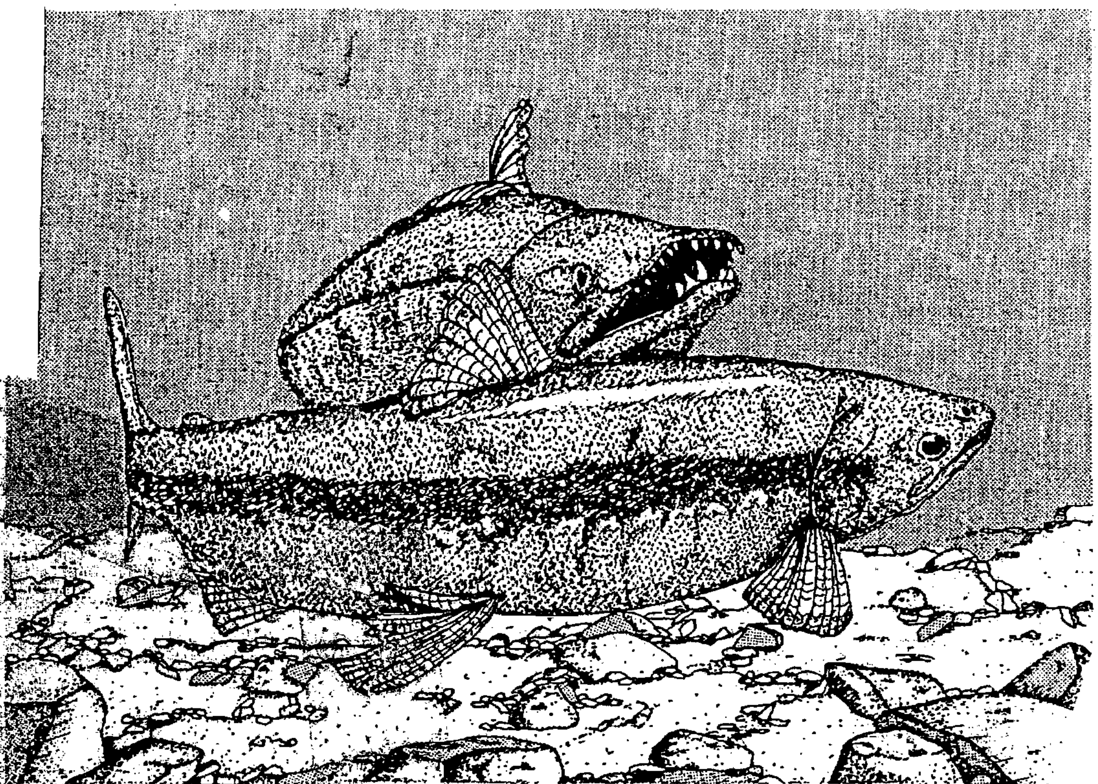

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SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 4: Aquatic Habitat and Instream Flow Studies, 1982.

Parts I and II

ALASKA DEPARTMENT OF FISH AND GAME

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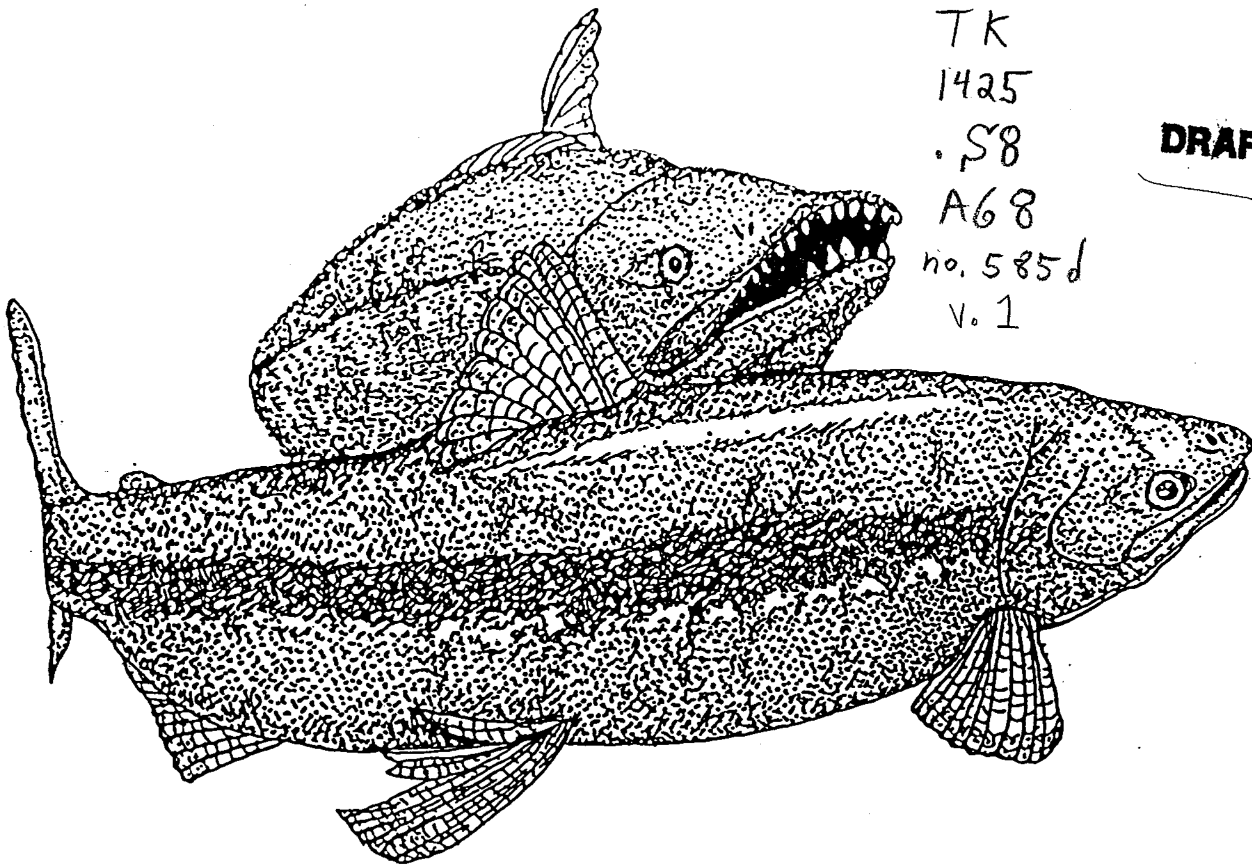

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 4. Aquatic Habitat and Instream Flow Studies, 1982.

Preface & Part I

-by-

ALASKA DEPARTMENT OF FISH AND GAME
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503
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PREFACE

This report is part of a five volume presentation of the fisheries, aquatic habitat, and instream flow data collected by the Alaska Department of Fish and Game (ADF&G) Susitna Hydroelectric (Su Hydro) Feasibility Aquatic Studies Program during the 1981-82 (October-May) ice-covered and 1982 open water (May-October) seasons. It is one of a series of reports prepared for the Alaska Power Authority (APA) and its principal contractor, Acres American (Acres) by the ADF&G and other contractors to evaluate the feasibility of the proposed Susitna Hydroelectric Project. This preliminary draft is an internal working document and intended for data transmittal to other Susitna Hydroelectric Feasibility Study participants. A final report will be distributed April 15, 1983.

The topics discussed in Volumes Two through Five are illustrated in Figure A. Volume One (to be distributed with the final report) will present a synopsis of the information contained in the other four volumes. Volume Two also includes a comparison of 1981 and 1982 adult anadromous fisheries data.

A second ADF&G report will include an analysis of the pre-project fishery and habitat relationships derived from this and related reports prepared by other study participants. A review draft will be circulated to study participants on May 1, 1983. The final report will be submitted to the APA on June 30, 1983 for formal distribution to study participants, state and federal agencies, and the public. Scheduled for completion on the same date is the first draft of the ADF&G 1982-83 ice covered season basic data report. It will include a presentation of 1982-83 incubation and other fishery and habitat data.

[1]Refer to Volume One for References.

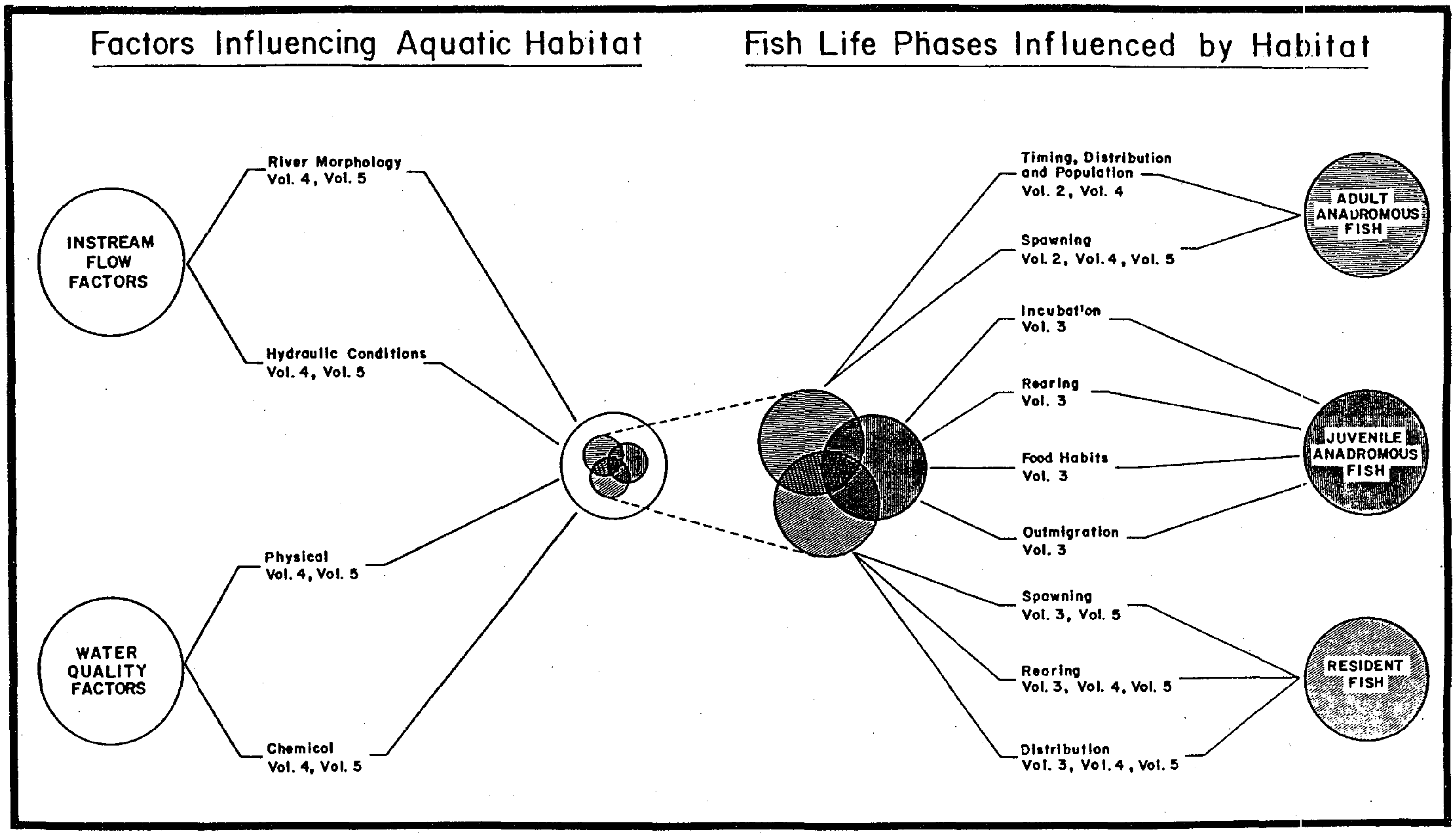

Figure A. Program elements presented in Volumes Two through Five.

These and other ADF&G reports (1974-1976, 1977, 1978, 1979, 1981a, b, c, d, e, f, 1982[1]) and information reported by others will be summarized and analyzed by the Arctic Environmental Information and Data Center (AEIDC) to evaluate post-project conditions. Woodward Clyde Consultants will, in turn, use this information to support their preparation of the Federal Energy Regulatory Commission License Application for Acres.

The five year (Acres 1980[1]) ADF&G Su Hydro Aquatic Studies program was initiated in November, 1980. It is subdivided into three study sections: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH).

Specific objectives of the three sections are;

1. AA - determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area (Figure B);

2. RJ - determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area; and

3. AH - characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

The 1982 ADF&G portion (Figures C and D) of the overall feasibility project study area (Figure B) was limited to the mainstem Susitna River and the mouths of major tributaries. Portions of tributaries which will

[1] Refer to Volume One for References.

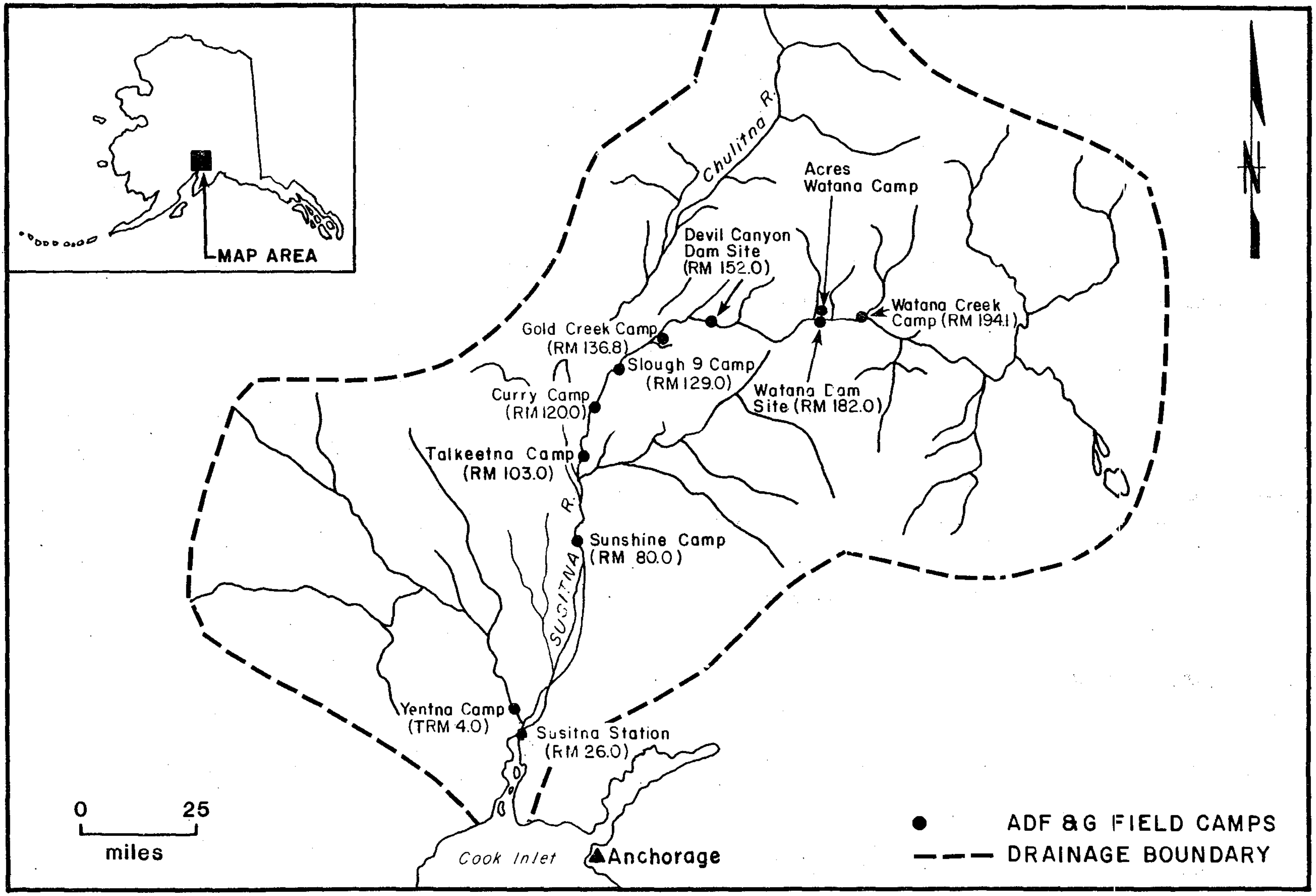

Figure 8. Susitna River drainage basin.

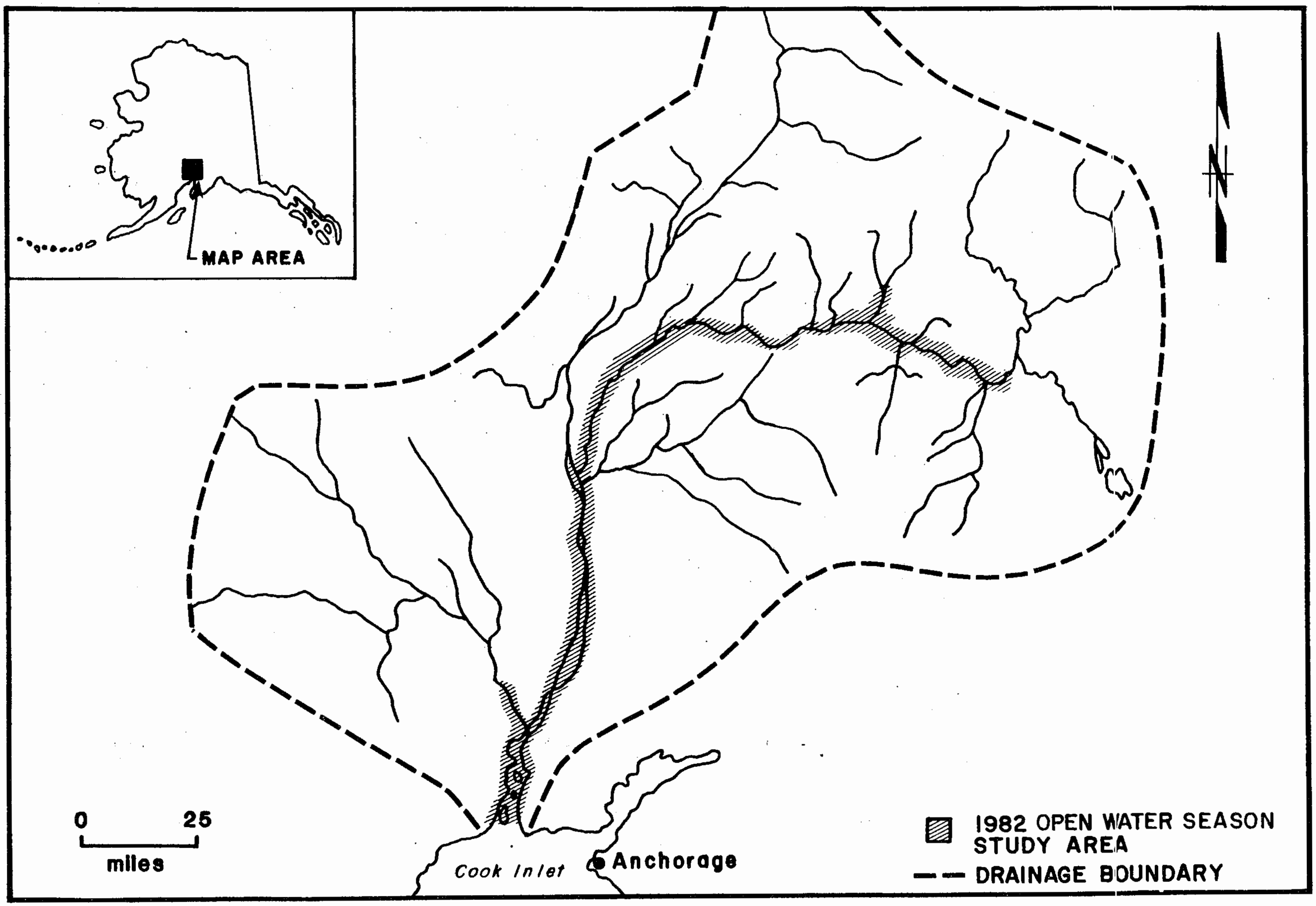

Figure C. 1982 ADF&G open water season (May through October) study area.

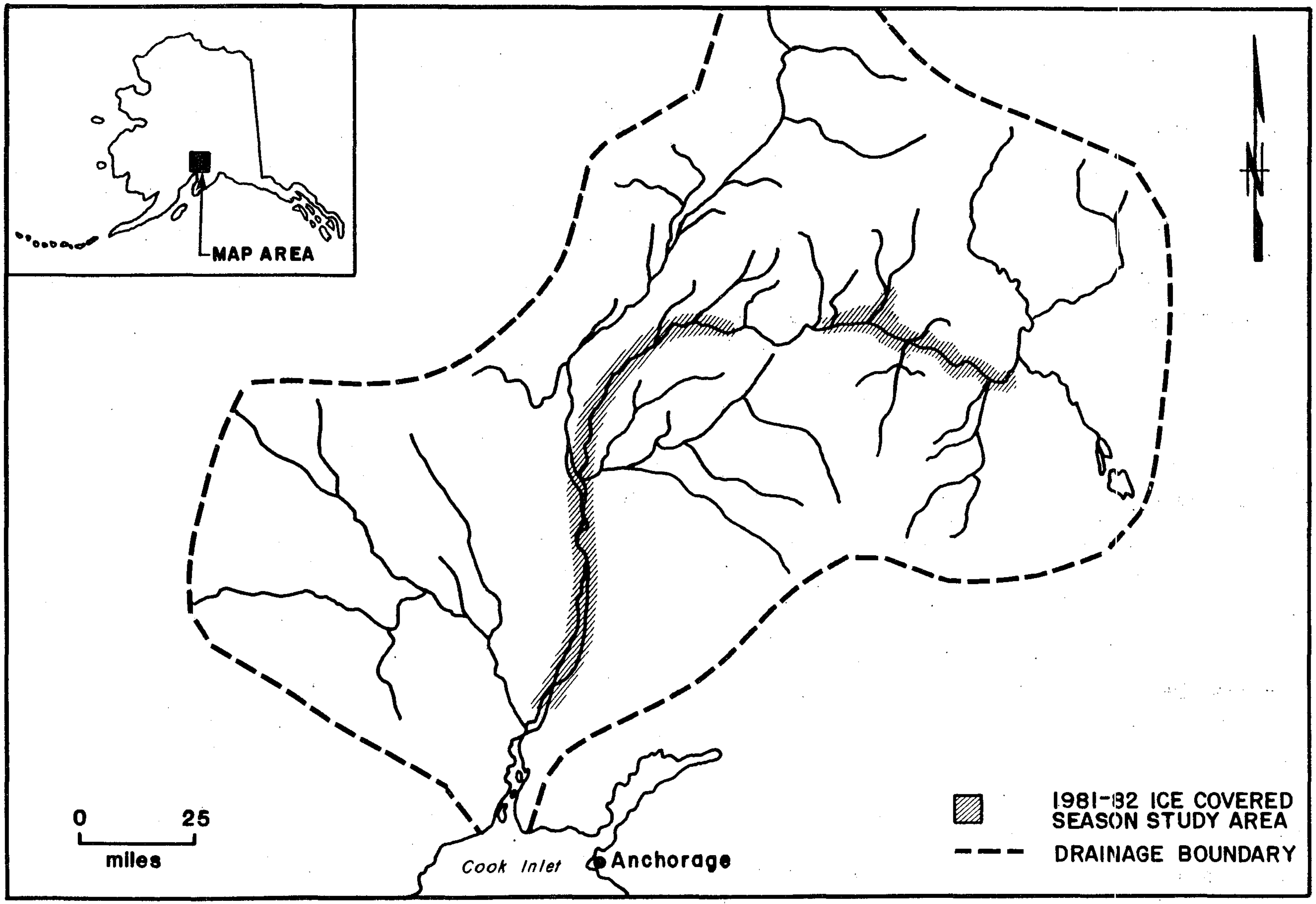

Figure D. 1981-82 ADF&G ice covered season (October through May) study area.

be inundated by the proposed impoundments were also evaluated. Descriptions of study sites are presented in each of these volumes including the ADF&G reports (ADF&G 1981a, b, c, d, e, f[1]).

The Susitna River is approximately 275 miles long from its sources in the Alaska Mountain Range to its point of discharge into Cook Inlet. Its drainage encompasses an area of 19,400 square miles. The mainstem and major tributaries of the Susitna River, including the Chulitna, Talkeetna and Yentna rivers, originate in glaciers and carry a heavy load of glacial flour during the ice-free months (approximately May through October). There are many smaller tributaries which are perenially clear.

Questions concerning these reports should be directed to:

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FOREWARD

This volume of the Aquatic Studies Draft Basic Data Report is divided into two parts (Figure 4-1). Part I, the "Hydrologic and Water Quality Investigations," is a compilation of the physical and chemical data collected by the ADF&G Su Hydro Aquatic Studies team. These data are arranged by individual variables for ease of access to user agencies. The combined data set represents the available physical habitat of the Susitna River.

Part II, the "Lower River Fisheries Habitat Investigations," describes the subset of available habitat compiled in Part I that is utilized by the various species and life phases of fish studied in the lower Susitna River (downstream of Devil Canyon). It represents the first stage of development for a fisheries and habitat relationships analysis report which will be completed in the spring 1983 (refer to Preface).

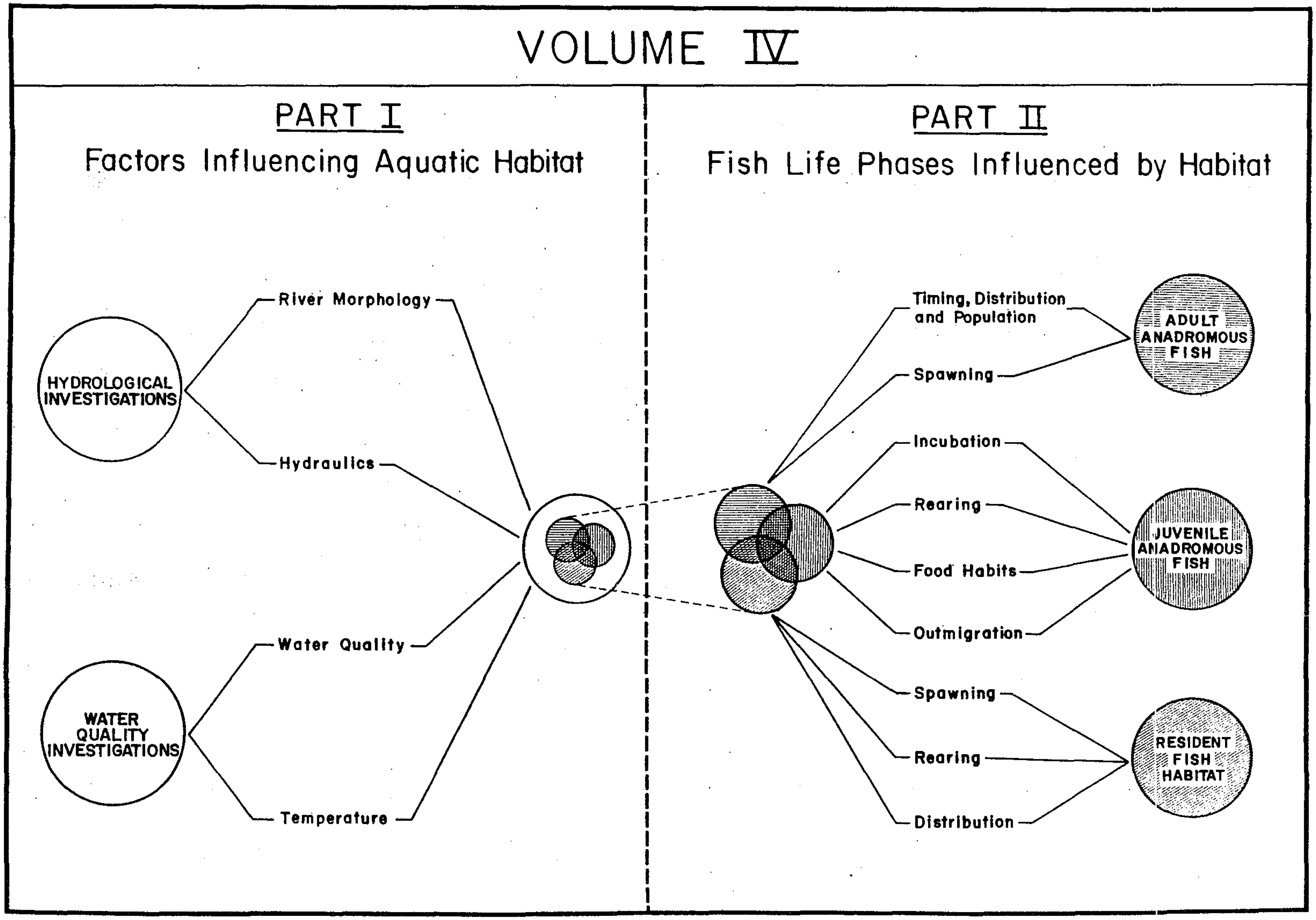

Figure 4-1. Organization of Volume 4.

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VOLUME FOUR

MAP SYMBOLS LEGEND

Silt (SI)

Sand (SA)

Gravel (GR)

Rubble (RU)

Cobble (CO)

Boulder (BO)

River Mile (RM)

Hydrolab Site

Datapod Site

Thermograph Site

Eddy

Log

Cut Bank

Railroad

Mixing Zone

Riffle

True North

P A R T   I

HYDRAULIC AND WATER QUALITY INVESTIGATIONS

1. OBJECTIVES

Investigations were initiated in 1981 by the Aquatic Habitat and Instream Flow Project (AH) to describe the physical and chemical characteristics of seasonal habitats utilized by juvenile and adult anadromous and resident fish within the Susitna River Basin (Preface Figures B, C and D). Studies conducted during 1981 provided baseline hydrological and water quality data for the various habitats (i.e., mainstem, side channel, slough and tributary, Figure 4I-1-1) present in the Susitna River and their relationships to changes in discharge of the mainstem Susitna River (ADF&G 1982b). These data were used to describe the seasonal habitat requirements of adult and juvenile anadromous and resident fish of the Susitna River and to evaluate the accuracy of hydrological and temperature models which will be used to predict discharge influenced impacts on fisheries habitat (ADF&G 1982a). The data collected during 1981 demonstrated the importance of these studies and the need to expand the data base during 1982 if the goals of defining discharge-influenced impacts to fishery habitats by the proposed project (as well as designing discharge-related mitigation options) are to be achieved.

The objectives of the hydrological and water quality investigations during 1982 were to further characterize:

1) the influence of mainstem Susitna River discharge on the hydrological and water quality characteristics of selected

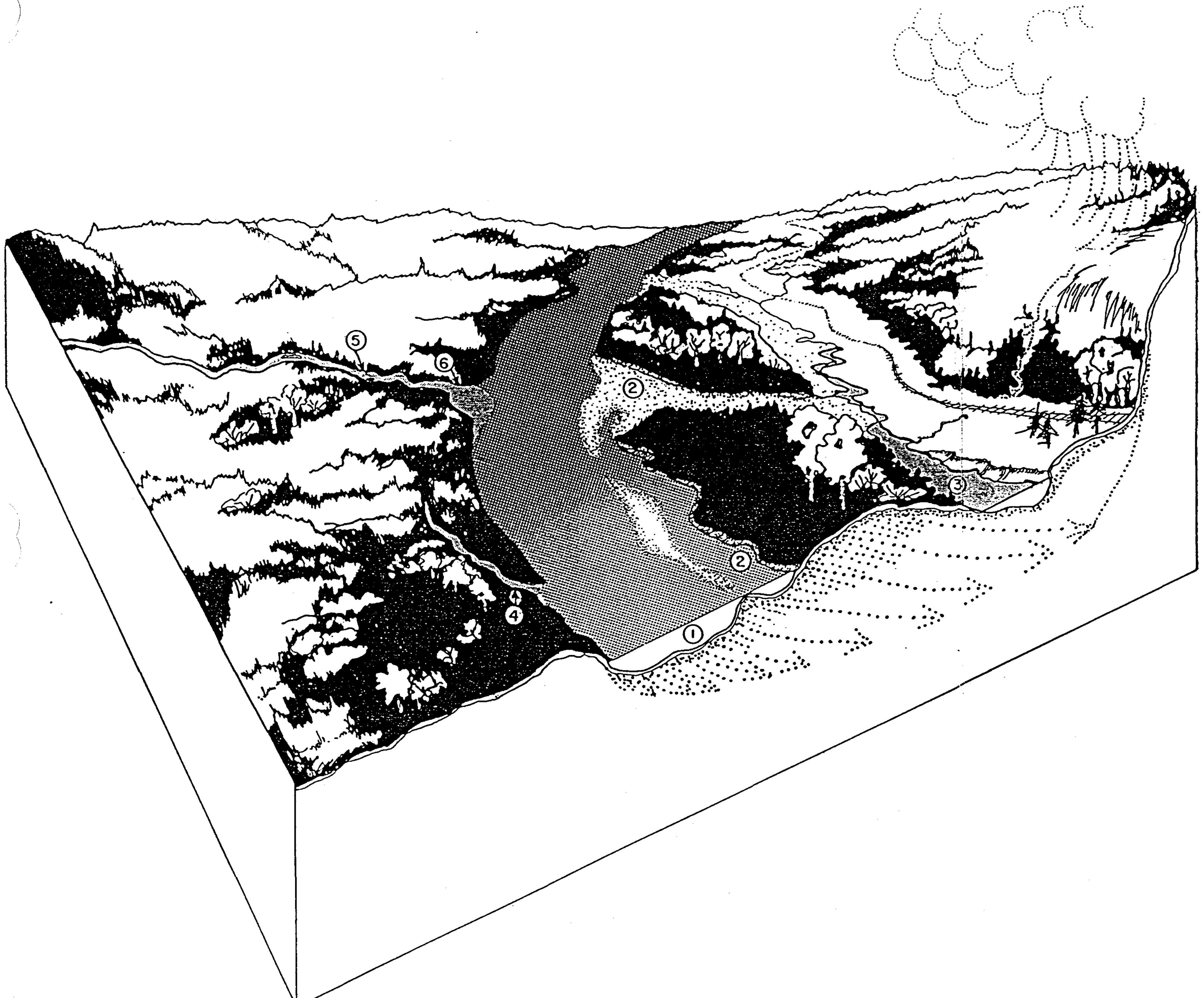

Figure 4I-1-1. General habitat categoties of the Susitna River - a conceptual diagram (adapted from AEDIC 1982; Trihey 1982).

GENERAL HABITAT CATEGORIES OF THE SUSITNA RIVER

1) Mainstem Habitat consists of those portions of the Susitna River that normally convey streamflow throughout the year. Both single and multiple channel reaches are included in this habitat category. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of mainstem habitat. Mainstem habitat is typically characterized by high water velocities and well armored streambeds. Substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands. Suspended sediment concentrations and turbidity are high during summer due to the influence of glacial melt-water. Streamflows recede in early fall and the mainstem clears appreciably in October. An ice cover forms on the river in late November or December.

2) Side Channel Habitat consists of those portions of the Susitna River that normally convey streamflow during the open water season but become appreciably dewatered during periods of low flow. Side channel habitat may exist either in well defined overflow channels, or in poorly defined water courses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side channel streambed elevations are typically lower than the mean monthly water surface elevations of the mainstem Susitna River observed during June, July and August. Side channel habitats are characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river.

3) Side Slough Habitat is located in spring fed overflow channels between the edge of the floodplain and the mainstem and side channels of the Susitna River and is usually separated from the mainstem and side channels by well vegetated bars. An exposed alluvial berm often separates the head of the slough from mainstem or side channel flows. The controlling streambed/streambank elevations at the upstream end of the side sloughs are slightly less than the water surface elevations of the mean monthly flows of the mainstem Susitna River observed for June, July, and August. At intermediate and low-flow periods, the side sloughs convey clear water from small tributaries and/or upwelling groundwater (ADF&G 1981c, 1982b). These clear water inflows are essential contributors to the existence of this habitat type. The water surface elevation of the Susitna River generally causes a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982b). Even though this substantial backwater exists, the sloughs function hydraulically very much like small stream systems and several hundred feet of the slough channel often conveys water independent of mainstem backwater effects. At high flows the water surface elevation of the mainstem river is sufficient to overtop the upper end of the slough (ADF&G 1981c, 1982). Surface water temperatures in the side sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff.

4) Upland Slough Habitat differs from side slough habitat in that the upstream end of the slough is not interconnected with the surface waters of the mainstem Susitna River or its side channels at higher flows.

5) Tributary Habitat consists of the full complement of hydraulic and morphologic conditions that occur in the tributaries. Their seasonal streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology, and climate of the tributary drainage. The physical attributes of tributary habitat are not dependent on mainstem conditions.

6) Tributary Mouth Habitat is characterized by the downstream portion of the tributary where a) the discharge of the mainstem Susitna River influences fish access into the tributary and b) the clear water of the tributary extends as a plume into the turbid waters of the mainstem Susitna River (ADF&G 1981c, 1982b).

slough, tributary and mainstem habitats downstream of Devil Canyon; and

2) the baseline hydrological and water quality characteristics of fishery habitats within the boundaries of the proposed impoundment areas (see Volume 5).

Tasks designed to meet objective one were:

1) to determine water surface elevations associated with various discharges of the Susitna River at selected mainstem, slough, and tributary locations from river mile 73.1 (Lower Goose 2) to RM 148.8 (Portage Creek);

   These data were collected to support analyses of the effects of mainstem Susitna River discharge on the availability of habitat for fish passage, rearing and spawning in slough, mainstem, and tributary habitats (eg., stage-discharge and stage-surface area relationships of hydraulic zones in sloughs, etc.).

2) obtain baseline discharge data of tributaries in the Talkeetna to Devil Canyon reach to quantify their contributions to the Susitna River;

3) monitor variations in seasonal surface water temperature of the mainstem Susitna River downstream of Devil Canyon to

support analysis of discharge and temperature relationships and relationships of temperature to fish passage and spawning;

4) monitor variations in seasonal surface and intragravel water temperatures at selected sloughs within the Devil Canyon to Talkeetna reach of the Susitna river to evaluate their relationship to mainstem discharge and support analyses of their relationships to fish passage and spawning;

5) obtain baseline water quality data to characterize the water chemistry of surface waters within selected sites of the Susitna River basin and support the analysis of the influence of discharge on water quality conditions and their relationships to fish passage, spawning and rearing; and

6) establish the baseline condition of supersaturation of dissolved gas in the vicinity of the Devil Canyon rapids of the Susitna River and the influence that changes in flow of the Susitna River have upon those conditions.

Objective two above is discussed in Volume 5.

2. METHODS

2.1 Hydrological Investigations

2.1.1 Stage and Discharge

2.1.1.1 Stage

Detailed methods pertaining to the collection of stage and discharge data are presented in the ADF&G procedure manuals (ADF&G 1981a, 1982a). The following discussion is a summary of those methods used in these investigations. Measurements of stage were obtained at least twice monthly at various mainstem and non-mainstem (i.e., sloughs and tributaries) sites in the Susitna River basin during the 1982 open water field season. Stage was determined to the nearest one-hundredth of a foot through observations of staff gages at all sites with the exception of Indian River and Portage Creek where an automatic recorder and associated pressure transducer was used to continuously monitor stage (ADF&G 1981a, 1982a).

At each staff gage placement site, staff gages were tiered to the high water marks to provide for the range of flows expected during 1982 as indicated from field observations during 1981 and the 31 year flow record (USGS 1977, 1978a, 1978b, 1979, 1980, 1981) obtained from the U.S. Geological Survey (USGS) gaging station at Gold Creek (15292000). Depending on the gradient of the streambank, each staff gage placement site was composed of a series of at least two to five individual staff gages (ADF&G 1982b). An assumed elevation, which was referenced to a temporary bench mark (TBM), was determined for each gage using basic survey techniques of differential leveling (ADF&G 1981, 1982). All TBM's were surveyed to a known elevation (project datum) so that resultant stage readings could be converted to true water surface elevations (with the exception of the staff gage on the Yentna River.

A continuous stage record was obtained at Indian River and Portage Creek with a pressure transducer installed on the streambed and connected to a recorder. This instrumentation system recorded an average water column depth every hour. These hourly stage recordings were used to calculate a mean daily stage. Periodically, the depth of flow over the pressure transducer was directly measured as a check on the accuracy of recorded values. The corresponding depth readings were recorded to determine the offset required to convert the depth of flow over the pressure transducer into equivalent stage readings.

Placement of staff gages varied, depending on the specific tasks of the various studies involved. Generally, staff gage placements consisted of mainstem Susitna River and non-mainstem staff gage locations (Figure 4I-2-1).

2.1.1.1.1 Mainstem staff gage locations

Staff gages were installed in the mainstem Susitna River (Figures 4I-2-2 and 4I-2-3) for the purpose of monitoring the relationships between

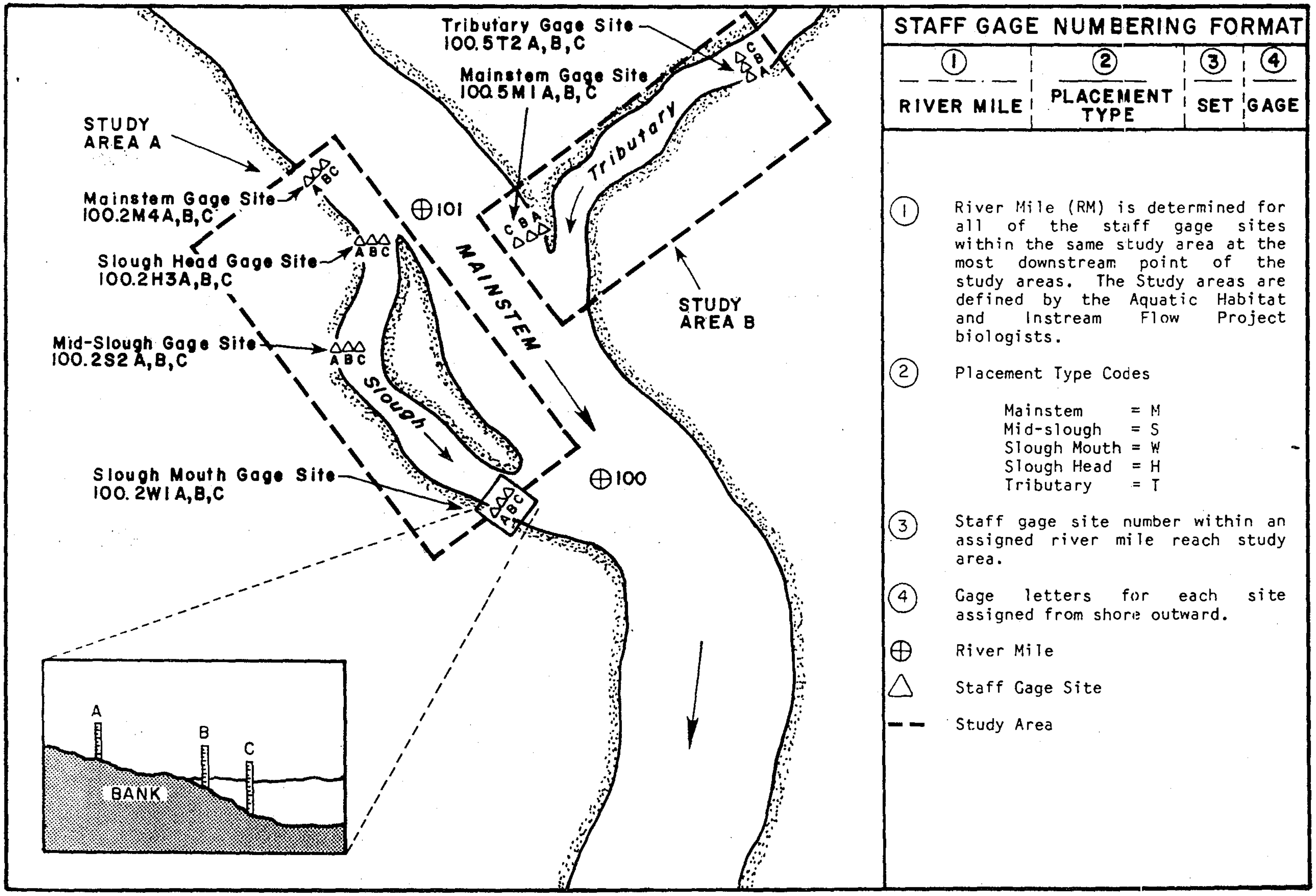

Figure 4I-2-1. ADF&G Staff Gage identification systems.

To be included in Final Draft.

Figure 4I-2-2. Mainstem staff gage locations in the Goose 2 Slough (RM 73.1) to Talkeetna reach.

To be included in final draft.

Figure 4I-2-3. Mainstem staff gage locations in the Talkeetna (RM 103.0) to Devil Canyon (RM 148.8) reach of the Susitna River.

relationships between mainstem water surface elevations and stage of the Susitna River to discharge values recorded by USGS gaging stations. Mainstem staff gages were located in the Talkeetna to Devil Canyon reach of the Susitna River are referenced to the USGS gaging station at Gold Creek (15292000). Mainstem staff gages located in the Susitna River downstream of Talkeetna are referenced to the USGS gaging station at the Parks Highway bridge (15292780).

Mainstem staff gages installed at each ADF&G Su Hydro fishwheel and sonar site were monitored daily. Mainstem staff gages installed at specific lower river cross section (LRX) sites established by R&M Consultants were monitored on an irregular basis.

Other mainstem staff gages were installed adjacent to study sloughs and tributaries and monitored periodically to determine the influence of stage and discharge of the mainstem Susitna River associated with these study areas (see 2.1.1.1.2).

2.1.1.1.2 Non-Mainstem Staff Gage Locations

Non-mainstem staff gages were located to monitor specific habitat characteristics in sloughs, side channels and tributaries. These staff gages were installed in various hydraulic zones of sloughs and tributaries and monitored a minimum of two times per month.

Staff gages located at the mouths (downstream end) of selected sloughs and side channels were monitored to evaluate fish accessibility between the mainstem and these habitats. Staff gages were located in the free-flowing portions of these study areas and were monitored to evaluate local stage-slough flow relationships. Other staff gages were located at the heads (upstream) portion of sloughs or side channels to evaluate the discharge of the Susitna River necessary to breach the heads of these areas. The ADF&G should be consulted for the interpretation of these data.

The following discussion describes the methods used for determining the mainstem discharges of the Susitna River at which breaching of selected side sloughs and channels situated in the reach of the Susitna River between Talkeetna and Devil Canyon occurred.

Cross section surveys, staff gage readings and on-site observations were used in conjunction with one another to determine the mainstem Susitna River discharges at which breaching of a slough began to occur.

The lowest representative elevation on a cross-section surveyed across the head of a slough is called the "point of zero flow" (PZF). Assuming the cross section at the head of a slough was surveyed at the point where streambed elevations control flow into the slough, the water surface elevation of the mainstem river at the head of the slough must be greater than the PZF before mainstem water can enter the head of the slough. PZF's were determined at selected sloughs in the Susitna River basin from the cross section surveys conducted by R&M Consultants, Inc.

Staff gages were installed at the head of study sloughs and side channels as near as possible to the upstream point that controlled mainstem flow into these areas so that the elevation of the bottom of the staff gage provided a good check on the accuracy of the point of zero flow (PZF) determined from the cross-section surveys. Mainstem water surface elevations necessary for breaching were obtained from staff gages tied into project datum which were installed in the mainstem near the head of the slough.

Periodic field observations were made to document at which mainstem discharge selected study sloughs and side channel areas were breached. However, even if field crews were fortunate enough to observe a site just as it was breached, this did not mean that the exact mainstem discharge required for breaching of that slough had been identified. Observations of slough breaching and staff gage readings obtained to determine breaching flows were referenced to the average daily streamflow at Gold Creek (USGS 1982). This gaging station is located up to 20 miles from various sloughs where breaching data were collected. Since the accuracy of the relationship between breaching and Gold Creek discharge was dependent on the rate that the river was rising or falling, the range of flows required for breaching were determined from a combination of the above methods.

2.1.1.2 Discharge

Measurements of discharge were obtained at selected sloughs and tributaries below Devil Canyon to determine the range of discharges which occur under an annual flow regime and thereby develop simple stage-discharge relationships in the form of rating curves. Discharge measurements were also obtained at six tributary locations upstream of Devil Canyon to monitor flow conditions and provide baseline flow data for future reservoir modeling. In addition, discharge measurements were also obtained as a byproduct of a series of depth and velocity measurements primarily intended to quantify potentially available fish habitat at several slough sites (refer to Part II - 2.1.3.2.1).

Downstream of Devil Canyon

Discharge sites (gaging stations) were placed within study locations in areas where conditions for obtaining stage and discharge measurements were maximized. Stream morphology was thus the major criteria used to establish gaging stations. Gaging stations were located in a free-flowing portion of the stream, removed from any backwater influences created by the mainstem river and within a uniform channel with a stable substrate; where water column velocities paralleled each other and were at right angles to the cross section. Discharge measurements were made by the current-meter method as outlined in the Procedures Manual (ADF&G 1981a), using standard USGS techniques (USGS 1977) employing either a Price AA or Pygmy meter. Cross sections at gaging stations were divided into a minimum of 20 cells to ensure that each velocity obtained measured no more than five percent of the total flows. The observed depth at each cell was then determined using a four foot top setting wading rod graduated into one-tenth foot increments. Mean water column velocities measured as feet/second (fps), were then determined at each cell using a two point or a six-tenth depth method. At depths less than six-tenths of a foot and velocities less than 2.5 ft/sec the Pygmy meter was utilized, while at greater depths and velocities a Price AA meter was used. At depths less than or equal to 2.5 feet, mean cell water column velocity was measured at six-tenth of the depth from the surface, while at depths exceeding 2.5 feet water column velocities were measured at two-tenths and eight-tenths of the depth from the surface and then averaged to yield a mean cell water column velocity. When velocities were observed not to be at right angles to the discharge transect, the velocity vector component normal to the measuring section was determined as described in the Procedures Manual (ADF&G 1981a). Total discharge was then determined as the summation of the products of cell area and mean cell column velocity. If sufficient discharge and corresponding stage data were collected at a gaging station, simple rating curves were developed by R&M Consultants.

Depth and velocity measurements were also obtained at specific intervals along each transect in the FHU study sites using a Marsh-McBirney model 201 electronic flow meter and methods outlined in the Procedures Manual (ADF&G 1981a). From these data, discharge was computed to estimate the range and quantity of habitat available to fish and to calibrate the IFG computer model for each study site (Milhous, et al. 1981).

Upstream of Devil Canyon

Discharge measurements were obtained in six tributaries located above Devil Canyon employing techniques outlined above and in the Procedures

Manual (ADF&G 1981a). Refer to Volume 5, section 2.2.3 for specific discharge methods employed upstream of Devil Canyon.

2.1.2 Thalweg Profiles

The thalweg, is defined in Nomenclature for Instream Assessments (Arnette 1975), as being

> "the line following the deepest part or middle of the bed or channel of a river or stream."

Thalweg data were collected using a surveying level, and standard surveying rod and rod level employing the standard surveying techniques of differential leveling. At the beginning of each survey a temporary bench mark (TBM) was established, that was later tied into project datum. To define the thalweg of each slough, the survey progressed downstream (or upstream) beginning at the head (or mouth) of each slough, selecting (based on visual assessments) the lowest points of significant change in gradient (i.e., tops and bottoms of riffles, bottoms of pools, etc.) as thalweg points. Distances between the surveyed points were measured (to the nearest foot) using a surveying tape and by reading the stadia on the level and computing distances. The data was then plotted with elevation as the ordinate and distance as the absissa.

In several sloughs, partial thalwegs were developed as a byproduct of other survey work in the slough. When applicable survey data (i.e., transects within study sites, cross sections at staff gages or mouth and head of a slough) was available and met the requirements of the thalweg profile, it was used in conjunction with the thalweg survey in order to conserve time and to avoid duplication of effort.

2.1.3 Other Hydrological Components

2.1.3.1 Backwater Areas

The purpose of this section is to present data describing the relationship between mainstem Susitna River discharge and the area of low velocity, backwater, which results from hydraulic barriers created by mainstem stage. These data were collected twice monthly at 17 slough and tributary habitat locations from June through September. The data base consists of a series of maps, one for each sampling period at each site, depicting the prevailing hydraulic features of the surface waters.

To map hydraulic conditions, nine different hydrological "zones" were defined to represent various conditions of water surface velocity, water source (tributary or mainstem) and hydraulic influence from mainstem water surface elevations present at the mouth of a study site. When the hydraulic conditions at a study area were categorized using the zone codes (numbers 1-9), maps of the wetted surface and zone boundaries were drawn.

Susitna River discharge data presented in results was provided by the USGS, as provisional data (USGS 1982). The June discharges for the upper river were estimated by the USGS from supporting data because the Gold Creek Gaging station was inoperative in June.

Descriptions of the field program and zone codes are presented in Volume 3, Section 2.1.3 and are discussed in detail in Part II, Section 2.2 of this volume. A narrative description of each habitat site is also available (Volume 4, Appendix 4-F). Included in the appendix descriptions are traced reductions of blueline zone-boundary maps (see Slough 21, Slough 6A, Whitefish Slough and Whiskers Creek and Sidechannel) which illustrate the mapping procedures.

Mapping

Aerial photographs of each habitat location were taken on May 31 and August 20, 1982 under contracts with R&M Consultants and North Pacific Aerial Surveys, Inc. These were printed as blueline copies at a scale of 1"=50' for use as reference maps. At the time of each sampling, the observed boundaries of wetted surfaces and the location of zones were drawn on the blueline maps. During the June samplings, blueline maps were not available; thus the June data compilations were constructed in Anchorage from sketches, measurements and photographs taken in the field. In general, wetted edge locations and zone boundaries were located on the blueline maps using natural points of reference (e.g., deadfall, trees, geographic features) and measurements made using surveyor's tapes. Wetted edge boundaries were typically mapped without a great amount of precision. Ground truth measurements were made at most sites to check and/or adjust the scales on the blueline photographs.

Surface Area Measurements

Surface areas were measured from the blueline maps (or direct tracings of the maps) with a Numonics[R] model 2400 Digitizer.

Several random and systematic errors are associated with the measured surface areas.

Random errors were introduced during various steps of map construction. Specific sources of random errors include inaccurately locating the wetted edge boundary and inaccurately locating the boundary between hydraulic zones (for more on this see Part II, section 2.2).

Systematically, deviations as large as 7 percent were found between indicated linear distances (map scale) and measured ground features at some sites. Unfortunately, some sites had no natural features to check map scales against. Deviations also appeared across the surface of maps as a result of photographic image distortion (parallax). Scales on blueline maps made from the May and August flights for some sites were also found to differ by several percent. A combined estimate of systematic error might reasonably approach 15 percent in some of the surface areas measured.

Precise surface area measurements were not the objective of this study, rather the goal was to document trends in the distribution of hydraulic conditions to relate to the fish distribution. Finer resolution in the maps was not practical within the constraints of the 1982 program.

2.1.3.2 Open Channel

Segments of sloughs 8A, 9 and 21, Rabideux Slough and Chum Channel were selected for computer modeling using hydraulic simulation programs developed by the Instream Flow Group (Milhous, et. al., 1981). Given channel depths, velocities and widths and water surface elevations from transects at known discharges, these models extrapolate and predict hydraulic parameters including depth, velocity, width, wetted perimeter and water surface elevation at unobserved stream flows. Data from actual field observations are used to calibrate the model. When predicted hydraulic parameters at known discharges fit measured parameters and when predicted hydraulic parameters at hypothetical discharges fit a realistic pattern based on past hydrological experience, the models are calibrated. Data collected during one field season will not necessarily include a sufficient range of conditions to calibrate the model at all potential discharges. Thus, the model is reliable only at stream flows within specified limits.

2.2 Water Quality Investigations

Water quality data were collected throughout the study area as discussed below.

2.2.1 Temperatures

Surface and intragravel water temperature were measured on an instantaneous and continuous basis at various locations in the Susitna River basin. Several types of temperature monitoring instruments were employed.

2.2.1.1 Surface Water Temperature

Instantaneous surface water temperature measurements were obtained at various locations in the water column from the streambed to the water surface. Continuous monitoring of the surface water temperature was confined to the portion of the water column adjacent to the streambed upon which the temperature sensor rested, usually 0.5 feet or less above the stream bed, or upon the streambed itself.

2.2.1.1.1 Instantaneous Water Temperature

Instantaneous water temperatures were obtained at each study site in the process of collecting the basic water quality field parameters. The measurements were collected with either a calibrated Brooklyn mercury thermometer or Hydrolab model 4041 electronic multiparameter unit using procedures outlined in the Phase I Procedures Manual (ADF&G 1981a).

2.2.1.1.2 Continuous Surface Water Temperature

Surface water temperature was measured during the 1982 open-water field season on a continuous basis at 23 stations (Figure 4I-2-4) within the Susitna River basin, including 10 mainstem sites (located from RM 5.0 to RM 140.0), ten major tributaries from the Yentna River (RM 28.4) to the

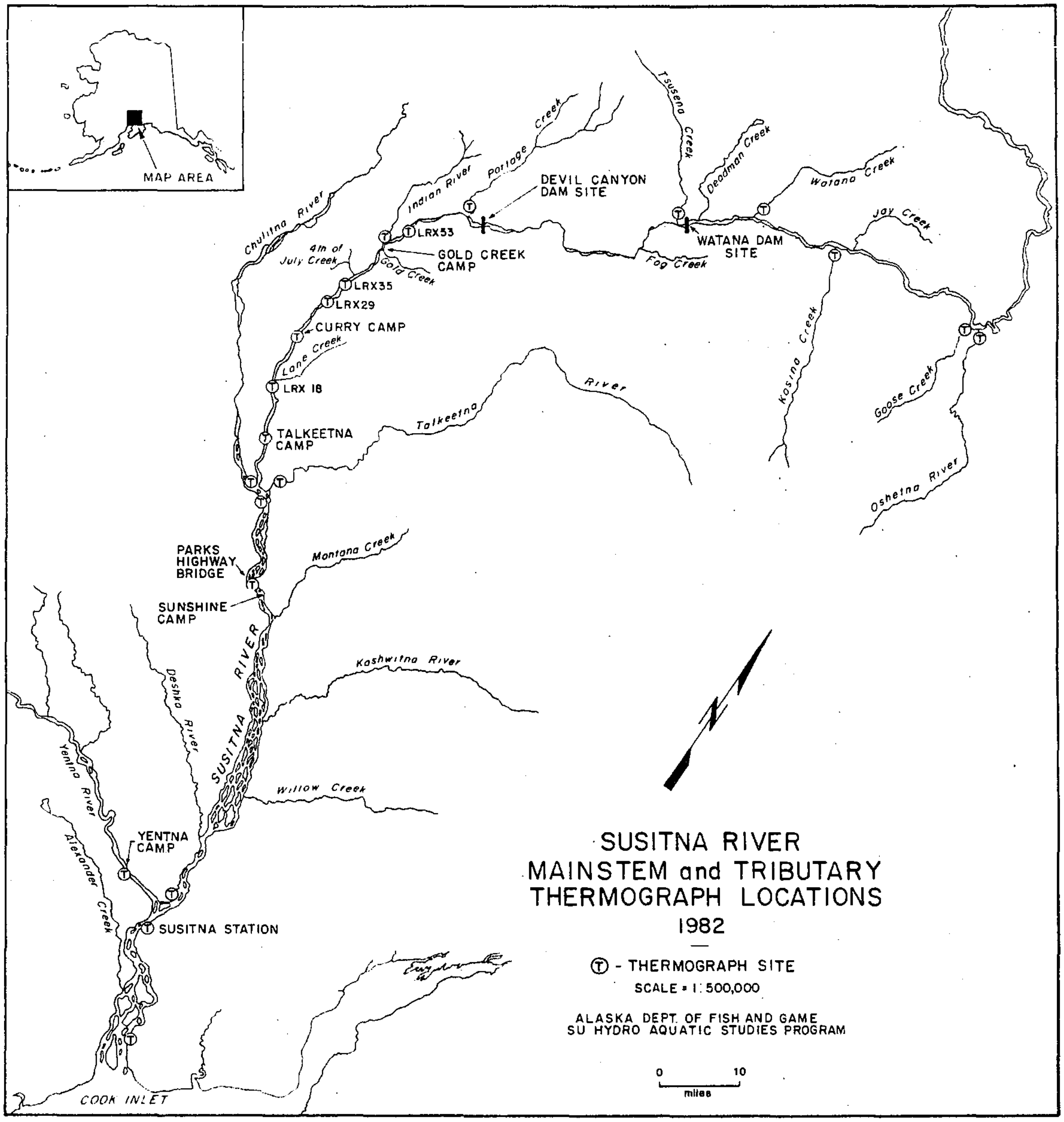

Figure 4I-2-4 Thermograph site map.

Oshetna River (RM 233.4) and three sloughs above Talkeetna (sloughs 8A, 9 and 21). Two types of instruments were employed in the continuous measurement of temperature: the Peabody-Ryan model J-90 submersible thermograph and the Omnidata recorder with associated thermistors. For both the Peabody-Ryan thermograph and the Omnidata recorder, the temperature sensor was placed on the bottom of the stream to record the water temperature of the lower portion of the water column adjacent to the streambed.

Peabody-Ryan model J-90 thermographs continuously monitor and record temperature with an error of 0.6°C on 90-day charts. Thermographs, after installation, were monitored and serviced (if necessary) twice monthly, except those located above Devil Canyon which were monitored on a monthly basis. To ensure accuracy of temperature data collected, each thermograph was screened at two temperatures (0°C and between 11-16°C) prior to installation using a calibrated Brooklyn or American Society for Testing and Manufacturing (ASTM) thermometer as a standard. Thermographs found to be in error by more than 3°C at either screening temperature were not used and were returned to the manufacturer for calibration. To ensure proper calibration of temperature readings, surface water temperatures were obtained, using a calibrated thermometer, at the time of installation and removal of the thermograph from each site. A unique calibration factor was then determined for each thermograph, calculated as the difference in the readings between the surface water temperature obtained with the thermograph and the calibrated thermometer at the time of thermograph removal. The calibration factor was determined from data at the time of thermograph removal rather than the time of installation, because response time after installation varied for each thermograph. The calibration factor was then used to correct 2-hour point temperature readings from each recording chart. From these corrected 2-hour point temperatures mean, maximum and minimum temperatures were calculated by computer for each 6-hour period. The installation and service methods are outlined in the Phase I Procedures Manual (ADF&G 1981a).

The Omnidata recorders and associated thermistors used to continuously monitor surface water temperatures, were capable of simultaneously recording both intragravel and surface water temperature with an error of 0.1°C. The Omnidata instrument incorporates a non-volatile, u-v erasable, solid state data storage module (DSM) to record data. The DSM is capable of approximately three months data storage recorded in 6 hour intervals as minimum, maximum and mean water temperatures. The units were virtually maintenance-free but were periodically checked for low battery charge and disturbance by wildlife (bears).

To obtain surface water temperatures with an Omnidata instrument, the associated thermistor was attached to a weight and placed upon the substrate of the stream channel. Each thermistor probe was calibrated prior to field installation by Dryden and LaRue (distributors of the instruments) and assigned a calibration factor. The surface water temperature probe was placed immediately adjacent to an intragravel temperature probe (see Section 2.2.1.2.2) associated with the same recorder. Immediately after installation of the recorder and prior to removal of the DSM, a surface water temperature was obtained with a calibrated mercury thermometer. In addition, a short data dump the recorder is programmed to yield (including errors accumulated, numbers of data points stored, minutes to next recording, surface water temperature and intragravel water temperature) was obtained. This information along with the probe calibration factors were compared to ensure the instrument was accurate. The data was retrieved from the DSM via an Omnidata model 217 Datapod/Cassette Reader, and printed as 6-hour maximum, minimum and mean temperatures.

2.2.1.2 Intragravel Water Temperature

Intragravel water temperature measurements were obtained on an instantaneous and continuous basis in the Susitna River basin during the 1982 open-water field season using Ryan thermographs and Omnidata recorders for the continuous measurements and Digi-Sense recorders for the instantaneous measurements.

2.2.1.2.1 Instantaneous Intragravel Water Temperature

Instantaneous intragravel water temperatures were obtained at salmon and Bering cisco mainstem spawning sites and in Sloughs 8A, 9, 11, and 21 using a Digi-Sense temperature recorder and associated YSI series 400 insertion probe. Variations in measurements associated with drift (±0.2°C) and damp field conditions (usually erroneous values) made it necessary to check instruments in the field (before and after a series of readings) with a calibrated mercury thermometer (verified accuracy

±0.2°C of an ASTM thermometer). A calibration factor was then determined for each set of readings as the difference between the mercury thermometer reading and Digi-Sense readings. The calibration factor was then used to correct the Digi-Sense readings.

The following procedure was utilized to obtain an instantaneous intragravel temperature using a Digi-Sense temperature meter and associated YSI insertion probe.

1) The wire lead was attached from the insertion probe to the Digi-Sense unit.
2) The insertion probe was pushed into substrate to a depth of at least six inches.
3) The unit was turned on for a period long enough to allow the digital readout to stabilize (usually within 30-60 seconds).
4) The water temperature was recorded.

2.2.1.2.2 Continuous Intragravel Water Temperature

Intragravel water temperature was continuously monitored and recorded at various sites in the Susitna River basin during 1982 using both the Peabody-Ryan model J-90 submersible thermograph and the Omnidata recorder and associated thermistor. Peabody-Ryan model J-90 thermographs were used only for determining intragravel water temperatures during the 1982 winter-spring ice covered period.

Peabody-Ryan model J-90 thermographs were buried 1-3 feet in the substrate. The installation procedure for these thermographs is the same as for the surface water temperature thermographs, with the exception that the intragravel water temperature monitoring thermographs were checked within 90 days and full 90 day recording charts were used (ADF&G 1981a). Methods of data reduction are the same as those presented in Section 2.1.1.2.2 for the continuous measurements of surface water temperature data by Peabody-Ryan model J-90 thermographs, except that the thermographs were not screened and calibrated according to procedures described in Section 2.2.1.1.2. Calibration factors were determined (for each thermograph) by allowing each thermograph to reach equilibrium in a water bath at 8°C (as determined by a calibrated Brooklyn thermometer) and then following procedures outlined in Section 2.2.1.1.2 for computing calibration factors.

The Omnidata recorder was also used to record intragravel water temperatures during the 1982 field season. The Omnidata recorders were found to be advantageous over the Peabody-Ryan thermographs because of several unique features the Omnidata recorders incorporate to record intragravel water temperatures including: (1) an ability to measure temperature to an accuracy of 0.1°C, (2) a minimal amount of effort is expended in calibrating the probes, (3) only the Data Storage Module (DSM) must be removed for data retrieval and not the entire instrument thus allowing for a continuous flow of intragravel water temperature data, (4) the recorder can be secured out of the water on a safe location with the risk of only losing the temperature probe during periods of flooding and bank erosion, (5) two probes can be used simultaneously to record both intragravel and surface water temperatures on the same DSM, and (6) there is considerably less data reduction time in comparison to the Peabody-Ryan thermograph.

Each Omnidata recorder was equipped to monitor simultaneously both the intragravel and surface water temperature. The associated thermistor was secured within a steel, slotted tube and inserted approximately 18 inches into the substrate. The thermistor probe wire was connected to the Omnidata recorder which was stored in a waterproof container secured on the stream bank out of the range of flood flows and eroding banks. A surface water temperature probe was weighted and placed adjacent to the intragravel probe (see section 2.2.1.1.2 for details). Field installation procedures and data reduction techniques are the same as described in Section 2.2.1.1.2.

2.2.2 Other Basic Field Parameters

The dissolved oxygen (DO), pH, temperature, and specific conductance of surface water were collected throughout the Susitna River basin during 1982 by Instream Flow Evaluation Study, Fishery Habitat Utilization Study, Fishery Distribution Study, Electrofishing Study and Impoundment Study personnel. The basic field parameters of DO, pH, water temperature, and specific conductance were measured in the field using a Hydrolab model 4041 portable multiparameter meter. The four parameters were measured simultaneously at the Sonde unit (underwater unit) and the readings were displayed in an indicator unit. Each hydrolab was calibrated prior to entering the field (see Procedures Manual for methods of calibration) except for temperature which was calibrated by the manufacturer. Measurement of the basic field parameters varied, depending on the specific tasks of the various studies involved.

The basic field parameters were obtained at each discharge transect within each Resident Fish Designated Habitat site at intervals necessary to characterize the water quality present.

The basic field parameters were collected to determine the overall differences in water quality within each Adult Anadromous Fish Habitat Investigation Slough site. Sites for measurement of water quality were located at the head and mouth of the FHU study slough and in, above and below any tributary (sufficiently far downstream to allow mixing) or other water sources (spring or upwelling) within the site.

Twice monthly, hydraulic zones were determined within each Resident Fish Designated Habitat site. To characterize the water quality present within each zone, the basic field parameters were collected in an area of the zone considered representative for the entire zone.

Measurements of the basic field parameters gathered in conjunction with the mainstem Adult Anadromous Fish Habitat investigations were collected at spawning sites of resident and anadromous fish species (refer to Vol. 4, Part II for specific information concerning site selection and data collection techniques).

The basic field parameters were obtained at least once per month at designated tributary, mainstem and lake sampling sites in the impoundment zone (see Vol. 5 for details). Additional sites, including minor tributaries and tributary study sections, were sampled on irregular intervals.

Water samples for turbidity analysis were collected by both the Fish Distribution Study (FDS) and the Impoundment Study personnel. Turbidity samples were collected in 250 ml bottles and stored for a maximum of 18 days in a cool, dark location prior to analysis. Samples were obtained within each FDS zone twice monthly and analyzed in the field on a HF Instruments DRT-15 turbidity meter according to procedures described in the Procedures Manual (ADF&G 1981a). Turbidity samples were also collected by Impoundment Study personnel on a monthly basis at designated tributary and mainstem sampling sites (see Impoundment WQ site selection Vol. 5). Analysis was performed on a Hach 2100A immediately upon returning from the field using procedures described in the Procedures Manual (ADF&G 1982b).

Turbidity values, reported as Nephelometric turbidity units (NTUs) were measured to the sensitivity of the turbidimeter calibrated with the appropriate standard. Measured turbidity values less than 1 NTU are reported as less than 1 NTU. Values equal to or less than 100 NTUs are reported to the nearest whole number. Values greater than 100 NTUs are reported to two significant figures.

2.2.3 Total Dissolved Gases

A study of dissolved gases was conducted in the Susitna River between the Chulitna River confluence and the upper extent of the Devil Canyon rapids. The uppermost sampling site was located approximately one quarter mile above the mouth of Devil Creek (RM 161.4). Dissolved gas concentrations were measured at several points through the 10 mile reach of the proposed Devil Canyon rapids, downstream to approximately 50 miles below the Devil Canyon dam site. During the summer of 1982, a continuous recording monitor was installed approximately two miles below the Devil Canyon dam site. Most of the decay data was collected between this monitor and the Alaska Railroad bridge at Gold Creek. Precise locations are indicated in the Appendix Tables by river mile (Appendix 4-D-1).

Dissolved gas measurements were taken approximately one meter below the surface, although this varied somewhat depending on conditions. Very minor variations in dissolved gas pressures were recorded with depth. Sampling was usually done from a river boat drifting with the current in the river below Devil Canyon. Above the Devil Canyon dam site, gas measurements were often made by suspending the probe from a hovering helicopter. Because of the high velocities, this was generally done in eddies below the rapids. Where possible in the canyon, measurements were made from shore by landing on islands or rock outcroppings. Approximately 15 to 30 minutes was allowed for the dissolved gas readings to stabilize before the probe readings were recorded. Temperature and tensionometer pressure readings were recorded at each site.

Because of the difficulties in sampling in the canyon, these values are somewhat less precise than those in the lower river. Two types of instruments were used to measure dissolved gas pressure during this study. A saturometer described by Bouck (1982) was used for the initial measurements during the 1981 field season. However, because of the lack of portability of this instrument, a tensionometer developed by Common Sensing was used for all subsequent measurements. This instrument was modified for continuous recording of dissolved gas pressure and was deployed during August through October 10, 1982. A Datapod solid state recorder was connected to the tensionometer and used to record temperature and dissolved gas pressure hourly throughout this period.

Dissolved oxygen was also recorded during the initial sampling periods of 1981 to determine the relative contribution of dissolved oxygen to the overall gas supersaturation. Measurements were made in the field with a YSI dissolved oxygen probe with duplicate measurements at some sites by use of the Winkler method. Because the dissolved oxygen levels closely paralleled total gas supersaturation, further measurements of dissolved oxygen during the remainder of the study were not conducted. Barometric pressure readings were recorded by use of the tensionometer atmospheric readings, when point measurements were made. The Talkeetna weather station barometric pressure data from the U.S. Weather Bureau was used for calibration of the continuous recording dissolved gas concentrations, using standard correction factors for altitude differences.

Discharge data used are the provisional records of the U.S. Geological Survey from the Gold Creek gaging station (15292000). Hourly data was obtained by digitizing copies of the original gage tracings and converting to discharge by use of the most current rating table for this gage.

Dissolved gas supersaturation and all other values were calculated using the formula of Bouck (1982). These formula are duplicated in Appendix Table 4-D-2 of this report. All statistics were calculated using microcomputer statistical programs or by use of programmable calculators. Further references in addition to details of statistical analysis are included in Appendix Table 4-D-3.

3. RESULTS

3.1 Hydrological Investigations

3.1.1 Stage and Discharge

Stage and discharge measurements were obtained during the 1982 open-water season from various mainstem, slough and tributary sites within the Susitna River basin (Appendix Table 4-A-1).

3.1.1.1 Mainstem Between Talkeetna and Devil Canyon

Periodic stage readings (converted to water surface elevations) were obtained at 31 mainstem locations between Talkeetna and Devil Canyon during the 1982 open-water season. These data, along with corresponding average daily discharges recorded at Gold Creek (USGS provisional data, 1982), are presented in Appendix Table 4-A-2. Plots of these data (Appendix Figures 4-A-1 - 4-A-16) indicate that the relationship between water surface elevation and mainstem discharge is relatively well defined at most of the 31 locations for the range of flows from 8,000 to 30,000 cubic feet/second (cfs). The water surface elevation of the river rises approximately 1.5 to 2.0 feet as stream flows increase from 10,000 to 20,000 cfs. A mainstem gradient map (Figure 4I-3-1) shows a drop of 10.6 ft/mi from Portage Creek to Curry and 7.8 ft/mi from Curry to Whiskers Creek Slough.

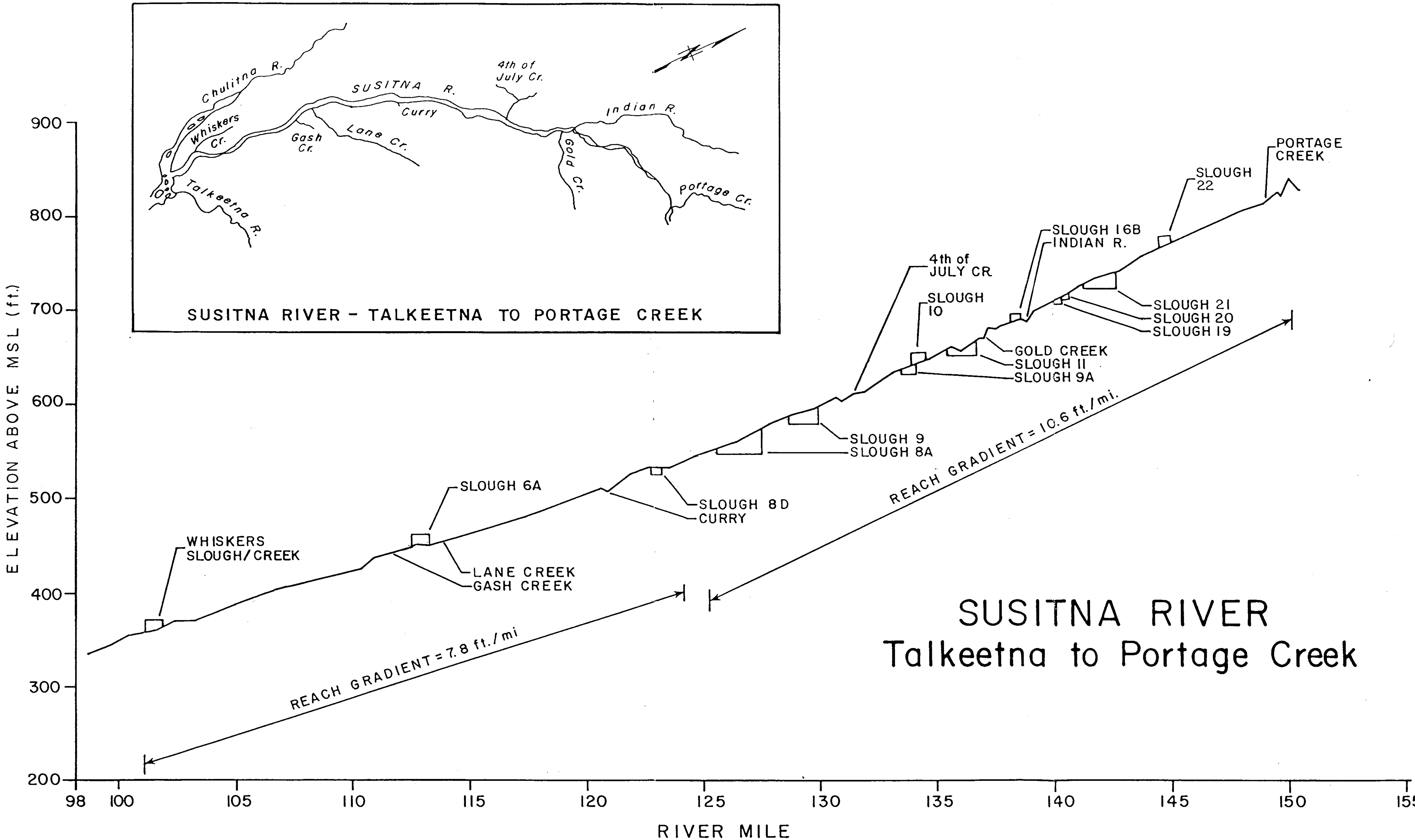

Figure 4I-3-1. Gradient of the Susitna River from Portage Creek to Whiskers Creek/Slough.

At the onset of the 1982 field season, it was intended to define the relationship of stage and discharge for the mainstem upstream of Talkeetna for the full range of discharges that normally occur during the open water season. However, abnormally low discharges this past summer, followed by high fall flows and an early freeze-up, precluded our ability to obtain the necessary field data to define water surface profiles for mainstem discharges in the 5,000 to 8,000 cfs or 30,000 to 45,000 cfs ranges.

3.1.1.2 Sloughs in the Talkeetna to Devil Canyon Reach of the Susitna River

Periodic staff gage readings and discharge measurements were obtained at nine sloughs located between Talkeetna and Devil Canyon during the 1982 open water field season. For five of these sloughs these baseline data were used to construct preliminary rating curves. Insufficient data at the other four sloughs did not permit the development of rating curves. For these nine sloughs plots were made comparing the observed water surface elevation within the slough to the mainstem discharge (Appendix Figures 4-A-17 - 4-A-30). Cross sections were made for six sloughs utilizing survey data at R&M Consultants (Appendix Figures 4-A-31 - 4-A-36). Additional cross sections were developed utilizing ADF&G survey data obtained in 1982 for Sloughs 8A, 9 and 21 (Appendix Figures 4-A-37 - 4-A-39).

The sloughs were characterized as either upland or side sloughs. Upland sloughs were defined as those having no connection to the mainstem other than at their mouth, with their water sources consisting primarily of ground water and/or surface water runoff. Side sloughs were defined as those connected to the mainstem at their mouth and, during periods of high mainstem flow, at their upstream juncture (head) with the mainstem.

3.1.1.2.1 Upland Slough

Slough 6A

Slough 6A (Figure 4I-3-2) is an area of clear backwater characterized by extremely low velocities with water sources primarily composed of ground water and surface runoff from a beaver dam in its upstream portion. Twelve staff gage readings were obtained at the mouth of Slough 6A showing a range of 3.2 feet of water surface elevation change over a corresponding range of mainstem flows from 8,440 to 32,000 cfs (Appendix Table 4-A-3). Water surface elevations obtained at the mouth of the slough were within 0.25 feet of the corresponding water surface elevations obtained in the mainstem (Appendix Table 4-A-1) for mainstem flows in the range of 14,000 to 32,000 cfs, indicating that a significant backwater effect occurs at the slough mouth for this range of mainstem flows. A single slough discharge, measured at 0.6 cfs, was obtained at the mouth of the slough when the corresponding mainstem discharge was 24,200 cfs (Table 4I-3-1).

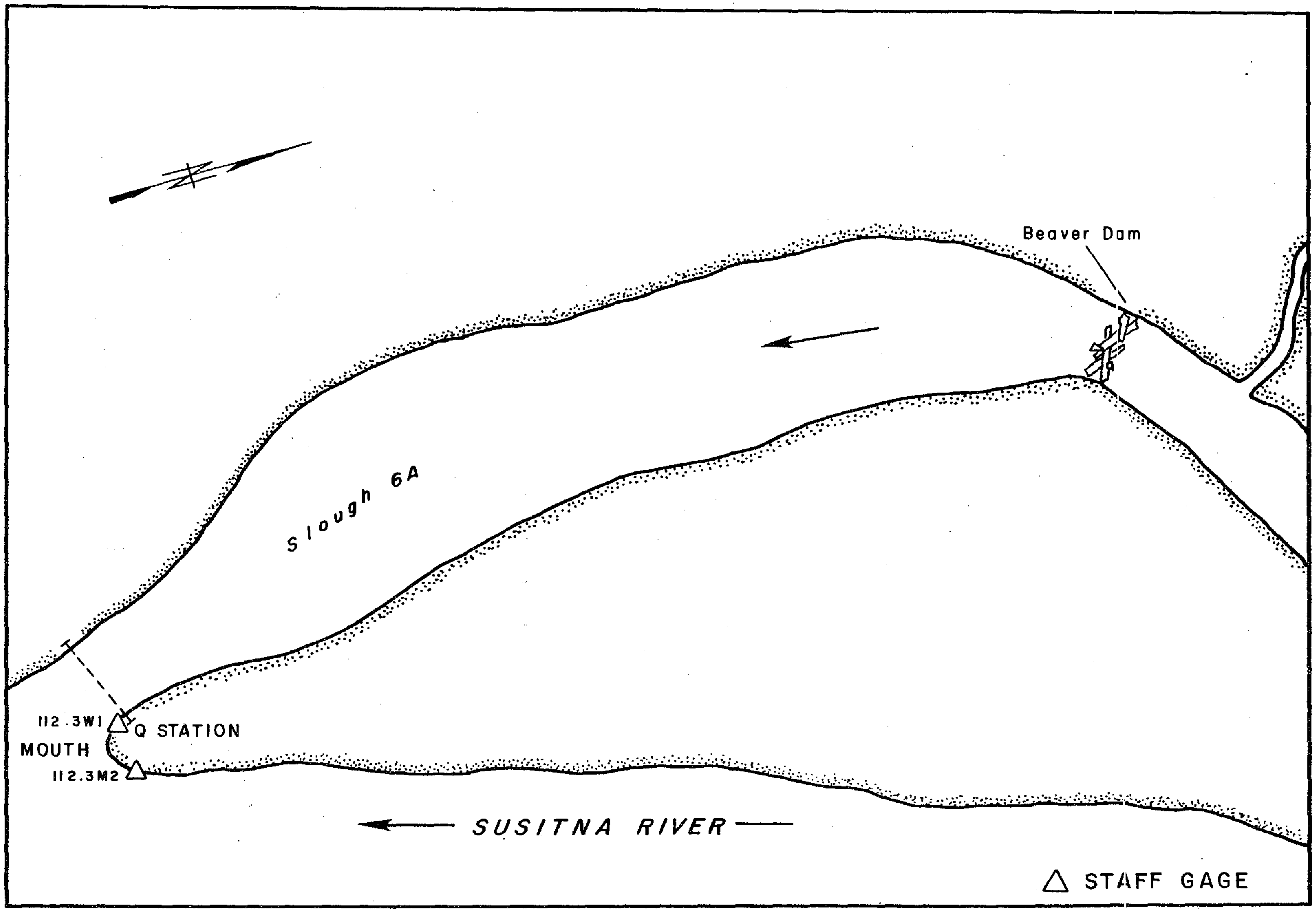

Figure 4I-3-2 Planimetric site map of Slough 6A, RM 112.3, GC S28N05W13CAC.

Table 4I-3-1. Comparison of periodic measurements of slough flow at selected locations upstream of Talkeetna to the corresponding mean daily mainstem discharge at Gold Creek.[a]

Location	Date	Time	Slough Discharge (cfs)	WSEL	Mainstem Discharge (cfs)
Whiskers Creek Slough	821009	1145	2.0	362.92	8,470
(RM 101.4)	820903	1625	0.7	363.97	14,600
	820816	1445	0.2	364.03	15,600
	820920	1530	35.1	365.38	24,000
Slough 6A	820817	1040	0.6	--	24,200
(RM 112.3)					
Lane Creek Slough	820903	1456	2.0	468.28	14,600
(RM 113.6)	820920	1333	9.9	469.41	24,000
	820917	1517	20.7	470.75	32,000
Slough 11	820830	1244	3.1		13,100
(RM 135.7)	820918	1010	5.5		27,500
Slough 16B	820919	1617	700.58	23.50	24,100
(RM 138.0)	820801	1551	700.85	54.80	26,400
	820915	1412	701.69	257.64	28,200
Slough 19	820819	1700	0.4	--	13,300
(RM 139.8)					
Slough 20	820820	1120	2.6	726.72	12,500
(RM 140.2)	820901	1643	11.6	726.89	17,900
	820802	1220	16.4	726.99	22,500
	820918	1825	44.8		27,500
	820916	1415	158.8	728.00	32,500
Slough 21	820831	1518	3.2	744.91	16,000
(RM 141.9)	820802	1400	5.0	744.99	22,500
	820916	1024	59.2	746.52	32,500
Slough 22	820919	1124	5.1	783.82	24,100
(RM 144.6)	820918	1425	31.2	784.30	27,500
	820915	1642	118.5	785.08	28,200

[a] USGS Provisional Data, 1982.

Slough 19

Slough 19 (Figure 4I-3-3) is a relatively short slough that, during periods of relatively high mainstem flow, exhibits a substantial area of backwater in its lower reaches. The primary sources of clear water in this slough, based on visual observations, appears to be groundwater and surface water runoff. Nineteen water surface elevations obtained at the downstream point of access (below the mouth) to Slough 19 had a range of 3.27 feet over a corresponding range of mainstem flows from 11,700 to 31,800 cfs (Appendix Table 4-A-3). Water surface elevations, obtained in the mainstem adjacent to the Slough 19, had a range of 3.54 feet during mainstem flows of 6,900 to 31,900 cfs (Appendix Table 4-A-2). A single slough discharge, measured at 0.4 cfs, was obtained at the mouth of Slough 19 when the mainstem discharge was 13,300 cfs (Table 4I-3-1).

3.1.1.2.2 Side Slough

Whiskers Creek Slough

Whiskers Creek Slough is a relatively open water channel that has as its primary water source, when it is not breached, Whiskers Creek, which empties into the slough approximately midway between its head and mouth (Figure 4I-3-4). Four discharge measurements, obtained in Whiskers Creek Slough above its confluence with Whiskers Creek, ranged from 0.2 to 35.1 cfs (Table 4I-3-1). The highest discharge measured (35.1 cfs) was recorded during a period when the head was breached and the mainstem

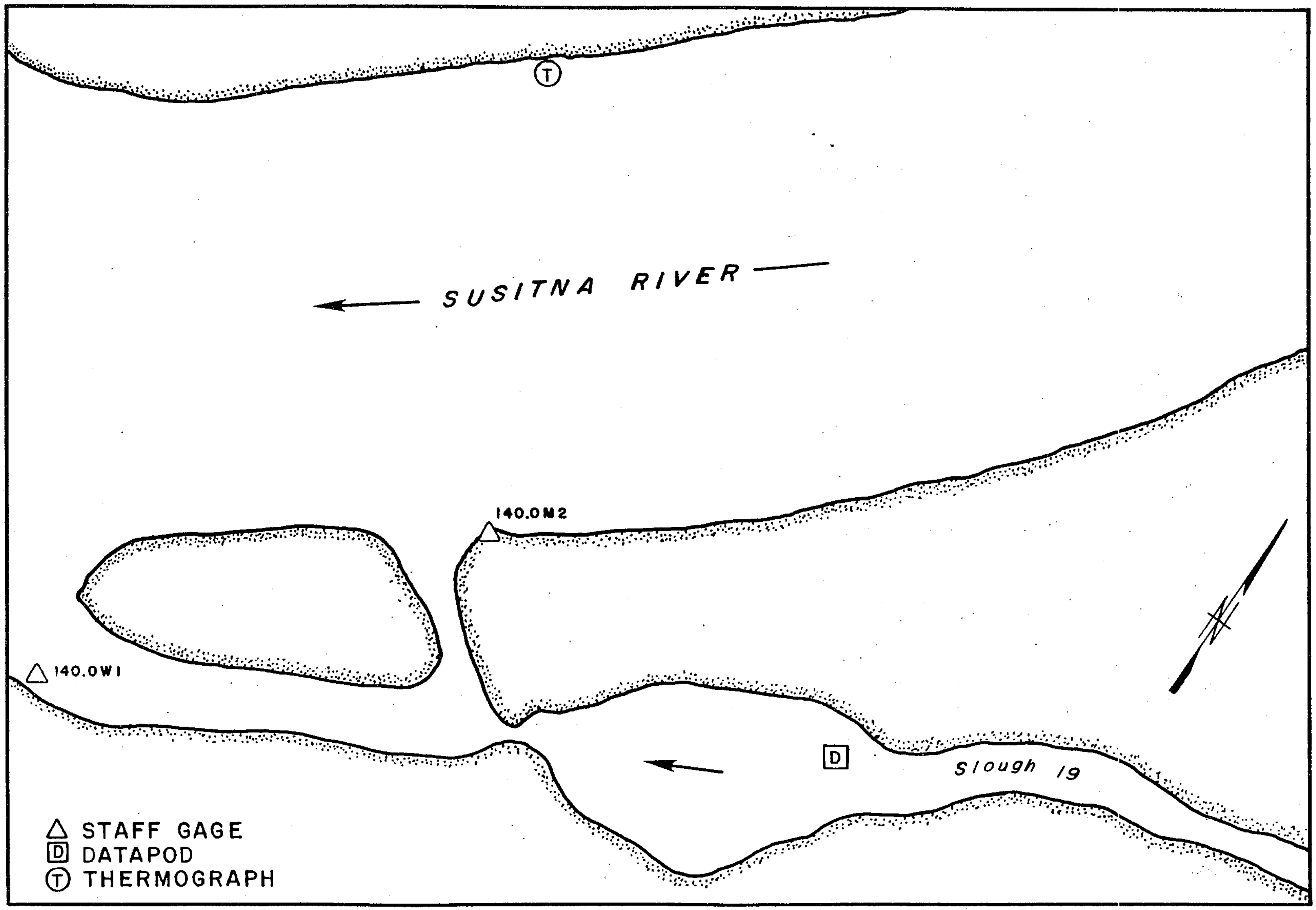

Figure 4I-3-3 Planimetric site map of Slough 19, RM 140.0, GC S31N02W10DBB.

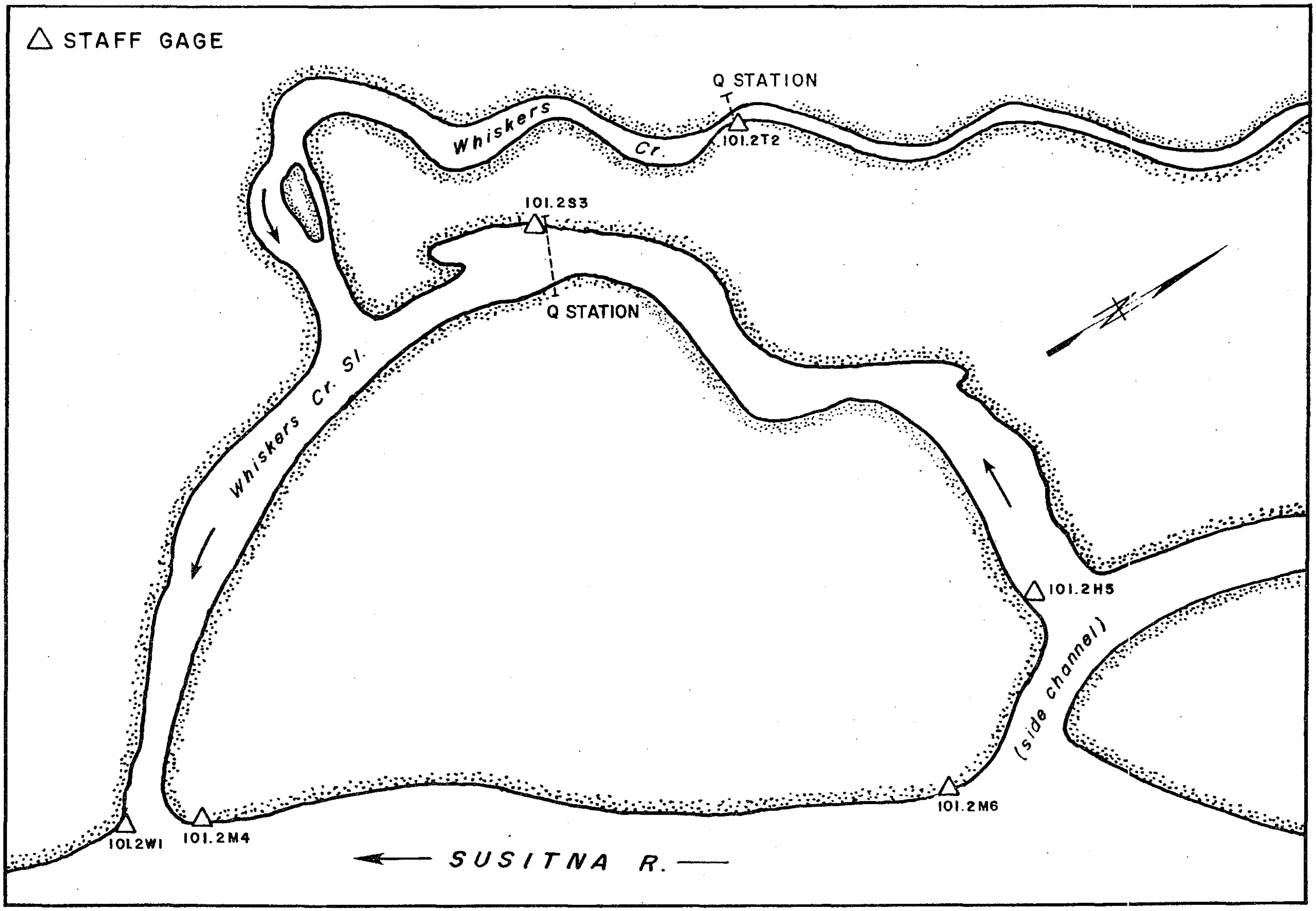

Figure 4I-3-4 Planimetric site map of Whiskers Creek and Whiskers Creek Slough, RM 101.2, GC S26N05W03AAC.

discharge was 24,000 cfs (Table 4I-3-2). The lower three flow measurements ranged from 0.2 to 2.0 cfs. The main water sources contributing to the flow during this period appeared to be groundwater and surface water runoff. Corresponding water surface elevations obtained during the low flows showed a range of 0.62 feet, with the overall range of water surface elevations being 2.03 feet (Appendix Table 4-A-3). These data were used to construct a preliminary rating curve (Figure 4I-3-5). Corresponding ranges of mainstem flows during this period were from 8,440 to 28,000 cfs.

Six water surface elevations obtained at the head of Whiskers Creek Slough (which joins a side channel of the Susitna River) had a range of 1.59 feet for corresponding mainstem flows of 13,600 to 31,900 cfs (Appendix Table 4-A-3). At mainstem discharges of 13,600 and 15,600 cfs, the head was not breached (staff gage readings were dry), while at mainstem discharges of 24,000 to 31,900 cfs, the head was breached, Table 4I-3-2.

Fourteen water surface elevations from the mouth of the slough were found to have a range of 4.0 feet corresponding to mainstem flows ranging from 8,440 to 31,900 cfs (Appendix Table 4-A-3). The water surface elevation of the mainstem, adjacent to the mouth of Whiskers Creek Slough, ranged 2.50 feet over mainstem flows from 8,440 to 24,000 cfs (Appendix Table 4-A-2). Water surface elevations obtained at the mouth of the slough were within 0.03 feet of the corresponding mainstem water surface elevations over the range of mainstem flows from 8,400 to

Table 41-3-2 Determination of the mainstem discharge at Gold Creek (cfs) required to breach the upstream end (head) of selected side sloughs in the Talkeetna to Devil Canyon Reach.

	Analytical Determination from Staff Gage at Slough Head		Field Observations		
Location	PZF at Slough Head	Mainstem Flow at Gold Creek	Date	Mainstem Flow at Gold Creek	Status of Slough
Whiskers Creek Slough RM 101.2	367.3	18,000	820816 820920	15,600 24,000	Not breached Breached
Lane Creek Slough RM 113.6	472.9	24,000	820920 820607	24,000 25,000	Almost breached Breached
Slough 11 RM 135.3	684.0	--	Never breached in 1982	Estimated breaching flow @ 42,000	
Slough 16B RM 138.0	703.0	19,000	820708 820914	18,100 20,200	Not breached Breached
Slough 20 RM 140.1	730.75	20,000	820914 820709	20,200 21,500	Not breached Breached
Slough 21, NW Channel RM 142.0	754.6	24,000	820720 820711 820728	22,900 24,000 25,600	Not breached Breached for a few feet Breached
Slough 21, NE Channel RM 142.0	755.5	26,000	820728 820622	25,600 26,000[a]	Not breached Breached
Slough 22 RM 144.3	787.8	21,000	820914 820919	20,200 24,100	Breached for a few feet Breached

[a]USGS gaging station was inoperable in June, mainstem discharges are estimates

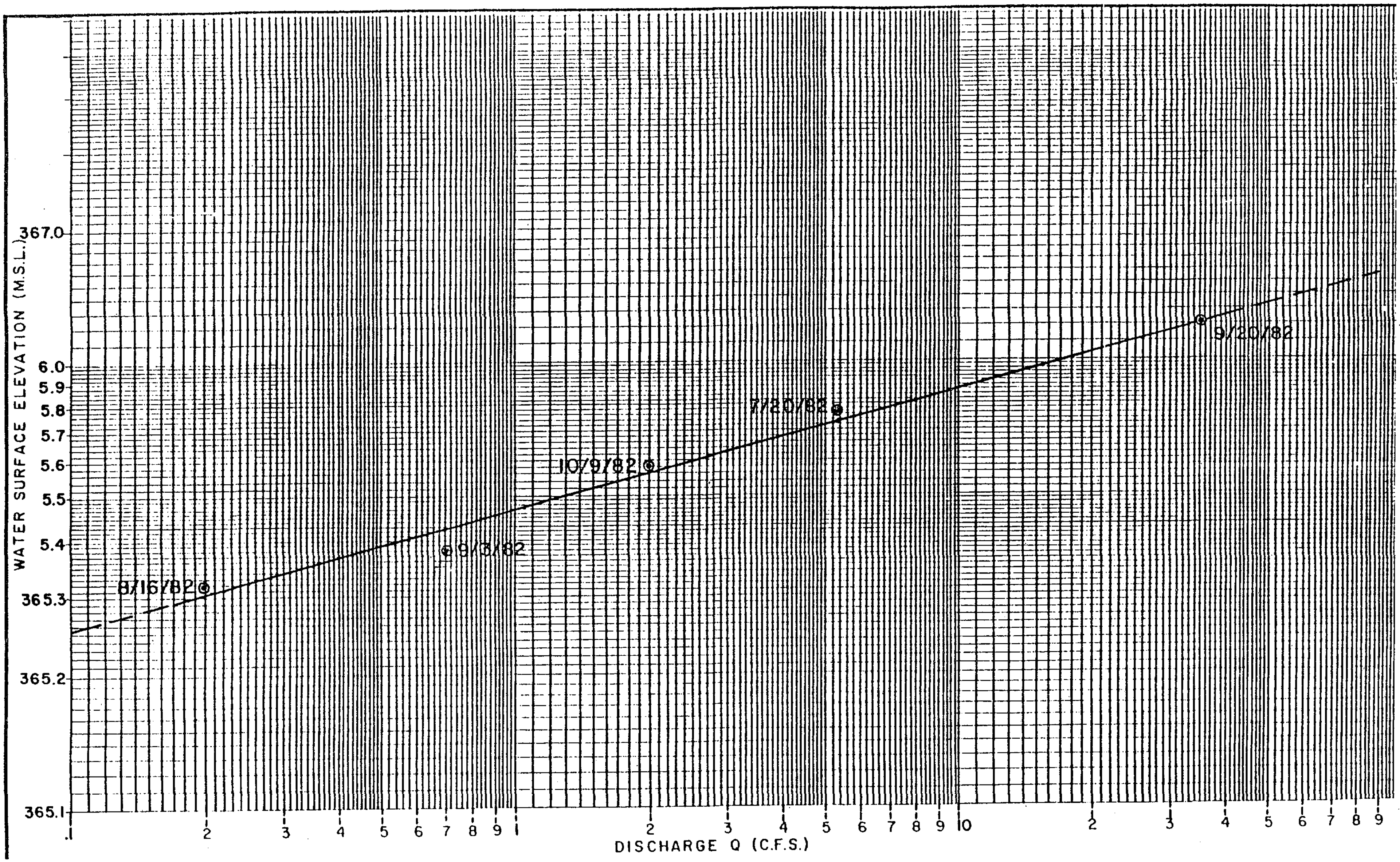

Figure 4I-3-5 Whiskers Creek Slough stage discharge rating curve (prepared by R&M Consultants 1982.)

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24,000 cfs, indicating that a substantial backwater effect occurs at the mouth of the slough for this range of mainstem flows.

Lane Creek Slough

Lane Creek Slough (Figure 4I-3-6) is a free-flowing, meandering slough which empties into the mouth of Lane Creek. Seven water surface elevations obtained at mid-slough gaging station showed a range of 2.5 feet over a corresponding range of mainstem flows from 10,500 to 32,100 cfs (Appendix Table 4-A-3). Three discharge measurements were also obtained at the mid-slough gaging station (Table 4I-3-1). Flow during the two lowest discharges (2.0 and 9.9 cfs) appeared to result primarily from ground water seepage and surface water runoff. Flow during the highest measured discharge (20.7 cfs), taken when the mainstem flow was 32,000 cfs, appeared to be primarily from the mainstem. The mainstem was observed to breach the head of Lane Creek Slough at mainstem flows of approximately 25,000 cfs (Table 4I-3-2). Of the three staff gage readings obtained at the head of the slough, two were dry at mainstem flows of 14,000 and 24,000 cfs and one showed a water surface elevation of 474.30 feet at a mainstem discharge of 32,000 cfs. Water surface elevations were not determined at the mouth of Lane Creek Slough. However, a small backwater area was noted at the mouth of the slough over all ranges of mainstem flows in 1982.

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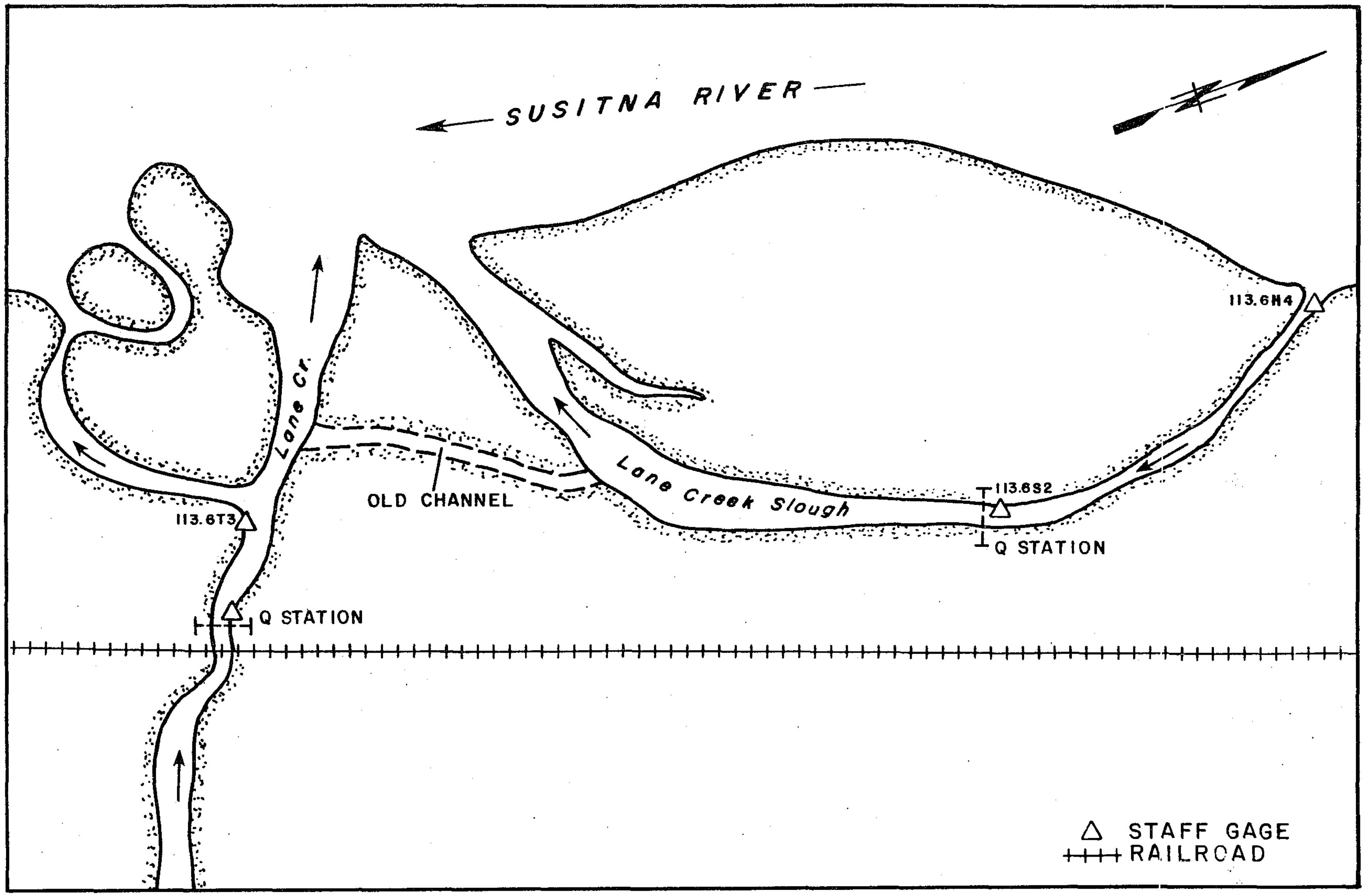

Figure 4I-3-6 Planimetric site map of Lane Creek and Lane Creek Slough, RM 113.6, GC S28N05W12ADD.

Slough 11

Slough 11 (Figure 4I-3-7) is a relatively long, unforked side slough with a head and mouth which join side channels of the mainstem. Six water surface elevations obtained from gages at the mid-slough gaging station were found to vary 0.05 feet (Appendix Table 4-A-3). Two discharge measurements obtained at the mid-slough gaging stations varied from 3.1 to 5.5 cfs (Table 4I-3-1). Due to the limited range of flows measured in Slough 11, a rating curve was not developed for this slough. The main sources of water contributing to the flow in Slough 11 during the open water season of 1982 appeared to be from groundwater and surface water runoff. The slough was never breached by the mainstem during the 1982 period of observation.

At the mouth, fifteen water surface elevations showed a range of 3.65 feet over a corresponding range of mainstem flows from 11,700 to 28,000 cfs. Water surface elevations of the mainstem, adjacent to the mouth, during this period had a range of 3.14 feet (Appendix Table 4-A-2). Backwater effects were limited to the immediate area of the mouth, increasing with mainstem discharge.

Slough 16B

Slough 16B (Figure 4I-3-8) consists of a relatively open, free-flowing channel which head and mouth confluence the mainstem. Eight water surface elevations obtained at the mid-slough gaging station showed a range of 1.61 feet (Appendix Table 4-A-3). Three discharge measurements

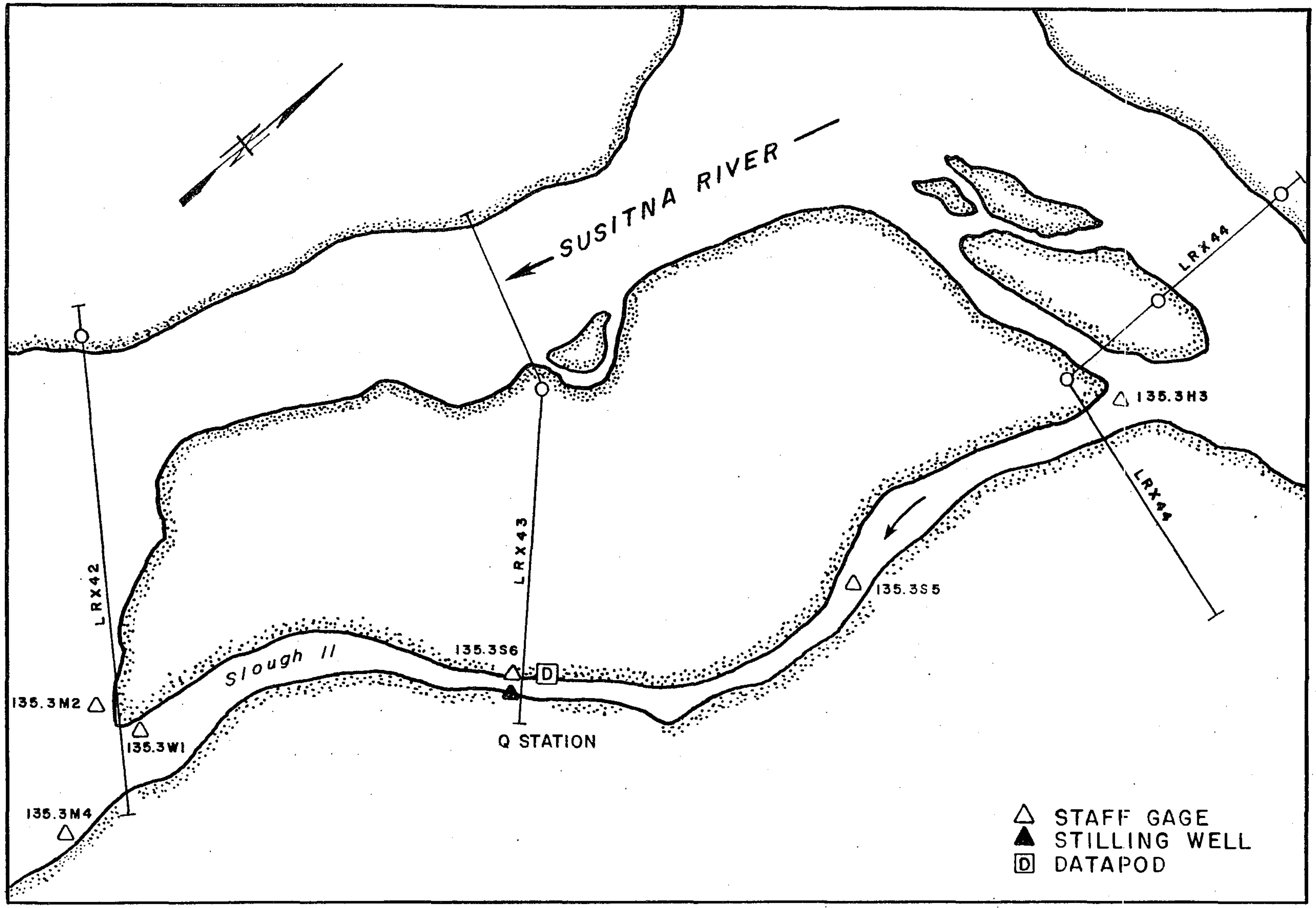

Figure 4I-3-7 Planimetric site map of Slough 11, RM 135.3, GC S31N02S19DDD.

were also obtained at the mid-slough gaging station ranging from 23.5 to 257.6 cfs (Table 4I-3-1). These data were used to construct a preliminary rating curve for this slough (Figure 4I-3-9). All discharge measurements measured at the mid-slough gaging station were obtained while the slough was breached by the mainstem. Corresponding mainstem flows ranged from 11,700 to 28,200 cfs. A single discharge measurement was made during a low flow, unbreached period near the mouth of the slough when the mainstem flow was 16,000 cfs. The flow was measured at 0.9 cfs and appeared to consist primarily of groundwater and surface water runoff.

Slough 16B was observed to be breached by the mainstem at the head of the slough when mainstem flows were 20,200 cfs (Table 4I-3-2). From five water surface elevations determined from staff gages placed at the head of Slough 16B, it was found that during a range of flows in the mainstem from 20,200 to 31,900 cfs, the water surface at the head ranged 1.4 feet.

The overall range of water surface elevations measured at the mouth of the slough was 2.88 feet over a corresponding range of mainstem discharges from 11,700 to 31,900 cfs. Thirteen water surface elevations of the mainstem, adjacent to the mouth of Slough 16B, ranged 5.83 feet over a range of mainstem discharges from 7,950 to 31,900 cfs. No pooling or backwater effect caused by the mainstem apparent at the mouth of this slough during 1982.

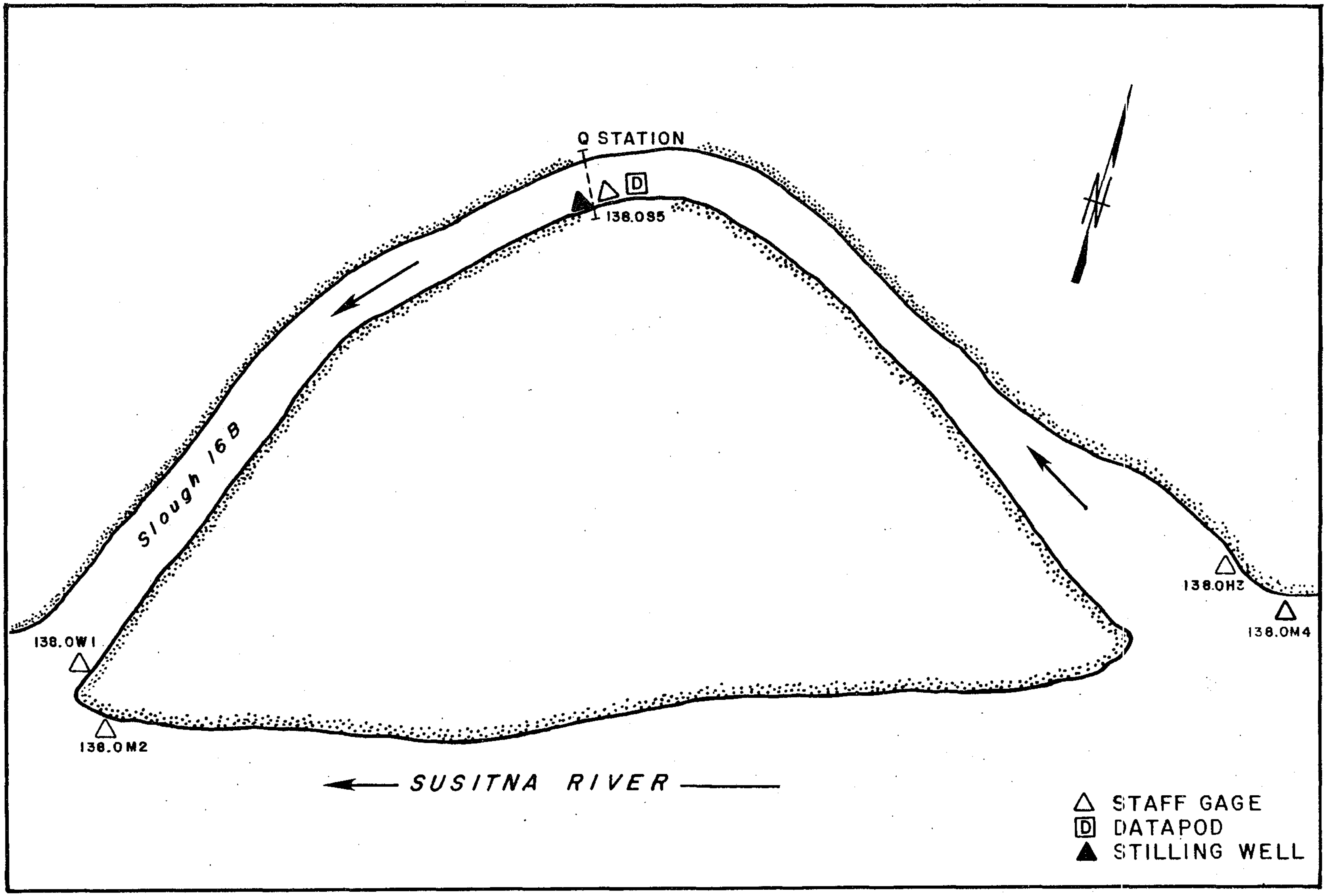

Figure 4I-3-8 Planimetric site map of Slough 16B, RM 138.0, GC S31N02W17ABC.

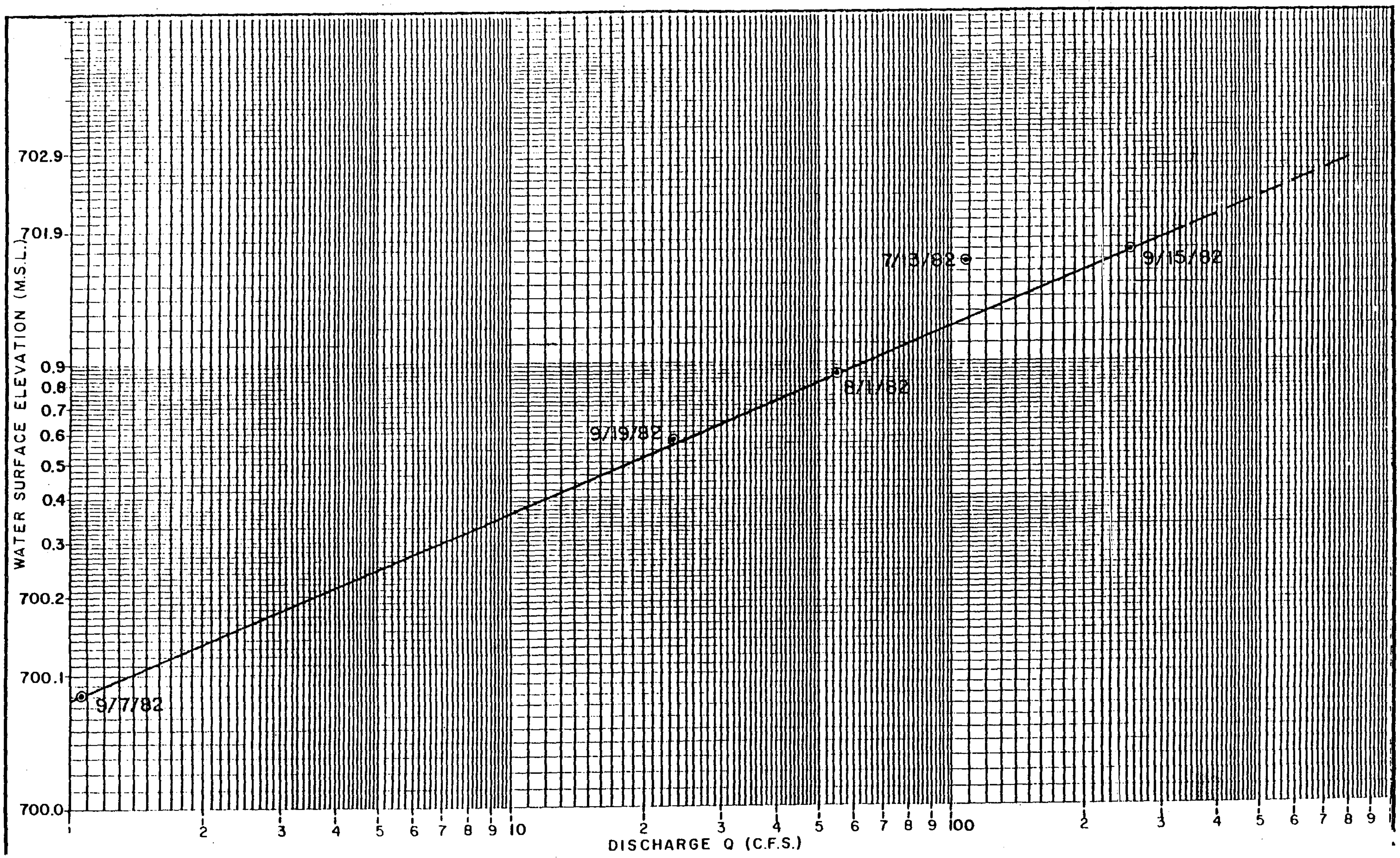

Figure 4I-3-9 Slough 16B stage-discharge rating curve (prepared by R&M Consultants).

Slough 20

Slough 20 (Figure 4I-3-10) as a relatively open, free-flowing channel which is fed by two clear water tributaries. Both its head and mouth confluence the mainstem Susitna River. Thirteen water surface elevations, obtained at the mid-slough gaging station varied 1.28 feet (Appendix Table 4-A-3). Five discharge measurements, taken at the mid-slough gaging station, ranged from 2.6 to 158.8 cfs (Table 4I-3-1). These data were used to construct a preliminary rating curve for this slough (Figure 4I-3-11). Corresponding mainstem flows during the period of measurements ranged from 8,480 to 32,500 cfs. Water surface elevations obtained at the mid-slough gaging station during breached and non-breached conditions varied 1.10 and 0.17 feet respectively while corresponding discharges measurements ranged from 16.4 to 158.8 cfs and 2.6 to 11.6 cfs, respectively. Mainstem flows during these periods ranged from 22,500 to 32,500 cfs and 12,500 and 17,900 cfs, respectively, with breaching occurring, as determined from the slough discharge measurements between the range of mainstem flows from 17,900 to 22,500 cfs.

Of the fourteen staff gage readings obtained at the head of the slough, three were dry at mainstem flows ranging from 12,500 to 20,200. The other eleven ranged from 0.40 to 1.39 feet over mainstem flows ranging from 21,500 to 32,500 cfs (Appendix Table 4-A-2). These data indicate the slough breaches between a mainstem discharge of 20,200 and 21,500 cfs (Table 4I-3-2.

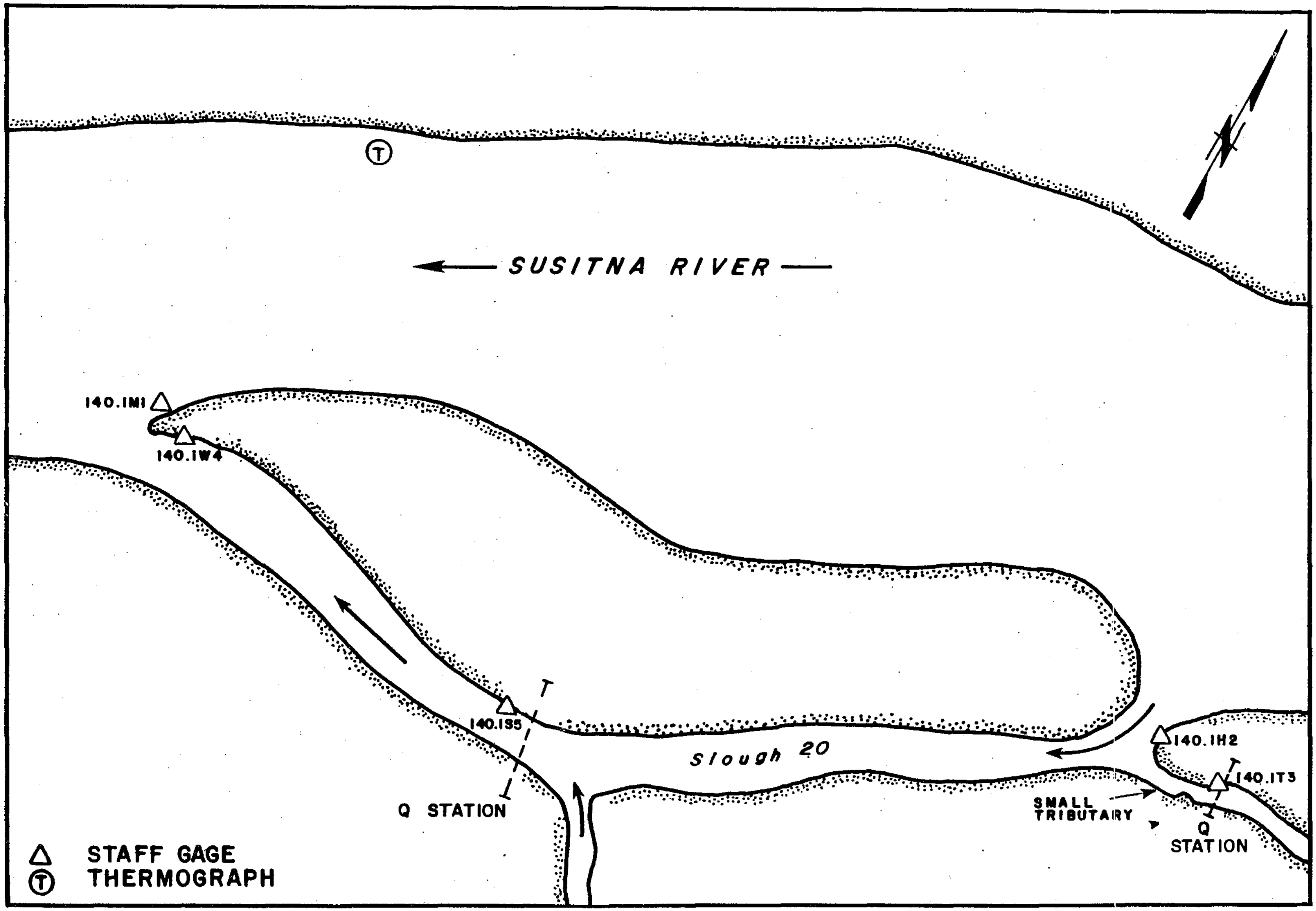

Figure 4E-3-10 Planimetric site map of Slough 20, RM 140.1, GC S31N02W11BBC.

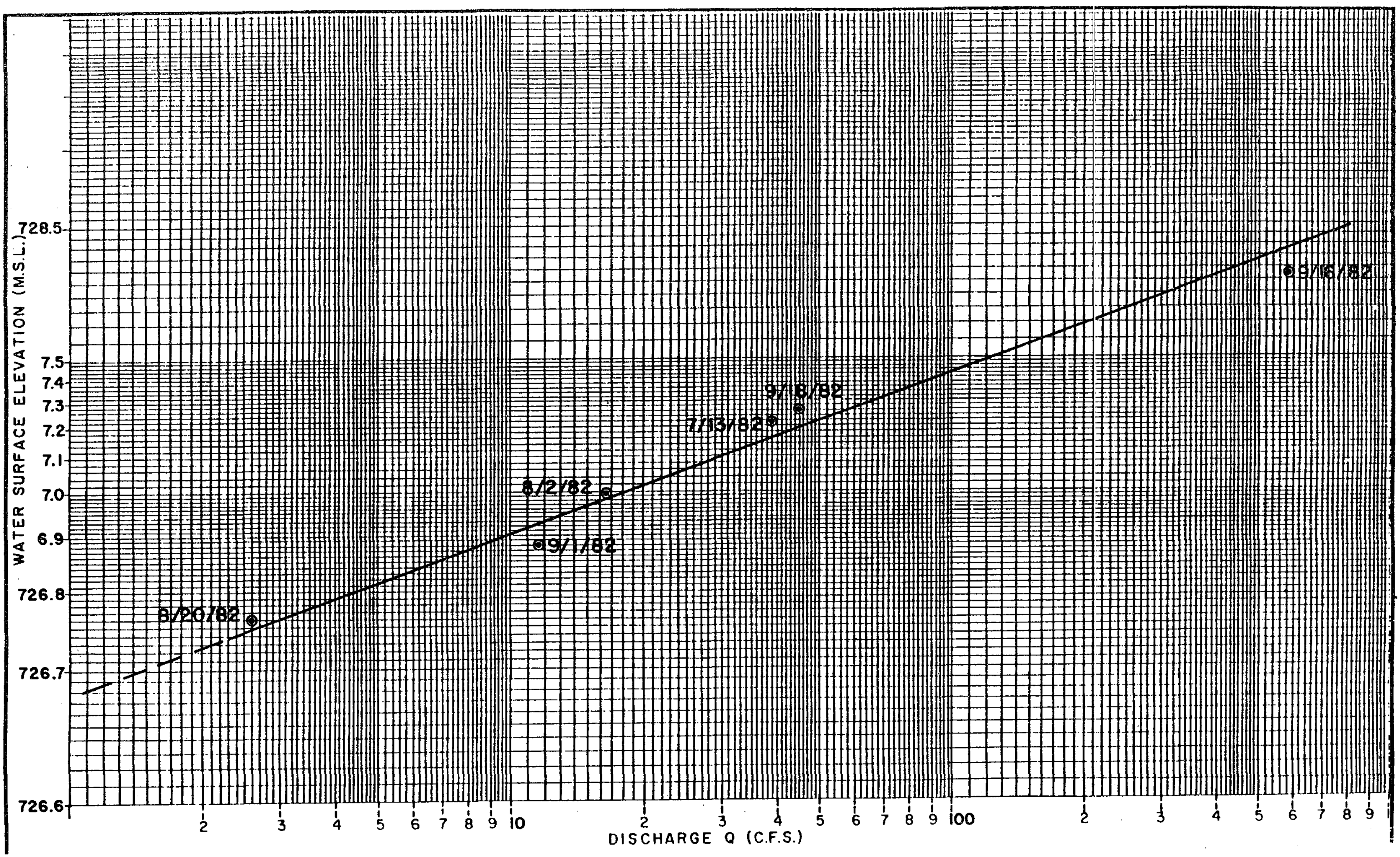

Figure 4E-3-11 Slough 20 stage-discharge curve (prepared by R&M Consultants 1982).

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Twenty water surface elevations recorded at the mouth of Slough 20 ranged 2.44 feet during corresponding mainstem flows from 8,480 to 32,500 cfs (Appendix Table 4-A-3). Mainstem water surface elevations recorded adjacent to the mouth of Slough 20 for this same period ranged 2.48 feet (Appendix Table 4-A-2). These data indicate a backwater effect takes place in the vicinity of the mouth of the slough for these ranges of mainstem flows. Observations in 1982 substantiate this conclusion.

Slough 21

Slough 21 (Figure 4I-3-12) portion of the Slough 21 complex is a relatively long slough which parallels the mainstem Susitna River. The upper portion of Slough 21 forks into two channels and both heads join the mainstem. The mouth of the slough joins with a side channel of the mainstem. Seventeen water surface elevations were obtained at the gaging station located downstream of the forks varied 2.10 feet (Appendix Table 4-A-3). Three discharge measurements were also obtained at this gaging station ranging from 3.2 to 59.2 cfs (Table 4I-3-1). These data were used to construct a preliminary rating curve for this slough (Figure 4I-3-13). Corresponding mainstem discharges over the period of measurement ranged from 11,000 to 32,500 cfs. The two lowest discharge measurements, 3.2 and 5.0 cfs, were recorded during non-breaching mainstem flows of 16,000 and 22,500. The highest recorded slough discharge measured 59.2 cfs and was recorded during a breaching mainstem flow of 32,500 cfs. The primary sources of water to the slough

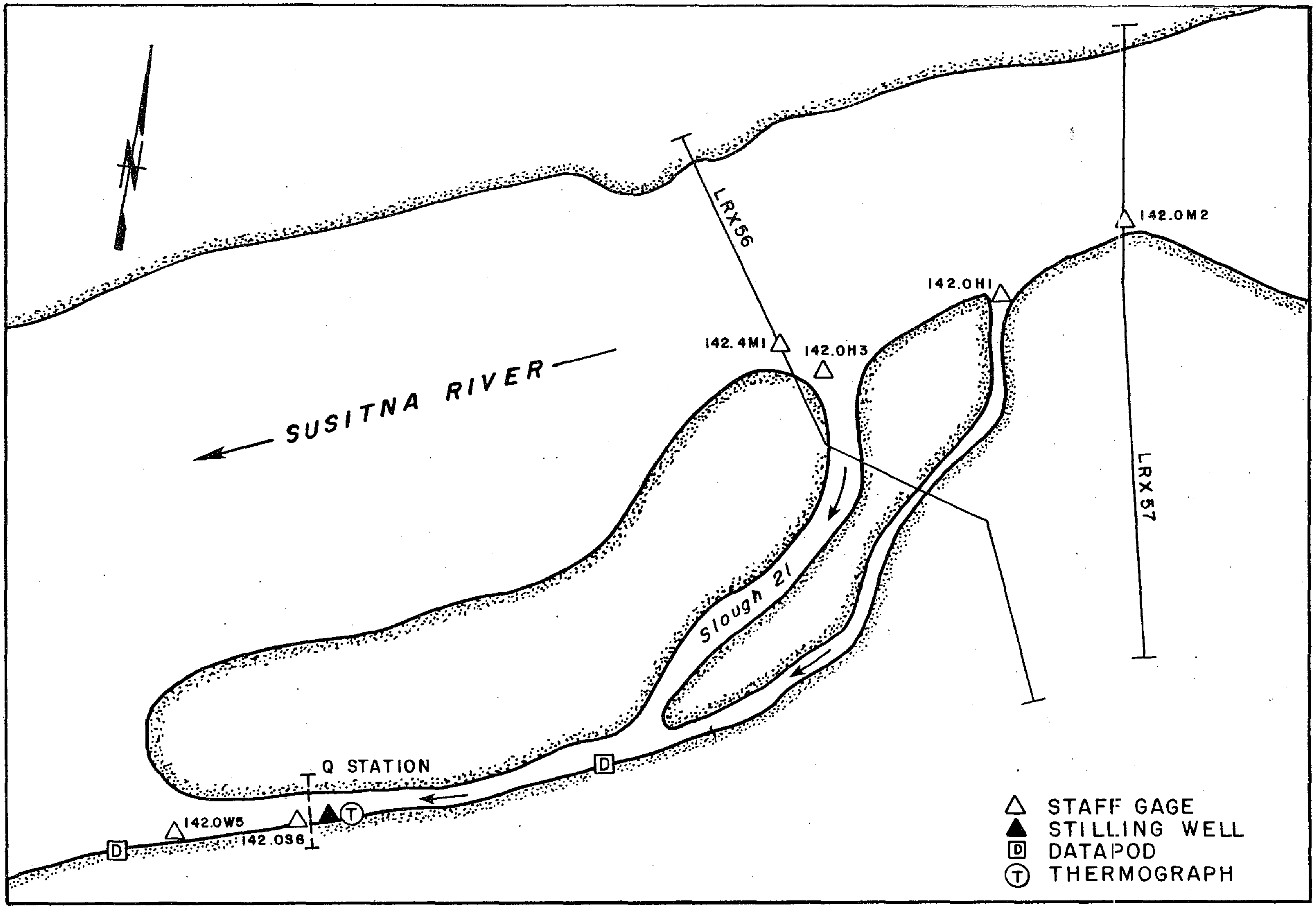

Figure 4I-3-12 Planimetric site map of Slough 21, RM 142.0, GC S31N02W02AAA.

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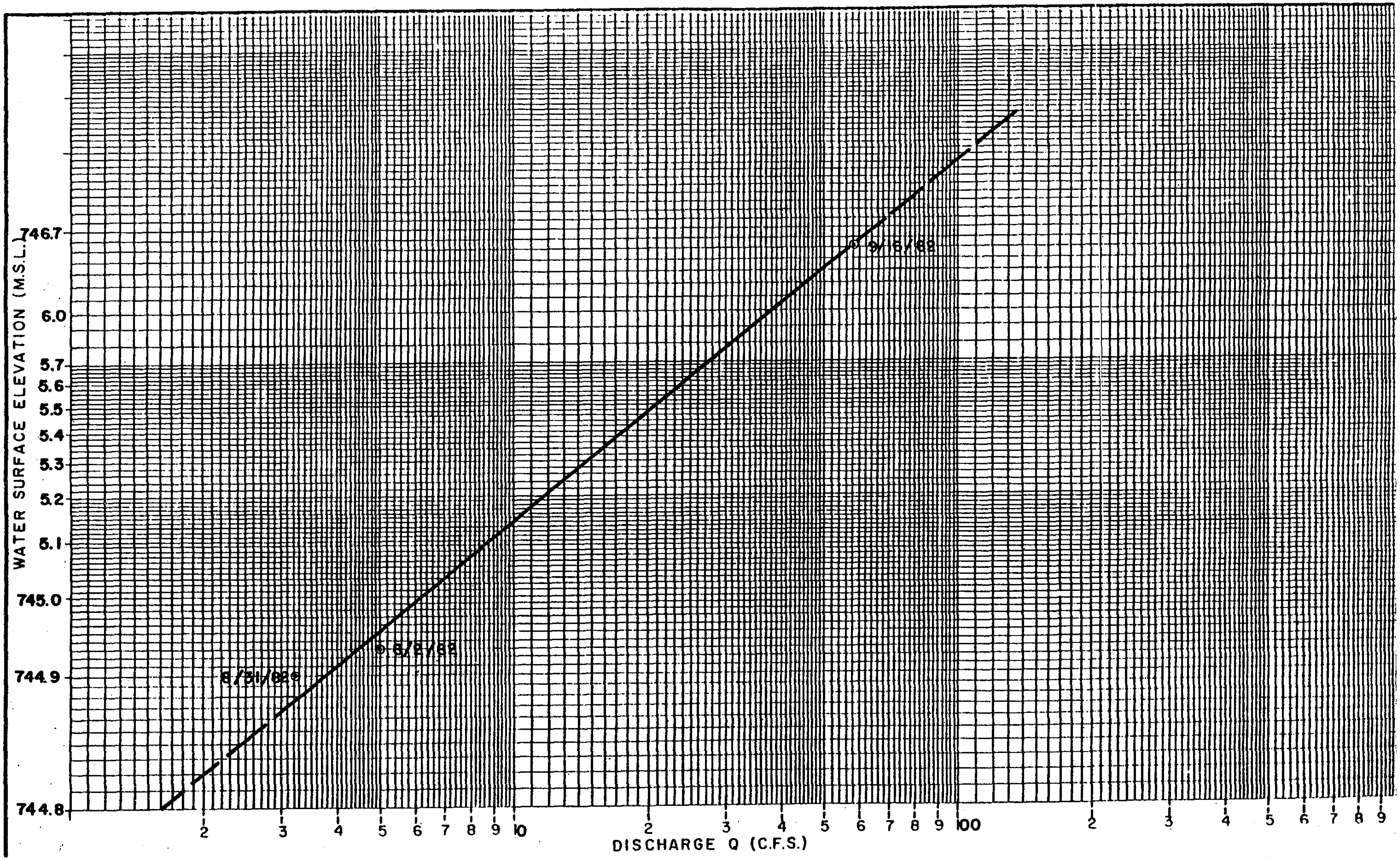

Figure 4I-3-13 Slough 21 stage- discharge curve (prepared by R&M Consultants 1982.)

flow during times of non-breaching mainstem flows appeared to be ground water and surface water runoff.

The NW (left channel looking upstream) head was observed to be breached by the mainstem at a mainstem flows greater than 24,000 cfs (Table 4I-3-2). Of the 12 staff gage readings obtained at the NW head of Slough 21, four were dry at mainstem flows between 16,000 and 22,900 cfs and eight had a range of 0.66 feet over mainstem flows from 24,000 to 32,500 cfs. Mainstem flows of at least 26,000 cfs, however, are required to breach the NE head. Of the nine staff gage readings obtained at the NE head of Slough 21, five were dry at mainstem flows ranging from 16,000 and 26,000 cfs and four had a range of 0.46 feet over mainstem flows from 26,000 to 31,900 cfs (Appendix Table 4-A-3). With a mainstem flow of 32,500 on September 16, both heads were breached by the mainstem.

Seventeen water surface elevations obtained at the mouth of Slough 21 (Appendix Table 4-A-3) had a range of 0.25 feet for mainstem flows from 12,200 to 24,100 cfs and a range of 1.42 feet for mainstem flows from 25,600 to 32,500 cfs. Very little backwater effects caused by the mainstem were observed in the vicinity of the mouth of Slough 21 in 1982.

Slough 22

Slough 22 is a relatively long, open-water channel with its head and mouth both confluenceing the mainstem Susitna River (Figure 4I-3-14).

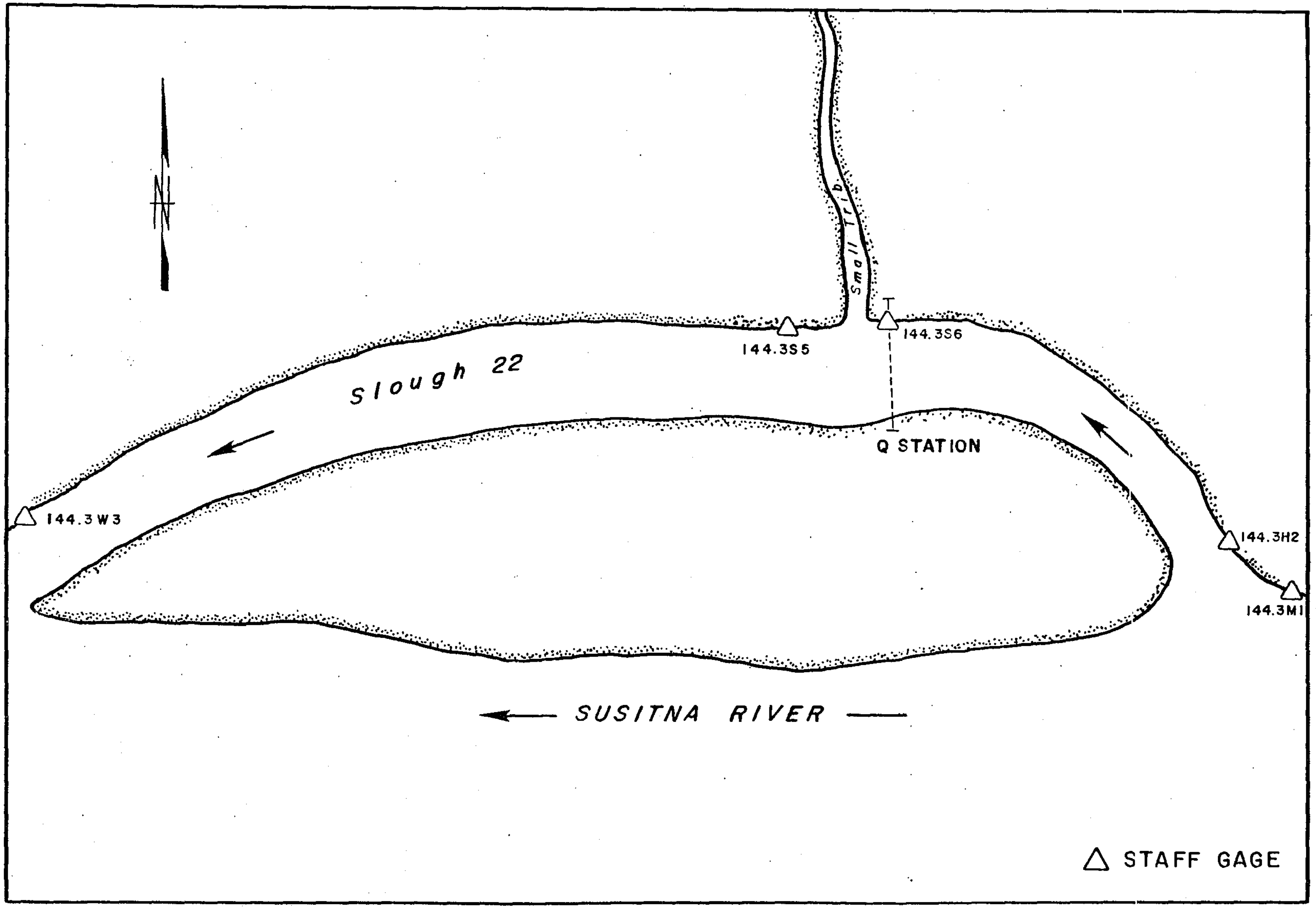

Figure 4I-3-14 Planimetric site map of Slough 22, RM 144.3, GC S32N02W32BBD.

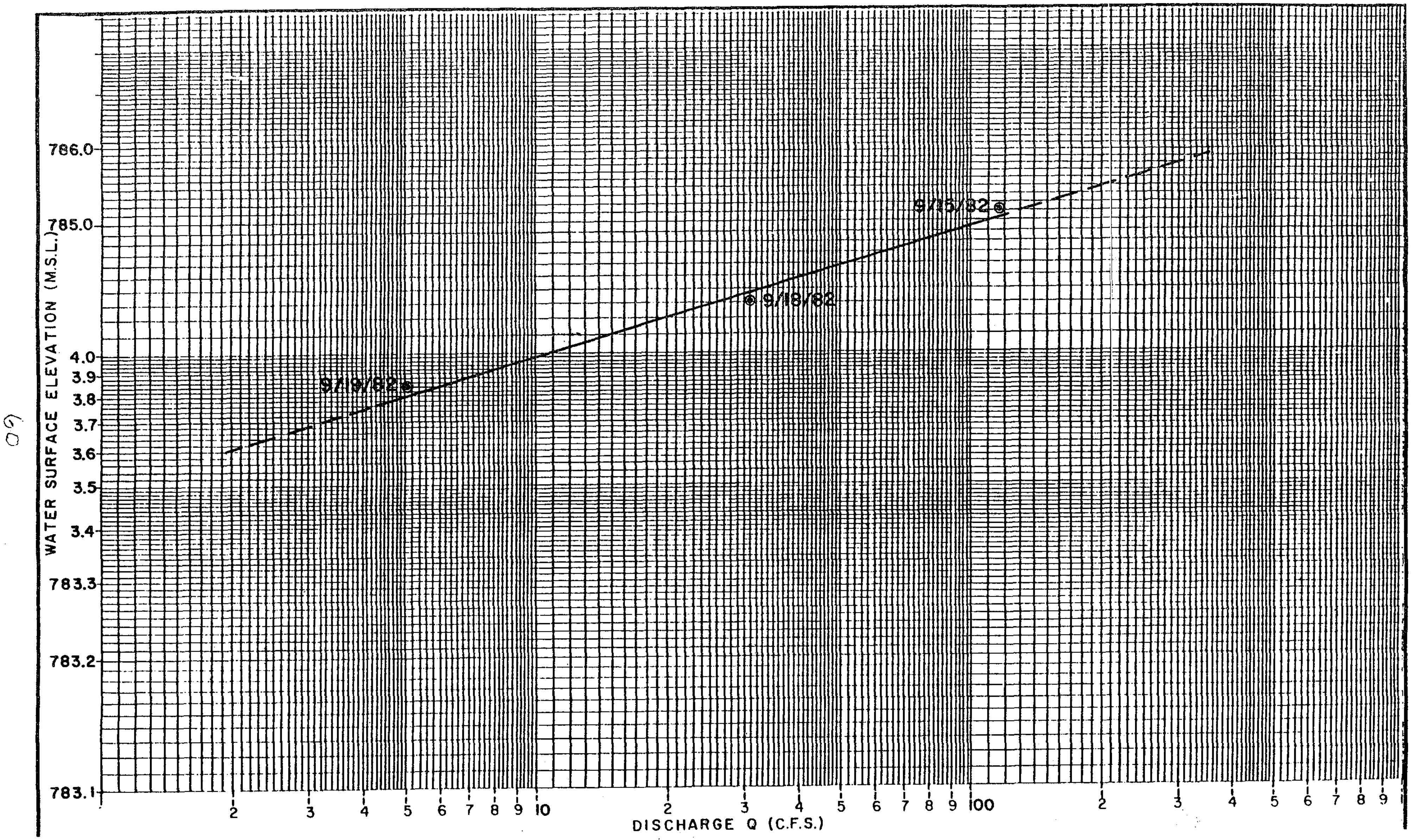

Figure 4I-3-15 Slough 22 stage-discharge curve (prepared by R&M Consultants 1982).

Nine water surface elevations obtained at the mid-slough gaging station had a range of 1.72 (Appendix Table 4-A-3). Three discharge measurements obtained at this gaging station ranged from 5.1 to 118.5 cfs (Table 4I-3-1). These data were used to construct a preliminary rating curve for Slough 22 (Figure 4I-3-15). Corresponding mainstem discharges over the periods of measurement ranged from 13,600 to 28,200 cfs. All slough discharges were measured under mainstem breaching conditions.

Mainstem water was observed to begin to breach the head of Slough 22 with flows of 22,500 cfs (Table 4I-3-2). For mainstem flows in range of 22,500 to 28,200 cfs, the water surface elevation of the slough at the head varied 1.40 feet. Three dry staff gage readings were obtained under non-breaching mainstem flows of 18,100, 16,000 and 13,600 cfs.

Water surface elevations obtained at the mouth of Slough 22 varied 0.44 feet for mainstem flows ranging from 11,000 to 24,000 cfs and 0.99 feet for mainstem flows ranging from 24,100 to 28,200 cfs. For mainstem flows of 24,100 to 28,200 cfs, water depths over the head of Slough 22 ranged from 0.51 to 1.63 feet. No backwater effects caused by mainstem water influence were observed in 1982 in the vicinity of the mouth of Slough 22.

3.1.1.3 Tributaries Between Talkeetna and Devil Canyon

Staff gage readings and discharge measurements were obtained at seven tributaries located between Talkeetna and Devil Canyon during the 1982 open water field season. For two of these tributaries, Indian River and

Portage Creek, preliminary rating curves were developed. Due to insufficient data at the other sites, no rating curves were developed for Whiskers, Gash, Lane or Fourth of July Creeks, and an unnamed tributary at the head of Slough 20.

Whiskers Creek

Three discharge measurements were obtained on Whiskers Creek (Figure 4I-3-4) ranging from 18.3 to 142.5 cfs over a corresponding change in water surface elevation of 1.51 feet (Table 4I-3-3). Fifteen additional water surface elevations not collected in conjunction with discharge data showed a change in water surface elevation during the period of June to early October of 2.35 feet.

Gash Creek

Three discharge measurements were obtained on Gash Creek (Figure 4I-3-16) ranging from 1.3 to 16.6 cfs over a corresponding change in water surface elevation of 0.5 feet (Table 4I-3-3). Six additional water surface elevations not collected in associatation with discharge measurements had a range of 0.6 feet during the period August to October, 1982. Flows in Gash Creek are influenced by a culvert located upstream of the gaging station.

Table 4I-3-3. A comparison of water surface elevation and discharge (cfs) measurement at selected tributary streams upstream of Talkeetna to mainstem discharge (cfs) at Gold Creek.[a]

Location	Date	Time	WSEL (ft)	Measured Streamflow	Mainstem Discharge (cfs)
Whiskers Creek (R.M. 101.4) gage 101.2T2	821009	1145	366.51	31.8	7,080
	821006	1300	366.59	--	7,500
	820822	1400	366.21	--	12,200
	820928	1715	366.84	--	12,900
	820909	1315	366.39	--	13,400
	820813	1405	366.48	--	13,600
	820903	1550	366.85	54.7	14,600
	820816	1700	366.37	18.3	15,600
	820808	1930	366.12	--	16,600
	820611	--	366.06	--	24,000
	820930	1615	367.88	142.5	24,000
	820715	1320	365.49	--	25,600
	820622	0930	367.07	--	26,000
	820621	1300	367.40	--	28,000
	820725	1525	368.47	--	31,900
Gash Creek (R.M. 111.5) gage 111.5T1	821009	1545	453.32	5.9	8,440
	821004	1430	453.34	--	10,500
	820813	1320	453.10	--	13,600
	820818	1150	453.18	1.3	14,200
	820920	1707	453.69	16.6	24,000
	820921	1240	453.34	--	24,200
Lane Creek (R.M. 113.6) gage 113.6T3	821004	1228	472.03	--	10,500
	820909	1100	471.94	--	13,400
	820926	1335	472.11	--	14,400
	820910	1630	471.91	--	14,400
	820903	1450	472.23	--	14,600
	820925	1640	472.14	--	15,000
	820817	1425	471.89	27.5	15,100
	820816	--	475.44	35.3	15,600
	820902	--	475.79	51.7	16,000
	820831	--	475.94	56.7	16,000
	820808	1430	471.95	--	16,600
	820917	1645	472.58	--	32,000
4th of July Creek (R.M. 131.1) gage 131.1T1	820907	1745	625.29	--	11,700
	820908	1345	625.24	--	11,900
	820822	1315	624.99	--	12,200
	821001	1524	625.53	--	12,400
	820813	1220	625.18	--	13,600
	820818	1805	625.18	--	14,200
	820903	1130	625.81	--	14,600

[a] USGS provisional data, 1982.

Table 4I-3-3 (continued).

Location	Date	Time	WSEL (ft)	Measured Streamflow	Mainstem Discharge (cfs)
4th of July Creek (R.M. 131.1) gage 131.1T1	820811	1015	625.33	--	15,400
	820902	1640	625.67	--	16,000
	820810	1835	625.38	--	16,700
	820924	1750	625.53	--	17,100
	820803	1625	625.35	38.3	19,800
	820920	1030	626.28	--	24,000
	820919	1026	626.28	--	24,100
	820728	1625	625.52	--	25,600
	820917	1050	626.17	--	32,000
Tributary at head of Slough 20 (R.M. 140.6) gage 140.1T3	821003	1715	731.23	--	11,000
	820820	1145	730.16	--	12,500
	820813	1005	730.19	--	13,600
	820901	1540	730.21	0.2	17,900
	820804	1220	730.04	--	18,500
	820914	1447	730.52	--	20,200
	820802	1230	730.37	--	22,500
	820619	--	730.77	--	25,000
	820623	1015	730.61	--	26,000
	820622	1145	730.98	--	26,000
	820918	1217	730.74	9.3	27,500
	820727	1205	730.84	--	29,100
	820916	1230	731.39	23.4	32,500

[a] USGS provisional data, 1982.

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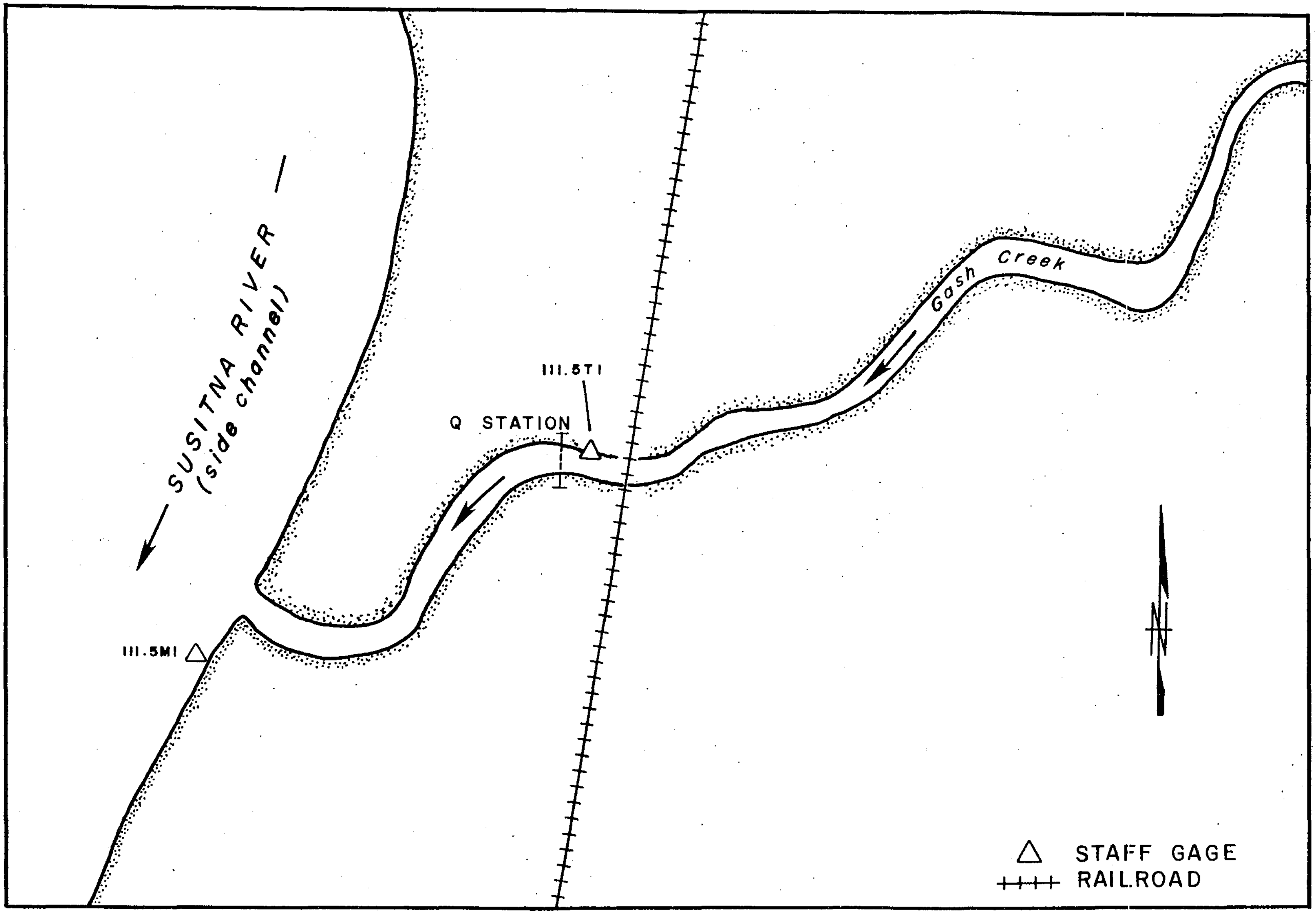

Figure 4I-3-16 Planimetric site map of Gash Creek, RM 111.5, GC S28N05W24ADA.

Lane Creek

Four discharge measurements were obtained on Lane Creek (Figure 4I-3-6) ranging from 27.5 to 56.7 cfs over a corresponding change in water surface elevation of 4.0 feet (Table 4I-3-3). Twelve additional water surface elevations not collected in conjunction with discharge data showed a range of 4.0 feet during the period August to October, 1982.

Fourth of July Creek

Due to high velocities, which made wading hazardous during most 1982 flows, only a single discharge measurement of 38.3 cfs corresponding to a water surface elevation of 625.35 feet was obtained on Fourth of July Creek (Figure 4I-3-17). Fifteen additional water surface elevations not collected in conjunction with discharge data showed a change in water surface elevation of 1.29 feet during the period July to October, 1982 (Table 4I-3-3).

Unnamed Tributary at the Head of Slough 20

Three discharge measurements were obtained on an unnamed tributary located at the head of Slough 20 (Figure 4I-3-10), ranging from 0.2 to 23.4 cfs over a corresponding change in water surface elevation of 1.18 feet (Table 4I-3-3). Ten additional water surface elevations not collected in conjunction with discharge data showed a change in water surface of 1.35 during the period of June to October, 1982.

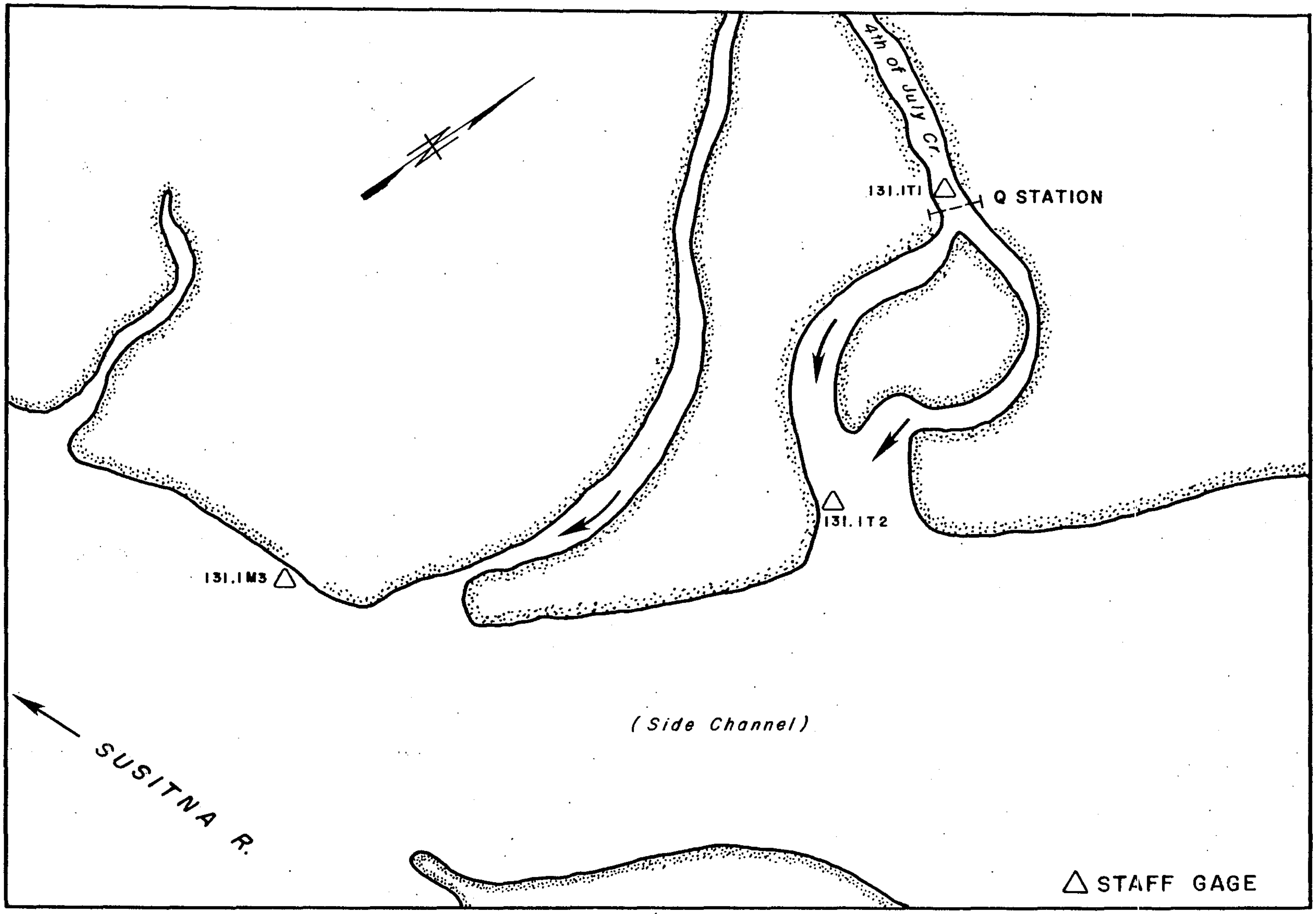

Figure 4I-3-17 Planimetric site map of Fourth of July Creek, RM 131.1, GC S30N03W03DAC.

Indian River and Portage Creek

Continuous streamflow records for Indian River (Figure 4I-3-18) and Portage Creek (Figure 4I-3-19) were obtained from August 9 through October 22 (Appendix Tables 4-A-4 and 4-A-5). Streamflows generally ranged between 100 and 400 cfs over a corresponding change in water surface elevation of 1.82 ft at Indian River (Table 4I-3-4) and 200 to 600 cfs over a corresponding change in water surface elevation of 2.79 ft at Portage Creek (Table 4I-3-5). Due to prevailing weather conditions during the measurement period of 1982 these streamflows may be considerably less than normally expected for this period.

The peak runoff recorded from early August through October was 1,815 cfs on September 15 at Indian River and 1,673 cfs on September 16 in Portage Creek. These streamflows were the effect of a 3-day rainstorm during which 2.7 inches of precipitation was recorded at Devil Canyon (R&M, 1982 observations). A cursory review of monthly precipitation values at Talkeetna indicate that this was a fairly large, but not uncommon, amount of precipitation for September. Preliminary rating curves were developed utilizing stage-discharge data collected by R&M Consultants (Figure 4I-3-20).

3.1.1.4 Mainstem, Sloughs and Tributaries Downstream of Talkeetna

Measurements of water surface elevation and discharge were obtained at four tributaries (Goose, Rabideux, Sunshine and Birch Creeks) and four

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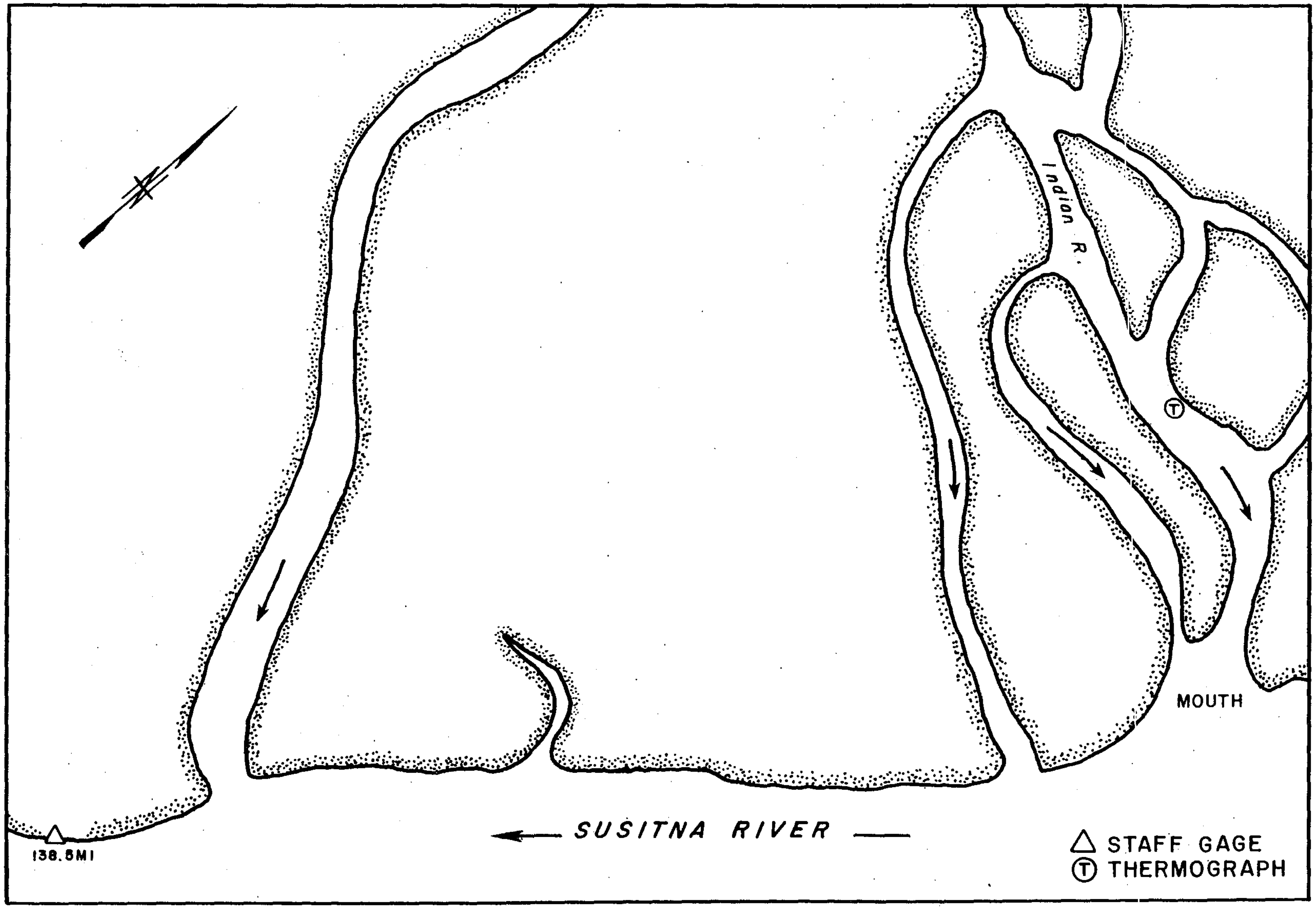

Figure 4I-3-18 Planimetric site map of Indian River, RM 138.6, GC S31N02W09CDA.

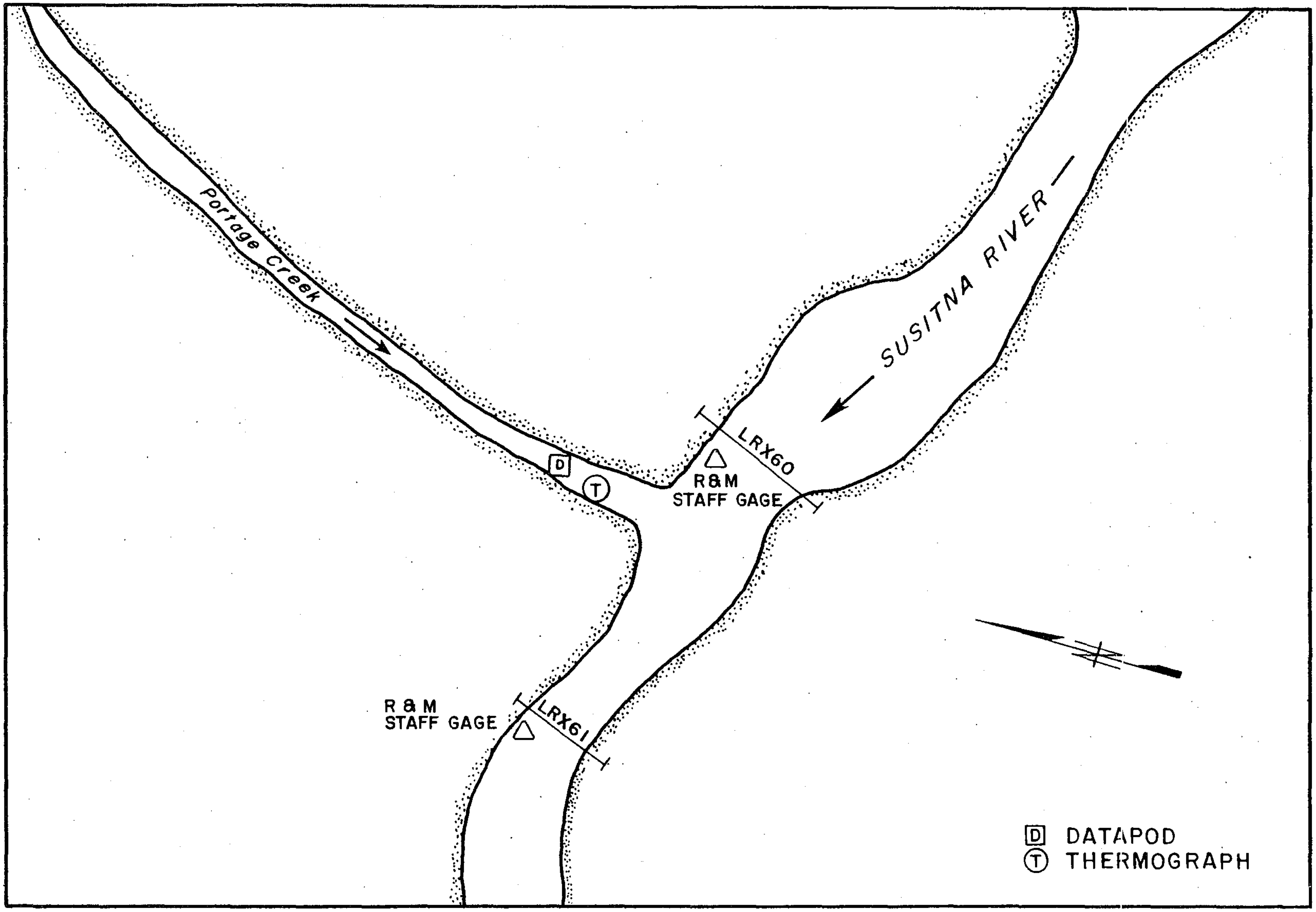

Figure 4E-3-19 Planimetric site map of Portage Creek, RM 148.8, GC S32N01W25CDB.

Table 4I-3-4 Daily mean streamflow and surface water temperature record for Indian River, Alaska.

DATE	GAGE HEIGHT (ft)	DISCHARGE (cfs)	SURFACE WATER TEMPERATURE (C)
820809	1.76	257	8.6
820810	1.73	244	8.4
820811	1.69	228	8.9
820812	1.59	195	8.9
820813	1.53	176	9.6
820814	1.51	169	9.0
820815	1.50	168	9.0
820816	1.46	156	9.4
820817	1.53	175	8.8
820818	1.53	177	8.4
820819	1.47	158	8.6
820820	1.42	145	9.4
820821	1.38	136	9.3
820822	1.36	131	9.3
820823	1.37	132	9.6
820824	1.35	130	9.7
820825	1.36	130	9.8
820826	1.36	131	9.7
820827	1.33	124	8.8
820828	1.33	123	8.6
820829	1.39	139	8.6
820830	1.80	275	8.0
820831	2.12	446	7.8
820901	1.99	367	7.9
820902	1.87	307	7.9
820903	1.90	322	7.6
820904	1.83	288	7.6
820905	1.77	259	7.5
820906	1.71	235	7.8
820907	1.72	240	8.1
820908	1.68	227	7.6
820909	1.67	220	7.4
820910	1.68	223	7.1
820911	1.71	238	6.6
820912	1.72	240	6.2
820913	2.15	473	6.2
820914	2.48	762	6.6
820915	3.13	1815	7.1
820916	3.01	1557	6.7
820917	2.71	1041	5.8
820918	2.44	716	6.0
820919	2.63	931	6.2

Table 4I-3-4 Cont.

DATE	GAGE HEIGHT (ft)	DISCHARGE (cfs)	SURFACE WATER TEMPERATURE (C)
820920	2.87	1291	6.1
820921	2.59	879	5.9
820922	2.42	693	5.7
820923	2.24	539	4.7
820924	2.11	444	4.2
820925	2.01	378	4.6
820926	1.96	352	5.0
820927	2.10	434	5.0
820928	1.95	347	4.0
820929	1.95	345	4.9
820930	1.92	330	5.1
821001	1.86	277	4.6
821002	1.80	252	4.5
821003	1.75	233	4.3
821004	1.70	215	3.3
821005	1.67	202	2.7
821006	1.61	183	2.2
821007	1.60	182	2.4
821008	1.58	174	2.4
821009	1.56	170	2.6
821010	1.53	161	2.6
821011	1.50	154	2.1
821012	1.53	162	2.0
821013	1.53	160	1.7
821014	1.47	146	1.3
821015	1.42	132	.1
821016	1.42	134	.6
821017	1.43	136	1.6
821018	1.40	130	.6
821019	1.40	129	1.0
821020	1.37	123	.6
821021	1.31	110	0.0
821022	1.32	111	0.0

Table 4I-3-5 Daily mean streamflow and surface water temperature record for Portage Creek, Alaska.

DATE	GAGE HEIGHT (ft)	DISCHARGE (cfs)	SURFACE WATER TEMPERATURE (C)
820809	2.17	602	8.0
820810	2.22	625	7.9
820811	2.16	594	8.7
820812	2.02	527	8.7
820813	1.94	489	9.7
820814	1.93	484	9.4
820815	1.96	495	9.3
820816	1.86	451	9.6
820817	1.89	464	8.6
820818	1.87	455	8.4
820819	1.79	418	8.6
820820	1.74	392	9.5
820821	1.70	376	9.4
820822	1.67	359	9.4
820823	1.69	369	9.8
820824	1.68	368	9.8
820825	1.69	371	10.0
820826	1.74	394	9.9
820827	1.67	362	8.7
820828	1.63	342	8.1
820829	1.72	385	8.4
820830	2.19	609	7.5
820831	2.50	766	7.3
820901	2.31	672	7.6
820902	2.19	612	7.5
820903	2.33	682	7.1
820904	2.28	658	7.1
820905	2.19	611	7.0
820906	2.13	579	7.5
820907	2.15	589	7.8
820908	2.09	563	7.0
820909	2.08	557	6.9
820910	2.15	592	6.8
820911	2.15	590	6.0
820912	2.16	595	5.7
820913	2.59	814	6.0
820914	3.19	1088	6.1
820915	4.06	1584	6.6
820916	4.21	1673	5.9
820917	3.73	1391	5.2
820918	3.41	1210	5.4
820919	3.58	1308	5.8

Table [illegible] Cont.

DATE	GAGE HEIGHT (ft)	DISCHARGE (cfs)	SURFACE WATER TEMPERATURE (C)
820920	3.70	1375	5.5
820921	3.45	1229	5.5
820922	3.24	1114	5.3
820923	3.01	988	4.1
820924	2.83	891	3.6
820925	2.69	817	4.1
820926	2.59	765	4.6
820927	2.57	754	4.7
820928	2.45	691	3.5
820929	2.41	670	4.4
820930	2.39	660	4.6
821001	2.30	613	4.1
821002	2.22	578	4.0
821003	2.16	544	3.6
821004	2.09	512	2.6
821005	2.03	484	2.0
821006	1.96	449	1.5
821007	1.94	441	1.6
821008	1.91	428	1.5
821009	1.88	413	1.5
821010	1.84	394	1.7
821011	1.80	376	1.2
821012	1.79	371	1.7
821013	1.77	360	1.5
821014	1.72	340	1.0
821015	1.61	290	0.0
821016	1.69	325	0.0
821017	1.69	324	.2
821018	1.62	292	0.0
821019	1.61	290	.1
821020	1.55	265	0.0
821021	1.42	210	0.0
821022	1.42	208	0.0

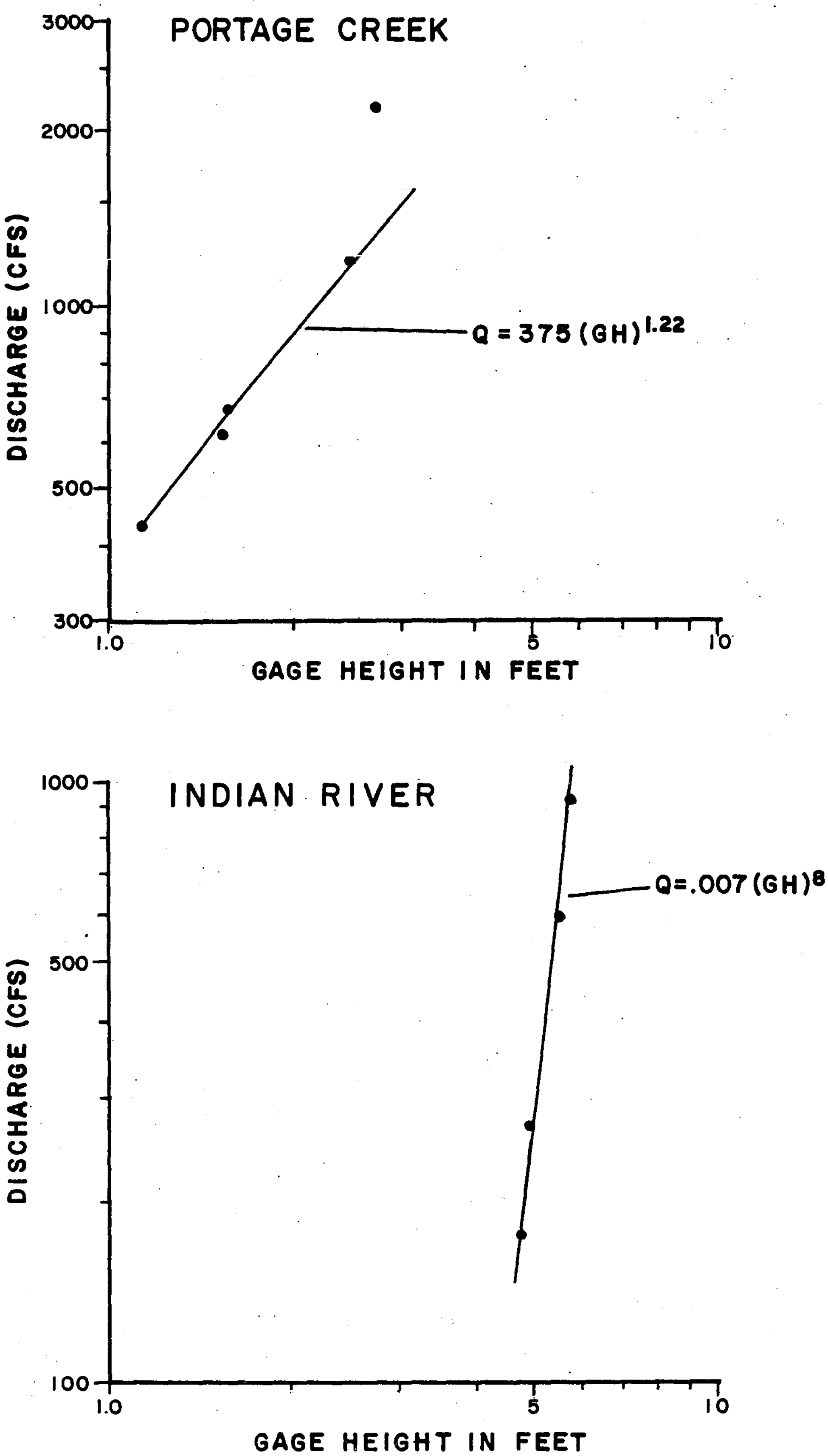

Figure 4I-3-20 Stage discharge rating curve for Indian River and Portage Creek.

sloughs (Goose II, Whitefish, Sunshine and Birch Creek Sloughs) located downstream of Talkeetna. These data are currently being developed into preliminary rating curves which will be presented in the final draft of this report. Goose II Slough and Sunshine Slough are also referred to in the backwater area section of this report as Goose II side channel and Sunshine minor side channel, respectively.

Stage readings were obtained in the mainstem Susitna River at Sunshine fishwheel station and mainstem Yentna River at the Yentna River fishwheel station. These data were compared to provisional USGS data collected at Sunshine (for the Susitna River) and the Yentna River respectively. In addition, mainstem Susitna River water surface elevation data was collected at the confluences of the tributary and slough sites noted above. This data is presented in conjunction with the slough and tributary data. Cross sections were made from survey data collected by ADF&G in 1982 for Rabideux Slough and Chum Channel (Appendix Figures 4-A-40 and 4-A-41).

3.1.1.4.1 Mainstem Sites

Sunshine Fishwheel Station

The Sunshine fishwheel station stage data is currently in the process of being reduced and will appear in the final draft of this report.

Yentna Fishwheel Station

A summary of the Yentna River fishwheel station stage data as compared to provisional USGS discharge data (1982) for the Yentna River is presented in Table 4I-3-6. The stage data at the Yentna River fishwheel station was relative to an arbitrary benchmark (elevation = 100.00 ft) and was not tied to project datum. Stage readings obtained periodically from June 30 to September 15, 1982, varied 3.51 feet. Corresponding discharges of the Yentna River varied from 30,000 to 61,000 cfs and within the Susitna River downstream of the Yentna River confluence from 71,000 to 142,000 cfs during the same period.

3.1.1.4.2 Tributaries

Lower Goose Creek 2

Three discharge measurements were obtained on Lower Goose Creek 2 (Figure 4I-3-21) ranging from 84.10 to 251.0 cfs over a corresponding change in water surface elevation of 0.92 feet. Nine additional water surface elevations not collected in conjunction with discharge data showed a change in water surface elevation during the period June through October, 1982, of 1.46 feet. Lower Goose Creek 2 was not directly influenced by mainstem flows as determined from comparisons of change in the observed water surface elevations in the creek to the mainstem discharge (Appendix Table 4-A-6).

Table 4I-3-6. Comparison of the relative water surface elevations of the Yentna River obtained from staff gages located at the Yentna River Fishwheel station to the mean daily Yentna River[a] and Susitna River[b] discharge (CFS).

Date	Time	WSEL (ft)[c]	Yentna River Discharge	Susitna River Discharge
820829	2000	86.55	30,000	71,000
820905	1730	86.68	31,000	75,000
820828	1740	86.72	31,500	74,000
820913	1920	87.36	32,000	90,000
820903	1740	87.26	32,000	82,000
820904	1850	87.35	32,000	72,000
820906	1800	87.49	33,000	74,000
820912	1950	88.00	33,000	77,000
820823	2200	87.19	33,100	78,000
820911	1920	88.03	34,000	77,000
820902	1930	87.67	34,000	87,000
820824	2130	87.43	34,200	80,000
820822	2350	87.28	34,200	78,000
820826	2300	87.11	34,400	80,000
820821	2350	87.51	34,800	79,600
820831	2100	90.16	35,000	92,000
820820	2100	87.50	35,200	81,600
820825	2200	87.48	35,500	82,000
820819	2200	87.60	36,800	86,700
820910	1815	87.66	37,000	80,000
820814	2030	87.83	37,400	88,100
820813	1000	88.01	39,200	91,800
820818	1930	88.07	40,300	93,300
820806	1450	88.28	41,500	104,000
820806	1945	88.33	41,500	104,000
820808	2150	88.42	41,900	109,000
820809	1830	88.33	42,100	107,000
820807	1945	88.33	42,300	103,000
820810	2000	88.48	42,600	107,000
820914	1930	88.96	43,000	140,000
820804	1645	88.48	43,900	112,000
820811	2100	88.71	44,500	104,000
820803	2045	88.88	47,100	120,000
820816	2030	88.95	48,300	103,000
820630	1630	90.15	61,600	142,000

[a]Gaging station on the Yentna River near Su Station (USGS provisional data, 1982).

[b]Gaging station at Su Station (USGS provisional data, 1982).

[c]Water surface elevations are relative to a temporary bench mark which was assigned an elevation of 100.00 feet.

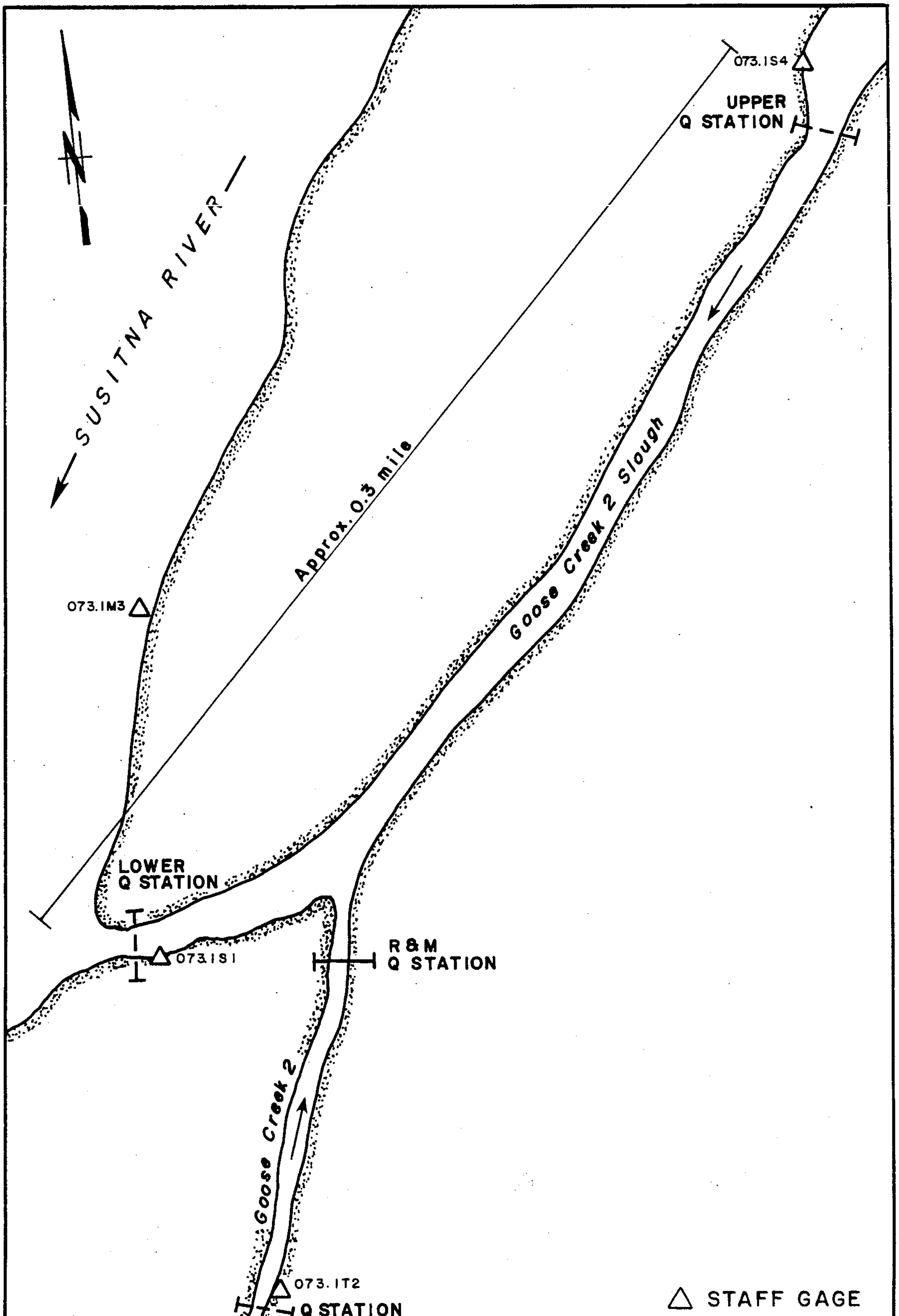

Figure 4E-3-21 Planimetric site map of Goose Creek 2 and Goose Creek 2 Slough, RM 73.1, S23N04W30BCB.

Rabideux Creek

Discharge measurements were obtained at two gaging stations in Rabideux Creek (Figure 4I-3-22), an upper site located 1.7 miles upstream from the mouth and a lower site approximately 0.25 miles upstream from the mouth. Three discharge measurements obtained at the upper gaging station ranged from 129.0 to 222.9 cfs over a corresponding change in water surface elevation of 0.51 feet. Two additional water surface elevations not collected in conjunction with discharge data showed the change in water surface elevation 1.65 feet overall (Appendix Table 4-A-6). Two discharge measurements obtained at the lower gaging site were 131.1 and 271.0 cfs over a corresponding change in water surface elevation of 0.80 ft. The mainstem flow during these two measurements was 29,700 and 36,400 cfs, respectively. Twelve additional water surface elevations not collected in conjunction with discharge data at this site showed a change in water surface elevation to be 6.37 feet overall, during which time the mainstem discharge varied from 24,000 to 88,400 cfs. From observations, the backwater area created during high mainstem discharges was substantial, extending upstream past the lower gaging station.

Sunshine Creek

Four discharge measurements were obtained 0.7 miles upstream of the mouth in Sunshine Creek (Figure 4I-3-23) ranging from 31.8 to 103.9 cfs over a corresponding range of water surface elevation of 1.98 feet (Appendix Table 4-A-6). Eleven additional water surface elevations, not collected in conjunction with discharge measurements, showed the

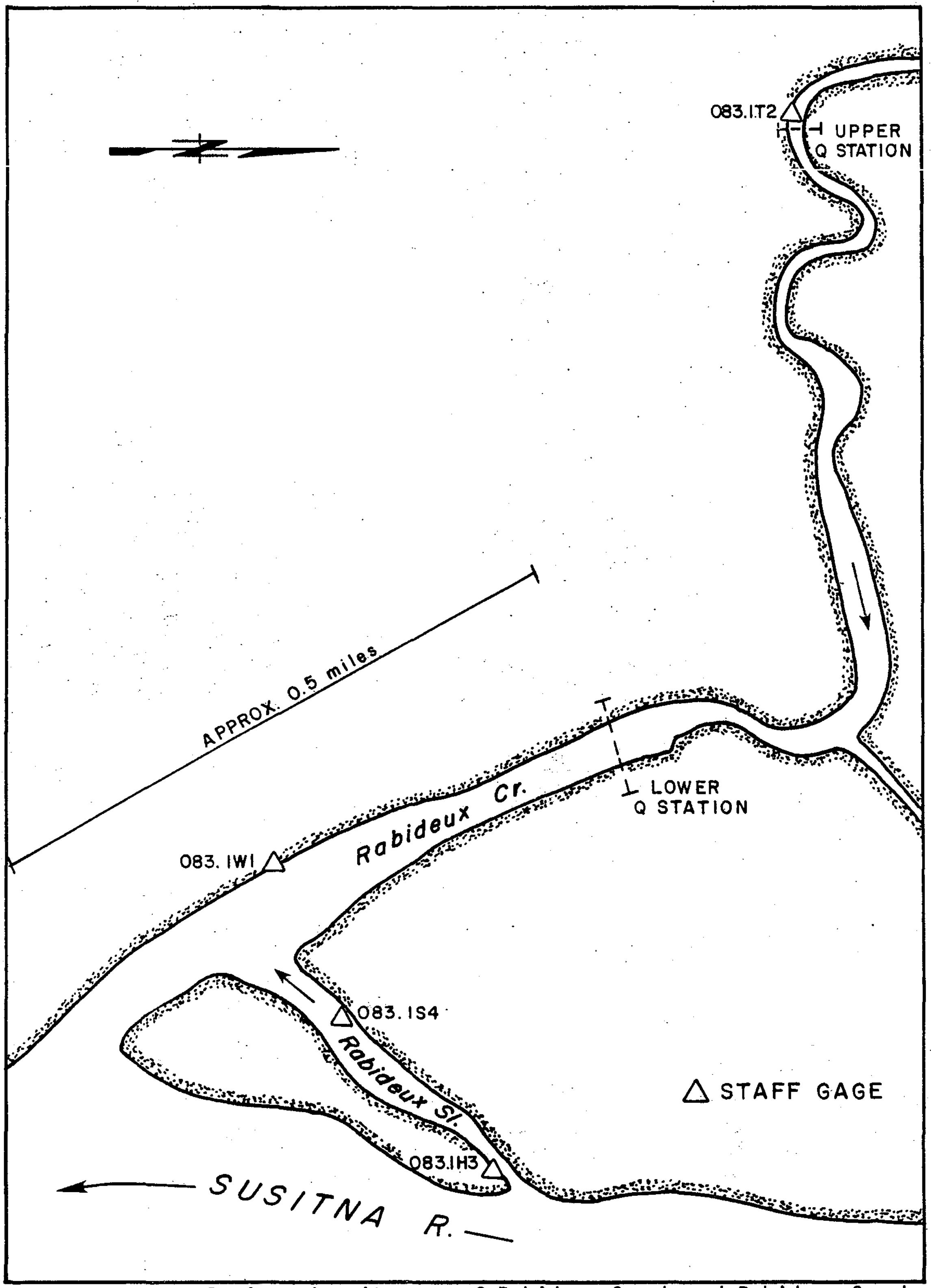

Figure 4E-3-2 Planimetric site map of Rabideux Creek and Rabideux Creek Slough, RM 83.1, GC S24N05W16ADC.

overall range in water surface elevation to be 4.14 feet at the gaging station. In addition, water surface elevation data was collected at the mouth of Sunshine Creek (which flows into Sunshine Creek Slough). This data had a range of 6.51 feet over a range of mainstem discharges of 21,400 to 91,300 cfs.

Sunshine Creek, during periods of high mainstem flow, was found to exhibit an area of low velocity backwater originating at the creek mouth and extending upstream at least as far as the upstream gaging station (0.7 miles upstream). A comparison of the creek discharge obtained on October 4 (68.6 cfs) to the discharge obtained on September 1 (31.7 cfs) showed that water surface elevations were higher for the lower flow (267.20 feet) than for the higher flow (266.93 feet). This stage-discharge relationship is evidence that the discharge site (Figure 4I-3-23) was within a backwater area created during mainstem flows of 45,200 cfs or greater.

Birch Creek

Four discharge measurements were obtained 0.1 miles upstream of the mouth in Birch Creek (Figure 4I-3-24) ranging from 62.4 to 114.1 cfs over a corresponding change in water surface elevation of 0.35 feet (Appendix Table 4-A-6). Six additional water surface elevations, not collected in conjunction with discharge data, showed an overall change in water surface elevation of 0.58 feet at the gaging station. In addition, 12 water surface elevations were collected at the mouth of Birch Creek varying 2.09 feet over a corresponding range of mainstem flows from

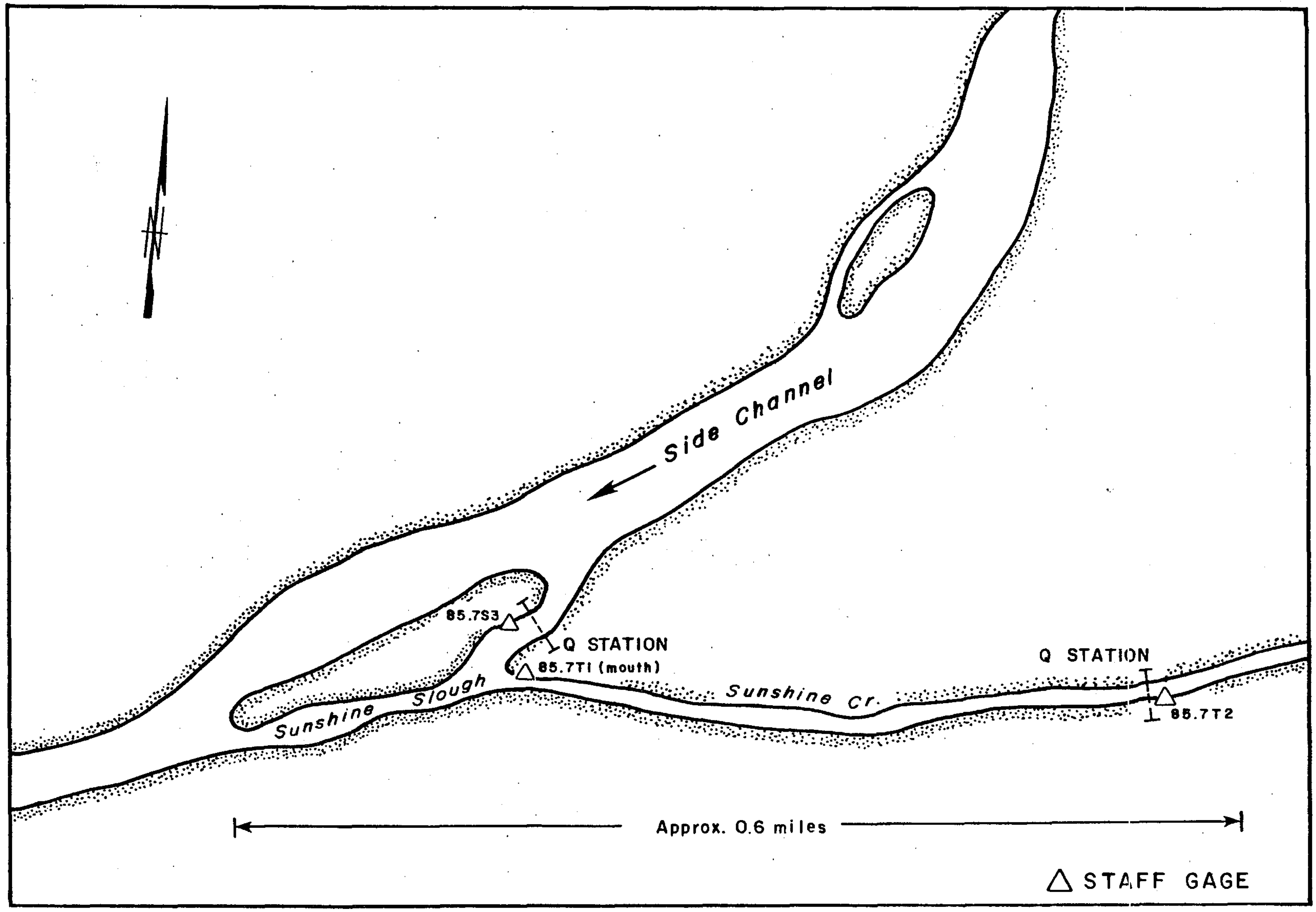

Figure 4E-3-23 Planimetric site map of Sunshine Creek and Sunshine Creek Slough, RM 85.7,
GC S24N05W14AAB.

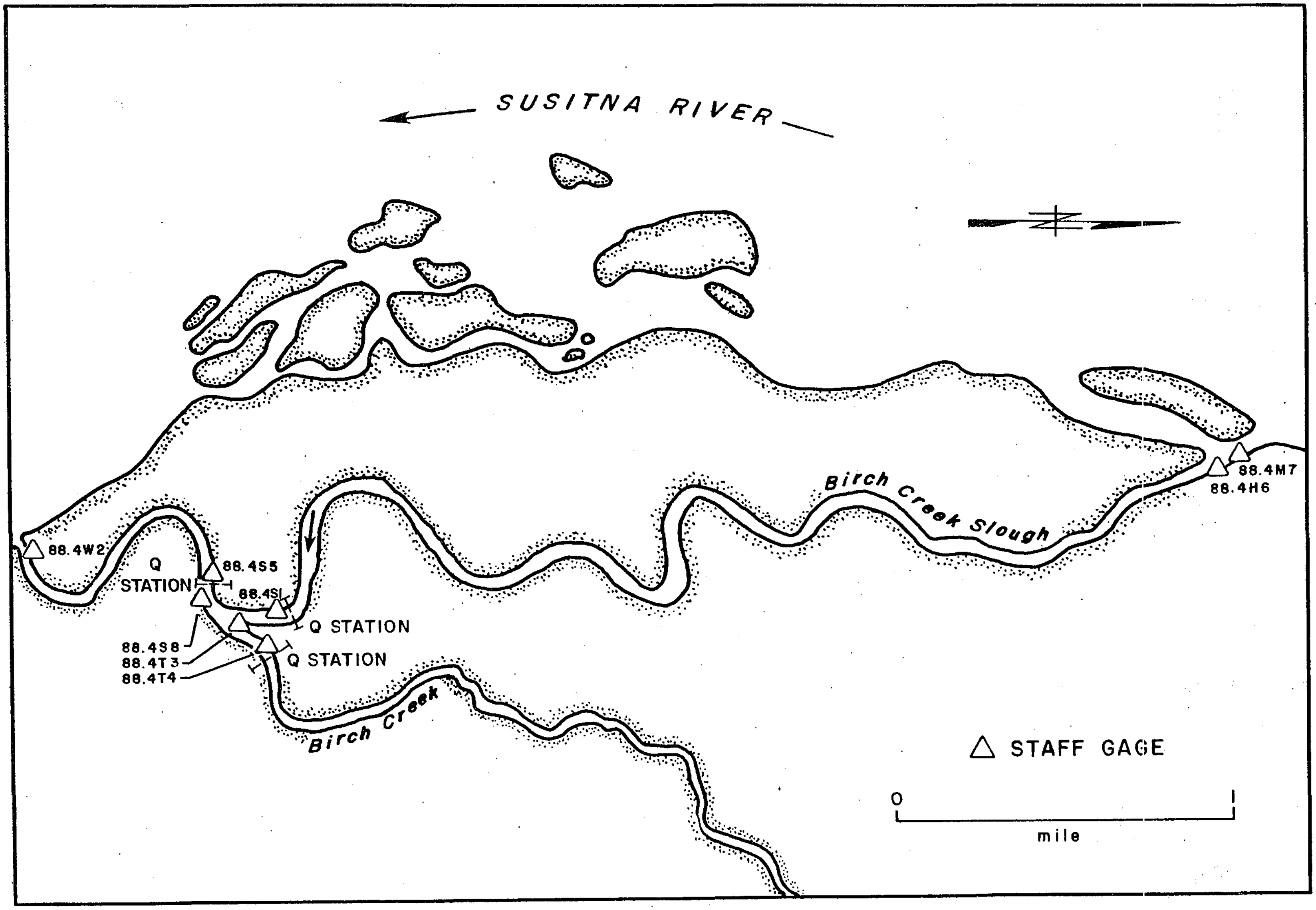

Figure 4I-3-24 Planimetric site map of Birch Creek and Birch Creek Slough, RM 88.4, GC S25N05W25DCC.

22,300 to 99,300 cfs. Backwater effects were observed to be only present in the immediate vicinity of the creek mouth, not extending up to the creek gaging station.

3.1.1.4.3 Sloughs

Lower Goose 2 Slough

Lower Goose 2 Slough (Figure 4I-3-21) is a relatively long slough with a head and mouth which confluence with the mainstem Susitna River. Two gaging stations were located in this slough, one above and one below the confluence with Lower Goose Creek 2. Three discharge measurements, obtained at the upstream gaging station (upstream of the confluence with Lower Goose Creek 2), ranged from 1.8 to 458.0 cfs over a corresponding change in water surface elevation of 1.55 feet (Appendix Table 4-A-6). The overall range of water surface elevation is the same as found for the range of discharge measurements because only two staff gage readings were obtained, one during each of the discharge measurements for the 1.8 cfs flow and one for the 458.0 flow. Only one discharge measurement (101.0 cfs) was obtained at the lower gaging station (below the confluence with Lower Goose Creek 2) corresponding to a water surface elevation of 209.33 feet (Appendix Table 4-A-6). Fourteen additional the water surface elevations, not collected in conjunction with discharge measurements at the lower gaging station, showed water surface elevation to range 1.82 feet over a corresponding mainstem discharge from 31,500 to 68,700 cfs. Mainstem water surface elevations, collected adjacent to the mouth of Goose 2 Slough, had a range of 2.85 feet for mainstem flows of 31,500 to 68,700 cfs. A substantial backwater effect was observed to occur at the mouth of this slough during the range of mainstem flows from 31,500 to 68,700 cfs.

Whitefish Slough

Three discharge measurements were obtained at the mouth of Whitefish Slough (Figure 4I-3-25) ranging from 6.6 to 24.2 cfs over a corresponding change in water surface elevation of 8.05 feet (Appendix Table 4-A-6). Corresponding mainstem flows during the periods of discharge measurement varied from 29,700 to 91,300 cfs. Seven additional water surface elevations, not collected in conjunction with discharge measurements, showed the overall change in water surface elevation at the gaging station to be 8.94 feet. At all mainstem discharges observed this year, a backwater effect was present at the gaging station which, during high mainstem discharges, extended approximately 3/4 of a mile up Whitefish Slough. No staff gages were placed in the mainstem adjacent to this site.

One discharge measurement (31.0 cfs) was obtained at a mainstem flow of 91,300 cfs in an unnamed tributary entering Whitefish Slough (Figure 4I-3-25). The slough discharge taken on the same day was found to be less than the flow from the tributary. This difference was attributed to the backwater, low velocity phenomenon created by mainstem flow occurring at the slough gaging station, lowering the slough discharge measurement.

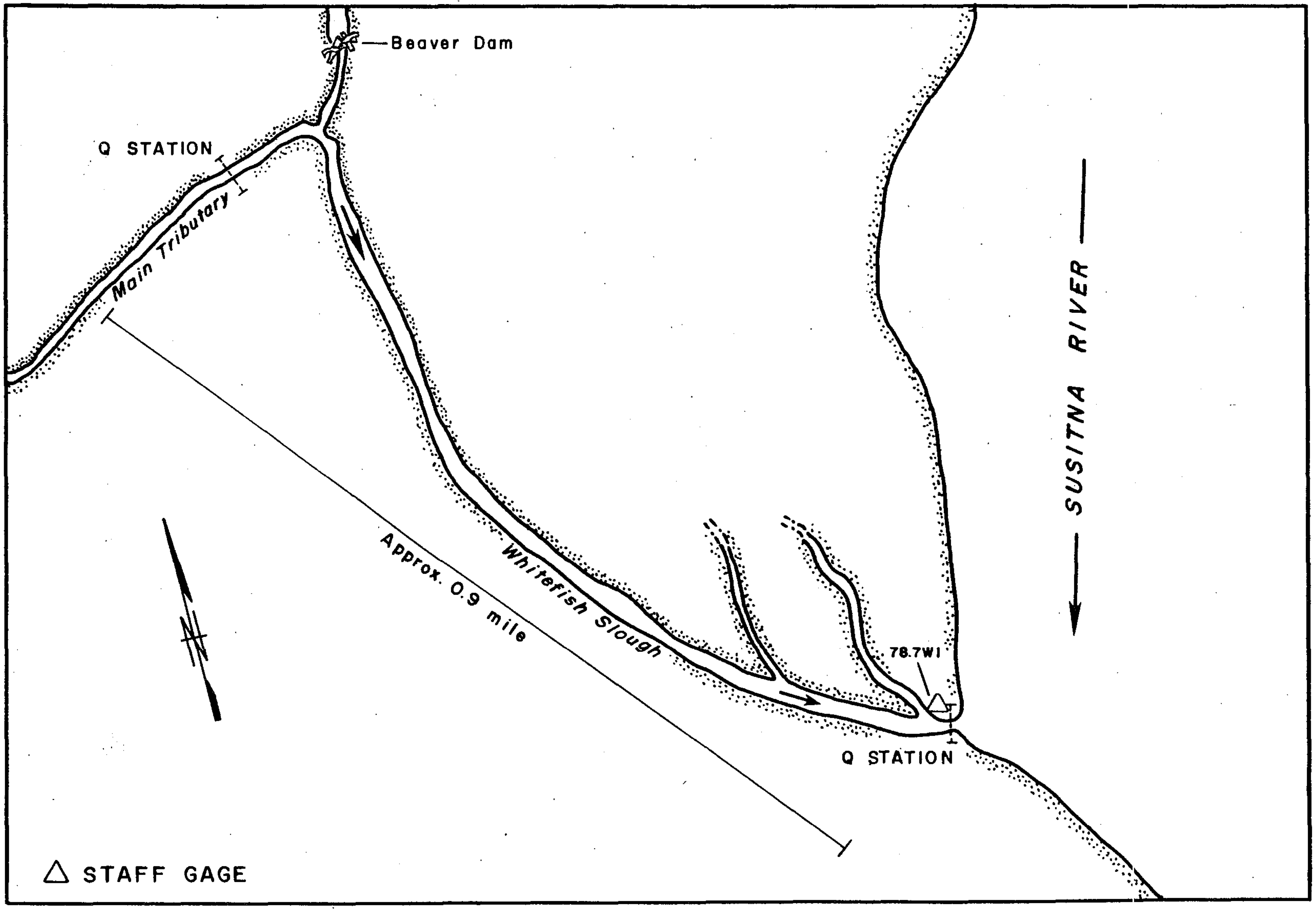

Figure 4E-3-25 Planimetric site map of Whitefish Slough, RM 78.7, GC S23N05W01BBC.

Sunshine Slough

Sunshine Slough is a relatively long, meandering slough with a head and mouth which confluence the mainstem Susitna River (Figure 4I-3-23). Three discharge measurements were obtained in Sunshine Slough which ranged from 0.2 to 607.0 cfs over a corresponding change in water surface elevation of 4.19 feet (Appendix Table 4-A-6). Thirteen additional water surface elevations, not collected in conjunction with discharge measurements, showed an overall change in water surface elevation at the gaging station of 6.25 feet. Corresponding mainstem flows during this period ranged from 25,800 to 91,300 cfs.

The slough was breached during the measured slough discharges of 85.7 and 607.0 cfs when corresponding mainstem flows were 47,200 and 76,500 cfs, respectively.

By comparing ranges of water surface elevations measured at the slough gaging station to those measured at the Sunshine Creek mouth gaging station (5.32 feet and 5.29 feet, respectively) while the slough was breached by the mainstem, it was apparent that backwater effects occurred at least as far upstream as these gaging stations. At a mainstem flow of 91,300 cfs the slough water surface elevation at the slough gaging station was 270.80 feet while at the gaging station at the mouth of Sunshine Creek it was 270.70 feet, and at the gaging station upstream on Sunshine Creek it was 270.81 feet.

Birch Creek Slough

Birch Creek Slough is a relatively long, meandering slough with a head and mouth which confluence with the mainstem Susitna River, (Figure 4I-3-24). Discharge measurements were obtained at two gaging stations in Birch Creek Slough; above the confluence with Birch Creek and below the confluence with Birch Creek. One discharge measurement (15.7 cfs) was obtained at the gaging station above the confluence with Birch Creek corresponding to a water surface elevation of 284.74 feet (Appendix Table 4-A-6). Eleven additional water surface elevations, not collected in conjunction with discharge measurements, showed an overall change in water surface elevation at the gaging station to be 2.05 feet. Four discharge measurements were obtained at the gaging station below the confluence with Birch Creek ranging from 75.4 to 131.8 cfs over a corresponding change in water surface elevation of 0.92 feet. Five additional water surface elevations, not collected in conjunction with discharge, showed an overall change in water surface elevation at the gaging site of 1.01 feet. Corresponding mainstem flows during this time ranged from 22,300 to 69,500 cfs.

Stage was also collected (not in conjunction with discharge) in Birch Creek Slough at the head at the confluence with Birch Creek and at the mouth. At mainstem discharges of 42,000 to 69,500 cfs, flow was observed through the head of the slough with the water surface elevation varying 2.03 feet. Water surface elevations measured in the mainstem adjacent to the head of Birch Creek Slough had a range of 3.51 feet during corresponding mainstem flows of 27,800 to 69,500 cfs. The range of water surface elevations in Birch Creek Slough at the confluence with Birch Creek were found to have a range of 0.75 feet. Water surface elevations at the mouth of Birch Creek Slough were found to have a range of 3.78 feet. during corresponding mainstem flows of 22,300 to 82,400 cfs. A significant area of backwater influence occur in this slough during high mainstem flows.

3.1.1.5 Upstream of Devil Canyon

Above Devil Canyon, periodic discharge measurements were obtained in seven tributaries. Appendix Table 4-A-1 compares the discharge of the tributaries to that of the mainstem Susitna River at Vee Canyon. Refer to Volume 5 for the specific results and discussion of these discharge measurements.

3.1.2 Thalweg Profile

Streambed profiles for Sloughs 8A, 9, 11, and 21 are presented in Figures 4I-3-26, 4I-3-27, 4I-3-28 and 4I-3-29, respectively. Each figure contains a schematic drawing (upper left of Figure) showing gross morphological features of the slough and mainstem Susitna River. In addition, each profile has been partitioned into discrete reaches defined by obvious changes in gradient. Corresponding gradients of the mainstem Susitna River are also provided below the key for surface substrate types. Also, study sites have been positioned on the profiles for sloughs 8A, 9, and 21 to provide a reasonably accurate representation of the gross morphological features in each slough and the relative

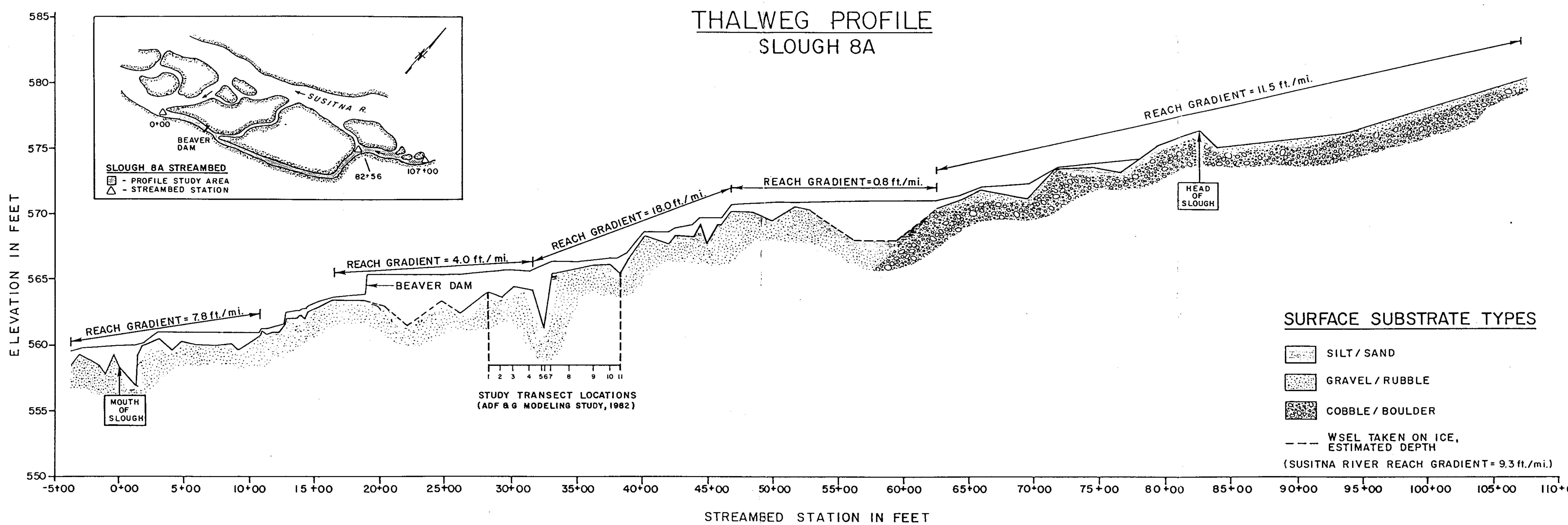

Figure 4I-3-26. Streambed profile for Slough 8A.

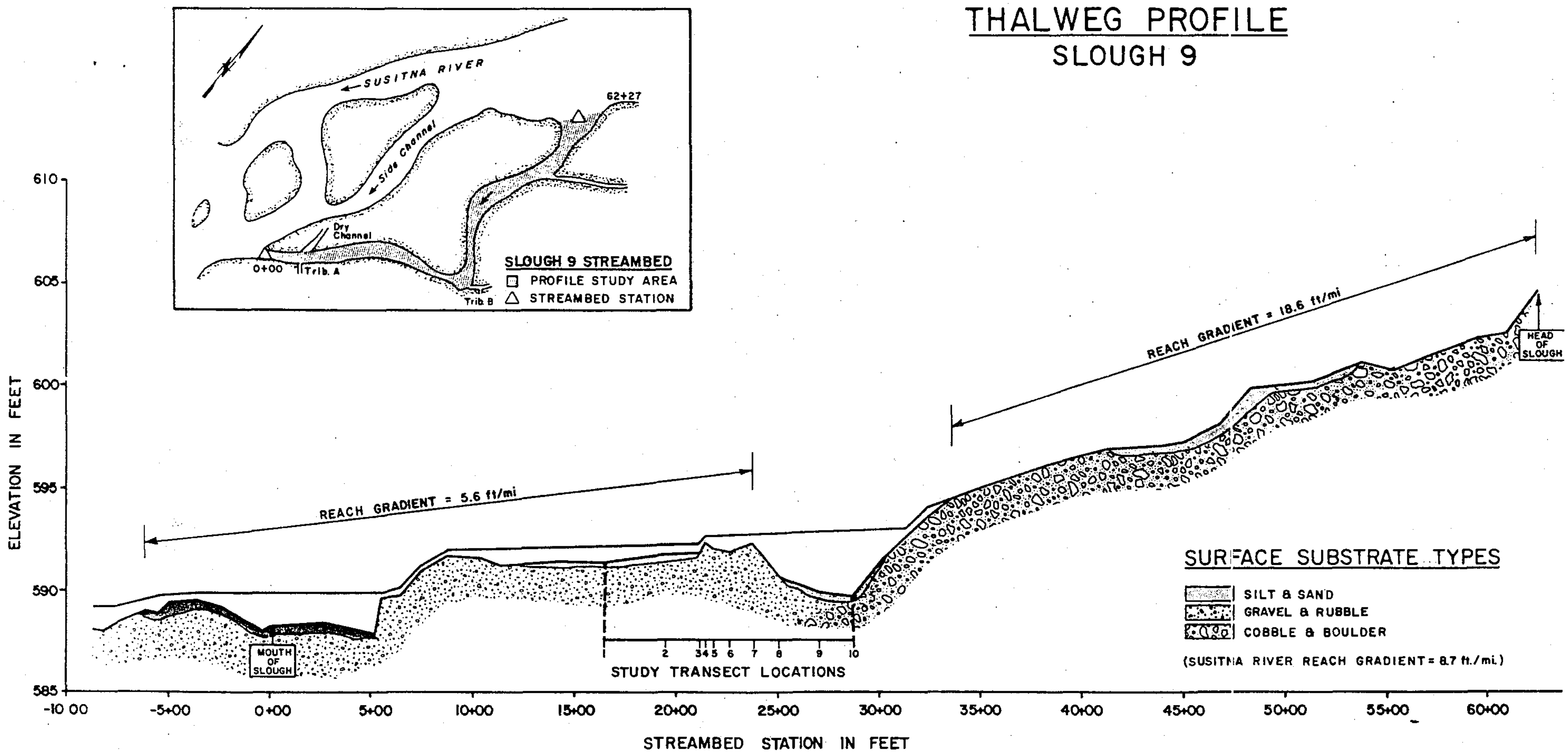

Figure 4I-3-27. Streambed profile for Slough 9.

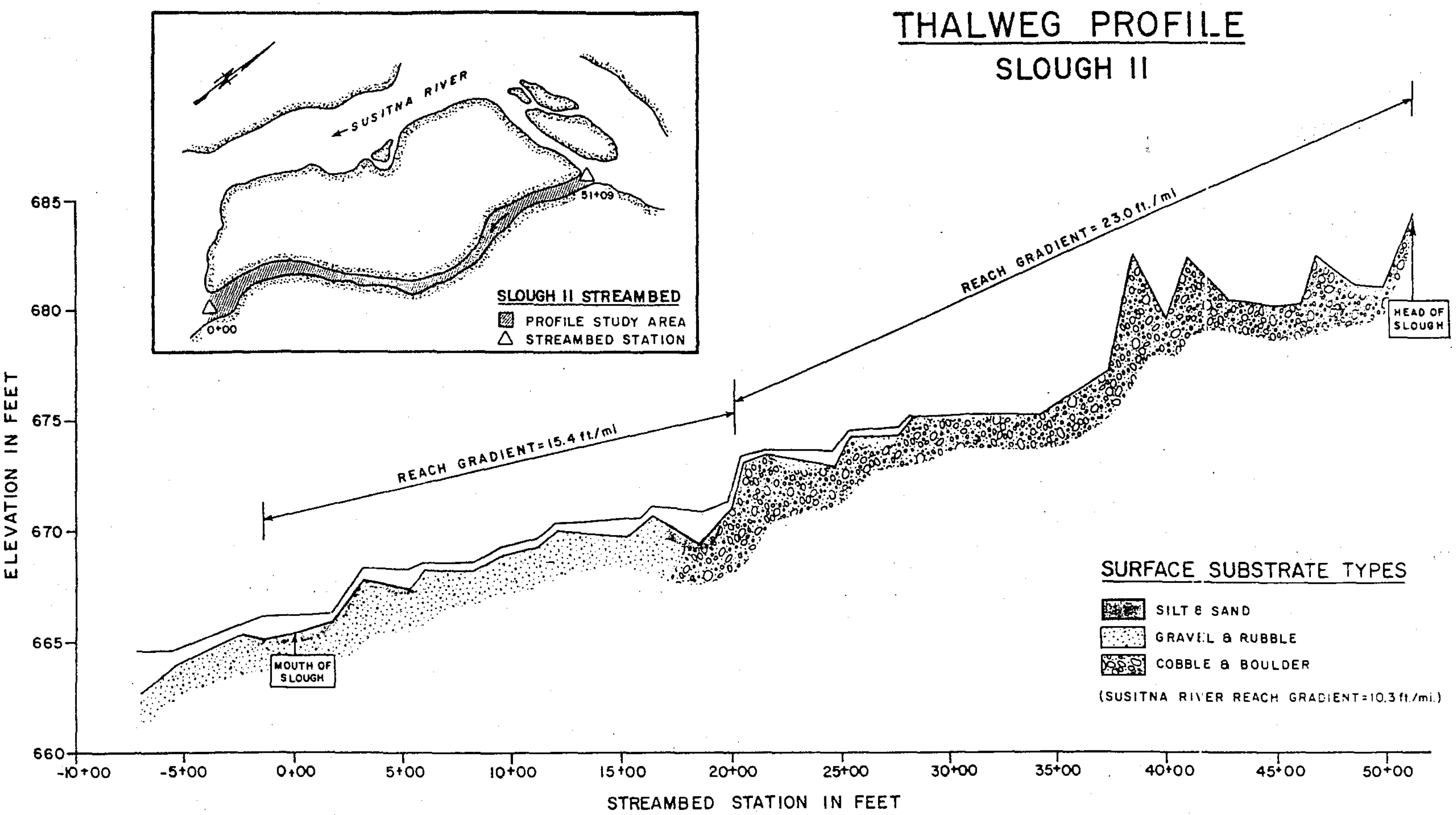

Figure 4I-3-28. Streambed profile for Slough 11.

91

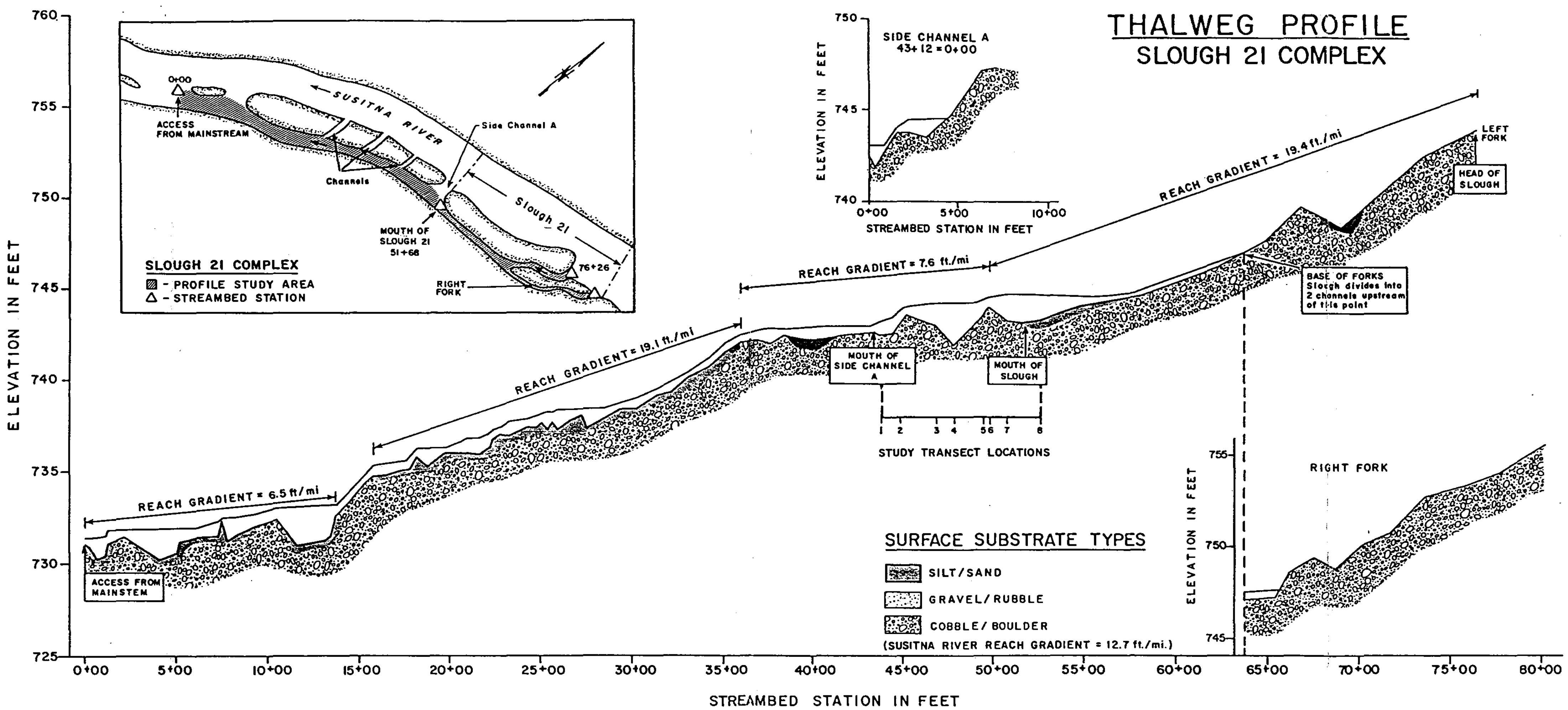

Figure 4I-3-29. Streambed profile for Slough 21.

position of important features (e.g., study transects, beaver dams, etc). At some points, streambed elevations and/or water surface elevations were estimated. The reader is advised to consult the methods section and data source (Appendix E) before extracting and applying information represented in the above figures. The following summary statements are primarily restricted to gross features of streambed gradient.

Slough 8A

Progressing upstream in Slough 8A, the streambed profile is comprised of a relatively gentle gradient near the mouth (7.8 ft/mi), followed by a riffle area (gradient undetermined) ending at a beaver beaver dam. The dam marks the downstream end of a short bench-like reach (4.0 ft/mi) followed by a steep incline (18.0 ft/mi) which terminates at another bench-like area (0.8 ft/mi). Above the second bench, water depths were much reduced and gradient increased to 11.5 ft/mi.

Slough 9

The most notable characteristics of Slough 9 are the obvious differences in gradient between the upper and lower reaches of the slough (18.6 and 5.6 ft/mi, respectively), and the "S" shaped configuration of the channel (see schematic drawing in upper left corner of Figure 4I-3-27). This sharp bend is near station 30+00, marking the area where the gradient changes and water levels decrease.

Slough 11

The upper reach of Slough 11 is more steeply inclined (23.0 ft/mi) than its lower reach (15.4 ft/mi), however both are relatively steep compared to other sloughs. This slough is relatively short and the streambed is structured in distinct pool/riffle sequences up to station 30+00, followed by a series of mounds near the head of the slough. These mounds may be the result of previous ice movement. It should be noted that since no water existed in this area and surveyors were selecting thalweg points on the basis of visual inspection, the mounds may misrepresent the true thalweg in this reach of the slough.

Slough 21 Complex

Morphology of the Slough 21 complex is more complicated than most sloughs since it is preceded by a long access channel which is longer than the slough itself. This access channel is connected to the mainstem Susitna River by several channels, two of which were observed dewatered for most of the open-water season. Note that the mouth of this slough is located near station 52+00 ft, and not at station 0+00 as for sloughs 8A, 9, and 11. The slough (from stations 52+00 to 76+00) has a relatively steep, uniform gradient (19.4 ft/mi) and had very little water present immediately above station 55+00. At its upper end, this slough is forked, with the left fork head functioning as the hydraulic control point.

3.1.3 Other Hydrological Components

3.1.3.1 Backwater Areas

Appendix Table 4-A-7 presents the measurements of the area of the low velocity surface water occurring behind the hydraulic barrier of mainstem Susitna River elevation at Designated Fish Habitat locations on 2 week intervals between June and September 1982. This water surface is called the aggregate zone type II (H-II) and is defined in Section 2.2, Part II of this volume. Each area is listed with the mean daily discharge either at gold Creek or Sunshine gaging station reported by the USGS (as provisional data), for the corresponding date. Figures 4I-3-30 to 4I-3-43 plot the surface areas measured at each site against mainstem discharge. The Portage, Indian, and Fourth of July River habitat locations, which had no significant aggregate type II areas above their geographic mouths, are not included. A descriptive summary of the hydraulic conditins associated with the data and curves presented for each site during these samplings are presented as follows.

The graphical presentation of the aggregate type II (H-II) zone surface area versus Susitna River discharge relationship at each site was carefully interpreted with respect to the smoothing of scattered area measurements (mostly mapping errors) for closely related mainstem water surface elevations. In the case(s) where it was not obvious that a specific distribution of area measurements was a result of data scatter (mapping errors) the data was not smoothed. Examples of both conditions occur in Figure 4I-3-32 (Slough 19). The measurements indicating a total loss of (H-II) water area at discharges near 15,000 cfs are accurate; but area measurements at higher discharges were highly scattered as a result of obvious mapping difficulties at this site. Sloughs 21 and 11 are two other sites where measured areas (at related discharges) are interpreted as obvious scatter (map errors) from our accumulated information on the site, and the measurements were smoothed as shown. Whiskers Creek and Sidechannel presented some unusual mapping difficulties at mainstem discharges of 25,000 cfs and above. These data were thus not connected at all (see Whiskers Creek section). Unless specifically noted, tributaty discharges are not considered in the data presentations.

Refer to photographs and additional site narratives of each habitat location in Appendix 4-F of Volume 4 for further information.

Summary By Habitat Location

Slough 21

At mainstem discharges at Gold Creek greater than approximately 24,000 cfs, the head of Slough 21 is breached, with mainstem water observed flowing through a series of islands (Slough 21 complex), which separate the slough's mouth from the mainstem at lower discharges. Mainstem flow also enters, when the slough is breached, directly across the mouth of the slough, forming a sort of "eddy," which creates the barrier for water exiting the slough from upstream. As the mainstem discharge

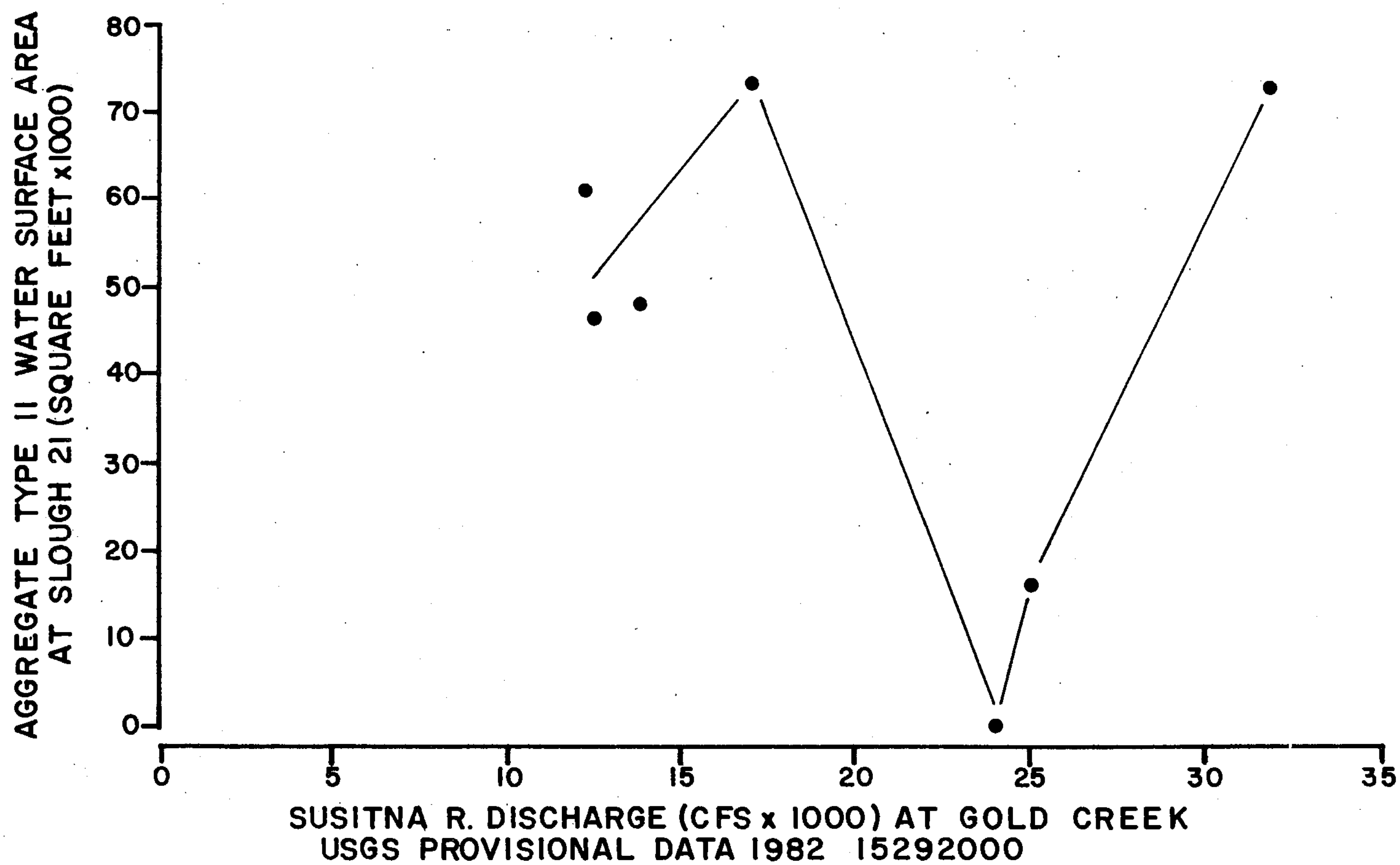

Figure 4I-3-30 Aggregate type II water surface area at Slough 21 versus mainstem discharge at Gold Creek (USGS, 1982).

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decreased, the elevation at the eddy decreased and the area of H-II water decreased on July 11th (at 24,000 cfs) the head of the slough had recently closed and the elevation at the eddy was not sufficient to create an area of H-II water in the slough.

During the August and September sampling trips discharges of 17,000 cfs and below water had stopped flowing through the islands at the locations referred to above (identified as reference mouths #1 and #2 on Appendix Plate 4-F-19). During these months, water existing the slough (e.g., ground water and surface runoff) joined the mainstem at reference mouth #3 (a lower island channel). The H-II water present during this time was found completely below the mouth (of the slough) as defined at the higher mainstem discharges.

During October, Slough 21 was visited only briefly and no maps were drawn. However, the new confluence of slough water with the mainstem was about 5,000 feet below the site of the mouth when the head of the slough was open. No appreciable H-II water was observed during this sampling trip (discharge was 8,220 cfs).

Slough 20

At 28,000 cfs, the head of Slough 20 was observed to be breached (refer to Table 4I-3-2). An H-II area extended from the slough mouth upwards for about 360 feet at this time.

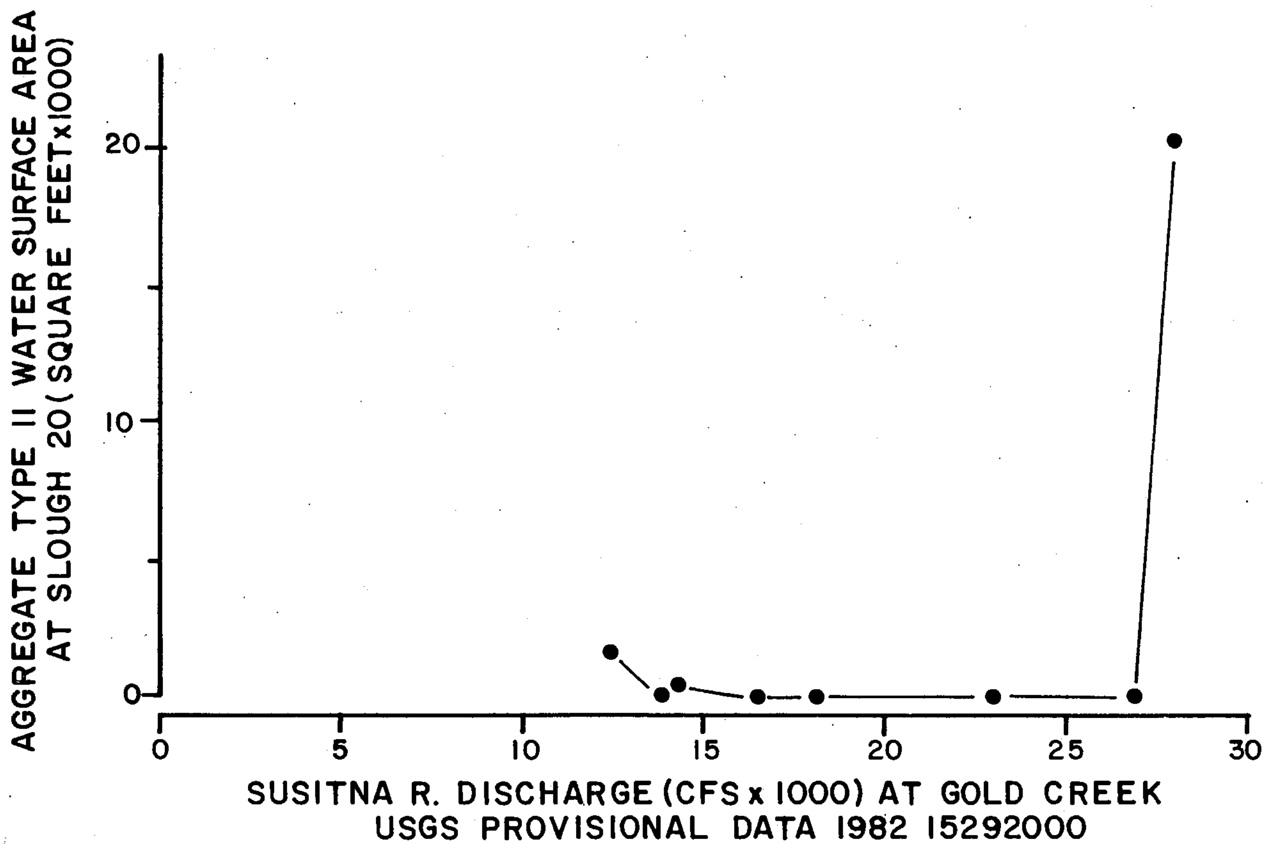

Figure 4I-3-31 Aggregate type II water surface area at Slough 20 versus mainstem discharge at Gold Creek (USGS, 1982).

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At observations during lower mainstem water surface elevation, flow from Slough 20 originating from Waterfall Creek (which enters the slough approximately 1,250 feet above the mouth) and a smaller tributary near the sloughs head freely entered the mainstem at the mouth of the slough.

At discharges between 12,500 and 14,400 cfs a small area of H-II water appeared directly above the barrier of confluence with the mainstem as a pool related to the streambed elevation.

Slough 19

Slough 19 is considered an upland slough which confluences the mainstem only at its mouth. The head of Slough 19 (most upstream portion) consists of a small pool fed by ground water and surface runoff which is the primary contributor of flow for the slough. Percolation in other respects, the hydraulic changes with decreasing discharges are analogous to those described for Slough 21 above. At mainstem discharges of 16,600 cfs and above the H-II area was regulated by mainstem stage and the cross-sectional shape of the pool bed.

At 15,000 cfs the mouth of the slough had moved downriver approximately 350 feet due to dewatring of the small sidechannel which accesses through a gravel island (reference mouth #1 on Appendix Plate 4-F-17). At this mainstem discharge the discharge from the head of the slough was free-flowing to the new confluence with mainstem water, indicated as reference mouth #2. At 13,300 cfs, continued dewatering of the gravel

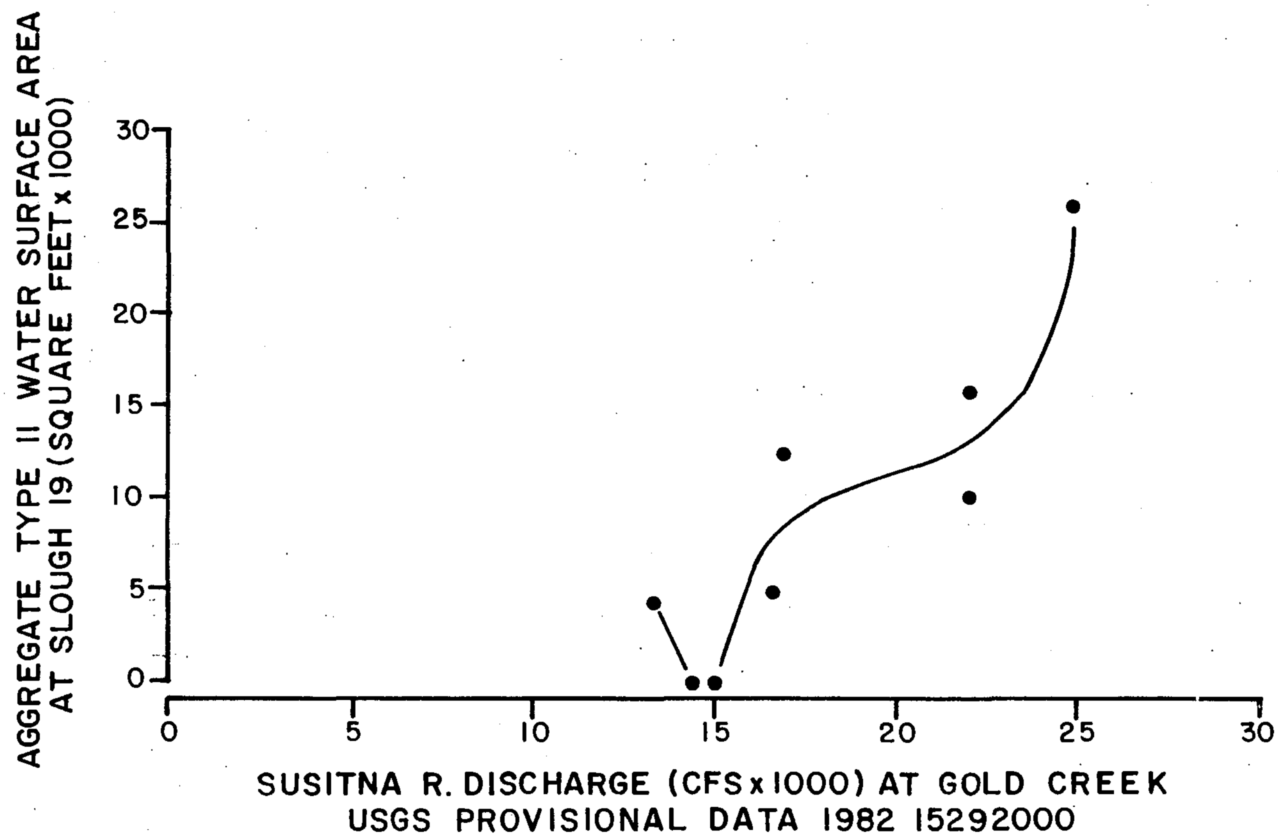

Figure 4I-3-32 Aggregate type II water surface area at Slough 19 versus mainstem discharge at Gold Creek (USGS, 1982).

island moved the confluence of slough and mainstem water an additional 300 feet to reference mouth #3. An area of H-II water existed between the free-flowing slough and the new mouth at this stage.

Slough 11

The head of Slough 11 was not breached by mainstem water during these sampling periods. The area of H-II type water measured this year in Slough 11 results completely from backwater in a pool at the slough's mouth. The area of this pool was controlled by the mainstem stage and the cross-section and elevation relationships that describe the slough (pool) bed.

Slough 9

The head of Slough 9 was open to mainstem flow during the June and July samplings trips. During the highest observed mainstem discharges, the surface water in the slough above the mouth possessed appreciable velocity, apparently conserving the momentum from water discharged from the head above.

During visits at mainstem discharges of 19,400 and 16,700 cfs the slough head was closed and a large area of H-II water (about 1000 feet long on August 10th) was found above the confluence of the slough and the mainstem. At the lower mainstem discharges sampled, the surface waters

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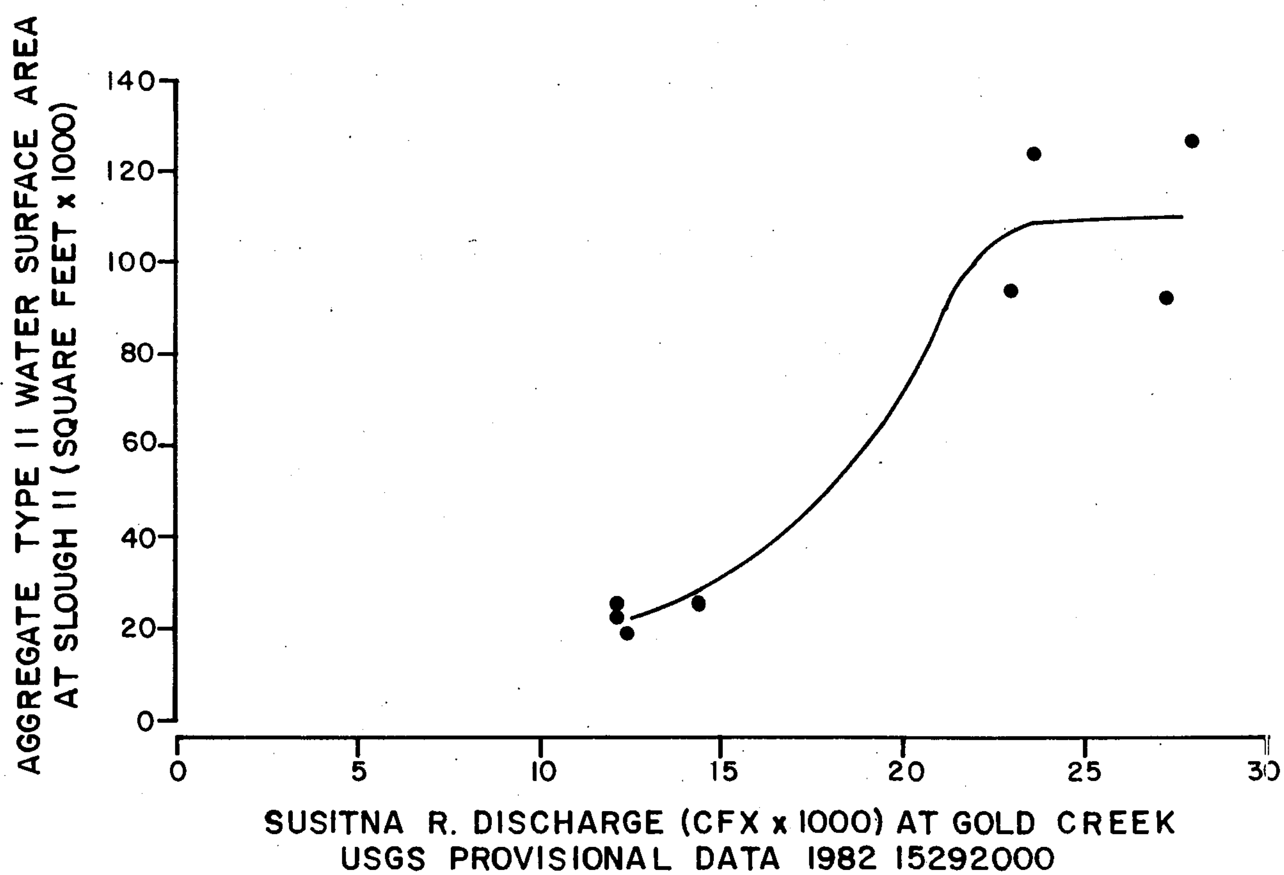

Figure 4II-3-33 Aggregate type II water surface area at Slough 11 versus mainstem discharge at Gold Creek (USGS, 1982).

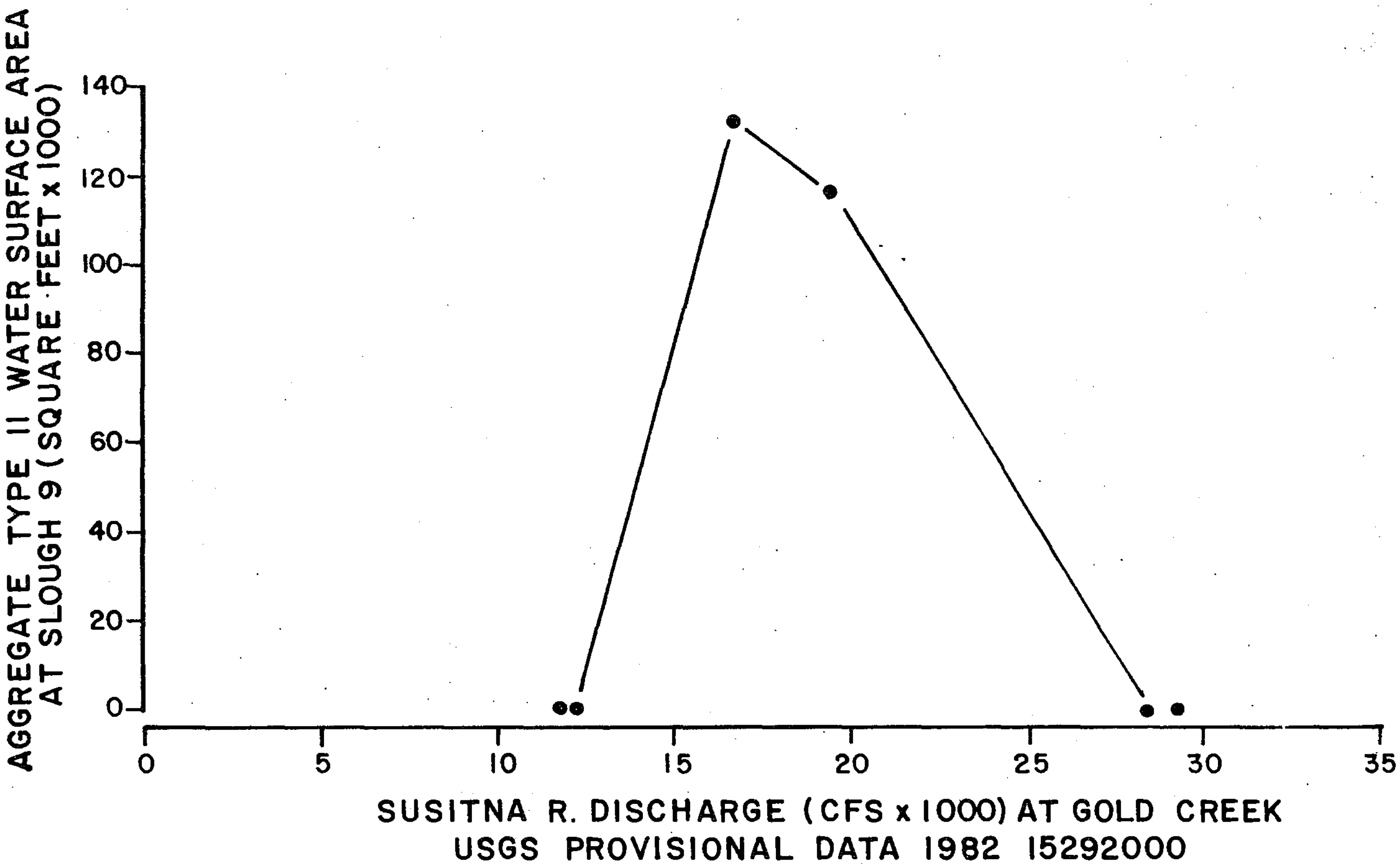

Figure 4-E3-34 Aggregate type II water surface area at Slough 9 versus mainstem discharge at Gold Creek (USGS, 1982).

in the study area were not controlled by mainstem elevation and the clear water exiting the slough was free-flowing to a mainstem confluence at a lower elevation.

Slough 8A

The area mapped in this study extended to the first series of riffles and beaver dams which begin approximately 1350 feet above the mouth, and excludes the very large area of calm water above. Within these boundaries, the area of H-II type water closely approaches the total wetted surface area of the site. The head of the slough was open during the June 8 visit (28,000 cfs) but the many physical barriers in mid slough prevented the overflow water (discharged into the lower slough study area) from significantly affecting the velocity or size of the H-II area. The area of H-II type water in the slough study area was directly regulated by mainstem stage.

Lane Creek and Slough 8

The Lane Creek site consists of a long and narrow (30-foot wide), steep-sided trench (Slough B) which, during the June and July trips, joined the outfall of Lane Creek to become a 70-foot wide eroded channel entering the Susitna River approximately 300 feet downstream. Both June trips to Lane Creek occurred at an indicated Gold Creek stage of 25,000 cfs. Observed water levels at Lane Creek and Slough 8 were lower on June 18 than on June 7 and that the head of the long channel was open to

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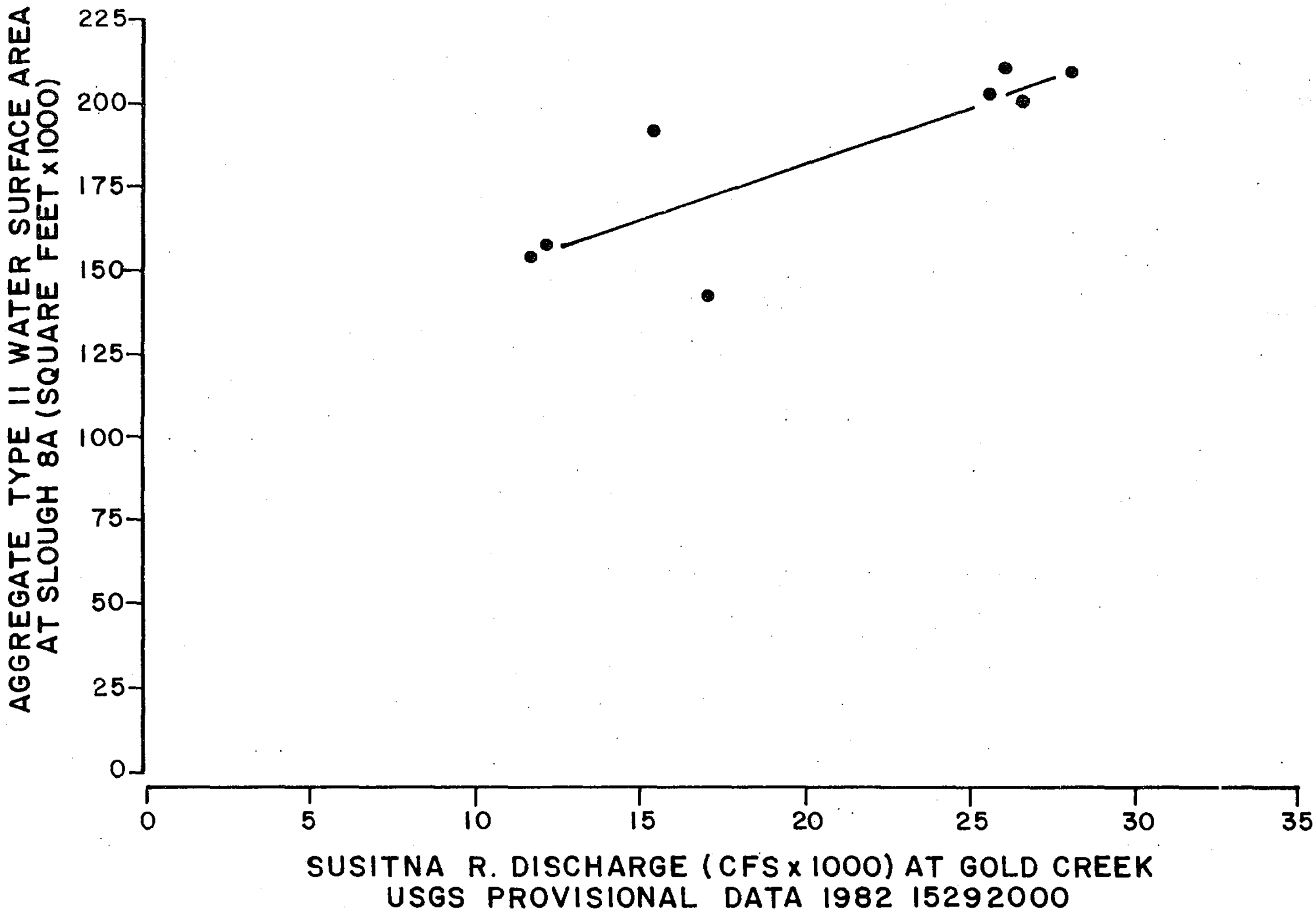

Figure 4I.3.35 Aggregate type II water surface area at Slough 8A versus mainstem discharge at Gold Creek.

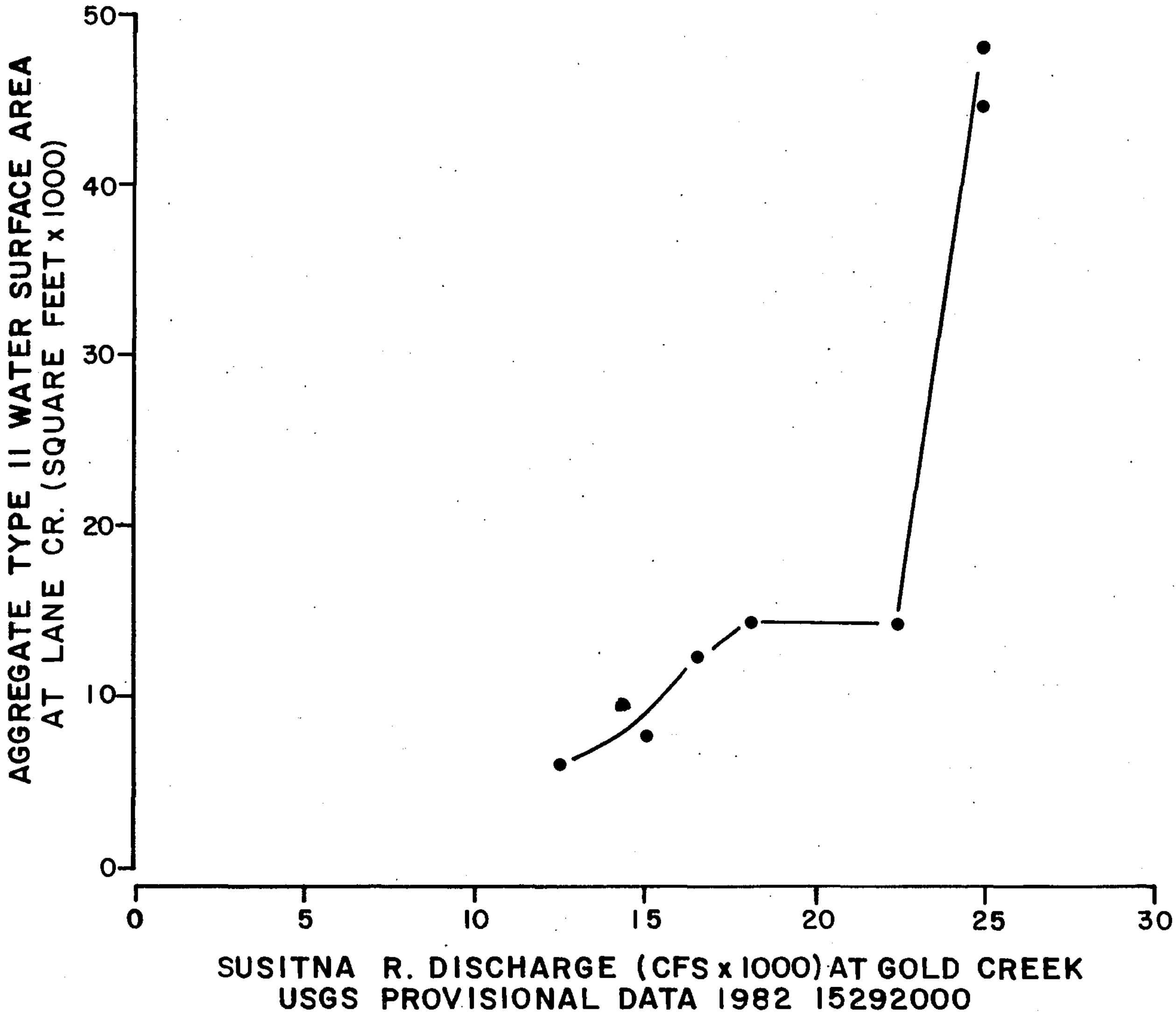

Figure 4I-3-36 Aggregate type II water surface area at Lane Creek versus mainstem discharge at Gold Creek (USGS, 1982).

the mainstem on June 7 but not on June 18. During both of these samplings, H-II type water covered the channel from about 700 feet above Lane Creek to the mouth.

At 22,400 and 18,100 cfs the H-II area was limited by mainstem stage to the channel area between the outfall of Lane Creek and the mainstem.

Between July 22 and August 8 Lane Creek formed a new mouth of two forks entering the Susitna River directly below the erosion channel mentioned above (Appendix Plate 4-F-10). The H-II area in the August and September sampling trips (16,600 to 12,500 cfs) decreased as a function of Susitna River elevation and the shape of the channel between the Susitna and the old outfall of Lane Creek.

Slough 6A

Slough 6A is a steep walled erosion feature which is connected to pools above it through a series of thick sedge tussocks and a beaver dam. The area of H-II type water within the physical bounds of the slough represents the total wetted surface of the slough up to the beaver dam. The water surface area in the slough is controlled by the water surface elevation of the mainstem in the manner presented graphically.

Whiskers Creek and Slough

Whiskers Creek flows into Whiskers Creek Slough approximately 1100 feet above the slough's mouth. During three visits with mainstem discharges

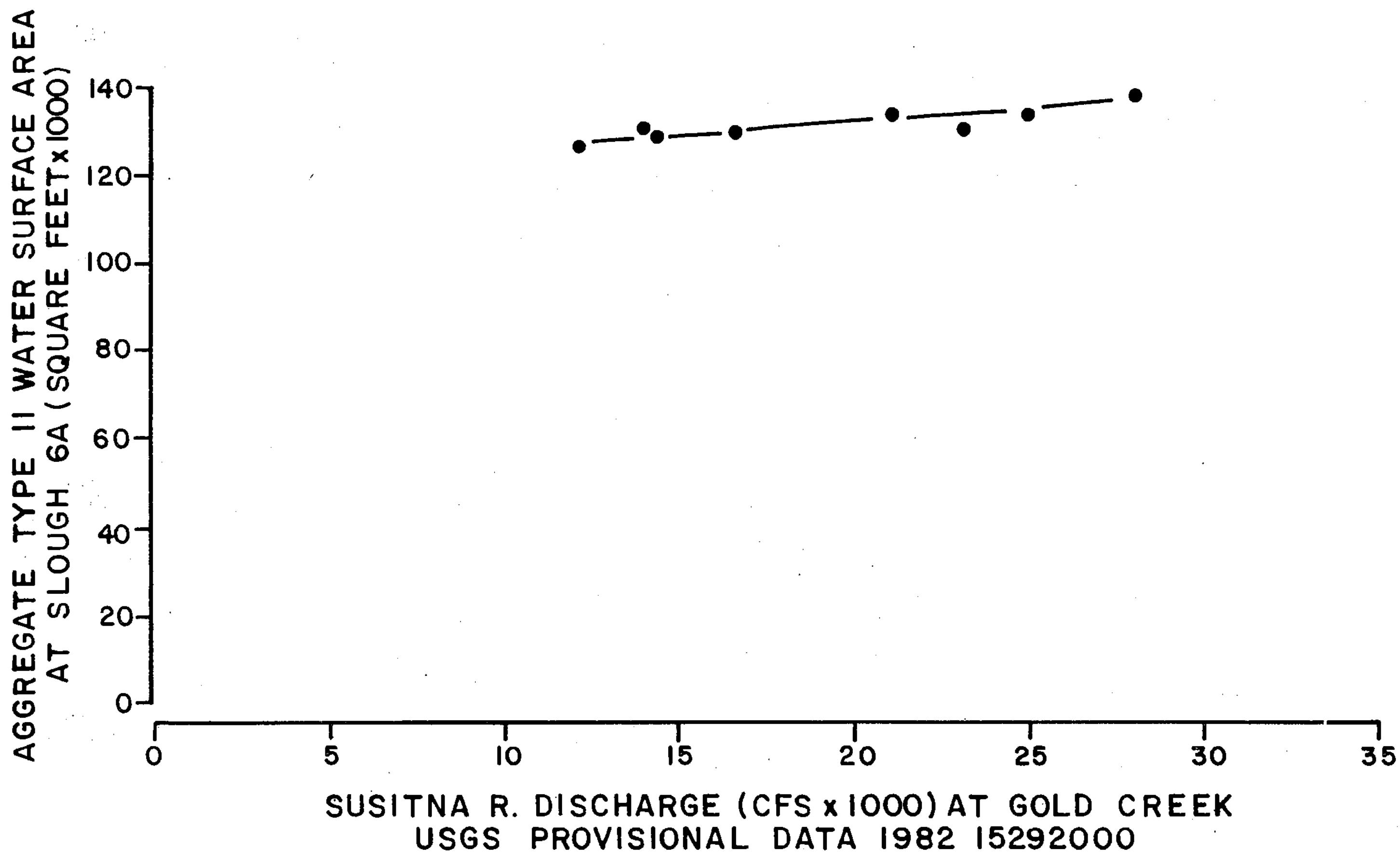

Figure 4E-3-37 Aggregate type II water surface area at Slough 6A versus mainstem discharge at Gold Creek (USGS, 1982).

of 25,000 cfs and above the mainstem stage was sufficient to back water up the slough to an elevation similar to that of water in Whiskers Creek. On each of these three occasions the head of the slough was open. Slough water (mixed with creek water) with varying velocity's separated the backwater area in the lower slough from a calm water area in the creek above. This velocity zone appeared to become more pronounced at higher mainstem discharges and to separate the creek pool from mainstem control. Based on the observations, the velocity barrier was deemed insignificant at 25,000 cfs, and dominating at higher mainstem discharges (with respect to joining the two calm water areas). Thus, at 25,000 cfs we measured the H-II area from the slough mouth to 1200 feet up Whiskers Creek and at higher discharges only up to below Whiskers Creek. The 25,000 cfs (H-II) area is reported as a maximum value and the H-II areas at high discharges as minimum areas. More observations at this area are needed to better describe the relationship between these two areas.

At mainstem discharges of 23,000 and 16,600 cfs the slough head was closed and H-II type water was backed up 715 and 550 feet, respectively, above the slough mouth. Free from tributary influence, the area of H-II type water near the mouth of the slough will vary as a function of mainstem stage and slough bed shape. That the water in this area is impacted by the discharge of Whiskers Creek was dramatically observed on September 28 when a rain swollen discharge of Whiskers Creek increased velocities near the mouth eliminating the H-II area of water. The

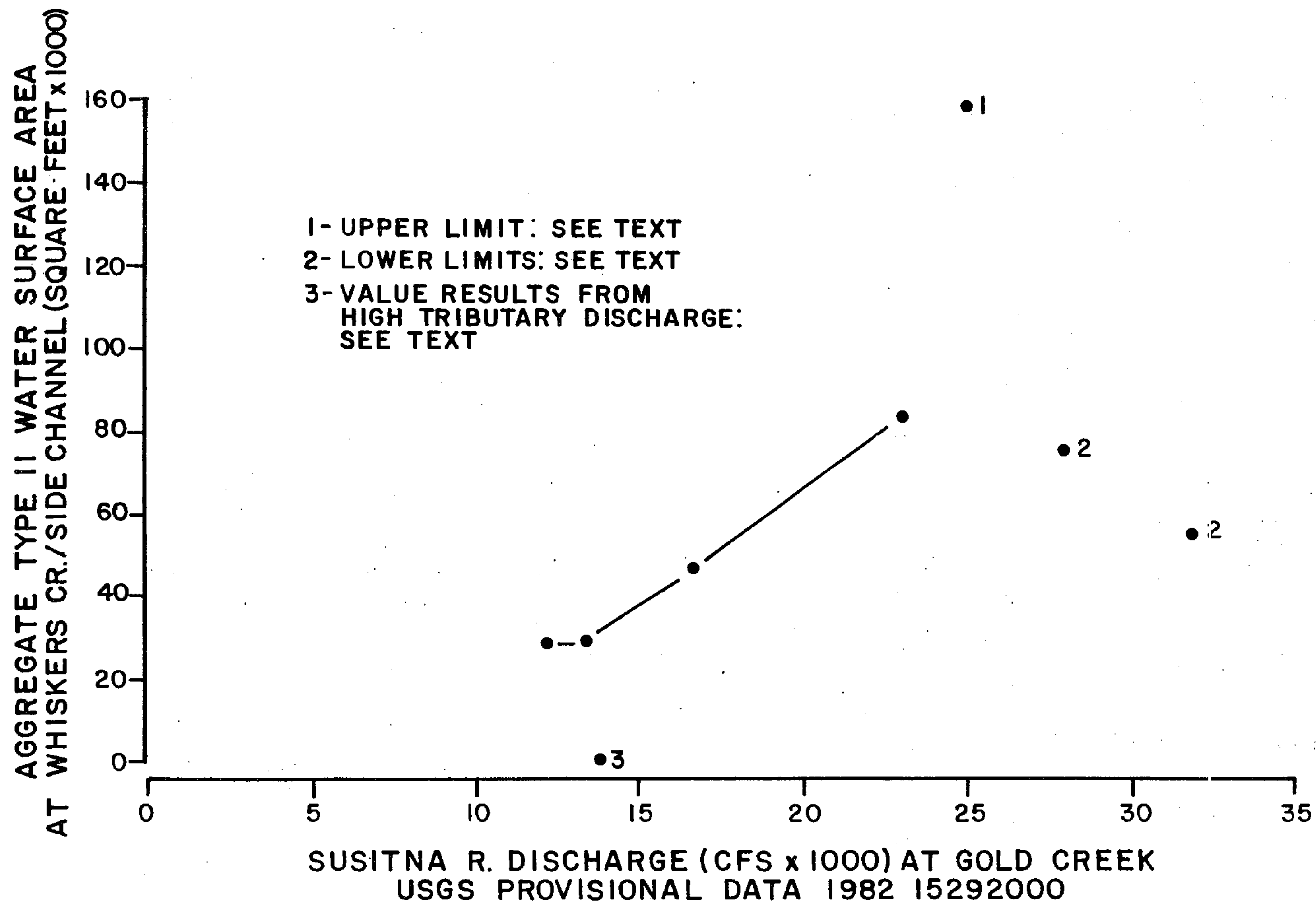

Figure 4I-3-34 Aggregate type II water surface area at Whiskers Creek/side channel versus mainstem discharge at Gold Creek (USGS, 1982).

(zero area) data point measured here was not used in drawing the H-II area versus mainstem discharge curve as it is a function of tributary discharge, not mainstem stage at 13,400 cfs.

Birch Creek and Slough

This site encompassed the nearly mile long lower section of Birch Creek slough between the Susitna River and its junction with Birch Creek, and one-tenth mile reaches of slough and tributary above this junction.

The length of the H-II type water area observed during four trips to this site (58,400 to a mainstem discharge of 99,300 cfs) was nearly constant, covering almost the entire site but Birch Creek itself, except at 99,300 cfs when a 160 foot section of the creek was also backed-up. The streambed elevations at the uppermost backwater boundaries just mentioned visually appeared steep enough to limit the backup observed.

At 52,500 cfs the slough head remained open but H-II water extended to only about 0.4 mile above the slough mouth. During trips where lower mainstem discharges prevailed (38,000 to 33,800 cfs) the head of the slough was closed and the backup zone extended only 0.14 mile above the slough mouth. The boundary between H-II and higher velocity waters at these intermediate discharges was partly regulated by the volume of slough and/or tributary water flowing into the backed up area. Judging the precise location of this boundary was often quite difficult.

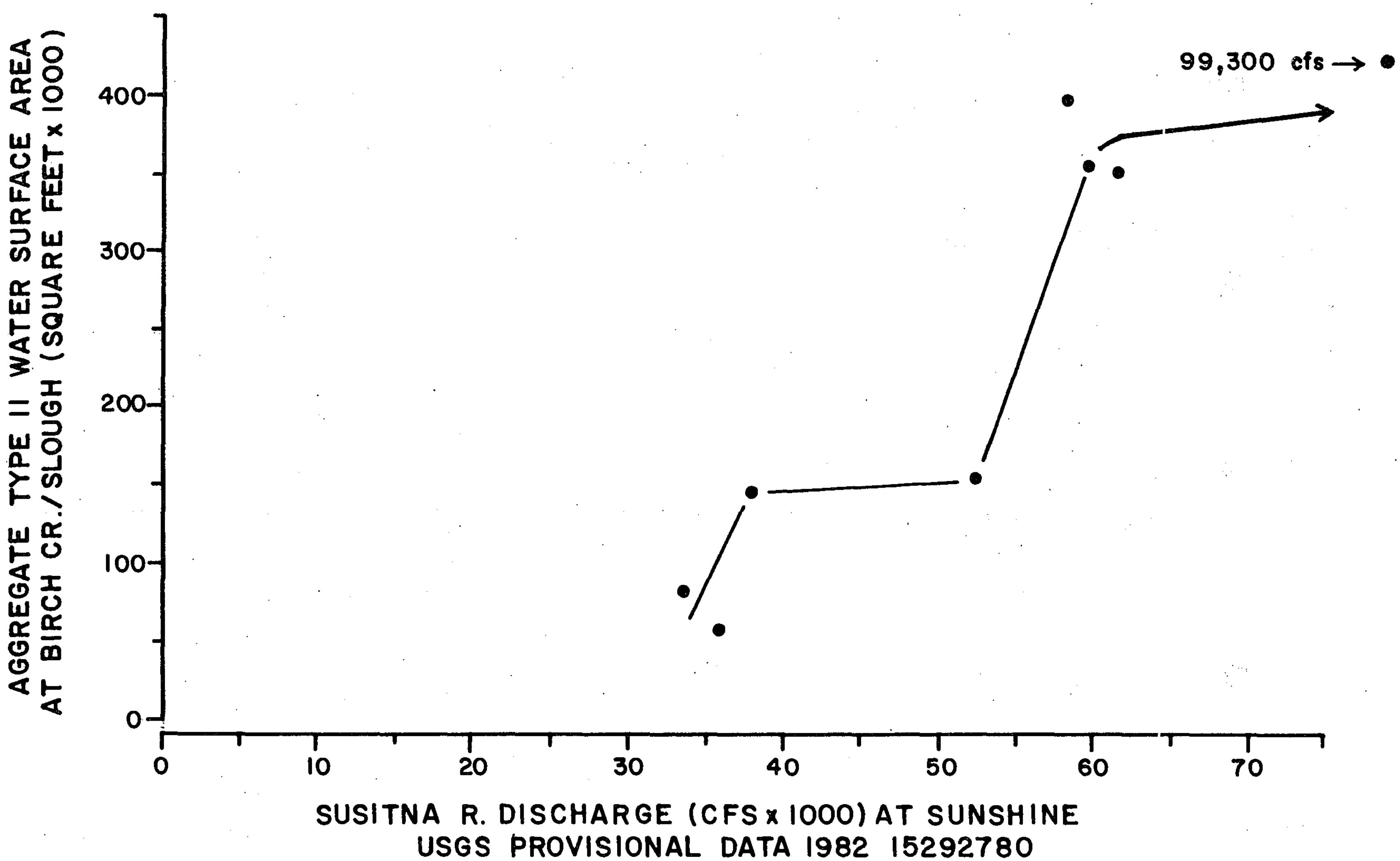

Figure 4E-3-39 Aggregate type II water surface area at Birch Creek/Slough versus mainstem discharge at Sunshine (USGS, 1982).

The mapping task at this site was also made somewhat imprecise by the extreme size of the wetted surface interface. During the limited time available for mapping, it was not possible to measure and record many slough width variations. The overall loss of H-II type area with decreasing mainstem stage is the significant result of the data collection at this site. More observations and more accurate mapping would be required to establish more accurate area data at this very large habitat location.

Sunshine Creek and Side Channel

This site was repeatedly sampled from the staff gage located about 0.75 miles up Sunshine Creek to its confluence with a minor sidechannel, then down another 1000 feet to the confluence with the a major side channel.

During our June and August sampling trips, mainstem discharges ranged from 82,400 to 60,100 cfs and the minor sidechannel's head was open. The H-II zone during these visits was determined to extend from the minor sidechannel-creek junction to about as far as 0.75 miles up the creek. The length of this backup zone was not easily determined nor relatable to mainstem discharges alone. This is visible in the decreases in H-II area seen at 70,200 and 62,700 cfs, relative to the areas mapped at higher and lower mainstem discharges. It is possible that the length of the H-II water zone in the creek was highly regulated by fluctuating creek discharges and not the result of errors in determining the exact location of the zone boundaries.

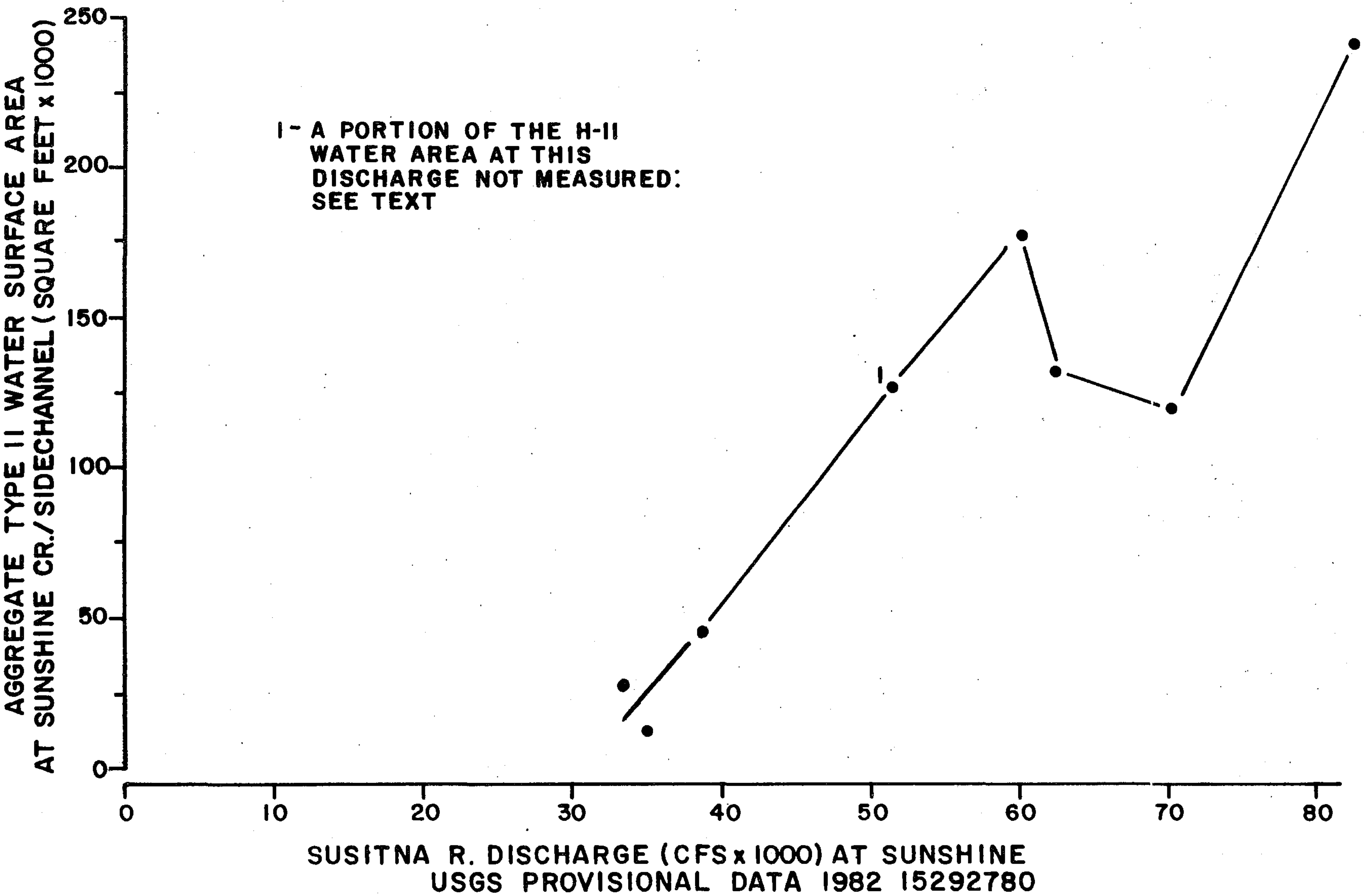

Figure 4E-3-40 Aggregate type II water surface area at Sunshine Creek/side channel versus mainstem discharge at Sunshine (USGS, 1982).

At 51,600 cfs the minor sidechannel's head was closing and the H-II boundaries extended from the minor sidechannel's confluence with the major side channel up into the creek and the closing minor channel's head. Part of the area of H-II water in the minor sidechannel at this discharge extended above the study boundary and was not mapped.

Between mainstem discharges of 38,700 and 33,400 cfs the backed up water area was located entirely between the major and minor sidechannel confluences and the minor sidechannel-creek junction.

The physical habitats in the reaches above and below the mouth of Sunshine Creek are notably dissimilar.

The field tasks at this site were subject to the same problems as at the Birch Creek site with the additional constraint that photographic bluelines showed sections of creek surface which were obscured by shadows. The significant result is the general relationship documented.

Rabideux Creek and Slough

Just below the old site of a bridge crossing (about 1 mile above its confluence with the Susitna River) Rabideux Creek widens into a pool like area. A sandy bottom channel about 700 feet in length connects the lower end of the pool to the upper end of a 0.5 mile long bay (or widening) of the creek which forms the creeks mouth area. At high mainstem discharges, the Susitna River breaches its banks and

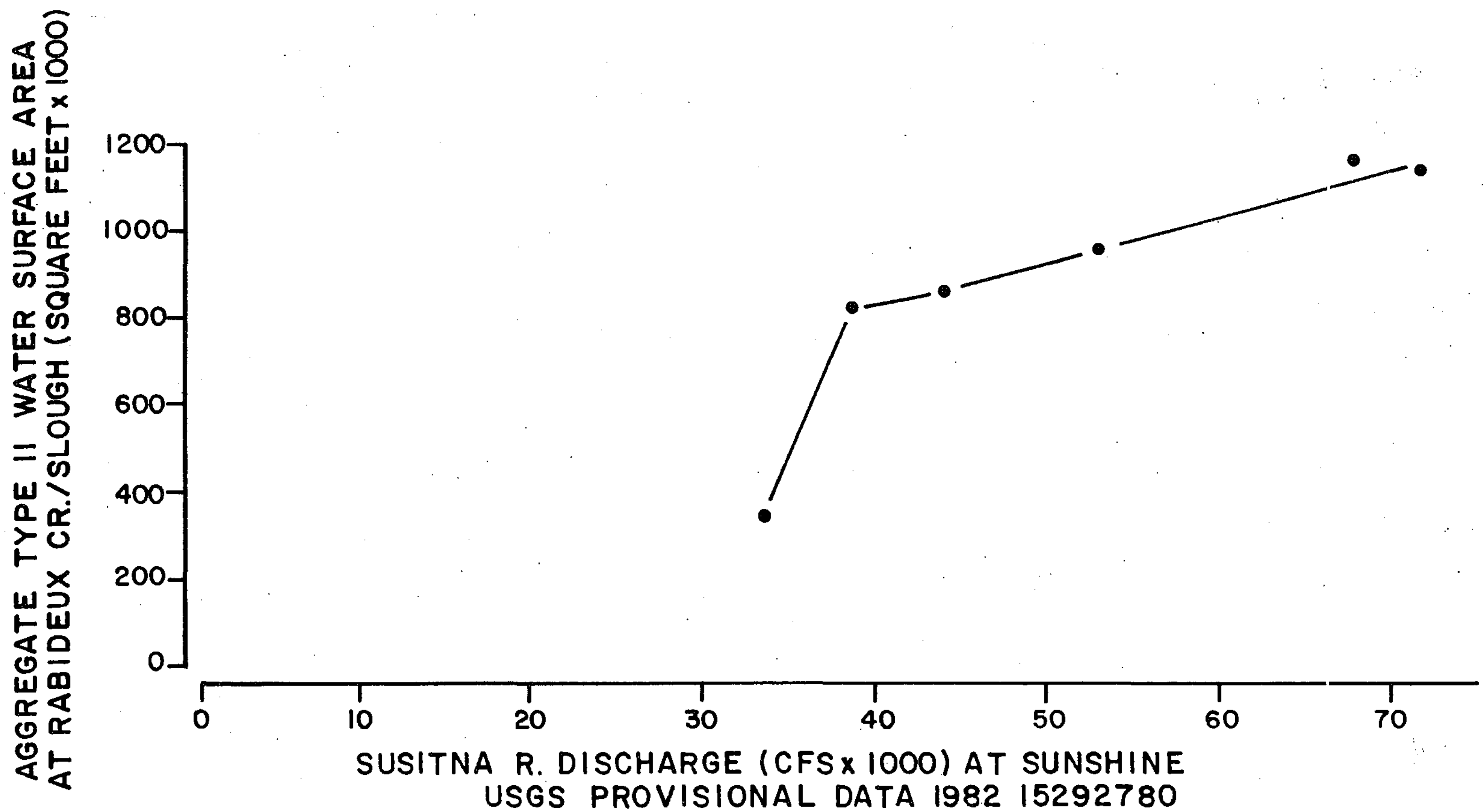

Figure 4C-3-41 Aggregate type II water surface area at Rabideux Creek/Slough versus mainstem discharge at Sunshine (USGS, 1982).

depressions and sections of this widening bay-like area become slough-like.

During every visit to this site a large backwater (H-II) area existed. At the highest mainstem discharges (71,700 cfs) the H-II area extended up to a point about 6,800 feet up from the Susitna River. Backwater thus extended approximately 1500 feet up the creek above the old bridge site and enlarged the wetted surface area in the pool area below the bridge site.

At mainstem discharges between 53,300 and 38,400 cfs, the boundary between the free flowing creek and the low velocity backwater occurred at locations in the pool area.

At the lowest mainstem discharge sampled (33,400 cfs) the elevation of mainstem water had dropped sufficiently to expose a controlling streambed elevation in the sandy bottom connecting channel, reducing the backwater area at this site to 41 percent of its previous observed area. The pool above the channel did not dewater; it simply became a geomorphological feature of the creek bed.

Whitefish Slough

The study boundaries of this site were limited to a 900 foot long section of the slough nearest the mouth. The surface area measurements are thus only partial totals of the entire H-II type area occurring in this long, channel-like area.

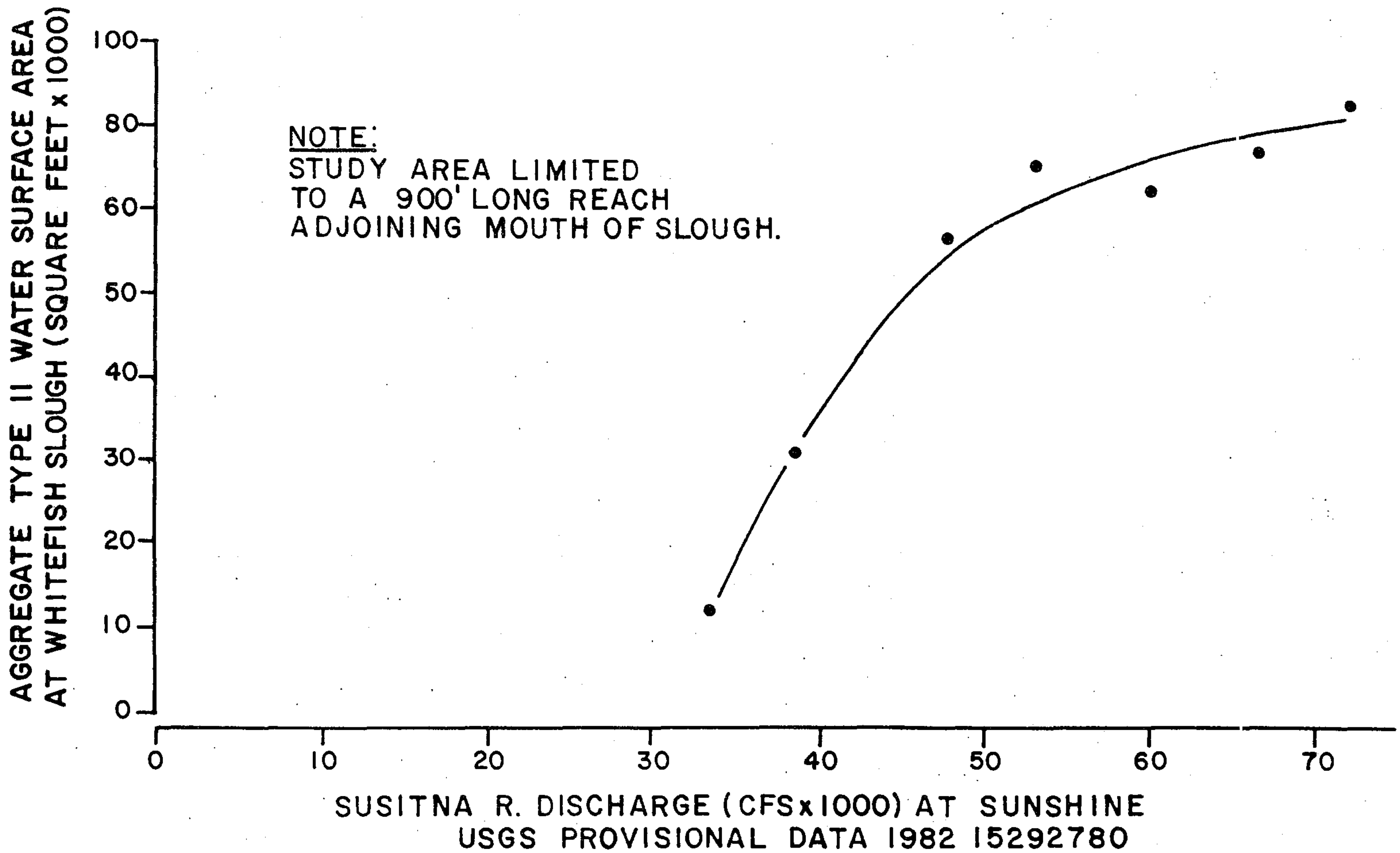

Figure 4I-3-42 Aggregate type II water surface area at Whitefish Slough versus mainstem discharge at Sunshine (USGS, 1982).

The entire wetted surface of this area was of the H-II type during each sampling. Its area was entirely controlled by mainstem water surface elevation at the mouth of the slough.

Lower Goose Creek 2 and Sidechannel

Lower Goose Creek 2 has two mouths. Its northernmost mouth empties into a sidechannel (460 feet above the sidechannel's mouth) over a log jam which maintained the elevation of the water in the creek over any sidechannel elevations observed in these samplings.

At all samplings between mainstem discharges of 38,700 and 64,200 cfs, the sidechannel's head was open. The volume of water which breached the head of the sidechannel significantly controlled the extent of H-II type backwater area in the lower (mouth) reach of the sidechannel by way of its effect on the velocity of these surfaces. At high flows over the sloughs head. The low velocity water was limited to a 600-foot reach nearest the sidechannel's mouth. As the breached water volume decreased the low velocity area extended further up the sidechannel until at 38,700 cfs the length of the H-II area was nearly 1,500 feet long.

During September visits (at mainstem discharges of 36,400 and 33,900 cfs), the sidechannel head was closed. Lower Goose Creek 2, at this point, was free-flowing to the confluence of the sidechannel and the Susitna River. The area of water in the sidechannel above the outfall of Lower Goose Creek 2 was not influenced by mainstem stage, it was

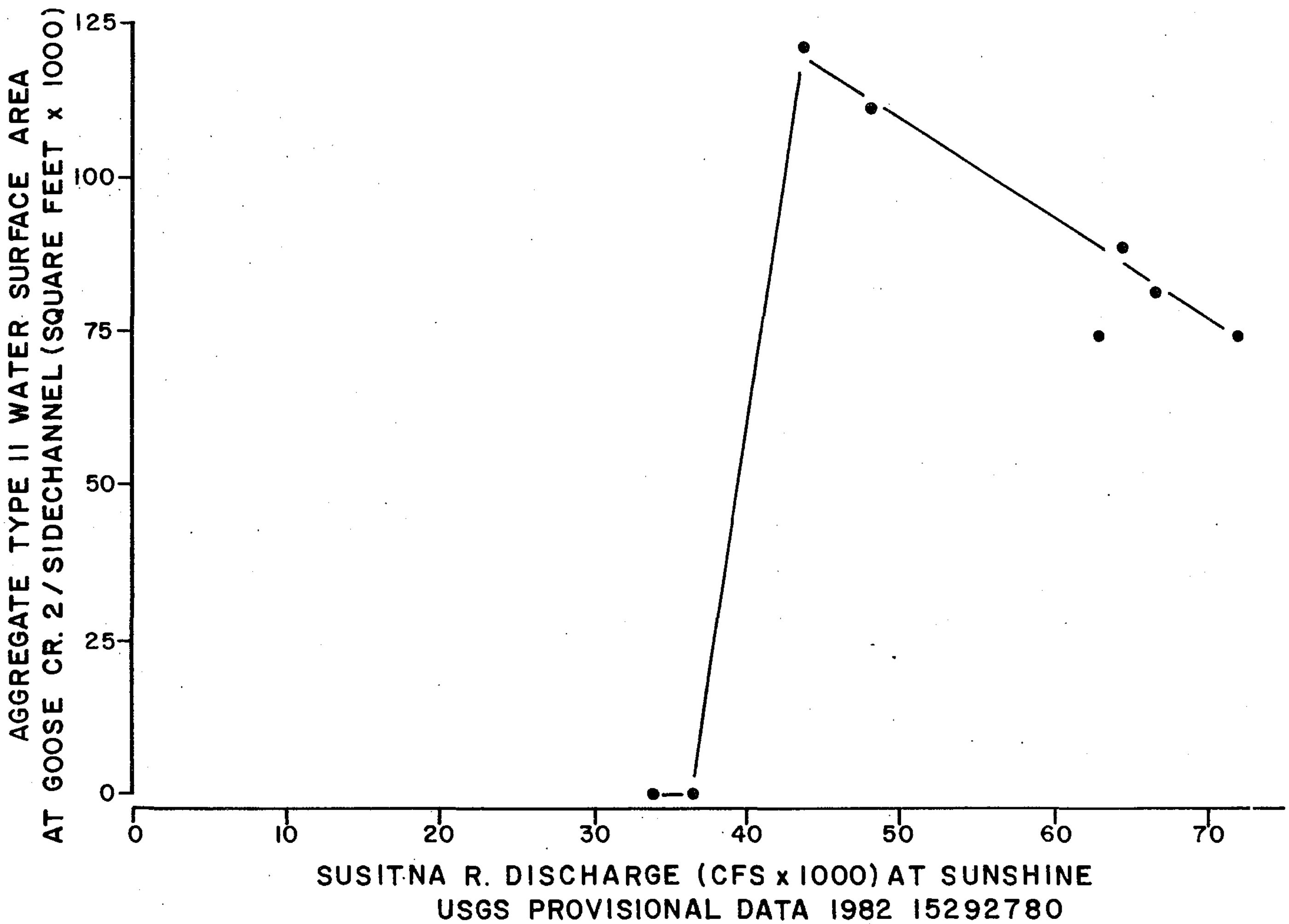

Figure 4/E-3-43 Aggregate type II water surface area at Lower Goose Creek 2/Slough versus mainstem discharge at Sunshine (USGS, 1982).

partly controlled by streambed elevation and partly by the barrier presented by Lower Goose Creek 2 water.

3.1.3.2 Open Channel

Depths, velocities, widths and water surface elevations used in the hydraulic simulations are tabulated and summarized in Appendices A, B and E. This data has been entered into the computer programs, however, the time of this report writing the calibration procedure has yet to be completed. Thus, hydraulic parameters at unknown discharges cannot be extrapolated at this time.

3.2 Water Quality Investigations

3.2.1 Water Temperature

Temperature measurements collected in 1982 included both instantaneous and continuous measurements.

Instantaneous temperature measurements were collected in conjunction with other water quality data and are compiled and presented in Appendix Table 4-D-4.

Continuous temperature data includes surface water and intragravel temperatures obtained with Peabody-Ryan thermographs, surface water and intragravel temperatures obtained with Omnidata recorders and associated thermistors (programmed as 2 channel temperature recorders) and surface water temperatures obtained with Omnidata recorders located at stream gage stations (Indian River and Portage Creek).

Temperatures obtained with Ryan-Peabody thermographs are presented in Appendix, Table 4-C-1 - 4-C-24 as six-hour minimum, mean and maximum temperatures calculated from corrected two-hour point temperature readings. Daily and monthly means, calculated from the 2 hour readings, are also shown in this table. Temperatures obtained with Omnidata 2 channel temperature recorders are presented in Appendix Tables 4-C-25 - 4-C-31 as mean, maximum and minimum temperatures for time periods of six hours and three minutes duration. Six-hour and daily means have been calculated from these temperatures using a two part linear equation interpolation method to "correct" readings from actual six hour and three minute time intervals to six hour intervals (Appendix Tables 4-C-32 - 4-C-38). Hourly and mean daily temperatures obtained with Omnidata recorders located at stream gage stations are presented in Appendix, Tables 4-A-4 and 4-A-5, with a summary of daily mean temperatures for these sites in Tables 4I-3-4 and 5.

3.2.1.1 Mainstem Between Talkeetna and Devil Canyon

3.2.1.1.1 Surface Water Temperature

Instantaneous Surface Water Temperature

Instantaneous measurements of surface water temperatures of the mainstem Susitna River were collected at various locations from May through

October, 1982 (Appendix Table 4-D-4). Instantaneous surface water temperatures ranged from 5.1°C to 13.4°C with the lowest occurring at RM 138.9 on September 6 and the highest occurring at RM 120.7 on July 7. In general, instantaneous surface water temperatures of the mainstem above Talkeetna increased from May to July and decreased from August to October, peaking in July and August.

Continuous Surface Water Temperature

Surface water temperature of the mainstem Susitna River between Talkeetna and Devil Canyon was continuously monitored with Peabody-Ryan thermographs at ten locations from May through October, 1982. This data is presented in Appendix C. Surface water temperature ranged from 0.0°C at LRX 18 (RM 113.0) in October to 15.2°C at LRX 29 (RM 126.1) in July. Generally, the mainstem surface water temperature increased during the period from May to July and decreased during the period from August to October usually peaking during July depending on location. 7 day average water temperatures based on a USGS water year will be included in the final draft of this volume.

3.2.1.1.2 Intragravel Water Temperature

Intragravel water temperature data was collected at various mainstem Susitna River locations between Talkeetna and Devil Canyon from May through October, 1982, in conjunction with the mainstem Adult Anadromous Fish Habitat Investigations (refer to Volume 4, Part II, section 3.1.1.1).

3.2.1.2 Sloughs Between Talkeetna and Devil Canyon

3.2.1.2.1 Surface Water Temperature

Instantaneous Surface Water Temperature

Instantaneous surface water temperatures of various sloughs situated between Talkeetna and Devil Canyon were collected from May through October, 1982 (Appendix Table 4-D-4). Due to the large variability among slough habitats and the periodic nature of the instantaneous surface water temperature data, no summary statements concerning the above data have been made.

Continuous Surface Water Temperature

During the open-water season, the surface water temperature of various sloughs located between Talkeetna and Devil Canyon was continuously monitored with Ryan-Peabody thermographs and/or Omnidata recorders at ten sites from August to October, 1982 (Appendix 4-C). During the winter the surface water temperature in seven of these sloughs was continously monitored using Peabody-Ryan thermographs from February - May, 1982 (Appendix Tables 4-C-39 - 4-C-45). Based on data from the open water season, the surface water temperatures in the sloughs ranged overall from 0.2°C at mid-slough in Slough 8A during October to 13.5°C in Slough 9 during August. Surface water temperatures in the sloughs were notably warmer than surface water temperatures in the mainstem during the months of September and October.

The greatest variance in maximum surface water temperatures among the sampled sloughs between Talkeetna and Devil Canyon for any one week occurred during the first week in September when the maximum surface water temperature in Slough 9 was 11.0°C and the maximum in Slough 11 was 3.5°C. The greatest variance in weekly minimum surface water temperatures between sloughs for a given week was 4.4°C occurring in the last week of August when the minimum temperatures in the mouth of Slough 8A and in Slough 11 were 7.7°C and 3.3°C, respectively. Comparing surface water temperatures in mid-slough 8A (RM 126.1) with surface water temperatures in the mainstem adjacent to the slough (at LRX 29, RM 126.1), for any given week, shows similar weekly maximum temperatures, but minimum weekly temperatures from 1° to 5.4°C colder in the slough than in the mainstem.

Based on data from the winter season, the overall range of surface water temperatures in the sloughs studied between Talkeetna and Devil Canyon was from 0.0°C in Whiskers Creek Slough in February to 10.3°C in Slough 9B in May. The greatest variance in maximum surface water temperatures among the sloughs occurred the first week of May when the surface water temperature reached 10.3°C in Slough 9B whereas the maximum in Whiskers Creek Slough was 2.0°C. Generally, winter surface temperatures in the sloughs increased gradually or remained stable through February and March and increased notably in April and the first week of May.

3.2.1.2.2 Intragravel Water Temperatures

Instantaneous Intragravel Water Temperature

Instantaneous measurements of intragravel water temperature were obtained at several sloughs between Talkeetna and Devil Canyon to identify groundwater sources and to obtain intragravel water temperature data on FHU study transects (see Volume 4, Part II section 3.1.1.2.3) and to characterize the intragravel water temperature regimes in locations of salmon redds (see Volume 4, Part II, section 3.1.2.2.4). Refer to the above sections for a summary of the results of this data.

Continuous Intragravel Water Temperature

During the 1982 open-water field season, the intragravel water temperature of various sloughs situated between Talkeetna and Devil Canyon was continuously monitored from late August to October, 1982 (Appendix Tables 4-C-25 - 4-C-38). During the winter, the intragravel water temperature in four of the sloughs was continuously monitored using Peabody-Ryan thermographs from February through the first week of May, 1982 (Appendix Tables 4-C-46 - 4-C-49).

Based on data from the open water season, the intragravel water temperature of the sloughs varied overall from 1.5°C at the mouth of Slough 21 during October to 7.5°C and 7.5°C in Slough 16B during August and during September. The overall range of intragravel water temperatures in the sloughs (1.5°C to 7.5°C) was considerably less than the range of surface water temperatures observed in the sloughs (0.2°C to 13.5°C).

In each slough studied, the minimum weekly intragravel water temperature was warmer than the corresponding surface water temperature from mid-September through October. Conversely, minimum intragravel water temperatures in the mouth of Slough 8A, upper Slough 8A, sloughs 11, 19 and upper Slough 21 were cooler than corresponding minimum surface water temperatures prior to September. The minimum intragravel temperatures in upper Slough 8A were consistently warmer than those in the other sloughs for this period. For August and September, the coolest intragravel temperatures in these sloughs were in Slough 19; the difference between minimum intragravel temperatures in the mouth of Slough 8A and in Slough 9 for September was 3.0°C.

Based on data from the winter season (February to April), overall of intragravel water temperatures ranged from 0.0°C in Slough 9 to 6.5°C also in Slough 9 in May. Conversely, the intragravel temperature in the mouth of Slough 21 remained a steady 3.0°C from February through April. In Slough 19, the average intragravel water temperature was warmer than the corresponding surface water temperature from February to April. The same was true in the mouth of Slough 21 for February and March, but by mid-April the average surface water temperature was warmer than the intragravel water temperature. In Slough 9 and 9B the surface water temperature was warmer than the intragravel water temperature from February through April.

3.2.1.3 Tributaries Between Talkeetna and Devil Canyon

3.2.1.3.1 Surface Water Temperature

Instantaneous Surface Water Temperatures

Instantaneous measurements of surface water temperatures in tributaries between Talkeetna and Devil Canyon were collected from June through October, 1982 (Appendix Table 4-D-4). In general, surface water temperature increased from June to August and decreased from September to October, peaking in August. Instantaneous measurements of surface water temperature ranged from 0.9°C in Portage Creek on October 11 to 12.1°C in Fourth of July Creek on August 22.

Continuous Surface Water Temperature

Surface water temperature was continuously monitored from June to October, 1982, in Indian River and Portage Creek. This data is presented in Appendix Tables 4-A-4 and 4-A-5 and Tables 4I-3-4 and 4I-3-5.

Based on the above data, the surface water temperature of Indian River varied from 0.0°C in late October to 12.5°C in mid-July. The surface water temperature of Portage Creek varied from 0.0°C beginning in mid-October to 13.0°C in mid-August. Temperatures in both Indian River and Portage Creek generally increased from June to August and decreased in September and October, peaking in August.

3.2.1.3.2 Intragravel Water Temperature

No intragravel water temperature data was collected from tributaries between Talkeetna and Devil Canyon during the 1982 open water field season.

3.2.1.4 Mainstem , Sloughs and Tributaries Downstream of Talkeetna

3.2.1.4.1 Surface Water Temperature

Mainstem Sites

Instantaneous Surface Water Temperature

Instantaneous measurements of surface water temperature of the mainstem Susitna River below Talkeetna were collected from May through October, 1982 (Appendix Table 4-D-4). Instantaneous measurements of surface water temperature in the mainstem below Talkeetna ranged from 0.2°C at RM 77.0 on October 14 to 11.2°C at RM 18.2 on June 1. Because of the limited quantity of instantaneous surface water temperature data for the mainstem below Talkeetna, no further summary statements on the above data are made.

Continuous Surface Water Temperature

Surface water temperature of the mainstem Susitna River below Talkeetna was monitored at three sites from May through October, 1982. This data is presented in Appendix Tables 4-C-1, 4-C-3 and 4-C-4.

The surface water temperature of the mainstem Susitna River below Talkeetna ranged from 0.0°C in October to 13.5°C in June and July. Both temperatures were recorded above the Yentna River confluence at RM 29.3. Generally, the surface water temperature of all mainstem sites below Talkeetna increased during the period from May through August and decreased from September to October, peaking from mid- July to mid-August. The timing of the peak water temperature in the mainstem below Talkeetna (mid July to mid August) appeared to occur later than in the mainstem above Talkeetna (July; see section 3.2.1.1.1).

Slough Sites

Instantaneous Surface Water Temperature

Instantaneous measurements of surface water temperature of various sloughs below Talkeetna were collected from June through October, 1982 (Appendix Table 4-D-4). Temperature measurements ranged from 3.7°C in Lower Goose 2 Slough on October 1 to 16.6°C in Rabideux Creek Slough on June 26. Surface water temperature in the sloughs below Talkeetna generally rose from June to July, peaking during July and August, and then decreased during September through October.

Continuous Surface Water Temperature

No sloughs below Talkeetna were continuously monitored for surface water temperature during 1982.

Tributary Sites

Instantaneous Surface Water Temperature

Instantaneous measurements of surface water temperature in various tributaries below Talkeetna were collected from June through October, 1982 (Appendix Table 4-D-4). Instantaneous measurements of surface water temperature in various tributaries below Talkeetna ranged from 17.4°C in Birch Creek on August 5 to 3.6°C in Sunshine Creek on October 4. Because of the limited quantity of instantaneous surface water temperature data for the tributaries below Talkeetna, no further summary statements on the above data have been made.

Continuous Surface Water Temperature

Surface water temperature was continuously monitored in the three major tributaries below Talkeetna, the Chulitna, Talkeetna and Yentna Rivers, from May through October, 1982 (Appendix Tables 4-C-2, 4-C-7 and 4-C-8).

The surface water temperature of the Yentna River ranged from 3.5°C in late September (October temperatures not obtained) to 13.0°C in late June. The surface water temperature in the Chulitna River ranged from

0.0°C in October to 8.5°C in September (July and August temperatures not obtained). In the Talkeetna River, the temperature ranged from 0.1°C in October to 11.5°C in August. From July to September, monthly mean mainstem surface water temperatures obtained at the Talkeetna fishwheel camp approximately 5 miles upstream from the confluence with the Chulitna and Talkeetna Rivers, were 1-2°C warmer than the monthly mean temperatures obtained in the Chulitna and Talkeetna rivers from July to September. In October both the Chulitna and Talkeetna Rivers and the mainstem averaged temperatures between 0.5°C and 1.0°C. Monthly mean mainstem surface water temperatures obtained in the mainstem above the Yentna River compared to monthly mean surface water temperatures obtained in the mainstem above the Yentna River were from 1.0°C to 2.5°C warmer than monthly mean surface water temperatures in the Yentna River.

3.2.1.4.2 Intragravel Water Temperature

No intragravel water temperature data was collected below Talkeetna during 1982.

3.2.1.5 Locations Upstream of Devil Canyon

3.2.1.5.1 Surface Water Temperature

Instantaneous Surface Water Temperature

Instantaneous measurements of surface water temperature were collected at various locations above Devil Canyon from May through October, 1982 and are presented in Appendix Table 4-D-4. Refer to Volume 5 for further details on these results.

Continuous Surface Water Temperature

Surface water temperatures were continuously monitored within five tributaries above Devil Canyon from June to October, 1982. This data is presented in Appendix Tables 4-C-20 - 4-C-24. Refer to Volume 5 for further details on these results.

3.2.1.5.2 Intragravel Water Temperature

No intragravel water temperature data was collected above Devil Canyon during 1982.

3.2.2 Other Basic Field Parameters

The basic field parameters of dissolved oxygen, pH, specific conductance and temperature were collected at various locations in the Susitna River basin from RM 5.0 to RM 233.4 during the 1982 open water field season. In addition, turbidity was measured at various locations from RM 73.1 to RM 233.4. These data are compiled and presented in Appendix Table 4-D-4. The water quality data summarized in this section are provisional. The variety and large quantity of information presented in Appendix Table 4-D-4 limited sufficient review of this data for this first draft.

3.2.2.1 Mainstem and Sidechannels Between Talkeetna and Devil Canyon

The basic field parameters of dissolved oxygen, pH, specific conductance and temperature were collected at various mainstem and side channel sites between Talkeetna and Devil Canyon primarily in conjunction with the electrofishing program (see section 3.1.1.1, Vol. 4, Part II). These data are presented in Appendix Table 4-D-4.

From RM 114.2 to RM 148.2, the range of dissolved oxygen was 7.1 to 14.0 mg/l over a corresponding range of surface water temperatures from 5.8°C to 10.6°C. Measurements of pH were observed to a range from 6.9 to 8.7 and specific conductance ranged from 33 to 132 umhos/cm. Turbidity in the mainstem Susitna River between Talkeetna and Devil Canyon during the 1982 open water field season ranged from 2.4 to 154 NTU from RM 111.5 to RM 148.2.

3.2.2.2 Sloughs Between Talkeetna and Devil Canyon

The basic field parameters of dissolved oxygen, pH, specific conductance, temperature and turbidity were measured at various upland and side sloughs situated between Talkeetna and Devil Canyon during the 1982 open water field season (refer to section 3.1.1.2 of Vol. 4, Part I for the definition of upland and side sloughs). This data is compiled and presented in Appendix Table 4-D-4.

3.2.2.2.1 Upland Sloughs

Two upland sloughs (Sloughs 6A and 19) were monitored for the basic field parameters discussed above, primarily in conjunction with the FDS program, from June to October, 1982. The results are presented in Appendix Table 4-D-4. In Slough 6A dissolved oxygen was found to range from 8.9 to 13.9 mg/l over a corresponding range of surface water temperatures from 4.9 to 15.0°C, while in Slough 19 the ranges for these parameters were 7.3 to 14.3 mg/l and 3.6° to 14.1°C, respectively. Measurements of pH and specific conductance in Slough 6A and 19 ranged from 6.3 to 7.8 and 28 to 135 umhos/cm and 6.0 to 7.7 and 52 to 159 umhos/cm, respectively. Turbidity in Slough 6A ranged from 3 to 146 NTUs while in Slough 19 it varied from less than 1 to 150 NTUs.

Overall, dissolved oxygen in the upland sloughs situated between Talkeetna and Devil Canyon was found to vary from 7.3 to 14.3 mg/l over a corresponding range of surface water temperatures from 3.6° to 15.8°C, while measurements of pH and specific conductance varied from 6.0 to 7.8 and 28 to 159 umhos/cm, respectively. Turbidity in upland sloughs was observed to vary from less than 1 NTU to 150 NTUs.

3.2.2.2.2 Side Sloughs

Twelve side sloughs situated between Talkeetna and Devil Canyon (Whiskers Creek and Lane Creek Slough and sloughs 8A, 9, 9A, 9B, 10, 11, 16, 20, 21 and 22) were monitored for dissolved oxygen, pH, specific conductance, temperature and turbidity during the 1982 open water field season in conjunction with the FDS, FHU, and IFE programs. These data are presented in Appendix Table 4-D-4 and discussed below on a site by site basis.

Overall, dissolved oxygen in the side sloughs situated between Talkeetna and Devil Canyon ranged from 4.8 to 15.7 mg/l over a corresponding range of surface water temperatures from 0.9° to 16.3°C, while measurements of pH and specific conductance varied from 5.3 to 7.9 and 14.0 to 277 umhos/cm, respectively. Turbidity was found to vary from less than 1 NTU to 200 NTUs.

Whiskers Creek Slough

In Whiskers Creek Slough from June to October, 1982, dissolved oxygen was observed to vary from 6.4 to 13.3 mg/l over a corresponding range of surface water temperatures from 3.3° to 12.7°C, while measurements of pH and specific conductance were found to range from 6.2 to 7.4 and 24 to 92 umhos/cm respectively. Turbidity measurements obtained from June to September, 1982, ranged from 3 NTUs to 41 NTUs.

Lane Creek Slough

In Lane Creek Slough from June to October, 1982, dissolved oxygen was found to vary from 6.8 to 14.5 mg/l over a corresponding range of surface water temperatures from 4.0° to 16.2°C, while measurements of pH and specific conductance ranged from 5.5 to 7.8 and 26 to 86 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 168 NTUs.

Slough 8A

In Slough 8A from June to October, 1982, dissolved oxygen was found to vary from 8.6 to 11.8 mg/l over a corresponding range of surface water temperatures from 2.4 to 14.0°C while measurements of pH and specific conductance ranged from 6.3 to 7.4 and 34 to 168 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 34 NTUs.

Slough 9

In Slough 9 from June to October, 1982, dissolved oxygen was observed to vary from 3.5 to 14.4 mg/l over a corresponding range of surface water temperatures from 4.9° to 13.4°C, while measurements of pH and specific conductance were found to range from 6.4 to 7.7 and 53 to 172 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged 2 to 48 NTUs.

Slough 9B

Measurements of the basic field parameters were measured once during the 1982 open water field season at Slough 9B. On October 4, the dissolved oxygen was observed to be 9.2 mg/l at a corresponding surface temperature of 3.3°C, while measurements of pH and specific conductance were 6.6 and 163 umhos/cm, respectively.

Slough 9A

Measurements of the basic field parameters were measured once during the 1982 open-water field season at three locations in Slough 9A. On September 3, dissolved oxygen was observed to range from 7.7 to 8.9 mg/l over a corresponding range of surface water temperatures from 3.6 to 5.0°C, while measurements of specific conductance varied from 121 to 161 umhos/cm. Measurements of pH was constant at 6.9 at all three locations.

Slough 10

Measurements of the basic field parameters were obtained twice in Slough 10 during the 1982 open-water field season. On June 8, measurements were made at two sites in Slough 10 while on October 4, measurements were obtained at four sites. At all measurement sites dissolved oxygen was observed to vary from 7.9 to 10.5 mg/l over a corresponding range of surface water temperatures from 4.2 to 6.5°C, while measurements of pH and specific conductance varied from 6.9 to 7.4 and 132 to 226 umhos/cm, respectively. Two turbidity samples, both obtained on June 8, were determined to be less than 1 NTU and 4 NTUs.

Slough 11

In Slough 11 from June to October, 1982, dissolved oxygen was observed to vary from 7.1 to 12.9 mg/l over a corresponding range of surface water temperatures from 3.0 to 11.6°C, while measurements of pH and specific conductances were found to range from 5.3 to 7.8 and 127 to 230 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 9 NTUs.

Slough 16

In Slough 16B, between June, and October, 1982, dissolved oxygen levels were measured on two occasions, 11.1 and 11.8 mg/l. Surface water temperature was found to vary from 4.3° to 7.5°C, while pH and specific conductance were found to range from 6.2 to 6.6 and 34 to 70 umhos/cm. A single turbidity measurement of 3 NTU was obtained on June 4.

Slough 20

In Slough 20 from July to October, 1982, dissolved oxygen was observed to vary from 10.3 to 15.7 mg/l over a corresponding range of surface water temperatures from 3.0 to 12.4°C while measurements of pH and specific conductance were found to range from 6.2 to 8.0 and 65 to 105 umhos/cm, respectively. Turbidity measurements obtained from July to October, 1982 ranged from less than one NTU to 50 NTUs.

Slough 21

In Slough 21 from June to September, 1982, dissolved oxygen was observed to vary from 5.3 to 12.7 mg/l over a corresponding range of surface water temperatures from 4.6 to 10.8°C, while measurements of pH and specific conductance were found to range from 6.0 to 7.8 and 115 to 277 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 62 NTUs.

Slough 22

In Slough 22 from June to September, 1982, dissolved oxygen was observed to vary from 9.3 to 13.2 mg/l over a corresponding range of surface water temperatures from 4.5 to 11.2°C, while measurements of pH and specific conductance were found to range from 6.3 to 7.4 and 34 to 141 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 8 NTU to 130 NTUs.

3.2.2.3 Tributaries Between Talkeetna and Devil Canyon

The basic field parameters of dissolved oxygen, pH, specific conductance, temperature and turbidity were collected at various tributaries situated between Talkeetna and Devil Canyon during the 1982 open water field season. These data are presented in Appendix Table 4-D-4. Overall, dissolved oxygen in the tributaries sampled ranged from 7.2 to 15.3 mg/l over a corresponding range of surface water temperatures from

0.9° to 15.3°C, while pH and specific conductance varied from 5.7 to 7.5 and 14 to 103 umhos/cm, respectively. Turbidity was found to vary from less than one NTU to 100 NTUs. These results are summarized below for each site.

Whiskers Creek

In Whiskers Creek from June to September 1982, dissolved oxygen was observed to vary from 7.9 - 13.0 mg/l over a corresponding range of surface water temperature from 4.3 to 12.2°C while measurements of pH and specific conductance were found to range from 5.8 to 7.4 and 24 to 31 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982 ranged from less than 1 to 40 NTUs.

Gash Creek

Measurements of the basic field parameters were measured once during the 1982 open water field season at Gash Creek. On August 18, the dissolved oxygen was observed to be 10.5 mg/l at a corresponding surface water temperature of 10.5, while measurements of pH and specific conductance were 6.7 and 9.4 umhos/cm, respectively.

Lane Creek

Measurements of water quality were obtained from Lane Creek from June to September, 1982. The basic field parameters of dissolved oxygen and pH were found to range from 11.9 to 14.5 mg/l and 6.0 to 7.8, respectively. Surface water temperature was found to vary from 4.0 to 8.3°C while specific conductance was found to range from 26 to 52 umhos/cm. Turbidity values were observed to range from 1-6 NTUs.

Fourth of July Creek (mouth)

In Fourth of July Creek from June to September, 1982, dissolved oxygen was observed to vary from 9.9 to 12.5 mg/l over a corresponding range of surface water temperatures from 5.6° to 12.0°C, while measurements of pH and specific conductance were found to range from 6.2 to 7.3 and 16 to 26 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 2 NTUs.

Indian River

In Indian River from June to September, 1982, dissolved oxygen was observed to vary from 10.3 to 14.2 mg/l over a corresponding range of surface water temperatures from 2.6° to 11.7°C, while measurements of pH and specific conductance were found to range from 6.0 to 7.2 and 29 to 46 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 85 NTUs.

Portage Creek

In Portage Creek from June to October, 1982, dissolved oxygen was observed to vary from 10.7 to 15.0 mg/l over a corresponding range of surface water temperatures from 0.9° to 9.7°C, while measurements of pH and specific conductance were found to range from 6.2 to 7.5 and 36 to 100 umhos/cm, respectively. Turbidity measurements obtained from June to October, 1982 ranged from less than 1 NTU to 8 NTUs.

3.2.2.4 Mainstem and Sidechannel Downstream of Talkeetna

The basic field parameters of dissolved oxygen, pH, specific conductance and temperature were collected at various mainstem Susitna River and side channel sites below Talkeetna during the 1982 open water field season primarily in conjunction with the electrofishing program (refer to Section 3.1.1.1, Vol. 4, Part II). These data are presented in Appendix Table 4-D-4. From RM 5.0 to RM 85.7, the range of dissolved oxygen varied from 5.7 to 13.8 mg/l over a corresponding range of surface water temperatures from 0.2° to 16.4°C. Measurements of pH were observed to vary from 5.6 to 7.6 while specific conductance ranged from 41 to 138 umhos/cm. Turbidity sampled solely from Sunshine Creek Sidechannel and ranged from 1 NTU to 100 NTUs.

3.2.2.5 Sloughs Downstream of Talkeetna

The basic field parameters of dissolved oxygen, pH, specific conductance, temperature and turbidity were collected at various sloughs below Talkeetna during the 1982 open-water field season primarily in conjunction with the FDS, FHU and IFE programs. These data are compiled and presented in Appendix Table 4-D-4.

Overall, dissolved oxygen ranged from 8.3 to 13.4 mg/l over a corresponding range of surface water temperatures from 4.5° to 16.4°C. Measurements of pH and specific conductance were observed to vary from 5.2 to 7.7 and 19 to 204 umhos/cm, respectively. Turbidity ranged from less than 1 NTU to 158 NTUs. These results are summarized below for each site.

Lower Goose 2 Slough

In Lower Goose 2 Slough from June to October, 1982, dissolved oxygen was observed to vary from 8.7 to 11.2 mg/l over a corresponding range of surface water temperature from 5.3° to 12.8°C, while measurements of pH and specific conductance were found to range from 6.7 to 7.7 and 33 to 179 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 5 NTUs to 115 NTUs.

Whitefish Slough

In Whitefish Slough from June to October, 1982, dissolved oxygen was observed to vary from 8.3 to 10.7 mg/l over a corresponding range of surface water temperature from 6.1° to 16.4°C, while measurements of pH and specific conductance were found to range from 6.7 to 7.3 and 14 to 121 umhos/cm, respectively. Turbidity measurements obtained from July to September, 1982, ranged from 18 NTUs to 46 NTUs.

Rabideux Creek Slough

In Rabideux Creek Slough from June to September, 1982, dissolved oxygen was observed to vary from 8.9 to 11.8 mg/l over a corresponding range of surface water temperatures from 5.1 to 15.6 while measurements of pH and specific conductance were found to range from 5.8 to 7.5 and 23 to 96 umho/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 2 NTU to 158 NTUs.

Sunshine Slough

In Sunshine Slough from May to October, 1982, dissolved oxygen was observed to vary from 5.7 to 11.4 mg/l over a corresponding range of surface water temperatures from 6.1° to 12.4°C while measurements of pH and specific conductance were found to range from 6.7 to 7.2 and 54 to 138 umhos/cm, respectively. Turbidity measurements obtained from June to September ranged from 1 NTU to 100 NTUs.

Birch Creek Slough

In Birch Creek Slough from June to October, 1982, dissolved oxygen was observed to vary from 9.9 to 12.8 mg/l over a corresponding range of surface water temperatures from 8.7° to 15.4°C, while measurement of pH and specific conductance were found to range from 6.4 to 7.7 and 60 to 165 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 2 NTU to 76 NTUs.

3.2.2.6 Tributaries Downstream of Talkeetna

The basic field parameters of dissolved oxygen, pH, specific conductance, temperature and turbidity were collected at various tributaries below Talkeetna during the 1982 open water field season primarily in conjunction with the FDS, FHU and IFE programs. These data are compiled and presented in Appendix Table 4-D-4.

Overall, dissolved oxygen varied from 9.2 to 12.0 mg/l over a corresponding range of surface water temperatures from 3.6° to 17.2°C. Measurements of pH and specific conductance were observed to vary from 6.1 to 6.8 and 14 to 204 umhos/cm, respectively. No measurements of turbidity were obtained at any tributaries below Talkeetna during 1982. These data are summarized below for each site.

Lower Goose 2 Creek

In Lower Goose 2 Creek from June - September, 1982, dissolved oxygen was observed to vary from 8.7 to 11.0 mg/l over a corresponding range of surface water temperature of 3.7° to 11.6°C while measurements of pH and specific conductances were found to range from 6.8 to 7.4 and 27 to 40 unhos, respectively. Turbidity measurements obtained from June to September, 1982, ranged from less than 1 NTU to 18 NTUs.

Whitefish Slough Tributary

A single measurement of the basic field parameters was obtained on September 16 from a tributary entering Whitefish Slough. Due to a meter malfunction, only surface water temperature (9.3°C) and specific conductance (14 umhos/cm) were obtained.

Rabideux Creek

In Rabideux Creek from September to October, 1983, dissolved oxygen was observed to vary from 8.9 - 10.6 mg/l over a corresponding range of surface water temperature 6.0°-17.2°C, while measurements of pH and specific conductance were found to range from 5.8 to 7.2 and 23 to 96 umhos/cm, respectively. Turbidity measurements, obtained from June to September, 1982 ranged from 2 NTUs to 10 NTUs.

Sunshine Creek

In Sunshine Creek from August to October, 1982, dissolved oxygen was observed to vary from 9.4 to 13.4 mg/l over a corresponding range of surface water temperature from 6/0° to 16.4°C, while measurements of pH and specific conductance were found to range from 5.6 to 7.3 and 27 to 63 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 1 NTU to 9 NTUs.

Birch Creek

In Birch Creek from June to October, 1982, dissolved oxygen was observed to vary from 8.5 to 13.4 mg/l over a corresponding range of surface water temperature from 5.2° to 16.0°C while measurements of pH and specific conductance were found to range from 5.5 to 7.4 and 50 to 94 umhos/cm, respectively. Turbidity measurements obtained from June to September, 1982, ranged from 1 NTU to 38 NTUs.

3.2.2.7 Locations Upstream of Devil Canyon

The basic field parameters of dissolved oxygen, pH, specific conductance, temperature and turbidity were collected at various locations in the Susitna River basin above Devil Canyon during the 1982 open-water field season. These data are compiled and presented in Appendix Table 4-D-4.

Overall, dissolved oxygen the tributaries above Devil Canyon ranged from 9.6 to 12.2 mg/l over a corresponding range of surface water temperatures from 0.1° to 14.8°C, while measurements of pH and specific conductance ranged from 6.7 to 8.1 and 22 to 212 umhos/cm, respectively. Turbidity in the tributaries ranged from less than 1 NTU to 25 NTUs.

In the mainstem above Devil Canyon, dissolved oxygen ranged from 9.0 to 13.5 mg/l over a corresponding range of surface water temperatures from 0.1° to 13.9°C, while measurements of pH and specific conductance ranged from 6.8 to 8.1 and 73 to 144 umhos/cm, respectively. Turbidity in the mainstem above Devil Canyon was found to vary from 14 to 150 NTUs.

Refer to Volume 5 for a site by site presentation of these results.

3.2.3 Total Dissolved Gases

All basic field data is recorded in Appendix Table 4-D-1 for all of the dissolved gas data recorded during 1981 and 1982. The 1981 data has been previously reported in TES (1981,1982). Some minor corrections in calculations were made in these data and are presented in this report. In addition, Appendix Table 4-D-3 is included on the residual analysis of the multiple regression examination of decay data. Although temperature was examined initially, only discharge (at Gold Creek) and distance below the proposed Devil Canyon dam site are examined as predictor variables. Temperature did not have any significant contribution to the variability in the concentrations of dissolved gas recorded. The decay of the supersaturation that began in the canyon near the dam site is plotted in Figure 4I-3-44 for four different sampling periods. The decay of the supersaturated gas follows a reasonable log decay function and the regression coefficients are indicated, but the slopes of the decay curves vary from sampling period to sampling period.

The concentrations of dissolved gas immediately above and below the rapids of the canyon were measured on two separate trips during the summer of 1981. During the initial trip, the dissolved oxygen was also recorded (Figure 4I-3-45).

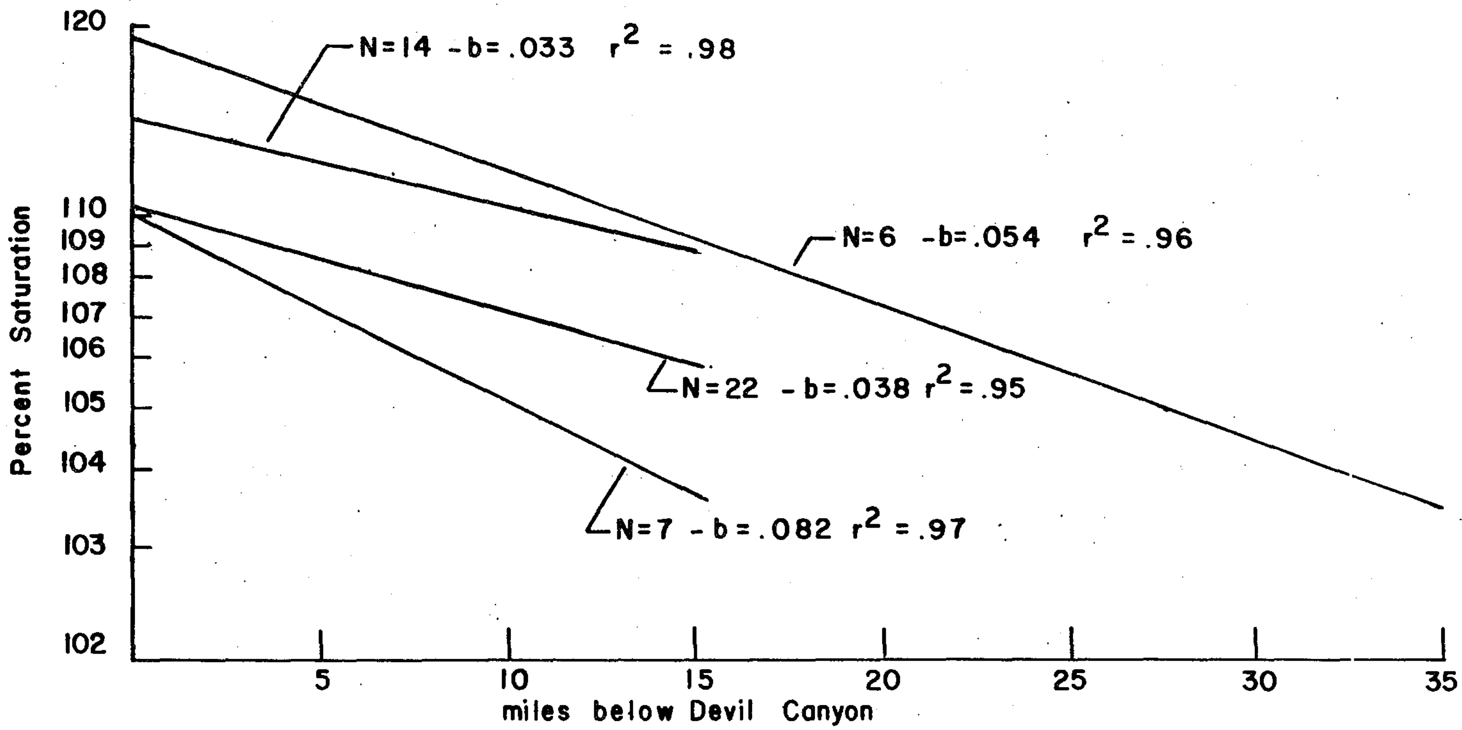

Figure 4.I-34 Percent concentration of total Dissolved gas versus distance below the Devil Canyon proposed dam site.

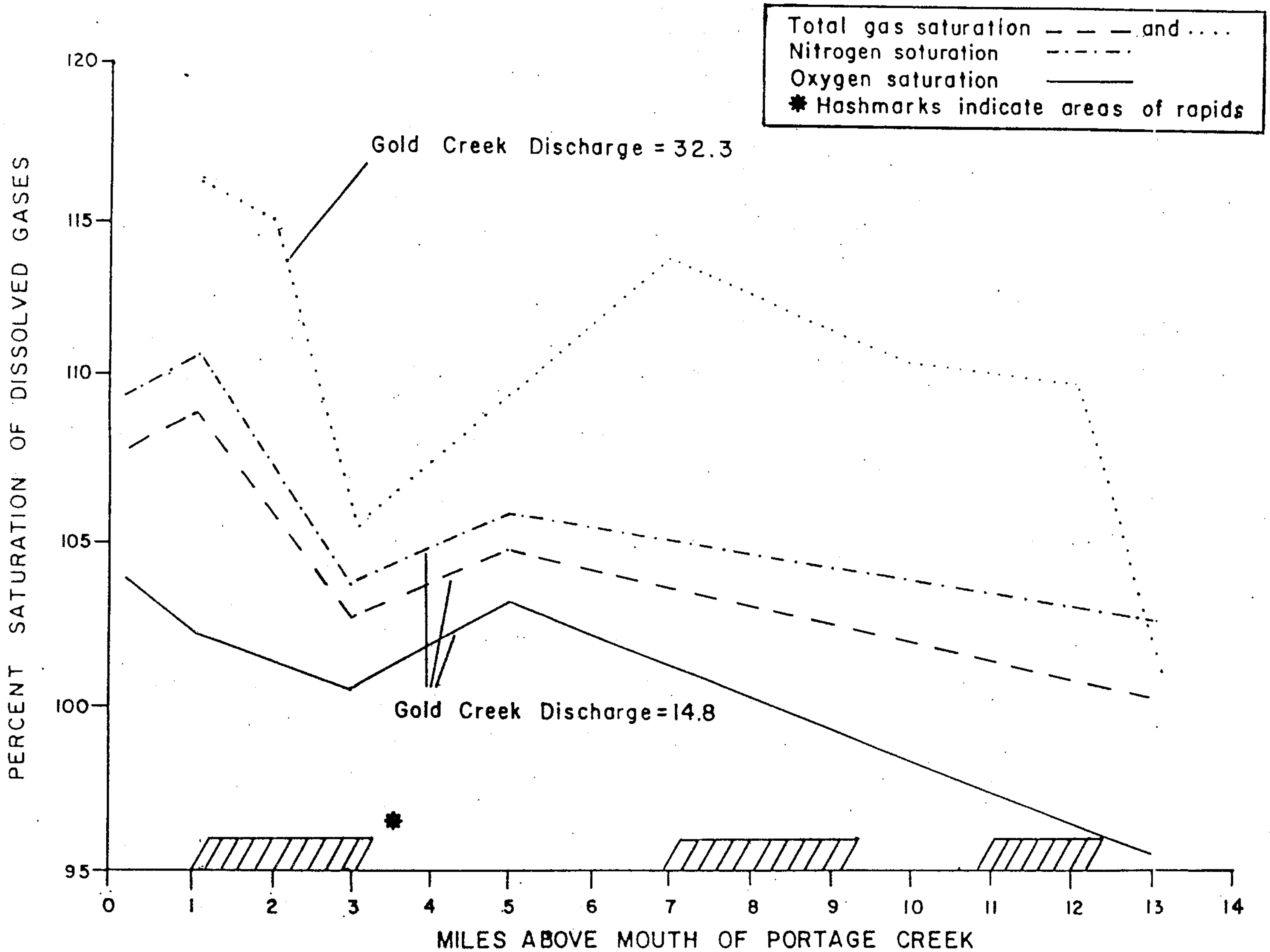

Figure 4I-3-45. Concentration of dissolved gases in the Devil Canyon rapids complex.

The continuous record of dissolved gas concentrations and temperature at the site immediately below Devil Canyon are listed in Appendix 4-D-5. The relationship of the dissolved gas concentrations to discharge is plotted in Figure 4I-3-46.

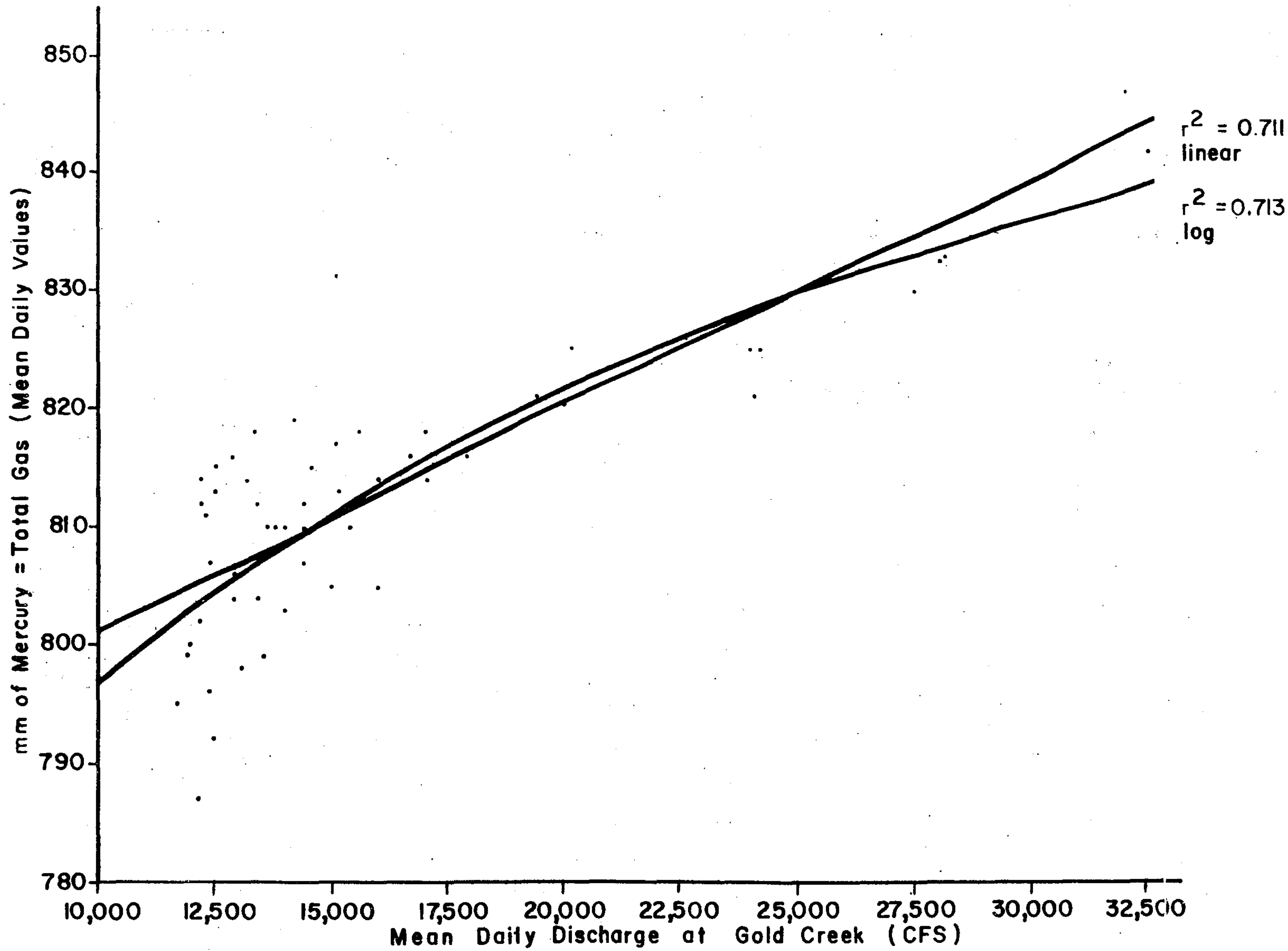

Figure 4I-3-46 Mean Daily Discharge versus saturometer readings below Devil Canyon.

4.1 Hydrological Investigations

4.1.1 Stage and Discharge

Talkeetna to Devil Canyon

Mainstem water surface elevations were monitored at 31 staff gage sites located between Talkeetna and Devil Canyon. Mainstem water surface elevations were compared to the mean daily mainstem discharge at the USGS Gold Creek gaging station. Changes in the mainstem water surface elevation were found to generally range between 3 to 5 feet for a range of mainstem discharge of 8,000 to 32,000 cfs. Review of 1949-1975 streamflow records (USGS 1978), indicate the mean monthly Susitna River discharge determined at Gold Creek for the months of June - October can range from a low of 3,124 cfs (October 1970) to a high of 50,850 (June 1964).

The stage-discharge relationship for the mainstem Susitna River between Talkeetna to Devil Canyon reach as determined from 1982 observations, is well defined for flows ranging from 12,000 to 25,000 cfs at Gold Creek. Additional data need to be obtained to further define the range of flows not adequately defined during the 1982 open water season (below 12,000 cfs and above 25,000 cfs).

Mainstem discharge was found to influence the water surface elevation at the slough mouths studied to varying degrees (also see section 4.1.3.1).

Backwater areas were still present at the mouths of Whiskers Creek Slough and Slough 6A as mainstem discharges at Gold Creek dropped to 8,500 cfs. A backwater area was present at the mouth of Slough 11 at mainstem discharge of 11,700 cfs; whereas mainstem discharges of 18,000 to 22,000 cfs were necessary before backwater areas even began to form at the mouths of sloughs 16B, 20 and 22. The effects of mainstem discharge on backwater area and access to sloughs 8A, 9 and 21 has been discussed partially in this report and further will be discussed in the final June report.

Except when overtopped at their upstream end by mainstem water, discharge within side-sloughs (sloughflows) are generally quite small. Of the nine sloughs (omitting Slough 9, refer to the June report) studied between Talkeetna and Devil Canyon, only Whiskers Creek Slough and Slough 20 had substantial flow from tributaries contributing to the sloughflow. The other seven sloughs were dependent on groundwater and surface runoff for flow. During the 1982 open water field season, sloughflows during unbreached conditions ranged from 0.2 to 16.4 cfs. Discharge measurements for two side sloughs during 1981 in the unbreached condition ranged between 0.7 cfs and 6.3 cfs. (ADF&G, 1981c) Once the side sloughs became breached, sloughflow generally increases by an order of magnitude. Measurements of sloughflow during 1982 ranged from 21 cfs to 282 cfs when sloughs were breached (ADF&G 1981c). The 1982 flow measurements are considerably less than the 60 cfs to 500 cfs range measured inside sloughs during breached conditions in 1981 (ADF&G 1982). This is primarily attributable to the abnormally low mainstem discharges occurring during the late summer of 1982. Mainstem discharges were relatively high during 1981 however the average daily discharges based on past records on the dates that slough flow measurements were made (in 1981) were not excessively large.

Most side sloughs between Talkeetna and Devil Canyon were found to breach as mainstem discharge at Gold Creek passed from 20,000 cfs to 26,000 cfs. Some error is associated with these discharge values because breaching observations are referenced to the average daily discharge at Gold Creek rather than a site specific discharge measurement. The error is believed to be slight, however, mounting to approximately ±15%.

Periodic discharge measurements were obtained at seven tributaries entering the Susitna River between Talkeetna and Devil Canyon. These measurements were made to determine the general flow contributed by these tributaries to the mainstream during the 1982 open water season. The discharge measurements obtained from these tributaries were found to range from 0.2 to 142.5 cfs. Sufficient data was not collected, however, to establish the overall ranges of flows or seasonal patterns of flows for each tributary.

Whiskers Creek and a small unnamed tributary near the head of Slough 20 were the only tributaries studied in this reach of river that contributed flow to a slough. Whiskers Creek provided a substantial contribution of the total slough flow of Whiskers Creek Slough while the unnamed tributary provided only a minimal contribution to the total slough flow of Slough 20. All other tributaries studied emptied into the mainstem. Continuous streamflow records were obtained for Indian River and Portage Creek from August 9 through October 22, 1982. These flow data were obtained to determine the general magnitude and variability of seasonal streamflows from these tributaries and to provide a basis for estimating their effect on the mainstem discharge at Gold Creek. Discharges estimated from Indian River and Portage Creek were found to be relatively stable with flows in August averaging approximately 180 cfs for Indian River and 465 cfs for Portage Creek. During most of September flows increased to an average of 316 cfs for Indian River and 648 cfs for Portage Creek. Mid-September was a period of high discharge for both Indian River and Portage Creek with a peak flow of 1815 cfs for Indian River and 1673 cfs for Portage Creek. These high flows were the result of a storm which occurred around September 14 or 15. Flows in both tributaries were found to recede in the month of October to 111 cfs in Indian River and 208 cfs in Portage Creek. Overall, the 1982 flows in Indian River and Portage Creek were relatively stable with a peak occurring in mid-September and flow decreasing in October.

Below Talkeetna

Mainstem water surface elevations were only measured adjacently to slough study areas below Talkeetna in order to determine the influence that the mainstem has on these sloughs at various discharges. These data are discussed below in conjunction with the sloughs. Mainstem discharge was found to influence to varying degree the water surface elevation at the mouths of the sloughs and tributaries studied downstream of Talkeetna (also see section 4.1.3.1). Backwater areas were present at Whitefish Slough mouth at mainstem flows of at least 34,000 cfs as determined from the USGS Sunshine gaging station. Backwater areas were also present at the mouth of Lower Goose 2 Slough at mainstem flows of 32,000 cfs, at Sunshine Creek Slough mouth at mainstem flows of 58,000 cfs and at Birch Creek Slough mouth at 23,000 cfs.

Except when overtopped at their upstream end by mainstem water sloughflow within Lower Goose 2 Slough, Sunshine Slough and Birch Creek Slough was generally provided by tributaries flowing into the slough. Upstream of the slough/creek interface, discharge was quite small during unbreached conditions consisting of surface water runoff and pondage within the slough. Whitefish Slough was the only slough studied below Talkeetna which confluenced with the mainstem at its mouth. The 1982 discharge measurements for Lower Goose 2, Sunshine Creek Slough and Birch Creek Slough ranged between 0.2 to 109.9 cfs upstream of the slough/creek confluence and from 86.5 to 131.8 cfs for Lower Goose 2 Slough and Birch Creek Slough downstream of the slough/creek confluence. Sunshine Creek Slough did not have a discharge site below the slough/creek confluence.

Periodic discharge measurements were also obtained at five tributaries located downstream of Talkeetna. These flow measurements were made to determine the general magnitude of flow contributed by these tributaries during the open water season of 1982. The discharge measurements obtained from these tributaries were found to range from 31 to 271 cfs. Of the five sloughs studied, only Rabideux Creek did not contribute flow into an adjoining slough. Lower Goose Creek 2, the unnamed tributary on Whitefish Slough, Sunshine Creek and Birch Creek emptied into adjoining sloughs. These tributaries provided during unbreached conditions provided the majority of flow passing through the mouth of the slough. During both unbreached and breached conditions, Lower Goose 2 Creek and Sunshine Creek contributed at least 90% of the flow within the slough. From site observations, Birch Creek provided at least 50% of the flow of Birch Creek Slough at the mouth during unbreached conditions.

4.1.2 Thalweg Profile

Thalweg proviles are valuable for assessing the effects of discharge and channel morphology on fish migration and access; thus they are discussed in Part II.

4.1.3 Other Hydrological Components

4.1.3.1 Backwater Areas

Calm backwater areas which are largely regulated by the stage of the mainstem Susitna River, occupy many of the sloughs and the lower reaches of low gradient rivers and side channels. The surfaces of these backwater areashave been designated as type H-II zones and consist of aggregates of nine broadly defined hydraulic conditions, defined in Volume 4, Part II, Section 2.2 of this report. These low velocity areas respond in a complex manner to the changes in discharge of the mainstem and to the discharges of associated tributaries. The proportion of the total wetted surface areas available as fisheries habitat, that these areas compose, often vary in an unusual, but predictive manner in response to discharge in the mainstem Susitna River. These areas have been traditionally recognized as unique ecological areas in riverine systems.

The total area of H-II zones within the boundaries of upper and lower Susitna River study sites is shown in Tables 4I-4-1 and 4I-4-2 and Figures 4I-4-1 and 4I-4-2. These values were obtained by recording the areas indicated at 2,500 and 5,000 cfs discharge intervals from Figures 4I-3-30 to 4I-3-43. Some of the data is synthesized by connecting data points in areas of discharge that had no data base. These curves represent the best available data of the overall availability of this specific hydraulic zone as a function of mainstem discharge. Generally the number of observations used to generate these curves are much higher for the upper river summary than for the lower river (h=9 vs. n=5 respectively). The upper river data indicate a rather marked inflection in the relationship of areas to Gold Creek discharges above and below 17,500 cfs. The lower river curves indicate that a change in the relationship of areas to Sunshine discharge occurs at 40,000 cfs.

Interpretation of surface area curves presented here and in results requires caution. These may be misinterpreted as broader concepts of overall wetted surface or of available habitat. They represent only the

Table 41-4-1 Total surface areas of Type II hydraulic zones within the boundaries of nine study areas on the upper Susitna River vs. Gold Creek discharge[a], June through September, 1982.

	Surface Areas[b] (Square Feet x 1000) at Habitat Location						
	Discharge (cfs)[a]						
Habitat Location	12,500	15,000	17,500	20,000	22,500	25,000	27,500
Slough 21	52.	63.8	69.	42.3	16.5	16.3	37.2
Slough 20	1.8	0.4	0	0	0	0	11.3
Slough 19	4.2[c]	0	9.4	11.3	13.7	26.[d]	26.[d]
Slough 11	22.	32.	46.	73.	105.	109.	110.
Slough 9	10.	84.	128.	109.	77.	44.	11.
Slough 8A	155.8	164.4	173.1	181.7	109.4	199.	107.7
Lane Creek/Slough 8	6.1	9.	13.8	14.5	16.2	46.5	46.5[e]
Slough 6A	127.7	129.2	130.7	132.3	133.8	135.4	136.9
Whiskers Creek/Sidechannel	29.	37.5	52.	66.	80.5	83.9[f]	76.[g]
Total by Discharge	408.6	520.3	622.	630.1	633.1	660.1	662.6

[a]USGS Provisional data at Gold Creek, 1982, 15292000.

[b]Data compiled from figures 4.3._ through 4.3._.

[c]Area measured at 13,300 cfs.

[d]Area measured at 24,900 cfs.

[e]Area measured at 25,000 cfs.

[f]Area measured at 23,000 cfs.

[g]Area measured at 28,000 cfs.

(63)

Table 41-4-2 Total surface areas of Type II hydraulic zones within the boundaries of five study areas on the Lower Susitna River vs. Sunshine station discharge[a], June through September, 1982.

	Surface Areas[b] (Square Feet x 1000) at Habitat Location							
Habitat Location	35,000	40,000	45,000	50,000	55,000	60,000	65,000	70,000
Birch Creek	84.	147.	150.	153.	225.	365.	392.	414.
Sunshine Creek/Sidechannel	25.	55.	86.	118.	148.	178.	128.	121.
Rabideux Creek/Slough	496.	826.	880.	933.	987.	1040.	1090.	1150.
Whitefish Slough	18.2	36.	50.	58.	63.	66.	69.	71.
Goose Creek/Sidechannel	0.	58.	117.	109.	103.	93.5	85.5	77.5
Total by Discharge	623.2	1122.	1283.	1371.	1526.	1743.	1765.	1833.

[a]USGS Provisional data at Gold Creek, 1982, 15292000.

[b]Data compiled from figures 4.3._ through 4.3._.

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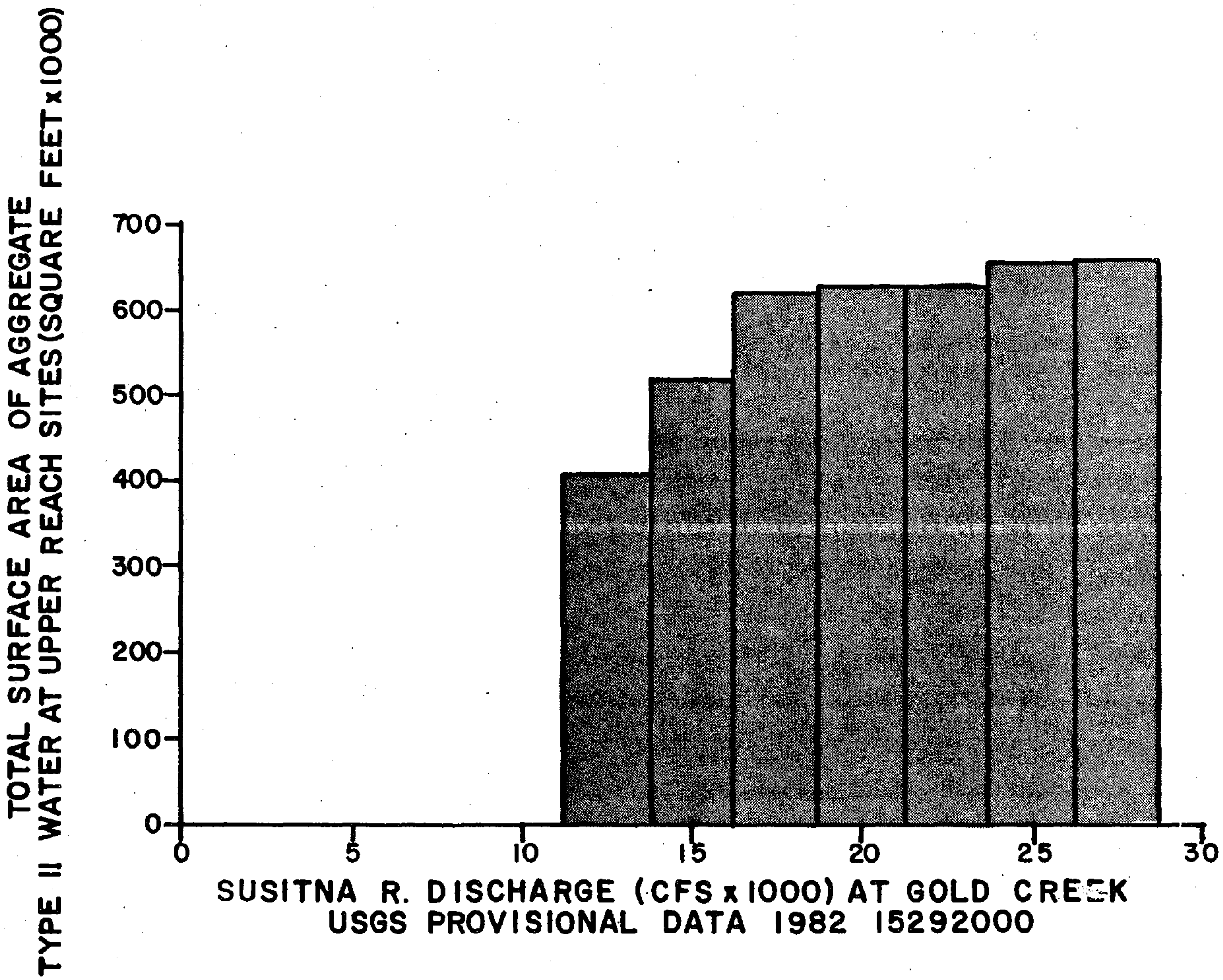

Figure 4L-4-1 Total surface area of aggregate type II water at upper reach sites versus Susitna River discharge at Gold Creek (USGS Provisional Data).

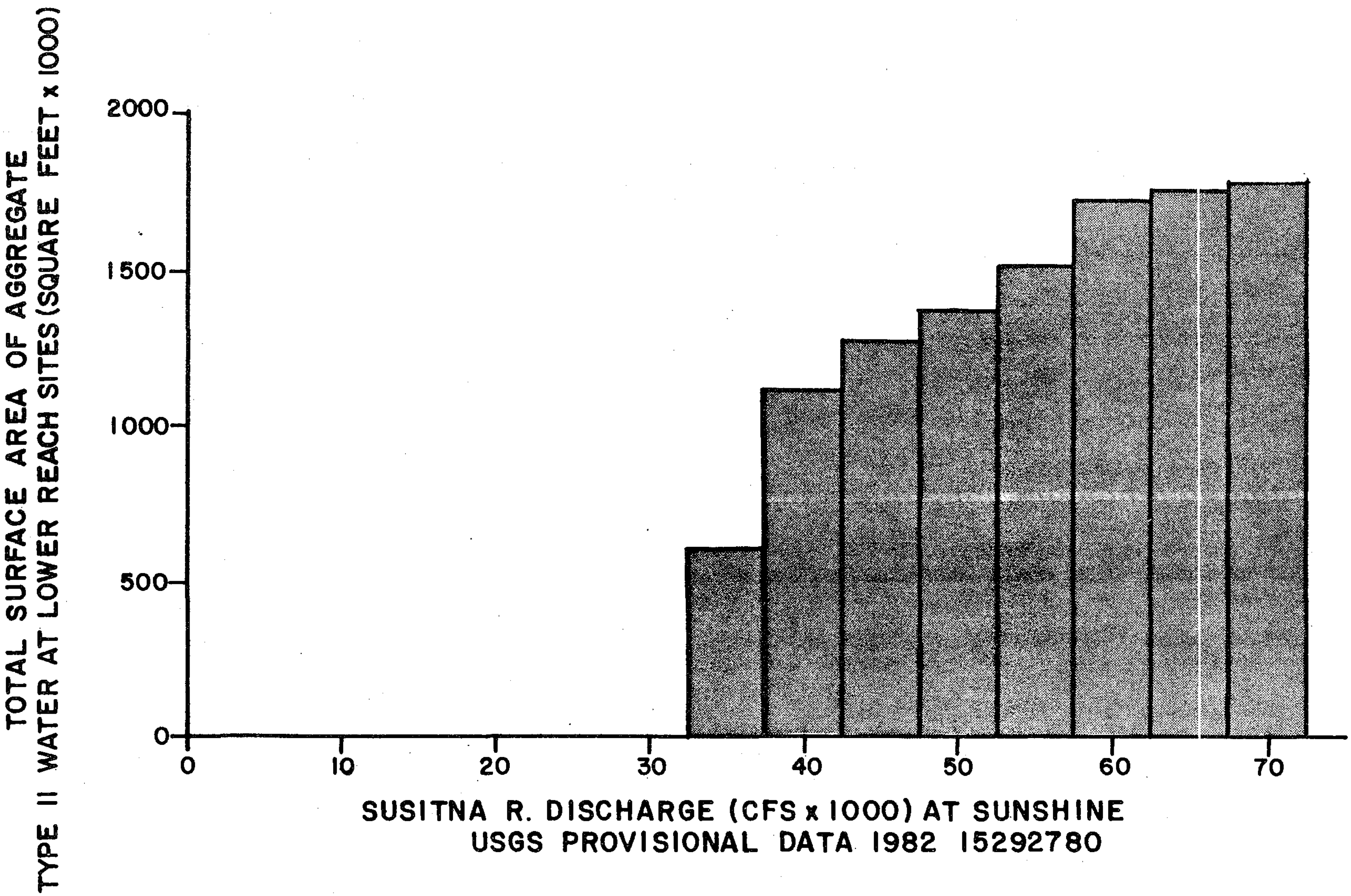

Figure 4E-4-2 Total surface area of aggregate type II water at lower reach sites versus Susitna River discharge at Sunshine (USGS Provisional Data).

surface area of low velocity reaches that are caused by Susitna River stage. For instance, at several locations it was noted that the area of these type H-II conditions begins to increase with decreasing Susitna River stage. At Slough 19 for example, above 16,000 cfs, it was observed That a type H-II wetted surface approached the total wetted surface area while at lower discharges, new type H-II areas developed downstream as the mainstem receded. Appendix Figure 4-F-4 demonstrates that trend was also apparent at Slough 21. These new type H-II areas often had very different depths, substrate conditions and rearing potential for juvenile fish because of unstable geomorphological conditions. These conditions were not a factor in this analysis. Similarly, in Rabideux Creek, the sudden loss of type H-II area requires interpretation. The pool area created by the mainstem backup disappears as the water recedes, thus reflecting a sudden decrease in surface area; what remained was a morphological pool that provided similar habitat. This pool however, is apparently maintained by geomorphological processes that are influenced by mainstem stage.

4.1.3.2 Open Channel

The open channel studies are comprised of the hydraulic model, used for simulation of hydraulic conditin under various flow regimes. These models are in the preliminary stages of calibration and are discussed in Part II.

4.2 Water Quality Investigations

4.2.1 Temperature

The continued monitoring of surface water temperatures through the 1982 field season provided background data concerning the thermal regime of the Susitna River.

Continuous surface water temperatures of the mainstem Susitna River were obtained at 12 locations during the 1982 open water season. Since the most notable effects in the thermal regime of the river during dam construction and operation will probably occur between Talkeetna and Devil Canyon, efforts were concentrated in this reach. Generally, monthly mean surface water temperatures were relatively constant in the reach from Talkeetna to Devil Canyon, varying at most about 2°C. Maximum daily temperatures recorded in the mainstem during 1982 peaked to 13-15°C in July and August and dropped down to 0°C by late October.

To better understand the intragravel/surface water temperature relationship in side sloughs, temperature recorders which continuously monitor both intragravel and surface water temperatures were installed in six sloughs upstream of Talkeetna. Except when the mainstem breaches the head of a slough, surface water temperatures in side sloughs are independent of surface water temperatures in the mainstem. When a side slough is not breached, surface water temperatures are largely affected by local runoff and solar radiation, and to a lesser degree, by groundwater percolation and air temperature. In Sloughs 21 and 8A, recorders were installed at 2 sites (near the head and near the mouth) and a thermograph monitoring surface water temperature was installed mid-slough. Data to date (August - October, 1982) shows significantly more fluctuation in surface water temperatures than in intragravel temperatures on both a daily and seasonal basis. Surface water temperatures in the mouth of Slough 8A varied as much as 5.6°C in one day in late August during which temperatures ranged from a high of 13.4°C to a low of 7.8°C. Overall, surface water temperatures ranged between 14.8° to 0.9°C in the period August - October. In comparison, intragravel temperatures at this site varied at most 0.2°C in one day, always remaining within the range of 5-7°C.

Surface water temperatures obtained in the mouth of Slough 8A were markedly warmer than surface water temperatures obtained in the other sloughs monitored. Generally, intragravel temperatures were in the range from 3-5°C from August to October and surface water temperatures ranged from 8-9°C in August down to 1-3°C in October. Slough surface water temperatures remained warmer than intragravel temperatures until mid to late September, when the surface water temperatures had dropped down to the 3-5°C range. As surface water temperatures continued to decrease into October, the intragravel temperature dropped at a slower rate and remained warmer than the corresponding surface water.

Continuous surface water temperatures were also obtained during the 1982 open water season in ten tributaries to the Susitna River between RM 30.1 (Yentna River) and RM 206.8 (Kosina Creek). Generally, surface water in the tributaries was 1-2°C cooler than adjacent (i.e., to the nearest mainstem temperature monitoring station) mainstem surface water. In the first couple weeks of October, however, when the mainstem dropped rapidly from 3-4°C for a couple weeks, the surface water temperature of the tributaries dropped to 0°C

4.2.2 Other Basic Field Parameters

The basic field parameters of specific conductance, pH, dissolved oxygen, water temperature and turbidity were collected in conjunction with various sub-projects of the ADF&G Su Hydro Aquatic Studies Team. The parameters were collected at various locations in the Susitna River basin from RM 5.0 to RM 258.0 during the 1982 open water field season. Portions of these data, as they relate to the respective sub-project involved in its collection, are discussed in Part II of this volume and Volume 5. The discussion of water quality in this section includes an overview of the water quality data collected in the mainstem (entire river), the sloughs and tributaries between Talkeetna and Devil Canyon and the sloughs and tributaries downstream of Talkeetna.

Mainstem (entire river)

Adequate water quality measurements were not collected in the mainstem Susitna River during the 1982 open water field season to quantify the overall ranges of water quality present in the mainstem throughout the ice-free season. From the limited data collected, the water quality of the mainstem Susitna River appeared to be relatively homogenous throughout the areas sampled (RM 5.0 - RM 148.5) with no apparent relation to mainstem discharge, location or date of collection. A comparison of the water quality in the mainstem between Talkeetna and Devil Canyon to that downstream of Talkeetna showed no significant differences between these reaches of the river.

Primarily, the basic field parameters gathered in the mainstem Susitna River during the 1982 open water field season were collected in conjunction with the electrofishing sub-program to characterize the water quality present at habitats utilized for spawning by adult anadromous and resident fish. Refer to Part II of this Volume for a further discussion of these results.

Sloughs Between Talkeetna and Devil Canyon

Water quality data were collected on a regular basis in various upland and side slough located between Talkeetna and Devil Canyon during the 1982 open water field season. In several of these sloughs, water quality was collected during both breaching and non-breaching mainstem flows. It is expected that water quality in a slough will vary depending on whether or not it is breached by the mainstem. During breaching conditions, the water quality present in a slough is expected to be directly tied to the mainstem while under non-breaching condition it is expected to be more closely tied to the characteristics of the slough. Thus a comparison of the water quality in a slough under breaching and non-breaching conditions can be used to determine the effect the mainstem has on the overall water quality present in the slough.

Two upland sloughs (Sloughs 6A and 19) were monitored for their water quality during the 1982 open water field season. Upland sloughs are defined as sloughs having no collection to the mainstem other than at their mouths (see Section 3.1.1.2). Thus it is expected that these sloughs will not exhibit any significant changes in water quality over than within the zone of backwater influence, that can be related directly to mainstem discharge. A comparison of the upland slough water quality to mainstem discharge revealed that for mainstem flows ranging from 12,400 to 28,000 cfs for Slough 19 and 11,700 to 28,000 cfs for Slough 6A the parameters of dissolved oxygen and pH remained constant. This indicates that the water quality in the upland sloughs is not related to mainstem discharge.

Both these sloughs were observed to have large backwater areas during relatively mainstem discharges. At Slough 19, the conductivity values were determined to be slightly higher in the areas of the slough removed from mainstem influence while the inverse of this was found for turbidity levels.

In addition, nine side sloughs were monitored for their water quality during the 1982 open water field season. Side sloughs are defined as those sloughs connected to mainstem at their mouth and, during periods of high mainstem flow, at their heads to the mainstem (see section 3.1.1.2). Thus these sloughs should exhibit a significant change in their water quality during breaching and non-breaching conditions.

Whiskers Creek Slough

Surprisingly, the water quality in Whiskers Creek Sloughs was similar during periods of both breaching and non-breaching mainstem flows. Ranges of surface water temperature, dissolved oxygen, pH and specific conductance were very similar during periods of both breaching and non-breaching mainstem flows. Even ranges for turbidity, which would be expected to increase during periods of breaching mainstem flows, were similar. The high turbidity levels obtained in the slough during periods of non-breaching mainstem flows are most likely attributable to the turbid flow from Whiskers Creek during periods of high creek discharge. During periods of non -breaching mainstem flow, the major source of flow into Whiskers Creek Slough is from Whiskers Creek. A comparison of the slough water quality to that of the creek during unbreached conditions showed that overall the water quality in the creek was similar to that in the slough except that the ranges of surface water temperature, dissolved oxygen and specific conductance were slightly greater in the slough. These data indicates that the major influence on the water quality in Whiskers Creek Slough during periods of both non-breaching and breaching mainstem flows is from Whiskers Creek.

Lane Creek Slough (Slough 8)

During periods of breaching mainstem flows, the water quality in Lane Creek Slough appears to be primarily influenced by the mainstem. A comparison of the ranges of dissolved oxygen, pH and specific conductance during periods of breaching and non-breaching mainstem flows shows that the ranges of these parameters were slightly less during periods of breaching mainstem flows than during periods of non-breaching mainstem flows. Due to a lack of turbidity samples collected during the 1982 open water field season, ranges of turbidity during periods of breaching and non-breaching mainstem flows could not unfortunately be determined for Lane Creek Slough.

During periods of non-breaching mainflows, the water quality in Lane Creek Slough appeared to be primarily influenced by groundwater and surface water. This is indicated in that ranges specific conductance and surface water temperature were slightly higher in the slough than in the mainstem during periods of non-breaching mainstem flows.

Sloughs 8A and 9

The mainstem flows necessary to breach the heads of sloughs 8A and 9 has not been adequately defined at the time of this report writing. Consequently, the water quality data cannot be referenced at this time to breaching or non-breached mainstem flows. The parameters of dissolved oxygen, pH, and specific conductance appear to be similar in range to those observed in other studied side sloughs.

Slough 11

Slough 11 was never breached by the mainstem Susitna River during the 1982 open water field season. The relatively high levels of specific conductance observed in the slough during this summer (127-230 umhos/cm) indicate that the primary source of water in the slough is groundwater, except during periods of high precipitation when surface water influence becomes important. The parameters of dissolved oxygen, pH and turbidity did not appear to be a limiting factor to fish in Slough 11.

Slough 16B

Water quality data was collected twice in Slough 16B during the 1982 open water field season; once during breaching and once during non-breaching mainstem flows. Based on this limited data, the water quality in the slough during periods of breaching mainstem flows appeared to be dependent on the mainstem while during periods of non-breaching mainstem flows appeared to be dependent on groundwater and surface water runoff. This is indicated in that the surface water temperature and specific conductance were lower in the slough during breached conditions than during non-breached conditions. From the 1981 data, the water quality in the slough during non-breaching mainstem flows appears to be influenced by Indian River (ADF&G 1981c).

Slough 20

During periods of breaching mainstem flows, the water quality in Slough 20 appeared to be primarily influenced by the mainstem. This is shown in a comparison of the ranges of surface water temperature and turbidity in the slough during periods of breaching and non-breaching mainstem flows. Surface water temperatures were generally lower and turbidity levels generally higher in the slough during periods of breaching mainstem flows. Ranges of dissolved oxygen, pH and specific conductance were very similar within the slough during both the breached and unbreached condition.

During periods of non-breaching mainstem flows, the water quality in Slough 20 appeared to be primarily influenced by Waterfall Creek. Ranges of pH, specific conductance and turbidity were similar in the slough and Waterfall Creek during unbreached conditions.

Slough 21

During periods of breaching mainstem flows, the water quality in Slough 21 appeared to be primarily influenced by the mainstem. This is shown in a comparison of the ranges of surface water temperature and turbidity in the slough during periods of breaching and non-breaching mainstem flows. Surfaces water temperature were generally lower and turbidity levels generally higher in the slough during periods of breaching mainstem flows. During periods of non-breaching mainstem flows, the water quality in Slough 21 appeared to be primarily influenced by groundwater and surface water runoff from a small tributary located near the head of the slough.

Slough 22

During periods of breaching mainstem flows, the water quality in Slough 21 appeared to be primarily influenced by the mainstem. This is shown in a comparison of the ranges of surface water temperature and turbidity during breaching and non-breaching mainstem flows. Surface water temperatures were generally lower and turbidity levels generally higher in the slough during periods of breaching mainstem flows. In addition, ranges of dissolved oxygen, pH and specific conductance were higher in the slough during periods of breaching mainstem flows. The main influences on the water quality in Slough 21 during periods of non-breaching mainstem flows appeared to be from surface water runoff. Groundwater did not appear to have a major influence on the water quality of this slough during unbreached conditions.

Sloughs and Tributaries Downstream of Talkeetna

All sloughs studied downstream of Talkeetna during the 1982 open water field season had tributary influences. Water quality data was collected in these sloughs during both breached and unbreached conditions, in the associated tributaries and the adjacent mainstem. The mainstem flows necessary to breach the heads of the studied sloughs downstream of Talkeetna are not currently defined. Consequently, the water quality data cannot, at this time, be referenced to mainstem flow conditions.

Based on a preliminary overview of the water quality data obtained in the sloughs and their associated tributaries downstream of Talkeetna, several relationships are apparent. Comparisons of the water quality in the slough to that in the adjacent tributary reveals that ranges of specific conductance, turbidity, surface water temperature and pH were higher in the sloughs than in the adjacent tributaries. Only the range of dissolved oxygen was lower in the sloughs than the associated tributaries.

Of the four sloughs and their adjacent tributaries studied downstream of Talkeetna, all are well within the water quality standards for fish production. Each are relatively similar in their water quality characteristics.

4.2.3 Dissolved Gases

The formation of dissolved gas below the lower Devil Canyon rapids provides an unusual phenomenon. Higher dissolved gas concentrations were recorded at this location than at any other in the ten mile reach of Devil Canyon. The continuous monitor installed during the summer of 1982 provided an extensive collection of baseline conditions and provided an accurate portrayal of the response of gas supersaturation to the volume of water passing through the canyon. This increased supersaturation depicted in Figure 4I-3-46 as a function of discharge is probably associated with increased depths of the plunge pools and the amount of air trapped as water passes through this precipitous set of rapids. Fish collected in the area of highest concentrations have not exhibited any embolisms associated with gas bubble disease. The concentrations of dissolved gasses are sufficiently high to create gas bubble disease at high water periods for sensitive species if exposure is for a sufficient period of time. These type of conditions did not occur during the low flow year experienced in 1982.

The formation of dissolved gas supersaturation appears to be a purely physical process, probably caused by plunge pools below the rapids within Devil Canyon. Figure 4I-3-45 depicts the changes in gas concentrations through the canyon during two separate sampling trips. This relationship suggests that both rapid formation and dissipation occur in the river through the canyon. Dissolved oxygen levels paralleled total dissolved gas suggesting also that the supersaturated conditions were caused by a physical process. Saturation above the canyon was consistently near 100% as were conditions in Gold Creek, a clear water tributary that was sampled occasionally as a control. This suggests that the supersaturated conditions found in the vicinity of Devil Canyon are apparently unique to the mainstem river. Although the data presented does not provide any direct support as to the fate of man caused supersaturated gas entering the canyon above the Devil Creek rapids, the wide range in values recorded would suggest equilibration to be likely. The elevated conditions occurring below the rapids would be similar to the natural situation. However, examination of data collected in a similar situation near Kootenai Falls below Libby dam in Montana suggests that elevated gas concentrations entering an area of entrainment may dissipate only partially when the concentrations initially entering the falls are above the natural level of supersaturation (USACOE, 1981). Therefore, major reductions in dissolved gas entering the lower Devil Canyon rapids, may not occur if high concentrations enter the rapids.

Initial examination of the decay data below Devil Canyon during the 1981 field season suggested a predictable response of the decay of supersaturated gas. The initial concentrations of dissolved gas appear to be a linear function of discharge, with the initial concentrations predictably increasing with increases in mainstem discharge. The supersaturated condition of the dissolved gas decreased, downstream as would be predicted, following standard relationships of gas law physics. It also appeared, from this limited initial data base, that the rate of decay was also dependent on mainstem discharge (Figure 4I-4-3). Further supporting this relationship was the data collected below Libby dam by the USACOE (1981). However, data collected during the summer of 1982 did not support this relationship and suggested other factors may affect the decay of dissolved gas.

The effects of the variables discharge, temperature, and distance downstream on the concentrations of dissolved gas were examined in depth by use of multiple regression analysis techniques. The computer printouts from this analysis are included in Appendix Table 4-D-3.

The main conclusion from these analyses is that a high degree of predictability of dissolved gas concentrations can be established using discharge and distance downstream for two variables for the first 11.8 miles of the river below the Devil Canyon dam site. Regardless of the initial concentration, decay of supersaturated gas occurs at a predictable rate of approximately a 50% decrease in the initial concentration for approximately every 20 miles downstream. Below this distance, the predictability becomes less reliable and the gas decays at a faster rate.

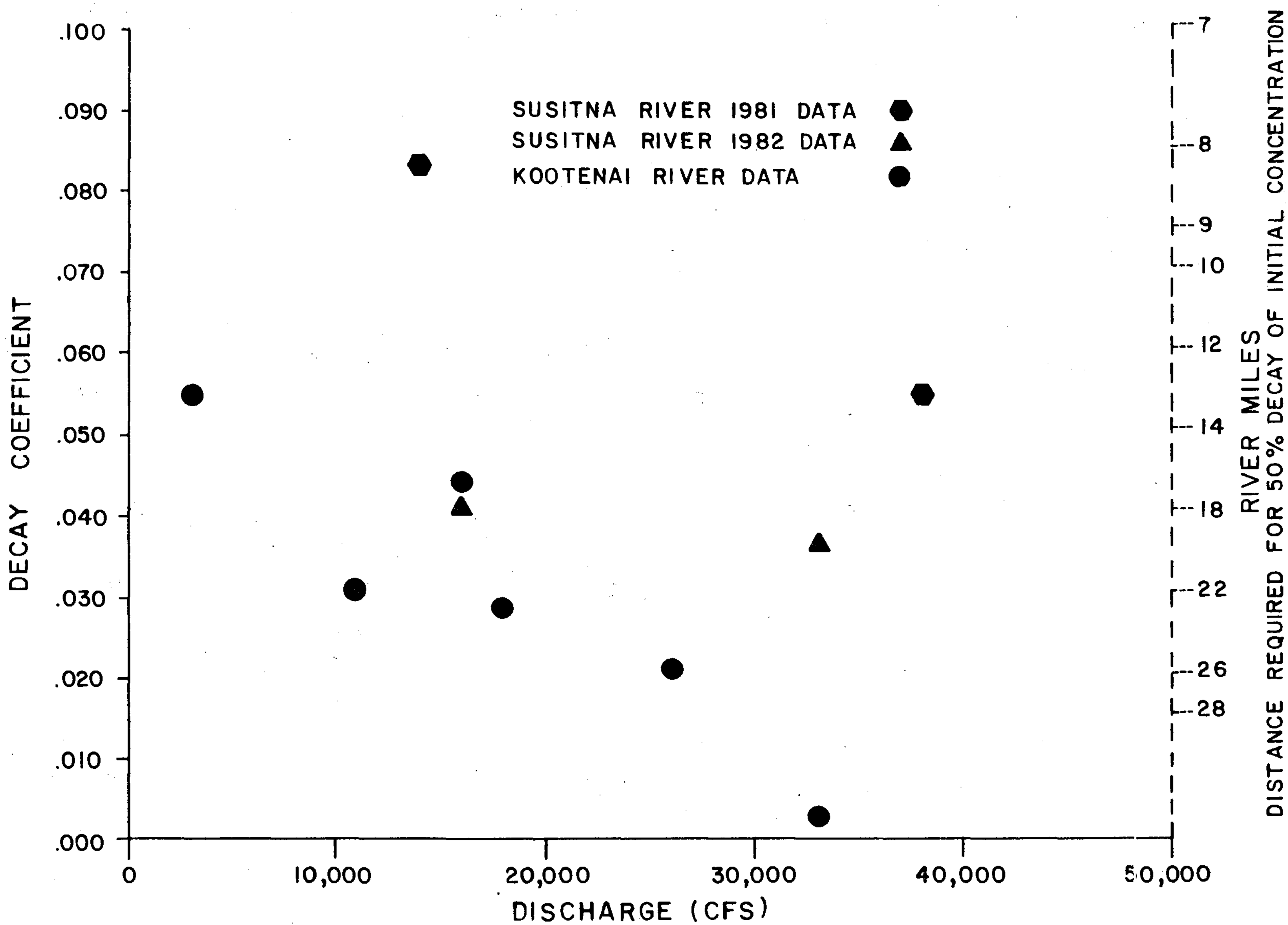

Figure 4E-4-3 Dissolved gas decay rates versus Gold Creek discharge with dissolved gas data below Libby Dam, Kootenai River, Montana provided as a comparison. (Source: U.S. Army Corp of Engineers, T. Bonde, Seattle, WA.).

Several factors may contribute to the above conclusions. These include changes in river morphology in this lower reach of the river. The channel is more braided with a mean depth less than that which is present in the river above mile 11.8. This would provide conditions for more rapid equilibration of the supersaturated water to stable conditions (100% of saturation). Dilution of the dissolved gas concentrations by the addition of water from Indian River and Gold Creek may also contribute to the increase in the decay rate.

However, one other major factor may contribute to the data observed. During the 1981 summer period, instrument problems occurred frequently. The high degree of autocorrelation observed when the data was ordered by time period suggest possible effects of the analytical procedure used in the field. When using only the data collected during the summer of 1982, this problem does not occur. The data points collected in the lower river were almost all collected during the 1981 field season. Further sampling of the lower river decay rates of dissolved gasses is planned for the 1983 open water season to determine if the dissipation of dissolved gas occurs at a different rate in this reach.

The results of this study can easily be applied to determining the relative hazard of supersaturated gas to downstream fisheries. The State of Alaska standard for dissolved gas supersaturation is 110%. This value is clearly exceeded under natural conditions below Devil Canyon. Concentrations of dissolved gasses produce increased mortalities in fish hatchery environments at levels between 105% and 110% (Weitkamp and Katz, 1980). Fish have no method of escaping the elevated gas conditions by sounding in hatchery holding areas. In natural systems, the threshold for increases in natural mortality caused by elevated gas supersaturation usually are documented to occur between 115 and 120%. These conditions are approached only under the highest discharge conditions that occur in the Susitna River, thus suggesting that the natural hazard to fish is very minimal.

The data presented suggests that the decay rate of dissolved gas is sufficiently low so that any elevation above the peak levels associated with the natural conditions could potentially create problems for the salmon stocks associated with Portage Creek and would probably affect the Indian River stocks as well. These systems are major producers of salmon in addition to resident species in the system.

P A R T I I

FISH HABITAT INVESTIGATIONS

1. OBJECTIVES

1.1 Adult Anadromous Habitat Investigations

Adult anadromous fish habitat studies were designed to meet the following objectives.

a) Identify the presence of spawning, activities and mainstem and slough habitats.

b) Identify the types and ranges of the physical and chemical conditions utilized for spawning and passage.

c) Support the analysis of the availability of spawning habitat within sloughs at a variety of flows of the mainstem Susitna River.

d) Support an evaluation of the accessibility of slough and tributary habitats to adult salmon at a variety of flows of the mainstem Susitna River.

e) Support an evaluation of whether to initiate detailed salmon spawning habitat investigations in the Susitna River between Cook Inlet and Talkeetna in 1983.

1.1.1 Salmon Habitat

1.1.1.1 Mainstem

Adult anadromous salmon have been reported to utilize the mainstem Susitna River for spawning (ADF&G 1981a). Tasks conducted from August 1 to September 15, 1982 included the following:

1) Determine the extent, timing and number of chum, pink, sockeye and coho salmon spawning in the mainstem Susitna River and its associated side channels.

2) Evaluate the physical and chemical characteristics of mainstem habitats utilized for spawning.

3) Identify the relationship between changes in mainstem discharge to the extent, timing and number of salmon present in the mainstem.

Results of the first task are summarized in Volume 2 of this draft report. Results of the second objective are summarized in section 3.1.1.1, of this volume.

1.1.1.2 Slough

This portion of the study focused on the evaluation of adult salmon spawning habitat (primarily chum salmon) in selected sloughs. It is integrally related to objectives stated in Volume 2 and Volume 4 Part I but expands them a step further and evaluates the habitat actually available to and used by fish. Tasks were as follow.

1) Identify the types and ranges of hydrological and water quality variables (e.g.. discharge, water velocity and depth, substrate composition, presence of upswelling, surface and intragravel water temperatures) in slough and side channel habitats during the adult salmon spawning period.

2) Identify the types and ranges of the above hydrological and water characteristics which are utilized by adult salmon for spawning in sloughs.

3) Model and quantify the availability of spawning habitat in sloughs at a variety of flows of the mainstem Susitna River.

4) Collect data supporting an evaluation of the accessibility of slough and tributary habitats to adult salmon at a variety of flows of the mainstem Susitna River.

1.1.2 Eulachon Habitat

Eulachon (Thaleichthys pacificus [Richardson]), an anadromous member of the smelt family, has been previously reported to spawn in the lower

Susitna River (Morrow 1980; Lee et al. 1980) Sampling conducted from May 16 (ice-out) to June 12, 1982 included the following tasks.

1) Determine the extent, timing and numbers of the spawning runs of eulachon in the Susitna River.

2) Evaluate the physical and chemical characteristics of habitats utilized for spawning by eulachon.

3) Identify the relationship between changes in mainstem discharge to the extent, timing and number of eulachon present.

Results of the first task are summarized in Volume 2 of this report. Results of the second and third tasks are summarized in Section 3.1.6 of this volume.

1.1.3 Bering Cisco Habitat

Bering cisco (*Coregonus laurettae* Bean), an anadromous member of the whitefish family, were first discovered to utilize the Susitna River basin for spawning in 1981 (ADF&G 1982b). A total of 747 fish were sampled during 1981 using fishwheels, gillnets, and electroshocking gear. Habitat evaluation surveys were also conducted at three major spawning areas located between RM 75 and 80 during 1981.

Tasks during the 1982 open water field season were as follows.

1) Determine the extent, timing and number of the spawning runs of Bering Cisco in the Susitna River.

2) Evaluate the physical and chemical characteristics of habitats utilized for spawning by Bering Cisco.

3) Identify the relationship between changes in mainstem discharge to the extent, timing and number of Bering Cisco present.

The results of the first task are summarized in Volume 2 of this report. Results of the second and third tasks are summarized in Section 3.1.7 of this volume.

1.2 Juvenile Anadromous Fish Habitat Investigations

Juvenile anadromous fish studies included measurements of a variety of physical and chemical habitat variables at 17 sites (see Appendix F) between Goose Creek and Portage Creek during the ice-free season of 1982. Details of the program and sampling sites are contained in Section 2.3 of Volume 3. These studies were designed to determine how fluctuations in mainstream discharge affect habitat parameters at sampling sites and how those changing habitat parameters affect fish distribution and relative abundance. Specific objectives are as follow.

1) Define the ranges for various habitat parameters at sampling sites and characterize seasonal habitat requirements of selected species.

2) Determine how spatial and temporal differences in habitat parameters affect fish distribution and relative abundance.

3) Determine the relative importance of the environmental factors which influence fish distribution and relative abundance.

4) Determine if a change in mainstem discharge has an effect on distribution and relative abundance of selected species at the sampling sites.

5) Characterize values of habitat variables within specific hydraulic zones, determine the preference of selected species for particular zones, and estimate the comparative value of habitats utilized by each species.

1.3 Resident Fish Habitat Investigations

Objectives listed previously in Section 1.2, Juvenile Anadromous Habitat Investigations apply also to Resident Fish Habitat Investigations. Additional objectives for these species are as follow.

1) Determine characteristics of habitats utilized for spawning by adult resident fish.

2) Determine movement and migrational patterns of adult resident fish.

3) Determine characteristics of overwintering habitats utilized by adult resident fish.

2. METHODS

2.1 Adult Anadromous Habitat Investigations

2.1.1 General Mainstem and Lower River Studies

2.1.1.1 Mainstem Salmon

Boat-mounted (Plate 4II-2-1) and backpack electrofishing gear (for methods and design see ADF&G 1982a) drift nets and foot surveys were utilized to identify spawning sites in the mainstem Susitna River below Devil Canyon (RM 152.0) from August 1 to September 15, 1982. The "mainstem" in this study is defined to include the main channel and its associated side channels. It does not include tributary-mainstem confluence zones or slough habitats (as defined in ADF&G 1982b).

The mainstem Susitna River was sampled for spawning salmon five days each week throughout the survey period. The sampling area extended from the estuary (RM 0.0) to Devil Canyon (RM 151.0) (Figure 4-1) and was sampled by three separate crews as follows:

1) Yentna crew - estuary (RM 0.0) to Kashwitna River (RM 61.0),

2) Sunshine crew - Kashwitna River (RM 61.0) to Talkeetna (RM 97.0), and,

Plate 4II-2-1. Electroshocking on the mainstem Susitna River.

3) Gold Creek crew - Talkeetna (RM 97.0) to Devil Canyon (RM 151.0).

Salmon were not assumed to be spawning at a catch site unless all of the following criteria were met.

1) Fish exhibited spawning maturation colors and morphology.

2) Fish expelled eggs or milt when slight pressure was exerted on the abdomen.

3) Fish were in vigorous condition, with 25% or more of the eggs or milt remaining in the body cavity.

4) Additional sampling efforts produced fish that met criteria one through three above.

When a mainstem spawning site was identified, the habitat of the site was also evaluated. This was a first year attempt at evaluating habitat characteristics of mainstem salmon spawning areas and the study design, procedures and methods of study were modified in the field as necessary. The following procedures were utilized.

1) River mile, geographic code (GC) and time of sampling were determined and recorded.

2) A qualitative description of general habitat characteristics, sampling methods and gear was documented.

3) Substrate composition was determined using methods described in the Procedures Manual (ADF&G 1982b).

4) Representative measurements of the following variables were collected at each site using techniques described in the Procedures Manual (ADF&G 1982b): air temperature, surface and intragravel water temperatures, pH, dissolved oxygen, specific conductance, turbidity and water depth and velocity.

5) A map of the area was drawn indicating salmon spawning sites and areas of data collection.

6) Representative photographs of the site were taken. (A complete set of photographs are on file at the ADF&G Su Hydro Office, 2207 Spenard Road, Anchorage, Alaska 99503).

2.1.1.2 Eulachon

Set and dip nets and boat-mounted electrofishing gear (for methods and design see ADF&G 1981b Procedures Manual) were utilized to define eulachon spawning sites and the upstream limits of their migration. Eulachon sampled by the above gear were not assumed spawning at a catch site unless all of the following criteria were met.

1) Fish freely expelled eggs or milt.

2) Fish were in a vigorous free-swimming condition.

3) Twenty or more fish were caught in the initial or subsequent site sampling efforts which met criteria one or two above.

It was difficult, however, to distinguish between migrational, milling and spawning areas using the above criteria. Eulachon are known to be broadcast spawners and thus do not fan a nest (Morrow 1980), making it difficult to observe the exact location and timing of spawning. Attempts were made to identify deposited eggs in substrate samples by direct observations. This proved largely unsuccessful, because the eggs are quite small and opaque white (Morrow 1980).

When a eulachon spawning site was identified, the habitat at the site was also evaluated. Because this was a first year attempt at evaluating the habitat characteristics of eulachon spawning areas, procedures and methods of study had to be designed and modified in the field. Due to the similarity between eulachon spawning to Bering cisco spawning behavior, adaptation of techniques similar to those used in the Bering cisco study were employed in this study (ADF&G 1982b). The following procedures were utilized.

1) The site was assigned a name and the river mile, geographic code, and time of sampling were determined and recorded.

2) A general narrative of the site and the sampling methods and gear used were recorded.

3) The overall substrate composition of the site was determined and recorded.

4) The following water quality measurements were collected and recorded: water and air temperature, pH, dissolved oxygen, specific conductance and turbidity.

5) A map of the area was drawn and a sampling grid for the collection of depth and water velocity data was developed based on procedures developed by Bovee and Cochnauer (1977).

6) Depth and water velocity data were collected and recorded.

7) Representative photographs of each site were taken.

Water quality and quantity data were collected using standard techniques described in the Procedures Manual (ADF&G 1982b).

Two Peabody-Ryan model J-90 thermographs were placed in the Susitna River to continuously monitor water temperature. These data were used to determine if any correlation existed between timing of eulachon spawning runs and surface water temperatures. Thermographs were placed along the east bank of the Susitna River at RM 5.5 (at the east bank gill net site) and RM 25.5 (at Susitna Station) (refer to Figure

4I-2-1). The thermograph and its recorded data at RM 5.5 was lost during an attempt to recover it. The thermograph at RM 25.5 was recovered and daily mean temperatures were calculated as the mean of four, six-hour point readings.

2.1.1.3 Bering Cisco

Sampling was conducted from September 1 to October 15 (freeze-up), 1982 in the mainstem Susitna River and its associated side channels and sloughs to ascertain the degree of spawning by Bering cisco. In addition, tributary mouths were occasionally sampled. Sampling was conducted utilizing fishwheels and standard boat-mounted electrofishing gear (for design and procedures see ADF&G 1982b).

Bering cisco are believed to be broadcast spawners (Morrow 1980). This makes it difficult to determine the exact timing and location of spawning. Bering cisco captured by the above gear were not considered to be spawning at a catch site unless all of the following criteria were met.

1) Fish freely expelled eggs or milt.

2) Approximately 20 or more fish, with a mixture of both sexes, were captured at a catch site.

3) Ripe or spent fish were present at the same site 24 hours after the initial sampling effort.

When a catch site was determined to be a Bering cisco spawning location, the habitat of the site was also evaluated. To assure consistency of data, procedures similar to those employed during the 1981 study of Bering cisco spawning grounds (ADF&G 1981a) were employed this year. The following procedures were utilized.

1) The site was assigned a name and the river mile, geographic code and time of sampling were determined.

2) A general description of the site and sampling methods used were recorded.

3) Overall substrate composition of the site was determined (ADF&G 1982a) and recorded.

4) The following water quality measurements were collected (ADF&G 1982a) and recorded: air temperature, surface and intragravel water temperatures, pH, dissolved oxygen, specific conductance and turbidity.

5) A map of the area was drawn and a sampling grid for the collection of depth and water velocity data was developed based on procedures developed by Bovee and Cochnauer 1977).

6) Depth and water velocity data were recorded.

7) Representative photographs of each site were taken.

2.1.2 General Slough and Tributary Studies

Several of the sloughs located within the Talkeetna to Devil Canyon reach of the Susitna River that were studied during the 1981 field season or that had previously been identified as important to the fishery, were sampled during the 1982 open water field season. The sloughs sampled included: Whiskers Creek Slough, Slough 6A, Lane Creek Slough, sloughs 9A, 10, 16, 19, 20, and 22. Substrate, upwelling and spawning areas were mapped and water quality was measured. Sloughs 8A, 9, 11 and 21 were sampled in the same manner; however, they were also studied in greater detail with respect to spawning areas, upwelling and hydraulic characteristics as discussed in Section 2.1.3.

Each of the sloughs surveyed for the general slough study were visited one time during early October. This was during a low flow period which enabled easy access and visibility of substrates and areas of upwelling. A foot survey was conducted at each slough, visually assessing substrate and upwelling areas and identifying these characteristics on scaled (1"-50') maps obtained by aerial photography. Point water quality measurements (pH, DO, specific conductance and temperature) were also taken. Spawning areas were marked later by the AA stream survey personnel who had monitored these sloughs throughout the spawning season.

2.1.3 Specific Slough Studies

The specific slough studies were comprised of two components: hydraulic modeling and fish spawning habitat availability and utilization.

Sloughs 8A, 9, 11 and 21 were selected for study because of their relative importance to the fishery and the comparatively large fishery data base available for them from previous fish and game studies. The hydraulic data required for modeling Slough 11 was not collected due to time and personnel limitations.

There was a significant overlap in data types required to fulfill objectives for the hydraulic modeling and fish spawning habitat availability and utilization components of the study in that both required discharge data collected across several transects at a variety of different flows. Within each slough specific sites and transect locations were selected to represent the range of hydraulic and other habitat conditions in the slough. These transects were numbered from downstream up for identification and used for both components of the study.

2.1.3.1 Modeling

Data collection for the hydraulic portion of the model involved collection of discharge along several transects within a site chosen to be representative of the reach being simulated. These transects were surveyed in order to be tied together in the model with respect to elevation and horizontal distances. The specific field procedures followed are outlined in detail in the 1981 and 1982 Procedures Manual (ADF&G 1981a, 1982a). In addition to the hydraulic portion of the model, a habitat simulation portion will eventually be combined to determine the amount of habitat useable by the appropriate life stage of the species being considered. The field data collection methods used are discussed in the utilization section (Section 2.1.3.2.2). The programming and analysis procedures used are discussed by Milhouse, et al. (1981).

2.1.3.2 Habitat Availability and Utilization

This portion of the study was designed to determine the ranges of several physical characteristics (water, depth, velocity and substrate) associated with habitats available to selected fish species and life stages at various mainstem discharges. In addition, this portion of the study was designed to determine the portion of the habitat that was actually utilized by the studied fish species and life stages at various mainstem discharges. The primary species studied was chum salmon, however limited data was also collected for sockeye and pink salmon.

2.1.3.2.1 Availability

The collection of availability data involved the collection of water depth and velocity and streambed substrate types at regular intervals along transects within the study site. The transects used included those used for the modeling portion and additional transects selected where fish activity occurred outside of the modeling site. These additional transects were labeled alphabetically going upstream. Substrate analysis was conducted following procedures outlined in the 1982 Procedures Manual (ADF&G 1982b).

2.1.3.2.2 Utilization

Utilization data were collected in order to describe the specific habitat that was used by the fish for spawning. When it was determined that a fish had established a redd and was determined to be spawning, depth, velocity, substrate and intragravel water temperature data were collected. The criteria used for confirming a spawning fish are described in the 1981 Procedures Manual (ADF&G 1981b) and Estes, et al. (1981). For each set of utilization data collected at redds at a particular stage, a set of discharge data was also collected along the transects. If the stage changed significantly and more utilization data was collected, additional transect data was collected.

Data collected at chum salmon redds were used to represent habitat used by the fish during spawning, a life stage potentially vulnerable to fluctuations in hydraulic conditions. Other species and life stages will be modeled as more data are compiled.

In the habitat availability and utilization study, transect data were used to represent amount of each habitat characteristic available. The data collected at the spawning sites were used to represent the portion of each type of habitat actually utilized. A comparison of the two can show what habitat characteristics are "preferred".

2.1.3.2.3 Water Quality

Water quality data were collected in each slough to determine the differences in water quality within the slough; what possible sources may be; and to document the quality of the water available to and utilized by the fish when present. The majority of this data is discussed in Part I of this volume, however interim analysis of intragravel temperatures collected at salmon redds brought up several questions concerning the source and importance of intragravel water sources. The following studies along transects and at specific locations of interest were developed to address these questions. In each slough, temperature (intragravel, substrate/water interface, and surface) measurements were obtained at study transects.

In addition to data obtained on study transects, intragravel, surface water temperatures and conductivity measurements were obtained at a variety of specified locations (Figures 4II-2-1 to 3) generally selected for specific comparative purposes (e.g., ground water vents vs. no vent areas).

2.2 Juvenile Anadromous Fish Habitat Investigations

Rationale

New methods were developed to sample the distribution and abundance of juveniles with respect to habitat conditions at a particular site during the 1982 field season, as suggested in the 1982 final report (1982b). This was necessitated by the relatively low density of juveniles at most of the habitat sites during earlier field observations (ADF&G 1981d). These observatins indicated that juvenile fish were often transient during their summer rearing period in the upper river. Concentrations

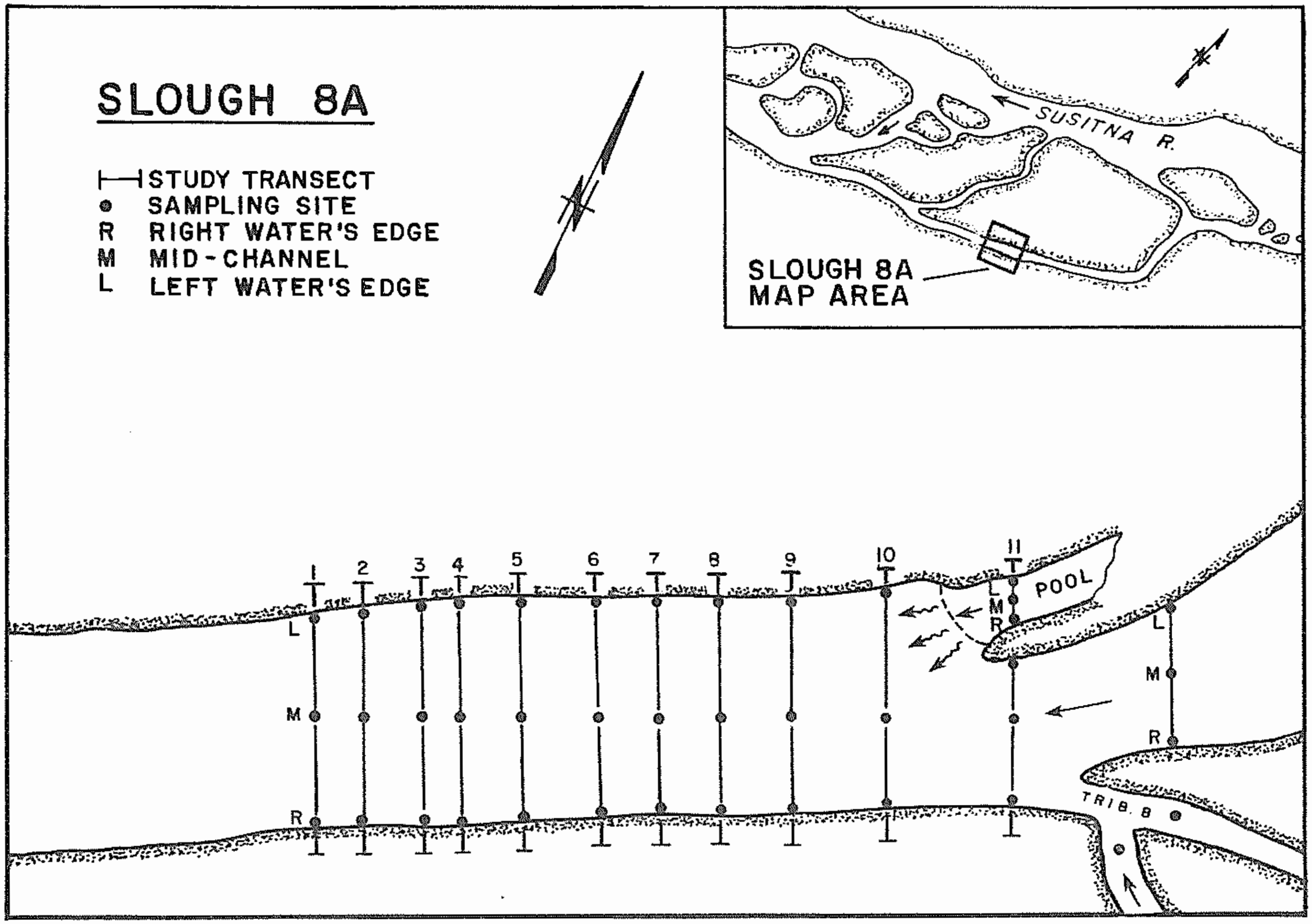

Figure VII-2-1. Water quality sampling locations in Slough 8A.

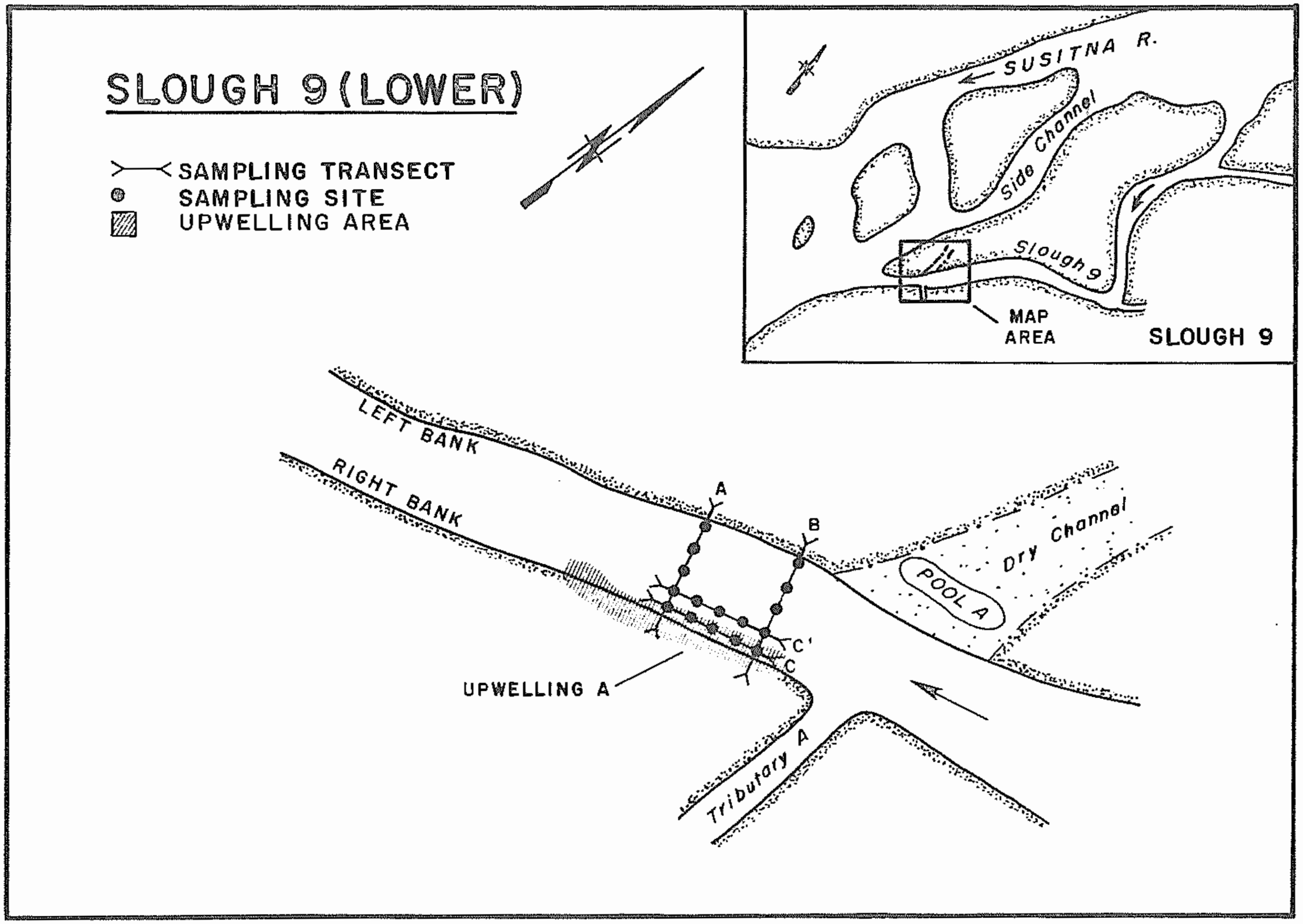

Figure VII-2-2. Water quality sampling locations in lower Slough 9.

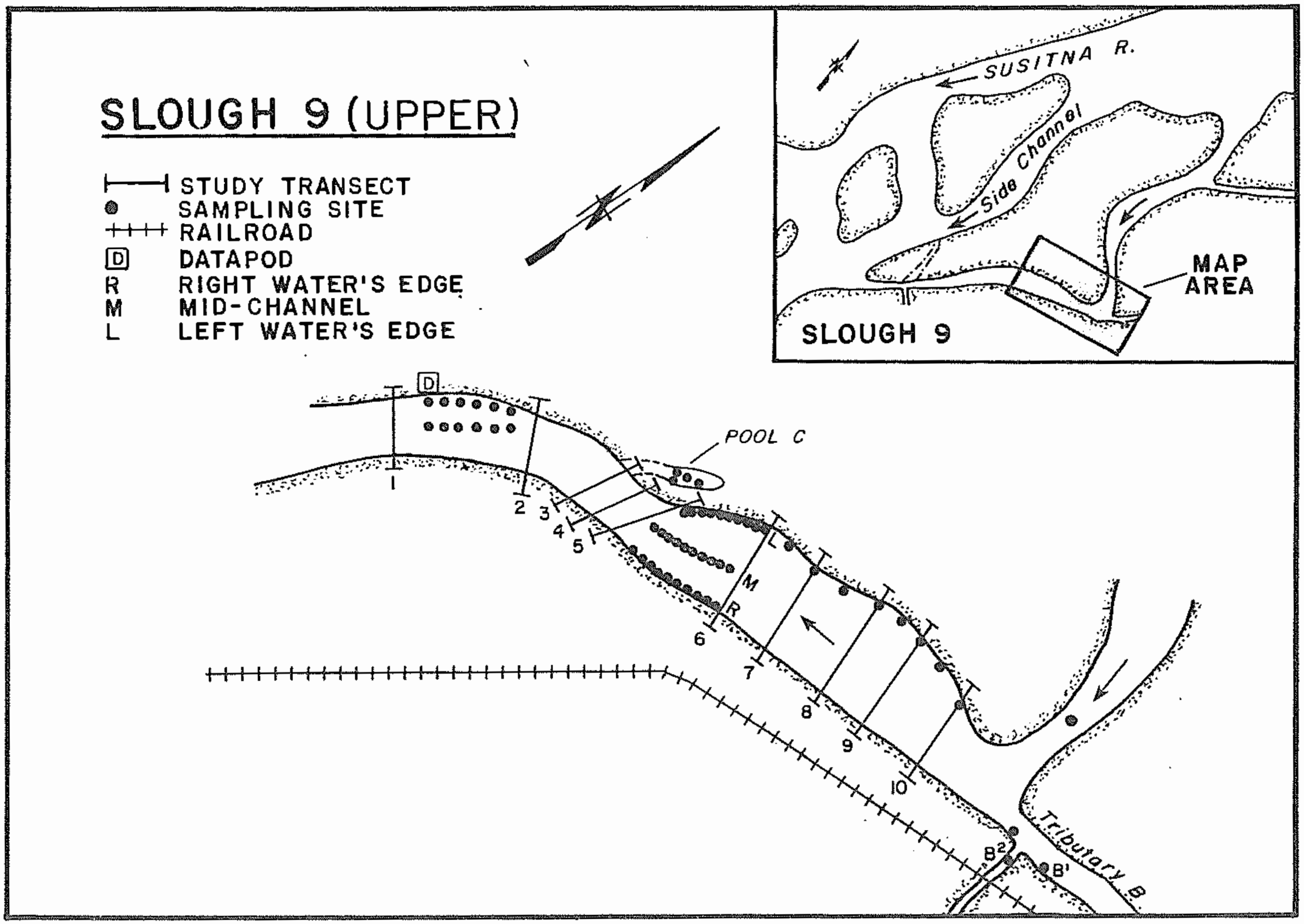

Figure 4II-2-3. Water quality sampling locations in upper Slough 9.

of juveniles often changed markedly between sampling periods. This probably reflects outmigration and behavioral responses to changing habitat conditions. At any given moment fish are able to select between different micro-habitats at a site which provides an indication of the behavioral preference for the variable conditions that existed at the sites.

Based on 1981 data (ADF&G 1981a), the numbers of fish collected were not expected to be sufficient to provide data that would allow a true multi-variate analysis of the myriad of environmental parameters at a given site if point measurements were made at each fish capture location. The wide variation in abundance would preclude collection of sufficient data. Also, a quantitative description of the amount of habitat that would be available for the fish to select from, as is typically done in the development of preference or selectivity curves, would not be possible at many of these sites because of the large number and diversity of unusual hydraulic conditions.

Therefore, stratification of habitat areas to cover a wide range of conditions was implemented. These areas were designated as habitat zones (Table 4II-2-1, Figure 4II-2-4) and reflected the surface water velocity at each location. These zones were further divided to reflect the influence of the origin of the water source on the zone. That is, the velocity areas that were similar were further subdivided into zones that were influenced by tributaries or ground water, versus those that were influenced by mainstem water. The distribution of zones at a hypothetical site at three different levels of mainstem discharge is

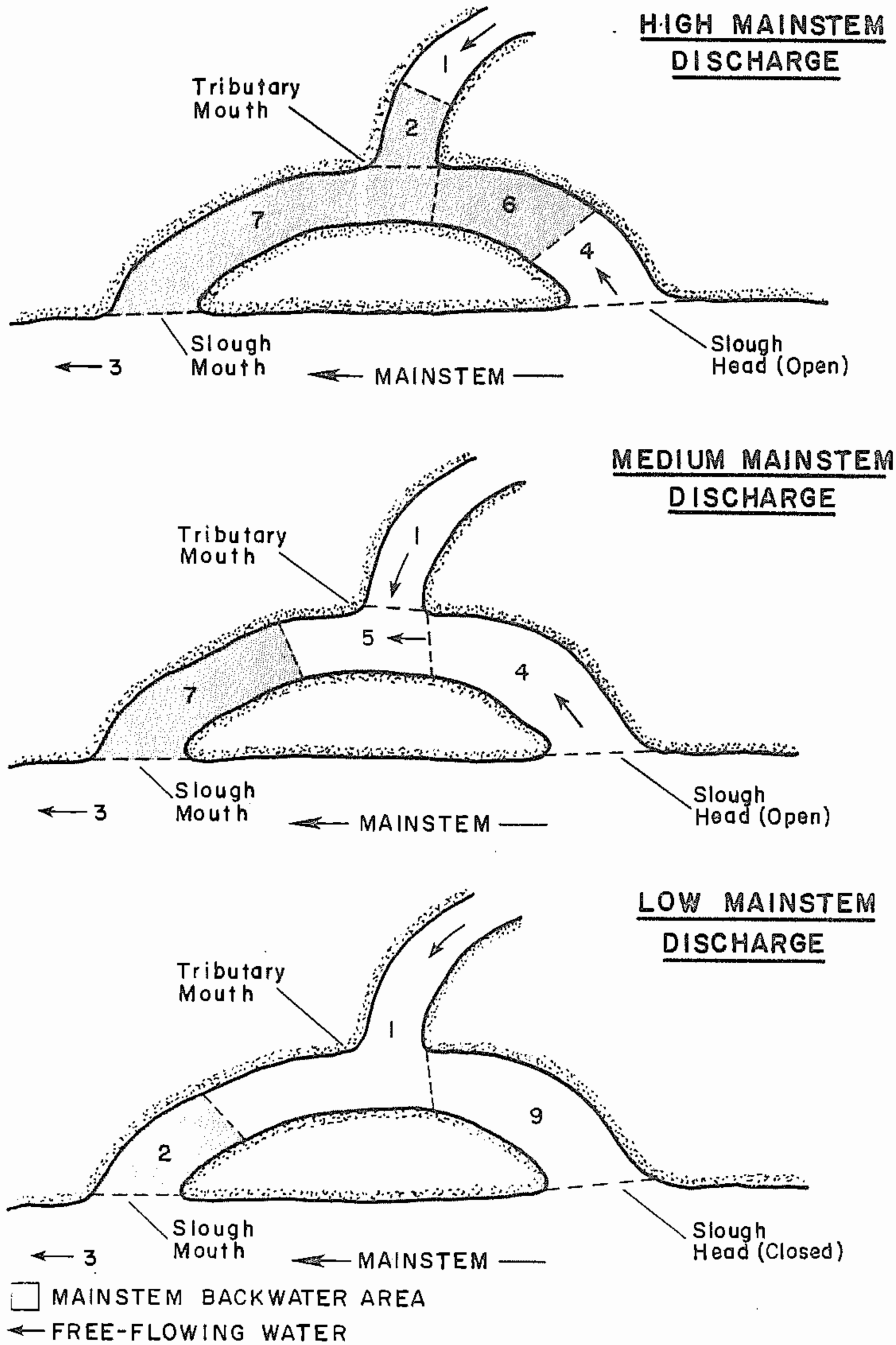

Figure 4/II-2-4. Hypothetical slough with associated tributary showing hydraulic zones present at three different levels of mainstem discharges.

shown in Figure 4II-2-4. The size and occurrence of these habitat zones responded, often dramatically, to changes in mainstem discharge. Fish collection efforts were designed to provide representative catch per unit effort within each day of these designated zones.

The response of the zones to mainstem discharge was characterized primarily by measuring changes in wetted surface area or in the linear extent of each zone at various mainstem discharges. Further analysis, using staff gage data and discharge measurements within the habitats, will evaluate changes in depth and possibly velocity of these zones with mainstem discharge. Ultimately, effects of tributary or ground water inflow on depth, surface area, and velocity, as well as the effects on temperature and turbidity will be examined. Long-term effects on cover and geomorphological changes have not been quantified, but observations by field biologists of the changes associated with flood or icing events on these parameters will be described in narrative form.

Table 4II-2-1. Description of habitat zones sampled at Designated Fish Habitat sites: June through September, 1982.

Zone Code	Description
1	Area with a tributary or groundwater source which are not influenced by mainstem stage and which usually have a significant surface water velocity.
2	Areas with a tribitary or ground water source which have no appreciable surface water velocity as a result of a hydraulic barrier created at the mouth of a tributary or slough by mainstem stage.
3	Areas of significant surface water velocities, primarily influenced by the mainstem, where tributary or slough water mixes with the mainstem water.

4 Areas of significant water surface velocities which are located in a slough or side channel above a tributary confluence (or in a slough where no tributary is present) when the slough head is open.

5 Areas of significant water surface velocities which are located in a slough or side channel below a tributary confluence when the slough head is open.

6 Backwater areas with no appreciable surface water velocities which result from a hydraulic barrier created a mainstem stage which occur in a slough or side channel above a tributary confluence (or in a slough or side channel where no tributary is present), when the head of the slough is open.

7 Backwater areas with no appreciable surface water velocities which result from a hydraulic barrier created by mainstem stage which occur in a slough or side channel below a tributary confluence, when the head of the slough is open.

8 Backwater areas consisting of mainstem eddies.

9 A pool with no appreciable surface water surface velocities which is created by a geomorphological feature of a free-flowing zone or from a hydraulic barrier created by a tributary; not created as a result of mainstem stage.

The relative importance of these different habitat zones for each species will be reflected in their preference for different zones. The proportion of catch per unit effort for each species or age class at a particular time will provide an index to the importance of the zones. It will then be possible to deduce the overall response of juvenile salmon habitat to the variable, mainstem discharge. This requires the assumption that reductions in wetted surface area reflect loss of habitat for a particular species or age class.

Methods

The sampling design, methods, and sampling sites of the biological data collection effort are described in Volume 3, section 2.1.3. The location of the 17 tributary mouth and slough sampling sites of this study, called Designated Fish Habitat (DFH) sites, are shown in Figure 4II-2-5. A general description and an aerial photo of each site are contained in Appendix F. A description of the techniques used in measuring the surface area of sampling zones backed up by the mainstem is contained in Part I of this volume (Volume 4) in section 2.1.3.1.

All of the sampling sites responded hydraulically to changes in mainstem discharge, some more than others. The prevailing hydraulic conditions at each site were evaluated each sampling trip prior to the deployment of any gear. The site was visually partitioned into habitat zones (Table 4II-2-1) using the following criteria: 1) presence or absence of a backed-up area resulting from a hydraulic barrier created by the mainstem at the mouth of the site; 2) slough head open or closed (for slough sites), and 3) source of water (tributary and/or ground water versus mainstem water). Water velocity and turbidity were used to help determine zone boundaries. In some cases where the gradient was very low, the decrease in surface water velocity at the point where a free-flowing stream or slough started to respond to the effect of a backed-up area was imperceptible to the observer. At those sites, a series of mean column water velocities was taken and a zone boundary drawn where the velocity of the backed up area was at least 0.2 ft/sec less than the velocity of the free-flowing area.

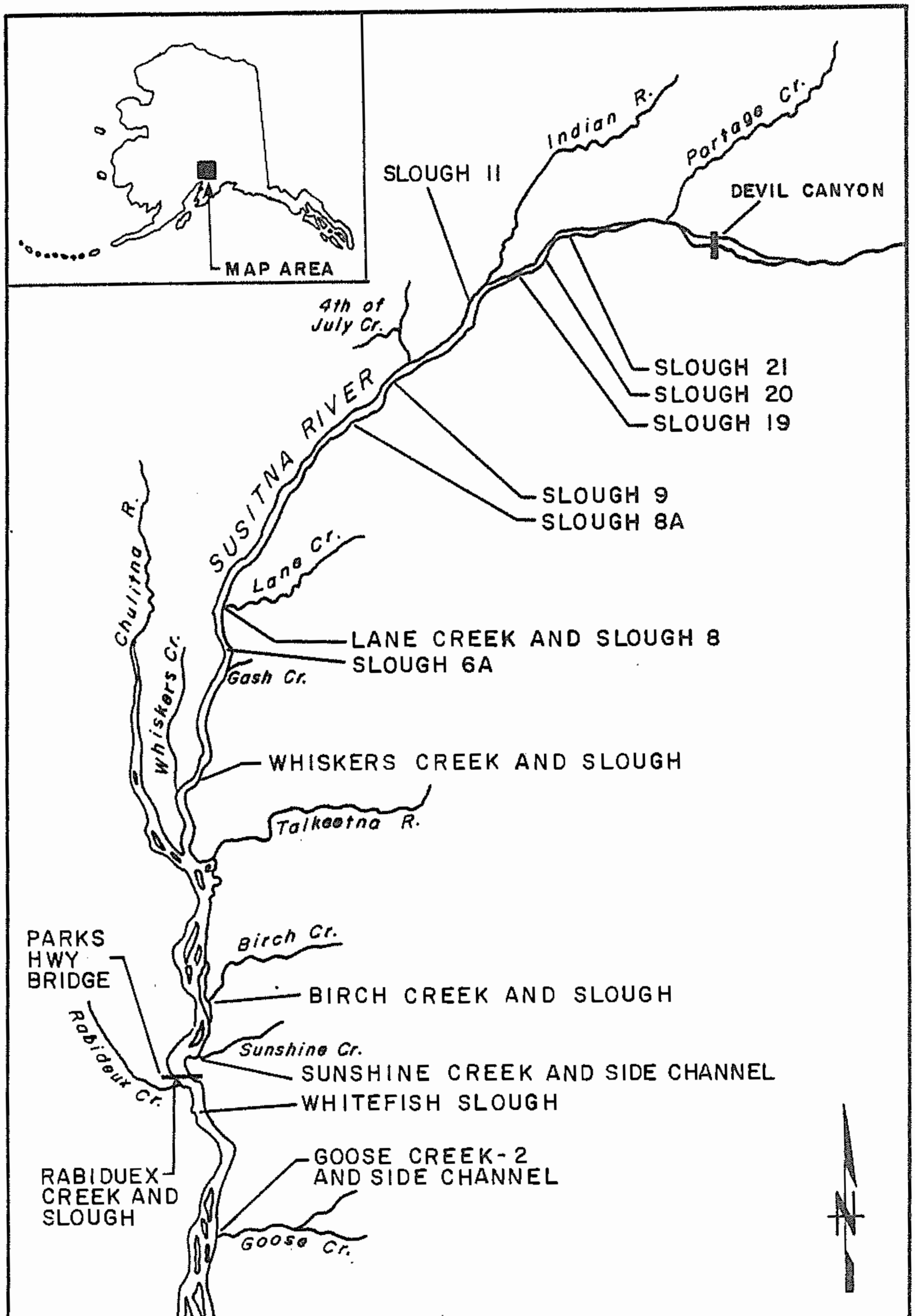

Figure 4/II-2-5. Location of Designated Fish Habitat (DFH) sites on the Susitna River, Goose Creek 2 to Portage Creek.

Water temperature, dissolved oxygen, pH, specific conductance, turbidity and water velocity were collected twice a month from each DFH sampling site, for each zone where fish data was collected. One to three measurements of each parameter were made in each zone in that part of the zone which was actually sampled by the fishing gear and the average reading recorded. Fluorescein dye was used initially in minnow traps to determine the location of the scent plume from the minnow trap. Measurements recorded were representative of the part of the zone which was sampled by the fish collection gear; they are not necessarily representative of the entire zone, although in most cases there is little difference.

Additionally, field notes on the dominant substrate type and amount and quality of cover in each zone were recorded. The equipment and techniques used to measure the different habitat parameters are described in Part I of this volume (section 2.2) and in the Procedures Manual (ADF&G 1982b).

Staff gages were installed at most of the DFH sites in such a manner that water surface elevations could be obtained for each zone. The methods are described in Part I of this volume (section 2.1.1). These staff gages were read twice a month concurrently with the collection of biological and habitat data.

The habitat zones discussed earlier were aggregated according to different criteria to aid in analysis of the data. Aggregate zones, using hydraulic condition as a criterion, are as follow.

Aggregate Zone	Numerical Zones Included	Definition
H-I	1, 4, 5, 9	not backed up by mainstem
H-II	2, 6, 7, 8	backed up by mainstem
H-III	3	mainstem

Zone 9, a pool created by morphological features, can occur within a zone 1, zone 4, or zone 5, so these three zones, which normally have medium to high water below, may include slackwater areas. The criterion is that the slackwater areas in Aggregate Zone H-I are not caused by mainstem backup.

Aggregate zones using water source as the criterion are as follow.

Aggregate Zone	Numerical Zones Included	Definition
W-I	1, 2	tributary water and/or ground water only
W-II	4, 6, 8, sometimes 3	mainstem water only
W-III	5, 7, sometimes 3	mixed water sources

The zones can also be aggregated using the open/closed status of the slough head as a criterion. The presence of any one of the numerical zones 4, 5, 6, or 7, indicates that the slough head is open. If none of these zones are present, the slough head is closed. In this case, for those sloughs that are associated with a tributary, the zone 1 and zone 2 move into the slough channel.

2.3 Resident Fish Habitat Investigations

2.3.1 General Mainstem

2.3.1.1 Radio Telemetry Studies

Five burbot and five rainbow trout were surgically implanted with radio transmitters from October 5 through 14, 1981 in the portion of the Susitna River between RM 76.3 and 84.7 to determine.

1) the movement and/or migrational patterns of these species and;

2) the location and characteristics of overwintering habitats utilized by these species.

These fish were tracked using aerial, boat and snowmachine surveys from the dates of implantation until early April, 1982, or until transmitter failure occurred. Preliminary studies of the overwintering habitats of these fish were attempted. Findings by species of these studies are in Sections 3.3.1 and 3.3.3.

2.3.1.2 Miscellaneous Spawning Fish

Preliminary evaluations of spawning habitats were conducted in 1982 for any resident fish observed spawning in the Susitna River basin. These evaluations included measurement of water temperature, pH, specific conductance, dissolved oxygen, substrate and water depth and velocity at observed spawning sites.

2.3.2 General Slough and Tributary

Methods of resident fish studies at Designated Fish Habitat sites, except for the fish collection gear, are the same as the methods outlined in section 2.2 of this volume. For the methods of resident fish studies at Selected Fish Habitat sites, refer to section 2.1.1 and 2.1.2 of Volume 3. Selected Fish Habitat sites are areas ranging from Cook Inlet to Devil Canyon which were primarily sampled by boat electrofishing.

3. RESULTS

3.1 Adult Anadromous Fish Habitat Investigations

3.1.1 Chum Salmon

3.1.1.1 Mainstem

During the 1982 mainstem salmon spawning surveys, no mainstem spawning sites were located for any of the salmon species except chum salmon. Mainstem chum salmon spawning sites were not found downstream of Lane Creek (RM 113.6). Eight mainstem chum salmon spawning sites (Figure 4II-3-1) were identified between Lane Creek (RM 113.6) and Devil Canyon (RM 152.0). These include:

River Mile	Site Number	Geographic Code
114.4	1	S28N04W06CAB
128.6	6	S30N03W16BCA
129.8	8	S30N02W09DAB
131.1	7	S30N03W03DAD
136.0	2	S31N02W19AD
137.4	5	S31N02W17DBB
138.9	4	S31N02W09DBD
148.2	3	S32N01W26DCA

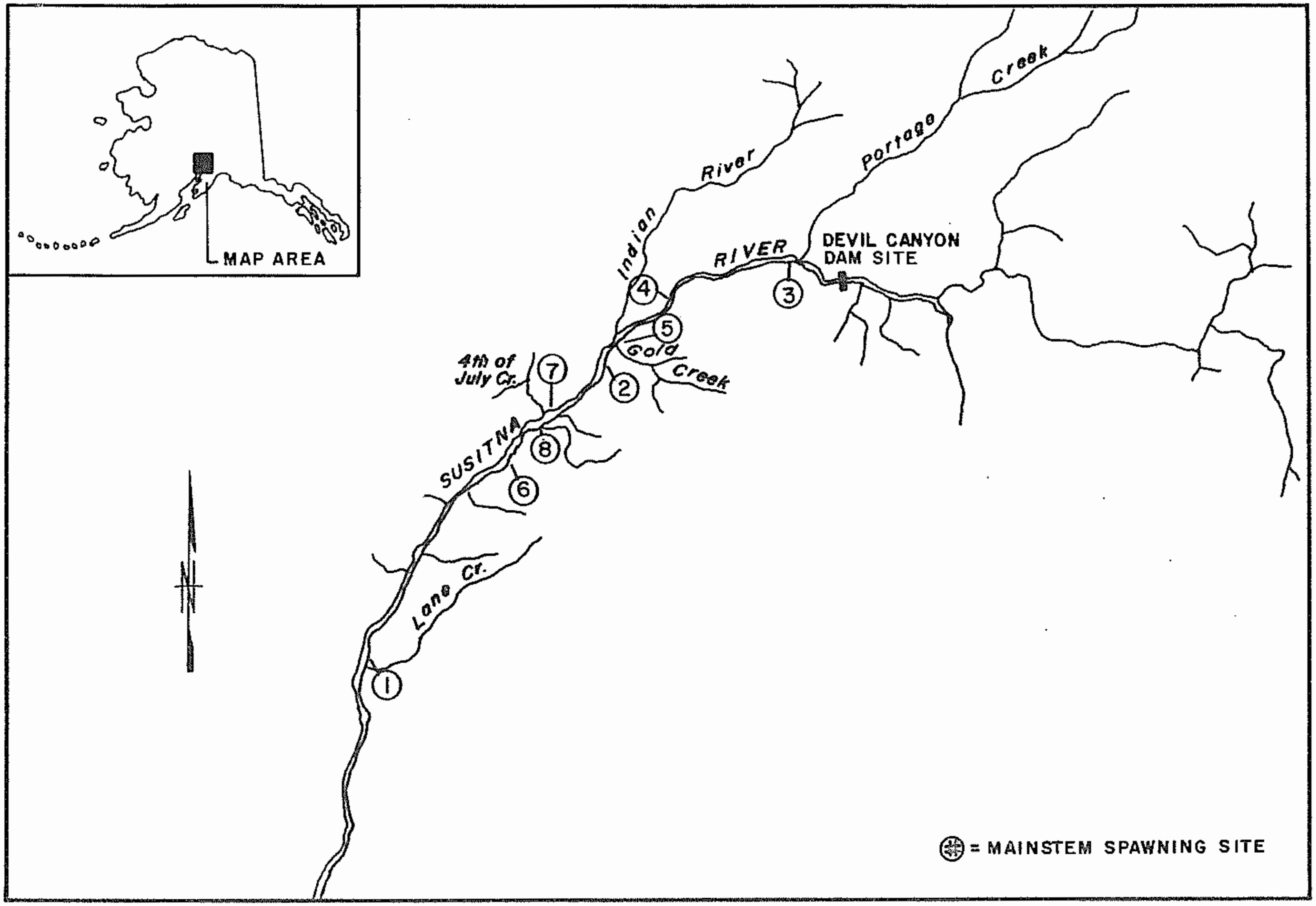

Figure 4II-3-1. Location of the "mainstem" chum salmon spawning sites on the upper Susitna River: September 4-15, 1982.

Planimetric maps, identifying the spawning areas within each of the identified spawning sites, are presented in Figure 4II-3-2 to Figure 4II-3-9. Representative chum salmon spawning areas are shown in Plates 4II-3-1 and 4II-3-2.

Water quality (Table 4II-3-1), water depths, velocities and substrates (Table 4II-3-2) are summarized for each spawning site.

3.1.1.2 Slough

The analysis of chum salmon spawning in sloughs was approached in several ways, including computer modeling, summarization of important spawning habitat variables (Figures 4II-3-10 to 31), comparisons of water quality from surface and ground water sources, and comparisons of available water depths and velocities versus those utilized for chum salmon redds.

3.1.1.2.1 Modeling

Water depths and velocities and substrates were recorded along transects at various flows at the Chum Channel, Rabideaux Slough, and sloughs 8A, 9 and Slough 21 study locations (Figures 4II-3-10 to 12, 4II-3-17, 4II-3-27). Before the hydraulic and habitat simulations can be combined, the hydraulic model must be calibrated (Milhous, et al. 1981). This task is currently in progress.

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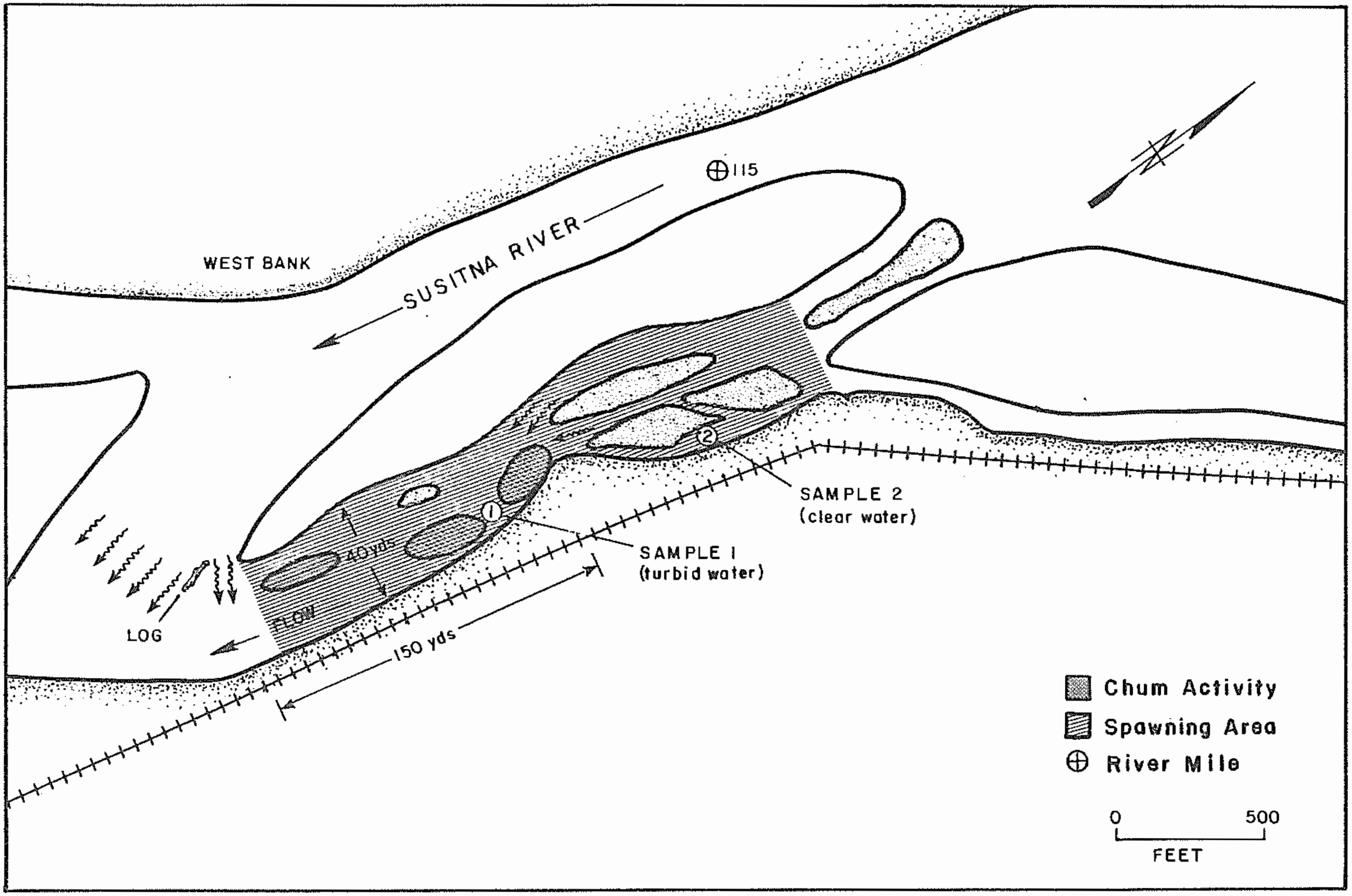

Figure 4II-3-2. Chum salmon spawning area on the Susitna River at RM 114.4, GC S28N04W06CAB: September 9, 1982.

Table 4II-3-1. Water quality at chum salmon spawning sites on the Susitna River, September 4-14, 1982.

Site Number	River Mile	Sample Number	Temperature (°C) Intra-gravel	Water	Air	Specific Conductance (umhos/cm)	Dissolved Oxygen (mg/l)	pH
1	114.4	1	7.6	10.6	13.4	85	13.4	7.5
		2	7.6	10.5	14.0	79	14.0	6.9
2	136.0	1	5.6	5.8	12.2	79	7.1	7.3
		2	5.8	6.1	12.2	80	8.0	7.6
		3	3.7	7.5	12.2	108	10.6	7.8
3	148.2	3	-[a]	7.5	13.0	96	9.9	8.1
4	138.9	1	3.3	5.1	12.2	58	9.0	7.1
5	136.9	1	3.3	7.7	12.2	91	10.4	7.3
6	128.6	1	4.5	8.8	12.0	106	12.3	7.1
		2	4.7	8.8	12.0	104	12.3	7.4
		3	4.7	9.1	12.0	112	12.1	7.7
		4	4.7	8.8	12.0	116	11.8	7.7
7	131.3	1	5.4	10.2	13.0	74	12.8	8.7
		2	5.2	10.2	13.0	74	12.8	8.7
		3	4.2	9.5	11.8	92	13.9	7.0
		4	3.8	8.6	11.8	124	12.9	7.9
		5	4.1	8.5	11.8	132	12.5	7.9
		6	7.0	9.3	11.8	33	13.1	8.0
8	129.8	1	4.1	7.2	7.6	113	6.4	7.4

[a] Meter malfunction, no reading taken.

Table 4II-3-2. Water depths, velocities and substrates at chum salmon spawning sites on the Susitna River: September 4-14, 1982.

Site Number	River Mile	Sample Number	Depth (ft)	Velocity (ft/sec)	Substrate	Embededness	Notes
1	114.4	1	0 - 4.0[a]	0 - 1.0[b]	30% silty sand 30% rubble 20% cobble 10% gravel	Yes (50%)	Turbid water
		2	1.5	0	(same as sample 1)		redd
2	136.0	1	1.5	0	25% cobble 20% rubble 15% gravel	Yes (80%)	redd clearwater
		2	0.5	0	25% cobble 5% gravel 70% silt	Yes (80%)	redd, clearwater
		3	0.5	0	(same as sample 2)		redd
3	148.2	1 2 3 4 5	1.5 2.1 1.3 1.9 2.0	0 0.2 0.1 0 0	60% boulder 20% silt 10% cobble 10% rubble	Yes	Turbid water
4	138.9	1	0 - 2.0[a]	0 - 0.2[b]	30% gravel 20% cobble 20% rubble 25% silt 5% boulders	Yes	clearwater
5	136.9	1	0 - 2.5[a]	0 - 0.3[b]	90% silt 10% boulders	Yes	clearwater
6	128.6	1	0.7	0	30% gravel 30% cobble 30% rubble 10% silt	Yes	redd, clearwater
		2	0.9	0	30% gravel 30% cobble 30% rubble 10% silt	Yes	redd, clearwater
		3	0.8	0	50% gravel 30% rubble 20% silty sand	Yes	redd, clearwater

[a] Range of depths in spawning area.

[b] Range of velocities in spawning area.

Table 411-3-2 (Continued).

Site Number	River Mile	Sample Number	Depth (ft)	Velocity (ft/sec)	Substrate	Embededness	Notes
		4	0.9	0	50% gravel 20% cobble 20% boulder 10% silt	Yes	redd, clearwater
7	131.3	1	0.7	0.2	70% cobble 10% gravel 20% silt	Yes (30%)	redd, clearwater
		2	0.9	0	70% cobble 10% gravel 20% silt	Yes (50%)	redd, clearwater
		3	0.8	0.2	40% gravel 30% rubble 20% sand 10% sand	Yes (40%)	redd, clearwater
		4	0.9	0	40% gravel 30% cobble 15% rubble 15% sand	Yes (30%)	redd, clearwater
		5	1.1	0	40% gravel 30% cobble 15% rubble 15% sand	Yes (30%)	redd, clearwater
		6	1.2	0	30% gravel 30% rubble 30% cobble 10% sand	Yes (40%)	redd, turbid water
8	129.8	1	1.0 - 2.5[a]	0 - 0.2[b]	40% cobble 40% rubble 20% silt	Yes	redd, clearwater

[a] Range of depths in spawning area.

[b] Range of velocities in spawning area.

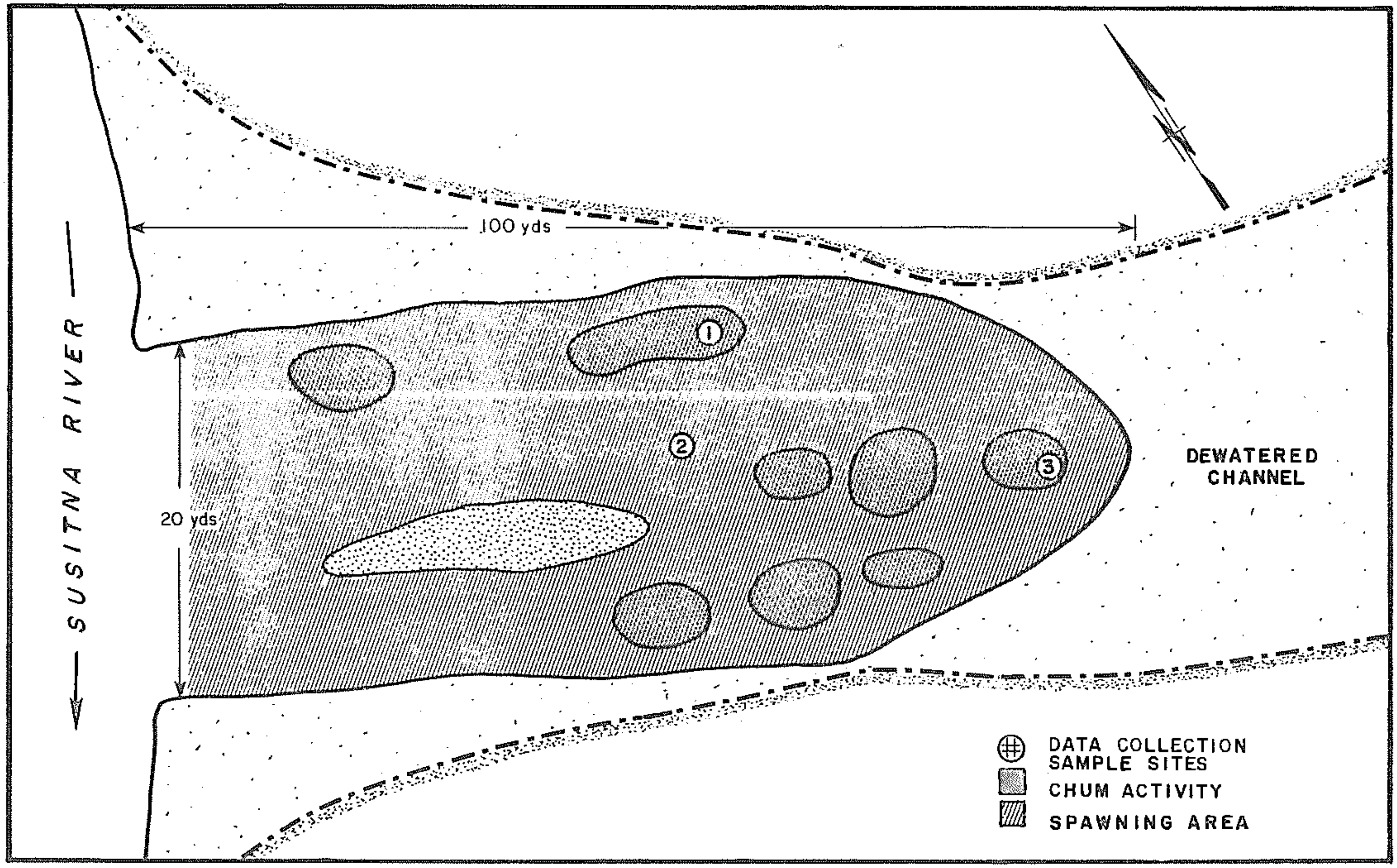

Figure 4II-3-3. Chum salmon spawning area on the Susitna River at RM 136.0, GC S31N02S19AD-: September 4, 1982.

223

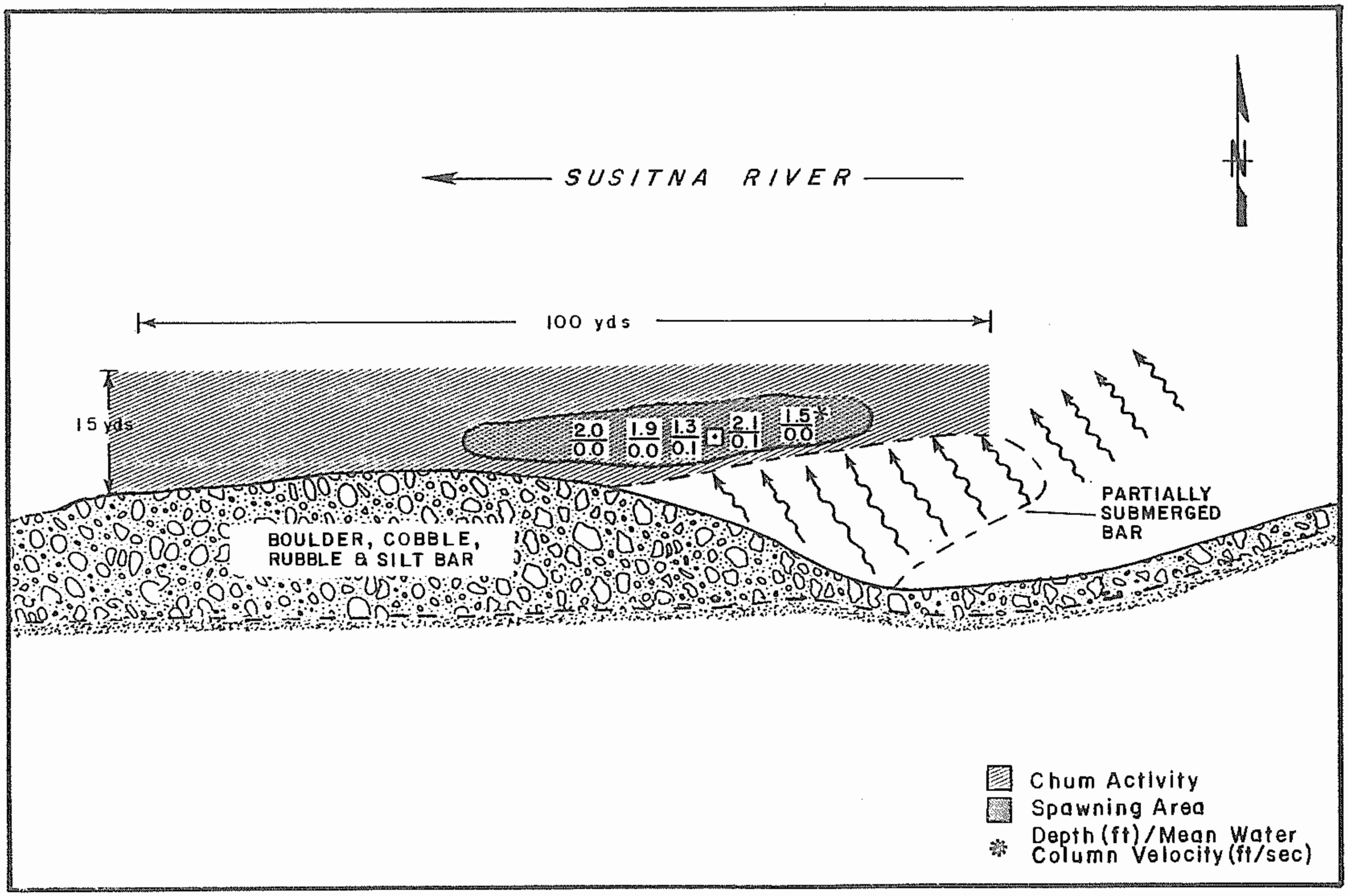

Figure 4II-3-4. Chum salmon spawning area on the Susitna River RM 148.2, GC S32N01W26DCA: September 5, 1982.

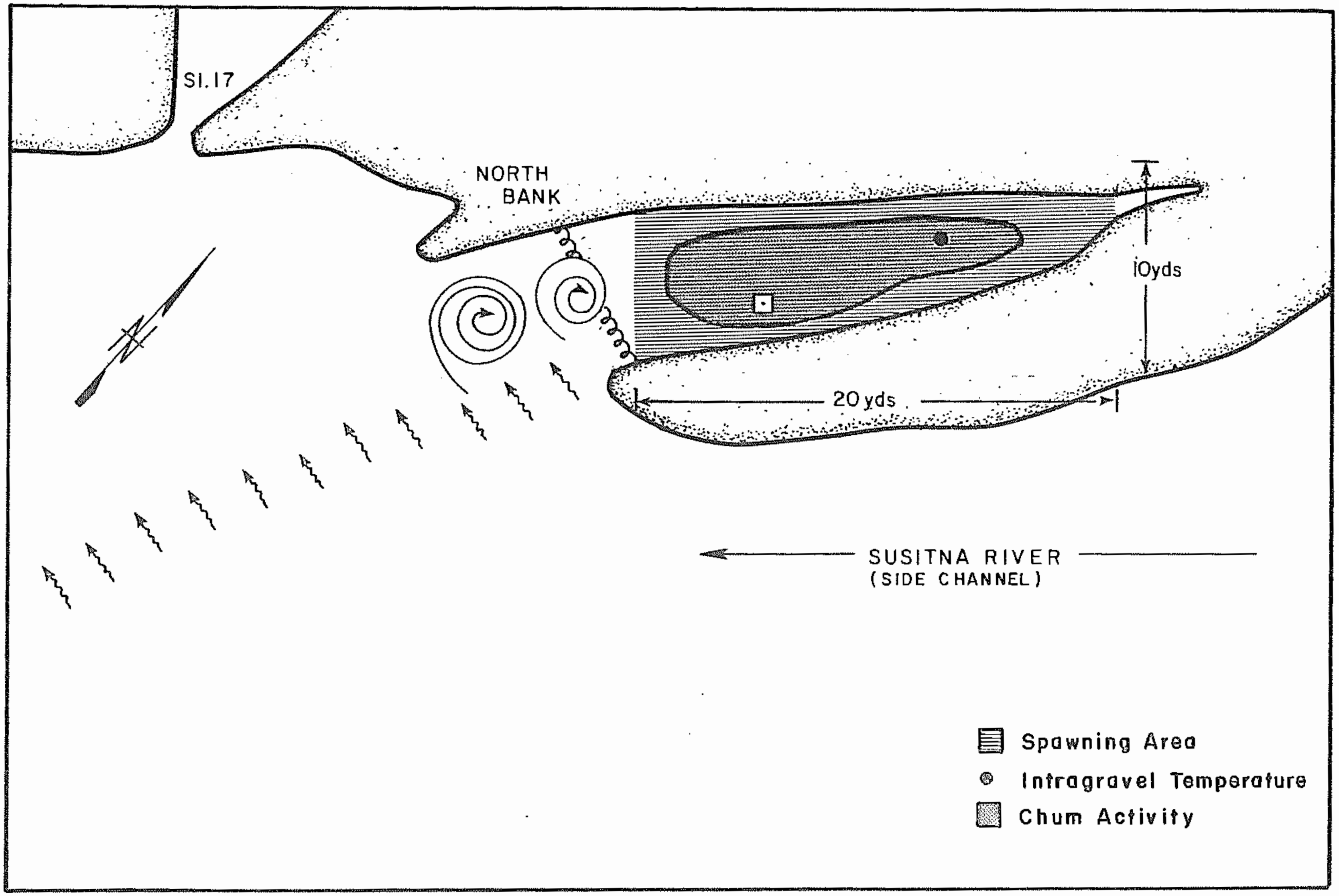

Figure 4II-3-5. Chum salmon spawning area on the Susitna River at R 138.9, GC S31N02W09DBD: September 6, 1982.

225

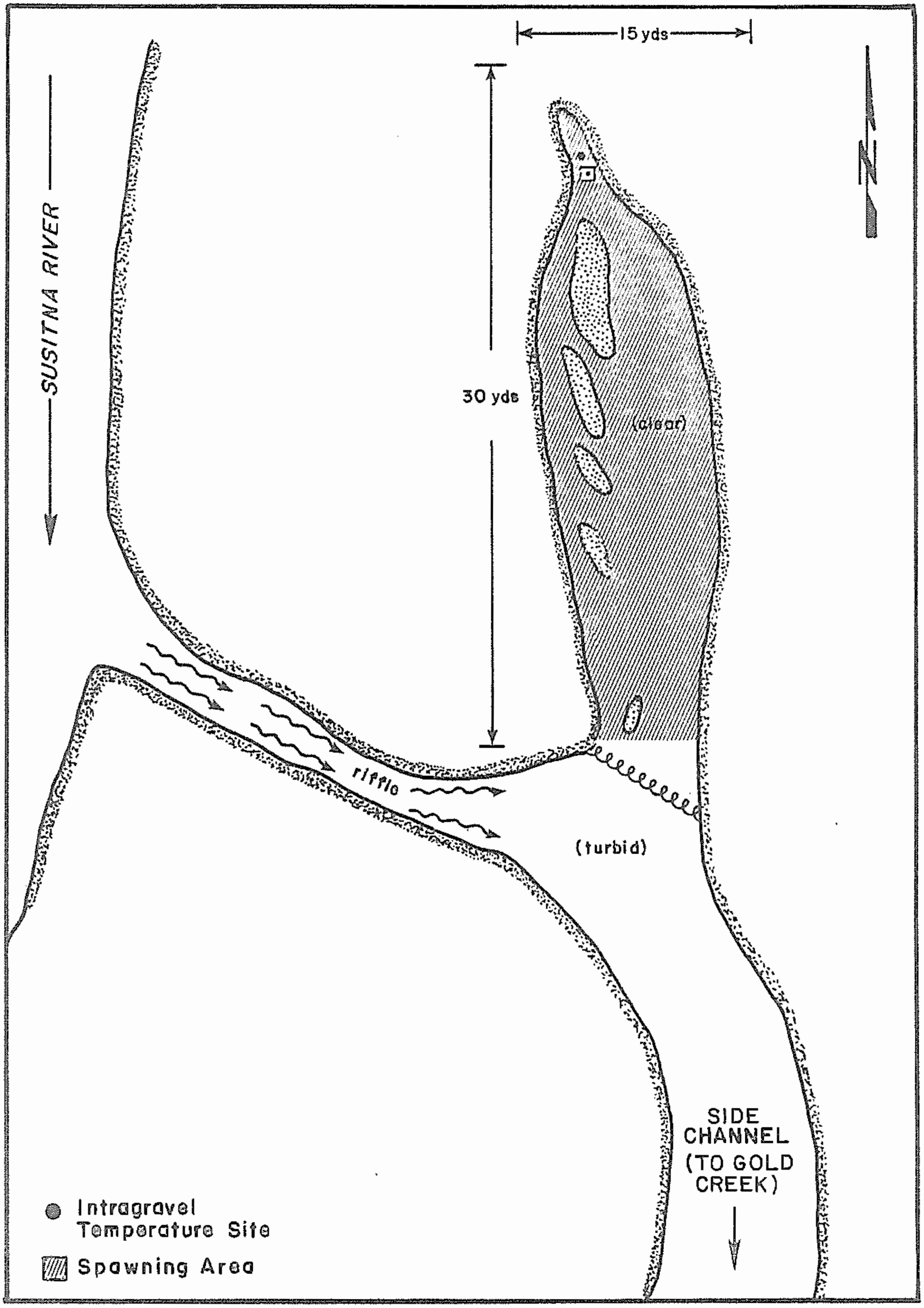

Figure 4II-3-6. Chum salmon spawning area on the Susitna River at RM 137.4, GC S31N02W17DBB: September 6, 1982.

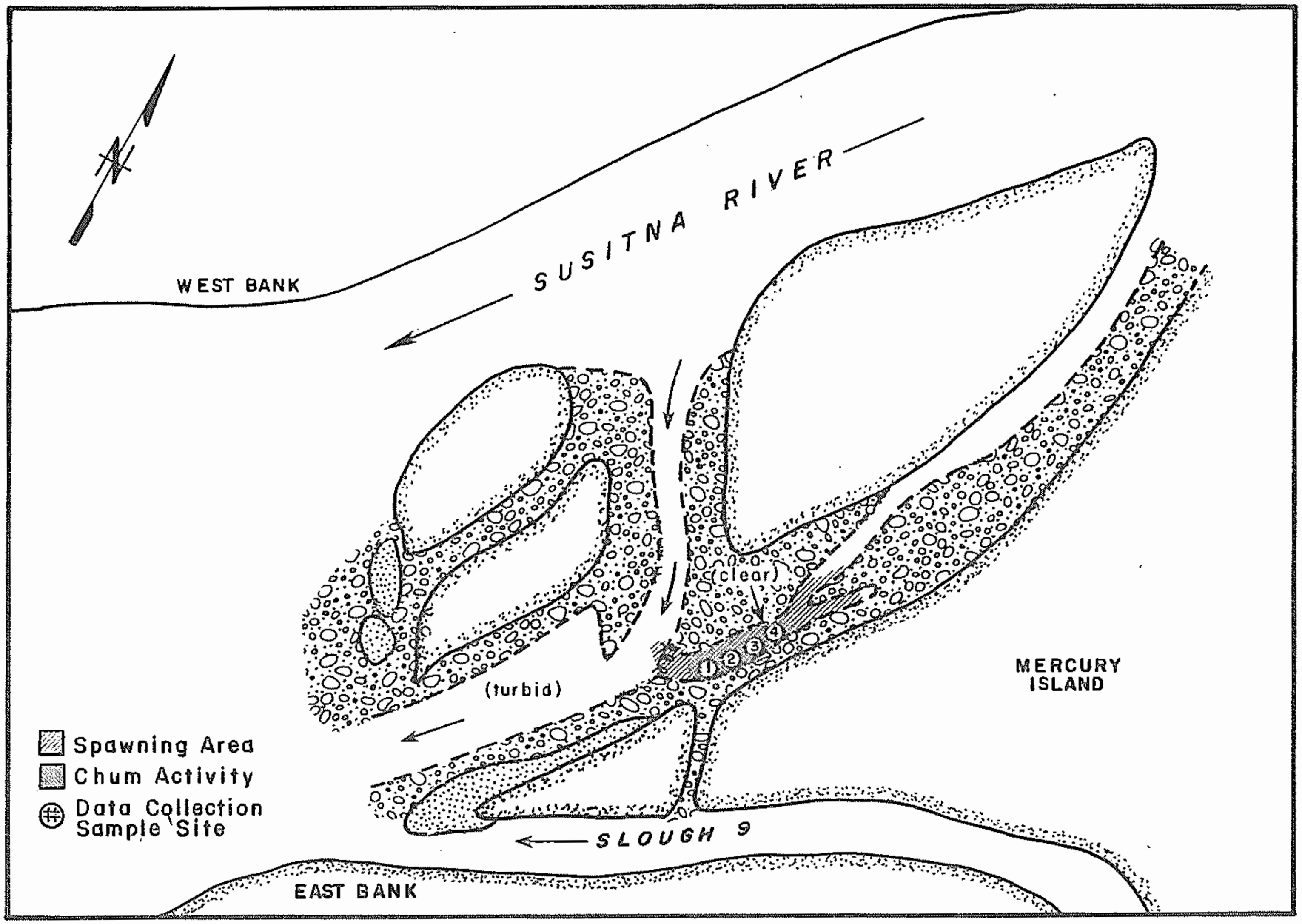

Figure 4II-3-7. Figure Chum salmon spawning area on the Susitna River at RM 128.6 (GC S30N03W16BCA): September 7, 1982.

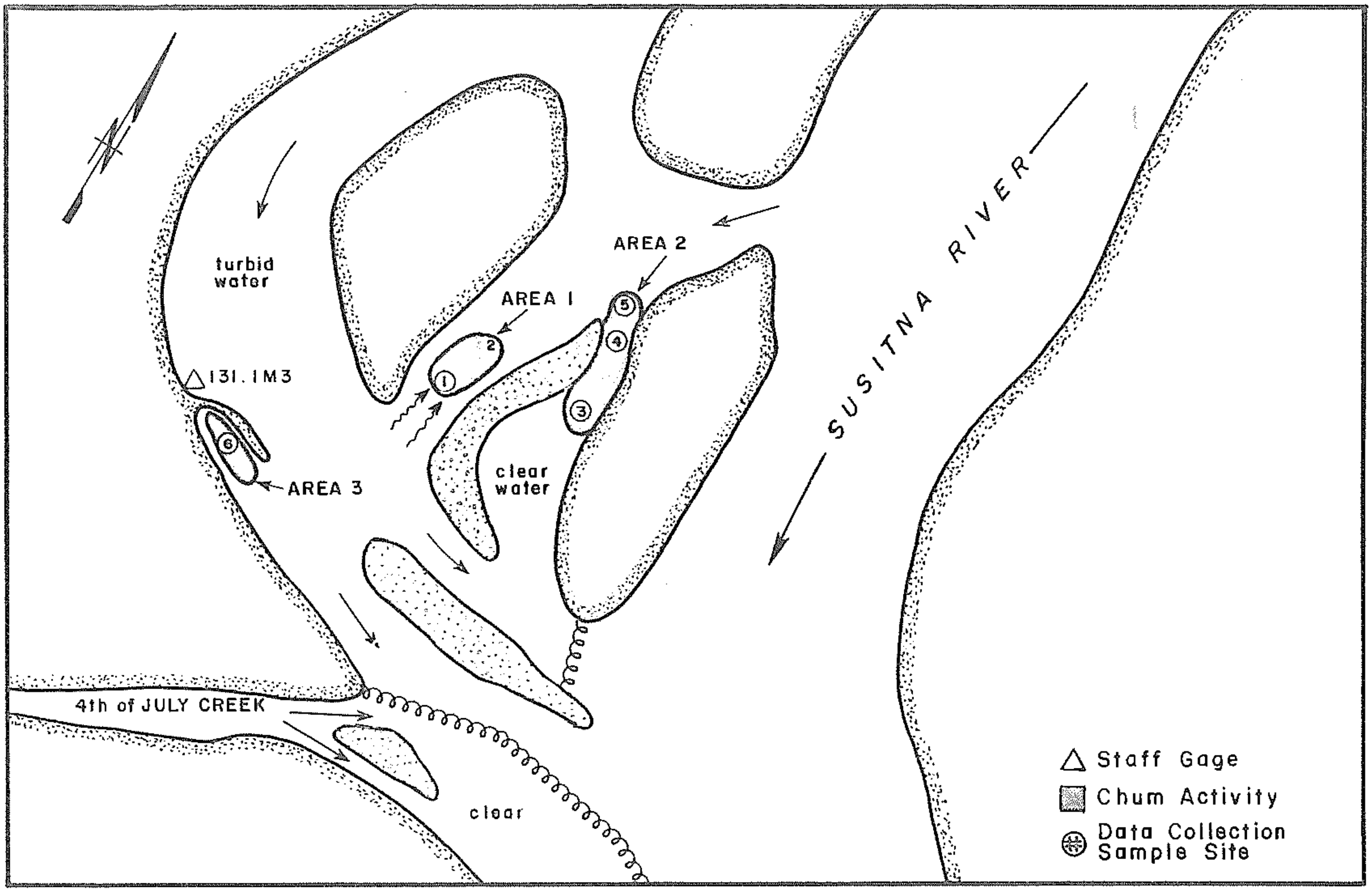

Figure 4II-3-8. Chum salmon spawning area on the Susitna River at RM 131.3, GC S30N03W03DAD: September 4-8, 1982.

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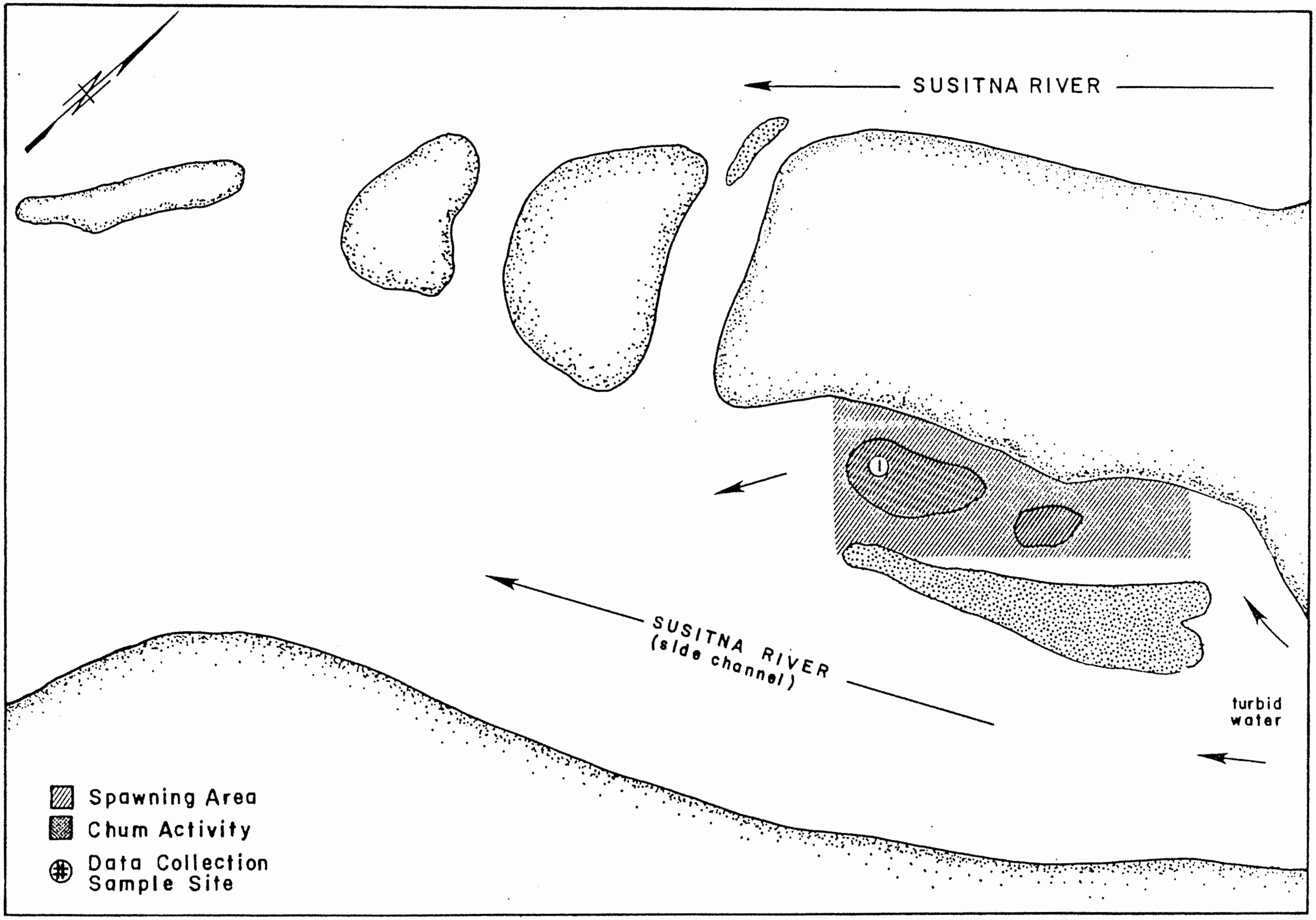

Figure VII-3-9. Chum salmon spawning area on the Susitna River at RM 129.8, GC S30N03W09DAB: September 14, 1982. Chum salmon were also observed spawning on September 13, 1982, when the water was clear at the site.

Plate 4II-3-1. Chum salmon spawning area on the Susitna River at RM 114.4 (GC S28N04W06CAB): September 9, 1982.

Plate 4II-3-2. Chum salmon spawning area on the Susitna River at RM 128.6 (GC S30N03W16BCA): September 7, 1982

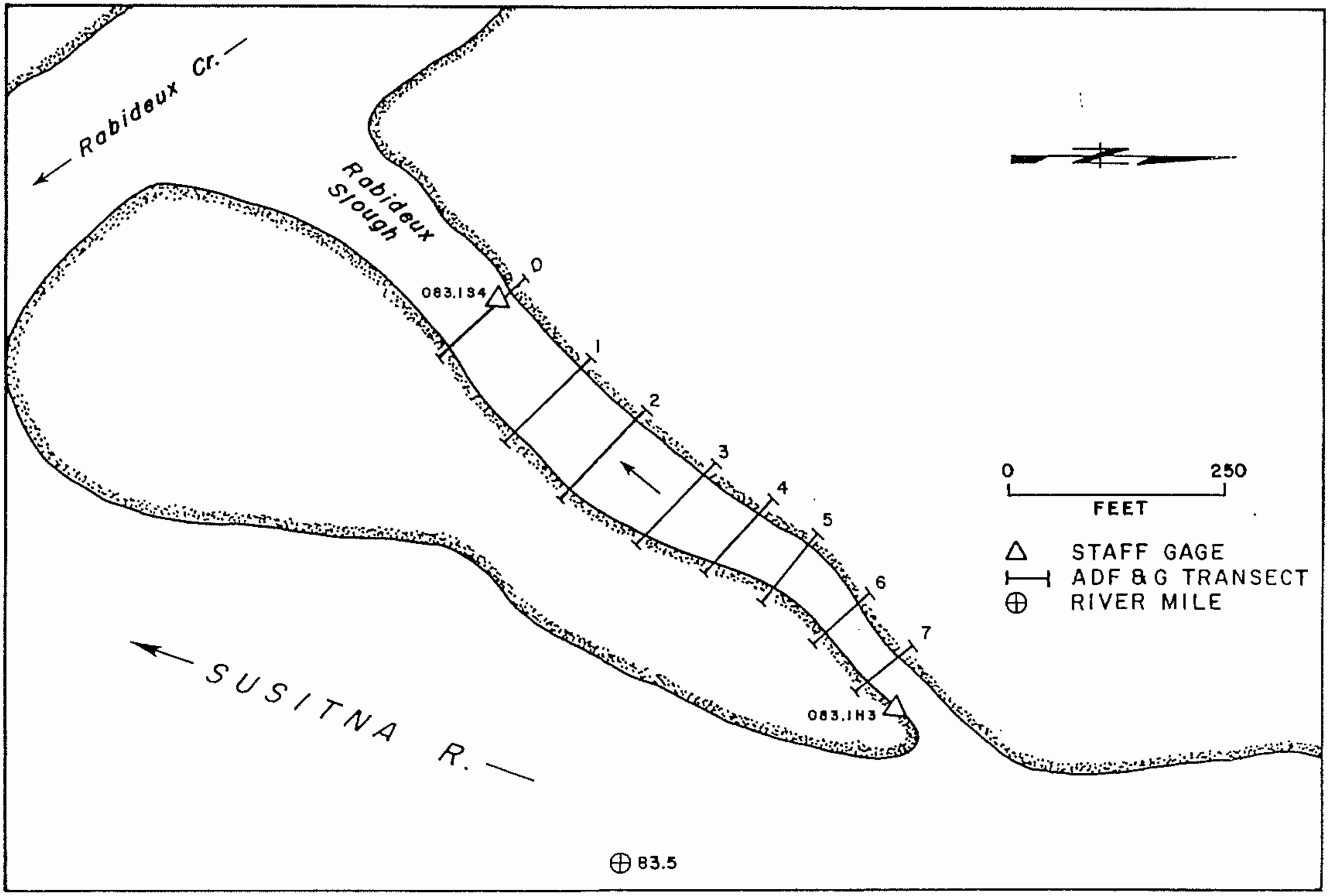

Figure 4II-3-10. Rabideux Slough transects.

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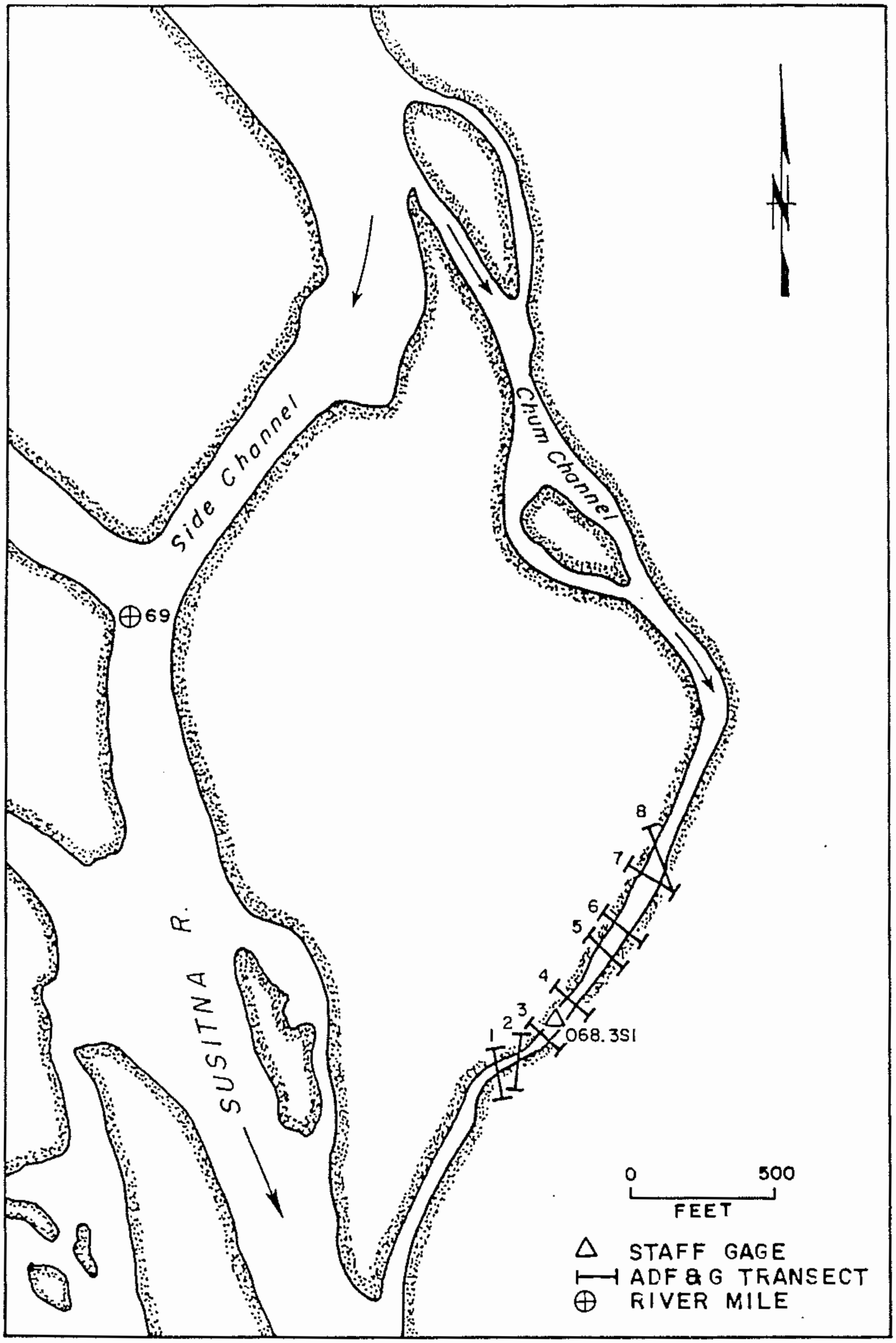

Figure VII-3-11. Chum Channel transects.

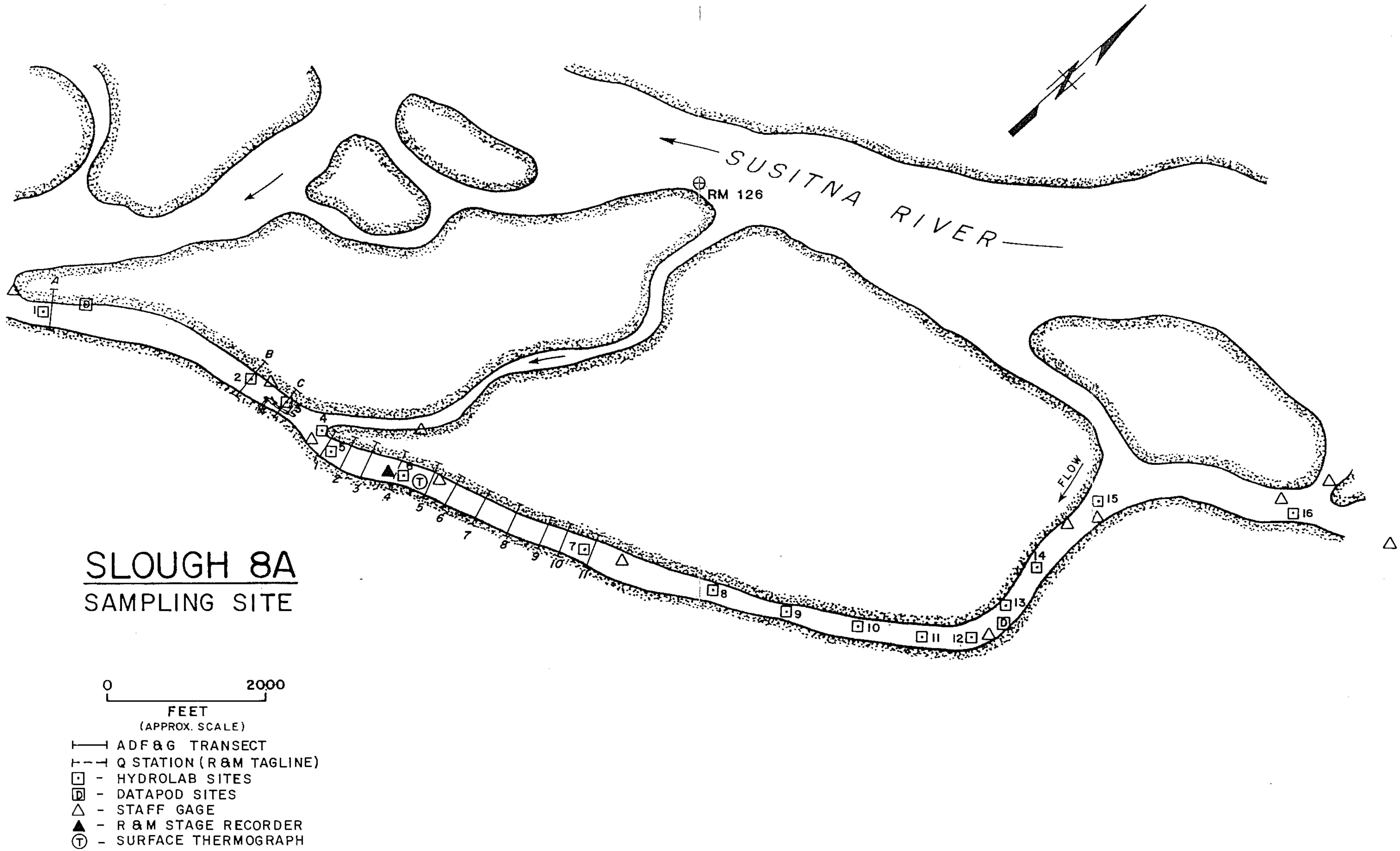

Figure 4II-3-12. Slough 8A sampling sites, 1982.

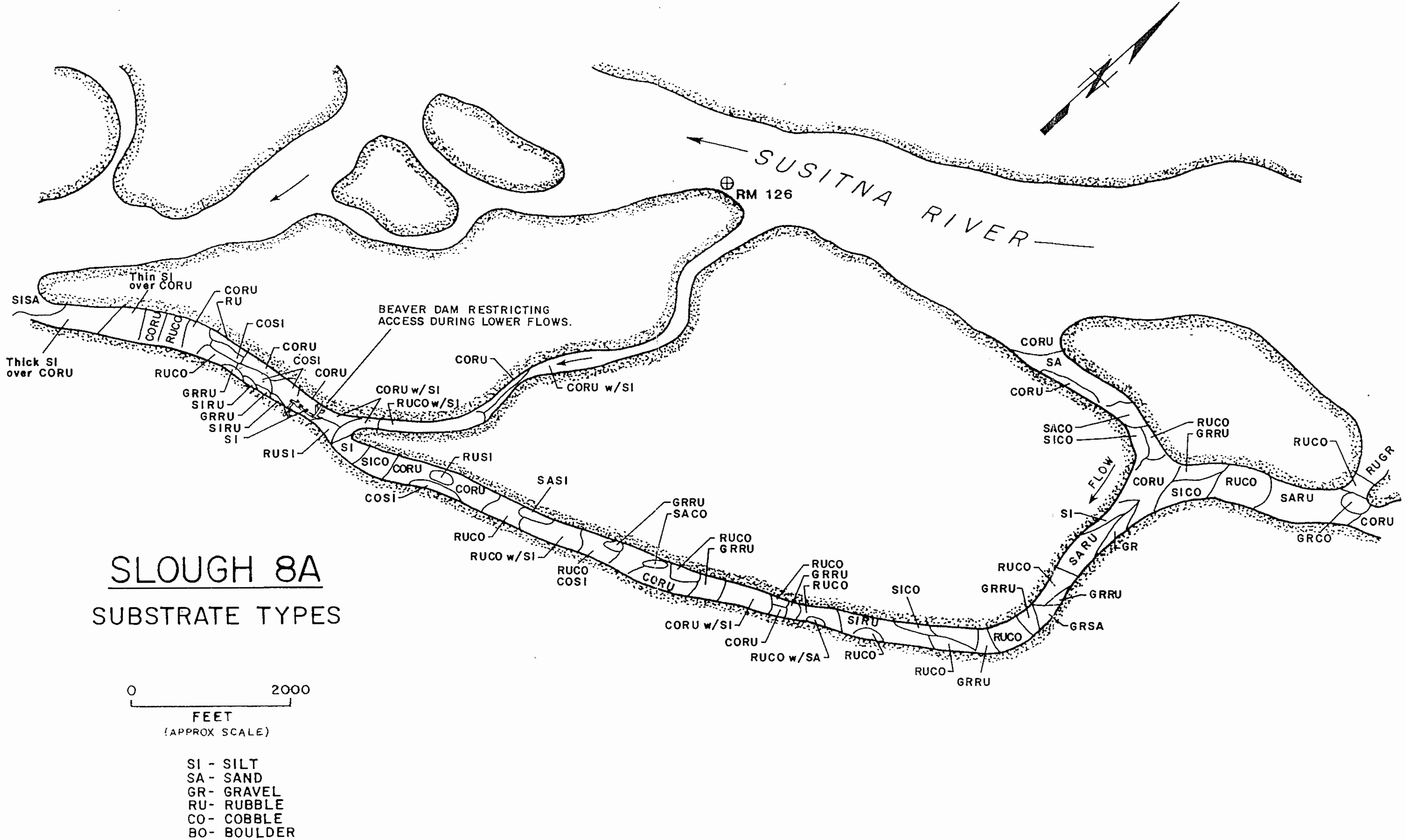

Figure 4II-3-13. Slough 8A substrate, 1982.

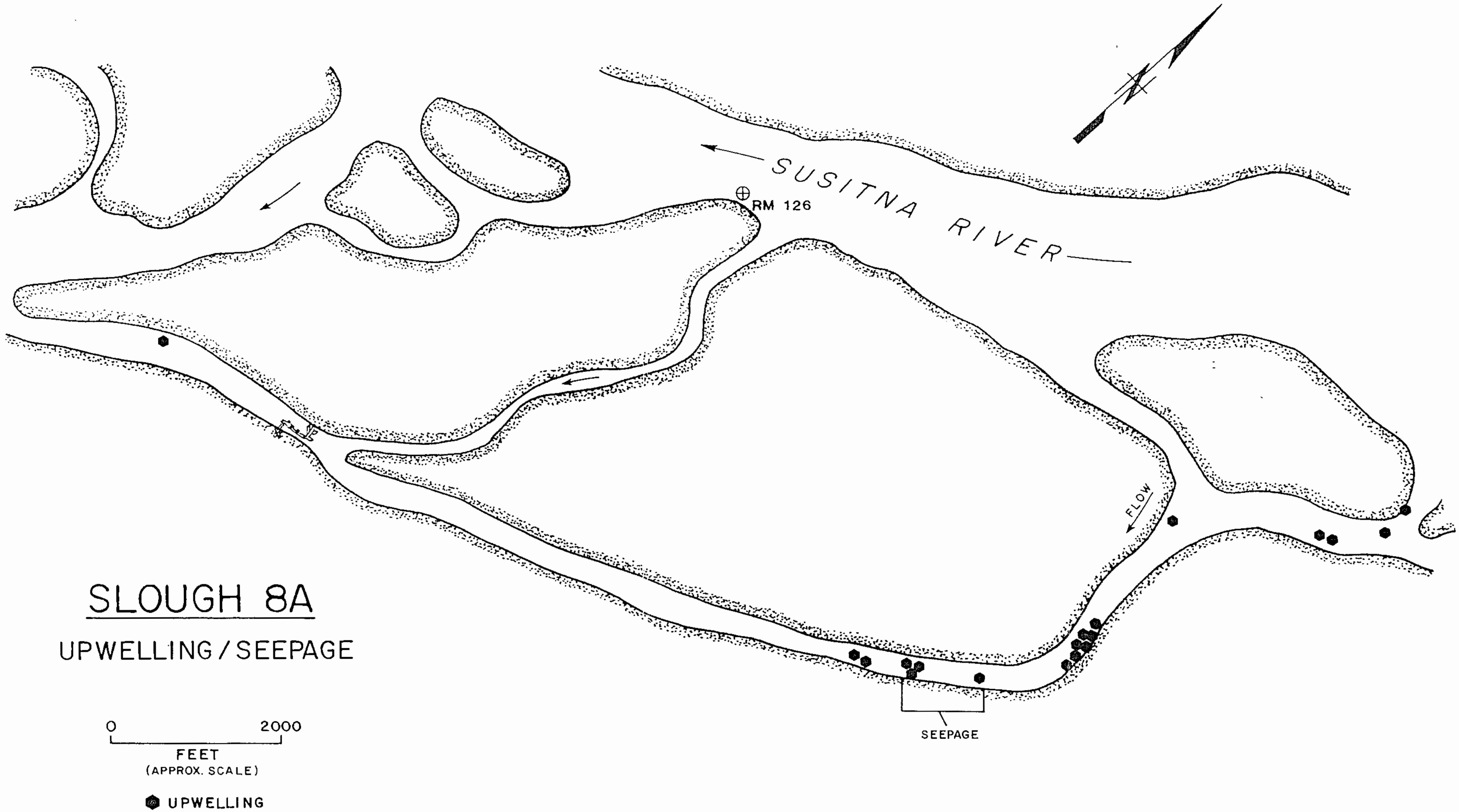

Figure 4II-3-14. Slough 8A upwellings, 1982.

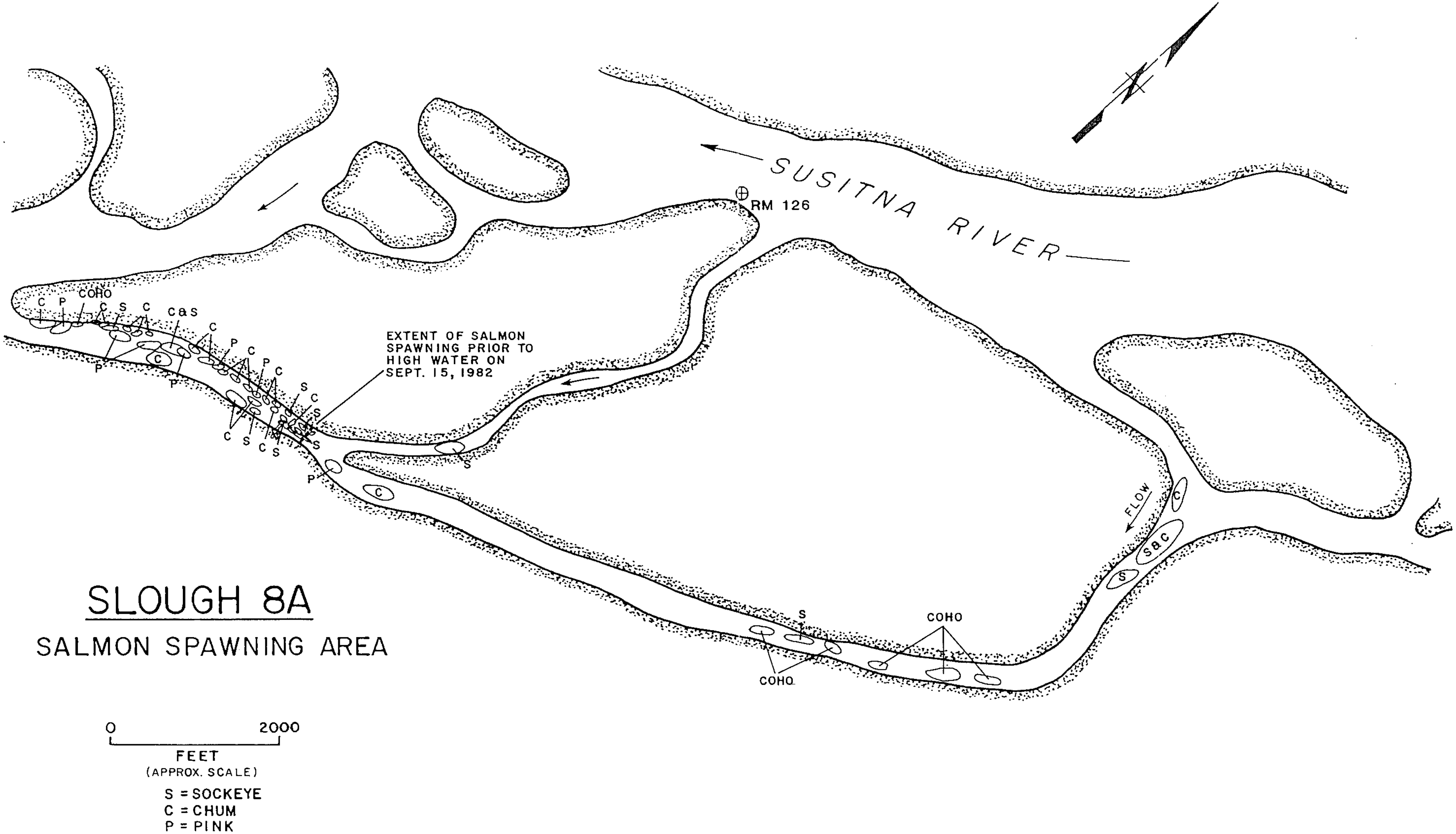

Figure 4II-3-15. Slough 8A spawning areas, 1982.

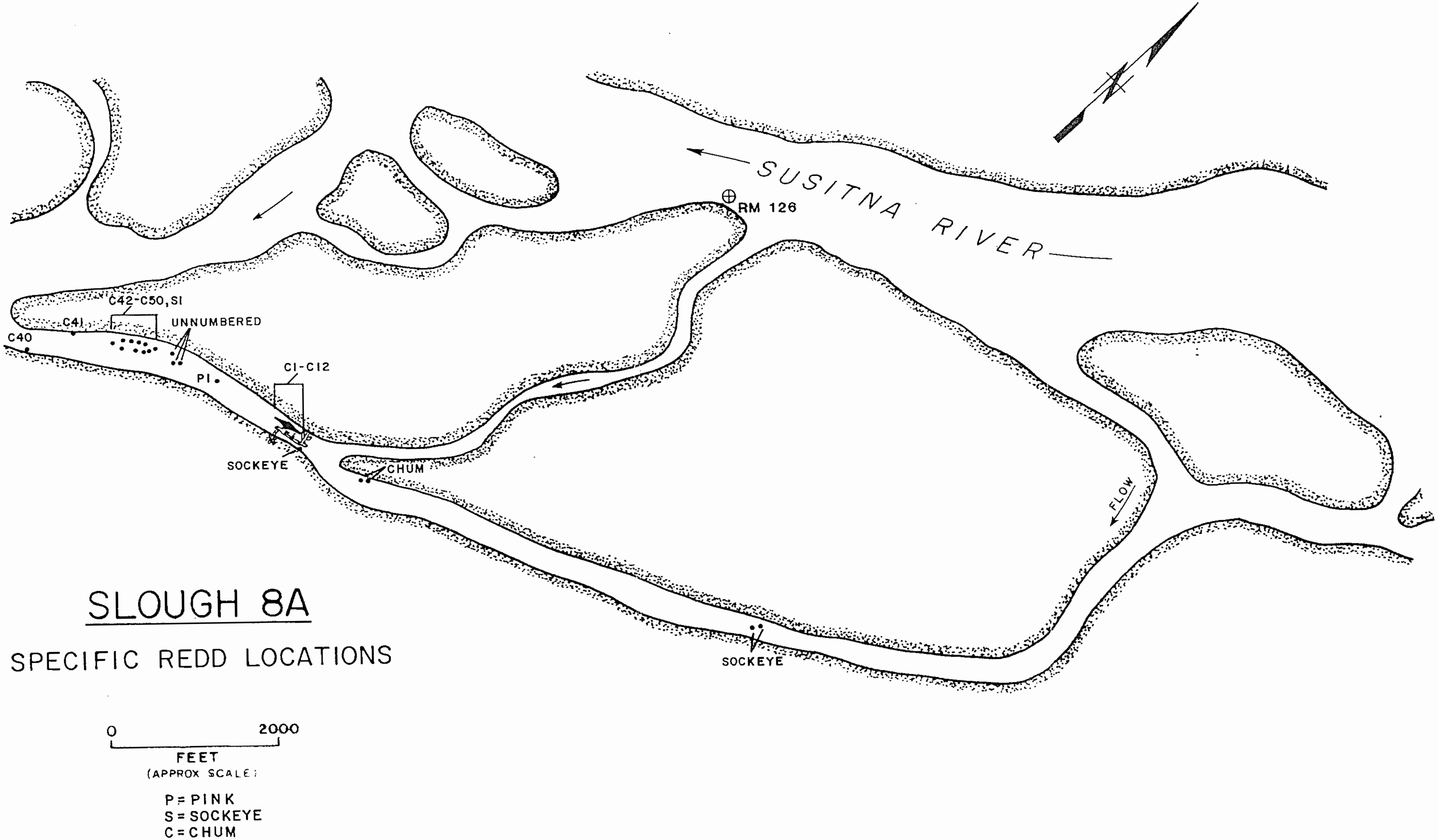

Figure 4II-3-16. Slough 8A redd locations, 1982.

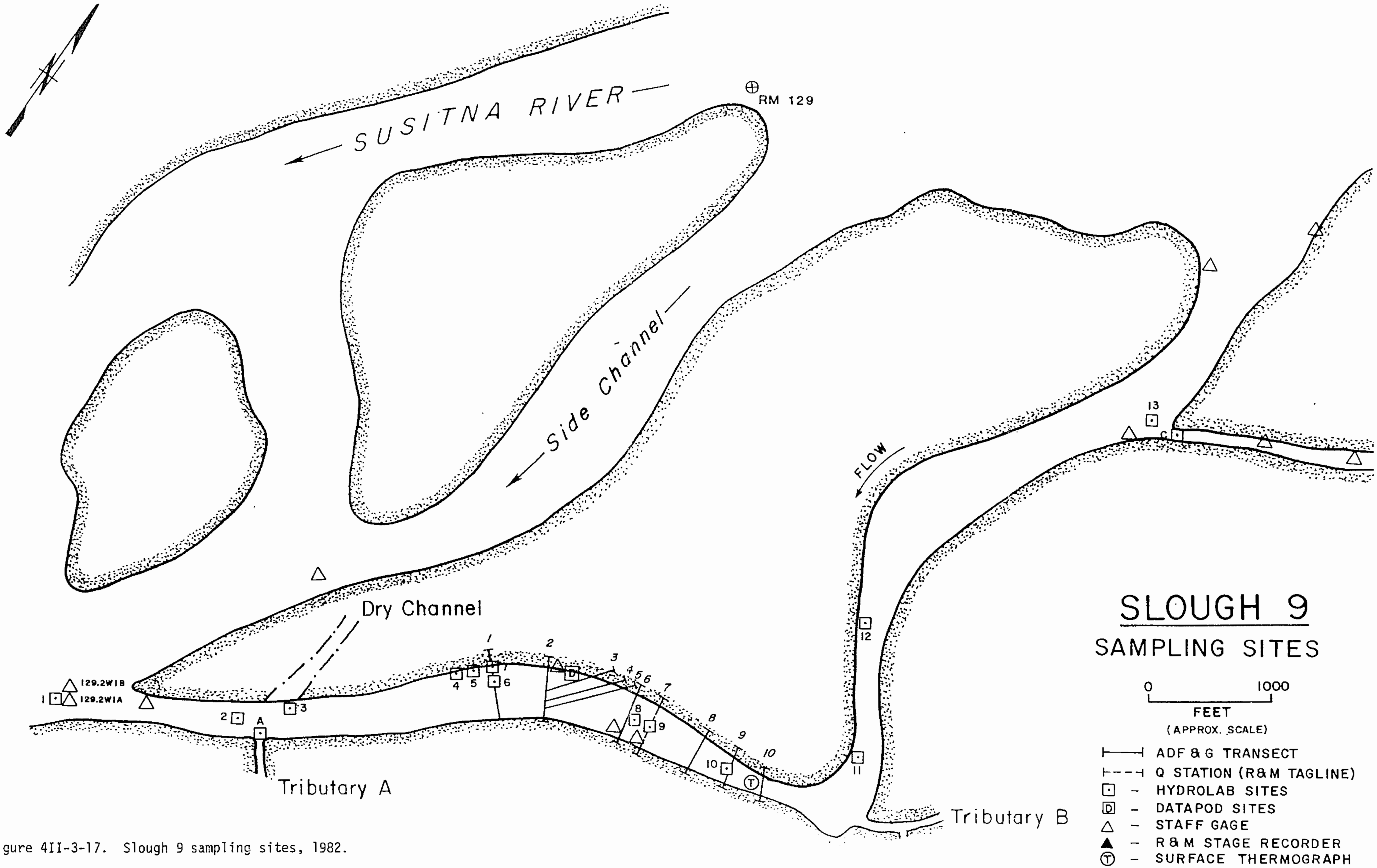

Figure 4II-3-17. Slough 9 sampling sites, 1982.

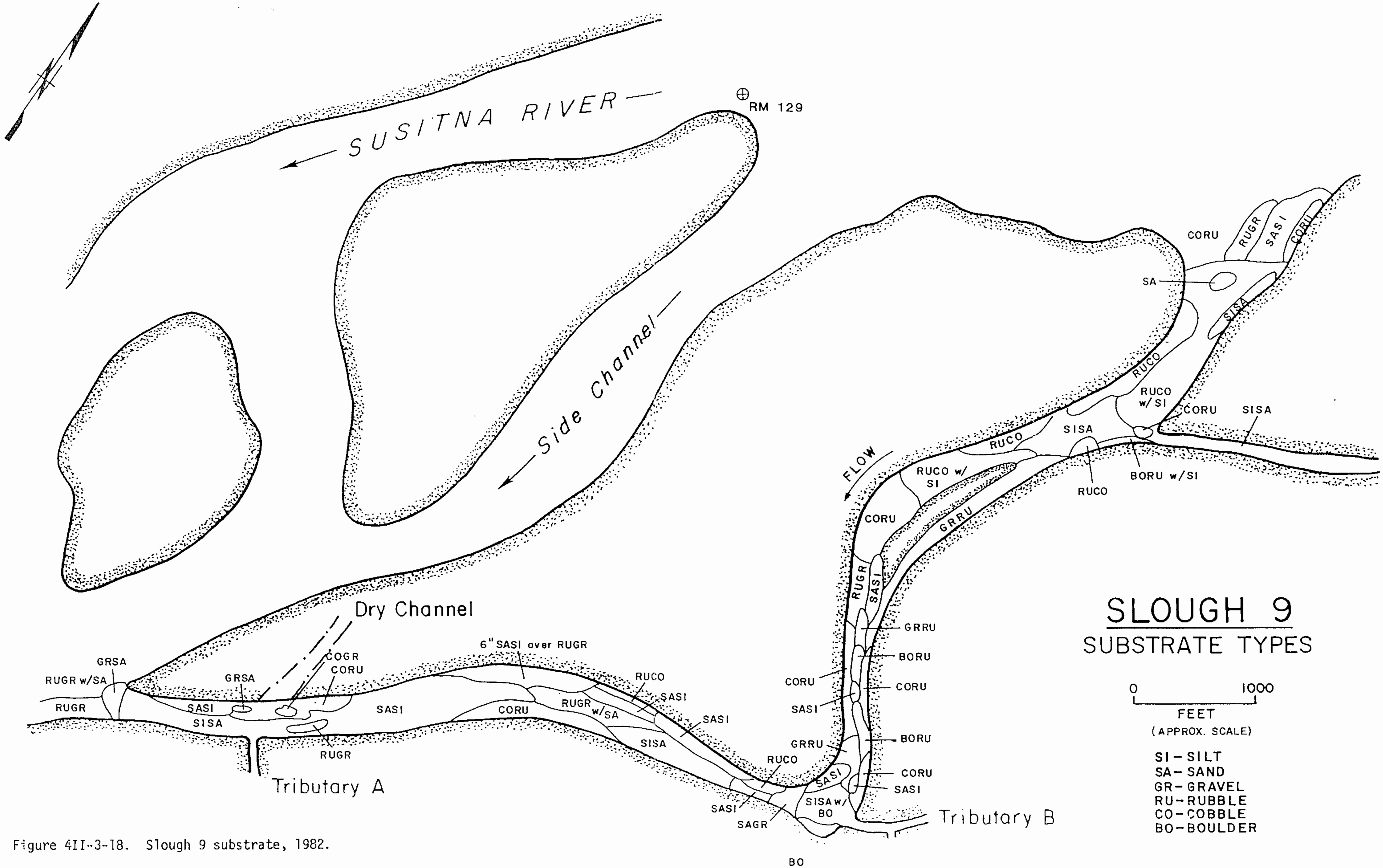

Figure 4II-3-18. Slough 9 substrate, 1982.

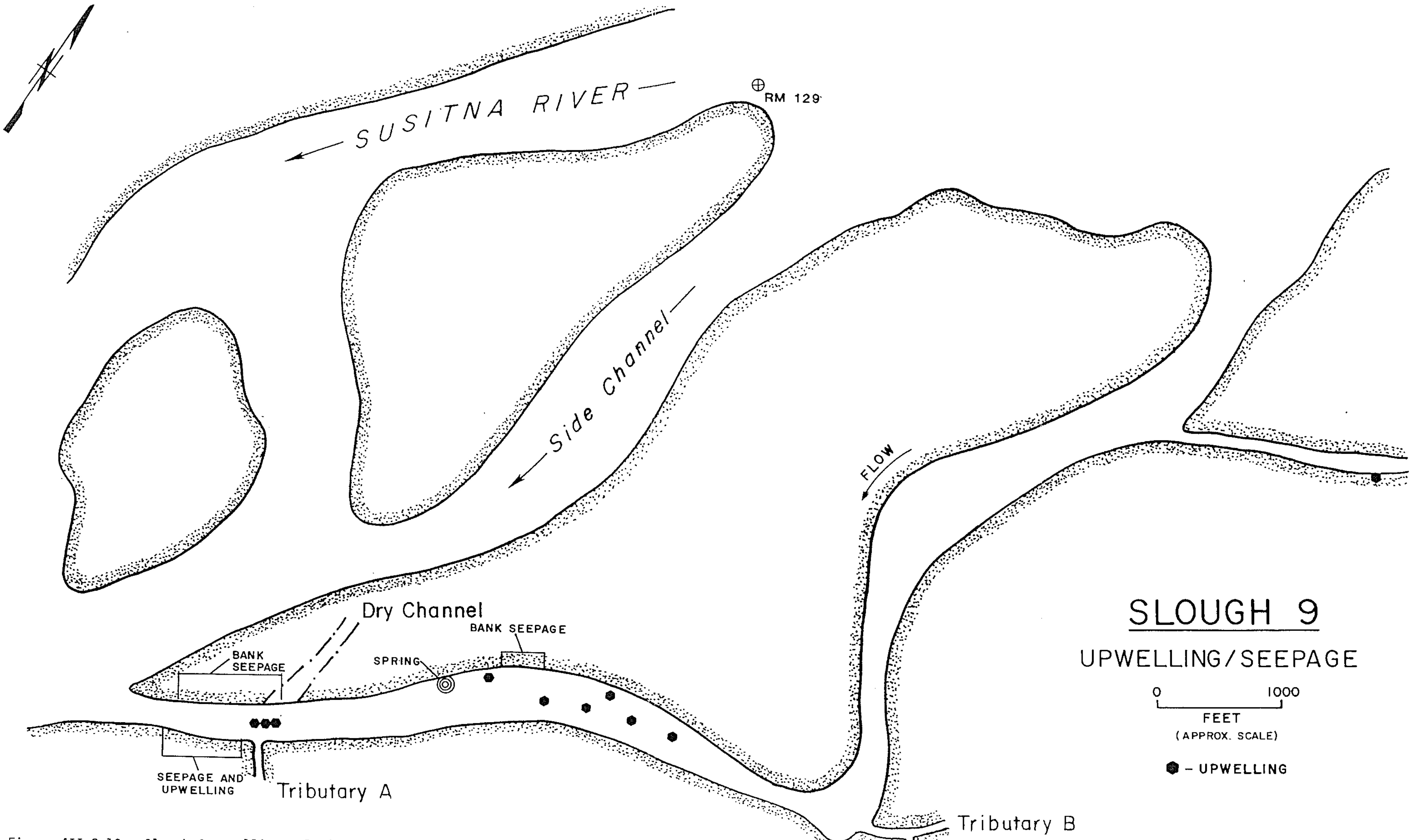

Figure 4II-3-19. Slough 9 upwellings, 1982.

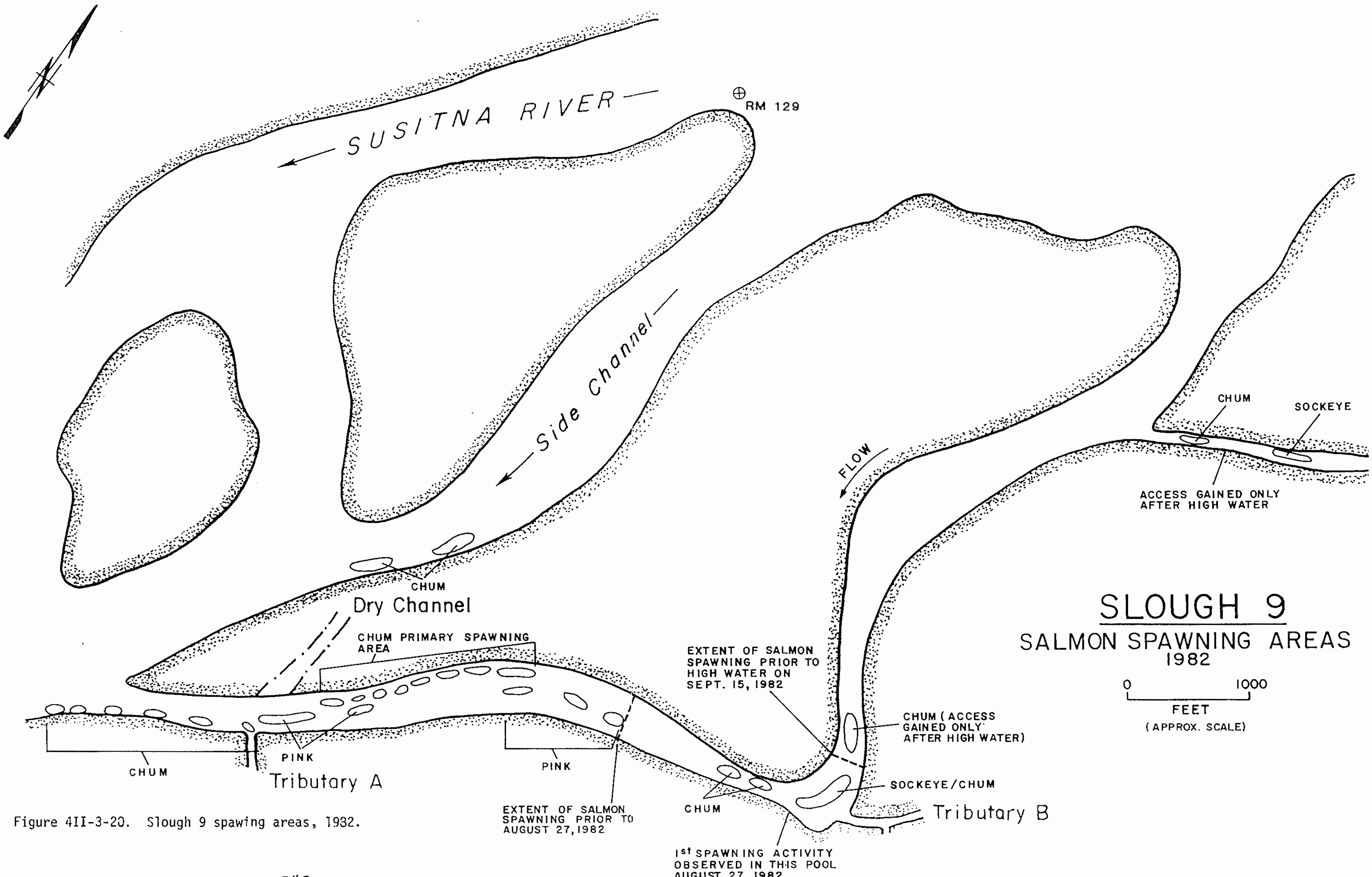

Figure 4II-3-20. Slough 9 spawing areas, 1932.

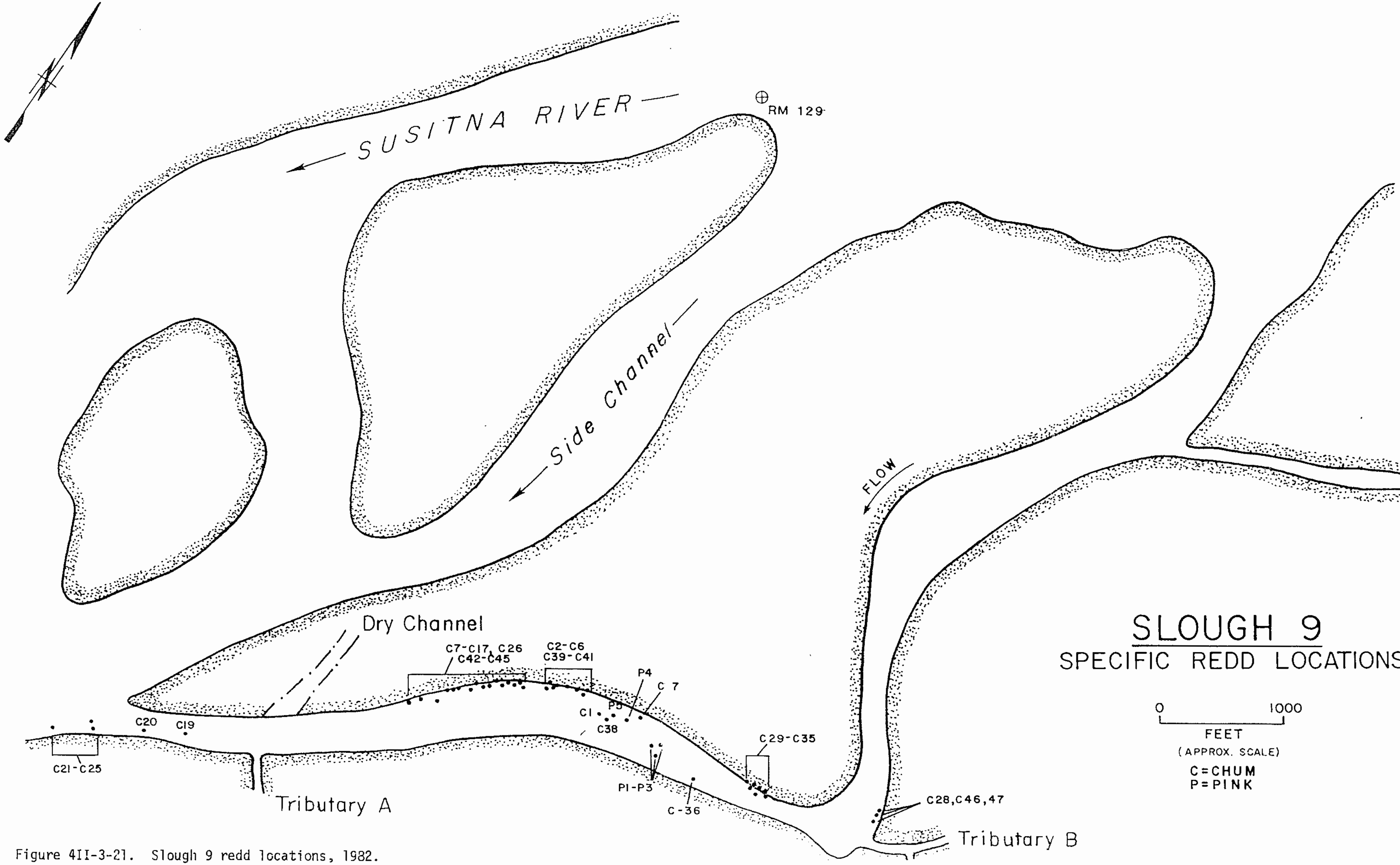

Figure 4II-3-21. Slough 9 redd locations, 1982.

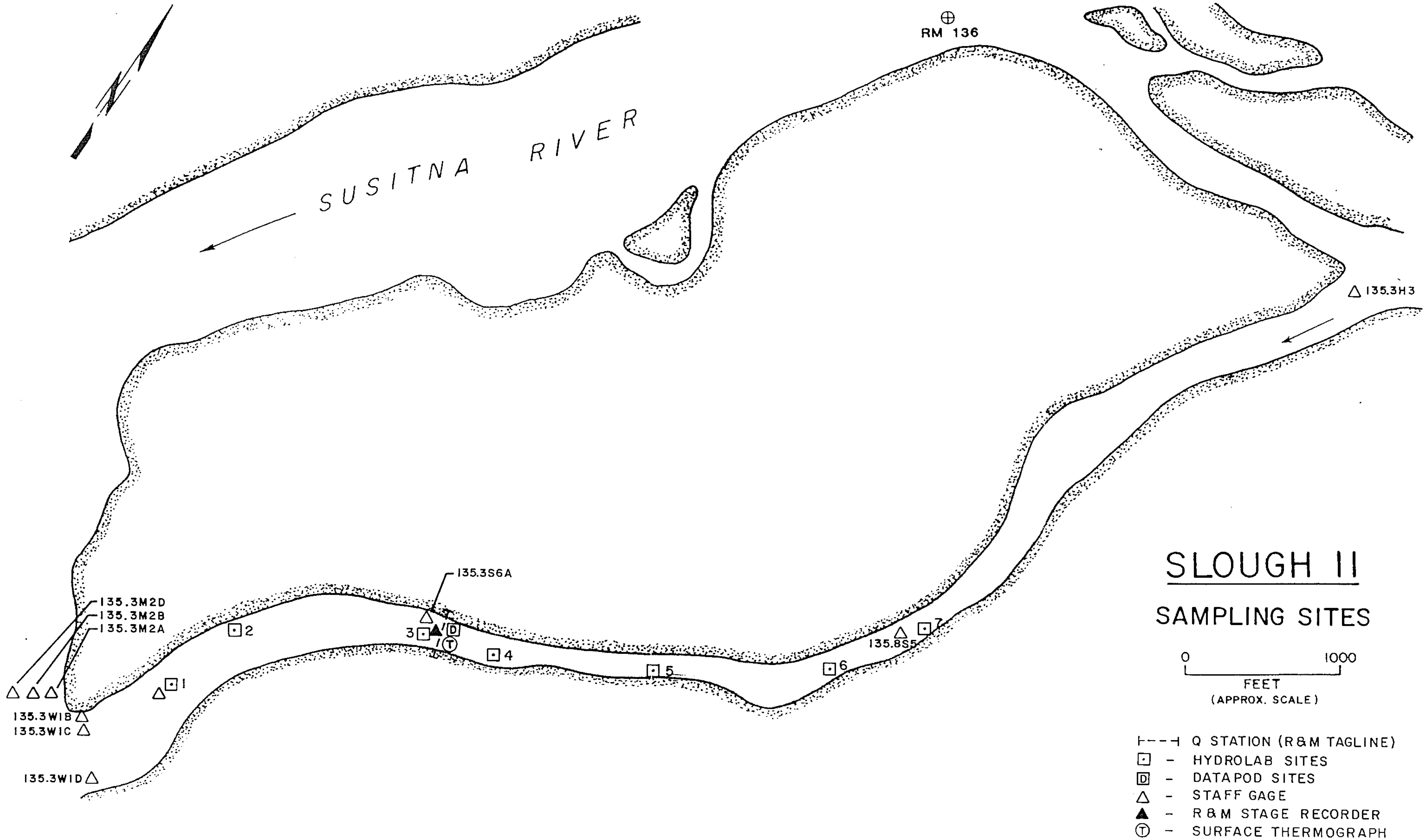

Figure 4II-3-22. Slough 11 sampling sites, 1982.

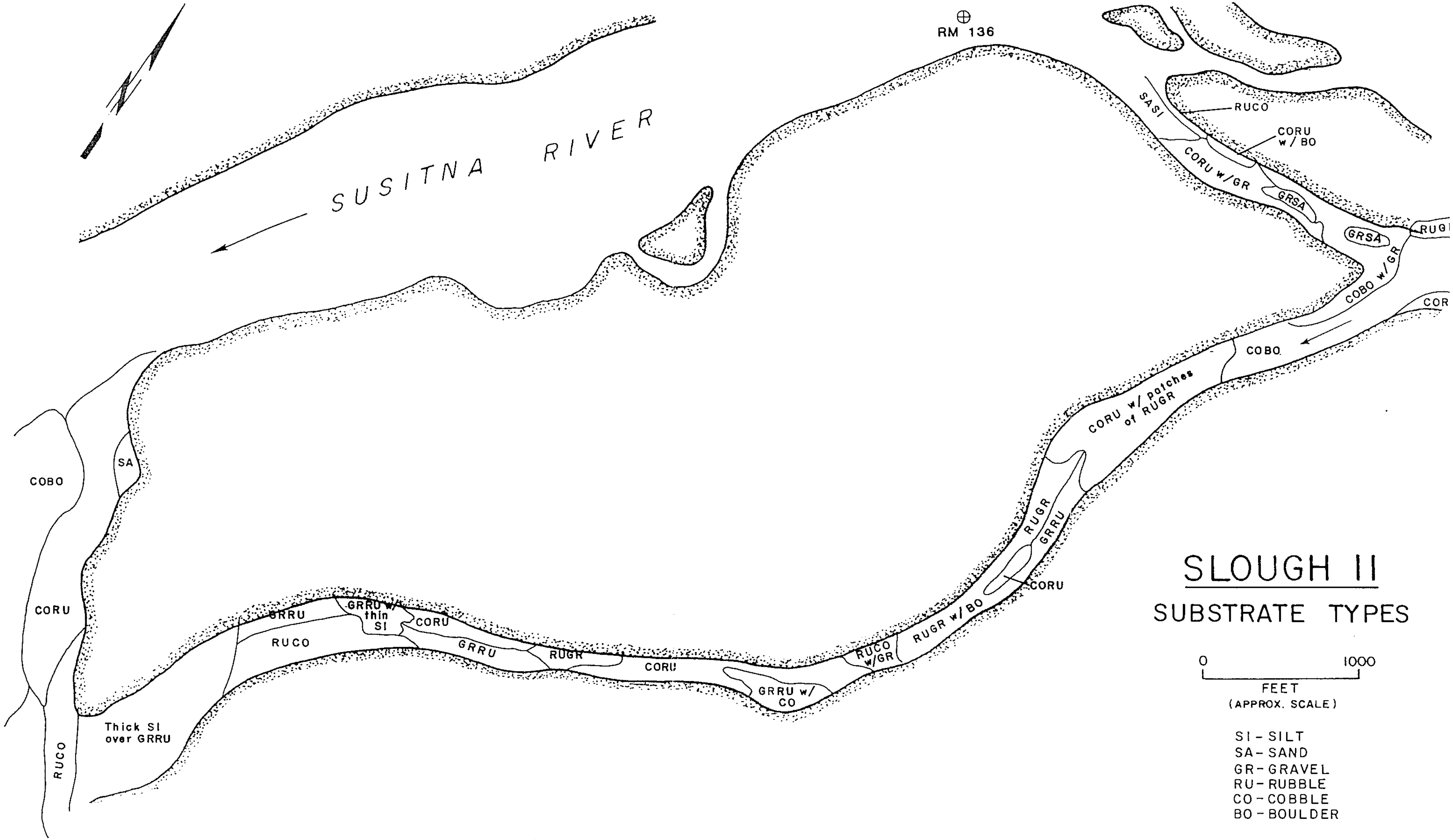

Figure 4II-3-23. Slough 11 substrate, 1982.

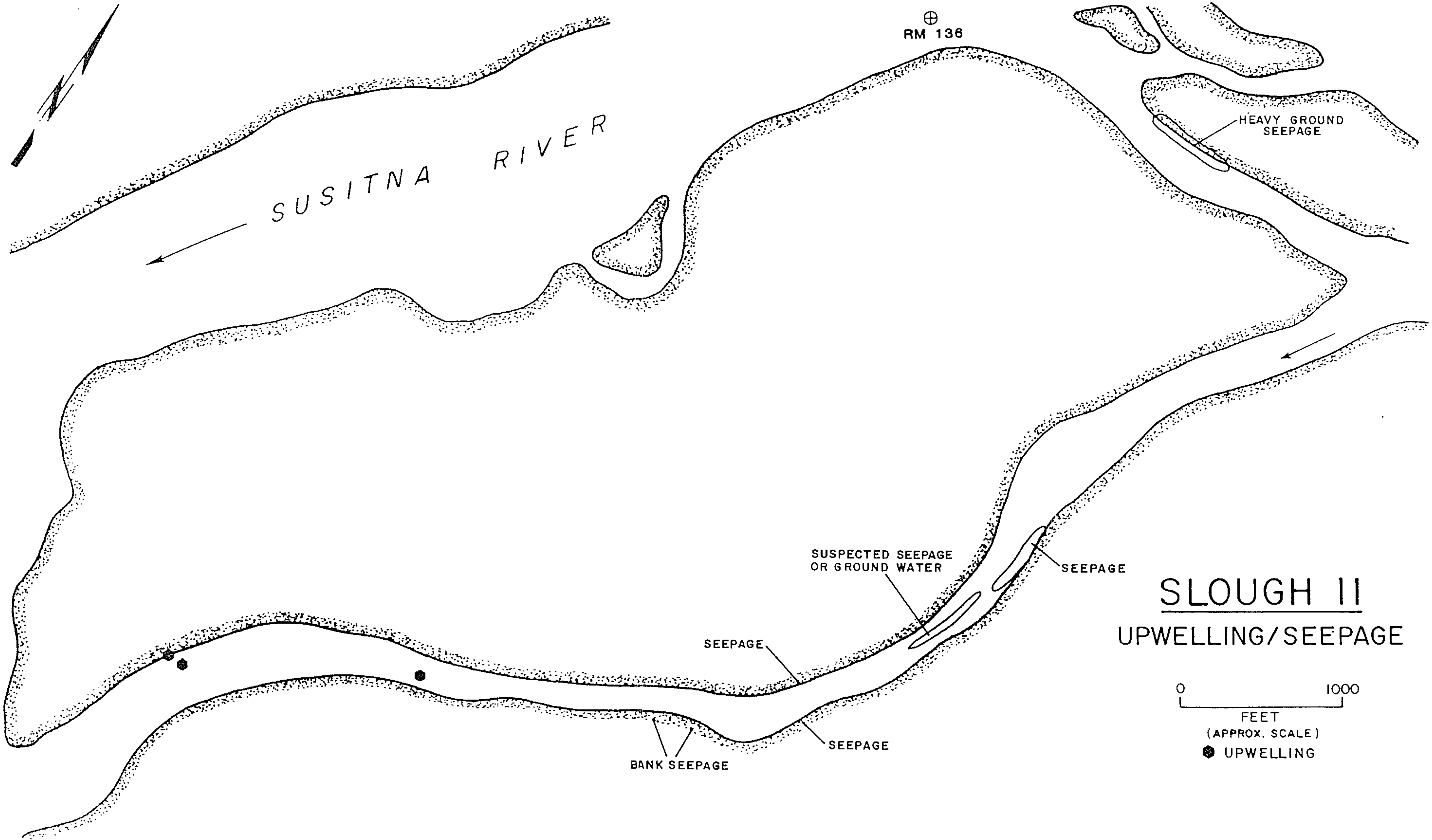

Figure 4II-3-24. Slough 11 upwellings, 1982.

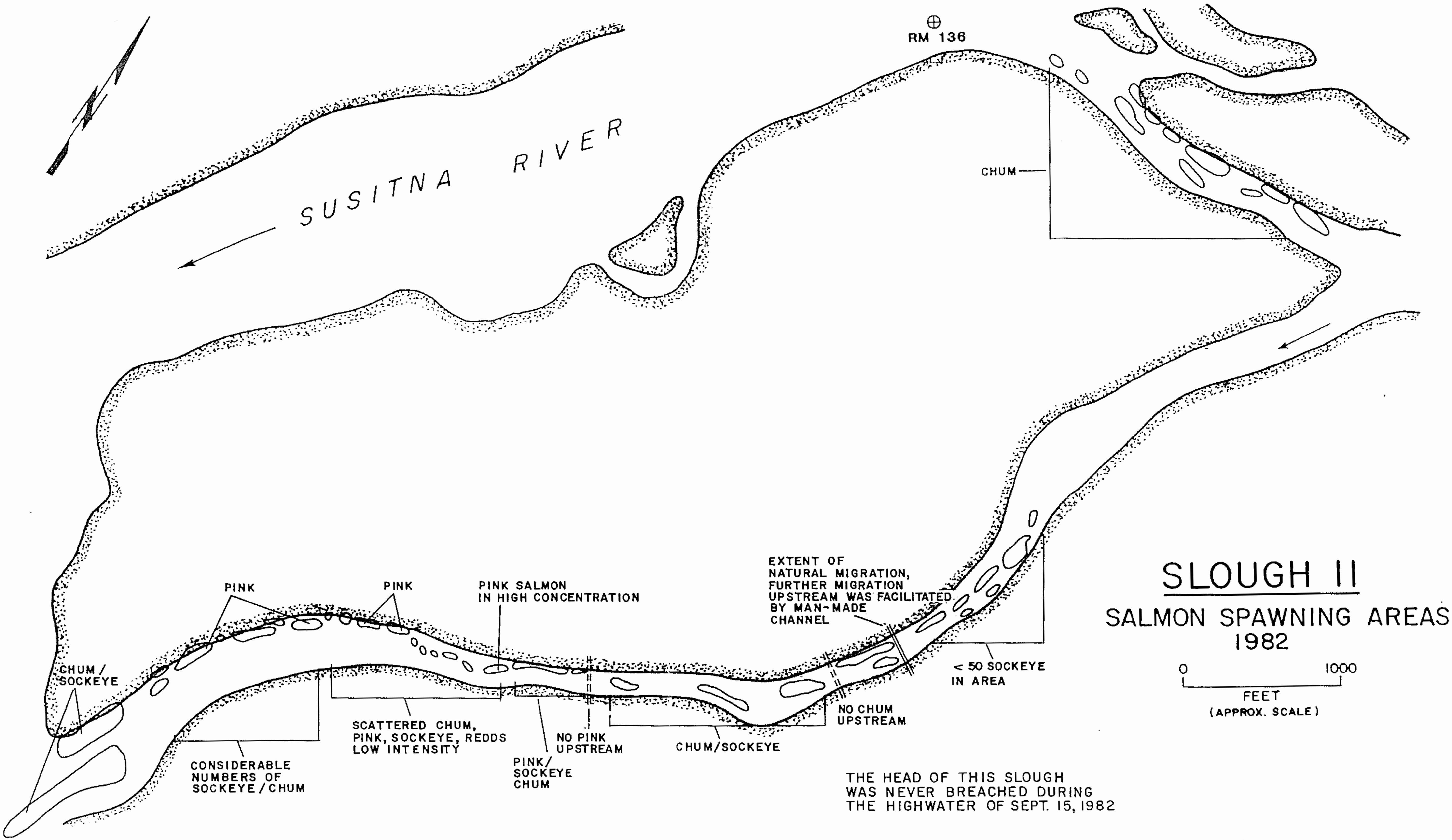

Figure 4II-3-25. Slough 11 spawning areas, 1982.

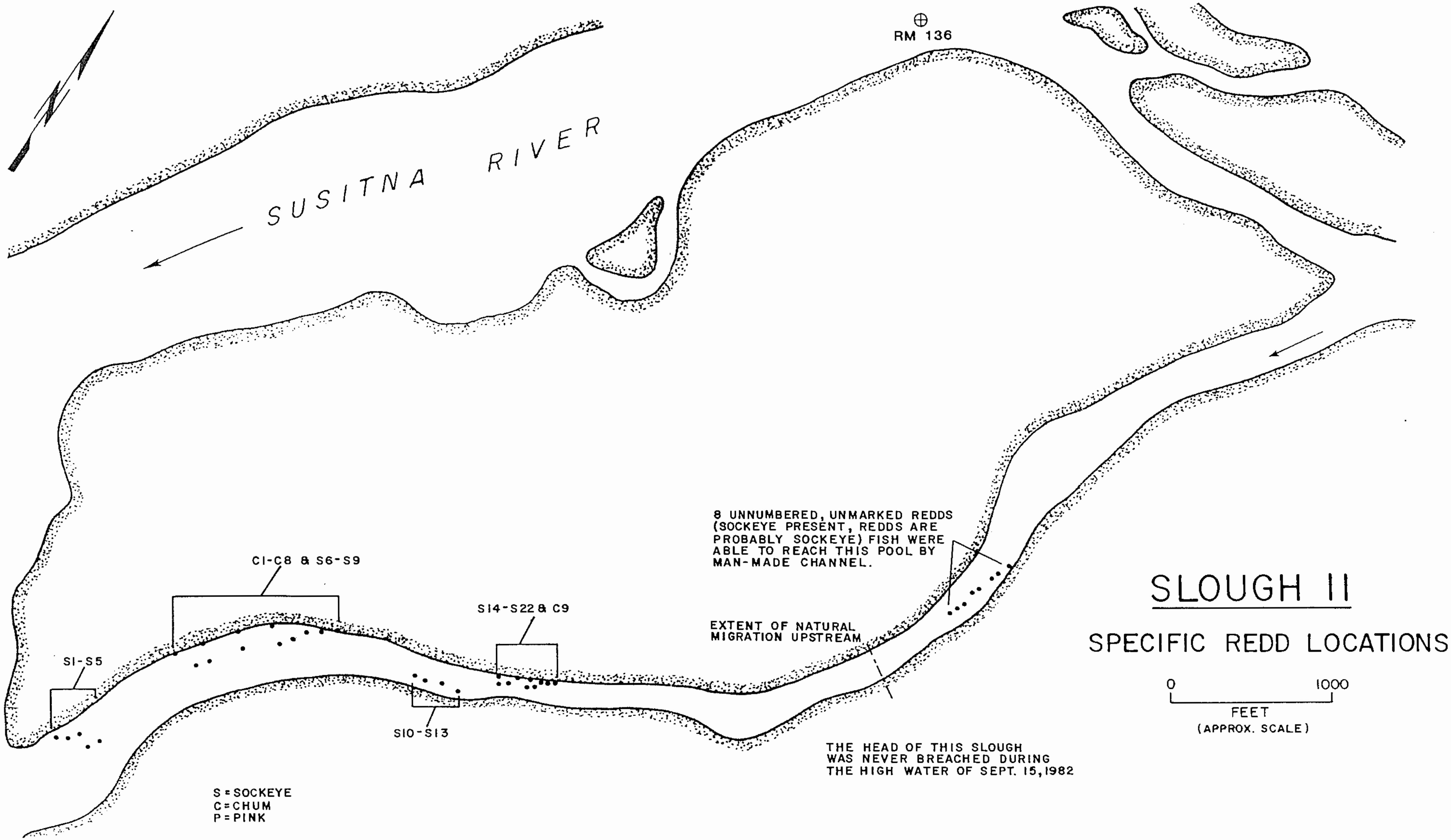

Figure 4II-3-26. Slough 11 redd locations, 1982.

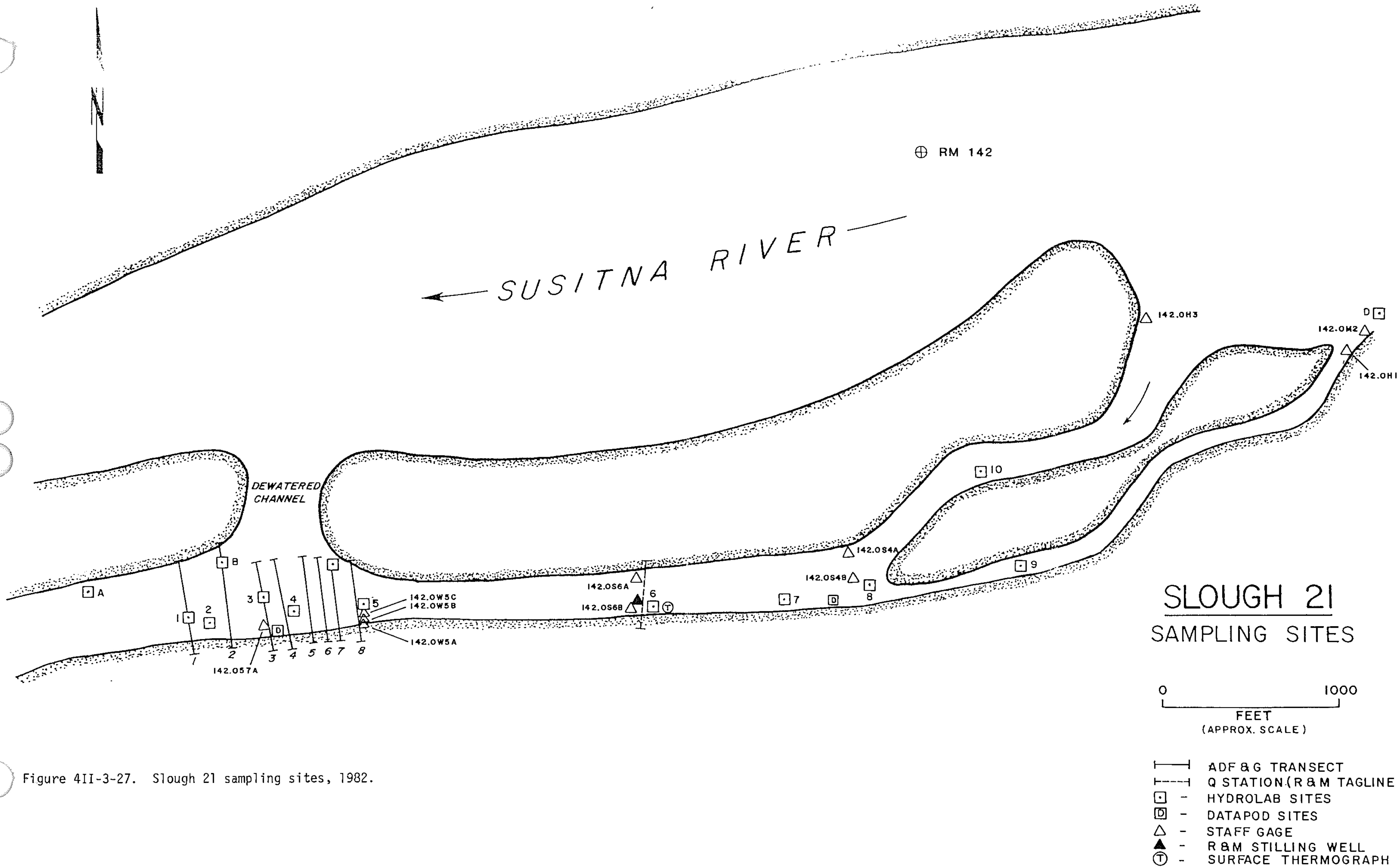

Figure 4II-3-27. Slough 21 sampling sites, 1982.

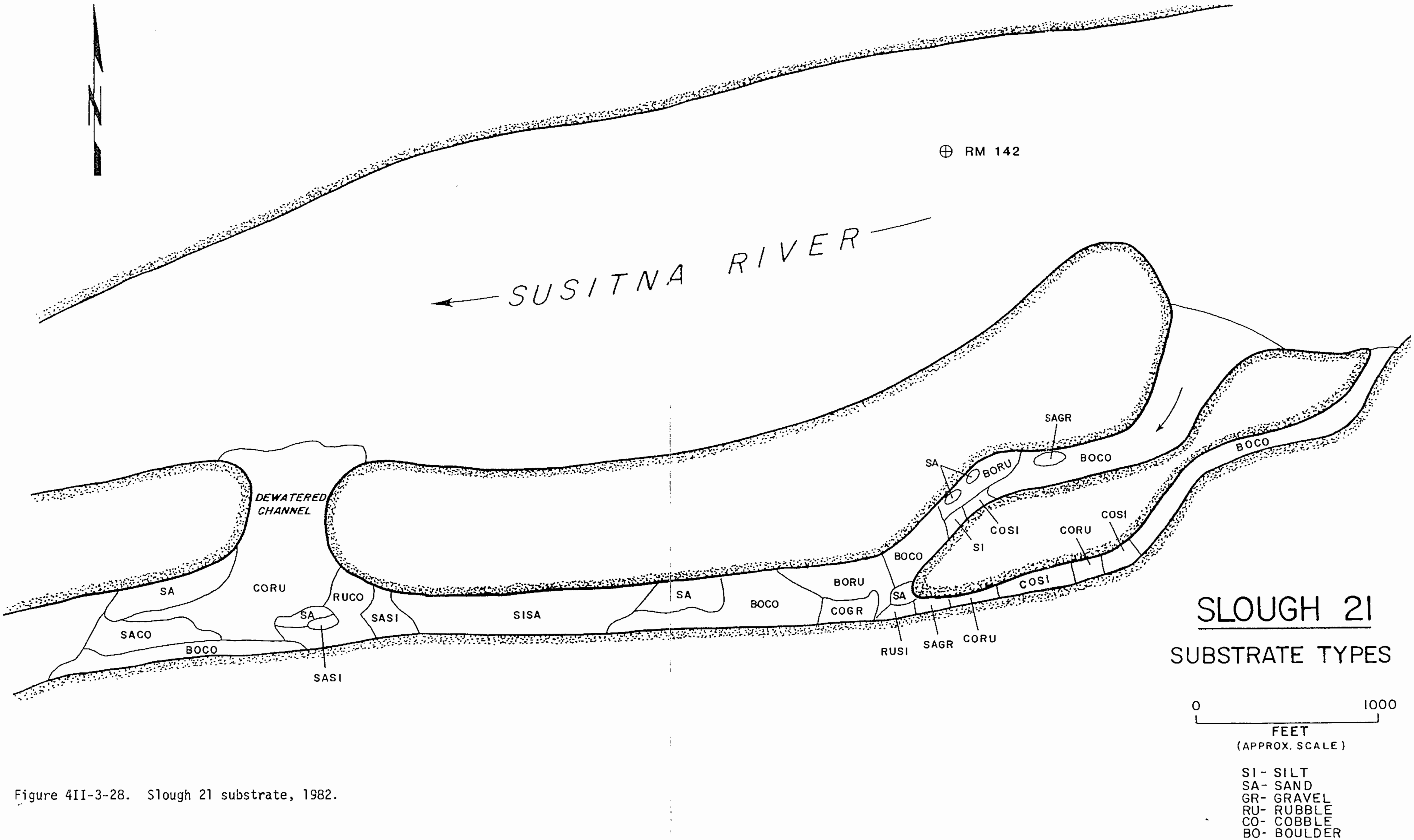

Figure 4II-3-28. Slough 21 substrate, 1982.

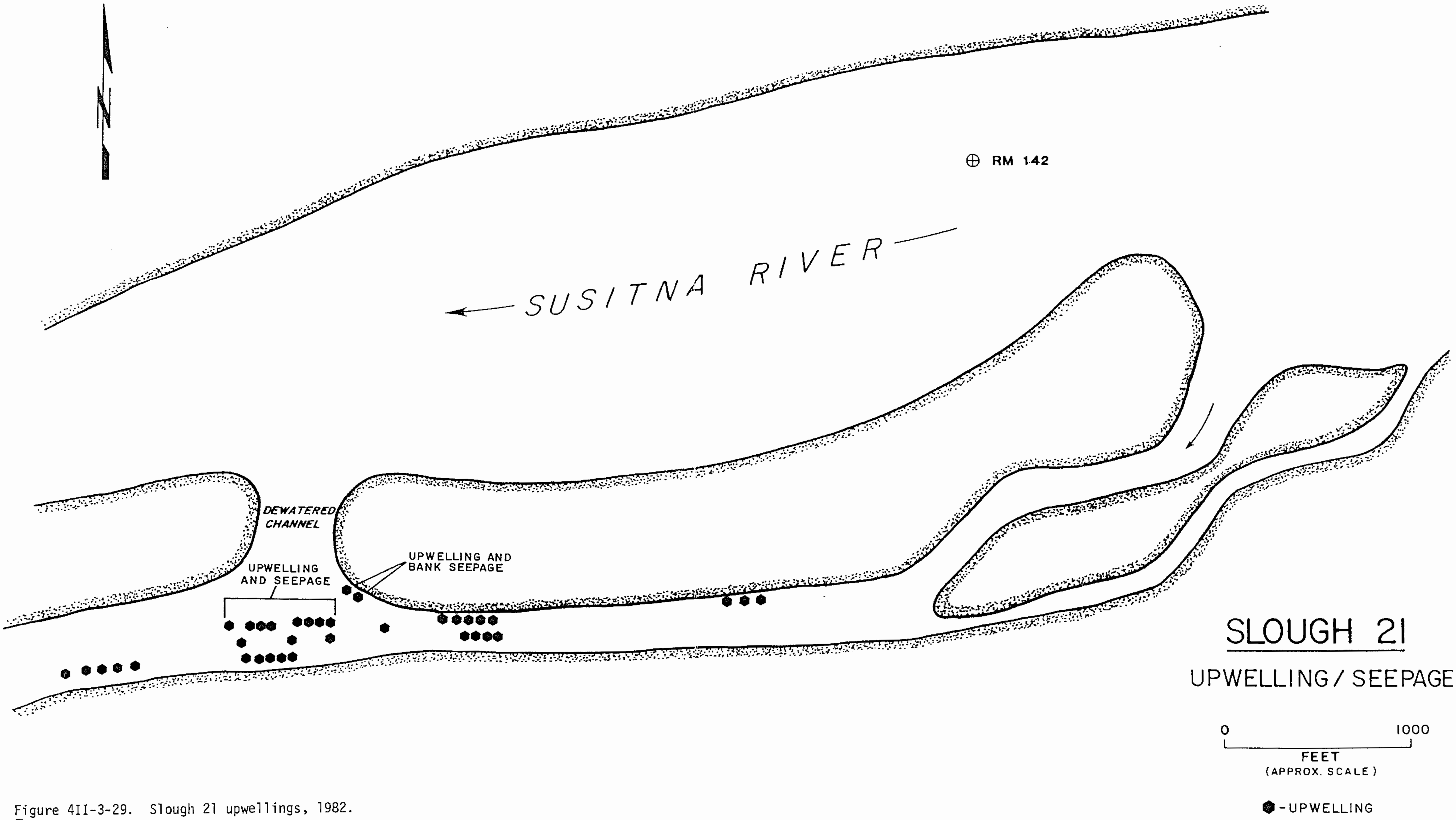

Figure 4II-3-29. Slough 21 upwellings, 1982.

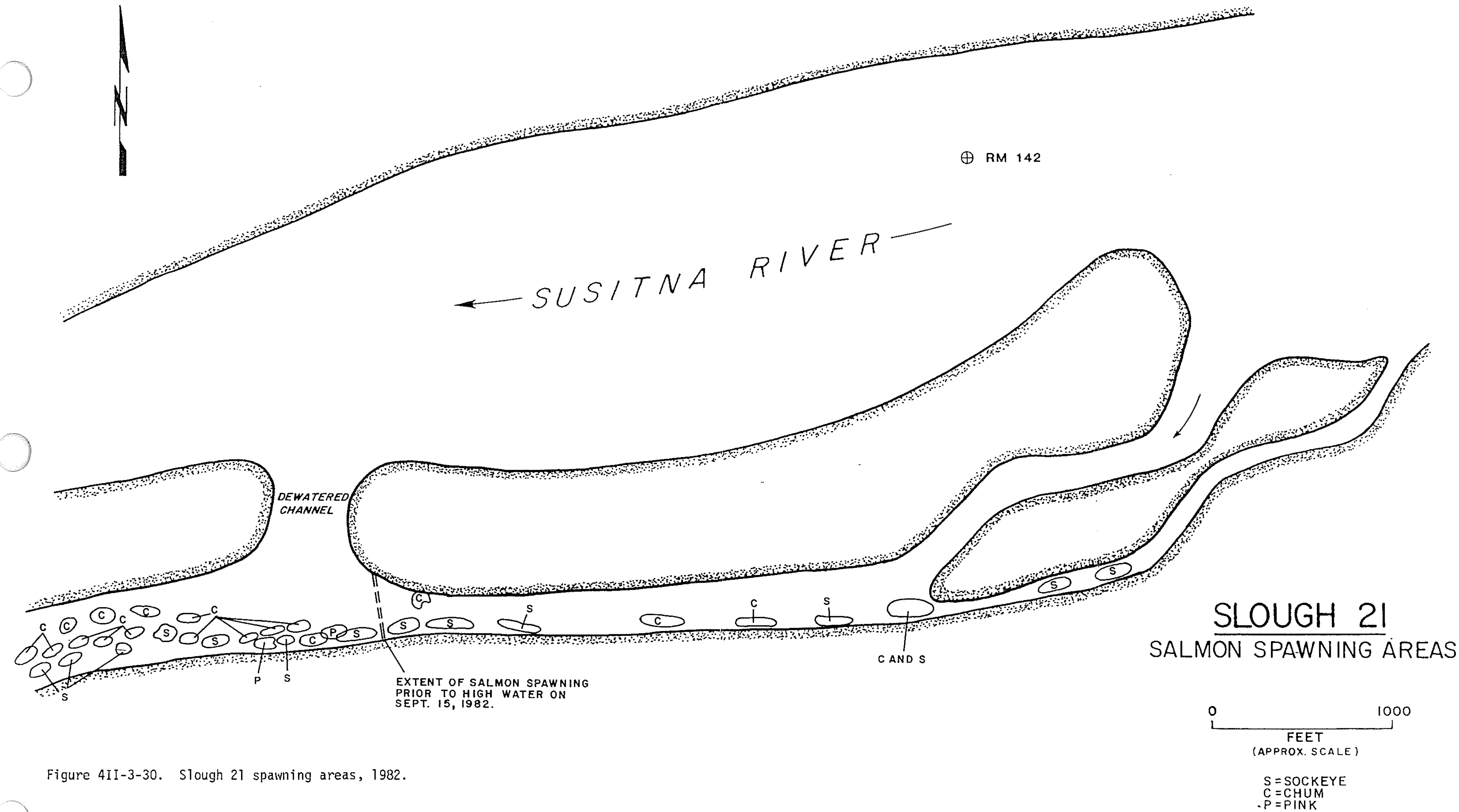

Figure 4II-3-30. Slough 21 spawning areas, 1982.

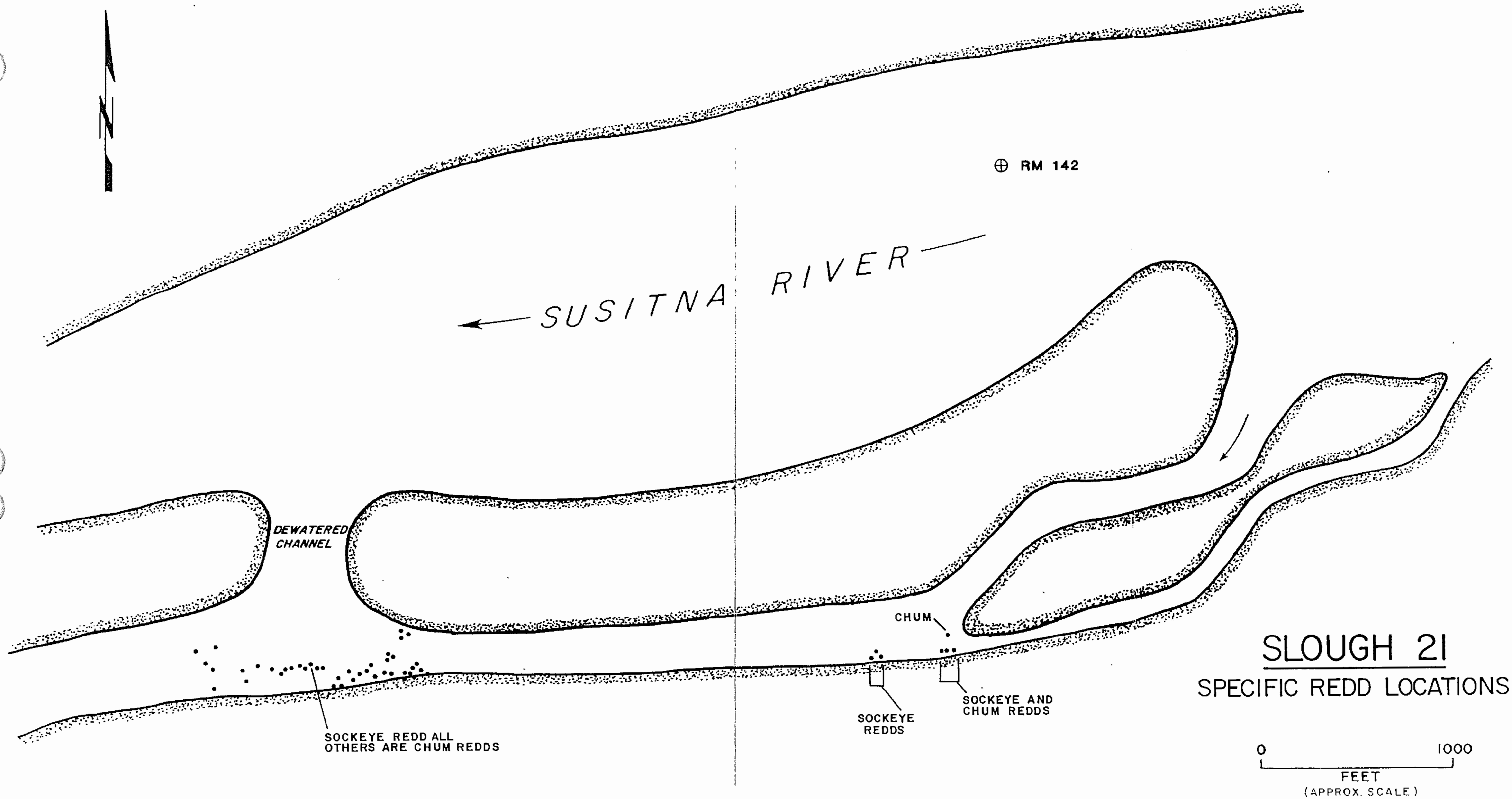

Figure 4II-3-31. Slough 21 redd locations, 1982.

3.1.1.2.2 Habitat Summaries

Site maps of substrates, upwelling areas, salmon spawning areas, specific redd sites, and sampling sites for sloughs 8A, 9, 11 and 12 show relationships of upwelling and substrates to selected spawning sites in each slough (Figures 4II-3-12 to 31). Chum salmon were the most abundant species found spawning in these sloughs, however, sockeye, pink and coho salmon were also observed spawning (also refer to sections 3.1.2, 3.1.3 and 3.1.4 of this report). Locations of observed spawning areas in the studied sloughs for these four species are presented in Figures 4II-3-15, 4II-3-20, 4II-3-25 and 4II-3-30.

Slough 8A

Slough 8A is relatively long (1.8 miles) and narrow, possessing two side branches and four major "heads" that allow hydrological influence with the mainstem Susitna River during medium and high flows.

At periods of low mainstem flow, the upper half of the slough was characterized by very low discharges (less than 5.0 cfs). During these periods, slough water is apparently comprised of surface runoff (from the right bank) and ground water, with no single source comprising an obvious majority of total water.

Due to restrictive beaver dams in the lower 0.5 mile section of the slough, the majority of chum salmon spawning sites occurred in the area below the dams. Cobble-rubble was the most commonly used substrate and only one site of upwelling was observed in this area. Dense concentrations of fish were found immediately below the dams, probably not because of a preference for this habitat but due to lack of access to upper slough areas.

During the high flow period in September, 1982, when the dams were breached, several salmon were observed spawning in upper slough areas. These fish also appeared to show a preference for cobble-rubble substrate. Several spawning sites occurred in areas of upwelling or seepage.

Slough 9

Slough 9 is a relatively short (1.2 miles) slough containing two tributaries along its right bank. Its non-vegetated channel is relatively wide and is maintained by periodic high flows of mainstem water breaching the head.

The extent of the backwater zone is highly variable, dependent upon the mainstem stage. In general, it varies from a small, relatively confined pool at very low mainstem levels, to an extensive backwater zone, over 600 feet long, at high mainstem discharges (for detailed discussion see Trihey 1982).

During periods when the head is not breached by mainstem water, most of the slough flow is contributed by surface runoff and groundwater, with groundwater sources probably being of lesser magnitude. During these times, flows are generally less than 10 cfs (when mainstem discharge at Gold Creek was 12,500 cfs on August 24, 1982 (USGS 1982), flow in Slough 9 was 3 cfs) which pose significant access problems for salmon.

Chum salmon spawning areas were found to be on both gravel-rubble and cobble-rubble substrates. However, it should be noted that when they occurred on gravel-rubble substrates there was extensive seepage and ground water in that area. This was the case in the primary chum spawning area for this slough.

Salmon spawning activity was limited to the lower half of the slough until high water on September 15, 1982, allowed access to the upper slough. During that period, salmon were observed as far up as Slough 9B.

Slough 11

Slough 11 is a relatively short slough (approximately 1.0 miles) that is essentially linear in shape and oriented almost parallel to the mainstem Susitna River. Unlike most sloughs, the head of this slough was never breached after spring breakup in 1982.

The channel bed is primarily devoid of silt (likely a result of infrequent breaching) and is arranged in an obvious pool/riffle sequence. Because it has no obvious tributaries, its flow is comprised almost entirely of ground water. However, since there is little or no silt on the slough bottom, upwelling areas are difficult to observe.

High concentrations of salmon were observed spawning in this slough. Chum salmon were observed most often on cobble-rubble substrates and several upwellings were observed in these areas.

Slough 21 Complex

The Slough 21 complex is basically comprised of the slough (as defined in ADF&G 1982a) and an extended access channel oriented parallel to the mainstem Susitna River.

During periods when the head is not breached, the relatively small discharge in the slough is primarily composed of water from a single small tributary (entering the right fork) and from ground water. Ground water appears to originate from localized seepages and upwellings along both banks below the mouth up to the fork (Plates 4II-3-3 and 4II-3-4).

Prior to the high water period on September 15, 1982, salmon spawning in this slough complex was limited to the channel immediately below the mouth of the slough. Observations of spawning fish was difficult in much of the access channel due to turbid water. Chum salmon were the most abundant species found spawning here. Most redds occurred on rubble-cobble substrates. Extensive upwelling and seepage were observed in these areas.

After high flows occurred, chum salmon were observed above the mouth. Several of these were found to be on silt-sand substrate in areas where upwelling occurred.

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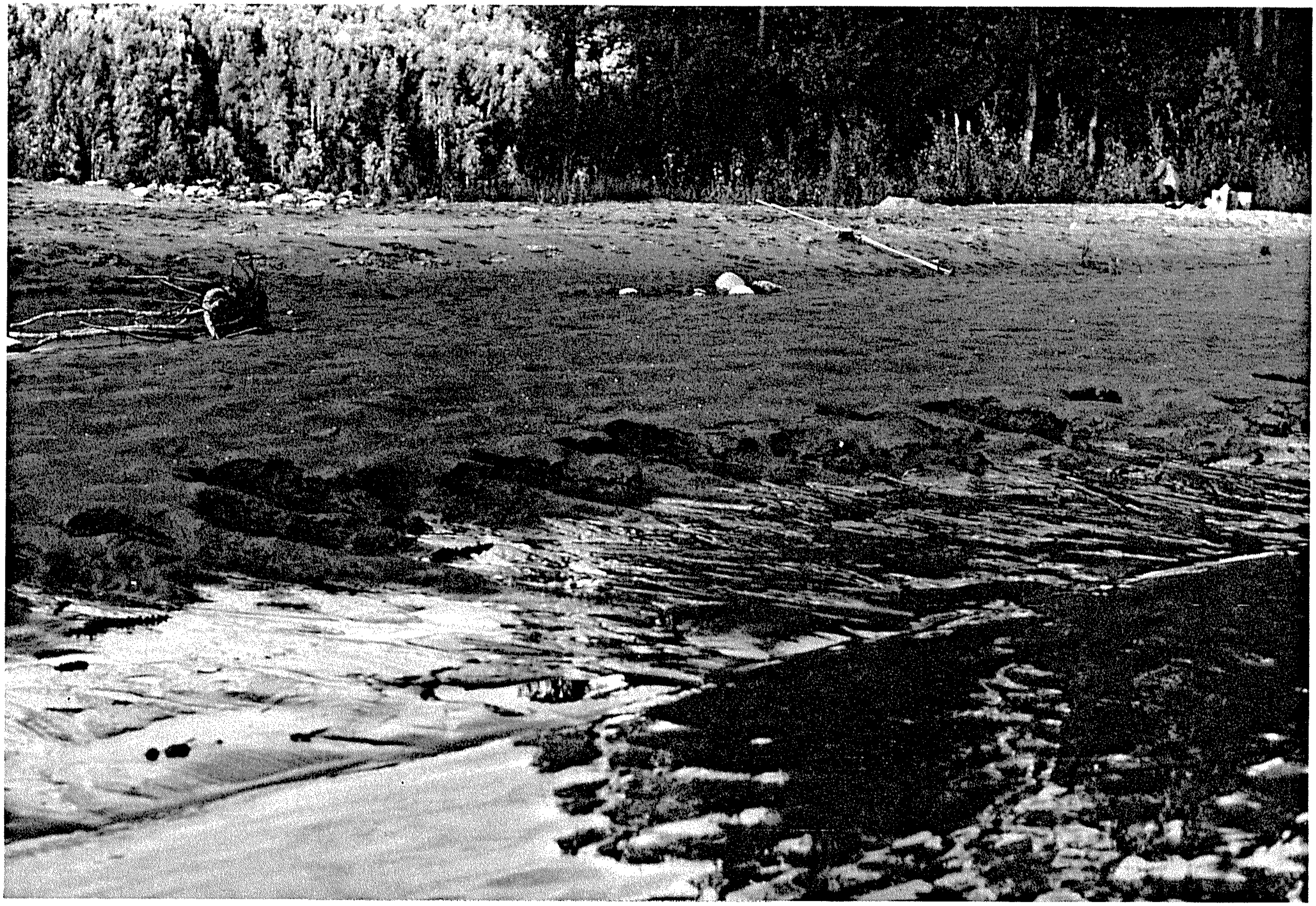

Plate 4II-3-3. Seepage of ground water sources into Slough 21

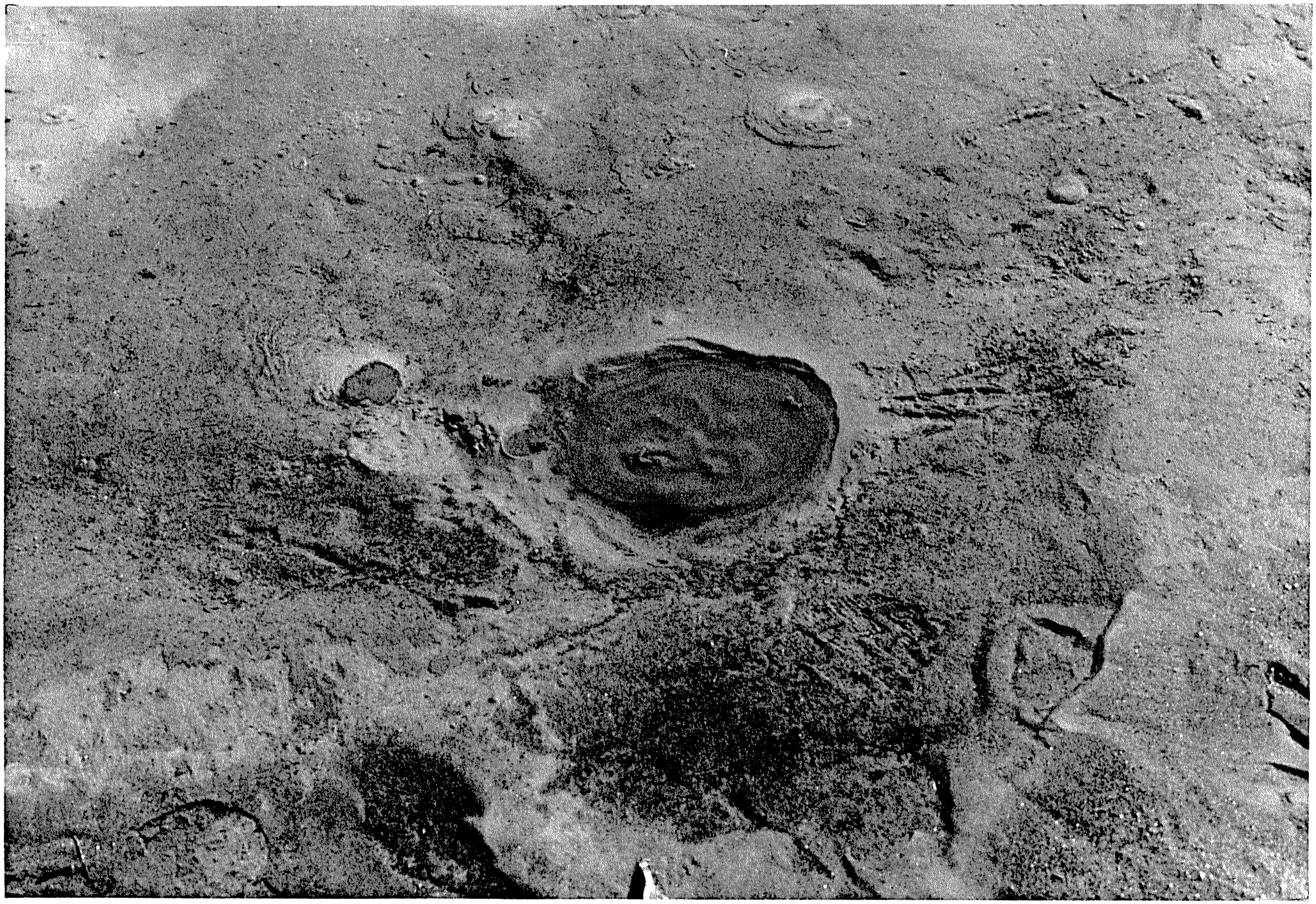

Plate 4II-3-4 Upwelling ground water in silted area of Slough 21.

3.1.1.2.3 Water Quality

The general water quality data collected in the sloughs to describe the characteristics in the slough are presented in Part I, section 3.2. The results of the specific study designed to look at intragravel water sources follows.

Intragravel temperatures were obtained along study transects to provide a basis for comparison to data collected at specified locations. In addition this data provides a means of evaluating variability in intragravel temperatures within transects of a particular slough and between study sites (data pooled for all transects within a study site). of different sloughs. These data (at study transects as well as at specific locations) are intended to supplement the continuous thermograph data (Appendix C) by providing a more detailed description of variability in water temperatures in sloughs at a single point in time (October, 1982). This time period was selected because mainstem flows and flows in sloughs are very low, allowing sources of ground water to be more easily observed. A summary of mean intragravel temperatures collected at transects (sloughs 8A, 9, 11, 21) and at specified locations (Slough 9B) is presented in Table 4II-3-3.

Surface water temperatures (Table 4II-3-4) were generally very cold since data were collected in early October. Mean temperatures for all locations (excluding tributaries and side channels) in sloughs 8A, 9, and 9B ranged between 1.4°C (Slough 9) and 4.2°C (Slough 9B). However,

Table 4II-3-3. Data summary of intragravel temperatures obtained at 1982 ADF&G study transects (sloughs 8A, 9, 21) and specified locations (sloughs 9B and 11) from September 30 to October 5, 1982.

Location	Mean (x)	Standard Deviation	Range	Sample Size (n)
Slough 8A	3.3	0.92	1.5 - 4.7	20
Slough 9	3.0	0.58	1.9 - 4.2	17
Slough 21	3.3	0.37	2.9 - 4.2	72
Slough 9B	3.8	0.18	3.6 - 4.3	16
Slough 11	4.6	0.65	3.7 - 5.7	18

Table 4II-3-4. Data summary for surface water temperatures (°C) at specified locations in sloughs 8A, 9, 9B, and 11 collected during October 1-5, 1982 (raw data in Appendix D).

Slough	Location[a]	$\bar{x}$	SD	Range	N
8A	Side channel	3.2	--	3.1-3.4	2
8A	Spawning A	3.0	--	2.5-3.4	2
8A	Spawning B	2.4	--	2.1-2.6	3
8A	Spawning C	2.8	--	2.7-2.9	3
9	Pool A	3.2	0.59	2.7-3.9	6
9	Upwelling A	3.1	0.94	1.8-4.7	10
9	Datapod (1-6)	3.1	0.08	3.0-3.2	6
9	Transects (5-6)L	1.8	0.18	1.5-2.2	10
9	Transects (5-6)M	1.6	0.00	1.6-1.6	10
9	Transects (5-6)R	1.4	0.11	1.2-1.5	10
9	Mid-slough	3.2	--	--	1
9	Tributary B	2.2	--	--	1
9	Tributary B'	2.3	--	--	1
9	Tributary B"	1.8	--	--	1
9	Pool C	2.9	--	2.4-3.2	4
9B	Mouth	2.5	0.81	1.5-3.2	5
9B	Mid-slough	2.9	0.25	2.5-3.2	5
9B	Upwelling B	4.2	0.20	3.9-4.4	7
11	Left bank (LB)	5.3	0.32	4.7-5.6	6
11	Mid-slough (M)	5.2	0.30	4.7-5.6	6
11	Right bank (RB)	5.0	0.53	4.2-5.6	6
11	Upper pool	5.2	0.11	5.0-5.3	5

[a] Refer to Figures 4II-2-1 to 4II-2-3 for schematic maps of sloughs 8A and 9.

surface water temperatures in Slough 11 were generally 1-2°C higher. Surface temperatures were not obtained in Slough 21.

Mean temperatures obtained at the substrate/water interface were generally between intragravel and surface water temperatures (Table 4II-3-5). The degree to which they resembled surface or intragravel temperatures appeared to be a function of depth and/or velocity, thus substrate/water temperatures were not reliable predictors of ground water upwelling.

Surface Water Sources

Specific conductance was a reliable indicator of different surface water sources (tributaries of prominent seepage) in sloughs 8A and 9. Their contribution to water quality in these sloughs was evaluated by measuring specific conductance at several locations downstream of their observed points of entry.

In Slough 8A (Table 4II-3-6) values of specific conductance varied in a consistent pattern. The mean value for the left side of the channel (Transects (1-11)L) was highest mid-channel (Transects (1-11)M) was intermediate and right side (Transects (1-11)R) was lowest. Specific conductance along the right side was probably due to surface water draining from beaver ponds along the bank (values were as low as 44 umhos/cm in this area).

Table 4II-3-5. Data summary for substrate/water interface temperatures (°C) collected at specified locations in sloughs 8A, 9, 9B, 11 and 21 during October 1-5, 1982 (raw data in Appendix D).

Slough	Location[a]	$\bar{x}$	SD	Range	N
8A	Transects (1-11)L	3.3	0.56	2.4-4.2	11
8A	Transects (1-11)M	2.6	0.37	2.1-3.4	11
8A	Transects (1-11)R	3.0	0.21	2.7-3.3	11
8A	Pool (L,M,R)	4.2	--	4.1-4.4	3
8A	Channel (L,M,R) Transect (1-2)L	2.4	--	2.2-2.6	3
9	Datapod (1-6) Transect (1-2)L'	3.0	0.20	2.6-3.2	6
9	Datapod (1'-6')	3.5	0.36	2.9-3.9	6
9B	Mouth	3.8	0.20	3.6-4.0	5
9B	Mid-slough	3.9	0.32	3.6-4.4	5
9B	Upwelling B	3.8	0.12	3.7-4.0	6
11	Left bank (LB)	4.9	0.79	3.8-5.8	6
11	Mid-slough (M)	4.7	0.50	4.2-5.5	6
11	Right bank (R)	5.0	0.64	4.1-5.6	6
11	Upper pool	4.4	0.11	4.2-4.5	5

[a] Refer to Figures 4II-2-1 to 4II-2-3 for schematic maps of sloughs 8A and 9.

Table 4II-3-6. Data summary for specific conductance (umhos/cm), collected at specified locations in sloughs 8A and 9 during October 3-5, 1982 (raw data in Appendix D).

Slough	Location[a]	$\bar{x}$	SD	Range	N
8A	Transects (1-11)L	118	16.60	98-147	11
8A	Transects (1-11)M	89	6.71	84-108	11
8A	Transects (1-11)R	74	16.16	44-90	11
8A	Pool (L,M,R)	139	--	132-152	3
8A	Channel (L,M,R)	86	--	84-88	3
8A	Side channel	166	--	115-218	2
8A	Spawning A	128	--	123-133	2
8A	Spawning B	111	--	110-112	3
8A	Spawning C	114	--	111-117	3
9	Pool A Transect (1-2)L	215	17.77	194-233	6
9	Datapod (1-6) Transect (1-2)L'	102	3.58	98-108	6
9	Datapod (1'-6')	115	2.58	111-118	6
9	Transect (5-6)L	132	6.29	121-140	10
9	Transects (5-6)M	92	3.92	89-102	10
9	Transects (5-6)R	89	1.10	87-90	10
9	Transects (6-10)L	132	5.79	122-142	8
9	Mid-slough	153	--	--	1
9	Tributary B	70	--	--	1
9	Tributary B'	69	--	--	1

Table 4II-3-6 (Continued).

Slough	Location[a]	$\bar{x}$	SD	Range	N
9	Tributary B"	39	--	--	1
9	Pool C	125	--	119-137	4
9	Transects (B1-B5)	94	9.73	78-103	5
9	Transects (A1-A5)	104	28.01	72-149	5
9	Transects (C1-C5)	72	4.82	65-76	5
9	Transects (C1'-C5')	82	3.42	78-87	5

[a] Refer to Figures 4II-2-1 to 4II-2-3 for schematic maps of sloughs 8A and 9.

Spawning areas had relatively higher specific conductance. It is likely that water from a side channel entering the left slough side immediately above the spawning location. Specific conductance elevated in downstream locations.

A similar pattern occurred in Slough 9. Low specific conductance on the right side of the slough was undoubtedly due to the effect of a plume extending downstream from the confluence of the Tributary B, B', B" complex (Table 4II-3-6). Specific conductance immediately above the tributary complex (153 umhos/cm) higher than either left, mid, or right bank specific conductance between transects five and six. These data indicate that tributary water remained partially unmixed as far downstream as transect 5 and resulted in a downstream reduction in specific conductance values. This was also evidenced along two parallel transects located below Tributary A. Specific conductance values along the right bank transect (C1-C5) were lower than those in the slough channel, suggesting a "plume effect" due to water entering from Tributary A (values in Tributary A were not obtained).

Ground Water Sources

Relatively high specific conductance was also detected Pool A, Transects (1-2)L and Pool C of Slough 9. Specific conductance in Pool A were the highest encountered. Water was apparently originating from a dry channel bed connecting the slough with the mainstem Susitna River. At Transects (1-2)L the specific conductance along the bank was significantly higher (Mann-Whitney U test, P=0.05) along a parallel transect, six feet into the slough channel. Pool C had a mean specific conductance similar to that at Transects (1-2)L and was also significantly different from water in the slough channel at Datapod (1-6) (Mann-Whitney U test, P=0.05).

In general, sloughs 8A and 9 exhibited the widest ranges in mean intragravel temperatures (Table 4II-3-7). Means within sloughs 9B, 11 and 21 differed by less than 1°C (0.2, 0.7 and 0.3°C, respectively). Undoubtedly, time of year, choice of sampling locations and different levels of sampling effort would effect mean temperature, limiting the application of the above data outside its present context.

In Slough 8A, intragravel water temperatures from Spawning B were lowest, probably reflecting surface water temperatures. This spawning area had more rapidly flowing water than either of the other locations, and water may have inundated the substrate to a greater degree.

In Slough 9, mean intragravel water temperatures were also quite variable between locations. Pool A and Upwelling A temperatures were approximately 1°C warmer than either transect near the datapod, with the warmest and coldest mean intragravel water temperatures at Pool A and Transects (1-2)L, respectively. Intragravel water temperature at Slough 9B were very uniform. Mean temperatures at three locations (Table 4II-3-7) were within 0.2°C. Since all values at Upwelling B were obtained in obvious upwelling vents, the uniformity in temperatures (and standard deviations) suggests that upwelling may be occurring in the other areas as well. However, this conclusion does not comply with

Table 4II-3-7. Data summary for intragravel temperatures (°C) collected at specified locations in sloughs 8A, 9B, 11 and 21 during October 1-5, 1982 (raw data in Appendix D).

Slough	Location[a]	$\bar{x}$	SD	Range	N
8A	Spawning A	4.0	--	3.9-4.1	2
8A	Spawning B	2.6	--	2.1-3.1	3
8A	Spawning C	4.6	--	4.4-4.9	3
9	Pool A	4.2	0.33	3.8-4.6	6
9	Upwelling A	4.0	0.32	3.6-4.7	10
9	Transects (1-2)L	2.8	0.24	2.7-3.2	6
9	Transects (1-2)L'	3.1	0.32	2.8-3.6	6
9B	Mouth	3.7	0.19	3.4-3.9	5
9B	Mid-slough	3.9	0.27	3.6-4.3	5
9B	Upwelling B	3.8	0.14	3.6-4.0	7
11	Left bank (LB)	4.8	0.87	3.7-5.9	6
11	Left bank (M)	4.7	0.50	4.2-5.5	6
11	Left bank (RB)	5.0	0.64	4.3-5.6	6
11	Upper pool	4.3	0.10	4.2-4.4	5
21	Transects (4-5)L	3.4	0.15	3.3-3.6	6
21	Transects (4-5)R	3.1	0.05	3.0-3.1	6

[a] Refer to Figures 4II-2-1 to 4II-2-3 for schematic maps of sloughs 8A and 9.

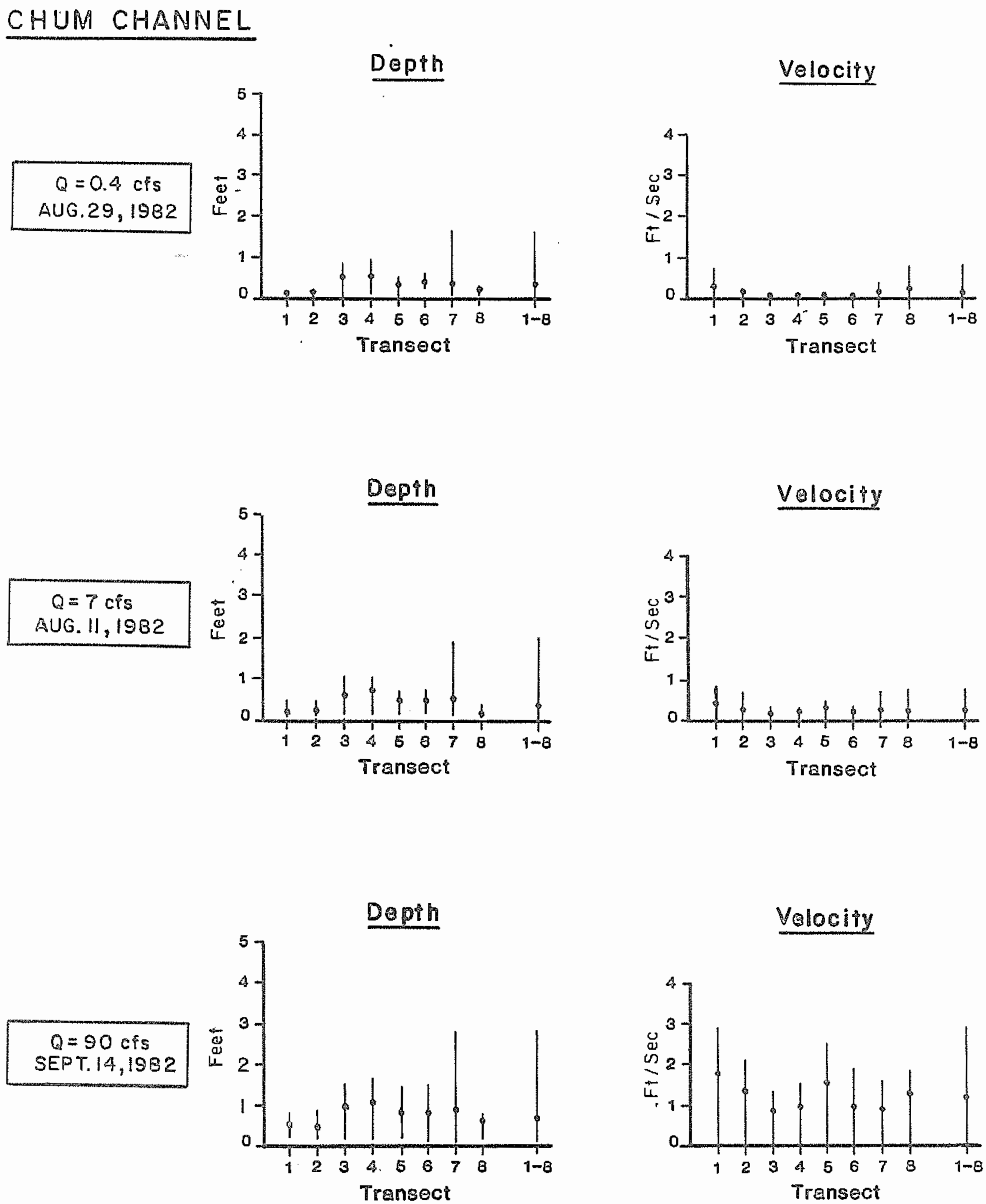

Figure VII-3-32. Depths and velocities (mean and range) of chum channel transects at three discharges in 1982.

RABIDEUX SLOUGH

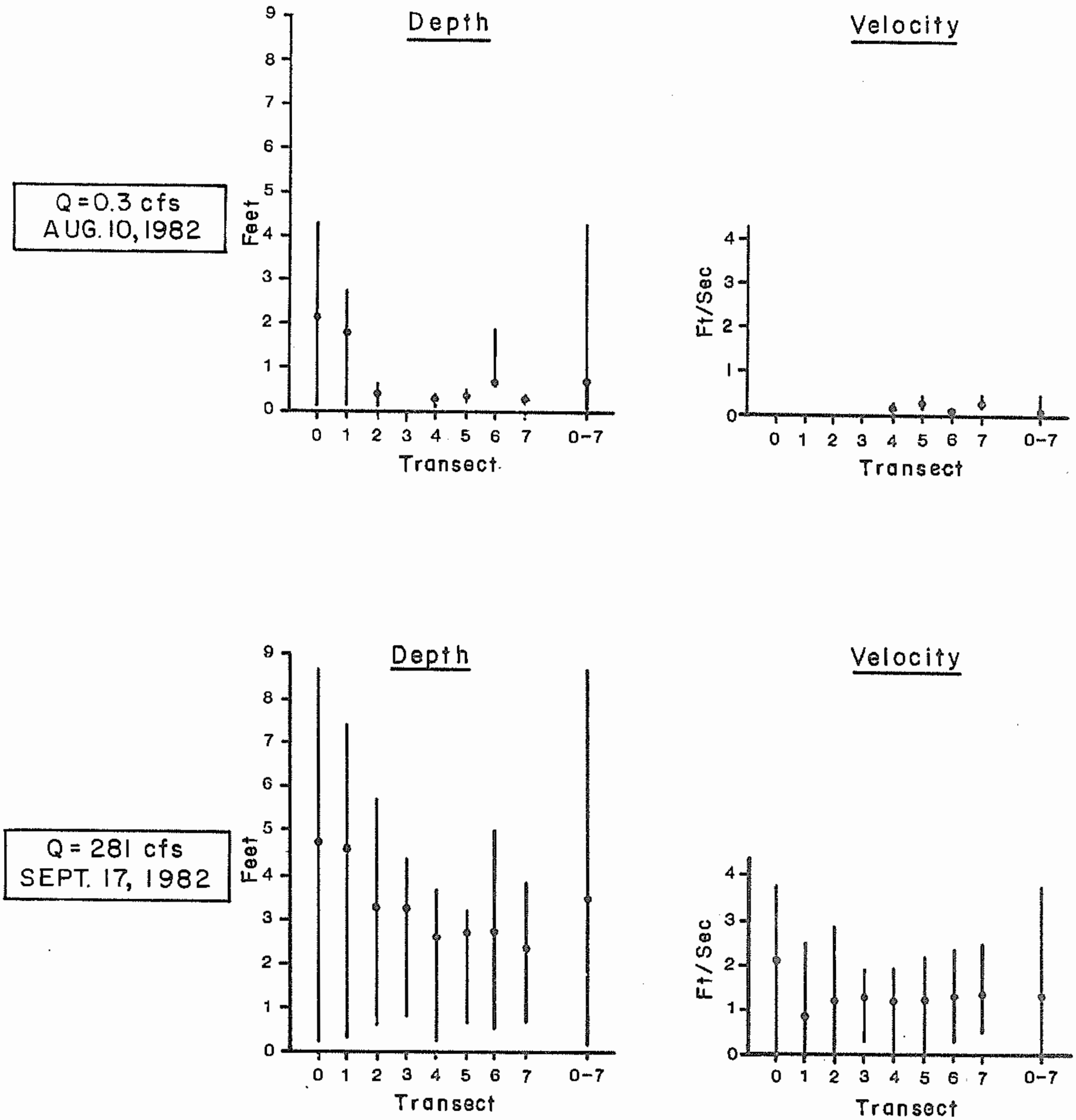

Figure 4/II-3-33. Depths and velocities (mean and range) of Rabideux Slough transects at two discharges in 1982.

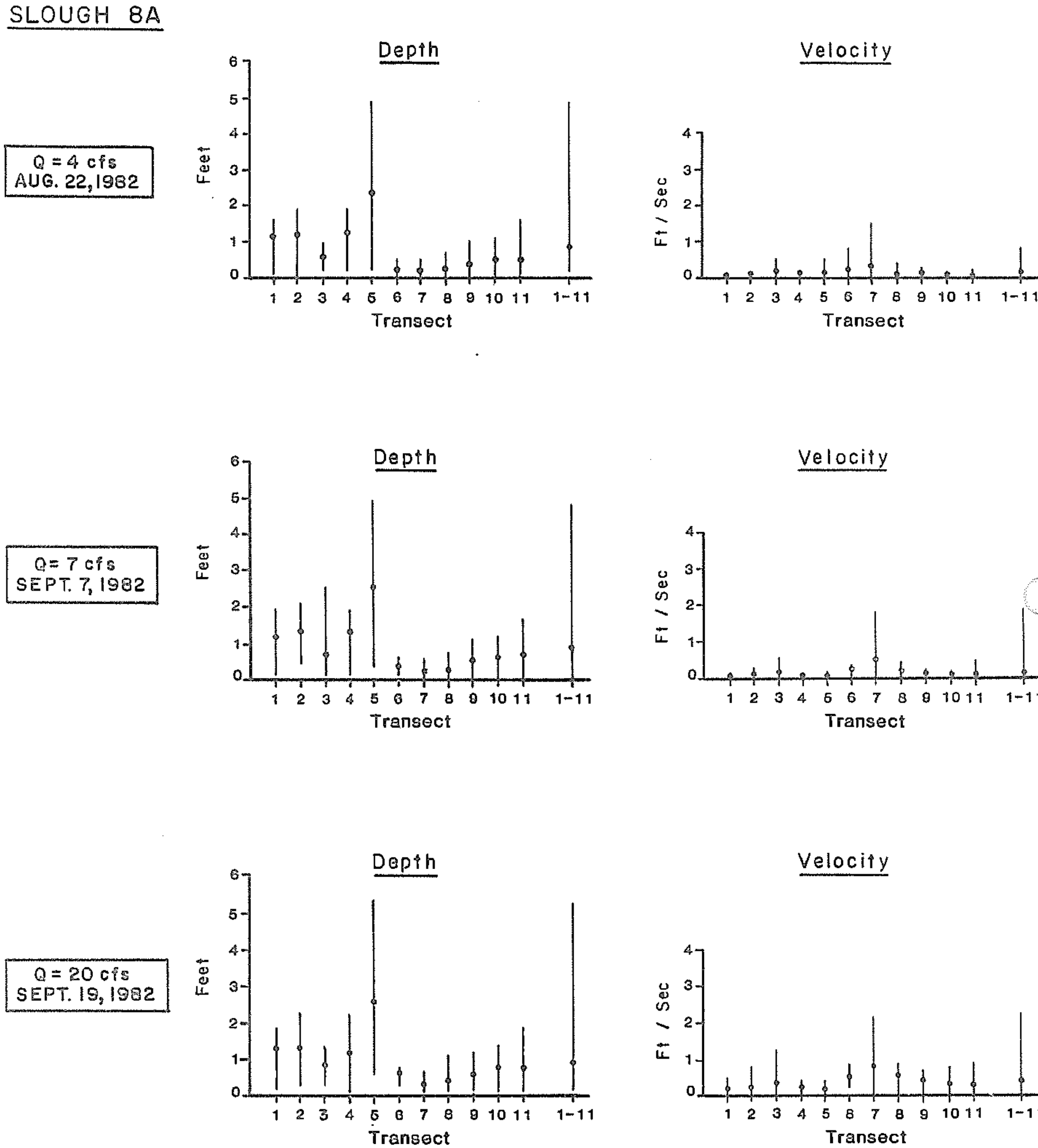

Figure VII-3-34. Depths and velocities (mean and range) of Slough 8A transects at three discharges in 1982.

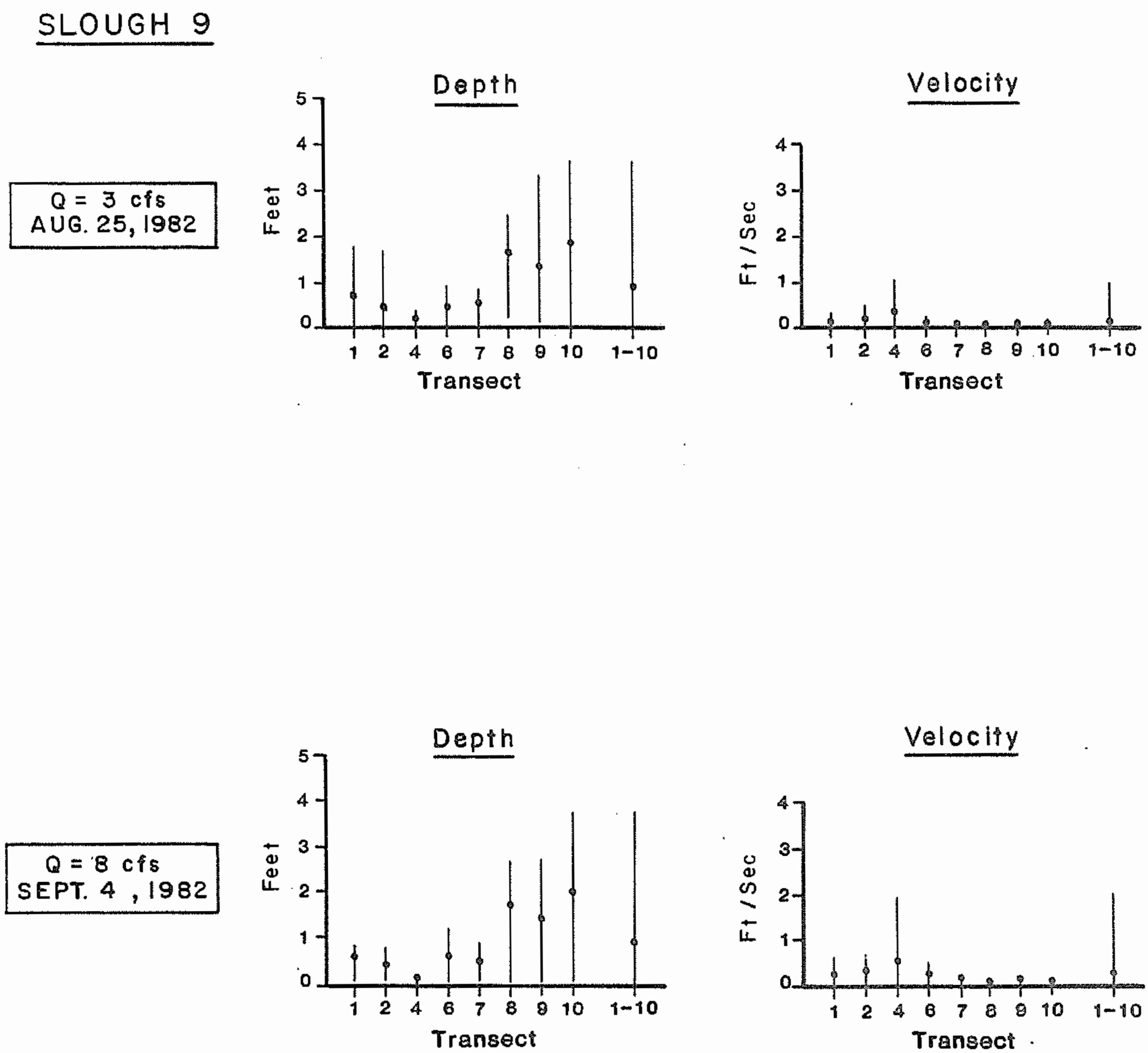

Figure 4II-3-35. Depths and velocities (mean and range) of Slough 9 transects at four discharges 1982.

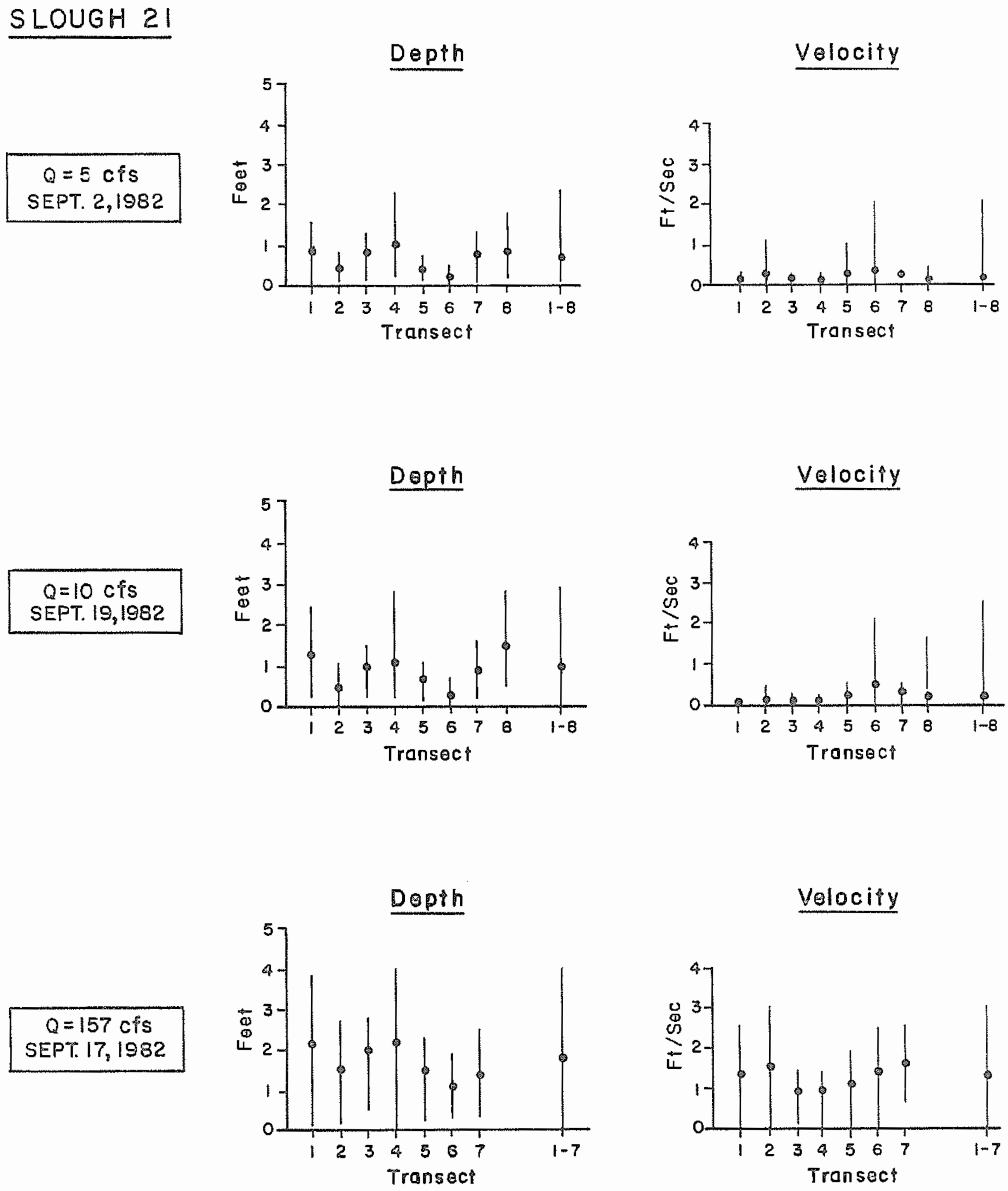

Figure VII-3-36. Depths and velocities (mean and range) of Slough 21 transects at three discharges in 1982.

observations made at the mid-slough location. Although this area was overlain with several inches of silt, no obvious upwelling vents were observed. More data would be necessary to support or refute the above hypotheses.

Mean intragravel water temperatures in Slough 11 were warmer than those in other sloughs, except in the uppermost pool (Table 4II-3-7). Readings in this pool were collected along the left bank where sockeye salmon had selected redds. This is noteworthy, since mean surface water temperatures were typically lower than mean intragravel water temperatures in all sloughs except Slough 11. Intragravel water temperatures in this pool were well below surface water temperature (x = 5.2°C). This suggests that one or more warm water sources were not detected. This is understandable since there is little silt in the entire slough, making visual detection of upwelling nearly impossible. To locate all areas of upwelling undoubtedly would have required a much larger sampling effort.

3.1.1.2.4 Available Habitat

Water depths and velocities were sampled across segments, including riffles, runs and pools, of Chum Channel, Rabideux Slough and sloughs 8A, 9 and 21, (Figures 4II-3-32 to 36, Appendix B). At low discharges, a transect with a narrow range of depths and wide range of velocities indicates a riffle. A transect with a wide range of depths and a narrow range of velocities indicates a pool. At higher discharges this relationship is obscured.

The range and weighted mean for each discharge (Figures 4II-3-34 to 36) are compared with the ranges and means of the depths and velocities at chum salmon redds in three sloughs during August and September (Figure 4II-3-37, Appendix B). The means of available and utilized water depths and velocities were approximately the same. However, chum salmon redds were located in the shallower depths, less than 2.5 feet. More samples are needed to verify this relationship at higher discharges. Not enough data are yet available to indicate similar patterns for sockeye and pink salmon which also spawn in these sloughs (Appendix B).

Because chum salmon are the primary users of side slough habitats for spawning, most intragravel temperatures were obtained at chum salmon redds. Temperatures at pink salmon redds were only collected at two redds in Slough 9, and data collected at sockeye redds was primarily limited to Slough 11. With the exception of two redds in Slough 8A, all intragravel temperatures collected at chum redds were between 4.7 and 6.3°C, with most temperatures between 4.5 and 4.9°C.

3.1.2.2.5 General Slough

Water quality data for Whiskers Creek Slough, Slough 6A, Lane Creek Slough, sloughs 9A, 10, 16, 19, 20 and 22 are found in Appendix D. Maps showing substrate, upwelling, and spawning areas are on file at ADF&G Su Hydro office (2207 Spenard Road, Anchorage, Alaska 99503). Detailed maps are not presented in draft due to limitations of time and manpower.

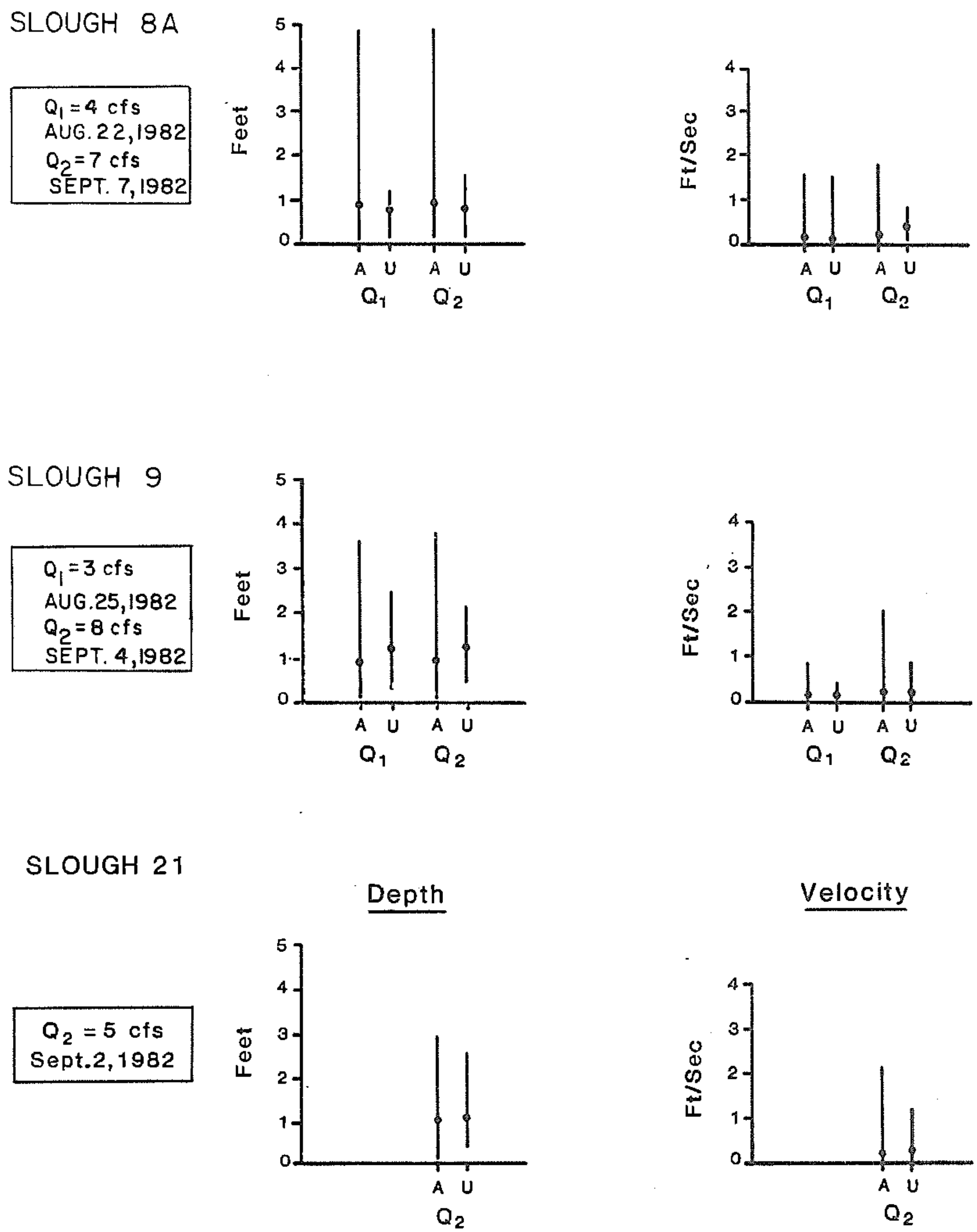

Figure 4II-3-37 Mean and range of depths and velocities available (A) and utilized (U) for chum redds in three sloughs during August 25-26 (Q_1) and September 2-7 (Q_2), 1982.

3.1.2 Sockeye

Sockeye salmon were observed spawning in specific study sloughs, however, they were not fund in large numbers. In Slough 11 (Figures 4II-3-23 to 26) they were observed most often on gravel-rubble substrates in areas of suspected or known groundwater seepage. It should be noted that access to the upper slough area was facilitated by a man-made channel in this slough as shown in Figure 4II-3-25. Prior to high flows, sockeye redds in Slough 21 were found among chum redds in rubble-cobble substrates, below the mouth of the slough. After high flows, they were also located on silt sand substrates in areas above the mouth where upwelling occurred.

3.1.3 Pink Salmon

Limited numbers of pink salmon were observed spawning in sloughs 9, 11 and 21 (Figures 4II-3-17 to 31). Gravel-rubble substrates were most commonly chosen. In Slough 9, both areas where pink salmon spawning occurred contained upwelling. Upwellings also were present in several areas where pink salmon were found in Slough 11.

3.1.4 Coho Salmon

Slough 8A is the only specific study slough where coho salmon were observed spawning. Most of their spawning activity occurred in areas where rubble-cobble substrate and ground water seepage were present (Figures 4II-3-13 to 15).

3.1.5 Chinook Salmon

Adult chinook salmon spawning occurred exclusively in tributaries and were not addressed in this study.

3.1.6 Eulachon

Twenty sites (Figure 4II-3-38) were surveyed for their spawning habitat utilizing the procedures outlined in the methods section. These include:

Site Number	River Mile	Geographic Code
1	26.0	S17N07W22DAA
2	25.9	S17W07W22DDA
3	26.3	S17N07W23CAB
4	25.5	S17N02W22CAA
5	25.8	S17N07W22DCD
6	21.4	S16N07W04CAC
7	18.2	S16N07W15CDB
8	16.5	S16N07W22DCD
9	44.0	S19N05W20CAC
10	41.3	S19N06W25CCD
11	28.0	S17N07W13DBB
12	31.1	S17N06W18BAA
13	31.8	S17N06W05ABA
14	15.0	S16N07W35BDD

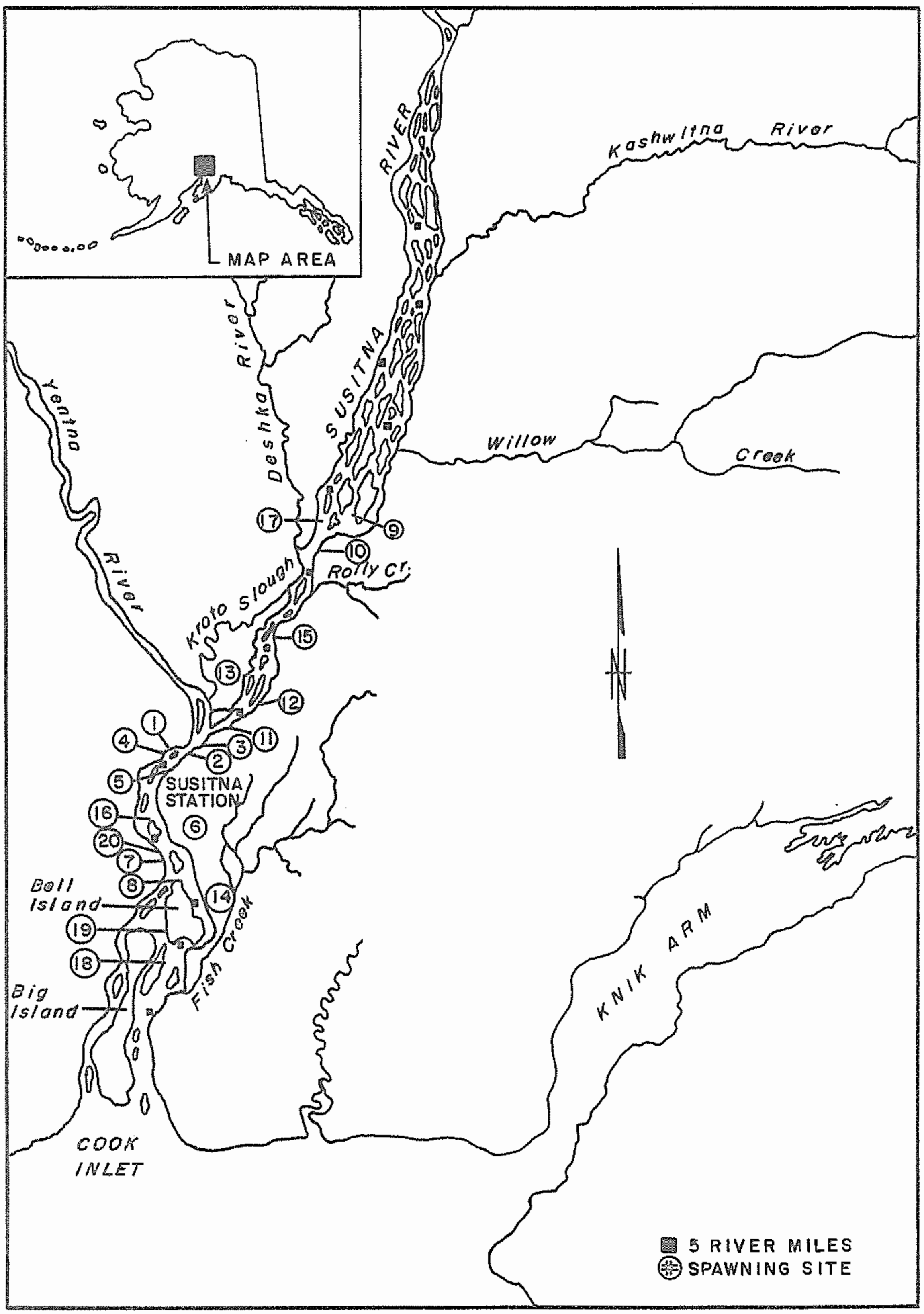

Figure 4II-3-38 Eulachon spawning sites surveyed for habitat characteristics on the Susitna River: May 24 - June 7, 1982.

Site Number	River Mile	Geographic Code
15	35.5	S18N06W15CCC
16	22.8	S16N07W04BBA
17	43.3	S19N06W24ACC
18	8.5	S14N07W22ACA
19	11.0	S15N07W10DCC
20	18.3	S16N07W15CDB

Water quality measurements were taken at 12 other sites (Table 4II-3-8) where it could not be determined whether eulachon were milling, migrating or spawning, using criteria outlined in the methods section. These sites include:

Planimetric maps identify spawning areas at each site (Figures 4II-3-39 to 58). Water quality, mean spawning depths, mean spawning velocities and substrates are tabulated for each site (Table 4II-3-9, Figures 4II-3-59 and 4II-3-60).

The water temperatures of the Susitna River at Susitna Station (RM 25.5) are graphed (Figure 4II-3-61). Mean daily water temperature and provisional discharge data (USGS 1982) for the Susitna River at Susitna Station are plotted with catch per unit effort (catch per minute per net) calculated for the gill net sets at high tides May 17 through June 9, 1982 (Figure 4II-3-62; refer also to Volume 2).

Table 4II-3-8. Eulachon spawning site evaluations on the Susitna River: May 24 - June 7, 1982.

Site	Date	Water Temp (°C)	pH	Conductance (umhos/cm)	Dissolved Oxygen (mg/l)	Mean Spawning Depth (ft)	Standard Deviation	Mean Spawning Velocity (ft/sec)	Standard Deviation	Substrate
1	820531	8.5	7.1	96	11.1	1.4	0.5 (n=15)[a]	1.5	0.3	Silty sand interspersed with 10% gravel.
2	820531	9.3	6.7	73	10.8	1.9	0.5 (n=18)[a]	1.1	0.6	Silty sand interspersed with 20% gravel and cobble.
3	820531	8.8	7.1	66	10.9	2.1	0.4 (n=16)[a]	0.8	0.3	Silty sand interspersed with 10% gravel.
4	820531	11.1	7.1	95	10.3	3.1	0.8 (n-10)[a]	0.8	0.3	Silty sand with 30-50% gravel and cobble present.
5	820601	9.3	7.0	72	10.7	2.7	10. (n=12)[a]	1.8	0.5	30% silty sand 30% gravel 30% rubble 10% cobble
6	820601	10.2	6.7	72	8.2	2.2	0.7 (n=24)[a]	1.3	0.4	Silty sand intermixed with 40% gravel and 20% rubble.
7	820601	11.2	6.8	100	7.5	1.8	0.7 (n=33)[a]	1.2	0.7	Silty sand mixed with 40% gravel and 20% rubble.
8	820601	11.2	6.7	102	6.4	1.2	0.4 (n=16)[a]	1.9	0.4	100% silt
9	820603	8.3	7.5	41	12.4	1.9	0.5 (n=27)[a]	1.7	0.5	Silty sand interspersed with 30% rubble.
10	820604	8.3	7.1	46	10.8	2.0	0.6 (n=16)[a]	0.7	0.5	100% silt
11	820605	7.9	7.2	63	11.0	1.9	0.8 (n=24)[a]	0.7	0.5	100% silt

[a] Sample size.

Table 411-3-8 (Continued).

						Mean Spawning				
Site	Date	Water Temp (°C)	pH	Conductance (umhos/cm)	Dissolved Oxygen (mg/l)	Depth (ft)	Standard Deviation	Velocity (ft/sec)	Standard Deviation	Substrate
12	820605	7.9	7.2	64	11.5	1.1	0.5 (n=18)[a]	1.4	0.9	50% gravel 30% rubble 10% cobble 10% silt
13	820605	8.2	7.2	67	10.6	1.9	0.6 (n=14)[a]	0.9	0.4	100% silt
14	820606	7.6	7.1	69	10.2	1.2	0.6 (n=29)[a]	1.6	0.8	30% silty sand 50% gravel 20% cobble
15	820607	7.1	7.0	51	12.3	1.7	0.6 (n=21)[a]	1.8	0.8	30% gravel 40% rubble 20% cobble 10% silty sand
16	820530	6.3	7.0	64	12.2	1.9	0.8 (n=17)[a]	0.9	0.6	Sand intermixed with 20% gravel.
17	820524	(hydrolab malfunction)				1.7	0.9 (n=10)[a]	0.7	0.3	Sand intermixed with 10% silt and gravel.
18	820526	6.2	6.6	70	11.9	1.8	0.8 (n=6)[a]	0.9	0.5	Sand interspersed with 5% gravel.
19	820526	6.3	6.3	71	11.3	2.3	0.5 (n=6)[a]	0.6	0.2	Sand interspersed with 10% gravel.
20	820526	6.9	6.8	82	10.9	2.0	1.0 (n=3)[a]	0.9	0.5	80% gravel intermixed with 70% sand.

[a] Sample size.

Table 4II-3-9. Miscellaneous eulachon spawning site habitat evaluations on the Susitna River: May 16 - June 12, 1982.

Site	River Mile	Date	Water Temp (°C)	pH	Specific Conductance (umhos/cm)	Dissolved Oxygen (mg/l)	Notes
Misc. 1	19.5	820601	10.0	6.7	72	7.9	
Misc. 2	41.1	820603	6.8	7.2	40	10.4	
Misc. 3	47.0	820602	9.2	7.2	61	11.5	
Misc. 4	5.0	820605	8.7	7.1	77	9.5	West Bank gill net site
Misc. 5	5.0	820538	6.1	6.8	78	11.9	West Bank gill net site
Misc. 6	5.5	820528	6.3	6.8	73	12.0	East Bank gill net site
Misc. 7	16.5	820528	6.8	6.9	81	11.3	Spawning site #8
Misc. 8	24.8	820530	6.1	6.9	70	12.0	
Misc. 9	36.7	820529	6.4	6.8	66	12.0	
Misc. 10	42.7	820529	6.1	6.9	65	12.2	
Misc. 11	49.0	820529	6.1	6.8	65	12.1	
Misc. 12	49.2	820529	5.0	6.9	46	12.0	Mouth of Willow Creek

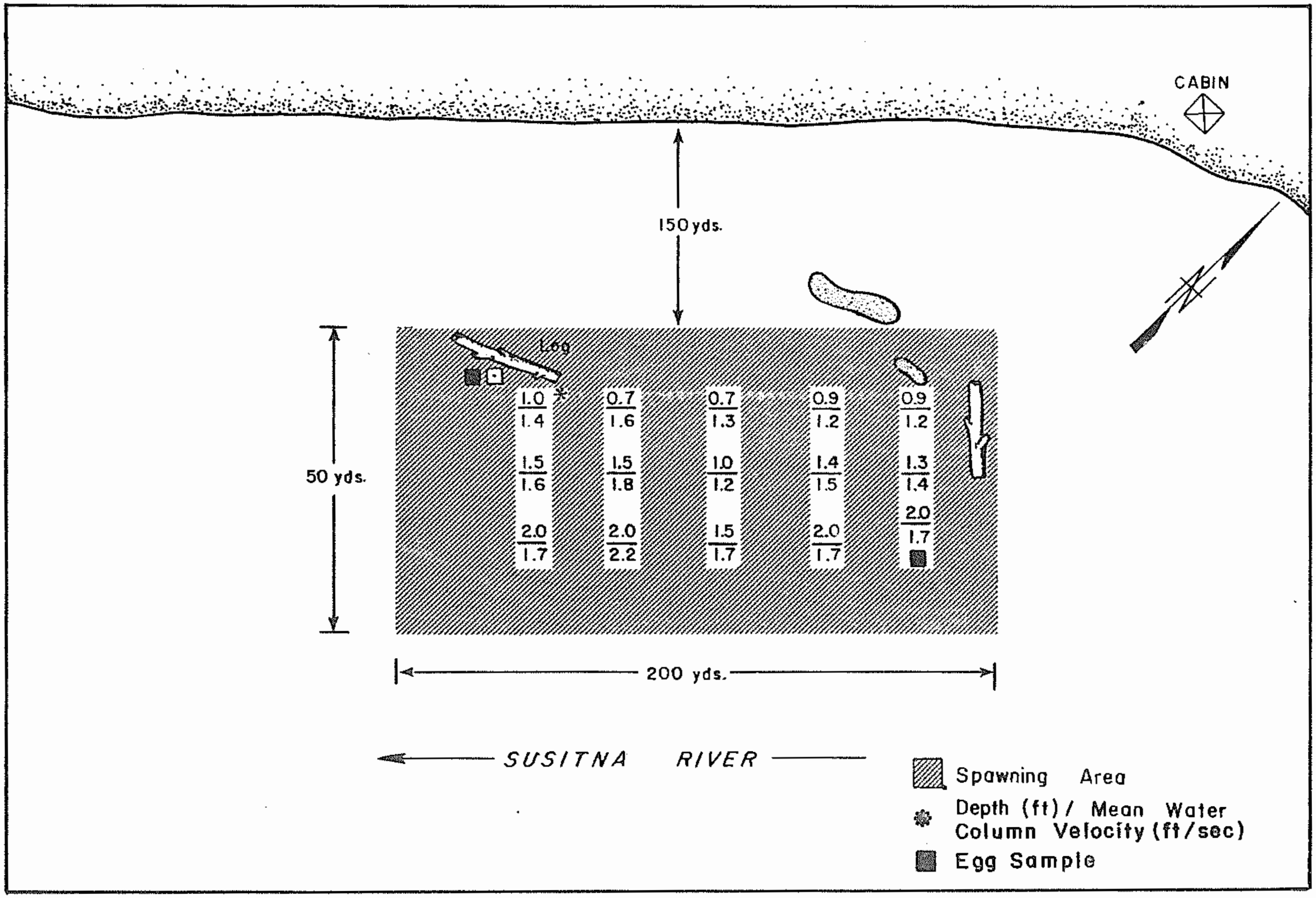

Figure 4II-3-39. Eulachon spawning area on the Susitna River at RM 26.0, GC S17N07W22DAA: May 31, 1982.

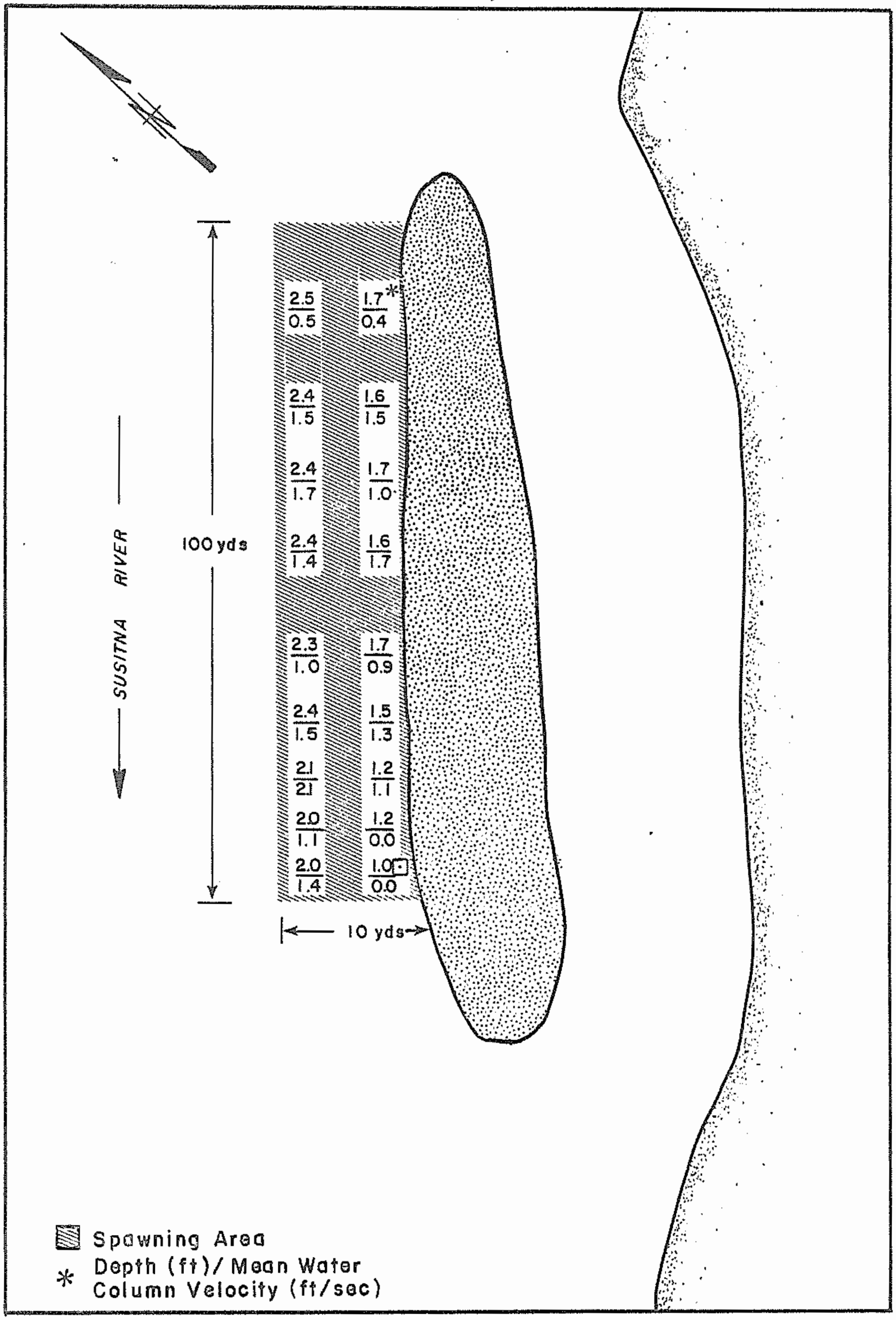

Figure 4II-3-40. Eulachon spawning area on the Susitna River at RM 25.9, GC S17N07W22DDA: May 31, 1982.

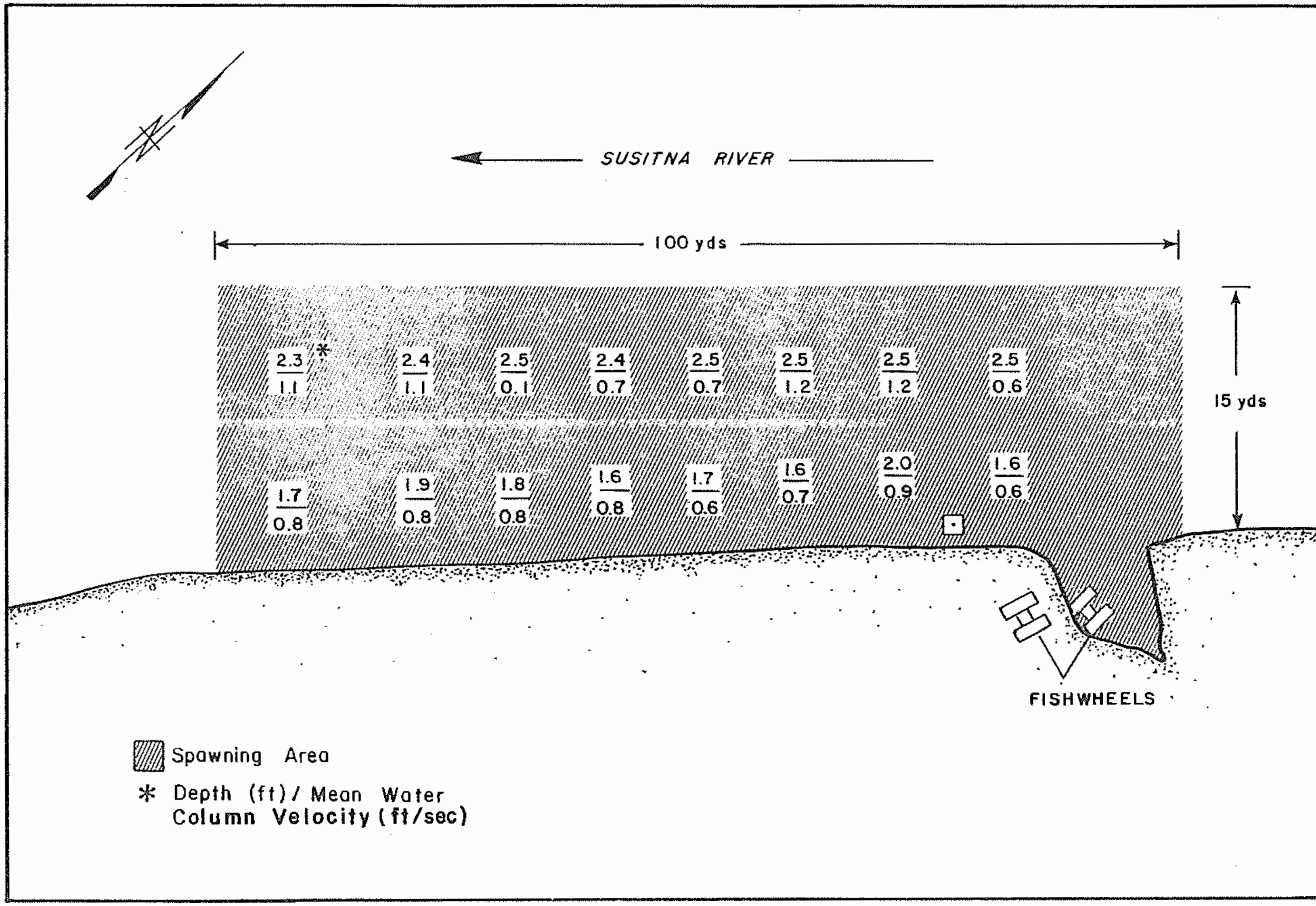

Figure 4II-3-41. Eulachon spawning area on the Susitna River at RM 26.3, GC S17N07W23CAB: May 31, 1982.

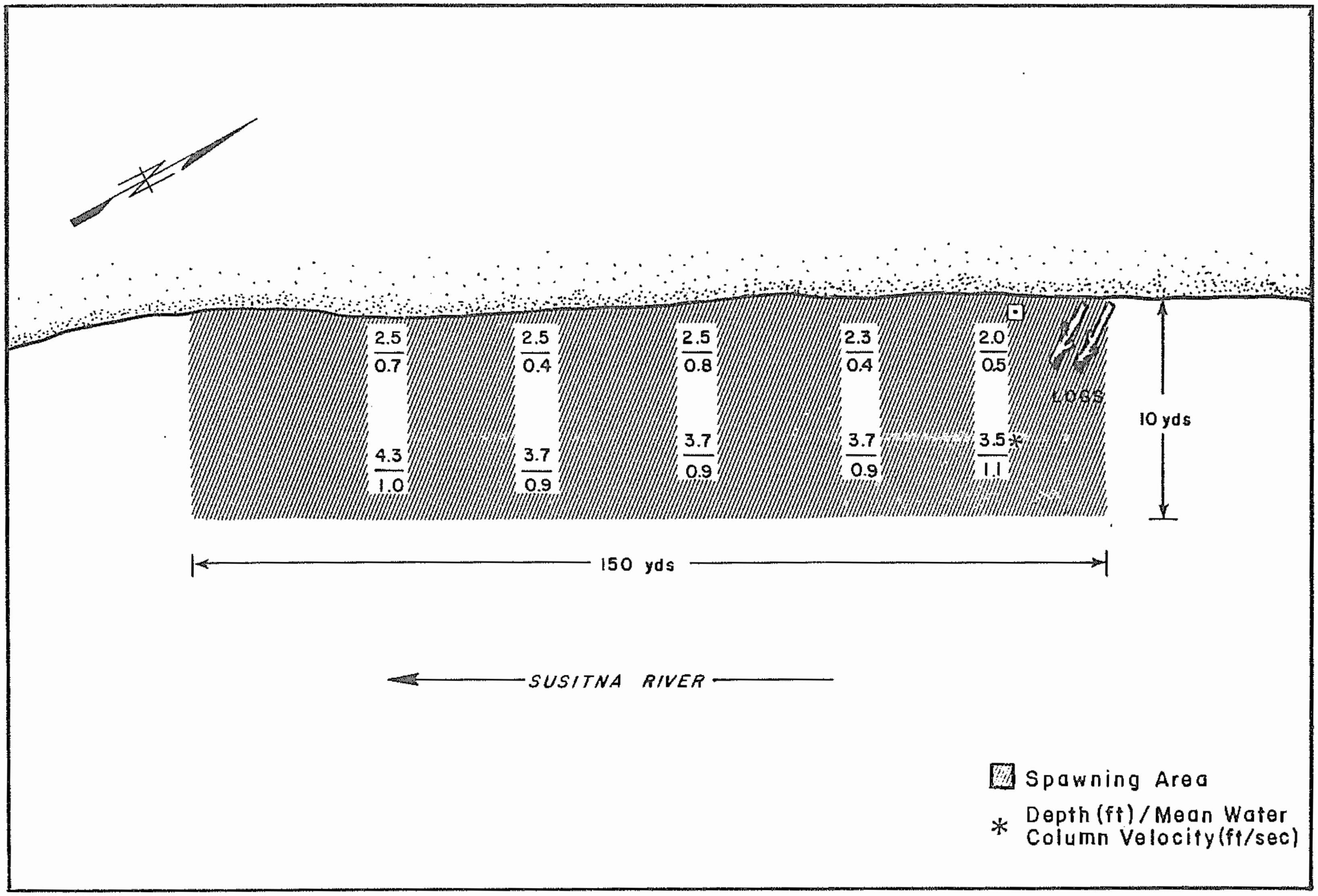

Figure 4II-3-42 Eulachon spawning area on the Susitna River at RM 25.5, GC S17N07W22CAA: May 31, 1982.

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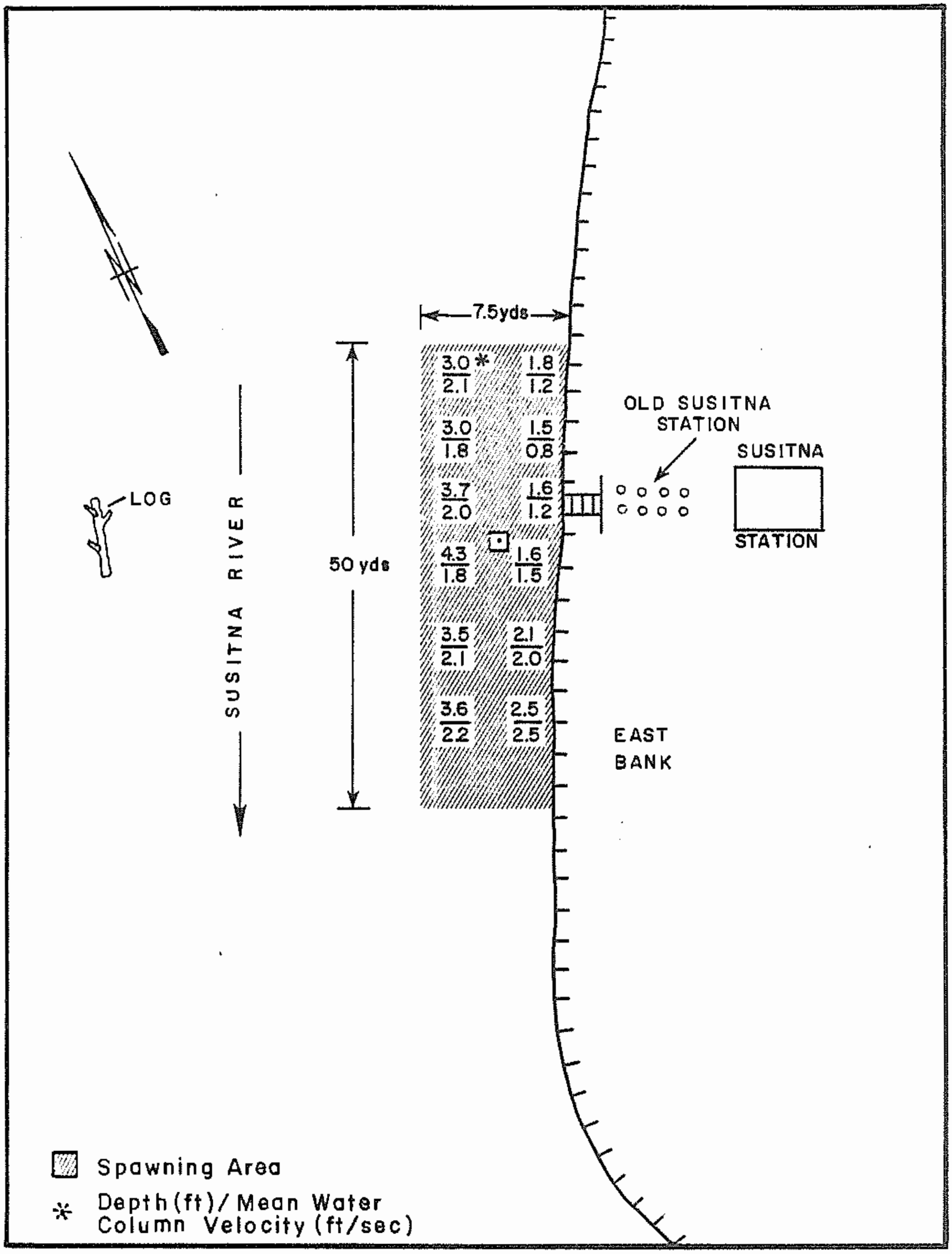


Figure 4II 3-43 Eulachon spawning area on the Susitna River at RM 25.8, GC S17N07W22DCD: June 1, 1982.

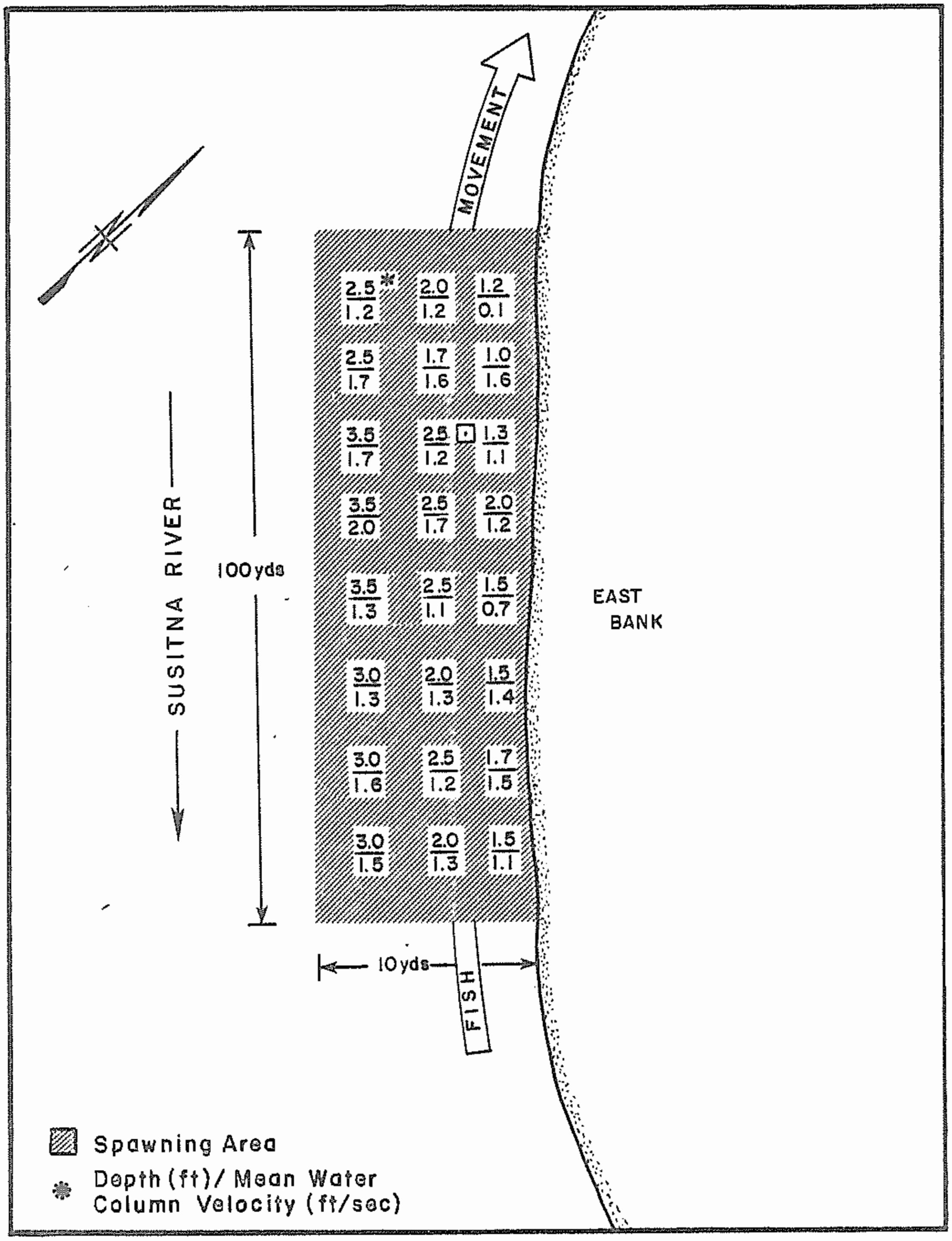


Figure VII-3-44 Eulachon spawning area on the Susitna River at RM 21.4, GC S16N07W04CAC: June 1, 1982.

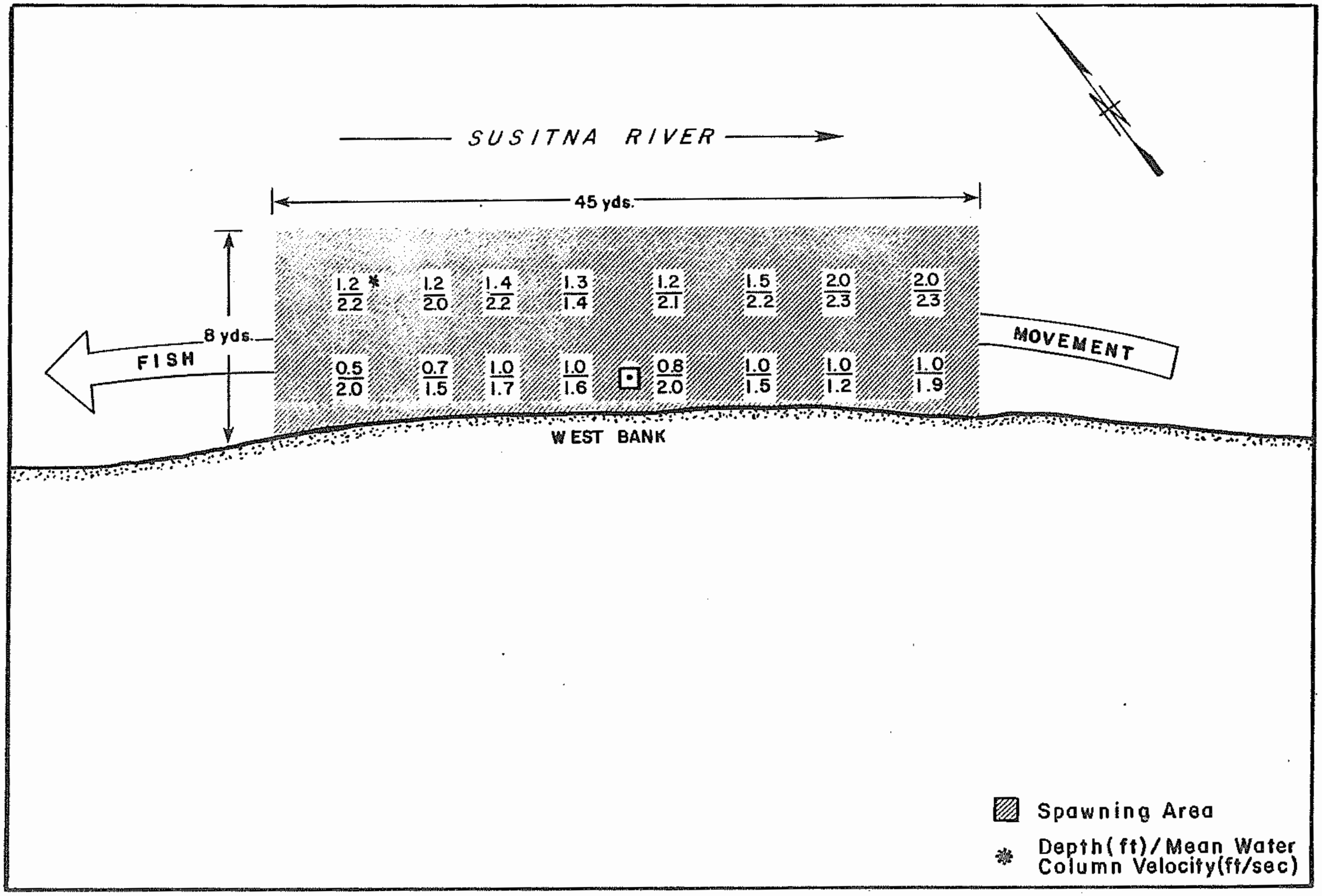


Figure 4II-3-45 Eulachon spawning area on the Susitna River at RM 18.2, GC S16N07W15CDB: June 1, 1982.

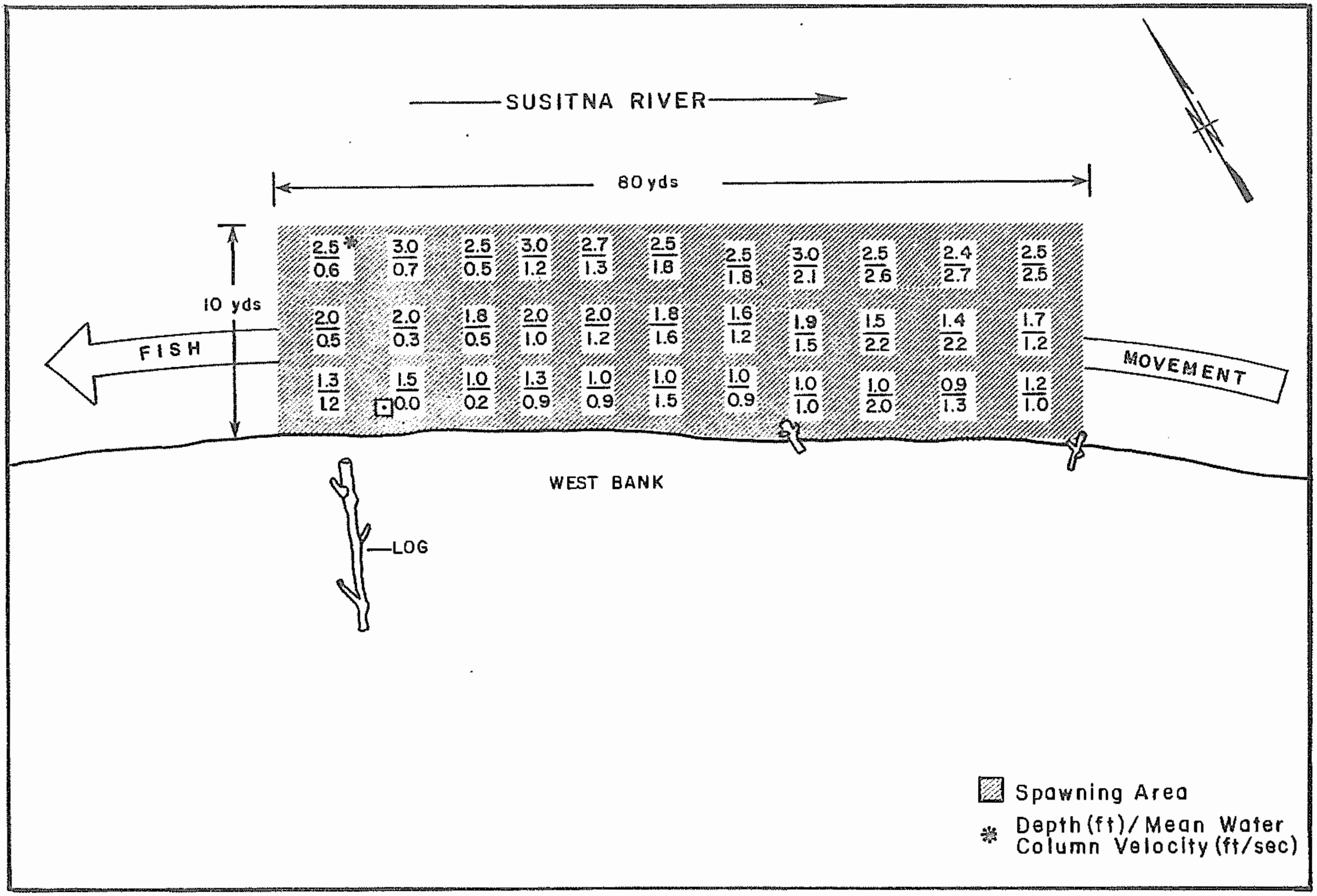


Figure [illegible] Eulachon spawning area on the Susitna River at RM 16.5, GC S17N07W22DCD: June 1, 1982.

292

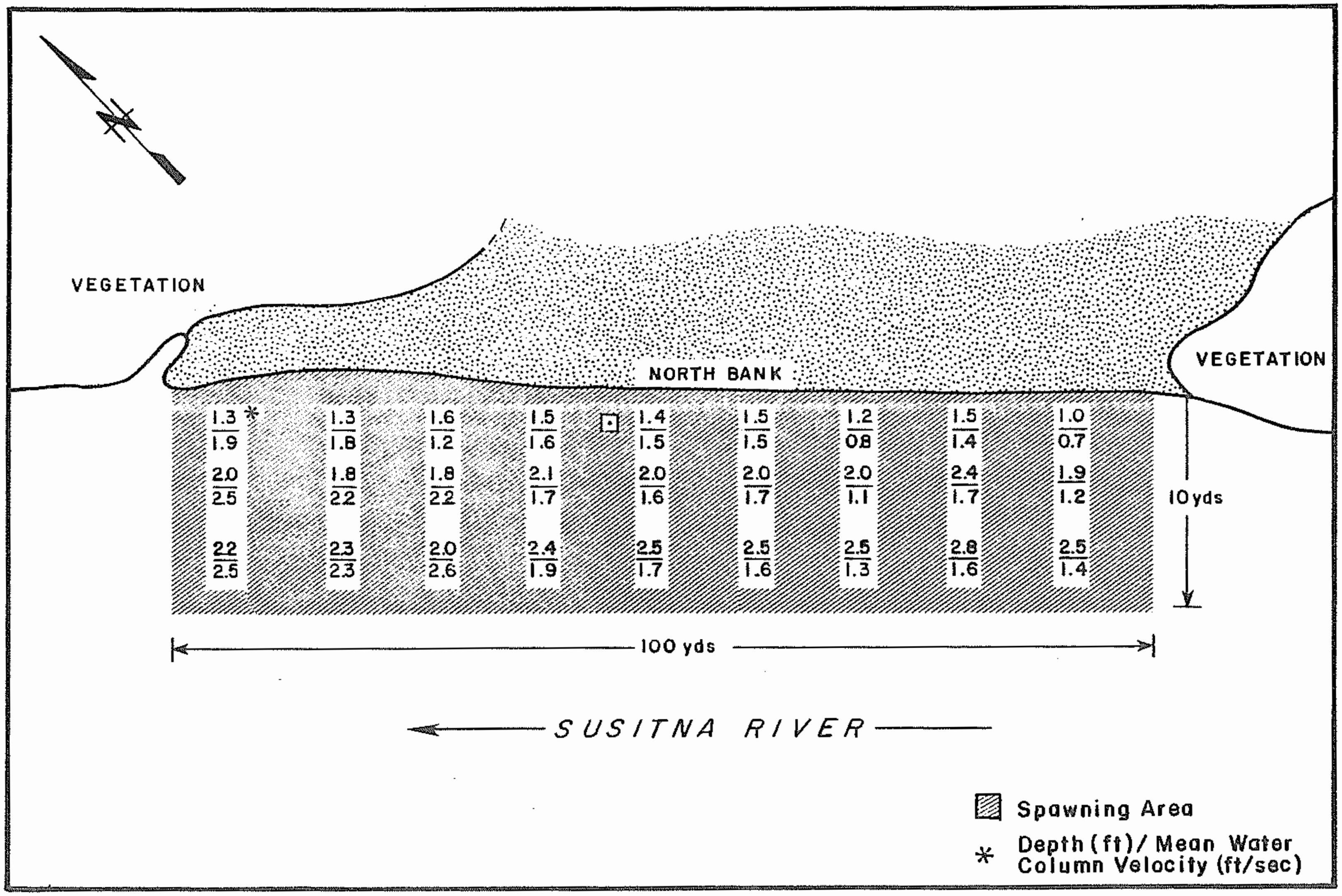


Figure 4II-3-47 Eulachon spawning area on the Susitna River at RM 44.0, GC S19N05W20CAC: June 3, 1982.

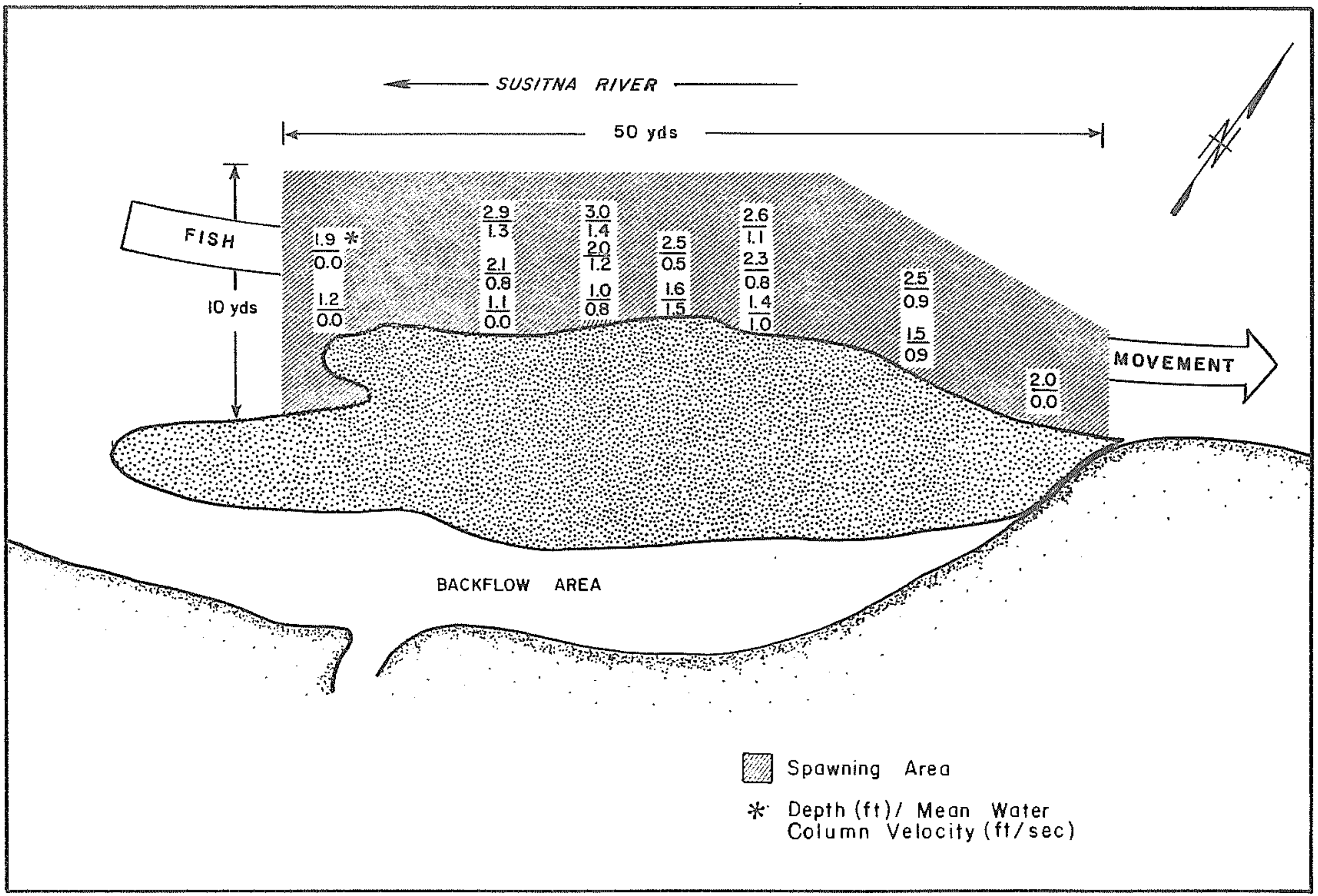


Figure 4II-3-13 Eulachon spawning area on the Susitna River at RM 41.3. GC S19N06W25CCD: June 4, 1982.

294

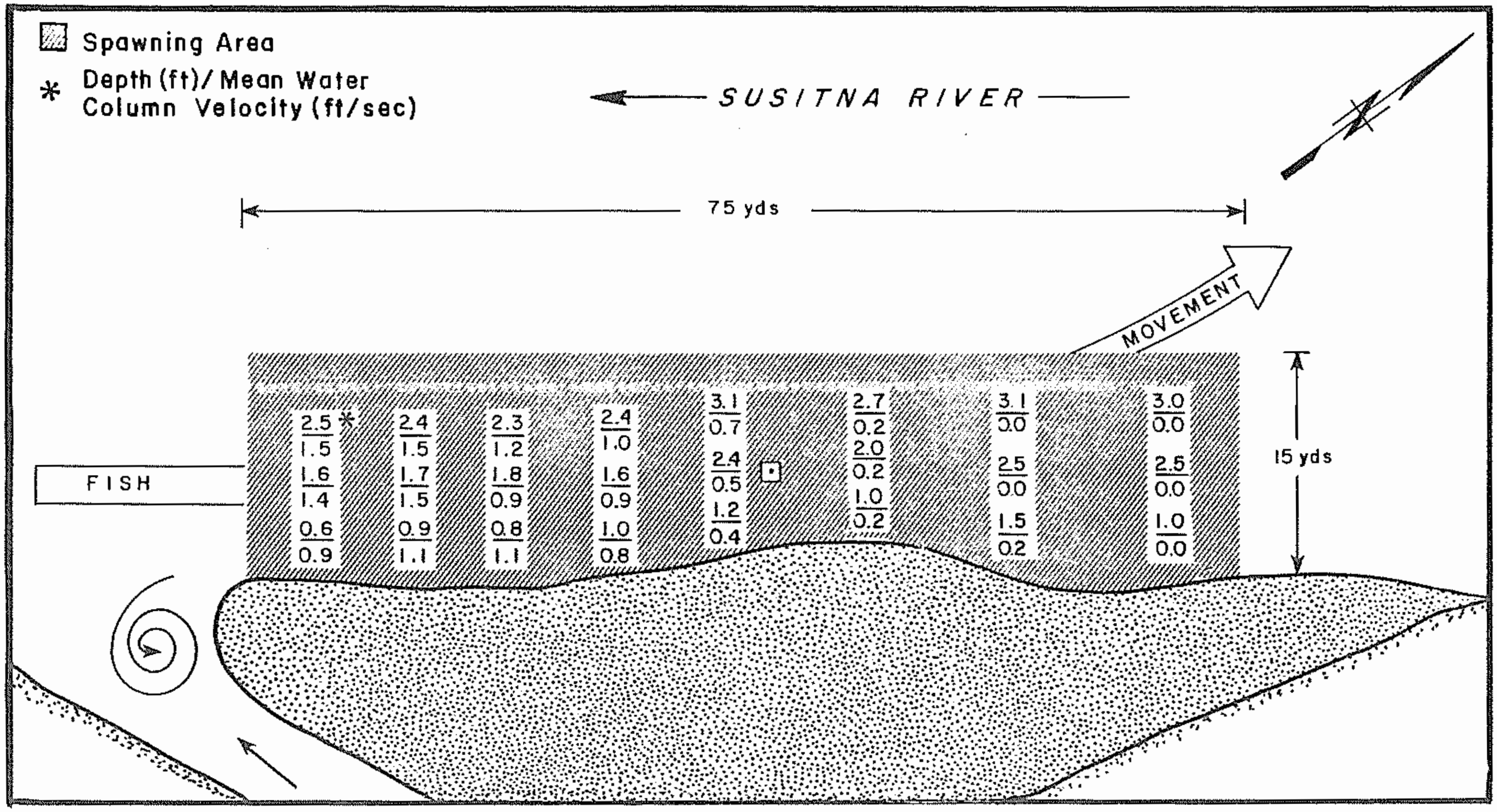


Figure 4II-3-49 Eulachon spawning area on the Susitna River at RM 28.0, GC S17N07W13DBB: June 5, 1982.

295

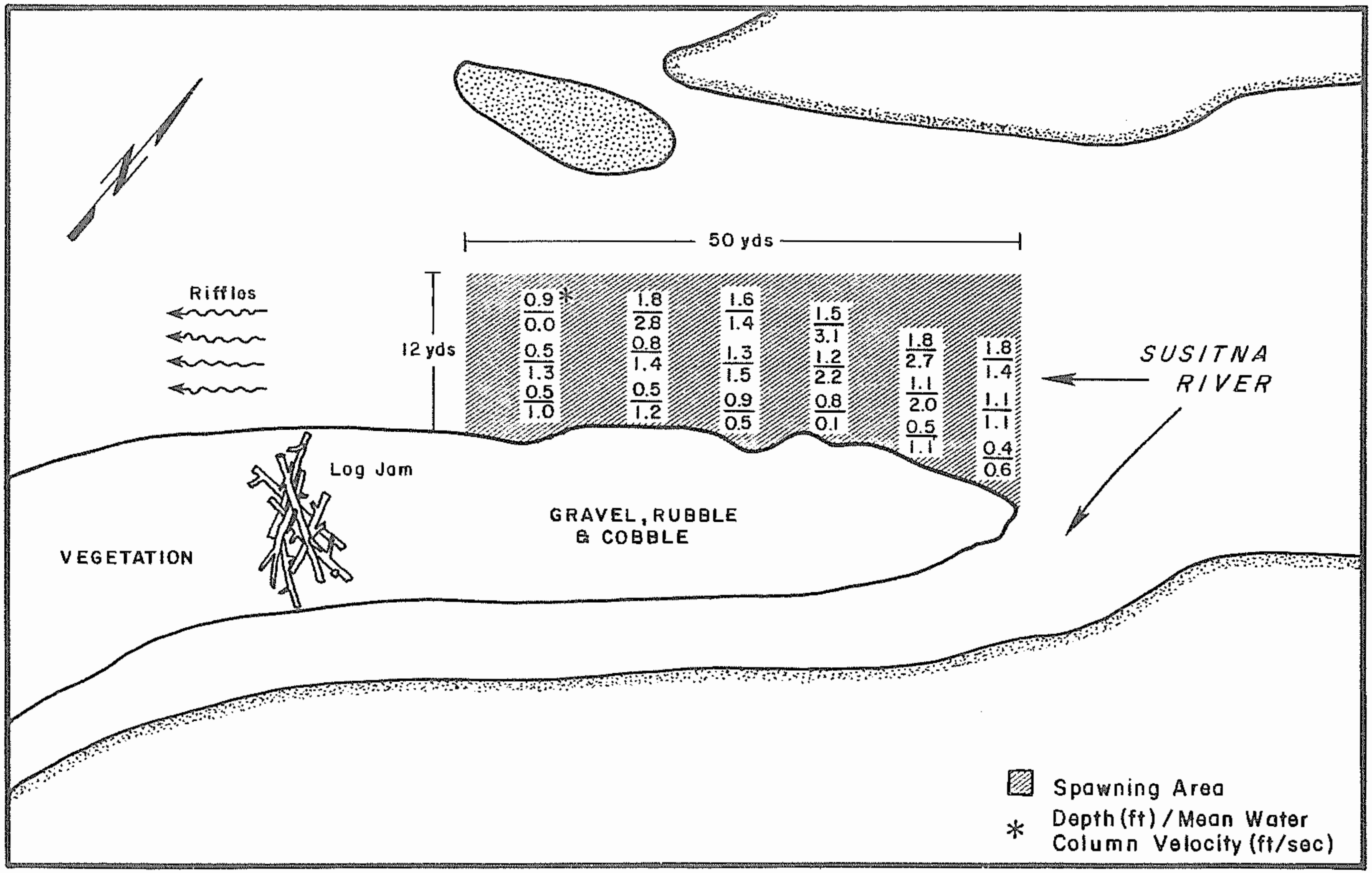


Figure 4E-3-56 Eulachon spawning area on the Susitna River at RM 31.1, GC S17N06W18BAA: June 5, 1982.

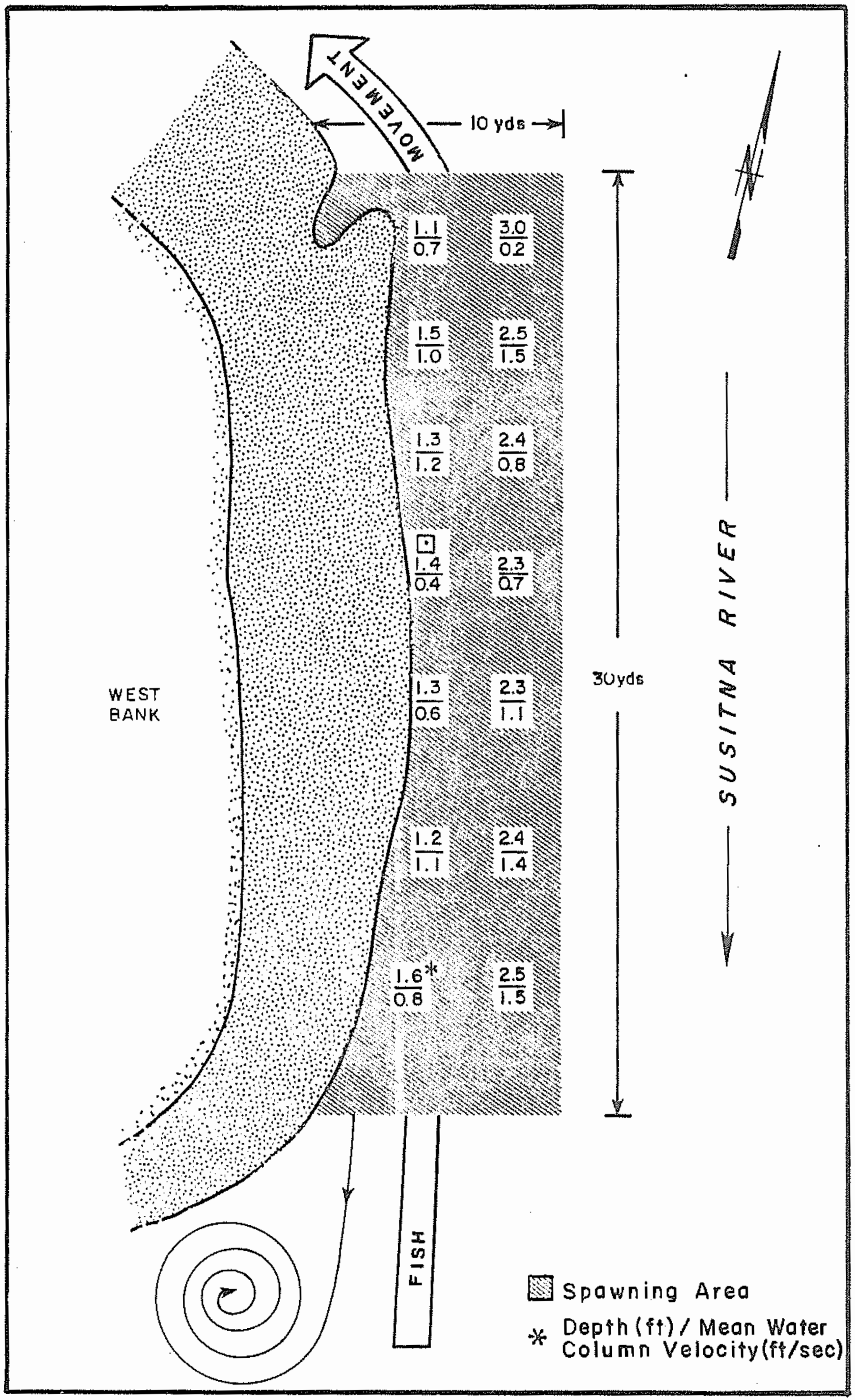


Figure 4B-3-51 Eulachon spawning area on the Susitna River at RM 31.8, GC S17N06W05ABA: June 5, 1982.

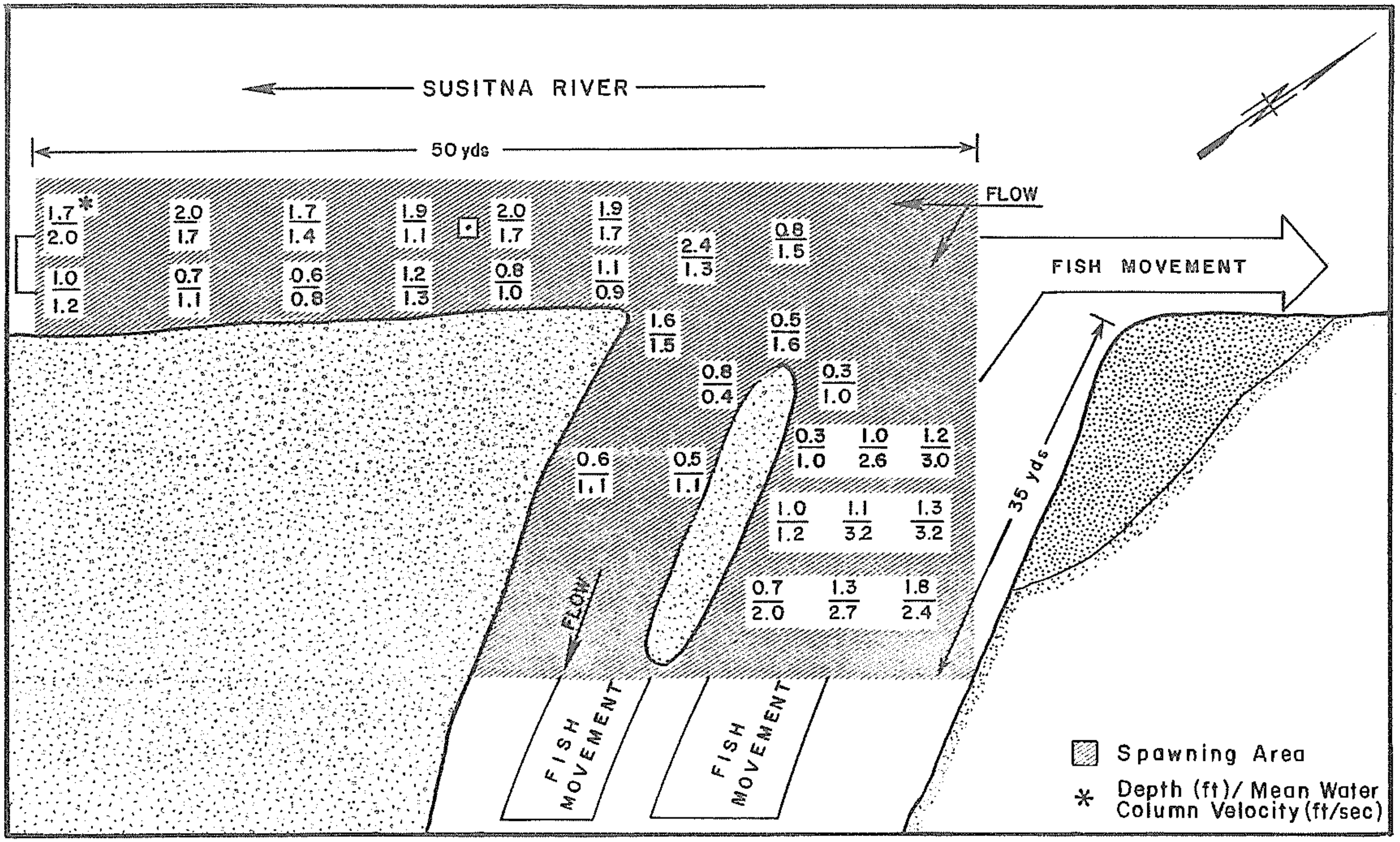


Figure 4II-3-12 Eulachon spawning area on the Susitna River at RM 15.0, GC S16N07W35BDD: June 6, 1982.

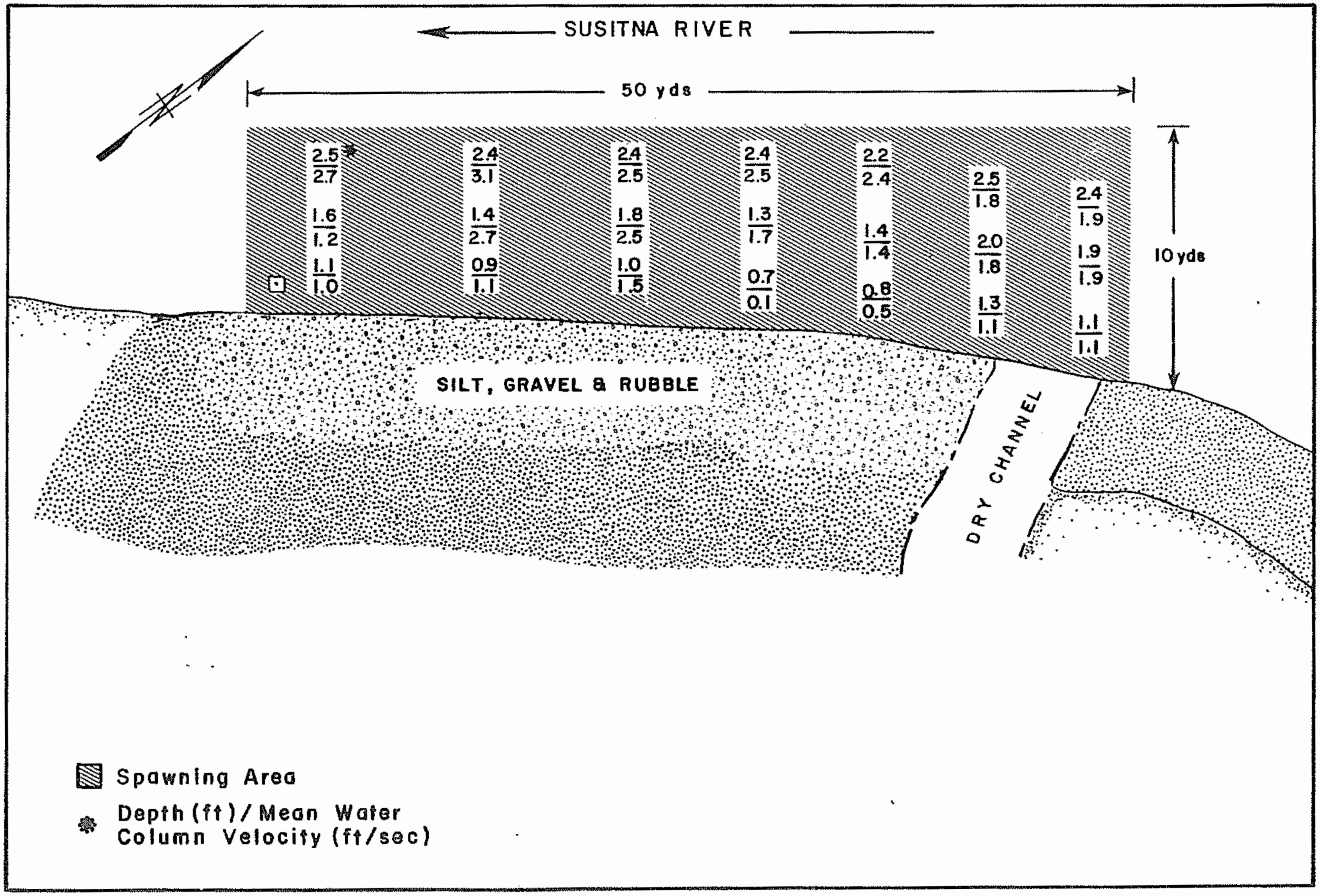


Figure 4II-3-53 Eulachon spawning area on the Susitna River at RM 35.5, GC S18N06W15CCC: June 7, 1982.

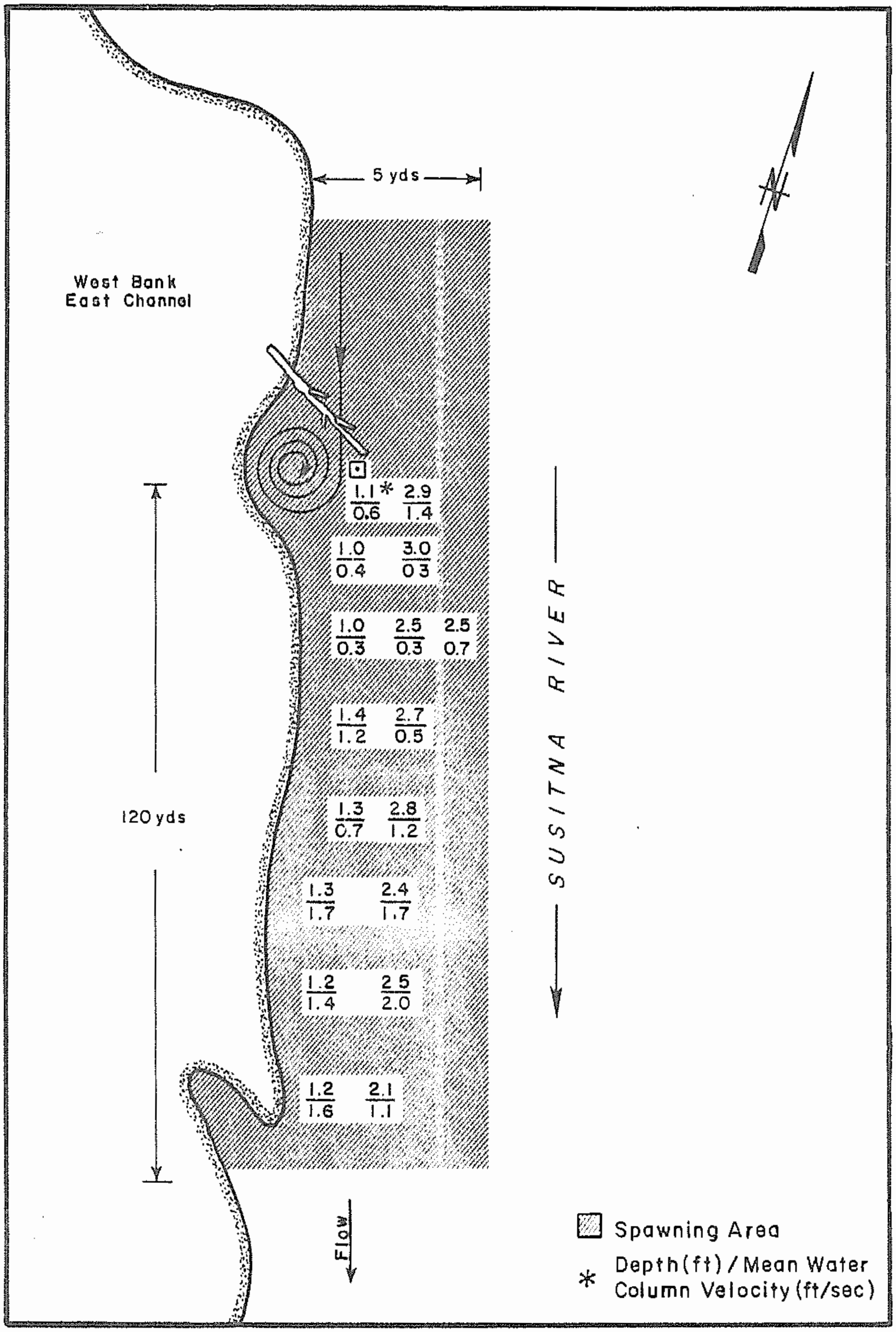


Figure 4II·3·54 Eulachon spawning area on the Susitna River at RM 22.8, GC S16N07W04BBA: May 30, 1982.

301

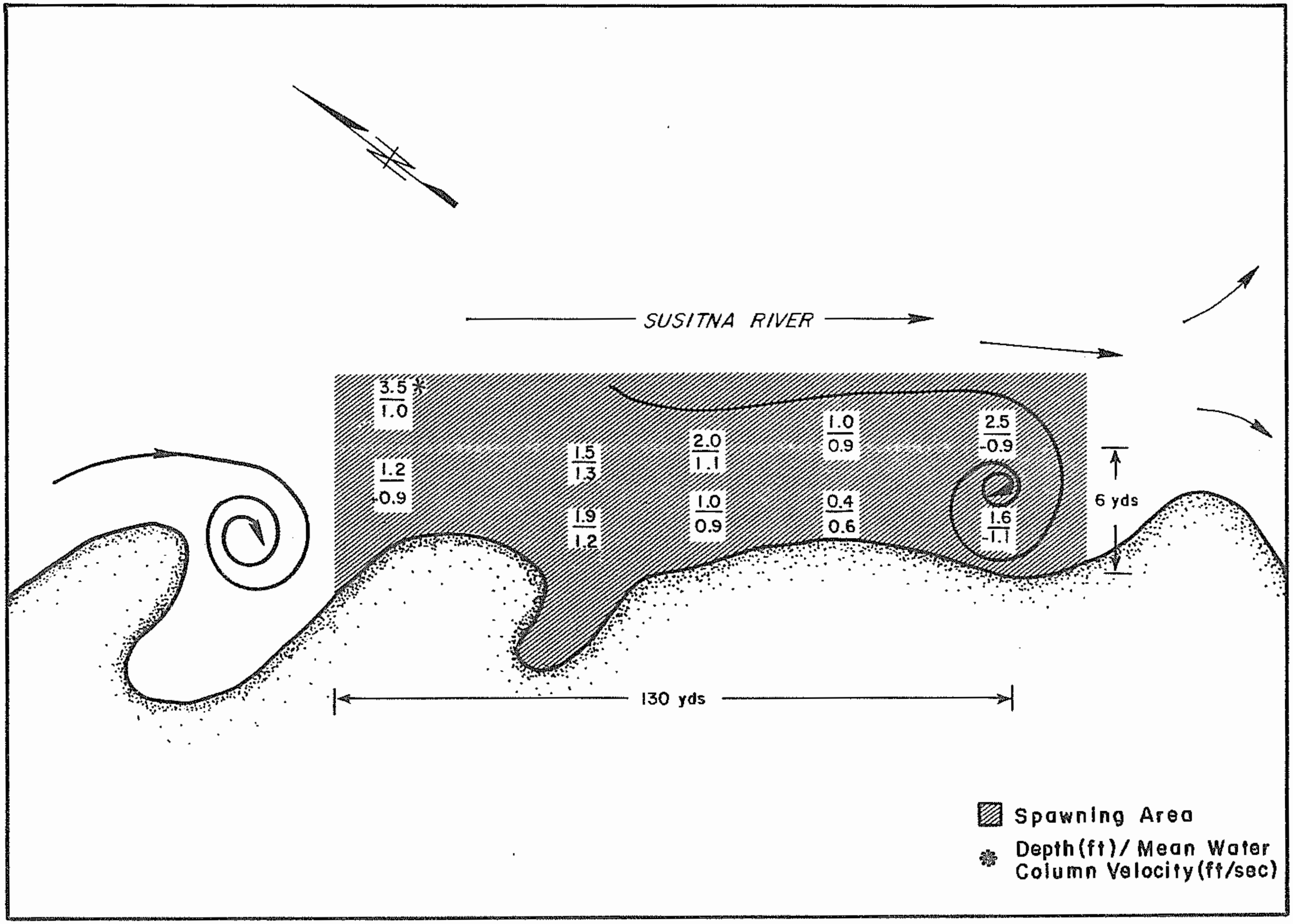


Figure 4II-3-55 Eulachon spawning area on the Susitna River at R 43.3, GC S19N06W24ACC: May 24, 1982.

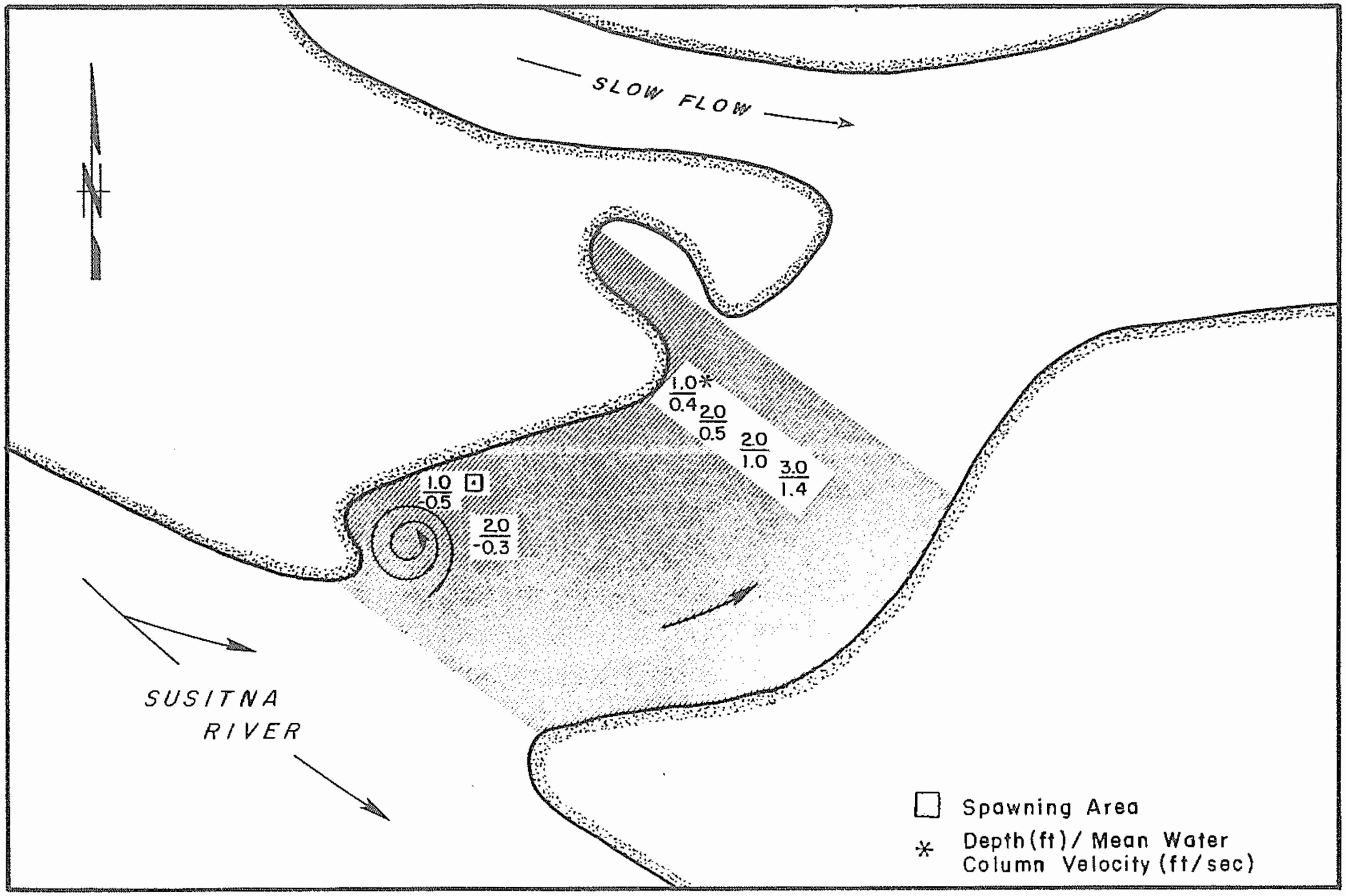


Figure 3-56 Eulachon spawning area on the Susitna River at RM 8.5, GC S14N07W22ACA:
May 26, 1982.

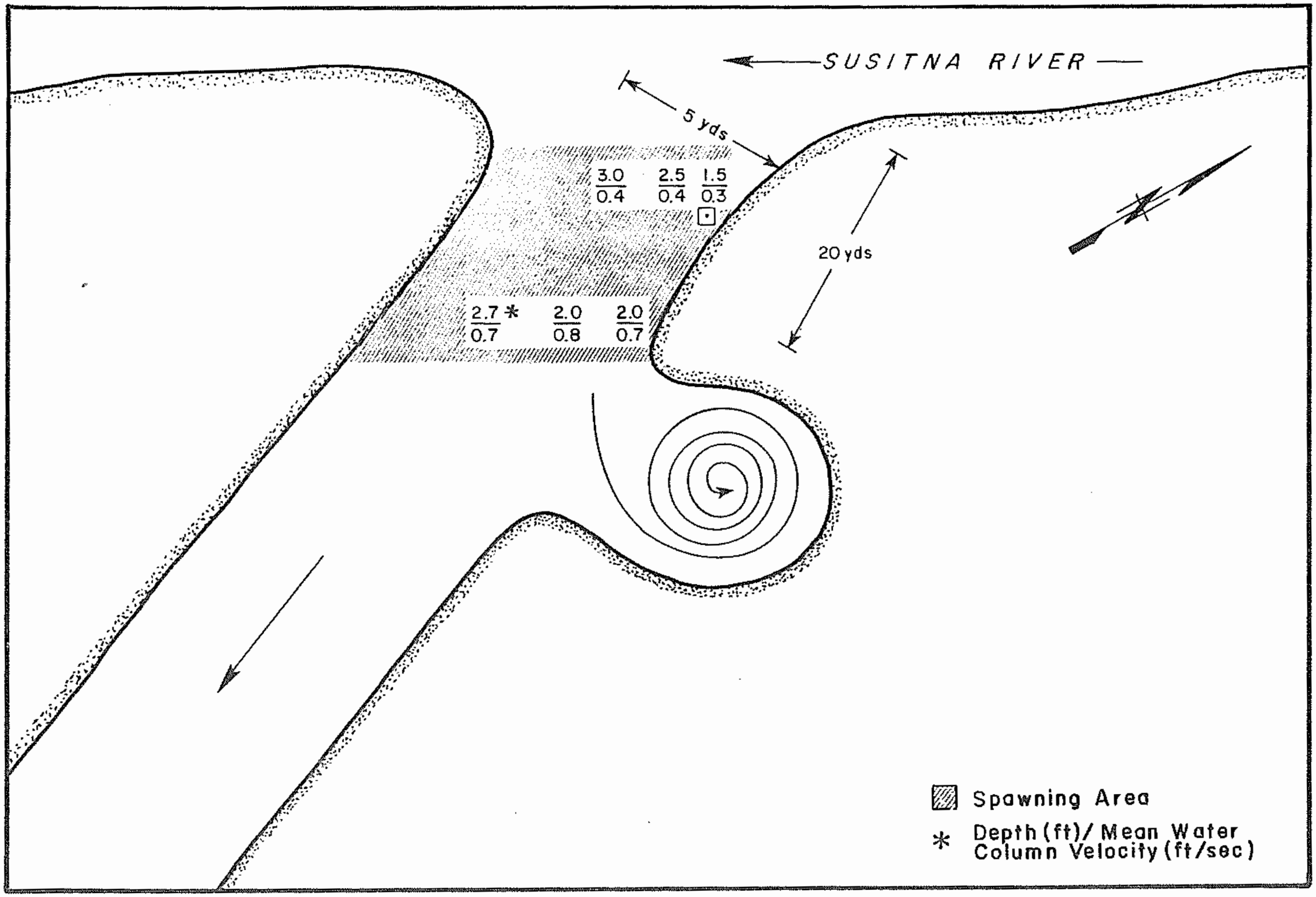


Figure 4II-3-57 Eulachon spawning area on the Susitna River at RM 11.0, GC S15N07W10DCC: May 26, 1982.

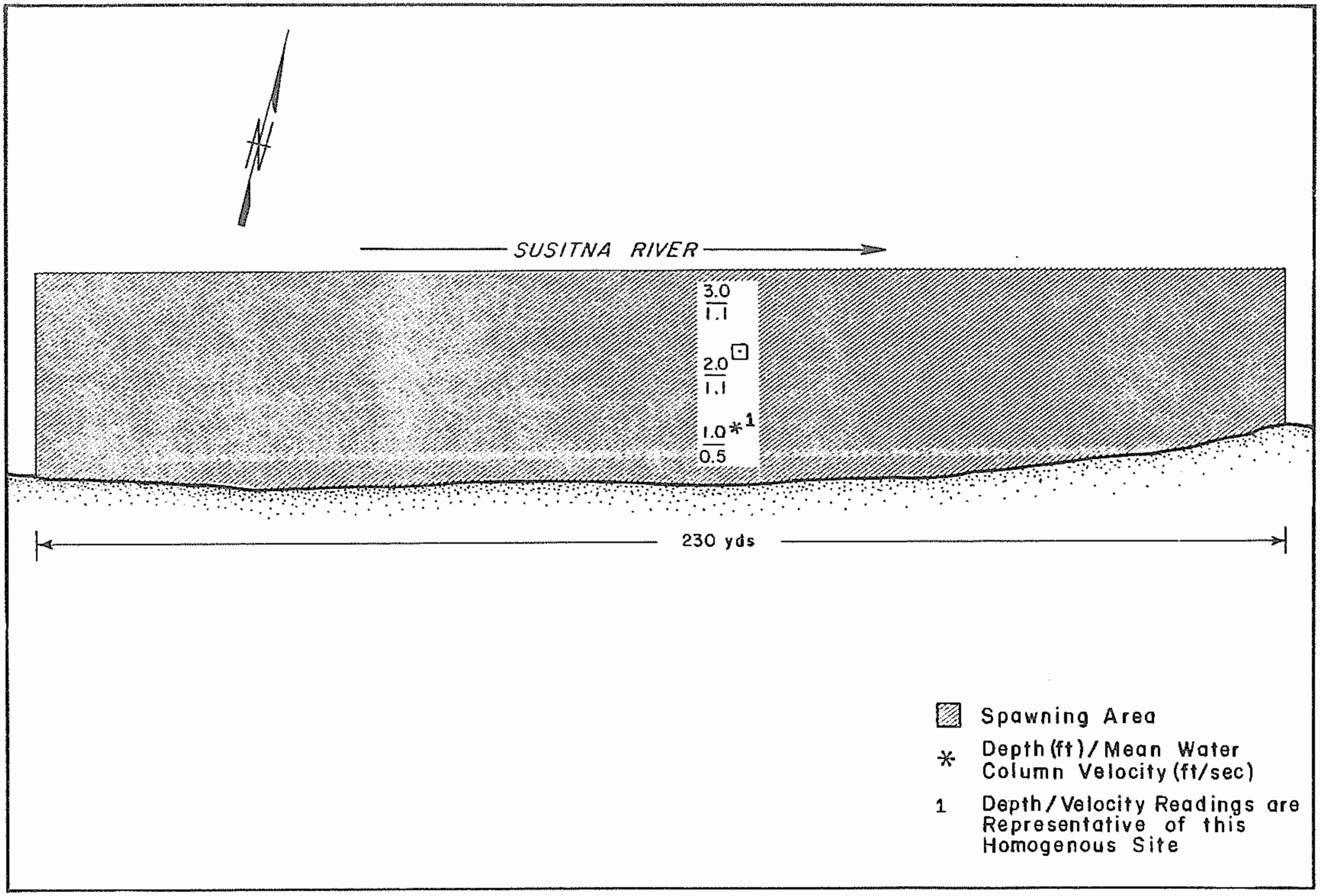


Figure [illegible] Eulachon spawning area on the Susitna River at RM 18.3, GC S16N07W15CDB: May 26, 1982.

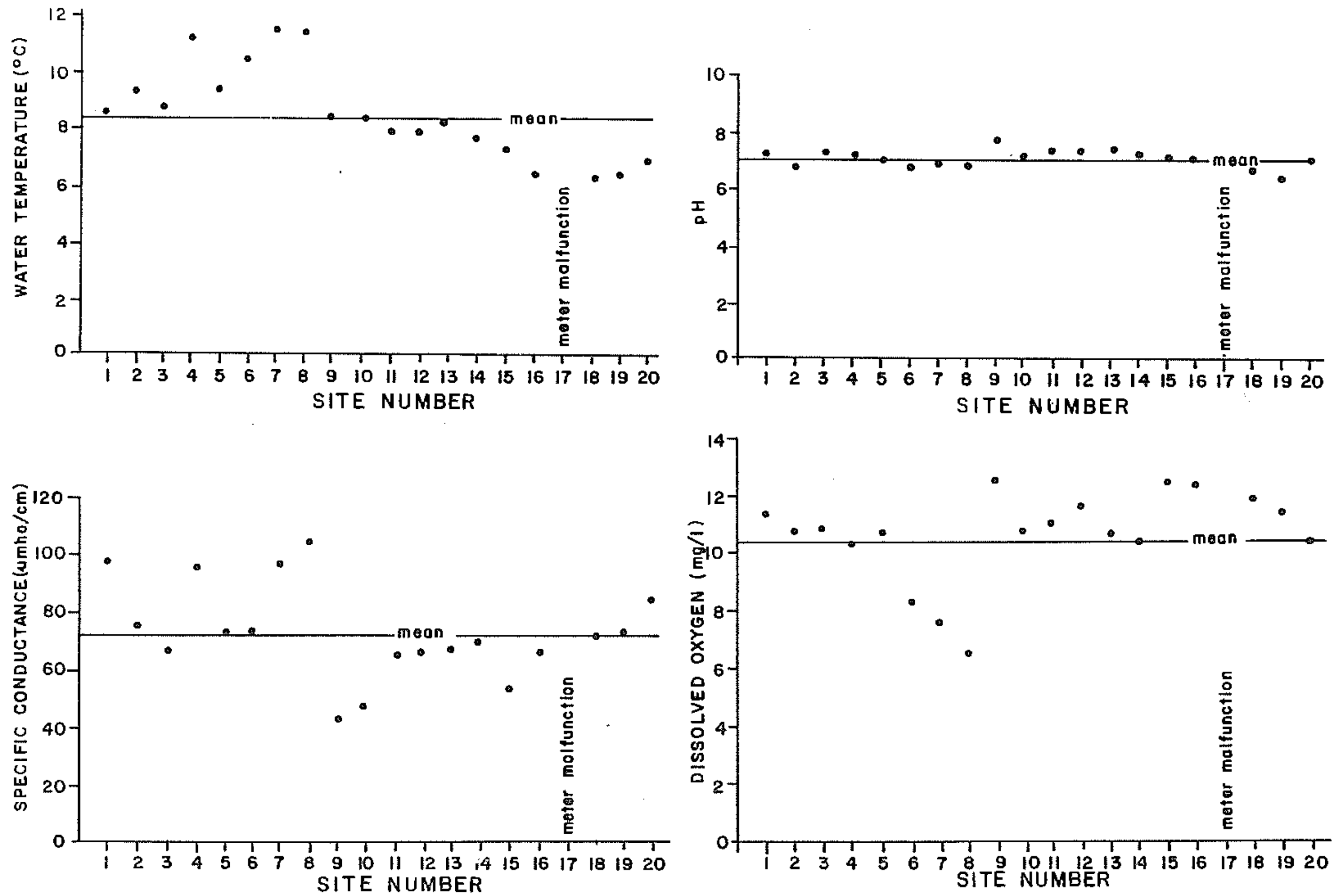


Figure 4II-3-59 Surface water temperature, pH, specific conductance and dissolved oxygen at 20 eulachon spawning areas on the Susitna River: May 24 - June 7, 1982.

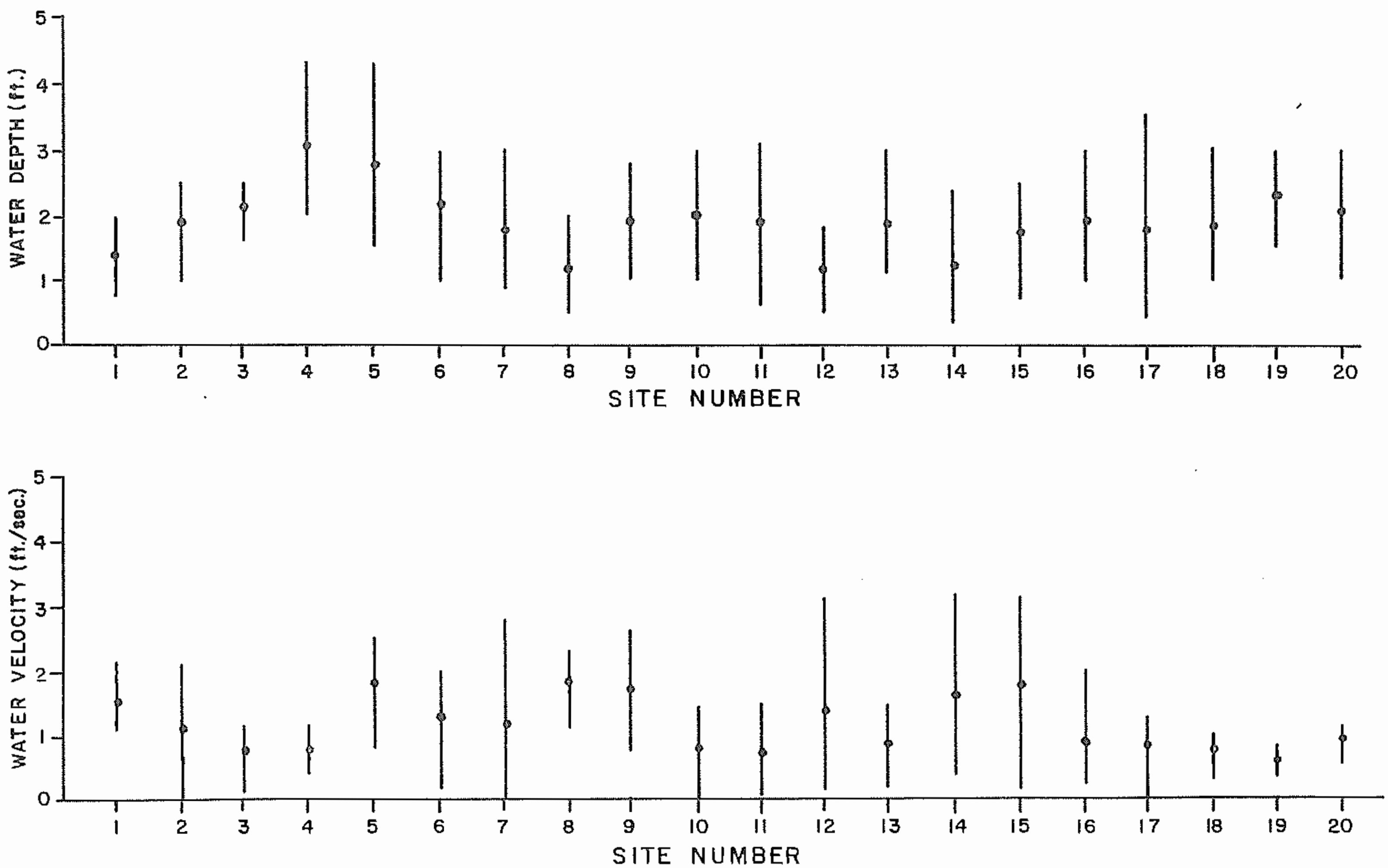


Figure [illegible]. Water depths and velocities (mean and range) at 20 eulachon spawning sites on the Susitna River: May 24 - June 7, 1982.

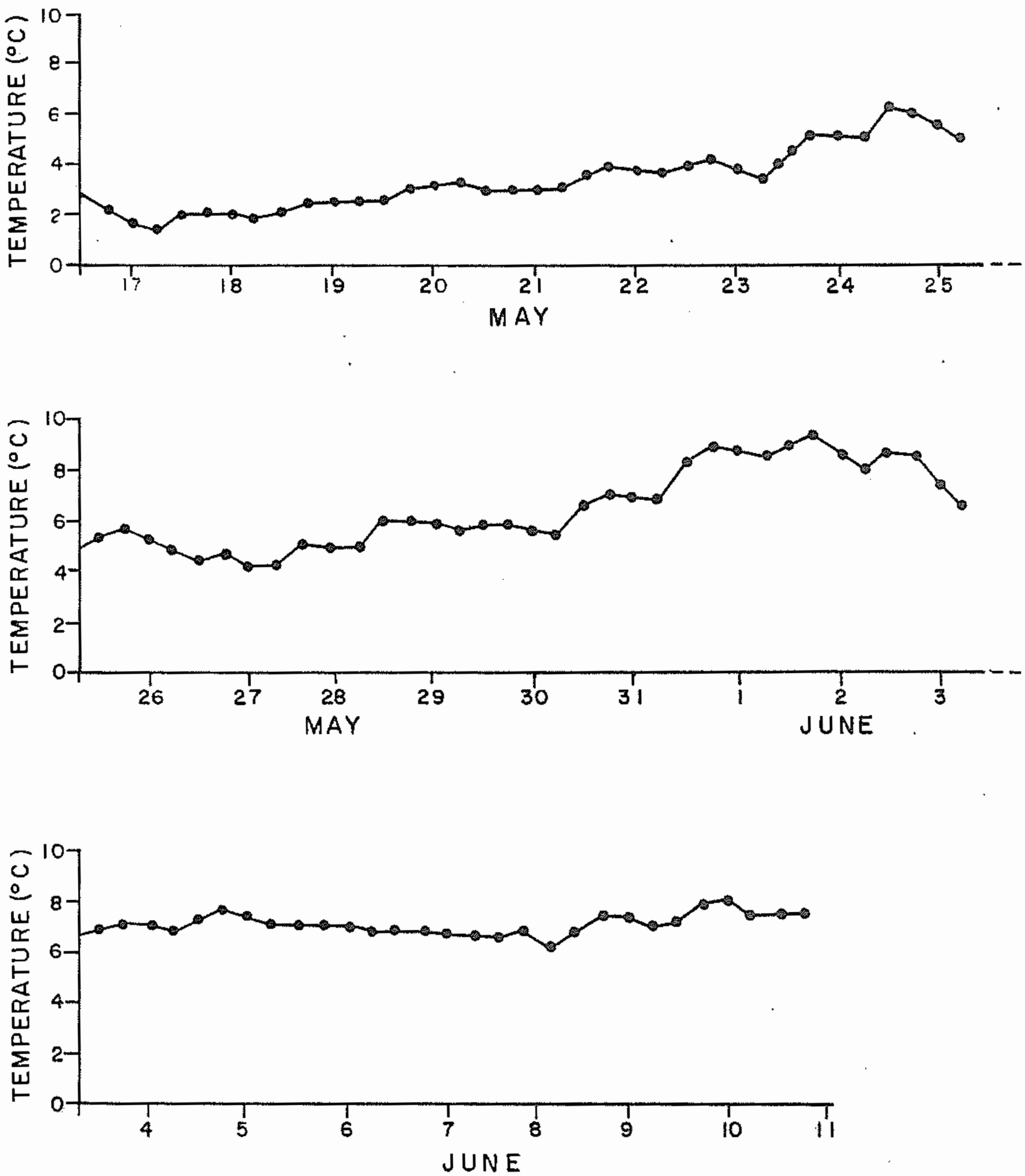


Figure 4II 3-61 Water temperatures for the Susitna River at Susitna Station (RM 25.5): May 16 - June 10, 1982.

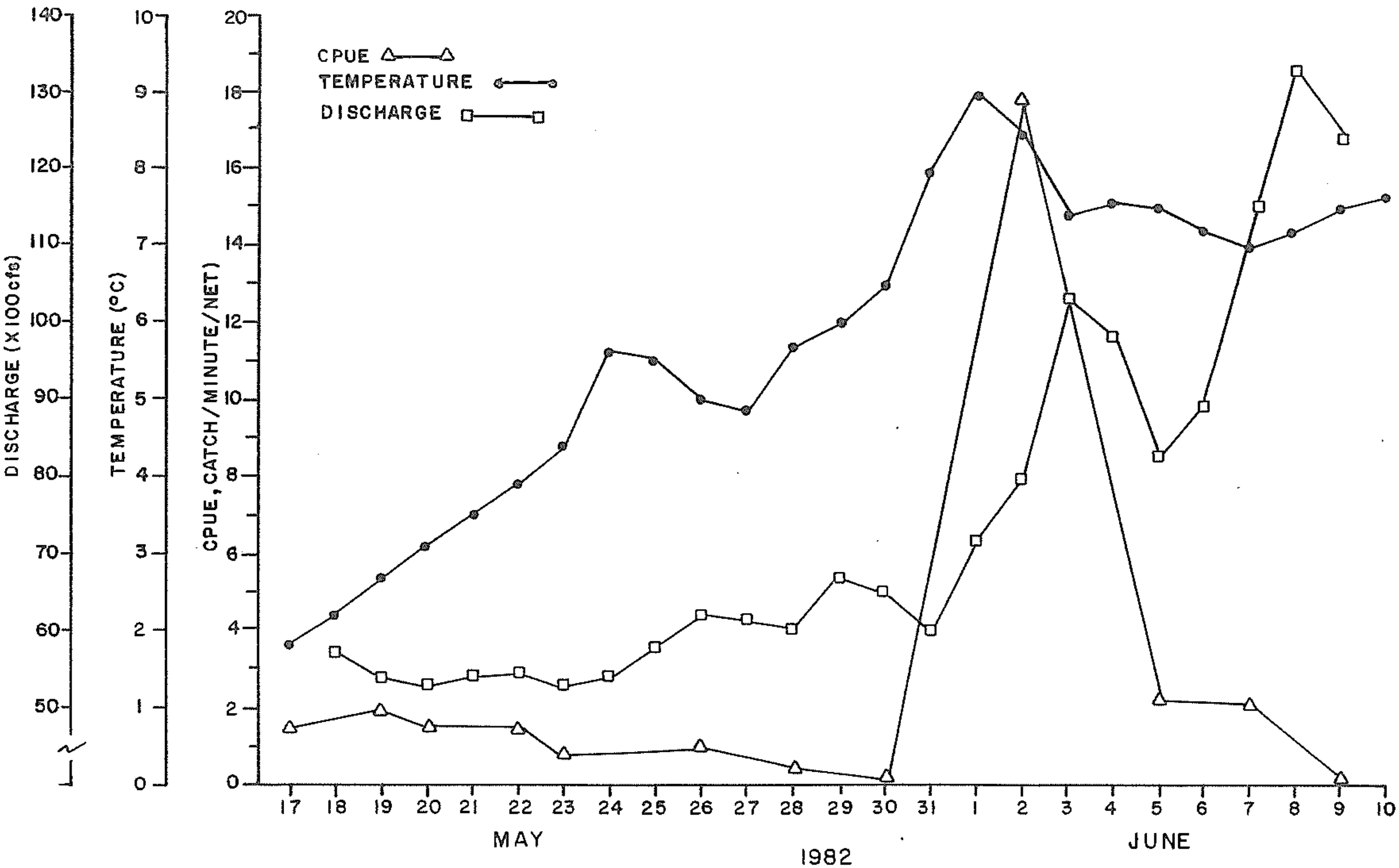


Figure 4-3 Discharge and daily mean water temperatures for the Susitna River at Susitna Station (RM 25.5) compared with CPUE (catch/minute/net) for the gillnet set at RM 5.0: May 17 - June 10, 1982.

3.1.7 Bering Cisco

A total of 730 Bering cisco were sampled by fishwheel (212/780, 29 percent) and electroshocking gear (518/730, 71 percent) from August 7 to freeze-up on October 15 (Volume 2). Only one catch site was determined to have Bering cisco spawning. The site (Figures 4II-3-63 and 4II-3-64) located along a gravel bar in the mainstem channel of the Susitna River opposite Montana Creek (RM 76.8-77.6), was a documented spawning site during last year's Bering cisco study (ADF&G 1981a). Fish were present at the site beginning in early September of this year, although none were in spawning condition until October 13, 1982. It is not known whether the fish present in early September were migrating through the site, milling or preparing to spawn at the site, because tagging studies were not initiated this past year. Based on last year's preliminary studies which included a limited tagging effort, however, it appears as though a portion of the fish which arrive early at a site remain and spawn at a latter date when river conditions facilitate spawning.

The spawning site was surveyed for its spawning habitat (Table 4II-3-10) utilizing procedures described in the methods section. Water temperatures and discharge data at time of spawning for the 1981 and 1982 Bering cisco spawning sites are also compared (Table 4II-3-11). Another catch site, located at RM 81.2 was suspected to have Bering cisco spawning, however spawning could not be confirmed. No habitat surveys were performed at this catch site.

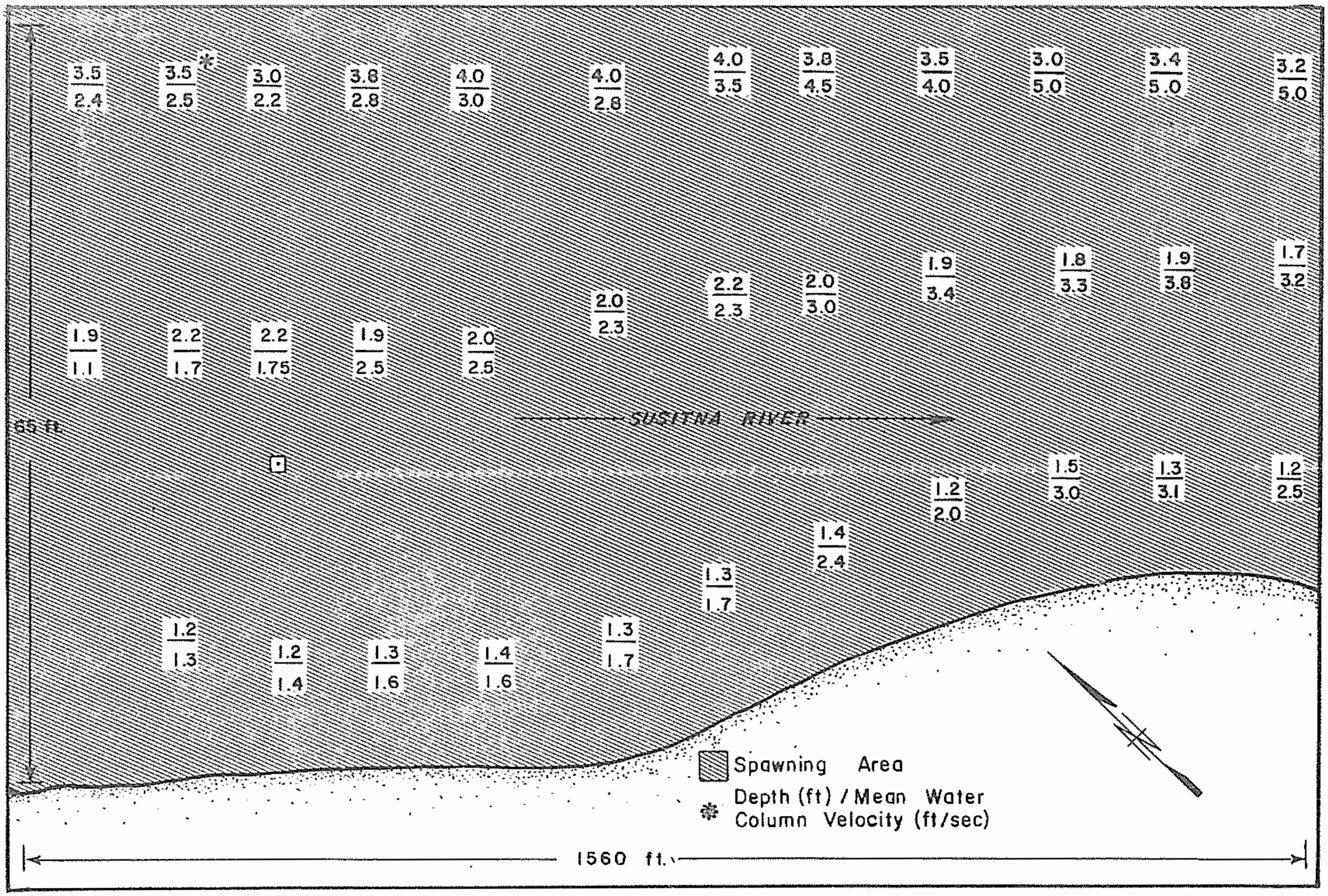


Figure 4E-3-63 The Lower Montana Bering cisco spawning area on the Susitna River at RM 76.8 - 77.3, GC S23N04W06ADD: October 14, 1982.

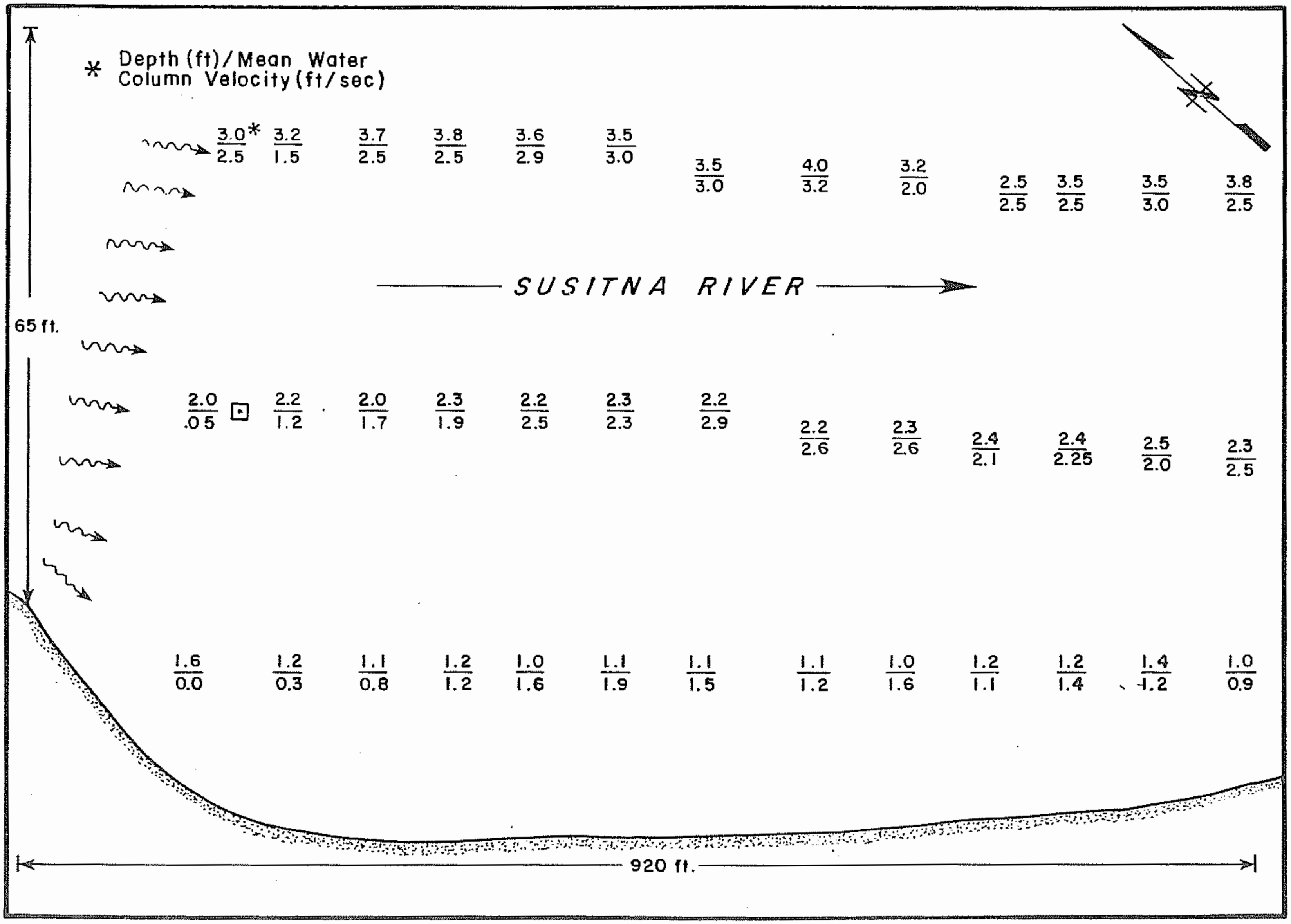


Figure 4II-3-64 The Upper Montana Bering cisco spawning area on the Susitna River at RM 77.3 - 77.6, GC S23N04W06CBB: October 14, 1982.

Table 4II-3-10. Bering cisco spawning site habitat evaluations for RM 76.8 - 77.6 on the Susitna River: October 14, 1982.

						Mean Spawning				
Site	River Mile	Water Temp (°C)	pH	Conductance (umhos/cm)	Dissolved Oxygen (mg/l)	Depth (ft)	Standard Deviation	Velocity (ft/sec)	Standard Deviation	Substrate
Upper Montana	77.3 - 77.6	0.4	7.6	126	1.80[a]	2.3	0.97 (n=39)[b]	1.9	0.84	Onshore 50% gravel 50% rubble Offshore 20% cobble 60% rubble 20% gravel
Lower Montana	76.8 - 77.3	0.2	7.6	131	17.8[a]	2.4	0.99 (n=35)[b]	2.7	1.06	Onshore 50% gravel 50% rubble Offshore 20% cobble 60% rubble 20% gravel

[a] These figures are probably inaccurate due to a meter malfunction.

[b] Sample size.

3/2 + 3/3

Table 4II-3-11. Water temperatures (°C) and discharges at Bering cisco spawning sites: 1981 and 1982.

Site	River Mile	Date	Water Temperature	Discharge[a] (cfs)
		(1981)		
Sunshine	78.0 - 79.0	811013	3.8	17,000
Montana 1	77.0 - 77.5	811015	3.0	19,000
Montana 2	76.0 - 77.0	811015	3.3	19,000
Mainstem-West Bank	75.0	811013	3.1	17,000
		(1982)		
Montana (Upper)	77.3 - 77.6	821014	0.4	17,900
Montana (Lower)	76.8 - 77.3	821014	0.2	17,900

[a] USGS data collected at Sunshine (Parks Highway Bridge), provisional data.

To determine the effects water temperature has on the movement patterns and timing of spawning of Bering cisco, surface water temperature was continuously collected for the Susitna River at Sunshine (Parks Highway Bridge, RM 84.0). This data was converted into daily means calculated as the mean of twelve two-hour point temperature readings. Daily mean water temperatures and provisional discharge data (USGS 1982) for the Susitna River at Sunshine (RM 84.0) are plotted with fishwheel catch per day at Sunshine for the period September 1-30, 1982 (Figure 4II-3-65). A similar graph of Bering cisco data (ADF&G 1981a) is included for comparison (Figure 4II-3-66).

3.2 Juvenile Anadromous Fish Habitat Investigations

Catch and catch per unit effort (CPUE) data for all juvenile salmon species at Designated Fish Habitat (DFH) sites is presented in Volume 3 (section 3.1.2). Catch and CPUE data ordered by specific site are contained in Appendices G and H of this volume (boat electrofishing data are not included in these tables). Habitat data for the DFH sites are contained in Appendix I of this volume and hydraulic conditions and discharge data are presented in Part I of this volume (section 3.1.3.1). Summaries of the hydraulic conditions, habitat data, and biological data for each DFH site are in Appendix F.

3.3 Resident Fish Habitat Investigations

Resident fish catch and CPUE data at DFH sites are presented with juvenile anadromous data (see previous section, section 3.2). Resident

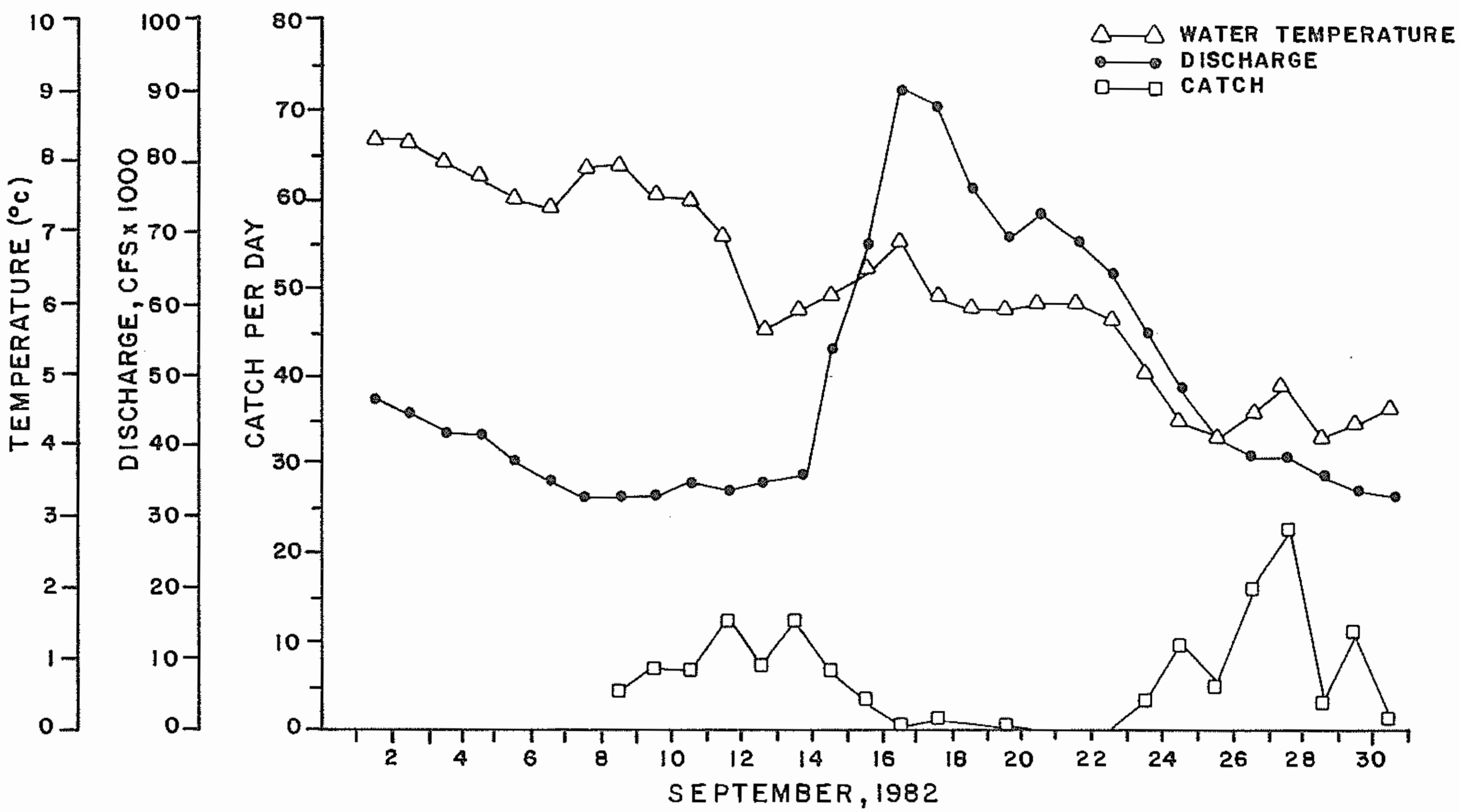


Figure III-3-65 Bering cisco catch per day at the Sunshine fishwheel compared with daily mean surface water temperatures of the Susitna River at Sunshine (RM 84.0) and provisional discharge at Sunshine (USGS, 1982): September, 1982.

3/17

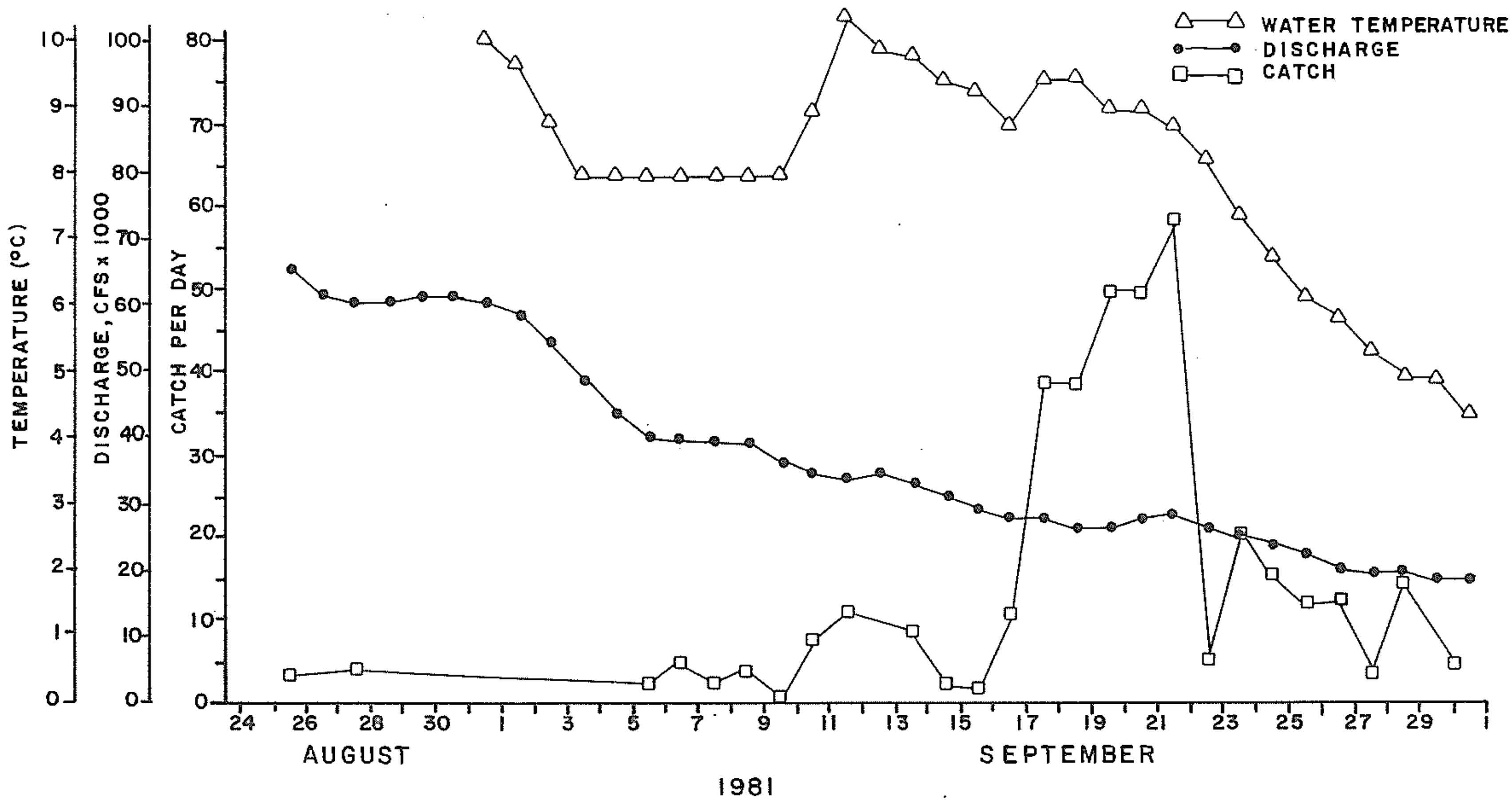


Figure 4F-3-66 Bering cisco catch per day at the Sunshine fishwheel compared with daily mean surface water temperature of the Susitna River above Montana Creek (RM 77.5) and provisional discharge (USGS, 1981) at Sunshine (RM 84.0): August 25 - September 30, 1981).

fish catch and CPUE data at Selected Fish Habitat (SFH) sites are contained in section 3.1.1 and Appendix A of Volume 3.

3.3.1 Rainbow Trout

The results of the 1981-82 winter radio telemetry studies for rainbow trout are presented in Figure 4II-3-67 and Table 4II-3-12.

3.3.2 Burbot

The results of the 1981-82 winter radio telemetry studies for burbot are presented in Figure 4II-3-68 and Table 4II-3-13.

3.3.3 Others

Two areas of longnose sucker spawning and one area of arctic lamprey spawning were located in 1982. Preliminary evaluations of these spawning habitats were attempted. The results of these preliminary evaluations are presented in Table 4II-3-14.

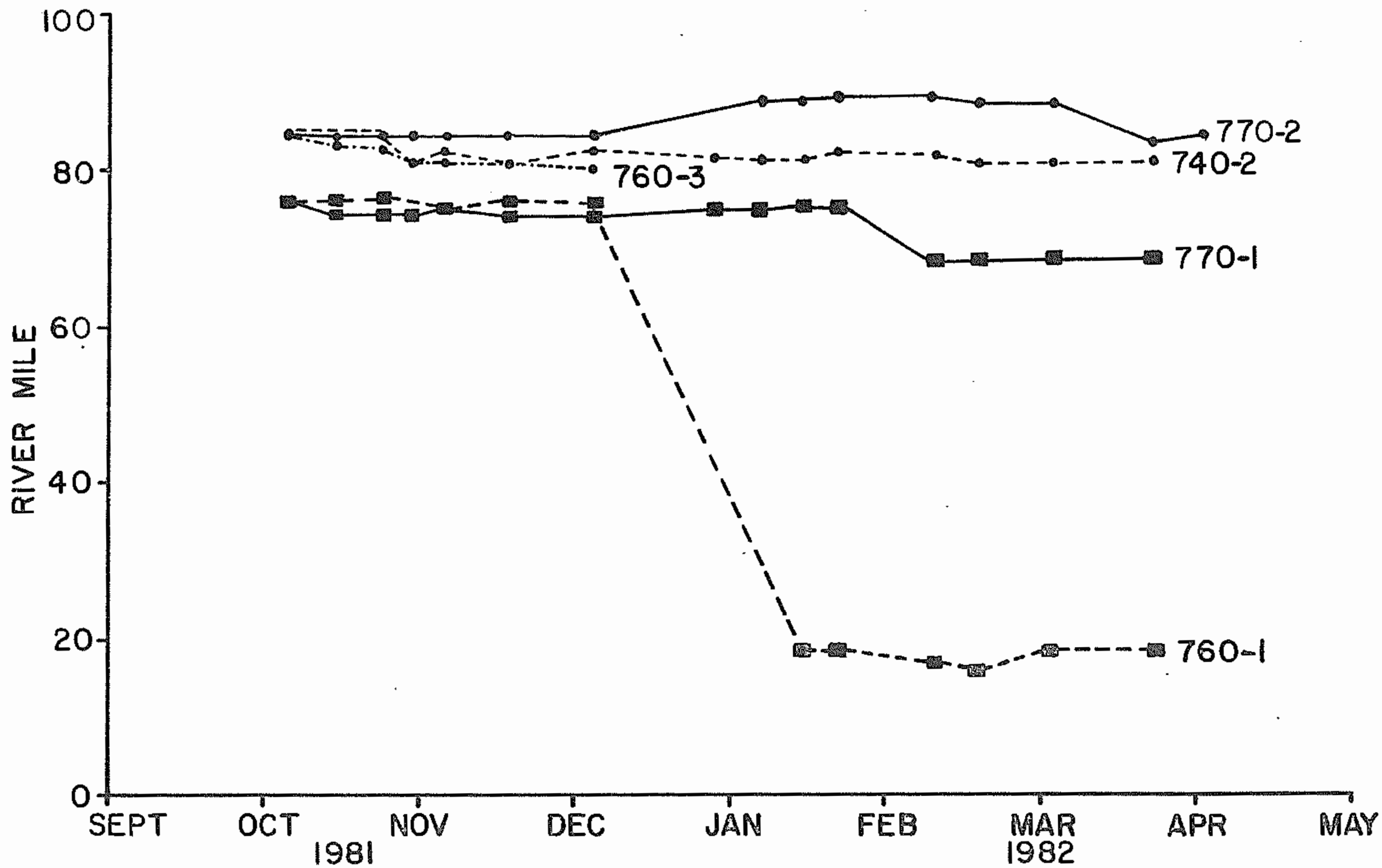


Figure 4II-3-67 Movement of five radio tagged rainbow trout in the Susitna River, October, 1981 through April, 1982.

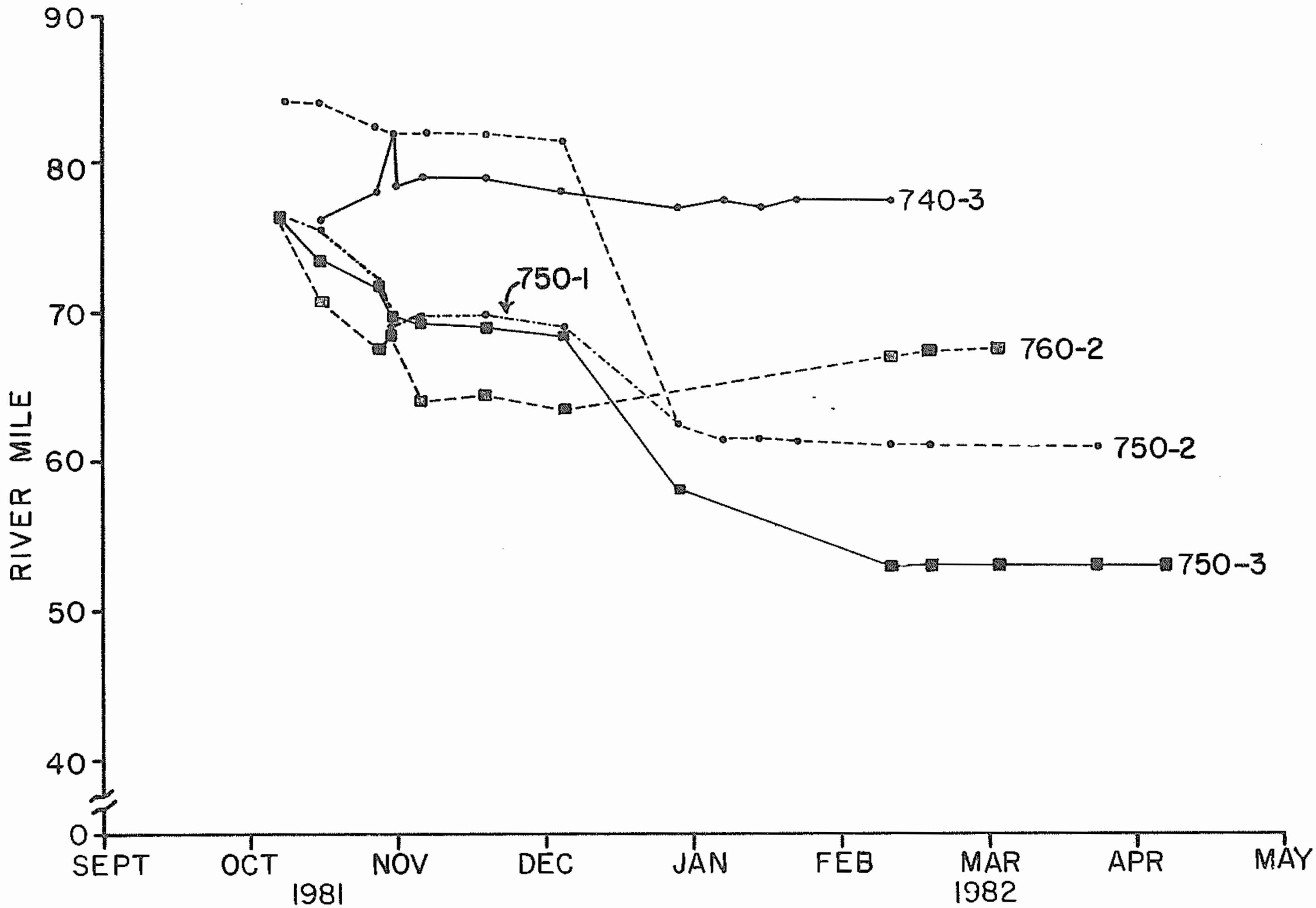


Figure [illegible] Movement of five radio tagged burbot in the Susitna River, October, 1981 through April, 1982.

Table 4II-3-12. Water quality and quantity and substrate data at overwintering areas utilized by radio tagged rainbow trout during 1981.

River Mile	Geographic Code	Date	Time	Water Temp. (°C)	pH	Dissolved Oxygen (mg/l)	Specific Conductance (umho/cm)	Water Depth (ft)	Water Velocity (ft/sec)	Substrate
67.5	S22N05W24DAC	820304	1230	0.0	7.1	11.2	162	-.-	0.5	30% sand 30% cobble 30% gravel
53.5	S20N05W14BCA	820221	1330	0.3	5.7	7.9	134	1.0	-.-	100% gravel
53.5	S20N05W14BCA	820221	1330	0.4	5.9	11.0	212	1.2	-.-	80% gravel 20% sand
61.0	S21N05W13BBA	820304	1200	0.0	7.3	11.6	243	5.8	0.1	-----
61.0	S21N05W13BBA	820221	1630	-0.1	6.1	11.4	147	2.5	-.-	20% cobble 50% gravel 20% sand

Table 4II-3-13. Water quality and quantity data at overwintering areas utilized by radio tagged burbot during 1981.

River Mile	Geographic Code	Date	Time	Water Temp. (°C)	pH	Dissolved Oxygen (mg/l)	Specific Conductance (umho/cm)	Water Depth (ft)	Water Velocity (ft/sec)
68.5	S22N05W14ADD	820305	1300	+0.6	7.1	12.8	225	6.2	-.-
68.5	S22N05W14ADD	820305	1300	+0.5	6.7	13.2	223	7.0	-.-
82.0	S24N05W22DAC	820308	1600	0.0	7.1	13.4	216	7.5	-.-
84.0	S24N05W10DCC	820305	1200	+0.1	6.6	9.7	119	-.-	-.-

Table 411-3-14. Spawning site habitat evaluations for longnose sucker and arctic lamprey: 1982.

Species	Site (River Mile)	Date	Water Temp (°C)	pH	Specific Conductance (umhos/cm)	Dissolved Oxygen (mg/1)	Range of Spawning Depths (feet)	Range of Spawning Velocity feet/second	Substrate	Embedded
Sucker	Sunshine Slough (RM 85.7)	820525	6.4	7.1	54	11.4	1.5 - 1.7 (n=5)[b]	0.9 - 1.7 (n=5)[b]	60% cobble 20% gravel 20% silt	Yes
Sucker	Trapper Creek mouth (RM 91.5)	820605	10.0	-[a]	-[a]	-[a]	2.2 - 2.8 (n=5)[b]	0.5 - 1.1 (n=5)[a]	60% cobble 20% gravel 20% silt	Yes
Arctic Lamprey	Birch Creek mouth (RM 89.2)	820624	15.3	6.8	50	10.0	0.9 (n=1)[b]	1.4 (n=1)[b]	100% gravel	No

[a] Data not available.

[b] Sample size.

4. DISCUSSION

4.1 Adult Anadromous Habitat Investigations

4.1.1 Salmon Species

4.1.1.1 Mainstem

Adult anadromous fish distribution data collected during the 1981 (ADF&G 1981b) and 1982 (Volume 2) open water field seasons indicate that adult salmon spawning activity in the mainstem Susitna River is limited (for a definition of how "mainstem" is defined in this report, refer to Part II, section 2.1.1.1 of this volume). It is currently unknown whether the limited use of the mainstem for spawning is the result of lack of suitable spawning habitats or the relative higher availability of more suitable spawning habitats in other areas (e.g., sloughs). Preliminary data, however, indicate that the substrate in the majority of the mainstem is cemented, making it unsuitable for adult salmon spawning.

Chum salmon appear to be the only salmon species which utilize the mainstem Susitna River for spawning. Coho, pink or sockeye salmon were not found to spawn in the mainstem Susitna River during the 1982 open water field season. Based on an evaluation of the data presented in Tables 4II-3-1 and 4II-3-2 and Figures 4II-3-2 through 4II-3-9, the majority of the mainstem chum salmon spawning sites surveyed were located in clear backwater habitats situated in side channels which were cut off either entirely or partially from mainstem water influence at their heads. Only one surveyed spawning site (located at RM 148.2, study site number 3) was located in the main channel (Figures 4II-3-1 and 4II-3-4).

Mean water depths and water column velocities measured at chum salmon spawning sites ranged from 0.0-4.0 feet and 0.0-1.0 feet/second, respectively. Substrate utilized for spawning ranged from silty sand to boulders. Gravel, rubble and cobble were preferred. The substrate was most often loosely embedded with silty sand which was cleared in areas of redds. Surface water temperatures, taken at a depth of approximately 1 to 2 feet below the surface, ranged from 3.3-7.0°C.

Each chum salmon spawning site, except site number 3 (at RM 148.2), had clear water zones indicating the surveyed spawning areas were isolated either entirely or partially from mainstem surface water influence. The clear water found suggests that these spawning sites receive a significant portion of their surface water flow from subsurface percolation, since very little surface drainage was observed into the study areas. Intragravel water temperatures ranged from 0.2 to 5.3°C cooler than surface water temperatures, suggesting that a subsurface water flow exists in the areas of spawning activity and that it is of a different nature ~~than~~ from the surface waterflow.

The tributary-mainstem confluence zone, which includes the area of the mainstem influenced either directly (i.e., the delta area and the downstream mixing zone) or indirectly (i.e., the tributary ground water influence zones) by the tributary, was not investigated this past year.

Observations, however, suggest that these zones may provide a substantial amount of spawning and juvenile rearing habitat for chum, pink and coho salmon, in addition to rearing habitat for selected resident fish. Since these confluence zones will be directly impacted by the proposed project, studies are planned to investigate the habitat of these zones during 1983.

Because this year was the first attempt at describing the habitat characteristics of mainstem salmon spawning areas, data and evaluations presented should be considered preliminary. Continuation of these studies are planned in 1983.

4.1.1.2 Slough

Chum salmon were found to be the salmon species which used the slough habitats most extensively for spawning. Sockeye and pink salmon were found to spawn frequently in the sloughs, coho salmon were found rarely and chinook salmon were not found to spawn in sloughs at all. Chum salmon were found in most sloughs upstream of Susitna RM 107 (sloughs 5, 6A, 8D, 8C, 8A, B, 9, 8B, Moose Slough, sloughs 9B, 9A, 10, 11, 15, 17, 19, 20, 21). Sloughs 8A, 9, 11 and 21 had the highest number of spawning chum salmon.

4.1.1.2.1 Spawning Site Selection

During the 1982 spawning season chum were observed using areas with significant amounts of silt overlaying rubble and gravel substrates

(Plate 4II-4-1). In Slough 21, one redd was observed where nearly 18 inches of silt had been fanned away. Survival of eggs deposited at this extreme depth of silt is questionable however upwelling ground water observed in silt covered areas could allow survival of eggs and alevin in this type of substrate by providing a continuous flow of sufficiently oxygenated water over the incubating eggs. The utilization of areas of heavy silt was likely a result of the salmon being forced to use less than OPTIMAL ~~optional~~ areas due to tow flows denying migration upstream to more desirable substrates. Chum salmon did appear to prefer areas with upwelling present.

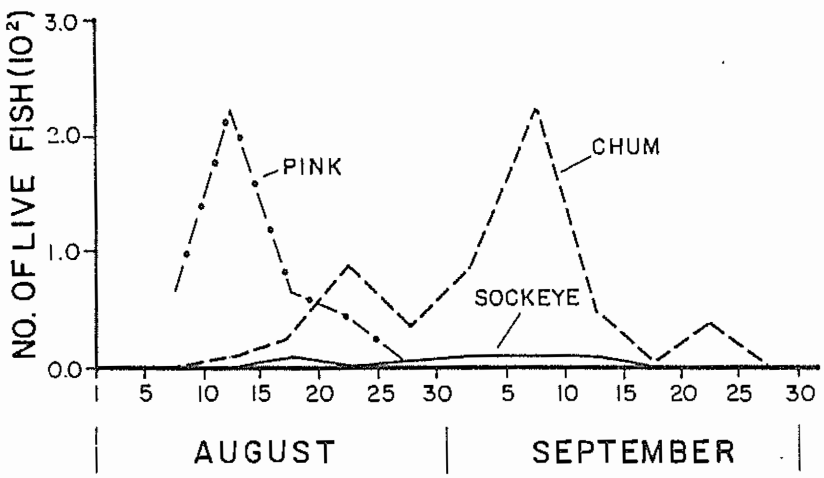
4.1.1.2.2 Timing of Spawning

Much of the following discussion was derived from data obtained and presented in Volume 2. Information has been arranged here to facilitate comparisons between sloughs that were most intensively studied by Fish Habitat Utilization personnel. Numbers of live chum, pink and sockeye salmon observed in side sloughs during the spawning season are presented in Figure 4II-4-I. Data for sloughs 8A, 9, 11 and 21 are presented individually and all other sloughs sampled are combined and presented collectively. In addition to sloughs 8A, 9, 11 and 21, other sloughs sampled include a, 2, 3A, 3B, 4, 5, 6, 6A, 7, 8, 8B, 8C, 8D, 9, 9A, 9B, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20. Because coho salmon were only present in limited numbers, they have not been included in the figures.

Sloughs 8A, 9, 11 and 21 each contained more fish than the other sloughs combined (Figure 4II-4-1). With the exception of Slough 11, where

Plate 4II-4-1. Chum salmon spawning in silted area at Slough 21. Note fish have fanned silt from spawning area.

OTHER SLOUGHS SAMPLED



SLOUGH 8A

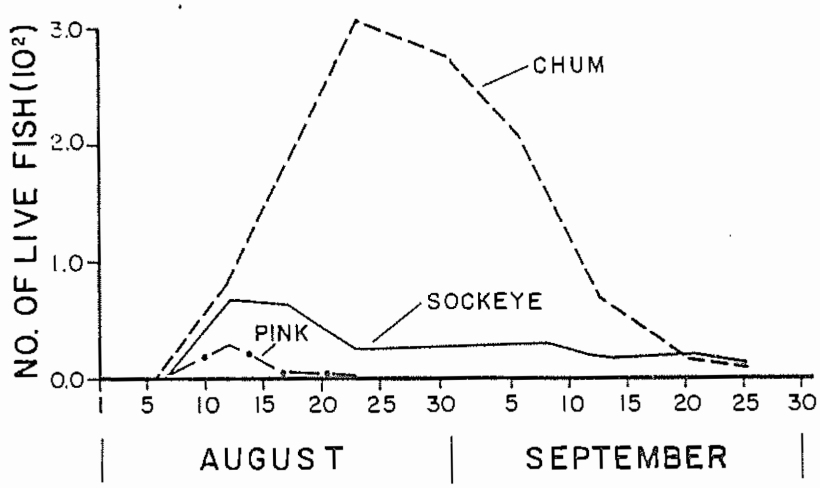
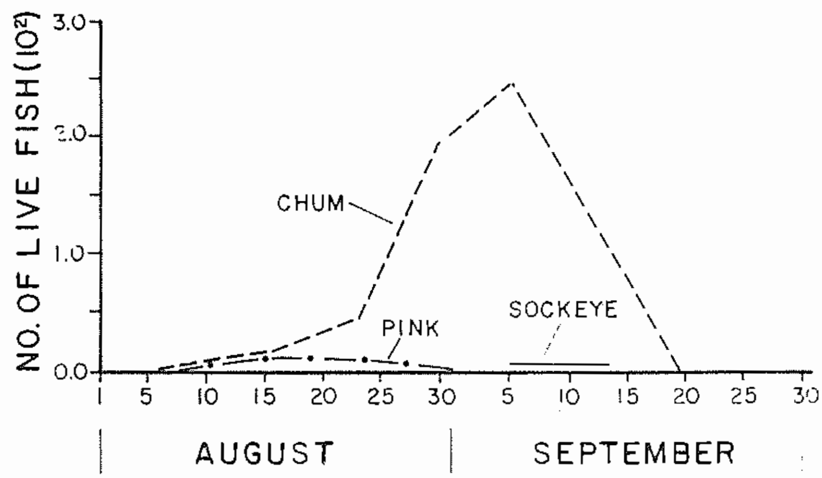


Figure 4II-4-1 Numbers of line salmon counted in August and September, 1982, in sloughs 8A, 9, 11, 21 and others (1, 2, 3A, 3B, 4, 5, 6, 6A, 7, 8, 8B, 8C, 8D, A, 9A, 9B, 10,12, 13, 14, 15, 16, 17, 18, 19, 20).

SLOUGH 9



SLOUGH 11

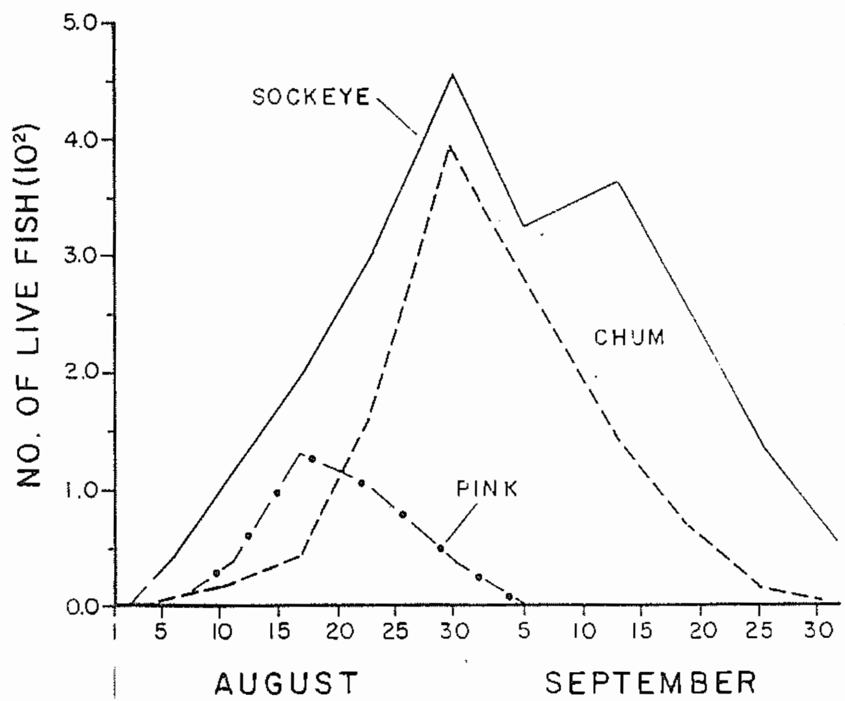


Figure 4II-4-1 Continued.

SLOUGH
21

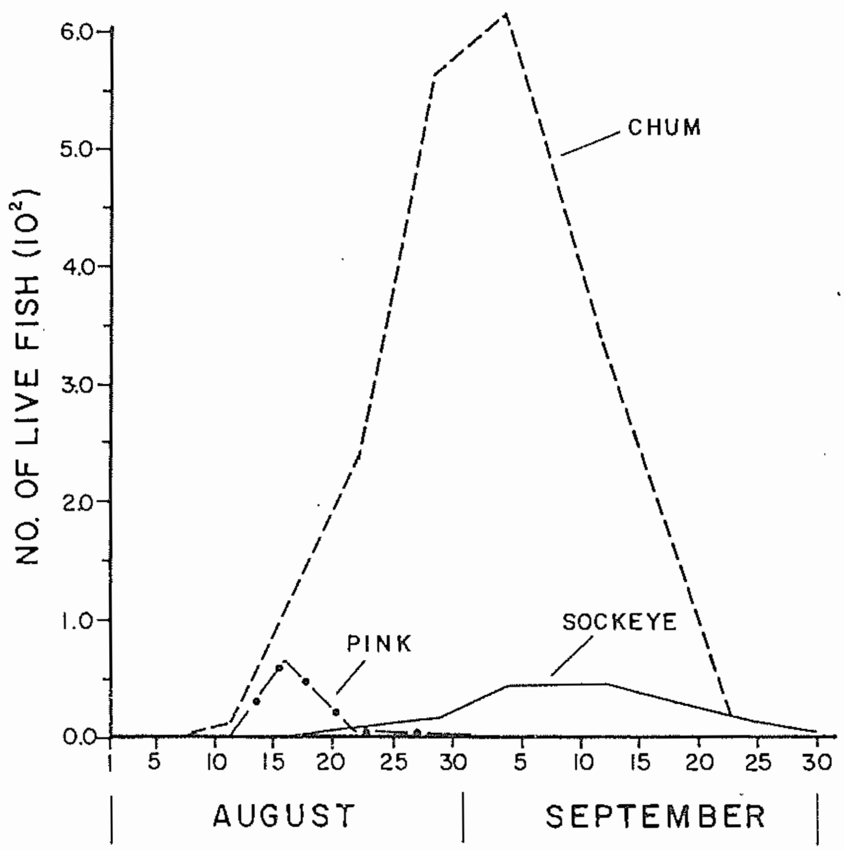


Figure II-4-1 Continued

sockeye salmon outnumbered chum salmon, chum salmon were numerically dominant almost every day (refer to Volume 2 for specific numbers). The timing of peak numbers of fish and their duration of residence inside sloughs generally followed consistent patterns. In general, pink salmon numbers peaked earlier than chum salmon in all sloughs. With the exception of Slough 11, numbers of pink salmon entered sloughs in early to mid-August, peaked in mid-August and were completely absent by September 1. Chum salmon typically entered sloughs by August 10, peaked sometime between August 20 and September 1, declined rapidly in mid-September and were completely absent by the end of September. In contrast to the pattern for pink and chum salmon, numbers of sockeye salmon generally lacked definite peaks, were much less abundant than chum salmon and persisted in low numbers in late September (sloughs 8A, 11, 21). The obvious exception to the above generalizations occurred in Slough 11 where sockeye salmon numbers exhibited a bimodal peak at August 30 and September 13 and persisted in the slough until mid-October.

In spite of the unique characteristics of Slough 11, it is obvious that of all sloughs sampled, sloughs 8A, 9, 11 and 21 contained the largest numbers of live salmon in 1982. In addition, there was a temporal segregation in usage pattern between species. This was most evident between pink and chum salmon, with numbers of pink salmon consistently peaking before chum salmon. The pattern for sockeye salmon was less distinct, but generally indicated that sockeye salmon spawned in sloughs during the period of, or later than, chum salmon spawning.

The above generalizations comprise a short summary description of the spatial and temporal distributions of live fish in side sloughs, as observed in 1982. However, at this time, factors accounting for these patterns are not known with certainty. We do know that the distributions of a species in space and time can be affected by limitation of dispersal ability, behavioral preferences, other species, or by physical and chemical factors (Krebs 1972).

Access to spawning areas may prohibit spawning in otherwise suitable habitats. This may occur on a large scale, such as the barrier imposed by the rapids at Devil Canyon to all upstream salmon migration, or it may occur on a smaller scale, such as access into a slough or tributary. Because access denied into an area eliminates consideration of all other factors (Figure 4II-4-2), it is of critical concern in light of potential impacts resulting from construction and operation of hydroelectric dams, the focus of the remainder of the discussion will be concerned with the access of salmon to sloughs between Talkeetna and Devil Canyon.

4.1.1.2.3 Access

If proposed Susitna hydroelectric dams are constructed, existing discharge levels, rates of sediment transport and seasonal thermal regimes are expected to change. Changes in these habitat characteristics are expected to alter existing quantity and/or quality of fish habitat (Acres American, Inc. 1982). It is anticipated that routine operations of the hydroelectric dams will result in reduced summer discharge levels and elevated winter flows, and that these changes in space

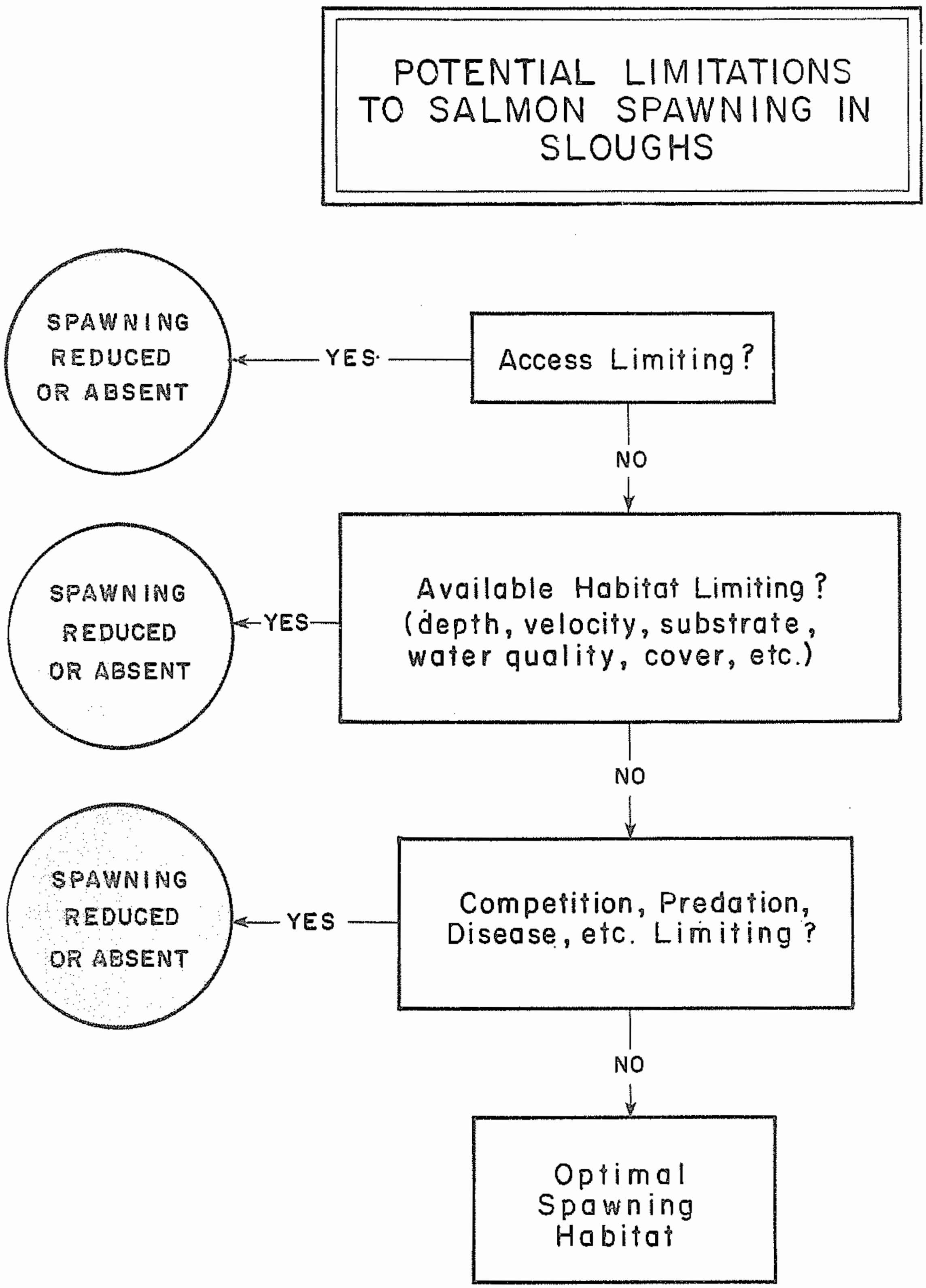


Figure 4II-4-2 Factors limiting salmon spawning.

flow-dependent habitat characteristics will be greatest between Talkeetna and Devil Canyon. In addition, it is feared that reductions in mainstem discharge levels may seriously inhibit fish access to traditional spawning habitats.

Streambed elevations at the downstream entrance to side sloughs are generally lower than the stage (water surface elevation) in the adjoining mainstem channel. Thus, the stage of the mainstem causes a hydraulic plug which impedes the flow of clear water from the mouth of the slough, causing a clear backwater zone to form in the vicinity of the mouth that may extend several hundred feet upstream into the slough. As mainstem discharge increases, the depth and size of the backwater zone at the mouth of the slough continues to increase. At some point, the stage in the mainstem river reaches a critical level, allowing flow from the mainstem to enter the slough at its upstream end. Once overtopped, flows within the sloughs often increase rapidly from less than 10 cfs to more than 500 cfs (ADF&G 1982a, R&M 1982).

Because sloughs 8A, 9, 11 and 21 contained the greatest numbers of live fish, they were studied more intensively and are the primary focus of the remaining discussion regarding fish access problems in side sloughs.

Although some mainstem spawning was documented (Section 4.1.1.1), the most intensively used spawning areas between the Talkeetna and Devil Canyon were located in tributary streams and side sloughs (ADF&G 1981a). It is hypothesized that changes in mainstem flows affect access of salmon into tributaries and side sloughs. The most complete information regarding access pertains to side slough and is the central topic of the following discussion.

Discharge levels in the mainstem Susitna River principally influence side slough habitats in two ways: 1) intermediate discharges cause a backwater effect at the mouth of the slough creating a special type of slough habitat which facilitates access of fish into the slough (ADF&G 1981b and 1982a); and 2) high flows overtop (breach) the upstream end of the slough and may provide a temporary access corridor to upper reaches of sloughs that would otherwise have been prohibited (refer to section 3.1.1.2 for summary of mainstem discharges at which sloughs breach).

Trihey (1982) emphasized that the interaction of mainstem and slough discharges, extent of backwater zone and the characteristics of streambed gradient largely define access conditions to a slough. Although high velocities have been identified as blocking the upstream migration of spawning fish in some Alaskan river s, entrance conditions and associated backwater effects in the lower portions of the side sloughs between Talkeetna and Devil Canyon make it nearly impossible for velocity barriers to exist at these locations. Thus, the ease at which adult salmon can enter the side sloughs from the mainstem Susitna appears to be primarily a function of depth.

Slough 9 was selected for detailed discussion because it represents an intermediate level of access difficulty: easier than sloughs 16 or 19, more difficult than Whiskers Slough or Slough 8A and comparable to sloughs 20 and 21 (Trihey 1982).

The thalweg and water surface profiles which defined entrance conditions for Slough 9 on August 24, 1982 are presented in Figure 4I-3-27. The mainstem discharge at Gold Creek was 12,500 cfs and flow in Slough 9 was 3 cfs.

The depth of flow at the mouth of Slough 9 is a function of the water surface elevation of the mainstem and the discharge from the slough. Data obtained during the 1981 and 1982 field seasons indicate that the flow from Slough 9 is quite small unless it is breached (Table 4II-4-1). On the basis of these data, 3 cfs was selected as being typical of the mid-summer clearwater flow from Slough 9.

A staff gauge was installed at the lower entrance to Slough 9, and numerous gauge height readings were recorded through September. The staff gauge was installed in the deepest water available in the passage reach so that it would not dewater before the reach. As a result, gauge height readings are 0.3 feet greater than the controlling depth at the mouth of the slough. Water surface elevations were determined for each staff gauge reading and compared to the average daily mainstem discharge at Gold Creek (Table 4II-4-2). A plot of these data indicates the relationship between mainstem discharge and the water surface elevation in the mouth of Slough 9 is well defined for the range of streamflows from 11,000 to 33,000 cfs (Figure 4II-4-3).

To evaluation the influence of mainstem discharge on fish passage, backwater profiles were determined for the 2,200-foot reach near the mouth of Slough 9 for incremental levels of mainstem discharge and a

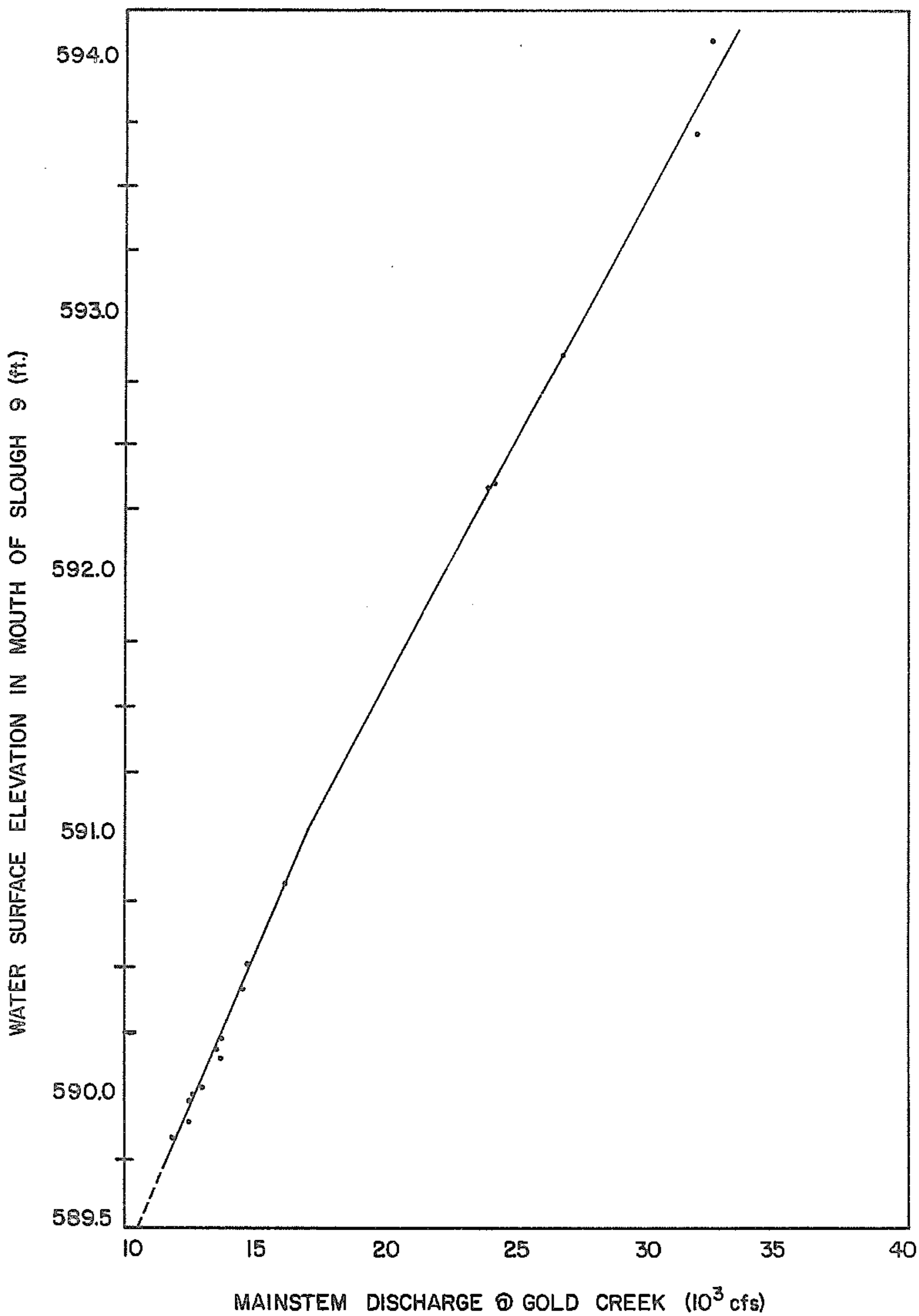


Figure II-43 Water surface elevation at mouth of Slough 9 versus mainstem discharge at Gold Creek.

Table 4II-4-1. Comparison of Slough 9 streamflow measurements with the average daily mainstem discharge at Gold Creek.

Date	Streamflow (cfs)	Mainstem (cfs)
6/24/81	2.9[a]	16,600
7/21/81	714.0[a]	40,800
9/30/81	1.5[a]	8,000
10/14/81	1.2[a]	7,290
6/23/82	182.0[b]	No Record
7/15/82	108.0[b]	25,600
7/20/82	28.5[b]	22,900
8/25/82	3.4[a]	13,400
9/4/82	8.4[a]	14,400
9/9/82	3.0[b]	13,400
9/18/82	232.0[a]	26,800
9/20/82	145.0[a]	24,000

[a] ADF&G 1981c and 1982.
[b] R&M Consultants 1982.

Table 4II-4-2. Comparison of water surface elevations (WSEL) at the entrance to Slough 9 and the average daily mainstem discharge at Gold Creek, 1982.

Date	WSEL[a] (ft)	Gold Creek Discharge (cfs)	Date	WSEL (ft)	Gold Creek Discharge (cfs)
8/24/82	590.03	12,500	9/05/82	590.16	13,600
8/25/82	590.19	13,400	9/06/82	589.91	12,200
8/26/82	590.24	13,600	9/07/82	589.84	11,700
8/27/82	590.04	12,900	9/16/82	594.09	32,500
8/28/82	589.98	12,400	9/17/82	593.71	32,000
8/29/82	589.91	12,200	9/18/82	592.86	26,800
9/02/82	590.82	16,000	9/19/82	592.37	24,100
9/03/82	590.51	14,600	9/20/82	592.36	24,000
9/04/82	590.42	14,400	9/29/82	589.98	12,400

[a] ADF&G gages 129.2 W1A and W1B.

constant sloughflow of 3 cfs (Figure 4II-4-4). Two potential problem areas exist for adult salmon entering Slough 9: a 125-foot reach approximately 400 feet downstream from the mouth of the slough, and a 280-foot reach from 620 to 900 feet upstream of the mouth. The approximate length and average depth within the two critical passage reaches were determined for each backwater profile (Table 4II-4-3.).

Based on data in Table 4II-4-3 and field observations by ADF&G personnel, upstream passage into Slough 9 by adult chum salmon does not appear restrictive at either passage reach A or B when mainstem discharges are 18,000 cfs or higher. At this discharge passage, reach A is no longer an obstacle, having an estimated depth of 1.75 feet (Table 4II-4-3); and passage reach B increases slightly in depth (from 0.20 to 0.30 feet) and decreased greatly in length (from 280 feet to 80 feet). However, access becomes increasingly more difficult as mainstem discharge decreases with acute access problem existing at streamflows of 12,000 cfs or less.

On August 24, 1982, when mainstem discharge at Gold Creek was 12,500 cfs and no appreciable backwater zone was observed at the entrance of the slough, several chum salmon were observed grounded in shallow water near the entrance to the slough (passage reach A) as well as at passage reach B (Plate 4II-4-2). Depths were measured at numerous points where fish were grounded, although few isolated depths of 0.5 feet were measured, the most representative depth restricting access at the entrance to the slough was found to be 0.2 feet.

Plate 4II-4-2 Chum salmon stranded in riffle (see Figure 4II-4-4, station 8 + 00) during low flow conditions in Slough 9, inhibiting access to spawning areas.

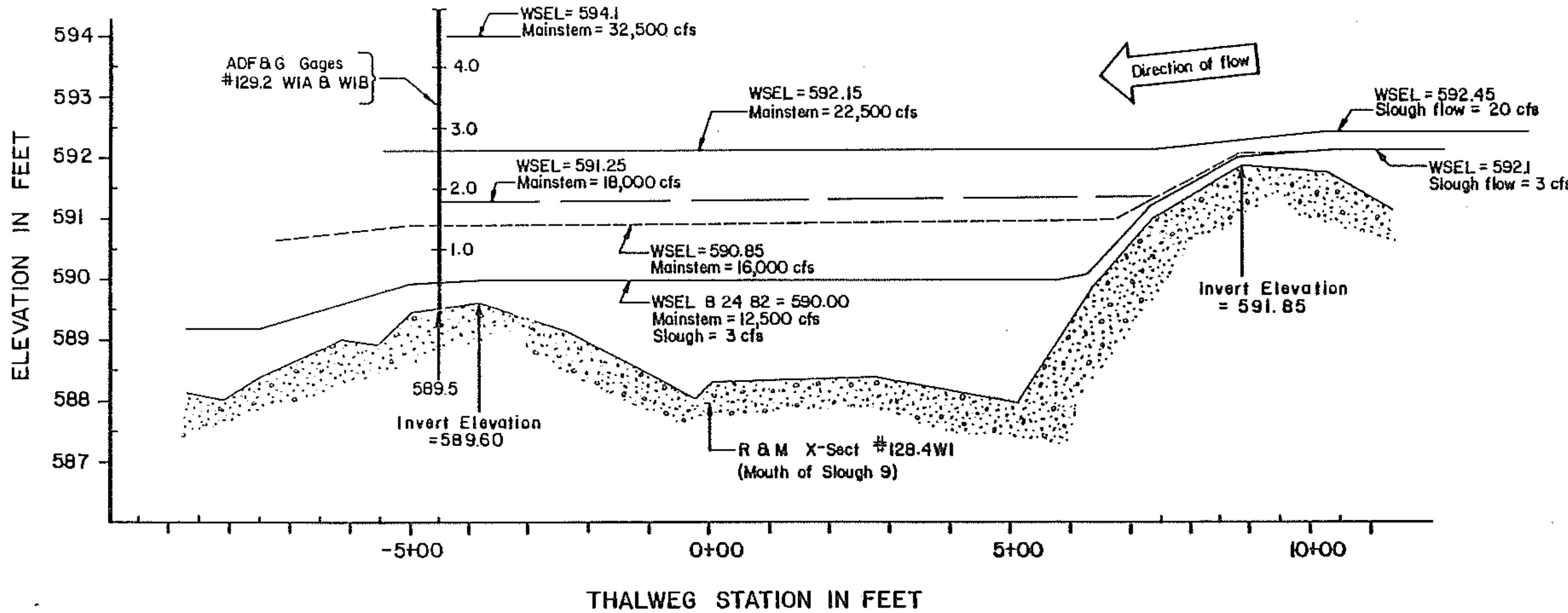


Figure 4II-4-4 Backwater profiles at the entrance to Slough 9 for selected mainstem stream flows at Gold Creek.

Table 4II-4-3 Entrance conditions at the mouth of Slough 9 at various mainstem discharges at Gold Creek when slough discharge was 3 cfs.

Mainstem Discharge cfs	Slough 9 WSEL (ft)	Passage Reach A		Passage Reach B	
		Average Depth (ft)	Reach Length (ft)	Average Depth (ft)	Reach Length (ft)
10,000	589.50	0.10	125	0.20	280
12,000	589.90	0.40	125	0.20	240
14,000	590.35	0.85	125	0.20	200
16,000	590.85	1.35	125	0.25	140
18,000	591.25	1.75	125	0.30	80
20,000	591.60	2.10	125	0.50	30
22,000	591.90	2.40	125	0.60	10

Mainstem conditions ranged between 12,200 and 13,300 cfs during the five days preceding these observations (USGS 1982). The limited number of chum salmon (20 total) observed above passage reach B, indicate that even during poor access conditions, blockage was not complete.

Additional evidence concerning access difficulty in sloughs involves observed changes in distributions of spawning salmon before and after heads of sloughs 8A, 9, and 21 were breached in mid-September (since the head of Slough 11 was not breached, access into this slough was relatively unchanged.) When the head of a slough is breached, water from the mainstem Susitna River enters the slough at its upstream end. Once overtopped, flows within sloughs often increase rapidly from less than 10 cfs to more than 500 cfs (ADF&G 1982a; R&M 1982). With these increased flows, fish are able to proceed to upper slough reaches that may otherwise have been inaccessible.

The breaching event in mid-September occurred as numbers of live chum salmon were sharply declining (Figure 4II-4-1) thereby limiting numbers of fish available to move upstream. Because this figure represents only live fish, and the mortality rates at this time were very high, it is likely that many live fish at September 15 were in poor condition and not able to migrate upslough. However, it is believed that if this high water event had occurred earlier in the year, when numbers of live fish were greatest (late August, early September), considerable spawning may have occurred in upper reaches of sloughs 8A, 9 and 21.

These observations suggest that if the timing of a peak mainstem flow (resulting in temporary breaching) more closely coincided with peak numbers of live spawners, access to upper reaches of sloughs may be facilitated. Such an event, if properly timed would probably reduce many access problems near the mouth (e.g., Slough 9).

In this discussion, the quantification of flow-related access problems for spawning salmon has only been attempted for Slough 9. However, a similar analysis is possible for sloughs 8A, 11 and 21, and will be presented in a future report. However, in light of the magnitude of its restrictive potential for salmon spawning, the following questions involving access to spawning habitats need to be addressed before flow-related impacts can be properly assessed.

1) Does denied or restricted access play a role in defining present distributions of spawning salmon in tributaries and side sloughs?

2) If hydroelectric dams are constructed and summer flows reduced in the mainstem Susitna River, what effect will this have on access to present and/or potential spawning areas?

3) Will changes in access difficulty favor particular species, due to a competitive advantage resulting from physiological differences?

A plan of study for FY 84 is being developed to address the first two questions in a quantitative fashion. Much hydraulic data involving the relationship of the mainstem Susitna River to side sloughs and tributaries already exists and will provide a basis from which to proceed.

4.1.1.2.4 Modeling

Discharge of the Susitna River sloughs cannot be correlated with discharges in the mainstem at this time because 1982 discharges were so low that samples were not representative of the normal range of conditions. The ranges of the various aquatic habitat types utilized by salmon species are also still being developed. The computer models will predict the surface area suitable for a species and/or specific life stage by weighing the utilized depth, velocity and substrate variables against those that were available (Milhous, et al. 1981). Some data have been collected for chum salmon redds. However, none of these variables have been measured at pink, sockeye and coho redds in the Susitna River sloughs. Data from other studies cannot be used to model Susitna River sloughs because fish habitat suitability data may not be comparable between stream systems (Estes, et al. 1981). For these reasons, the surface area utilized for salmon redds cannot be determined.

The vulnerability of salmon redds in sloughs is an important consideration in regulating mainstem flows during the critical spawning season. It is essential that the data base which predicts usable spawning area be reliable under a variety of hydraulic conditions. Because utilized and suitable habitat surface areas cannot be determined this year, they cannot be correlated with discharge regimes on the mainstem Susitna River. Long-term objectives of this study are to develop habitat utilization curves for the salmon species and life phases using the sloughs and side channels of the Susitna River, to develop relationships between the discharge (in mainstem and sloughs) and ~~useable~~ usable area and to determine mainstem discharges that would minimize impact to the fishery.

The data are sufficient to discuss the general hydraulic conditions and range of flows present when sloughs are breached by the mainstem versus when they are not. This discussion will be included in the 1983 Final Draft Fisheries Habitat Relationships report.

4.1.2 Eulachon

Eulachon (Plate 4II-4-3) were observed from the mouth of the Susitna River (RM 0) to a point upstream of the Susitna River near Willow Creek (RM 49.5). The Yentna River was not surveyed upstream of Kroto Slough mouth where eulachon were observed, however, historical accounts (personal communications) of past runs show an upstream limit of the run on the Yentna River to Big Bend with isolated accounts of fish presence to Skwentna.

Eulachon appeared to utilize the majority of the mainstem Susitna River and its associated side channels for passage and spawning. Eulachon did not, however, appear to utilize the clear water tributaries upstream of the confluence zones.

Eulachon appeared to key on water velocity for upstream direction during their spawning migration run. Eulachon were seldom observed in areas of low water velocity (less than 0.3 ft/sec) or backwater or eddy habitat zones. They appear to bypass these areas in favor of areas with moderate downstream velocities. The majority of the upstream eulachon migration appeared to occur along banks with moderate water velocities (0.3-3.0 ft/sec). At times, the upstream movement of fish was so dense as to create a visible surface wave (Plates 4II-4-4 and 4II-4-5).

The habitat requirements necessary for eulachon appear quite broad (Tables 4II-3-8 and 4II-3-9, Figures 4II-3-39 to 60). Thus, a significant portion of the lower Susitna River is available as spawning habitat.

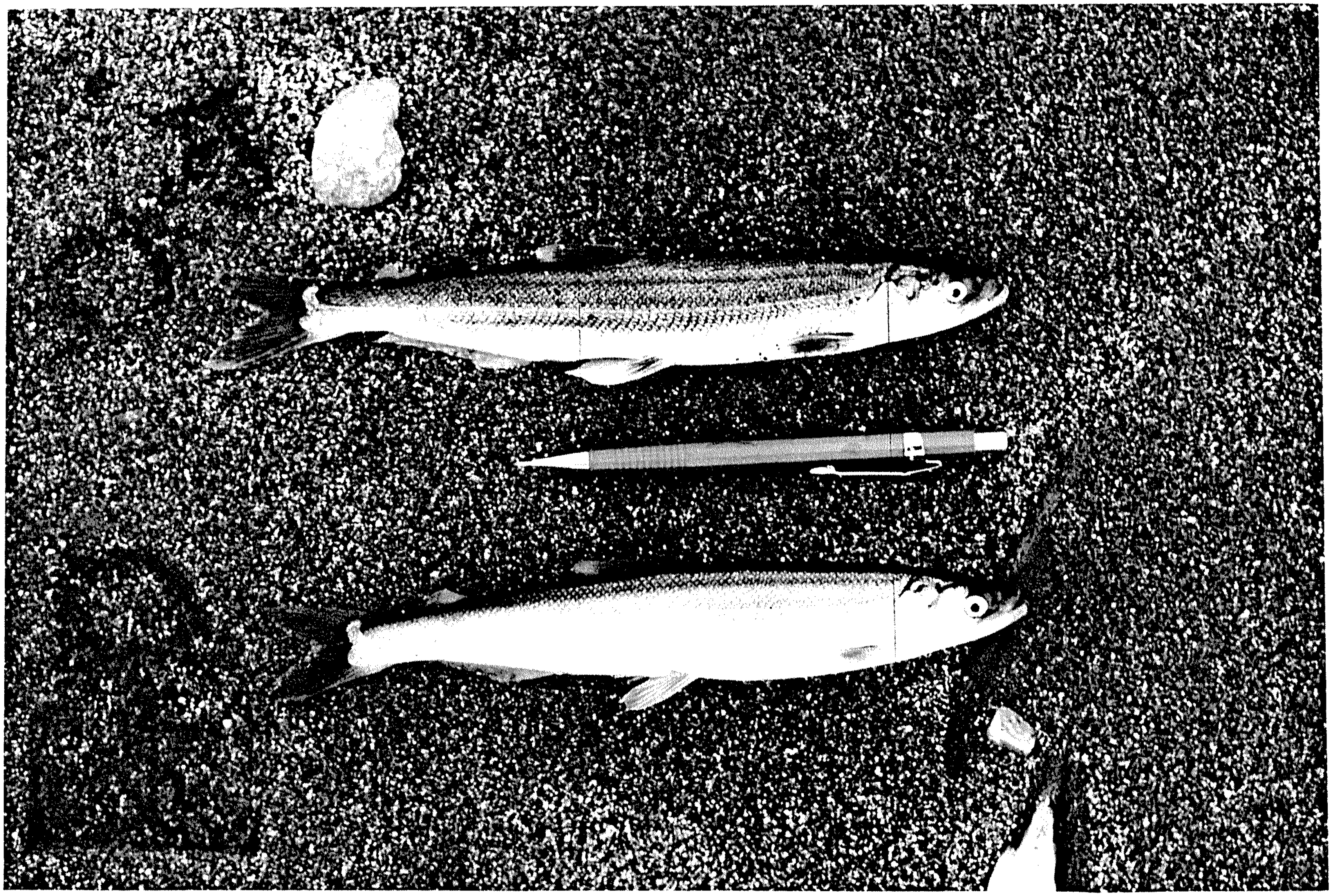


Plate 4II-43 Male and female eulachon taken from the Susitna River at RM 21.4, June 1, 1982.

Plate 4II-4-4 Upstream movement of Eulachon along the west bank of the Susitna River at RM 16.5, June 1, 1982.

Plate 4II-4-5 Upstream movement of eulachon creating a visible surface wave along the east bank of the Susitna River at RM 15.0, June 6, 1982.

Spawning occurred throughout the mainstem Susitna River and its associated side channels, but bar and riffle zones with moderate water velocities appeared to be preferred. One riffle zone (spawning site #14) had approximately 10,000 fish milling in what appeared to be spawning behavior (Plates 4II-4-6 and 4II-4-7). In addition, over 10,000 fish were observed dead along the banks, with most fish being spawned out (Plates 4II-4-8). Deposited eggs were found in substrate samples at this site.

Eulachon spawn over course sand and pea-sized gravel in water up to 7.6 feet deep (Morrow 1980). The mean water depth measured at surveyed spawning sites ranged from 1.1 - 3.1 feet with the range of depths varying at all survey sites from 0.3 - 4.3 feet. The mean water column velocity measured at surveyed spawning sites ranged 0.6 - 1.9 ft/sec with the range of velocities varying at all survey sites from 0.0 - 3.2 ft/sec. Substrate used for spawning varied from 100 percent silt to silt and sand intermixed with gravel, rubble and cobble. The preferred substrate ranged from silt to sand intermixed with gravel.

Water temperatures at surveyed spawning sites ranged from 6.2° to 11.2°C. These values are somewhat higher than the water temperatures recorded at Susitna Station (RM 25.5) which range from 1.0° - 9.0°C (Figure 4II-3-61). Local variability may be in part responsible for these deviations in values. Water temperature at time of spawning ranged form 3.0° - 9.5°C while during the peak of the run (as seen by an

Plate 4II-4-6. Milling fish in what appeared to be spawning behavior along the east bank of the Susitna River at RM 15.0, June 6, 1982.

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Plate 4II-4-7 Milling fish in what appeared to be spawning behavior along the east bank of the Susitna River at RM 15.0, June 6, 1982.

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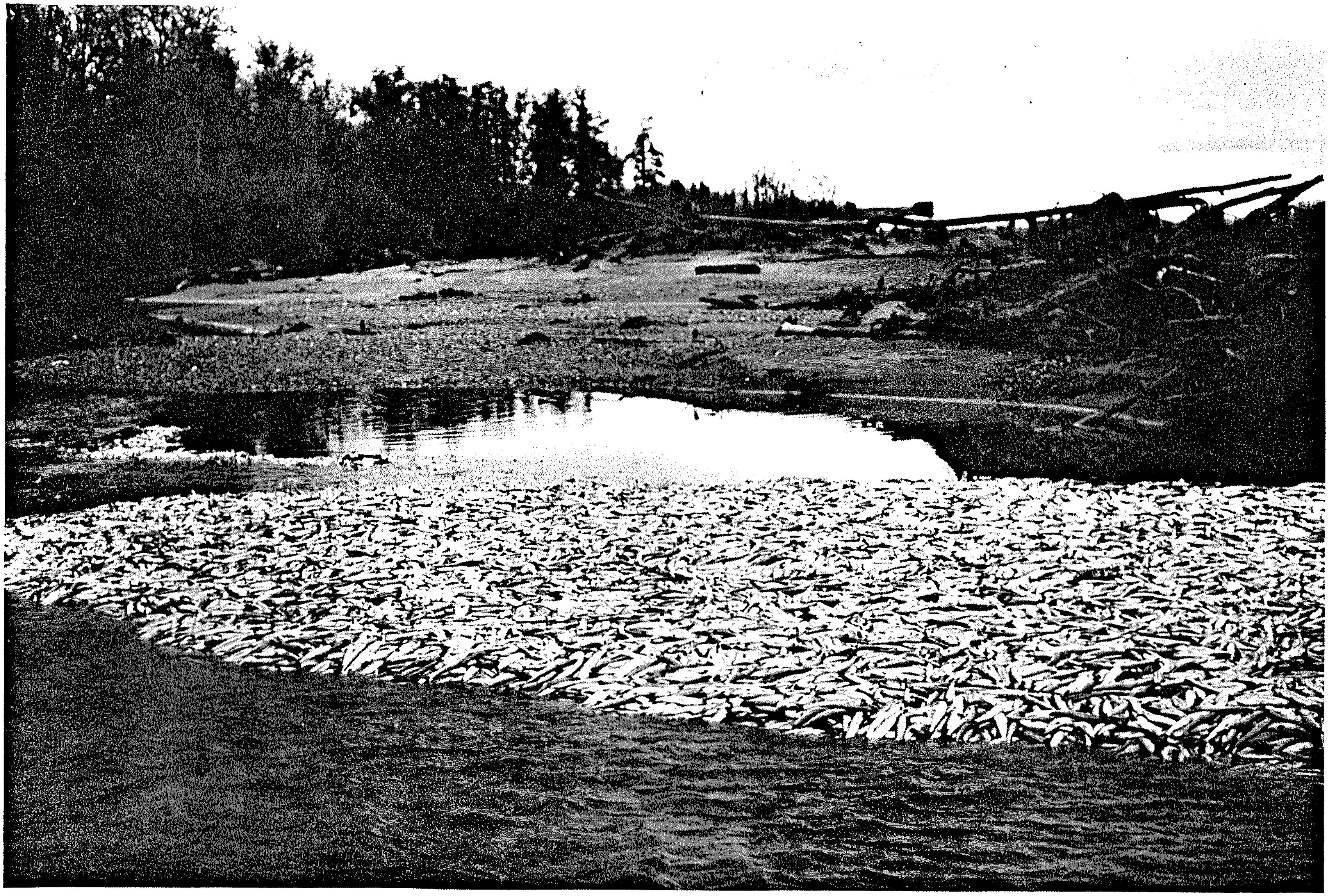

Plate 4II-4-8 Accumulation of dead eulachon along the east bank of the Susitna River at RM 15.0, June 6 1982.

increased CPUE) varied from 6.0° - 9.0°C (Figure 4II-3-62). These observed water temperatures are somewhat higher than previously reported, preferred spawning temperatures of 4.4° - 7.8°C (Morrow 1980).

In closing, it should be noted that because this was a first year attempt at describing the habitat characteristics of eulachon spawning areas, these data and evaluations that are presented should be considered preliminary. Continuation of these studies are planned in 1983.

4.1.3 Bering Cisco

Based on 1982 fishwheel and electrofishing catch data in this report (Volume 2), Bering cisco began their spawning migration into the Susitna River during early August. The earliest capture of a Bering cisco was in a fishwheel at Susitna River (RM 25.5) on August 7. The upstream limit of migration in the Susitna River (based on 1982 electrofishing catch data) appears to be RM 101.9. This compares to 1981 findings (ADF&G 1981b), which showed the upstream limit of migration to be RM 100.5. The Yentna, Chulitna and Talkeetna Rivers were not sampled above their confluence, however, it is possible that a portion of the spawning run utilizes these drainages. Bering cisco have been captured at the ADF&G fishwheel site six miles upstream on the Yentna River.

In general, Bering cisco spawning runs occur during periods of general declines in both surface water temperature and discharge (Figures 4II-3-65 and 4II-3-66). In addition, increases in discharge seem to discourage movement. For example, during 1982 a high discharge event which occurred on September 13 corresponded to a reduced catch at the Sunshine fishwheel. Further, during this period the electrofishing catch was low.

Bering cisco appear to utilize the mainstem channels of the Susitna River exclusively for spawnings and passage. They do not appear to utilize sloughs or clear water tributary confluence zones. They were most often distributed individually or in small aggregates along gravel bars in the mainstem channel. These findings generally concur with 1981 findings.

Bering cisco were not present in the east channel of the Susitna River between RM 62 and RM 70.0 during either 1981 or 1982, although habitats in this reach of the river are similar to those in other reaches utilized by Bering cisco. There were no discharge or velocity measurements taken in the east channel. However, the discharge and overall velocity regime of the east channel is less than that in the main west channel, which may, in part, be responsible for these observations. In addition, the east channel has several clearwater tributaries which empty into it, which may create less favorable conditions of turbidity or temperature. Bering cisco have never been observed in the vicinity of clearwater tributaries in the Susitna River Basin.

Only one spawning site for Bering cisco was found in 1982. This site, which was a documented spawning site in 1981 (ADF&G 1981b) was located along a mainstem gravel bar opposite Montana Creek (RM 76.8 - 77.6). The site was divided into two study areas and surveyed for its spawning habitat and had substrate which ranged from gravel to cobble, with gravel being predominant. The smaller substrate types were located in zones with low to medium velocities (less than 3.5 ft/sec) and shallow depths (less than 2.5 feet). Spawning water column velocities and depths ranged from 0.0 to 5.0 ft/sec and 1.0 to 4.0 feet, respectively. The mean spawning water column velocity and depth were 2.3 ft/sec and 2.4 feet, respectively. These habitat characteristics generally concur with 1981 findings at this site (ADF&G 1981b). Water temperatures at the time of spawning, however, were different. Water temperatures in 1981 at the time of spawning ranged from 3.0 - 3.8°C, while 1982 water temperatures ranged from 0.2 - 0.4°C (Table 4II-3-11). Discharge at the time of spawning during both 1981 and 1982 ranged from 15,000 - 20,000 cfs.

Fewer spawning sites for Bering cisco were located in 1982 than in 1981. One reason for this may be that in 1982 Bering cisco appeared to have begun spawning later. No ripe fish were found in 1982 until October 13, while in 1981 ripe fish were found beginning in early October. Due to an early freeze up, sampling was prevented after October 14, 1982, because spawning sites could not be located and studied. It is likely that Bering cisco utilized other areas for spawning after October 14, 1982.

Because there is a limited data base on Bering cisco spawning sites during 1981 and 1982, the data and evaluations presented should be considered preliminary. Continuation of these studies are planned in 1983.

4.2 Juvenile Anadromous Fish Habitat Investigations

The assumption in the study design for sampling based on hydraulic zones was that the fish have a choice of habitat types at each sampling location and will be found in the highest concentration in those zones which have the habitat conditions most desirable to the fish. This assumption holds well for chinook and coho juveniles which remain in the system for one or two years and have the capability of moving upstream in tributaries and sloughs. The assumption may not hold as well for chum and pink juveniles which do not overwinter and may be outmigrating from the spawning areas. Sockeye salmon juveniles probably exhibit both types of behavior. Chum juveniles rear in the Susitna system, holding in some of the slough and tributary areas, and exhibiting growth (see Volume 3, Section 3.2); however, they probably would not migrate from a slough up into a tributary. Chum adults spawn in tributaries and both chum and sockeyes spawn in the free-flowing area (zone 1) of sloughs such as Slough 21, Slough 11, and Slough 8A. In these sloughs, juveniles can remain in the zone 1 areas or migrate, either down to the mainstem backwater area or into the mainstem itself. At the time of spawning by chum and sockeyes in these three sloughs, the zone 1 areas were located in the slough channel, fed by springs or by very small tributaries.

Birch Creek and Slough is an example of an area where the juvenile salmon catch was strongly segregated by zone. During June and July, the slough was backed up by the mainstem to a point about 600 feet above the confluence of Birch Creek, creating a zone 6 in the slough above the creek, a zone 7 in the slough below the creek, and a zone 1 in the creek itself. Sixty percent of the chinook salmon juveniles captured were from zone 7, the rest were evenly distributed between zone 1 and zone 6. Chums were evenly distributed between zone 6 and zone 7; none were captured in zone 1. Eighty-eight percent of all cohos captured were from zone 1. These three species were clearly exhibiting a preference for a particular habitat type. No sockeye or pink salmon were captured at this site. An attempt will be made in the next report (Fish and Habitat Relationships) to correlate these kinds of habitat preferences with measured habitat variables such as temperature, turbidity, and the amount of cover available.

In the following discussion of each juvenile salmon species, the number of juvenile salmon of each species captured in the mainstem backwater zone as a percentage of the total juveniles of that species captured in all zones sampled is presented to provide an indication of the relative habitat importance of the backwater zone to that species. Because the surface area of the backup zone is a function of mainstem discharge, this analysis provides an indication of how varying mainstem discharge might be related to those juvenile salmon that demonstrate use of these areas. Chum and sockeye salmon juveniles were captured mainly in the backwater zone, whereas cohos and chinooks were captured mainly in other zones. Cohos were the least likely to be captured in the backwater zone. Pink salmon juveniles are not discussed because very few were captured. Our present hypothesis is that low discharges which lead to the closure of slough heads and the decline in surface area of mainstem backwater zones have the most serious repercussions for chum and sockeye juveniles; there is a lesser impact on chinook and coho juveniles.

The nature of habitat conditions that make the mainstem backwater zone a desirable habitat for juvenile salmon will be analyzed more thoroughly in the next report (Fish and Habitat Relationships). Habitat conditions in sloughs can undergo radical changes when the slough head opens or closes because of the change in water source and water velocity. The backwater zone may buffer this phenomenon, as well as rainwater runoff, and may provide a more stable set of habitat conditions than the zones above and below. Backwater zones are generally conducive to vegetative growth, which provides cover. Water velocities are low, thus providing a good holding area. Backup zones may provide juvenile salmon with an edge effect; a variety of habitat conditions are available in a usually short distance. Also, tributaries of various sizes are often near the backup zones, providing a source of food.

A further analysis of the effect of slough heads opening and closing on fish distribution in sloughs will be presented in the next report. This phenomenon causes changes in slough habitat conditions and fish respond to these changes. The opening or closing of a slough head is not an abrupt event; fish have time to respond by moving to areas of more favorable habitat if the new conditions are not desirable.

4.2.1 Chum Salmon

Of the five species of Pacific salmon which spawn in the Susitna River, the chum salmon, Oncorhynchus keta (Walbaum), is the only one which spawns extensively in both tributaries and sloughs. Consequently, the population of fry is exposed to a wider variety of habitat conditions than other species from the time of emergence to the time of outmigration from the system.

The number of chum salmon juveniles captured steadily declined from the beginning of sampling in early June to mid-August, when the last chum was caught. Generally, juvenile chum salmon distribution and relative abundance appeared to be a function of where the parents spawned the previous fall and of seasonal outmigration.

Little can be concluded regarding chum salmon preference for a certain range of any particular habitat parameter because of their relatively short time in the system and the relatively small numbers of fish collected. A general idea of the ranges of values for varying habitat parameters can be obtained by extracting from Appendix G those sites where chum juveniles were abundant and, from Appendix I, the habitat data for those sites. Chums were generally captured in areas of low water velocity. The chums present in Indian River (zone 1) during June were observed in small backwaters created by gravel bars and by deadfall. They also seemed to prefer areas with cover provided by turbidity contributed by the mainstem. There is a possibility that the different temperature regime in tributary redds versus slough redds affects emergence timing. The chum eggs in sloughs, which have warmer intragravel temperature resulting from upwelling ground water, would be expected to have a shorter incubation time than chum eggs in tributaries. Data are needed on intragravel temperatures at spawning areas in tributaries.

Interpretation of the relative importance of different habitat conditions is difficult because of difficulty in determining if the fish collected were rearing (feeding) or simply migrating through an area where they were collected. Chums were mainly captured in zones backed up by the mainstem except for areas where adult chums spawn in tributaries (for example, Indian River and Goose Creek). Slough areas with slack water caused by mainstem backwater and with at least moderate turbidity were evidently an important habitat type which chums used as rearing areas during outmigration. An example of such an area is Slough 6A. Very few adult chums spawn in this slough, but juvenile chums were abundant during June. Taking the percentage of chums caught in the zones influenced by mainstem backwater (zone 2, zone 6, zone 7) as a percentage of chums caught in all zones at each sampling site (only for those sampling periods where there was beach seine or electrofishing sampling effort in both kinds of areas) and summing all sites shows that 59 percent of all chum juveniles captured in early June, 85 percent in late June, and 94 percent in early July were captured in a mainstem backwater zone. The lower percentages earlier in the season reflects chums captured in Zone 1 during outmigration from stream spawning areas.

The relationship of the total surface area of the aggregate type H-II backwater zone habitat type to mainstem discharge is shown in Figures 4I-4-1 and 4I-4-2. The availability (surface area) of this type of habitat at the sampling site generally declined with a decrease in mainstem discharge over the range of mainstem discharges observed. Although chum juveniles were caught in this kind of habitat more than in other zones, the relationship of chum catch to the availability of this type of habitat cannot be explicitly analyzed because there are only three data points (sampling periods). A more definitive analysis is presented for chinook and coho juveniles, which are present in the system all year and were caught in larger numbers than chums. A more intensive sampling effort for chums will have to be conducted in late spring and early summer of next season to understand the dependency of this species on mainstem discharge conditions.

The closure of slough heads during the early part of the summer may create conditions that are undesirable to juvenile chums rearing in sloughs. About 1,800 chum fry were visually observed in Slough 8 (adjacent to Lane Creek) in late June in a mainstem backwater zone. The head of this slough had recently closed and the backwater zone was undergoing significant changes in habitat conditions, including water temperature and turbidity. Fourteen days later, no chums were observed in this area. It can not be concluded at this time whether their absence at the later date is a function of undesirable habitat caused by closure of the slough head or simply a result of seasonal outmigration out of this slough. This problem points out difficulties in establishing cause-effect relationships when behavior of juveniles correlates with natural changes in habitat conditions. An examination of behavior differences between sites may ultimately provide better insight into the importance of the stimulus associated with mainstem by discharge changes.

The closure of slough heads can also cause stranding of juvenile salmon in isolated pools. Shortly after the head of Slough 8 closed, 10 juvenile chum salmon were observed in an isolated pool in the slough just below the head. This has also been noted elsewhere on the river.

4.2.2 Sockeye Salmon

Surveys conducted to date indicate that adult sockeye salmon, Oncorhynchus nerka (Walbaum), which spawn above Curry (RM 130.7) in the Susitna River, do so almost entirely in sloughs. The majority of the few thousand sockeye adults which migrate upstream past Curry have spent one additional winter after the winter of emergence in the freshwater system. However, the scanty evidence collected so far on juvenile sockeyes indicates that there may not be much overwintering occurring above Curry (see discussion in Volume 3, section 4.1.2.4). The farthest upstream that an age 1+ or 2+ sockeye juvenile has been collected is Slough 6A (RM 112.3). This does not mean that sockeyes do not overwinter above this point. The methods used in 1981 did not effectively collect sockeye juveniles, and effective techniques (electrofishing and beach seining) used in 1982 were not as intensive in early June as they were later. The sockeye smolts may have moved downstream before these methods were fully deployed.

Sockeye juveniles are found in those sloughs where adults spawn and also in the mainstem backwater zone of other sloughs. The number of sockeye juveniles captured in the mainstem backwater zone (zone 2, zone 6, zone 7) as a percentage of the total sockeyes captured in all zones was high (greater than 88 percent) for all sites in the lower reach (Goose Creek to Chulitna confluence). Except for Slough 8A, Slough 11, and Slough 21, this percentage was also high (greater than 71 percent) for all sites in the upper reach (Chulitna confluence to Portage Creek). The free-flowing areas (zone 1) of Slough 8A, Slough 11, and Slough 21 have a low gradient with many small pools which sockeye juveniles seemed to prefer. Also, the adult sockeye normally spawn in zone 1 at these sloughs, which contributes to the broader distribution of the juveniles. ? Ok

The availability of the mainstem backwater zone type of habitat as a function of mainstem discharge is shown in Figures 4I-4-1 and 4I-4-2. The surface area of this habitat type generally declines with a decrease in mainstem discharge over the range of mainstem discharges observed. This could have deleterious effects for this species which was found in such high proportions in this habitat type. A more intensive sampling effort at sloughs during the period immediately after ice-out will be necessary to collect more definitive data on this species.

4.2.3 Coho Salmon

Coho salmon, Onchorhynchus kisutch (Walbaum), adults in the Susitna River system spawn primarily in tributaries.

Coho salmon juveniles were captured in the tributaries and sloughs of the Susitna River between Goose Creek-2 (RM 73.1) and Slough 21 (RM 142.0) from June to September. Juvenile coho salmon were found in all major habitat types in the system, including tributaries, sloughs, sidechannels and the mainstem, but were observed with a greater frequency at tributary sites, including sloughs associated with tributaries.

Adult cohos spawn in the tributaries upstream of all the sampling sites where the most cohos were captured (Rabideux Creek, Sunshine Creek, Birch Creek).

Juvenile cohos exhibit a seasonal movement between the major habitat types with a preference for tributaries and sloughs that have an abundance of cover. They were captured in larger numbers and with a greater frequency in areas with emergent or aquatic vegetation and/or overhanging and deadfall cover. Fewer juvenile cohos were observed at many of the sites in the Chulitna to Portage reach than observed at similar habitat types in the reach below the Chulitna confluence. These sites above and below the Chulitna confluence were significantly different in the amount of available cover. Several sites above the Chulitna confluence were lacking in the amount and quality of cover as compared to some sites below the Chulitna confluence. Juvenile coho salmon were generally captured in areas of low water velocity with moderate turbidity and abundant aquatic or emergent vegetation. Some of these areas of low velocity and emergent cover were created by the backwater effects of the mainstem water surface elevation at the mouths of tributaries and sloughs. The mainstem backwater zones at sites below the Chulitna confluence inundated considerable amounts of emergent vegetation creating suitable rearing habitat with sufficient cover for coho juveniles. Mainstem backwater areas at sites above the Chulitna confluence were typically smaller in area than sites below Chulitna, primarily because of steeper gradients in the sloughs and tributaries and the narrowness of the flood plain.

Coho juvenile salmon were often captured in the mainstem backwater zone, but were also frequently captured in tributaries above the influence of the mainstem backwater. They were not captured in the area below the mainstem backwater zone nearly as often as were chinook salmon.

The following table indicates the number of coho juveniles captured in the mainstem backwater zones (zone 2, zone 6, and zone 7) as a percentage of the number of cohos captured in all zones sampled at the site, summed for all 17 Designated Fish Habitat (DFH) sites. The data are from minnow traps only and are weighted by the effort (number of traps) deployed in each zone.

Sampling Period	Percent cohos captured in mainstem backwater zones
June 1-15	23
June 16-30	32
July 1-15	31
July 16-31	15
August 1-15	20
August 16-31	20
September 1-15	23
September 16-30	23

One-third or less of cohos captured at all sites were captured in the mainstem backwater zone. This percentage is lower than that of any other salmon species. Specific sites did show higher percentages. Goose Creek and Side Channel, Whitefish Slough, and Slough 6A were all greater than 50 percent. However, in general, coho salmon juveniles appear to use the mainstem backwater zone less than other salmon species. Furthermore, compared to the other salmon species, the percent use of the mainstem backup zone by coho salmon juveniles is relatively constant from June to September, thus indicating that there is not a seasonal dependence on this type of habitat as there may be with chinook salmon juveniles. The availability (surface area) of the type of habitat as a function of mainstem discharge is shown in Figures 4I-4-1, and 4I-4-2, for the range of mainstem discharge observed.

4.2.4 Chinook Salmon

Chinook salmon, Oncorhynchus tshawytscha (Walbaum), adults spawn primarily in tributaries of the Susitna River in the reach covered by the juvenile anadromous fish studies. However, juvenile chinooks are found in all major habitat types in the system, including large and small tributaries, sloughs, sidechannels, and the mainstem. The juveniles exhibit seasonal movement back and forth among these areas, but present data do not allow a definite conclusion with regard to the seasonal importance of each of these major habitat types. The majority of adult chinooks migrating upstream past the Talkeetna camp have spent an additional winter as juveniles after the winter of emergence in the freshwater system.

Chinook juveniles were often captured in the area of the sampling sites which was backed up due to mainstem stage, but were also frequently captured in tributary mouths (zone 1) and in the mixing zone (zone 3) below the mouth of a slough or tributary. The following table shows the number of chinook juveniles captured in the mainstem backwater zone (zone 2, zone 6 and zone 7) as a percentage of the number of chinooks captures in all zones sampled at the site, summed for all 17 DFH sites. The catch data are from minnow traps only and are weighted by the effort (number of traps) deployed in each zone.

Sampling Period	Percent Chinooks Captured in mainstem backup zones
June I	60
June II	68
July I	33
July II	33
Aug I	22
Aug II	35
Sept I	41
Sept II	4

The majority of chinooks captured in June were in the mainstem backwater zone; the percentage in this zone halved in July and remained below 50 percent the rest of the season. It is difficult to determine why the percentage was high in June, but it is probably a result of chinook juvenile migrating out of tributary systems at that time of year. The availability (total surface area) of the mainstem backwater zone habitat type as a function of mainstem discharge is shown in Figures 4I-4-1 and 4I-4-2. Generally, the greatest amount of this type of habitat was present in June when mainstem discharge was highest.

The aggregate mainstem backewater zone in sloughs includes zone 6 in sloughs above the confluence of tributaries and zone 7 in sloughs below tributaries. Chinook juveniles exhibited a preference for zone 7 over zone 6, evidently attracted by tributary effluents. Chinooks were also often found in zone 3, which is the mixing zone of tributary/slough effluent with mainstem water. The desirability of these types of habitats is probably related to a supply of food drifting out of tributaries and the availability of cover provided by the turbidity of mainstem water.

4.3 Resident Fish Habitat Investigations

Similar habitat conditions may attract different species of resident fish with comparable habitat requirements. These fish may be in association with at a site and may compete with each other for food, space, or other biological needs. Interspecies associations, however, need not be competitive but it is unlikely that such associations would be beneficial.

The mixing zones (zone 3) of Lane Creek, 4th of July Creek, Indian River, Slough 20, and Portage Creek are all very similar and the species composition of resident fish inhabiting them is also similar. Mixing zones at these sites typically have moderate water velocities, turbidities, and temperatures and the substrate is normally gravel or sand with rocks ranging up to several feet in diameter with cover provided by the turbid water flow of the Susitna River. Resident fish associated with these mixing zones normally include round whitefish, Arctic grayling, and rainbow trout. Large longnose suckers also may congregate in these zones, especially in August and September. Skull Creek and Jack Long Creek, two selected fish habitat sites, also have similar mixing zones and resident fish populations using them.

During June and July, the associated species of rainbow trout, Arctic grayling, and round whitefish may compete for food. Food habits of these species are very similar and food items generally include immature stages of various insects (TES 1981, Morrow 1980). Competition might be reduced, however, by time or place of feeding. Arctic grayling are primarily surface or mid-depth feeders (TES 1981) while round whitefish feed on the bottom (Hale 1981). It is also possible that the various species partition the space within a mixing zone; for instance, Arctic grayling might feed in areas with higher water velocities than round whitefish do. Rainbow trout, being larger in size, would probably be more able to compete for available cover in the form of large rocks or submerged brush piles.

In August and September, the resident fish present presumably feed almost entirely on salmon eggs of which there is an abundant supply. Stomachs of sampling mortalities examined during this period were almost always full of eggs. Large longnose suckers may gather at the mixing zones at this time to take advantage of this food source. Food would probably not limit resident numbers and competition for space may become more important.

At designated fish habitat sites such as Goose Creek 2 and Side Channel, Sunshine Creek and Side Channel, and Whiskers Creek and Slough, mixing zones typically have lower water velocities, higher turbidities and finer materials for substrates than in many of the upper sites. Species associated here are adult and juvenile longnose suckers, juvenile round whitefish, slimy sculpins, and sometimes juvenile Arctic grayling. With the exception of Arctic grayling, all of these fish are bottom feeders. Spatial separation of habitat within a zone could be important in limiting competition.

Sloughs not associated with tributaries, such as Whitefish Slough and sloughs 6A, 8A, 11, 19, and 21 typically had fewer residents present. Often these sloughs were used by rearing juvenile round whitefish, Arctic grayling, longnose suckers and slimy sculpins. Adult rainbows also made some use of these sloughs and probably preyed on these juveniles at times. Sometimes adult longnose suckers, round whitefish, and humpback whitefish were also found in mixing zones and backed up zones where the turbidity was moderate.

4.3.1 Rainbow Trout

Rainbow trout (*Salmo gairdneri* Richardson) are generally recognized as spring spawners (Morrow 1980, Scott and Crossman 1970). Susitna River rainbow trout generally begin their spawning migration to the clear water tributaries from the mainstem and its various side channels during May to late June (Volume 3). Trotline catches of rainbow trout at designated fish habitat sites were comparatively high in June in mixing zones of slough or tributary water and mainstem water (aggregate zone W-III) and then dropped in July as the rainbow trout moved from these zones farther up into the tributaries to spawn (Figure 4II-4-5). Electrofishing catch rates at mainstem and tributary or slough sites also dropped in July indicating a spawning migration during June (Figure 3-4-1).

Actual spawning of rainbow trout has not been observed in the Susitna River basin and therefore the exact periods of spawning and the habitat conditions associated with successful spawning are not known. Spawning has been shown to occur over a bed of fine gravels in a riffle zone above a pool (Morrow 1980). The female fans a redd, drops her eggs which are simultaneously fertilized by the male during a courtship ritual then recovers the redd. Several redds may be used, with 800-1000 eggs deposited per redd. The eggs hatch in 4-7 weeks with alevin development lasting 3-7 weeks. The young emerge from the redds during June-September, depending on temperature (Morrow 1980, Scott and Crossman 1973). After spawning, rainbow trout move into their summer rearing habitat.

Rainbow trout were captured with trotlines at designated fish habitat sites in zones with a tributary or slough water source (aggregate zone W-I) consistently during July and August (Figure 4II-4-5). Trotline catches of rainbow trout in mixing zones (zone W-III) and mainstem water zones (zone W-II), on the other hand, were comparatively lower during this time period. In addition, boat electrofishing catch rates were also very low in these habitat zones during July and August (Volume 3,

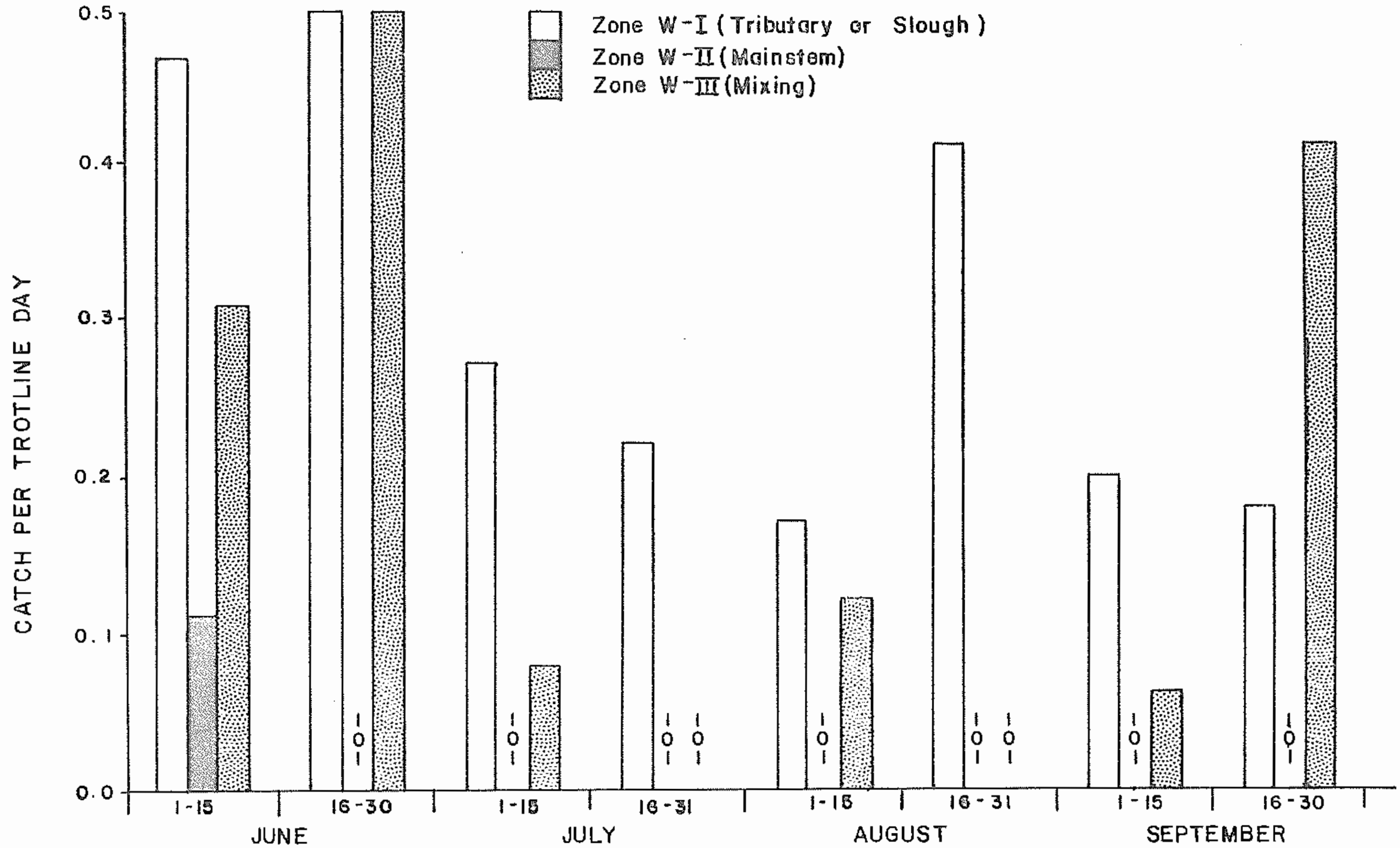

Figure 4-5 Rainbow trout catch per unit of trotline effort by aggregate water source zones at Designated Fish Habitat (DFH) sites on the Susitna River between Goose Creek 2 and Portage Creek, June through September, 1982.

Figure 3-4-1). These data suggest that the preferred summer rearing habitat for rainbow trout in the Susitna River basin are the clear water tributaries and sloughs upstream from their confluence zones. Juvenile rainbow trout in particular are very rarely captured near confluence zones of tributaries or sloughs during the summer. Since very little study has been conducted in these upstream areas, little is known of the habitat characteristics associated with summer rearing habitats of rainbow trout in the Susitna River basin.

Trotline catch rates of rainbow trout in mixing zones (aggregate zone W-III) of slough or tributary water with mainstem water rose in September (Figure 4II-4-5) as did boat electrofishing catch rates at both tributary and mainstem sites (Figure 3-4-1). These results indicate that rainbow trout move out of the tributaries into the mainstem and its various side channels for overwintering during mid-August to late September. The movement out of the tributaries is likely cued to water temperature, with decreasing water temperatures in the tributaries during fall, initiating out migration.

Based on 1981-82 catches Volume 3 and radio telemetry studies, the preferred habitats for overwintering rainbow trout are the sloughs and side channel habitats exhibiting slow to moderate velocities (0.2 to 3.0 ft/sec) free of under-ice slush. (Table 4II-3-12). Fish are generally not observed or caught in areas of open leads, suggesting that ice may be used as cover. The preferred substrate is gravel, rubble, and cobble rather than silt and sand, although fish are present in areas of silt and sand. Rainbow trout are most often observed in areas of higher specific conductance (above 200 umhos/cm) and water temperatures (above 0.5°C), indicating areas of upward percolation of water. Food sources during the winter period are unknown, since studies on food habits were not initiated this past year. Preliminary observations indicated however, that benthic invertebrates may make up a significant portion of the winter diet of rainbow trout.

The movement patterns of rainbow trout from the time they leave the tributaries in fall to when they re-enter the tributaries in spring has been largely unknown. Radio telemetry studies (Figure 3-3-3) show that between the period of freeze-up and the time the fish move into their overwintering habitat, the fish move in a general downstream pattern, probably in searching for suitable overwintering habitat. Once in their overwintering habitats, they appear to remain fairly sedentary until they begin their movement into the tributaries after breakup.

4.3.2 Arctic Grayling

Arctic graying (*Thymallus arcticus* Pallas) are generally recognized as spring spawners, with spawning occurring immediately after breakup (Morrow 1980, Scott and Crossman 1973). Arctic grayling in the Susitna River begin their spawning migration from their overwintering habitats into clear water tributaries in May (Volume 3). Although Arctic grayling spawning has not been observed in the Susitna River basin it is presumed to occur only in the clear water tributaries during May to mid June. Arctic grayling sampled in late June were found to be spawned out. Male and female Arctic grayling have been reported to engage in a courtship ritual, during which time spawning takes place (Morrow 1980). No particular substrate is reportedly preferred for spawning, but sandy gravel substrate is reported to be most often used. Development to hatching requires 11 to 21 days, depending on temperature. No ~~date~~ data is currently available on the habitat requirements of Arctic grayling spawning in the river.

Do spawning fish rear?

After spawning, Arctic grayling move into their summer rearing habitats. Boat electrofishing catch rates (see Volume 3, section 3.1.1.2) show that the preferred summer rearing habitat for adult Arctic grayling appears to be the clear water tributaries, especially those above the Chulitna River confluence, rather than the mainstem. Adult Arctic grayling were captured most often during the summer in mixing zones (zone 3) at the mouths of large tributaries such as Lane Creek, Indian River, and Portage Creek (see Volume 3, section 3.1.1.2). Very large Arctic grayling greater than 300-mm fork length comprised only a very small portion of the catch during July and August. (Figure 3-4-3). These large fish are probably able to set up feeding territories in desirable pools in upstream areas of the tributaries and displace small fish which then move down to the less desirable habitat at the confluence and in the mainstem. Since very little study has been conducted in the upstream areas of clear water tributaries, little is known of the specific habitat characteristics associated with summer rearing habitats of adult Arctic grayling in the Susitna River, below Devil Canyon.

Juvenile (fork length under 200mm) Arctic grayling during the summer were found mostly in the mixing zone (zone 3) of tributaries in the reach of river between the Chulitna River confluence and Devil Canyon. These tributaries, such as Lane Creek, Skull Creek, Indian River, and Jack Long Creek, seasonally flow clear and cold water. The juveniles appeared to rear in areas of slow to moderate water velocities (under 1.5 ft/sec) and with moderate to high turbidities (over 20 NTUs) at the mouths of these tributaries.

Although Arctic grayling juveniles were most prevalent at tributary mouths, they were also found in relatively large numbers at mainstem sites above the confluence, notably after August. At these sites, juveniles were found rearing in areas with similar water velocities and turbidities to that found at tributary sites. With the decrease in water discharge at the tributaries and the decrease in turbidity in the mainstem during fall, it is probable that these fish were migrating to overwintering areas, or were at their overwintering habitat.

Adult Arctic grayling begin to move out of their summer rearing habitats into their overwintering habitats in late August to early September (Volume 3, Section 4.1.1.2). Due to very low catches of Arctic grayling during the winter, the locations and habitat characteristics of Arctic grayling overwintering habitats in the Susitna River are currently unknown. It is presumed that Arctic grayling overwinter in the mainstem and its associated side channels.

4.3.3 Burbot

Burbot (Lota lota) are generally recognized as under-ice winter spawners (Morrow 1980, Scott and Crossman 1973). Due to the timing of burbot spawning (i.e., during freeze up causing logistical and safety problems) and that spawning is presumed to occur under the ice at night, actual spawning of burbot in the Susitna River has not been observed. Because of this, the exact period of burbot spawning in the Susitna River is currently unknown. In the lower reaches of the Susitna River, the gonads of burbot begin to enlarge in late August, but spawning does not appear to take place until sometime in mid-winter. Burbot have been shown to congregate in what appears to be preparation for spawning beginning in late September, with actual spawning not taking place until late January to February in such areas as the mouth of the Deshka River (RM 40.6) (Volume 3). The habitat characteristics necessary for successful spawning of burbot to occur in the Susitna River basin, are unknown. Burbot have been shown to congregate in moderately shallow water under the ice over a substrate ranging from sand to coarse gravel (Morrow 1980). During spawning, males and females form a "globular mass of fish" during which spawning takes place (Morrow 1980). Preliminary investigations of habitat conducted in areas of burbot milling during the 1982-83 winter (Table 4II-3-13) reveal that burbot appear to mill in preparation for spawning in areas with an ice cover having low to medium (0.1-4.0 ft/sec) water column velocities. In areas of milling, moderately high specific conductances (70-150 umhos/cm) have been observed, suggesting that upwelling may be occurring. Development of eggs takes 30-70 days, depending on temperature (Morrow 1980).

After spawning, burbot appear to use the mainstem and to a lesser extent the associated side channels and sloughs for overwintering habitats. (Volume 3). Areas of relatively deep water (2-10 ft) under the ice in the mainstem seem to be preferred (Table 4II-3-13). Burbot are rarely observed or captured in areas of open leads, which may be due to their strong negative phototrophism (Morrow 1980). Burbot have been observed utilizing areas of both gravel, rubble and cobble and silt and sand substrate during the winter, but seem to prefer a substrate composed of silt and sand. Burbot are most often found in lower velocity backwater areas (0.0-1.0 ft/sec), but have been observed in areas of higher velocities. Since burbot are bottom dwellers, they do not seem to be hampered by under ice slush so long as at least six inches of water is present. Based on radio telemetry studies, most burbot overwinter in mainstem areas having relatively high specific conductances (above 200 umhos/cm) and water temperatures (above 0.5°C) indicating areas with an upward percolation of flow.

For summer rearing habitat adult burbot appear to prefer relatively deep eddies in the mainstem (Appendix 4-G). Trotline catch rates at designated fish habitat sites were highest in mainstem water (zone W-II) and in mixing zones (zone W-III) (Figure 4II-4-6). Tributary or slough water (zone W-I) held relatively few adult burbot as indicated by very low catch rates. Burbot may avoid this clear water due to their negative phototrophism. After water temperatures in sloughs, side channels, and tributaries drop below 10°C, adult burbot have been observed to move into shallow water at night to feed. Trotline catches suggest this may happen in early September (Figure 4II-4-6). Prior to this time, the

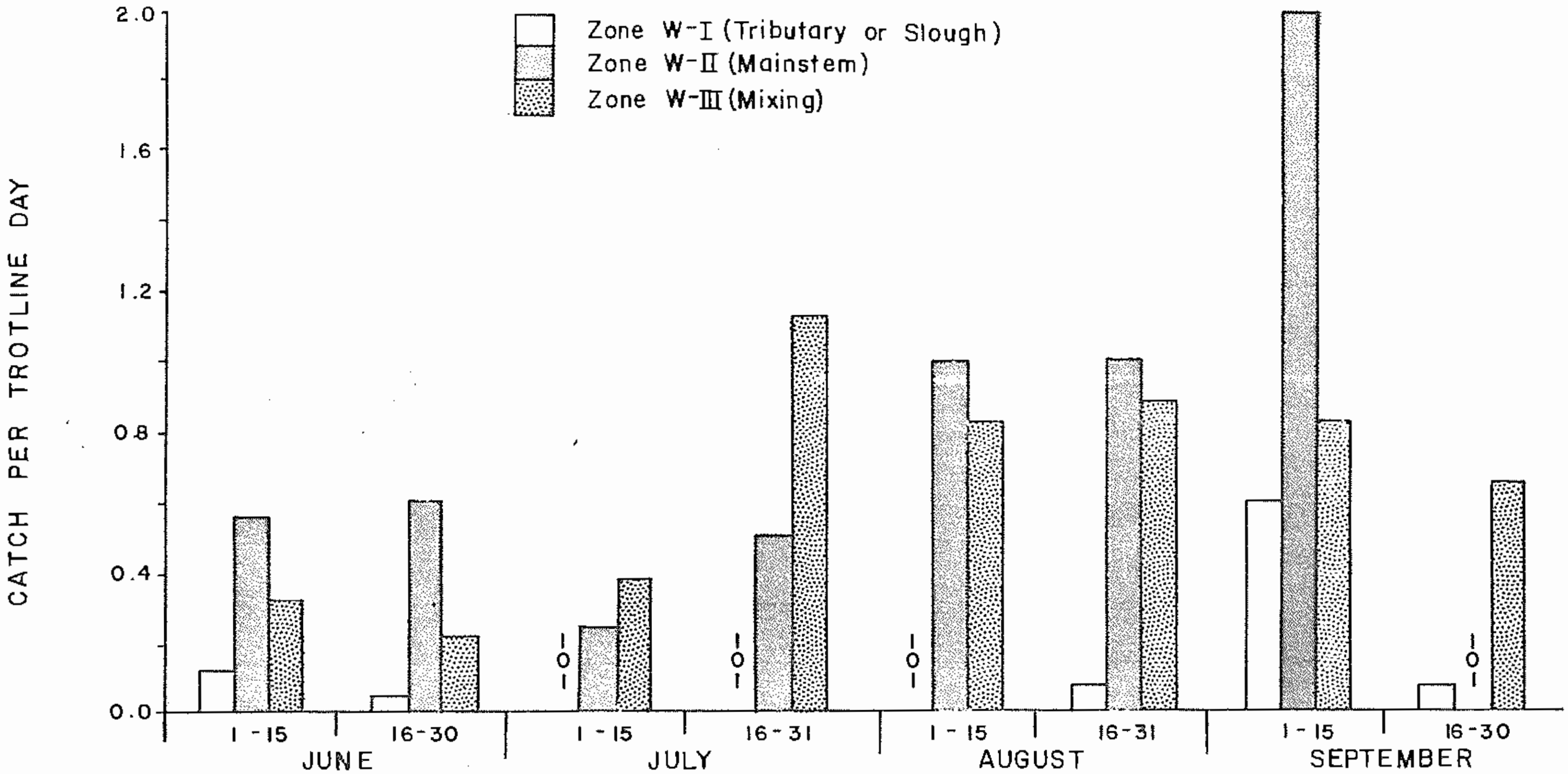

Figure 4II-4-6 Burbot catch per unit of trotline effort by aggregate water source zones at Designated Fish Habitat (DFH) sites on the Susitna River between Goose Creek 2 and Portage Creek, June through September, 1982.

burbot remain in the mainstem in deep holes or in mixing zones. Scott and Crossman (1973) report the optimal temperature for burbot ranges from 15.6° to 18.3°C. Catches of juvenile burbot (Appendix 4-G) at designated fish habitat sites were small but they were most often captured in mixing zones (zone 3) and in backed up zones or pools (zones 2, 6, 7 and 8).

The movement patterns of burbot are largely unknown (Morrow 1980). Based on radio telemetry studies (Volume 3), burbot in the Susitna River are usually sedentary, but they are capable of long distance movements (Volume 3). One radio tagged burbot, for instance, moved downstream a distance of approximately 60 miles in the winter and then held its new position.

4.3.4 Round Whitefish

Round whitefish (Prosopium cylindraceum Pallas) are recognized as fall spawners with spawning taking place from late September to early November (Morrow 1980). Because round whitefish spawn during freezeup, actual spawning of round whitefish in the Susitna River has not been observed; although ripe fish have been captured in the mainstem during late summer to early fall (ADF&G 1981a). Thus, the exact period of round whitefish spawning in the Susitna River is unknown. In the upper reaches of the Susitna River, the gonads of round whitefish appear to enlarge in late June, but spawning does not appear to take place until at least late September or early October. Spawning has been reported to be annual, with spawning beds located along gravelly shallows or rivers

(Morrow 1980). In the Susitna River, round whitefish may utilize both the clear water tributaries and the mainstem for spawning (Volume 3). No nest is dug during spawning, with eggs being broadcast over the substrate. Egg development has been reported to take about 140 days depending on temperature (Morrow 1980).

After spawning, round whitefish move into their overwintering habitats. Due to very low catches of round whitefish during the winter, the locations and habitat characteristics of round whitefish overwintering in the Susitna River are unknown. It is presumed round whitefish overwinter in the mainstem and its associated side channels.

Round whitefish appear to move out of their overwintering habitats into their summer rearing habitats from May to June (Figure 3-4-4). Large concentrations of round whitefish were observed at tributary mouths in June. Preferred summer rearing habitat for adult round whitefish appears to be the clear water tributaries upstream of their confluences. However, round whitefish also appear to utilize, to a lesser extent, the mainstem for summer rearing habitat. Small numbers of adult round whitefish were electroshocked along mouths of sloughs and tributaries and along bars in the mainstem throughout the summer (Figure 3-4-4). Adult round whitefish were usually captured in mixing zones with a moderate current (zone 3) or in backed up zones (zone 2 or zone 7) at the designated fish habitat sites studied. In late August or early September, round whitefish apparently begin to move into overwintering habitat or to spawning areas (Volume 3).

Juvenile round whitefish (fork length less than 200mm) were found at all of the designated fish habitat sites studied (Appendix 4-G). Juvenile round whitefish were most often found rearing in clear water sloughs such as Slough 6A, Slough 8A, Slough 9, and Slough 21 in the reach of river between the Chulitna River confluence and Devil Canyon. The hydraulic zone in the sloughs which recorded the highest catch was the mixing zone (zone 3). Most of the catch at tributary sites was also in the mixing zones (zones 2 and 3). Juveniles, however, were also present in areas at sloughs and tributaries that contained mainstem water. The only areas where juveniles were captured in clear tributary or slough water were Whitefish Slough, Slough 6A and Slough 8A. Most of the zones with juvenile round whitefish present were characterized by low water velocities or pools.

Turbidity, at least under 120 NTUs, does not appear to exclude juvenile round whitefish from a rearing area. Juveniles were captured at a variety of sites with the turbidities ranging to 120 NTUs. However, no mainstem sites were consistently sampled by effective juvenile capture methods and very high turbidities may exclude juvenile round whitefish from rearing in an area.

Little is currently known of the specific habitat requirements of summer rearing of juvenile or adult round whitefish in the Susitna River

4.3.5 Humpback Whitefish

The taxonomy of the humpback whitefish (Coregonus spp.) is unclear. Morrow (1980) states that the humpback whitefish appears to be truly anadromous, while McPhail and Lindsey (1970) state that humpback whitefish typically occur in lakes and large rivers, with a portion of the population in rivers being anadromous. In the Susitna River, the humpback whitefish population appears to be divided into both an anadromous and resident population. The species of humpback whitefish inhabiting the Susitna River below Devil Canyon is believed to be Coregonus pidschian (Volume 3).

Anadromous populations of humpback whitefish in Alaska have been reported to spawn during the fall, with their spawning runs beginning in June and lasting through October (Morrow 1980). In the Susitna River, the anadromous portion of the humpback whitefish population begins their spawning runs in early August in the lower reaches of the river, reaching the upper reaches by mid-September (Volume 3). Although actual spawning of humpback whitefish has not been observed in the Susitna River, it is presumed that spawning occurs in the fall prior to freeze-up.

Little is known of the spawning behavior or spawning habitat, but it is assumed to be similar to the Alaska whitefish (Morrow 1980). Following the completion of spawning, humpback whitefish are reported to move back downstream, with small numbers remaining in deep pools to overwinter

(Morrow 1980). The timing of their return migration in the Susitna River is also not known.

Young of the year have been reported to hatch in the late winter to early spring, subsequently moving downstream. Due to the limited catch of juvenile humpback whitefish in the Susitna River, little is known of their timing of outmigration and the characteristics of rearing habitat in the Susitna River. Catches of juvenile humpback whitefish at a downstream migrant trap in the mainstem (RM 102.0) peaked in August (Volume 3) suggesting a juvenile outmigration during August.

A resident population of humpback whitefish appear to inhabit a number of clear water sloughs and tributaries of the Susitna River especially those above the Chulitna River confluence such as Slough 1, Slough 6A, Slough 17, Slough 19 and Portage Creek (Volume 3). Many of the catches were made in backed up zones (zones 2 or 7), or in areas where the water from a tributary or clear water slough mixed with mainstem water in a low velocity mixing zone or pool (zone 3). Few habitat measurements were taken during 1981 and 1982, however, so little is known of the characteristics of summer rearing habitats used by humpback whitefish in the Susitna River.

The timing of resident humpback whitefish spawning is expected to be very similar to that of any anadromous populations present although it is possible that resident humpback whitefish spawn at a different time than anadromous fish. Spawning migrations, of course, would be shorter in length than those of anadromous populations. It is not known if the distribution of wintering fish is similar to that of fish rearing during the summer. No juvenile humpback whitefish (fork length less than 200mm) have been captured above RM 102.0 (Volume 3).

4.3.6 Longnose Sucker

Longnose suckers (Catostomus catostanus Forster) are generally recognized as spring spawners, with spawning occurring as early as May and as late as July (Morrow 1980). In the lower Susitna River, longnose suckers have been observed spawning in late May to early June (Table 4-3-14). Spawning occurs most commonly over a gravel substrate in shallow water (0.3-2.0 feet) with a current ranging from 1.0 to 1.5 feet per second (Morrow 1980). Water temperature at time of spawning is reported to be between 5.0 to 10.0°C.

The limited data collected on longnose sucker spawning habitat in the Susitna River basin concur fairly well with published data The data, however, suggest that longnose suckers utilize a wider range of depths and water velocities for spawning than previously reported. In the Susitna River, longnose suckers have also been captured in ripe condition during the fall. Males upon slight abdominal pressure, discharged milt; and females, upon necropsy, showed well developed, separated eggs. Longnose suckers have not been previously reported to spawn in the fall. It is possible that the fish overwinter in this ripe condition.

After spawning, longnose suckers move into their summer rearing habitats. In the Susitna River, longnose suckers appear to prefer tributary and clear water slough mouths for summer rearing over mainstem sites (Volume 3). Longnose suckers however, have been observed to utilize deep back eddy zones in the mainstem as summer rearing habitat.

Schools of longnose suckers were present in Rabideux Creek Slough in a backed up zone (zone 2) during July and August in 2-5 feet of water. Often these fish were in submerged brush piles or near overhanging riparian vegetation. Adult longnose suckers were associated with this type of habitat at a number of other sites electrofished.

Data collected at Designated Fish Habitat (DFH) sites allow a basic description of rearing areas used by juvenile longnose suckers (Appendix 4-F). Juvenile longnose suckers (less than 200mm fork length) were most often found in association with clear water slough sites where water velocities were less than 1 ft/sec. Catches at tributary mouths were also typically in backed up zones (zones 2, 6, 7, and 9) where flow was insignificant. Turbidity in these backed up zones varied greatly and juvenile longnose suckers were often found in very turbid water. At Goose Creek 2 and side channel for example, longnose sucker juveniles were captured in zones 4 and 6 during June and July when the turbidity in these zones was very high. In Slough 9, longnose sucker juveniles were also captured in turbid water in zones 4 and 6 in late June and early July. On the other hand, young of the year longnose suckers were captured in Slough 8A during early September in clear water in zone 1. Slough 6A also provided a clear water rearing area for age class 1+ longnose suckers in zone 2 during late June and early July. Mainstem sites may also provide suitable rearing area for longnose sucker juveniles, but these sites have not been extensively sampled with beach seines.

Based on this years electrofishing observations, adult longnose suckers appear to begin to move out of their summer rearing habitats into their overwintering habitats during August. Due to very low catches of longnose suckers during the winter, the locations and habitat characteristics of longnose sucker overwintering habitats in the Susitna River are currently unknown. It is presumed that longnose suckers overwinter in the mainstem and its associated side channels. Morrow (1980) states that "except for movement to and from spawning grounds, the longnose sucker apparently does not undertake any definite migrations." No major migrations have been observed for longnose suckers in the Susitna River to date.

4.3.7 Other Species

4.3.7.1 Dolly Varden

Dolly Varden (*Salvelinus malma* Walbaum) were infrequently caught at the sites sampled in the Susitna River below Devil Canyon. When found, they were most frequently associated with large, cold, fast flowing tributaries such as the Kashwitna River, Lane Creek, Indian River, and Portage Creek. Dolly Varden are generally recognized as fall spawners (Morrow 1980). Adult catches at these sites and other sites are typically highest in June and September. The high catches in June are believed to be due to fish moving into the tributaries for summer rearing from the mainstem and the high catches in September are due to movements back into the mainstem or to spawning streams (ADF&G 1981d).

Dolly Varden occupied the designated fish habitat sites studied only during spring or fall migrations. No more than a few scattered fish were thought to occupy any of the hydraulic zones studied on a consistent basis during the ice-free season (Appendix G). Dolly Varden captured are mostly likely transients passing through the zone. Because of low catch rates, little specific information is currently known about the summer rearing or fall spawning habitat requirements of Dolly Varden in the Susitna River.

4.3.7.2 Threespine Stickleback

Threespine stickleback (Gasterostens aculeatus L.) usually inhabit shallow water areas associated with aquatic plants (Morrow 1980) and this appears to be the case in the Susitna River. In the Susitna River, threespine stickleback are found in shallow warm-water sloughs or slow flowing tributaries, especially those with emergent vegetation such as Rolly Creek, Caswell Creek, Whitefish Slough, Sunshine Creek and Side Channel, and Birch Creek and Slough. Substrate at sites preferred by threespine stickleback was often silt or sand. Populations at these sites may fluctuate greatly from year to year (Volume 3).

Distribution may also vary from year to year but populations generally decrease upstream of the Chulitna River confluence (RM 98.5). Threespine stickleback are only rarely present at the mouths of cold, fast flowing tributaries like Lane Creek and Slough, 4th of July Creek, Indian River, or Portage Creek. Sloughs well above the Chulitna confluence such as Slough 10 have very few threespine stickleback even though they may have abundant emergent vegetation. Abundance and distribution above the Chulitna confluence may be limited by water temperatures or velocities or a combination of these factors.

4.3.7.3 Slimy Sculpin

The slimy sculpin (Cottus cognatus Richardson) is an often abundant species which inhabits lakes and streams across northern North America. It prefers streams with a rocky substrate and fairly high water velocities (Morrow 1980). Spawning occurs in the spring soon after breakup.

In the Susitna River, the slimy sculpin is a widely distributed species. It has been sampled in moderate numbers during the summer at most locations sampled with relatively high numbers being observed along rocky banks of the mainstem and its associated side channels, tributaries and sloughs (Volume 3). At a given designated fish habitat site, slimy sculpins were found to inhabit almost all zones present (Appendix 4-G. Generally the highest numbers of slimy sculpins were found in zones 1, 2, and 3. Often slimy sculpins were associated with substrates where some rocks were present. Rocks are used by slimy sculpins as escape cover and as spawning nest sites (Morrow 1980). Since winter catch data on slimy sculpins are limited, little is currently known about the overwintering habitat of this species although catches have often been made in the same areas where they were found in the summer.

4.3.7.4 Arctic Lamprey

Arctic lamprey (*Lampetra japonica* Martens) are generally recognized as spring spawners (Morrow 1980). In the Susitna River basin, Arctic lamprey have been observed spawning in late June in isolated locations (Table 4II-3-14). During spawning, male and female engage in a nest building ritual in an area of gravel substrate in water depths ranging from a few inches to 3.0 feet deep in a current of 0.5 to 1.0 ft/sec (Morrow 1980). Based on preliminary habitat evaluation data Arctic lamprey spawning habitat at Birch Creek and Slough (RM 88.3) concur fairly well with the published data. Since very few arctic lamprey have been captured, little is known about their summer rearing or overwintering habitats.

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