

F. SUMMARY OF QUALITY IMPACTS

Generally, the water quality at Vernalis has deteriorated since the 1930's. How much degradation has occurred and what have been the principal causes, have been the topics of this chapter. In the analysis of data and interpretation of results, several methods have been employed, sometimes with differing results. The discussion that follows attempts to summarize results and reconcile differences wherever possible. In cases where the methods yield disparate results, ranges are given to include all estimates.

Changes that have occurred in the quality of water at Vernalis between the pre-1944 and post-1952 periods are summarized in tables VI-28 and VI-29. The tables present data derived from the records of mean monthly TDS at Vernalis (mg/L) given in tables VI-13, VI-14, and VI-18. Maximum and mean values are given for three periods--the maximum month, the April-September period and the entire water year--and for each type of year--dry, below normal, above normal and wet.

Data presented in the tables indicate that the TDS at Vernalis has increased in almost all categories listed. The greatest effect is shown in the drier years and the least in the wettest years. Table VI-30 is a composite of tables VI-28 and VI-29, showing the range of estimated impacts at Vernalis. Using the April-September period in a dry year as an example, the mean TDS increased somewhere between 327 and 363 mg/L from pre-1944 to post-1952 years. This increase corresponded to 93 to 116 percent of the pre-1944 period TDS.

As noted in previous discussion, the general deterioration in quality at Vernalis is identified both with reductions in flows along the main stem of the San Joaquin and increases in salt burden transferred to the river. When

Table VI-28. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS
PRE-1944 AND POST-1952

YEAR TYPE & PERIOD	Total Dissolved Solids, mg/L				Percent Increase	
	PRE-1944		POST-1952		PRE-1944 to POST-1952	
	Max	Mean	Max	Mean	Max	Mean
DRY						
Max.month	444	387	941	765	112	98
April-Sept	383	314	840	677	119	116
Full Year	342	288	651	549	99	91
BELOW NORMAL						
Max.month	370	370	729	544	97	47
April-Sept	282	287	683	419	142	46
Full Year	282	261	502	364	78	40
ABOVE NORMAL						
Max.month	517	382	805	641	56	68
April-Sept	244	260	387	325	59	52
Full Year	269	233	489	394	82	69
WET						
Max.month	384	374	462	439	20	17
April-Sept	180	173	226	209	26	21
Full Year	224	197	252	237	13	20
ALL YEARS						
Max.month	517	381	941	584	82	53
April-Sept	383	239	840	433	119	81
Full Year	342	234	651	392	99	65

*BASED ON MOSSDALE DATA

TABLE VI-29. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS
PRE-1944 AND POST-1952

Year type and period	Total dissolved solids, mg/L				Percent increase	
	PRE-1944		POST-1952		PRE-1944 to POST-1952	
	Max	Mean	Max	Mean	Max	Mean
DRY						
Max month	616	490	941	765	53	56
Apr-Sept	453	350	840	677	85	93
Full year	374	310	681	549	82	77
BELOW NORMAL						
Max month	407	407	729	544	79	34
Apr-Sept	278	278	683	419	146	51
Full year	262	262	502	364	92	39
ABOVE NORMAL						
Max month	415	398	805	641	94	61
Apr-Sept	236	228	387	325	64	43
Full year	251	229	489	394	95	72
WET						
Max month	366	358	462	439	26	23
Apr-Sept	202	194	226	209	12	8
Full year	207	200	252	237	22	19
ALL YEARS						
Max month	616	424	941	588	53	39
Apr-Sept	453	267	840	434	85	63
Full year	372	254	681	383	82	51

TABLE VI-30. RANGE OF ESTIMATED IMPACTS* ON QUALITY AT VERNALIS
(1930-1944) to (1952-1966)

Year type & period	Total dissolved solids, mg/L		Percent increase	
	Max	Mean	Max	Mean
DRY				
Max month	325 - 497	275 - 378	53 - 112	56 - 98
Apr-Sept	387 - 457	327 - 363	85 - 119	93 - 116
Full year	307 - 339	239 - 261	82 - 99	77 - 91
BELOW NORMAL				
Max month	322 - 359	137 - 174	79 - 97	34 - 47
Apr-Sept	401 - 405	132 - 141	142 - 146	46 - 51
Full year	220 - 240	102 - 103	78 - 92	39 - 40
ABOVE NORMAL				
Max month	288 - 390	243 - 259	56 - 94	61 - 68
Apr-Sept	143 - 151	65 - 97	59 - 64	25 - 43
Full year	220 - 238	161 - 165	82 - 95	69 - 72
WET				
Max month	78 - 96	65 - 81	20 - 26	17 - 23
Apr-Sept	24 - 46	15 - 36	12 - 26	8 - 21
Full year	45 - 59	37 - 40	22 - 31	19 - 20
ALL YEARS				
Max month	325 - 497	164 - 203	53 - 112	39 - 53
Apr-Sept	387 - 457	167 - 194	85 - 119	63 - 81
Full year	307 - 339	129 - 158	82 - 99	51 - 68

* Based on results from Mossdale data and load-flow regression data. See tables VI-28, VI-29.

the total change in quality at Vernalis that has occurred between the two periods is distributed between reduced flow and increased salt load, it is noted that the effect of increased salt load is becoming relatively more important in recent years. Tables VI-31 and VI-32 summarize the changes in total salt load that have occurred in the two decades 1950-59 and 1960-69 in relation to the period of 1930-49.

In the 1950's, the estimated increased in annual TDS load at Vernalis. In the 1960's the load increased 530 to 569 kilotons TDS per year. This increase between the 1950's and 1960's, a 50-56 percent jump, indicates the more recent impact on water quality at Vernalis. During the 1960's the average annual runoff at Vernalis was about 710,000 acre-feet lower than for the 1930-1949 period while the total TDS load actually increased.

In the 1950's the estimated increase in the April-September TDS load at Vernalis ranged from -18 to +21 kilotons TDS. In the 1960's the load increased +251 to 290 kilotons TDS per year. This increase, 44 to 54 percent of 1930-1949 is indicative also of more recent impacts on Vernalis water quality. During the 1960's the average April-September runoff at Vernalis was about 610 thousand acre-feet lower than in the 1930-1949 period.

A similar analysis based on chloride data summarized in table VI-10, indicates an overall increase in salt load (as chlorides) of about 0-35 percent in the post-1949 years depending on year classification, the dry and below normal years showing the greatest change.

Analysis of the sources of salt load contributing to the San Joaquin River, and which account for, in part, the increases noted at Vernalis, indicates that about 45 to 85 percent of the total load, depending somewhat on the

Table VI-31. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS,
1930-1969

Month of Year	TDS Load, Tons x 10 ³		
	1930-49 *	1950-59	1960-69
Oct	41	49	61
Nov	42	66	63
Dec	57	81	90
Jan	71	97	152
Feb	122	98	186
Mar	148	131	208
Apr	140	168	199
May	136	137	207
Jun	155	119	215
Jul	75	58	104
Aug	35	35	47
Sep	35	41	55
Apr-Sep	576	558	827
Percent change from 1930-49	0	-3	44
Year	1057	1080	1587
Percent Change from 1930-49	0	2	50

* Based on Mossdale chloride data

TABLE VI-32. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS,
1930-1969

Month of year	TDS load, tons x 10 ³		
	1930-49*	1950-59	1960-69
Oct	48	49	61
Nov	44	66	63
Dec	62	81	90
Jan	66	97	152
Feb	108	98	186
Mar	153	131	208
Apr	102	168	199
May	111	137	207
Jun	149	119	215
Jul	94	58	104
Aug	40	35	47
Sept	41	41	55
Apr-Sept	537	558	827
% Change from 1930-49	0	4	54
Year	1018	1080	1587
% Change from 1930-49	0	6	56

* Based on load-flow regression data.

quality constituent considered and the year type, enters within upper San Joaquin River basin. The remaining fraction includes the contributions of the Tuolumne gas wells that have been the subject of efforts by the State of California to reduce point source salt accretions to the river, local drainage returns between Newman and Vernalis and runoff from the east side streams.

Table VI-33 is a summary of the results obtained from salt balances using chloride data for the four representative months of October, January, April, and July. The tabulated results show that virtually no change has occurred in the proportion of salt load contributed by the upper San Joaquin River basin. The table shows that the most apparent changes have taken place on the Tuolumne River and in "other" flows, the unidentified sources and sinks of salt load within the San Joaquin River basin.

Table VI-33 summarizes estimated impacts on the water quality of the San Joaquin River at Vernalis as determined by the two methods, one utilizing the Mossdale chloride data and the second based on chloride load-flow regressions. Data presented in the summary table were derived from various tables presented earlier in this chapter; specifically tables VI-9, 30, 31, 32, and 33 were utilized. Footnotes on table VI-34 describe the procedures used in calculation of the values given.

The effects of upstream development, both in the entire San Joaquin River basin and in the upper San Joaquin River basin as given in table VI-34, are outlined briefly for each year classification as follows:

Dry Years

In dry years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 350 mg/L for the April-September

Table VI-33 PERCENT OF VERNALIS CHLORIDE LOAD
AND THEIR ORIGINS*

	Upper San Joaquin River Basin		"Others"		Stanislaus River		Tuolumne River		Upper San Joaquin plus "others"	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DRY										
Apr-Sep	107	86	-67	-55	4	2	57	69	40	30
Full Year	72	71	-22	-28	3	2	47	56	50	43
BELOW NORMAL										
Apr-Sep	83	81	-28	-49	3	2	43	66	55	32
Full Year	61	67	-1	-21	3	2	38	52	59	46
ABOVE NORMAL										
Apr-Sep	59	63	17	1	2	3	23	35	75	63
Full Year	51	55	22	9	2	2	26	34	72	64
WET										
Apr-Sep	68	56	37	25	2	3	16	21	82	77
Full Year	47	49	31	25	2	2	21	26	78	73
ALL YEARS										
Apr-Sep	78	73	-11	-24	3	2	35	51	63	48
Full Year	58	62	7	-7	2	2	33	44	65	55

*Based on load-flow regression salt balances.

Pre refers to 1930-1944 period with 5-Dry, 1-B.Norm., 2-A.Norm., 2-Wet

Post refers to 1952-1966 period with 4-Dry, 5-B.Norm., 2-A.Norm., 4-Wet

TABLE VI-34. SUMMARY OF ESTIMATED IMPACTS ON THE QUALITY OF THE SAN JOAQUIN RIVER AT VERNALIS

<u>1</u> Year Type & Period	<u>2</u> Total increase in TDS mg/L at Vernalis	<u>3</u> Increase in TDS mg/L due to decreased flow		<u>4</u> Percent due to CVP	<u>5</u> Increase in total salt load			
		Percent of Pre-CVP	Percent due to CVP		<u>6</u> Vernalis total		<u>7</u> Increased caused by CVP	
					Increase Tons x 10 ³	% of Pre-CVP	Increase Tons x 10 ³	% of Pre-CVP
DRY								
Apr-Sep	327 - 363	84 - 100	1.8 - 2.1	68	49	58	42	
Full Year	239 - 261	22 - 26	6.3 - 7.4	143	55	102	39	
BELOW NORMAL								
Apr-Sep	132 - 141	100	36	95	57	77	46	
Full year	102 - 103	100	45	193	62	129	41	
ABOVE NORMAL								
Apr-Sep	65 - 97	100	37	33	39	21	25	
Full year	161 - 165	100	59	72	46	40	26	
WET								
Apr-Sep	15 - 36	81 - 100	45 - 55	76	46	43	26	
Full year	37 - 40	65 - 73	44 - 50	143	46	70	23	
ALL YEARS								
Apr-Sep	167 - 194	90 - 100	30 - 33	73	49	54	36	
Full year	129 - 158	70 - 73	37 - 39	147	53	91	33	

Col. 2 - See Table VI-30.

3 - Obtained by assuming no change in salt load and flow reduction TDS=50 mg/L.

4 - Col 3 x ratio of upper San Joaquin flow reductions to total San Joaquin flow reduction.

5 - Obtained by pro-rating average TDS load increase between 1960's and 1930-49 period (Tables VI-31 and 32) in proportion to salt load increase in each year type (Table VI-9) and number of years of each year type in 1950-69 period.

6 - Col 5 salt load for 1930-49 period x proportion of years in each class.

7 - Col 5 x proportion of total chloride load contributed by upper San Joaquin basin (Table VI-33)

8 - Col 7 x proportion of years in each year class.

Table VI-33 PERCENT OF VERNALIS CHLORIDE LOAD
AND THEIR ORIGINS*

	Upper San Joaquin River Basin		"Others"		Stanislaus River		Tuolumne River		Upper San Joaquin plus "others"	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DRY										
Apr-Sep	107	86	-67	-55	4	2	57	69	40	30
Full Year	72	71	-22	-28	3	2	47	56	50	43
BELOW NORMAL										
Apr-Sep	83	81	-28	-49	3	2	43	66	55	32
Full Year	61	67	-1	-21	3	2	38	52	59	46
ABOVE NORMAL										
Apr-Sep	59	63	17	1	2	3	23	35	75	63
Full Year	51	55	22	9	2	2	26	34	72	64
WET										
Apr-Sep	68	56	37	25	2	3	16	21	82	77
Full Year	47	49	31	25	2	2	21	26	78	73
ALL YEARS										
Apr-Sep	78	73	-11	-24	3	2	35	51	63	48
Full Year	58	62	7	-7	2	2	33	44	65	55

*Based on load-flow regression salt balances.

Pre refers to 1930-1944 period with 5-Dry, 1-B.Norm., 7-A.Norm., 2-Wet
Post refers to 1952-1966 period with 4-Dry, 5-B.Norm., 2-A.Norm., 4-Wet

TABLE VI-34. SUMMARY OF ESTIMATED IMPACTS ON THE QUALITY OF THE SAN JOAQUIN RIVER AT VERNALIS

<u>1</u> Year Type & Period	<u>2</u> Total increase in TDS mg/L at Vernalis	<u>3</u> Increase in TDS mg/L due to decreased flow		<u>5</u> <u>6</u> <u>7</u> <u>8</u> Increase in total salt load			
		Percent of Pre-CVP	Percent due to CVP	Vernalis total		Increased caused by CVP	
				Increase Tons x 10 ³	% of Pre-CVP	Increase Tons x 10 ³	% of Pre-CVP
DRY							
Apr-Sep	327 - 363	84 - 100	1.8 - 2.1	68	49	58	42
Full Year	239 - 261	22 - 26	6.3 - 7.4	143	55	102	39
BELOW NORMAL							
Apr-Sep	132 - 141	100	36	95	57	77	46
Full year	102 - 103	100	45	193	62	129	41
ABOVE NORMAL							
Apr-Sep	65 - 97	100	37	33	39	21	25
Full year	161 - 165	100	59	72	46	40	26
WET							
Apr-Sep	15 - 36	81 - 100	45 - 55	76	46	43	26
Full year	37 - 40	65 - 73	44 - 50	143	46	70	23
ALL YEARS							
Apr-Sep	167 - 194	90 - 100	30 - 33	73	49	54	36
Full year	129 - 158	70 - 73	37 - 39	147	53	91	33

Col. 2 - See Table VI-30.

3 - Obtained by assuming no change in salt load and flow reduction TDS=50 mg/L.

4 - Col 3 x ratio of upper San Joaquin flow reductions to total San Joaquin flow reduction.

5 - Obtained by pro-rating average TDS load increase between 1960's and 1930-49 period (Tables VI-31 and 32) in proportion to salt load increase in each year type (Table VI-9) and number of years of each year type in 1950-69 period.

6 - Col 5 salt load for 1930-49 period x proportion of years in each class.

7 - Col 5 x proportion of total chloride load contributed by upper San Joaquin basin (Table VI-33)

8 - Col 7 x proportion of years in each year class.

period and 250 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, but only 25 percent for the entire year. The impact of the CVP on water quality (as expressed by changes in TDS) in dry years, caused by flow reductions in the upper San Joaquin basin, was relatively small, only 2 percent in the April-September period and 7 percent for the entire year.

Salt loads at Vernalis in dry years were estimated to have increased in the period subsequent to 1947, by 68,000 tons in the April-September period and by 143,000 tons for the whole year. These increases corresponded to roughly 49 percent and 55 percent, respectively, of the pre-1944 TDS loads at Vernalis. The CVP salt load impact in dry years was estimated at 58,000 tons in the April-September period and 102,000 tons for the full year, corresponding to 42 percent and 39 percent increases, respectively, of pre-1944 salt loads at Vernalis.

Below Normal Years

In below normal years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 135 mg/L for the April-September period and slightly more than 100 mg/L for the full year. Virtually all of this increase is attributed to reductions in flow from all sources. The impact due to reduced flow attributed to the CVP was about 36 percent in the April-September period and 45 percent for the full year.

TDS load increases in below normal years subsequent to 1947 are estimated at 95,000 tons for the April-September period and 193,000 tons for the year. Of this increase, 77,000 tons and 129,000 tons, respectively, were estimated to have been derived from the upper San Joaquin basin. The proportionate impact

of the CVP on salt loads at Vernalis was largest for below normal years, 46 percent of the total increase at Vernalis in the April-September period and 41 percent for the whole year.

Above Normal Years

In above normal years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 80 mg/L for the April-September period and 165 mg/L for the full year. Of this increase, the proportion due to reduced flow from all sources was 100 percent in both the April-September and full year periods. The impact of the CVP on water quality (as expressed by changes in TDS) in above normal years, caused by flow reductions in the upper San Joaquin basin, was 37 percent in the April-September period and 59 percent for the entire year.

Salt loads at Vernalis in above normal years were estimated to have increased in the period subsequent to 1947 by 33,000 tons in the April-September period and by 72,000 tons for the entire year. These increases correspond to roughly 39 percent and 46 percent, respectively, of pre-1944 TDS loads at Vernalis. The CVP salt load impact in above normal years was estimated at 21,000 tons in the April-September period and 40,000 tons for the full year, corresponding to 25 and 26 percent increases respectively, in pre-1944 salt loads at Vernalis.

Wet Years

In wet years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 25 mg/L for the April-September period and about 40 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, and 70 percent for the entire year. The impact due to

reduced flow attributed to the CVP was about 50 percent for both the April-September and full year periods.

TDS load increases in wet years subsequent to 1947 are estimated at 76,000 tons for the April-September period and 143,000 tons for the year. Of this increase, 43,000 tons and 70,000 tons, respectively, were estimated to have been derived from the Upper San Joaquin Basin. The proportionate impact of the CVP on salt loads at Vernalis was 26 percent of the total increase at Vernalis in the April-September period and 23 percent for the full year.

CHAPTER VII

EFFECTS OF OPERATION OF CVP AND SWP EXPORTS PUMPS NEAR TRACY

CHANNEL DEPTHS AND CROSS SECTIONS

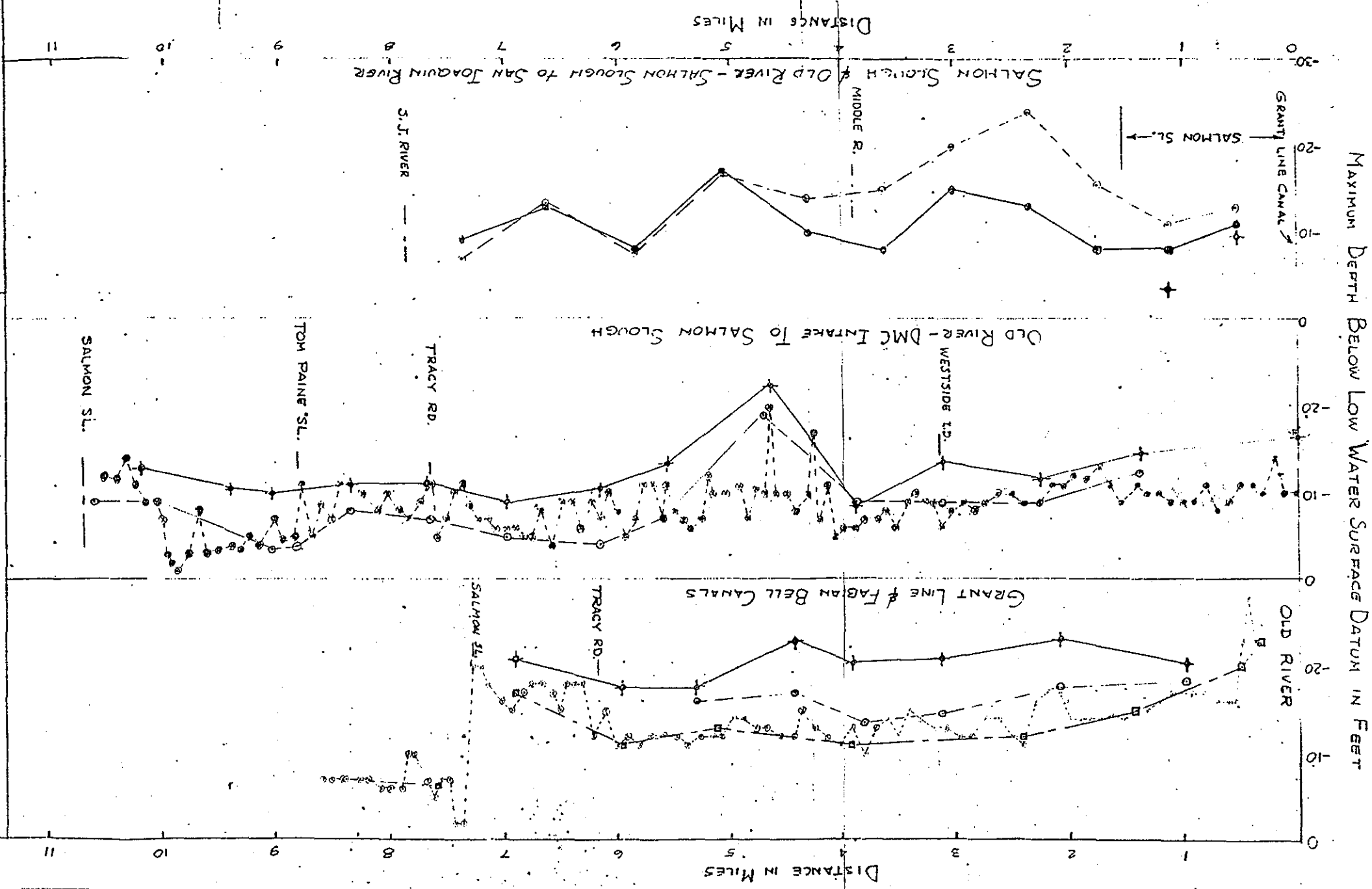
The geometry of the channels within the southern Delta was studied to determine whether the channel cross sections and bottom elevations have changed since the 1930's in such a way as to alter water circulation patterns and water depths to a degree that modifies the southern Delta water supply.

Channel Surveys

Prior to 1913, most existing channels within the South Delta Water Agency were well defined, due in part to the sidedraft clamshell dredge which was used over many years to construct the levee system within the South Delta and to keep channels clean of sediment. Since 1913 most of the channels in the South Delta have been surveyed several times. The results of surveys are summarized in figure VII-1.

Available survey data include:

<u>Date of survey</u>	<u>Channels surveyed</u>	<u>Source of data</u>
1913	Old River - Middle River to Victoria Canal Middle River - Old River to Victoria Canal Grant Line and Fabian Canals	USCE
1933-34	All SDWA channels	USC&GS
1957	Grant Line and Fabian Canals, plus Salmon Slough and Paradise Cut	DWR
1965	Grant Line and Fabian Canals	USCE
1973	Old River-San Joaquin River to Victoria Canal Middle River-Old River to Victoria Canal Grant Line and Fabian Canals	DWR
1976	San Joaquin River-Vernalis to Mossdale	DWR

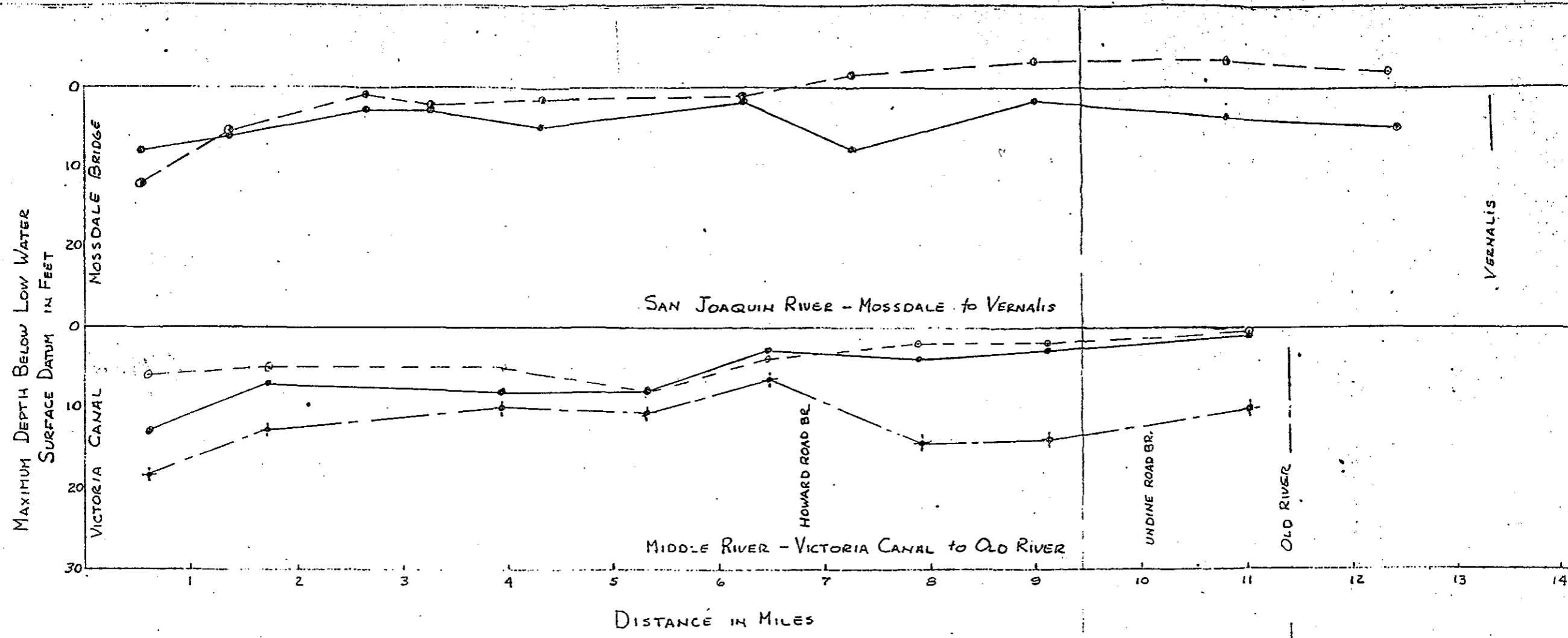


SOUTH DELTA CHANNEL DEPTH SURVEYS

Dated April 1980

Water and Power Resources Service

FIGURE VII-1



SOUTH DELTA CHANNEL
 DEPTH SURVEYS
 WATER AND POWER RESOURCES SER.
 DATED APRIL 1980 FIGURE 2
 (CONT.)

In describing the geometry of the channels, especially the depth, it is appropriate to use a fixed reference plane. For example, navigation charges which need to be site specific use local MLLW. However, this locally oriented datum varies from -0.2 ft MSL to +0.5 ft MSL within the SDWA and is dependent upon the condition of San Joaquin River inflow.

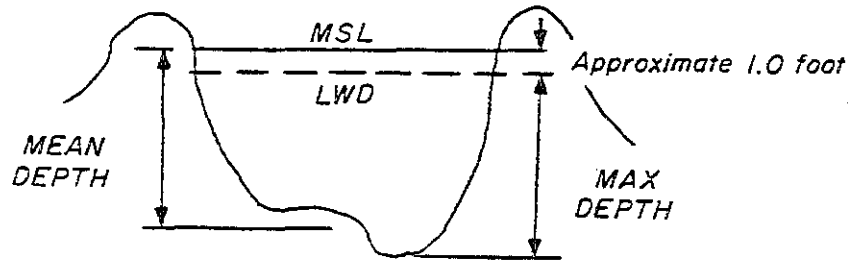
Much of the hydrographic data used in this study was taken from charts used by the Corps of Engineers to build the Sausalito model of the Bay-Delta, the low water datum, (LWD) of 1.0 foot below mean sea level as shown in the sketch below, which was used by the Corps to integrate data from diverse sources, was also adopted for the present study. It is a conservative datum in that it is lower than the local MLLW levels throughout the SDWA by a foot or more.

Most of the channels, dredged prior to 1913, were 10 to 20 feet below the LWD. By 1933-34, however, most channels surveyed had aggraded significantly. Existing survey data indicate that in some channels, such as the southern reaches of Middle River, little dredging has been done. Data on dredging to maintain the levees and to provide fill for road construction were not available.

In the 1973 and 1976 surveys channel geometry was determined for reaches from Vernalis on the San Joaquin River to the State and Federal pumping plants near Clifton Court Forebay, including Old River and the Grant Line and Fabian-Bell Canals, and for the Middle River between Old River and Victoria Canal. To determine channel bottom profiles, bottom elevations taken at 1/2 to 1-1/2-mile intervals were averaged. The shapes of the channels studied were such that the average water depths approximated the hydraulic radius. An example of the channel mean depths and cross sections observed in the 1973 survey for the

reach of Old River between Clifton Court and the San Joaquin River is presented in figure VII-2.

The diagram below illustrates the differences between average and maximum depths and between LWD and MSL.



Bottom elevations of the major channels were further analyzed in relationship to the survey dates and the initial operations of the Federal and State pumping plants.

San Joaquin River--Vernalis to Mossdale Bridge. Most of this reach has aggraded since the 1933-34 surveys. By 1976 the elevation of the stream bottom had risen 0.5 to 9.5 feet above the 1933-34 levels, with an average increase of about 4.0 feet. The bottom elevation of the reach from Vernalis to a point approximately 4.8 miles north of the San Joaquin River club varied from 2 to 7 feet below the LWD in 1933 and varied from 1.5 to 3.5 feet above LWD in 1976. This aggradation generally causes a corresponding reduction in water depth.

Old River, San Joaquin River to and including Salmon Slough. In 1973, streambed elevations of this 7.5-mile reach were equal to or below that measured in the 1933-34 survey. The 1973 elevations ranged from 8 to 24 feet below LWD with an average of about 14 feet; the 1933-34 elevations varied from 8 to 17 feet with an average of about 10 feet. Therefore, during the intervening

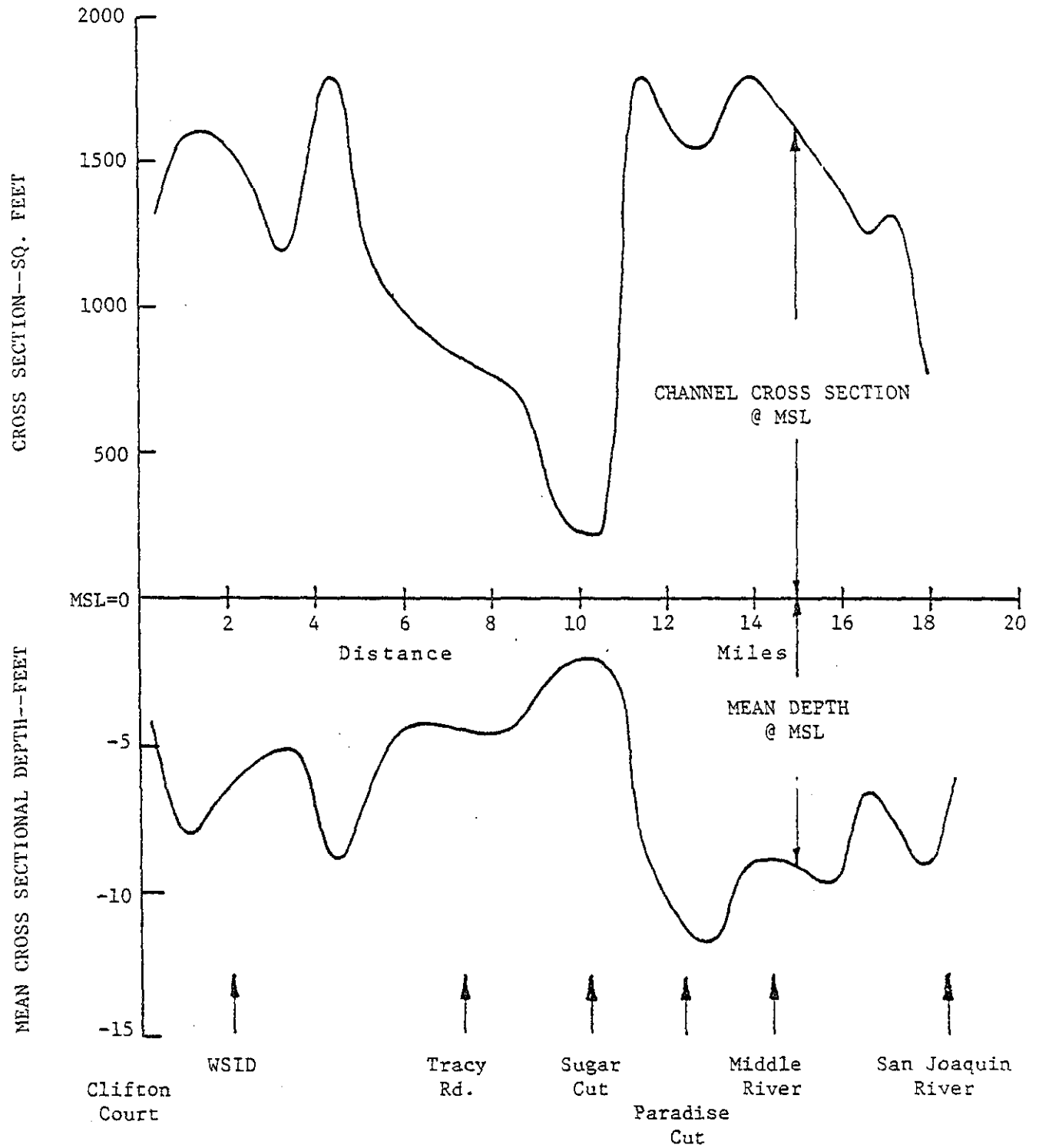


Figure VII-2 CHANNEL PROPERTIES, OLD RIVER, CLIFTON COURT TO SAN JOAQUIN RIVER (Data from 1973 DWR Survey, Datum is Mean Sea Level)

40 years, the channel had degraded an average of 4 feet, but with very little change in the upstream 1/3 of the reach.

Old River, to Salmon Slough to Delta-Mendota Canal Intake Channel. Bottom elevations of this 11-mile channel averaged 12 feet in 1913, with a range of 9 to 22 feet below LWD. The channel had displayed a 3.5-foot aggradation by the 1933-34 survey. However, the channel had not had any further significant change by the 1973 survey. The 1933-34 and the 1973 surveys each indicated a similar channel restriction near the bifurcation of Old River and Tom Paine Slough. Maximum cross sectional depths measured in 1973 through the 4-mile restricted section averaged about 6 feet with a minimum of 4 feet with reference to LWD elevation. The mean elevation of the bottom of the most restricted area is about 2 feet below mean sea level as shown in figure VII-2. Where as the maximum depth below LWD was about 3.7 feet.

Grant Line and Fabian Canals--In 1913 the elevation of these paralleling 7-mile channels averaged more than 20 feet below LWD. By 1957 they had aggraded about 8 feet with an average depth of 12 feet below LWD, remaining at that depth until after the 1965 survey. By the 1973 survey, however, the channels had degraded to an average of about 16 feet below LWD. The channel depths could have been influenced by maintenance dredging and/or increases in channel velocities due to operation of Clifton Court Forebay. Flow restrictions have not been apparent in these channels.

Middle River--Old River to Victoria Canal--In 1913, the channel elevation of this 11.5-mile reach of Middle River varied between 7 and 18 feet below LWD with an average of about 12 feet below LWD. By the 1933-34 survey, channel bed had aggraded to an average of about 6 feet below LWD elevation. Further

aggradation was shown by the 1973 survey to an average depth of 4 feet below LWD elevation. However, the 6-mile reach directly north of Old River has only aggraded about 0.5 feet since the 1933-34 survey. Both the 1933-34 and 1973 surveys recorded a restriction 0.4 of a mile north of the head of Middle River with maximum depths of 1.0 in 1933-34 and 0.5 feet in 1973, below LWD elevation.

Calculated Hydraulic Resistance in Old River

The resistance to flow, assuming present channel geometry in Old River, was studied as a basis for examination of the effect of reduced water levels on water circulation through this channel.

Using channel cross section data obtained by the DWR in 1973, the hydraulic resistance characteristics were estimated for some 22 channel segments of Old River between Clifton Court and the main stem of the San Joaquin River. It can be shown by open channel flow hydraulics that resistance, the relationship between head loss and channel discharge, is proportional to the square of channel width and the $10/3$ power of the mean depth. In essence, this means that a narrow, shallow channel greatly restricts flow--much more dramatically than might at first appear to be the case by inspection in the field. For example, simply reducing channel width and depth by one-half each, thereby reducing the effective area to one-quarter, increases hydraulic resistance for the same length and roughness more than 40 times. These effects are especially evident in the central section of Old River in the vicinity of Tom Paine Slough where mean channel depths below mean sea level average less than 3 feet and widths are less than 100 feet.

The channel cross sections and depths along Old River are illustrated graphically in figure VII-2. In figure VII-3 the cumulative hydraulic resistance

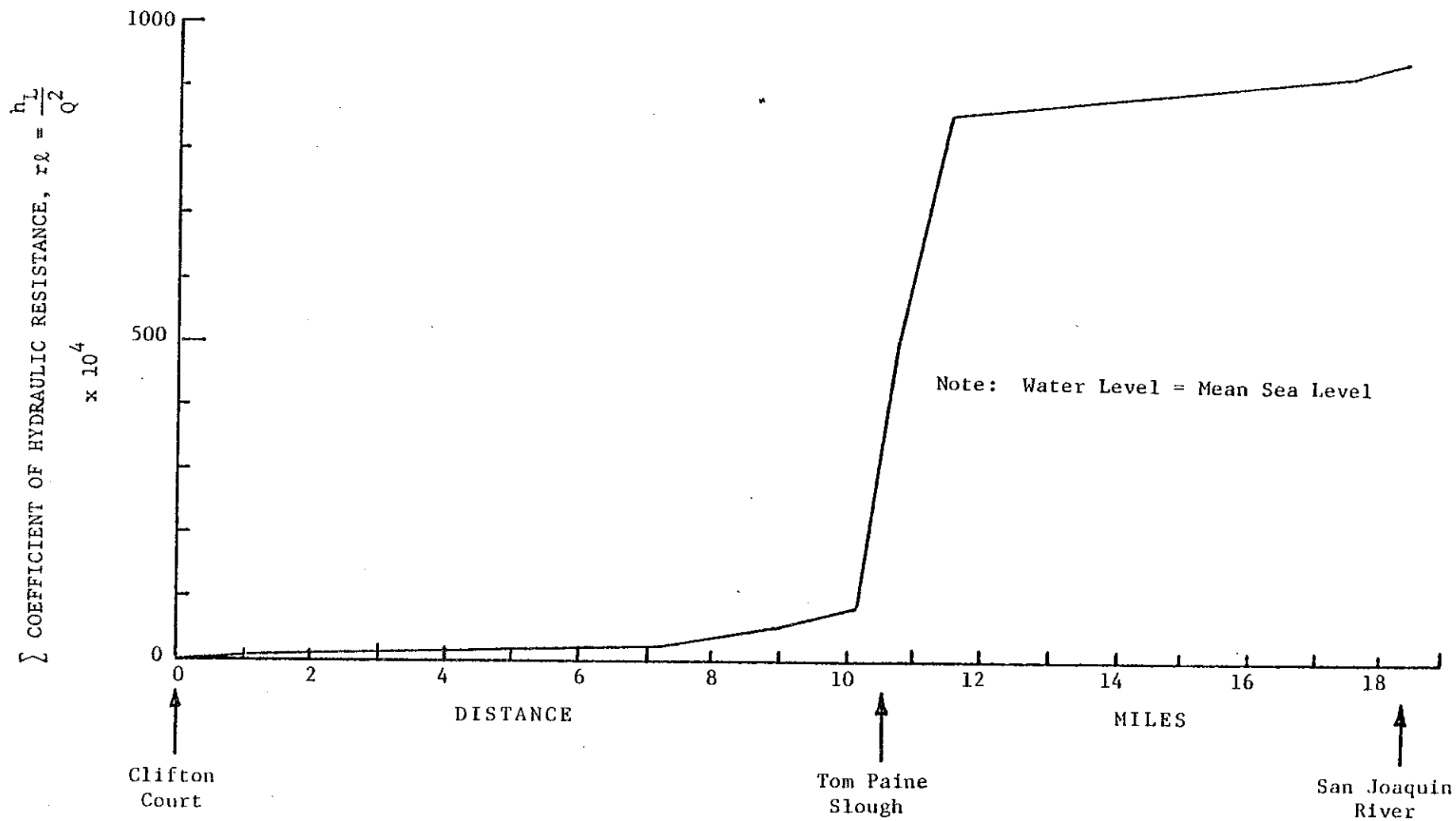


Figure VII-3 CUMULATIVE HYDRAULIC RESISTANCE IN OLD RIVER, CLIFTON COURT TO SAN JOAQUIN RIVER

to flow is plotted for the entire channel from Clifton Court to the San Joaquin River. The same data are visually keyed to a partial map of Old River in figure VII-4. It is noted that most of the effect, about 90 percent of the total, is concentrated in a short section about 2 miles long in the vicinity of Tom Paine Slough. This restriction was evident during the 1933-34 channel survey. Obviously, this area controls the rate of flow in an east-west direction through Old River. Actually, it forces the largest proportion of the east to west flow through Grant Line and Fabian-Bell Canals rather than through the westerly section of Old River.

Sediment Movement

In 1950, the USBR improved the operation of the Delta-Mendota Canal intake channel by dredging the Old River Channel to a minus 17-foot elevation from the Delta-Mendota Canal headworks downstream to approximately Grant Line Canal. By 1969 the dredged channel was nearly obliterated by sediment which continued to move into the Delta-Mendota Canal Intake Channel. The Old River Channel was dredged again in 1969 and in 1974. Another example of sediment movement is the accumulation of 60,000 cubic yards of sediment in Clifton Court Forebay during the first 4 years of its operation.

During the same period a large but unestimated amount of sediment was pumped into the Delta-Mendota Canal as suspended load and deposited within the canal, O'Neill Forebay and Mendota Pool. The available suspended solids data for both the DMC and State Aqueduct and vicinity are located in STORET, a Federal data storage system, and summarized below for the period of record:

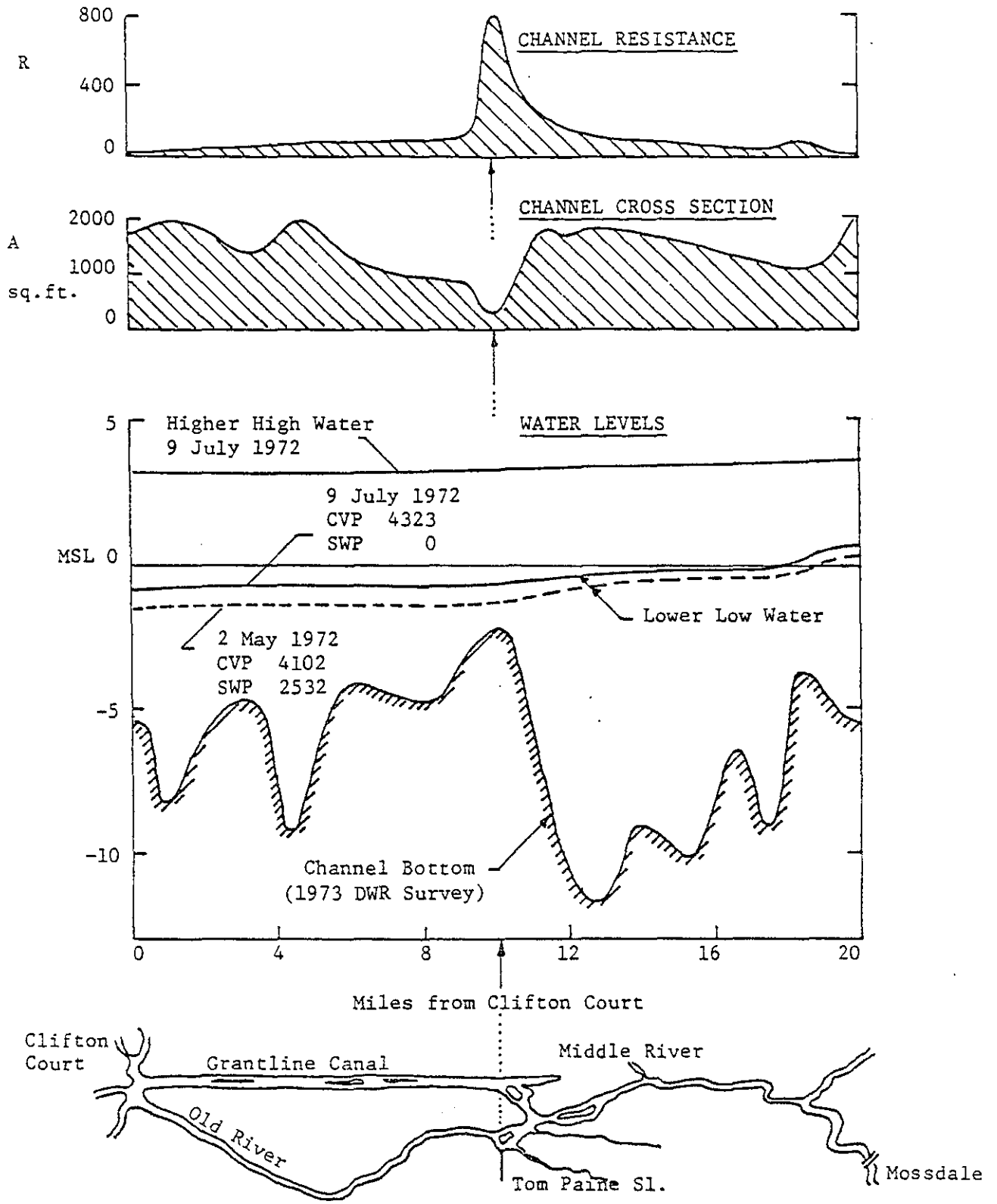


Figure VII-4 WATER LEVELS AND CHANNEL CHARACTERISTICS
OLD RIVER--SOUTH DELTA

<u>Stations</u>	<u>Period of record</u>	<u>Average total suspended solids</u>	
		<u>mg/L</u>	<u>pounds/acre-foot</u>
DMC near Head	1973 - 1974	42.0	115
Delta Pumping Plant Headworks	1973 - 1979	21.3	58
Clifton Court	1973 - 1979	41.6	114
Old River at Mouth of Clifton Court Intake	1973 - 1974	44.1	120
Old River at Mossdale Bridge	1973 - 1978	48.0	123
Old River opposite Rancho Del Rio (near Rock Slough)	1973 - 1979	23.0	63

The Service and the Department of Water Resources established a Scour Monitoring Program primarily in Old and Middle Rivers north of the pumps to identify any channel scouring. The Department makes soundings repetitively at selected cross sections and the Service makes an annual aerophotographic survey of channels contiguous to the export pumps. Results indicate some degradation and aggradation at the selected cross sections north of the pumping plants, but no overall erosion or scour patterns. There are no stations east of Tracy Road in the South Delta Water Agency in the program.

IMPACT OF EXPORT PUMPS ON SOUTHERN DELTA WATER LEVELS, WATER DEPTHS, AND WATER QUALITY

Impact of Export Pumping on Water Levels and Water Depths

Any diversion from the Delta, including export pumping, lowers the water levels to some distance from the point of diversion, and the lowering of level is superimposed on whatever level would otherwise result from the combination of tides and net advective or downstream flows. The effect of large

diversions from Delta channels is a depression in channel water surface which provides the gradient for the movement of water in all connecting channels toward the pumps. The distribution of flow and the water level drawdown among connecting channels is a function of channel geometry, roughness, pumping rate and in the instance of the SDWA channels, the flows in the San Joaquin River. A generalized impact of operating the CVP and SWP export pumps is a reduction of water levels and a modification of channel flows in the southern Delta.

The Clifton Court Forebay was incorporated into the SWP primarily to allow the use of offpeak power to pump water into the State Aqueduct and to prevent channel scouring prior to the creation of a Delta transfer facility.

Water level data are available in considerable detail at a number of stations throughout the Delta, including nine stations within the southern Delta. Since the drawdown of water level by the export pumps is superimposed on the water level fluctuations that would otherwise occur, two approaches have been used to determine the degree and spatial extent of the drawdown caused by the export pumps. These methods of determination include field tests and mathematical modeling.

Field tests--Steady export pumping field tests were made in May and August of 1968 wherein levels were measured at high and low export pumping rates with other conditions substantially the same. These tests were precipitated by concerns that export pumping was a contributing cause of reductions in water level such that the operation of agricultural pumps in Tom Paine Slough and in the southern portion of Middle River was restricted during low tide, and siphons around Victoria Island were losing prime. Reductions in pump capacity due to low water levels were also reported at the Westside Irrigation

District intake on Old River south of Fabian Tract. The test evaluations were limited to low tide levels which were considered by the project operators to represent the periods when steady export pumping has the maximum effect on southern Delta water supply. However, the reduction in channel water supply is also influenced by the reduction in tidal prism upstream from the export pumps and this is related to water level reductions at all levels of tide.

The flows in the San Joaquin River near Vernalis were about 700 and 900 ft³/s for the May and August testing period, respectively.

These 1968 tests are described and the results summarized in two cooperative reports by DWR and the USBR, both titled "Summary of Effect of Export Pumping on Water Levels in the Southern Delta." One report describes the May 25-30, 1968 tests and was issued in July 1968. The other report describes the August 29 to September 9, 1968 tests and was issued in December 1968. Results of these tests indicated that steady export pumping at the rates observed in the tests lowered the lower low tide level at Clifton Court by 0.07 to 0.08 foot for each 1,000 ft³/s of export pumping.

The effects of water level depression due to State and Federal export pumping extends northward and eastward from the points of diversion. The 1968 test results in vicinity of Clifton Court, after correction by a constant amount for the normal tidal fluctuation at Antioch (assumed to be outside of the influence of the pumps), are presented in table VII-1.

The general effect of export pumping is to reduce local water levels, creating a gradient toward the point of diversion and redistributing flows in the principal channels of the southern Delta. Depending on the level of export and rate of inflow to the Delta near Vernalis, the effect is sometimes to

TABLE VII-1
1968 PUMP TESTS RESULTS

Stations	<u>1</u>		<u>2</u>		<u>3</u>	
	May Test 6725 to 1950 ft ³ /s Differential (4775 ft ³ /s)		Aug/Sep Test 6934 to 800 ft ³ /s Differential (6134 ft ³ /s)		Difference in water level depression be- tween pump tests ¹	
	Water Level Depression		Water Level Depression		Col.1	Col. 2
	Feet	Ft/1000 ft ³ /s	Feet	Ft/1000 ft ³ /s	Feet	
Old River at Clifton Court	0.33	0.07	0.47	0.08	0.13	
Old River at Tracy Road	0.30	0.063	0.40	0.065	0.10	
Tom Paine Slough above Mouth	0.29	0.06	0.35	0.06	0.06	
Grant Line at Tracy Road	0.30	0.06	0.38	0.06	0.08	
Middle River at Bacon Island	0.12	0.03	0.10	0.02	-0.02	
San Joaquin River at Mossdale	0.14	0.03	--	--	--	
San Joaquin River at Brant Bridge	0.16	0.03	0.12	0.02	-0.04	
Old River near Byron	0.29	0.06	0.32	0.05	0.03	
Old River near Rock Slough	0.08	0.02	0.12	0.02	0.04	
Middle River at Borden Hwy.	0.29	0.06	0.30	0.05	0.01	
Rock Slough at CCC Intake	0.15	0.03	0.14	0.02	-0.01	

^{1/} This column illustrates that with an increase in diversion rate of about 1,400 ft³/s the water level depression either decreased or increased only slightly at stations beyond Tom Paine Slough. This is indicative of the significance of pumping impact during the tests at these outlying stations.

reverse the net flow downstream of the bifurcation of the San Joaquin and Old Rivers.

Another examination of recorded water levels was made for the June 14-30, 1972 period. Dr. G. T. Orlob's November 15, 1978 memorandum to the SDWA Board examined the hydraulic depression created by the export pumps and the gradient toward the export pumps along various channels during this period. Table VII-2 and figure VII-5 are taken from pages 8 and 10 of that memorandum. Table VII-2 shows the drawdown of HHW indicated for various dates and export rates. The period of June 22-25 was used to develop figure VII-5. During this period only the CVP steady export pumping was being made. Figure VII-5 shows the difference between Bacon Island tide levels and Clifton ferry tide levels as a function of CVP export rates. The figure also indicates a high tide level depression at Clifton Court of 0.1 foot for each 1,000 ft³/s of steady export pumping.

Data collected in 1977 was used by the DWR to compare two 15-day periods with markedly different export rates and with other pertinent conditions only moderately different (see table VII-3). The period October 17-31, 1977 included an average export of about 300 ft³/s and a San Joaquin River flow at Vernalis of about 250 ft³/s. The period December 17-31, 1977 included an average export rate of about 9,400 ft³/s and a San Joaquin River flow at Vernalis of 470 to 600 ft³/s. Table VII-4 compares the differences in the 15 day means of each tidal phase between the selected control station at Rock Slough and stations in the South Delta for the two periods. About 5,800 ft³/s of this average export rate was by the SWP which diverted at high tide. Therefore, the differences in water level depression near Clifton Court was greatest during the high tidal phase. The comparison between the October and December

TABLE VII-2
 EXAMPLE OF TIDAL ELEVATION DATA
 FOR SOUTH DELTA - JUNE 1972

Date	Export, ft ³ /s		HHW, feet MSL		ΔH, feet
	SWP	CVP	Bacon Island	Clifton Ferry	
6-16-72	2109	4191	2.79	1.67	-1.12
6-17-72	2090	4196	2.34	1.18	-1.16
6-18-72	2382	4204	2.81	1.56	-1.25
6-19-72	2331	4180	3.45	2.28	-1.17
6-20-72	2411	4233	3.42	2.22	-1.20
6-21-72 ^{1/}	2362	3561	3.39	1.85	-1.54
6-22-72	0	2558	2.93	2.51	-0.42
6-23-72	0	1173	3.46	3.25	-0.21
6-24-72	0	923	3.25	3.07	-0.18
6-25-72	0	926	3.45	3.28	-0.17
6-26-72	487	947	3.69	3.52	-0.17
6-27-72	911	968	3.68	3.37	-0.31
6-28-72	945	965	3.52	3.17	-0.35
6-29-72	1564	963	3.35	2.98	-0.37
6-30-72	1682	1041	2.98	2.34	-0.64
6-30-72	1682	1041	3.10	2.38	-0.72

^{1/} Andrus and Brannon Islands were filling due to a levee failure June 21 at about 0030. The effect on the tidal elevation at Bacon Island is indicated in figure VII-6, where a small depression in the water level curve is noted for about an hour following the break. It may be expected that this effect would have had only a minor influence in the water levels in the Southern Delta.

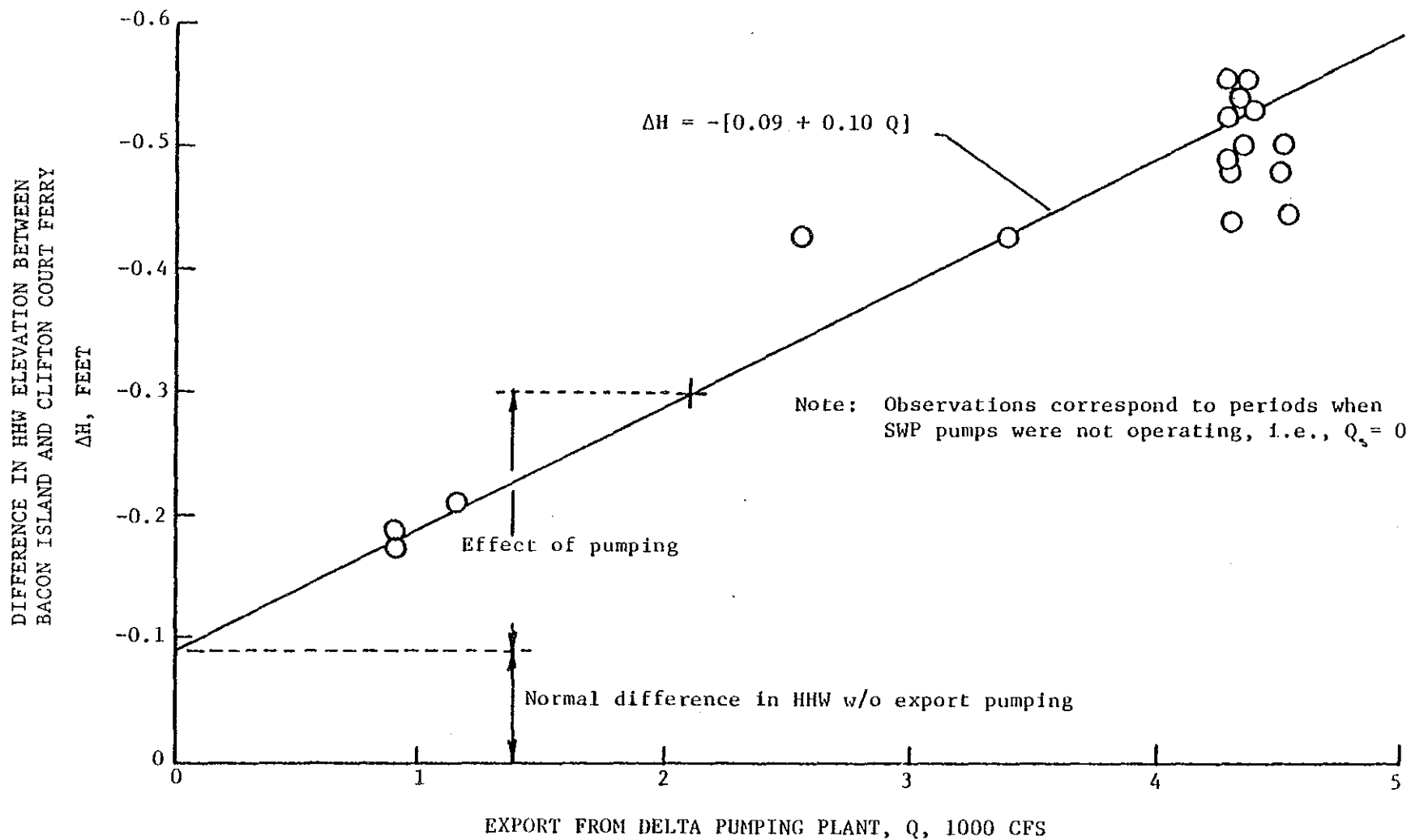


Figure VII-5 DEPRESSION IN HWL AT CLIFTON COURT RELATIVE TO MIDDLE RIVER
AT BACON ISLAND AS A RESULT OF CVP EXPORT PUMPING AT TRACY

TABLE VII-3
CLIFTON COURT FOREBAY
Daily Operation of Gates

Month <u>October</u> , 1977				Month <u>December</u> , 19 <u>77</u>			
DATE	TIME OPENED	TIME CLOSED	DAILY AMOUNT OF INFLOW IN ACRE-FEET	DATE	TIME OPENED	TIME CLOSED	DAILY AMOUNT OF INFLOW IN ACRE-FEET
17			0	17	0016		13,231
18	1010	1325	198	18	0807	0430 1845	
19	1800	1848	99			0617	10,468
20	2000	2050	99	19	0840	1836	
21	1311	1625	595				10,168
22	1733	2000	595	20		2007	11,615
23			0	21	0005	2050	3,866
24			0	22	0015	0740 1120	9,332
25	1041	1217	298	23	0723	1640	7,735
26			0	24	0219	0710 0910	10,897
27			0	25	0300	2153	13,095
28	0842	1000	298	26	0330	2200	12,473
29	0855	0945	298	27	0330	2200	11,074
30	0853	1012	298	28	0445		11,931
31	1015	1250	1,388	29		0005	
					0517		12,083
				30		0042	
					0530		11,382
				31		0021	
					0555		10,063

TABLE VII-4

EXPORT EFFECTS ON TIDE STAGES^{1/}

15 Day Mean Tidal Differences
between Old River at Rock Slough
and indicated locations

Delta Tide Stations	Tidal Stage	1977	
		Oct. 17-31	Dec. 17-31
		296 ft ³ /s ^{2/}	9,368 ft ³ /s ^{2/}
1. Old River near Byron	HH	0.10	0.55
	LH	0.10	0.49
	HL	0.16	0.41
	LL	0.10	0.23
2. Middle River at Borden Hwy.	HH	0.02	0.52
	LH	0.03	0.44
	HL	0.10	0.36
	LL	0.06	0.18
3. Old River at Clifton Court Ferry	HH	0.04	1.08
	LH	0.06	0.95
	HL	0.17	0.47
	LL	0.09	0.32
4. Grantline Canal at Tracy Road Bridge	HH	0.12	1.04
	LH	0.12	0.88
	HL	-0.04	0.30
	LL	-0.30	-0.07
5. Middle River at Mowry Bridge	HH	-0.13	0.55
	LH	-0.11	0.42
	HL	-0.31	0.00
	LL	-0.67	-0.60
6. Old River near Tracy Road Bridge	HH	0.25	1.20
	LH	0.62	0.99
	HL	-0.55	0.08
	LL	-0.93	-0.61
7. Tom Paine Slough above Mouth	HH	0.13	1.05
	LH	0.13	0.88
	HL	-0.12	-0.30
	LL	-0.32	-0.13
8. San Joaquin River at Mossdale	HH	0.02	0.57
	LH	-0.10	0.37
	HL	-0.18	-0.42
	LL	-1.35	-1.01

^{1/} Range of San Joaquin River flows near Vernalis was 232-268 ft³/s and 470-600 ft³/s during the Oct 17-31 period, and the Dec 17-31 period, respectively.

^{2/} Tracy Pumping Plant and Clifton Court Intake combined 15 day mean diversion rate.

periods demonstrates, in general, that reductions in 15 day average water levels due to an increase in export as measured in the prototype are of the same order as those obtained in mathematical model studies to be discussed later in the text. The reduction in 15 day average water level at high tide at Clifton Court is a composite effect of high tide diversion into Clifton Court Forebay and steady diversion into the Delta-Mendota Canal. The impact of steady pumping is estimated to be about an average of 0.08 foot depression at Clifton Court Ferry per 1,000 ft³/s based on the analysis of the 1977 data. The impact of intermittent diversion into Clifton Court Forebay at high tide is approximately 0.14 foot per 1,000 ft³/s of average daily diversion. The combined effect of steady and intermittent pumping was to depress the high tide level by about 1.1 feet. Table VII-5 discusses the data and describes the procedures used to calculate these estimates.

The above tests showed that water level drawdown was about the same in Old River near Tracy Road and at Clifton Court. A depression in water level was evident as far away as Mossdale. However, an exact effect at Mossdale cannot be determined by tests in which San Joaquin River flows and agricultural diversions upstream from the export pumps vary between test periods. For example, in December 1977 the San Joaquin River flow was two to three times greater, and the agricultural diversions were presumably less than in October 1977.

A graphic presentation of the effect of intermittent export pumping on water levels at high tide is shown in figure VII-6. This figure shows the tide levels during the upper portion of the tide at Clifton Court and at Old River at Tracy Road on June 20-21, 1972, and compares them to the Bacon Island tide level. During this period, the average daily export rates were 2,362 ft³/s

Table VII-5. Impact of CVP and SWP export on water levels in Old River at Clifton Court Forebay¹

Observation period	CVP-SWP mean daily diversion rate in ft ³ /s		Mean 15-day tidal elevation difference between Old River at Rock Slough and Clifton Court Forebay in feet			
	CVP	SWP	HH	LH	HL	LL
October 17-31, 1977	180	140	0.04	0.06	0.17	0.09
December 17-31, 1977	3,600	5,800	1.08	0.95	0.47	0.32
Differential	3,420	5,660	1.04	0.89	0.30	0.23

$$\text{Steady pumping impact} = \frac{\text{HL Diff.} + \text{LL Diff.}}{2}$$

$$\text{average DMC Diversion in } 1,000 \text{ ft}^3/\text{s}$$

$$= \frac{0.30 + 0.23}{2} = 0.08 \text{ ft}/1,000 \text{ ft}^3/\text{s}$$

$$3.42$$

$$\text{Intermittent pumping impact} = \frac{\text{HH Diff.} - \text{steady pumping impact}}{\text{average daily diversion to CCFB in } 1,000 \text{ ft}^3/\text{s}}$$

$$= 1.04 - \frac{0.08 \times 3,420}{1,000} = 0.14 \text{ ft per } 1,000 \text{ ft}^3/\text{s}$$

$$5.66 \text{ of average daily diversion}$$

$$\text{Intermittent pumping impact} = \frac{\text{HH} - \text{Steady pumping impact}}{\text{Average daily diversion to CCFB} \times \frac{24 \text{ hours}}{\text{Diversion period}}}$$

$$= \text{feet per } 1,000 \text{ ft}^3/\text{s} \text{ of intermittent diversion.}$$

$$= \frac{1.04 - 0.08 \times 3.42}{5.66 \times \frac{24}{17}} = \frac{1.04 - 0.27}{7.99} = 0.096 \text{ or } 0.10 \text{ feet}$$

$$\text{per } 1,000 \text{ ft}^3/\text{s}$$

$$\text{Total impact at high high tide} = 0.08 \times 3.42 + 0.14 \times 5.66 = 0.27 + 0.79$$

= 1.06 feet as compared to the measured value of 1.04 feet.

¹The rates of impacts identified in this analysis are approximations only.

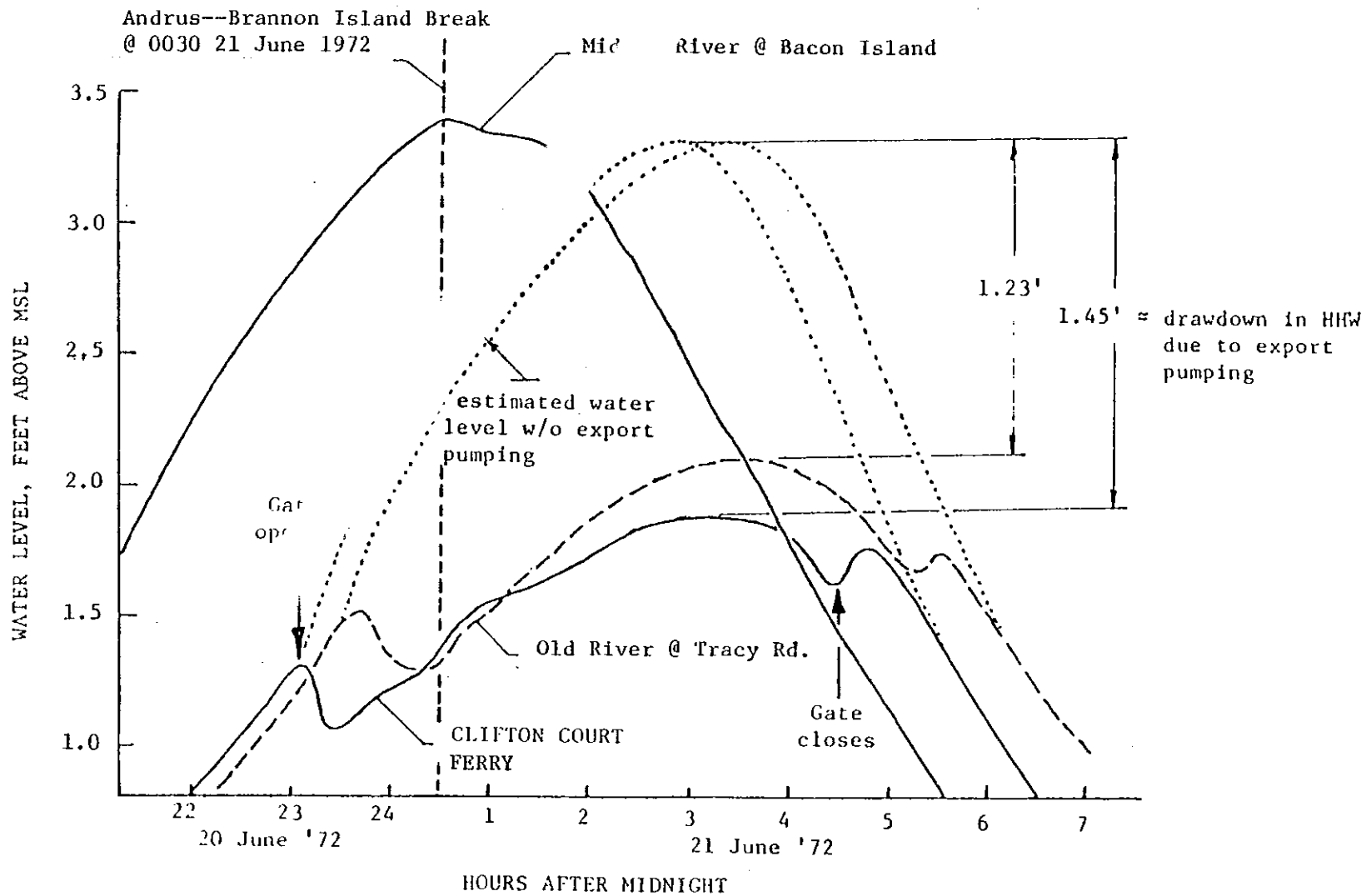


Figure VII-6 WATER LEVELS IN SOUTHERN DELTA, 20-21 JUNE 1972

CVP Export = 4233 cfs

SWP Export (Avg) = 2411 cfs

for the SWP and 3,561 ft³/s for the CVP. The southern Delta tide levels would probably have been about the same height as the Bacon Island tide in the absence of pumping. Using the indicated difference between HH water at Bacon Island and Clifton Court as the effect of pumping and the procedure outlined in table VII-5, it is estimated that the intermittent pumping impact was about 0.5 feet per 1,000 ft³/s of average daily diversion and 0.122 feet per 1,000 ft³/s of actual intermittent diversion rate. The total impact was a reduction in water level at high tide of about 1.5 feet, extending as far upstream on Old River to Tom Paine Slough.

The comparison of the impact of intermittent pumping rates on the water levels near Clifton Court in feet per 1,000 ft³/s of average daily diversion is appropriate when the periods of diversion are approximately the same. Comparing the impact of intermittent pumping during the June 20-21, 1972 period with the October 17-31, 1977 and December 17-31, 1977 periods, in feet per 1,000 ft³/s of average daily diversion will give a distorted result. During the 1972 period the actual diversion of 10,300 ft³/s occurred over a period of 5.5 hours whereas during the 1977 period the actual diversion of 7,990 ft³/s was sustained for 17 hours. The maximum pumping water level drawdown on June 21, 1972, between Bacon Island and Clifton Court was 1.26' feet; during the 1977 period between Rock Slough and Clifton Court the drawdown was 0.77 foot. Expressing these drawdowns in terms of actual rates of diversion for each period results in 0.122 foot per 1,000 ft³/s and 0.10 foot per 1,000 ft³/s, respectively.

The impact of export pumping on water levels in the vicinity of Clifton Court Forebay is relatively insensitive to the flows in the San Joaquin River

at Vernalis. However, the effects of export pumping on the hydraulic gradient between Clifton Court Ferry and the San Joaquin River does vary with the riverflows. The project impact on net flow rates and water levels in this reach are greatest at low rates of inflow.

A mathematic procedure (Hardy Cross network analysis) was used to describe the relationship between head loss within individual channels and the average exports and flows in the San Joaquin River. A memorandum dated February 16, 1951, summarized the network analyses of the Lower Sacramento-San Joaquin Delta that were made in connection with the design of the Delta Cross Channel. Copy of this memorandum is included in Appendix 4. A simplified technique, based on the assumption of steady flow with no tidal fluctuation was used to demonstrate the effect of San Joaquin River inflow on the distribution of drawdown related to a constant export. This procedure assumes no agriculture diversion within the southern Delta. (During periods of low flow this is seldom a realistic assumption.)

For the semi-quantitative use the various channels were combined into four equivalent channels as shown. The ship channel because of its relatively large cross-section was assumed to act as a manifold at a constant level. The resistance values represent channel resistance coefficients such that head loss $(h) = 5.543 \times 10^{-8} rQ^2$ where the constant was derived from the Manning equation.

Flow distributions were developed: Case A with 4,600 ft³/s export and a downstream flow at Mossdale of 1,000 ft³/s, and Case B with the same export (4,600 ft³/s), but a downstream flow of 300 ft³/s.

Case A

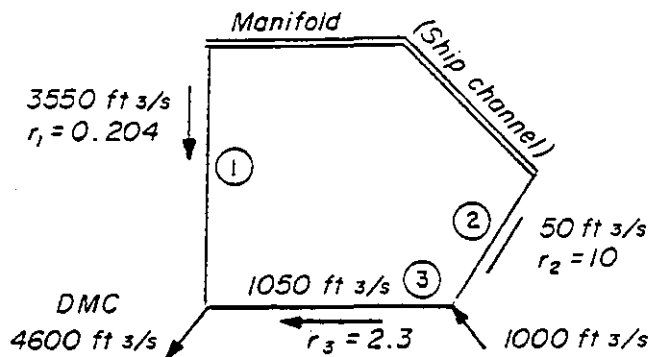
$$Q_1 \text{ in channel 1} = 3,550 \text{ ft}^3/\text{s}$$

$$Q_2 \text{ in channel 2} = 50 \text{ ft}^3/\text{s}$$

$$Q_3 \text{ in channel 3} = 1,050 \text{ ft}^3/\text{s}$$

$$\Delta h_1 = 0.145, \Delta h_2 = 0.00014$$

$$\text{and } \Delta h_3 = 0.1405$$



The junction of channel 2 and 3 which represents Mossdale approximately is subject to negligible drawdown (1 percent of drawdown at Tracy).

Case B

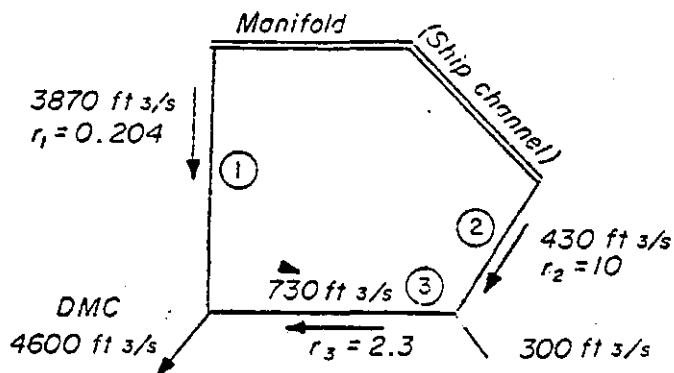
$$Q_1 = 3,870 \text{ ft}^3/\text{s}$$

$$Q_2 = 430 \text{ ft}^3/\text{s}$$

$$Q_3 = 730 \text{ ft}^3/\text{s}$$

$$\Delta h_1 = 0.169, \Delta h_2 = 0.102$$

$$\text{and } h_3 = 0.068$$



At Mossdale the drawdown (Δh_2) is 0.102 or 60 percent of the drawdown at the DMC intake.

The analysis indicated that when the flows at Mossdale are less than 500 ft³/s and the pumping is approximately 4,600 ft³/s, the gradient between the pumps and the bifurcation was very flat. Therefore, depression of the water levels at Clifton Court would be felt as far away as the bifurcation and even upstream beyond Mossdale. However, with riverflows at Mossdale of a magnitude of about 1,000 ft³/s, the gradient is much steeper and, therefore, the pumping impact is less at the bifurcation.

Model studies--Tests such as those just described in 1968 and 1977 are difficult to arrange. They are, therefore, limited in the range of condi-

tions tested. Furthermore, conditions of tide, riverflow, and agricultural diversions vary during the tests, thereby modifying results, particularly for points far upstream of the export pumps. Therefore, it was necessary to develop a mathematical model in order to examine a wider range of conditions and to avoid the uncertainties of test data wherein conditions other than export rates vary during the tests. A mathematical model for this purpose was developed for SDWA by Dr. G. T. Orlob per his report entitled "Investigation of Water Level Problems in the Southern Delta - Model Studies" and dated May 14, 1979. The model is a refinement of an earlier Delta-wide model which was developed under Dr. Orlob's direction and commonly referred to as the WRE model.

It was first necessary to establish a reference station for southern Delta tides. Delta tides do not correlate reliably with ocean tides for various reasons. (See DWR-USBR report dated September 1970 and titled "Sacramento--San Joaquin River Delta Low Tides of April--May 1970.") The Bacon Island tide station was, therefore, chosen as being reliably related to the southern Delta tide levels which would occur in the absence of all pumping.

The model was calibrated so as to obtain a close a match as possible between model results and the measured data from southern Delta tide gages during various conditions of tide, export diversion, and riverflow. Comparison of the model's predictions and actual tidal curves for conditions of steady diversion indicate that the model is a useful tool for water level studies. The model still requires verification for some special cases . However it improves understanding of the interrelationships between water level changes and export pumping under the dynamic conditions induced by tides in the southern Delta.

Table VII-6 shows the model's predicted change in water level due to export pumping at various southern Delta points and for various export rates. With a CVP export rate of 4,323 ft³/s and no SWP export and a 550 ft³/s riverflow rate at Vernalis, the drawdown of water levels by the export pumps is calculated to be 0.52 foot at HHW and 0.40 foot at LLW at the CVP intake channel; 0.51 at HHW and 0.47 at LLW at the Westside Irrigation District intake channel on Old River; 0.41 foot at HHW and 0.37 foot at LLW at Old River and Tom Paine Slough; 0.35 foot at HHW and 0.31 foot at LLW at Old River and Middle River; and 0.34 foot at HHW and 0.13 at LLW at Mossdale. Steady pumping impacts predicted by the mathematical model presented in table VII-6 is compared to the LLW value calculated using the 1968 pumping test rated of depression presented on table VII-1.

	<u>Model Run</u>	<u>May 1968 Test^{1,2} Results</u>
Old River at Clifton Court Ferry	-.40	-.30
Old River at Tracy Road	-.39	-.27
Grant Line at Tracy Road	-.44	-.27
Tom Paine Slough	-.37	-.27
San Joaquin River at Mossdale	-.13	-.13

¹The May 1968 test results were adjusted to reflect the same rate of diversion as simulated in the model run, i.e., the 1968 test results were multiplied by the factor of $\frac{4,323}{4,775}=0.90$.

²During the 1968 test 10 to 31 percent of the flows diverted from the Delta by the SWP were withdrawn from Italian Slough not Clifton Court Forebay as simulated in the model study.

With the same CVP export rate and the same riverflow rate at Vernalis, but with a 4,800 ft³/s average daily SWP export rate (drawn off the high

TABLE VII-6

SUMMARY OF WATER LEVEL CHANGES IN THE SOUTHERN DELTA
DUE TO EXPORT PUMPING BY THE CVP AND SWP^{1/}

Node	Location	RUN SD-29A			RUN SD-29B			RUN SD-30			RUN SD-32		
		HHW	MTL	LLW	HHW	MTL	LLW	HHW	MTL	LLW	HHW	MTL	LLW
		$Q_e^{2/} / (DMC) = 4323$ $Q_e^{3/} (SWP) = 0$			$Q_e^{2/} (DMC) = 4323$ $Q_e^{3/} (SWP) = 1600$ $Q_{ep}^{3/} (SWP) = 2000$			$Q_e^{2/} (DMC) = 4323$ $Q_e^{3/} (SWP) = 2800$ $Q_{ep}^{3/} (SWP) = 7000$			$Q_e^{2/} (DMC) = 4323$ $Q_e^{3/} (SWP) = 4800$ $Q_{ep}^{3/} (SWP) = 12,000$		
1	Bacon Isl. (Input)	0	0	0	0	0	0	0	0	0	0	0	0
20	Clifton Ct.	-0.36	-0.35	-0.34	-0.89	-0.47	-0.36	-1.08	-0.58	-0.34	-1.74	-0.77	-0.26
22	Old R. @ DMC	-0.52	-0.49	-0.40	-1.01	-0.59	-0.40	-1.17	-0.70	-0.39	-1.83	-0.89	-0.32
26	WSID	-0.51	-0.47	-0.47	-1.01	-0.58	-0.49	-1.17	-0.68	-0.46	-1.84	-0.87	-0.38
32	Old R. @ Tracy Rd.	-0.43	-0.43	-0.39	-0.97	-0.54	-0.40	-1.12	-0.64	-0.37	-1.81	-0.83	-0.29
115	Grancline @ Tracy Rd.	-0.44	-0.40	-0.44	-0.93	-0.60	-0.46	-1.09	-0.61	-0.43	-1.76	-0.80	-0.36
34	Tom Paine Sl.	-0.41	-0.42	-0.37	-0.92	-0.53	-0.40	-1.11	-0.62	-0.39	-1.78	-0.81	-0.34
35	Salmon Sl.	-0.40	-0.39	-0.33	-0.90	-0.50	-0.37	-1.06	-0.59	-0.36	-1.73	-0.79	-0.31
39	Old R. @ Middle R.	-0.35	-0.33	-0.31	-0.81	-0.46	-0.35	-1.00	-0.56	-0.34	-1.63	-0.74	-0.31
44	Old R. @ San Joaquin	-0.31	-0.27	-0.18	-0.65	-0.38	-0.24	-0.89	-0.46	-0.26	-1.32	-0.61	-0.29
139	San Joaquin @ Mossdale	-0.34	-0.26	-0.13	-0.66	-0.38	-0.22	-0.87	-0.46	-0.27	-1.33	-0.65	-0.37

^{1/} Based on mathematical model analysis using a version of the WRE Model

^{2/} Q_e is the average daily diversion

^{3/} Q_{ep} is the actual diversion during HHW

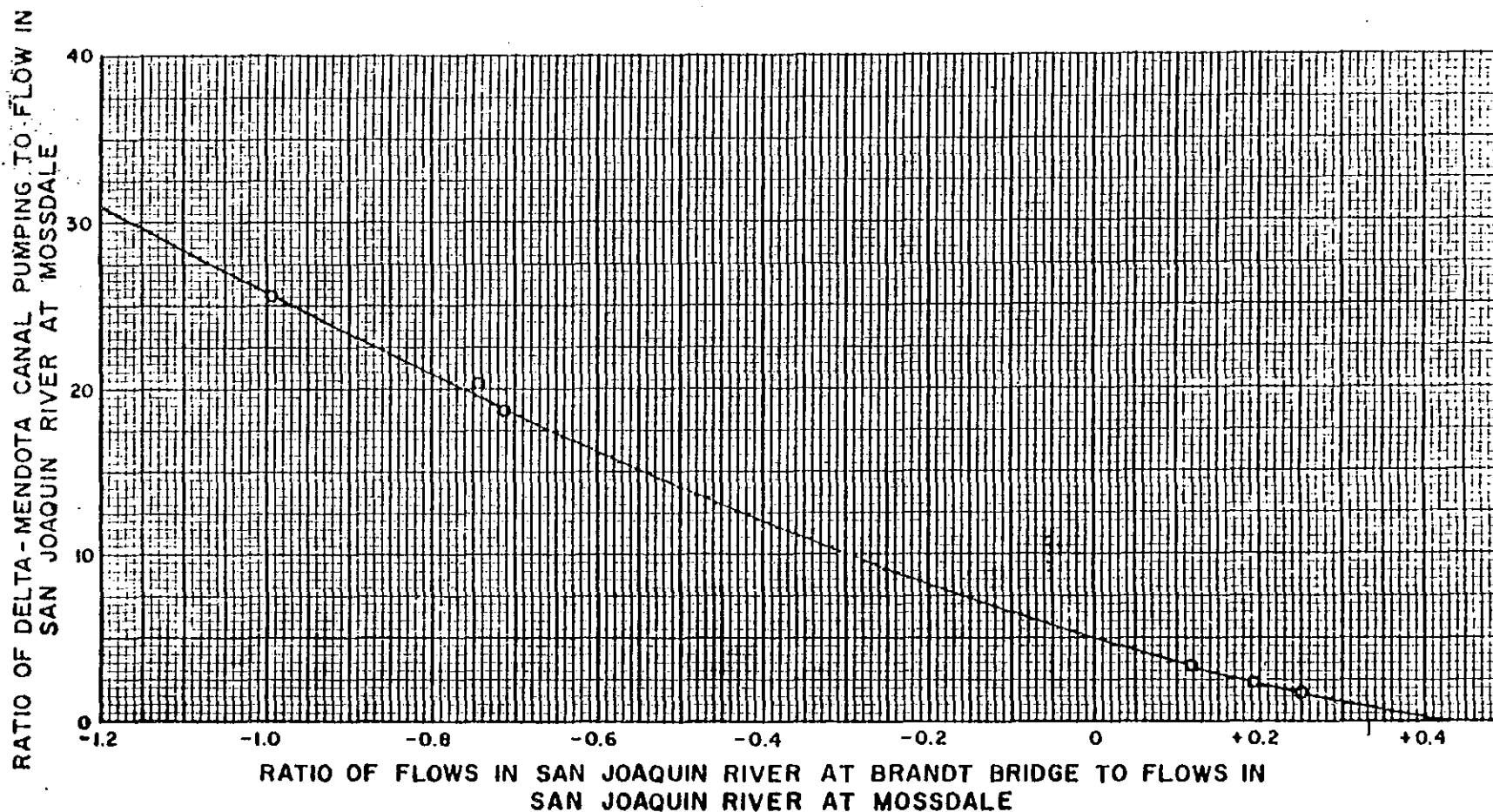
Note: Vernalis flow rate 550 cfs.

tide at about 12,000 ft³/s), the drawdown at the CVP intake channel is increased to 1.83 feet at HHW and 0.32 foot at LLW; at Old River and Tom Paine Slough it is 1.78 feet at HHW and 0.34 foot at LLW; and at Mossdale it is 1.33 feet at HHW and 0.37 foot at LLW. The intermittent pumping impact at Clifton Court was calculated at 0.127 foot per 1,000 ft³/s at HHW, which compares favorably with the rate calculated using the June 21-22, 1972 data (0.122 ft/1,000 ft³/s).

Impact of Export Pumping and Channel Configuration on Water Circulation and Water Quality

Circulation of water in southern Delta channels and the related water quality in those channels is influenced by tidal activity, export and local pumping, inflow and channel configuration. Tidal activity is the dominant factor influencing circulation for short time periods. For longer periods, net flow direction and primarily by export pumping and inflows becomes the major influence. The circulation is determined by the excursion and the volume of displacement during tidal cycle, which are related to the tidal prism upstream from any given station taken together with the cross sectional area at that station. Values of excursion from a low slack to a high slack tide range to as much as 3 miles in the southern Delta.

Net flow direction is markedly changed by various physical works such as pumps, siphons, and tidal gates. Circulation changes have been studied in the field and by models, both physical and mathematical. A relationship between the division of flow at the head of Old River and export pumping has been developed per figure VII-7. This figure is a modification of plate 11 of the appendix to DWR Bulletin 76. This plot depicts the flow split at the



NOTE: Flows in northwesterly direction in San Joaquin River at Brandt Bridge positive and in opposite direction negative.

This is plate 11 from the California Department of Water Resources' Report entitled Salinity Incursion and Water Resources Bulletin No. 76 Appendix on Delta Water Facilities dated April 1962.

**RATIO OF FLOW AT TWO LOCATIONS
ON SAN JOAQUIN RIVER AS INFLUENCED
BY DELTA-MENDOTA CANAL PUMPING**

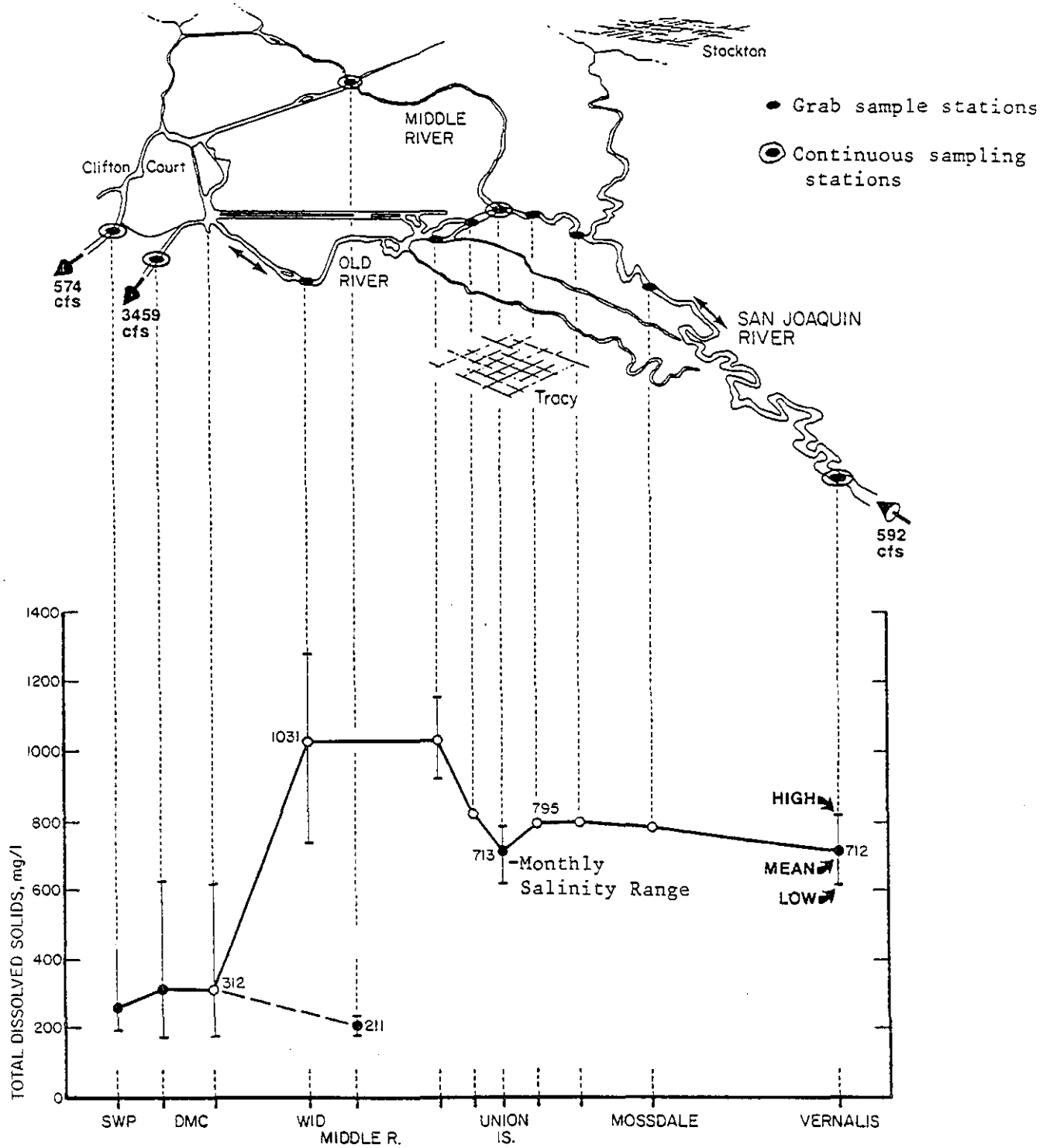
APRIL 1962

bifurcation of Old River and the San Joaquin River in relationship to the rate of export pumping. This determination of the relationship is an approximation because it does not account for the seasonally varying channel depletions between Vernalis and the head of Old River and because net flows are difficult to determine in tidal channels. However, the approximation is useful in analyses of the circulation and water quality. Depending upon the rate of export and local pumping, varying percentages of the San Joaquin inflow are drawn toward the export pumps even to the extent of reversing the normal downstream flow of the San Joaquin River below its bifurcation with Old River.

The induced flow toward the export pumps is carried mainly by Salmon Slough and Grant Line and Fabian Canals. Downstream flows in Middle River and Old River west of Salmon Slough have serious impediments to flow in the form of width and/or depth constrictions as previously discussed. These limitations are exacerbated to some degree by the lowering of water levels at the entrance of these channels.

Hydraulic restrictions in Middle River and portions of Old River tend to limit circulation and increase the likelihood of stagnation and poor water quality. These conditions may be aggravated further by reductions in water level, depth and/or tidal prism. Such occurrences are illustrated by the behavior of Old River between Salmon Slough and the DMC intake channel during July 1976, as shown in figure VII-8. The average monthly TDS concentration in Old River between Salmon Slough and the Westside Irrigation District intake generally exceeded 1,000 mg/L, while at the DMC intake the TDS averaged 312 mg/L. The rather large gradient of TDS between these two locations indicates that the effects of tidal mixing, and any available advective flow is not

Figure VII-8 TOTAL DISSOLVED SOLIDS IN THE SOUTH DELTA CHANNELS* JULY 1976



Sources: WPRS continuous EC recorders, grab samples by Westside Irrigation District, Reclaimed Islands Land Co., Piscadero Reclamation District and Nelson Laboratories.

*Where ranges are indicated, they represent extreme values of daily observation or continuous records during the month. Where no range is indicated, data correspond to a very small number of samples.

sufficient to offset the effect of salt accumulation in this channel. Such circulation as did exist may have been aided by the Westside Irrigation District diversion since there are no other significant diversions between the district's intake and the DMC intake.

The operation of the export pumps draws water from all contributing channels, including the Old River--Salmon Slough--Grantline Canal principal channel through which water from the San Joaquin River enters the zone affected by export. Data derived from the Service's continuous EC monitors show that at low tide following a downstream tidal excursion the EC near Clifton Court is generally higher than at high tide when cross Delta flows from the Sacramento River are most likely to be dominant. As an illustration the quality of water in San Joaquin River at Vernalis between July 9 and July 18, 1978, averaged about 635 umhos EC with no tidal variation whereas the quality in the Delta-Mendota Canal intake channel varied about threefold between the high and low tidal stages. The 10-day average qualities in each tidal phase in umhos at the various tidal phases between July 9 through July 18, 1978 were as follows:

<u>Tidal phase</u>	<u>Water quality (micromhos)</u>
HH	323
LH	212
LL	631
HL	385

SUMMARY AND CONCLUSIONS

CHANNEL DEPTHS AND CROSS SECTIONS

Changes in channel geometry were assessed by comparison of surveys made in 1913 and 1965 by the Corp of Engineers and in 1933-34 by the United States Coast and Geodetic Survey and at various times during the period 1957 through 1976 by the Department of Water Resources. Results of the analysis for each principal channel is summarized below:

San Joaquin River--Vernalis to Mossdale Bridge

The bottom elevation increased from 0.5 to 9.5 feet, with an average increase of about 4 feet. This aggradation raised the bottom elevation of about 45 percent of this reach to an elevation of 1.5 to 3.5 feet above LWD whereas it was 2 to 7 feet below LWD in 1933. This probably has occurred due to reduced floodflows, a normal supply of river sediment load, and the fact that this reach is where the river enters the tidal zone. Sediments tend to deposit at the entry to a tidal zone.

Old River--San Joaquin River to Salmon Slough

The bottom elevation dropped an average of 4 feet, i.e., the channel degraded. This degradation is unexplained.

Grant Line and Fabian Canals

These channels degraded between 1957 and 1973 by an average of 4 feet. This period corresponds to an increase in Delta export pumping. Channel degradation could have been due to maintenance dredging of the channels performed by the local reclamation districts and the Corps of Engineers.

Middle River--Old River to Victoria Canal

This channel has aggraded since the 1933 survey from an average maximum bottom elevation of 6 feet below LWD to an average maximum bottom elevation of 4 feet below LWD. About 55 percent of the reach, that immediately north of Old River, has aggraded an average of 0.5 foot since 1933-34. The most restrictive section is now about 0.5 foot below LWD as compared to the previous 1 foot below LWD. The channel conveyance capacity is quite low and often less than the agricultural diversion rate. There is no evidence of recent channel maintenance dredging (access to 55 percent of the most restrictive sections is hampered by two fixed span bridges).

Old River--Salmon Slough to DMC Intake Channel

This channel also has restrictive cross sections with maximum depths of about 3.5 feet below LWD and a minimum mean depth of about 2 feet below LWD. There has been little change since the 1933-34 survey.

Changes in channel cross sections that have been observed since 1933-34 are a consequence of modifications in the hydraulic regimen of the southern Delta: export pumping by the CVP initiated in 1951, intermittent diversions by the SWP commencing in 1968, and reduced San Joaquin River inflows at Vernalis. The analysis of channel depths within the South Delta Water Agency does not establish whether or not export pumping has caused appreciable siltation or scour within the SDWA channels. Channel degradation in the reach of Old River between Salmon Slough and the San Joaquin River is unexplainable. The channel degradation within Grant Line--Fabian Canals could be attributed to export pumping and/or dredging. This channel carries the largest proportion of San Joaquin River flows which are drawn to the export pumps. The decrease in

channel resistance in this channel modifies the proportion of flows carried by this channel and the proportion carried by the reach of Old River between Salmon Slough and the export pumps.

The control of siltation in some South Delta channels requires periodic channel maintenance. No routine channel maintenance program exists in this area of the Delta at this time.

IMPACT OF EXPORT PUMPS ON WATER LEVELS

Steady diversion of flows by the CVP reduces the water level at Clifton Court and adjacent channels by a range of 0.07 to 0.10 foot per 1,000 ft³/s, or about 0.32 to 0.46 foot at full capacity of 4,600 ft³/s. This impact influences the water levels in Old River and Grant Line Canal upstream to Salmon Slough, at about the same magnitude, thereby directly impacting the entrance to Tom Paine Slough, which relies on tidal elevation differences to produce the gradient for flow into the Slough.

The intermittent diversions into Clifton Court Forebay by the SWP reduce the HHW levels by about 0.10 to 0.127 per 1,000 ft³/s of water diverted. At full capacity of the CVP, operating at 4,600 ft³/s on a steady basis, and the SWP, operating only on the high tide, with a 10,000 ft³/s diversion rate,¹ the water level depression at HHT may be expected to be in the range of 1.34 to 1.76 feet.

Reductions in water level also are evident at Mossdale Bridge on the San Joaquin River. However, the water level depression at this point is related to the portion of the inflow from the San Joaquin River which reaches

¹ The maximum SWP pumping rate of 6,000 ft³/s into the aqueduct corresponding to this 10,000 ft³/s high tide diversion to Clifton Court Forebay over a period of approximately 14 hours.

the bifurcation with Old River. When the riverflows at the bifurcation are less than 1,000 ft³/s, the gradient between the pumps and the bifurcation flattens and the pumping effect is increased whereas at 1,000 ft³/s the effect is relatively insignificant.

IMPACT OF EXPORT PUMPING ON WATER CIRCULATION AND QUALITY

During most summer periods, the San Joaquin River flows are now less than the net rate of channel depletion within the SDWA. The induced flow toward the export pumps which is caused by the drawdown of levels, is carried mainly by Salmon Slough and Grant Line and Fabian Canals. Downstream advective flows into the reach of Middle River between Old River and Victoria Canal and in the reach of Old River west of Tom Paine Slough are generally less than the agricultural diversions from those channels during dry seasons, thereby causing water to flow into these reaches from both ends permitting accumulation of salts from local return flows as illustrated in figure VII-8. Both of these channels have serious impediments to flow in the form of width and/or depth constrictions as previously discussed. However, it is apparent that substantial portions of low summer San Joaquin River flows pass through the upstream end of Old River and Grant Line and Fabian Canals and are diverted with the export.

The increase in net unidirectional flow from the San Joaquin River toward the pumps reduces the accumulation of drainage salts in the upper end of Old River and in Grant Line and Fabian Canals. However, the drawdown which causes this increase in flow does not necessarily induce net daily unidirectional flows through Middle River in the southern Delta, or in Old River from Tom Paine Slough west toward the DMC intake channel as discussed above.

Tidal circulation is reduced by the lowering of water levels. However tidal exchange of salts is dependent both on circulation and the difference in salt concentration between any two points in a channel. For example in the restricted reach of Old River even with the reduced tidal prism in the vicinity of the DMC intake channel, there is some flushing resulting from tidal exchange with better quality of water available.

Quality in dead end sloughs such as Paradise Cut and Old Oxbows rely entirely on tidal exchange. When San Joaquin River flows at Vernalis are less than the agricultural diversions south of Mossdale, the reach of San Joaquin River channel south of the bifurcation of Old River functions also functions like a b. Slough and tidal flushing becomes important for water quality as well as for depth in that reach of channel.

The overall effect of export pumping on the South Delta channels includes:

1. Reduction in hydraulic capacity of channels with consequent reduced water availability at local diversion points.
2. Increase in gradient toward the Delta export pumps which results in increased downstream advective circulation from the San Joaquin River through the east end of Old River to Old River Court via Grant Line Canal.
3. Availability of Sacramento River water as the northern boundary of the southern Delta which is drawn into portions of the southern Delta channels through tidal mixing.
4. Increase in suction lift required of pumps of local diverters.
5. Increase in frequency of loss of prime (due to inadequate water depth) by pumps of local diverters.

6. Reduction in tidal prism with resultant decrease of tidal flows and of tidal flushing of salts, particularly in shallow, or stagnant, or blind channels.

This report does not attempt to quantify all of these export pump impacts or to determine the water levels, hydraulic capacities, and salinity levels needed in southern Delta channels. Water level drawdown, of the magnitude indicated, obviously has an impact on water availability in the shallowest channels, but determining the net effect on salinity due to changes in advective and tidal flow would require additional study of the net effect in each channel. Furthermore, the impact of export pumping also varies with the degree to which San Joaquin River flow and salinity at Vernalis are altered.

APPENDIX 1

MONTHLY FLOW DATA (KAF) AND
MONTHLY CHLORIDE DATA (P/M)

THIS IS THE DATA FILE OF ACTUAL SAN JOAQUIN RIVER FLOWS (KAF) AT VERNALIS.

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	VN	86.70	73.20	79.30	111.00	94.40	151.00	154.00	136.00	164.00	76.20	56.60	85.10
1931	VN	103.00	97.60	117.00	95.30	88.90	54.20	23.10	27.30	23.30	14.30	14.00	19.00
1932	VN	29.40	38.30	76.90	205.00	621.00	301.00	286.00	713.00	898.00	356.00	71.30	63.70
1933	VN	103.00	113.00	115.00	124.00	167.00	107.00	68.40	84.80	316.00	68.20	41.00	68.40
1934	VN	94.10	91.00	148.00	169.00	124.00	105.00	41.80	39.30	37.30	24.30	23.60	29.80
1935	VN	52.20	76.80	98.80	223.70	196.30	250.60	878.20	1007.00	938.80	165.90	61.20	80.30
1936	VN	125.10	115.40	155.90	203.20	688.00	878.10	773.10	1020.00	661.60	187.40	69.00	76.20
1937	VN	116.20	116.60	175.60	202.40	688.30	812.20	860.60	1233.00	925.70	200.50	69.40	83.10
1938	VN	116.70	117.80	326.40	381.20	1301.00	2100.00	1333.00	1743.00	2181.00	898.30	206.60	132.40
1939	VN	163.90	226.00	227.50	251.50	231.60	124.60	146.80	125.20	59.00	46.50	44.00	61.50
1940	VN	91.30	85.40	97.60	254.00	493.10	902.30	965.20	879.30	645.60	122.70	72.90	100.40
1941	VN	98.60	102.00	185.20	438.60	727.90	1302.00	1017.00	1309.00	1327.00	562.10	128.80	100.30
1942	VN	135.20	138.60	293.70	518.40	706.90	533.40	798.20	1017.00	1323.00	478.20	103.60	114.00
1943	VN	137.50	138.80	268.40	347.20	725.80	1422.00	1075.00	920.60	693.40	135.80	94.80	100.50
1944	VN	129.60	116.20	146.80	165.40	164.60	294.70	136.90	235.30	201.40	76.60	67.10	71.40
1945	VN	101.40	147.20	232.90	237.60	604.30	566.70	534.80	855.60	673.80	238.60	109.40	120.90
1946	VN	169.60	207.30	352.50	584.80	330.70	229.60	357.90	802.90	344.10	90.10	75.30	88.30
1947	VN	111.60	155.70	222.40	171.10	133.70	138.90	88.50	125.80	56.10	32.40	35.00	63.90
1948	VN	80.80	105.50	104.20	85.10	47.50	36.80	82.90	307.50	512.10	81.70	44.60	64.70
1949	VN	95.20	88.80	91.40	107.00	78.60	213.30	122.40	217.00	119.20	34.60	37.00	42.50
1950	VN	77.90	94.10	96.60	122.90	196.70	135.60	319.30	308.20	298.30	42.30	38.20	56.30
1951	VN	81.40	482.10	1545.00	632.10	600.50	477.70	157.80	401.20	198.60	53.50	46.70	61.60
1952	VN	109.70	104.90	192.80	544.20	661.90	845.30	1202.00	1699.00	1389.00	215.10	83.30	96.40
1953	VN	114.70	129.50	225.00	365.70	204.00	71.50	90.40	188.10	292.40	98.60	46.00	65.00
1954	VN	100.20	98.90	108.30	101.90	131.00	274.30	301.00	412.90	76.50	33.30	33.60	44.90
1955	VN	32.30	82.50	111.50	182.30	136.10	96.00	54.60	70.70	89.00	25.60	26.50	36.30
1956	VN	49.20	63.70	670.60	1663.00	993.90	460.30	372.60	859.30	729.00	214.20	116.90	112.20
1957	VN	122.90	131.60	154.00	118.10	97.90	187.80	78.90	158.70	223.70	53.80	46.30	68.30
1958	VN	126.40	133.80	153.30	148.80	301.80	743.60	1661.00	1379.00	929.30	251.60	94.40	133.40
1959	VN	174.30	216.10	181.70	143.40	181.50	127.20	48.30	48.60	31.70	19.20	24.70	46.70
1960	VN	53.90	62.60	72.80	85.80	99.10	36.60	30.80	38.00	17.40	13.70	16.50	22.90
1961	VN	43.80	60.30	79.10	82.30	62.10	27.30	11.90	23.40	12.30	6.40	9.30	19.10
1962	VN	25.20	35.30	43.80	49.50	320.90	364.80	124.10	161.20	208.10	52.60	42.70	59.10
1963	VN	89.40	97.80	149.70	107.80	454.60	160.30	512.70	574.20	396.50	112.00	67.40	90.20
1964	VN	164.60	179.80	217.20	176.60	97.60	57.10	45.50	43.20	38.70	23.60	27.10	53.50
1965	VN	86.80	140.20	371.20	894.80	440.30	327.50	586.70	325.60	336.20	121.30	75.10	99.90
1966	VN	181.00	216.80	383.80	323.90	227.20	117.70	58.40	53.10	33.90	27.00	30.70	43.20
1967	VN	67.70	79.10	269.00	197.30	353.40	401.90	862.50	1252.00	1190.00	642.50	124.20	120.70
1968	VN	167.60	206.70	223.50	130.80	150.50	190.20	85.40	54.80	35.20	30.90	47.20	55.80
1969	VN	85.10	95.50	155.70	849.40	1808.00	1898.00	1316.00	1513.00	1659.00	356.80	142.90	193.70
1970	VN	274.40	275.40	246.70	683.50	510.50	441.50	99.53	147.20	160.90	81.70	64.22	78.51

THIS IS THE DATA FILE FOR STANISLAUS RIVER FLOW AT RIPON.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1931 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1932 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1933 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1934 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1935 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1937 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1938 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1939 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1940 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1941 RP	15.19	18.40	28.29	52.11	72.00	186.10	178.90	386.50	173.90	36.34	14.73	13.63
1942 RP	15.46	27.82	53.31	77.20	175.90	71.01	215.00	294.30	232.10	56.69	13.33	14.70
1943 RP	16.51	27.44	52.74	113.80	122.20	313.20	265.30	203.30	108.20	17.13	14.71	13.87
1944 RP	16.51	17.46	26.32	31.60	17.42	81.66	31.01	104.40	51.71	14.11	11.97	11.69
1945 RP	13.40	31.88	60.44	55.84	105.40	111.40	125.80	265.20	152.00	25.57	14.42	13.41
1946 RP	16.30	30.36	74.98	146.90	50.39	64.93	155.20	234.30	61.95	15.50	13.59	12.54
1947 RP	11.83	21.40	38.42	11.56	11.15	37.56	52.60	82.53	15.35	9.70	9.37	9.59
1948 RP	10.72	16.19	25.94	17.35	12.07	10.46	53.08	216.70	180.30	21.01	10.90	9.76
1949 RP	12.14	14.62	14.11	24.34	12.62	68.69	44.82	158.70	52.26	10.85	9.86	9.80
1950 RP	11.78	11.38	13.60	37.55	53.77	42.70	152.40	235.50	112.30	13.36	11.36	10.38
1951 RP	11.39	268.90	467.40	152.90	122.10	127.60	81.59	130.90	38.28	13.55	11.01	10.18
1952 RP	23.12	21.25	54.38	78.75	116.60	155.00	224.90	473.60	294.80	57.17	15.56	14.01
1953 RP	15.91	20.93	35.03	84.12	39.03	12.43	56.38	109.50	153.60	30.36	12.19	11.73
1954 RP	15.30	21.20	21.35	13.62	22.92	70.90	146.00	147.50	13.96	9.62	9.99	8.93
1955 RP	11.97	15.36	33.63	47.53	28.22	35.62	13.14	37.40	63.93	8.67	7.98	7.14
1956 RP	8.32	9.77	275.70	317.50	117.40	80.34	147.90	312.30	187.90	62.18	12.01	10.71
1957 RP	23.82	27.18	21.32	17.86	7.96	30.62	11.10	73.48	81.53	12.04	10.30	10.69
1958 RP	14.07	10.43	10.46	32.43	78.41	136.90	242.80	362.20	217.00	36.62	18.55	20.04
1959 RP	19.91	29.56	49.61	28.05	23.29	38.99	9.97	9.16	7.85	6.98	7.96	9.71
1960 RP	9.17	8.69	9.00	8.24	9.70	6.83	7.21	8.64	6.66	5.96	6.09	6.10
1961 RP	7.65	9.66	11.02	11.18	8.71	6.50	5.58	5.38	3.84	3.15	3.74	4.56
1962 RP	5.61	6.34	6.87	6.63	54.76	70.77	49.61	73.72	103.40	11.44	8.73	9.24
1963 RP	13.48	14.84	19.22	11.40	133.50	42.46	177.80	288.80	118.10	16.34	11.24	13.74
1964 RP	24.04	17.54	32.15	54.94	24.78	12.03	10.23	8.16	7.15	6.37	6.53	7.98
1965 RP	9.99	13.12	189.30	254.40	109.30	102.40	202.00	131.20	124.20	25.84	13.72	16.75
1966 RP	24.47	47.96	86.83	90.41	65.17	16.00	11.39	9.95	7.82	6.11	5.54	6.07
1967 RP	8.26	9.35	60.27	70.59	97.84	137.00	225.40	267.20	329.10	107.20	19.36	23.00
1968 RP	29.79	36.09	52.79	38.72	15.90	28.53	28.00	9.38	7.68	6.29	7.01	7.44
1969 RP	11.59	11.70	13.34	309.90	266.70	225.70	187.10	359.40	233.60	41.12	17.09	29.64

END OF FILE

040766

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THIS IS THE DATA FILE FOR THE ACTUAL FLOW AT MAZE ROAD BRIDGE (KAF).

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1931	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1932	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1933	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1934	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1935	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1936	0.00	0.00	0.00	162.20	564.30	668.20	574.60	767.60	503.80	150.60	55.10	64.10
1937	102.50	106.60	161.00	176.70	617.40	722.80	708.90	970.30	818.80	177.60	52.30	71.80
1938	110.50	100.80	0.00	341.20	1268.00	2077.00	1092.00	1265.00	1798.00	776.40	185.20	123.00
1939	140.70	206.70	206.80	216.00	212.40	114.60	90.20	84.70	43.10	34.10	36.20	51.50
1940	84.20	76.40	83.80	194.70	394.30	707.20	727.90	643.40	527.20	99.80	57.90	91.20
1941	87.80	88.70	166.60	388.00	660.50	1094.00	819.20	990.00	1202.00	510.10	116.30	93.40
1942	118.70	113.10	241.60	464.30	547.30	468.20	572.00	737.20	1113.40	427.50	88.80	101.50
1943	124.10	115.90	210.10	247.20	578.00	1088.20	773.60	683.60	565.20	113.80	79.10	85.70
1944	110.70	101.20	127.70	135.80	144.20	218.60	100.50	140.20	146.20	58.10	49.20	58.40
1945	96.40	117.10	169.20	166.20	496.00	466.90	400.00	600.80	538.90	214.80	95.90	104.40
1946	150.50	177.60	288.60	451.60	278.00	171.60	217.50	557.40	282.70	79.50	62.10	74.20
1947	97.60	131.40	178.80	162.00	118.40	106.60	37.30	52.10	40.30	26.10	27.30	60.60
1948	71.30	89.00	80.40	65.90	34.70	25.40	29.30	123.90	323.80	61.10	36.20	56.20
1949	88.80	73.20	77.20	82.40	61.60	154.50	83.50	83.90	75.30	24.80	30.80	35.90
1950	66.50	82.40	84.20	88.90	145.60	88.70	172.50	99.00	178.70	33.00	30.60	46.00
1951	73.40	341.40	1003.00	455.90	474.60	351.30	93.20	271.90	159.50	41.80	35.40	50.80
1952	82.20	74.80	140.60	445.40	546.00	698.40	942.50	1402.50	1006.30	171.80	76.50	79.20
1953	88.40	94.00	175.30	279.70	158.40	59.90	48.70	66.90	161.10	73.70	35.00	51.20
1954	80.20	73.20	81.90	84.10	104.00	201.60	179.60	270.20	60.70	33.20	31.40	38.20
1955	51.60	59.30	72.70	131.70	102.20	61.00	43.30	42.20	37.30	23.50	23.10	30.40
1956	37.90	47.40	394.60	1303.00	768.60	342.90	244.20	609.00	555.20	148.60	103.30	97.00
1957	94.90	96.00	116.30	100.10	85.00	149.80	70.20	103.30	154.90	43.80	43.40	53.40
1958	101.90	114.20	130.20	103.50	239.40	668.00	1583.00	1121.00	719.60	236.70	87.20	112.90
1959	149.40	209.60	134.20	116.30	137.70	89.80	42.80	43.80	29.00	19.90	22.80	39.20
1960	45.50	52.50	61.40	81.40	90.10	37.00	29.30	32.20	17.90	16.00	17.40	20.80
1961	37.90	52.10	69.70	76.10	55.60	25.30	15.00	24.40	13.50	9.60	12.00	20.00
1962	22.40	30.60	39.20	43.60	271.10	255.40	72.90	87.90	109.00	41.20	36.00	46.70
1963	64.30	70.30	101.80	83.50	374.70	110.40	384.70	410.40	293.40	77.90	48.80	65.30
1964	136.10	155.60	173.80	120.20	70.30	40.90	37.00	38.60	33.80	24.40	27.70	45.00
1965	0.00	0.00	240.60	555.70	324.90	236.90	400.90	227.20	233.90	91.20	63.20	80.40
1966	151.90	173.80	297.00	245.60	169.30	100.10	48.90	42.80	26.90	22.30	24.60	35.40
1967	57.40	67.40	220.60	146.30	267.90	279.40	685.10	970.30	906.60	485.50	101.50	86.80
1968	120.90	162.10	157.10	123.40	122.30	149.30	56.10	45.10	29.10	27.80	42.80	48.10

THIS IS DATA FILE FOR THE TUOLUMNE RIVER FLOW AT TUOLUMNE CITY.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 TC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.20	47.00	37.00	58.70
1931 TC	59.30	0.00	0.00	0.00	0.00	0.00	0.00	16.50	15.70	15.50	15.40	15.40
1932 TC	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.60	23.40
1933 TC	60.80	0.00	0.00	0.00	0.00	0.00	0.00	19.80	90.80	25.70	19.70	39.50
1934 TC	62.50	0.00	0.00	0.00	0.00	0.00	0.00	19.00	17.90	17.70	19.00	17.10
1935 TC	33.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.60	23.80	40.90
1936 TC	49.70	0.00	0.00	72.90	231.10	247.60	199.20	328.10	258.60	56.30	25.00	30.60
1937 TC	55.90	54.70	79.30	59.80	161.30	210.30	222.30	388.50	222.20	34.00	23.40	36.00
1938 TC	59.50	70.30	0.00	88.10	402.10	444.10	342.70	398.40	620.00	186.10	45.80	56.60
1939 TC	67.30	125.90	88.40	70.90	58.00	38.40	23.90	28.90	20.10	27.50	27.10	29.50
1940 TC	50.50	52.00	50.40	58.60	159.00	293.20	264.20	213.20	184.10	26.70	27.70	52.80
1941 TC	47.90	64.10	83.30	88.30	132.90	270.90	225.90	319.90	390.40	109.00	47.30	45.70
1942 TC	63.50	68.30	107.60	144.80	118.90	141.10	172.80	255.30	445.90	131.80	42.30	52.80
1943 TC	63.40	54.40	132.60	95.30	179.20	378.80	231.70	251.90	214.30	39.40	33.70	44.20
1944 TC	59.10	61.70	78.70	55.20	48.50	74.80	35.20	63.60	40.90	23.20	22.00	21.80
1945 TC	46.50	71.00	118.10	70.20	183.00	167.90	119.90	127.90	238.20	83.00	29.60	35.90
1946 TC	53.50	85.90	121.60	145.50	85.90	58.10	118.80	282.50	119.30	30.10	28.20	24.60
1947 TC	51.10	93.50	86.20	55.30	48.30	49.00	20.60	18.10	16.50	15.20	17.30	39.80
1948 TC	48.40	67.60	53.10	41.90	17.80	18.10	20.90	79.30	174.20	37.40	21.50	24.20
1949 TC	48.30	47.50	52.40	43.70	32.10	80.50	51.10	31.00	23.00	20.60	20.80	19.50
1950 TC	45.60	63.90	63.70	51.80	79.70	51.30	148.70	69.10	113.40	24.00	21.90	21.30
1951 TC	41.80	250.00	522.20	205.70	160.10	181.20	39.70	164.20	108.40	25.10	23.20	21.70
1952 TC	54.30	48.80	98.00	209.90	168.20	277.50	390.70	481.50	302.30	50.00	26.10	26.50
1953 TC	41.70	67.30	132.20	128.20	93.90	30.30	29.70	36.00	120.20	68.50	22.80	20.10
1954 TC	49.10	48.10	52.70	54.10	47.30	134.00	85.00	125.90	24.60	20.50	19.80	18.50
1955 TC	31.40	38.90	46.40	72.10	69.60	37.90	20.40	19.00	17.20	16.30	16.20	22.00
1956 TC	22.00	34.80	294.80	507.00	236.10	145.20	108.80	204.30	190.80	69.50	59.40	52.30
1957 TC	51.30	64.10	80.40	58.60	37.60	70.30	29.30	33.40	51.10	21.90	20.70	21.40
1958 TC	60.60	88.90	96.80	55.60	95.10	288.10	530.50	444.30	305.00	106.00	29.60	46.90
1959 TC	93.90	162.00	96.10	66.70	92.60	46.10	21.40	20.50	17.40	16.40	15.60	16.80
1960 TC	26.20	34.20	42.20	48.50	39.60	21.70	16.40	15.40	13.40	13.40	13.20	14.10
1961 TC	27.40	35.80	52.10	43.20	23.90	14.80	11.00	10.90	9.90	8.80	10.50	13.60
1962 TC	14.60	20.30	16.60	12.60	102.20	120.20	37.90	22.30	18.60	17.90	19.20	23.00
1963 TC	42.50	60.10	105.50	54.10	0.00	0.00	155.20	125.20	122.10	44.60	25.10	23.40
1964 TC	69.30	131.10	147.30	73.10	37.80	19.30	16.50	15.50	14.30	12.50	12.60	14.40
1965 TC	21.90	82.80	189.40	378.40	209.80	97.70	240.10	89.00	107.50	45.80	25.90	0.00
1966 TC	115.60	120.00	159.40	113.00	96.60	56.70	21.10	18.30	14.40	13.50	13.10	13.10
1967 TC	34.40	40.10	164.70	80.90	144.80	201.50	341.10	238.40	326.80	218.50	25.00	23.10
1968 TC	49.70	116.60	94.70	63.70	59.80	92.10	20.80	14.90	12.00	12.40	15.30	15.20
1969 TC	23.50	30.00	98.10	359.20	437.60	289.70	285.10	376.80	458.20	88.60	16.50	35.20

END OF FILE

THIS IS THE DATA FILE FOR SAN JOAQUIN RIVER FLOW AT NEWMAN.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 NA	8.90	8.50	9.70	26.30	19.70	29.80	19.00	20.10	18.90	12.70	12.40	12.30
1931 NA	11.10	10.90	14.60	28.80	28.70	17.10	7.30	7.10	6.80	3.60	2.60	3.10
1932 NA	4.50	5.10	24.80	151.00	309.00	141.00	96.40	223.00	339.00	164.00	21.20	19.60
1933 NA	19.70	13.80	24.60	62.10	98.90	38.90	24.30	27.40	94.60	21.60	12.90	14.50
1934 NA	11.70	9.90	21.00	86.10	62.20	40.90	15.80	12.10	10.90	8.20	5.60	5.60
1935 NA	7.10	8.40	18.50	110.40	118.80	152.60	368.30	430.00	375.30	78.80	22.80	20.50
1936 NA	31.80	38.00	58.40	79.20	388.90	349.50	368.80	451.40	222.90	77.40	26.90	26.30
1937 NA	28.20	36.40	77.60	104.60	499.10	439.10	413.00	528.50	479.10	109.60	26.30	26.30
1938 NA	28.60	21.00	174.10	233.80	797.00	1445.00	683.00	941.20	1250.00	530.30	107.30	45.70
1939 NA	43.50	63.30	89.30	120.90	135.60	41.80	57.10	38.60	19.80	14.40	13.80	16.50
1940 NA	13.90	11.30	26.00	135.10	260.80	411.70	394.80	426.40	324.30	55.50	22.80	23.00
1941 NA	20.10	12.80	79.50	278.60	538.90	769.90	548.20	689.50	755.90	345.50	44.40	29.60
1942 NA	25.20	25.00	126.00	314.30	389.60	285.70	370.90	427.80	657.10	249.70	37.30	30.40
1943 NA	33.60	43.00	79.80	163.70	405.10	762.90	555.00	437.30	325.20	52.80	27.50	26.80
1944 NA	29.50	19.70	37.80	74.10	87.20	129.00	51.90	61.10	88.40	31.40	25.60	25.80
1945 NA	31.10	35.00	45.10	82.80	311.80	274.30	257.70	414.80	301.50	107.70	51.80	47.20
1946 NA	67.00	74.30	155.60	278.10	178.10	83.30	93.90	259.80	128.90	40.80	29.00	34.30
1947 NA	26.90	30.30	81.80	92.00	60.70	54.00	25.60	40.00	28.80	20.10	17.40	19.80
1948 NA	14.10	14.70	16.10	18.00	11.80	13.10	21.90	35.70	136.60	20.00	20.10	28.40
1949 NA	20.70	13.20	13.20	21.90	19.80	59.80	29.20	38.90	49.80	14.60	15.60	15.70
1950 NA	10.60	11.00	12.50	29.40	60.60	34.00	33.90	34.10	60.90	13.70	14.20	18.40
1951 NA	12.60	61.10	408.70	253.40	295.30	142.30	47.40	110.00	42.80	20.60	18.60	23.00
1952 NA	16.90	14.80	30.60	250.60	316.80	386.80	525.60	687.00	625.30	71.20	34.50	36.40
1953 NA	28.10	17.00	58.70	149.90	45.70	21.00	22.80	31.40	28.10	14.30	14.80	22.30
1954 NA	15.60	12.40	14.70	23.60	54.50	54.90	58.40	121.20	32.60	17.80	17.30	17.50
1955 NA	10.80	12.40	16.10	50.10	29.30	21.40	22.40	26.50	20.50	15.20	14.50	14.40
1956 NA	10.10	9.70	198.20	711.40	508.40	186.10	78.90	284.50	261.10	46.70	26.70	30.60
1957 NA	26.70	15.60	15.10	26.40	37.10	75.70	45.40	48.50	104.20	21.00	21.70	22.50
1958 NA	19.40	12.60	17.70	43.90	111.70	318.70	827.30	659.40	426.10	84.60	31.50	37.00
1959 NA	25.90	13.10	16.90	35.00	42.90	28.90	24.90	26.80	16.20	11.00	11.40	12.90
1960 NA	9.80	9.90	12.80	24.30	42.50	18.50	16.40	19.70	12.00	9.80	10.40	7.80
1961 NA	6.40	9.50	13.40	24.60	21.80	13.80	11.20	14.50	10.40	6.00	6.30	6.60
1962 NA	5.60	8.30	17.60	28.30	193.90	141.10	33.20	64.90	94.40	22.30	19.30	18.90
1963 NA	15.40	15.90	19.10	25.80	156.40	53.50	133.40	200.40	126.20	27.50	22.60	25.10
1964 NA	37.20	23.40	23.30	31.20	18.70	15.70	18.30	21.60	19.90	13.00	13.40	20.50
1965 NA	38.50	41.10	61.40	247.70	91.10	129.20	155.70	118.50	113.30	32.00	27.40	31.00
1966 NA	19.50	52.80	130.10	97.70	37.00	24.40	23.10	21.60	16.60	12.60	11.10	11.30
1967 NA	10.30	17.00	52.00	38.80	96.40	62.90	376.50	716.00	539.10	277.50	63.70	44.50
1968 NA	48.90	33.80	58.80	55.10	52.20	38.20	27.10	25.90	14.70	13.80	22.30	23.70
1969 NA	29.30	35.20	38.90	332.40	979.40	1129.00	750.00	758.30	830.70	149.40	63.10	89.00

END OF FILE

THIS IS THE DATA FILE FOR SAN JOAQUIN RIVER FLOW AT NEWMAN.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 NA	8.90	8.50	9.70	26.30	19.70	29.80	19.00	20.10	18.90	12.70	12.40	12.30
1931 NA	11.10	10.90	14.60	28.80	28.70	17.10	7.30	7.10	6.80	3.60	2.60	3.10
1932 NA	4.50	5.10	24.80	151.00	309.00	141.00	96.40	223.00	339.00	164.00	21.20	19.60
1933 NA	19.70	13.80	24.60	62.10	94.90	38.90	24.30	27.40	94.60	21.60	12.90	14.50
1934 NA	11.70	9.90	21.00	86.10	62.20	40.90	15.80	12.10	10.90	8.20	5.60	5.60
1935 NA	7.10	8.40	18.50	110.40	118.80	152.60	368.30	430.00	375.30	78.80	22.80	20.50
1936 NA	31.80	38.00	58.40	79.20	388.90	349.50	368.80	451.40	222.90	77.40	26.90	26.30
1937 NA	28.20	36.40	77.60	104.60	499.10	439.10	413.00	528.50	479.10	109.60	26.30	26.30
1938 NA	28.60	21.00	174.10	233.80	797.00	1445.00	683.00	941.20	1250.00	530.30	107.30	45.70
1939 NA	43.50	63.30	89.30	120.90	135.60	41.80	57.10	38.60	19.80	14.40	13.80	16.50
1940 NA	13.90	11.30	26.00	135.10	260.80	411.70	394.80	426.40	324.30	55.50	22.80	23.00
1941 NA	20.10	12.80	79.50	278.60	538.90	769.90	548.20	689.50	755.90	345.50	44.40	29.60
1942 NA	25.20	25.00	126.00	314.30	389.60	285.70	370.90	427.80	657.10	249.70	37.30	30.40
1943 NA	33.60	43.00	79.80	163.70	405.10	762.90	555.00	437.30	325.20	52.80	27.50	26.80
1944 NA	29.50	19.70	37.80	74.10	87.20	129.00	51.90	61.10	88.40	31.40	25.60	25.80
1945 NA	31.10	35.00	45.10	82.80	311.80	274.30	257.70	414.80	301.50	107.70	51.80	47.20
1946 NA	67.00	74.30	155.60	278.10	178.10	83.30	93.90	259.80	128.90	40.80	29.00	34.30
1947 NA	26.90	30.30	81.80	92.00	60.70	54.00	25.60	40.00	28.80	20.10	17.40	19.80
1948 NA	14.10	14.70	16.10	18.00	11.80	13.10	21.90	35.70	136.60	20.00	29.10	28.40
1949 NA	29.70	13.20	13.20	21.90	19.80	59.80	29.20	38.90	49.80	14.60	15.60	15.70
1950 NA	10.60	11.00	12.50	29.40	60.60	34.00	33.90	34.10	60.90	13.70	14.20	18.40
1951 NA	12.60	61.10	408.70	253.40	295.30	142.30	47.40	110.00	42.80	20.60	18.60	23.00
1952 NA	16.90	14.80	30.60	250.60	316.80	386.80	525.60	687.00	625.30	71.20	34.50	36.40
1953 NA	28.10	17.00	58.70	149.90	45.70	21.00	22.80	31.40	28.10	14.30	14.80	22.30
1954 NA	15.60	12.40	14.70	23.60	54.50	54.90	58.40	121.20	32.60	17.80	17.30	17.50
1955 NA	10.80	12.40	16.10	50.10	29.30	21.40	22.40	26.50	20.50	15.20	14.50	14.40
1956 NA	10.10	9.70	198.20	711.40	508.40	186.10	78.90	284.50	261.10	46.70	26.70	30.60
1957 NA	26.70	15.60	15.10	26.40	37.10	75.70	45.40	48.50	104.20	21.00	21.70	22.50
1958 NA	19.40	12.60	17.70	43.90	111.70	318.70	827.30	659.40	426.10	84.60	31.50	37.00
1959 NA	25.90	13.10	16.90	35.00	42.90	28.90	24.90	26.80	16.20	11.00	11.40	12.90
1960 NA	9.80	9.90	12.80	24.30	42.50	18.50	16.40	19.70	12.00	9.80	10.40	7.80
1961 NA	6.40	9.50	13.40	24.60	21.80	13.80	11.20	14.50	10.40	6.00	6.30	6.60
1962 NA	5.60	8.30	17.60	28.30	193.90	141.10	33.20	64.90	94.40	22.30	19.30	18.90
1963 NA	15.40	15.90	19.10	25.80	156.40	53.50	133.40	200.40	126.20	27.50	22.60	25.10
1964 NA	37.20	23.40	23.30	31.20	18.70	15.70	18.30	21.60	19.90	13.00	13.40	20.50
1965 NA	38.50	41.10	61.40	247.70	91.10	129.20	155.70	118.50	113.30	32.00	27.40	31.00
1966 NA	19.50	52.80	130.10	97.70	37.00	24.40	23.10	21.60	16.60	12.60	11.10	11.30
1967 NA	10.30	17.00	52.00	38.80	96.40	62.90	376.50	716.00	539.10	277.50	63.70	44.50
1968 NA	48.90	33.80	58.80	55.10	52.20	38.20	27.10	25.90	14.70	13.80	22.30	23.70
1969 NA	29.30	35.20	38.90	332.40	979.40	1129.00	750.00	758.30	830.70	149.40	63.10	89.00

END OF FILE

JOB ACTIVE.

list,f=vufile

THIS IS THE DATA FILE OF UNIMPAIRED FLOW AT VERNALIS.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 VU	9.70	12.20	57.20	102.10	182.50	400.50	713.70	796.30	773.60	152.50	34.04	20.46
1931 VU	27.36	51.51	33.67	70.02	107.90	167.30	422.95	563.45	151.50	36.70	17.60	10.19
1932 VU	12.00	24.20	316.80	236.00	680.60	524.40	817.60	1673.20	1628.70	561.60	112.10	35.40
1933 VU	29.60	22.80	38.30	81.40	91.40	237.10	535.20	794.20	1200.30	245.70	54.50	25.70
1934 VU	12.10	28.90	125.70	163.90	230.60	425.00	544.90	420.40	239.70	56.20	24.20	16.80
1935 VU	33.30	108.50	130.40	300.40	290.10	404.30	1414.60	1728.90	1538.80	348.80	91.30	28.90
1936 VU	34.90	52.20	50.40	234.90	1009.00	625.40	1250.40	1662.00	1096.00	376.40	82.00	21.90
1937 VU	26.30	33.20	94.00	112.00	863.50	655.90	956.30	2149.40	1212.80	335.00	70.10	21.60
1938 VU	27.30	47.00	844.40	291.00	945.80	1425.20	1389.00	2498.80	2459.60	990.10	243.20	86.60
1939 VU	119.87	117.63	97.90	118.67	152.39	393.74	850.90	638.68	253.55	83.48	36.58	45.47
1940 VU	111.58	47.24	50.10	614.27	698.75	967.46	1055.72	1780.52	1005.96	206.31	45.40	13.40
1941 VU	32.20	39.90	361.60	348.00	659.20	785.50	866.60	2202.30	1705.30	745.50	156.20	42.70
1942 VU	47.20	97.50	409.60	478.10	431.20	473.70	1075.90	1577.10	1890.70	749.60	133.50	34.70
1943 VU	31.56	209.75	236.59	715.74	490.72	1181.94	1254.17	1591.95	997.98	434.53	106.38	32.44
1944 VU	34.92	47.17	62.51	113.60	215.08	406.96	487.09	1372.99	803.72	313.03	61.72	20.05
1945 VU	30.02	232.17	214.58	162.62	911.63	524.49	926.16	1529.06	1387.33	533.99	120.24	39.28
1946 VU	162.65	257.53	555.41	339.16	206.58	479.22	1091.18	1521.44	793.04	239.60	60.20	28.08
1947 VU	67.02	197.81	241.00	138.66	229.90	392.55	604.57	1055.02	370.13	89.69	22.12	16.44
1948 VU	88.06	67.42	50.83	96.56	74.83	188.55	649.70	1380.41	1271.07	285.30	46.27	19.42
1949 VU	25.05	33.85	57.56	61.96	107.02	336.65	890.61	1359.82	736.33	130.67	38.89	20.83
1950 VU	20.80	43.23	45.12	200.66	348.87	366.58	1037.36	1419.17	901.25	215.82	38.69	19.14
1951 VU	58.29	1395.26	1494.97	478.82	429.31	501.43	763.11	1080.94	753.76	235.20	54.14	16.88
1952 VU	35.92	78.22	322.04	617.42	418.42	716.58	1393.43	2647.17	1910.71	885.42	218.67	67.97
1953 VU	37.20	49.17	151.67	367.88	180.56	292.57	798.35	785.41	1124.88	479.18	65.00	22.44
1954 VU	27.02	50.33	60.65	116.59	258.36	585.84	1063.52	1371.46	569.67	163.93	31.12	16.19
1955 VU	18.50	49.04	124.84	176.51	169.95	249.94	439.02	1128.28	925.17	177.11	36.61	16.96
1956 VU	17.30	40.00	1831.30	1207.30	494.10	555.00	923.60	1846.70	1761.00	759.90	176.70	66.90
1957 VU	67.70	75.60	69.00	94.70	294.00	422.30	540.30	1188.10	1209.10	250.70	55.20	25.80
1958 VU	45.14	61.08	133.25	169.38	491.84	774.83	1319.13	2535.83	1822.49	722.78	217.41	73.65
1959 VU	38.65	37.69	33.39	174.57	330.68	375.87	694.22	667.98	410.46	82.76	21.29	118.67
1960 VU	37.82	26.55	30.64	68.38	291.52	398.28	703.09	847.07	443.46	77.27	23.20	13.63
1961 VU	16.37	57.31	92.03	56.44	119.50	195.99	481.55	606.47	353.92	57.17	43.76	19.51
1962 VU	18.65	32.64	66.90	68.87	673.90	399.52	1240.79	1217.04	1362.56	427.62	81.69	28.67
1963 VU	56.49	31.68	66.20	285.40	907.54	343.03	728.87	1683.95	1386.11	575.68	128.36	56.85
1964 VU	59.85	256.78	134.83	143.59	133.16	206.91	495.68	903.16	612.32	135.85	45.18	23.77
1965 VU	69.12	153.05	1143.86	877.22	437.81	455.60	964.37	1381.29	1423.25	710.37	353.72	138.32
1966 VU	38.66	350.81	238.94	223.72	202.78	438.75	940.10	1066.90	322.48	96.33	41.29	24.95
1967 VU	29.44	132.56	663.70	377.93	349.53	912.80	930.90	2165.70	2487.10	1517.20	309.30	116.57
1968 VU	50.70	53.60	94.00	125.90	352.60	343.90	572.30	801.80	392.20	86.40	43.40	21.70
1969 VU	37.40	189.00	218.70	1477.70	818.70	888.10	1564.80	7917.80	2791.80	1874.50	341.10	78.80

THIS IS THE DATA FILE FOR UNIMPAIRED SAN JOAQUIN RIVER FLOW (KAF) AT FRIANT.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 FR	5.00	6.20	8.30	18.20	35.60	80.00	165.10	213.50	243.60	60.80	16.90	5.90
1931 FR	10.60	13.40	10.20	16.00	23.40	38.90	100.20	173.50	59.70	16.00	11.10	7.20
1932 FR	5.90	8.40	71.80	58.90	167.70	156.60	238.10	491.50	543.60	238.80	51.40	14.70
1933 FR	12.60	8.90	14.60	26.50	30.00	73.40	159.00	213.40	410.10	118.90	29.30	14.70
1934 FR	6.80	10.30	38.10	46.80	50.30	109.40	166.10	146.20	68.90	27.30	13.40	7.90
1935 FR	12.60	26.60	36.20	72.50	85.20	110.90	356.60	496.80	519.20	144.20	43.80	18.60
1936 FR	13.60	15.80	16.40	38.30	195.90	163.50	348.60	510.00	347.70	150.50	42.10	10.90
1937 FR	10.90	12.60	36.40	34.90	252.70	190.60	303.80	704.80	456.80	159.70	34.00	10.80
1938 FR	9.80	12.30	210.70	70.90	207.30	433.80	434.20	795.00	912.70	431.20	127.90	42.60
1939 FR	38.90	33.10	28.70	32.70	43.30	102.80	239.90	208.80	110.30	43.40	24.80	14.10
1940 FR	34.80	14.20	11.40	134.10	139.80	210.00	290.00	558.60	362.90	96.60	21.20	7.00
1941 FR	10.10	11.70	98.40	105.80	182.80	208.60	242.40	711.20	641.50	330.90	85.80	23.30
1942 FR	21.50	30.30	96.00	113.10	102.60	128.50	298.50	465.40	632.60	284.00	64.70	16.70
1943 FR	10.10	42.50	43.40	169.70	113.30	267.70	335.10	502.50	325.10	178.80	49.90	15.60
1944 FR	10.50	15.10	19.80	31.20	55.40	111.60	140.80	408.20	279.50	142.60	35.00	15.70
1945 FR	12.70	58.40	56.10	44.10	237.70	147.90	275.90	476.80	487.60	240.20	73.90	26.80
1946 FR	59.10	65.60	118.30	78.90	53.80	125.80	310.40	463.90	279.90	117.80	36.90	19.10
1947 FR	28.50	64.90	84.50	47.70	64.00	100.30	171.00	347.70	145.80	42.70	16.90	11.60
1948 FR	22.80	18.20	15.40	18.90	20.20	42.60	164.60	390.60	372.60	107.90	26.00	15.00
1949 FR	10.50	7.90	14.60	16.20	25.90	73.00	234.50	409.50	268.30	63.20	25.60	14.90
1950 FR	9.80	16.10	17.20	43.20	90.10	89.60	280.10	379.00	262.90	87.00	21.70	13.80
1951 FR	17.10	247.00	300.40	111.20	104.20	119.20	201.90	321.90	278.00	114.70	31.70	11.70
1952 FR	12.30	20.40	83.40	133.00	98.70	176.70	385.20	819.90	640.80	335.30	101.40	33.00
1953 FR	16.90	18.70	42.90	85.00	48.00	71.50	197.20	211.30	320.20	171.60	30.20	13.20
1954 FR	9.40	16.60	16.60	33.40	65.40	121.20	218.40	439.50	217.60	80.40	20.20	9.10
1955 FR	6.00	17.80	31.20	41.60	48.90	74.10	126.50	337.80	348.20	87.90	29.60	11.40
1956 FR	6.10	13.20	460.50	271.20	140.80	169.50	278.30	568.00	613.80	317.80	86.50	34.40
1957 FR	26.30	21.70	20.70	29.50	66.90	90.10	142.20	326.70	439.90	115.00	31.70	15.90
1958 FR	16.40	18.50	43.30	42.60	112.50	181.40	362.60	795.50	622.30	287.50	107.90	40.50
1959 FR	16.10	14.60	14.60	37.00	89.60	113.60	203.10	208.10	153.00	41.50	16.80	41.40
1960 FR	18.40	9.70	9.50	18.00	55.00	86.10	177.90	240.70	146.90	42.60	16.40	7.50
1961 FR	8.50	22.30	31.20	19.00	30.80	48.90	124.60	171.60	128.00	27.40	24.80	10.40
1962 FR	9.80	14.90	23.10	23.50	184.80	109.90	381.00	396.90	505.20	202.60	51.70	20.20
1963 FR	17.60	10.80	10.70	81.90	207.90	101.40	191.90	464.20	492.40	264.20	70.70	31.40
1964 FR	25.50	64.30	36.40	31.20	30.80	51.80	126.70	256.90	200.00	59.30	28.70	10.50
1965 FR	10.10	34.00	203.90	187.80	114.10	128.20	250.80	431.20	472.20	266.70	137.80	35.10
1966 FR	17.50	101.10	66.50	61.90	55.50	125.80	276.90	361.60	147.70	50.40	25.00	8.80
1967 FR	6.40	29.70	212.70	92.50	100.70	243.00	249.60	659.90	823.50	594.30	154.20	66.80
1968 FR	26.90	22.90	34.30	36.90	75.40	82.90	146.10	231.10	131.20	43.80	22.10	8.40
1969 FR	15.10	40.00	52.20	396.60	233.60	227.20	464.50	1096.40	874.20	462.80	137.10	40.50
1970 FR	32.60	31.70	47.10	150.40	83.30	136.00	146.00	375.80	278.50	106.60	36.70	11.00

list,1 ernali

THIS IS THE DATA FILE CHLORIDES (PPM) AT VERNALIS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	20	0	18	18	10	7	8	53	82
1939	47	32	41	30	31	84	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	17	21	23	9	8	8	52	78	72
1943	59	43	26	27	11	13	10	7	24	88	80	64
1944	66	66	48	49	35	49	42	23	86	120	98	78
1945	61	52	37	43	19	17	14	18	7	0	0	0
1946	0	0	0	26	31	66	16	10	62	120	100	110
1947	83	59	62	71	77	78	80	63	140	160	150	76
1948	85	84	94	77	180	160	29	10	14	140	120	100
1949	88	0	96	68	130	30	70	60	110	140	130	140
1950	93	100	100	62	37	63	18	16	76	140	140	110
1951	78	10	0	0	0	0	0	0	0	0	0	0
1952	80	86	52	21	15	18	10	9	10	58	106	83
1953	89	78	48	32	72	147	108	66	23	54	134	123
1954	94	97	94	107	80	45	28	23	132	177	167	160
1955	140	113	94	33	79	106	121	142	71	174	170	159
1956	163	143	63	13	25	57	40	14	14	68	92	89
1957	93	84	64	100	124	61	133	100	39	152	151	135
1958	84	72	70	93	52	34	21	16	16	62	125	100
1959	0	0	50	97	83	109	172	178	201	256	240	172
1960	161	138	124	138	125	236	199	193	263	281	272	263
1961	175	140	110	129	168	252	348	253	315	407	401	286
1962	250	194	196	213	110	49	96	55	67	162	186	154
1963	124	101	67	129	44	97	27	15	36	109	167	130
1964	87	70	50	58	95	209	223	171	146	248	259	182
1965	112	108	92	21	35	46	42	32	21	88	153	122
1966	28	32	11	36	37	112	66	52	90	0	110	112
1967	89	37	31	53	25	35	12	12	9	26	34	101
1968	75	56	50	32	108	35	32	82	0	214	188	179
1969	75	42	94	2	6	15	13	8	4	17	49	35

READY.

THIS IS THE DATA FILE OF CHLORIDES (PPM) AT MAZE ROAD BRIDGE.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	90	56	146	108	106	94
1940	78	82	72	35	15	24	11	10	9	54	126	66
1941	73	85	74	24	0	15	21	13	7	46	79	79
1942	67	75	49	0	17	0	0	0	0	50	0	90
1943	62	0	39	0	0	0	0	0	0	120	0	99
1944	0	0	0	0	0	0	68	0	0	0	107	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	91	74	0	0	0	211	0	187	170	162	0	0
1948	0	87	0	0	0	0	213	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	75	13	37	92	60	46
1952	0	58	0	8	11	9	0	0	0	116	136	65
1953	0	70	0	34	73	0	0	72	69	33	166	0
1954	0	117	20	0	0	230	31	31	95	196	194	194
1955	188	100	137	0	0	0	213	216	199	198	191	187
1956	206	0	124	18	23	0	0	19	20	154	127	91
1957	103	0	84	142	150	45	205	154	42	172	165	140
1958	82	74	88	67	24	60	23	17	16	80	164	81
1959	110	55	109	119	120	146	195	210	240	295	0	262
1960	227	132	104	135	175	190	280	250	285	278	246	269
1961	260	144	132	122	0	287	325	206	258	344	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0
1964	89	80	60	89	151	271	218	0	0	265	0	180
1965	139	132	98	49	42	25	52	0	76	117	0	25
1966	66	82	22	74	67	126	220	222	190	244	0	245
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0

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list,f=arflow

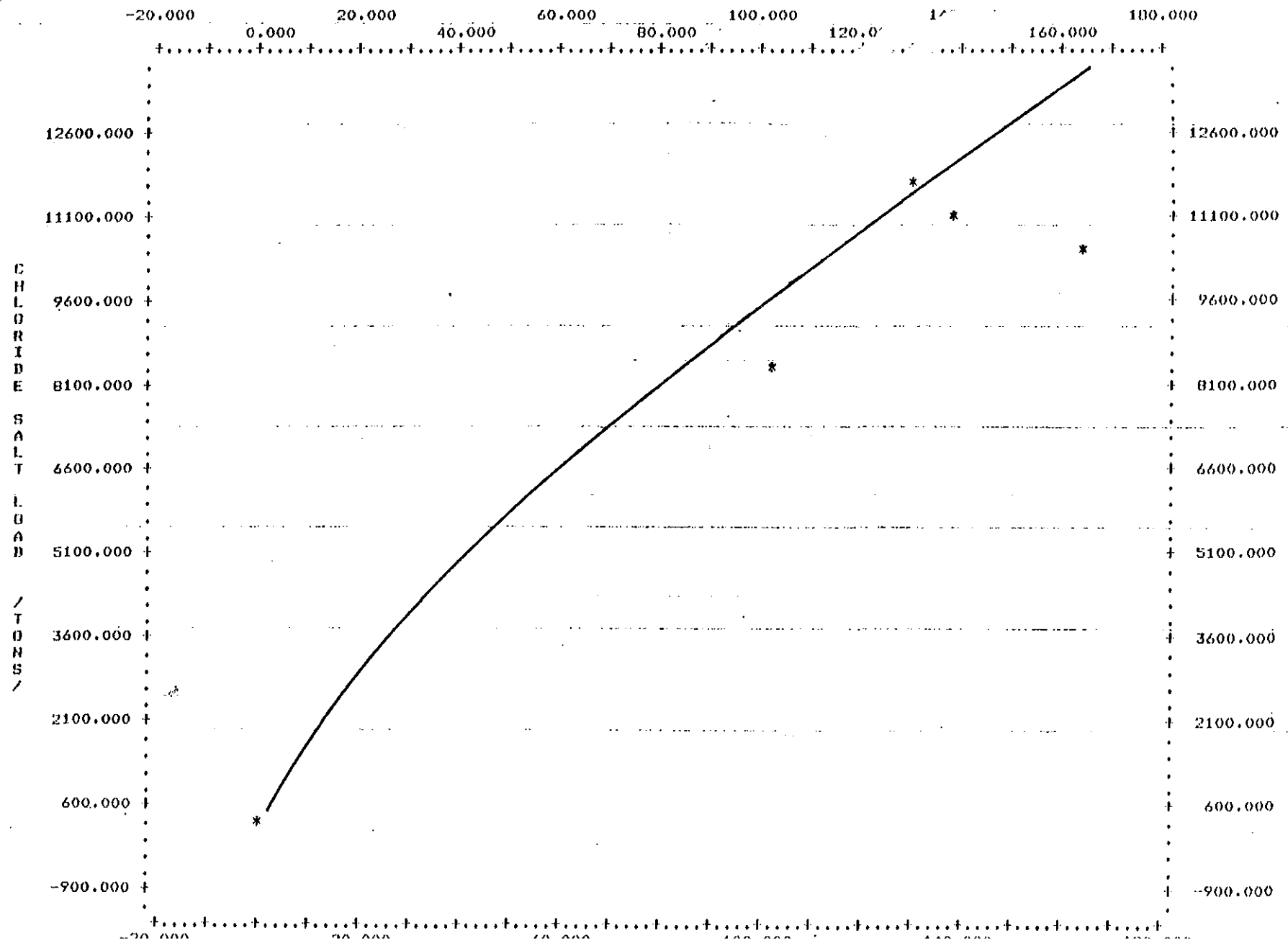
THIS IS THE DATA FILE OF CHLORIDES (PPM) AT GRAYSON

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	195	199	213	240	202	0
1935	0	0	0	0	0	0	0	0	0	0	159	0
1936	0	0	0	0	0	0	0	0	0	0	189	0
1937	0	0	0	0	0	0	0	0	0	0	0	100
1938	112	0	0	23	0	22	0	12	8	9	54	99
1939	89	54	57	73	50	180	50	31	88	135	124	111
1940	97	184	110	39	22	24	13	3	9	80	131	87
1941	113	187	117	26	20	23	20	9	6	40	153	100
1942	98	137	52	19	28	19	16	11	7	38	130	112
1943	93	130	66	69	19	14	10	16	16	118	91	94
1944	0	0	88	52	34	49	66	56	73	130	84	69
1945	78	100	110	62	17	18	29	13	9	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	66	168	0	56	0	206	0	148	127	185	0	0
1948	0	207	0	175	0	0	246	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	123	35	148	146	184	95
1952	169	205	97	16	22	35	13	6	8	116	127	76
1953	153	168	130	36	161	232	180	103	134	190	159	91
1954	106	192	212	250	119	174	41	21	96	168	155	170
1955	210	224	209	116	174	218	177	114	176	191	159	184
1956	234	222	191	17	25	78	120	28	12	132	154	122
1957	118	192	198	191	170	102	179	131	36	159	146	128
1958	162	218	192	66	65	100	0	18	12	111	165	100
1959	112	216	240	160	250	277	218	220	228	235	0	0
1960	181	225	280	250	205	306	248	213	248	210	191	238
1961	270	239	225	235	0	318	288	180	175	200	256	257
1962	295	298	205	233	292	53	220	232	39	158	161	158
1963	208	0	282	309	42	210	0	70	37	114	168	148
1964	115	231	225	186	238	343	240	155	162	216	0	154
1965	115	204	208	57	127	21	118	0	65	126	156	116
1966	122	245	30	96	228	305	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
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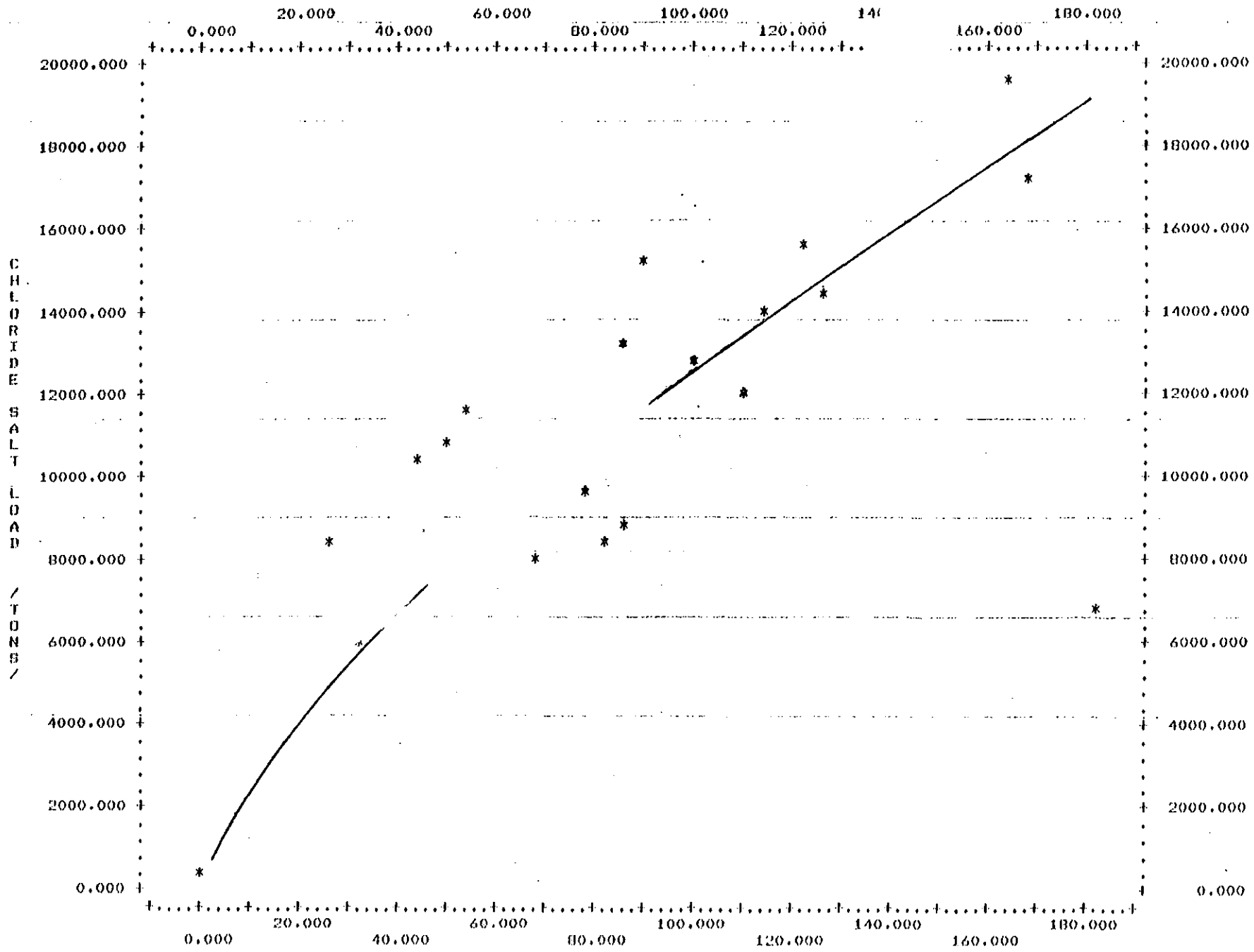
APPENDIX 2

CHLORIDE LOAD-FLOW REGRESSION
CURVES

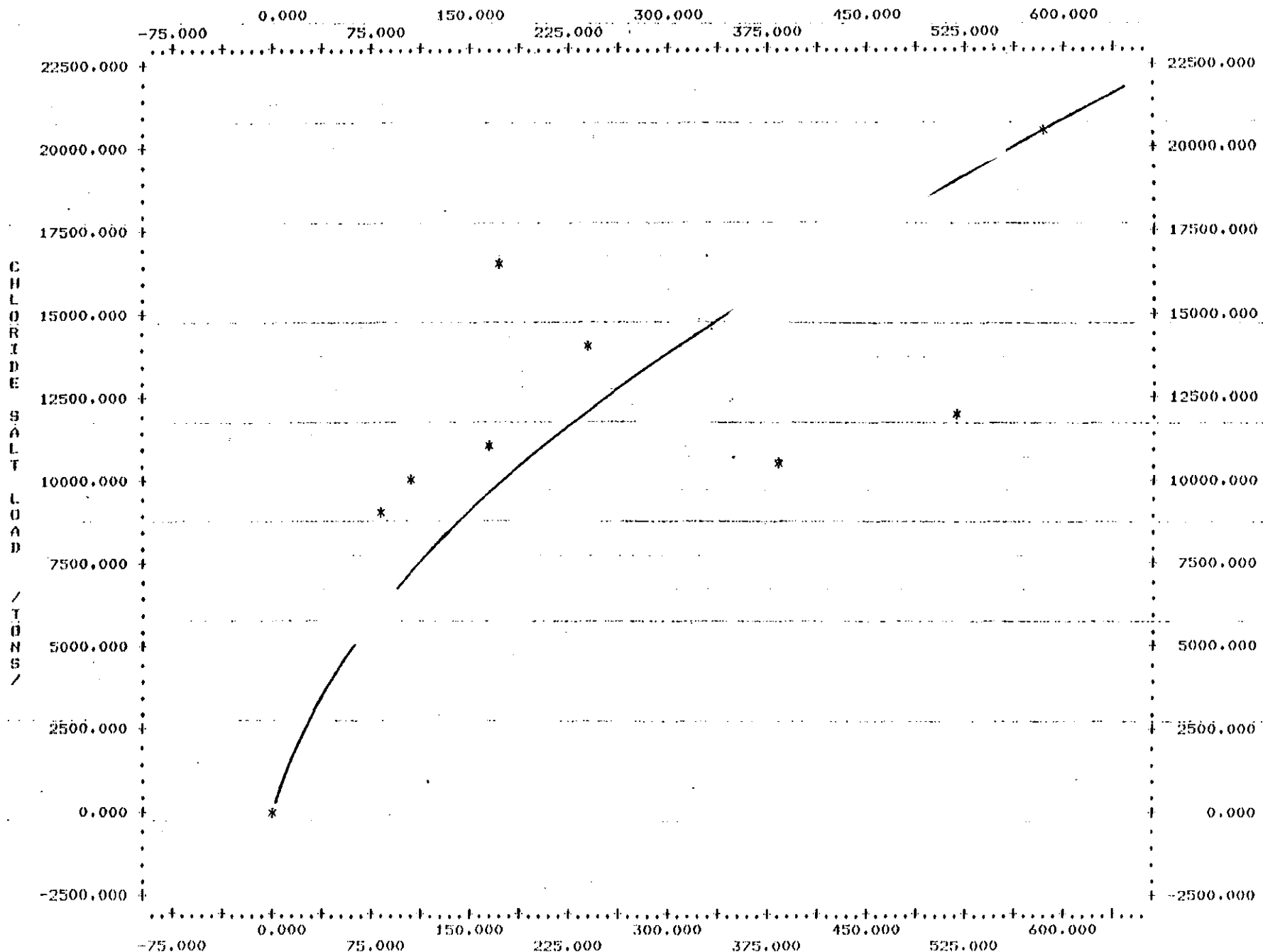
SALT LOAD VS. FLOW AT VERNALIS PRE CVP OCTOBER



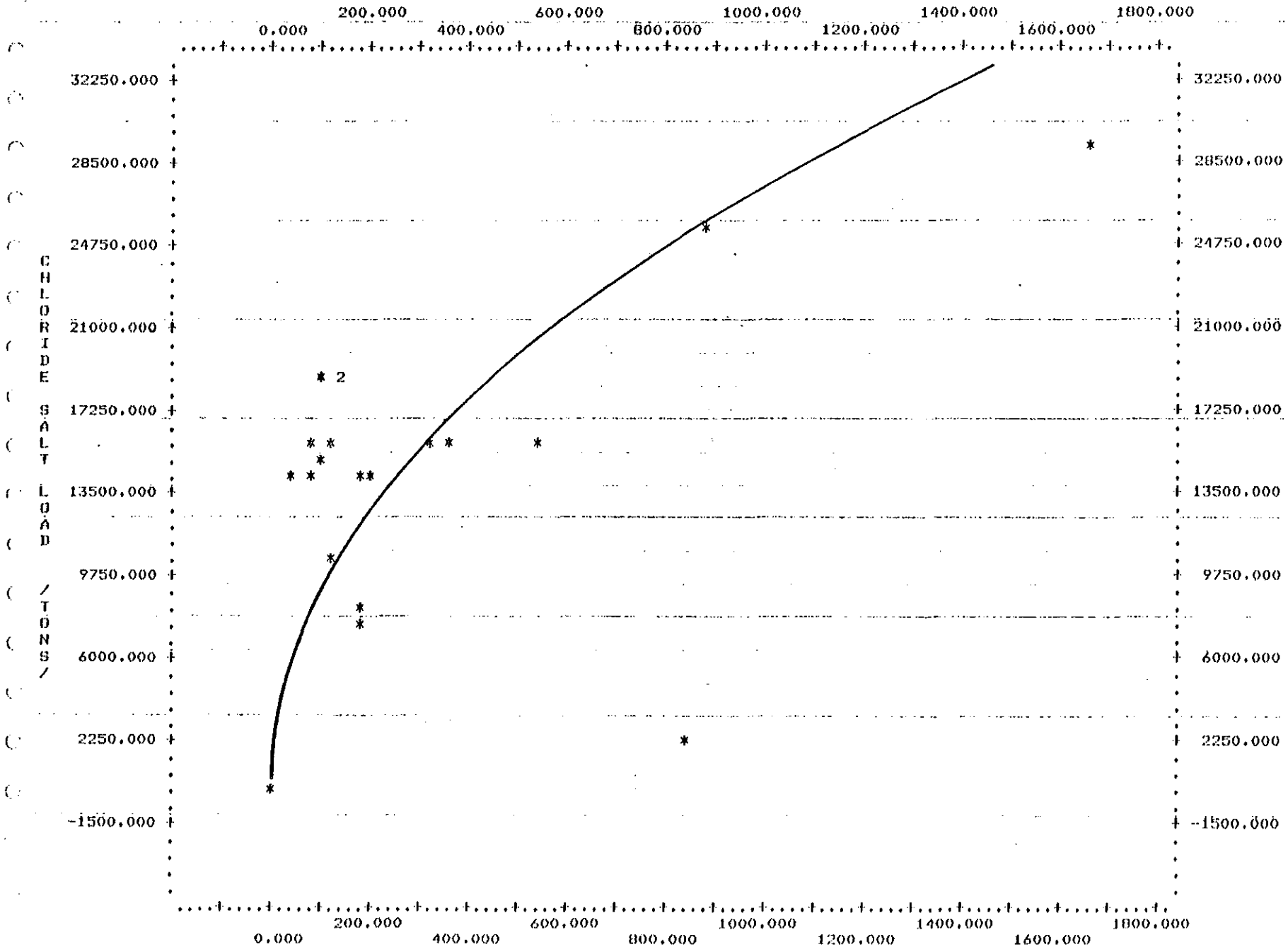
SALT LOAD VS. FLOW AT VERNALIS POST CVP OCTOBER



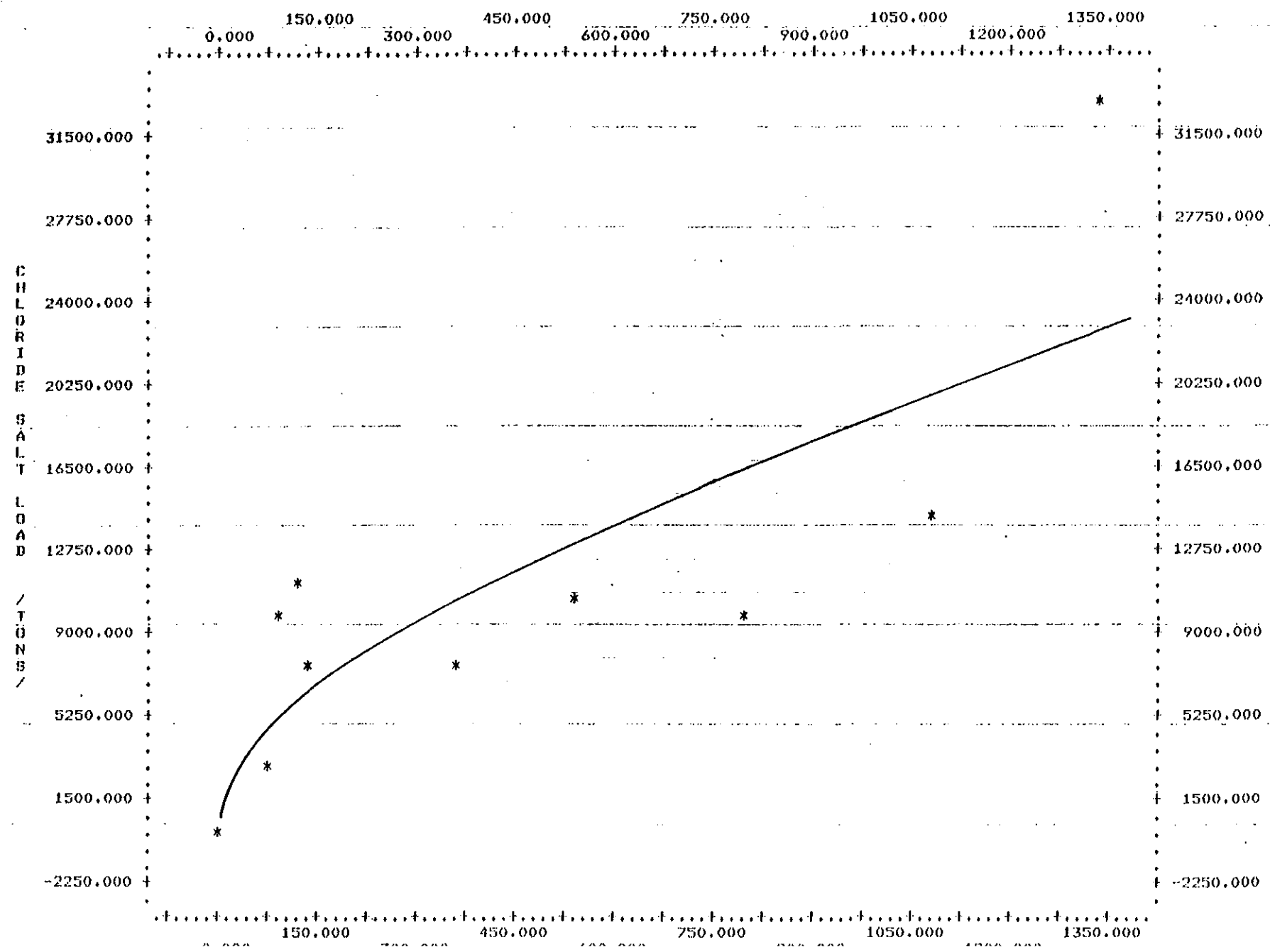
SALT LOAD VS. FLOW AT VERNALIS PRE CVP JANUARY



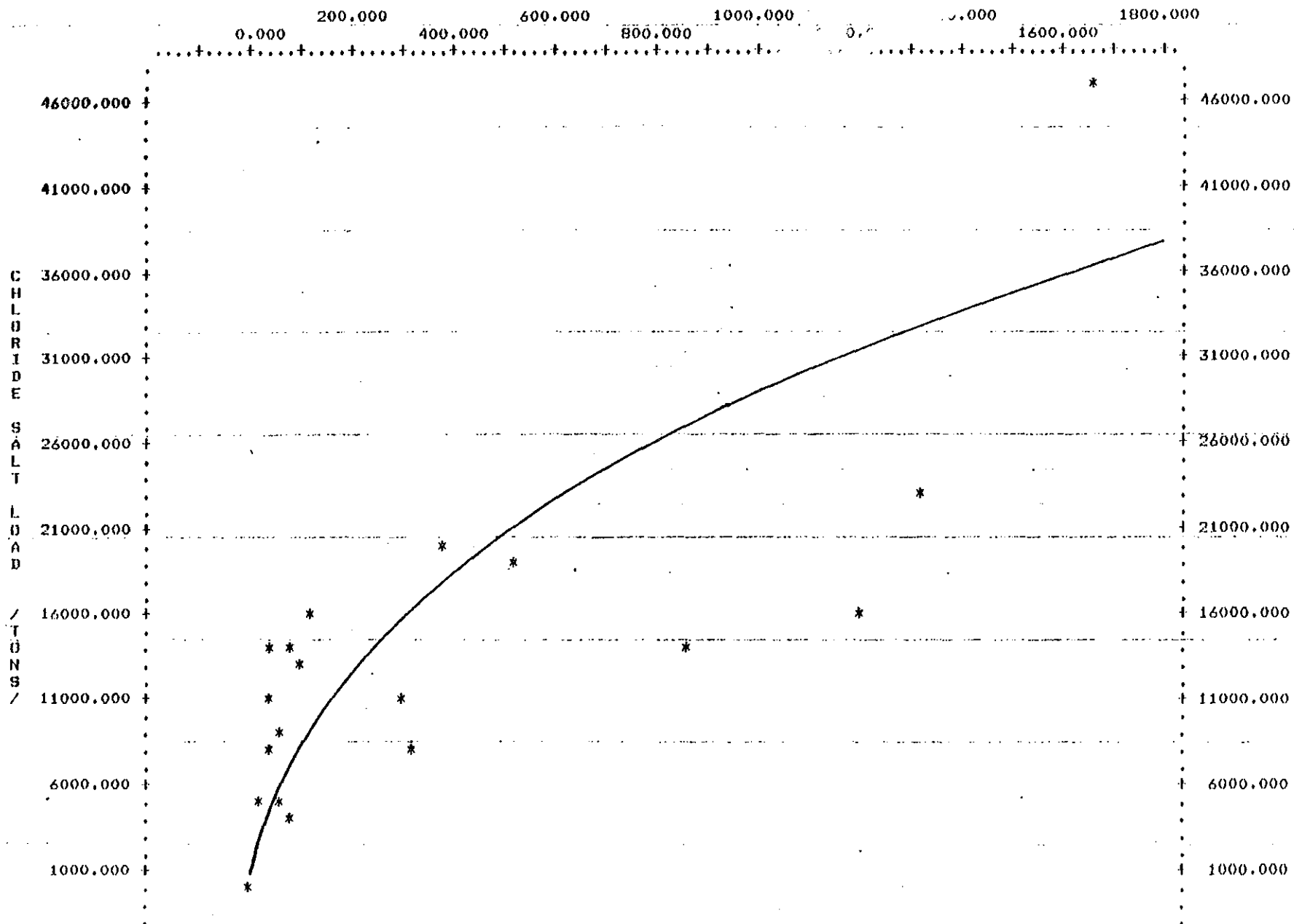
SALT LOAD VS. FLOW AT VERNALIS POST CVP JANUARY



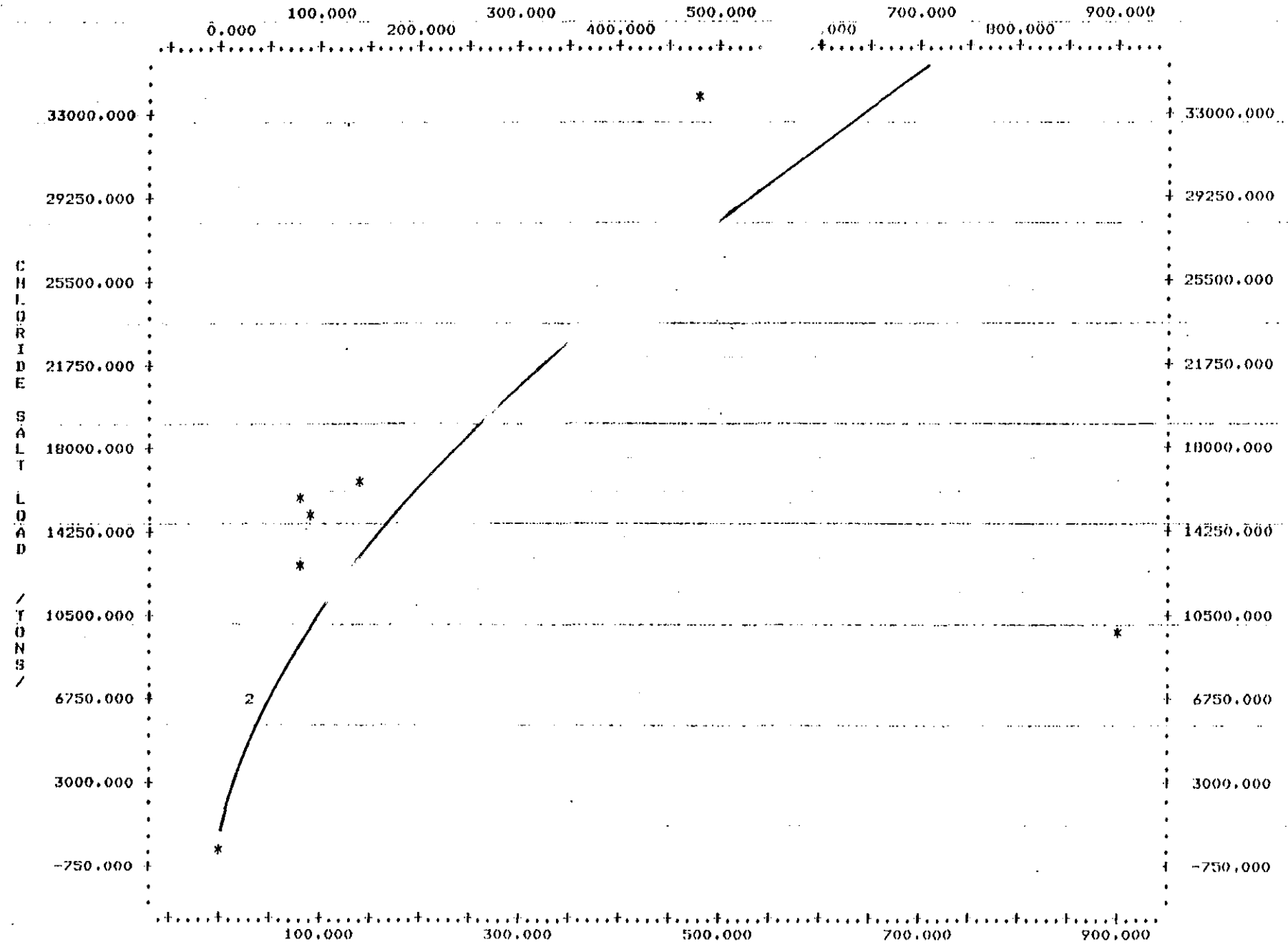
SALT LOAD VS. FLOW AT VERNALIS PRE CVP APRIL



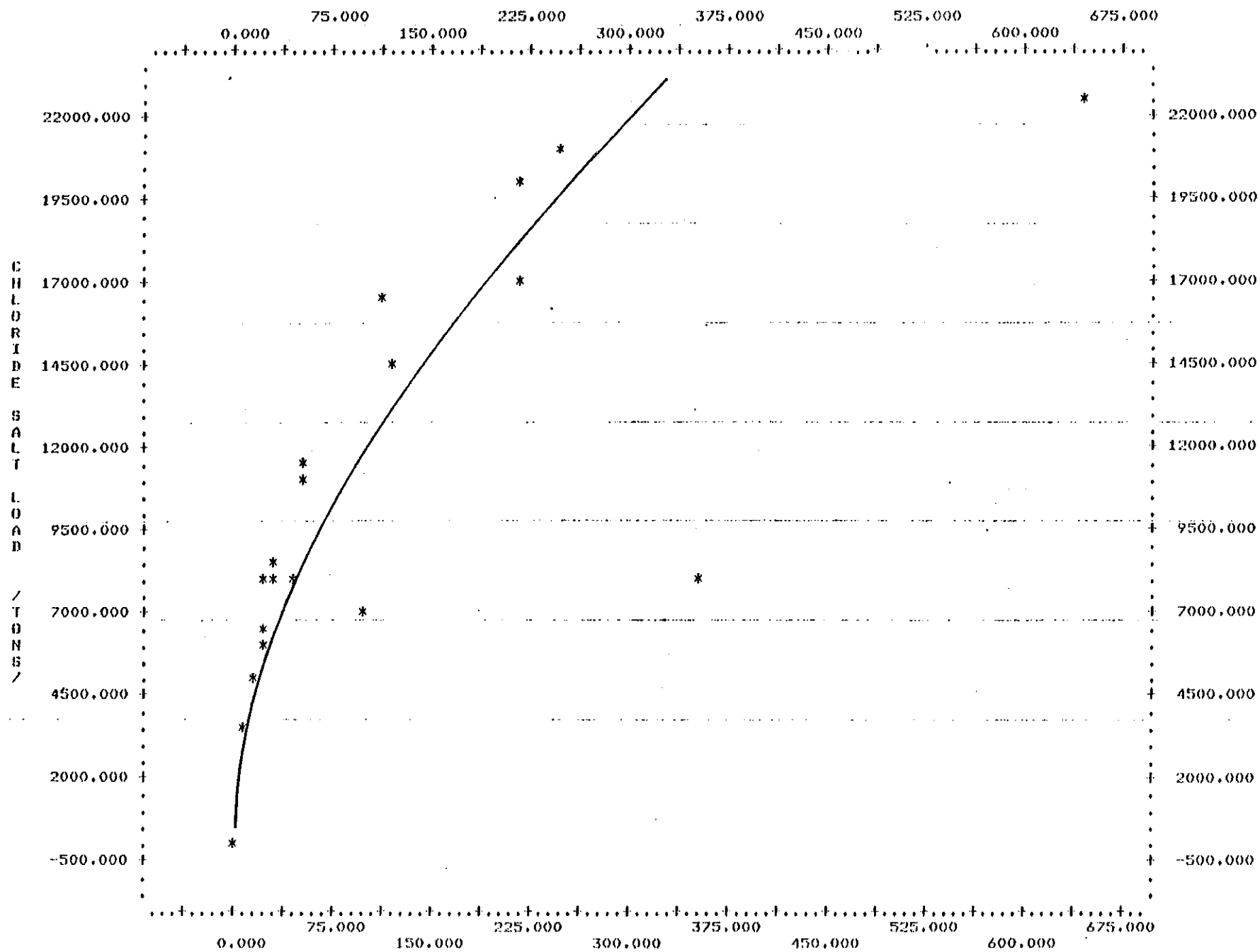
SALT LOAD VS. FLOW AT VERNALIS POST CUP APRIL



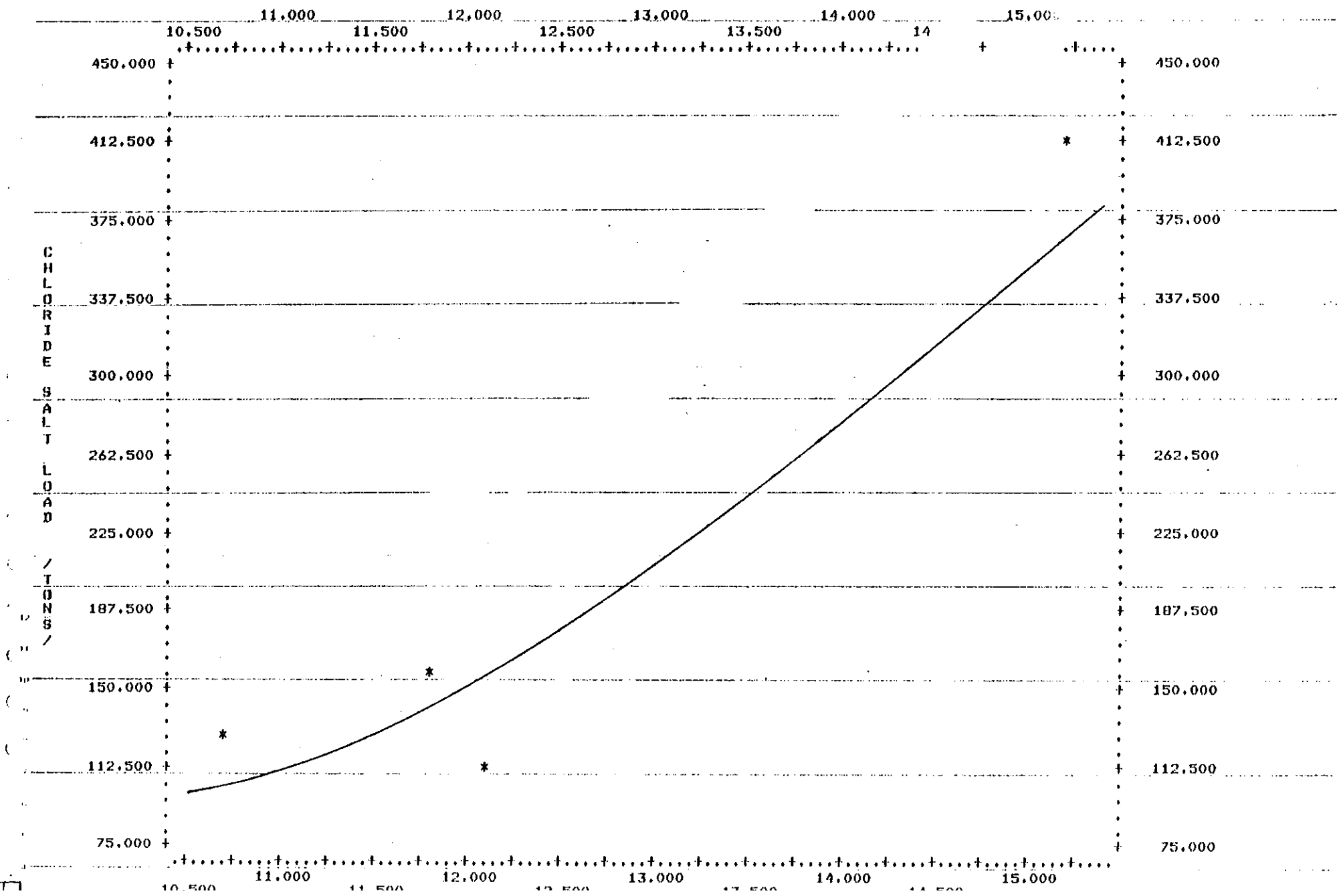
SALT LOAD VS. FLOW AT VERNALIS PRE CVI



SALT LOAD VS. FLOW AT VERNALIS POST CVP JULY



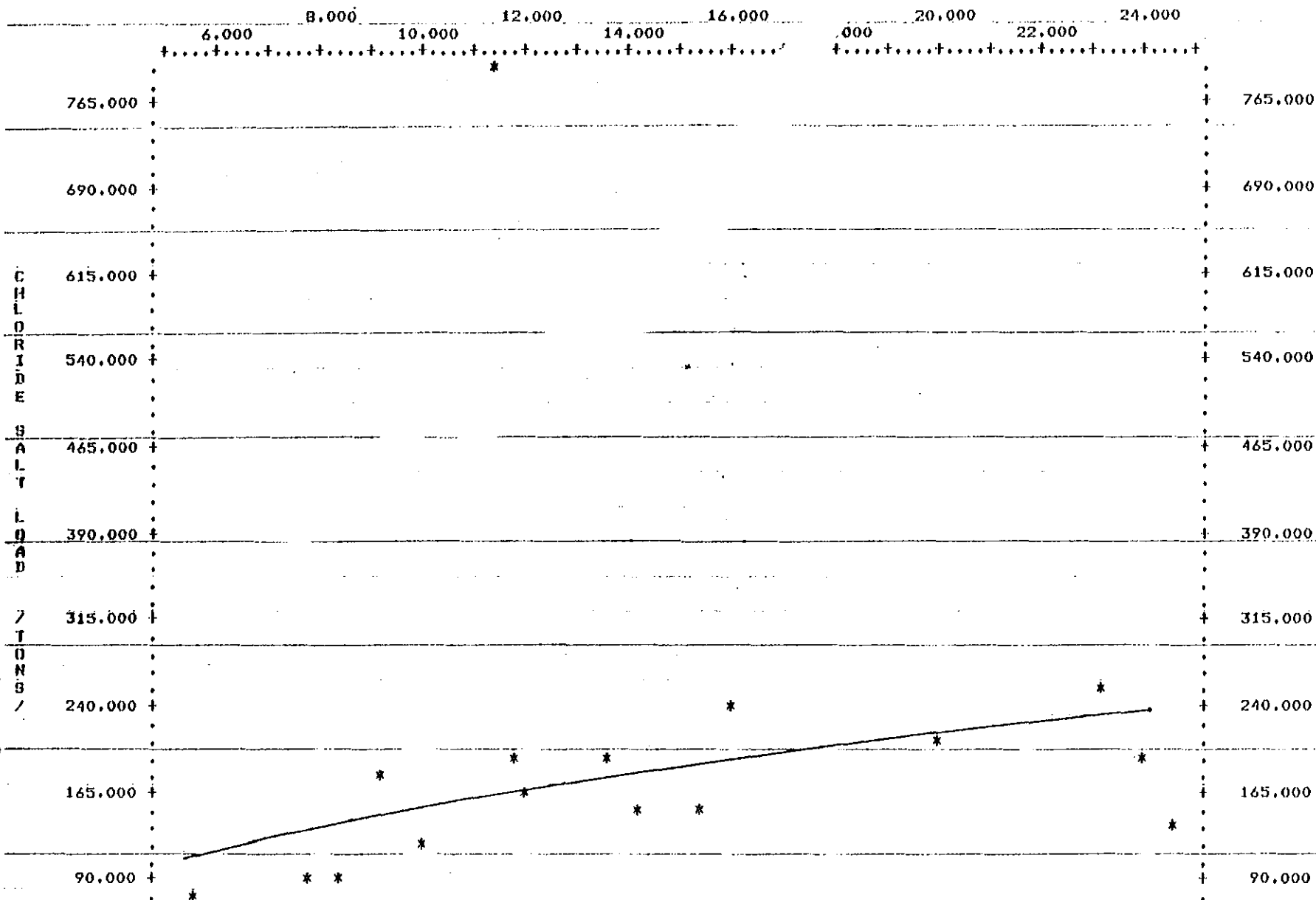
FLOW VS. SALT LOAD TANISLAUS RIVER FRE CVP OCTOBER



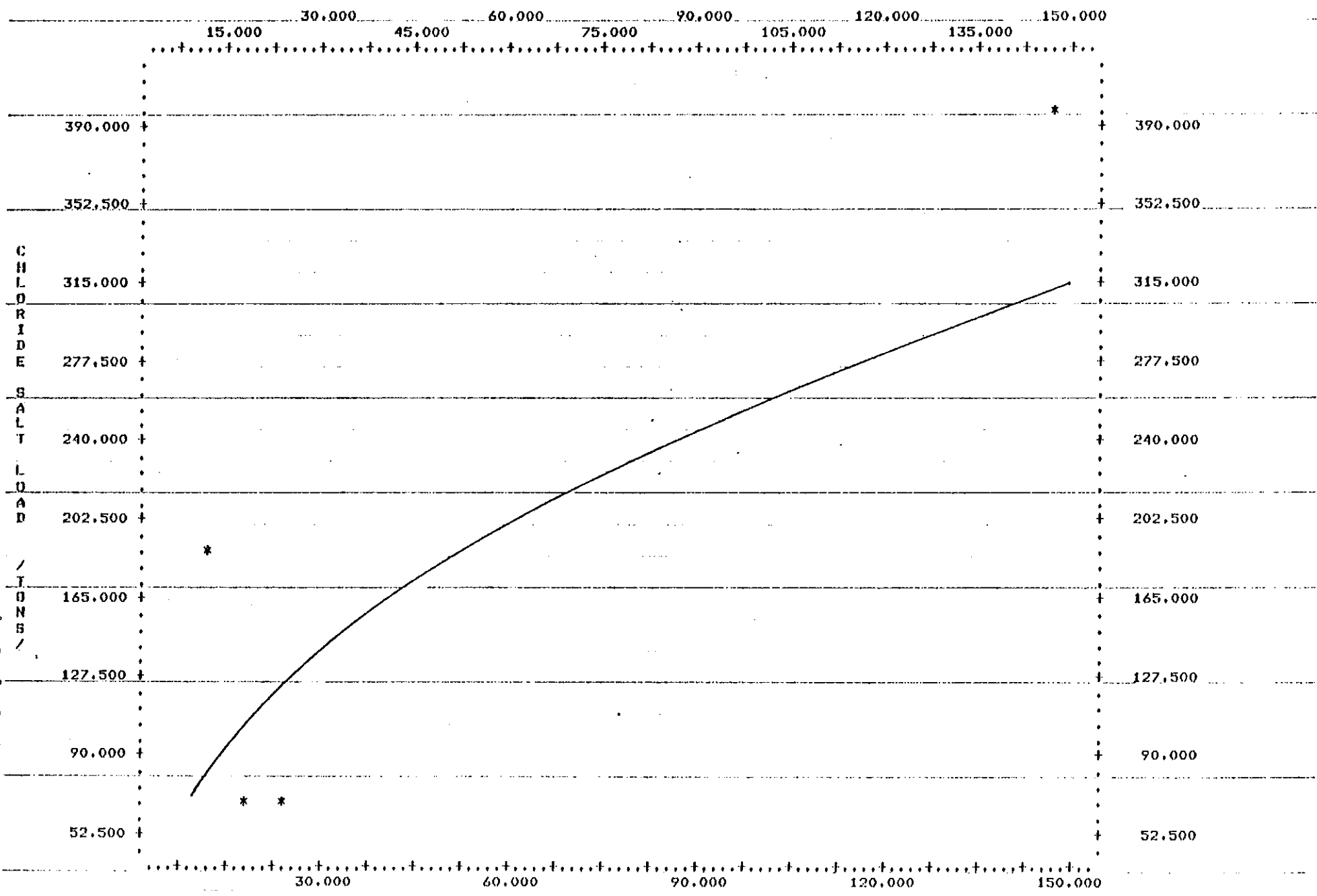
CHLORIDE SALT LOAD

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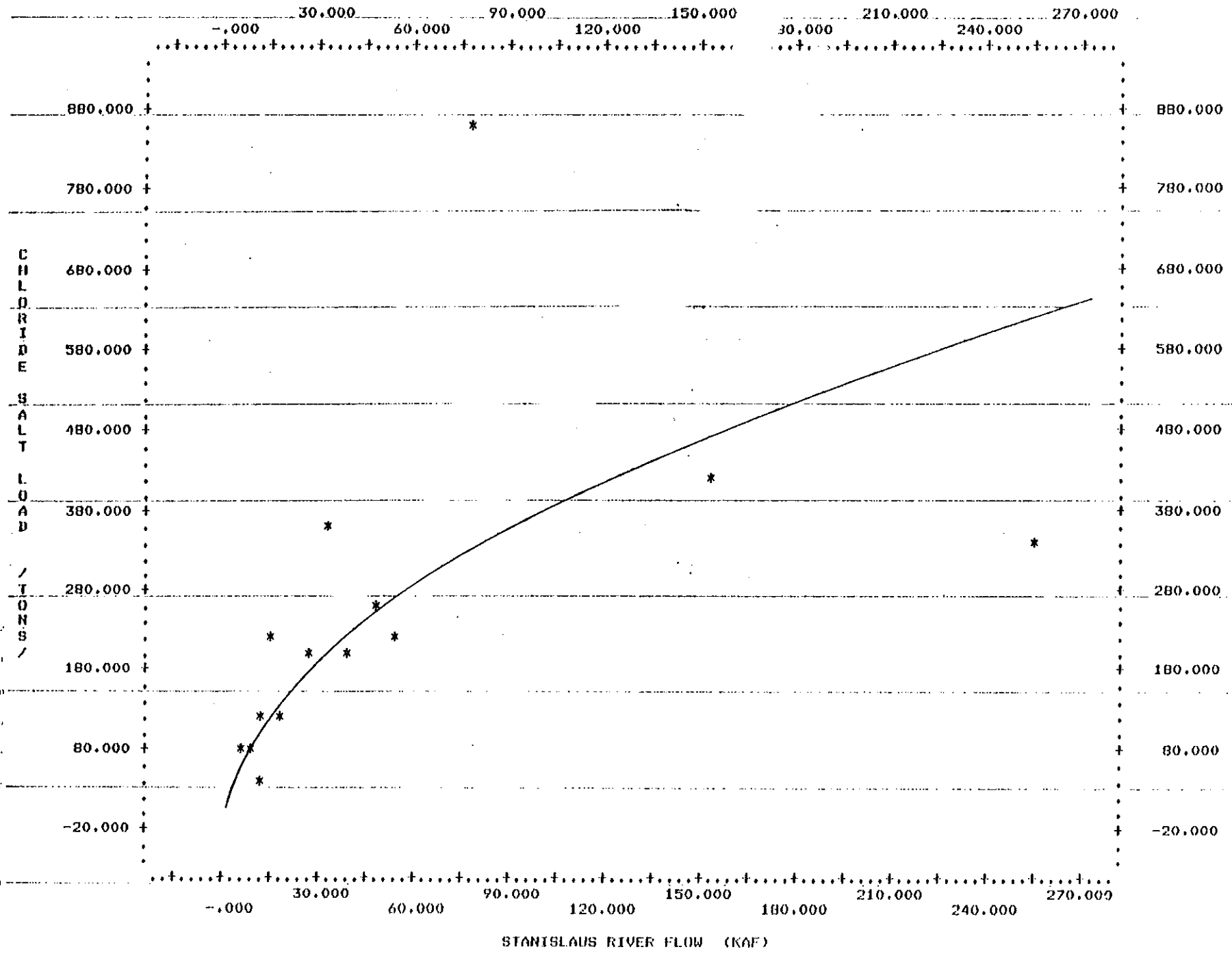
FLOW VS. SALT LOAD ON STANISLAUS RIVER POST C OCTOBER



FLOW VS. SALT LOAD ON STANISLAUS RIVER FRE CVP JANUARY

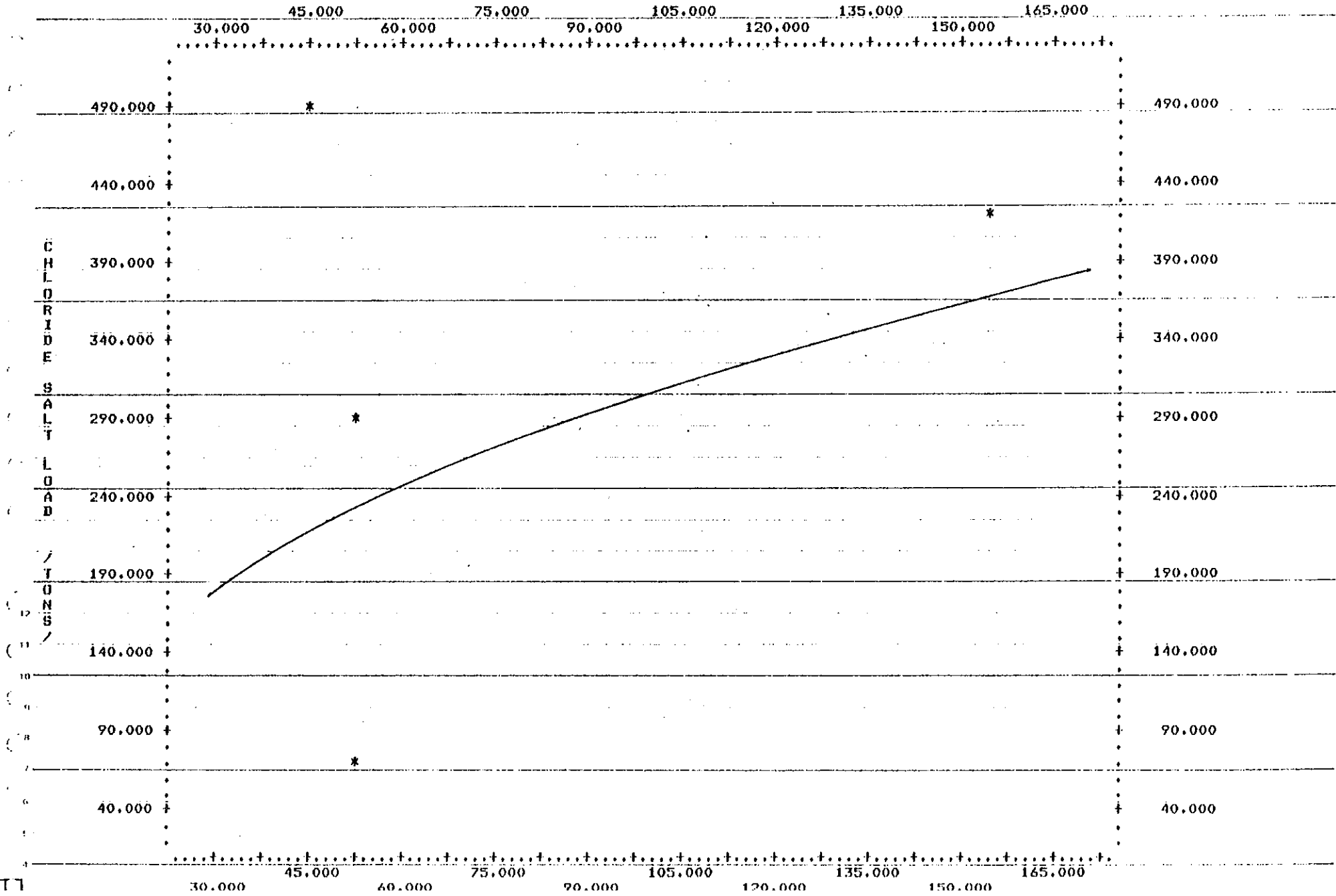


FLOW VS. SALT LOAD ON STANISLAUS RIVER F. JANUARY

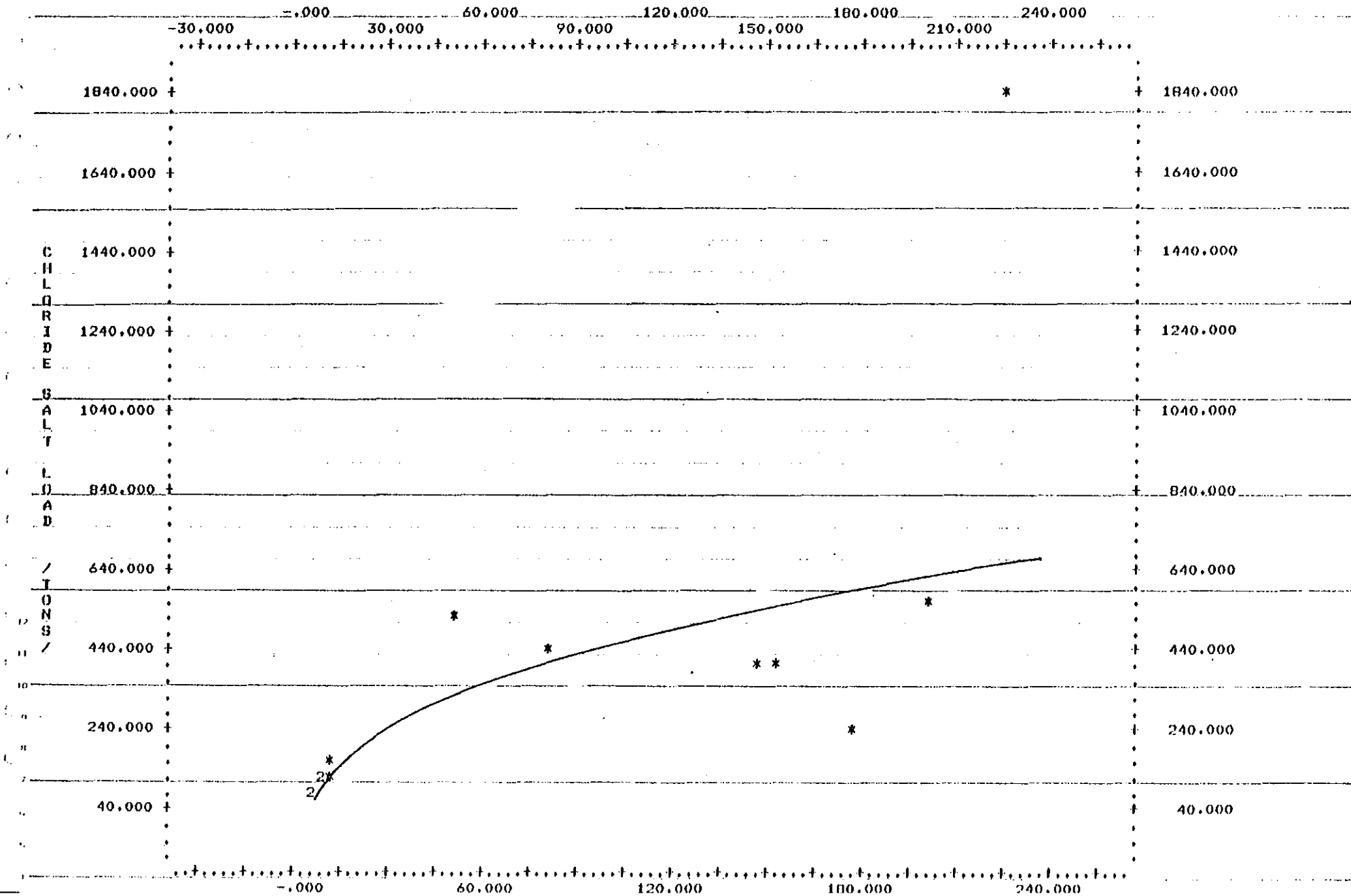


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FLOW VS. SALT LOAD ON STANISLAUS RIVER PRE CVP APRIL

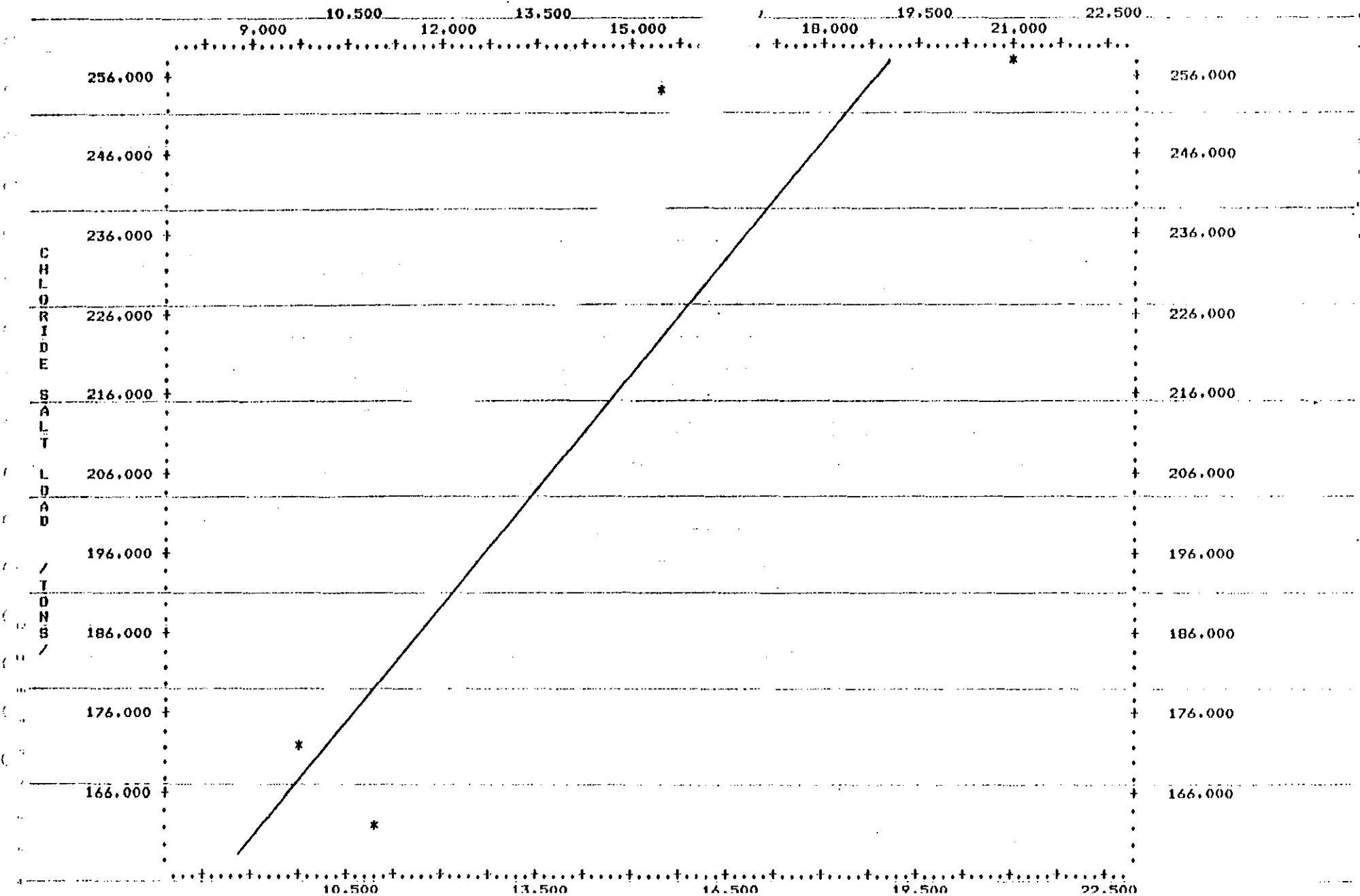


FLOW VS. SALT LOAD ON STANISLAUS RIVER POST CVP APRIL

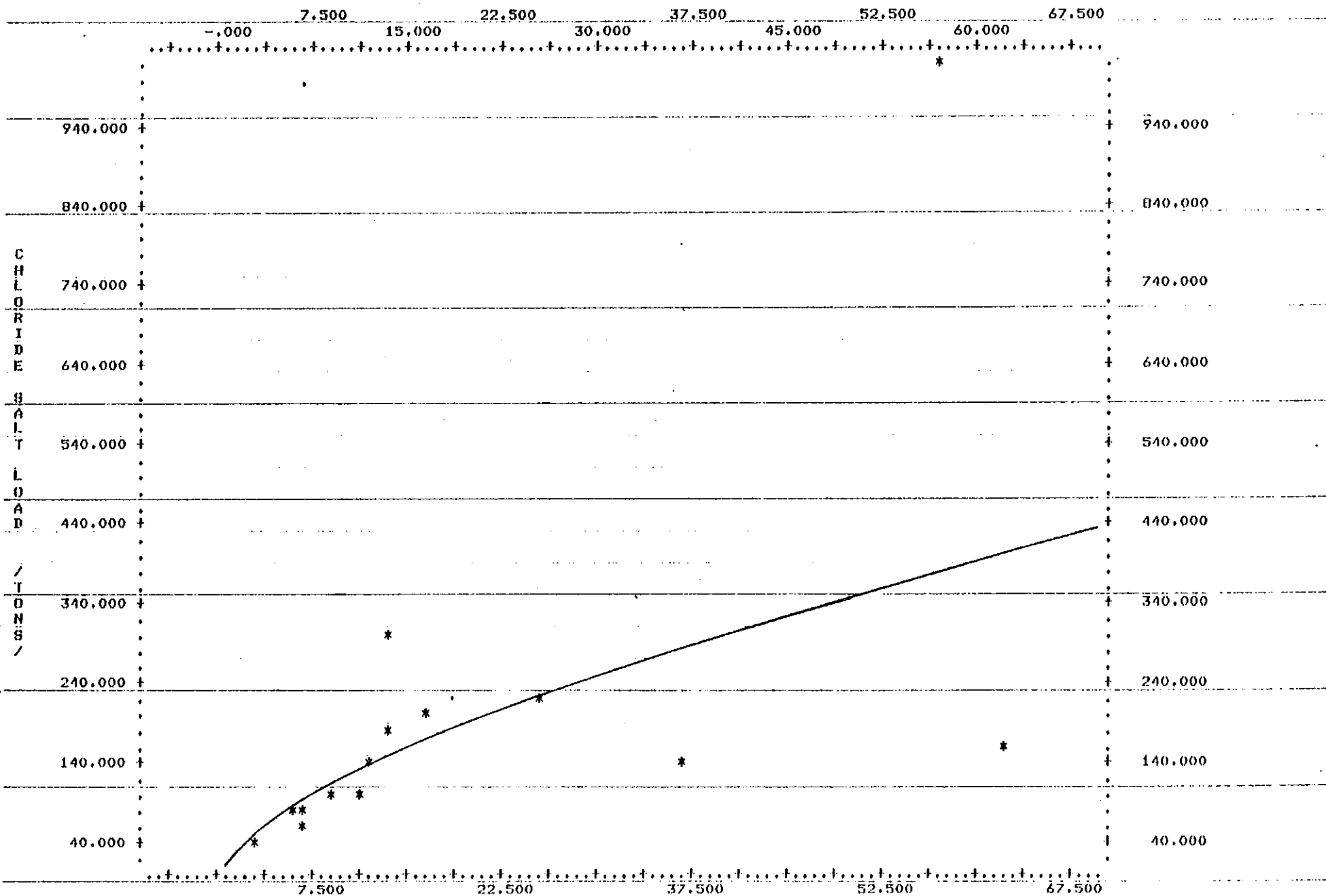


FLOW VS. SALT LOAD ON STANISLAUS RIVE

E CVP JULY

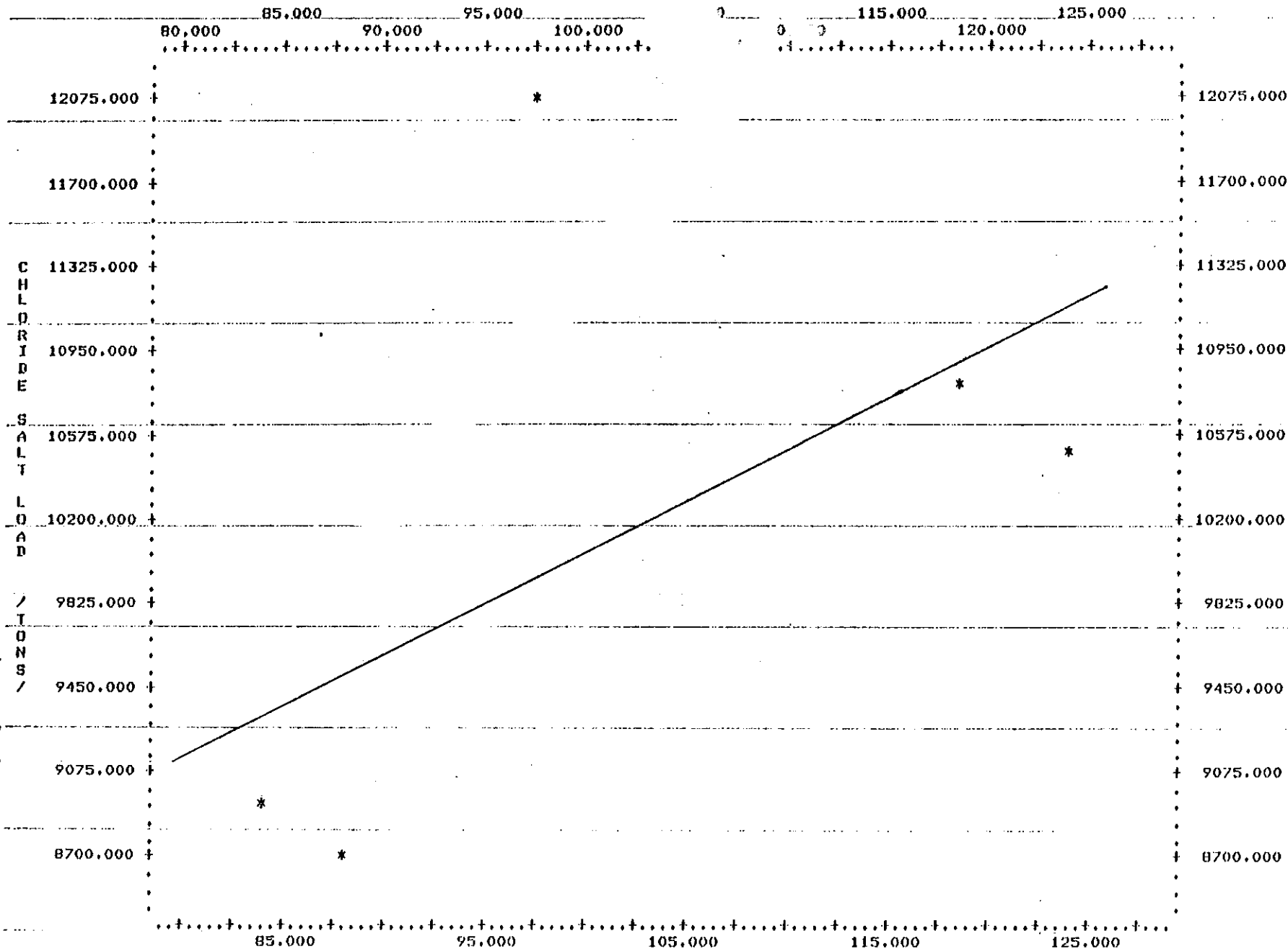


FLOW VS. SALT LOAD ON STANISLAUS RIVER POST CVP JULY



FLOW VS. SALT LOAD AT MAZE ROAD

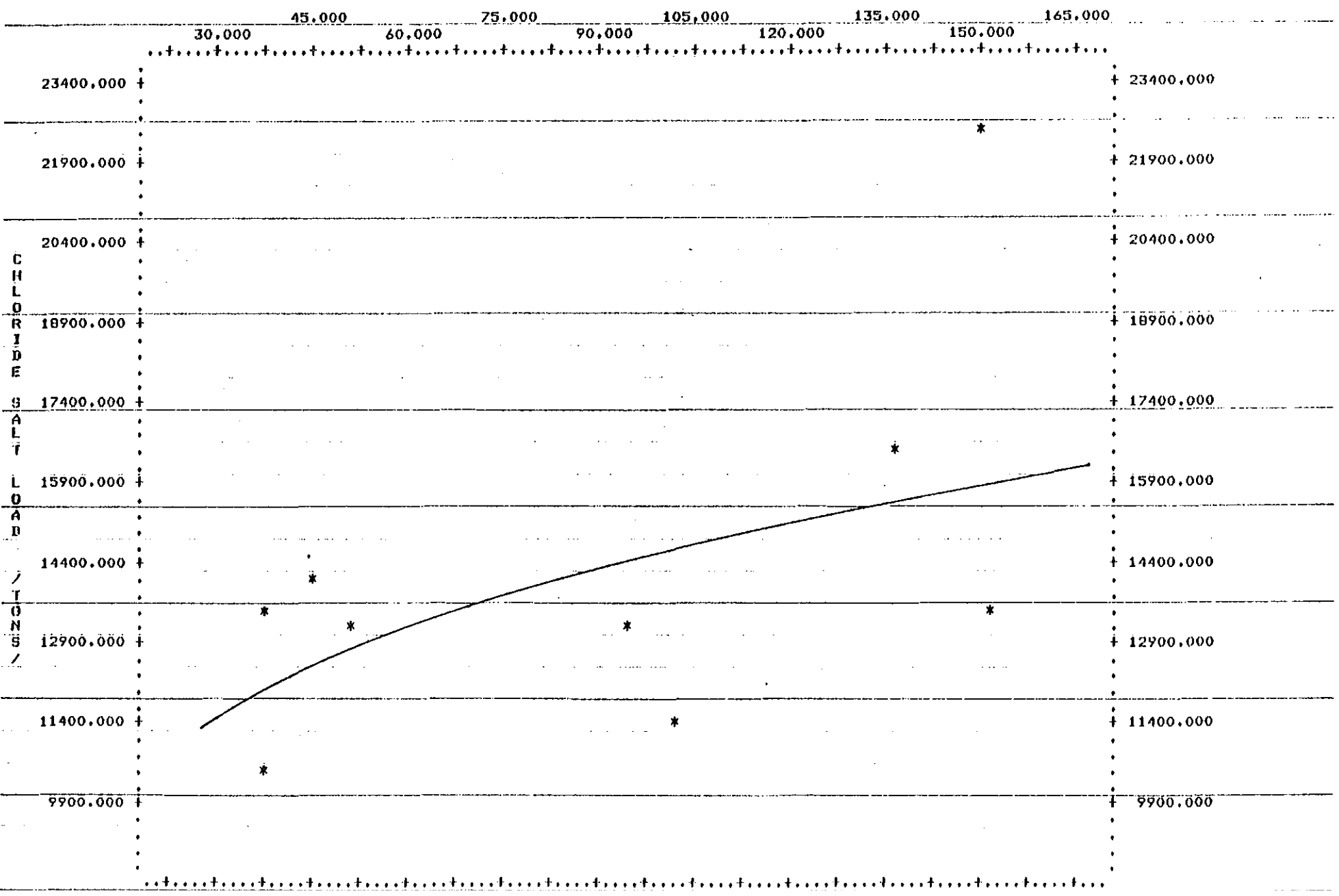
E PRE CVP OCTOBER



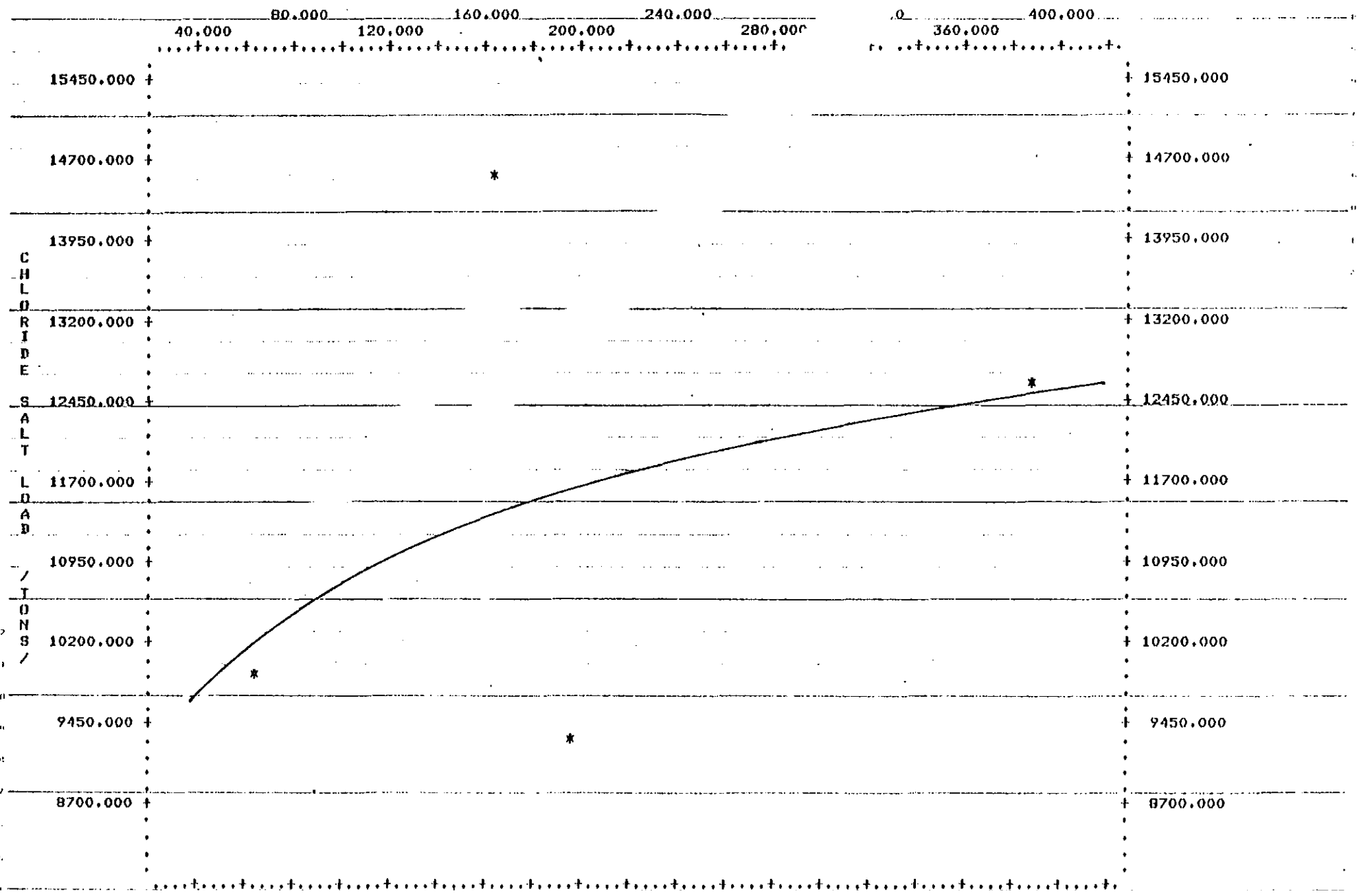
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FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP OCTOBER

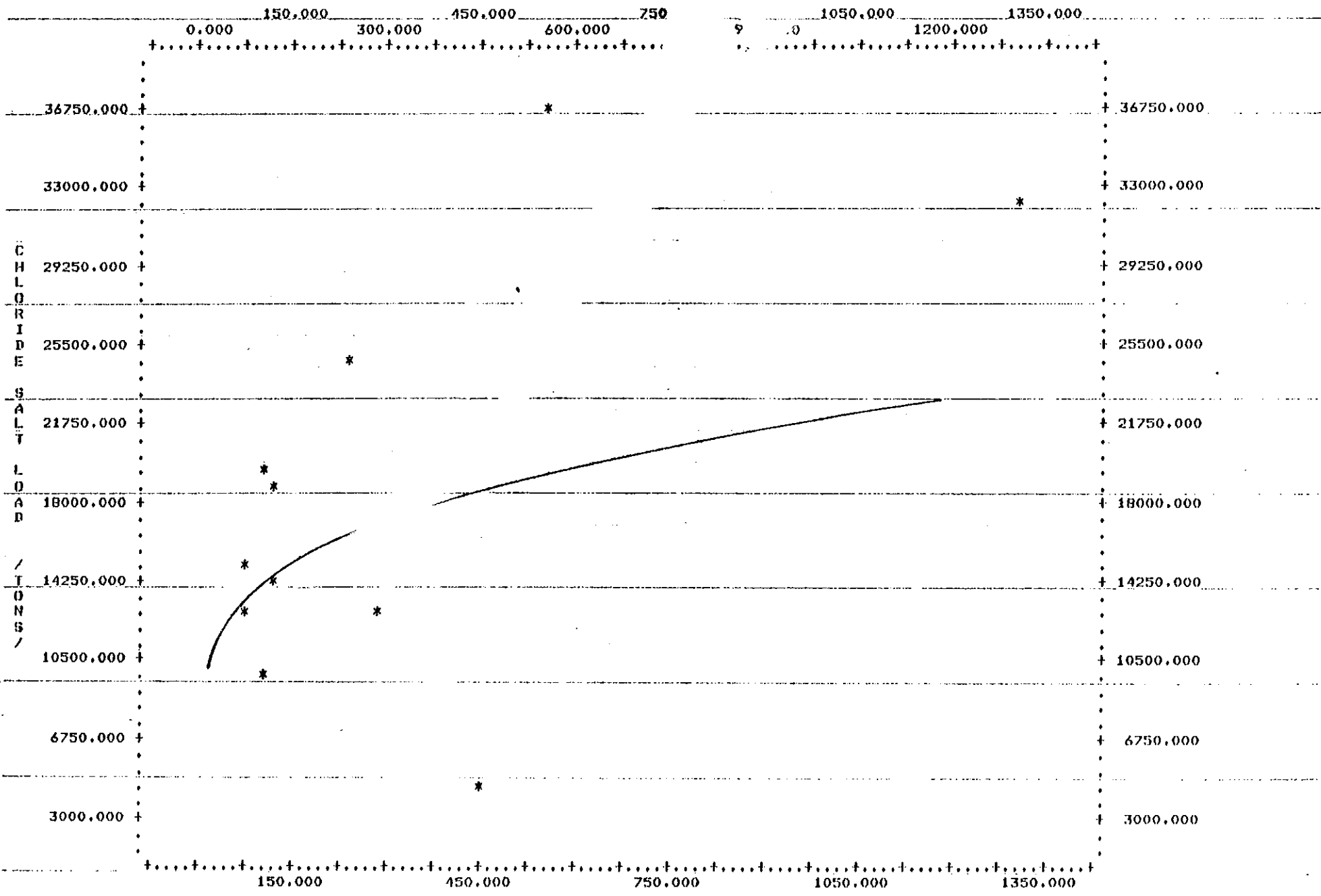


FLOW VS. SALT LOAD AT HAZE ROAD BRIDGE . PRE CVP JANU



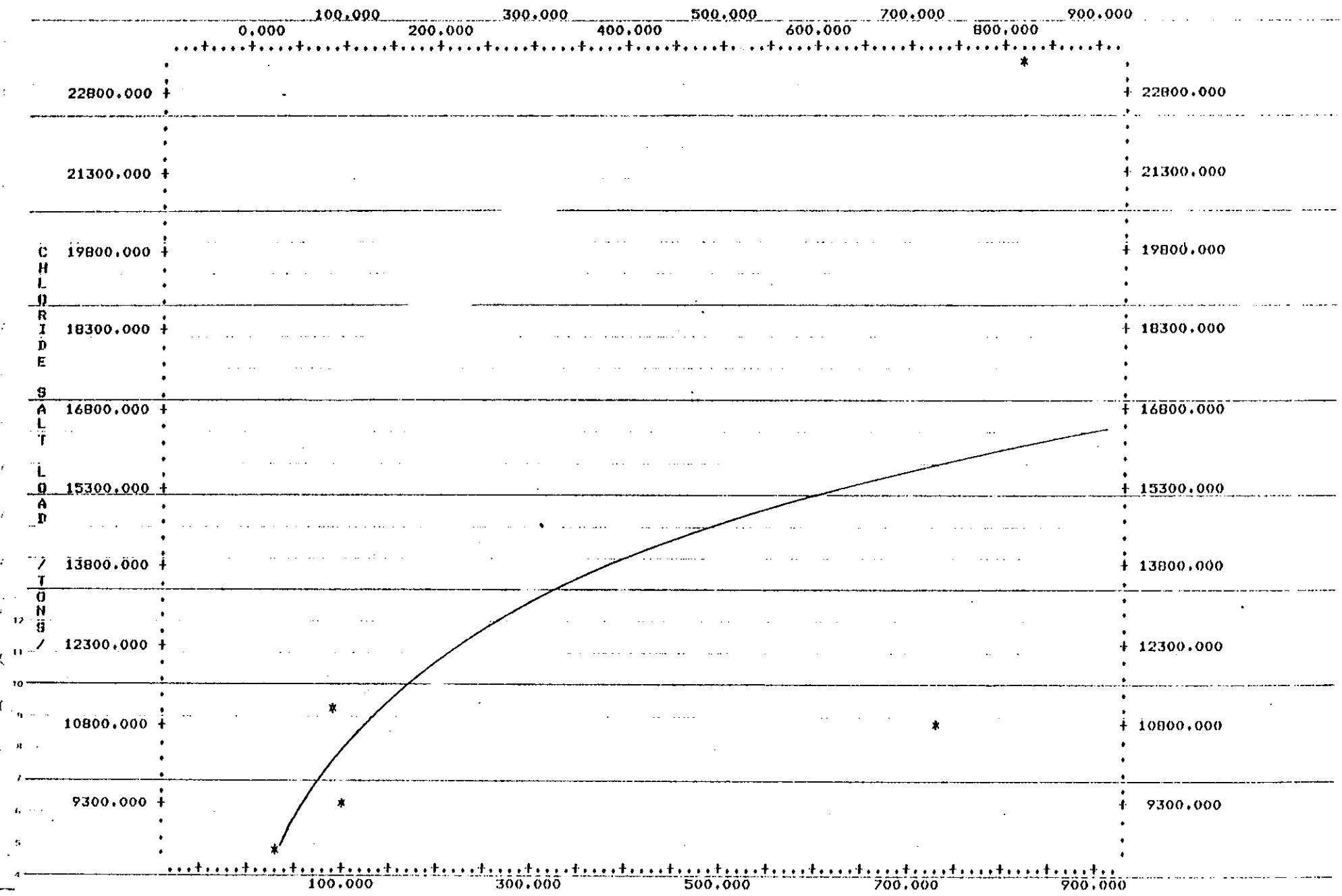
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE

CVP JANUARY



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FLOW VS. SALT LOAD AT HAZE ROAD BRIDGE PRE CVP APRIL

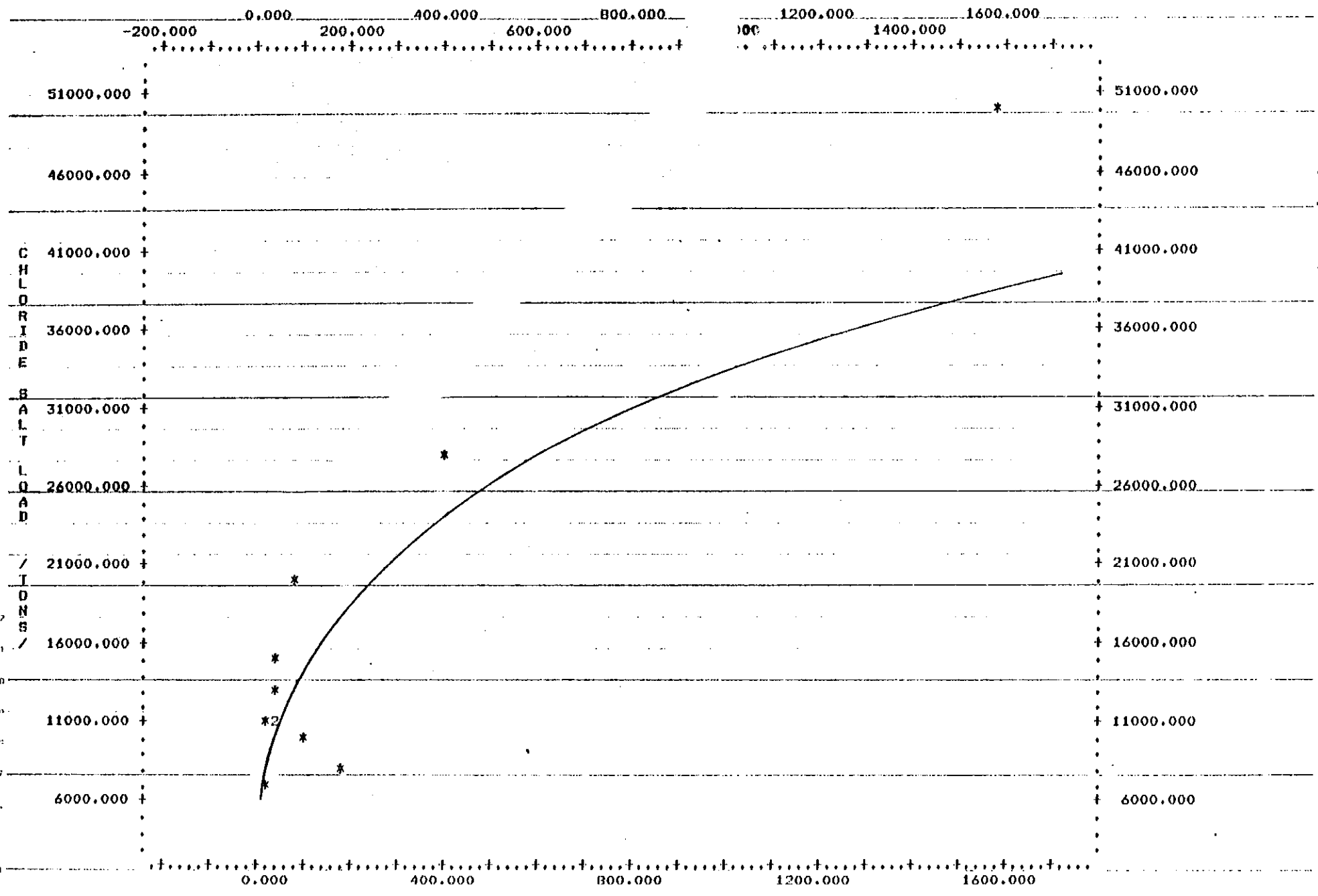


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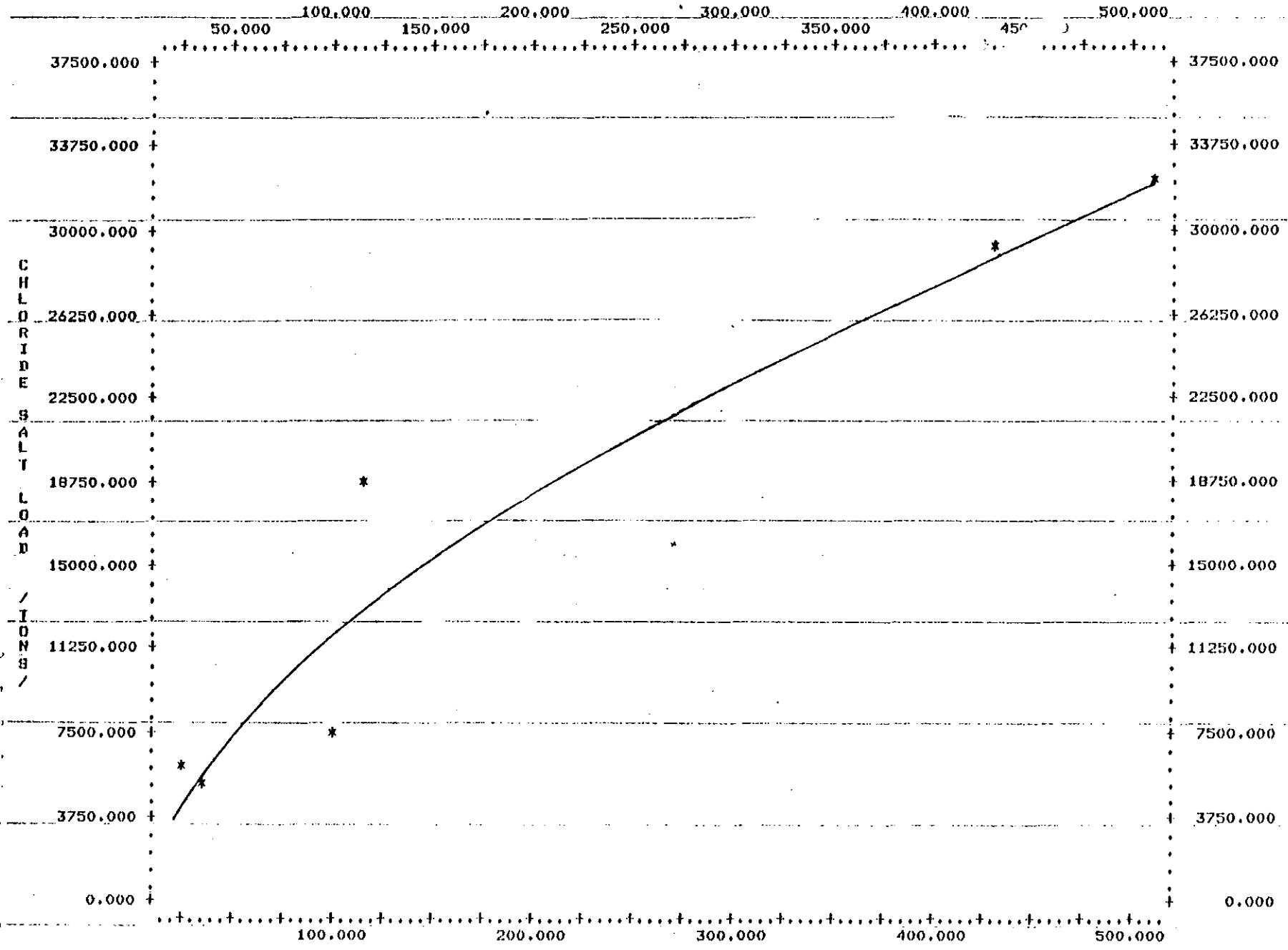
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE

CVP APRIL

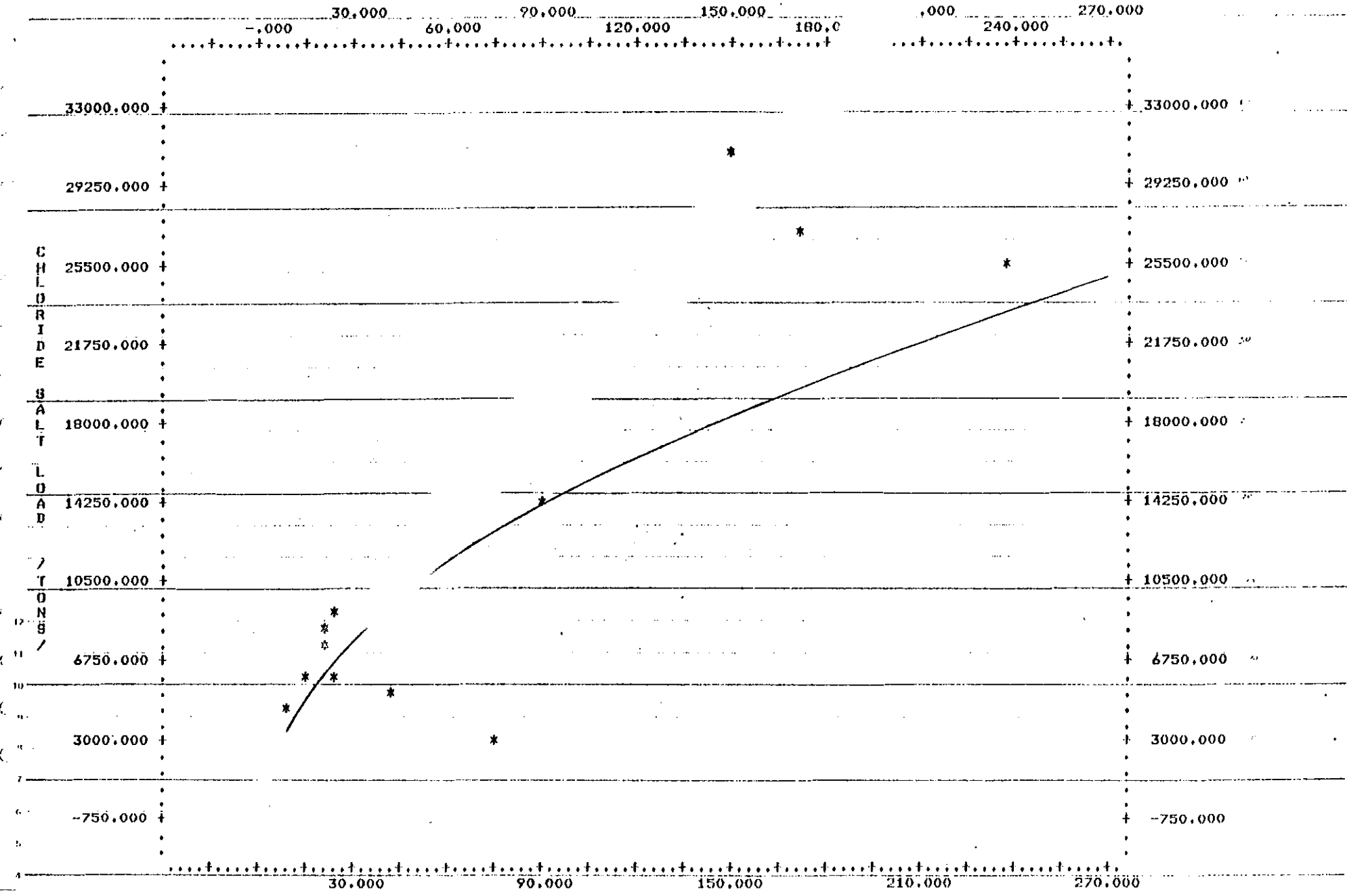


CHLORIDE
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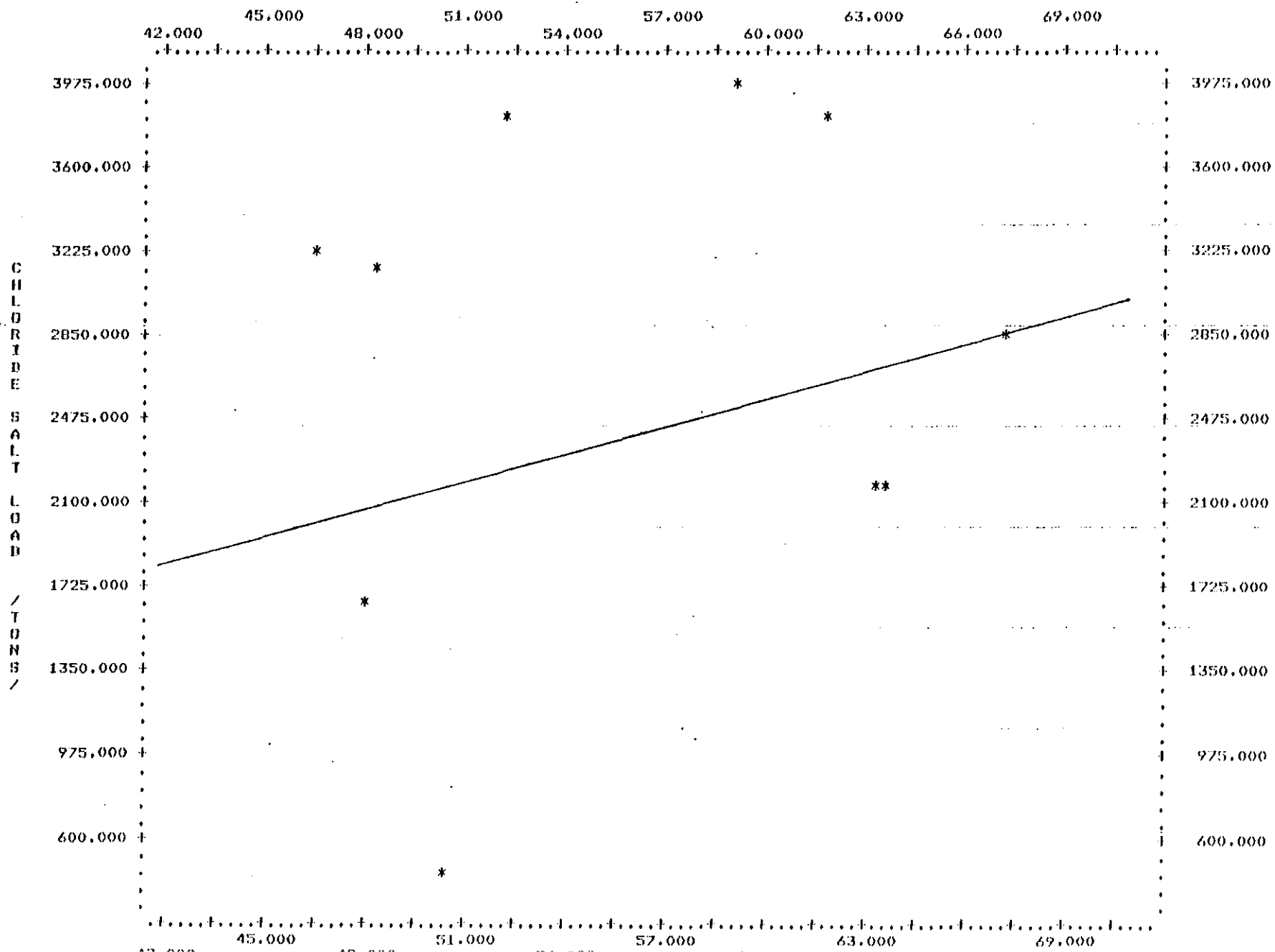
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE PRE CVP JULY



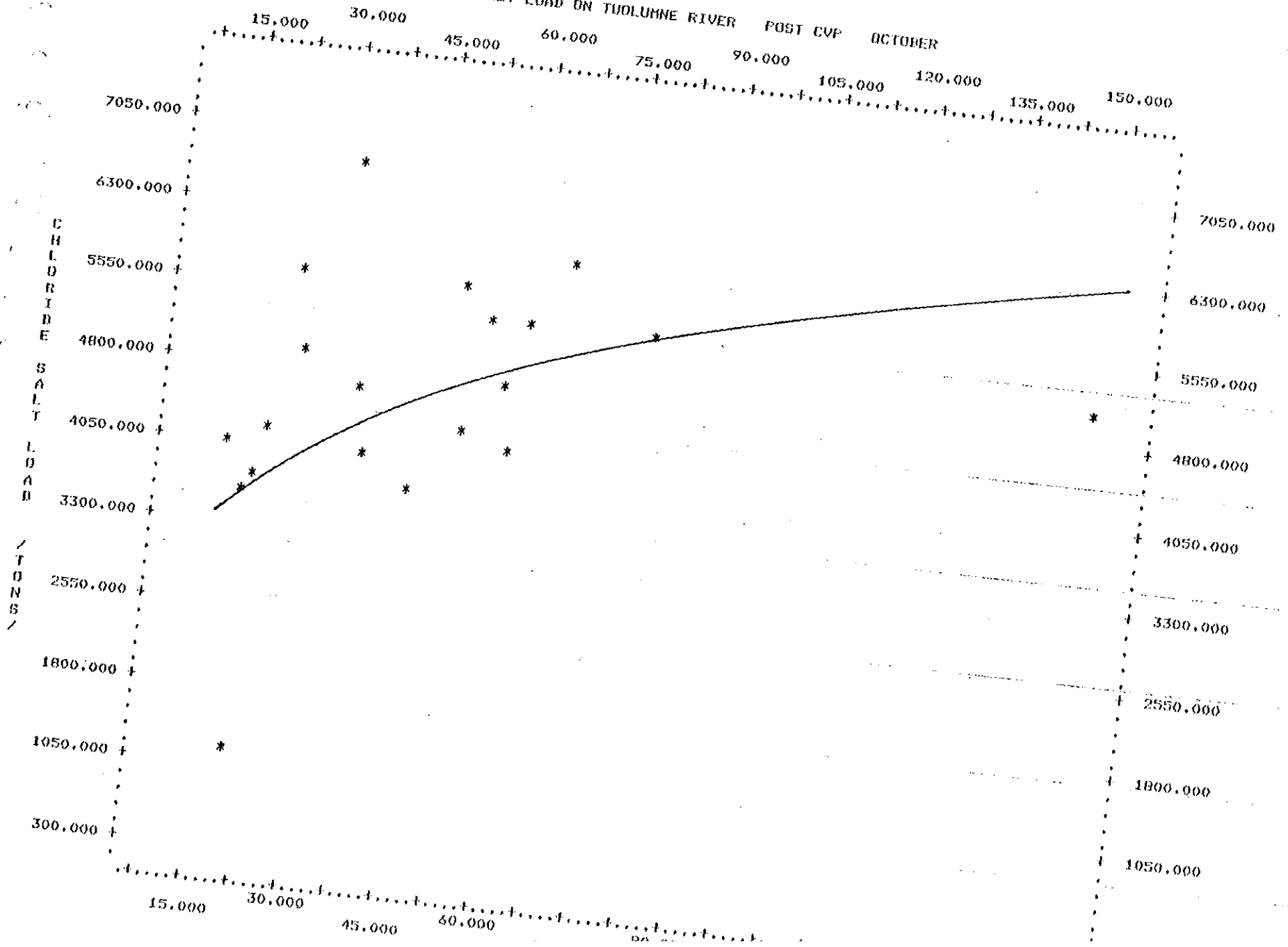
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP JL



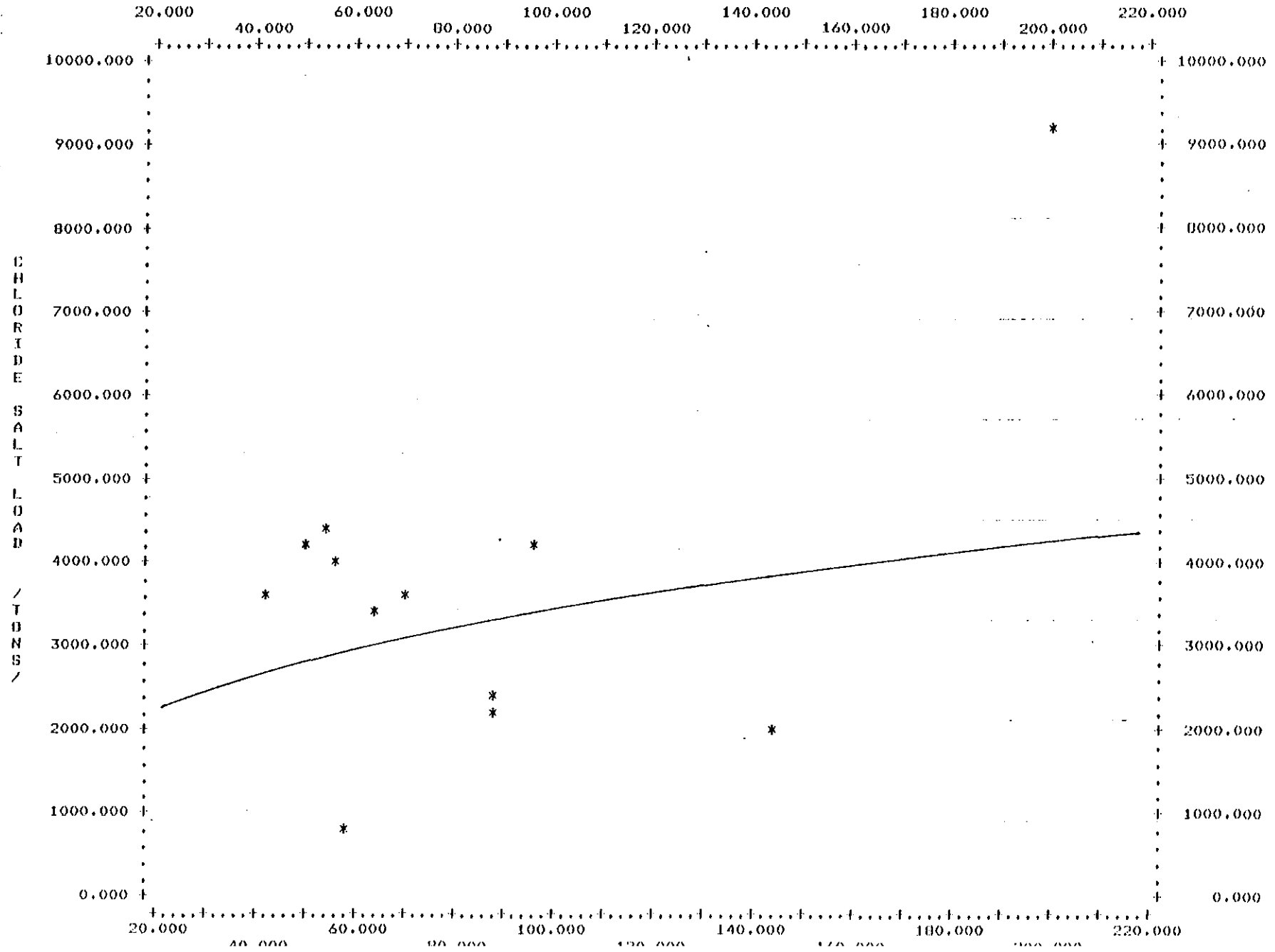
FLOW VS. SALT LOAD ON TIRULUMNE RIVER PRE CVP OCTOBER



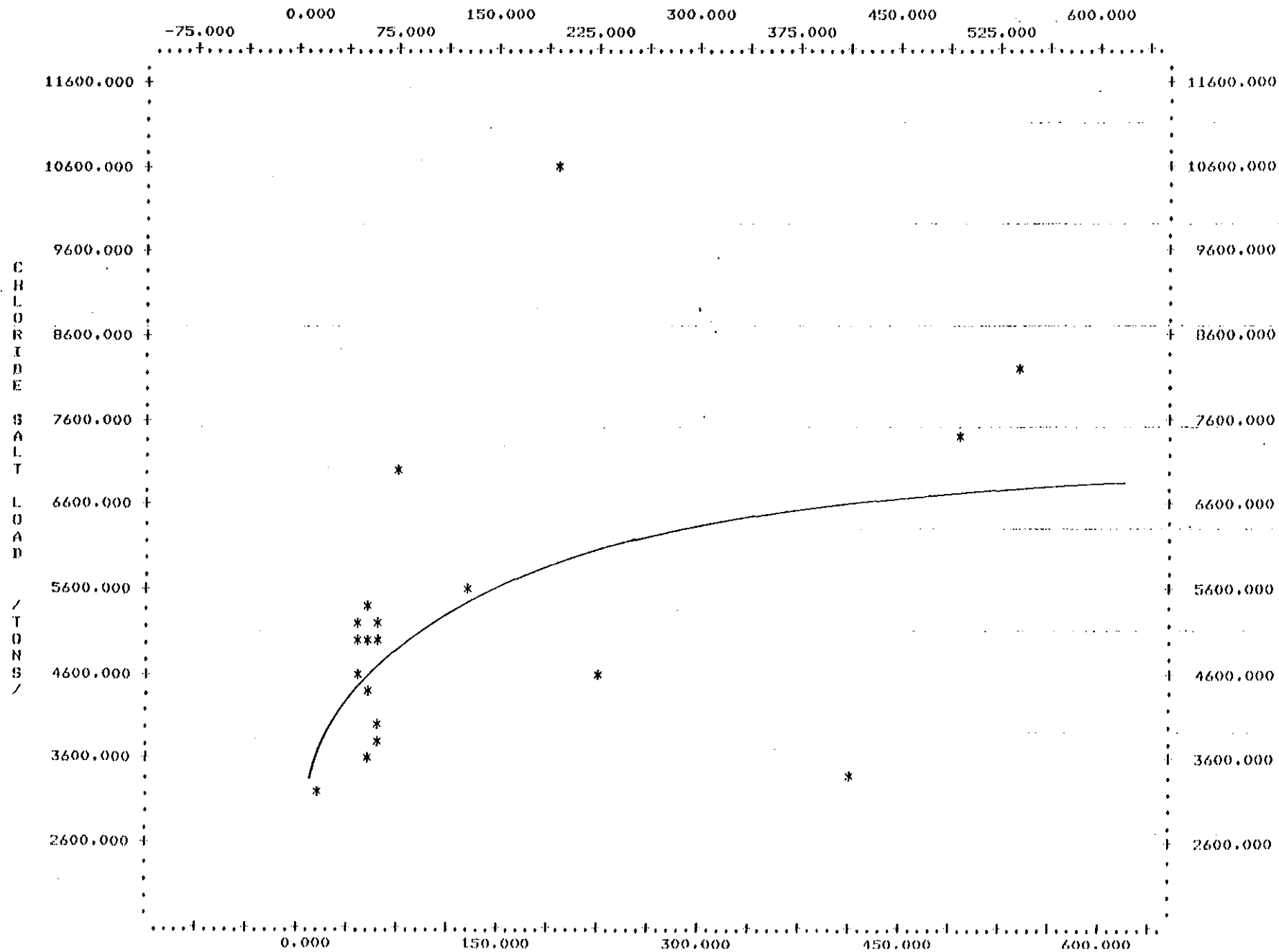
FLOW VS. SALT LOAD ON TUOLUMNE RIVER POST CVP OCTOBER



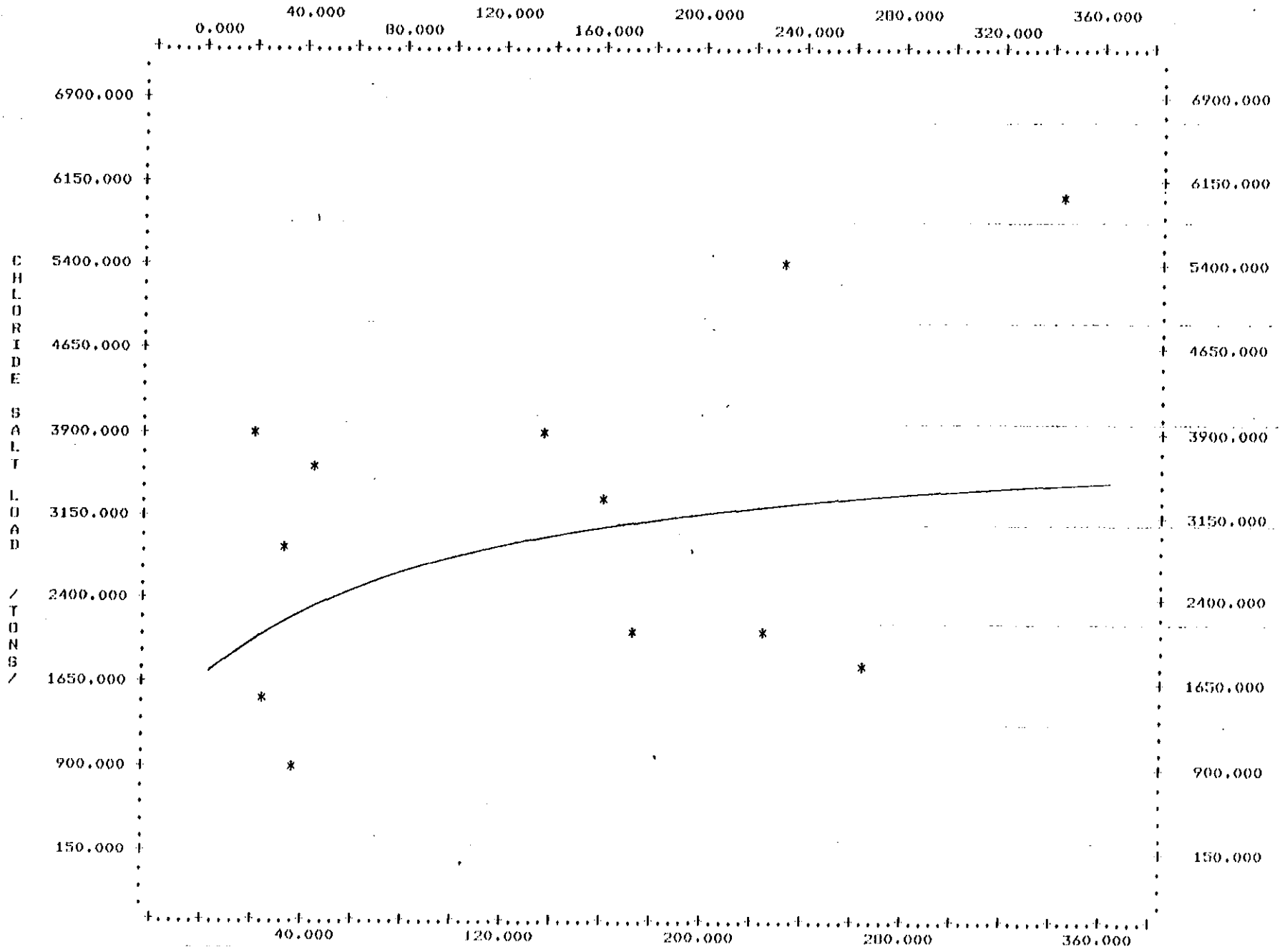
FLOW VS. SALT LOAD ON TUOLUMNE RIVER PRE CVP JANUARY



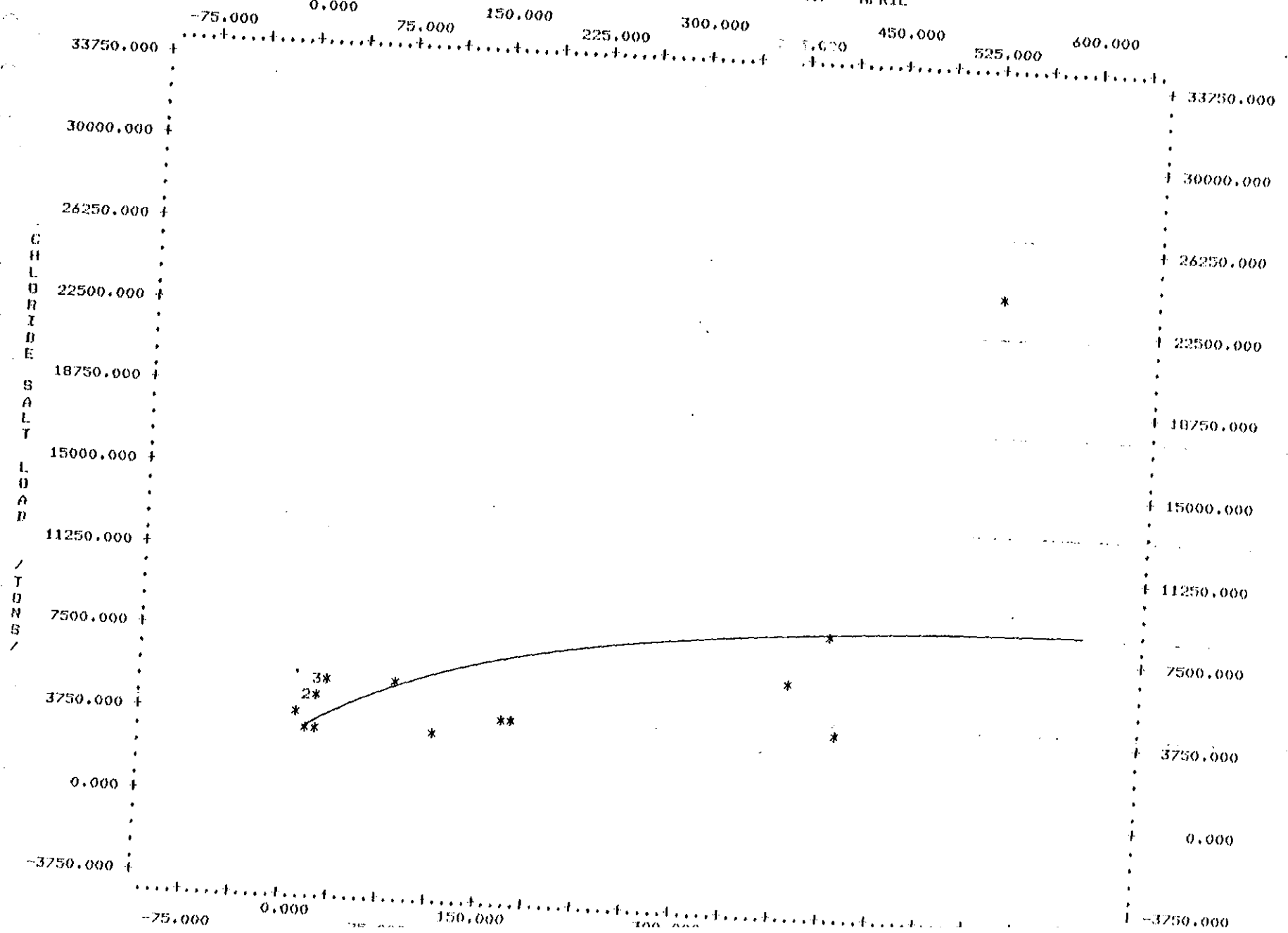
FLOW VS. SALT LOAD ON TUDLUMNE RIVER POST CVP JANUARY



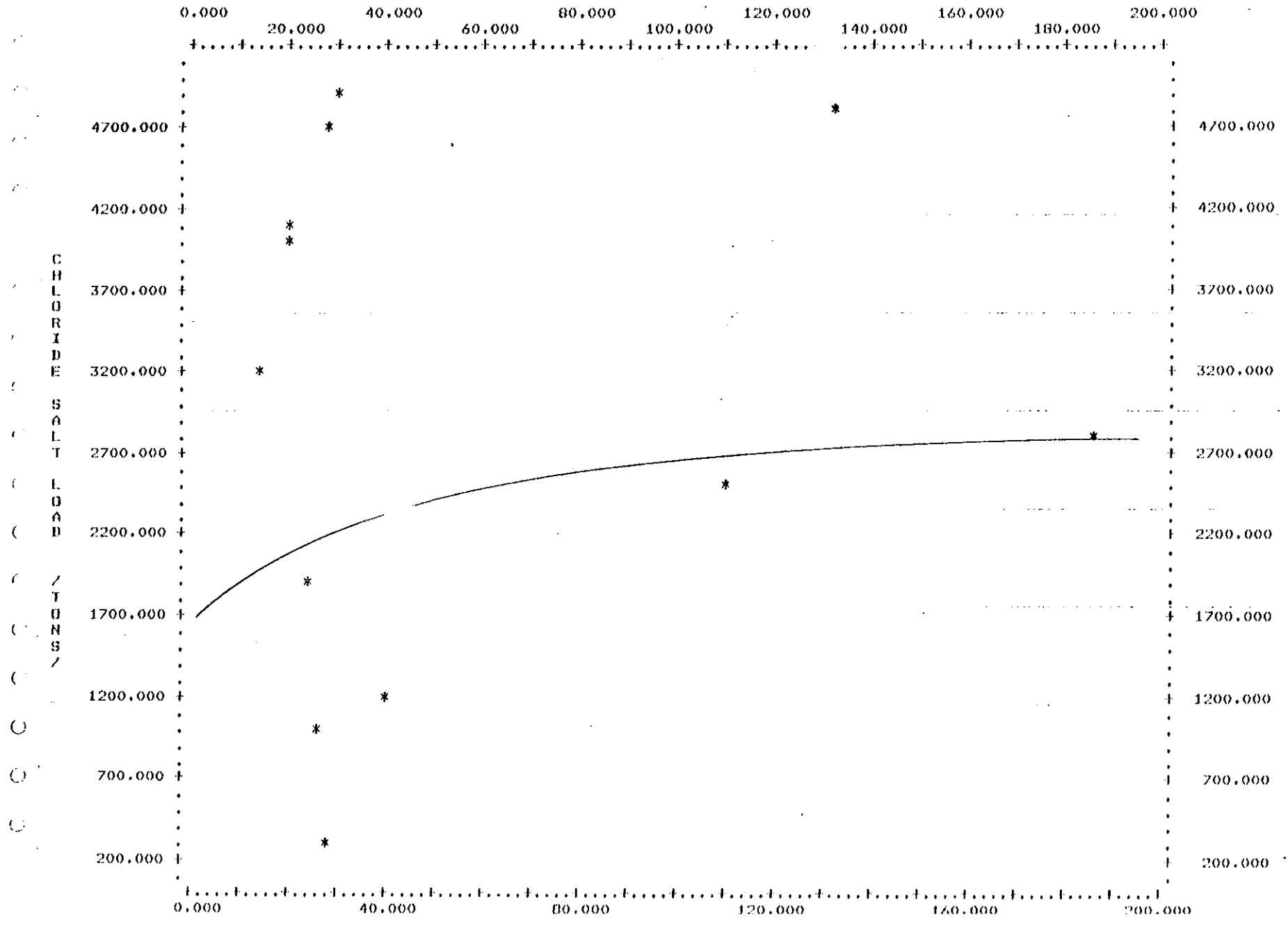
FLOW VS. SALT LOAD ON TUOLUMNE RIVER PRE CVP APRIL



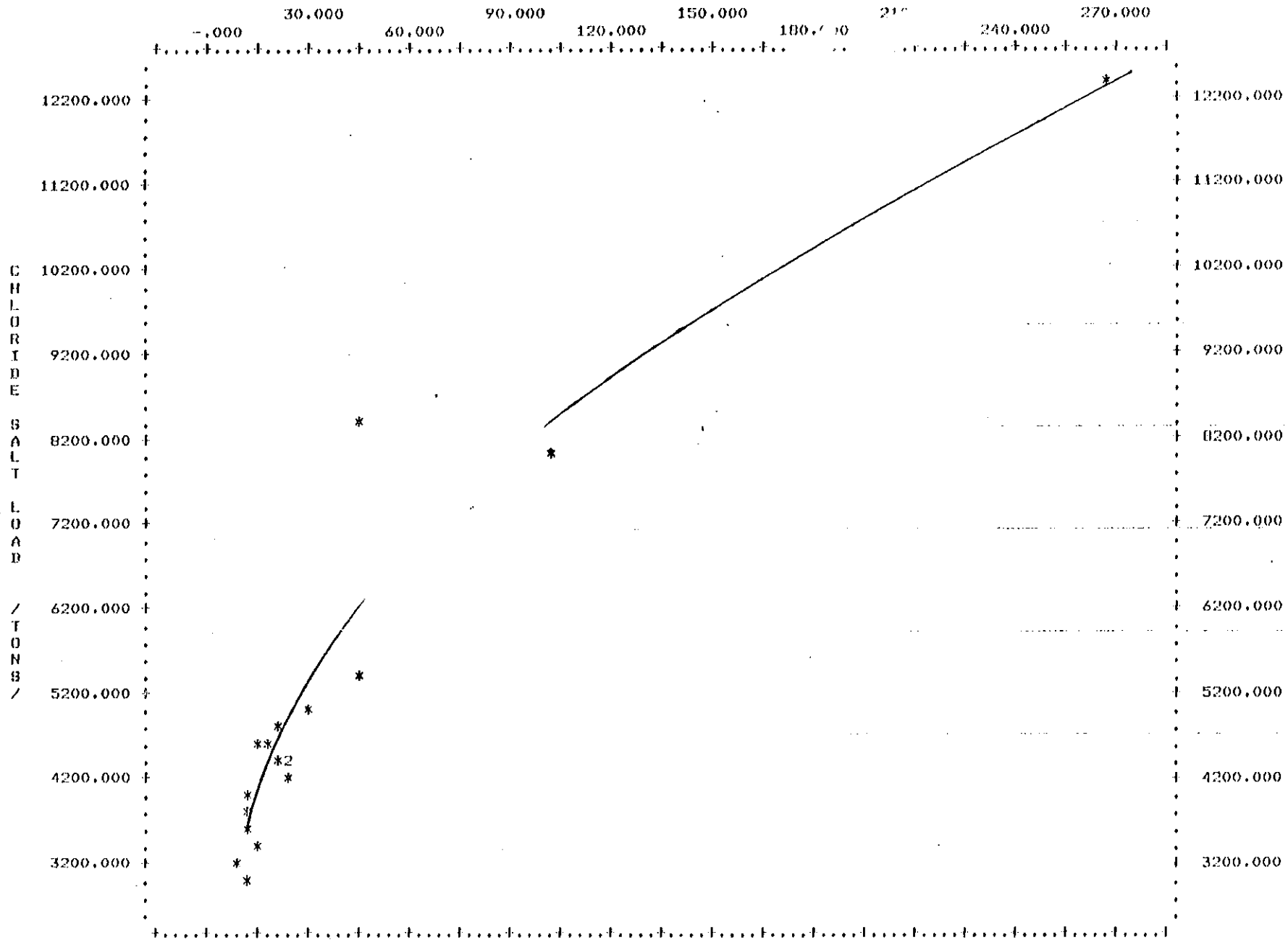
FLOW VS. SALT LOAD ON TIDALUMNE RIVER FOR CUP APRIL



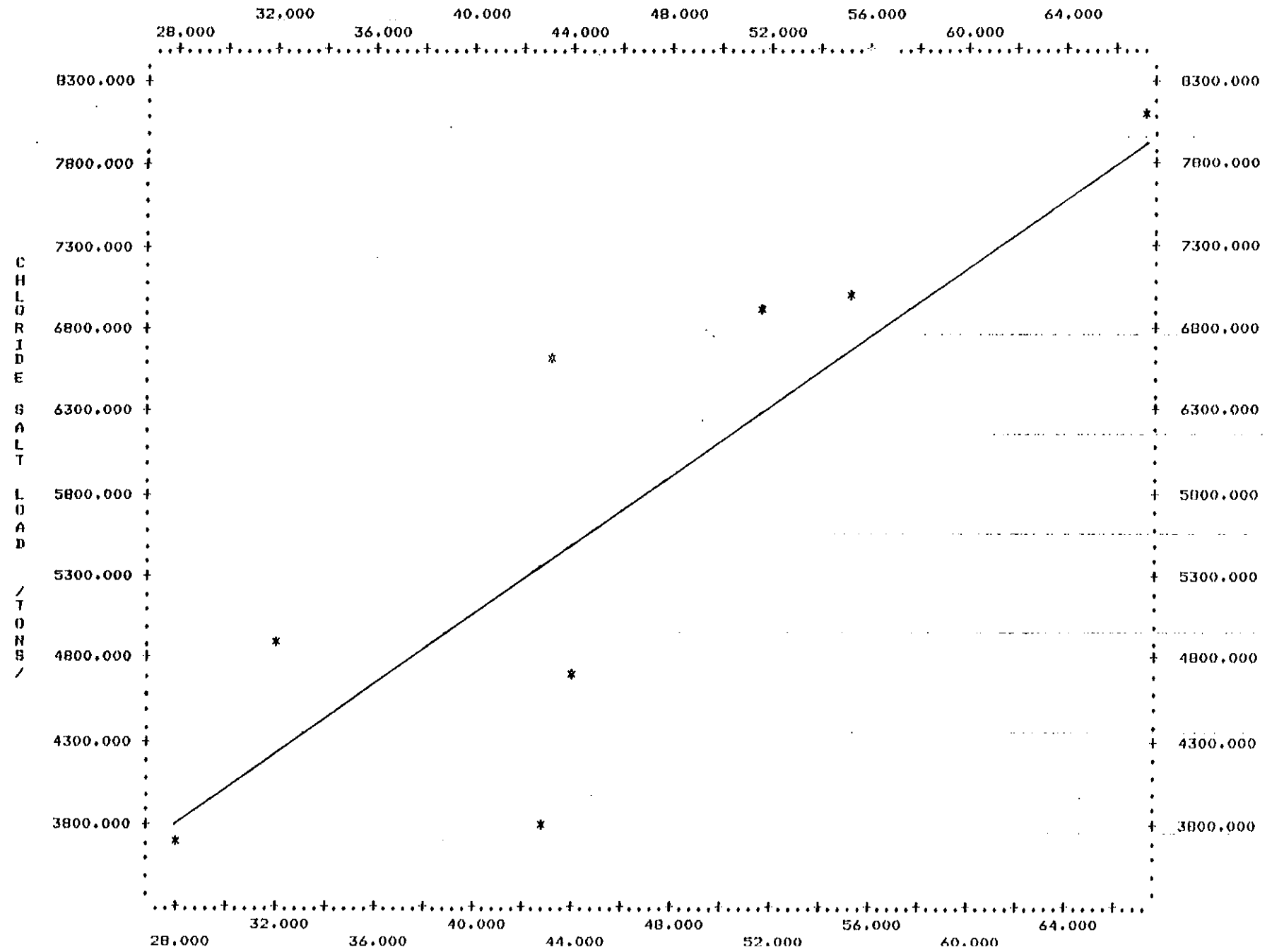
FLOW VS. SALT LOAD ON TUOLUMNE RIVER FRE CC JULY



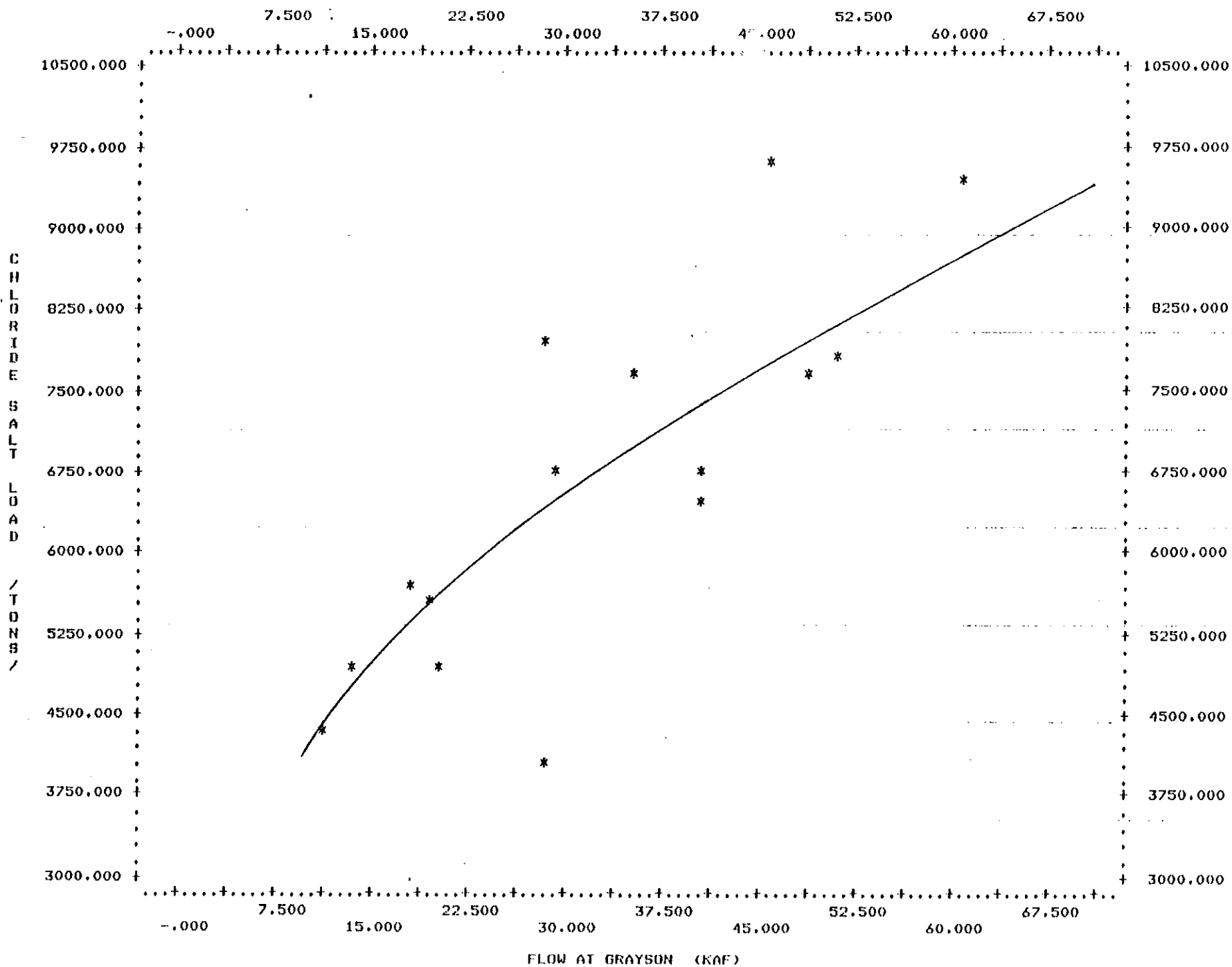
FLOW VS. SALT LOAD ON TUGLOHNE RIVER POST CVP JULY



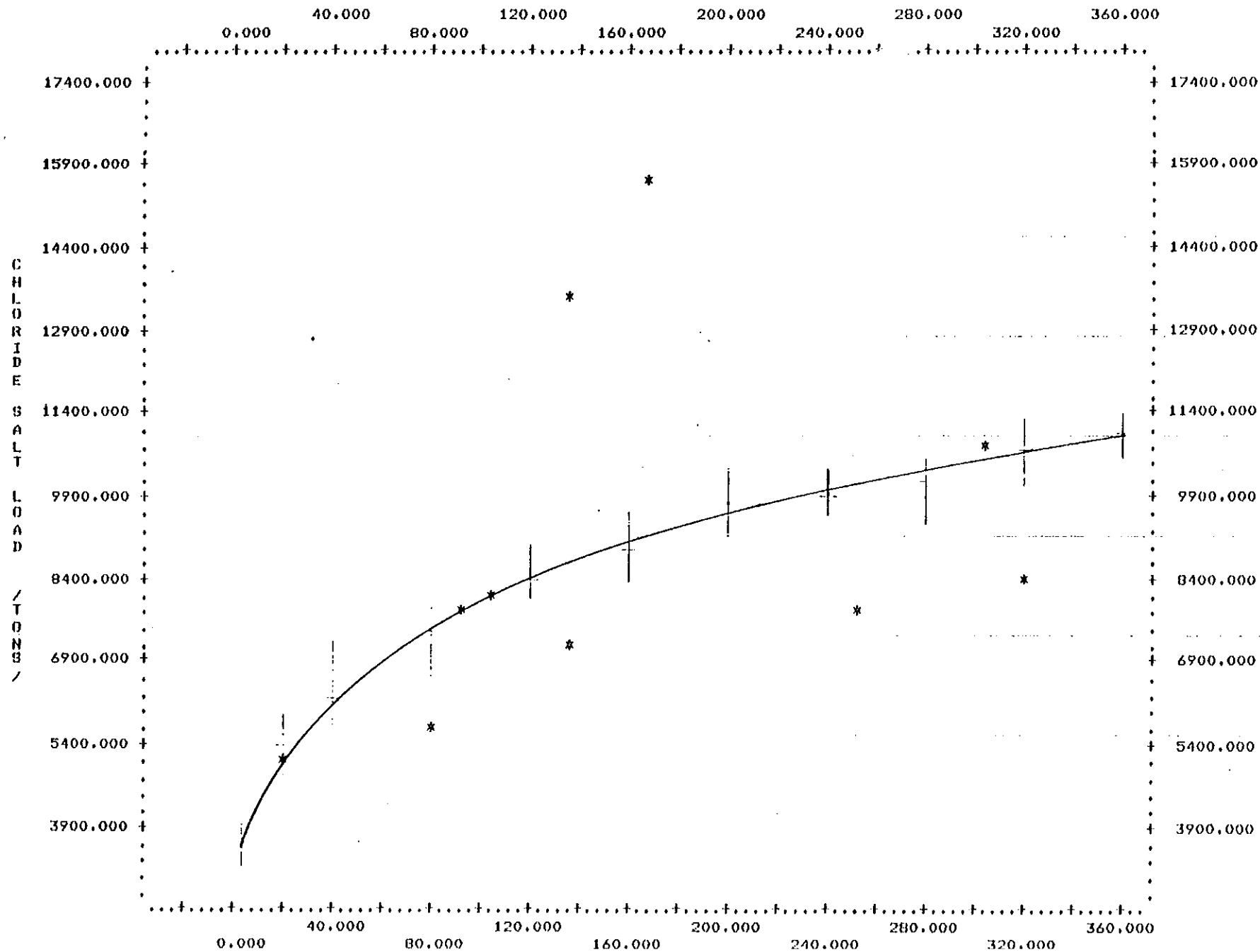
FLOW VS. SALT LOAD AT GRAYSON PRE CVP OCTOBER



FLOW VS. SALT LOAD AT GRAYSON POST CVP DBER

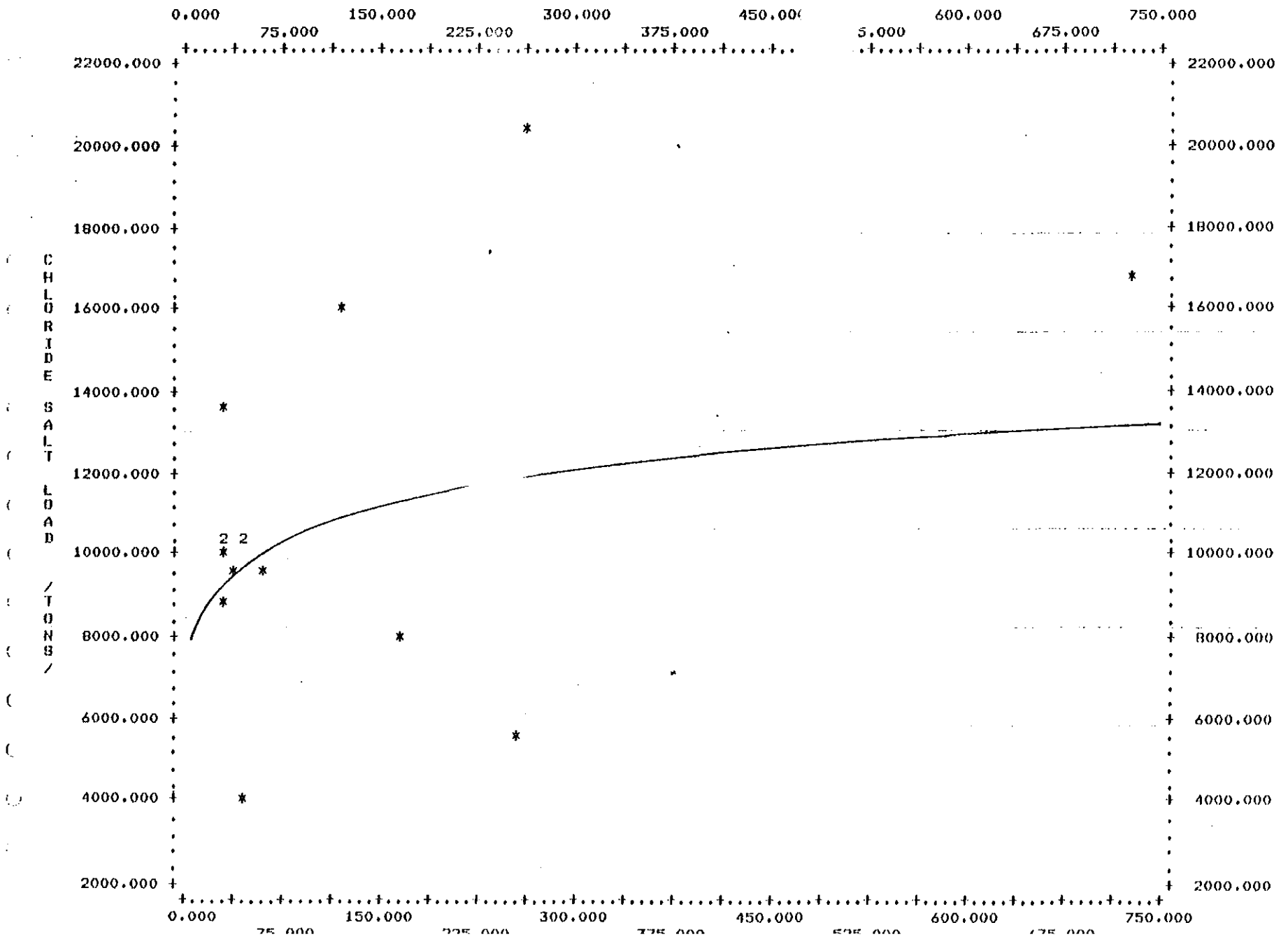


FLOW VS. SALT LOAD AT GRAYSON PRE CVP JANUARY

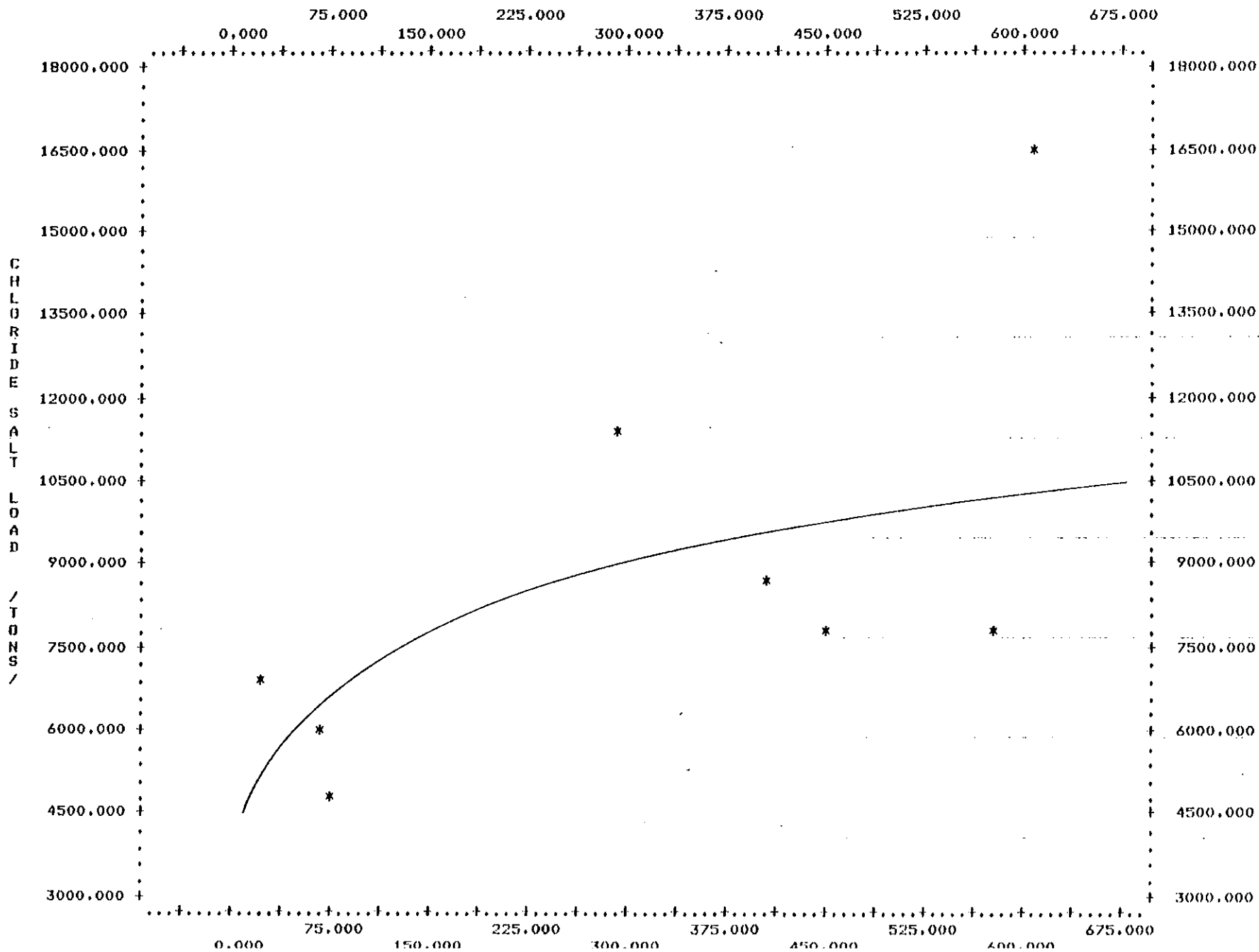


FLOW VS. SALT LOAD AT GRAYSON POST CUP

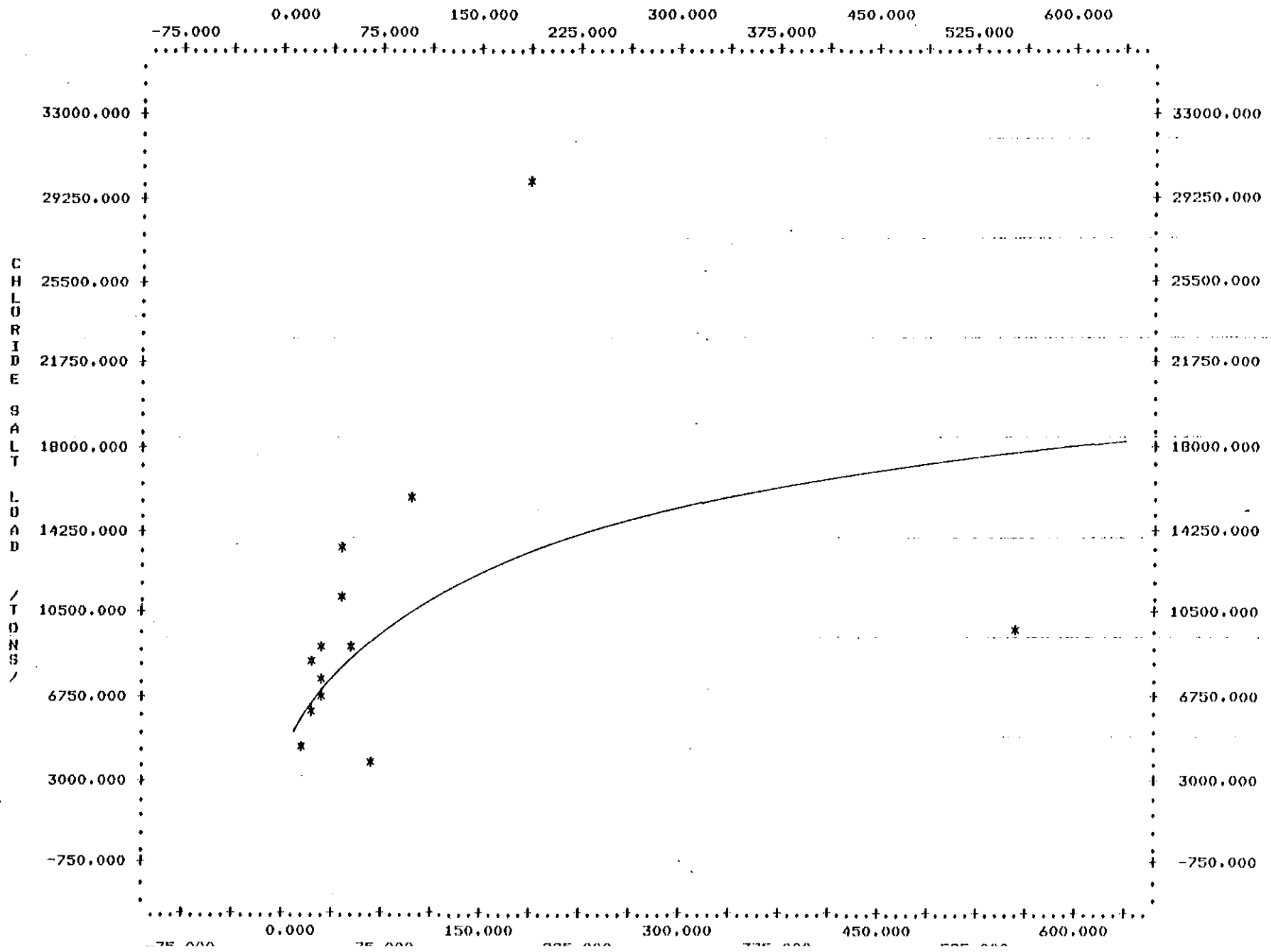
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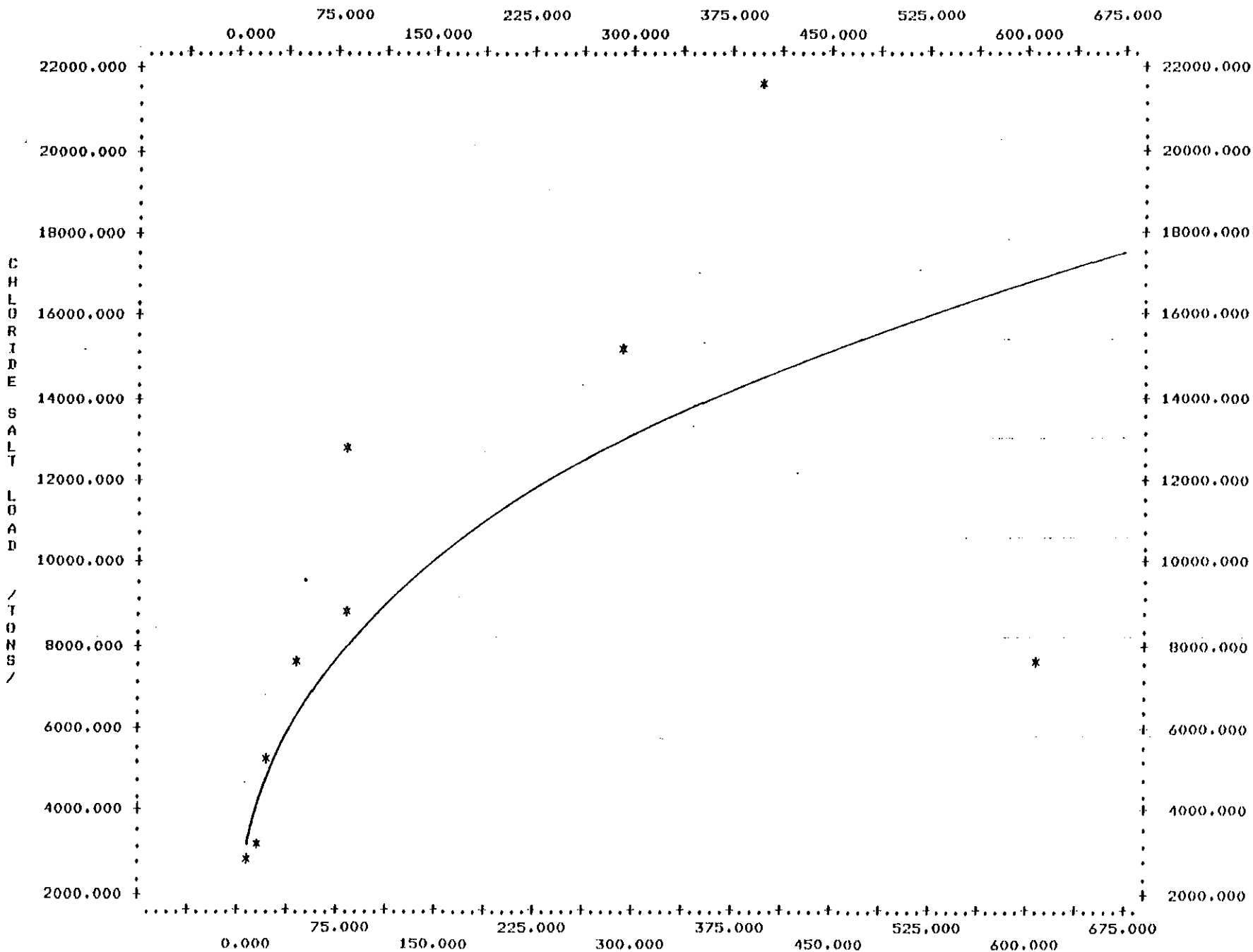
FLOW VS. SALT LOAD AT GRAYSON PRE CVP APRIL



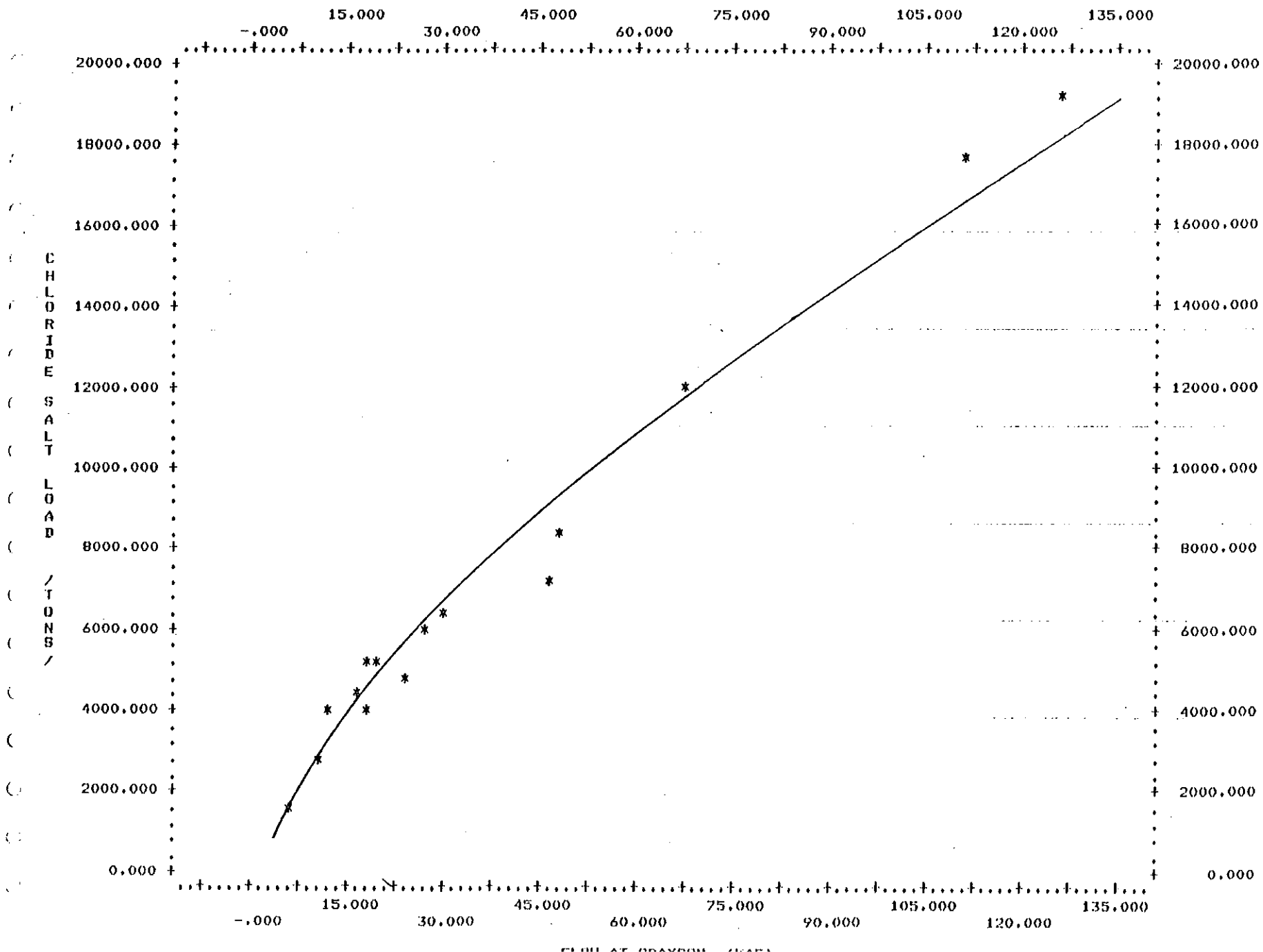
FLOW VS. SALT LOAD AT GRAYSON POST CVP APRIL



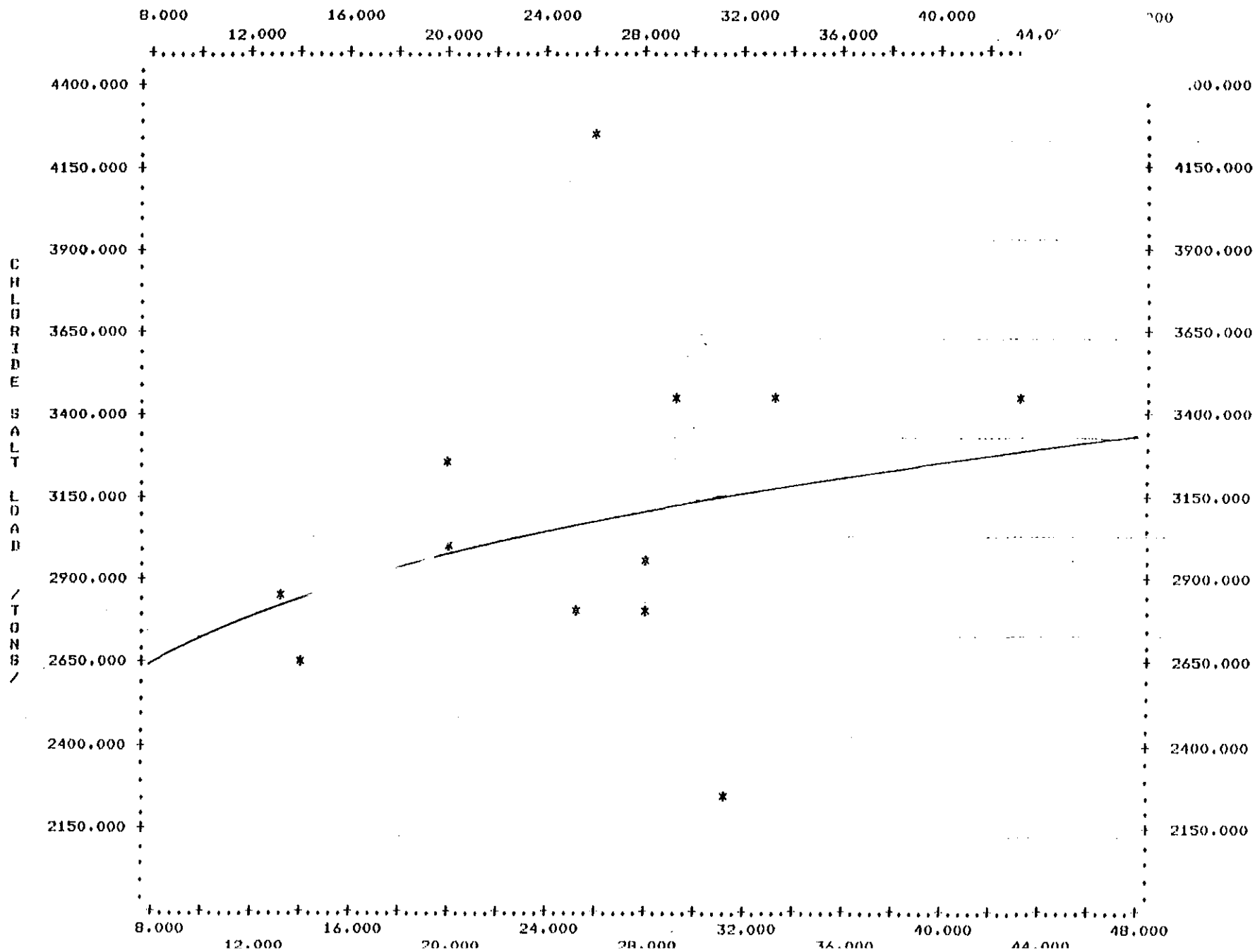
FLOW VS. SALT LOAD AT GRAYSON FRE CVP JULY



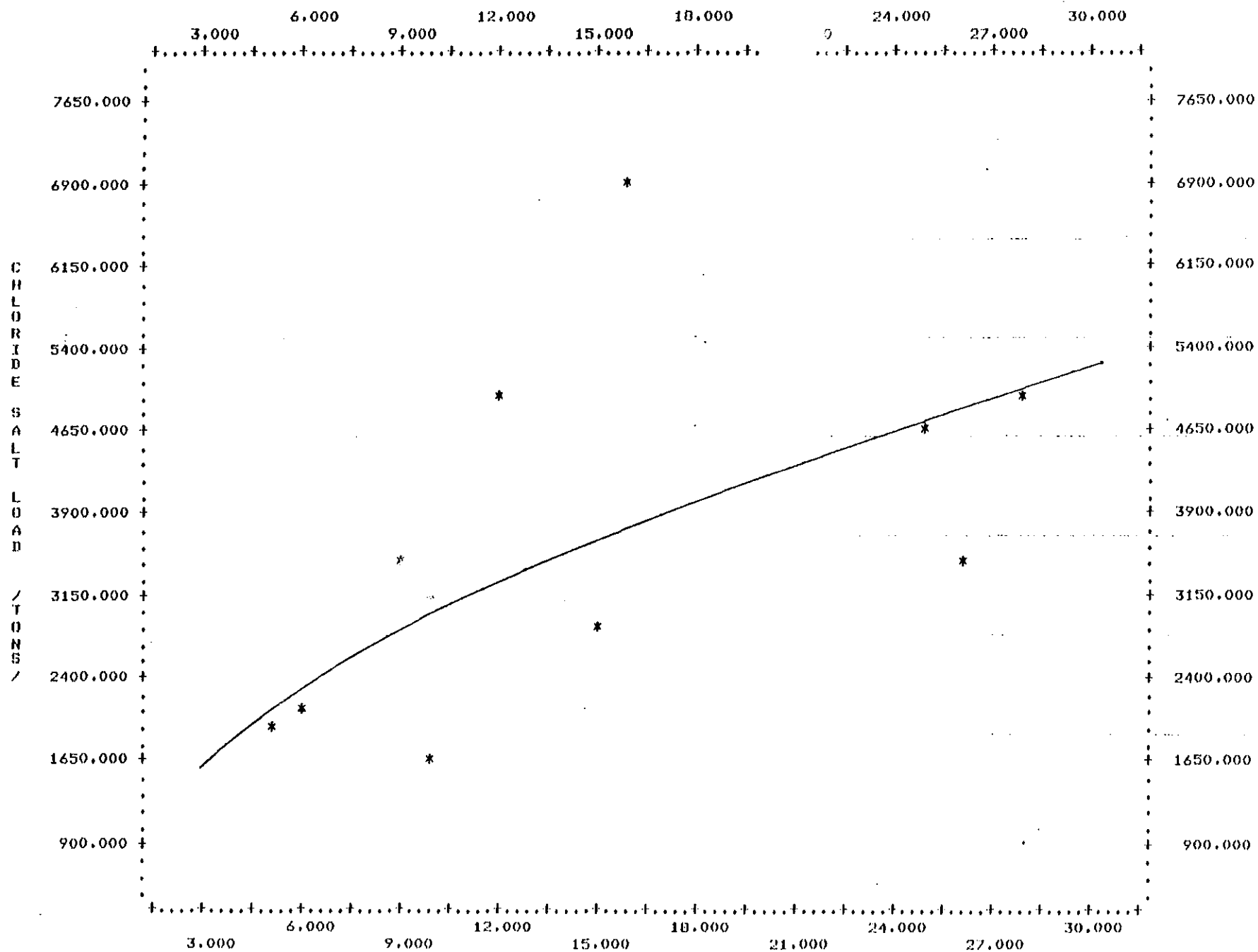
FLOW VS. SALT LOAD AT GRAYSON POST CVP JULY



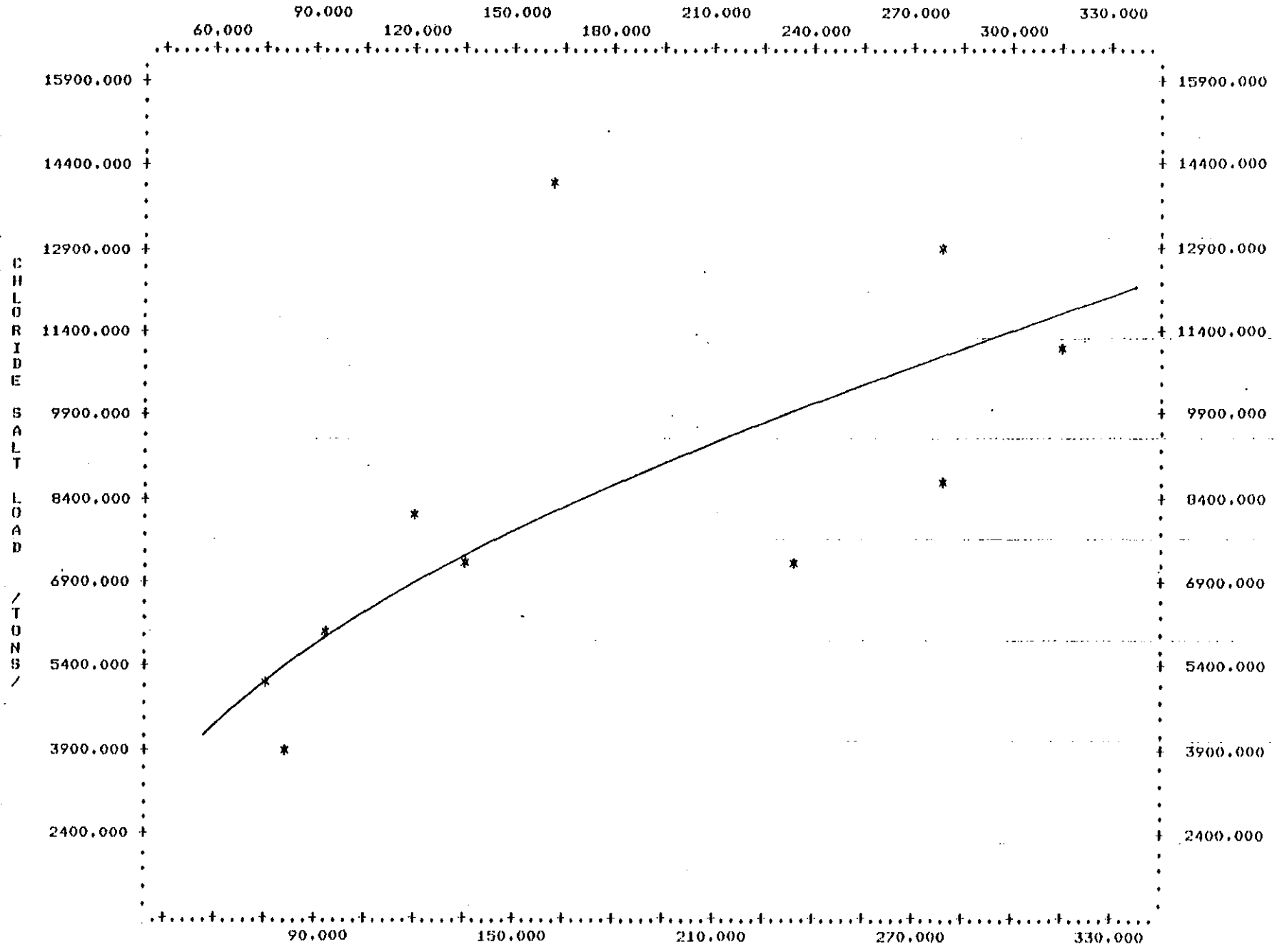
FLOW VS. SALT LOAD AT NEWMAN PRE CVF OCTOBER



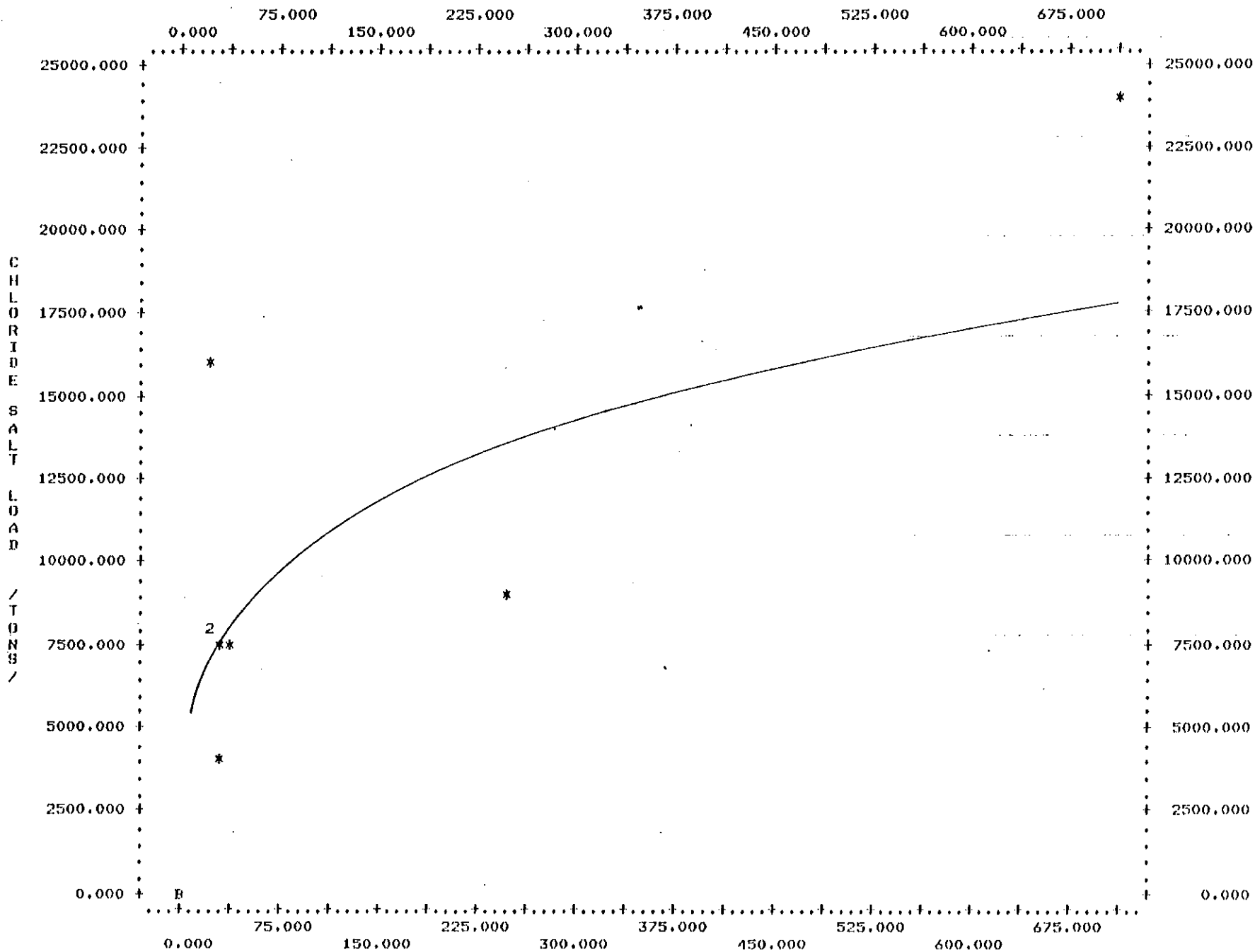
FLOW VS. SALT LOAD AT NEWMAN POST CV.



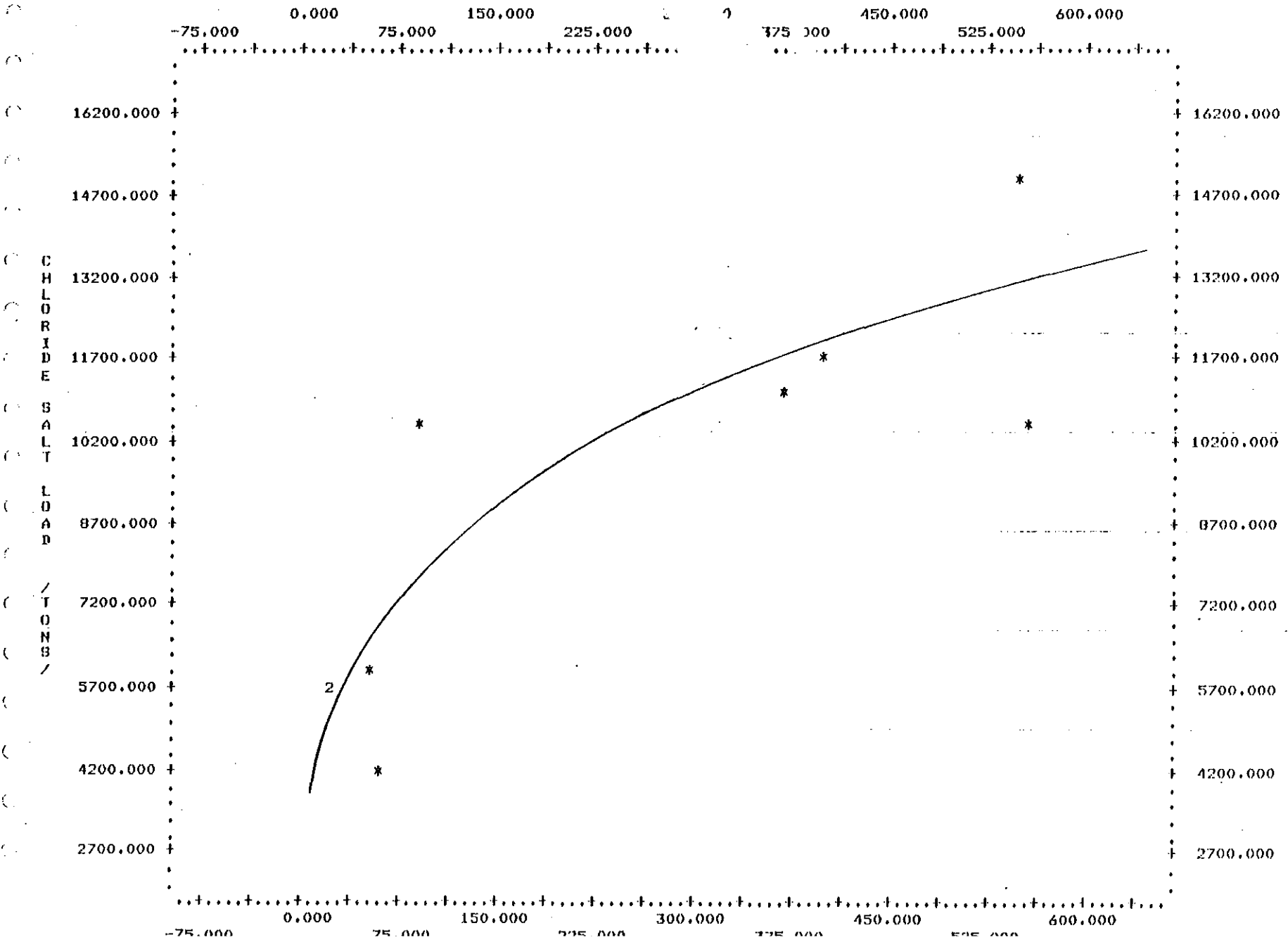
FLOW VS. SALT LOAD AT NEWMAN PRE CVP JANUARY



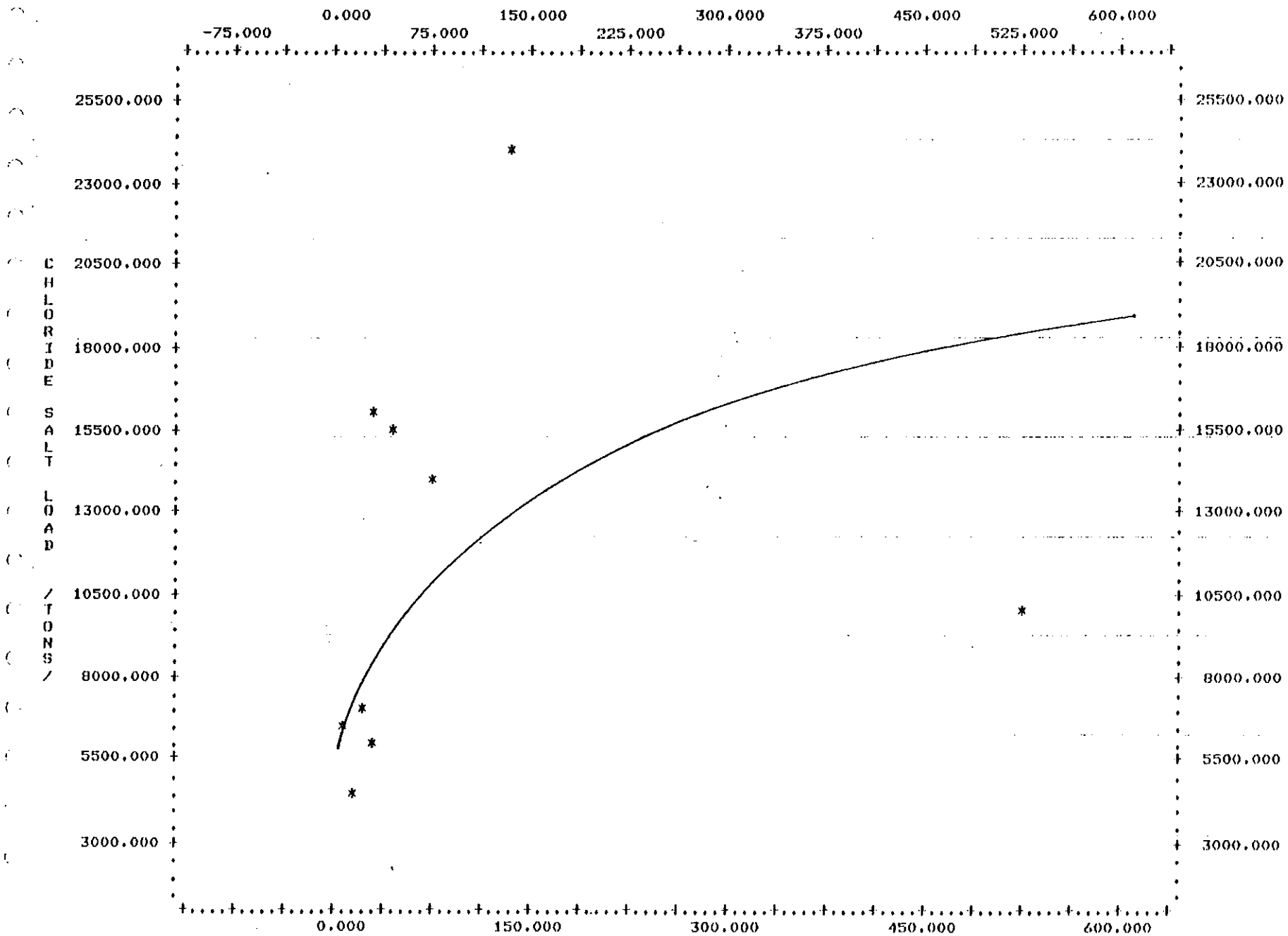
FLOW VS. SALT LOAD AT NEWMAN POST CVP JANUARY



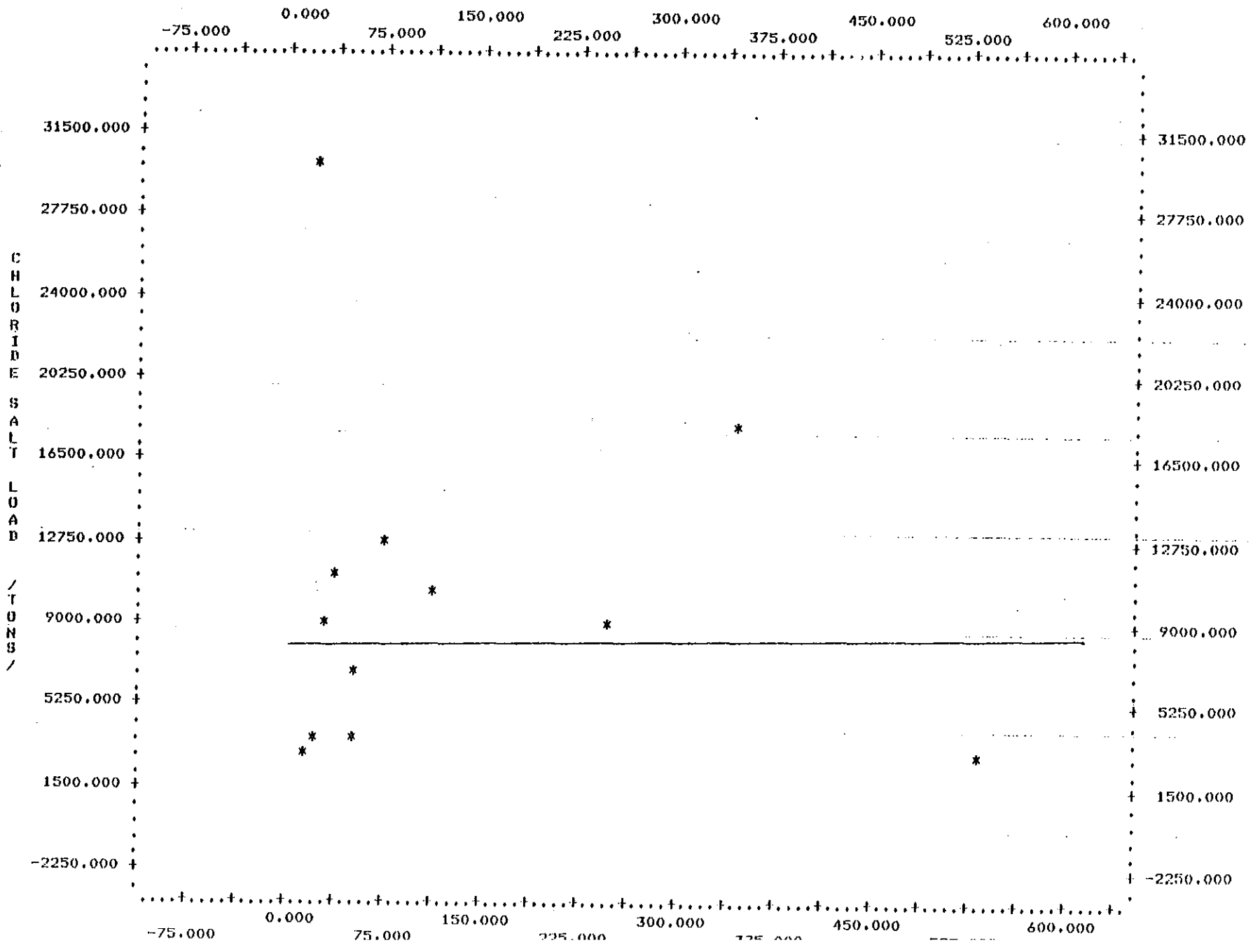
FLOW VS. SALT LOAD AT NE RE CVP APRIL



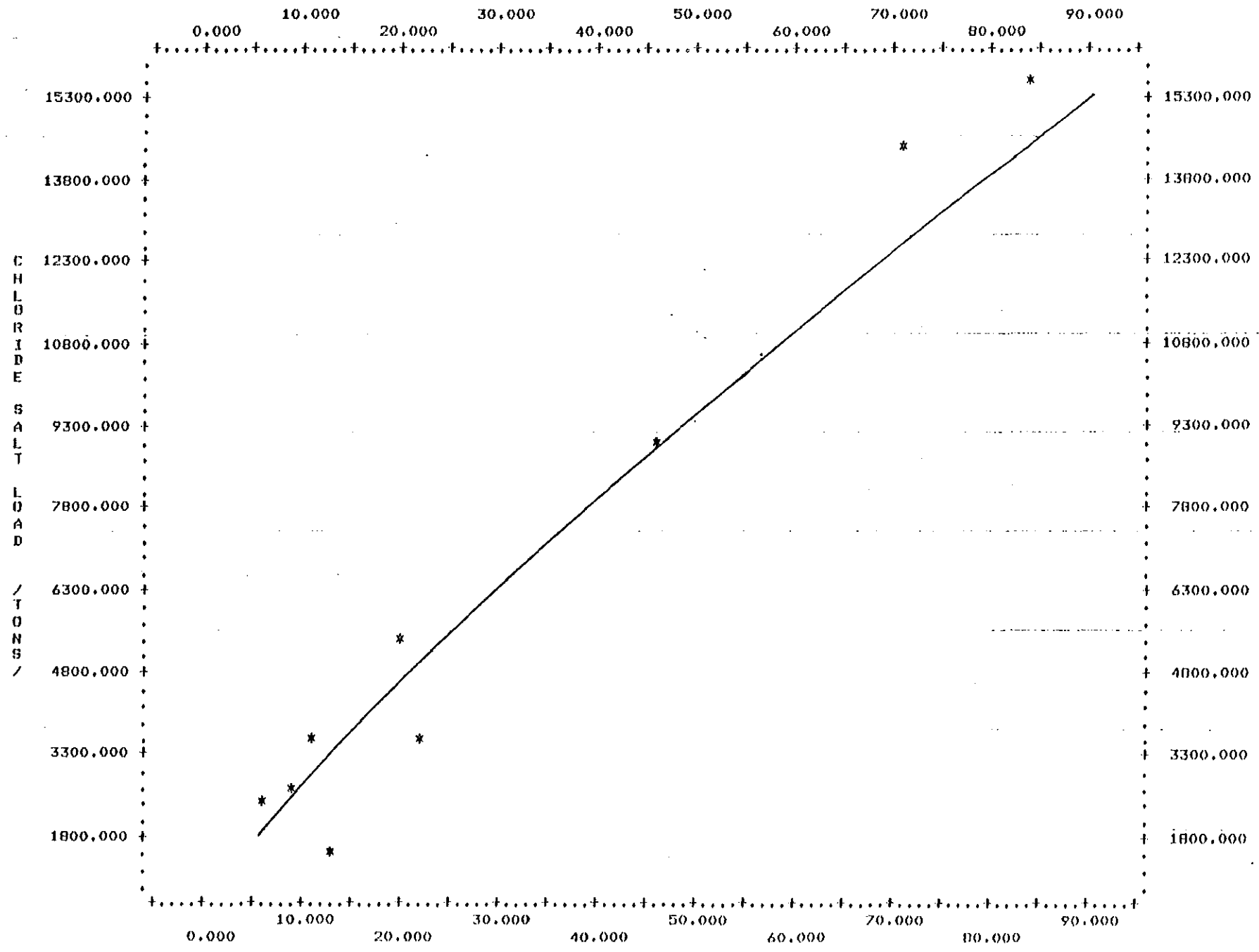
FLOW VS. SALT LOAD AT NEWMAN POST CVP APRIL



FLOW VS. SALT LOAD AT NEWMAN PRE CUP JULY



FLOW VS. SALT LOAD AT NEWMAN POST CVP JULY



APPENDIX 3
SALT (CHLORIDE) BALANCES BY
REPRESENTATIVE MONTHS

80/05/12.

13.40.05.

OCTOBER

39

AF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	(PCT)	POST (TONS)	(PCT)
24.	20.	NEWMAN	3040.	30.	4170.	29.
16.	16.	OTHF	1960.		2820.	
39.	36.	LN	5000.	49.	6990.	49.
55.	51.	JLUMNE	3830.	37.	5050.	35.
5.	9.	OTHER	1210.		2540.	
99.		MAZE ROAD	10040.	98.	14570.	102.
14.	17.	STANISLAUS	260.	3.	200.	1.
-3.	7.	OTHER	-40.		-470.	
110.	120.	VERNALIS	10260.	100.	14290.	100.
		TOT. OTHERS	3130.	31.	4890.	34.
		NMN. + OTH.	6170.	60.	9060.	63.

QUALITY PPM (CL) / (TDS)

PRE PPM = 69. / 324.
POST PPM = 88. / 383.
DEGRADATION = 19. / 59.

80/05/12.

13.50.38.

JANUARY

110.5 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	PRE (PCT)	POST (TONS)	POST (PCT)
51.	37.	NEWMA	4240.	48.	8380.	80.
7.	9.	OT	2690.		1310.	
58.	46.	LYSON	6930.	78.	9690.	93.
54.	55.	TUOLUMNE	3490.	39.	4740.	45.
9.	4.	OTHER	580.		-330.	
121.	106.	MAZE ROAD	11010.	123.	14100.	135.
27.	24.	STANISLAUS	130.	1.	170.	2.
2.	3.	OTHER	-2220.		-3850.	
150.	133.	VERNALIS	8920.	100.	10420.	100.
		TOT. OTHERS	1050.	12.	-2870.	-27.
		NMN. + OTH.	5290.	59.	5510.	53.

QUALITY PPM (CL) / (TDS)

PRE PPM = 44. / 221.
 POST PPM = 58. / 291.
 DEGRADATION = 14. / 71.

80/05/12.

14.01.24.

APRIL

601. / AF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	(PCT)	POST (TONS)	(PCT)
23.	18.	NEUMAN	5210.	110.	7830.	130.
5.	4.	OTHER	410.		-580.	
28.	22.	GRAYSL	5630.	119.	7250.	120.
26.	21.	MNE	3410.	72.	4420.	73.
-9.	-7.	HER	-190.		-1340.	
43.	37.	MAZE ROAD	8830.	186.	10310.	171.
41.	14.	STANISLAUS	210.	4.	150.	2.
1.	-6.	OTHER	-4300.		-4430.	
86.	44.	VERNALIS	4740.	100.	6030.	100.

: TOT. OTHERS :	-4080.	: -86.	: -6350.	: -105.
: NMN. + OTH. :	1130.	: 24.	: 1480.	: 25.

QUALITY PPM	(CL) / (TDS)
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PRE PPM =	41. / 208.
POST PPM =	101. / 423.
DEGRADATION =	60. / 215.

80/05/12.

14.12.25.

JULY

101.4 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	PRE (PCT)	POST (TONS)	POST (PCT)
19.	10.	NEWM	7610.	117.	2670.	59.
4.	2.	"	-2540.		490.	
23.	12.	RYSON	5070.	78.	3160.	70.
18.	12.	TUOLUMNE	3690.	57.	3810.	84.
-5.	-5.	OTHER	-2800.		-1020.	
36.	.	MAZE ROAD	5950.	91.	5940.	131.
12.	6.	STANISLAUS	190.	3.	80.	2.
-1.	-6.	OTHER	390.		-1480.	
46.	18.	VERNALIS	6530.	100.	4540.	100.
		∑ TOT. OTHERS	-4950.	-75.	-2010.	-44.
		∑ NMN. + OTH.	2660.	41.	660.	15.

QUALITY PPM (CL) / (TDS)

PRE PPM	=	104.	/	432.
POST PPM	=	185.	/	681.
DEGRADATION	=	81.	/	249.

* NOTE:

FCT COLUMN IS PERCENT OF VERNALIS.

80/05/12, 13.42.33, OCTOBER 49.3 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

STATION	PRE (KAF)	POST (KAF)	PRE (TONS)	POST (TONS)	PRE (PCT)	POST (PCT)	CHLORIDES
VERNALIS	101.	104.	9650.	9650.	100.	100.	12920.
OTHER	-3.	3.	-260.	-260.			-1480.
STANISLAUS	13.	16.	220.	220.	2.	2.	190.
MAZE ROAD	92.	85.	9690.	9690.	100.	100.	14220.
OTHER	5.	7.	1420.	1420.			2580.
TUOLUMNE	53.	46.	3820.	3820.	40.	40.	4930.
GRAYSON	34.	32.	4450.	4450.	46.	46.	6700.
ER	14.	15.	1470.	1470.			2780.
NEV	20.	17.	2980.	2980.	31.	31.	3920.
TOT. OTHERS	30.	27.	2630.	2630.	27.	27.	3880.
NMN. + OTH.	60.	30.	5610.	5610.	58.	58.	7800.

QUALITY PPM (CL) / (TDS)

PRE PPM = 20. / 328.

POST PPM = 91. / 392.

DEGRADATION = 21. / 64.

STATION	PRE (TONS)	POST (TONS)	PRE FPM	POST FPM	DEGRADATION	QUALITY FPM	(CL) / (TDS)
NEWMAN	3500	9430	45	74	60	36	
OTHER	2880	750			12	6	
GRAYSON	6370	10190	83	80	71	42	
TUOLUMNE	3400	4950	44	39	85	46	
OTHER	950	100			0	7	
MAZE ROAD	10720	15230	139	120	157	95	
STANISLAUS	120	230	2	2	40	21	
OTHER	-3110	-2730			5	2	
VERNALIS	7720	12730	100	100	202	119	
TOT. OTHERS	720	-1880	9	-14			
NMN. + OTH.	4220	7550	55	59			

PRE FPM = 48 / 237
 POST FPM = 46 / 254
 DEGRADATION = -2 / 17

80/05/12, 13,53,13, JANUARY 167.3 KAF UNPAIRED AT VERNALIS
 BELOW NORMAL YEAR

80/05/12.

14.03.58.

APRIL

794.9 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	(PCT)	POST (TONS)	(PCT)
32.	52.	NEWMAN	5760.	104.	10230.	92.
6.	11.	OTHER	250.		-520.	
38.	63.	GRAYSON	6000.	109.	9710.	88.
33.	61.	TUOLUMNE	3460.	63.	4770.	43.
-11.	-8.	OTHER	-20.		1000.	
60.	115.	MAZE ROAD	9440.	171.	15490.	140.
50.	44.	STANISLAUS	230.	4.	270.	2.
3.	-8.	OTHER	-4130.		-4670.	
113.	150.	VERNALIS	5520.	100.	11080.	100.
		TOT. OTHERS	-3900.	-70.	-4190.	-37.
		NMN. + OTH.	1860.	34.	6040.	55.

QUALITY PPM (CL) / (TDS)

PRE PPM = 36. / 187.

POST PPM = 54. / 279.

DEGRADATION = 18. / 91.

80/05/12.

14.15.13.

JULY

224.9 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES								
PRE	POST		PRE (TONS)	POST (PCT)	PRE (TONS)	POST (PCT)					
27.	19.	WMAN	7690.	96.	4370.	57.					
7.	5.	OTHER	-1890.		1060.						
34.	24.	GRAYSON	5790.	72.	5430.	71.					
23.	23.	TUOLUMNE	3720.	46.	4260.	55.					
-5.	-5.	OTHER	-2090.		-480.						
51.	42.	MAZE ROAD	7420.	93.	9210.	120.					
14.	12.	STANISLAUS	210.	3.	140.	2.					
0.	-8.	OTHER	390.		-1640.						
64.	46.	VERNALIS	8020.	100.	7700.	100.					
		;	TOT. OTHERS	;	-3590.	;	-44.	;	-1060.	;	-13.
		;	NMN. + OTH.	;	4100.	;	51.	;	3310.	;	43.

QUALITY PPM (CL) / (TDS)

PRE PPM = 92. / 396.

POST PPM = 123. / 491.

DEGRADATION = 31. / 95.

80/05/12.

13.45.43.

OCTOBER

42.4 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	POST (PCT)	POST (TONS)	POST (PCT)
19.	12.	NEWMAN	2960.	31.	3190.	34.
13.	11.	OTHER	1310.		2650.	
33.	23.	GRAYSON	4270.	45.	5840.	63.
52.	32.	TUOLUMNE	3820.	40.	4580.	49.
4.	2.	OTHER	1480.		2700.	
89.	57.	MAZE ROAD	9570.	101.	13120.	141.
13.	11.	STANISLAUS	210.	2.	160.	2.
-4.	-3.	OTHER	-330.		-3990.	
98.	65.	VERNALIS	9440.	100.	9280.	100.
		TOT. OTHERS	2460.	26.	1360.	15.
		NMN. + OTH.	5420.	57.	4550.	49.

QUALITY PPM (CL) / (TDS)

PRE PPM = 71. / 331.

POST PPM = 105. / 435.

DEGRADATION = 34. / 104.

80/05/12.

13.56.03.

JANUARY

352.5 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	PRE (PCT)	POST (TONS)	POST (PCT)
130.	80.	NEWMAN	7130.	54.	10160.	70.
11.	14.	OTHER	1560.		350.	
141.	94.	GRAYSON	8700.	66.	10510.	73.
81.	111.	TUOLUMNE	3750.	29.	5080.	35.
6.	-4.	OTHER	-630.		400.	
229.	201.	MAZE ROAD	11810.	90.	16000.	111.
51.	56.	STANISLAUS	180.	1.	270.	2.
0.	6.	OTHER	1140.		-1820.	
279.	263.	VERNALIS	13130.	100.	14450.	100.
		TOT. OTHERS	2070.	16.	-1070.	-7.
		NMN. + OTH.	9200.	70.	9090.	63.

QUALITY PPM (CL) / (TDS)

PRE PPM = 35. / 183.

POST PPM = 40. / 236.

DEGRADATION = 5. / 53.

80/05/12. 14.06.23. APRIL 1055.7 KAF UNIMPAIRED AT VERNALIS
 ABOVE NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	(PCT)	POST (TONS)	(PCT)
366.	84.	NEWMAN	11730.	70.	11570.	79.
46.	17.	OTHER	-2170.		-450.	
413.	102.	GRAYSON	9550.	57.	11110.	76.
199.	98.	TUOLUMNE	3880.	23.	4950.	34.
-2.	-3.	OTHER	1730.		2610.	
609.	196.	MAZE ROAD	15160.	91.	18680.	127.
190.	74.	STANISLAUS	400.	2.	370.	3.
5.	-6.	OTHER	1100.		-4370.	
805.	264.	VERNALIS	16660.	100.	14670.	100.
		: TOT. OTHERS :	660.	4.	-2210.	-15.
		: NMN. + OTH. :	12390.	74.	9360.	64.

QUALITY PPM	(CL)	(TDS)
PRE PPM =	15.	101.
POST PPM =	41.	239.
DEGRADATION =	26.	138.

80/05/12.

14.17.48.

JULY

425.1 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	PRE (PCT)	POST (TONS)	POST (PCT)
108.	25.	NEUMA'	8000.	44.	5540.	56.
33.	9.	OTF'	1830.		1510.	
141.	34.	SON	9830.	55.	7040.	71.
55.	31.	OLUMNE	3860.	21.	4490.	45.
3.	-	OTHER	4010.		-170.	
200.	62.	MAZE ROAD	17710.	98.	11360.	115.
28.	17.	STANISLAUS	330.	2.	170.	2.
7.	-7.	OTHER	-10.		-1620.	
235.	72.	VERNALIS	18020.	100.	9910.	100.
		TOT. OTHERS	5830.	32.	-280.	-2.
		NMN. + OTH.	13830.	77.	5260.	53.

QUALITY PPM (CL) / (TDS)

PRE PPM = 56. / 270.

POST PPM = 101. / 423.

DEGRADATION = 45. / 153.

80/05/12.

13.48.12.

OCTOBER

29.8 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	POST (PCT)	POST (TONS)	POST (PCT)
22.	15.	NEWMAN	3020.	30.	3620.	32.
15.	13.	OTHER	1800.		2740.	
38.	28.	GRAYSON	4820.	48.	6360.	56.
54.	40.	TUOLUMNE	3830.	38.	4800.	42.
5.	5.	OTHER	1280.		2630.	
97.	73.	MAZE ROAD	9930.	99.	13790.	121.
14.	14.	STANISLAUS	240.	2.	180.	2.
-3.	0.	OTHER	-110.		-2570.	
107.	87.	VERNALIS	10060.	100.	11400.	100.
		TOT. OTHERS	2970.	30.	2800.	25.
		NMN. + OTH.	5990.	60.	6420.	56.

QUALITY PPM (CL) / (TDS)

PRE PPM = 69. / 324.
 POST PPM = 96. / 408.
 DEGRADATION = 27. / 84.

80/05/12

13.58.57

JANUARY

695.7 KAF UNPAIRED AT VERNALIS

NET YEAR

STATION	PRE (KAF)	POST (KAF)	PRE (TONS)	POST (TONS)	PRE (PCT)	POST (PCT)
VERNALIS	410	714	16690	100	100	100
OTHER	-4	13	4140			
STANISLAUS	75	185	220	1		2
MAZE ROAD	339	516	12330	74		83
OTHER	-10	-61	-1590			
TUOLLUMNE	104	310	3910	23		24
GRAYSON	246	268	10010	60		51
OTHER	13	27	160			
NEWMAN	233	246	9850	59		58
TOT. OTHERS	2710	2710	2710	16		16
NMN. + OTH.	12560	12560	12560	75		74

QUALITY PPM	PRE PPM	POST PPM	DEGRADATION
30 / 163	30 / 187	-6 / 24	

90/05/12.

14.09.13.

APRIL

1169.0 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	PRE (PCT)	POST (TONS)	POST (PCT)
585.	267.	NEWMAN	13450.	65.	15470.	54.
67.	47.	OTHER	-3000.		-190.	
652.	314.	GRAYSON	10450.	51.	15270.	54.
281.	306.	TUOLUMNE	3960.	19.	5390.	19.
19.	73.	OTHER	2190.		8380.	
952.	693.	MAZE ROAD	16600.	81.	29040.	102.
246.	256.	STANISLAUS	450.	2.	720.	3.
-23.	51.	OTHER	3560.		-1340.	
1175.	1000.	VERNALIS	20620.	100.	28410.	100.
		TOT. OTHERS	2750.	13.	6850.	24.
		NMN. + OTH.	16200.	79.	22320.	79.

QUALITY PPM (CL) / (TDS)

PRE PPM = 13. / 92.

POST PPM = 21. / 178.

DEGRADATION = 8. / 85.

80/05/12.

14.20.10.

JULY

921.0 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF)		STATION	CHLORIDES			
PRE	POST		PRE (TONS)	POST (PCT)	POST (TONS)	POST (PCT)
365.	65.	NEWMAN	8280.	23.	11740.	53.
129.	40.	OTHER	7300.		4360.	
494.	105.	GRAYSON	15580.	43.	16100.	73.
119.	80.	TUOLUMNE	3980.	11.	5320.	24.
49.	29.	OTHER	18210.		720.	
662.	214.	MAZE ROAD	37780.	104.	22140.	100.
50.	51.	STANISLAUS	480.	1.	360.	2.
17.	34.	OTHER	-1780.		-360.	
730.	300.	VERNALIS	36470.	100.	22130.	100.
		TOT. OTHERS	23730.	65.	4720.	21.
		NMN. + OTH.	32010.	88.	16460.	74.

QUALITY PPM (CL) / (TDS)

PRE PPM = 37. / 192.

POST PPM = 54. / 279.

DEGRADATION = 17. / 87.

APPENDIX 4
SUMMARY OF NETWORK ANALYSES OF THE
LOWER SACRAMENTO-SAN JOAQUIN DELTA

R. F. Blanks

February 16, 1951

D. J. Hebert and W. B. McBirney

Summary of network analyses of lower Sacramento-San Joaquin Delta

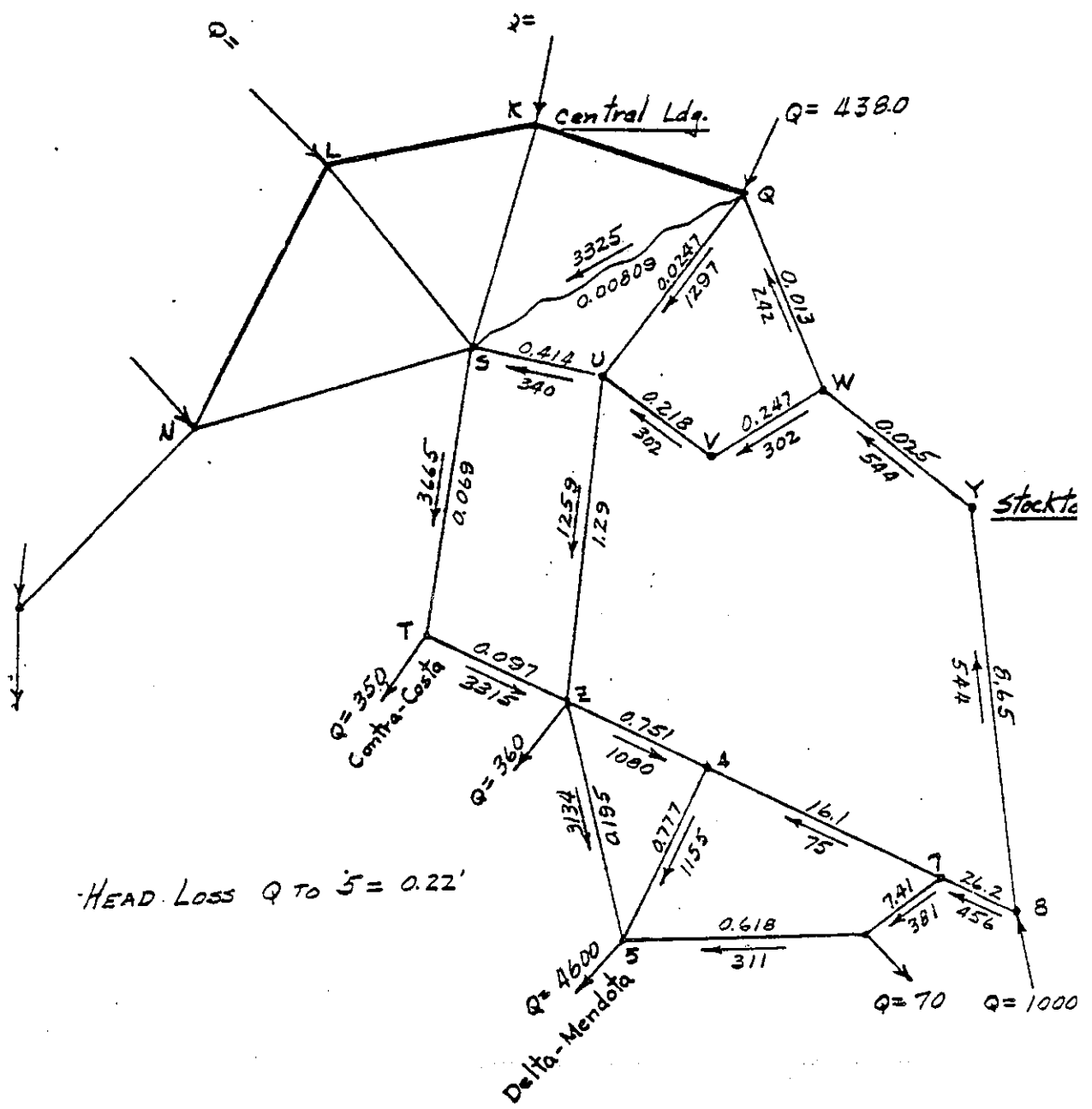
1. The results of all network analyses of the lower Sacramento-San Joaquin Delta have been summarized on the six diagrams attached. Rate and direction of flow are shown on one side of a channel, and a resistance value based on channel characteristics is given on the other side. Resistances were computed from $r = \frac{L \times 10^4}{b^2 d^{10/3}}$. Three channels

NL, LK, and KQ, are very large and have been assumed at constant level regardless of discharge. Computations made to test this premise show that a large increase in discharge can be accommodated by a negligible increase in slope. The wavy connection shown from S to Q represents channels NS, LS, and KS, and the resistance value used is the hydraulic equivalent of the three channels having S as a common point and terminating at N, L, K, or Q.

2. The first few schemes tried made use of resistance values which were derived from channel cross-sections as shown on available maps. It became evident they gave a division of flow which was contrary to that actually prevailing, and therefore at points such as 7 and 8, the resistances of connecting channels were arbitrarily adjusted until the division was more nearly correct. Thus, in channel (7-8) the resistance was changed to 26.2 and to 0.832 from 239.0, and in channel 8-Y, the resistance was increased to 10.0 from 8.65. Resistance in channel 6-7 was decreased to 2.0 from 7.41.

3. The results of the network analysis can be used to estimate the drop in water surface from Central Landing to Tracy Pumping Plant when the pumps are working at design capacity of 4,600 cubic feet per second. For mean tide height in the lower Delta this drop has been estimated to be 0.25 foot. Were the levels to be at mean low tide height an increase to approximately 0.34 foot may be expected. Making allowance for indeterminate factors, it is thought the maximum head loss, or draw-down, to Tracy Pumping Plant will be about 0.5 foot.

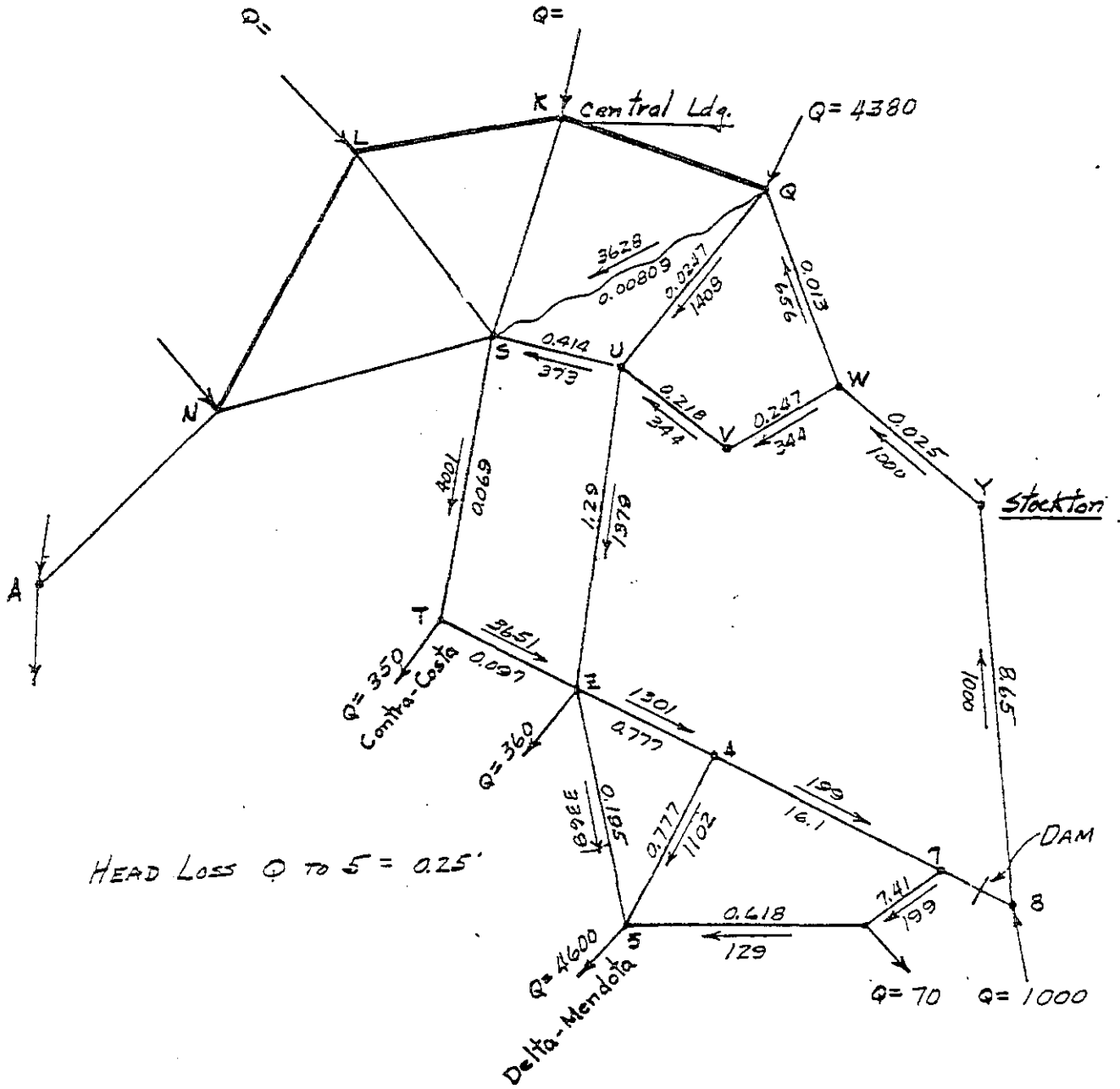
DELTA NETWORK ANALYSIS



HEAD LOSS Q TO 5 = 0.22'

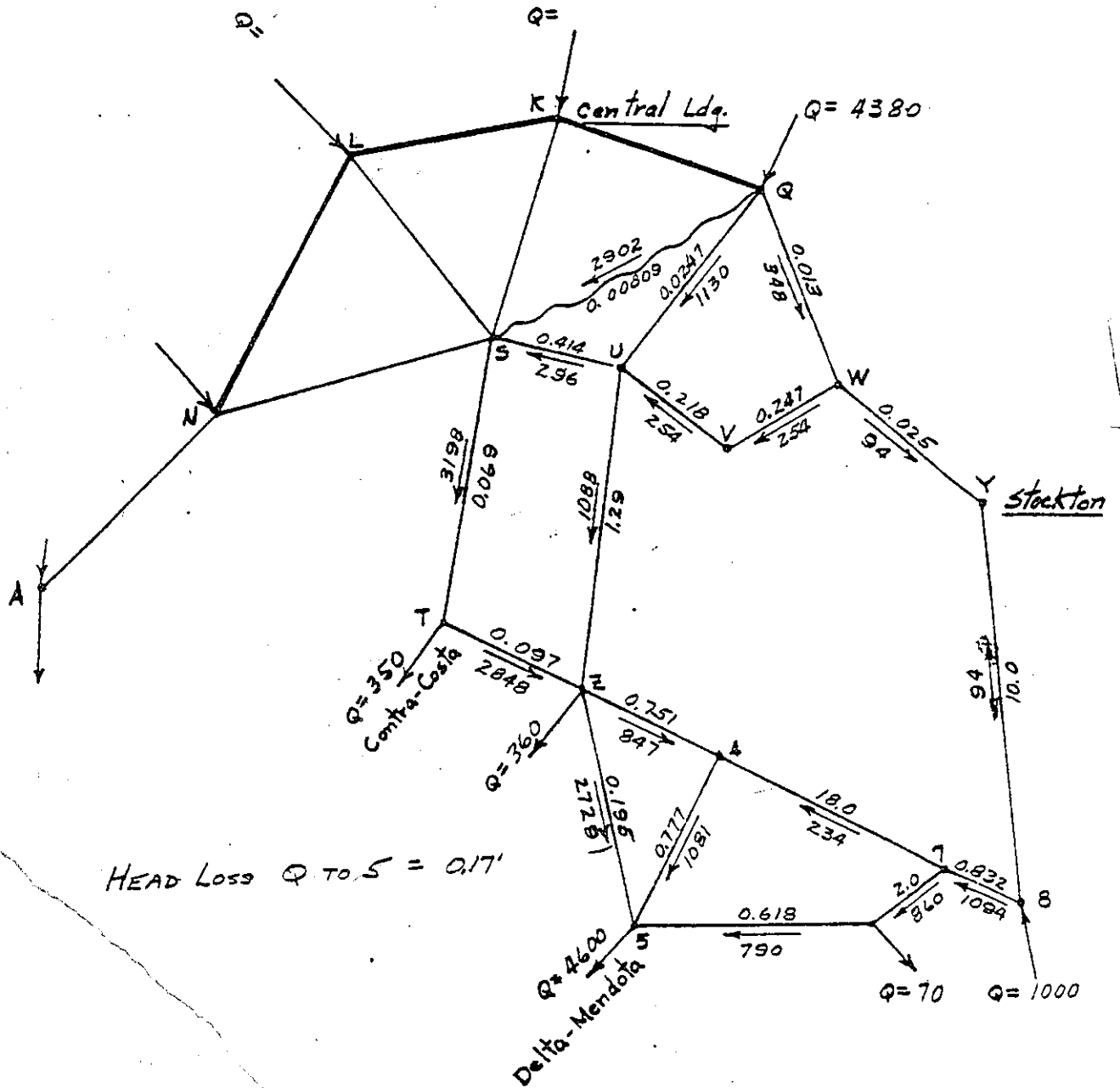
SCHEME 8 TRIAL FINAL

DELTA NETWORK ANALYSIS



SCHEME 9 TRIAL FINAL

DELTA NETWORK ANALYSIS



SCHEME 14 TRIAL FINAL