SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
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WATER BALANCE STUDIES OF MIDDLE SUSITNA SLOUGHS

PREPARED BY

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

FINAL REPORT

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

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Final Report
April 1985

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1.0 ABSTRACT

Groundwater discharge into sloughs along the Middle Susitna River maintains habitat for salmon spawning, rearing of the juvenile salmon and the incubation of salmon embryos. The operation of the proposed Susitna Hydroelectric Project upstream of these areas would change the flow regime in the river. The effects of these changes in flow regime on the groundwater discharge into the sloughs were studied.

Analysis of previously collected data and rainfall-runoff data collected during 1984 lead to the following conclusions:

1. Groundwater flow into the slough is related to the stage in the river. The gradients in the alluvial deposits are controlled by the river stage. Also, a percentage of the ground water contributed to the slough originates from the river. The effects vary from slough to slough, being dependent on local stratigraphy, gradient, and slough morphology. Relationships have been developed for Sloughs 8A, 9 and 11.

2. Upland groundwater is a significant source of water to some sloughs. This also varies between sloughs. The availability of this water to the sloughs depends upon that portion of the watershed area which has deeper soils, preventing rapid runoff.

2.0 INTRODUCTION

On the Susitna River, side sloughs are defined by the Alaska Department of Fish and Game (ADF&G, 1983) as the sidechannel or adjacent wetted habitats to the mainstem Susitna River which periodically receive a portion of their surface water from the mainstem Susitna River in addition to other sources. Numerous sloughs exist between Talkeetna and Devil Canyon, an area referred to as the middle Susitna River. Some of these sloughs provide spawning, rearing, and incubation habitat for chum, pink and sockeye salmon. For the years 1981-83 the estimated total number of these species using these sloughs for spawning are as follows: 1,100 - 2,200 sockeye; 2,400 - 5,100 chum; 0 - 300 pinks.

The major characteristic of these sloughs which makes them suitable habitat for salmon spawning, rearing, and incubation is the continuous flow of water through the year, either as surface or intragravel flow. The sources of this flow and the manner in which it would be affected by the regulation of flow in the Susitna River have been the focus of studies that have been in progress since 1982. Previously published reports include Acres American (1983), R&M Consultants (1982), and Alaska Power Authority (1984).

The purpose of this report is to present both 1984 data and additional analyses of the hydrologic conditions at selected sloughs in the middle Susitna River. Data from previous years have not been included. To further refine previous estimates of groundwater flow into Slough 9, falling head tests were conducted at three wells. Water levels were also continuously monitored at two wells. Instead of further attempting to separate the local and mainstem components of groundwater flow into Slough 9, an attempt was made to directly measure the flow which the uplands contributed to the slough. Additional streamgages and precipitation gages were installed at and near Slough 9 in order to conduct a water balance study. In addition, streamgages were maintained on Sloughs

8A and 11 to continue to document flow on sloughs which rarely receive mainstem flow.

3.0 DESCRIPTION OF BASINS

Three sloughs (8A, 9, and 11) were studied in 1984. The relative locations of each of the study sloughs are shown in Figure 3.1.

The following basin descriptions are modified slightly from those by ADF&G - Su Hydro.

3.1 Slough 8A - RM 125.3

Slough 8A is located at River Mile (RM) 125.3 on the left bank of the Susitna River (Figures 3.1, 3.2), just downstream of Slough 9. The slough is approximately two miles long and cuts inland from the mainstem Susitna through its historic floodplain until it intersects the steep upland slopes and the Alaska Railroad railbed. The slough then parallels the mainstem until emptying into a side channel. The banks range from low, gently sloping banks to five-foot high steep cut banks. The overall slough gradient is 10.5 feet/mile. Cobble/boulder substrate predominates in the upper half of the slough. Gravel/rubble is the predominant substrate in the lower half of the slough. Silt/sand deposits are found in the backwater area at the mouth and in the pools.

A backwater area extends approximately 1,000 feet upstream of the mouth during periods of moderate to high mainstem discharge. Above the backwater area is a 100-300 foot long riffle followed by a large beaver dam. There is a second channel besides the main connection of the slough to the mainstem. This channel flows into a large pool behind the beaver dam. The controlling discharge of the northwest channel is 27,000 cfs, while that of the upstream channel is approximately 33,000 cfs. The non-overtopped flow in Slough 8A is composed of groundwater input and surface runoff. There are numerous small streams which drain off the upland slopes directly into the slough. Bedrock is exposed on the slopes, and rapid runoff occurs.

3.2 Slough 9 - RM 128.3

Slough 9 is a 1.2 mile long unobstructed "S"-shaped channel on the left bank of the Susitna River, midway between Curry and Gold Creek (Figures 3.1, 3.3). Both the head and mouth of the slough open into side channels of the mainstem Susitna River. The lower half of the slough has a relatively shallow gradient which steepens past a point where the slough makes a sharp bend, roughly 3,000 feet upstream of the mouth. The overall slough gradient is 13.7 feet/mile. Gravel/rubble substrate is predominant in the lower half of the slough, while cobble/boulder substrate predominates in the upper half. Silt/sand deposits are found in the pool areas and the backwater area at the mouth. The area at the mouth consists of sand bars that are in a constant state of change. The banks generally have a moderate to steep slope and are 3-4 feet high. A small slough (9B) branches off in a northeasterly direction near the head of Slough 9. The Alaska Railroad parallels the southeast bank of the lower half of the slough.

The head of the slough has an initial breaching discharge of 16,000 cfs. Below this discharge the upper half of the slough is primarily dry, with an intragravel flow of water. At controlling discharge conditions of 19,000 cfs or above, river water flows freely through the slough, changing it to a completely turbid environment.

At mainstem discharges less than 12,000 cfs the backwater area at the mouth extends 500 feet upstream to the base of the first riffle. At higher mainstem discharges, the riffles are inundated and the lower portion of the slough becomes one long pool. The lower half of the slough is a series of pools and riffles ending with the backwater area at the mouth. Base slough flow is maintained by two small tributaries and contributions from groundwater percolation (upwelling). The upstream tributary was gaged at 2 locations in 1984. This tributary originates at a small lake at elevation 1900 feet, draining the steep upland areas before becoming ponded on the uphill side of the railroad tracks and meeting another small drainage. After flowing through culverts under the railbed, the creek flows through a meadow into Slough 9. The stream is occasionally dammed by beavers, both upstream of the railroad tracks and between the tracks and Slough 9.

3.3 Slough 11 - RM 135.3

Slough 11 is approximately one mile long and is located on the left bank of the Susitna River (Figures 3.1, 3.4). Both the head and the mouth of the slough join side channels of the mainstem Susitna River. The slough has a winding channel that is a series of pools and riffles, with an overall gradient of 19.8 feet/mile. Substrate in the upper half of the slough is composed mostly of cobbles/boulders, with the lower half composed of gravel/rubble. Silt/sand deposits are confined mostly to the backwater pool at the mouth. This pool is formed by a relatively stable sand/gravel bar at the mouth.

Slough 11 is a very recently formed feature of the Middle Susitna River. Local residents have indicated that this slough was created in May of 1976 by an extreme ice jam event on the mainstem which shunted flow from the mainstem through the adjacent floodplain, carving out the slough. The slough has a breaching discharge of approximately 42,000 cfs and was last breached in June 1984. In an unbreached state, intragravel flow can be observed entering the slough through the berm at the head. However, this flow is minimal, and below breaching discharges most of the upper third of the slough is dewatered with isolated shallow pools. Groundwater input maintains a year-round flow of water in the lower two-thirds of the slough. The backwater pool at the mouth exhibits considerable fluctuation in direct response to changes in mainstem discharge. The backwater area is quite broad, encompassing the entire slough width, in contrast to the narrow channel in the rest of the slough.

The flow in Slough 11 is very steady. It varies by only a few cfs throughout the year, except for the few times it is overtopped. There are no streams which feed the slough. The streamgage in Slough 11 was located 250 feet upstream of the mouth of the slough in order to avoid the existing backwater effects.

4.0 1984 DATA COLLECTION

4.1 Streamflow

Five stream gaging stations were established and maintained during 1984 to define the flow characteristics on three sloughs. Three of these stations were in Sloughs 8A, 9 and 11, while the other two were located on a major tributary stream to Slough 9. Gaging locations are shown on Figures 3.2, 3.3 and 3.4. Average daily discharges at each site are tabulated in Tables 4.1 through 4.5, with footnotes in Table 4.6. All gage sites consisted of a stilling well and a float-operated Stevens Type F recorder. Rating curves were developed at each site to relate the rate of flow to the measured stage. Biweekly servicing of these gages allowed 8-10 discharge measurements to be made at each site. At one site (the gage on the upper part of the slough 9 tributary), a weir was installed to allow accurate measurement of the flow in an area where no suitable natural controls existed. Prior to August 13, 1984, this was a 90° V-notch weir. After this date a suppressed rectangular weir with a crest length of 1.97 feet was used.

USGS provisional mean daily flow data for the Susitna River at Gold Creek are included as Table 4.7

Flow measurements were made at two sites at Slough 11 on September 12, 1984. On this date the stage in the mainstem was low enough to eliminate the backwater area which usually exists at the lower end of Slough 11 and which sometimes extends almost all the way to the gage. A discharge of 5.64 cfs was measured 1250 feet downstream of the gage, while 2.62 cfs were measured at the gage. The slough had gained over 3 cfs in the 1250 foot stretch. Large amounts of water were observed entering the slough from the upland side of the slough.

4.2 Precipitation

At the beginning of the 1984 field season there were three weather stations in the middle Susitna River basin, the Talkeetna NOAA station and the Devil Canyon and Sherman Stations from the Susitna Hydroelectric Project. The Devil Canyon site has provided precipitation data for the summer months since 1981. The Sherman site was installed in May 1982. However, the precipitation recorder at this site worked only intermittently from mid-August 1983 to August 21, 1984, when the site was repaired.

Five additional rain gages were installed in the basin in 1984. These sites are described in Table 4.8. Daily and cumulative precipitation values are tabulated in Tables 4.9(a) - 4.9(g).

4.3 Evaporation

Pan evaporation data have been collected at Watana Camp since 1981. The daily and monthly values for 1984 are tabulated in Table 4.10.

4.4 Groundwater Levels

Fluctuations in the groundwater table were measured continuously at two sites in the Slough 9 area. Boreholes were instrumented with pressure transducers connected to Omnidata Datapod recorders. Fluctuations in groundwater levels are plotted along with mainstem discharge at Gold Creek on Figures 4.1 (a) - 4.1 (k).

4.5 Aquifer Properties

Aquifer properties in the areas near the sloughs have not previously been well defined. An attempt was made to conduct a rising head pump test at Well 9-1 at Slough 9. However, the test was not successful in providing usable data with which to estimate aquifer properties. Subsequently, falling head tests were made at well sites 9-1, 9-2, 9-3 and 9-4. The data were analyzed using the technique described by Cooper, Bredehoeft, and Papadopulos (1967). The resulting transmissivity values determined from the data are tabulated in Table 4.11.

5.0 ANALYSES

5.1 Precipitation

In the small drainage basins of the sloughs, daily precipitation is more significant than total monthly precipitation when estimating peak local runoff. The small basins are likely to have short runoff periods of concentration, and would respond rapidly to local precipitation. Consequently, daily and monthly precipitation records at Talkeetna for the period 1943-1983 were reviewed to determine if the summer precipitation records for 1981-1984 were unusual in any way. The total monthly precipitation values were ranked in order, and are plotted on the monthly cumulative percent frequency curves on Figure 5.1. The 1984 monthly precipitation totals are included on this figure. The probabilities of the total monthly precipitation exceeding the values for the June, July, August and September for 1981-1984 are in Table 5.1. It can be easily seen that summer of 1981, June-July 1982 and August 1984 unusually wet; August 1982 and July 1984 were average; June-July 1983, June 1984, and September 1984 were very dry; and August 1983 was wet. This pattern can also be observed in the precipitation exceedance curves for the months of June through September (Figures 5.2-5.5).

Daily precipitation values have been previously summarized in Table 4.9. Data from four periods have been summarized in Table 5.2 for the 1984 network in the middle Susitna basin. Monthly and specific storm data from the continuous recording gages at Devil Canyon, Sherman, and Talkeetna have been summarized in Tables 5.3 and 5.4. Examination of the above data indicates the following general trends for summer precipitation along the Susitna River between Talkeetna and Devil Canyon.

(a) Local elevation changes have little or no affect on summer precipitation. As seen in Table 5.2, precipitation at Curry is similar at elevations 500 and 1750 feet. During September 13-25, precipitation at the Sherman (elevation 1900 feet) and 4th of July Creek (elevation 1600 feet) stations are about equal, and only slightly higher than that at the lower Sherman site (elevation 700 feet). Similarly, precipitation at both Sherman sites is nearly equal during the intense rainstorm of August 21-26, 1984.

(b) Summer precipitation varies longitudinally along the Susitna River. During the two significant rainfall periods noted in Table 5.3 (August 13-27 and September 13-25), rainfall at Curry was 57-71 percent greater than that at Talkeetna. Rainfall amounts then decreased upstream from Curry, with the Devil Canyon site receiving the least precipitation. This general trend seems to hold true in the monthly and other storm-specific data in Tables 5.3 and 5.4, although it varies from storm to storm. Coefficients for transferring precipitation data to ungaged areas along the middle Susitna River are shown in Table 5.5.

5.2 Slough Discharge - vs. - Mainstem Discharge

Linear and log-transformed regression equations relating slough discharge to mainstem discharge were determined for Sloughs 8A, 9, and 11. The resulting equations are shown in Table 5.6, with the regression lines on Figures 5.6 and 5.7. Regression analyses were also conducted using slough discharge lagged by one and two days from mainstem discharge, but the regressions did not improve the determination coefficient.

At Slough 8A, the equation developed using low-flow data (mainstem flow less than 12,500 cfs) explained significantly more variance than that using mainstem discharges up to 27,000 cfs. Under natural low-flow conditions, local runoff is less likely to be making a significant contribution to slough discharge. Slough discharge during these periods is more closely related to seepage affected by variations in mainstem discharge, and would not be affected by local runoff.

Only data from periods when the upstream berm was not overtopped were used for analyzing Slough 9. Maximum discharge from Tributary B was only 0.18 cfs during this period (September 3 - October 31, 1984), so Slough 9 flow was primarily from seepage. However, there was significant water loss in the tributary between the upper and lower gaging sites. The water may have re-emerged as seepage in the slough.

Data at Slough 11 were collected during non-overtopped periods. No surface water tributaries flow into Slough 11.

5.3 Storm Runoff

Runoff from a drainage basin is influenced both by climatic factors and physiographic factors (Chow, 1964). Climatic factors include the forms and types of precipitation, interception, evaporation, and transpiration, all of which exhibit seasonal variations. Physiographic factors are further classified into basin characteristics and channel characteristics. Basin characteristics include such factors as size, shape, and slope of drainage areas, permeability and capacity of groundwater formations, presence of lakes and wetlands in the basin, and land use. Channel characteristics are primarily related to the hydraulic properties of the channel which govern the movement of streamflows and determine channel storage capacity. Many of the above factors are interdependent to a certain extent, and can be highly variable in nearby basins.

Precipitation and stream discharge data were collected in 1984 to determine storm runoff, water balance and mainstem-slough flow relationships. At Slough 9, the upstream berm was breached continuously from June 4 through August 15 and from August 19 through

August 30, so storm runoff could not be analyzed. However, flow data were collected at two sites on the tributary entering the upper part of the slough, so direct storm runoff could be analyzed at these sites. Storm runoff analyses for the Slough 9 tributary for the rainfall periods of August 17-25 and September 15-20, 1984 are summarized in Table 5.7 with flow patterns shown on Figure 5.8. The upper and lower gages indicated a runoff percentage of about 50 percent in the August storm. However, the percent runoff was considerably less in the September storm, dropping to 12 percent for the upper site and 1.6 percent for the lower site. Several possible reasons may exist for the significant changes in runoff percentages, including:

(a) The volume, intensity, and timing of rainfall. The August storm was more intense and had a much greater precipitation volume. High rainfall rates occurred early in the August storm, saturating the ground early in the storm and resulting in higher runoff rates later. In the September storm, the higher rainfall amounts did not occur until late in the storm.

(b) Antecedent moisture. The August storm followed a 1-week period of no precipitation, while the 3 weeks prior to the September storm had little or no precipitation. The soil mantle was probably drier in September, therefore absorbing more moisture before surface runoff could occur. The precipitation timing previously mentioned also affected soil moisture.

(c) Groundwater levels. The water level in well 9-3 was about 2 feet lower during the September storm. This likely affected the rate of water loss between the upper and lower gages on the tributary. During the August storm, mainstem flow of the Susitna River at Gold Creek was about 20,000 cfs greater than in the September storm.

5.4 Water Balances

Monthly water balances were estimated for July through October for Sloughs 8A and 11 and the two sites on Tributary 9B of Slough 9 (Tables 5.8 and 5.9). Monthly precipitation at each site was determined from either gages at the site or from nearby gages adjusted by the coefficients in Table 5.5. Evaporation was estimated by using the 1984 pan evaporation data from Watana Camp, multiplied by 0.7. Flow data were recorded at the gaging stations.

At Slough 8A, 62-73% of the available precipitation ran off during July, September and October. The high percentage of 124% in August reflects the storm in late August, in which the upstream berm of the slough was likely overtopped for a short period of time, affecting the runoff values. Precipitation not running off as surface flow would remain as groundwater, and could seep into the slough during a later time period. However, slough discharge is very low (0.1 cfs) by late October.

Slough 11 maintains a relatively steady flow throughout the summer. Even the heavy rainfall in late August caused only a minor variation in streamflow which was closely correlated to mainstem discharge, as already shown in Section 5.2. This correlation may also be illustrated by comparing average monthly flows for both the mainstem and Slough 11. The corresponding monthly runoff ratios are shown below.

	Flows (cfs) Susitna River at Gold Creek	Slough 11	Slough 11 Runoff Ratio(a)
June	26,770	3.17	-0.17
July	23,440	2.82	0.77
August	20,100	2.75	0.44
September	9,380	2.44	1.19
October	5,110	1.45	1.47

(a) (Slough discharge)/(Precipitation - Evaporation)

Despite the strong negative balance in June (evaporation far exceeded precipitation), average flow in Slough 11 was the highest for the summer. (Slough 11 was overtopped in June for 3 days but those values are not included in the average monthly flow.) Seepage meter data from 1983 and the strong slough discharge vs. mainstem discharge correlation in Table 5.6 indicate that Slough 11 is primarily affected by mainstem flow (stage). The lack of surface tributaries indicates all precipitation infiltrates into the watershed. The runoff ratios for Slough 11 are somewhat spurious, since slough discharge would likely have been very similar for similar mainstem flows, no matter what precipitation fell on the watershed.

The upper gaging site on Tributary B, Slough 9, is at the base of the hillslope, monitoring flow just before the stream reaches the large alluvial fan. The data indicate that most available water runs off as surface flow, with about 10-20 percent remaining as groundwater. However, this does not occur at the lower gaging site, which is located near the confluence of Tributary B and Slough 9. From the data in Table 5.9, it is apparent that much of the flow reaching the head of the alluvial fan seeps into the ground. As the water table drops through September and October, reflecting the change in mainstem flow and water level, the tributary loses significantly more flow than when the water table is high. The rate of water loss from the stream is a function of the groundwater level. The higher the water table, the slower the water is lost from the tributary. The high surface runoff percentage in August is likely due to the intensity of the storm and to the higher groundwater levels (Figure 4.1 (g)).

The water loss in Tributary B, Slough 9, likely explains the relatively poor correlation between seepage meter data for meters 9-2 and 9-3 and mainstem discharge. In 1983, both seepage meters 9-2 and 9-3 were located at a spring upstream of the lower gaging site of Tributary B (APA, 1984). This site would have been affected both by mainstem stage levels and by water loss from Tributary B.

5.5 Timing of Surface Runoff

Local surface runoff may provide sufficient flow for fish access into the sloughs. However, monthly precipitation records do not provide sufficient time resolution to determine whether surface runoff will contribute an adequate amount of flow in addition to the groundwater. A simple technique was utilized to estimate local daily surface runoff at Slough 8A during low, average, and high periods of monthly precipitation at Talkeetna. When combined with the groundwater flow expected under with-project conditions, the runoff estimates provide additional insight into the type of flows expected when the project is operational.

The daily surface runoff pattern into Slough 8A was estimated for high, moderate, and low monthly precipitation (Tables 5.10, 5.11, 5.12). The recorded slough discharges for August 1984 (high precipitation), September 1983 (moderate precipitation), and September 1984 (low precipitation) were separated into surface runoff and groundwater flow. Groundwater flow was estimated using the regression equation for slough discharge and the average daily flows for the Susitna River at Gold Creek. The estimated groundwater flow was then subtracted from the recorded value. (When the groundwater flow estimate from the regression equation exceeded the recorded value, groundwater flow was reduced to the recorded value.) Surface runoff was assumed to be the difference between the recorded discharge and the estimated groundwater flow.

Although the estimates for surface runoff are not precise, Tables 5.10 through 5.12 do indicate that there are long periods when little surface runoff is contributed to Slough 8A, even in months when precipitation is well above average. In Table 5.10, a 13-day period of zero surface runoff is indicated, even though the monthly precipitation is exceeded only 20 percent of the time in August. Similar periods of zero surface runoff were indicated for the low rainfall month (September 1984). Surface runoff contributed an estimated 57%, 64%, and 15% for the high, moderate and low precipitation patterns illustrated in Tables 5.10 through 5.12.

The data in Table 5.10 also indicate that the runoff period extends for several days after a major precipitation event. Apparently, there is sufficient shallow subsurface flow on the valley slopes to maintain the flow for several days.

The above technique can also be applied at Slough 9 for periods of moderate-to-low precipitation and flow when the upstream berm is not overtopped. The runoff estimate for September 1983 (moderate precipitation, 61% exceedance) and September 1984 (low precipitation, 93% exceedance) are shown in Tables 5.13 and 5.14, respectively.

Tributary B on Slough 9 drains a lake which covers about 7.35 acres. The presence of the lake will result in a sustained surface flow for most summer conditions. However, the lower mainstem water levels which would occur during summer during projection operation will result in a lower water table in the alluvial fan at the upper end of Slough 9. The lower water table will result in Tributary B losing water to groundwater in the reach between the confluence with Slough 9 and the base of the valley wall.

6.0 CONCLUSIONS

The results of the 1984 water balance studies, taken together with results from previous studies in the area, lead to the following conclusions:

a. Talkeetna precipitation records, adjusted by an appropriate coefficient, may be used to estimate precipitation along the middle Susitna River. The estimated precipitation values may be used to estimate local runoff into selected sloughs.

b. A high percentage of precipitation (60-90%) runs off the steep rock hillslopes above Sloughs 8A and 9. However, the tributary streams may lose a significant portion of their surface flow to groundwater in alluvial fans at the base of the slopes such as at Slough 9. The rate of loss is affected by the depth of the water table.

c. Water level in the mainstem is the primary control of the groundwater level in the alluvial soils adjacent to the sloughs. Under with-project conditions, the reduced groundwater levels will affect the rate of runoff across alluvial fans such as that at Tributary B in Slough 9.

d. Strong linear and logarithmic relationships exist at Sloughs 8A, 9, and 11 between mainstem discharge and slough discharge during periods when the upstream berm of the slough is not overtopped. These relationships may be used to estimate groundwater discharge under with-project conditions. Sloughs will also receive local surface runoff.

e. Examination of watershed characteristics can give an indication of how sloughs which have not yet been studied would react to changes in mainstem flow, although with-project slough discharges could not be accurately quantified.

7.0 REFERENCES

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TABLES

TABLE 4.1

MEAN DAILY FLOW, SLOUGH 8A

Location: Gage was midway along the length of slough 8A.
Drainage Area: 1.51 sq. mi.

Discharge, in Cubic Feet Per Second, 1984 Mean Values

Day	July	August	September	October
1	-	5.9	4.1	1.4
2	-	5.6	3.2	1.4
3	2.6	5.2	2.6	1.3
4	2.6	4.8	2.4	1.3
5	2.4	4.8	2.0	1.2
6	2.2	4.4	1.7	1.1
7	2.2	4.1	1.5	1.0
8	2.0	3.8	1.4	1.0
9	2.0	4.4	1.2	1.0
10	2.2	4.1	1.2	0.9
11	2.0	3.6	1.0	0.9
12	2.2	3.2	1.0	0.8
13	2.0	2.6	1.0	0.7
14	2.0	2.4	0.9	0.6
15	1.7	2.2	0.8	0.6
16	1.5	2.0	0.9	0.5
17	1.2	1.7	0.9	0.4
18	1.5	2.6	1.2	0.4
19	1.7	4.1	1.7	0.3
20	2.2	4.8	2.2	0.3
21	2.2	5.2	2.2	0.3
22	2.2	5.9	2.2	0.3
23	2.2	8.0	2.2	0.4
24	2.2	34.0	2.0	0.3
25	2.6	65.0	2.0	0.3
26	4.4	44.0	1.7	0.3
27	5.6	17.0	1.5	0.2
28	7.1	11.0	1.5	0.1
29	6.2	8.0	1.4	0.1
30	8.4	5.9	1.4	0.1
31	7.1	4.8		0.1
TOTAL	86.4	285	51.0	19.6
Mean	2.98	9.19	1.70	0.63
Max	8.4	65	4.1	1.4
Min	1.2	1.7	0.8	0.1

TABLE 4.2
MEAN DAILY FLOW, SLOUGH 9

Location: Downstream end of Slough 9
Drainage Area: 2.26 sq. mi.

Discharge, in Cubic Feet Per Second, 1984 Mean Values

Day	June	July	August	September	October
1	9.1	190	190	18	2.1
2	11	240	130	14	2.1
3	9.7	210	66	11	2.1
4	11(a)	92	56	9.5	2.0
5	11	66	69	7.1	2.0
6	12	65	160	5.6	1.9
7	18	58	170	4.8	1.9
8	23	55	150	4.2	1.9
9	30	53	220	3.6	1.9
10	35	51	200	3.2	1.8
11	30	81	160	2.8	1.8
12	29	62	50	2.4	1.7
13	140	52	40	2.4	1.6
14	500	51	24	2.1	1.6
15	440	28	17	2.1	1.6
16	810	20	14	2.1	1.5
17	-	41	13	2.1	1.6
18	-	60	18	2.7	1.4
19	-	59	34	3.2	1.4
20	-	52	43	3.6	1.4
21	-	70	56	4.2	1.3
22	32	100	52	3.6	1.4
23	34	110	43	3.2	1.4
24	44	57	300	2.8	1.4
25	59	110	790	3.3	1.4(e)
26	140	590	750	3.3	1.4(e)
27	60	680	480	2.8	1.3(e)
28	27	500	160	2.4	1.3(e)
29	45	410	52	2.4	1.3(e)
30	65	380	35	2.1	1.3(e)
31		260	25		1.3(e)
TOTAL	-	4,853	4,567	136	50.1
Mean	-	156	147	4.53	1.62
Max	-	680	790	18	2.1
Min	9.1	20	13	2.1	1.3

(a) The berm at the upstream end of Slough 9 was overtopped continuously between June 4 through August 15 and August 19 through August 30.
(e) Estimated values.

TABLE 4.3

MEAN DAILY FLOW
UPPER SITE, TRIBUTARY B, SLOUGH 9

Location: Gage was 150 feet uphill from the Railroad tracks on the tributary stream
Drainage Area: 0.73 sq. mi.

Discharge, in Cubic Feet Per Second, 1984 Mean Values

Day	August	September	October
1	0.92	1.89	0.80
2	1.02	1.59	0.75
3	1.03	1.48	0.75
4	1.02	1.26	0.75
5	1.08	1.15	0.71
6	1.11	1.10	0.66
7	0.95	0.99	0.66
8	0.85	0.94	0.66
9	1.14	0.90	0.66
10	1.03	0.84	0.66
11	0.92	0.75	0.66
12	0.82	0.75	0.62
13	0.73	0.78	0.62
14	0.71	0.73	0.57
15	0.71	0.69	0.53
16	0.62	0.66	0.49
17	0.57	0.66	0.49
18	0.85	0.80	0.45
19	1.89	0.88	0.45
20	2.27	1.10	0.41
21	2.20	1.07	0.38
22	2.53	1.04	0.41
23	3.07	1.02	0.38
24	8.89	0.97	0.38
25	14.7	0.97	0.34
26	9.91	0.90	0.30
27	6.23	0.90	0.27
28	4.74	0.85	0.24
29	3.42	0.85	0.20
30	2.79	0.85	0.18
31	2.33		0.18
TOTAL	81.1	29.4	15.6
Mean	2.62	0.98	0.50
Max	14.7	1.89	0.80
Min	0.57	0.66	0.18
CFSM	3.59	1.34	0.68
IN	4.13	1.50	0.80

TABLE 4.4
MEAN DAILY FLOW
LOWER SITE, TRIBUTARY B, SLOUGH 9

Location: Gage was 400 feet upstream of the mouth of the tributary stream.
Drainage Area: 1.46 sq. mi.

Discharge, in Cubic Feet Per Second, 1984 Mean Values

Day	June	July	August	September	October
1	2.2	1.5	1.7	1.9	0.09
2	2.7	1.4	2.4	1.4	0.09
3	2.4	1.4	1.7	1.2	0.09
4	2.2	1.3	1.3	0.85	0.09
5	1.8	1.2	1.4	0.45	0.09
6	1.4	1.2	1.4	0.28	0.09
7	1.4	1.2	1.3	0.25	0.09
8	1.1	1.0	1.1	0.16	0.09
9	1.5	1.0	1.7	0.12	0.09
10	0.95	0.95	1.4	0.12	0.08
11	0.85	0.95	1.2	0.10	0.08
12	0.45	0.90	0.85	0.10	0.08
13	0.45	0.85	0.55	0.10	0.08
14	-	0.70	0.40	0.10	0.08
15	-	0.60	0.25	0.08	0.08
16	-	0.45	0.16	0.08	0.08
17	-	0.65	0.15	0.06	0.08
18	-	0.70	0.25	0.10	0.07
19	-	0.45	1.7	0.12	0.07
20	-	0.35	2.1	0.16	0.07
21	-	0.45	2.2	0.18	0.07
22	-	0.40	2.3	0.18	0.06
23	1.7	0.40	2.9	0.16	0.06
24	1.5	0.28	16.0	0.14	0.06
25	1.4	0.30	43.0	0.14	0.06
26	1.4	1.7	34.0	0.12	0.06
27	1.6	4.7	14.0	0.10	0.06
28	1.7	2.6	6.6	0.10	0.06
29	1.7	2.5	4.2	0.10	0.06
30	1.6	3.0	3.0	0.10	0.06
31		2.3	2.5		0.06
TOTAL	-	37.4	154	9.1	2.3
Mean	-	1.21	4.97	0.30	0.07
Max	-	4.7	43	1.9	0.09
Min	-	0.28	0.15	0.06	0.06
CFSM	-	0.83	3.40	0.21	0.05
IN	-	1.95	3.92	0.23	0.06

TABLE 4.5
MEAN DAILY FLOW, SLOUGH 11

Location: Gage was 2500 feet upstream of the mouth of Slough 11.
Drainage Area: 1.69 sq. mi.

Discharge, in Cubic Feet Per Second, 1984 Mean Values

Day	June	July	August	September	October
1	1.7	3.6	2.7	2.7	2.2
2	1.6	3.2	2.6	2.7	2.2
3	1.7	3.2	2.4	2.7	2.2
4	1.9	3.2	2.4	2.7	2.0
5	2.2	2.9	2.4	2.6	2.0
6	2.2	2.9	2.4	2.6	2.0
7	2.2	2.9	2.4	2.6	1.7
8	2.4	2.9	2.7	2.4	1.7
9	2.4	2.9	2.6	2.4	1.7
10	2.7	2.9	2.4	2.4	1.7
11	2.7	2.7	2.4	2.4	1.7
12	2.6	2.9	2.2	2.4	1.6
13	2.9	2.7	2.2	2.4	1.6
14	2.9	2.7	2.2	2.4	1.4
15	2.9	2.6	2.2	2.4	1.4
16	3.4(e)	2.4	2.2	2.4	1.3
17	3.9(e)	2.4	1.9	2.4	1.3
18	4.4(e)	2.4	2.4	2.4	1.2
19	4.8	2.4	2.4	2.4	1.1
20	4.4	2.4	2.2	2.6	1.1
21	4.0	2.4	2.4	2.4	1.1
22	4.0	2.6	2.6	2.4	1.1
23	4.0	2.4	2.7	2.4	1.1
24	4.0	2.4	3.2	2.4	1
25	4.0	2.7	4.4	2.4	1
26	4.0	2.9	4.4	2.4	1
27	3.6	3.2	4.4	2.2	1
28	3.6	3.6	4.0	2.2	1
29	4.0	3.2	3.6	2.2	1
30	4.0	3.2	3.2	2.2	1
31		2.9	2.9		1
TOTAL	95.1	87.7	85.1	73.2	43.4
Mean	3.17	2.82	2.75	2.44	1.45
Max	4.8	3.6	4.4	2.7	2.2
Min	1.6	2.4	1.9	2.2	1.0

(e) Slough 11 was overtopped during the period of 6-16 to 6-18. The values listed are estimated non-overtopped flows.

TABLE 4.6

FOOTNOTES FOR DISCHARGE DATA

- No data available

a Overtopping of berm at upstream end of slough provides part of flow

Daily Mean - Average discharge over a 24 hour period in cubic feet per second. This value includes flow from the mainstem if the upstream berm of the slough is overtopped.

Total - Total of daily mean discharges for the month.

Max - Maximum daily mean discharge for the month.

Min - Minimum daily mean discharge, for the month.

CFSM - Runoff in cubic feet per second per square mile is the average number of cubic feet of water flowing per second from each square mile of area drained. This value is reported only if the data is not affected by the mainstem, either as overtopped flow or groundwater flow. This additional flow from the mainstem does not reflect the natural yield of the drainage basin.

IN - Runoff in inches shows the depth of which the drainage area would be covered if all the runoff for the month were uniformly distributed on it. This value is reported only if the data is not affected by the mainstem (See CFSM above).

TABLE 4.7

MEAN DAILY FLOW (USGS PROVISIONAL)
SUSITNA RIVER AT GOLD CREEK

Day	June	July	August	September	October
1	12,200	25,500	22,900	12,500	7,800
2	13,100	24,800	21,500	11,800	8,000
3	15,100	25,100	19,900	11,200	7,700
4	17,200	23,200	19,500	10,800	7,350
5	18,000	22,400	20,600	10,400	7,100
6	18,200	22,300	22,800	10,300	6,800
7	19,300	21,900	22,900	10,600	6,700
8	20,300	21,500	22,500	10,800	6,600
9	21,100	21,400	23,900	10,600	6,650
10	21,900	21,200	23,500	9,800	6,800
11	21,500	23,100	22,100	9,300	6,600
12	21,300	21,900	18,500	9,000	6,700
13	25,900	21,200	17,100	9,000	6,150
14	31,500	21,200	15,600	8,700	5,550
15	31,200	19,400	14,600	8,500	5,000
16	40,600	18,600	14,000	8,200	5,000
17	52,000	20,500	14,300	8,100	4,400
18	40,600	21,700	15,200	8,300	4,300
19	33,600	21,600	17,000	9,400	3,800
20	31,500	21,100	18,000	10,400	3,700
21	31,400	22,300	19,400	11,400	3,900
22	30,900	23,000	18,600	10,300	4,300
23	31,100	23,500	17,900	9,000	4,500
24	30,000	21,600	22,700	8,300	4,800
25	28,400	22,300	30,300	7,950	4,000
26	26,600	29,800	31,700	7,650	3,100
27	28,700	33,500	28,000	7,400	2,700
28	32,000	30,300	21,400	7,200	2,400
29	30,100	27,900	17,300	7,200	2,200
30	27,900	27,000	15,700	7,400	2,200
31		24,700	13,600		2,200
TOTAL	803,200	725,500	623,000	281,500	158,500
MEAN	26,770	23,400	20,100	9,380	5,110
MAX	52,000	33,500	31,700	12,500	8,000
MIN	12,200	18,600	13,600	7,200	2,200
CFSM	4.35	3.80	3.26	1.52	0.83
IN	4.85	4.38	3.76	1.70	0.96

TABLE 4.8

MIDDLE SUSITNA PRECIPITATION GAGES
Downstream to Upstream Order

Location	River Mile	Period of Record	Type of Station
Talkeetna FAA	97	1941-Present	Observer
Curry Camp	121	8/1/84-10/31/84	Observer
Curry at 1750'	121	8/14/84-10/31/84	Collecting buckets checked biweekly.
Sherman	129.5	6/1/82-9/30/82	Recording tipping bucket.
		6/1/83-7/31/83 8/21/84-10/31/84	
Sherman at 1900'	129.5	6/1/84-7/31/84	Collecting bucket checked biweekly.
		8/14/84-10/31/84	Recording tipping bucket.
4th of July @ 1600'	129.5	8/14/84-10/31/84	Collecting bucket checked biweekly.
Gold Creek	136.5	8/16/84-10/31/84	Observer
Devil Canyon	151	7/17/80-Present	Recording tipping bucket.

TABLE 4.9 (a)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

May 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation	345	500	1750	700	1900	1600	700	1700
Day								
1	0.19							0
2	0.10							0
3	T							0
4	0.16							0
5	0.10							0
6	0.01							0
7	0							0
8	0							0
9	0							0
10	0							0
11	0							0
12	0							0
13	0							0
14	0							0
15	0							0
16	0							0
17	0							0
18	0.05							0
19	T							0
20	0							0
21	0.01							0
22	0.12							0
23	0.01							0
24	0							0
25	0.04							0
26	0.15							0
27	0.04							0
28	0							0
29	0.22							0
30	0.15							0.15
31	0.05							0
TOTAL	1.40							0.15

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (b)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

June 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation	345	500	1750	700	1900	1600	700	1700
Day								
1	0							0
2	0							0
3	0							0
4	0							0
5	0							0
6	0.02							0.09
7	0.08							0.02
8	0							0.10
9	0.14							0.06
10	0.06							0
11	0							0
12	0							0
13	0.08				1.00			0.31
14	0.02							0.18
15	0.04							0.01
16	0.64							0.40
17	0.03							0
18	0							0
19	0							0
20	0							0.02
21	0							0
22	0				0.50			0
23	0.01							0
24	0.03							0.02
25	0.03							0
26	0.07							0.08
27	0.21							0.21
28	0							0
29	0.01							0
30	T							0
TOTAL	1.47				1.65(e)			1.50

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (c)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

July 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation	345	500	1750	700	1900	1600	700	1700
Day								
1	0.30							0.08
2	0.02				0.30			0.04
3	0.01							0.01
4	0							0.01
5	0							0.06
6	0							0
7	0.01							0
8	T							0.04
9	0.10							0
10	0.11							0.26
11	0.01							0
12	0.06							0.03
13	0.11							0.02
14	0							0
15	T							0
16	T							0
17	0.02							0
18	0.13							0.02
19	0.06							0.04
20	0.52							0.19
21	0.13							0.05
22	0							0.06
23	T							0
24	0.18							0
25	0.61							0.80
26	0.59							0.65
27	0							0.04
28	0.01							0.11
29	0.08							0.13
30	0.16							0.02
31	T				5.10			0
TOTAL	3.22				5.25(e)			2.66

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (d)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

August 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation	345	500	1750	700	1900	1600	700	1700
Day								
1	0.17	Start	-	-	-	-	-	0.02/0
2	0.07		-	-	-	-	-	0.01/0.02
3	T	0.05	-	-	-	-	-	0.01/0.01
4	0	0	-	-	-	-	-	0 /0.01
5	0.54	0.59	-	-	-	-	-	0.41/0.10
6	0	0	-	-	-	-	-	0.02/0.33
7	0.11	0	-	-	-	-	-	0
8	0.04	0.63	-	-	-	-	-	0.04/0
9	0.52	0	-	-	-	-	-	0.76/0.79
10	T	0	-	-	-	-	-	0
11	0	0	-	-	-	-	-	0
12	0	0	-	-	-	-	-	0
13	0	0	-	-	-	-	-	0
14	0	0	Start	-	0 /0	Start	-	0
15	0	0		-	0 /0		-	0
16	0	0		-	0 /0		Start	0
17	0.03/0	T		-	0.07/0		0.01	0
18	0.63/0.28	0.39		-	1.26/0.26		0.49	1.03/0.10
19	0.52/0.70	1.32		-	0.54/1.35		1.11	0.33/1.02
20	0.40/0.38			-	0.29/0.44		0.26	0.01/0.24
21	0.13/0.32	0.75		0.27/0	0.06/0.10		0.04	0.02/0.02
22	0.30/0.23	0.42		0.49/0.46	0.60/0.28		0.19	1.00/0.07
23	0.24/0.20	0.97		0.46/0.35	0.35/0.45		1.75	0.48/0.95
24	1.31/0.40	1.24		1.83/1.16	2.05/1.21		1.60	1.42/1.33
25	1.62/1.65	1.54		1.19/1.51	1.24/1.50		-	0.70/0.83
26	0.02/1.04	1.51		0 /0.76	0 /0.87	6.65	0	0.01/0.39
27	0	0	8.18	0			0	0
28	0	0		0			0.01	0
29	0	0		0			0	0
30	0	0		0			0	0
31	0	0		0			0	0
TOTAL	6.65	9.41	-	-	-	-	-	6.28

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (e)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

September 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation Day	345	500	1750	700	1900	1600	700	1700
1	0	0	-	0			0	0
2	0	0	-	0			0	0
3	0	0	-	0			0	0
4	0	0	-	0			0	0
5	0	0	-	0			0	0
6	0.06/0	0	-	0			0.09	0
7	0.02/0.08	0.07	-	0.10/0.09			0.11	0.32/0.08
8	0	0	-	0 /0.01			0	T /0.25
9	0	0	-	0			0	0
10	0	0	-	0			0	0
11	0	0.10	-	0			0.13	0
12	0.08/0	0.15	-	0.22/0.09	0.20	0.18	0.29	0.08/T
13	0.06/0.12	0.34		0.17/0.21			0.04	0.09/0.10
14	0 /0.02	0		0 /0.08			0	0 /0.06
15	0	0.02		0.02/0				0.06/0
16	0.02/0	0		0.11/0.02				0 /0.06
17	0.12/0.06			0.04/0.12				0.35/0.28
18	0.05/0.10			0.57/0.29			0.68	0.15/0.15
19	0.76/0.03	0.92		0.61/0.33			0.51	0.13/0.24
20	0.11/0.87	0.82		0.05/0.64			0	0 /0.01
21	0			0			0	0
22	0		1.95	0			0	0
23	0			0			0	0
24	T/0			0			0.15	0.05/0.04
25	0.17/0.12	0.18		0.12/0.10	1.98	2.09	0	0 /0.01
26	0 /0.05	0		0 /0.02	0	-	0	0
27	0	0		0	0	-	0	0
28	0.02/0	0		0	0.01	-	0.06	T/T
29	0.16/0.17	0.10		0.02/0.01	0.03	-	0.09	0
30	0.10/0.11	0.21		0.05/0.06	0.06	-	0	0
TOTAL	1.73	2.91	-	2.08	2.28	2.27	2.15	1.28

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (f)

MIDDLE SUSITNA RIVER
PRECIPITATION DATA - (Inches)

October 1984

Station	Talkeetna	Curry	Curry	Sherman	Sherman	4th of July	Gold Creek	Devil Canyon
Elevation	345	500	1750	700	1900	1600	700	1700
Day								
1	0.02	0		0	0	-	0	0
2	0.04	0		0.04	0.06	-	0.04	0.02
3	0	0.06		0	0	-	0.06	0.01
4	0	0		0	0	-		0
5	0	0		0	0	-		0
6	T	-		0.02	0.05	-		0
7	T	-		0	0	-		0
8	0.30	-		0.22	0.12	-		0.05
9	0.21	-		0.04	0	-	0.30	0.04
10	0	-	0.38	0.01	0	-	-	0.01
11	0.04			0.01		-	-	0.01
12	0.16			0.08			-	0.06
13	0			0			-	0
14	0			0			-	0
15	0			0			-	0
16	0			0			-	0
17	0			0			-	0
18	0			0			-	0
19	0			0.02			-	0
20	T			0			-	0
21	0.48			0.09			-	0
22	0.11			0.17			-	0.03
23	0.24			0.15			-	0.03
24	0			0			-	0
25	0			0.01			-	0
26	0			0			-	0
27	0			0			-	0
28	0			0			-	0
29	0			0			-	0
30	T			0			-	0
31	0	0.62	0.88	0	0.45	0.64	-	0
TOTAL	1.60	-	N/A	0.87	0.58	-	-	0.26

See notes on Precipitation at end of tables for explanation of symbols.

TABLE 4.9 (g)

NOTES ON PRECIPITATION

1. Talkeetna FAA Station reports daily precipitation from midnight to midnight for the days noted. Where a slash (/) appears, the first number is the reported precipitation and the second number is the precipitation from 9 a.m. of the previous day to 9 a.m. of the date noted.

2. "Curry at 500" is monitored daily, with an attempt to measure between 8 a.m. and 10 a.m. each day.

3. "Curry at 1750" and "4th of July Creek at 1600" are cumulative stations measured at approximately 2 week intervals.

4. "Sherman at 700", "Sherman at 1900" and "Devil Canyon" are continuously recording stations. Where a slash (/) appears, the first number is the precipitation from midnight to midnight and the second number is the precipitation from 9 a.m. of the previous day to 9 a.m. of the date noted.

T - Trace amounts of rainfall

(e) - estimated value

\- - No data

TABLE 4.10

EVAPORATION DATA, WATANA CAMP, 1984

Day	May	June	July	August	September
1		0.18	0.21	0.08(e)	0.10(i)
2		0.19	0.07	0.02(e)	0.09
3		0.20	0.11	0.05(e)	0.08(i)
4		0.12	*	0.17(e)	*
5		0.22	0.40	0.15(e)	0.21
6		0.12	0.58	0.00(e)	0.06
7		*	0.28	0.20(e)	0.02
8		*	0.17	0.19	0.06
9		*	0.14	0.17	0.12(i)
10		*	0.06	0.00	0.06(i)
11		0.37	0.11	0.55	0.04
12		0.06	0.18	*	0.08
13		0.07	0.14	0.38	0.02
14		0.19	0.00	0.17	0.08
15		0.00(e)	0.09(e)	0.14	0.12
16		*	0.08(e)	0.16	end of data
17		*	0.01(e)	0.13	
18		0.42	0.00(e)	0.06	
19		0.21	0.04(e)	0.04	
20		0.81	0.07(e)	0.00	
21		0.64	0.00(e)	0.05	
22		0.28	0.00(e)	0.04	
23	Start	0.81	0.08	0.00	
24	0.03	0.30	0.15	0.00	
25	0.06	0.12	0.09	0.00	
26	0.09	0.24	0.00	0.04	
27	*	0.05	0.00(e)	0.23	
28	*	0.03	0.01(e)	0.14(i)	
29	0.28	0.02	0.00(e)	0.03(i)	
30	0.00(e)	0.01	0.03(e)	0.24(i)	
31	0.73		0.06	0.12	
TOTAL	1.19M	5.66(e)	3.16(e)	3.55(e)	1.14M

NOTE: All values are for a 24-hour period ending at approximately 0800 on date shown.

* No pan observation on this date. Amount included in following measurement, time distribution unknown.

(e) Precipitation data missing but estimated from observers notes and records from nearby stations.

(i) Ice layer on water surface.

M Monthly total is approximate, based on a partial record only.

TABLE 4.11

FALLING HEAD TEST RESULTS
SLOUGH 9 - BOREHOLES

Borehole	Well I.D. (ft)	Depth of Screen (ft)	Date of Test	Transmissivity Ft^2/Day	Comments
9-1	0.146	24-27	07/17/84	3.5	Good curve fit
9-1	0.146	24-27	07/31/84	5.4	Good curve fit, retest
9-1	0.146	24-27	08/15/84	3.4	Good curve fit, retest
9-1	0.063	9.4-10.7	08/15/84	0.2	Good curve fit
9-1	0.063	9.4-10.7	08/29/84	0.2	Good curve fit, retest
9-2	0.146	7-10	08/13/84	50	Sparse data, poor curve fit
9-2	0.146	7-10	08/15/84	92	Sparse data, poor curve fit, retest
9-2	0.146	7-10	08/29/84	12	Poor curve fit, retest
9-2	0.063	10.7-12.1	08/15/84	--	No curve fit
9-2	0.063	10.7-12.1	08/25/84	2.6	Poor curve fit, retest
9-3	0.146	37-40	07/31/84	3.4	Good curve fit
9-3	0.146	37-40	08/14/84	3.6	Retest
9-3	0.146	37-40	08/14/84	2.4	Retest after surging well. Value probably affected by previous testing.
9-4	0.063	11.7-13.1	08/13/84	--	No useable data
9-4	0.063	11.7-13.1	08/13/84	--	No useable data, retest

TABLE 5.1

MONTHLY PRECIPITATION AND PROBABILITY
OF EXCEEDANCE
TALKEETNA, ALASKA
June - September, 1981 - 1984

	June	July	August	September
1981 Precipitation-Inches	5.25	8.74	7.39	2.02
Probability of Exceedance	8%	2%	15%	87%
1982 Precipitation-Inches	4.20	5.74	4.55	7.54
Probability of Exceedance	16%	11%	42%	11%
1983 Precipitation-Inches	1.77	1.75	5.69	3.29
Probability of Exceedance	59%	88%	29%	61%
1984 Precipitation-Inches	1.47	3.22	6.65	1.73
Probability of Exceedance	70%	48%	20%	93%
Mean - 1943-1983	2.47	3.46	4.65	3.97

TABLE 5.2

1984 GEOGRAPHIC DISTRIBUTION OF PRECIPITATION
MIDDLE SUSITNA RIVER

Period	Talkeetna 345	Curry 500	Curry 1750	Sherman 700	Sherman 1900	4th of July 1600	Gold Creek 700	Devil Canyon 1700
8/13 - 8/27	5.17	8.14	8.18	-	6.46	6.65	5.45	5.00
8/28 - 9/12	0.16	0.32	0.32(e)	.032	0.20	0.18	0.63	0.40
9/13 - 9/25	1.29	2.28	2.13(e)	1.69	1.98	2.09	1.38	0.83
9/26 - 10/10	0.85	0.38(e)	0.38	0.40	0.33	-	0.55	0.13
TOTAL (8/13-10/10)	7.47	11.12	11.01		8.97		8.01	6.36

TABLE 5.3

MIDDLE SUSITNA RIVER
MONTHLY PRECIPITATION TOTALS
(Inches)

	Talkeetna	Sherman	P(Sherman) / P(Talkeetna)	Devil Canyon	P(Devil Canyon) / P(Talkeetna)
1982					
May 15-31	0.47	0.29	0.62	0.33	0.70
June	4.20	3.98	0.95	3.35	0.80
July	5.74	6.37	1.17	4.19	0.73
August	4.55	3.70	0.81	1.38	0.30
September	7.54	9.14	1.21	6.17	0.82
1983					
May 1-25	0.96	0.76	0.79	0.76	0.79
June 14-30	0.62	0.52	0.84	0.57	0.92
July	1.75	2.13	1.22	1.83	1.05
August	5.69	--	--	4.06	0.71
September	3.29	--	--	--	--
1984					
June	1.40	--	--	1.50	1.07
July	3.06	--	--	2.69	0.88
August	6.63	--	--	6.28	0.95
September	1.73	2.07	1.20	1.28	0.74

TABLE 5.4

STORM - SPECIFIC PRECIPITATION TOTALS

Period of Rainfall	Event	Devil Canyon	Sherman	Talkeetna	P(Sherman)/ P(Talkeetna)	P(Devil Canyon)/ P(Talkeetna)
July 1-12	1982	1.98	2.34	2.03	1.15	0.98
July 10-19	1982	1.46	1.30	1.36	0.96	1.07
July 21-25	1982	2.08	4.09	3.28	1.25	0.63
July 27-31	1982	0.60	1.28	1.02	1.25	0.59
August 7-11	1982	0.49	1.18	1.57	0.75	0.31
August 28-September 5	1982	0.88	3.32	3.32	0.97	0.27
September 6-23	1982	4.88	6.12	5.84	1.05	0.84
June 26-July 2	1983	0.72	0.65	0.34	1.91	2.12
July 4-9	1983	0.13	0.37	0.45	0.82	0.29
August 17-26	1984	5.00	6.40	5.20	1.23	0.96
TOTAL		18.22	27.05	24.41		
AVERAGE					1.11	0.75

TABLE 5.5

PRECIPITATION COEFFICIENTS FOR TRANSFER OF RECORDED DATA

Site	Continuous Station Talkeetna	Sherman	Devil Canyon
Curry	1.5	1.2	1.7
Slough 8A	1.3	1.07	
Slough 9 (Sherman)	1.2	1.0	1.4
Gold Creek	1.07	0.9	1.3

To obtain precipitation estimate for above sites, multiply precipitation at the continuous station by the appropriate multiplier.

TABLE 5.6

REGRESSION EQUATIONS FOR
SLOUGH DISCHARGE vs. MAINSTEM DISCHARGE

Slough	Period	Regression Equation	R^2	Points	Comments
8A	July 3 - October 30, 1984 (excl. 8/23-8/28)	Q8 = -.08 + .00017 QGC log Q8 = -5.0 + 1.29 log QGC	0.53 0.79	115 115	Flow range (2,200-27,900 cfs)
	Sept 1 - October 20, 1984	Q8 = -.67 + .00025 QGC log Q8 = -7.13 + 1.85 log QGC	0.73 0.91	61 61	Low runoff period. (2,200-12,500 cfs)
9	Sept 8 - October 30, 1984	Q9 = -.62 + .00039 QGC log Q9 = -4.1 + 1.15 log QGC	0.82 0.84	56 56	Flow range (2,200-11,400 cfs)
11	May 25 - October 22, 1983	Q11 = 1.52 + .000105 QGC	0.76	156	From 1983 slough report.
	June 1 - October 30, 1984	Q11 = 1.3 + .000072 QGC log Q11 = -1.5 + 0.45 log QGC	0.68 0.76	153 153	Flow range (2,200-40,600 cfs)
	May 25 - October 22, 1983 & June 1 - October 30, 1984	Q11 = 1.43 + .000087 QGC	0.63	309	

TABLE 5.7

STORM RUNOFF ANALYSES
SLOUGH 9 TRIBUTARY

	Slough 9 Tributary, Upper Site		Slough 9, Tributary Lower Site	
Precipitation Period (1984)	08/17-08/25	09/15-09/20	08/17-08/25	09/15-09/20
Runoff Period	08/17-09/06	09/15-09/28	08/17-09/06	09/15-09/28
Total Precipitation (Inches)	6.46	1.40	6.46	1.40
Max. Daily Precipitation (Inches)	2.05	0.61	2.05	0.61
Total Precipitation Volume (million cubic feet)	10.96	2.37	21.91	4.75
Total Runoff Volume (million cubic feet)	6.468	1.081	12.181	0.149
Baseflow Volume (million cubic feet)	1.034	0.798	0.272	0.073
Storm Runoff Volume (million cubic feet)	5.434	0.283	11.909	0.076
% Runoff	50%	12%	54%	1.6%
Groundwater Level, Well 9-3			606.8	604.8
Maximum Daily Flow Susitna River at Gold Creek			31,700	11,400

TABLE 5.8

1984 MONTHLY WATER BALANCES
SLOUGHS 8A AND 11

	June	July	August	September	October
Slough 8A					
Flow, Q (cfs)		2.98	9.19	1.70	0.63
(million cu. ft.)		7.46 (3-31)	24.62	4.41	1.69
Precipitation, P (inches)		5.46	8.16	2.52	0.78
(million cu. ft.)		19.14	28.61	8.85	2.72
Evaporation, E (inches)		2.02	2.49	0.80	0
(million cu. ft.)		7.07 (3-31)	8.72	2.80	0
(P-E)		12.07	19.89	6.05	2.72
Q/(P-E)		0.62	1.24(1)	0.73	0.62
Slough 11					
Flow, Q (cfs)	3.17	2.82	2.75	2.44	1.45
(million cu. ft.)	8.21	7.58	7.35	6.32	3.75
Precipitation, P (inches)	1.49	4.72	6.78	2.15	0.65
(million cu. ft.)	3.93	18.55	26.60	8.44	2.56
Evaporation, E (inches)	5.66	2.21	2.49	0.80	0
(million cu. ft.)	22.14	8.68	9.76	3.13	0
(P-E) (million cu. ft.)	-18.21	9.87	16.84	5.31	2.56
Q/(P-E)	-0.17	0.77	0.44	1.19	1.47

(1) Slough 8A likely overtopped in late August.

Table 5.9

1984 MONTHLY WATER BALANCE
SLOUGH 9, TRIBUTARY 9B

	July	August	September	October
Slough 9 Tributary (Upper Site)				
Flow, Q (cfs)	-	2.62	0.91 (1)	0.50
(million cu. ft.)	-	7.02	2.54	1.34
Precipitation, P (inches)	-	7.44	2.11	0.87
(million cu. ft.)	-	12.62	3.58	1.48
Evaporation, E (inches)	-	2.49	0.80	
(million cu. ft.)	-	4.21	1.35	0
P-E, Precipitation-Evaporation	-	8.41	2.19	1.48
Q/(P-E)	-	0.83	1.16 (1)	0.91
Slough 9 Tributary (Lower Site)				
Flow, Q (cfs)	1.21	4.97	0.30	0.07
(million cu. ft.)	3.23	13.31	0.78	0.19
Precipitation, P (inches)	5.25	7.44	2.11	0.87
(million cu. ft.)	17.81	25.24	7.16	2.95
Evaporation, E (inches)	2.21	2.49	0.80	0
(million cu. ft.)	7.50	8.43	2.71	0
(P-E), Precipitation-Evaporation	10.31	16.81	4.45	2.95
Q/(P-E)	0.31	0.79	0.18	0.06

(1) Affected by runoff from storm in late August.

TABLE 5.10
ESTIMATED DAILY RUNOFF, SLOUGH 8A
HIGH RAINFALL PATTERN(1)

Date	Daily Precipitation(2) (inches)	Measured Flow(3) (cfs)	Estimated Groundwater Flow(4) (cfs)	Estimated Surface Runoff (cfs)	Estimated With-Project Groundwater Flow(5) (cfs)	Estimated With-Project Slough Flow (cfs)
1		5.9	5.1	0.8	1.6	2.4
2		5.6	4.7	0.9	1.6	2.5
3	0.4	5.2	4.3	0.9	1.6	2.5
4		4.8	4.2	0.6	1.6	2.2
5	.51	4.8	4.5	0.3	1.6	1.9
6		4.4	4.4	0	1.6	1.6
7		4.1	4.1	0	1.6	1.6
8	.55	3.8	3.8	0	1.6	1.6
9		4.4	4.4	0	1.6	1.6
10		4.1	4.1	0	1.6	1.6
11		3.6	3.6	0	1.6	1.6
12		3.2	3.2	0	1.6	1.6
13		2.6	2.6	0	1.6	1.6
14		2.4	2.4	0	1.6	1.6
15		2.2	2.2	0	1.6	1.6
16		2.0	2.0	0	1.6	1.6
17	0.7	1.7	1.7	0	1.6	1.6
18	1.35	2.6	2.6	0	1.6	1.6
19	.58	4.1	3.6	0.5	1.6	2.1
20	.31	4.8	3.8	1.0	1.6	2.6
21	.06	5.2	4.2	1.0	1.6	2.6
22	.64	5.9	4.0	1.9	1.6	3.5
23	.37	8.0	3.8	4.2	1.6	5.8
24	2.19	34	5.0	29	1.6	3.1
25	1.33	65	6.9	58	1.6	6.0
26		44	7.3	37	1.6	34
27		17	6.3	11	1.6	13
28		11	4.7	6.3	1.6	7.9
29		8.0	3.7	4.3	1.6	5.9
30		5.9	3.3	2.6	1.6	4.2
31		4.8	2.7	2.1	1.6	3.7

(1) 20% exceedance probability
(2) August 1984 precipitation. Data are from Talkeetna through day 21, from Sherman after day 21. All data are adjusted to Slough 8A.
(3) August 1984
(4) Q8 = -0.67 + 0.00025 QGC
(5) Assumes flow at Gold Creek is 9,000 cfs

TABLE 5.11
ESTIMATED DAILY RUNOFF, SLOUGH 8A
MODERATE RAINFALL PATTERN(1)

Date	Daily Precipitation(2) (inches)	Measured Flow(3) (cfs)	Estimated Groundwater Flow(4) (cfs)	Estimated Surface Runoff (cfs)	Estimated With-Project Groundwater Flow(5) (cfs)	Estimated With-Project Slough Flow (cfs)
1	.08	7.7	5.7	2.0	1.6	3.6
2		20.8	5.7	15.1	1.6	16.7
3		17.0	5.2	11.8	1.6	13.4
4		15.3	4.6	10.7	1.6	12.3
5		11.6	3.9	7.7	1.6	9.3
6		9.3	3.3	6.0	1.6	9.6
7		7.7	3.0	4.7	1.6	6.3
8	0.7	6.4	2.8	3.6	1.6	5.2
9	.39	6.0	2.6	3.4	1.6	5.0
10	.07	5.3	2.5	2.8	1.6	4.4
11		4.6	2.4	2.2	1.6	3.8
12		4.0	2.2	1.8	1.6	3.4
13		3.3	2.1	1.2	1.6	2.8
14	.39	3.3	2.0	1.3	1.6	2.9
15	.74	3.0	2.0	1.0	1.6	2.6
16		2.8	2.0	0.8	1.6	2.4
17		2.4	1.8	0.6	1.6	2.2
18		2.2	1.7	0.5	1.6	2.1
19		2.1	1.6	0.5	1.6	2.1
20		2.2	1.7	0.5	1.6	2.1
21	.04	2.8	2.0	0.8	1.6	2.4
22	.30	3.8	2.7	1.1	1.6	2.7
23	.13	3.5	3.5	0	1.6	1.6
24		2.1	2.1	0	1.6	1.6
25		1.6	1.6	0	1.6	1.6
26		1.5	1.5	0	1.6	1.6
27		3.8	1.7	2.1	1.6	3.7
28	.21	19.8	1.6	18.2	1.6	19.8
29	1.46	25.3	1.7	23.6	1.6	25.2
30	.42	19.8	2.2	17.6	1.6	19.2

(1) 61% exceedance probability.
(2) September 1983 Talkeetna precipitation adjusted to Slough 8A.
(3) September 1983
(4) Q8 = -0.67 + 0.00025 QGC
(5) Assumes flow at Gold Creek is 9,000 cfs.

TABLE 5.12
ESTIMATED DAILY RUNOFF, SLOUGH 8A
LOW RAINFALL PATTERN(1)

Date	Daily Precipitation(2) (inches)	Measured Flow(3) (cfs)	Estimated Groundwater Flow(4) (cfs)	Estimated Surface Runoff (cfs)	Estimated With-Project Groundwater Flow(5) (cfs)	Estimated With-Project Slough Flow (cfs)
1		4.1	2.5	1.6	1.6	3.2
2		3.2	2.3	0.9	1.6	2.5
3		2.6	2.1	0.5	1.6	2.1
5		2.0	1.9	0.1	1.6	1.7
6		1.7	1.7	0	1.6	1.6
7	.11	1.5	1.5	0	1.6	1.6
8		1.4	1.4	0	1.6	1.6
9		1.2	1.2	0	1.6	1.6
10		1.2	1.2	0	1.6	1.6
11		1.0	1.0	0	1.6	1.6
12	.24	1.0	1.0	0	1.6	1.6
13	.18	1.0	1.0	0	1.6	1.6
14		0.9	0.9	0	1.6	1.6
15	.02	0.8	0.8	0	1.6	1.6
16	.12	0.9	0.9	0	1.6	1.6
17	.04	0.9	0.9	0	1.6	1.6
18	.61	1.2	1.2	0	1.6	1.6
19	.65	1.7	1.7	0	1.6	1.6
20	.05	2.2	1.9	0.3	1.6	1.9
21		2.2	2.2	0	1.6	1.6
22		2.2	1.9	0.3	1.6	1.9
23		2.2	1.6	0.6	1.6	2.1
24		2.0	1.4	0.6	1.6	2.2
25	.13	2.0	1.3	0.7	1.6	2.3
26		1.7	1.2	0.5	1.6	2.1
27		1.5	1.2	0.3	1.6	1.9
28		1.5	1.1	0.4	1.6	2.0
29	.02	1.4	1.1	0.3	1.6	1.9
30	.05	1.4	1.2	0.2	1.6	1.8

(1) 93% exceedance probability
(2) September 1984 Sherman precipitation, adjusted to Slough 8A
(3) September 1984
(4) Q8 = -0.67 + 0.00025 QGC
(5) Assumes flow at Gold Creek is 9,000 cfs

TABLE 5.13
ESTIMATED DAILY RUNOFF, SLOUGH 9
MODERATE RAINFALL PATTERN(1)

Date	Daily Precipitation(2) (inches)	Measured Flow(3) (cfs)	Estimated Groundwater Flow(4) (cfs)	Estimated Surface Runoff (cfs)	Estimated With-Project Groundwater Flow(5) (cfs)	Estimated With-Project Slough Flow (cfs)
1	.07					
2						
3						
4						
5						
6		8.3	5.6	2.7	2.9	5.6
7		7.8	5.2	2.6	2.9	5.5
8		7.1	4.7	2.4	3.9	5.3
9	.65	6.8	4.5	2.3	2.9	5.2
10	.36	6.4	4.3	2.1	2.9	5.0
11	.06	6.1	4.1	2.0	2.9	4.9
12		5.7	3.9	1.8	2.9	4.7
13		5.5	3.7	1.8	2.9	4.7
14	.36	5.3	3.6	1.7	2.9	4.6
15	.68	5.5	3.5	2.0	2.9	4.9
16		5.3	3.5	1.8	2.9	4.7
17		5.3	3.3	2.0	2.9	4.9
18		5.1	3.0	1.9	2.9	4.8
19		5.1	2.9	2.2	2.9	5.1
20		5.5	3.0	2.5	2.9	5.4
21	.04	5.7	3.5	2.2	2.9	5.1
22	.28	6.1	4.7	1.4	2.9	4.3
23	.12	6.6	6.2	0.4	2.9	3.3
24		7.3	5.3	2.0	2.9	4.4
25		6.1	4.1	2.0	2.9	4.9
26		5.9	3.5	2.1	2.9	5.3
27		5.7	3.1	2.6	2.9	5.5
28	.19	5.7	2.9	2.8	2.9	5.7
29	1.35	8.1	3.0	5.1	2.9	8.0
30	.39	14.2	3.9	10.3	2.9	13.2

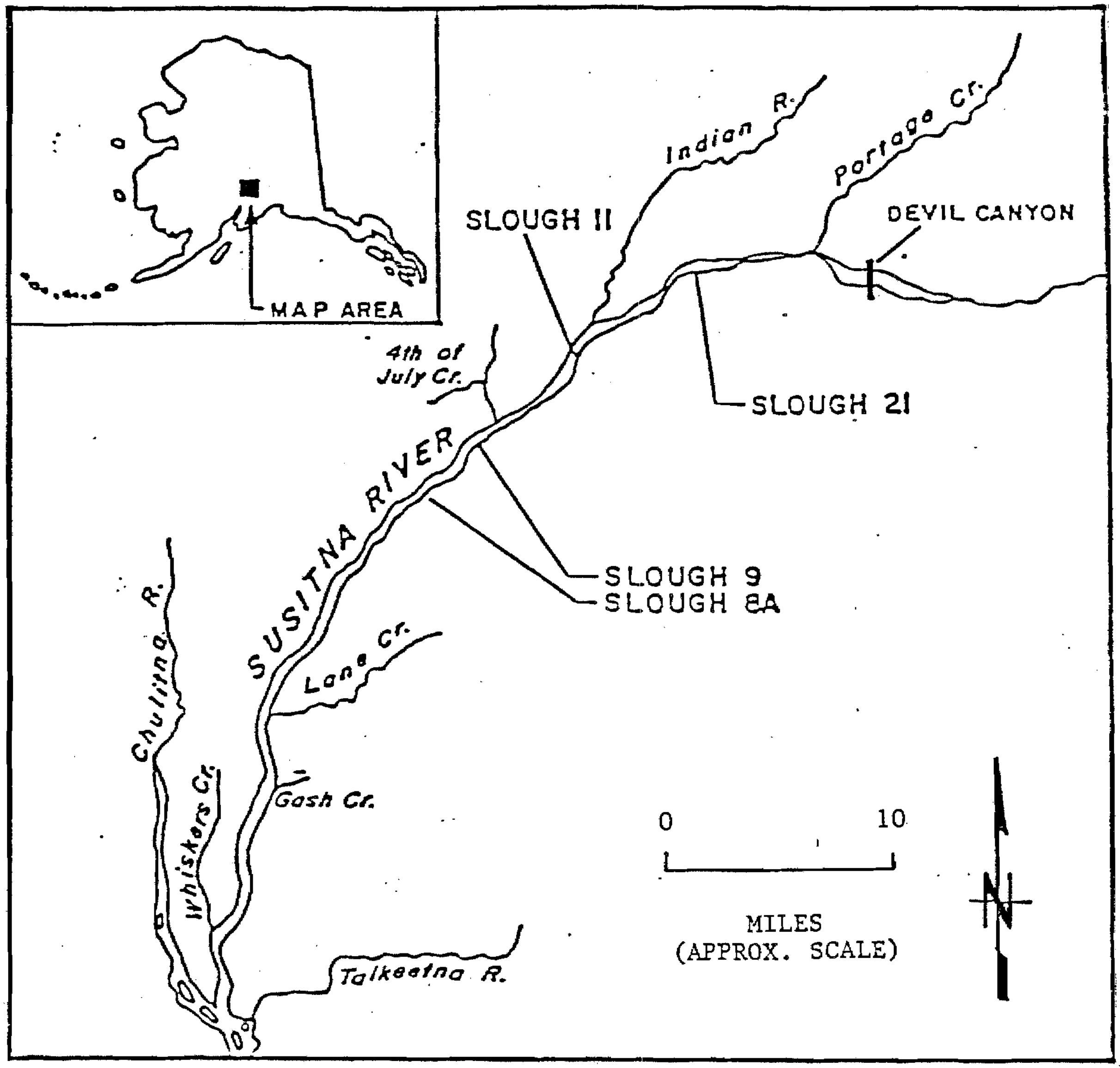
(1) 61% exceedance probability
(2) September 1983 Talkeetna precipitation, adjusted to Slough 9
(3) September 1983
(4) Q8 = -0.67 + 0.00025 QGC
(5) Assumes flow at Gold Creek is 9,000 cfs

TABLE 5.14
ESTIMATED DAILY RUNOFF, SLOUGH 9
LOW RAINFALL PATTERN(1)

Date	Daily Precipitation(2) (inches)	Measured Flow(3) (cfs)	Estimated Groundwater Flow(4) (cfs)	Estimated Surface Runoff (cfs)	Estimated With-Project Groundwater Flow(5) (cfs)	Estimated With-Project Slough Flow (cfs)
1						
2						
3		11	3.7	7.3	2.9	10.2
4		9.5	3.6	5.9	2.9	8.8
5		7.1	3.4	3.7	2.9	6.6
6		5.6	3.4	2.2	2.9	5.1
7	.10	4.8	3.5	1.3	2.9	4.2
8		4.2	3.6	0.6	2.9	3.5
9		3.6	3.5	0.1	2.9	3.0
10		3.2	3.2	0	2.9	2.9
11		3.8	3.0	0	2.9	2.9
12	.22	2.4	2.9	0	2.9	2.9
13	.17	2.4	2.9	0	2.9	2.9
14		2.1	2.8	0	2.9	2.9
15	.02	2.1	2.7	0	2.9	2.9
16	.11	2.1	2.6	0	2.9	2.9
17	.04	2.1	25	0	2.9	2.9
18	.57	2.7	2.6	0.1	2.9	3.0
19	.61	3.2	3.0	0.2	2.9	3.1
20	.05	3.6	3.4	0.2	2.9	3.1
21		4.2	3.8	0.4	2.9	3.3
22		3.6	3.4	0.2	2.9	3.1
23		3.2	2.9	0.3	2.9	3.2
24		2.8	2.6	0.2	2.9	3.1
25	.12	3.3	2.5	0.8	2.9	3.7
26		3.3	2.4	0.9	2.9	3.8
27		2.8	2.3	0.5	2.9	3.4
28		2.4	2.2	0.2	2.9	3.1
29	.02	2.4	2.2	0.2	2.9	3.1
30	0.5	2.1	2.3	0	2.9	2.9

(1) 93% exceedance probability
(2) September 1984 Sherman precipitation
(3) September 1984
(4) Q8 = -0.67 + 0.00025 QGC
(5) Assumes flow at Gold Creek is 9,000 cfs

FIGURES



SOURCE: MODIFIED FROM ADF&G 1982.

1. LOCATIONS OF PRINCIPAL SLOUGH STUDY SITES, 1982-1983.

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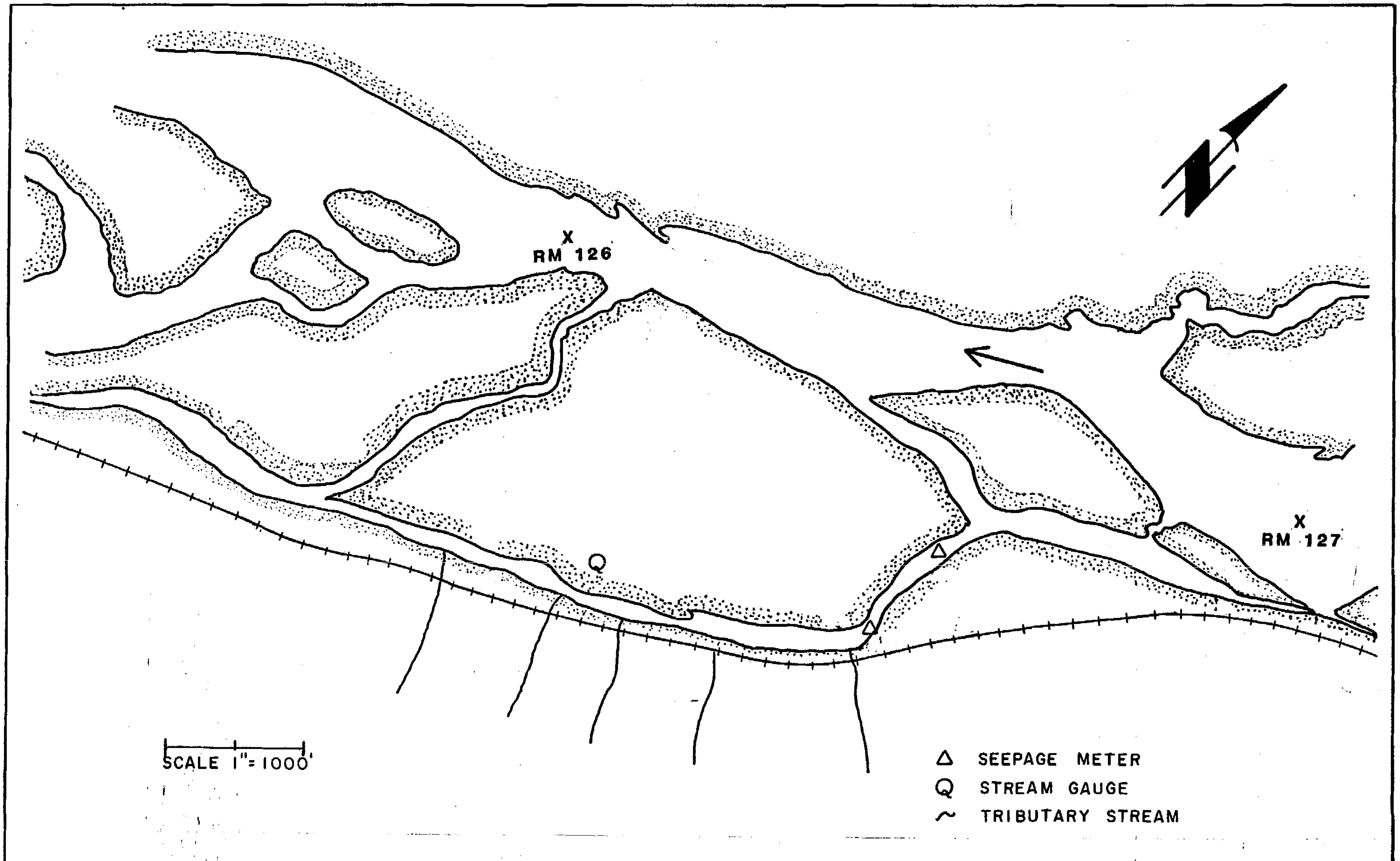

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Figure 3.2 SLOUGH 8A

PREPARED FOR:
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SUSITNA JOINT VENTURE

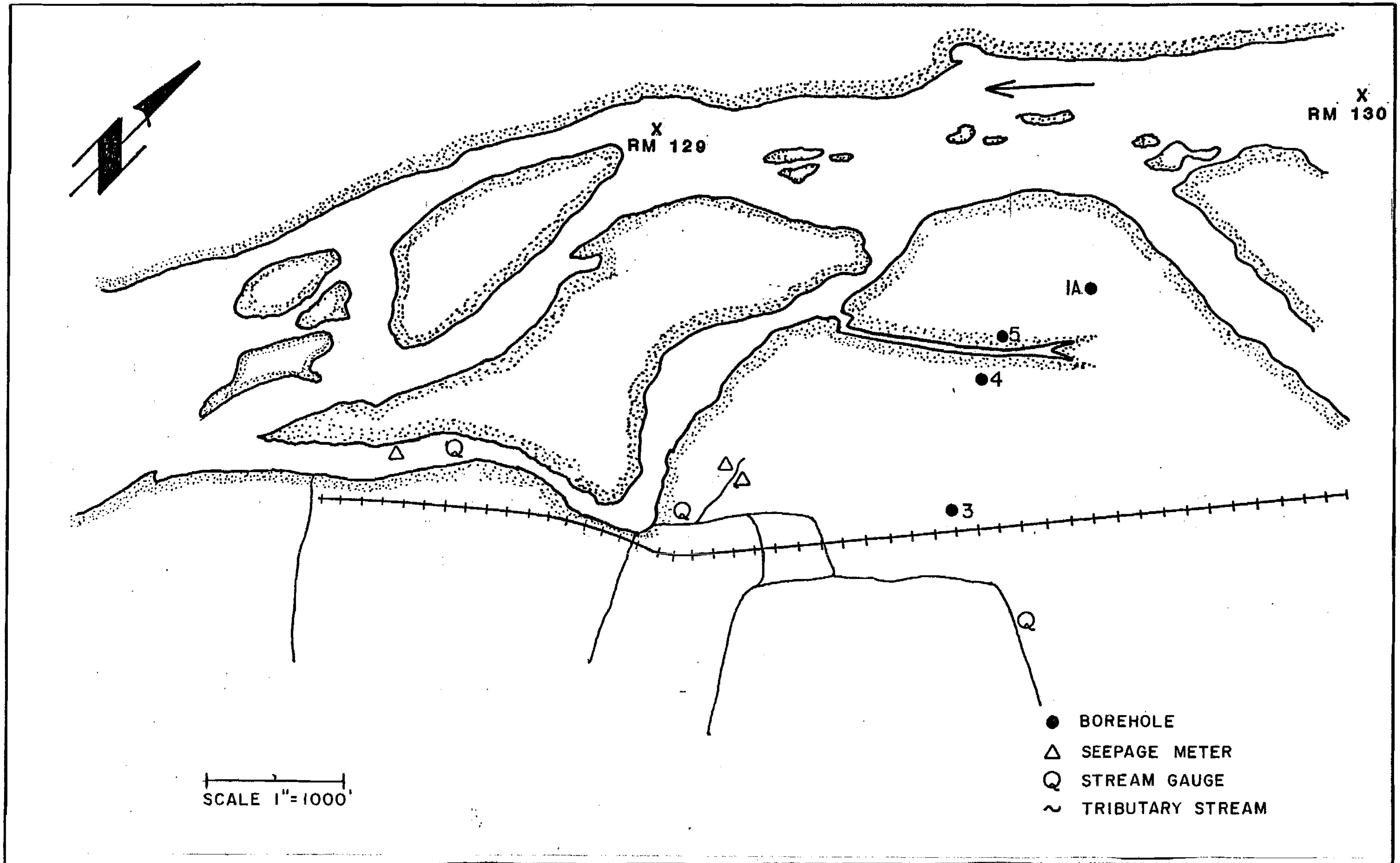

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Figure 3.3 SLOUGH 9

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SUSITNA JOINT VENTURE

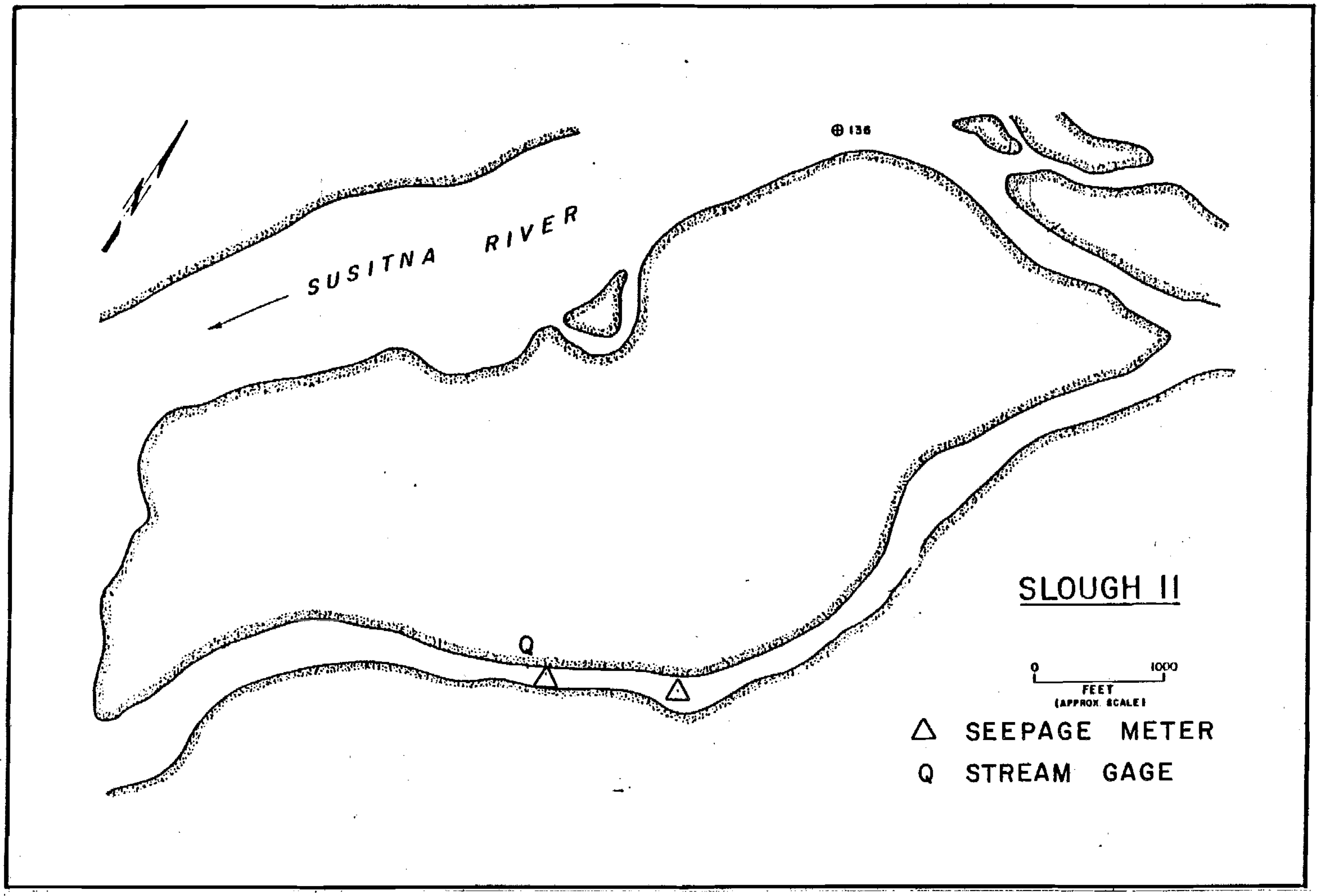

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FIGURE 3.4 SLOUGH 11

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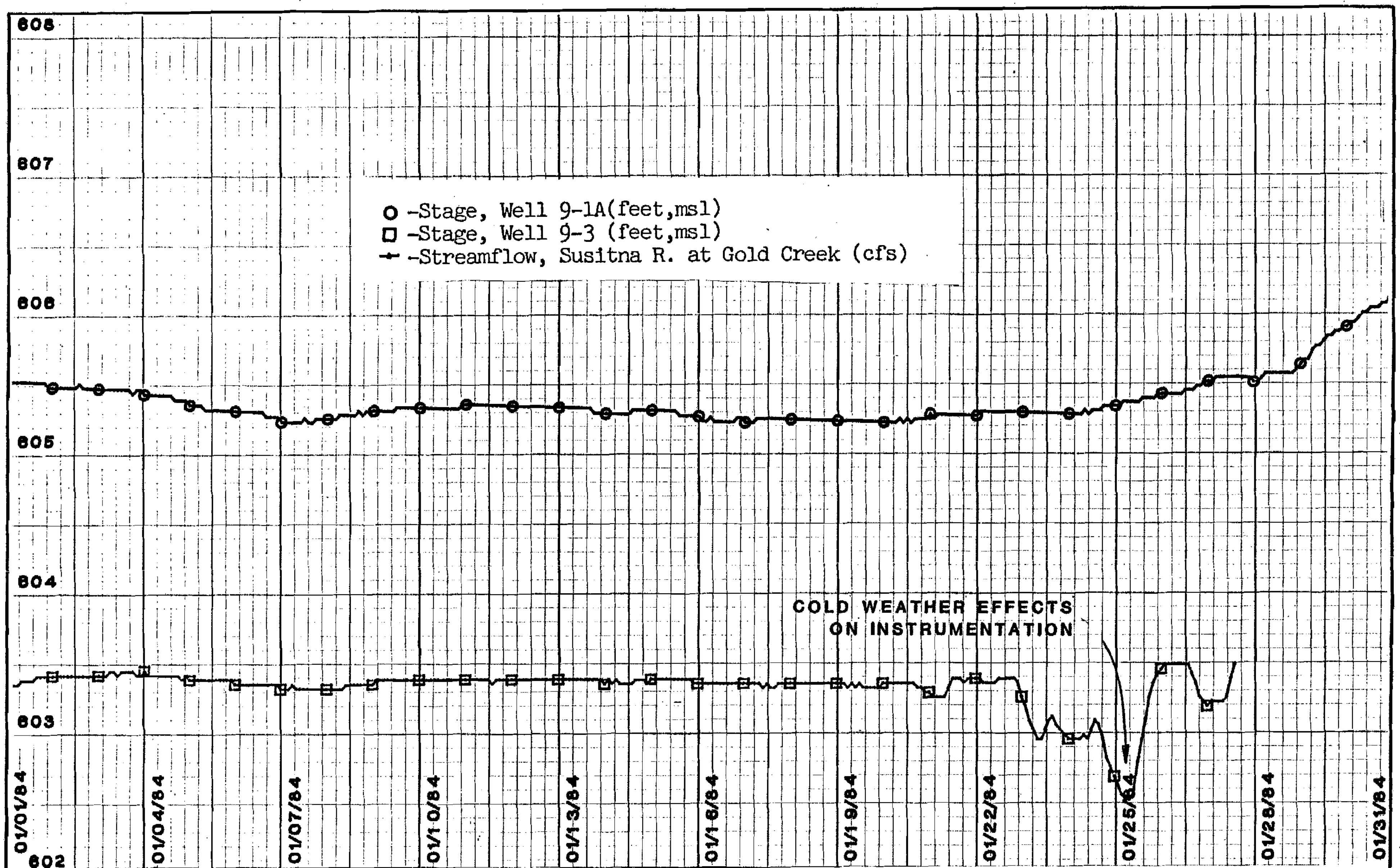
SUSITNA JOINT VENTURE



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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (a)

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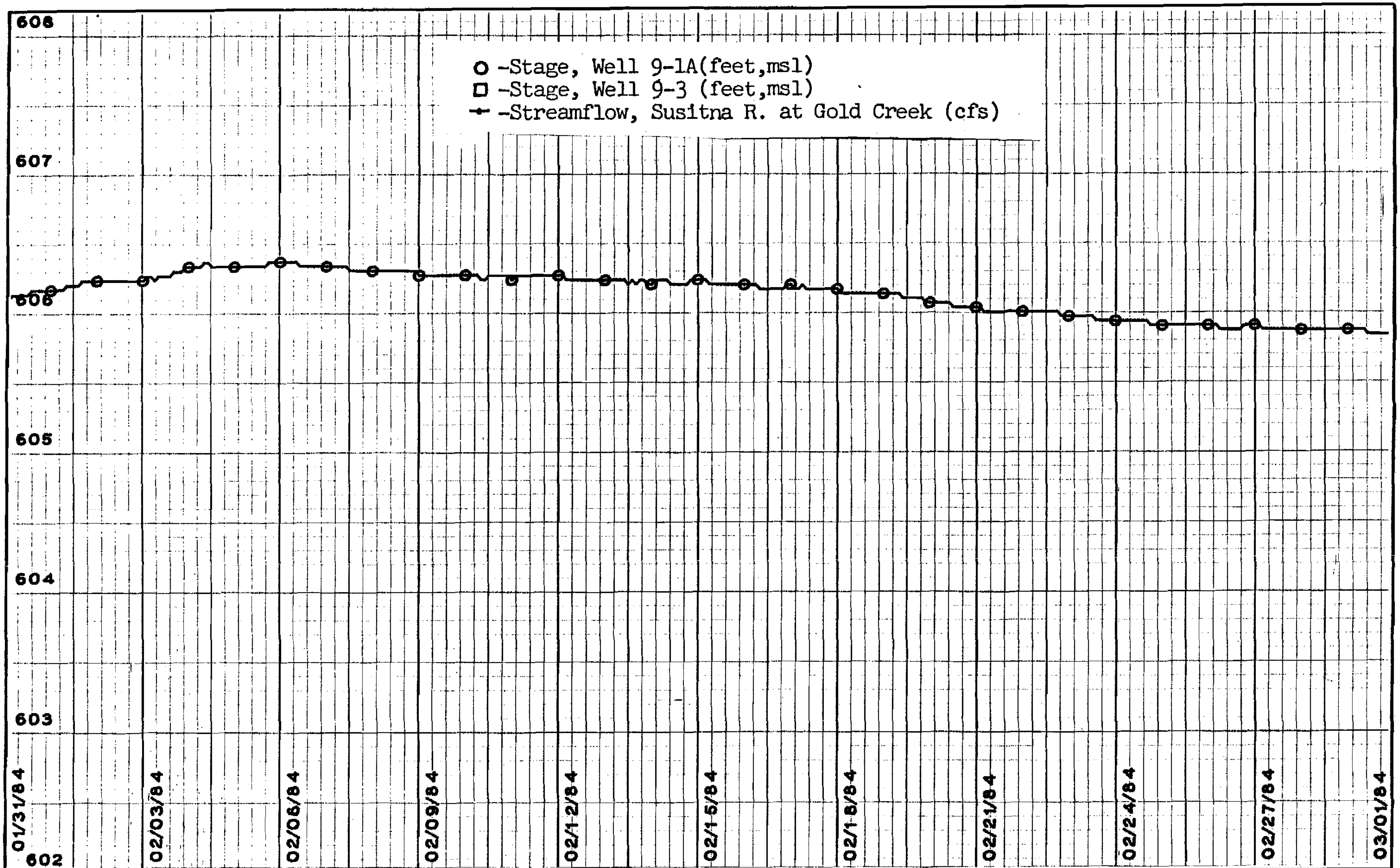
SUSITNA JOINT VENTURE



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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (b)

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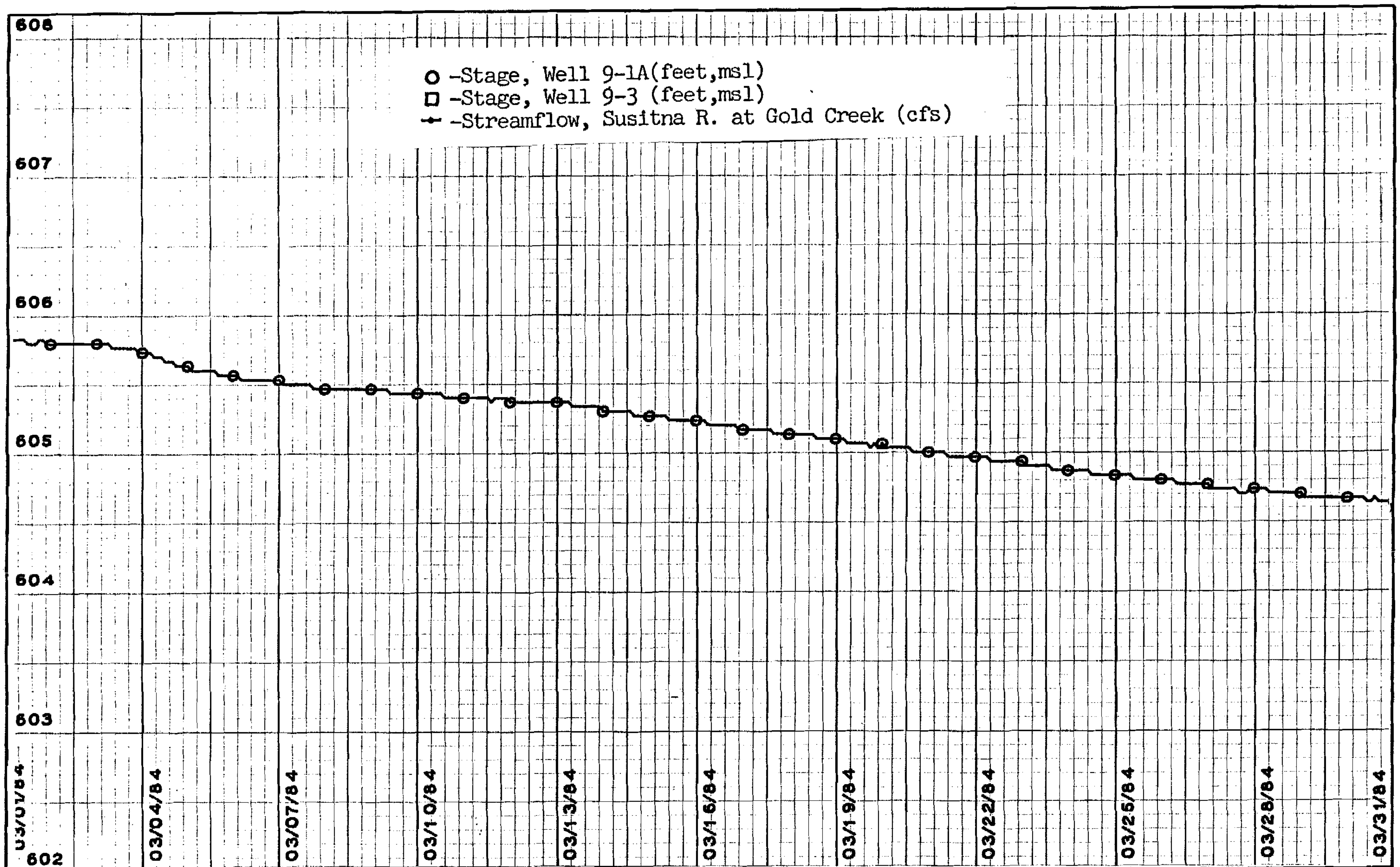

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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (c)

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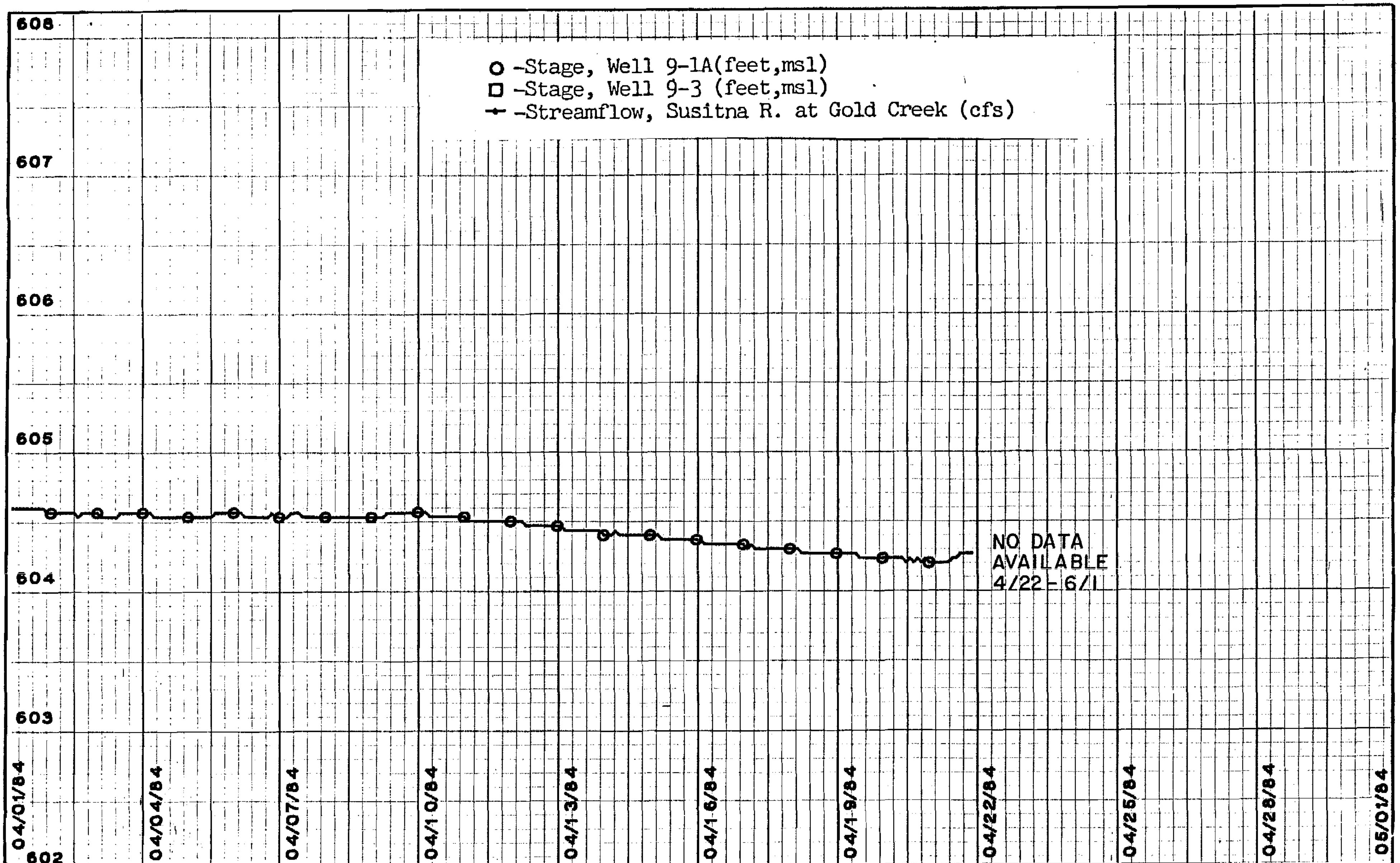
SUSITNA JOINT VENTURE



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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (d)

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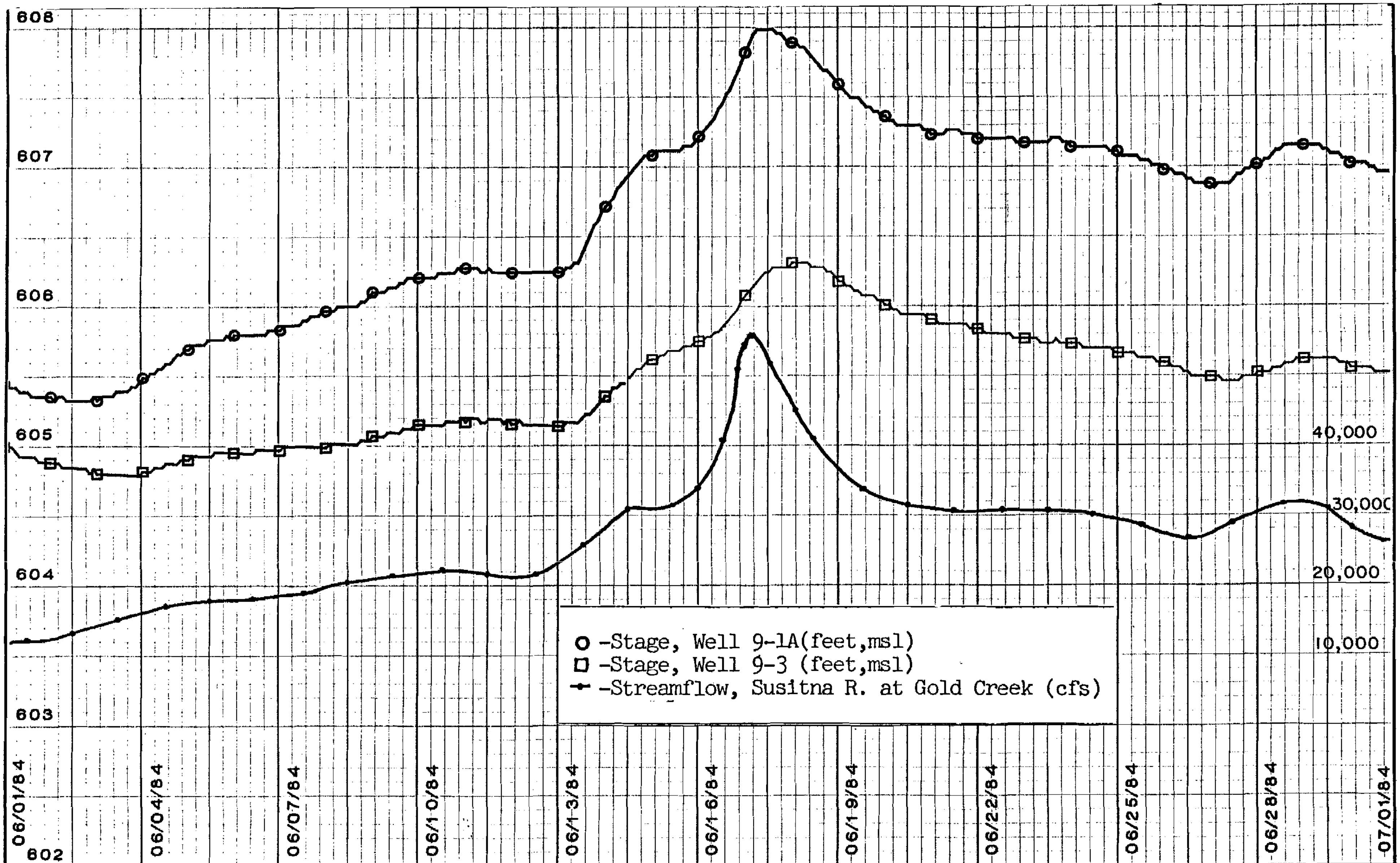

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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (e)

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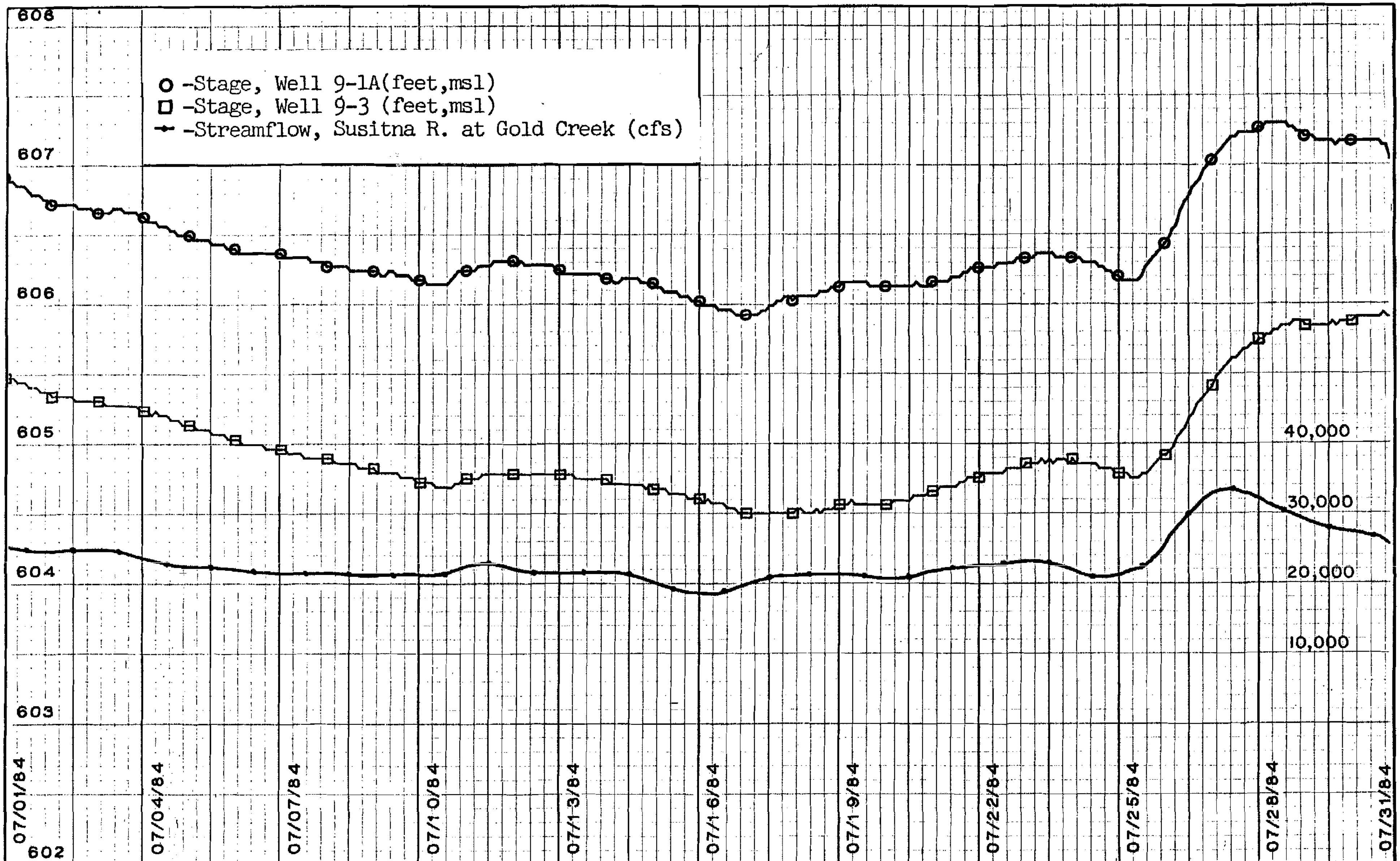

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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (f)

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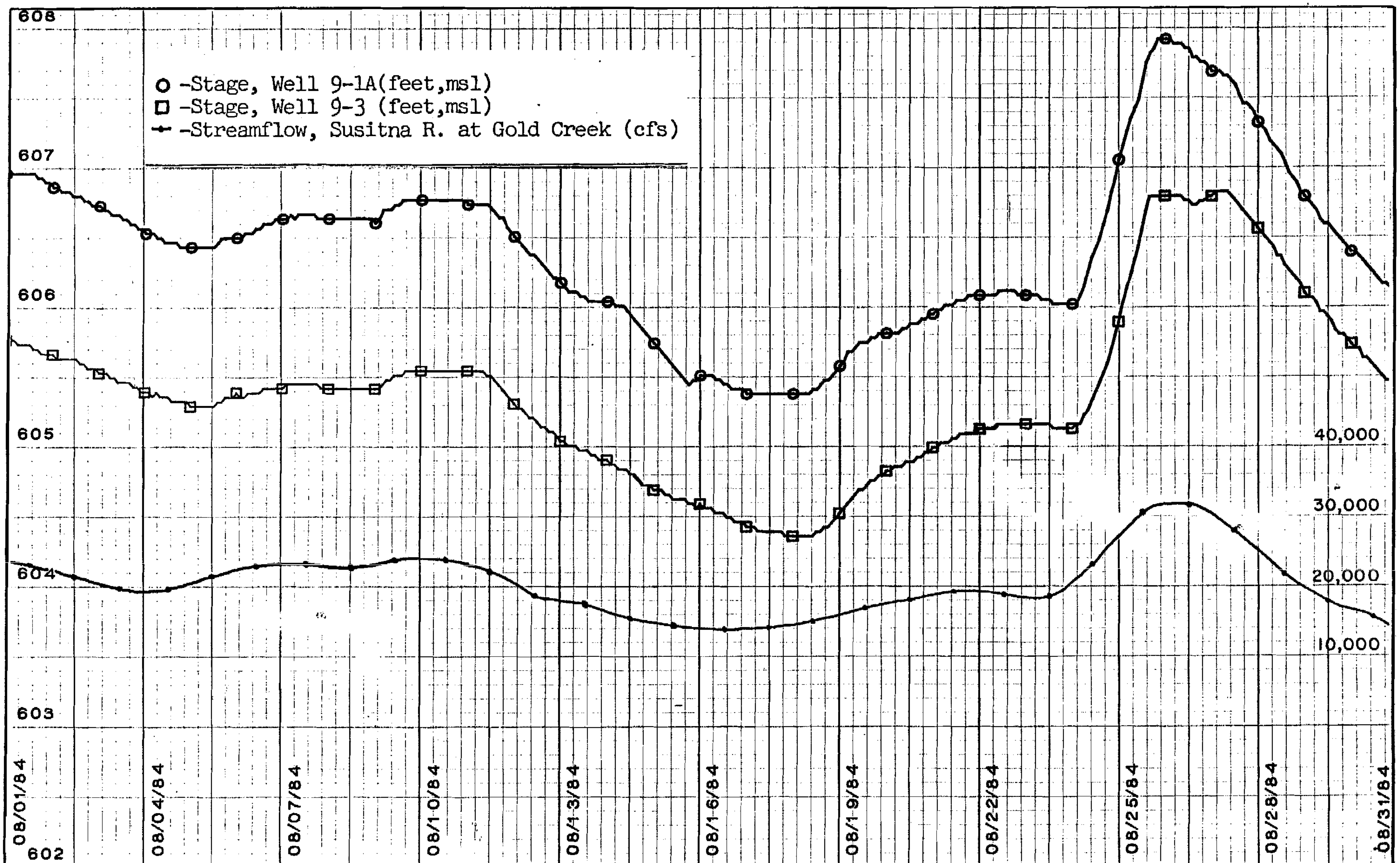
SUSITNA JOINT VENTURE



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SLOUGH 9 - Groundwater observation wells
Stage Comparison Figure 4.1 (g)

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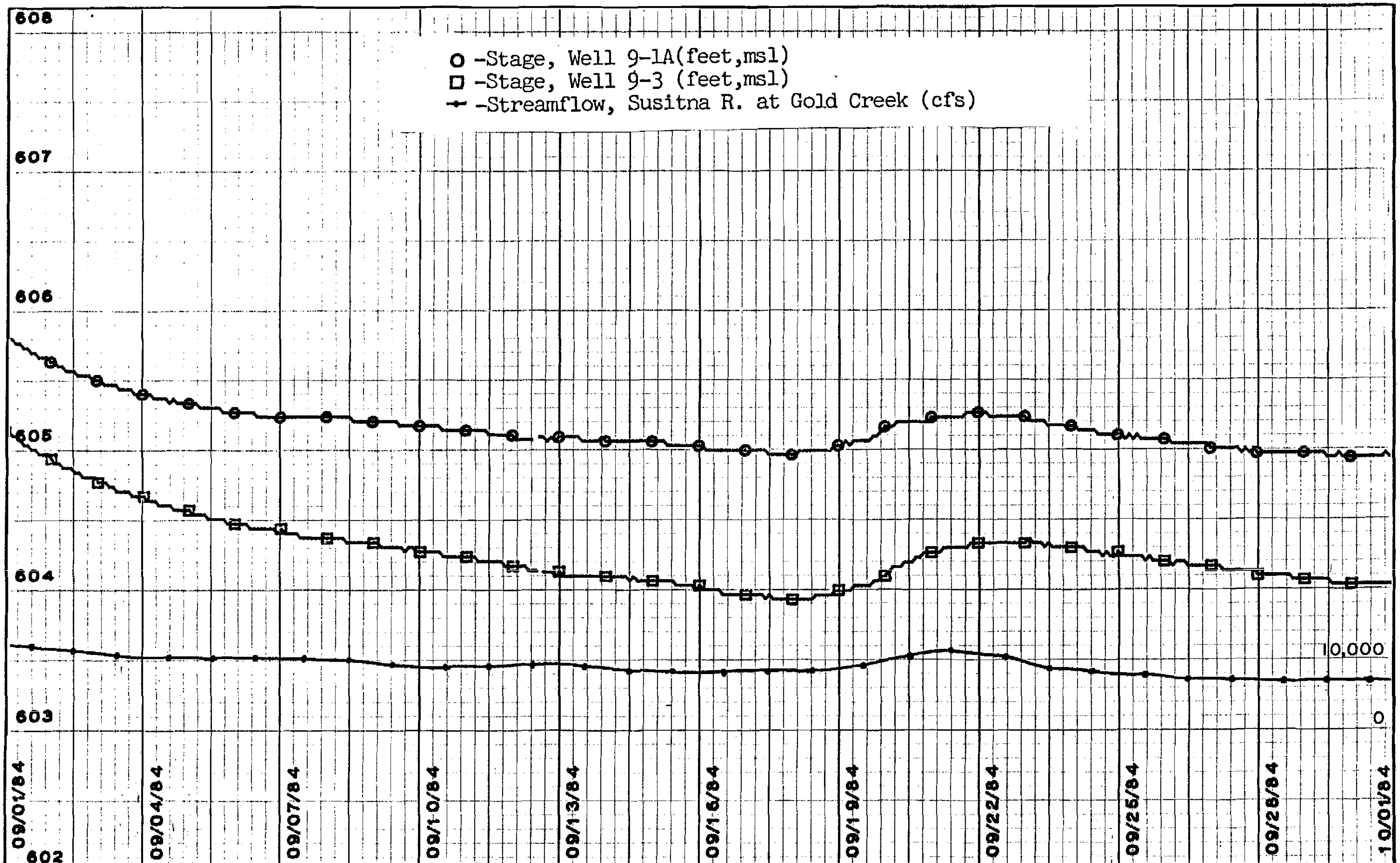
SUSITNA JOINT VENTURE



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SLOUGH 9 - Groundwater observation wells

Stage Comparison Figure 4.1 (h)

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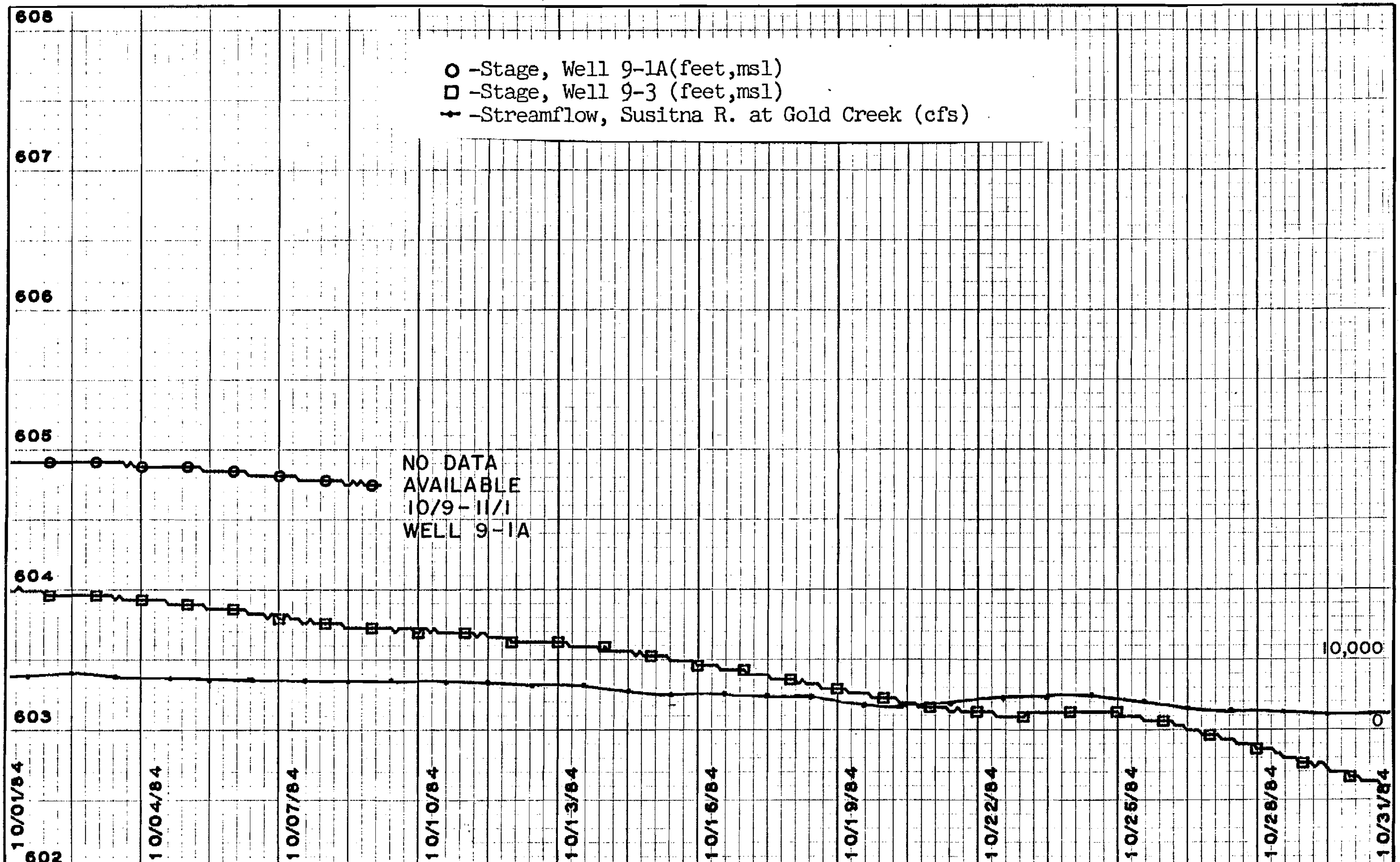

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SLOUGH 9 - Groundwater observation wells
Stage Comparison Figure 4.1 (i)

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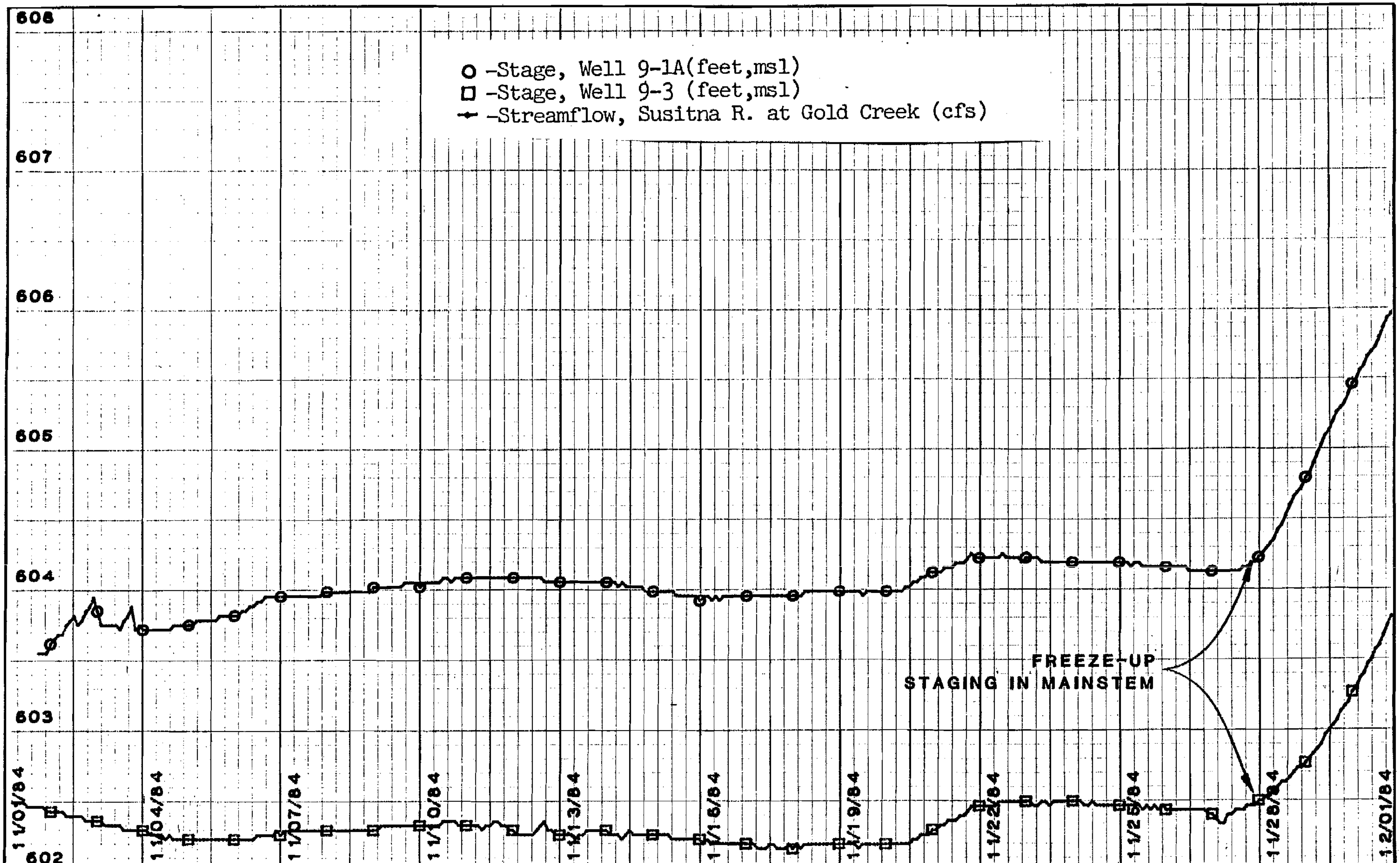

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SLOUGH 9 - Groundwater observation wells
Stage Comparison Figure 4.1 (j)

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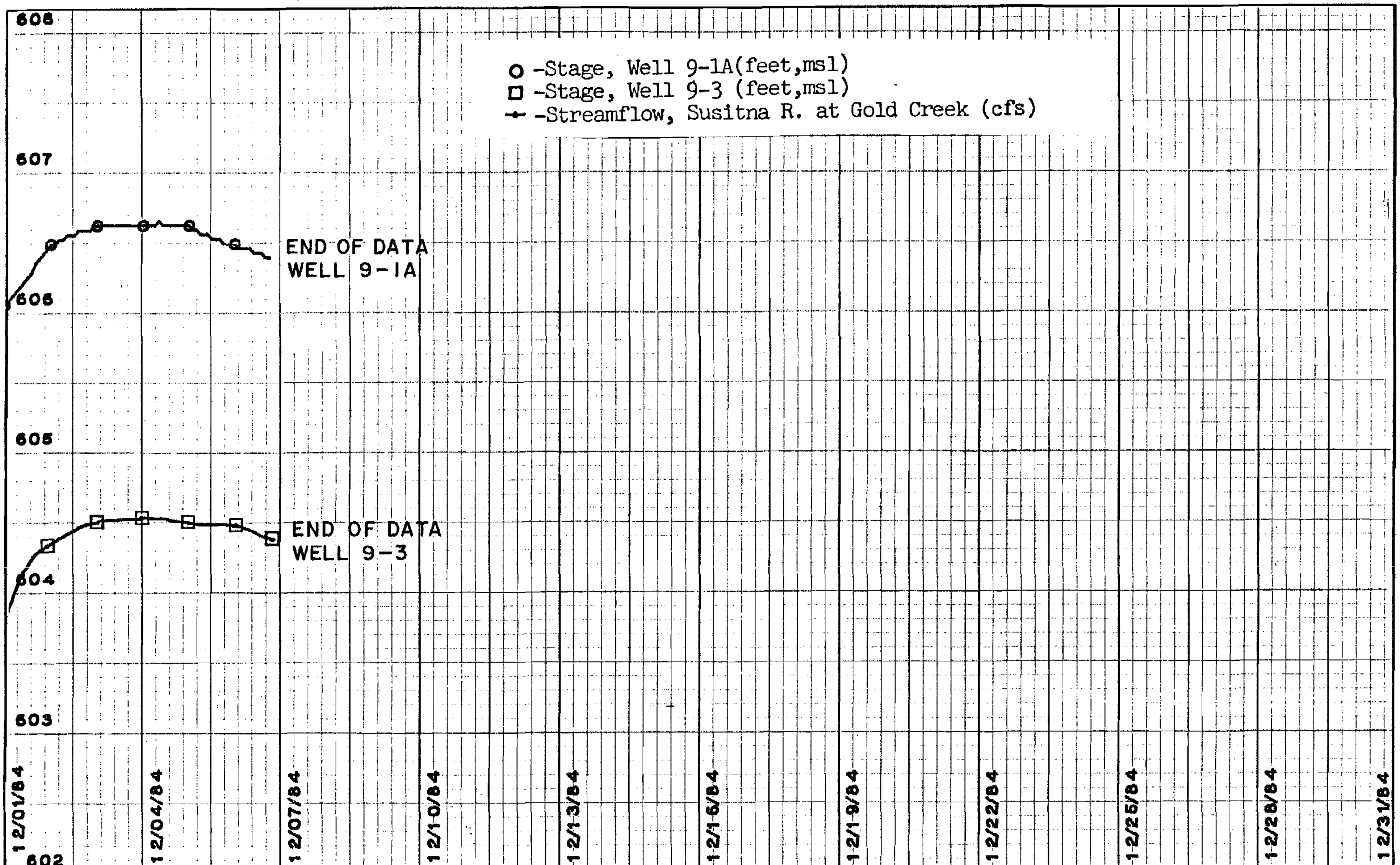

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SLOUGH 9 - Groundwater observation wells
Stage Comparison Figure 4.1 (k)

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SUSITNA JOINT VENTURE

MONTHLY RAINFALL EXCEEDANCE CURVES
TALKEETNA, ALASKA

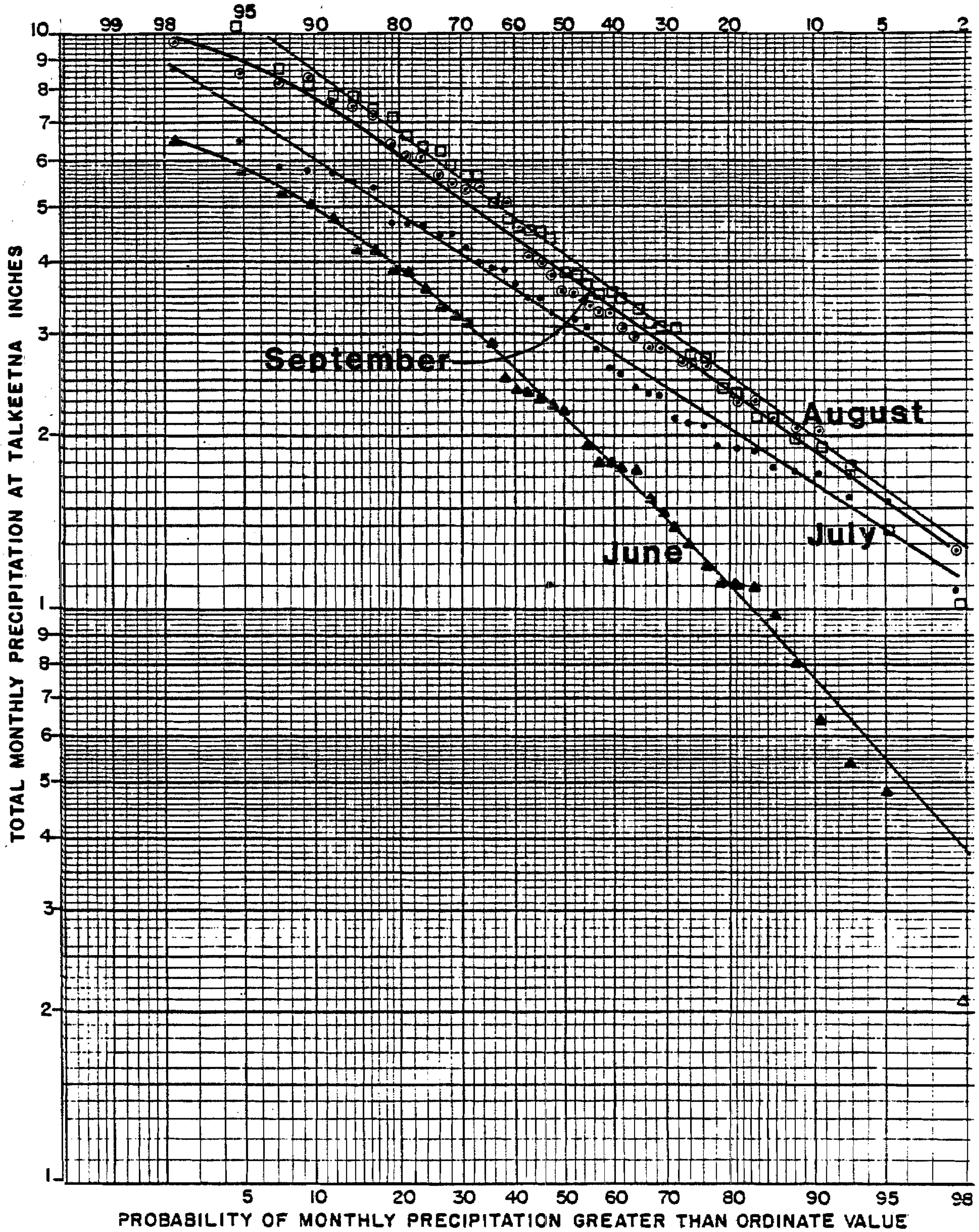

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Figure 5.1

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SUSITNA JOINT VENTURE

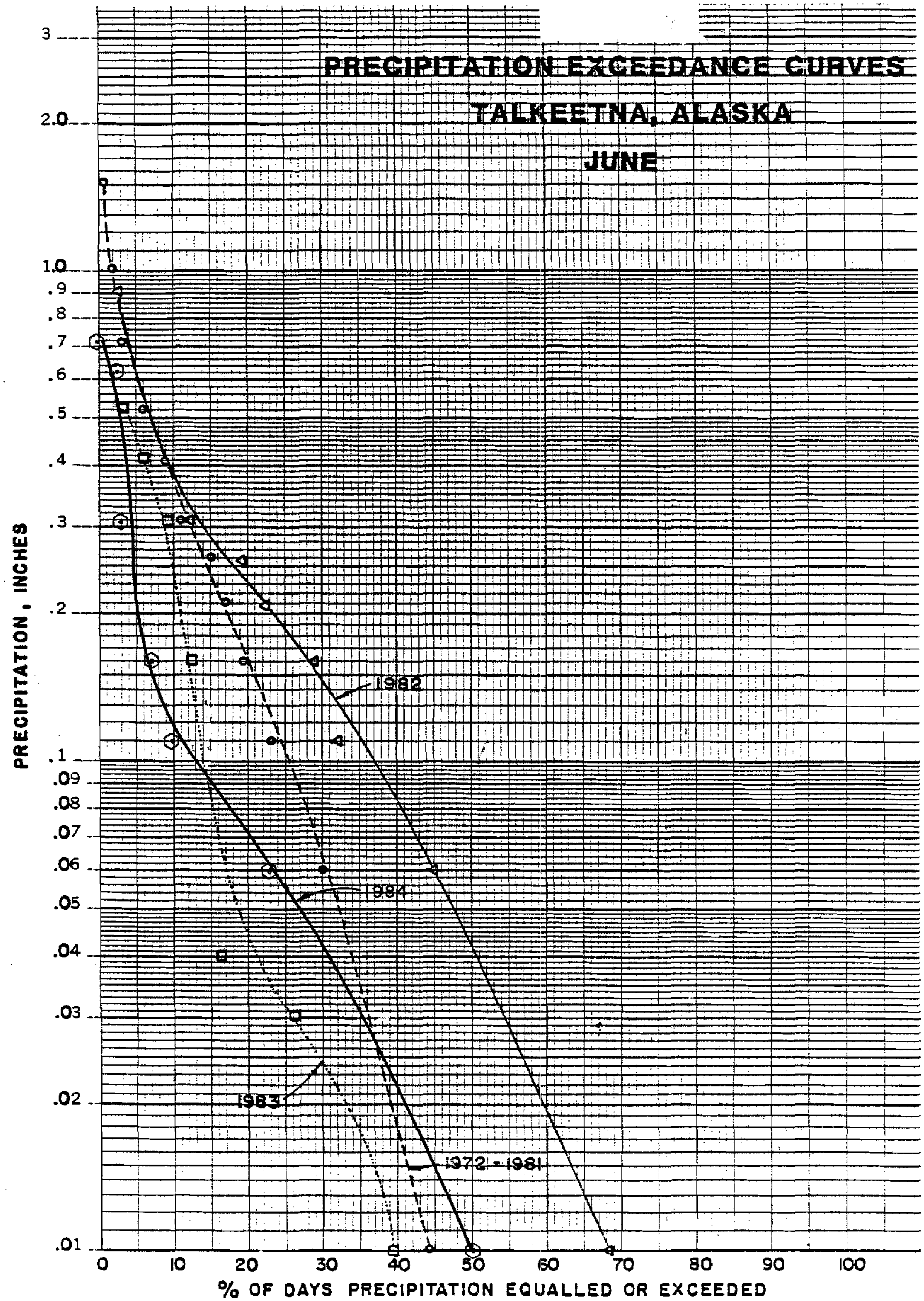

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Figure 5.2

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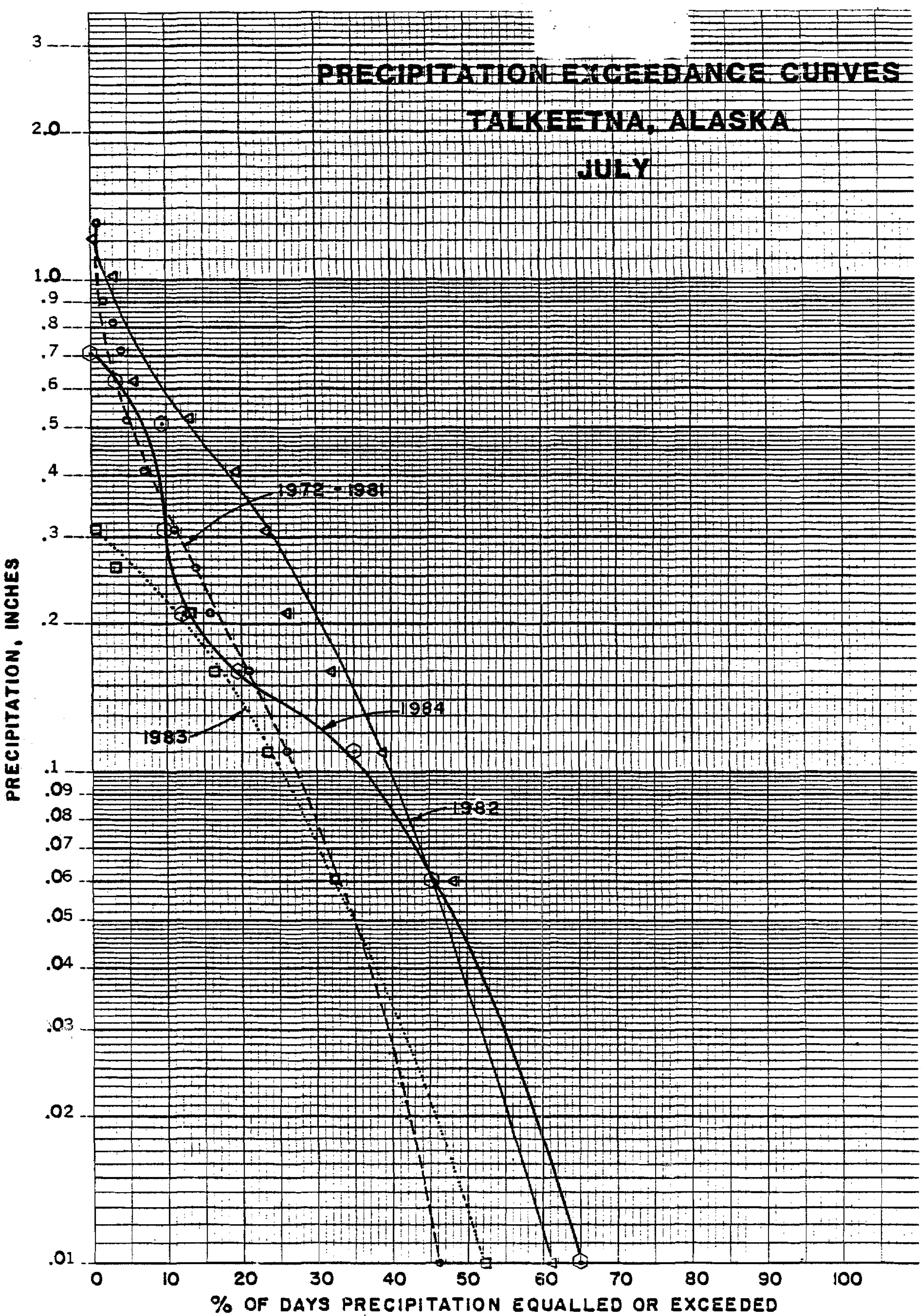

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Figure 5.3

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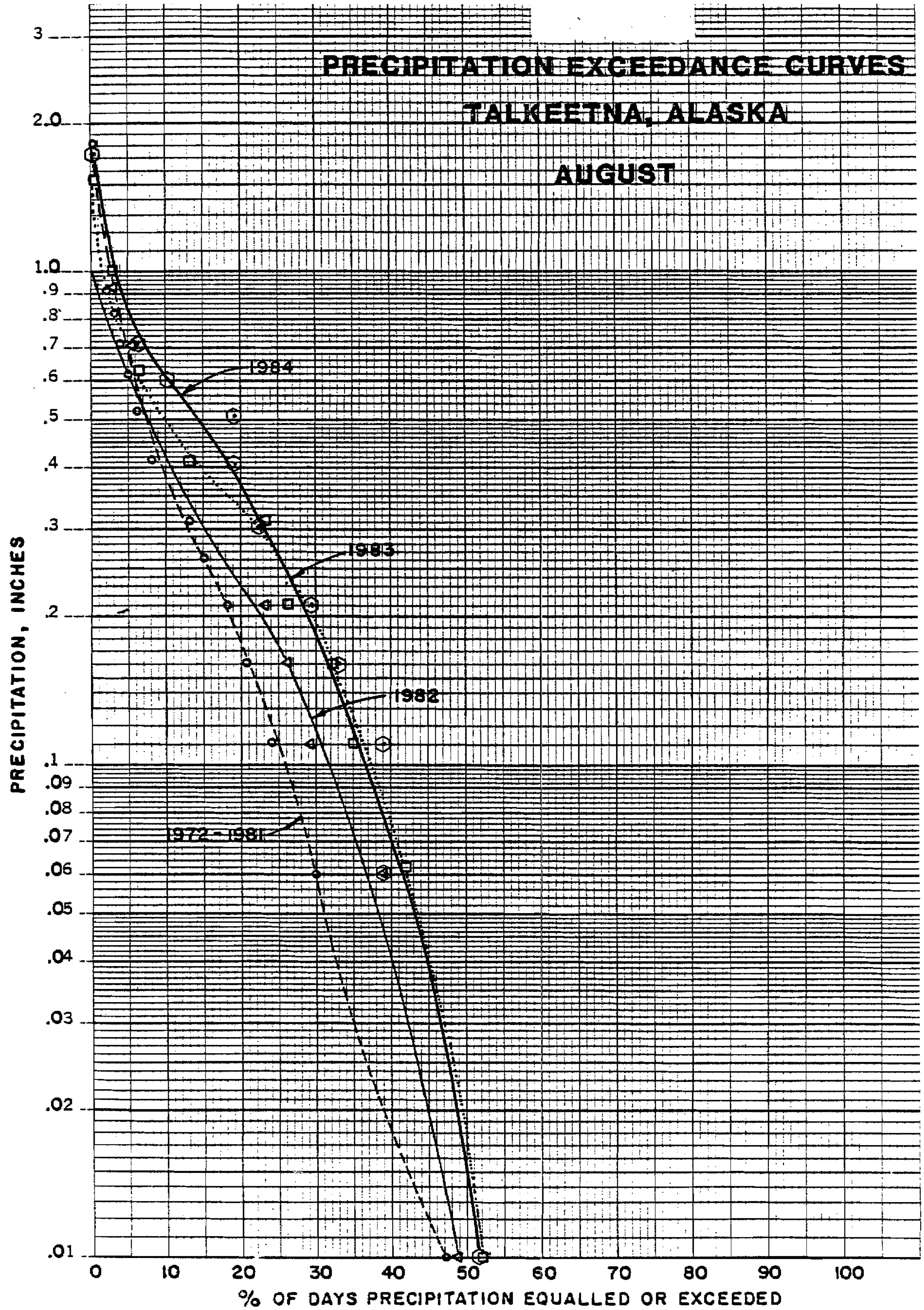

PREPARED BY: R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS	Figure 5.4	PREPARED FOR: HARZA-EBASCO SUSITNA JOINT VENTURE

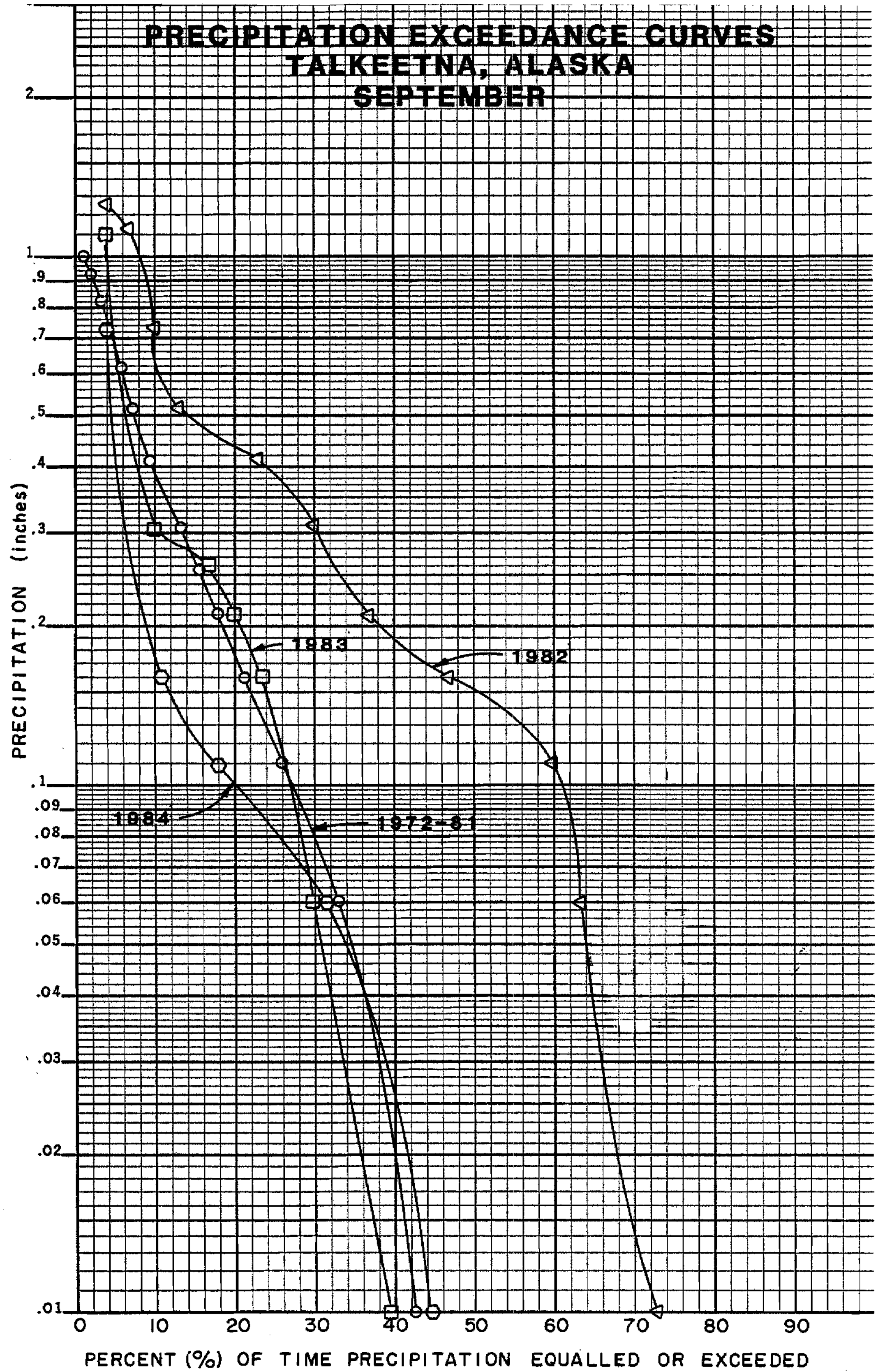

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FIGURE 5.5

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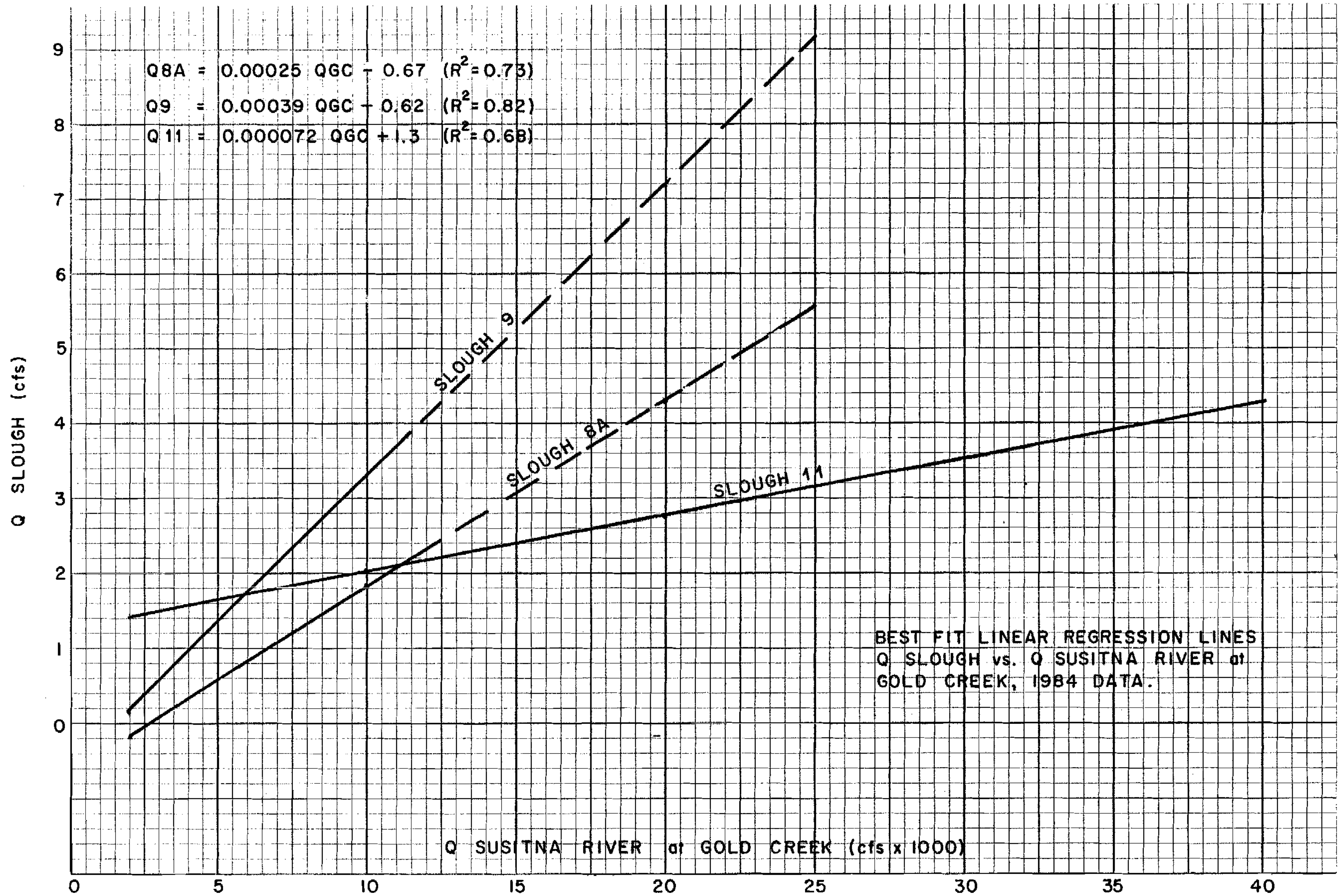

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Figure 5.6

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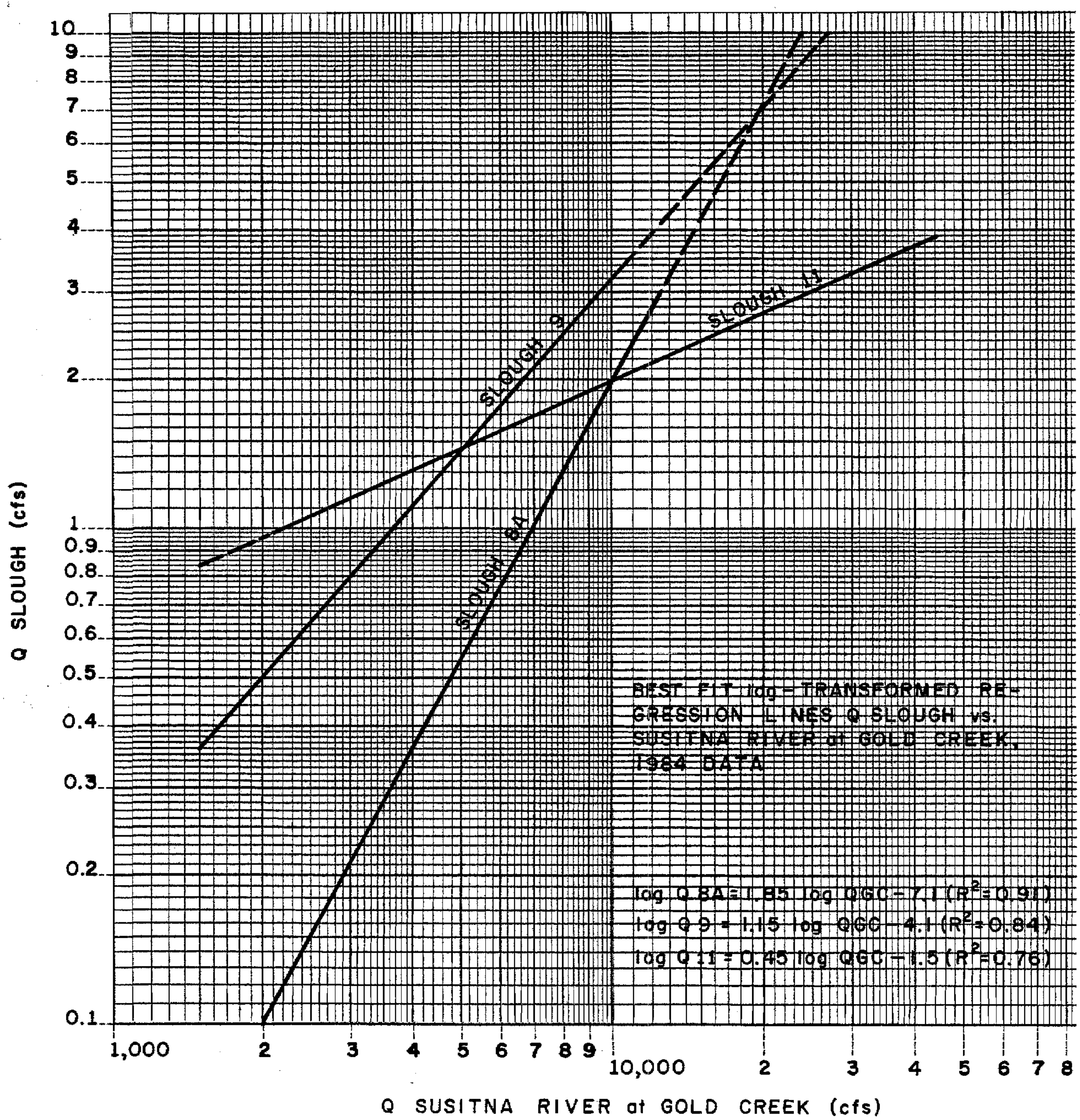

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FIGURE 5.7

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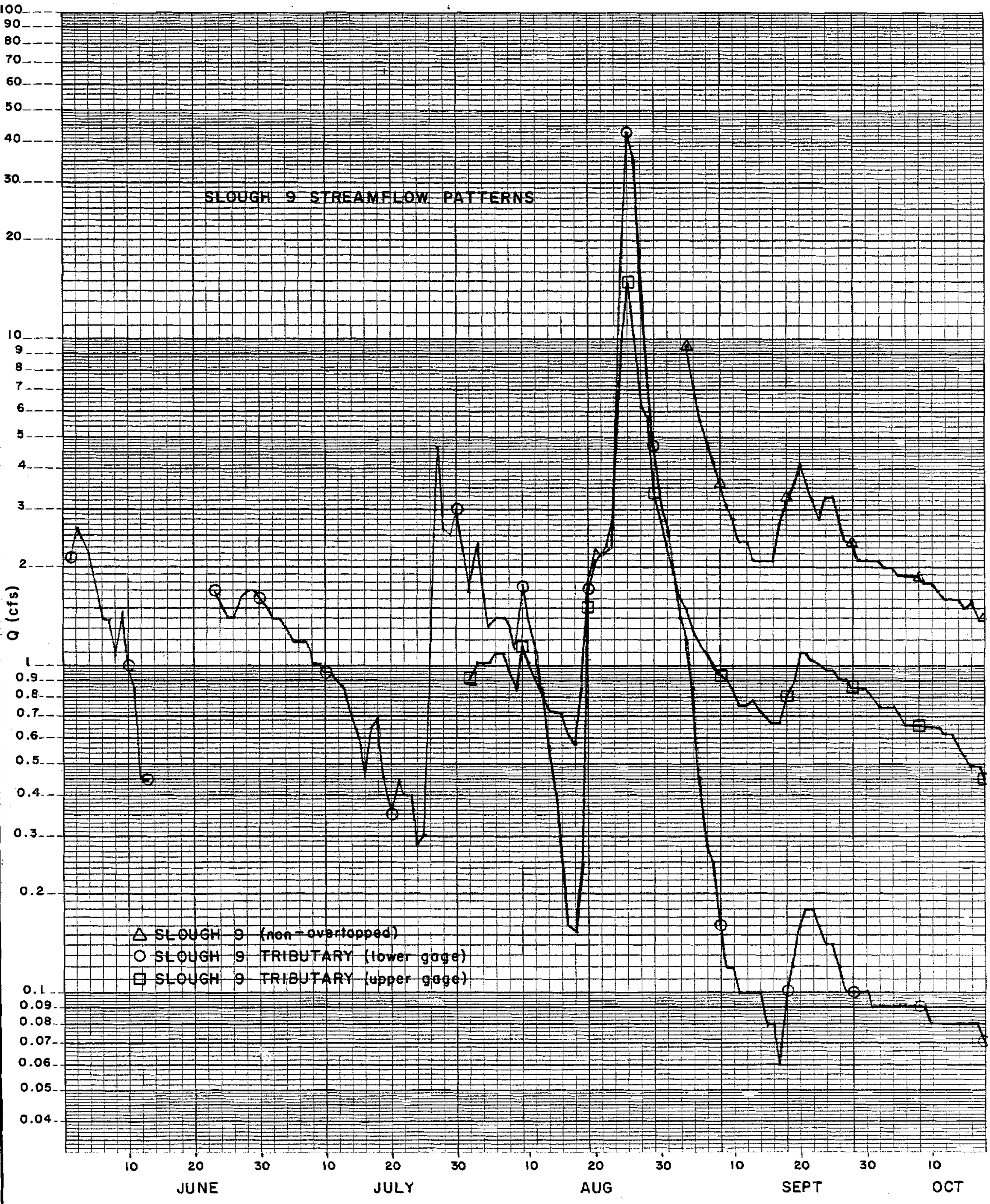

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FIGURE 5.8

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