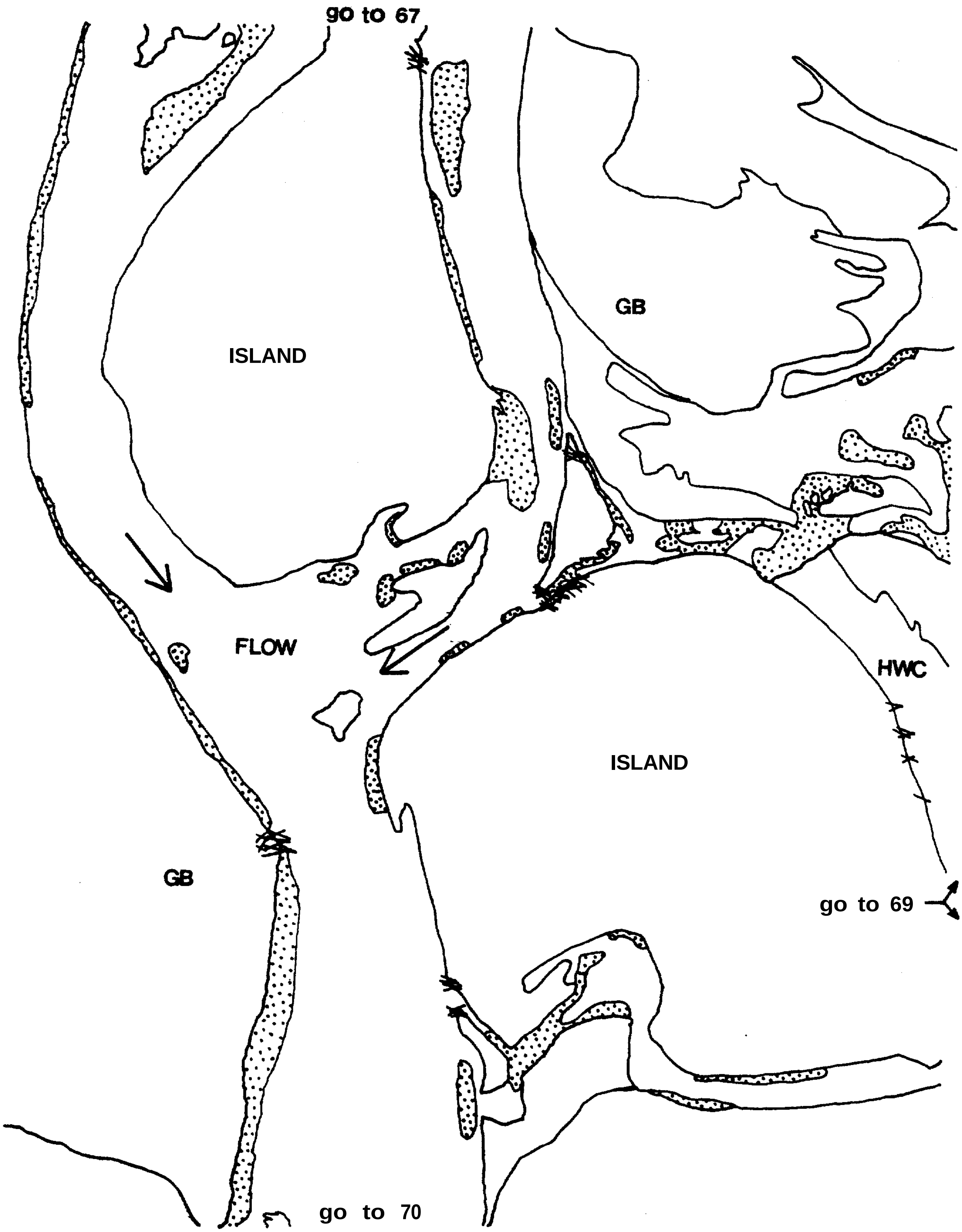


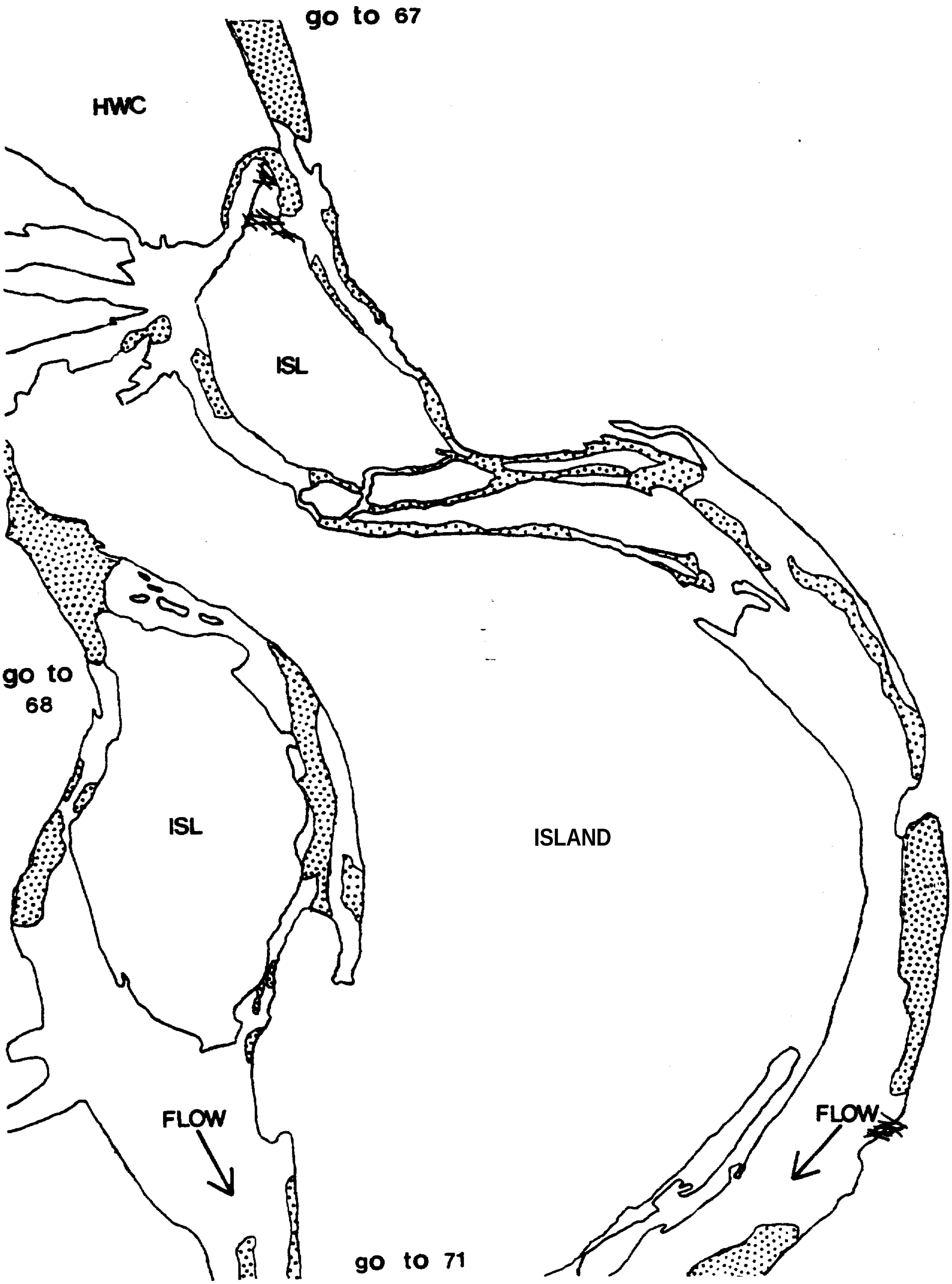
go to 6 6
GB
GB
go to 65
HWC
go to 63

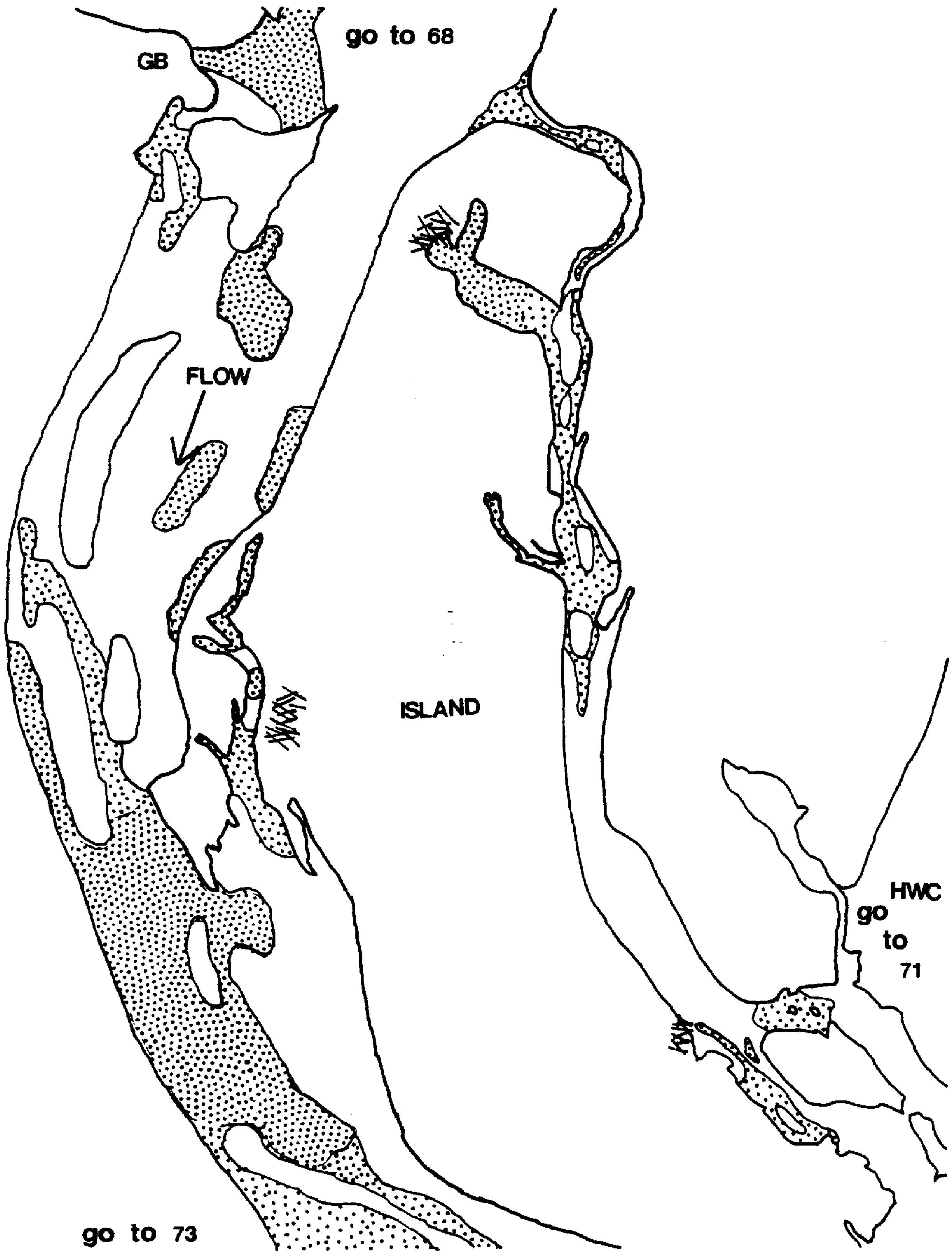

go to 63
GB
go to 64
HWC
FLOW
GB
go to 66

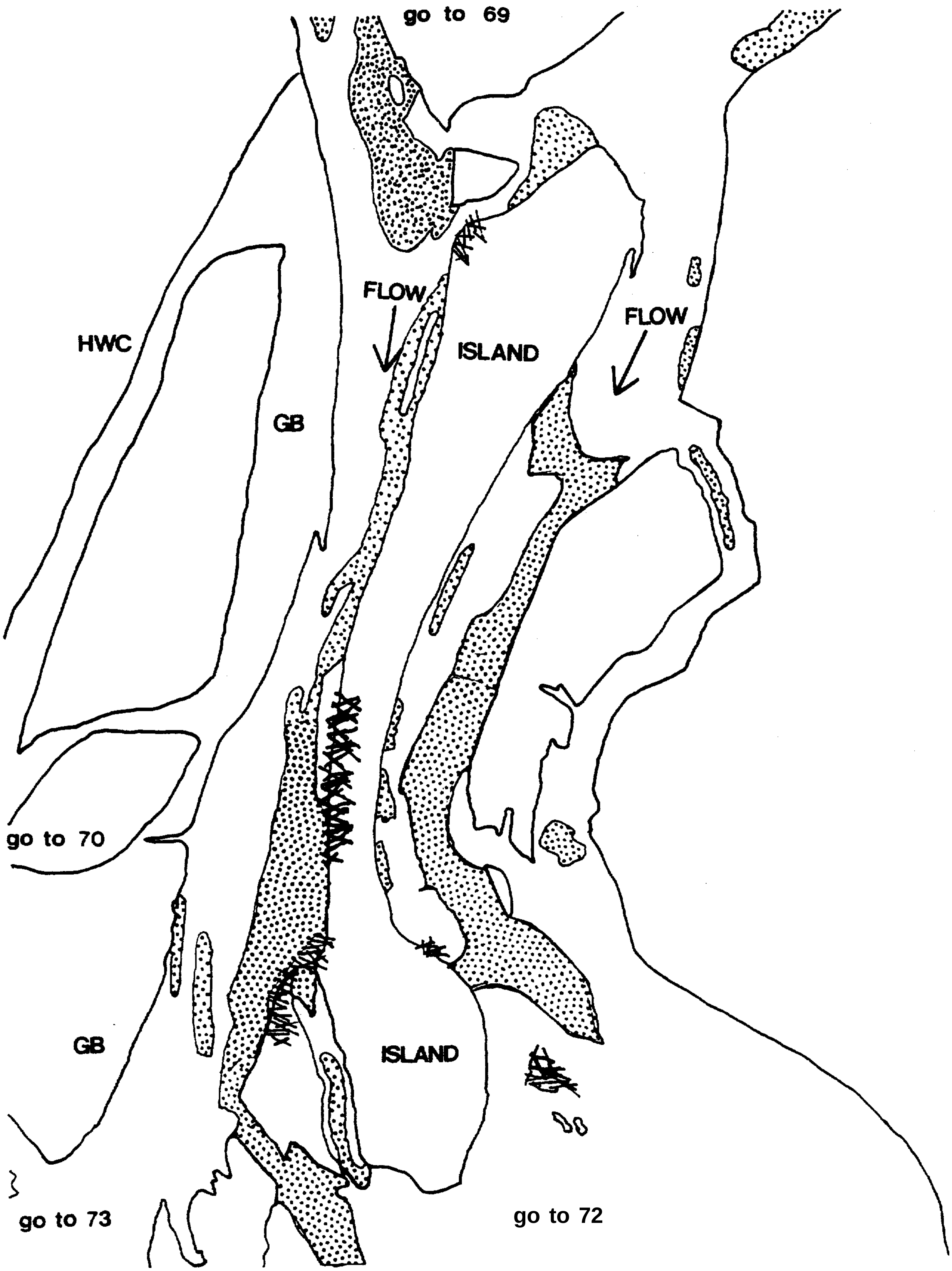

go to 64
GB
go to 65
ISLAND
2
GB
FLOW
FLOW
GB
go to 67


go to 66
GB
GB
HWC
FLOW
go to 68
go to 69

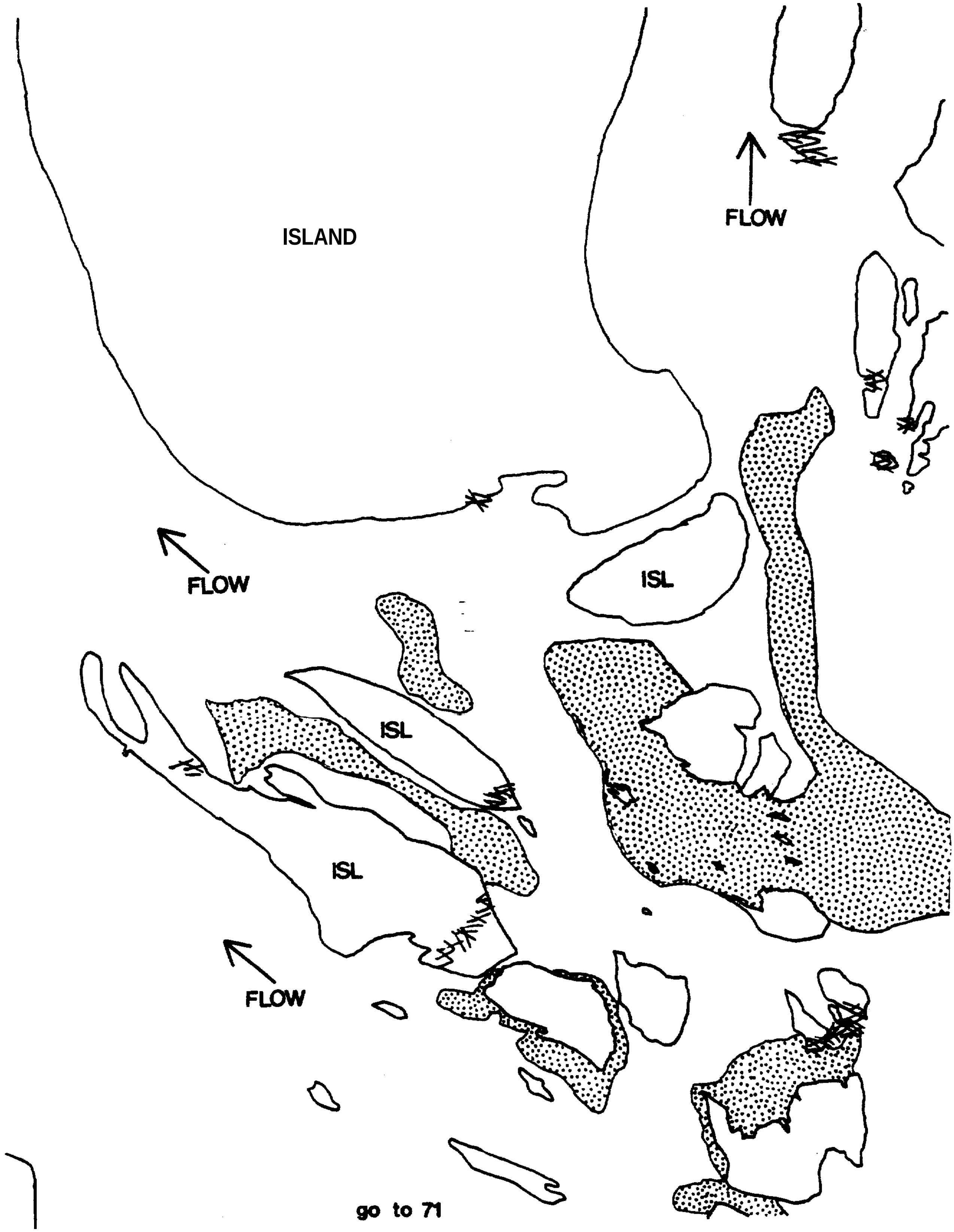

go to 67
GB
ISLAND
FLOW
HWC
ISLAND
GB
go to 69
go to 70


go to 67
HWC
ISL
go to
68
ISL
ISLAND
FLOW
FLOW
go to 71

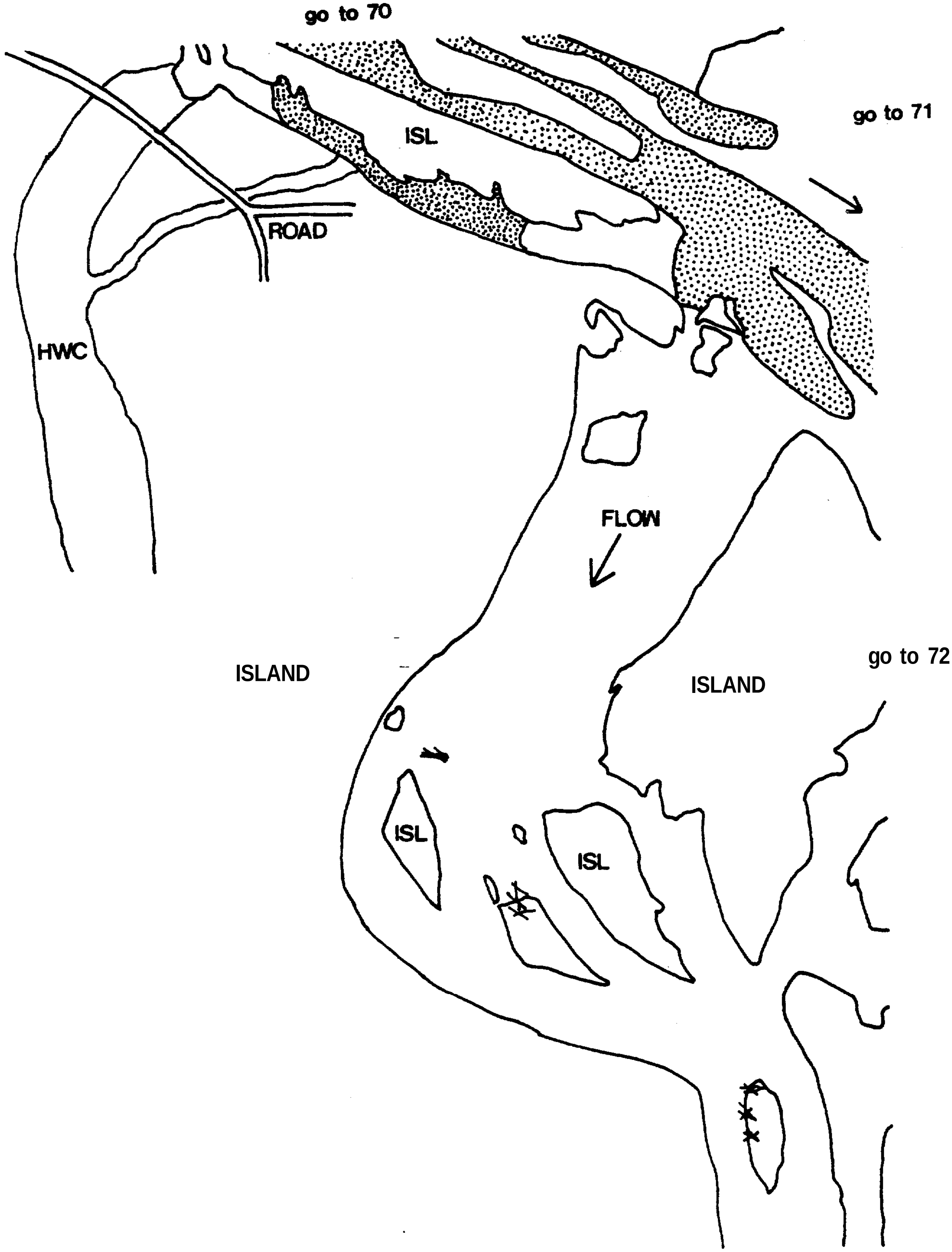

go to 68
GB
FLOW
ISLAND
HWC
go
to
71
go to 73



go to 69
FLOW
FLOW
HWC
ISLAND
GB
go to 70
GB
ISLAND
go to 73
go to 72



go to 71


go to 70
go to 71
ISL
ROAD
HWC
FLOW
ISLAND
ISLAND
go to 72
ISL
ISL