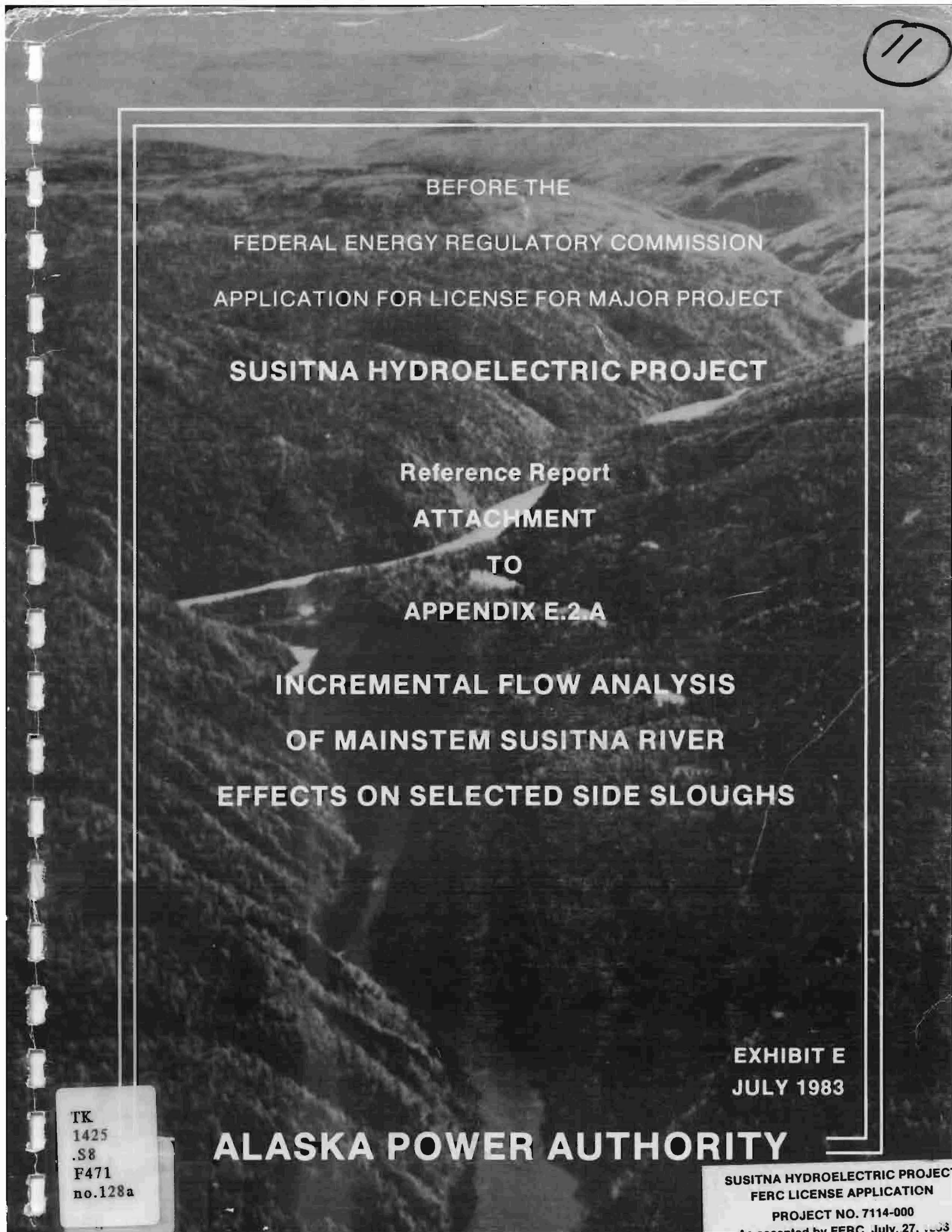

11

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

Reference Report

ATTACHMENT

TO

APPENDIX E.2.A

INCREMENTAL FLOW ANALYSIS OF MAINSTEM SUSITNA RIVER EFFECTS ON SELECTED SIDE SLOUGHS

EXHIBIT E

JULY 1983

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT
FERC LICENSE APPLICATION
PROJECT NO. 7114-000
As accepted by FERC July 27, 1983

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

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EXHIBIT E
JULY 1983

ALASKA POWER AUTHORITY

ATTACHMENT

Table of Contents

ATTACHMENT

PART 1

SLOUGH 8A PHYSICAL HABITAT VARIABLES

ATTACHMENT
PART 1
SLOUGH 8A PHYSICAL HABITAT VARIABLES

Slough Description

Slough 8A is located near Susitna River Mile 126. A vicinity map and a streambed profile are shown on Worksheets 1 and 2, respectively. Worksheet 1 shows that Slough 8A has an intermediate channel (also called Slough 8) with an intermediate berm. The lengths of Slough 8A, main channel, and intermediate channel are about 1.5 miles and 0.6 mile, respectively. A beaver dam exists downstream of the intermediate channel.

Slough Discharge

Discharges at the downstream end of Slough 8A range from 3 cfs to 43 cfs as Susitna River discharges vary from 1,000 cfs to 31,000 cfs. All Susitna River discharges referred to in this attachment are discharges at Gold Creek gage. The intermediate berm is overtopped at Susitna River discharge of about 26,000 cfs. The upstream berm is overtopped at a discharge between 30,000 and 32,000 cfs. Slough discharges are listed in Table A- 2 of Appendix E.2.A.

Worksheet 3 shows the relation between Slough 8A discharges and mainstem discharges. The slough discharges were estimated from:

- measurements by R&M at a gage on Slough 8A.
- measurements by ADF&G (1982, 1983)

These discharge data were used in combination with other analyses described below to determine Susitna River threshold discharges and corresponding slough discharges.

Aerial photographs of Slough 8A on 1 August 1980, when Susitna River discharge was 31,100 cfs, indicate that the intermediate berm was overtopped but the upstream berm was not. Therefore, Regime III flow does not occur in the range of Susitna River discharges being analyzed (1,000 cfs to 31,000 cfs).

The threshold discharge for overtopping the intermediate berm (Section H4, see Worksheet 1), was estimated from a plot of water surface elevations versus discharges of the Susitna River at the berm, as shown on Worksheet 4. The worksheet indicates that the intermediate berm with an invert elevation of 573.1 ft,msl (R&M, Dec. 1982 a) is overtopped when Susitna River discharge rises to about 26,000 cfs. This threshold discharge was confirmed by a field observation made on June 29, 1983. Worksheet 4 is based on three sets of data. The first is a set of water surface elevations of the Susitna River at cross section LRX-29 (ADF&G 1983, see Worksheet 1). The second set consists of unpublished observations made by R&M at LRX-29 in 1982. The third set of water surface elevations were estimated from water surface widths of Section H4 measured from aerial photographs, taken by the National Aeronautical and Space Administration (NASA), as shown in the following table:

Discharge at Gold Creek cfs	Date	Water Surface Width ft	Water Surface Elevation ft,msl
22,600	8/11/1980	0	-
31,100	8/1/1980	80	573.5
41,000	6/19/1977	155	574.0

Water surface elevations at surveyed cross sections were estimated by finding elevations at which the sections have the widths measured from the aerial photographs. The mainstem discharge water surface elevation relationship was plotted on Worksheet 4. The curve fitted to all data points shows a threshold discharge between Regimes II and II-A of about 26,000 cfs.

The threshold discharge between Regimes I and II was estimated by field observation to be approximately 10,000 cfs.

Worksheet 3 indicates an approximate slough discharge of 8 cfs in Regime II. Slough discharge in Regime I is about 3 cfs based on one measurement by ADF&G (1982) when Susitna River discharge was 8,000 cfs.

Slough discharge in Regime II-A was estimated by computing discharge over the intermediate berm and adding it to Regime II discharge. Discharge over the berm for a given mainstem flow was computed by the broad-crested weir formula with a discharge coefficient of 2.7 and headwater elevations equal to water surface elevations in the Susitna River (Worksheet 5). The discharge over the berm is 0.1 cfs at a mainstem discharge of 27,000 cfs. Slough discharges are listed in Table A-2 of Appendix E.2.A.

Slough Water Surface Elevation

Slough Mouth

Worksheet 6 shows measured water surface elevations at the mouth of Slough 8A (Section W1) for mainstem discharges between 11,700 cfs and 26,500 cfs. The data are from readings at staff gages 125.2 and 125.2 E1B (see Worksheet 1) and a surveyed water surface elevation of Section W1 (see Worksheet 1) on August 4, 1982 by R&M (Dec. 1982a). Gage 125.2 is located at Section W1 and gage 125.2 E1B is located a few feet upstream of Section W1. The plotted data were fitted visually with a curve, and the curve was extrapolated between 10,000 cfs and 11,500 cfs and between 26,500 cfs and 31,000 cfs.

For mainstem discharges less than 10,000 cfs (Regime I), the water surface elevation at the slough mouth was estimated to be 559.4 ft. msl. This was obtained by computing the water surface elevation at a control section immediately downstream of Section W1 (Worksheet 2) and assuming a horizontal water surface profile between the control section and Section W1. The shape of the control section was assumed to be the same as that of Section W1 but the invert of the control section is 1.0 ft. higher as shown in Worksheet 2. The water surface elevation at the control section was computed by both uniform flow and critical flow formulas. Both yield a flow depth of approximately 0.1 ft and a water surface elevation of 559.4 ft, msl.

Mid-Slough

Water surface elevations in mid-slough at Section S6 (see Worksheet 1) corresponding to various mainstem discharges are shown in Worksheet 7 based on field measurements. A horizontal line was fitted visually to the points for mainstream discharges greater than 10,000 cfs. The points show some scatter, but the water surface elevations vary within 0.6 ft for mainstem discharges between 10,000 cfs and 32,500 cfs.

For mainstem discharges less than 10,000 cfs, the water surface elevation was computed to be 568.6 ft, msl by assuming uniform flow conditions. The flow depth is estimated to be 0.2 ft. The slough discharge is 3 cfs, as at the slough mouth. This is based on the observation that, when the berms are not overtopped, all flow in the slough originates from groundwater upwelling upstream of Section S6 (ADF&G, 1983, Fig. 4II-3-14).

Intermediate and Upstream Berms

When the intermediate berm is overtopped, the discharge and depth of flow over the berm have been estimated by the broad-crested weir formula. The water surface elevations were computed by adding flow depths to the invert elevation (Worksheet 5).

The upstream berm is not overtopped for the range of discharges being studied. Therefore, no water surface elevations are listed in Table A-2 of Appendix E.2.A.

Slough Flow Depths

The depths of flow at the slough mouth, mid-slough, and intermediate berm were determined by subtracting the appropriate thalweg elevations from the water surface elevations.

The thalweg elevations are 558.3 ft,msl, at the mouth (Section W1), 568.4 ft,msl, at mid-slough (Section S6) and 573.1 ft.msl, at the intermediate berm (Section H4). These elevations were taken from surveys by R&M (Dec. 1982a).

Flow depths are zero at the intermediate berm for mainstem discharges less than 26,000 cfs, and at the upstream berm for discharges less than 31,000 cfs.

Slough Velocities

The average flow velocities in the slough were computed by dividing slough discharges by the flow cross-section areas. For the slough mouth, the discharges are those listed in Table A-2, and the flow areas were determined using Section W1 and water surface elevations in the table.

For the mid-slough (Section S6), discharges are 3 cfs for Regime I and 8 cfs for both Regimes II and IIA because Section S6 is upstream of the intermediate channel. The flow areas were computed using Section S6 and mid-slough water surface elevations in Table A-2. The computed average velocities are listed in Table A-2 of Appendix E.2.A.

Average velocities at the intermediate berm were computed by dividing discharges over the berm by flow area using Section H4.

Worksheets 8 and 9 present examples of lateral distribution of flow velocities within cross sections. These velocities were measured at a cross-section about 1600 ft upstream of the slough mouth (Worksheet 1).

Wetted Surface Area

Worksheet 10 shows wetted surface areas of Slough 8A measured from aerial photographs taken by NASA, R&M, and North Pacific Aerial Surveys, Inc. A straight line was fitted to the plotted data and extrapolated to a mainstem discharge of 10,000 cfs.

For Regime I (less than 10,000 cfs), slough water level is not affected by Susitna River backwater. Thus, the wetted surface area should remain constant since slough discharge remains unchanged.

To compute wetted surface area for Regime I, the water surface profile for Slough 8A was approximated by plotting water surface elevations at the mouth, mid-slough and Well No. 5 as shown on Worksheet 11. Water surface elevations at all available cross-sections were then read from the profile, and the corresponding water surface widths were determined from surveyed cross-sections. The wetted surface area for the slough was then computed using water surface widths at the cross-sections and the distances in between. The wetted surface area of the intermediate channel was computed similarly. The water surface elevation at Section S3 was estimated to be the same as the water level in Well No. 10 (Worksheet 1).

Based on observations, groundwater elevations near the slough were used to approximate slough water surface elevations. For example, slough water surface elevations at Section S6 at a mainstem discharge of 15,000 cfs, shown on Worksheet 7, were observed to be about 568.5 ft. msl, to 568.8 ft. msl. Groundwater level in the nearby well No. 9 was observed to be about 568.5 ft. msl, as shown on Worksheet 14.

The wetted surface areas for Regimes I, II, and II-A are presented in Table A-2 of Appendix E.2.A.

Slough Wetted Perimeter

Wetted perimeters at the slough mouth were determined from appropriate water surface elevations at Section W1 and the geometry of Section W1. Wetted perimeters at mid-slough and the intermediate berm were determined at Sections S6 and H4, respectively, in a similar manner.

Slough Water Table Elevations

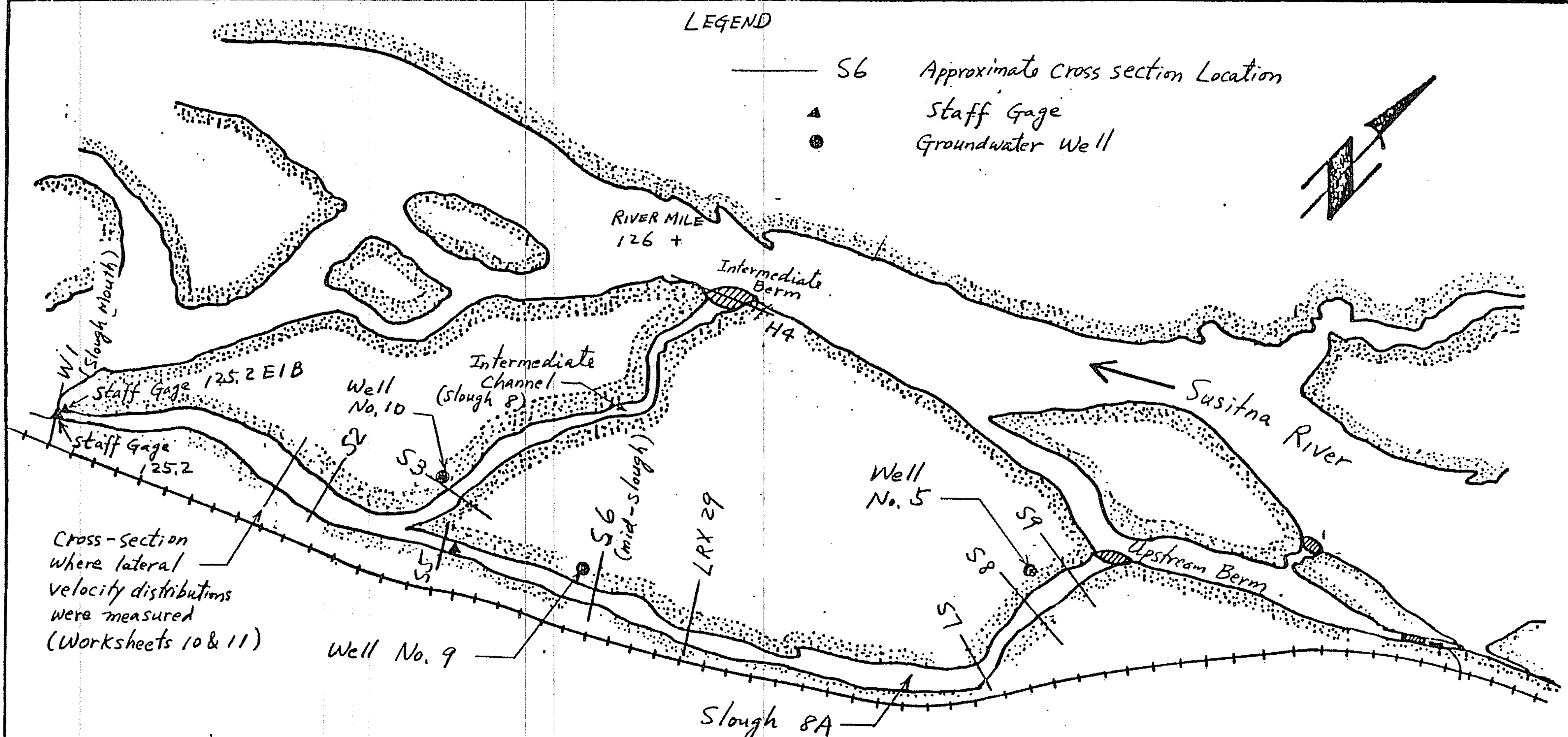
The groundwater monitoring system at Slough 8A consists of 15 observation wells shown on Worksheet 12. The relation between water table elevation and mainstem discharge is shown on Worksheet 13. Three wells were chosen to represent the general groundwater conditions at the slough. The wells were chosen using the following general criteria:

1. representation of the groundwater conditions in the upstream area (Well No. 5) and mid-slough (Wells No. 9 and 10).

2. availability of data for the widest range of mainstem discharges; and

3. location far enough removed from the mainstem to reduce short-term water level fluctuations.

For each of the selected wells, the relations between water table elevations and mainstem discharges were plotted (Worksheet 14). For each mainstem discharge the corresponding water table elevation was read from Worksheet 14. The results are summarized in Table A-2 of Appendix E.2.A.



A-1-6

Source: "Slough Hydrology Interim Report," Dec. 1982

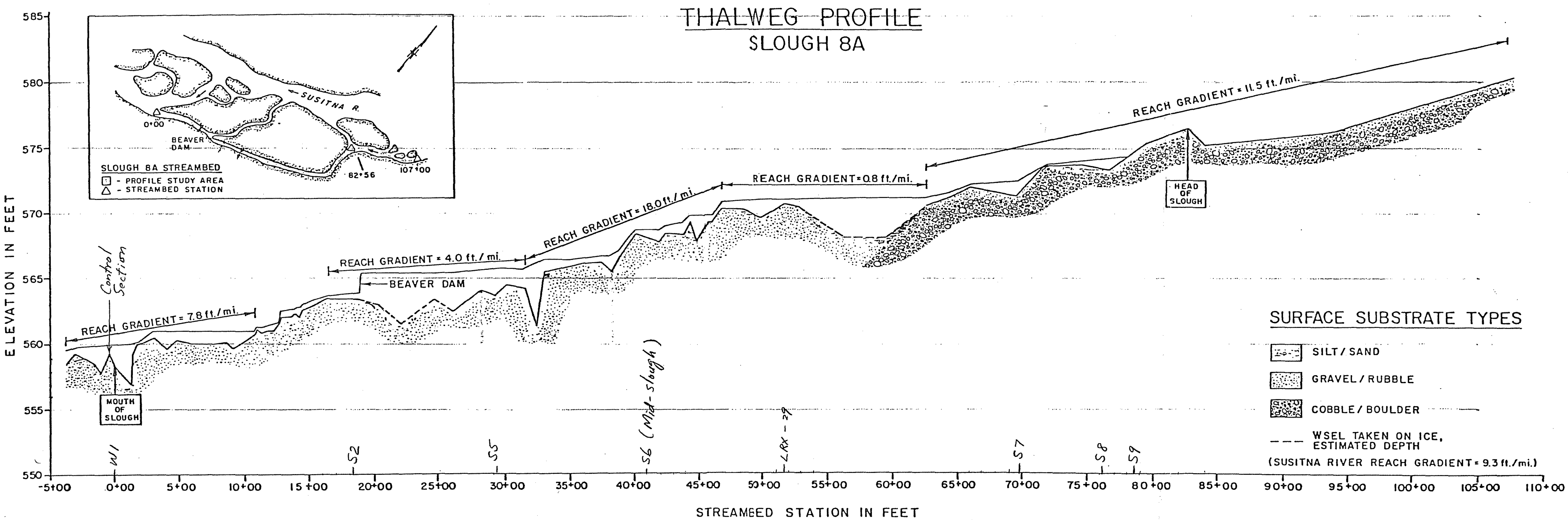
PREPARED BY:

R&M CONSULTANTS, INC.

WORKSHEET 1
ATTACHMENT A-1

VICINITY MAP
OF SLOUGH 8A

WORKSHEET 2
ATTACHMENT A-1

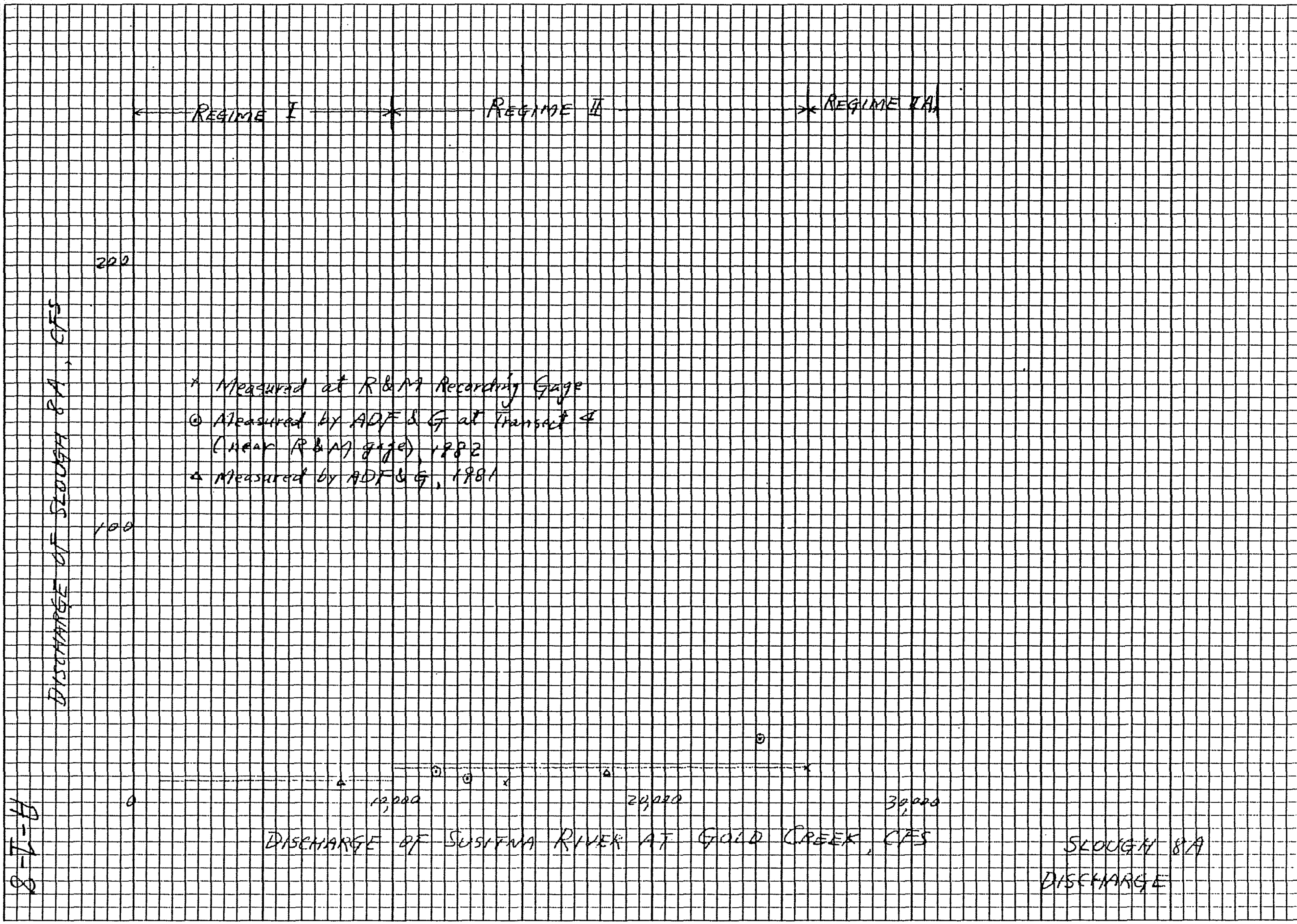


Source ADF & G, phase II, Vol. 4, Part I, P. 89

STREAMBED PROFILE FOR SLOUGH 8A

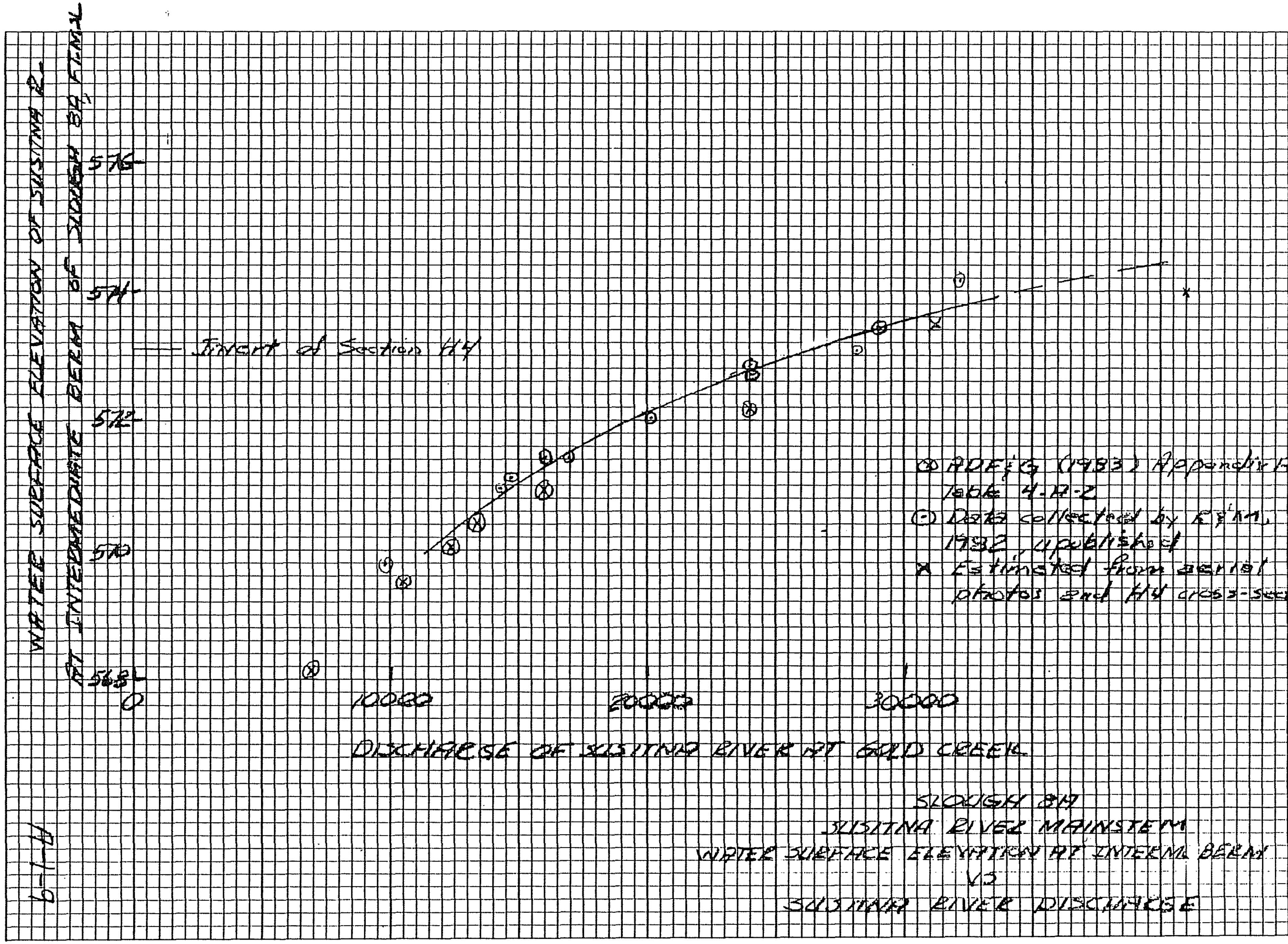
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0707



A-I-8

WORKSHEET 3
ATTACHMENT A-1


WATER SURFACE ELEVATION OF SUSITNA R.
AT INTERMEDIATE BERM OF SLOUGH 8A, FT.M.S.L.
576
574
572
570
568
Invert of Section 114
0
10000
20000
30000
DISCHARGE OF SUSITNA RIVER AT GOLD CREEK
ADF&G (1983) Appendix A
Table 4-A-2
Data collected by R&M,
1982, unpublished
Estimated from aerial
photos and 114 cross-section
SLOUGH 8A
SUSITNA RIVER MAINSTEM
WATER SURFACE ELEVATION AT INTERMED. BERM
VS
SUSITNA RIVER DISCHARGE

HARZA-EBASCO SUSITNA JOINT VENTURE	SUBJECT: Slough 8 — Discharge over Intermediate Berm	FILE NO. 1494.162
	COMPUTED: SCLY — CHECKED: CDS	DATE 5/30/1983
		PAGE 1 OF 5 PAGES

Section H4

Discharge at Gold Creek, cfs	Susitna Water Elev., ft, msl (p.5/5)	Flow Area, ft² (p.2/5)	L Top Width, ft	$H = \frac{A}{L}$ Avg Head, ft	Q, cfs [1]
27,000	573.2 ✓	0.24 ✓	6 ✓	0.04 ✓	0.1 ✓
29,000	573.4 ✓	$\left(\frac{0.28}{2}\right)(20)+\left(\frac{0.08}{2}\right)(55) = 5$ ✓	75 ✓	0.06 ✓	3.0 ✓
31,000	573.6 ✓	$5 + (0.2)(125) - \left(\frac{0.12}{2}\right)(30) = 28.2$ ✓	135 ✓	0.21 ✓	35 ✓

1/ Broad-crested weir flow

$$Q = CLH^{3/2} = 2.7\,LH^{3/2}$$

$Q_{Gold\ Creek}$ cfs	Susitna Water Elev, ft, msl	Water Surface above Invert, ft [1]	Depth above Invert, ft [2]	Water Surface Elev. at H4 ft, msl
27,000	573.2	0.1	0.05	573.15
29,000	573.4	0.3	0.15	573.25
31,000	573.6	0.5	0.25	573.35

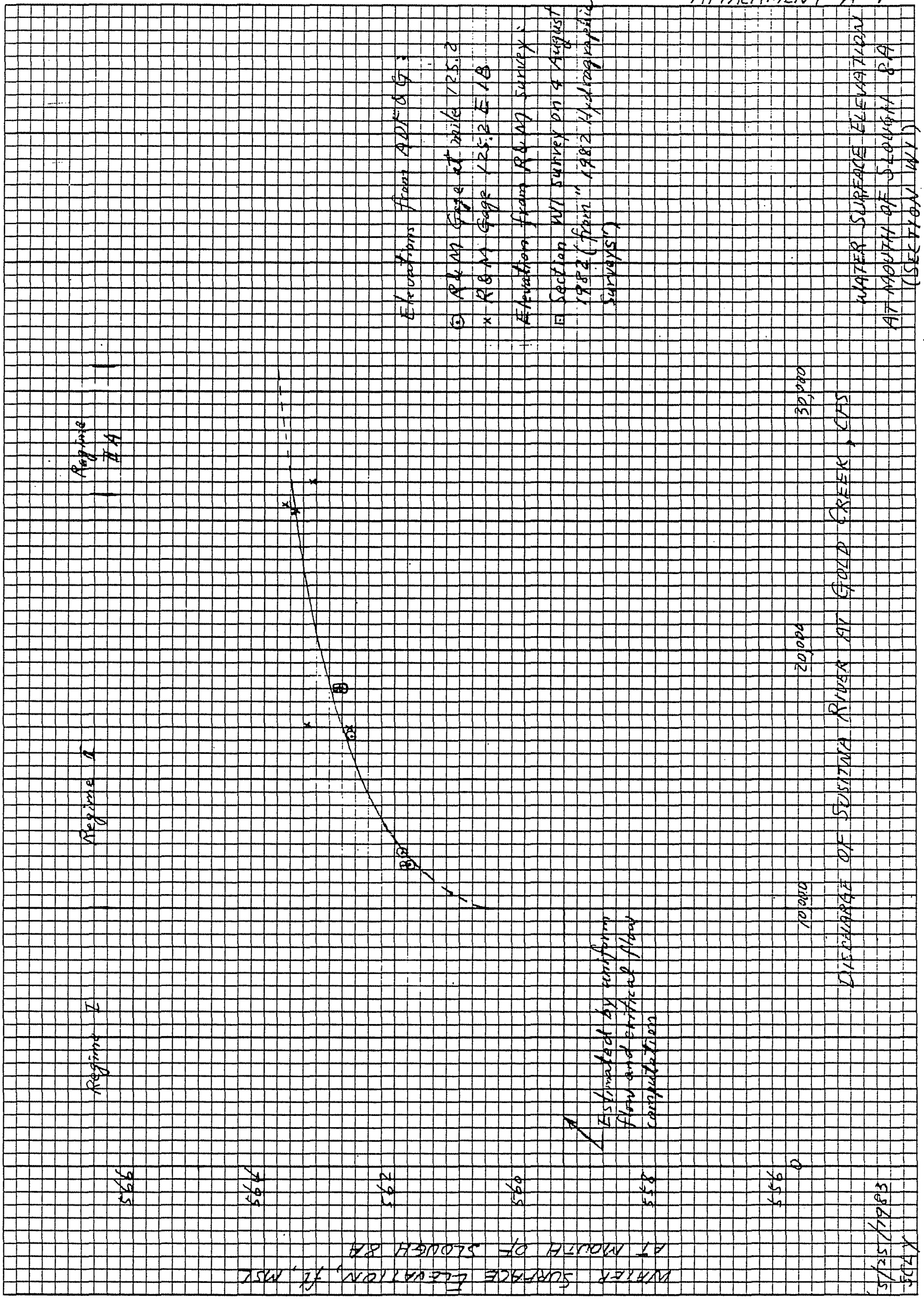
✓

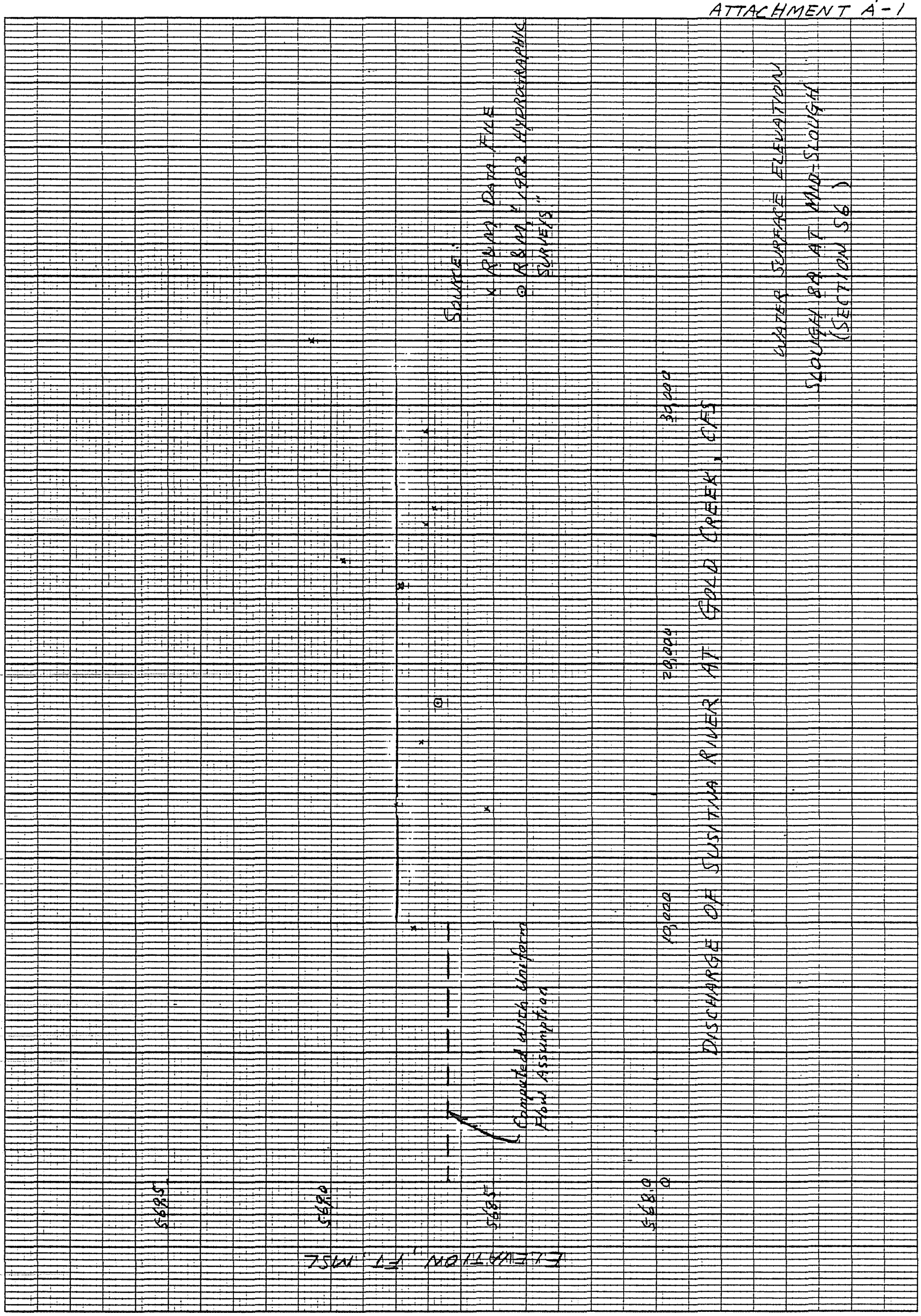
1/ Invert of Section H4 = 573.1 ft, msl

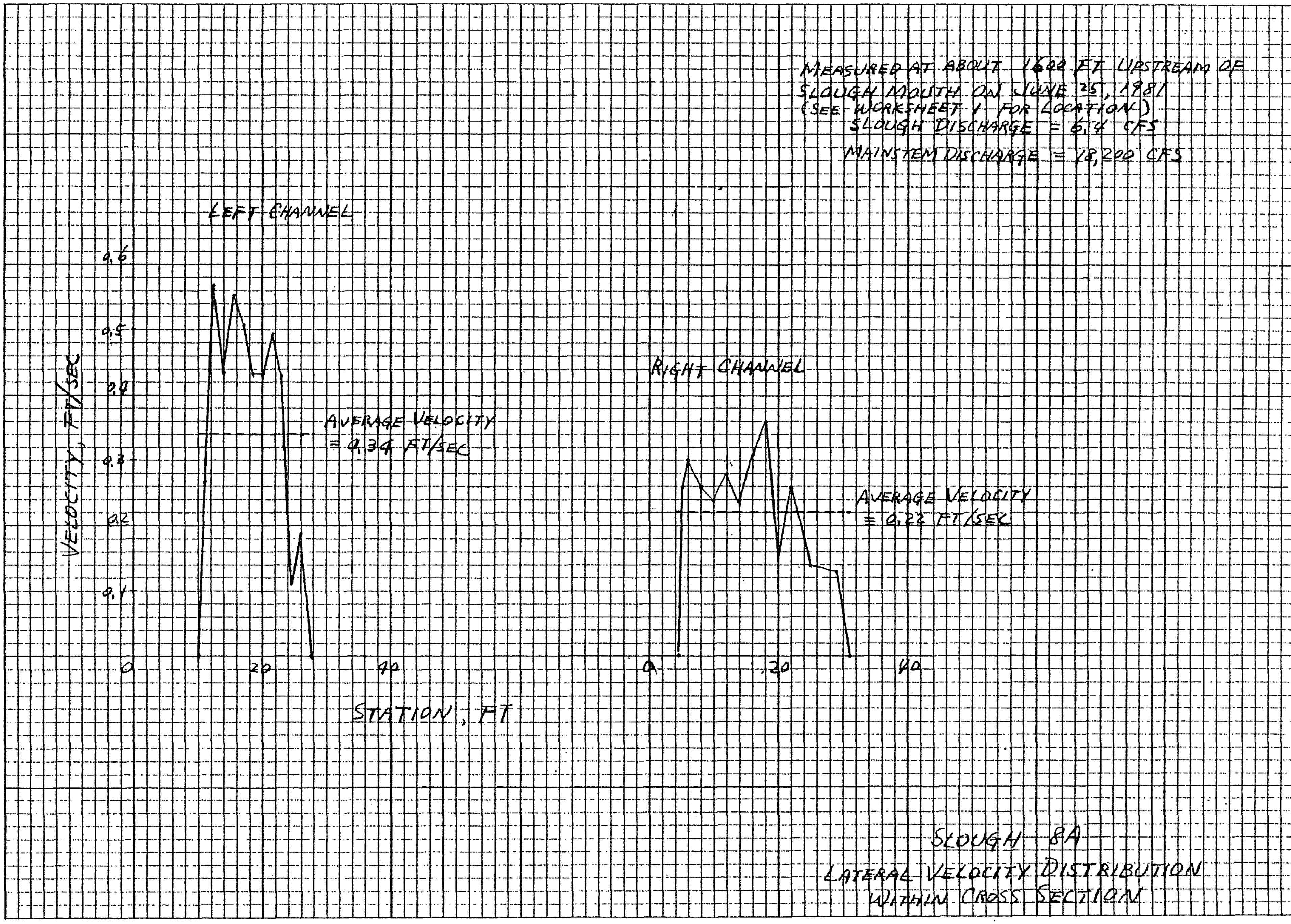
2/ half of preceding column (see Ref.)

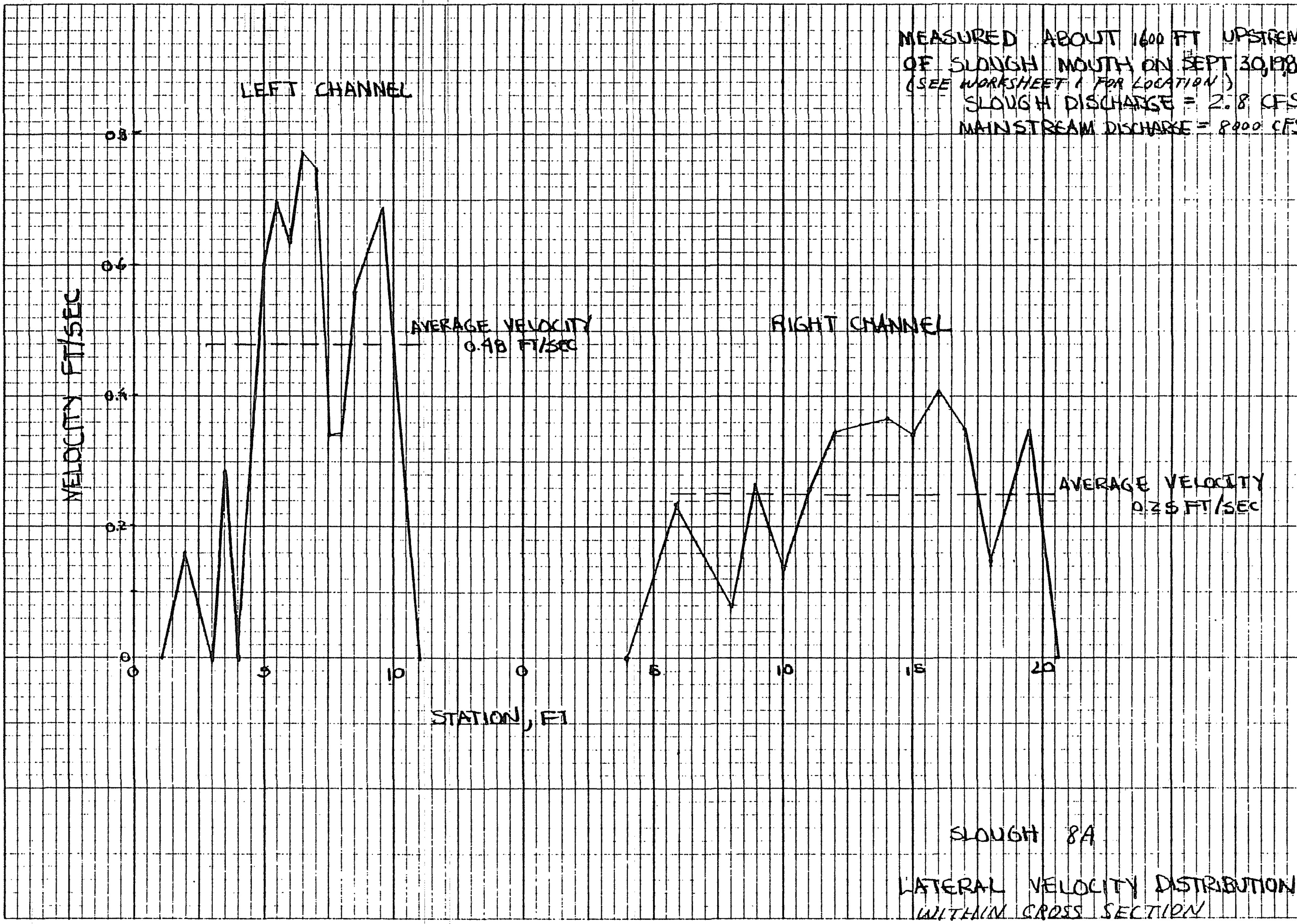
Ref. Chow, "Open Channel Hydraulics," p. 52-53

WORKSHEET 6
ATTACHMENT A-1

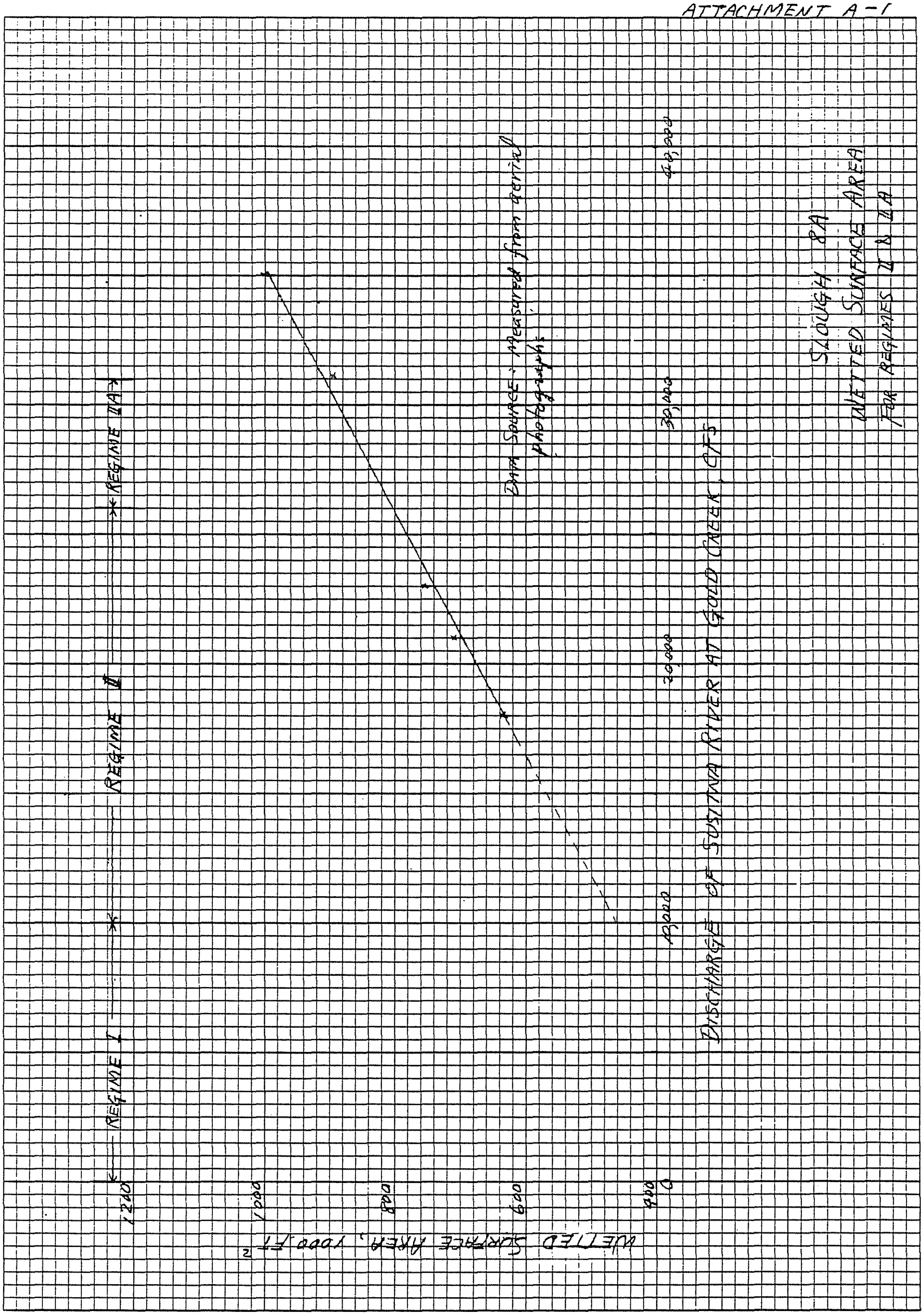



WATER SURFACE ELEVATION
SLOUGH 8A AT MID-SLOUGH
(SECTION S6)
SOURCE:
x R&M DATA FILE
⊙ R&M "1982 HYDROGRAPHIC SURVEYS"
Computed with Uniform Flow Assumption
10,000
20,000
30,000
DISCHARGE OF SUSITNA RIVER AT GOLD CREEK, CFS
ELEVATION, FT MSL

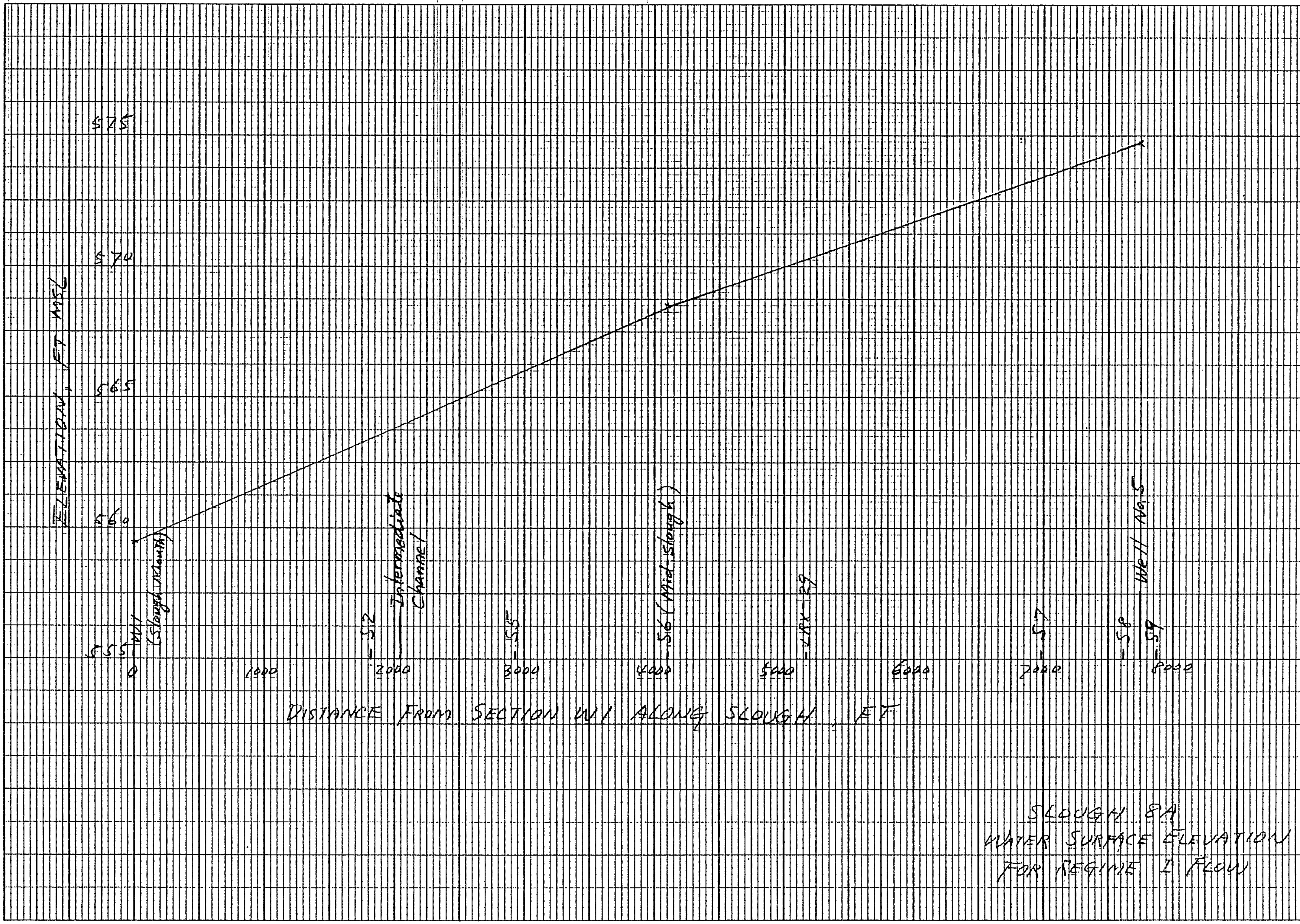

MEASURED AT ABOUT 1600 FT UPSTREAM OF
SLOUGH MOUTH ON JUNE 25, 1981
(SEE WORKSHEET 1 FOR LOCATION)
SLOUGH DISCHARGE = 6.4 CFS
MAINSTEM DISCHARGE = 18,200 CFS
LEFT CHANNEL
RIGHT CHANNEL
AVERAGE VELOCITY
= 0.34 FT/SEC
AVERAGE VELOCITY
= 0.22 FT/SEC
VELOCITY, FT/SEC
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
0
20
40
STATION, FT
SLOUGH 8A
LATERAL VELOCITY DISTRIBUTION
WITHIN CROSS SECTION


MEASURED ABOUT 1600 FT UPSTREAM OF SLOUGH MOUTH ON SEPT 30,1981
(SEE WORKSHEET 1 FOR LOCATION)
SLOUGH DISCHARGE = 2.8 CFS
MAINSTREAM DISCHARGE = 8000 CFS
LEFT CHANNEL
RIGHT CHANNEL
AVERAGE VELOCITY 0.48 FT/SEC
AVERAGE VELOCITY 0.25 FT/SEC
VELOCITY FT/SEC
0
0.2
0.4
0.6
0.8
0
5
10
0
5
10
15
20
STATION, FT
SLOUGH 8A
LATERAL VELOCITY DISTRIBUTION
WITHIN CROSS SECTION

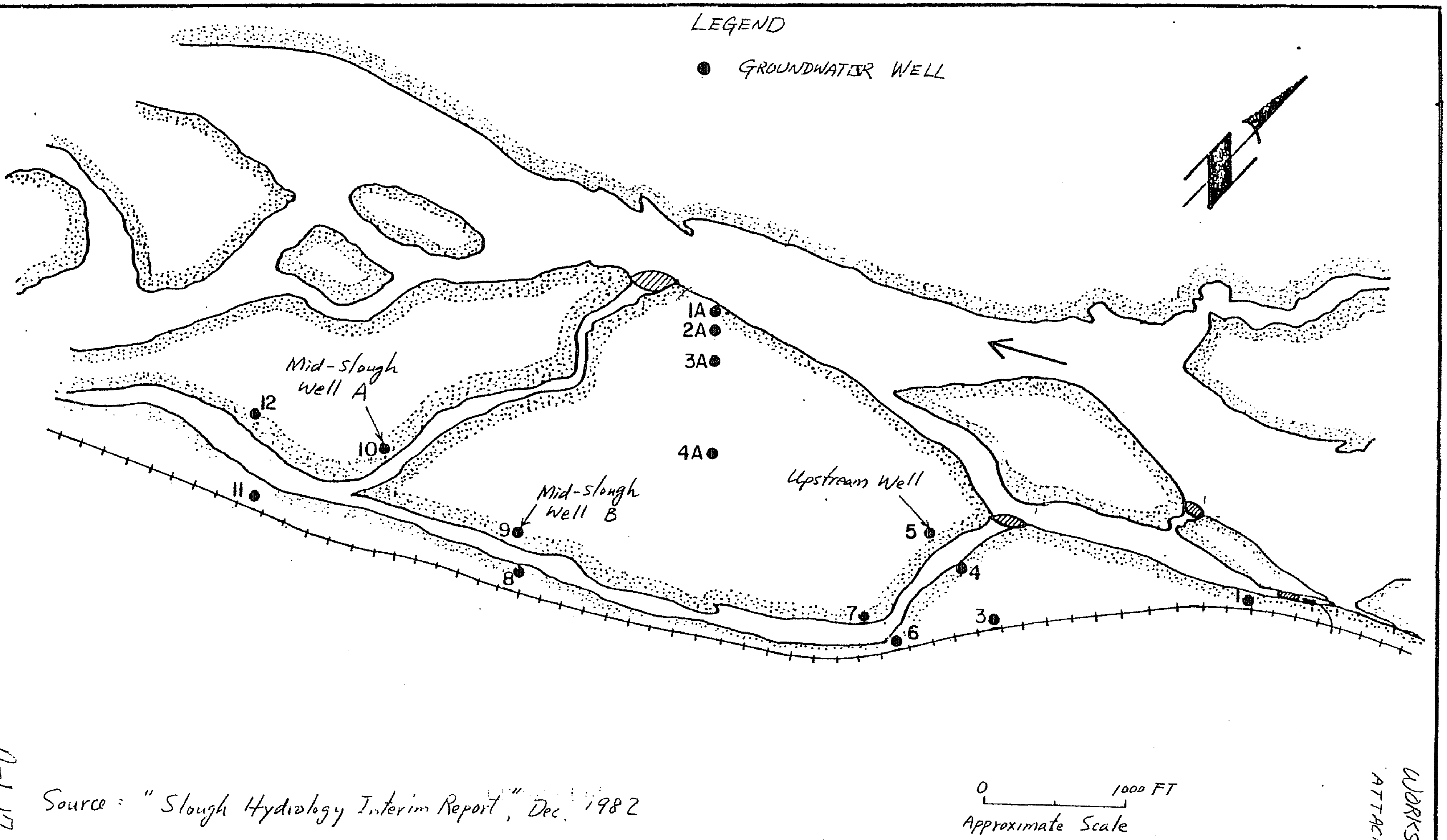
WORKSHEET 10
ATTACHMENT A-1



WORKSHEET 11
ATTACHMENT A-1



SLOUGH 8A
WATER SURFACE ELEVATION
FOR REGIME I FLOW



Source: "Slough Hydrology Interim Report", Dec. 1982

PREPARED BY:
R&M CONSULTANTS, INC.

LOCATIONS OF GROUNDWATER WELLS SLOUGH 8A

WORKSHEET 13:
ATTACHMENT A-1

1982 GROUNDWATER ELEVATION AT SLOUGH 8A (FT, MSL)

Date	Well No. S.G. x-s 29	8-1	8-3	8-4	8-5 [1]	8-6	8-7	8-8	8-9 [2]	Susitna Discharge at Gold Creek, cfs
Apr. 26		579.47	575.42	574.39	574.76	d	572.79	568.24	568.42	ice cover
May 15						576.31				15,000
May 27		581.16	577.87	573.94	574.91	573.22	573.43	569.91	568.62	23,000
June 24		581.42	577.54	575.06	574.99	573.11	573.32	569.36	568.56	26,000
June 29	573.45	581.26	576.38	575.00	574.94	572.98	573.23	569.03	568.55	29,000
July 18		580.99	575.69	574.89	574.83	572.89	573.13	568.61	568.40	25,400
Aug. 3										19,800
Aug. 5										17,400
Aug. 6	571.61									16,800
Aug. 9	571.61	580.41	576.18	574.87	574.77	572.97	573.12	569.09	568.43	17,000
Aug. 27										12,900
Sep. 3	571.06	-	577.41	575.10	574.97	573.17	573.32	569.66	568.52	14,600
Sep. 5										13,600
Sep. 10	570.97	-	575.54	574.64	574.56	572.90	572.96	569.12	568.31	14,400
Sep. 20	572.84	581.41	578.45	575.32	575.30	573.44	573.58	570.33	568.91	24,000
Oct. 5	569.80	d	576.57	574.90	574.77	573.03	573.15	569.64	568.37	9,800
Oct. 13	-	d	574.74	574.06	d	572.78	572.78	-	568.16	7,500

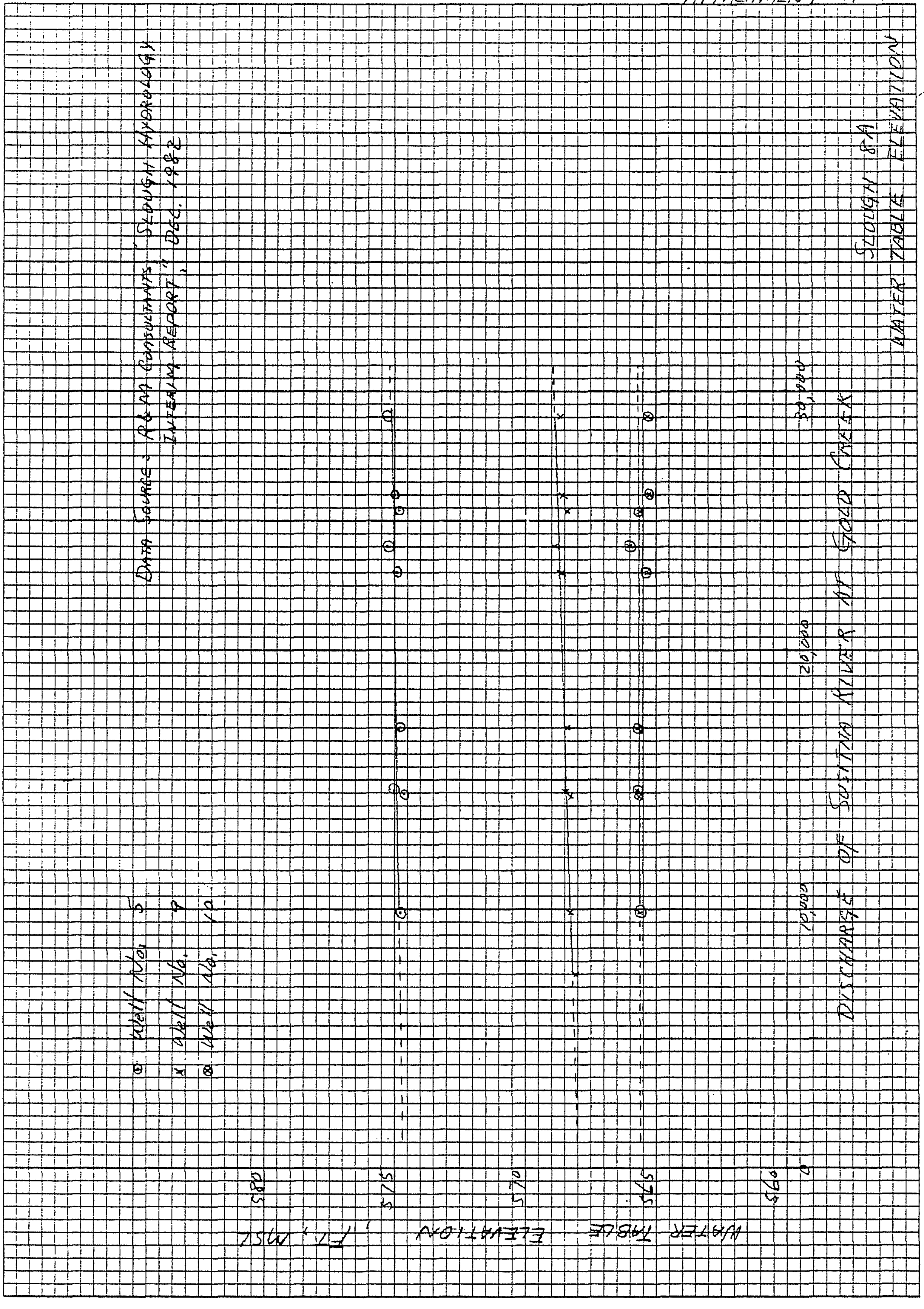
Date	Well No. 8-10 [3]	8-11	8-12	S.G. 8-1A	8-1A	8-2A	8-3A	8-4A	Susitna Discharge at Gold Creek, cfs
Apr. 26	566.15	565.64	566.33						ice cover
May 15									15,000
May 27	565.30	565.49	s						23,000
June 24	565.15	565.79	s						26,000
June 29	565.34	-	s						29,000
July 18	565.54	565.51	564.38	572.63	572.32	572.23			25,400
Aug. 3				572.19	572.33	572.35			19,800
Aug. 5				571.85	571.86	571.83			17,400
Aug. 6				571.79	571.75	571.73	571.87		16,800
Aug. 9	565.56	565.83	564.29	571.81	d	571.61	571.81		17,000
Aug. 27					d	d	571.05	571.26	12,900
Sep. 3	565.76	566.28	d	571.24	d	571.41	571.87	572.32	14,600
Sep. 5				570.99	d	-	571.74	572.28	13,600
Sep. 10	565.75	-	-	571.16	d	d	571.36	572.24	14,400
Sep. 20	566.00	566.70	564.44	573.24	573.33	573.25	573.42	573.72	24,000
Oct. 5	565.70	566.12	d	570.39	d	d	571.22	573.09	9,800
Oct. 13	-	-	d	-	d	d	570.48	572.58	7,500

- = not observed
s = silted
d = dry

Source: R&M Consultants, "Slough Hydrology Interim Report," Dec. 1982.

[1] Well No. 5 (Upstream Well)
[2] Well No. 9 (Mid-slough Well B)
[3] Well No. 10 (Mid-slough Well A)

WORKSHEET 14
ATTACHMENT A-1



ATTACHMENT

PART 2

SLOUGH 9 PHYSICAL HABITAT VARIABLES

ATTACHMENT
PART 2
SLOUGH 9 PHYSICAL HABITAT VARIABLES

Slough Description

Slough 9 is located near River Mile 129. A vicinity map and a thalweg profile are shown in Worksheets 1 and 2. Slough 9 is approximately 1.2 miles long.

Slough Discharge

Worksheet 3 shows Slough 9 discharge values plotted against Susitna River discharges at Gold Creek. The slough discharges were determined from:

- o discharge measurements made during 1981 and 1982 .
- o daily discharge values from August 10 through September 14, 1982 determined from continuous stage data and a rating curve for the slough (see Worksheet 1 for the location of the stage recorder, daily values were plotted on Worksheet 4).

Worksheet 3 was used to estimate the threshold discharge between Regimes II and III to be about 20,500 cfs (see Table A-1 of Appendix E.2.A.).

Worksheet 5 shows slough discharges plotted against main stem discharges for Regimes I and II flow only, using the same data source as Worksheet 3. The data indicate that slough discharge is greater during Regime II than in Regime I. This is expected since Regime II usually implies wetter basin conditions. However, the data also indicate that there is no definite relationship between slough discharge and mainstem discharge for Regimes I and II. Therefore, for the purposes of this analysis, a constant value was assigned to slough discharge for each of Regimes I and II. A higher value was used for Regime II.

The values of slough discharge presented in Table A-3 of Appendix E.2.A were taken from Worksheets 3 and 5.

Slough Water Surface Elevations

Worksheet 6 shows water surface elevations at the berm just downstream of the mouth of Slough 9 plotted against Susitna River discharge Gold Creek. This berm acts as the entrance to the slough mouth. Worksheet 6 was used to estimate the threshold discharge between Regimes I and II to be about 11,000 cfs (see Table A-1 of Appendix E.2.A). The data are from two sources:

- o For flows above about 11,000 cfs, water surface elevations were determined from staff gages 129.2 W1A and W1B during

1982 (see Worksheet 1 for location). This staff gage is located downstream of the mouth (see Worksheet 7).

- For flows below 11,000 cfs, a constant water surface elevation was used based on an estimate of flow depth at staff gage 129.2 W1A (Trihey, 1982, Table 4, p. 21) for:

  -- mainstem flow of 10,000 cfs, and
  -- slough discharge of 3 cfs.

The water-surface elevations at the mouth of Slough 9 shown in Table A-3 of Appendix E.2.A, were determined from Worksheet 6.

Worksheet 8 shows water surface elevations at mid-slough in Slough 9 plotted against Susitna River discharges at Gold Creek. The data are from staff gages 913A & 913B (see Worksheet 1). The water surface elevations at mid-slough presented in Table A-3 of Appendix E.2.A, were determined from Worksheet 8.

The water surface elevations at the upstream end of the slough (cross section H9) were computed using the backwater program HEC-2 (U.S. Army Corps of Engineers, January, 1981). The program was run for four overtopping discharge conditions. Overtopping discharge was computed to be slough discharge minus 6 cfs for baseflow. Starting water surface elevations were determined from the rating curve at the staff gages 913A and 913B, located at cross-section S3. Channel geometry was taken from the following surveyed cross-sections, shown on Worksheet 1:

- transect 6 (1982)
- transect 10 (1982)
- transect 3 (1981)
- transect 2 (1981)
- section S8
- section H9

A Manning's n-value of 0.035 was used, based on field observations.

Water surface elevations, depths, average velocities, and wetted perimeters resulting from the HEC-2 runs are plotted against slough overtopping discharges and Susitna River discharges at Gold Creek on Worksheet 9. The water surface elevations at cross section H9 shown in Table A-3 of Appendix E.2.A, were taken from Worksheet 9.

Slough Depths

The depths of flow at the mouth, the mid-slough and the upstream end were determined by subtracting the appropriate thalwegs from the water surface elevations.

The thalweg of the section at staff gages 129.2 W1A and W1B is 539.5 ft. msl. This value was subtracted from the water surface elevation at the mouth presented in Table A-3 of Appendix E.2.A, to obtain the flow depths at the mouth in the same table.

Worksheet 1 indicates that staff gages 913A and 913B are at cross-section S3 (surveyed in 1982). The thalweg of cross-section S3 is 592.4 ft. msl. This value was subtracted from the water surface elevations at staff gages 913A and 913B for mid-slough shown in Table A-3 of Appendix E.2.A, to obtain the depths at mid-slough shown in the same table.

The method for determining the depths at the upstream end was discussed in the previous section.

Slough Velocities

The average velocities in the sloughs were determined by dividing the slough discharges by the cross-section areas.

A surveyed cross-section was not made at staff gages 129.2 W1A and W1B. The nearest surveyed cross-section was about 450 feet upstream (Section 128.4 W1, see Worksheet 7). The cross-sectional shape of the two sections was estimated to be similar. Based on this estimate, the elevations of section 128.4 W1 were adjusted such that its thalweg matched the invert elevation of the staff gage section. This estimated cross-section at the staff gage was used to determine the average velocities at the mouth using the methodology described above. These values are shown in Table A-3 of Appendix E.2.A.

The average velocities corresponding to four discharge measurements made near the mouth of Slough 9 during 1981 and 1982 are shown on Worksheet 10. They were added to the worksheet for comparison with the average velocities computed using the method described previously. Scatter in the comparison can be attributed to the fact that the discharge measurements were not made at the same cross-section at which the staff gage was located.

The average velocities at mid-slough were computed by dividing slough discharges, listed in Table A-3 of Appendix E.2.A, by corresponding flow areas. The flow areas were determined with cross-section S3 using water surface elevations listed in Table A-3. The resulting average velocities at mid-slough are shown in Table A-3 of Appendix E.2.A.

Worksheet 9 was used to determine the values of average velocity at the upstream end shown in Table A-3 of Appendix E.2.A. Worksheet 9 was determined from the HEC-2 backwater runs described previously.

To supplement average velocities shown in Table A-3 of Appendix E.2.A., the following is provided:

- o lateral velocity distributions obtained from discharge measurements (Worksheets 11 through 15).
- o velocity and depth ranges for transects 1 through 10 (1982) for four discharge events (Worksheet 16). (See Worksheet 1 for location of transects).

Total Wetted Surface Areas

The total wetted surface areas of Slough 9 were computed by:

- o measuring surface areas from aerial photographs of the slough for a range of Susitna River discharges at Gold Creek (see Worksheet 20).
- o using the average end width method.

Seepage ponds, which often appear within the slough in the aerial photos, were not considered part of the total wetted surface area if they were not connected via surface flow to the wetted surface area downstream.

Worksheet 17 shows the surface areas plotted vs. Susitna River discharge at Gold Creek. Scatter in the relationship can be attributed to:

- o varying clarity of aerial photos
- o judgment used in delineating surface area boundaries on aerial photos, especially when shadows, banks, trees, etc. impede sight of wetted boundary.

The total wetted surface area values presented in Table A-3 of Appendix E.2.A, were determined from Worksheet 17.

Slough Wetted Perimeters

For the slough mouth the wetted perimeters were estimated to be equal to the top widths. This estimate is reasonable for flat, shallow cross-sections. Field observations confirm that flat, shallow sections are typical in Slough 9. The top widths for the mouth (Section W1) were determined by the following methods:

- o measurements from aerial photos.
- o field measurements.

The top widths for the mouth are plotted against Susitna River discharge at Gold Creek on Worksheet 18. The values of wetted perimeter shown in Table A-3 of Appendix E.2.A, were taken from this worksheet.

The wetted perimeters at mid-slough were computed with cross-section S3 and water surface elevations listed in Table A-3 of Appendix E.2.A., and are shown on Worksheet 19.

The top widths at the upstream end were taken from the HEC-2 run described previously (see Worksheet 9). Worksheet 9 was used to determine the values of wetted perimeter at the upstream end shown in Table A-3 of Appendix E.2.A.

Slough Water Table Elevations

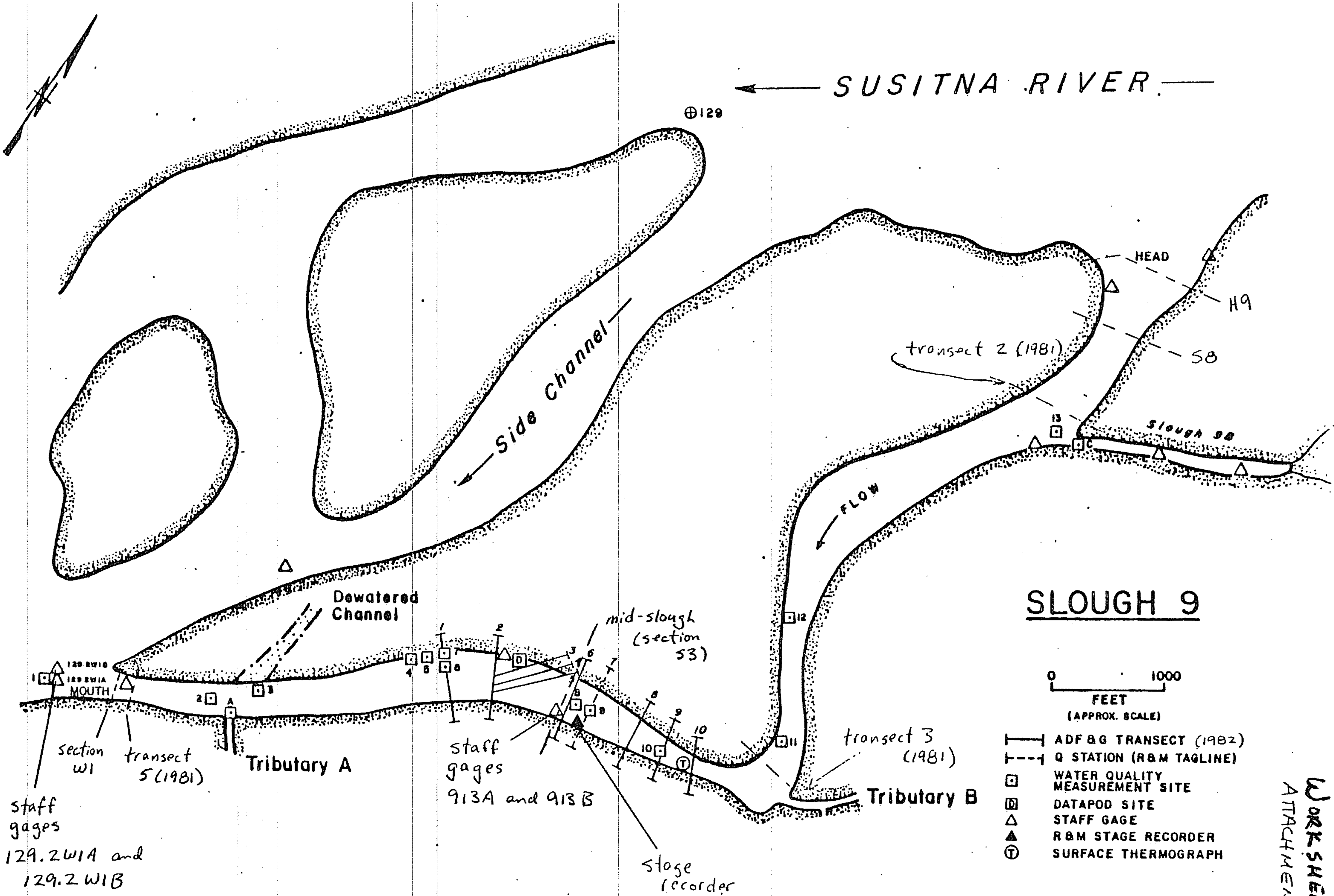
The groundwater monitoring system in Slough 9 consists of 14 observation wells installed during 1982 (see Worksheet 20). Water table elevations and corresponding Susitna River discharges at Gold Creek are shown in Worksheet 21. Wells 5, 11, and 14 (referred to as upstream well B, upstream well A, and mid-slough well in Table A-3 of Appendix E.2.A), were chosen to represent the general groundwater conditions in the slough, based on the following criteria:

- representation of the groundwater conditions in the upstream and intermediate areas of the slough. (No wells were installed near the mouth).

- availability of data for the widest range of mainstem discharges.

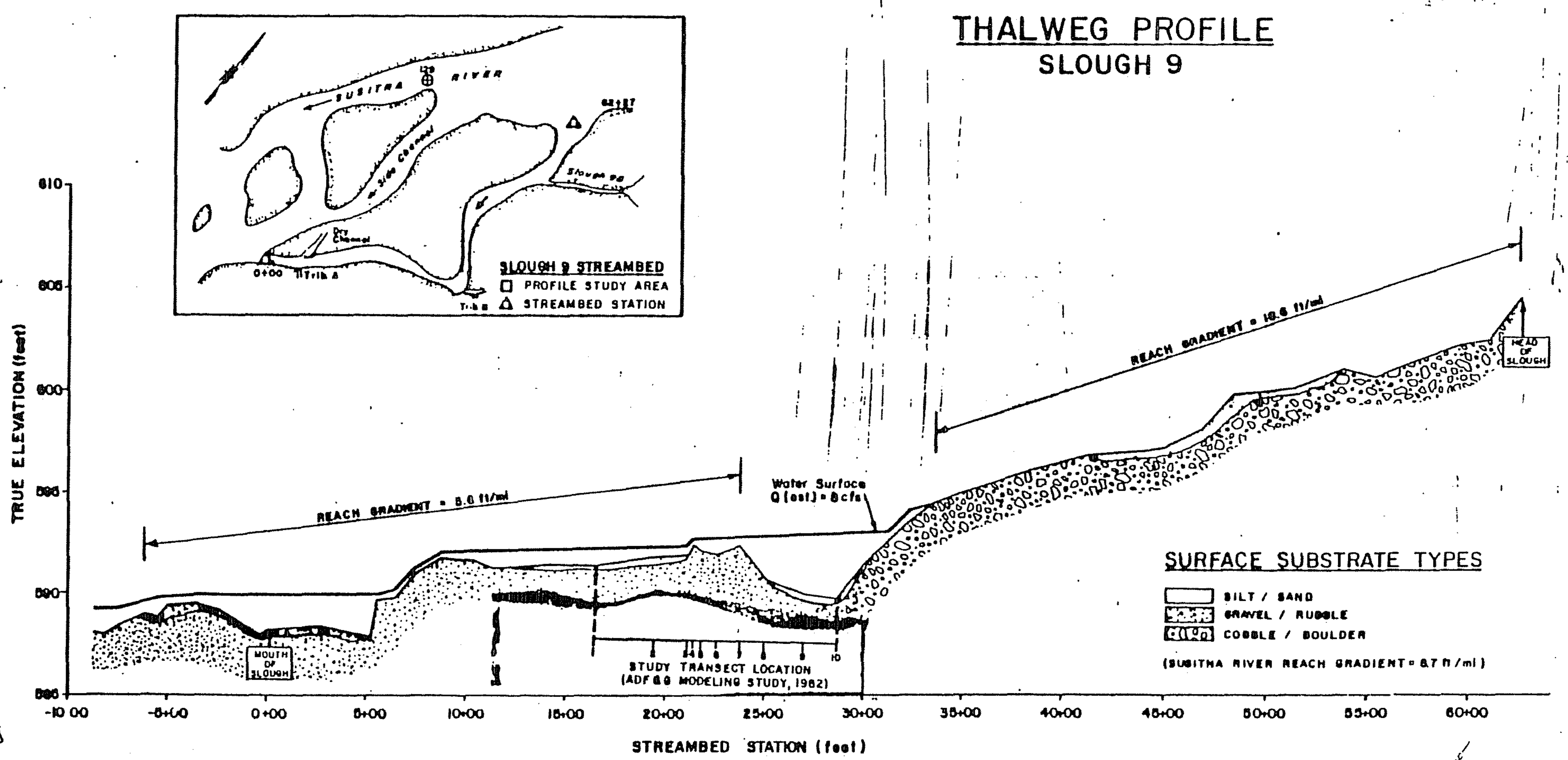
- location far enough removed from the mainstem to reduce short-term river water-level fluctuations.

Water table elevations are plotted against Susitna River discharges at Gold Creek in Worksheet 22; this plot was used to determine the water table elevations shown in Table A-3 of Appendix E.2.A.



A-2-6 Slough 9 Vicinity Map

WORKSHEET 1
ATTACHMENT A-2



WORKSHEET 2
ATTACHMENT A-2

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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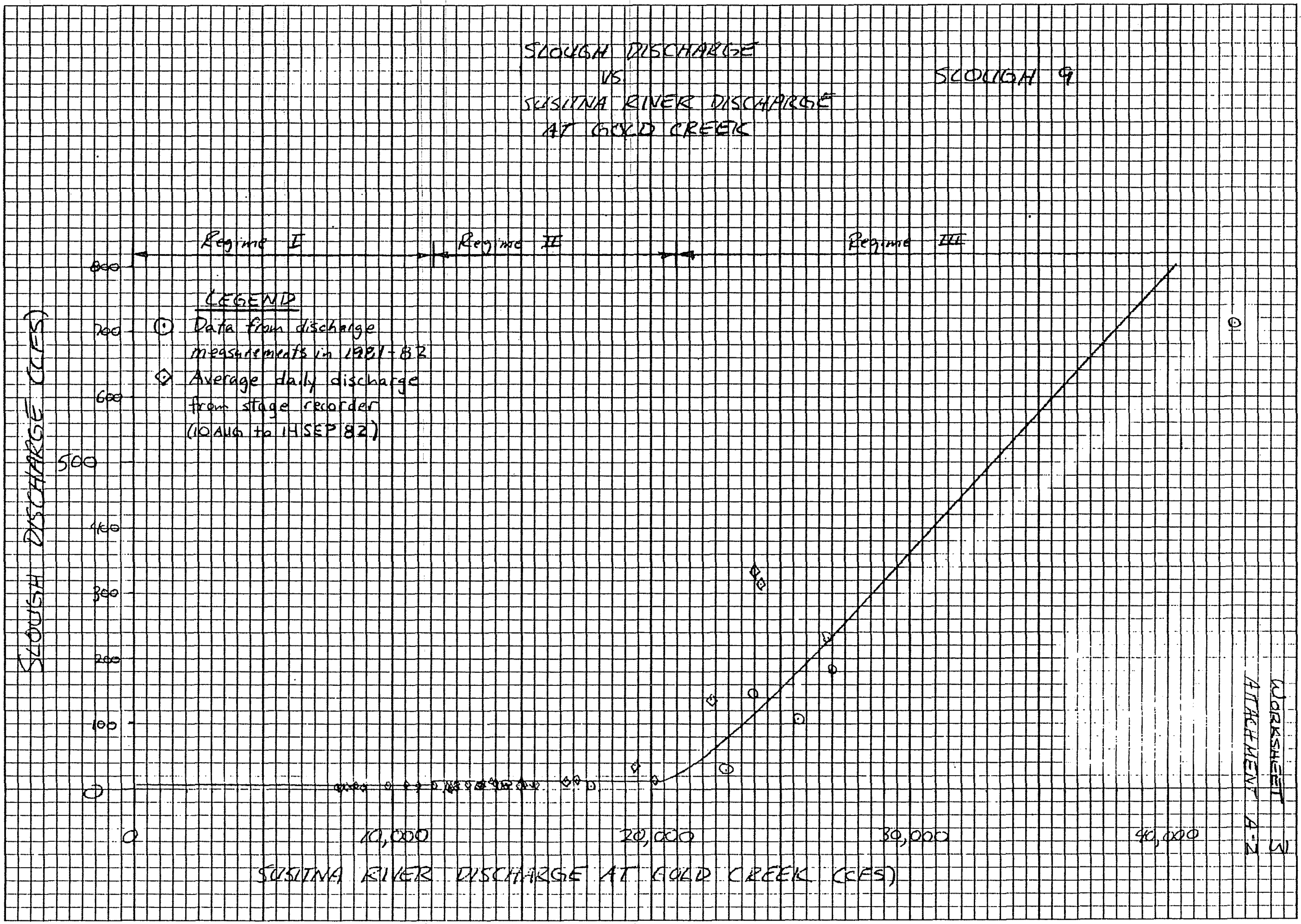
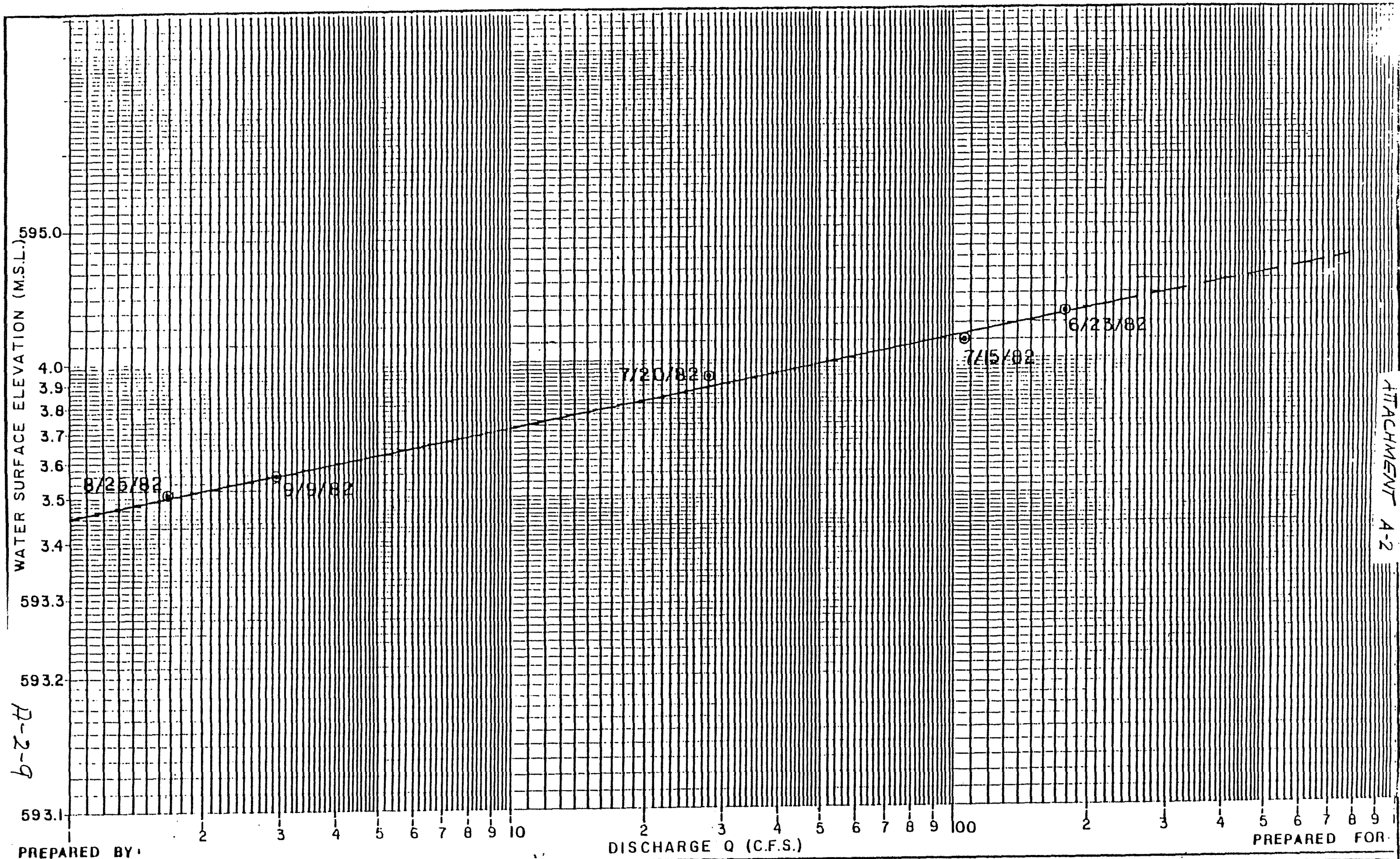
CDS
24 MAY 83 / 30 MAY 83





WORKSHEET 4
ATTACHMENT A-2

A-2-9

PREPARED BY:

R&M CONSULTANTS, INC.

STAGE DISCHARGE RATING CURVE
SLOUGH 9

PREPARED FOR:

ACRES

Figure 2.1.2

46 0707

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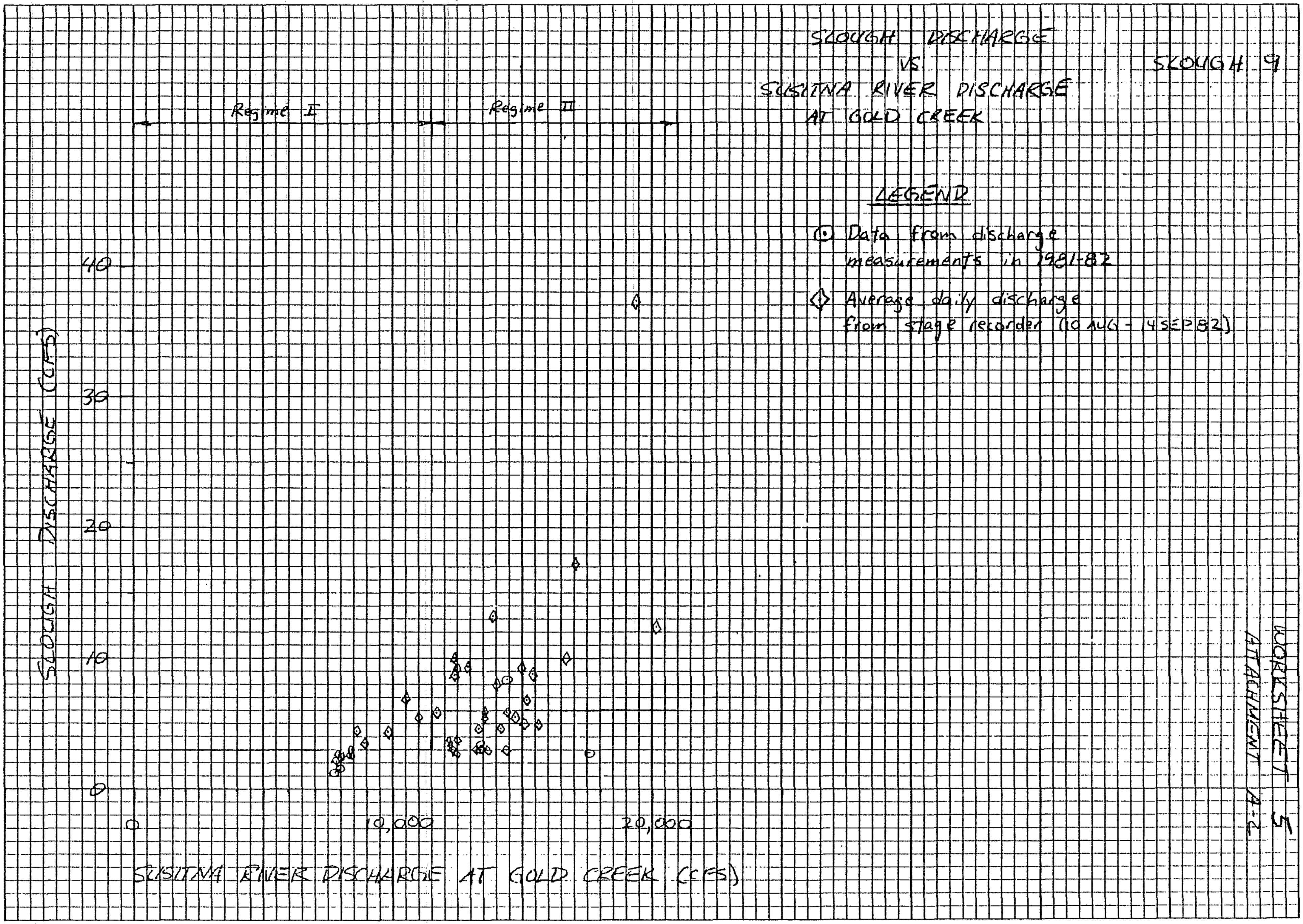
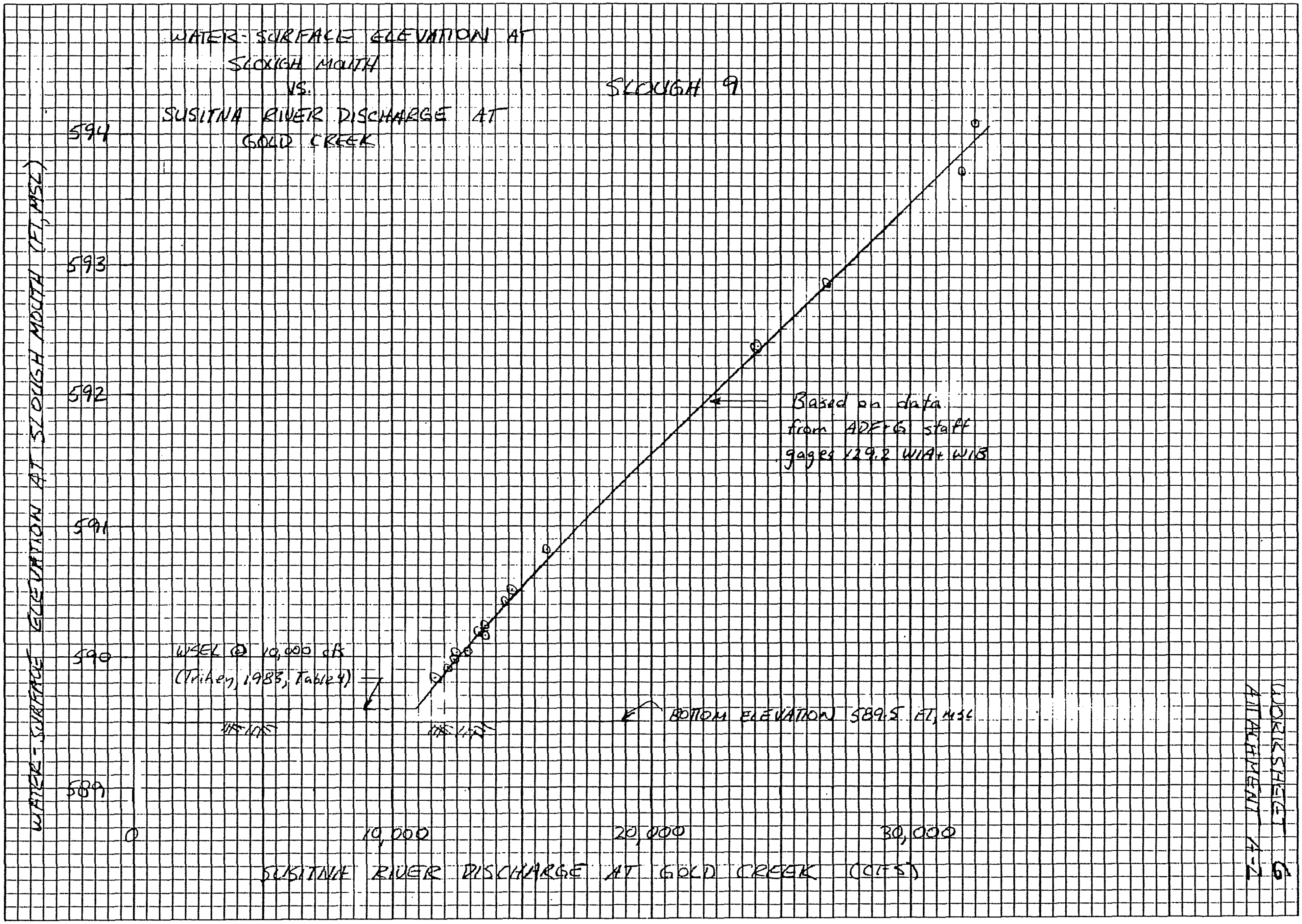
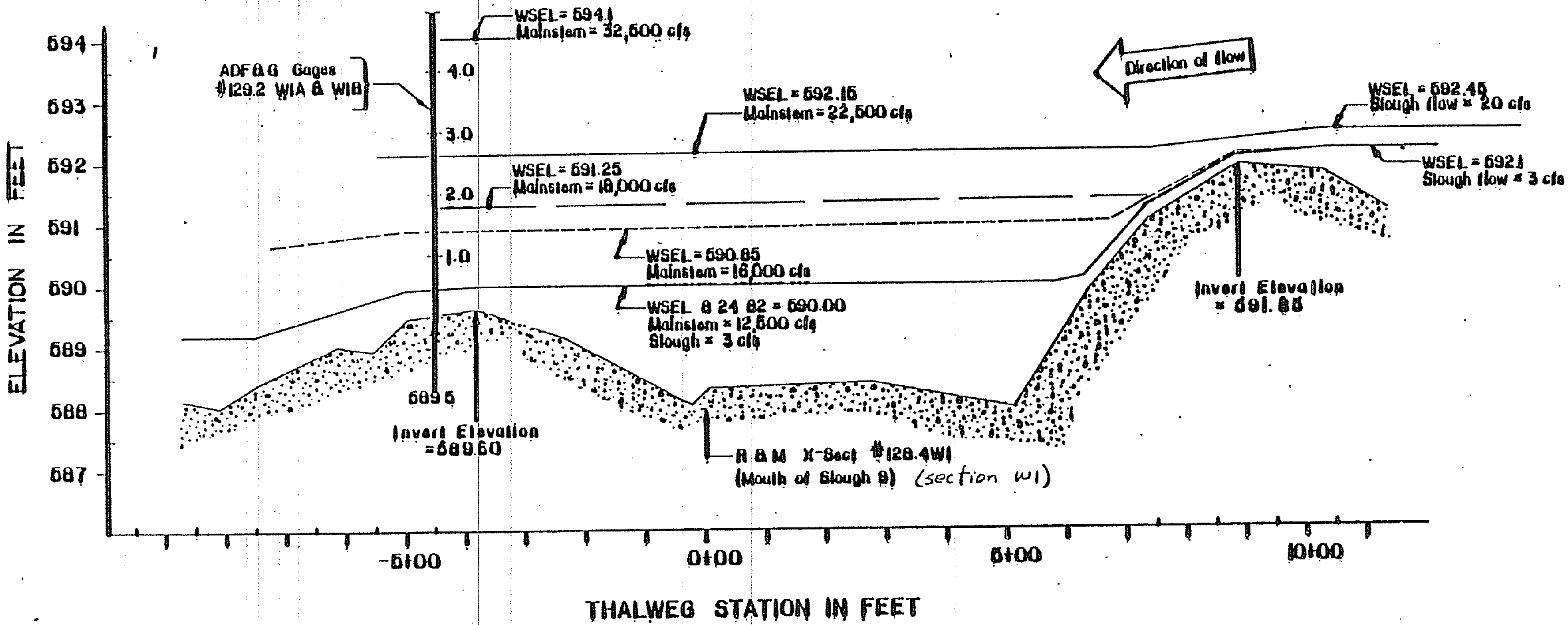
30 MAY 83



CDS
24 MAY 83

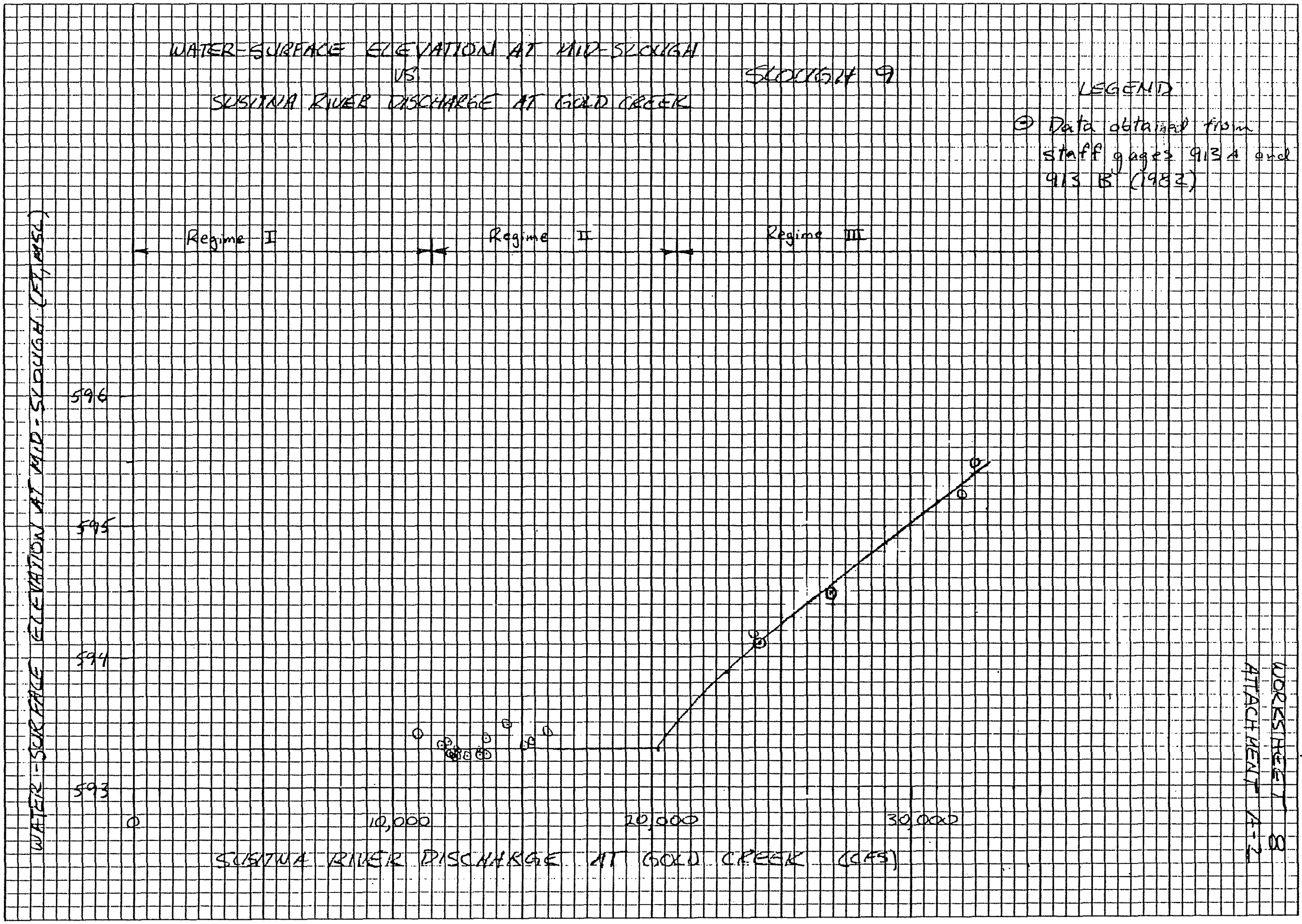

WATER-SURFACE ELEVATION AT
SLOUGH MOUTH
VS.
SUSITNA RIVER DISCHARGE AT
GOLD CREEK
SLOUGH 9
WORKSHEET 6
ATTACHMENT A-2
Based on data
from ADF+G staff
gages 129.2 W1A + W1B
WSEL @ 10,000 cfs
(Trihey, 1983, Table 4)
BOTTOM ELEVATION 589.5 FT, MSL
594
593
592
591
590
589
0
10,000
20,000
30,000
SUSITNA RIVER DISCHARGE AT GOLD CREEK (CFS)
WATER-SURFACE ELEVATION AT SLOUGH MOUTH (FT, MSL)



Worksheet 9 Thalweg and water-surface profile of mouth area of Slough 9

Worksheet 7 Attachment A-2

CDS
30 MAY 83
rev. 6/29/83

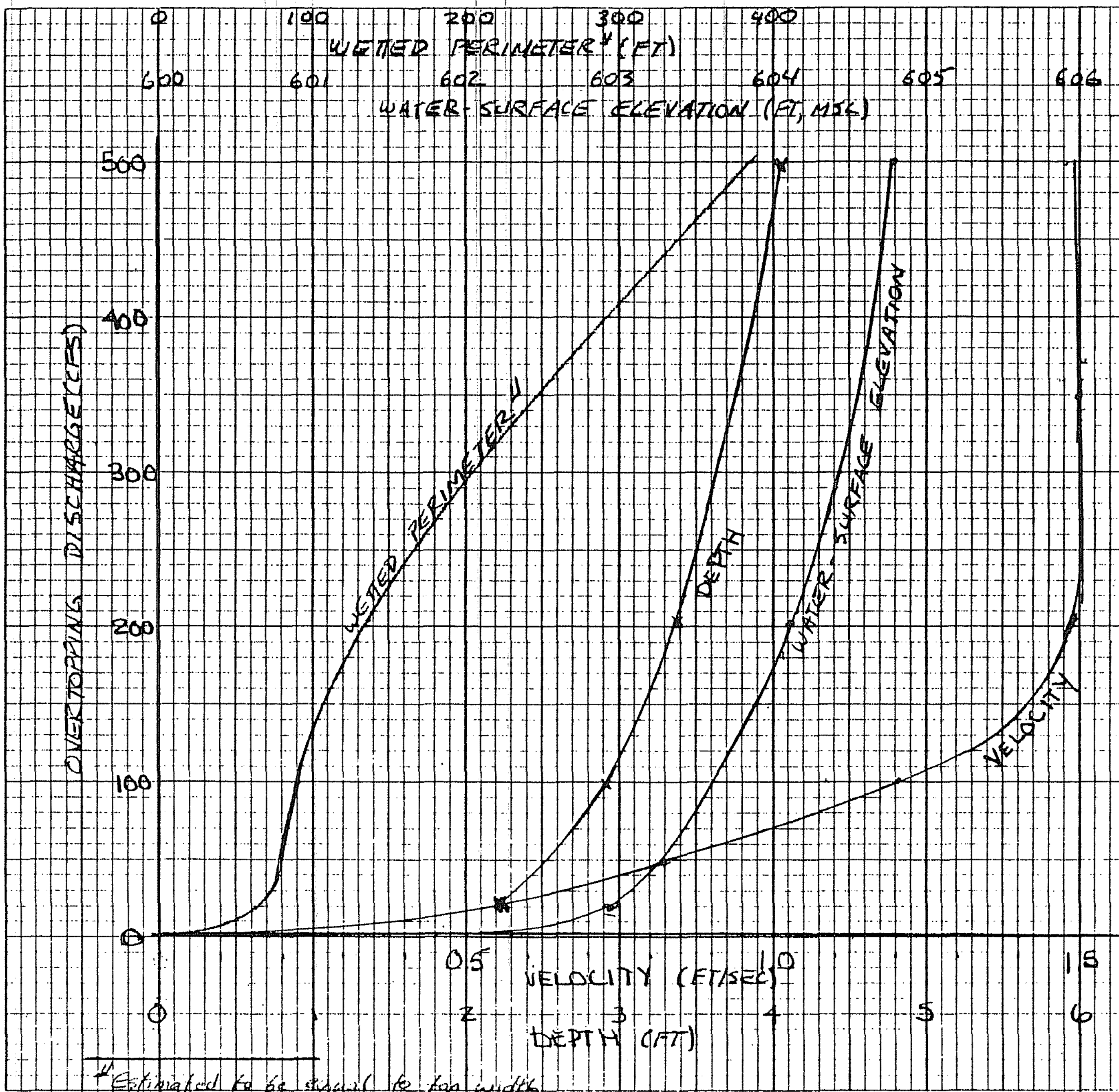


CLEARPRINT CHARTS

JTH/CWS 16 JUN83, 20 JUN83

WORKSHEET 9
ATTACHMENT A-2

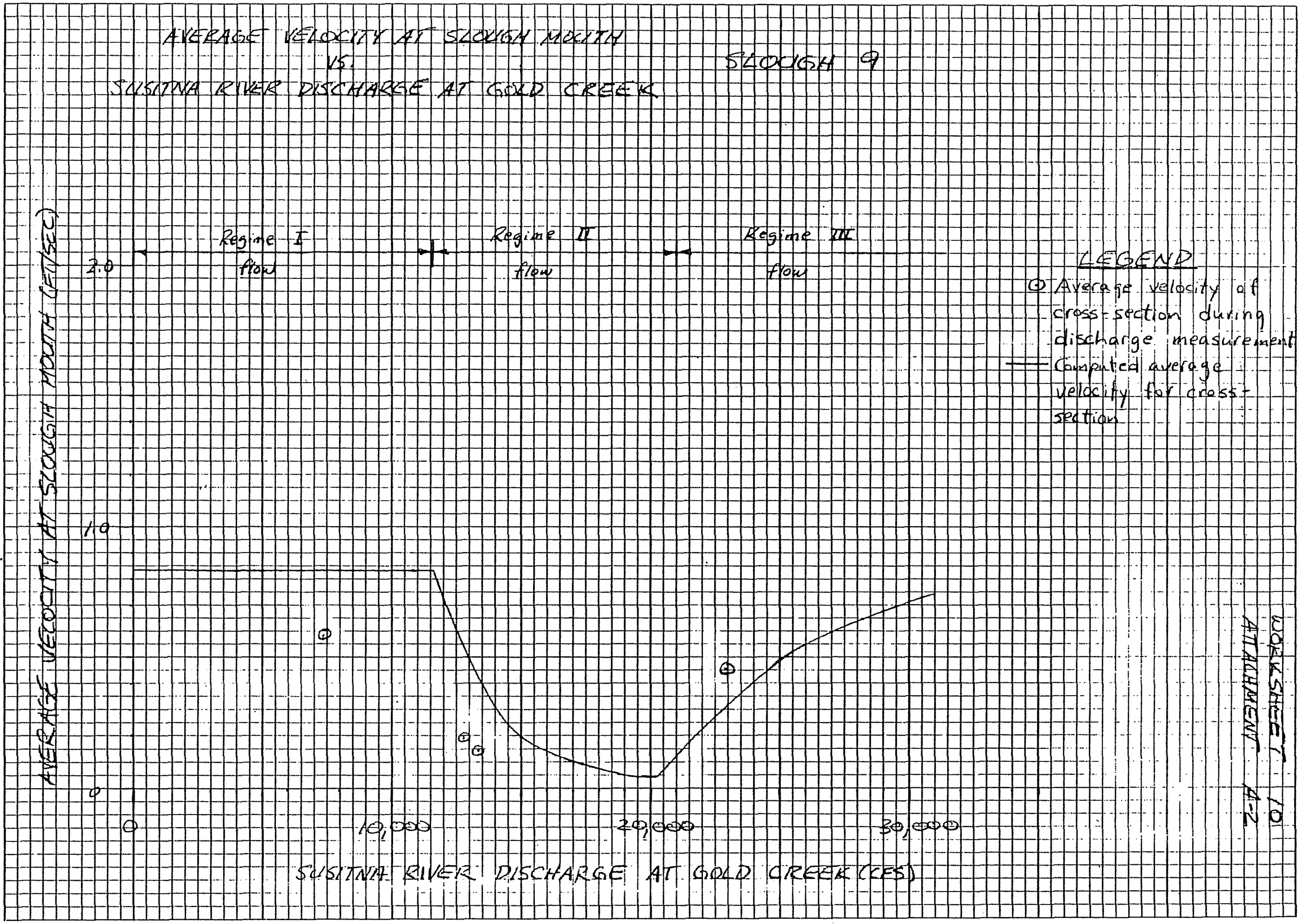
PHYSICAL HABITAT VARIABLES AT UPSTREAM END VS. OVERTOPPING DISCHARGE AND SUSITNA RIVER DISCHARGE AT GOLD CREEK
SLOUGH 9



NOTES: 1. Upstream end is section 119
2. Variables taken from HEC-2 run

¹ Estimated to be equal to top width

CDS/13 MAY 83, 17 MAY 83, 25 MAY 83, 30 MAY 83



CDS/13 MAY 83

WORKSHEET 11
ATTACHMENT A-2

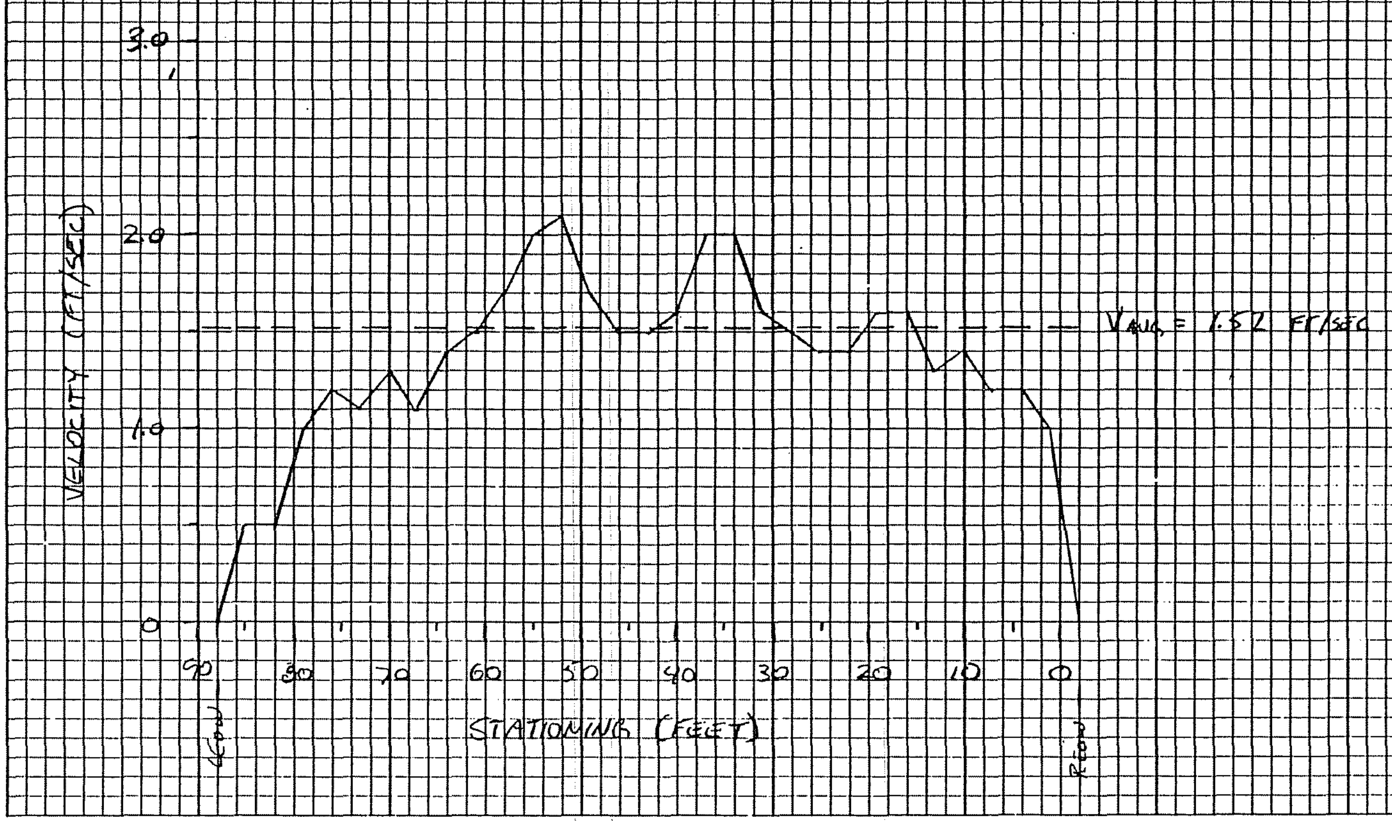
LATERAL VELOCITY DISTRIBUTION WITHIN CROSS-SECTION
~1800' U/S OF MOUTH OF
SLOUGH 9

Q_{SLOUGH} = 182.88 CFS

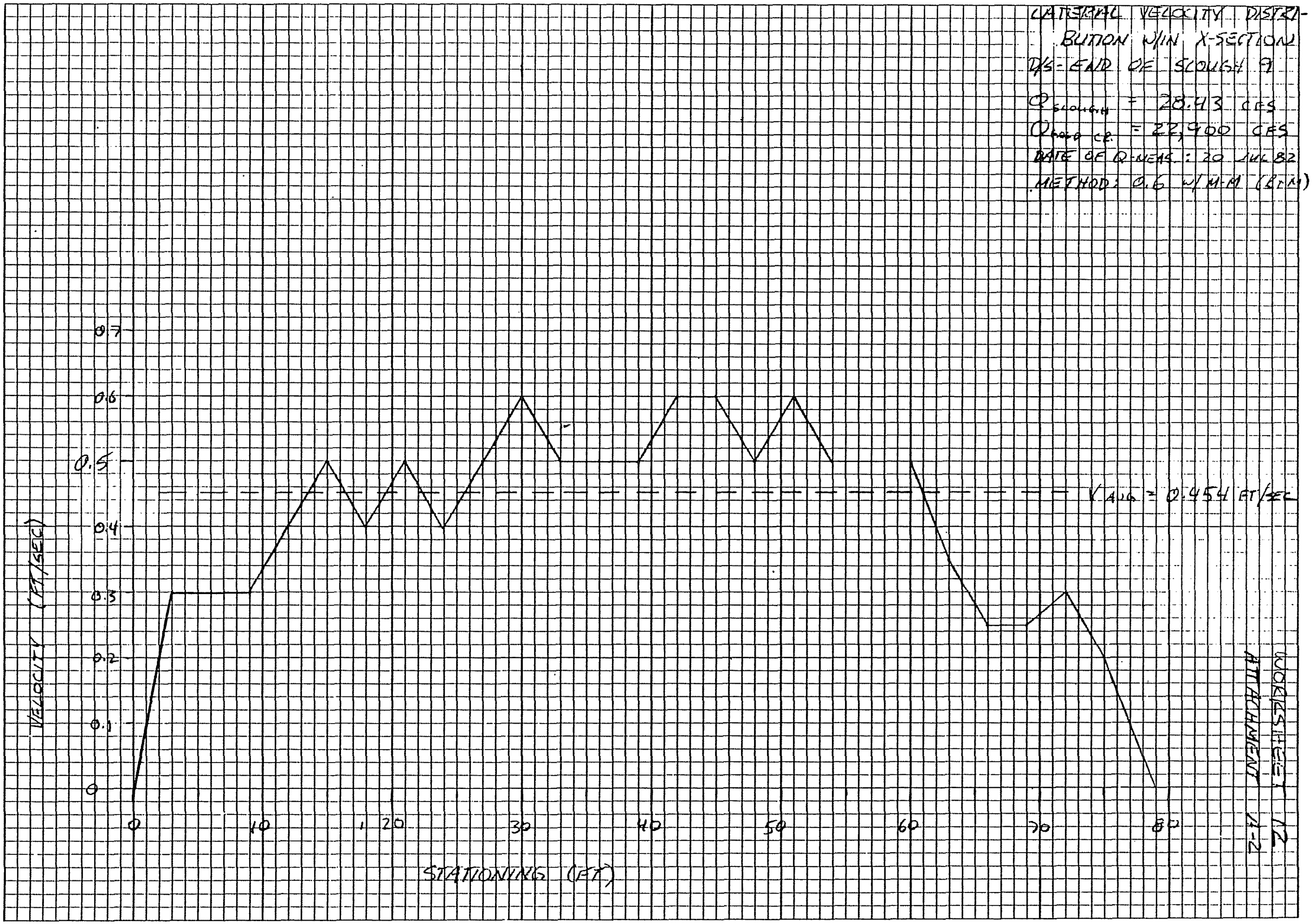
$Q_{GOLD\ CR}$ = 27,000 CFS

DATE OF Q-MEAS: 23 JUN 82

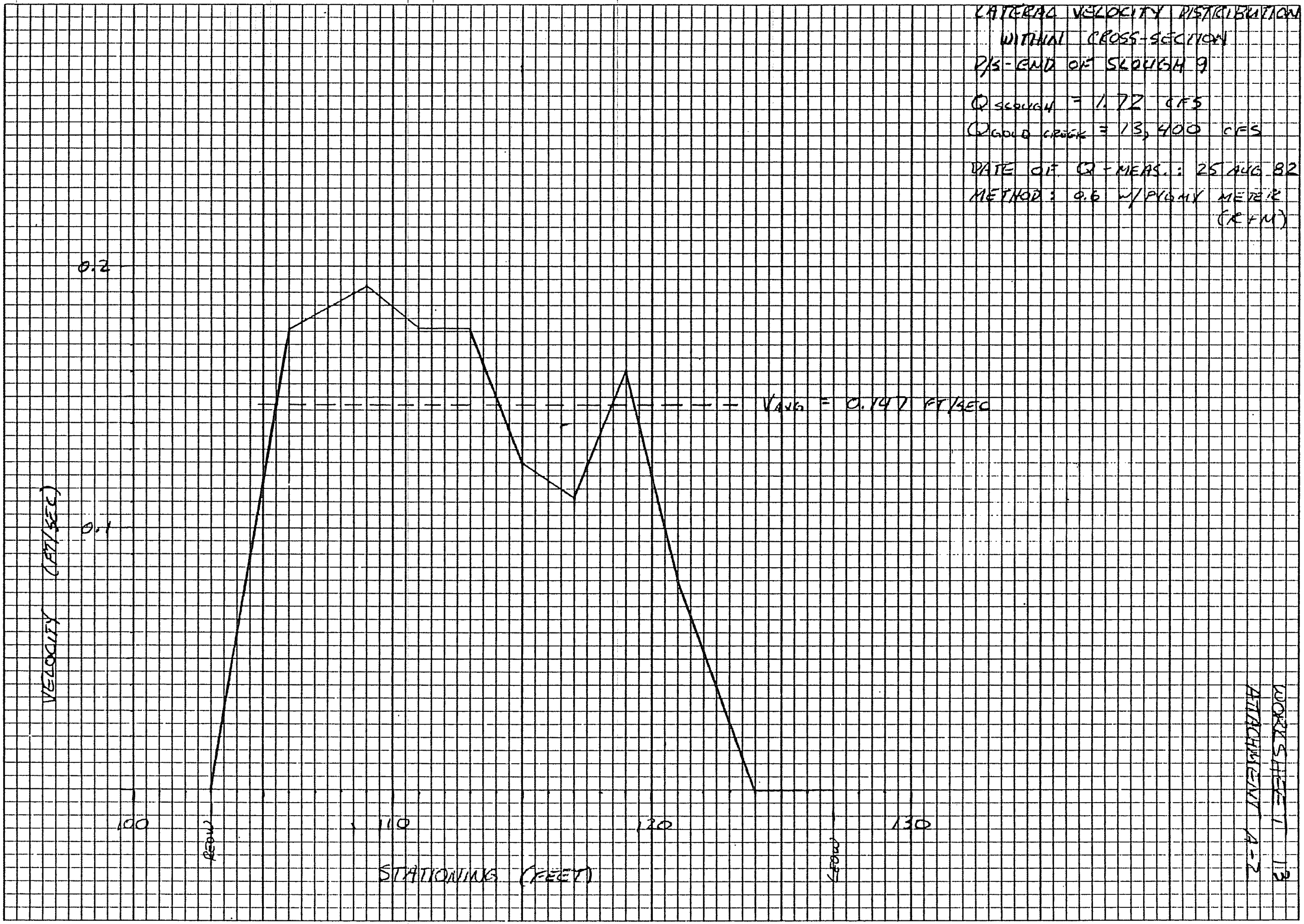
METHOD: N/A (R+M)



CDS/12 MAY 83

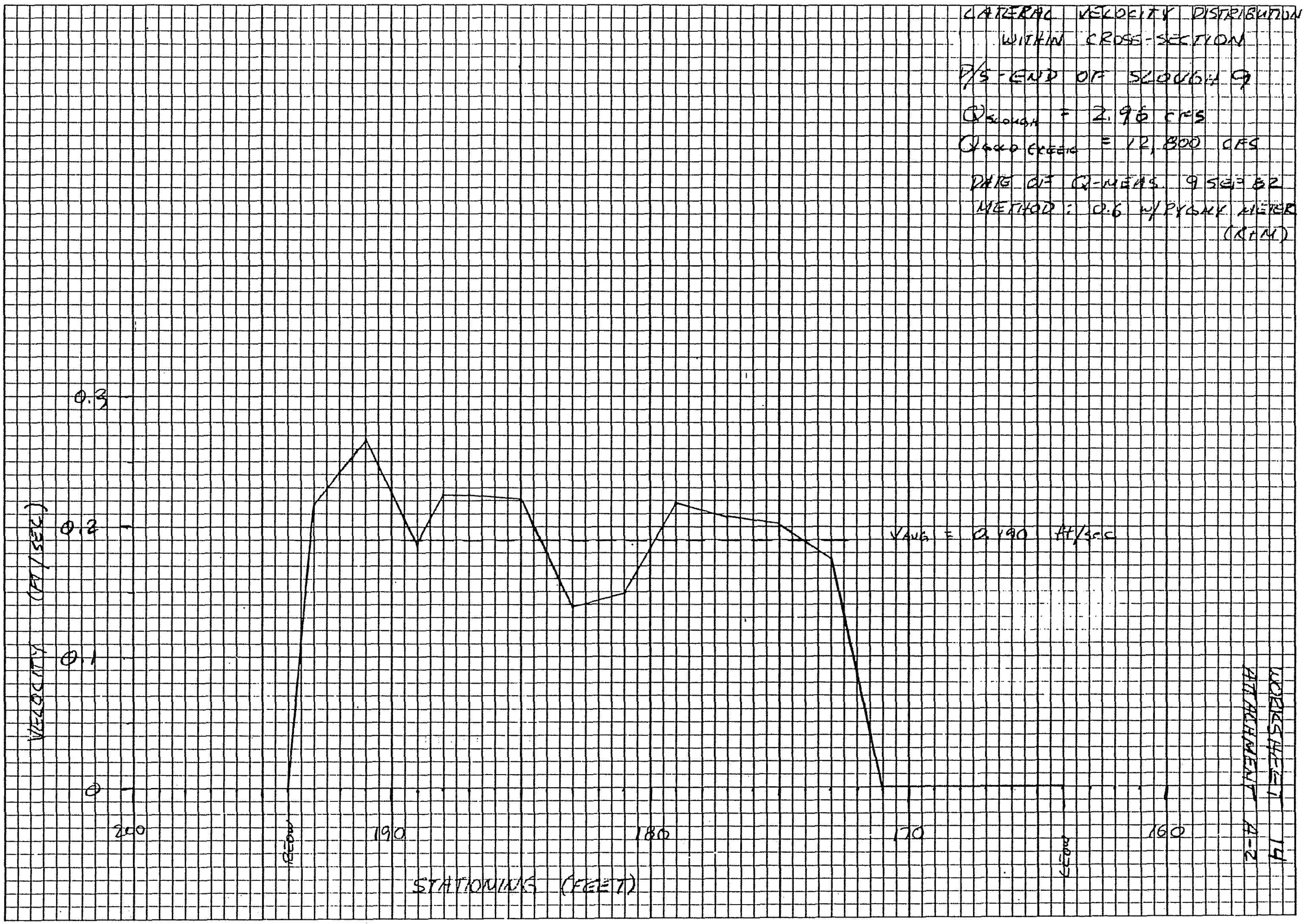

LATERAL VELOCITY DISTRIBUTION W/IN X-SECTION
D/S-END OF SLOUGH 9
Q_{SLOUGH} = 28.43 CFS
$Q_{GOLD\ CR.}$ = 22,900 CFS
DATE OF Q-MEAS: 20 JUL 82
METHOD: 0.6 W/M-M (BLM)
V_{AVG} = 0.454 FT/SEC
VELOCITY (FT/SEC)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
STATIONING (FT)
0
10
20
30
40
50
60
70
80
WORKSHEET 12
ATTACHMENT A-2

CDS/13 MAY 83


WORKSHEET 13
ATTACHMENT A-2
LATERAL VELOCITY DISTRIBUTION
WITHIN CROSS-SECTION
D/S-END OF SLOUGH 9
Q SLOUGH = 1.72 CFS
Q GOLD CREEK = 13,400 CFS
DATE OF Q-MEAS.: 25 AUG 82
METHOD: 0.6 W/PYGMY METER
(R+M)
VAVG = 0.147 FT/SEC
0.2
0.1
VELOCITY (FT/SEC)
100
110
120
130
REDW
LEDW
STATIONING (FEET)

K&E TO 1 CH • 7 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46-0707

CDS/12 MAY 83



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ODS/17 MAY 83

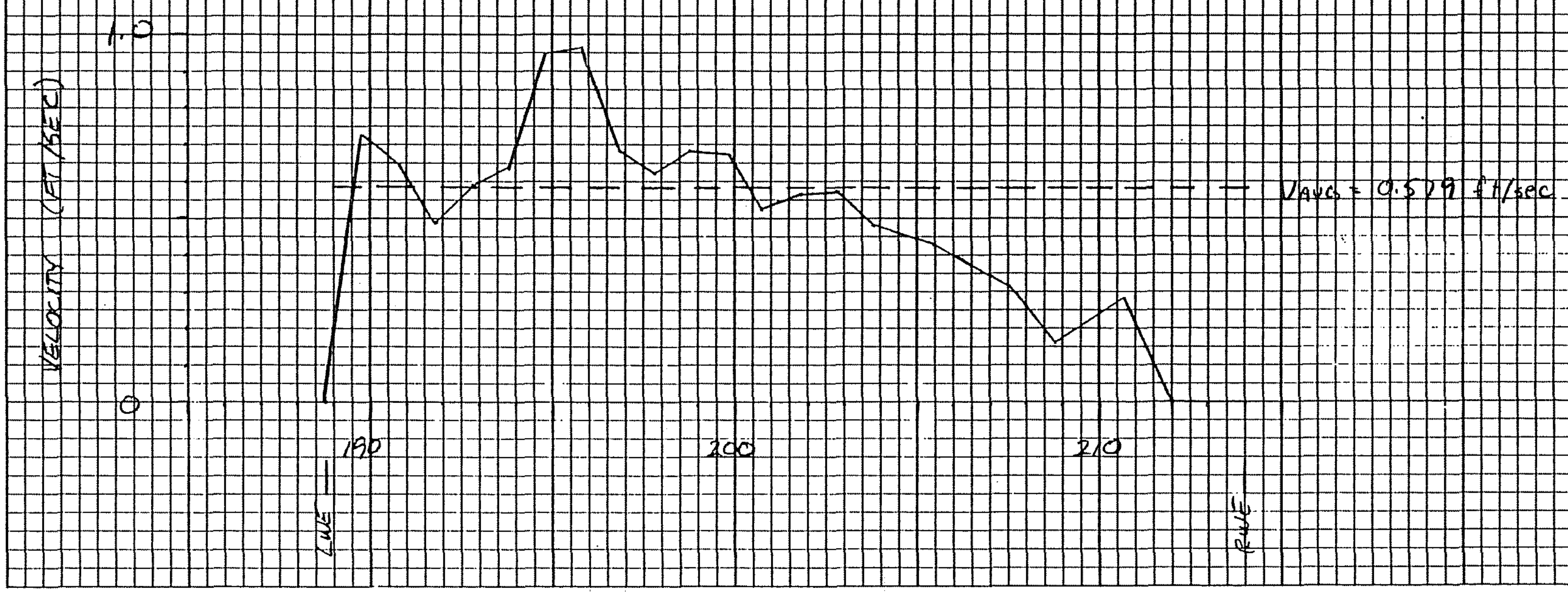
LATERAL VELOCITY DISTRI-
BUTION W/IN X-SECTION
D/S END OF SLOUGH 9

Q_{SLOUGH} = 3.865 cfs

$Q_{GOLD\ CREEK}$ = 7290 cfs

DATE OF Q-MEAS: 14OCT81

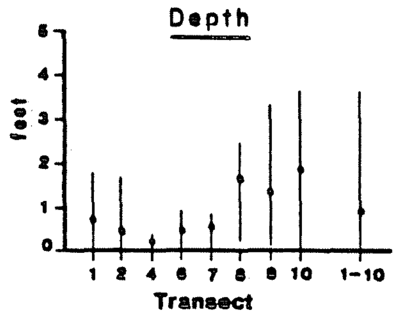
METHOD: 0.6 (METER - N/A)
(ADF&G)

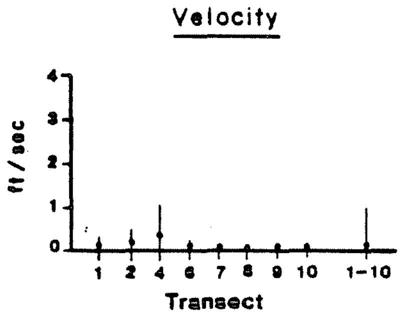


WORKSHEET 15
ATTACHMENT A-2

SLOUGH 9

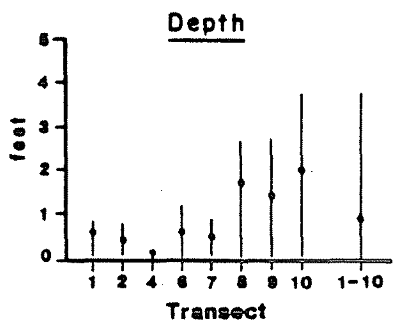
Q = 3 cfs
AUG. 25, 1982

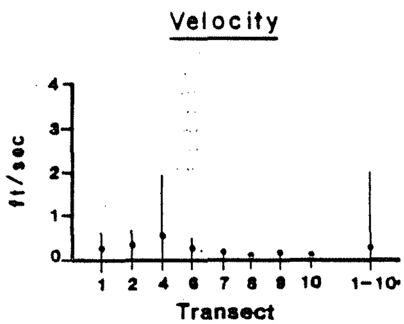




Susitna R.
discharge at Gold Creek = 13,400 cfs

Q = 8 cfs
SEPT. 4 , 1982



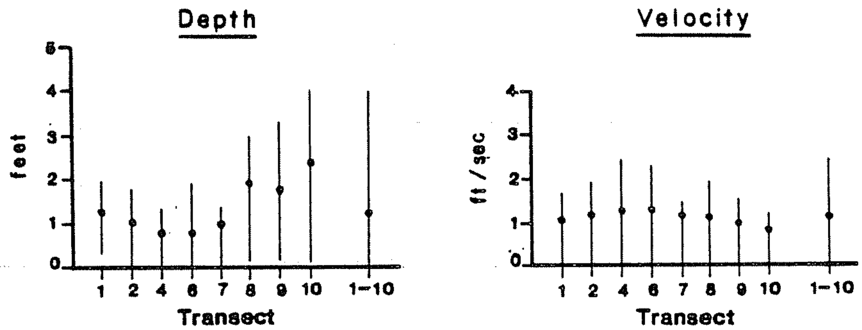


Susitna R
discharge at Gold Creek = 14,400 cfs

Worksheet 16
sheet 2 of 2
Attachment A-2

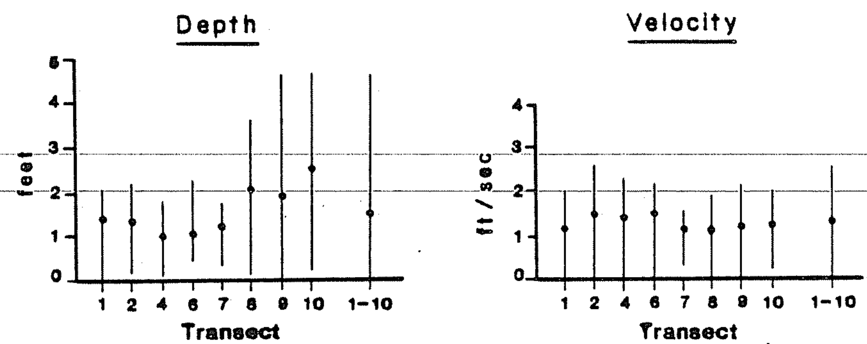
SLOUGH 9

Q = 145 cfs
SEPT. 20, 1982



Susitna R.
discharge at Gold Creek = 24,000 cfs

Q = 232 cfs
SEPT. 16, 1982



Susitna R.
discharge at Gold Creek = 26,800 cfs

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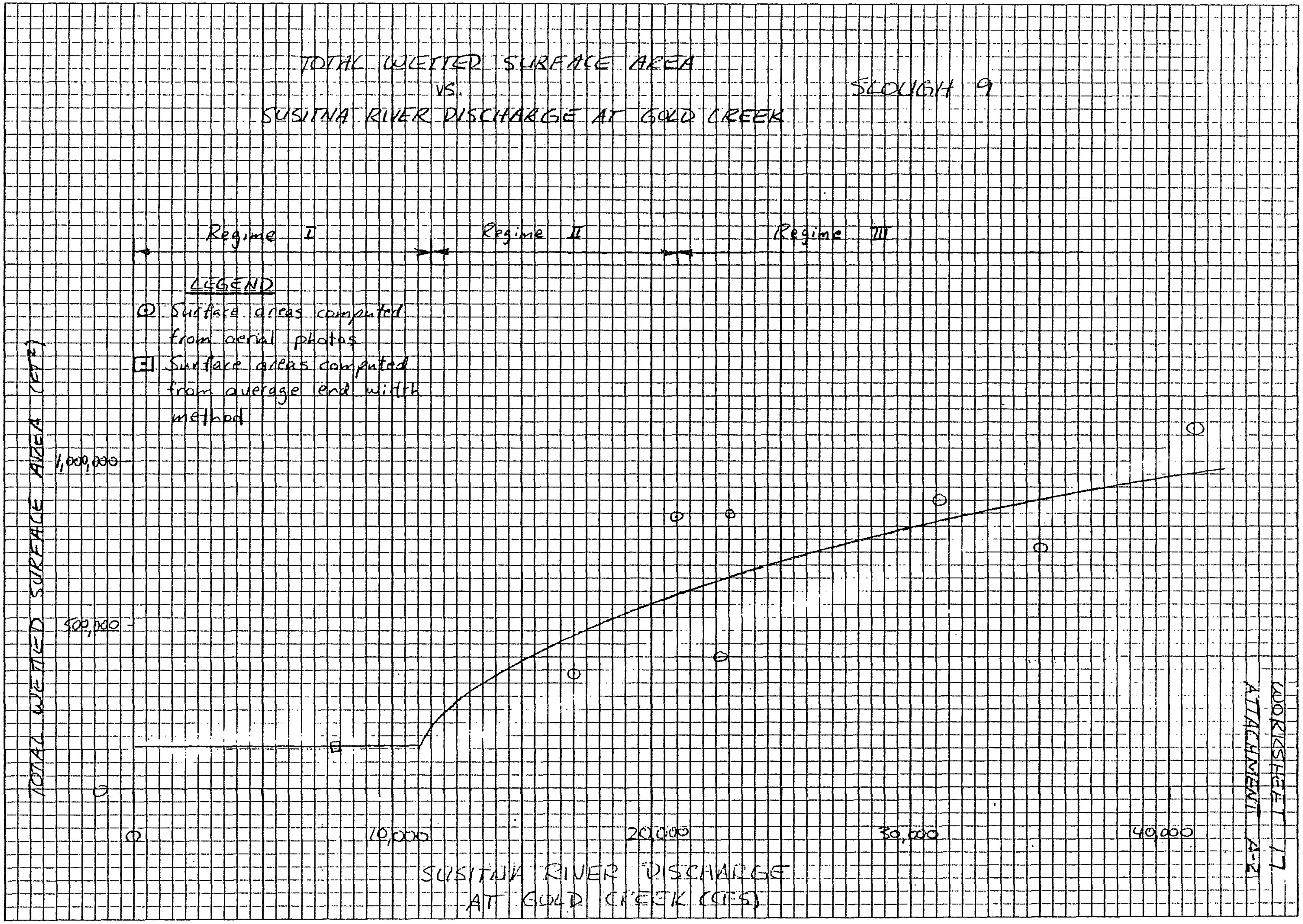
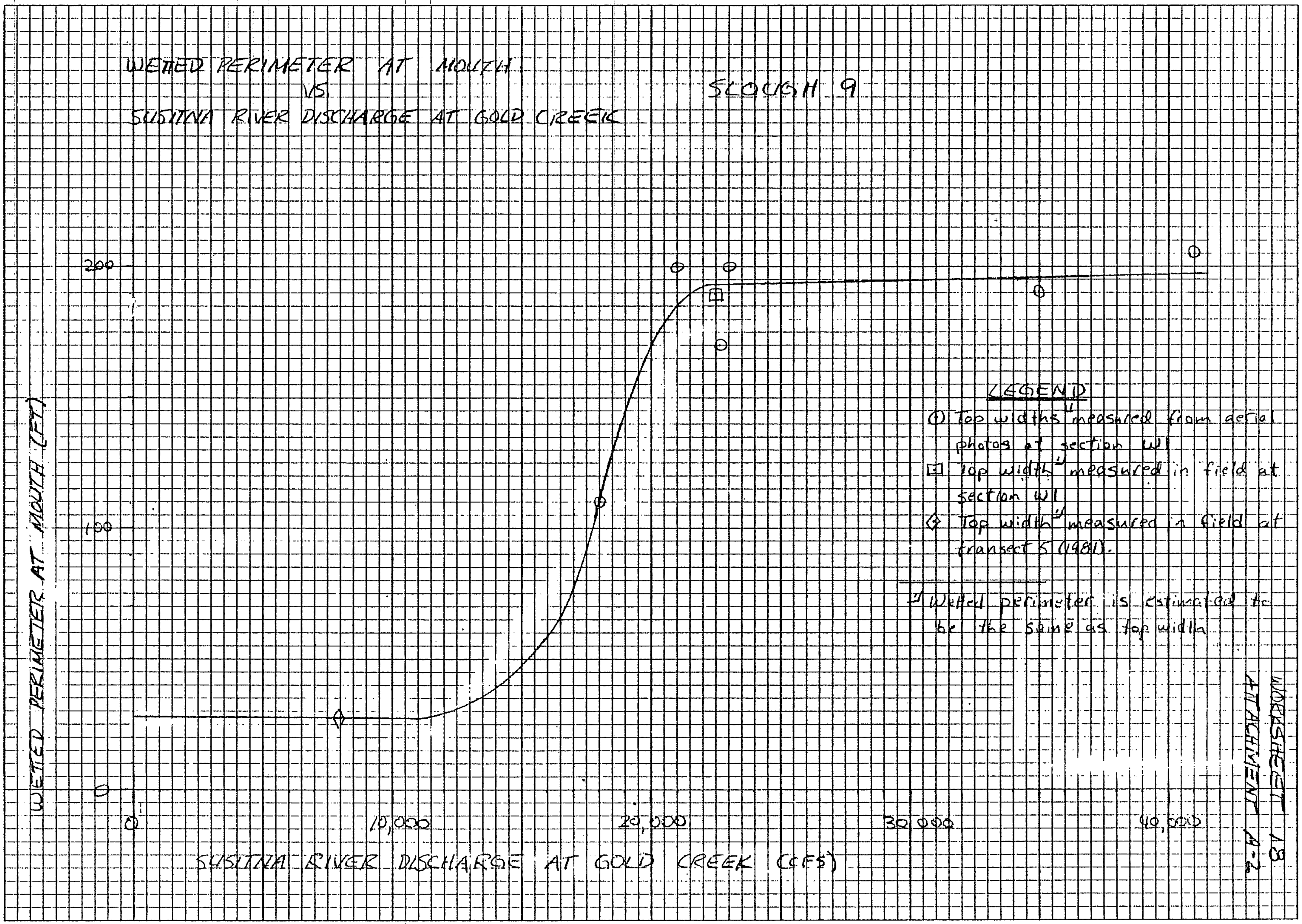
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0707

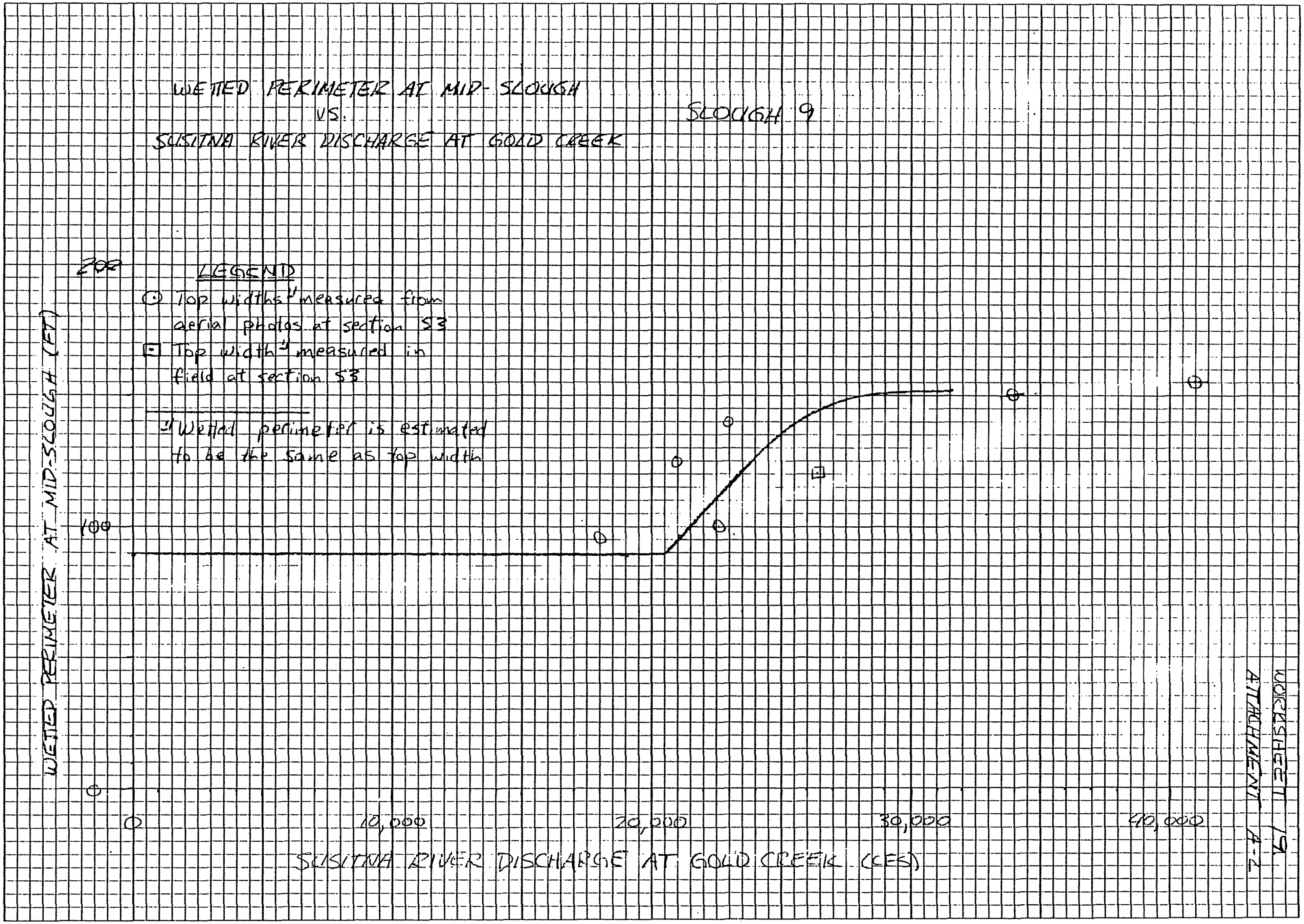
CDS
31 MAY 83 / 1 JUN 83



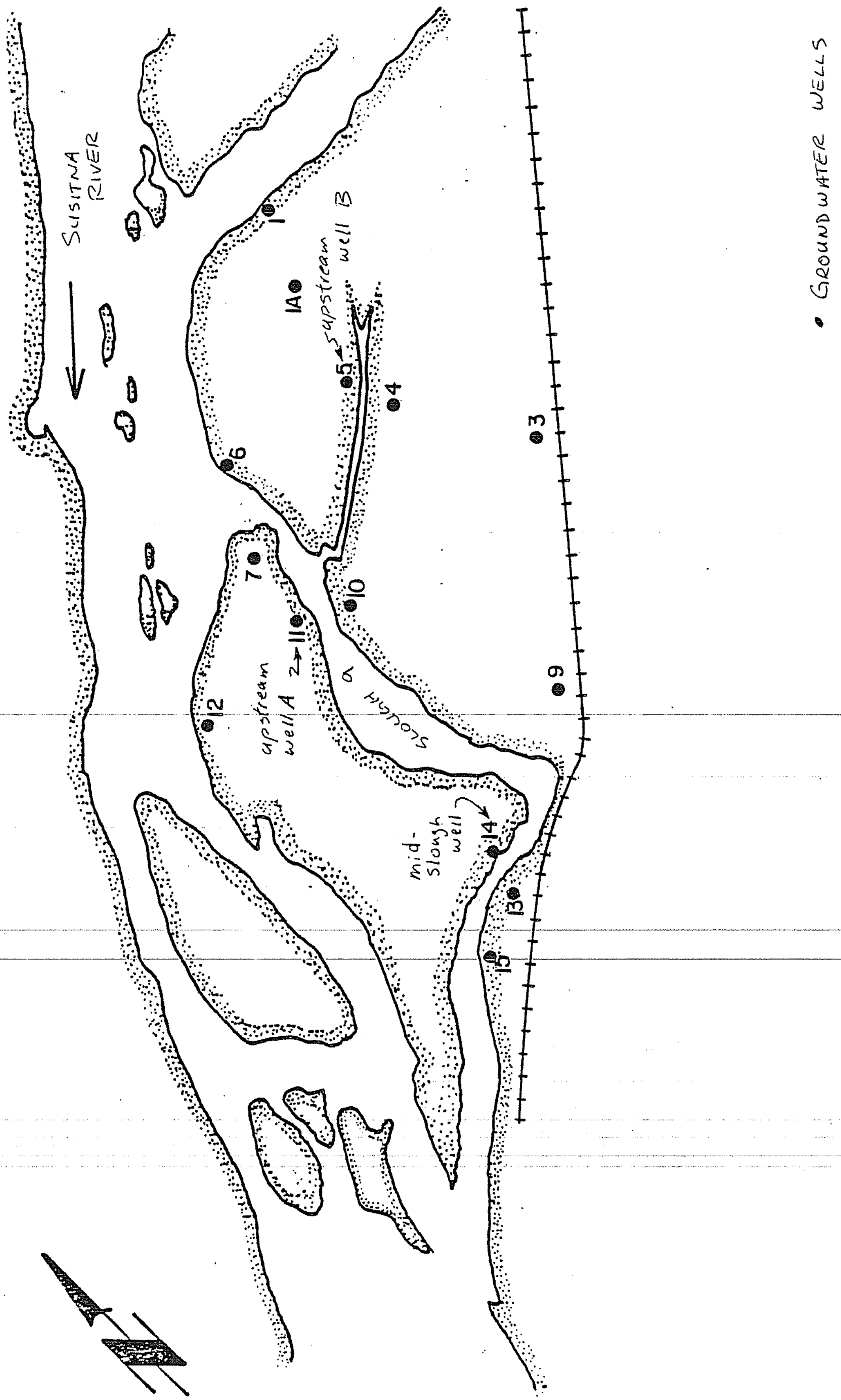
CDS
31MAY83 / 1JUN83



CDS
31 MAY 83
rev. 6/28/83



WORKSHEET 20
ATTACHMENT A-2



Worksheet 26. Location Map of Slough 9 Groundwater Wells

s6/gl

WORKSHEET 26

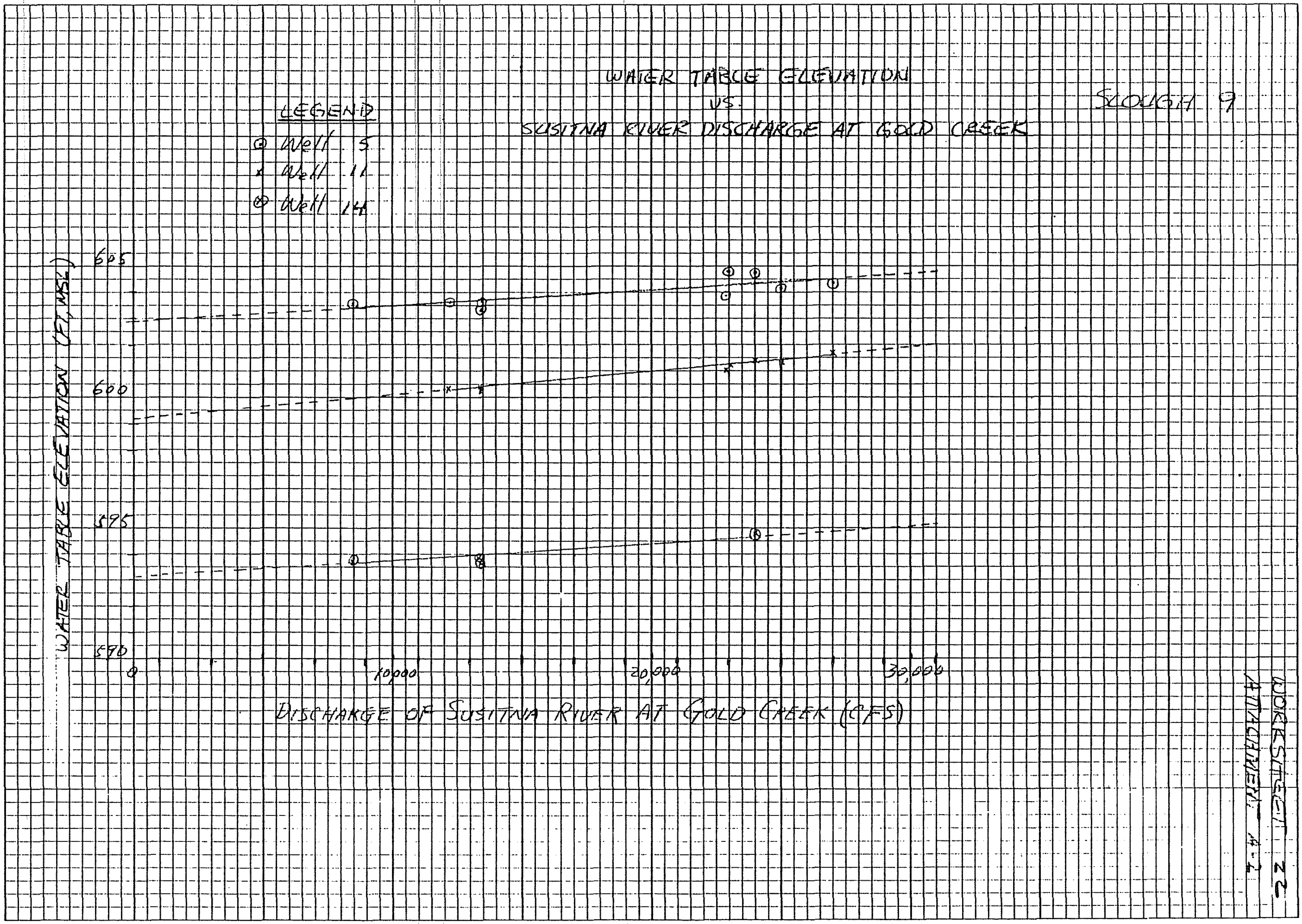
1982 GROUNDWATER ELEVATION AT SLOUGH 9 (ft, msl)

Date	9-1	9-1A	9-3	9-4	9-5 (Well 5) Upstream Well B	9-6	9-7	9-9	9-10	9-11 (Well 11) Upstream Well A	9-12	9-13	9-14 (Well 14) Mid-Slough Well	9-15	Susitna River Discharge at Gold Creek (cfs)
Apr. 26	-		603.06	603.62	603.33	d	d	603.01	600.32	600.06	598.53	d	594.14	d	1,550
May 11	607.71		605.42	604.46	604.51	604.15	602.68	-	601.20	601.21	-	694.09	594.57	593.90	10,500
May 15	-		-	-	-	-	-	-	604.00	-	-	-	-	-	15,000
May 27	607.58		606.62	604.47	604.76	604.34	602.45	-	s	601.16	599.94	s	s	s	23,000
June 23	608.50		606.66	604.77	604.40	604.91	603.02	-	s	601.69	600.64	s	s	s	27,000
July 1	607.94		606.22	604.67	604.11	604.48	602.78	604.08	s	601.38	600.40	s	s	s	25,000
July 20	607.32		605.67	604.03	603.81	604.08	602.30	-	600.99	601.07	599.55	s	s	s	22,900
Aug. 25	605.99		604.69	d	603.34	d	601.05	602.56	600.34	600.28	d	d	593.66	592.74	13,400
Sep. 6	606.16	605.50	605.70	604.16	603.61	d	601.32	604.37	600.50	600.46	-	-	-	-	12,200
Sep. 9	606.08	605.27	605.49	d	603.60	d	601.14	604.22	600.43	600.35	d	d	593.74	592.83	13,400
Sep. 20	608.01	607.07	607.65	605.23	604.74	604.62	602.78	605.07	601.37	601.49	d	594.29	594.77	-	24,000
Oct. 7	605.88	605.21	605.29	603.97	603.52	d	d	603.26	d	d	d	d	593.76	d	8,640
Oct. 15	605.81	604.85	604.91	d	603.39	d	d	602.91	d	d	d	d	593.66	d	7,110

- = not observed
s = silted
d = dry

WORKSHEET 21
ATTACHMENT 4-2

17-9-67


WATER TABLE ELEVATION
VS.
SUSITNA RIVER DISCHARGE AT GOLD CREEK
SLOUGH 9
LEGEND
Well 5
Well 11
Well 14
WATER TABLE ELEVATION (FT, MSL)
605
600
595
590
0
10000
20,000
30,000
DISCHARGE OF SUSITNA RIVER AT GOLD CREEK (CFS)
WORKSHEET 22
ATTACHMENT A-2

ATTACHMENT

PART 3

SLOUGH 21 PHYSICAL HABITAT VARIABLES

ATTACHMENT
PART 3
SLOUGH 21 PHYSICAL HABITAT VARIABLES

Slough Description

Slough 21 is located near River Mile 142. A vicinity map and a thalweg profile are shown in Worksheets 1 and 2, respectively. Worksheet 2 shows that Slough 21 is located in the upstream end of a larger slough system called the Slough 21 Complex. In fact, Slough 21 does not flow into the Susitna River directly, but into the Slough 21 Complex. Slough 21 has an intermediate berm and an upstream berm. The slough is about 0.5 miles long.

Slough Discharge

Worksheet 3 shows slough discharge values plotted against Susitna River discharges at Gold Creek. The slough discharges were determined by:

- seven discharge measurements made downstream of transect 7 (see Worksheet 1) during 1981 and 1982.

- average daily discharges from August 10 until October 22, 1982 determined by applying stage data to rating curves.

Worksheets 3 and 7 were used to estimate the threshold discharge for Regime II-A to occur to be about 24,800 cfs.

Worksheet 4 shows the slough discharge plotted against the mainstem discharges for Regime I and II flow only. It shows that Regime II has slightly higher slough discharge than Regime I. Constant slough discharge values were used for Regimes I and II. The values of slough discharge shown in Table A-4 of Appendix E.2.A., are derived from Worksheets 3 and 4.

Slough Water-Surface Elevation

Worksheet 5 shows water-surface elevations at the mouth of Slough 21 plotted against Susitna River discharges at Gold Creek. The elevations were determined from staff gage readings at Gage 142.0W5 (see Worksheet 1). Worksheet 4 was used to estimate the threshold discharge between Regimes I and II. The water-surface elevations at the mouth of Slough 21 presented in Table A-4 of Appendix E.2.A., were determined from Worksheet 5.

Worksheet 6 shows water surface elevations at mid-slough plotted against Susitna River discharges at Gold Creek. The elevations were determined from:

- staff gage readings at Gage 142.0S6 (see Worksheet 1).

- average daily water surface elevations from stage data charts at the recording gage (see Worksheet 1).

The water surface elevations at mid-slough shown in Table A-4 of Appendix E.2.A., were determined from Worksheet 6.

Worksheet 7 shows water surface elevations at the intermediate berm plotted against Susitna River discharges at Gold Creek. The elevations were determined from staff gage 142.0H3 (see Worksheet 1). Worksheet 7 was used to confirm the threshold discharge estimate for Regime II-A (24,800 cfs). The values of water surface elevations at the intermediate berm for Slough 21, shown in Table A-4 of Appendix E.2.A, were determined from Worksheet 7.

Worksheet 8 shows water surface elevations at the upstream berm plotted against Susitna Rivers discharge at Gold Creek. The elevations were determined from staff gage 142.0H1 (see Worksheet 1). The elevations plotted in Worksheet 1 were insufficient to estimate a threshold discharge for Regime III to occur. However, this value has been estimated to be about 26,000 cfs based on field observations (ADF&G, 1983, Table 4I-3-2, p.43). The values of water surface elevations at the upstream berm of Slough 21, shown in Table A-4 of Appendix E.2.A, were determined from Worksheet 8.

<u>Slough Depths</u>

The depths of flow at the mouth, mid-slough, intermediate berm, and upstream berm of Slough 21 were determined by subtracting the corresponding thalweg elevations from the water surface elevations.

Transect 13 (surveyed in 1981) is located adjacent to staff gage 142.0W5 at the mouth of Slough 21 (see Worksheet 1); the thalweg is at 743.15 ft. msl. This value was subtracted from the water surface elevations at the slough mouth to obtain flow depths at the mouth. These depths are shown in Table A-4 of Appendix E.2.A.

The thalweg elevation at mid-slough was determined for a cross-section obtained from the discharge measurement on September 16, 1982 at the stage recorder. The value, 744.37, was subtracted from the water surface elevations at mid-slough to obtain flow depths at mid-slough shown in Table A-4 of Appendix E.2.A. The thalwegs of the intermediate and upstream berms were estimated to be respective elevations of zero flow of their staff gages (see Worksheets 7 and 8). Those elevations, 754.6 and 755.5 ft. msl, respectively, were subtracted from the intermediate and upstream berm water surface elevations to obtain flow depths for the two berms. The flow depths are shown in Table A-4 of Appendix E.2.A.

Slough Velocities

The average velocities at the mouth were determined using the following procedures:

- o an elevation vs. cross-sectional area relationship was determined for transect 13 (surveyed in 1981). (See Worksheet 1 for location).

- o the slough discharges, determined from Worksheets 3 and 4, were divided by the corresponding cross-sectional areas at transect 13 to determine the average velocities.

This procedure was used to determine the average velocities at the mouth presented in Table A-4 of Appendix E.2.A.

The average velocities at mid-slough were determined by the following procedures:

- o field measurements of average velocity at the stage recorder (see Worksheet 1) were plotted against Susitna River discharge at Gold Creek.

- o a relationship was visually fitted (see Worksheet 9).

The average velocities at the mid-slough determined from this procedure are shown in Table A-4 of Appendix E.2.A.

The average velocities at the intermediate berm were determined by the following procedures:

- o a cross-section was estimated for the intermediate berm staff gage site (Gage 142.0H3). The estimate was obtained by adjusting the elevations of a nearby section (transect 1, surveyed in 1981) such that the thalweg of the section matched the elevation of zero flow for the staff gage.

- o an elevation-area relationship was developed for this estimated section.

- o the slough discharge, determined from Worksheets 3 and 4, were divided by corresponding cross-sectional areas at the estimated section to obtain average velocities at the upstream berm.

The shape of the estimated section caused the average velocity to decrease slightly with an increase in depth. This is because a relatively large increase in area occurs compared with a small increase in discharge.

The average velocities at the intermediate berm determined from this relationship are shown in Table A-4 of Appendix E.2.A.

The velocities over the upstream berm were not computed because discharge over the upstream berm is negligible for the range of Susitna River discharges at Gold Creek being analyzed.

To supplement the average velocities shown in Table A-4 of Appendix E.2.A, the following was provided:

- o lateral velocity distributions obtained from discharge measurements (Worksheets 10 through 14)
- o velocity and depth ranges from transects 1 through 8 (1982) for three discharge conditions (Worksheet 15). It should be noted that transects 1 through 7 are located downstream of the mouth of Slough 21; transect 8 is located at the mouth.

Slough Wetted Surface Area

Worksheet 16 shows total wetted surface areas plotted against Susitna River discharges at Gold Creek for Slough 21. The surface areas were computed from aerial photos of Slough 21 under various mainstem discharge conditions. Worksheet 16 was used to determine the surface area values presented in Table A-4 of Appendix E.2.A.

Slough Wetted Perimeters

The wetted perimeter was estimated to be equal to the top width for this study. This is a reasonable estimate for flat, shallow cross-sections. Field observations confirm that flat, shallow cross-sections are typical in Slough 21. Top widths were determined by the following methods:

- o measurements from aerial photos
- o field survey

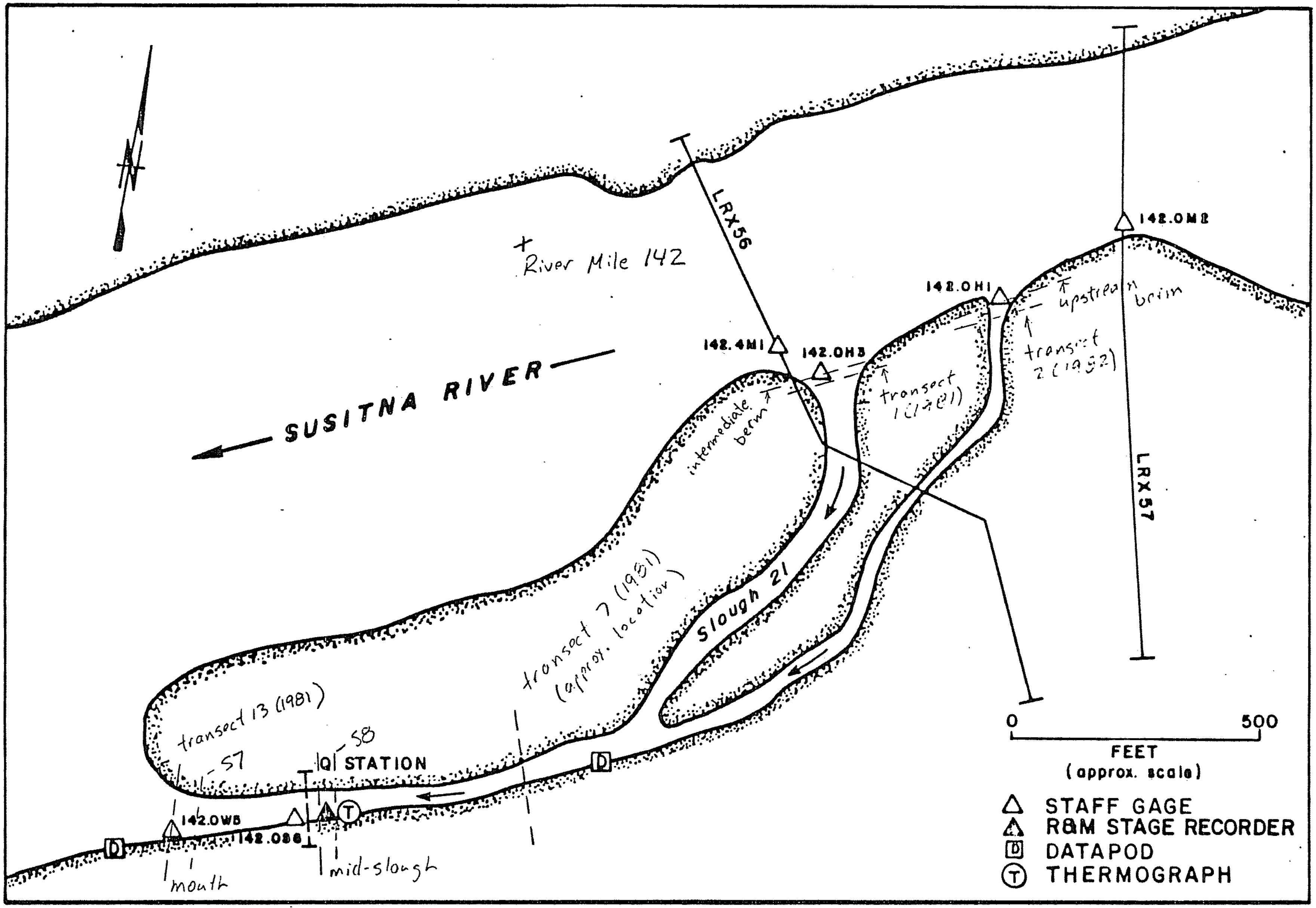
They were computed for the following sections:

- o S7 (at mouth)
- o S8 (at mid-slough)
- o transect 1, surveyed in 1981 (at intermediate berm)
- o transect 1A, surveyed in 1991 (at upstream berm)

Worksheets 17 through 20 show wetted perimeters at these sections plotted against Susitna River discharges at Gold Creek. These worksheets were used to determine the values of wetted perimeter shown in Table A-4 of Appendix E.2.A.

Slough Water Table Elevations

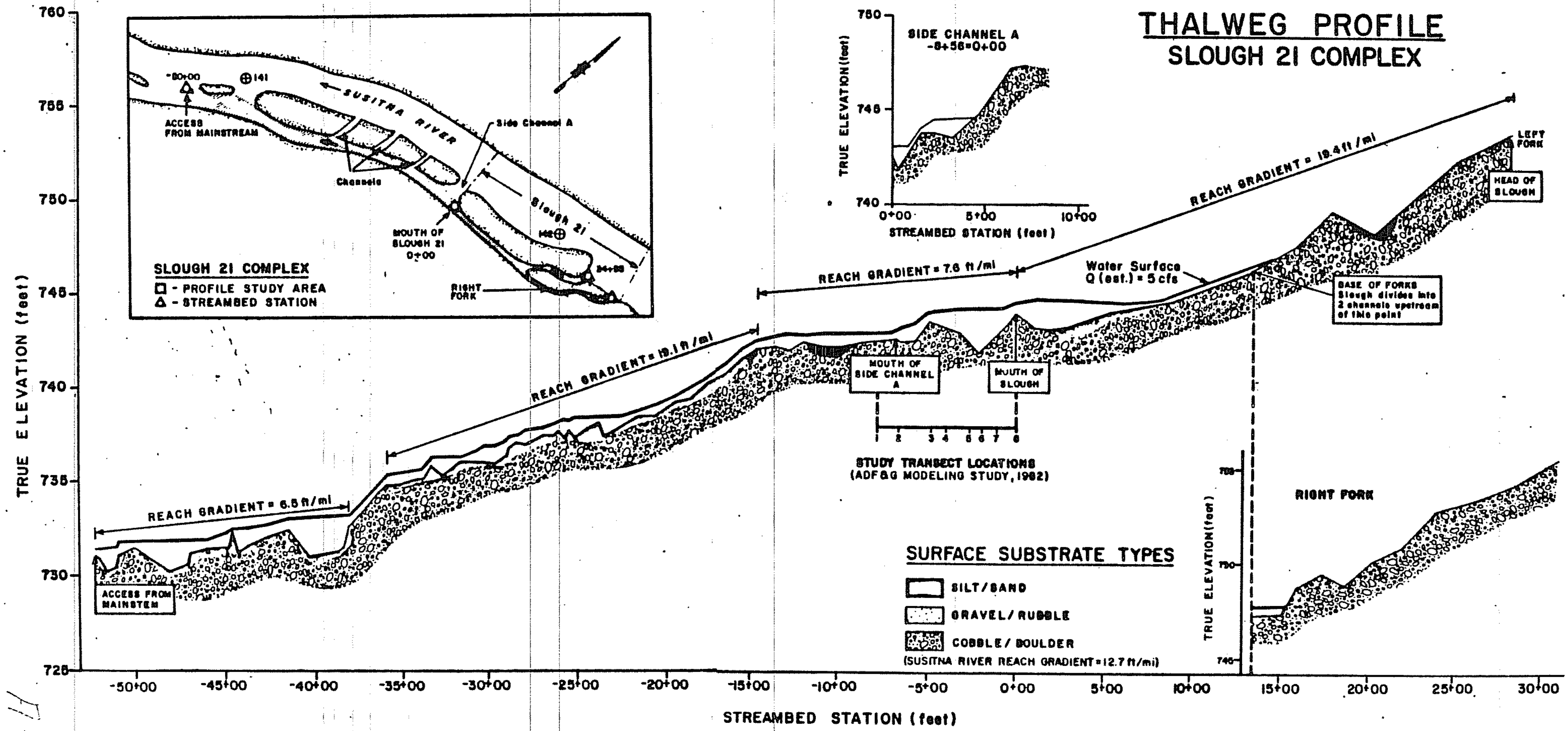
At the present time there are no data on the groundwater regime of Slough 21. However the geologic materials at this slough are expected to be similar to what is found at Sloughs 8A and 9 (mainly gravels and cobbles). Because of the expected similarity of the physical framework, the water-table elevation versus mainstem discharge relationship is expected to be similar to what was found at Sloughs 8A and 9.



WORKSHEET 1 ATTACHMENT 1.5

WORKSHEET 1 : SLOUGH 21 VICINITY MAP

WORKSHEET 2



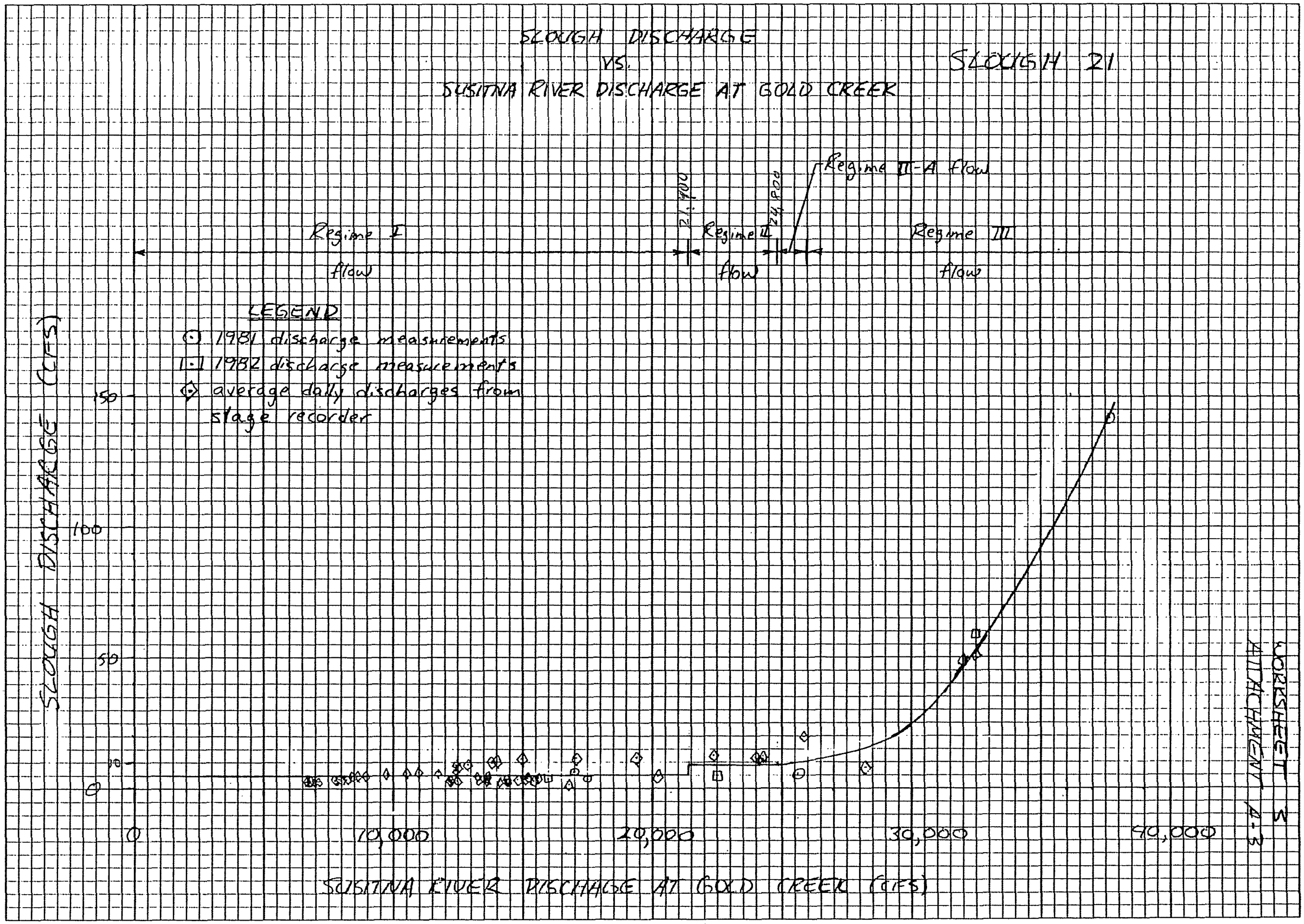
WORKSHEET 2

F.3-6

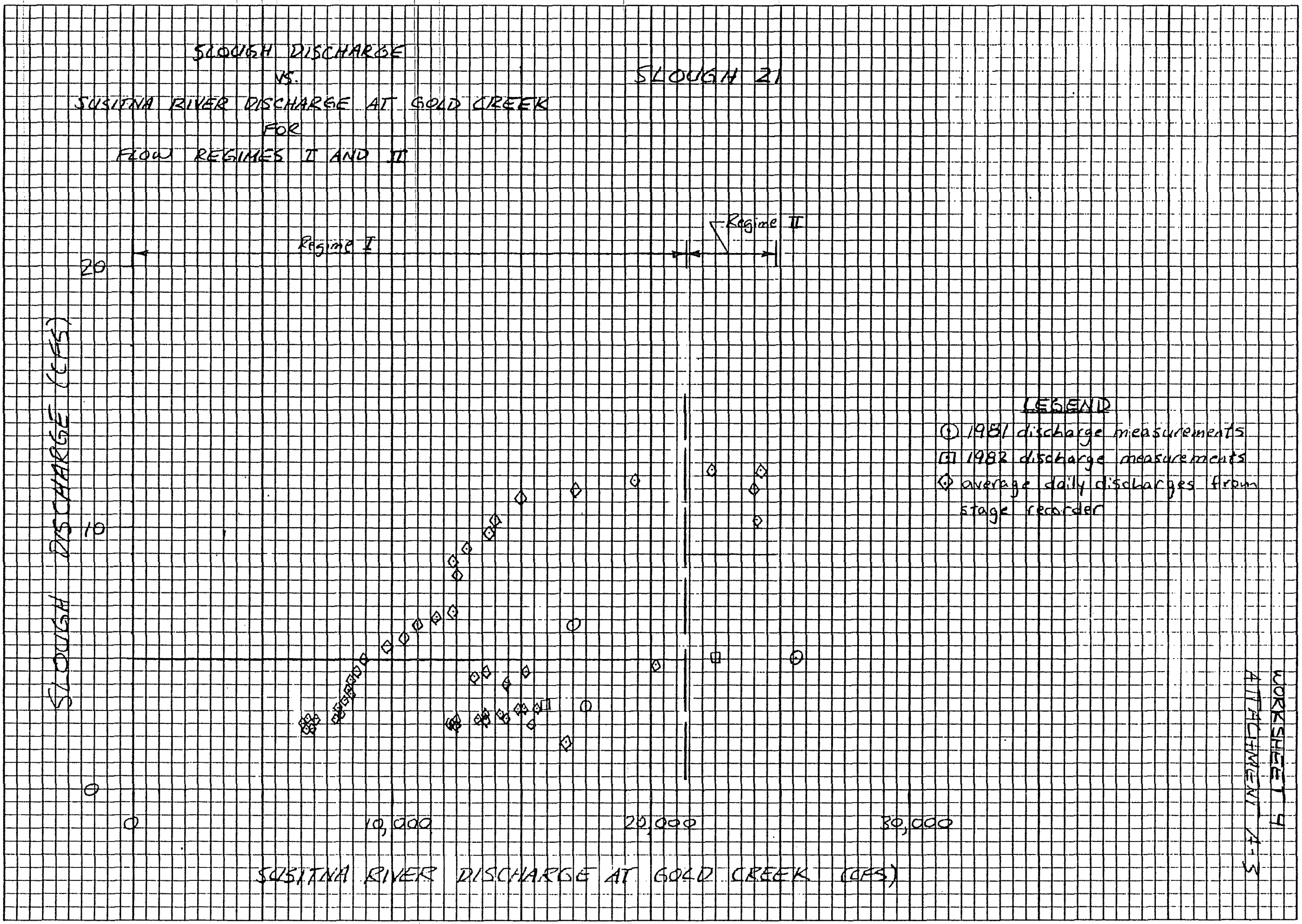
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0707

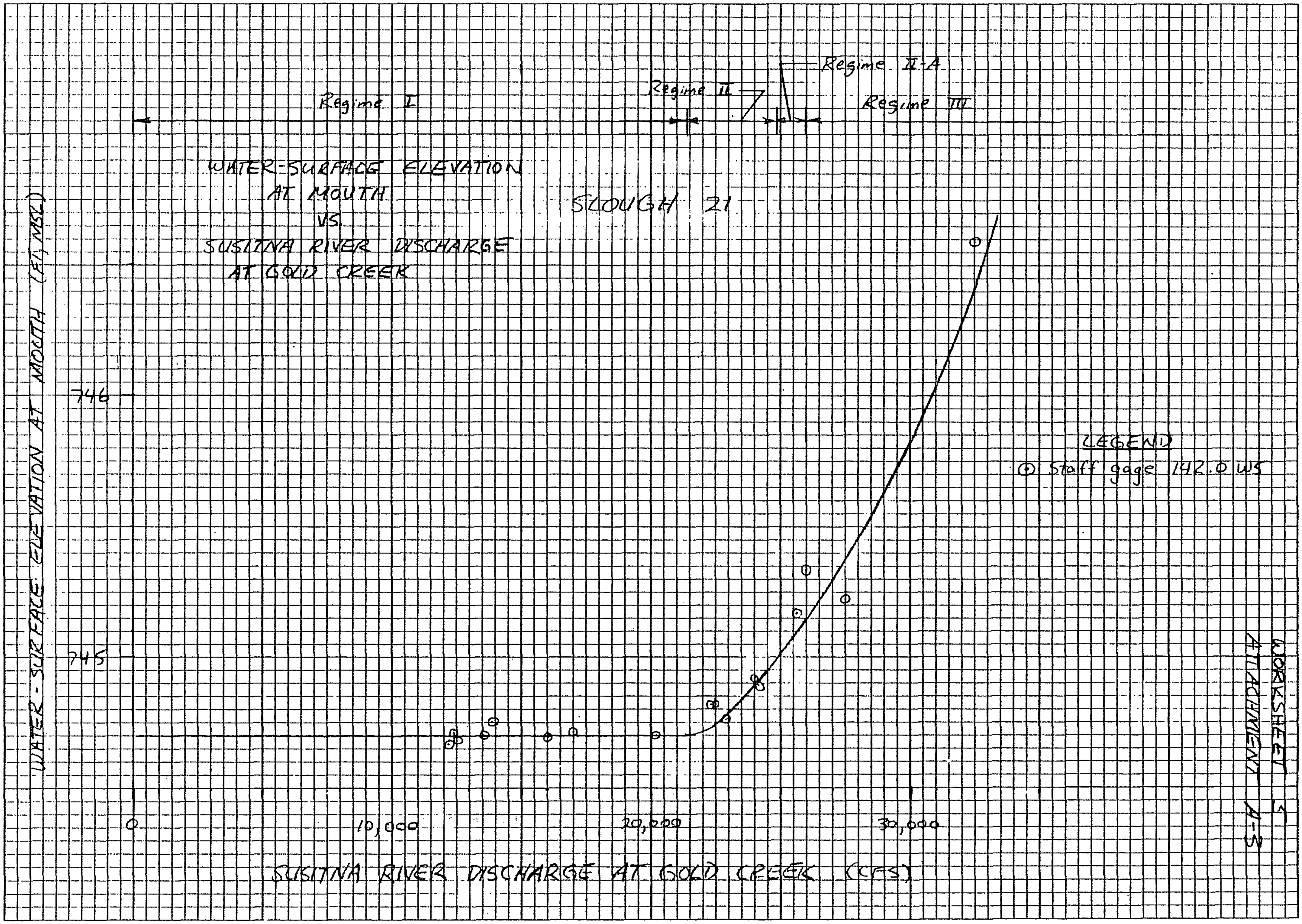
CDS 18 MAY 83 / 27 MAY 83 28 MAY 83



CDS
28 MAY 83


SLOUGH DISCHARGE
VS.
SUSITNA RIVER DISCHARGE AT GOLD CREEK
FOR
FLOW REGIMES I AND II
SLOUGH 21
Regime I
Regime II
20
10
0
0
10,000
20,000
30,000
SLOUGH DISCHARGE (CFS)
SUSITNA RIVER DISCHARGE AT GOLD CREEK (CFS)
LEGEND
1981 discharge measurements
1982 discharge measurements
average daily discharges from stage recorder
WORKSHEET 4
ATTACHMENT A-3

WORKSHEET 5
ATTACHMENT A-3



ODS/18 MAY 83
28 MAY 83

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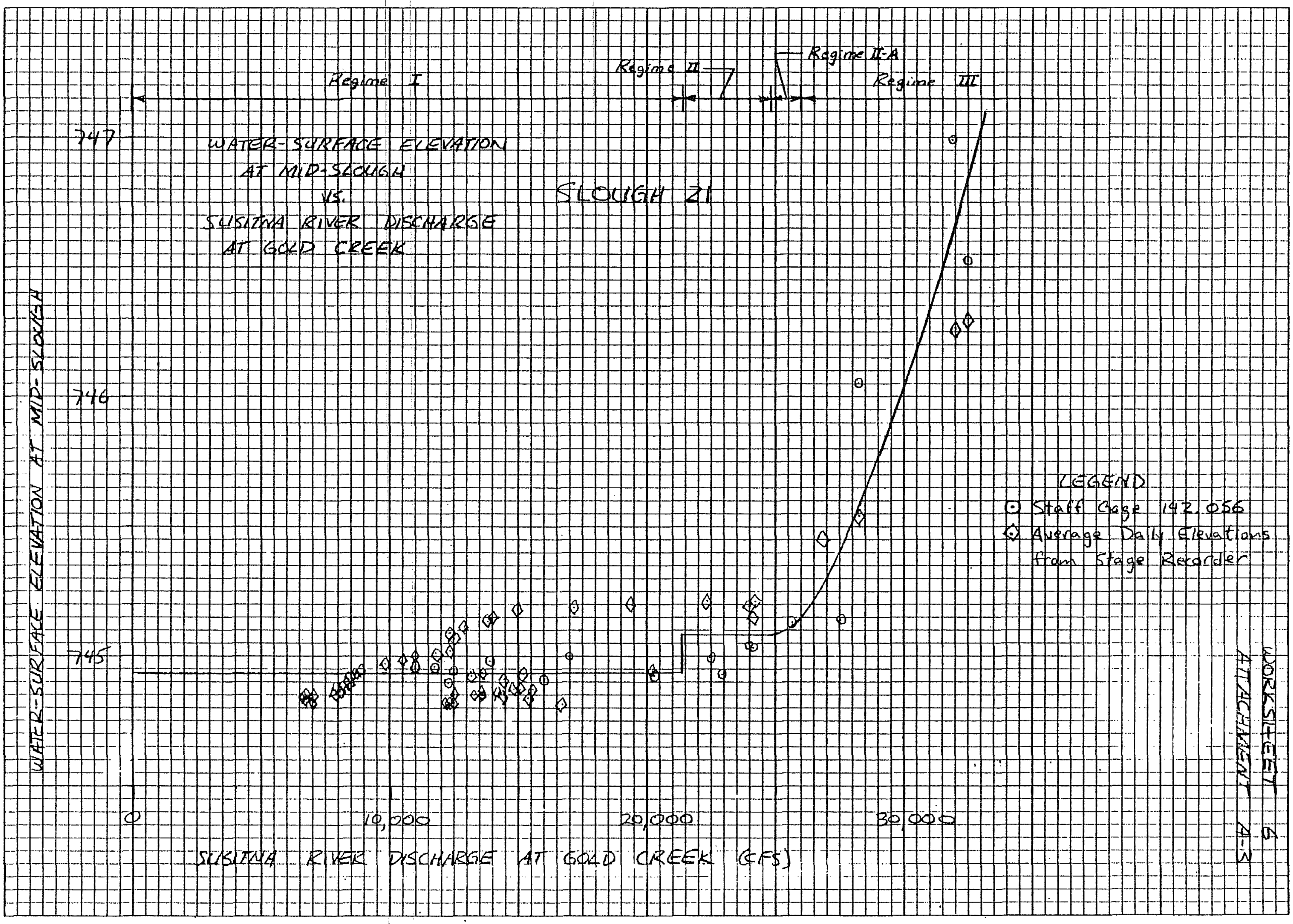
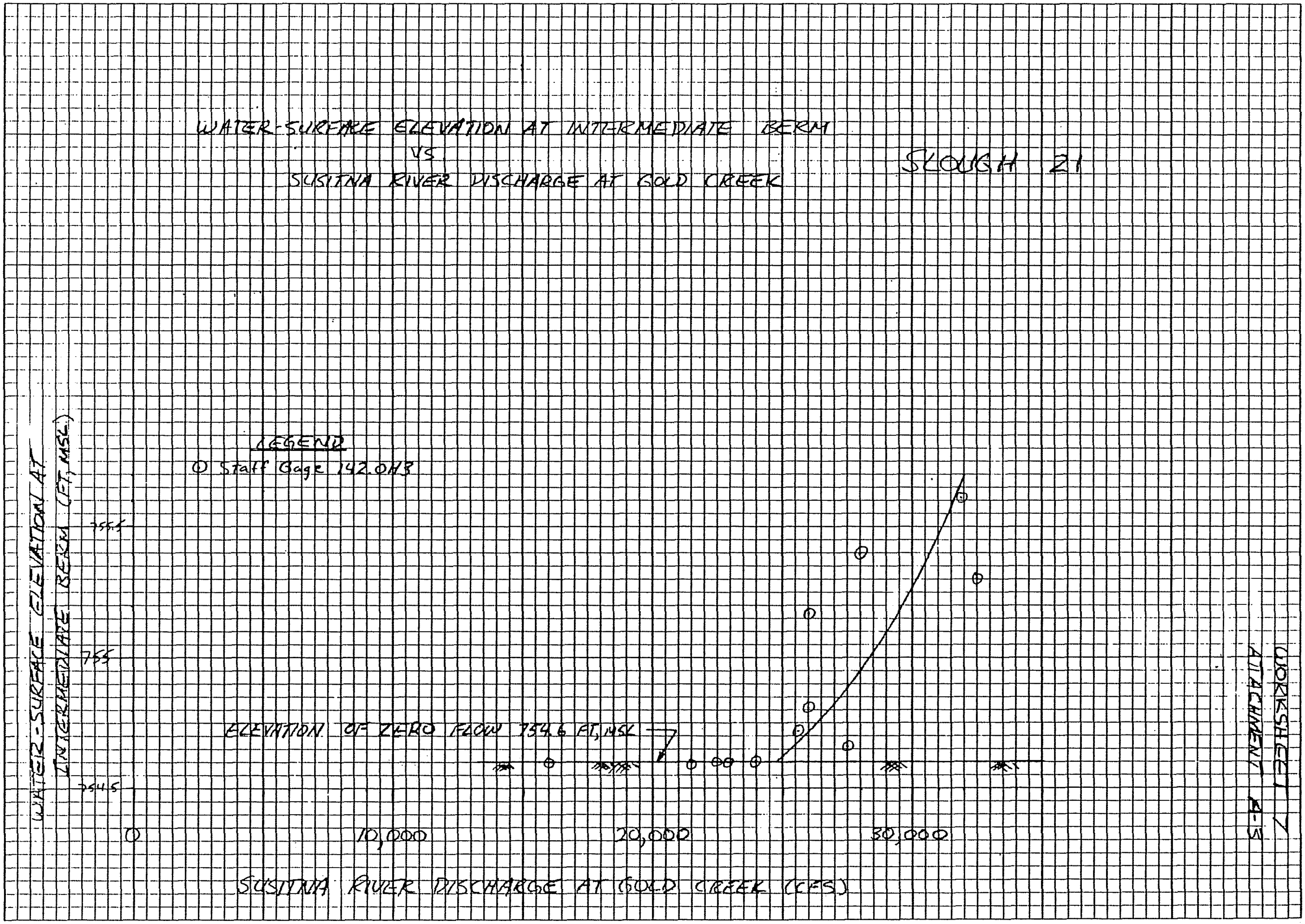
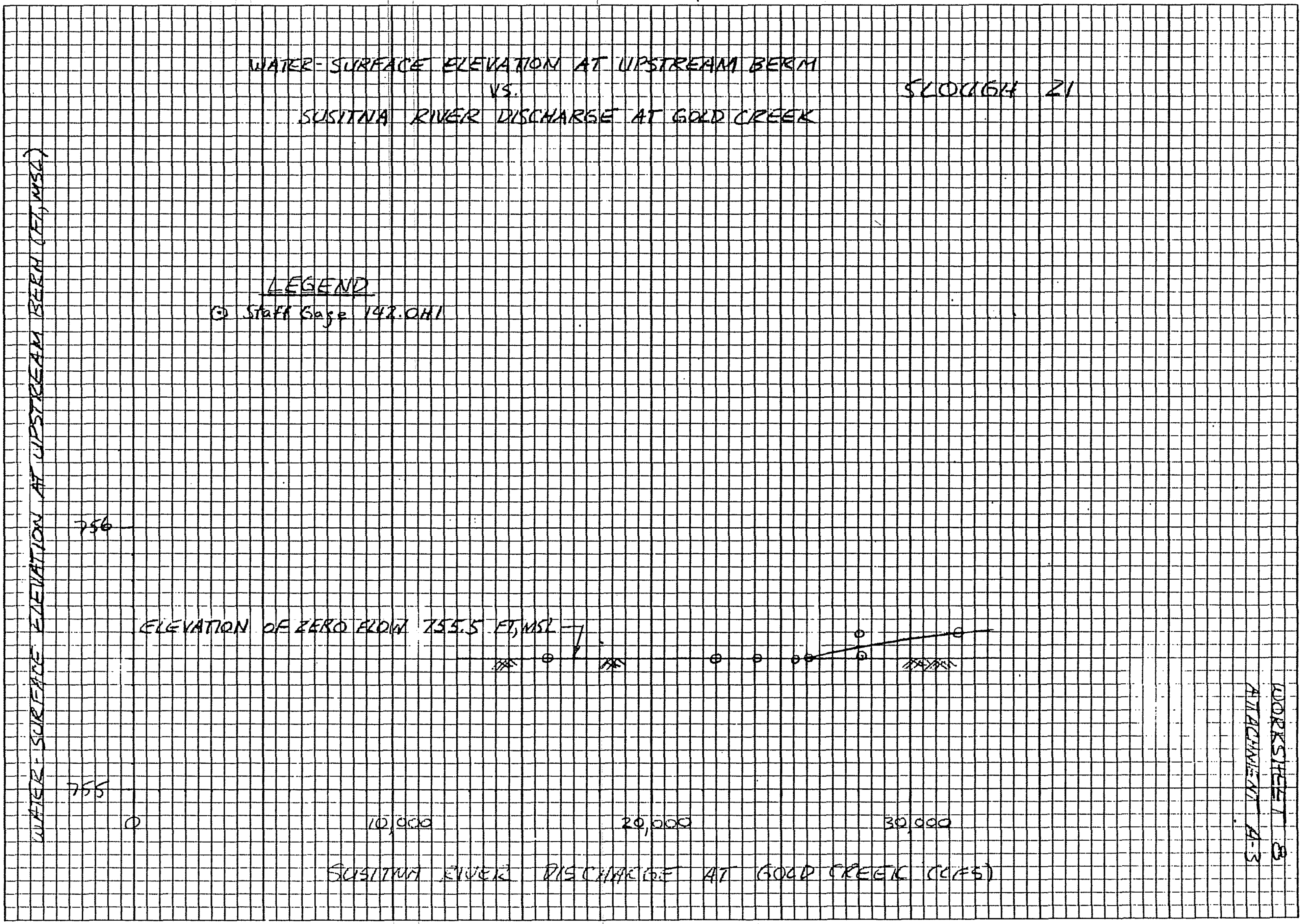
ODS
28 MAY 83



CDS/18 MAY 83, 28 MAY 83



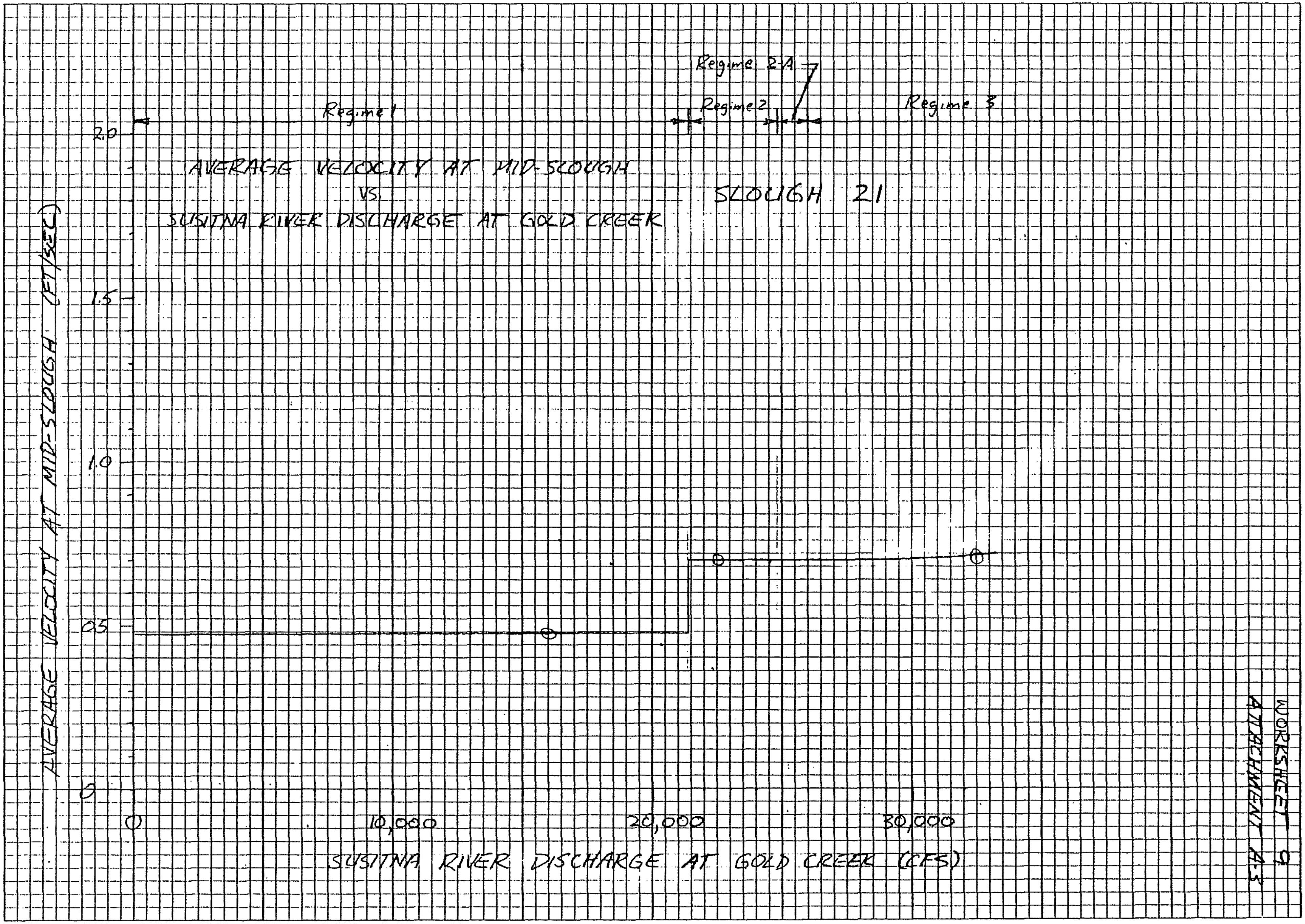
CDS / 18 MAY 83

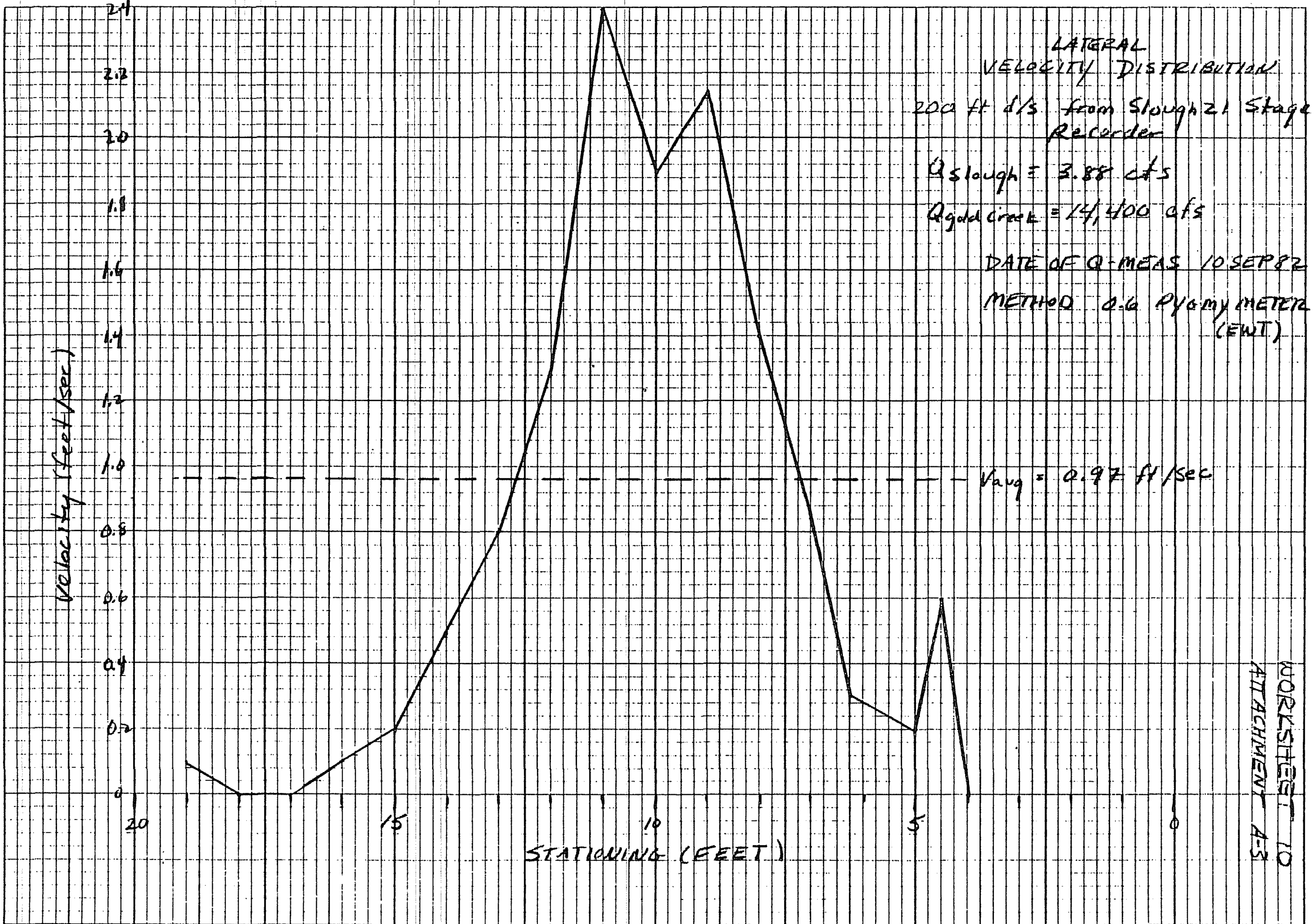

WORKSHEET 8
ATTACHMENT A-3
WATER-SURFACE ELEVATION AT UPSTREAM BERM
VS.
SUSITNA RIVER DISCHARGE AT GOLD CREEK
SLOUGH 21
LEGEND
⊙ Staff Gage 142.0H1
ELEVATION OF ZERO FLOW 755.5 FT, MSL
756
755
0
10,000
20,000
30,000
SUSITNA RIVER DISCHARGE AT GOLD CREEK (CFS)
WATER-SURFACE ELEVATION AT UPSTREAM BERM (FT, MSL)

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

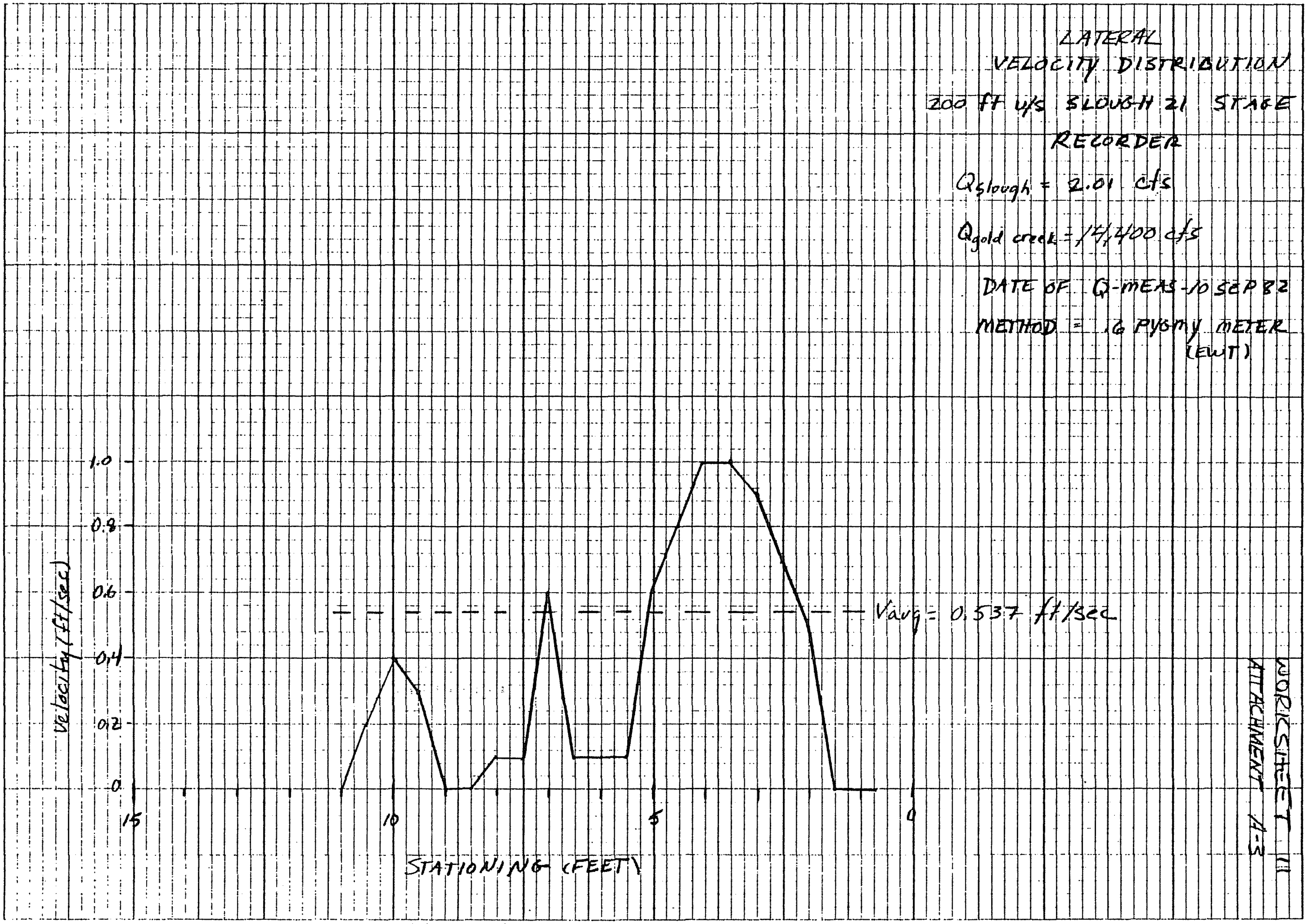
46 0707

CDS
29 MAY83




LATERAL
VELOCITY DISTRIBUTION
200 ft d/s from Slough 21 Stage Recorder
Qslough = 3.88 cfs
Qgold creek = 14,400 cfs
DATE OF Q-MEAS 10 SEP 82
METHOD 0.6 Pygmy METER (EWT)
Vavg = 0.97 ft/sec
WORKSHEET 10
ATTACHMENT A-3
Velocity (feet/sec)
STATIONING (FEET)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
20
15
10
5
0

RGG/15 June 1983



WORKSHEET III
ATTACHMENT A-3

R99/15 June 1983

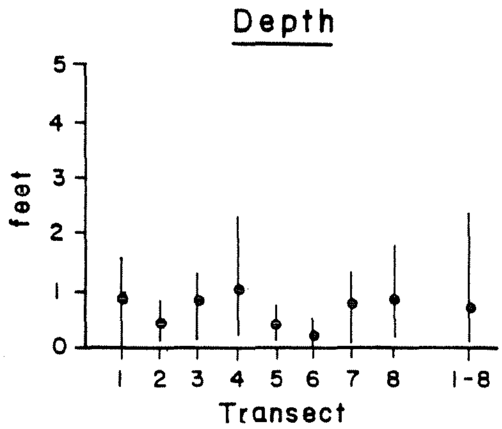
R99/15 June 1983

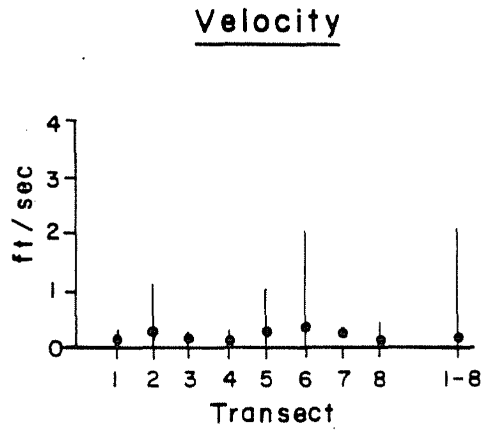
R99/15 JUNE 1983

WORKSHEET 14
ATTACHMENT A-3

SLOUGH 21

Q = 5 cfs
SEPT. 2, 1982

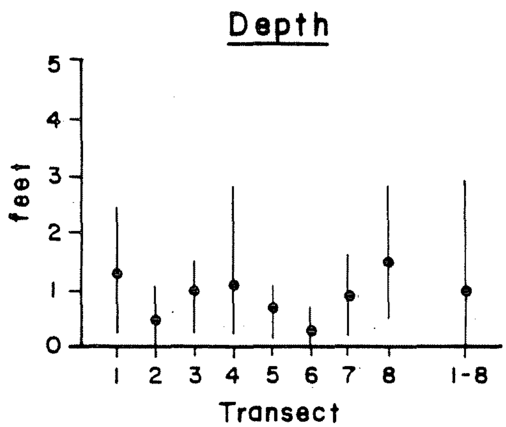


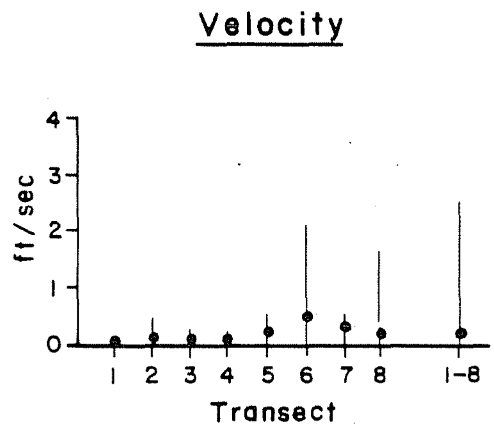


SUSITNA R.

DISCHARGE AT GOLD CREEK = 13,600 CFS

Q = 10 cfs
SEPT. 19, 1982

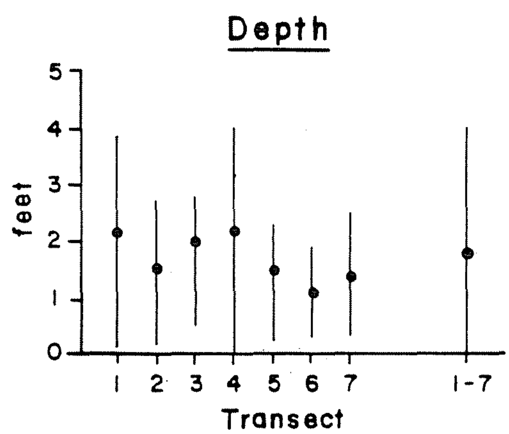


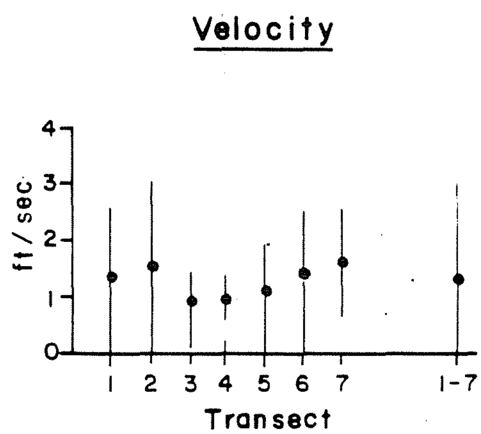


SUSITNA R.

DISCHARGE AT GOLD CREEK = 14,400 CFS

Q = 157 cfs
SEPT. 17, 1982





SUSITNA R

DISCHARGE AT GOLD CREEK = 32,000 CFS

NOTE: TRANSECT 8 IS LOCATED AT MOUTH; ALL OTHER TRANSECTS ARE LOCATED DOWNSTREAM OF THE MOUTH

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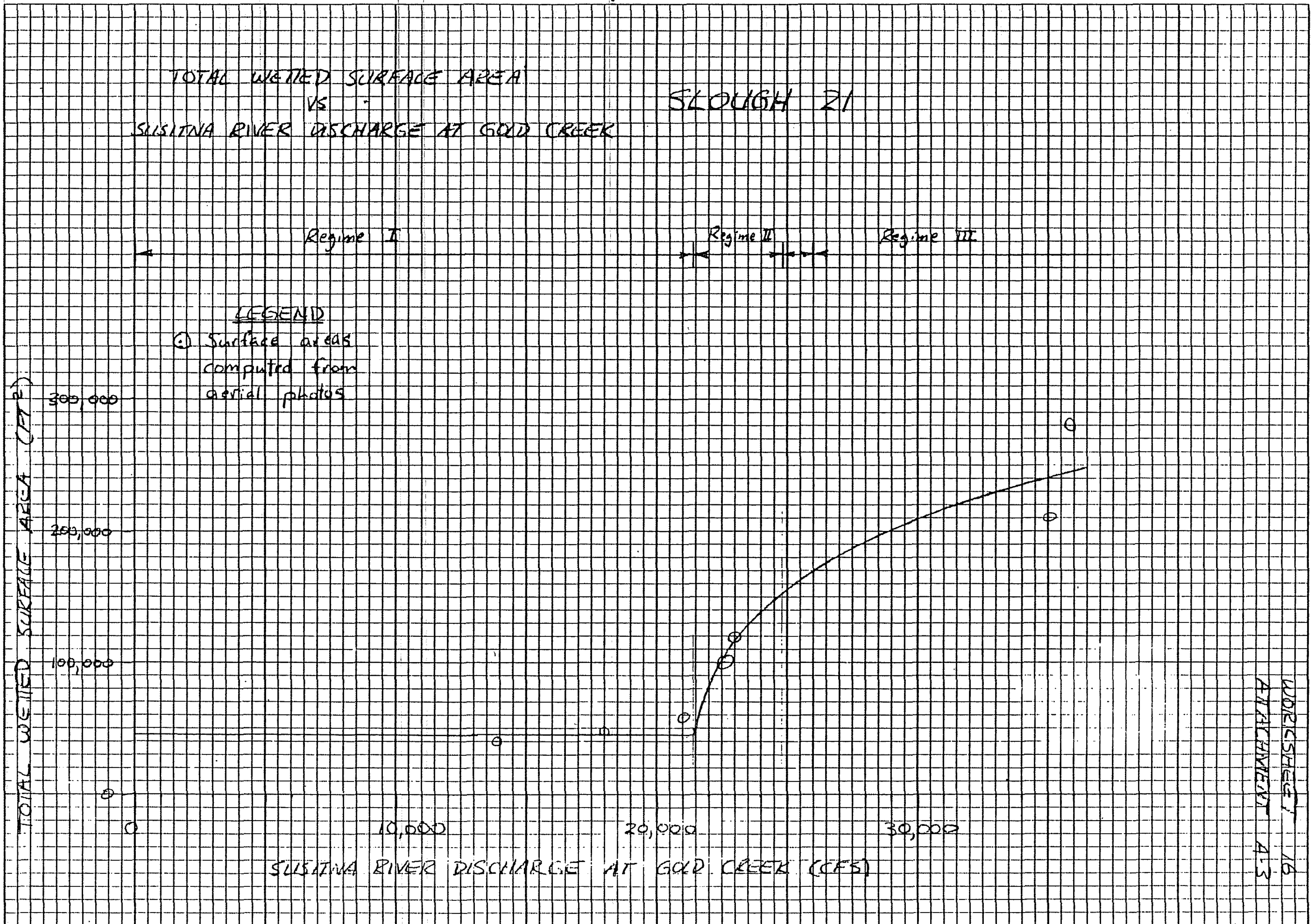
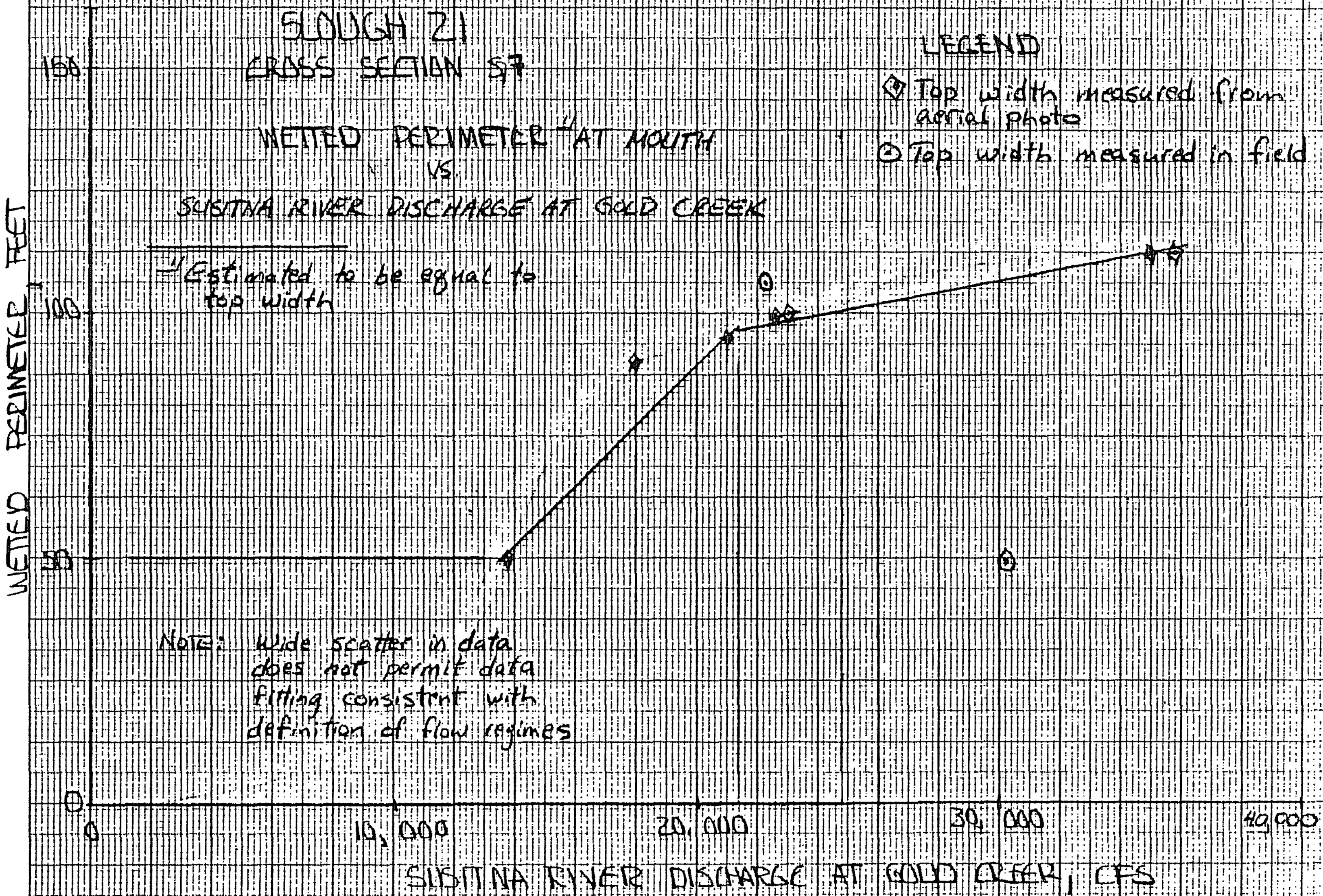
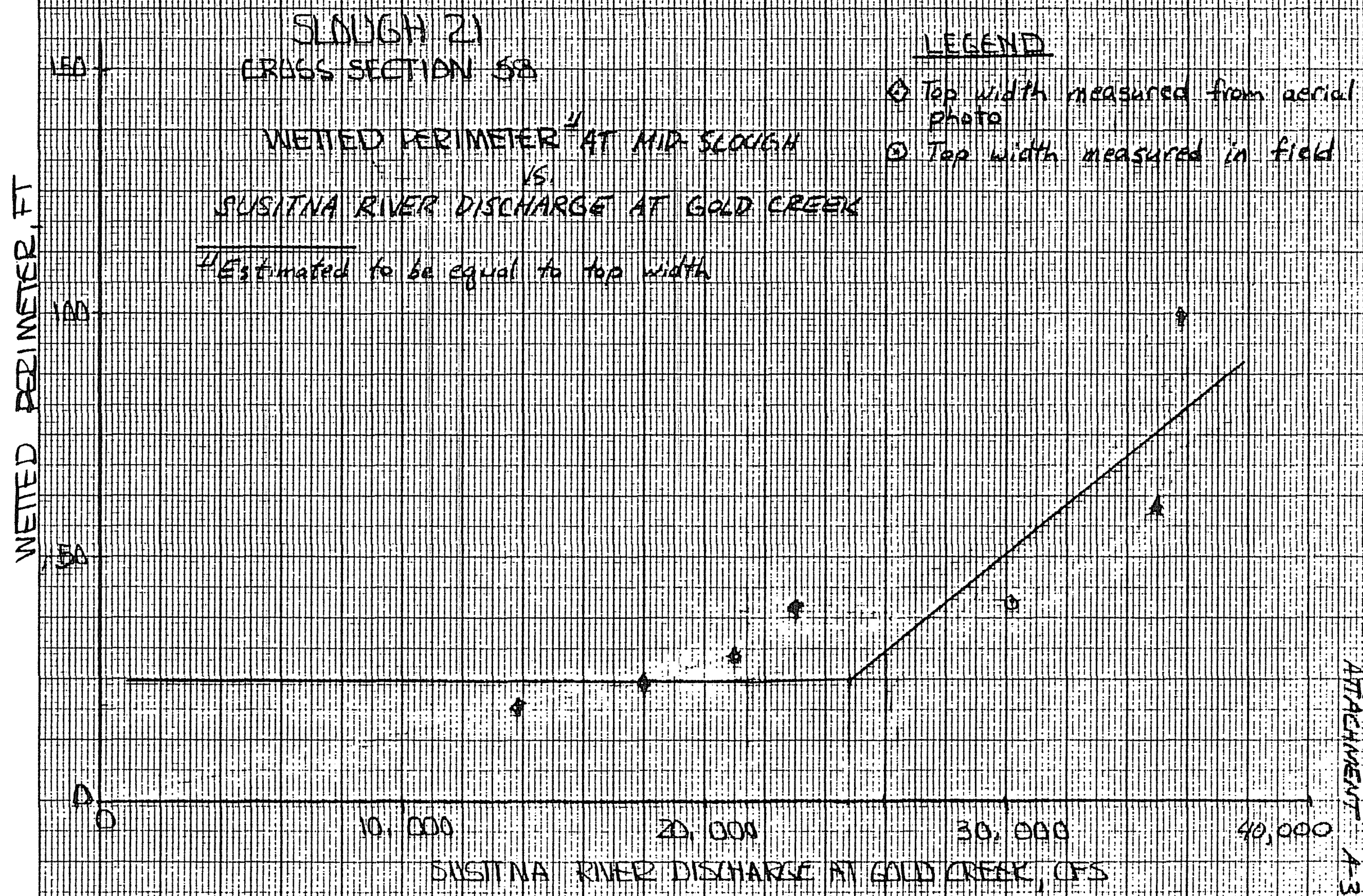
30 MAY 83 / 7 JUN 83



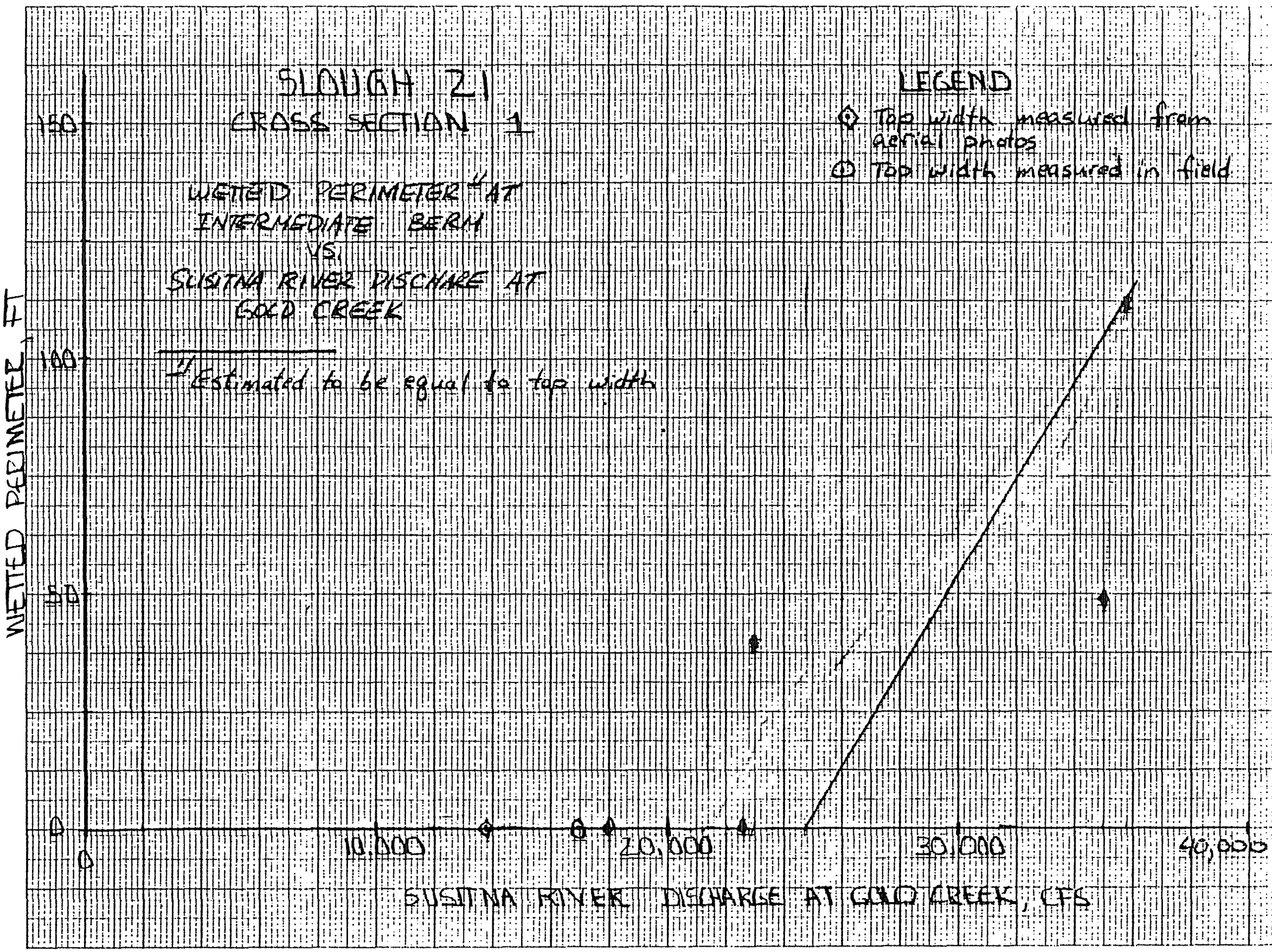
WORKSHEET 17
ATTACHMENT A-3

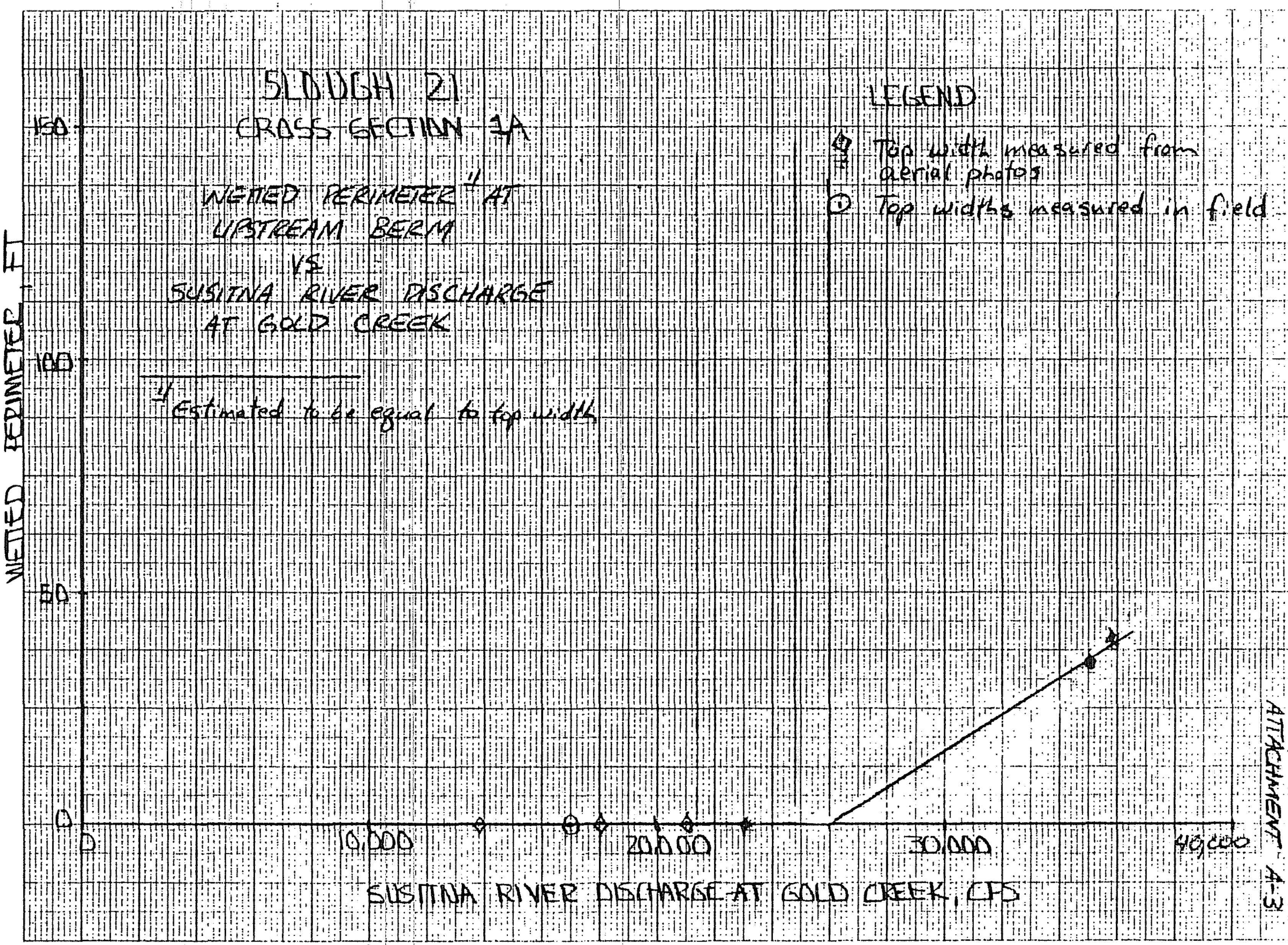


WORKSHEET 18
ATTACHMENT A-3



WORKSHEET 19
ATTACHMENT A-3




SLOUGH 21
CROSS SECTION 1A
WETTED PERIMETER 1/ AT
UPSTREAM BERM
VS
SUSITNA RIVER DISCHARGE
AT GOLD CREEK
1/ Estimated to be equal to top width
LEGEND
Top width measured from aerial photos
Top widths measured in field
WETTED PERIMETER, FT
150
100
50
0
0
10,000
20,000
30,000
40,000
SUSITNA RIVER DISCHARGE AT GOLD CREEK, CFS

ATTACHMENT

PART 4

RABIDEUX SLOUGH PHYSICAL HABITAT VARIABLES

ATTACHMENT
PART 4
RABIDEUX SLOUGH PHYSICAL HABITAT VARIABLES

Slough Description

Rabideux Slough is located near River Mile 83.5. A vicinity map is shown in Worksheet 1. Rabideux Slough consists of a large pond in the upstream area and a backwater area from Rabideux Creek and the mainstem Susitna at the downstream end. Aerial photos indicate that the backwater area occurs at low flow events (Susitna River discharge at Sunshine gage of 15,000 cfs). Existence of a backwater area at such a low flow indicates that either:

- o Regime I flow does not exist for this slough, or
- o Threshold discharge for Regime II flow to occur is less than 15,000 cfs at Sunshine. The low flow condition being analyzed, Condition 1 (see Table A-5 of Appendix A, main text) begins at the Susitna River discharge at Sunshine of 10,000 cfs. The possibility of Regime I flow occurring for flows of from 10,000 to 15,000 cfs was not considered.

Rabideux Slough is unique in that there are two upstream berms of which, the downstream berm, "Berm 2" (See Worksheet 1) has been observed to act as an outlet rather than an inlet to Rabideux Slough. Therefore, at overtopping discharges (Regime III) some of the flow over the upstream berm may bypass the slough. The remaining flow is discharged both from the pond into transect 7 and over the floodplain into the slough downstream of transect 3 (Worksheet 1). This was indicated by a field measurement on September 17, 1982. A slough discharge of 853 cfs was measured at transect 0. Upstream of this, at transects 3, 4, 5, 6, and 7, the discharge was measured to be approximately 167 cfs. (ADF&G 1982).

Slough Discharge

Worksheet 2 shows Rabideux Slough discharges for the slough mouth and for transect 7 (mid-slough) plotted against Susitna River flows at Sunshine. The slough discharges were determined from:

- o three discharge measurements made in 1982.
- o one discharge observation made in 1983

Worksheet 2 indicates that there is little flow in the slough (less than 1.0 cfs) until the upstream berm is overtopped. The values of slough discharge presented in Table A-5 of Appendix E.2.A were determined for the slough mouth from Worksheet 2.

Slough Water-Surface Elevations

Worksheet 3 shows water surface elevations at the mouth of Rabideux Slough plotted against Susitna River flows at Sunshine. The data are from two sources:

- o Staff gage readings at gage 083.1W1 in 1982. Worksheet 1 shows that this staff gage is located on Rabideux Creek near the confluence of Rabideux Slough. Field measurements indicate that water surface elevations at the staff gage are tions at the the staff gage are approximately equal to the elevations at the mouth (within 0.1 feet).

- o A surveyed water surface elevation at the mouth in 1983.

Worksheet 3 was used to determine the water surface elevations at the slough mouth shown in Table A-5 of Appendix E.2.A. Note that the water surface elevations are extrapolated for discharges less than 30,000 cfs.

Water surface elevations at mid-slough (transect 7) were determined by the following methods:

- o Surveyed water surface elevations at transect 7 (surveyed in 1982).

- o Estimates of water surface elevations at transect 7 determined from top widths obtained from aerial photos. These top widths were projected on a plot of the surveyed cross section to obtain an estimate of the water surface elevation.

At a mainstem flow of 25,800 cfs, transect 7 was observed to be dry. Therefore, for all mainstem flows less than 26,000 cfs, transect 7 was assumed to be dewatered. At Susitna River discharges greater than 53,000 cfs, water levels at transect 7 are influenced by mainstem backwater effects.

The observed and estimated water surface elevations are plotted against Susitna River flows at Sunshine in Worksheet 4. Worksheet 4 was used to determine the values of water surface elevation at mid-slough shown in Table A-5 of Appendix E.2.A.

Water surface elevations at the upstream berm were estimated using the following methodology:

- o assume overtopping flow follows triangular broad crested weir relationship $Q = CLH^{3/2}$, where H is weighted average head.

- o use top widths measured from aerial photos as wier lengths, L.

- o use slough discharge, Q, determined from Worksheet 2

- o use broad-crested weir coefficient, C = 2.7, corrected for submergence for mainstem discharges greater than 79,000 cfs

- o use weir equation to compute H

- o add H to upstream berm elevation (262.5 ft,msl).

The resulting water surface elevations are shown on Worksheet 5. observed water surface elevations were available for comparison. Values of water surface elevation at the upstream berm shown in Table A-5 of Appendix E.2.A were determined from Worksheet 5.

Slough Depths

The depths of flow at the mouth, mid-slough, and upstream berm were determined by subtracting the appropriate thalweg elevations from the water surface elevations.

To obtain the flow depths at the mouth, the thalweg of the cross section at the mouth (Worksheet 1) was subtracted from the water surface elevations obtained from Worksheet 3.

To obtain the flow depths at mid-slough, the thalweg of transect 7 (surveyed in 1982) was subtracted from the water surface elevations obtained from Worksheet 4.

No cross section was surveyed at the upstream berm. However, spot elevations were surveyed at several points between the upstream pond and the Susitna River. A spot elevation was surveyed adjacent to the area labeled "Berm 1" on Worksheet 1. "Berm 1" is the area where overtopping first occurs at the upstream berm of Rabideux Slough. This surveyed spot elevation, 262.50 ft,msl, was assumed to be the thalweg of the upstream berm and was subtracted from the water surface elevations determined from Worksheet 5 to obtain the flow depths at the upstream berm.

The flow depths at these three locations are shown in Table A-5 of Appendix E.2.A.

Slough Velocities

The average velocities at the mouth of Rabideux Slough were computed by:

- o developing an elevation - area curve for the cross-section at the mouth.

- o dividing slough discharges obtained from Worksheet 2 by appropriate areas from the elevation-area curve.

These average velocities are shown in Table A-5 of Appendix E.2.A.

The average velocities at mid-slough were computed based on the stage disharge relationship in Worksheet 4 using an elevation-area curve for surveyed transect 7. Slough discharges for transect 7 (Worksheet 2) were divided by the appropriate areas to obtain average velocities. The average velocities resulting from this analysis are shown in Table A-5 of Appendix E.2.A.

The average velocities at the upstream berm were computed in the following manner:

- o a triangular cross-section was used to estimate the flow area of overtopping flows.
- o dimensions of the triangular section were determined as follows:
  - -- top widths were measured from four aerial photos
  - -- flow depths were taken from those shown in Table A-5 of Appendix E.2.A.
- o cross-sectional areas were determined using top widths and depths.
- o slough discharge corresponding to the Susitna River discharges at Sunshine were determined from Worksheet 2.
- o average velocities were determined by dividing slough discharge by cross-sectional area.

The resulting average velocities were plotted against the Susitna River discharges at Sunshine as shown in Worksheet 6. The average velocities at the upstream berm shown in Table A-5 of Appendix E.2.A were determined from Worksheet 6.

The following is provided to supplement the average velocities shown in Table A-5 of Appendix E.2.A.

- o a lateral velocity distribution within transect 0 (surveyed in 1982) obtained from a discharge measurement (Worksheet 7) (Note that transect 0 is upstream from the mouth. Because of the difference in cross-sectional areas between transect 0 and the mouth, velocities at transect 0 are higher than at the mouth.)
- o velocity and depth ranges for transects 0 through 7 for two discharge events (Worksheet 8). (See Worksheet 1 for location for transects).

Slough Wetted Surface Area

The total wetted surface areas were computed for Rabideux Slough from aerial photos taken over a range of Susitna River discharges at Sunshine. For flows less than 40,000 cfs surface areas were based on extrapolation of the pond surface areas and slough surface areas. Slough surface areas were checked by multiplying the top widths at each of the transects by the distance between them. The shaded area in Worksheet 1 represents the area delineated for surface area measurements. For consistency in aerial photography interpretation, the downstream end of the surface area delineations was taken as the extension of a line along the edge of the treeline at right angles to the slough flow. At a mainstem flow of 40,000 cfs there is no surface water connection between the pond at the head and the lower part of the slough. However, the pond area was included in all surface area measurements. At 40,000 cfs there are isolated ponds at transects 6 and 7. The surface areas are plotted aginst Susitna River flows at Sunshine in Worksheet 9. The values of total wetted surface area tabulated in Table A-5 of Appendix E.2.A were obtained from Worksheet 9.

Slough Wetted Perimeters

The cross-sections in Rabideux Slough were determined to be sufficiently wide and shallow such that the wetted perimeter could be estimated to be equal to the top width.

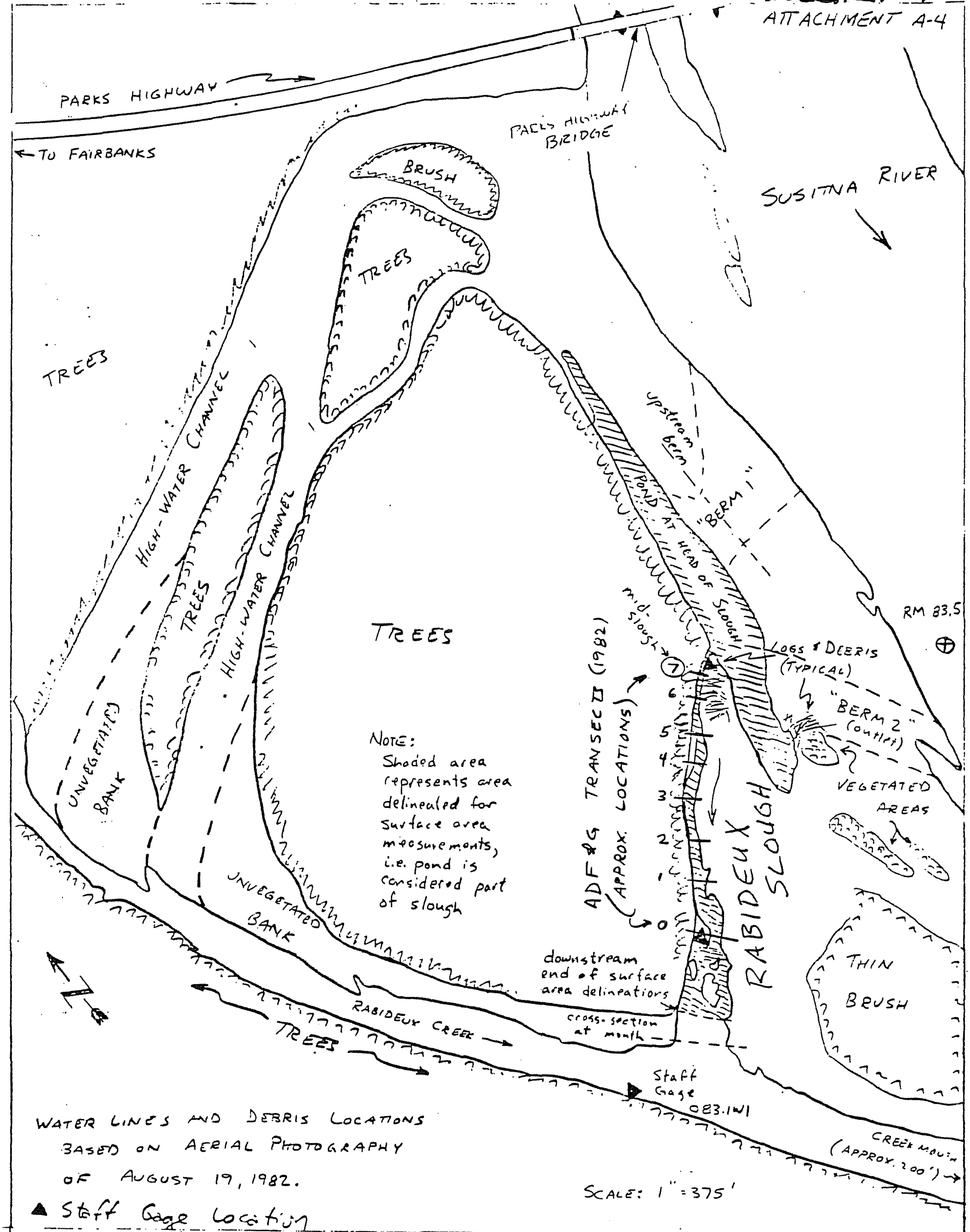
The top width at transect 0, rather than the cross section at the mouth, was used to determine wetted perimeters at the mouth because at high flows backwater from the mainstem Susitna increases the water level and makes wetted perimeters indeterminable at the slough mouth cross section. At mainstem flows below 75,000 cfs wetted perimeters were determined by superimposing the water surface elevation on the cross section and measuring top width. Top widths were checked by measurements from aerial photos. Above 75,000 cfs aerial photos were used to estimate top widths.

The wetted perimeters at mid-slough were computed in a similar manner. Transect 7 was used to determine wetted perimeters for mainstem flows up to 77,000 cfs. Above this flow top widths were estimated from aerial photography since much of the slough flow which overtops the upstream berm bypasses surveyed transect 7 and enters the slough upstream of transect 0. Aerial photographs were used to estimate top widths at the upstream berm at overtopping discharges.

These top widths were plotted against Susitna River discharges at Sunshine as shown in Worksheets 10, 11, and 12. The wetted perimeters shown in Table A-5 of Appendix E.2.A were obtained from Worksheets 10, 11, and 12.

Slough Water Table Elevations

Rabideux Slough is located approximately 15 miles downstream of the junction of the Chulitna, Talkeetna, and Susitna rivers. (see Figure 1 of Appendix E.2.A). The Chulitna River carries significantly more suspended sediment than the Susitna above Talkeetna. Therefore, the geologic materials at Rabideux Slough are expected to consist of finer grained materials (sands and gravels) than is generally found above Talkeetna (gravels and cobbles at Sloughs 8A and 9). However, fairly high permeabilities are still expected at this slough. The response of the groundwater levels to change in the Susitna River discharge at Sunshine should be similar to the sloughs above Talkeetna. However, the response may be somewhat less pronounced because the permeability of the finer material at Rabideux Slough is expected to be somewhat less than at Slough 8A and 9. Therefore, the travel time of the groundwater through the berms and islands will probably be longer.



WORKSHEET 1 RABIDEUX SLOUGH VICINITY MAP

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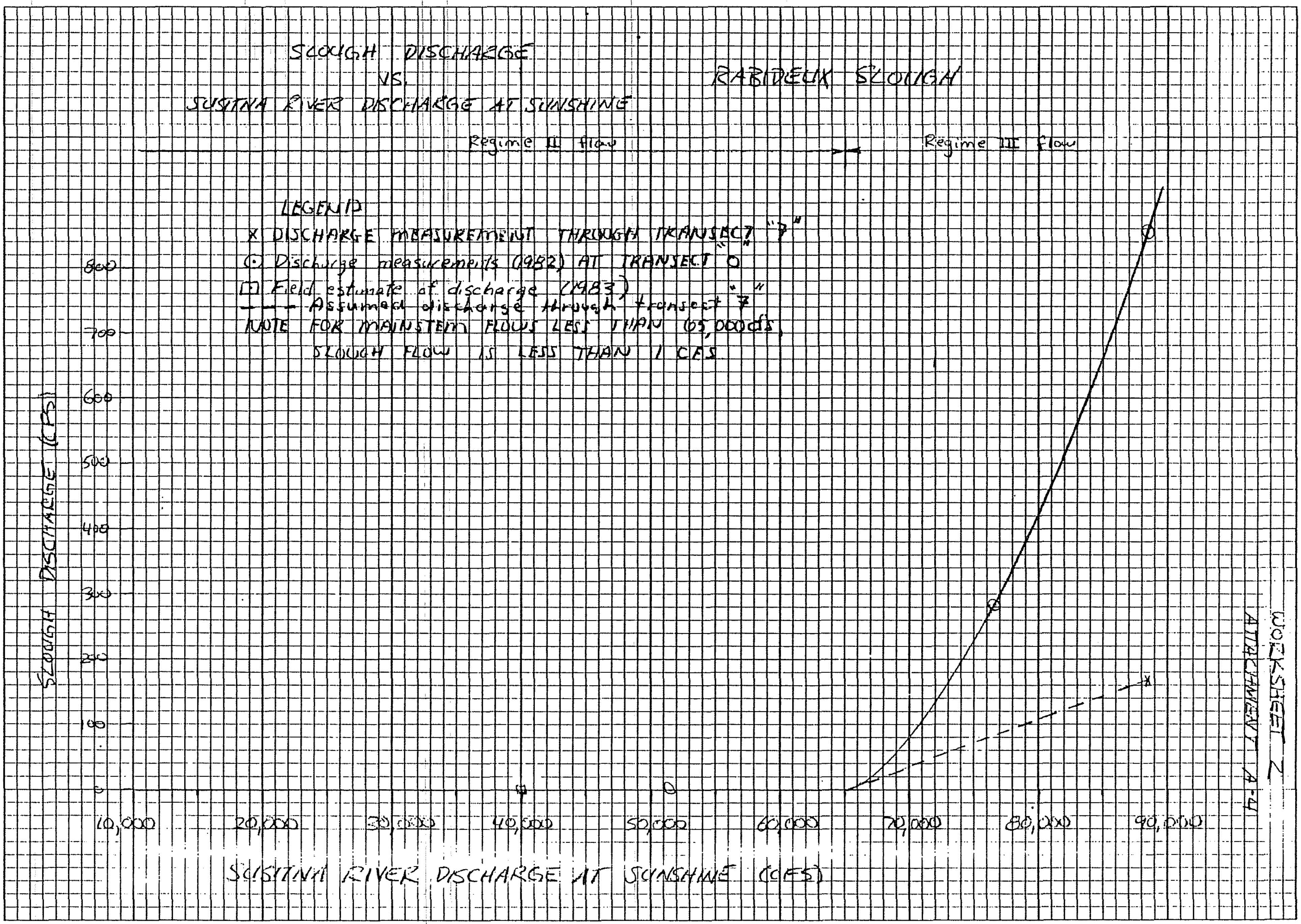
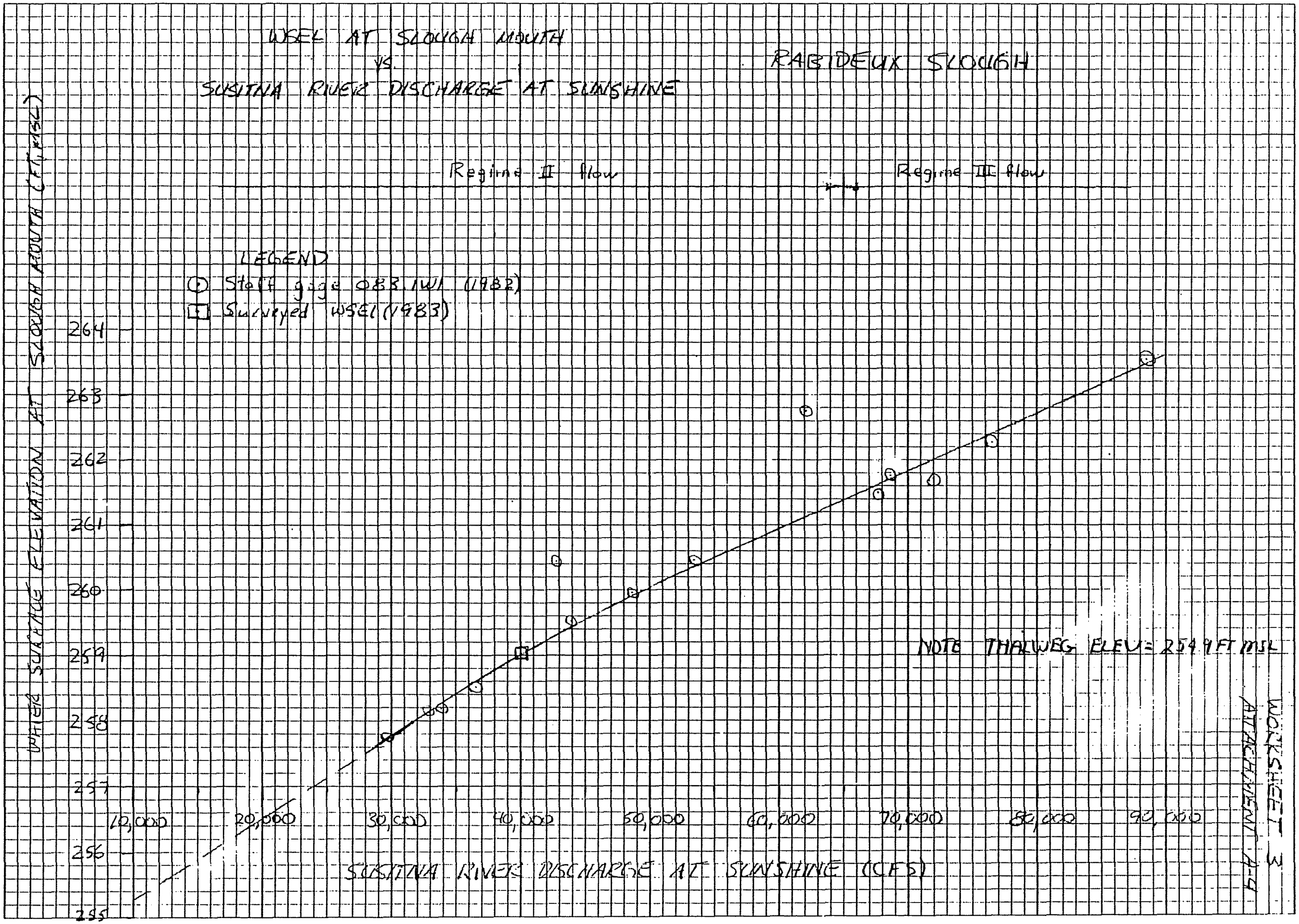
[illegible]/2 JUN 83



CDS/2 JUN 83


WSEL AT SLOUGH MOUTH
VS.
SUSITNA RIVER DISCHARGE AT SUNSHINE
RABIDEUX SLOUGH
Regime II flow
Regime III flow
LEGEND
Staff gage 083.1W1 (1982)
Surveyed WSEL (1983)
NOTE THALWEG ELEV = 254.9 FT MSL
WATER SURFACE ELEVATION AT SLOUGH MOUTH (FT, MSL)
264
263
262
261
260
259
258
257
256
255
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
SUSITNA RIVER DISCHARGE AT SUNSHINE (CFS)
WORKSHEET 3
ATTACHMENT A-4

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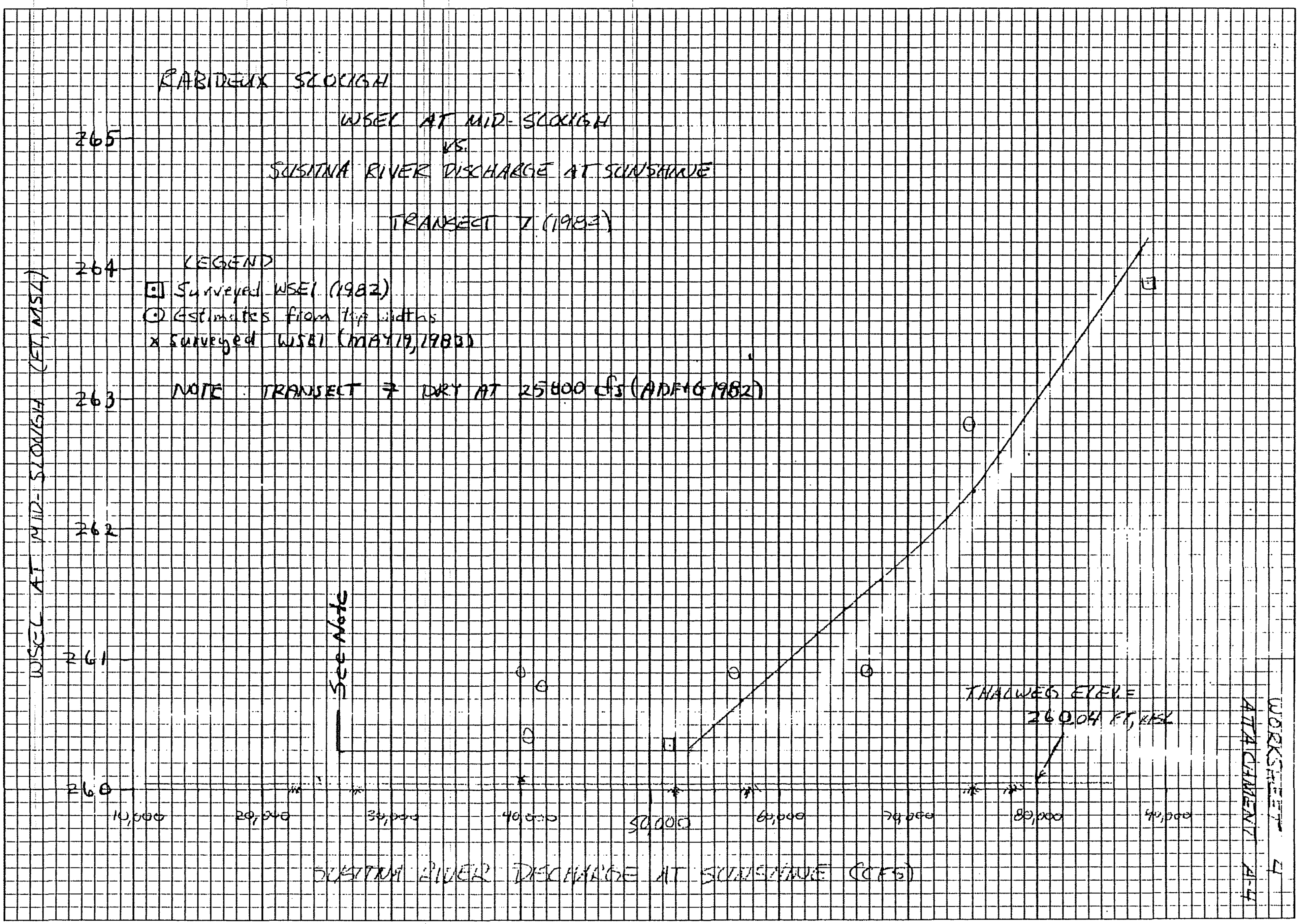
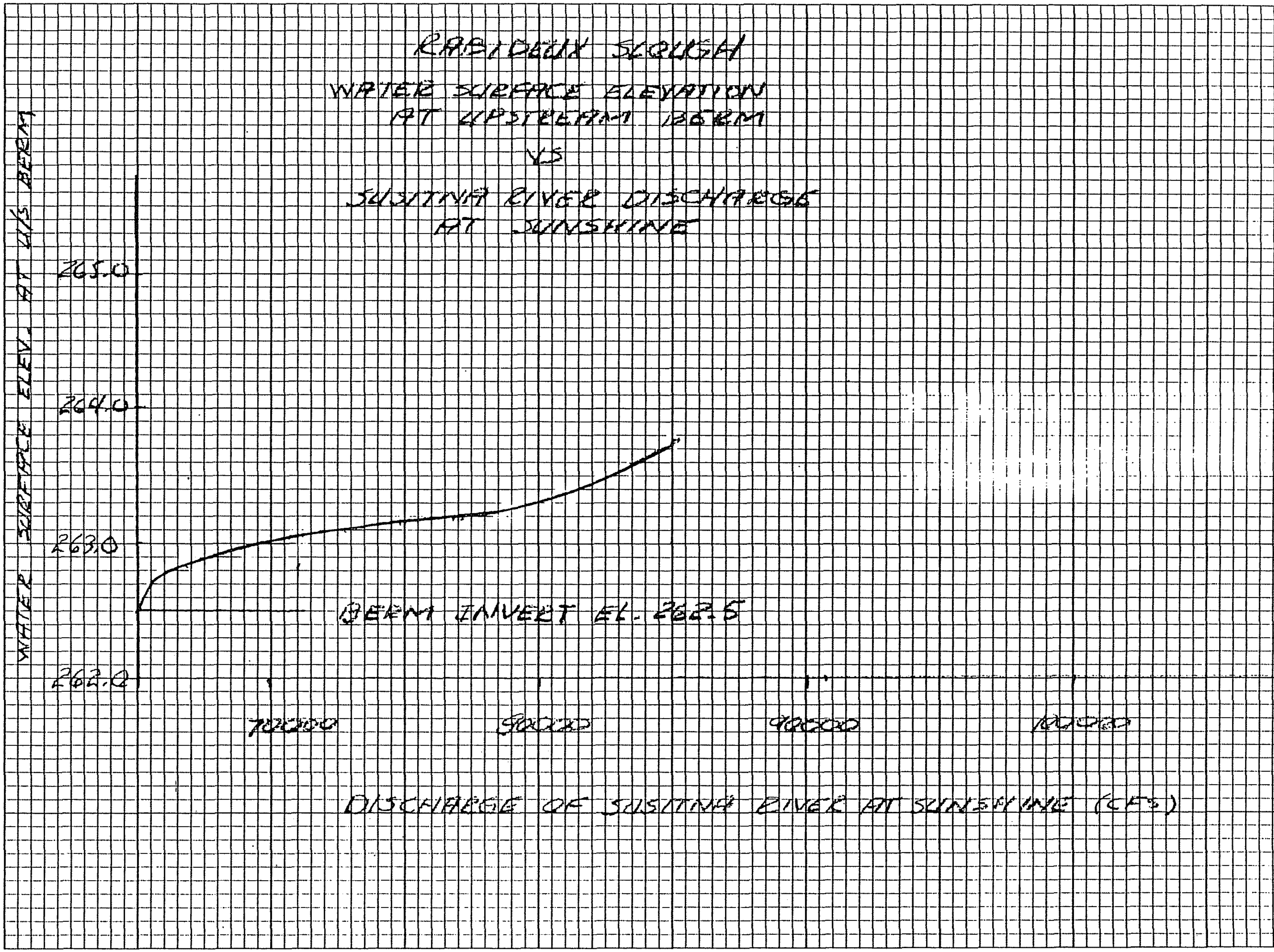
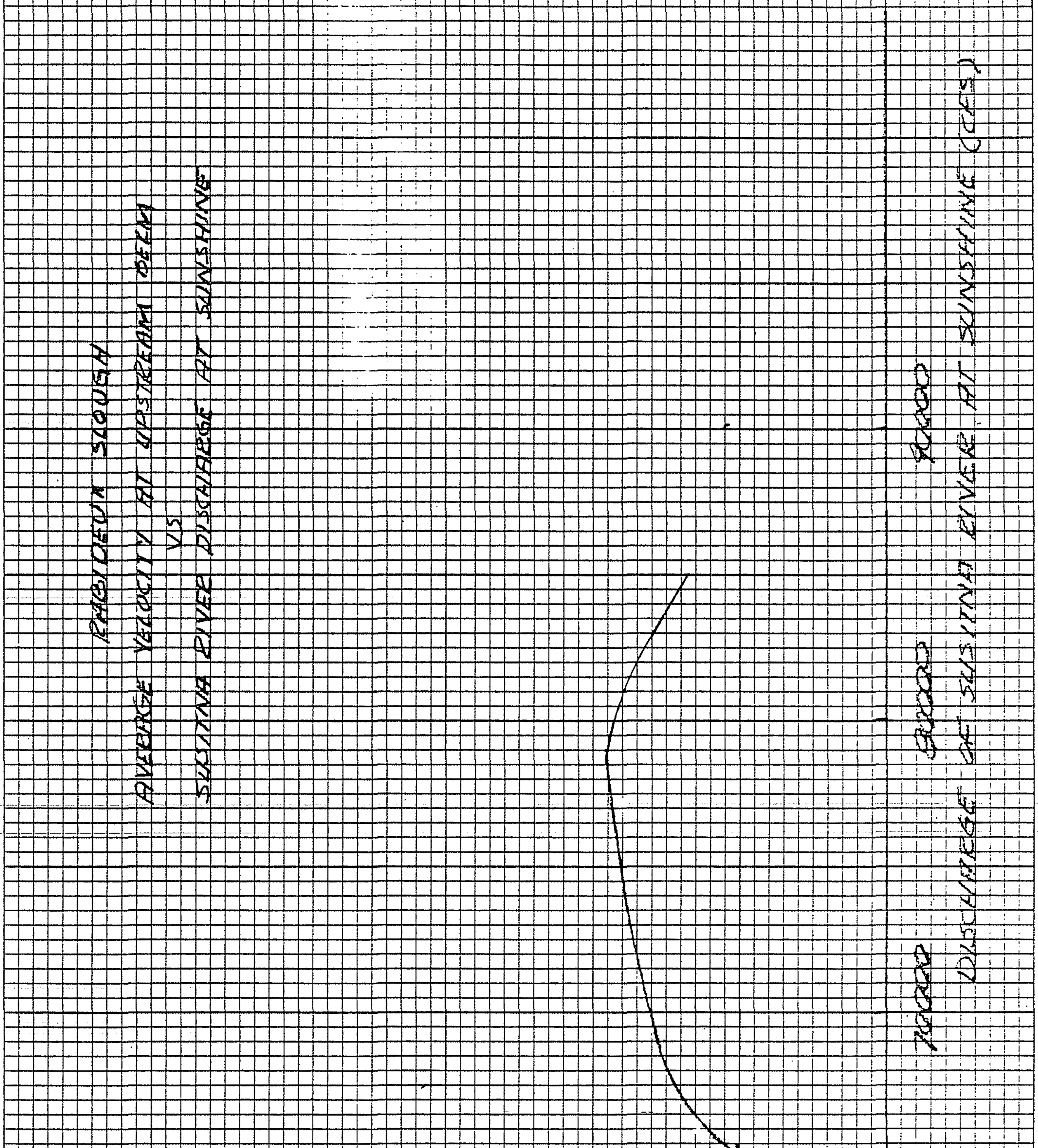
CDS 4 JUN 83 Revised 28 JUN 83 WMD



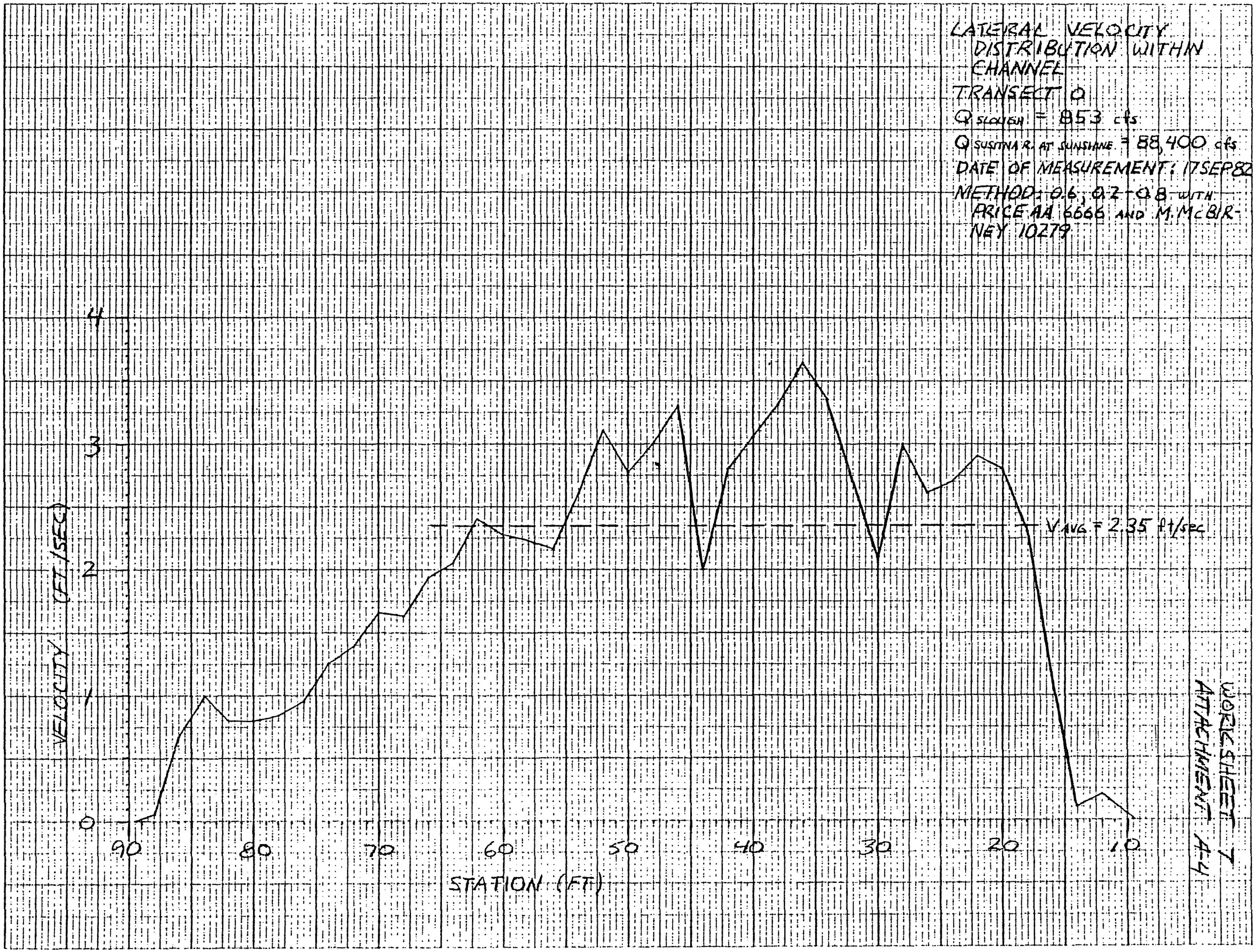

RABIDEUX SLOUGH
WATER SURFACE ELEVATION
AT UPSTREAM BERM
VS
SUSITNA RIVER DISCHARGE
AT SUNSHINE
WATER SURFACE ELEV. AT U/S BERM
265.0
264.0
263.0
262.0
BERM INVERT EL. 262.5
70000
80000
90000
100000
DISCHARGE OF SUSITNA RIVER AT SUNSHINE (CFS)

WORKSHEET 6
ATTACHMENT A-4



CLEARPRINT CHARTS

CPS/19JUN83

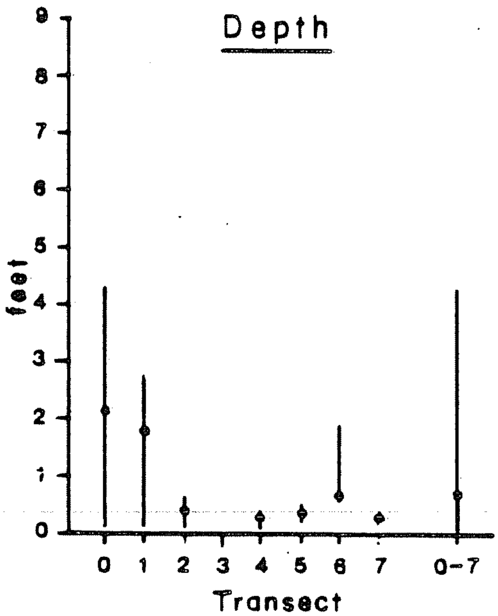


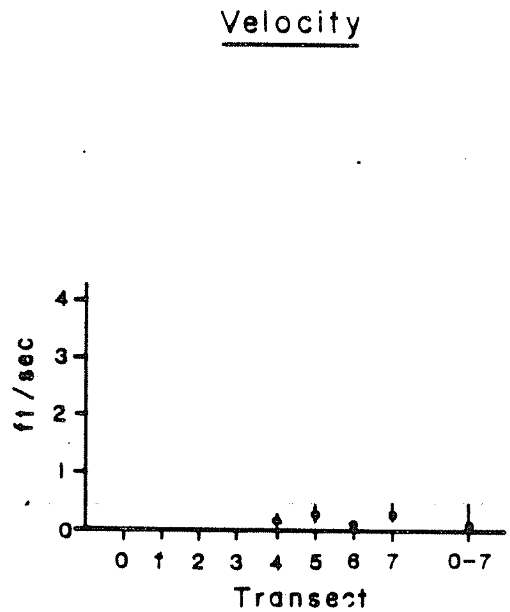
D-4-12

RABIDEUX SLOUGH

Q = 0.3 cfs
AUG. 10, 1982

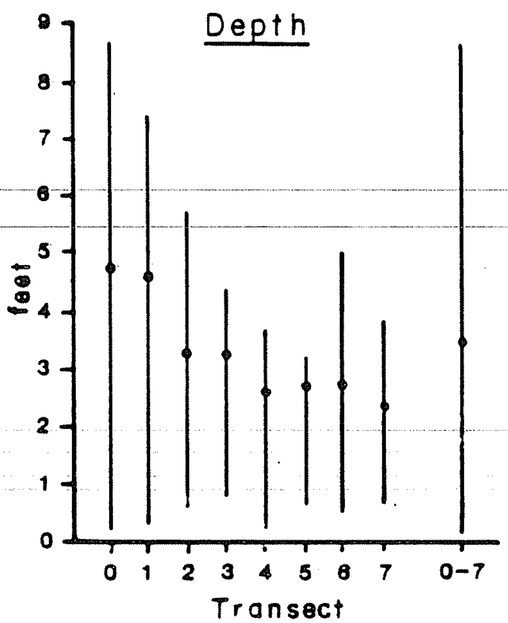
SUSITNA RIVER
DISCHARGE AT
SUNSHINE = 51,600 cfs

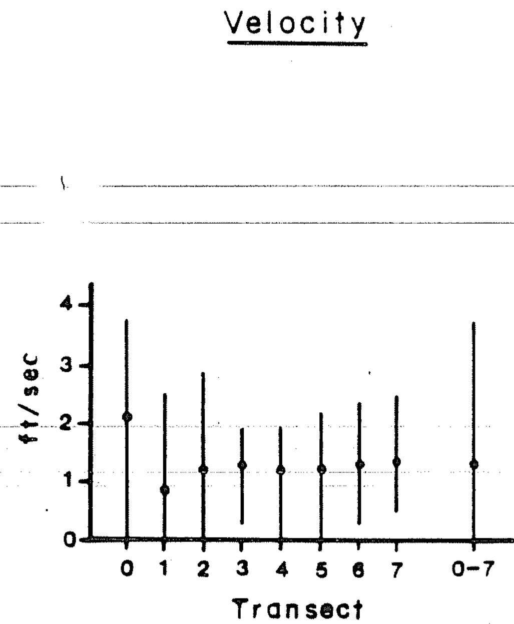




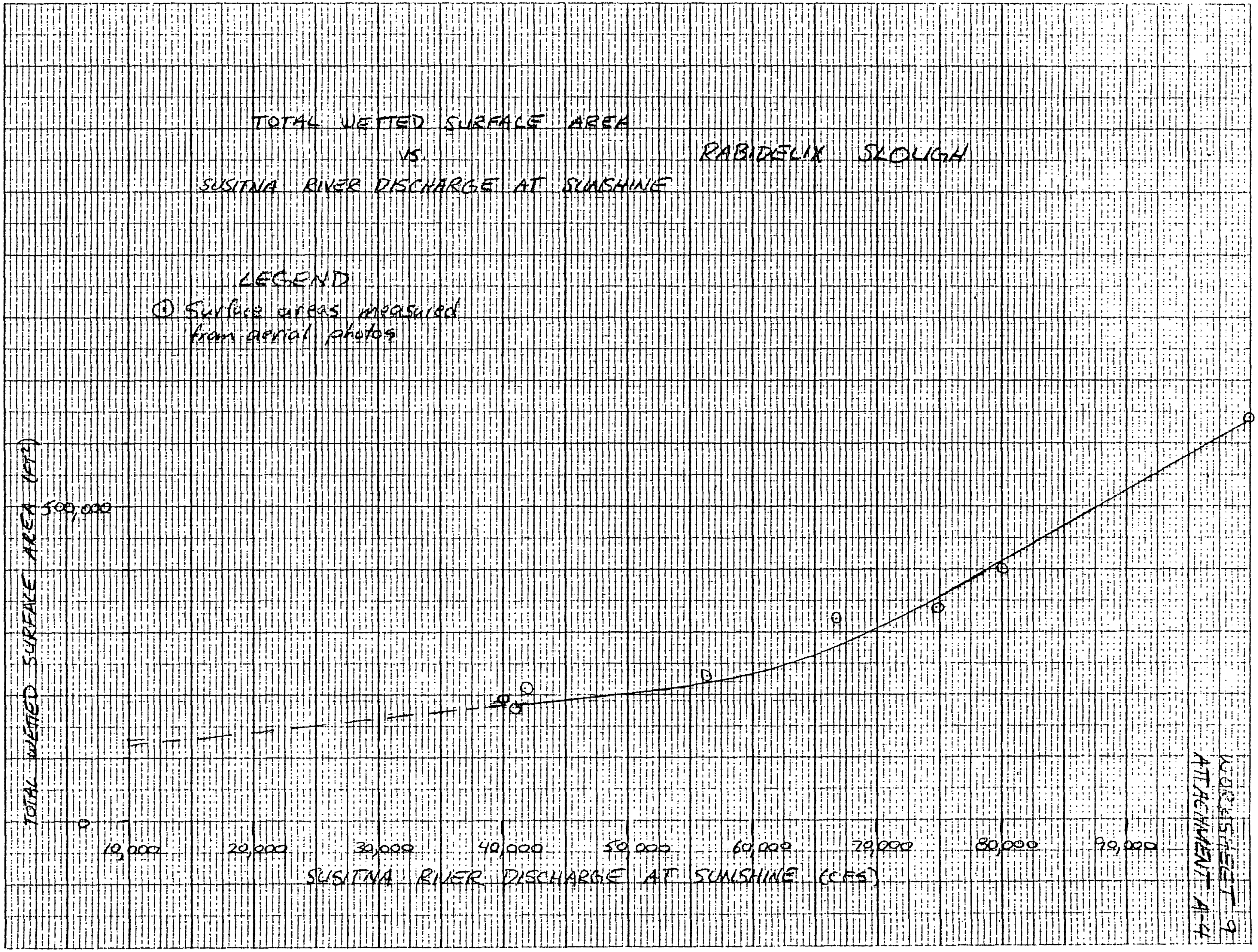
Q = 281 cfs
SEPT. 18, 1982

SUSITNA RIVER
DISCHARGE AT
SUNSHINE = 76,500 cfs

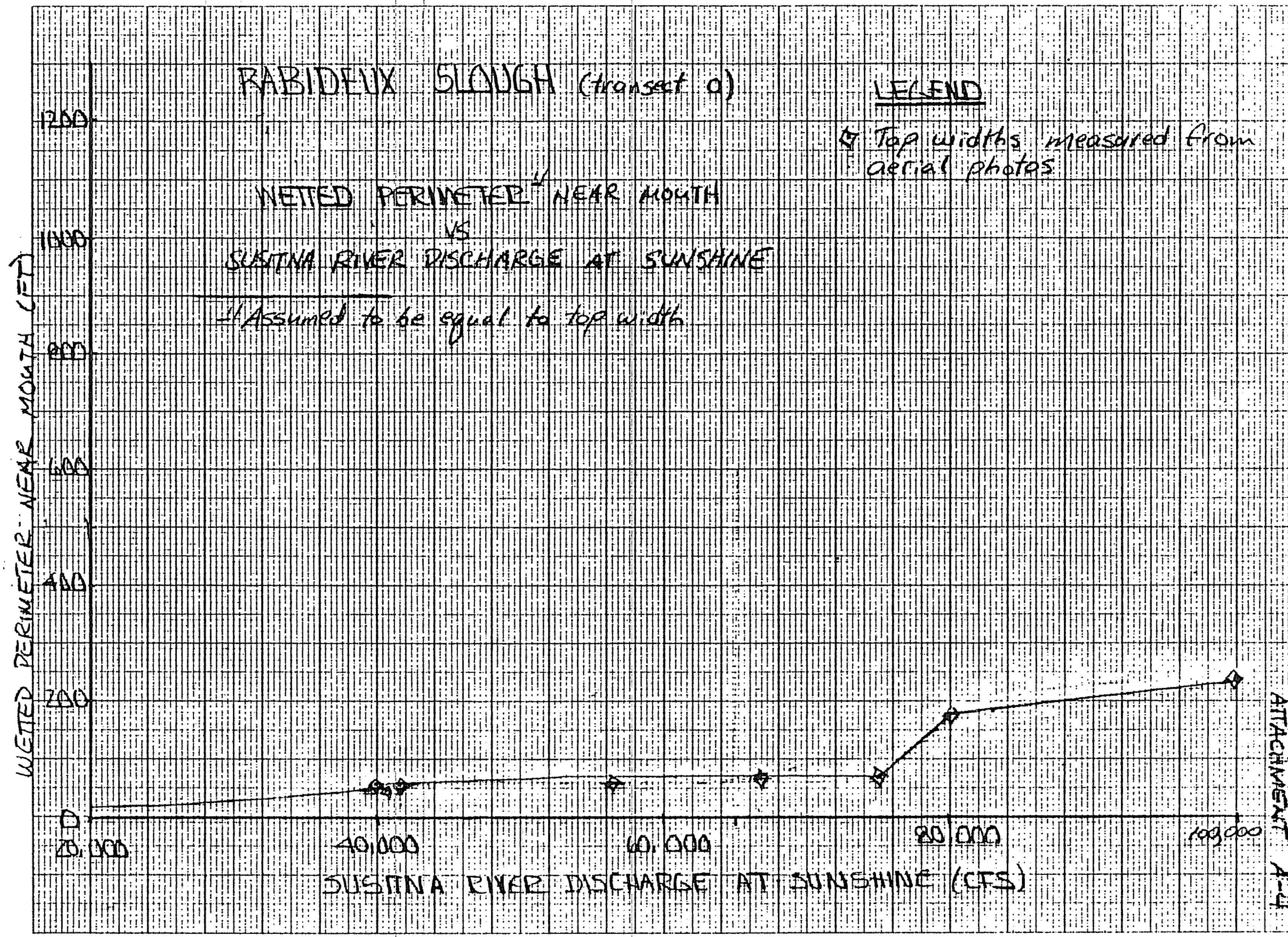




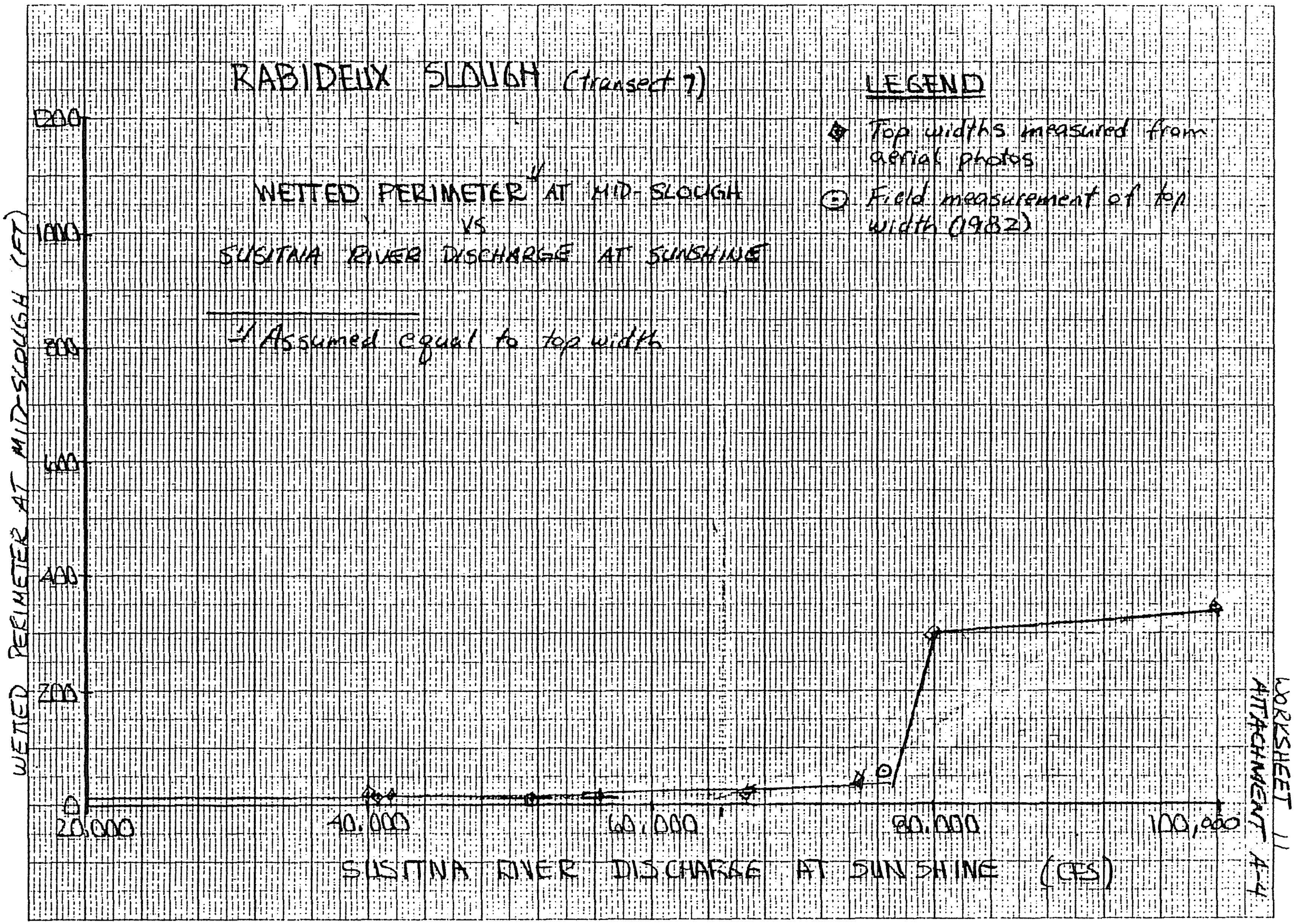
CWS
7 JUN 83 / Revised 28 JUN 83 WMD.



JTM/CDS 7JUN83 Revised 20 JUN 83 WMD



JTH/CAS — 7 JUN 83
Revised 28 JUN WMD



A-4-17

WORKSHEET 12
ATTACHMENT A-4