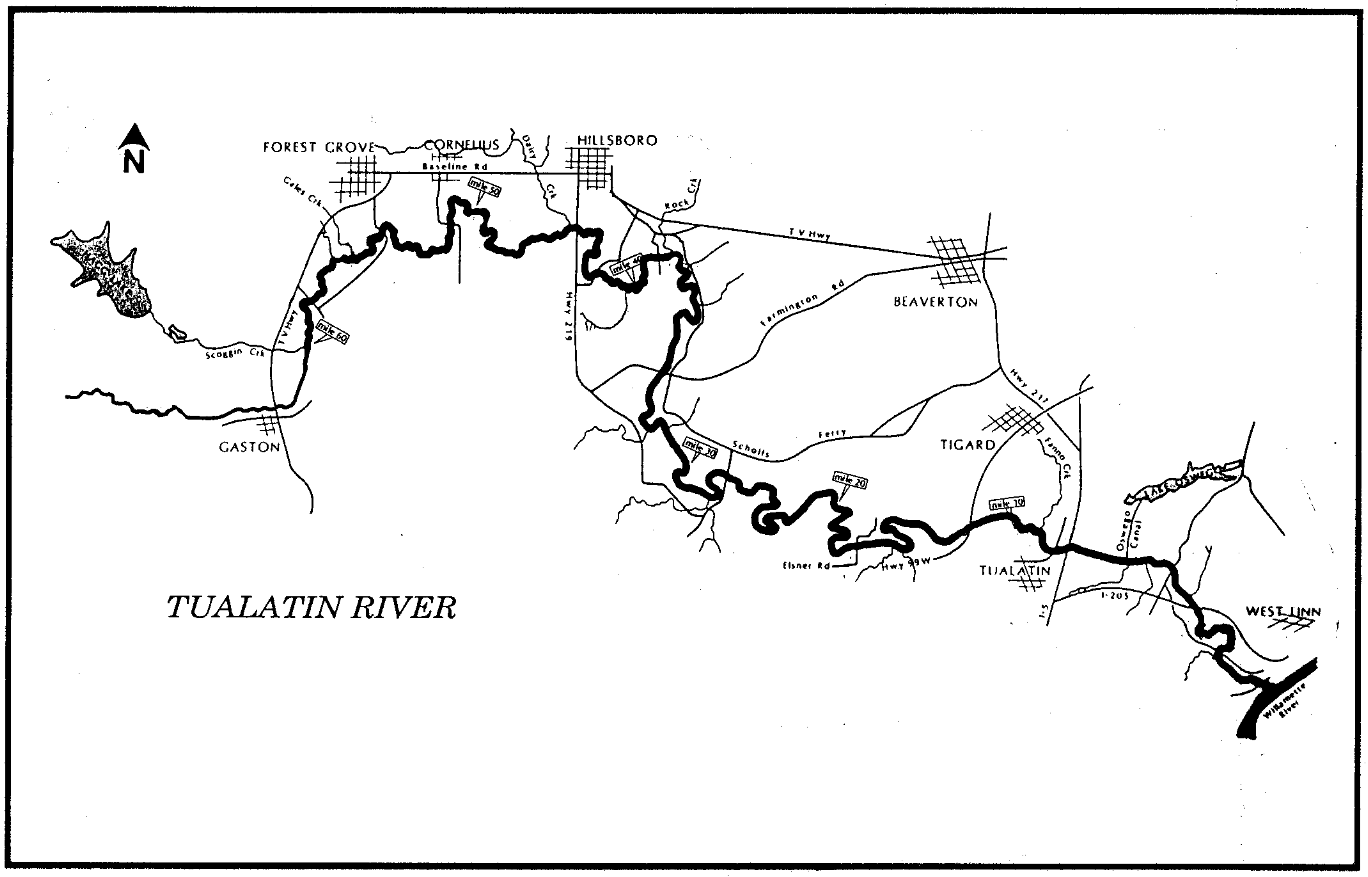
Data Analysis: Water Quality of Dairy Creek and Major Tributaries



August 1995

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Oregon Water Resources Research Institute

TUALATIN RIVER BASIN SPECIAL REPORTS

The Tualatin River Basin in Washington County, Oregon, is a complex area with highly developed agricultural, forestry, industrial, commercial, and residential activities. Population has grown in the past thirty years from fifty to over 270 thousand. Accompanying this population growth have been the associated increases in transportation, construction, and recreational activities. Major improvements have occurred in treatment of wastewater discharges form communities and industries in the area. A surface water runoff management plan is in operation. Agricultural and forestry operations have adopted practices designed to reduce water quality impacts. In spite of efforts to-date, the standards required to protect appropriate beneficial uses of water have not been met in the slow-moving river.

The Oregon Department of Environmental Quality awarded a grant in 1992 to the Oregon Water Resources Research Institute (OWRRI) at Oregon State University to review existing information on the Tualatin, organize that information so that it can be readily evaluated, develop a method to examine effectiveness, costs and benefits of alternative pollution abatement strategies, and allow for the evaluation of various scenarios proposed for water management in the Tualatin Basin. Faculty members from eight departments at Oregon State University and Portland State University are contributing to the project. Many local interest groups, industry, state and federal agencies are contributing to the understanding of water quality issues in the Basin. This OWRRI project is based on all these research, planning and management studies.

This publication is one in a series designed to make the results of this project available to interested persons and to promote useful discussions on issues and solutions. You are invited to share your insights and comments on these publications and on the process in which we are engaged. This will aid us in moving towards a better understanding of the complex relationships between people's needs, the natural environment in which they and their children will live, and the decisions that will be made on resource management.

DATA ANALYSIS: WATER QUALITY OF DAIRY CREEK AND MAJOR TRIBUTARIES

by
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Tualatin River Basin Water Resources Management
Report Number 5

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ABBREVIATIONS

NH-3 .... Ammonia

NO2-3 .... Nitrite plus Nitrate

OPO4 .... Ortho Phosphorus

TDS .... Total Dissolved Solids

T-PO4-P .... Total Phosphate

TS .... Total Solids

ACKNOWLEDGMENT

The authors would like to thank Unified Sewerage Agency, especially Jan Miller and her staff, for collection of water quality data, and Oregon State Climatologist, George Taylor for providing precipitation data from the Hillsboro climatological recording station.

ABSTRACT

Dairy Creek, located in Washington County, Oregon, has a drainage area of approximately 230 square miles, and includes West Fork, East Fork, and McKay Creek drainages. Dairy Creek is a major tributary of the Tualatin River which experiences algal problems during the late summer when stream flows decrease and water temperatures increase.

The upper reaches of Dairy Creek are forested land, while the lower reaches are devoted to intensively irrigated agricultural production. It has been proposed that excessive algae blooms are associated with elevated nutrient concentrations during summer low-flow conditions. The objective of this project was to evaluate nutrient loading to the Tualatin River from the Dairy Creek watershed. Water quality parameters were selected to examine relationships between precipitation, flow, solids and nutrient constituents.

The following conclusions were reached:

1. Surface runoff and erosion processes did not appear to occur and hence had little impact on water quality during the months of July through October during 1990 and 1991.
2. Groundwater moving to the stream appears to drive flow and have significant influence on water quality during summer low-flow conditions.
3. Nutrient concentrations are greatest during the summer. This may be a consequence of increased solubility and greater contact time between soils and groundwater moving toward the creek. A second alternative is the winter time sediment deposition.
4. Most of the nutrient and solids loading occurs during the winter and early spring at times of highest stream flows.

INTRODUCTION

The purpose of this study is to evaluate water quality data form the Dairy Creek drainage basin. Data used was accumulated by the Unified Sewerage Agency from March, 1990 through February of 1991. Dairy Creek is a second order tributary of the Tualatin River located in Washington County in Northwest Oregon. Dairy Creek flows into the Tualatin River at R.M. 44.8.

Dairy Creek watershed has a drainage area of approximately 230 square miles, and includes West Fork, East Fork, and McKay Creek drainages. East Fork, West Fork, and McKay Creek originate in the mountain ranges north of the Tualatin River Basin and flow generally south. The upper reaches are characterized by steep forested terrain and narrow canyons. The topography changes abruptly as the streams emerge from the foothills, giving way to broad valleys and mixed forest and agricultural land use. The lower ten miles of each of the tributaries, and the reach between the confluence of East Fork and West Fork to the mouth of Dairy Creek, are characterized by heavily irrigated agricultural land use.

Selected water quality data from eight sampling stations were evaluated. A summary of the 1990 and 1991 data is provided in Appendices I and II, respectively. Figure 1 provides a listing of water quality collection stations evaluated, and approximate locations of each. The lower reaches of the Tualatin are susceptible to excessive algae growth associated with elevated nutrient concentrations and stream temperature during summer low-flow conditions. For this reason, relationships between precipitation, flow, solids and nutrient constituents were examined.

PRECIPITATION and STREAM FLOW

Precipitation data from Hillsboro climatological recording station, was plotted with flow data (Figures 2 and 3), from the mainstem of Dairy Creek (at the Highway 8 Sta. #3816021), for May through October of 1990 and 1991. These plots illustrate a pattern of regularly occurring precipitation events and significant flow in the spring, (May through mid-June), followed by drier summer months and characteristic low-flows (July through October), and increased flows in the fall with the resumption of frequent rainfall. Figure 3 indicates the Dairy Creek watershed responds rapidly to precipitation, as shown in the close relationship between the flow hydrograph and daily rainfall record.

Figure 4 shows the contributions of the three tributaries to the mainstream flow of Dairy Creek. In each case, the stations representing the individual tributaries were located as near as possible to the confluence with Dairy Creek. Each tributary shows similar seasonal patterns as discussed previously, with East Fork Dairy Creek contributing the greatest flow volume of water followed by West Fork and McKay Creek respectively. The flow contributions are not linearly related to relative drainage areas, however, as West Fork has the largest drainage area with 80.6 square miles, followed by McKay Creek with 65.2 square miles, and East Fork 63.0 square miles.

SOLIDS and STREAM FLOW

The relationship between precipitation and solids concentrations was examined to determine the effect of erosion processes on water quality. Figures 5 and 6 show a plot of precipitation and total solids (TS) at Dairy Creek Highway 8 for 1990 and 1991. These figures do not show any apparent relationship between TS concentration and precipitation events during the summer months. Figure 7 includes winter data along with available flow data from the summer of 1990. Total solids concentrations do not indicate a seasonal pattern, nor do total solids concentrations show any relationship to streamflow. Actual flow data were not available for characteristic wet winter periods.

Figures 8 and 9 show the TS concentrations of the three Dairy Creek tributaries and the mainstem for 1990 and 1991. A TS peak was observed in mid-July at the mainstem station both years. This peak appears to be independent of the tributaries and may be due to a localized agricultural land use activity such as irrigation return flow. A peak occurs again in mid-October; this response was noted at every monitoring station. A very sharp increase in total solids was noted at the East Fork Fern Flat Road station during early October of 1990. Figures 10, 11, and 12 show plots of total solids, concentration, and precipitation at two stations on each of the tributaries. In each figure, the longer period of record is for the downstream station. Again, there appears to be no relationship between the precipitation which occurred and total solids concentration.

Indeed, a peak occurred at the same time in mid-August at each tributary, while the data indicate no precipitation occurred until the end of August. In each case, similar responses were observed at the upstream and downstream stations.

Without complete flow records, it is difficult to either establish or disapprove a firm connection between erosion processes and water quality during the winter months. However, during the summer, while the flows do appear to be responsive to precipitation, there is not appreciable surface runoff. This observation is supported by the absence of any relationship between precipitation and solids. One may conclude that soils in Dairy Creek basin readily absorb precipitation and groundwater is the driving influence of water quantity. Surface runoff is not a major contributor to water quality.

NUTRIENT LOSSES

Figures 13 and 14 show plots of total and dissolved solids and total and orthophosphate concentrations on the mainstem of Dairy Creek at Highway 8. These plots show that total dissolved solids (TDS) are the primary solids component. This result supports a hypothesis that groundwater dominates flow and water quality. Erosion would generate suspended solids. There is a suggestion of a relationship between total solids and total phosphate during the early spring of 1990 and again in the fall of 1990 extending into the spring of 1991. However, this relationship was not observed at the lower Dairy Creek sampling station during the summer months nor during the winter of 1991 and the spring of 1992. Phosphate concentrations increase toward the end of August in the Dairy Creek tributaries, reaching a maximum near the beginning of October, followed by a decline as winter approaches. One would expect phosphate to have a higher solubility with higher temperatures in the summer months. Ortho-phosphate concentrations remain relatively constant, averaging approximately 0.03 mg/l throughout the year.

The relationship between solids and total phosphate was further examined on the tributaries of Dairy Creek. Figures 15, 16, and 17 show plots of TS and total phosphates for two stations on each tributary in 1991.

Figures 18 and 19 show that nitrite plus nitrate concentrations at the mainstem station drop considerably in the summer and rise abruptly in the late fall. Only during the summer do responses between TS and NO2-3 show any similarity at the mainstem sampling location.

Figures 20, 21, and 22 show plots of total solids and nitrite concentrations plus nitrate at two stations on each tributary of Dairy Creek. There does not seem to be a relationship between these two parameters at any of the sampling stations under consideration.

Figures 23, 24, and 25 examine further the relationship between precipitation and nutrient concentrations in the Dairy Creek tributaries. In no case is there evidence to suggest surface runoff during the period of data collection. This lack supports the hypothesis that the precipitation which occurred was absorbed by soils, rather than contributing to runoff, and that nutrients moved with the groundwater or were extracted form bottom deposits. In the Dairy Creek tributaries, concentrations of nitrogen show a peak at some time during the summer. As with the mainstem station, phosphate concentrations generally increase toward the end of August in the Dairy Creek tributaries, reaching a maximum near the beginning of October, followed by a decline as winter approaches.

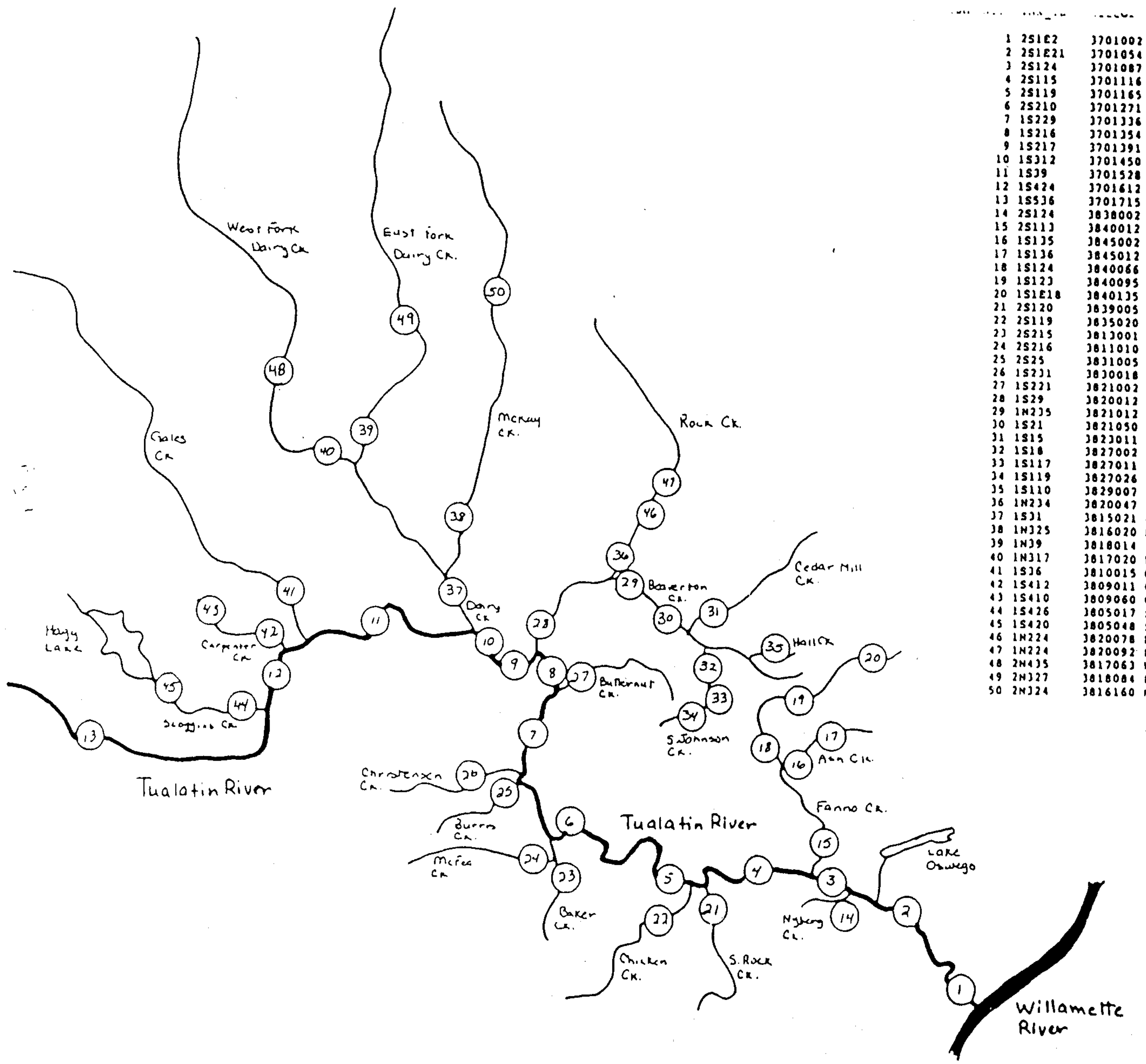
Figures 26, 27, 28, and 29 show that the majority of both nutrient loading and total solids loading occurs during the winter and early spring in response to increased stream flows. Figure 26 show that solids loading is a function of flow. A relatively small portion of the total solids loading is comprised of suspended particulate material. Figures 28 and 29 show the phosphate loading at the Dairy Creek Highway 8 station. Much of the total phosphate loading is ortho-phosphate during the summer rather than particulate. Figure 30, 31, and 32 show that loading of nitrogen is also proportional to streamflow the majority of nitrogen loading occurring in the winter an early spring.

SUMMARY

During the summer, while the stream flows in Dairy and McKay Creeks appear to be responsive to precipitation, there is no evidence of appreciable surface runoff in the data collected. There is no relationship between precipitation and solids concentrations. Soils in Dairy Creek basin are capable of absorbing summer precipitation. It was shown that Total Dissolved Solids (TDS) are the primary solids component in the streams. Surface runoff would likely generate suspended solids. An equilibrium response between water, dissolved solids, suspended organics, and phosphates could result from a greater solubility of phosphate and a greater contact time between soils and groundwater as flows decrease and temperatures increase. No strong relationship was observed between TS and nitrate. Phosphate concentrations generally increase toward the end of summer and decline as winter approaches, at sampling locations on the mainstem and tributaries.

While nutrient concentrations appear to be greatest during the summer, the majority of both nutrient loading and total solids loading occurs during the winter and early spring in response to increased stream flows.

Figure 1
Water Quality Sampling Stations on the Tualatin River



1	2S1E2	3701002	TUALATIN R	WEISS	(WSLO)
2	2S1E21	3701054	TUALATIN R	STAFFORD RD	(LOCS)
3	2S124	3701087	TUALATIN R	UPPER BOONES FERRY	*BOON
4	2S115	3701116	TUALATIN R	HWY 99	
5	2S119	3701165	TUALATIN R	ELSNER BRIDGE RD	
6	2S210	3701271	TUALATIN R	SCHOLLS (HWY 210)	
7	1S229	3701336	TUALATIN R	FARMINGTON	FRMO
8	1S216	3701354	TUALATIN R	MERIWETHER	(FRMO)
9	1S217	3701391	TUALATIN R	ROOD BRIDGE RD	ROOD
10	1S312	3701450	TUALATIN R	HWY 219	TRJB
11	1S39	3701528	TUALATIN R	GOLF COURSE RD	TRGC
12	1S424	3701612	TUALATIN R	SPRINGHILL (DILLY)	DLLO
13	1S536	3701715	TUALATIN R	CHERRY GR	(CAST)
14	2S124	3838002	NYBERG CK	NYBERG LN	*NYBG
15	2S113	3840012	FANNO CK	DURHAM RD	FANO
16	1S135	3845002	ASH CK	GREENBURG RD	ACGR
17	1S136	3845012	ASH CK	LOCUS	
18	1S124	3840066	FANNO CK	SCHOLL FRY NR NIMBUS	*FCSN
19	1S123	3840095	FANNO CK	SCHOLLS FRY (ALLEN)	FCSA
20	1S1E18	3840135	FANNO CK	39th ST SHADDUCK	(FCSR)
21	2S120	3839005	S ROCK CK	HWY 99 & ONION FL	SRCO
22	2S119	3835020	CHICKEN CK	SHERWOOD RD	CCSR
23	2S215	3813001	BAKER CK	HWY 210	*BCKR
24	2S216	3811010	MCFEE CK	HWY 219	MCFE
25	2S25	3831005	BURRIS CK	HWY 219	BURS
26	1S231	3830018	CHRISTIANSEN	HWY 219 (ROBINSON)	*CSTN
27	1S221	3821002	BUTTERNUT CK	RIVER RD	
28	1S29	3820012	ROCK CK	HWY 8	RCTV
29	1N235	3821012	BEAVERTON CK	216th	BVTS
30	1S21	3821050	BEAVERTON CK	170th	BCOS
31	1S15	3823011	CEDAR MILL C	JAY ST OFF JENKINS	CMCJ
32	1S18	3827002	S JOHNSON CK	HWY 8	*
33	1S117	3827011	S JOHNSON CK	GLENBROOK	*
34	1S119	3827026	S JOHNSON CK	BRIDLEHILLS/HART MDS	*
35	1S110	3829007	HALL CK	110th & CANYON	*
36	1N234	3820047	ROCK CK	QUATAMA	RCOR
37	1S31	3815021	DAIRY CK	HWY 8	DAIRY
38	1N325	3816020	McKAY CK	HORNECKER	MCKH
39	1N39	3818014	E FK DAIRY C	ROY RD	EFDR
40	1N317	3817020	W FK DAIRY C	EVERS RD	WFDE
41	1S36	3810015	GALES CK	NEW HWY 47	GALES
42	1S412	3809011	CARPENTER CK	HWY 47	
43	1S410	3809060	CARPENTER CK	PLUMLEE	
44	1S426	3805017	SCOGGINS CK	OLD HWY 47	(SCOO)
45	1S420	3805048	SCOGGINS CK	STIMSON BRIDGE	SCOO
46	1N224	3820078	ROCK CK	ROCK CREEK BLVD	
47	1N224	3820092	ROCK CK	WEST UNION	RCWU
48	2N435	3817063	W FK DAIRY C	HWY 6	WFDB
49	2N327	3818084	E FK DAIRY C	DAIRY CK RD	EFDM
50	2N324	3816160	McKAY CK	NORTHRUP RD	MCKN

Figure 2

Dairy Creek at HW8 1990

Precipitation vs. Flow

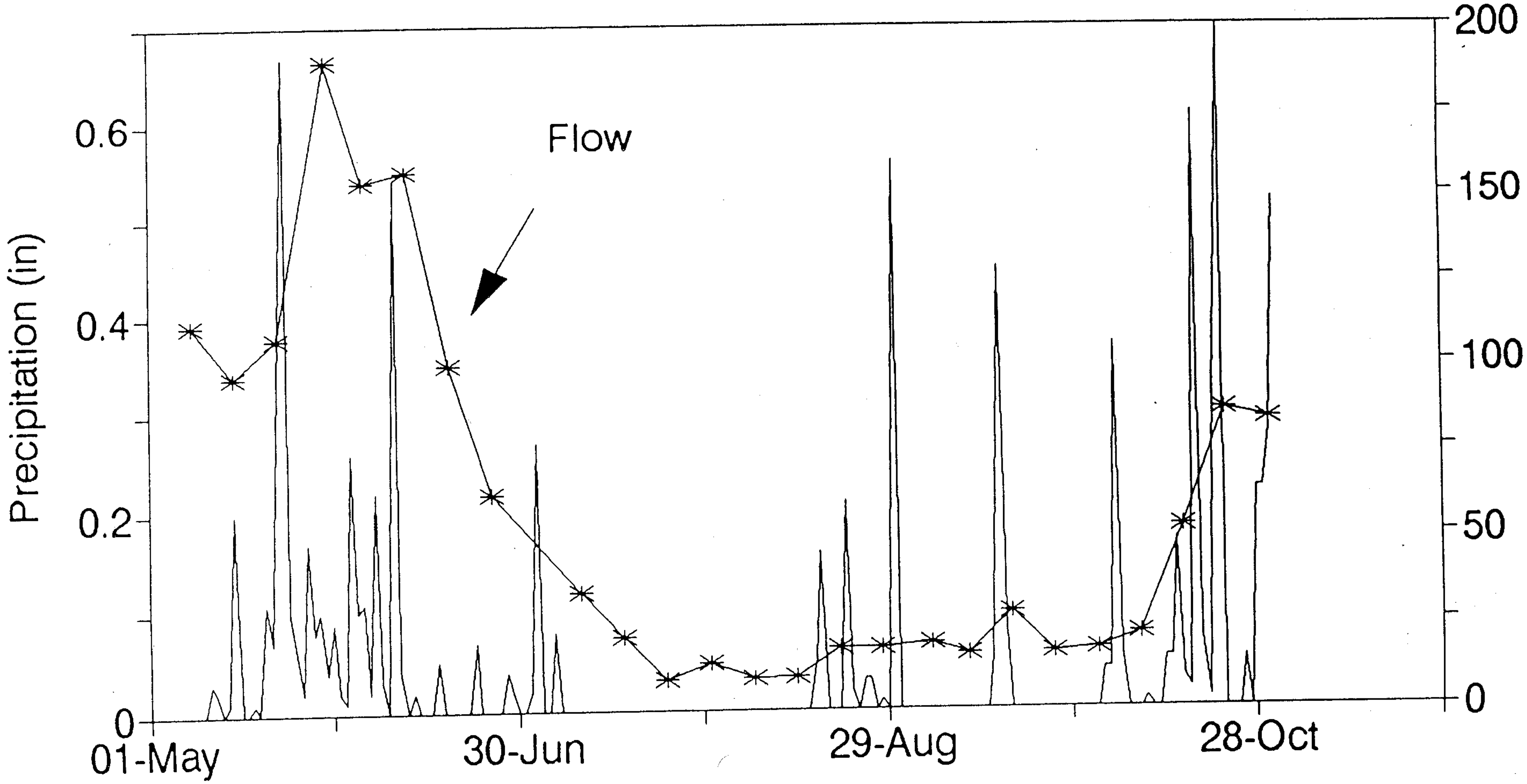


Figure 3

Dairy Creek at HWY 8, 1991

Precipitation vs. Flow

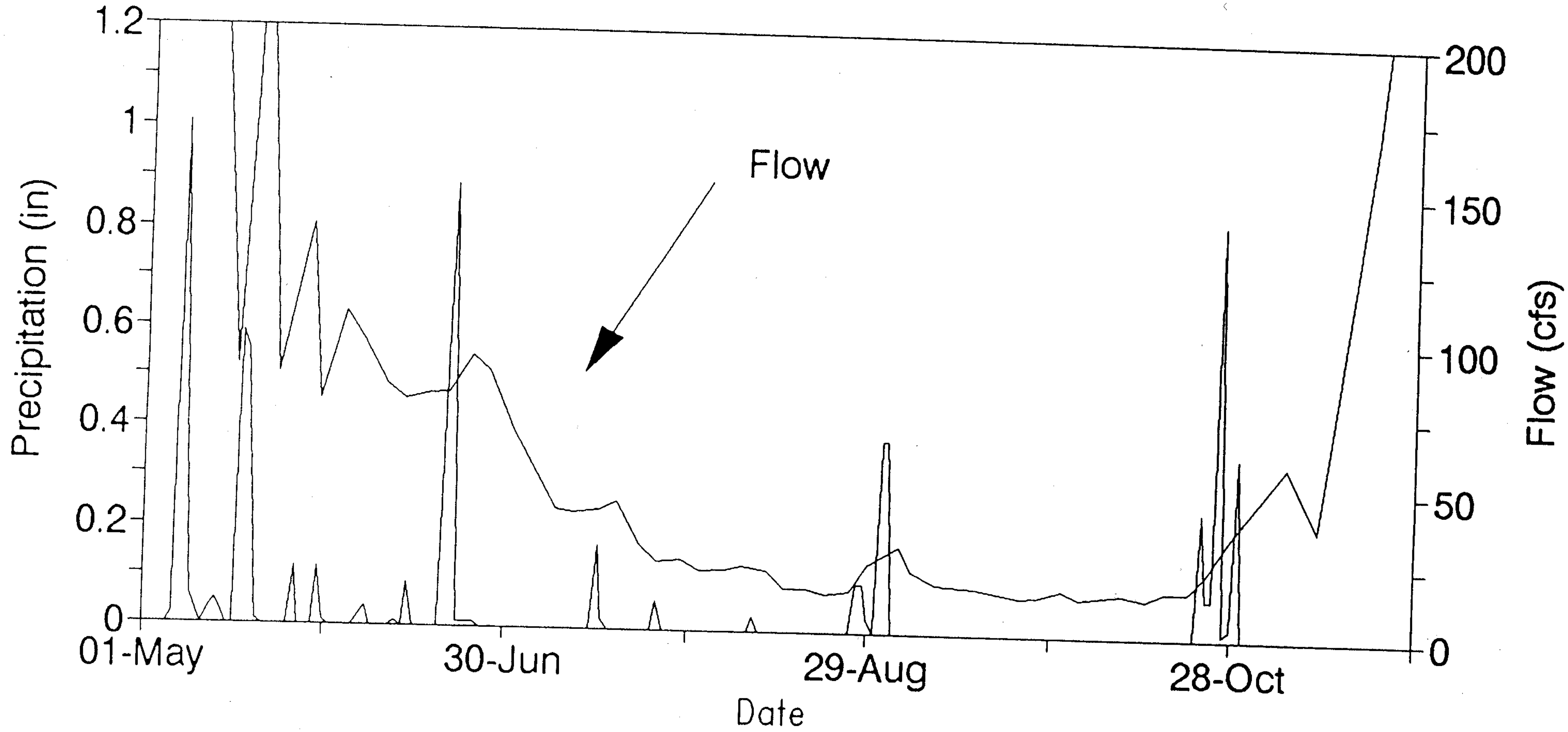


Figure 4

Dairy Creek Tributaries, 1991

Flow Contributions

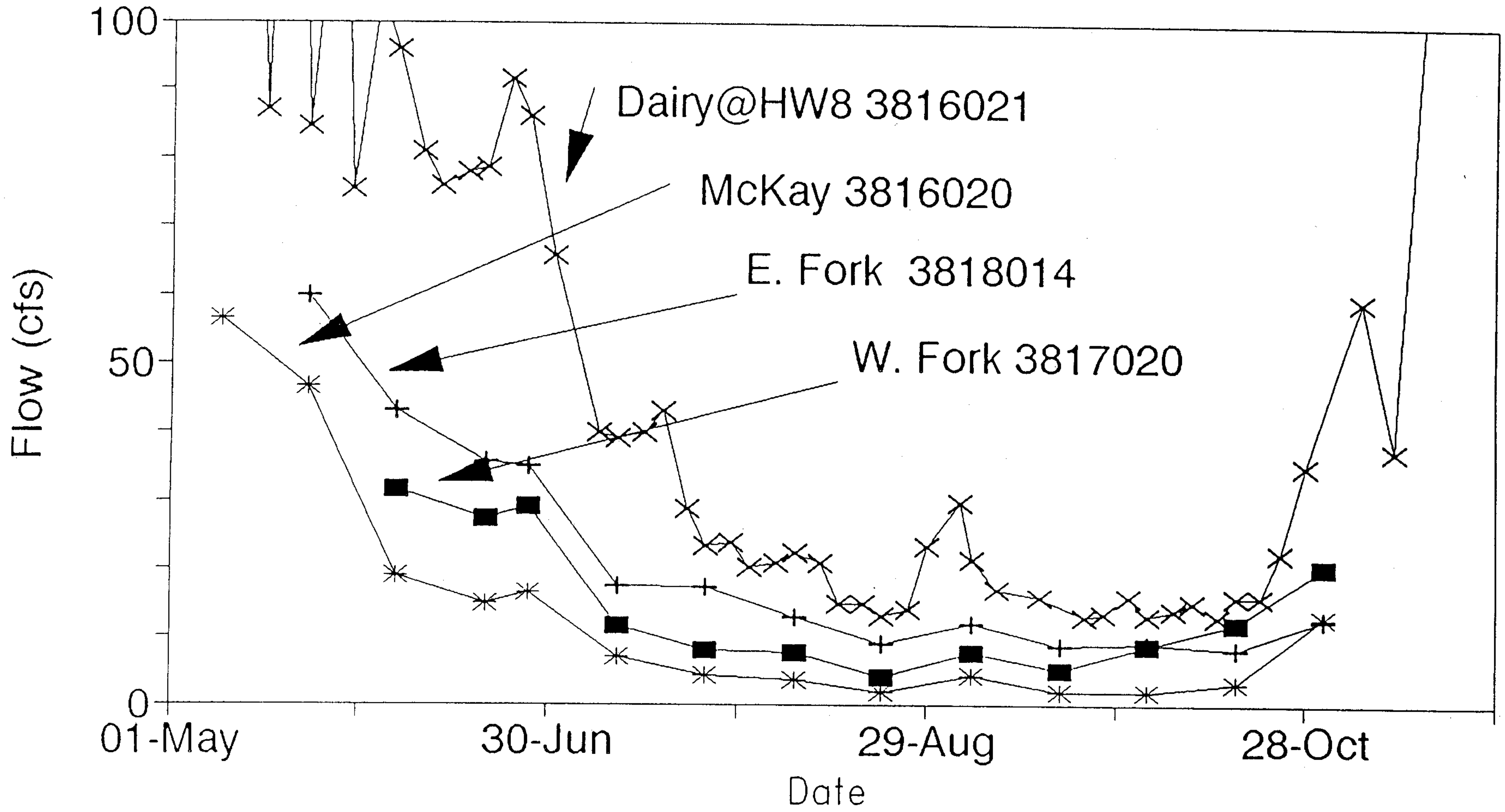


Figure 5

Dairy Creek at HW8 1990

Precipitation vs. TS

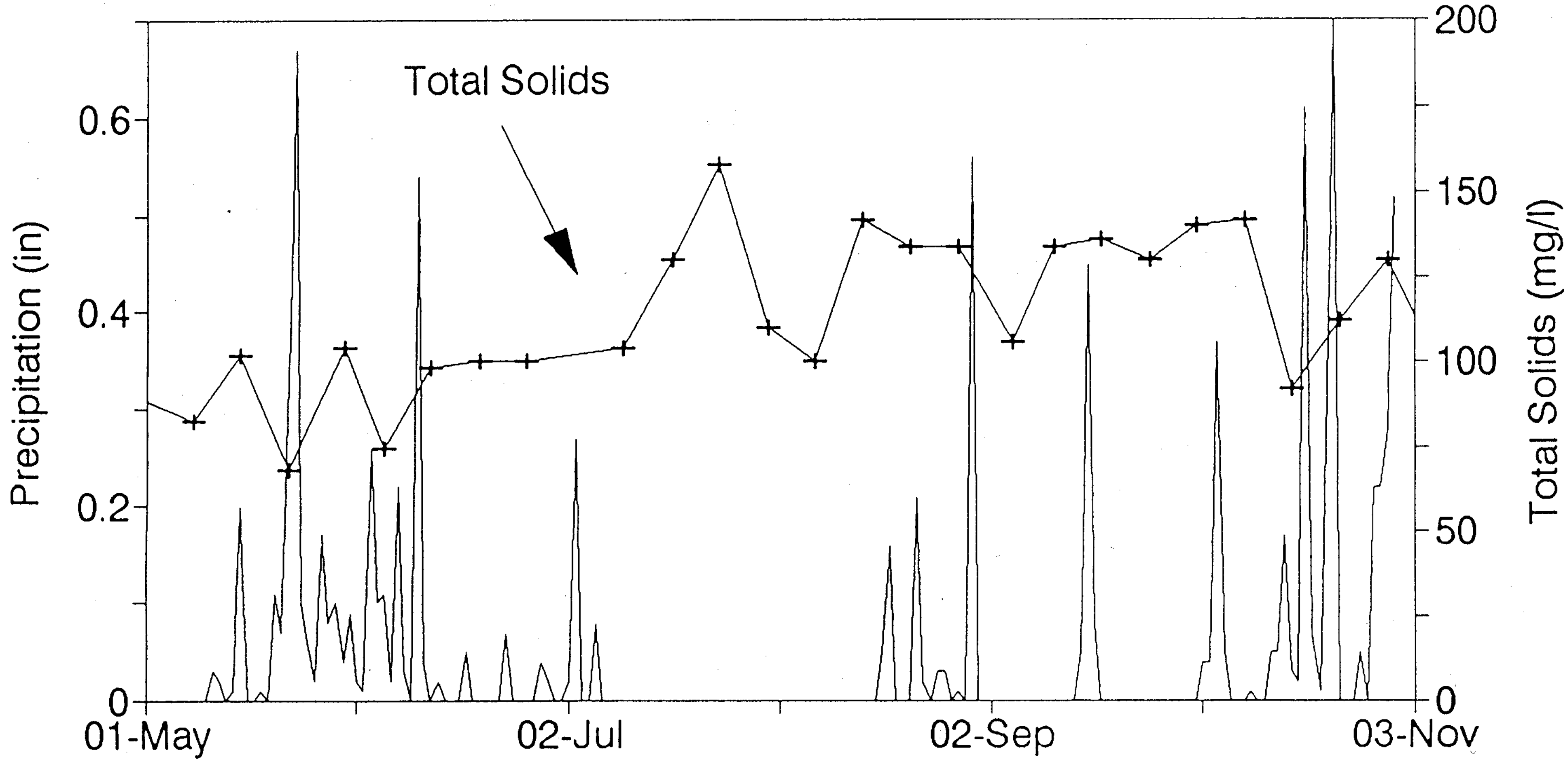


Figure 6

Dairy Creek at HW8 1991

Precipitation vs. TS

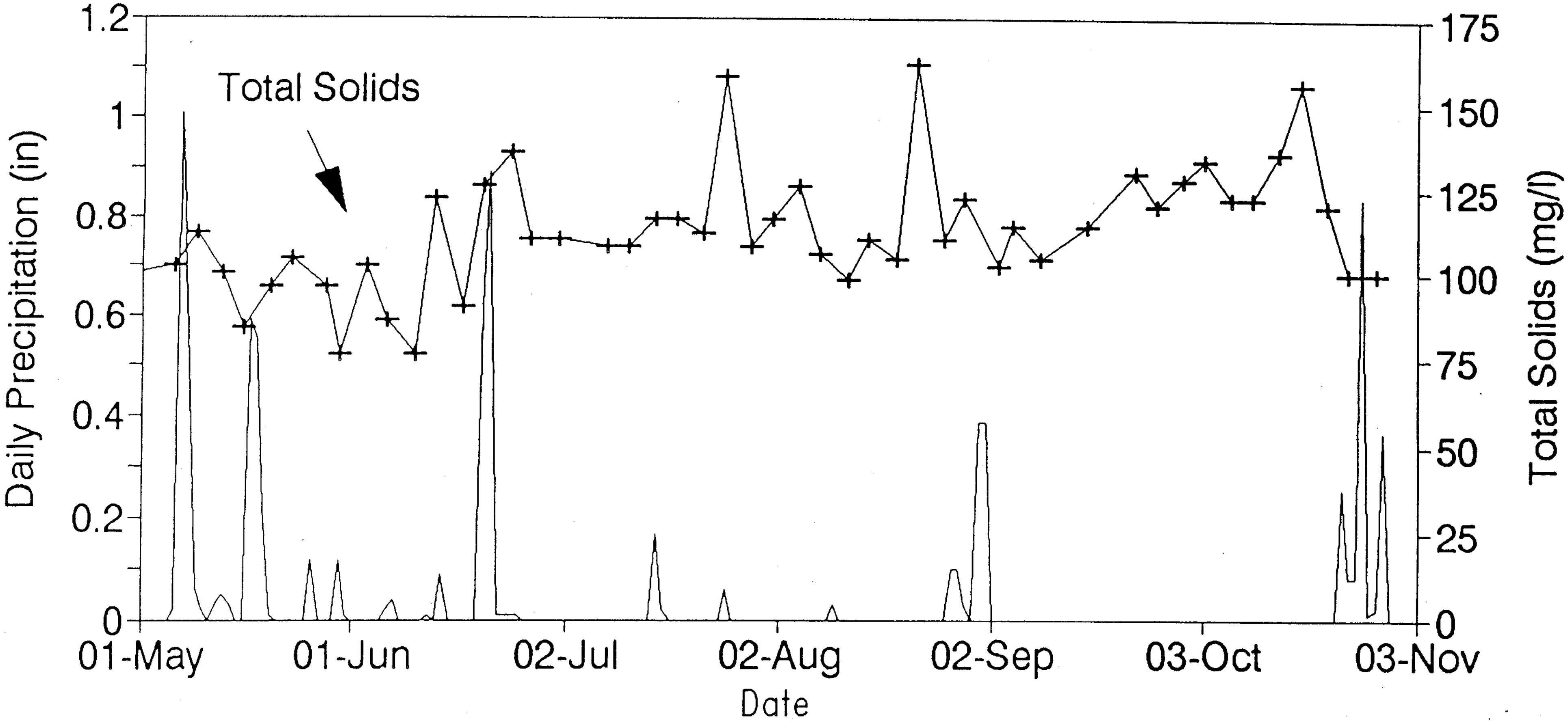


Figure 7

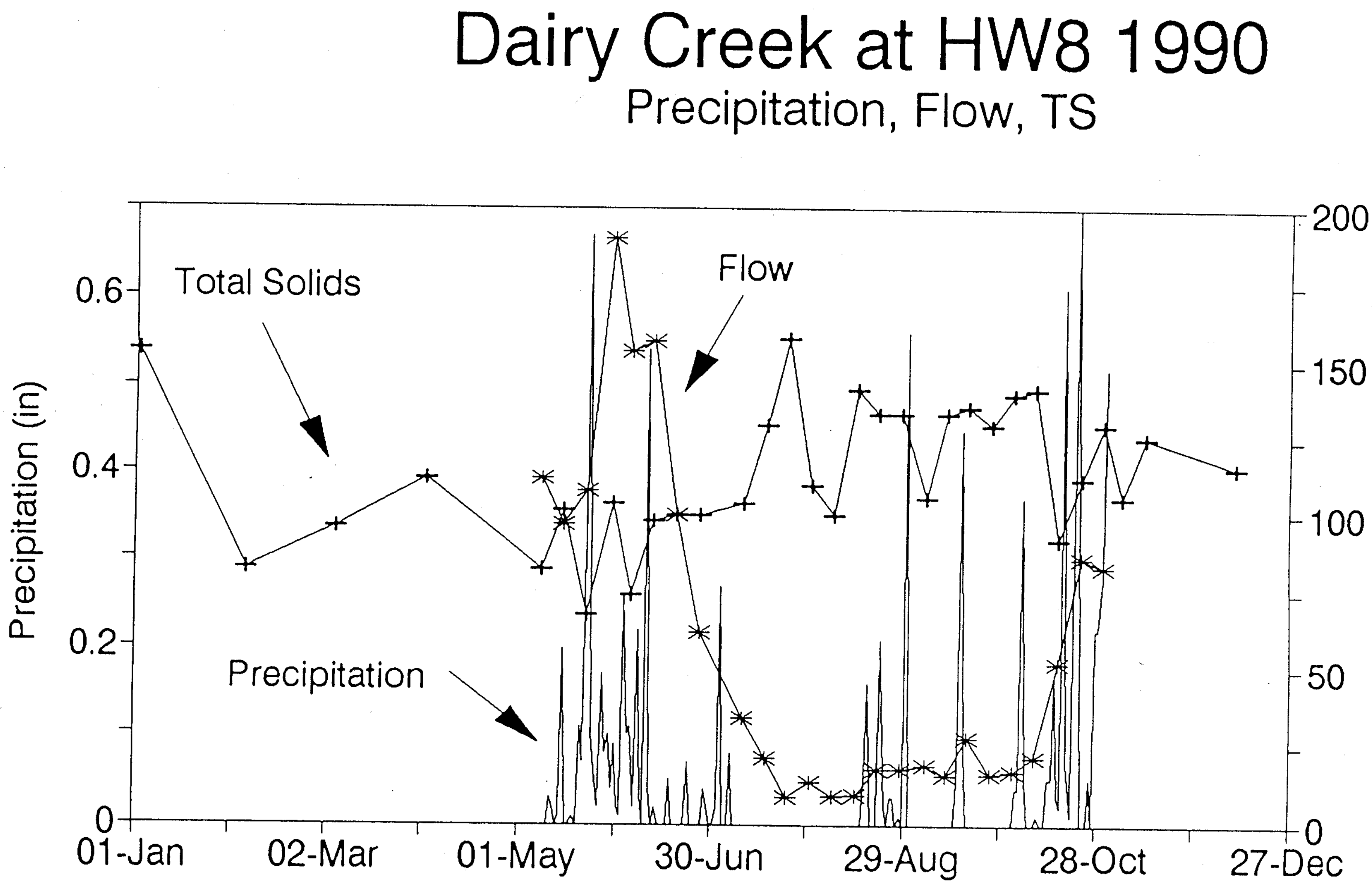

Dairy Creek at HW8 1990
Precipitation, Flow, TS
Total Solids
Flow
Precipitation
Precipitation (in)
Total Solids (mg/l) Flow (cfs)
0.6
0.4
0.2
0
200
150
100
50
0
01-Jan
02-Mar
01-May
30-Jun
29-Aug
28-Oct
27-Dec

Figure 8

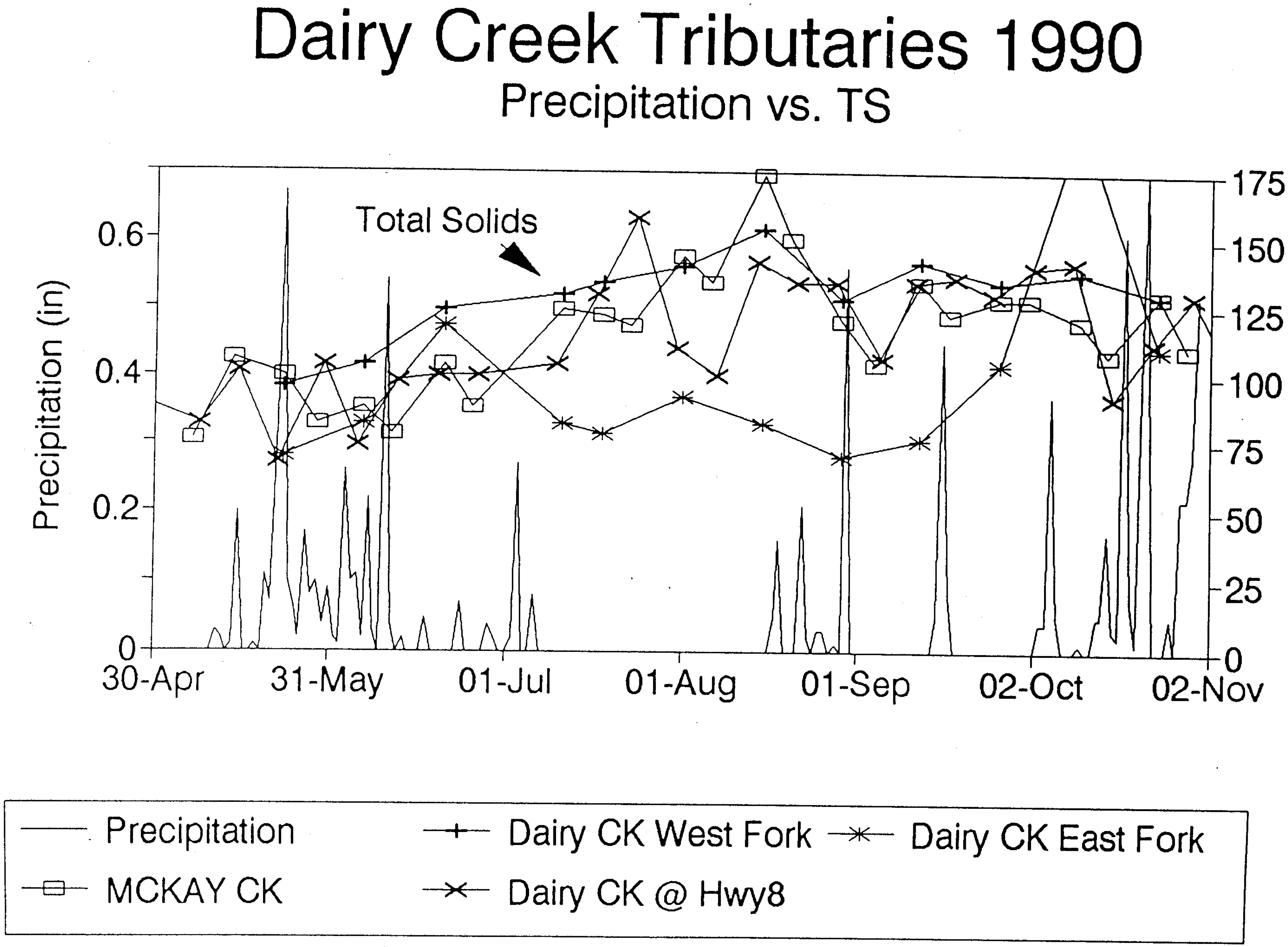

Dairy Creek Tributaries 1990
Precipitation vs. TS
Total Solids
Precipitation (in)
Total Solids (mg/l)
0
0.2
0.4
0.6
0
25
50
75
100
125
150
175
30-Apr
31-May
01-Jul
01-Aug
01-Sep
02-Oct
02-Nov
Precipitation
Dairy CK West Fork
Dairy CK East Fork
MCKAY CK
Dairy CK @ Hwy8

Figure 9

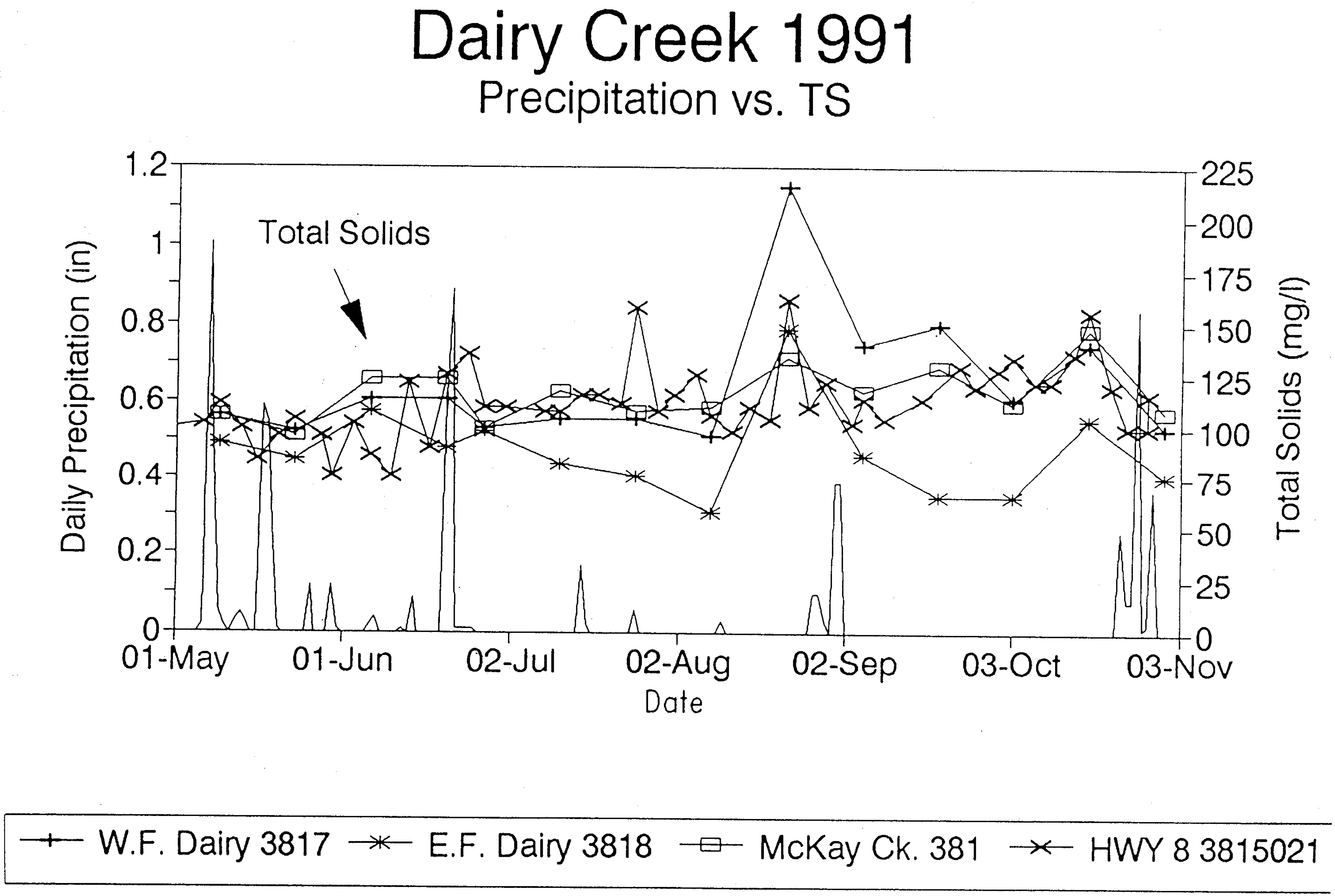

Dairy Creek 1991
Precipitation vs. TS
Total Solids
Daily Precipitation (in)
Total Solids (mg/l)
1.2
1
0.8
0.6
0.4
0.2
0
225
200
175
150
125
100
75
50
25
0
01-May
01-Jun
02-Jul
02-Aug
02-Sep
03-Oct
03-Nov
Date
W.F. Dairy 3817
E.F. Dairy 3818
McKay Ck. 381
HWY 8 3815021

Figure 10

West Fork Dairy Creek 1991

Precipitation vs. TS

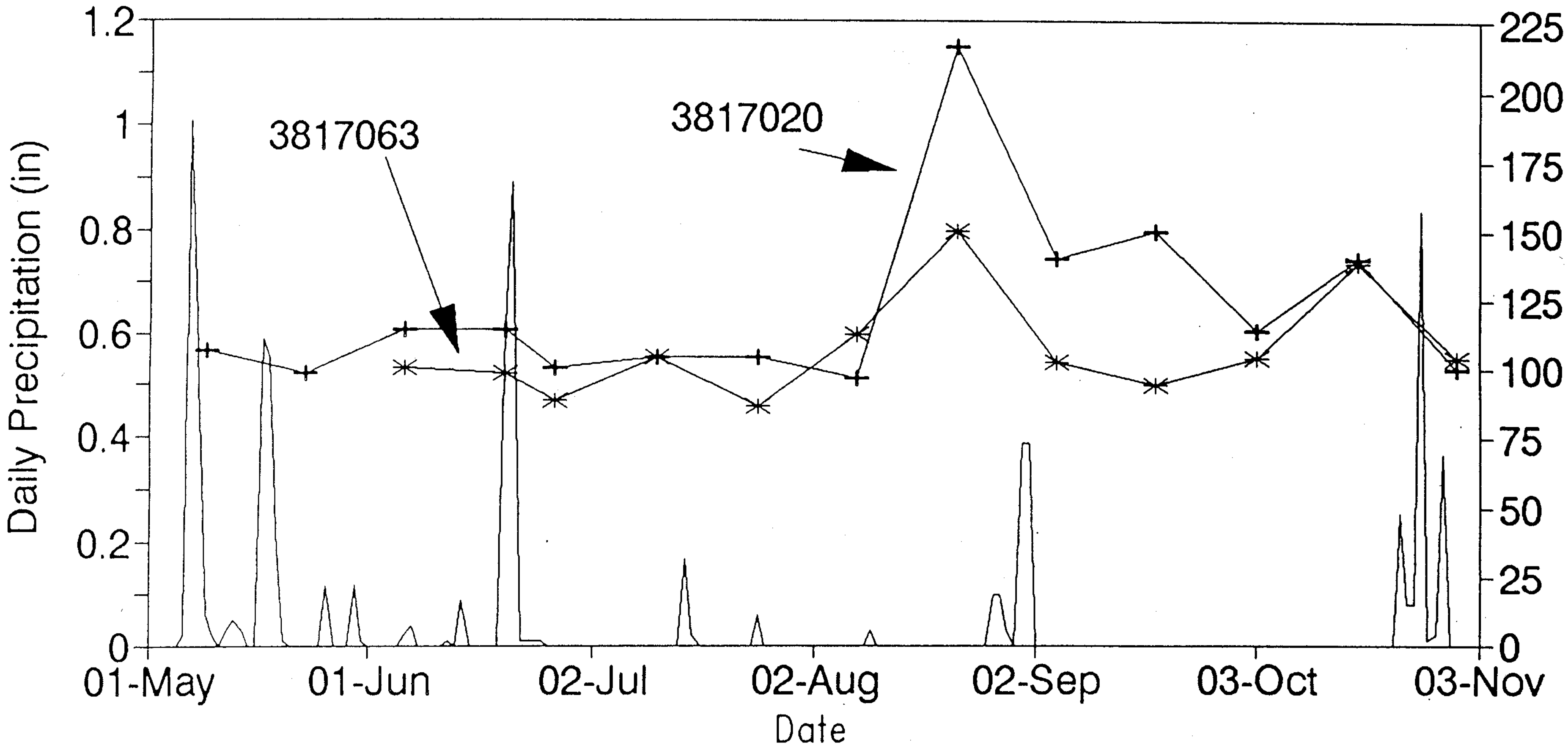


Figure 11

East Fork Dairy Creek, 1991

Precipitation vs. TS

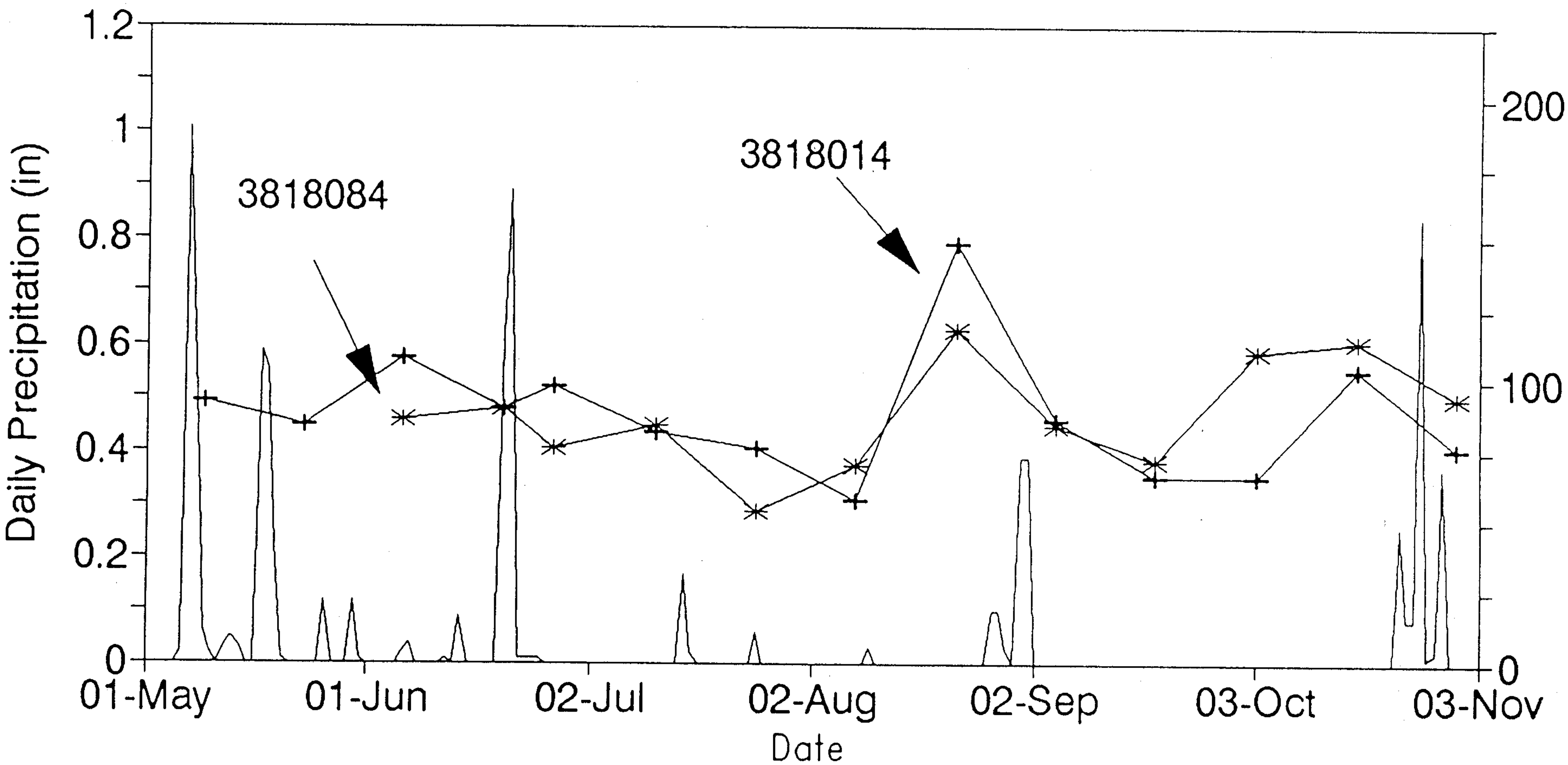


Figure 12

McKay Creek, 1991

Precipitation vs. TS

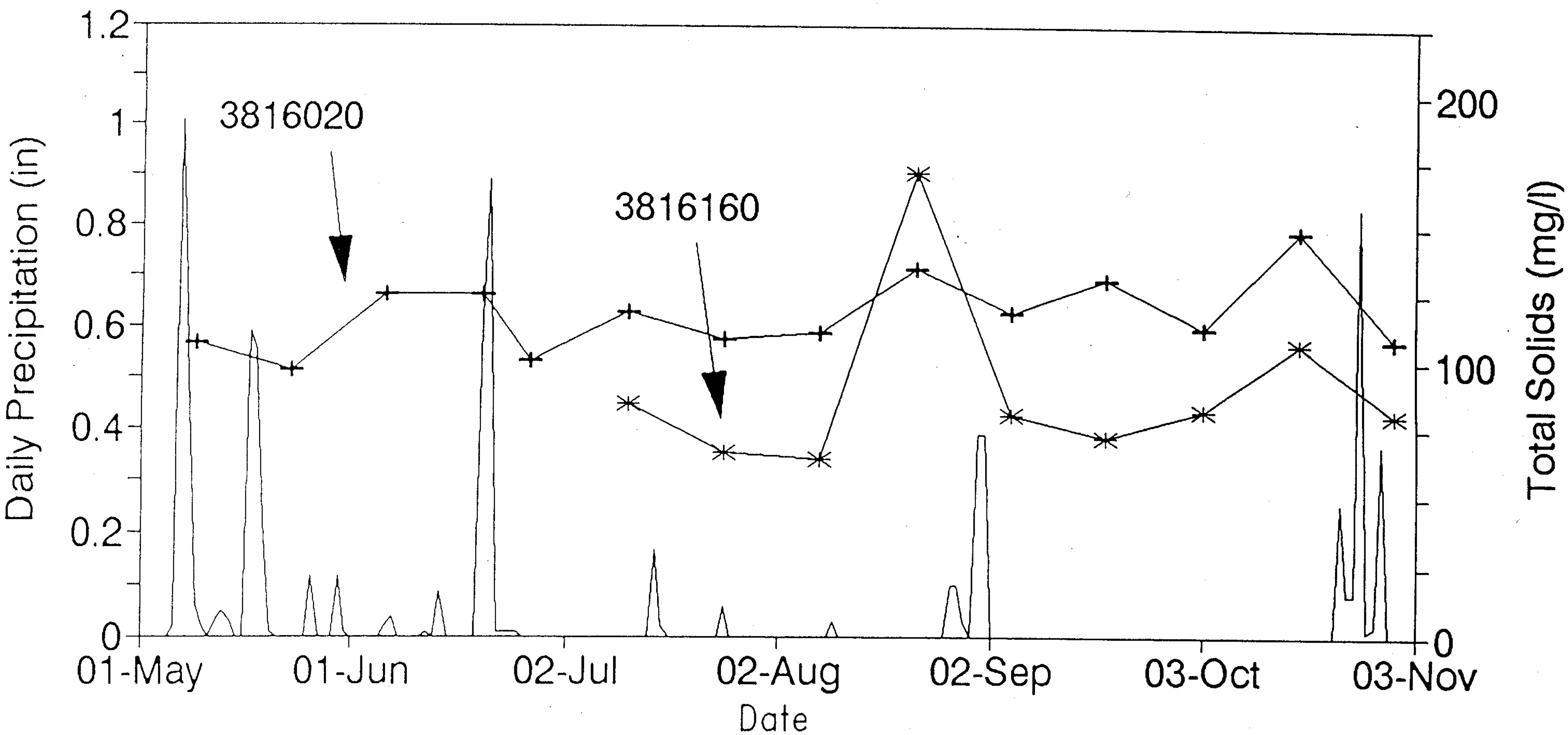


Figure 13

Dairy Creek at HW8 1990

TS, TDS vs. T-PO4-P & OPO4

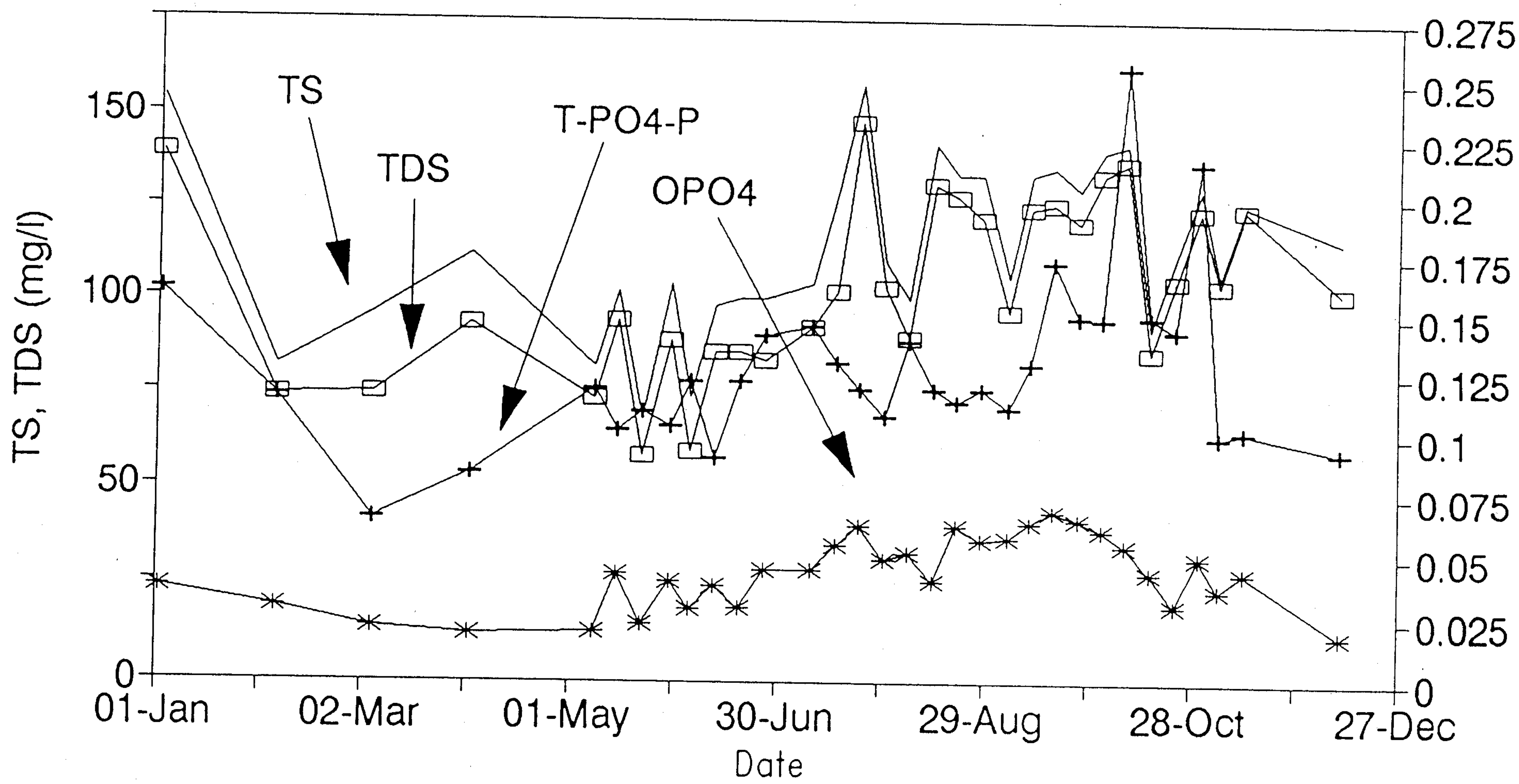


Figure 14

Dairy Creek at HW8, 1991-1992

TS & TDS vs. T-PO4-P & S-OPO4-P

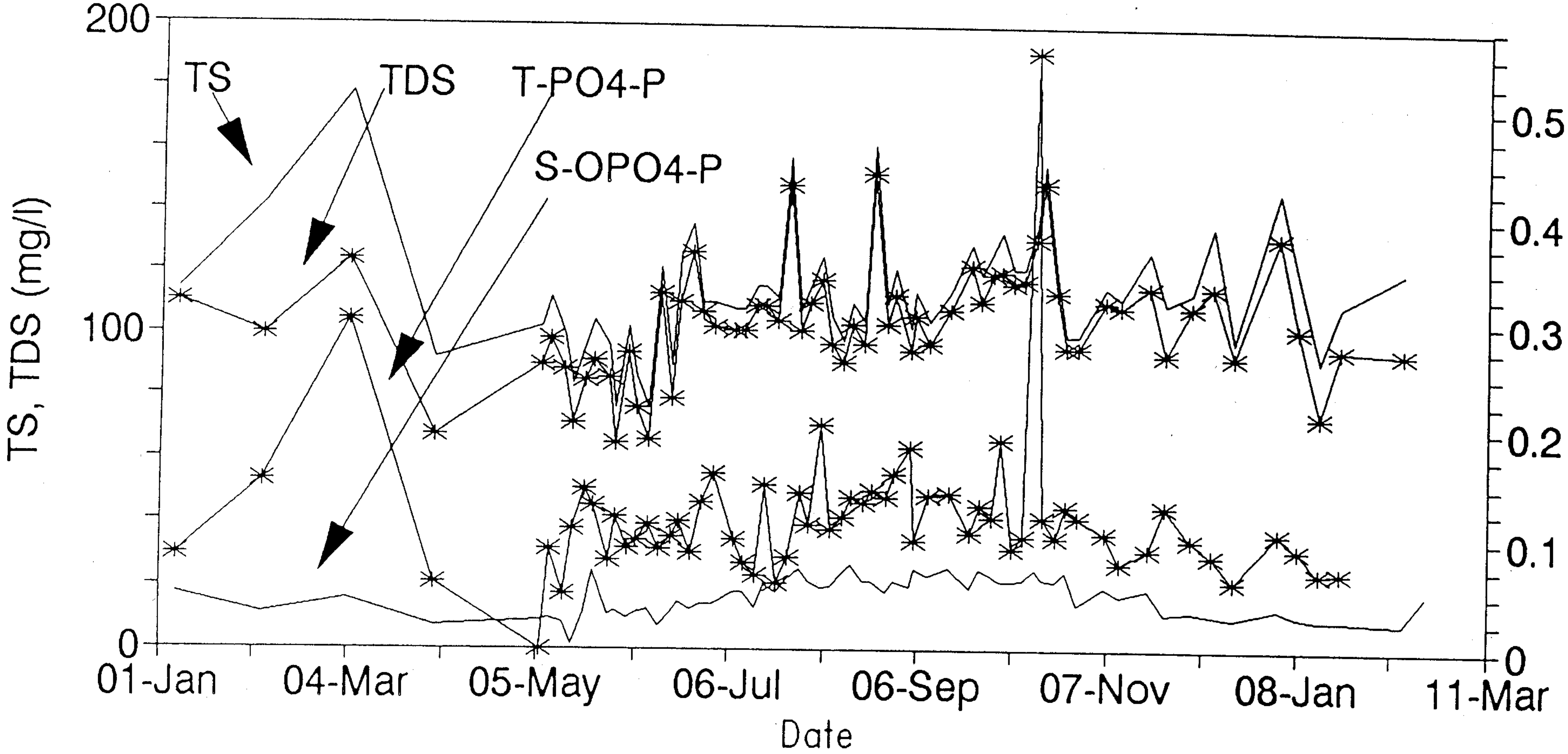


Figure 15

West Fork Dairy Creek, 1991

TS vs. T-PO4

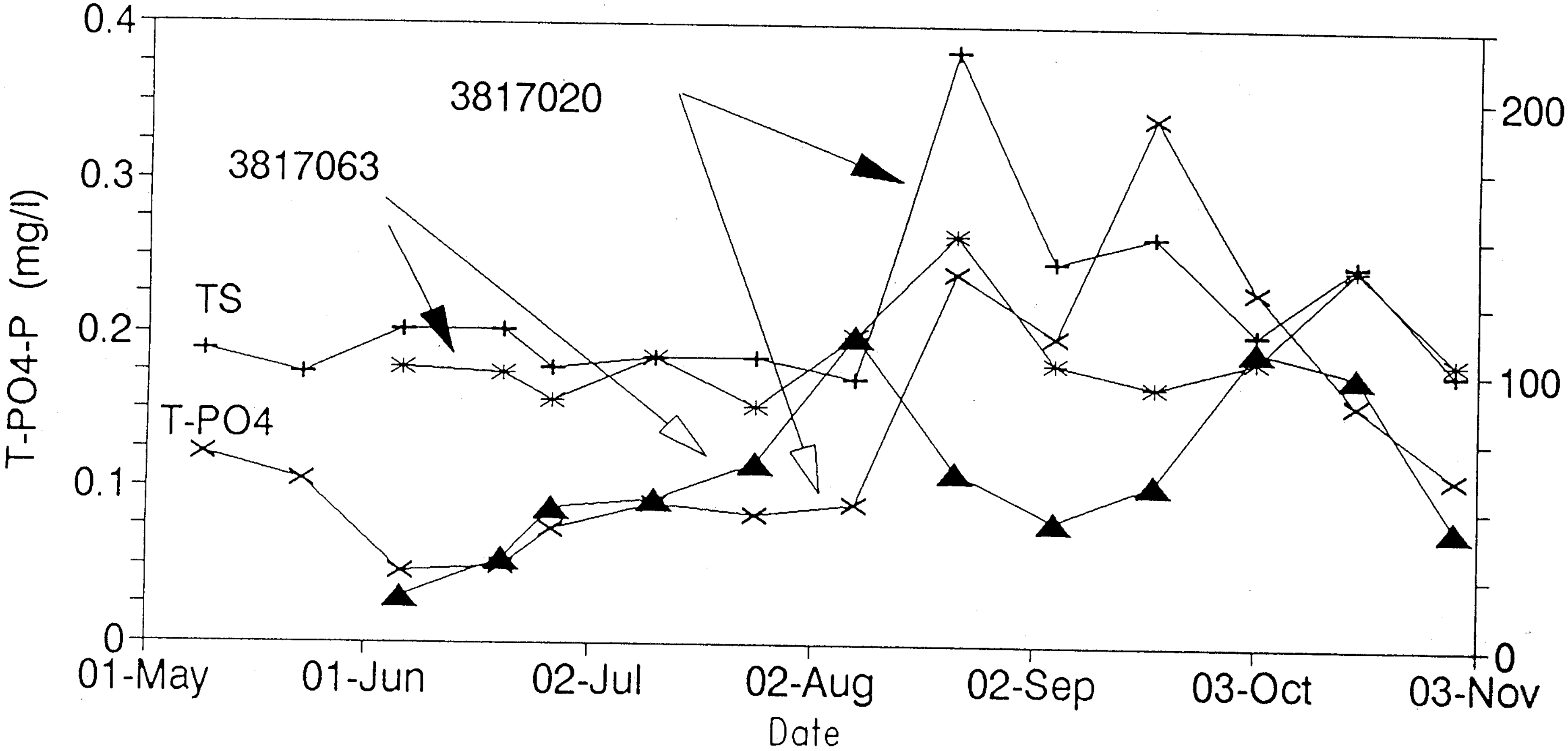


Figure 16

East Fork Dairy Creek, 1991

TS vs. T-PO4

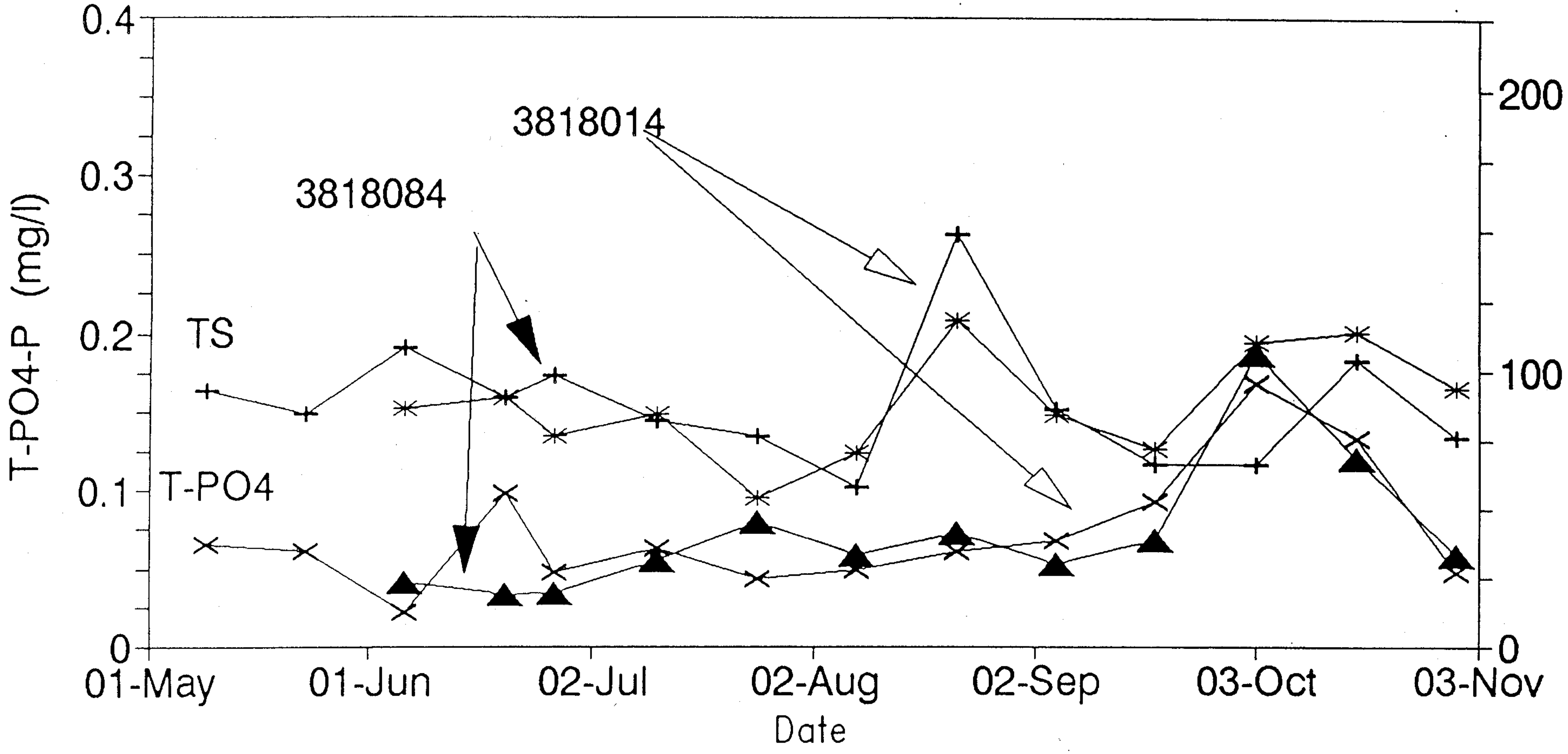


Figure 17

McKay Creek, 1991

TS vs. T-PO4

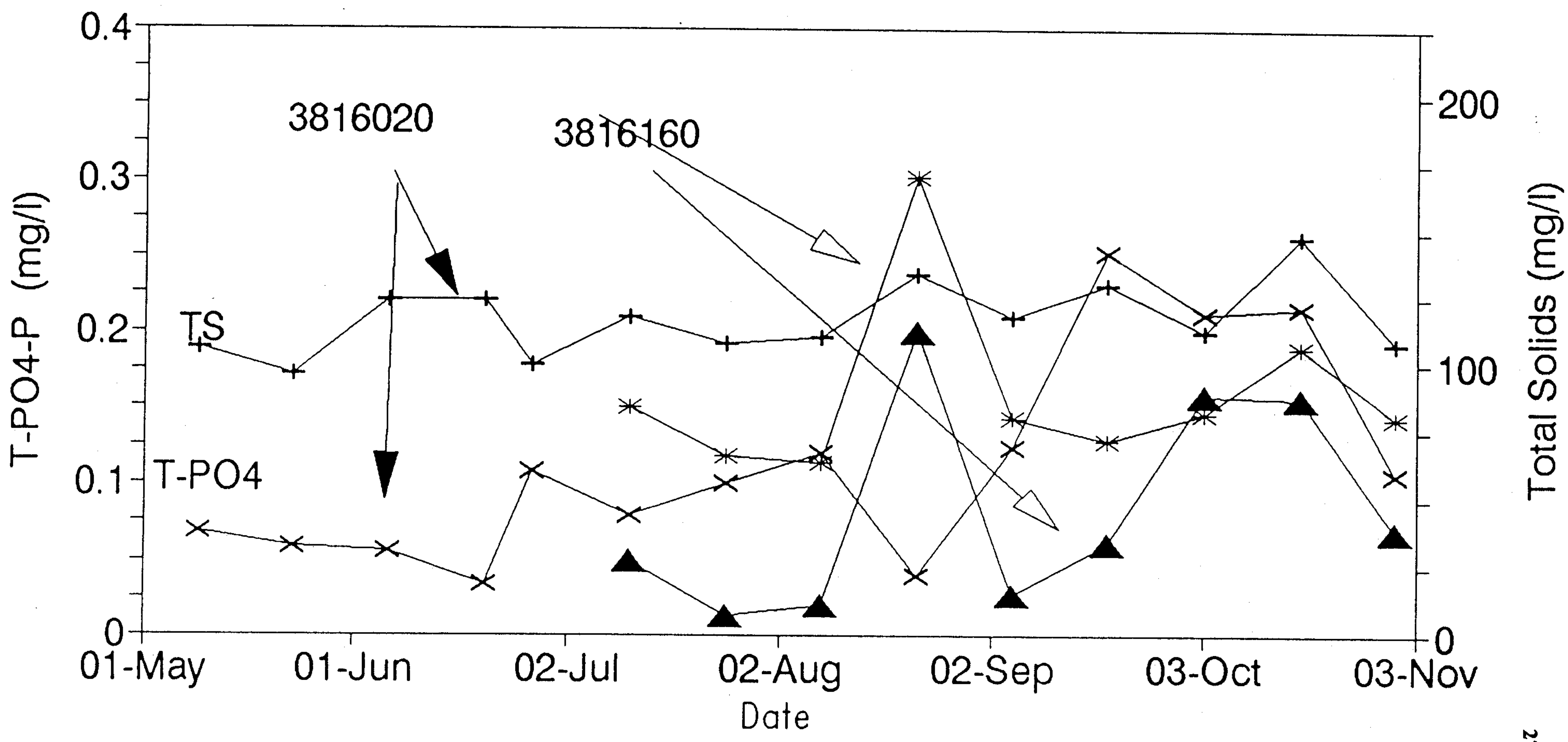


Figure 18

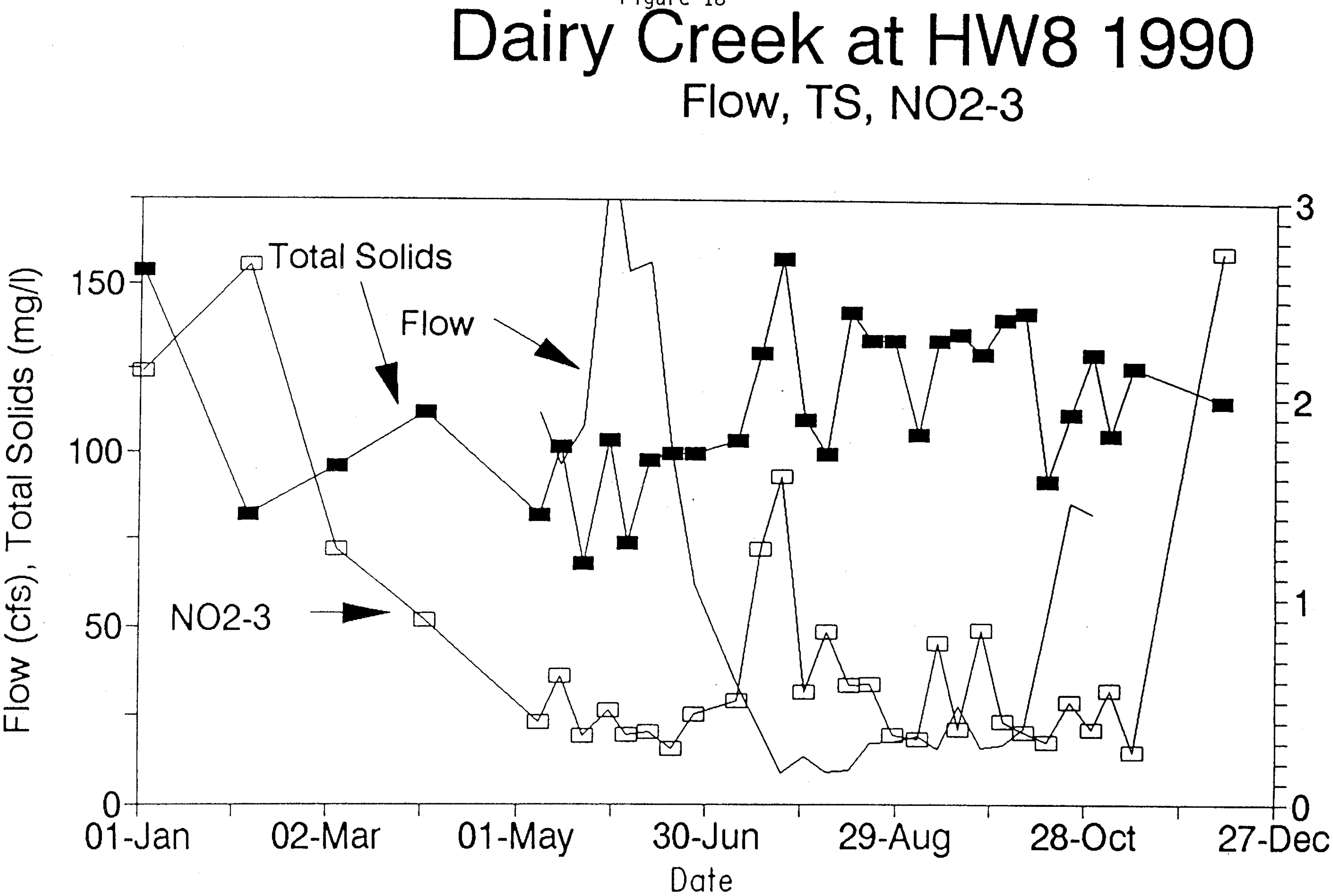

Dairy Creek at HW8 1990
Flow, TS, NO2-3
Total Solids
Flow
NO2-3
Flow (cfs), Total Solids (mg/l)
NO2-3 (mg/l)
150
100
50
0
3
2
1
0
01-Jan
02-Mar
01-May
30-Jun
29-Aug
28-Oct
27-Dec
Date

Figure 19

Dairy Creek at HWY 8, 1991

Flow vs. TS, NO2-3

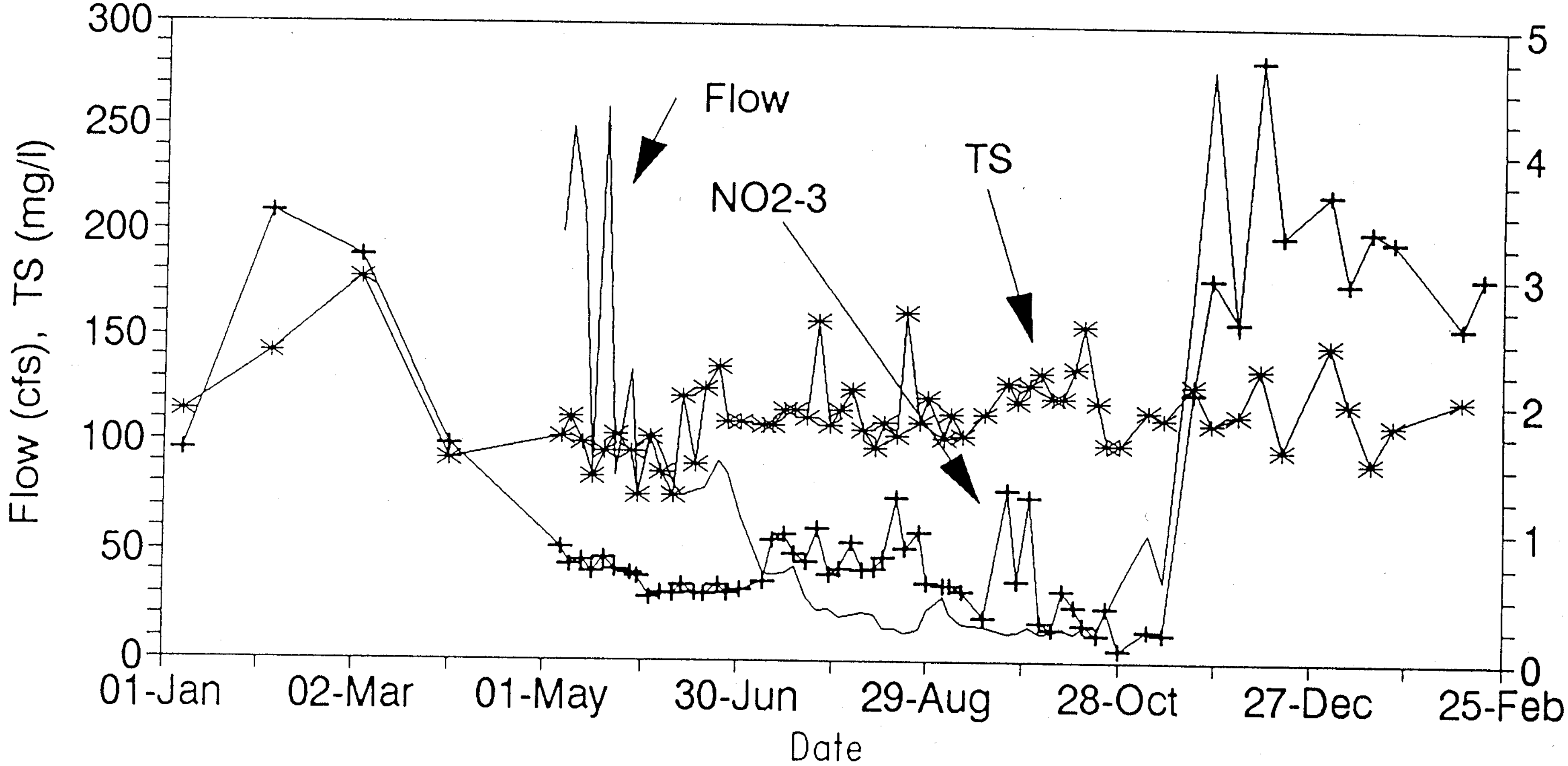


Figure 20

West Fork Dairy Creek, 1991

TS vs. NO2-3

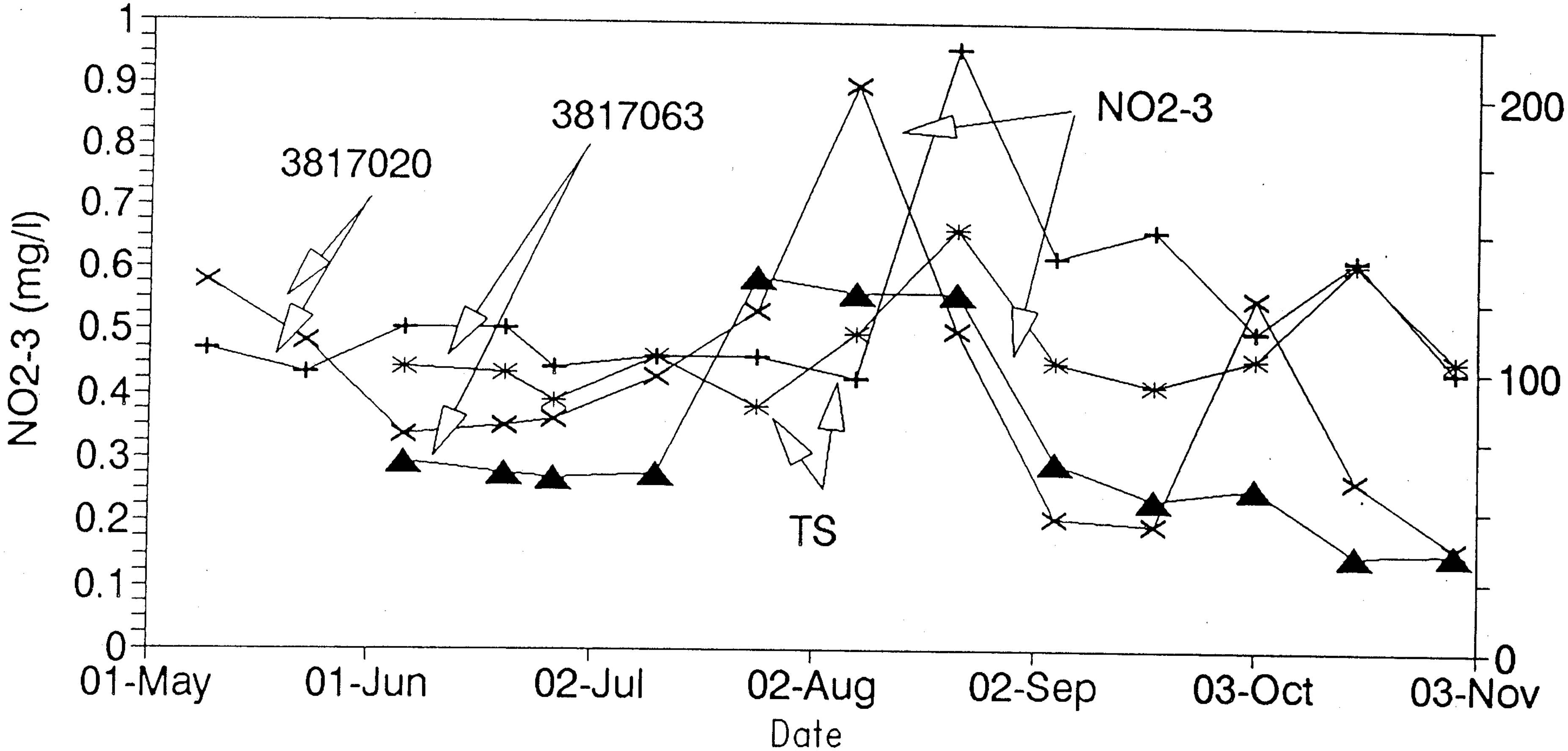


Figure 21

East Fork Dairy Creek, 1991

TS vs. NO2-3

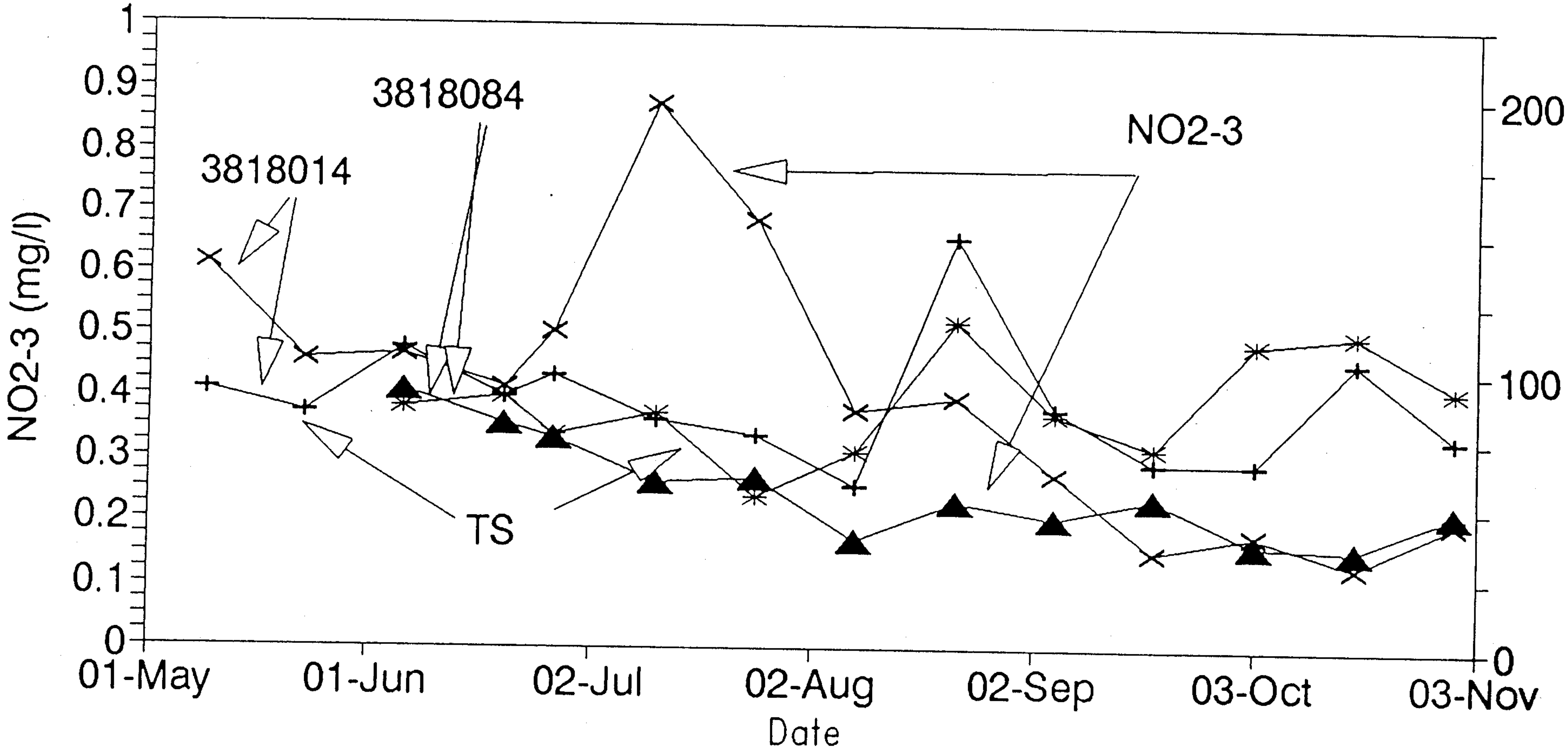


Figure 22

McKay Creek, 1991

TS vs. NO2-3

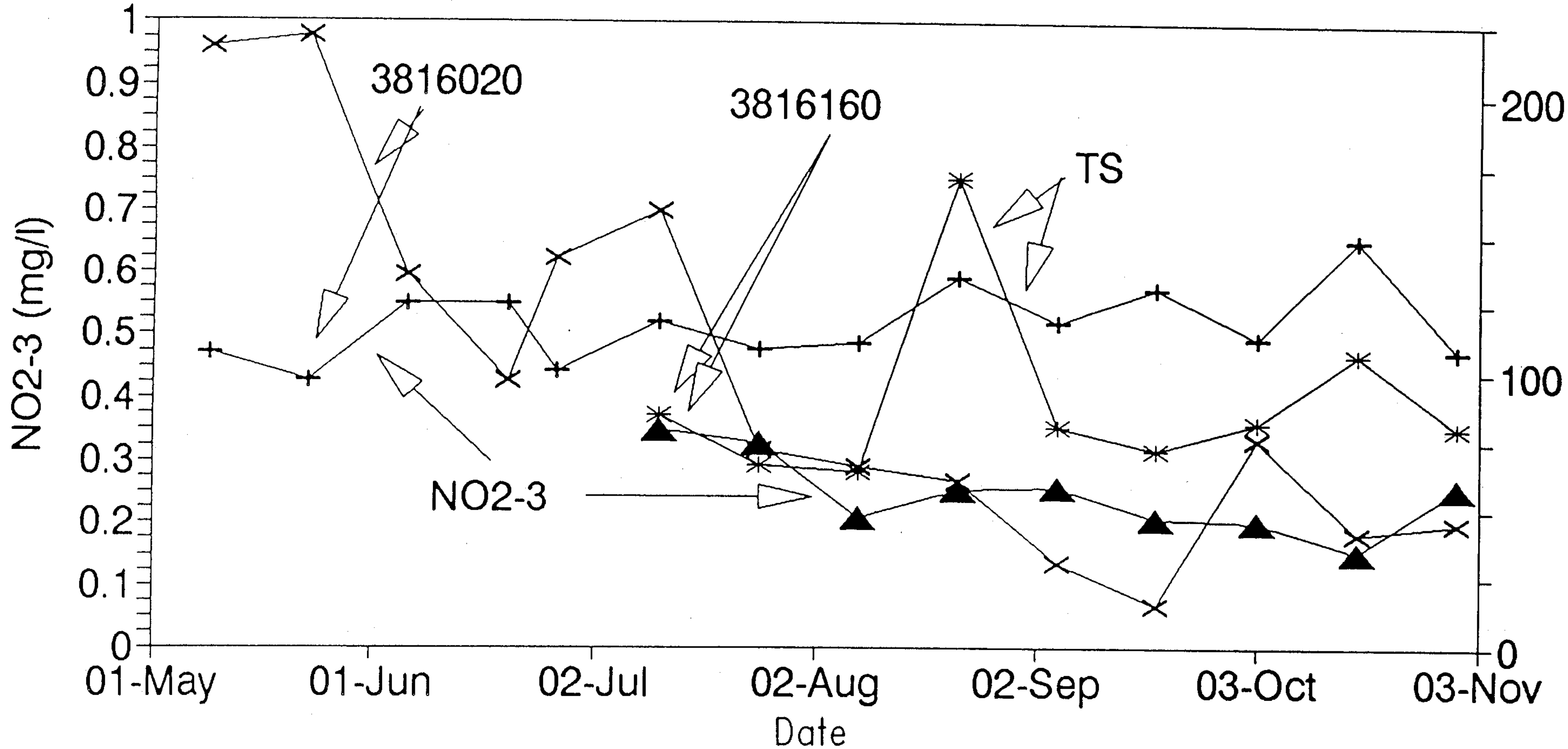


Figure 23

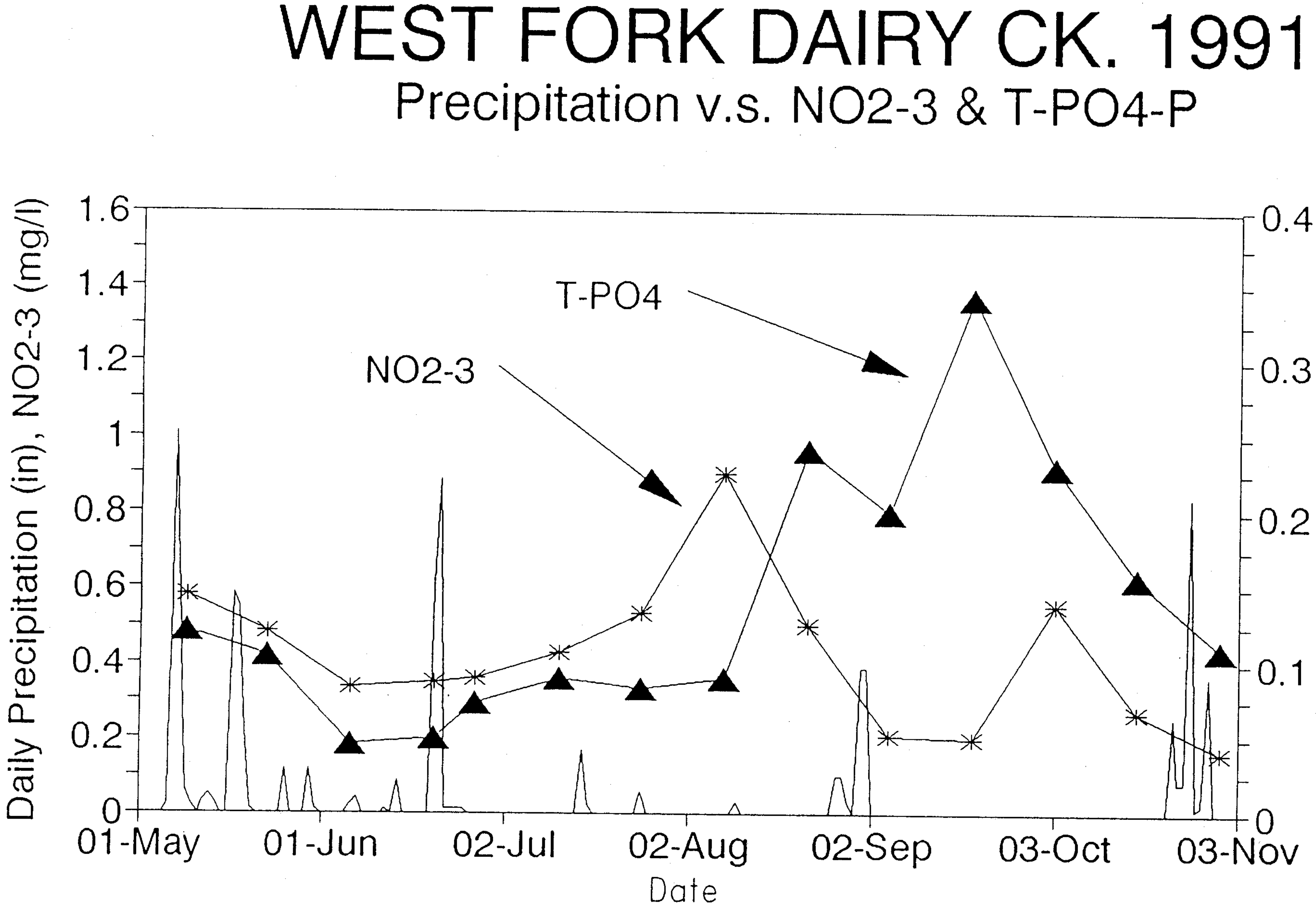

WEST FORK DAIRY CK. 1991
Precipitation v.s. NO2-3 & T-PO4-P
Daily Precipitation (in), NO2-3 (mg/l)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
T-PO4
NO2-3
0.4
0.3
0.2
0.1
0
T-PO4-P (mg/l)
01-May
01-Jun
02-Jul
02-Aug
02-Sep
03-Oct
03-Nov
Date

Figure 24

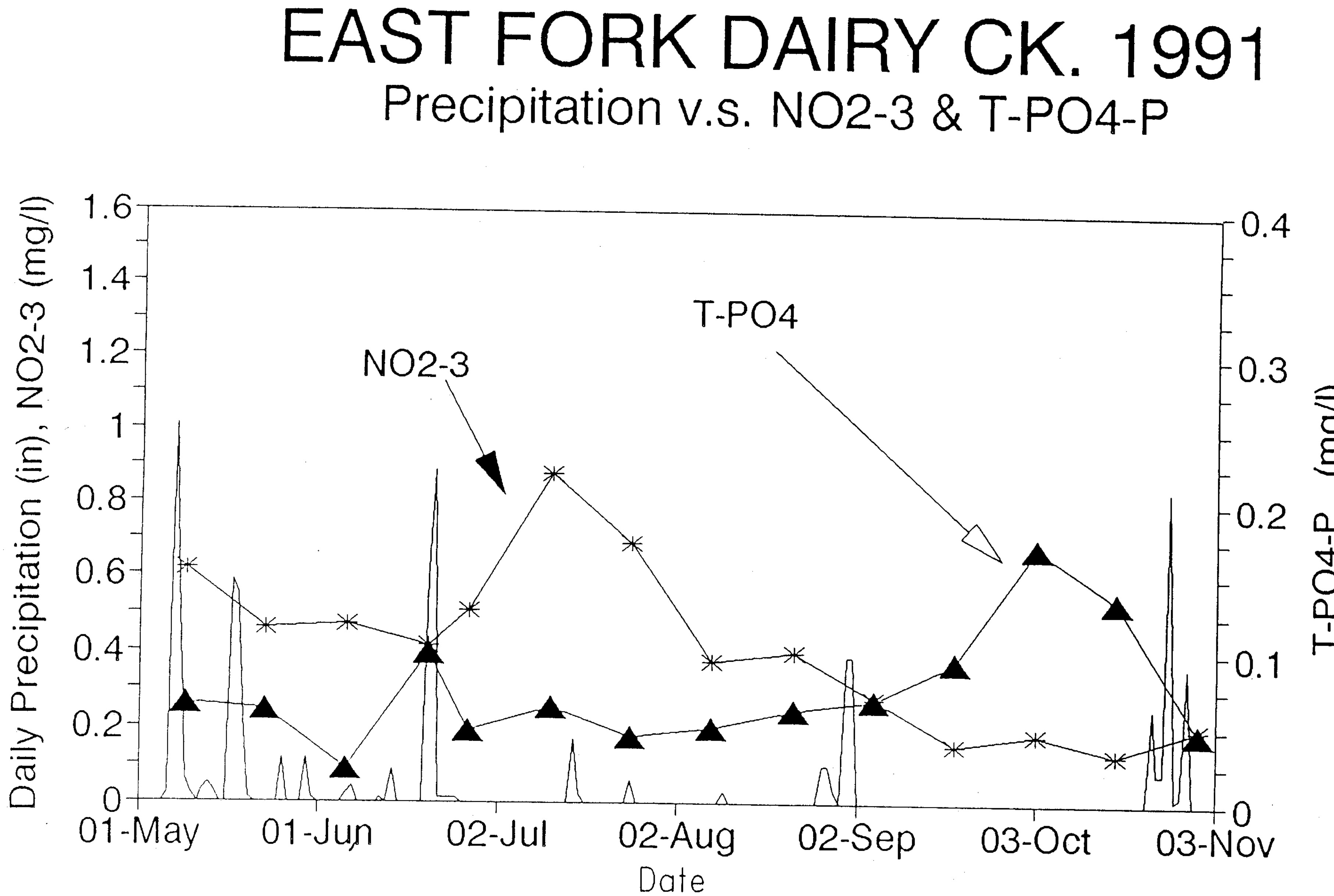

EAST FORK DAIRY CK. 1991
Precipitation v.s. NO2-3 & T-PO4-P
Daily Precipitation (in), NO2-3 (mg/l)
T-PO4-P (mg/l)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.4
0.3
0.2
0.1
0
NO2-3
T-PO4
01-May
01-Jun
02-Jul
02-Aug
02-Sep
03-Oct
03-Nov
Date

Figure 25

MCKAY CREEK, 1991

Precipitation v.s. NO2-3 & T-PO4-P

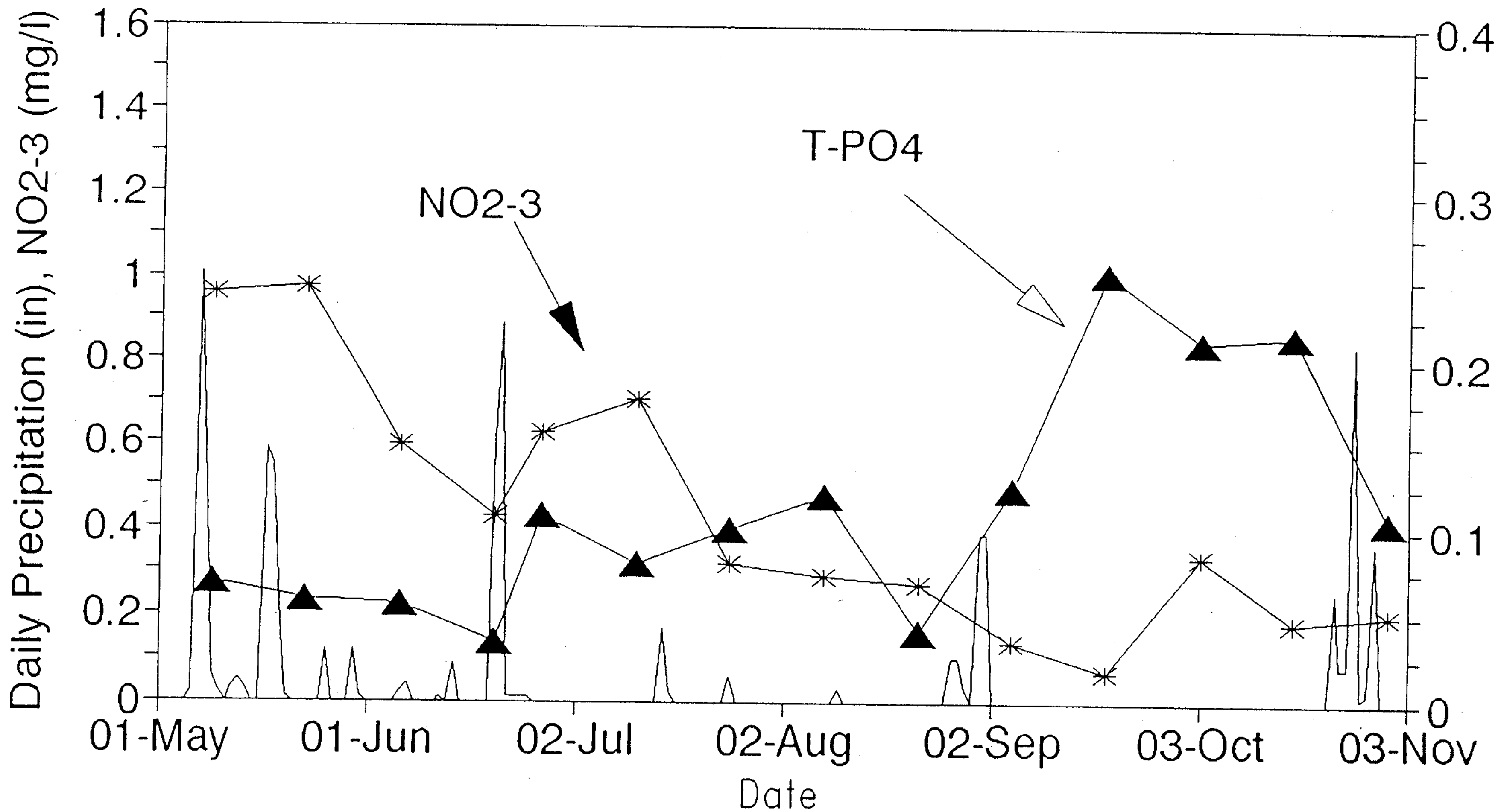


Figure 26

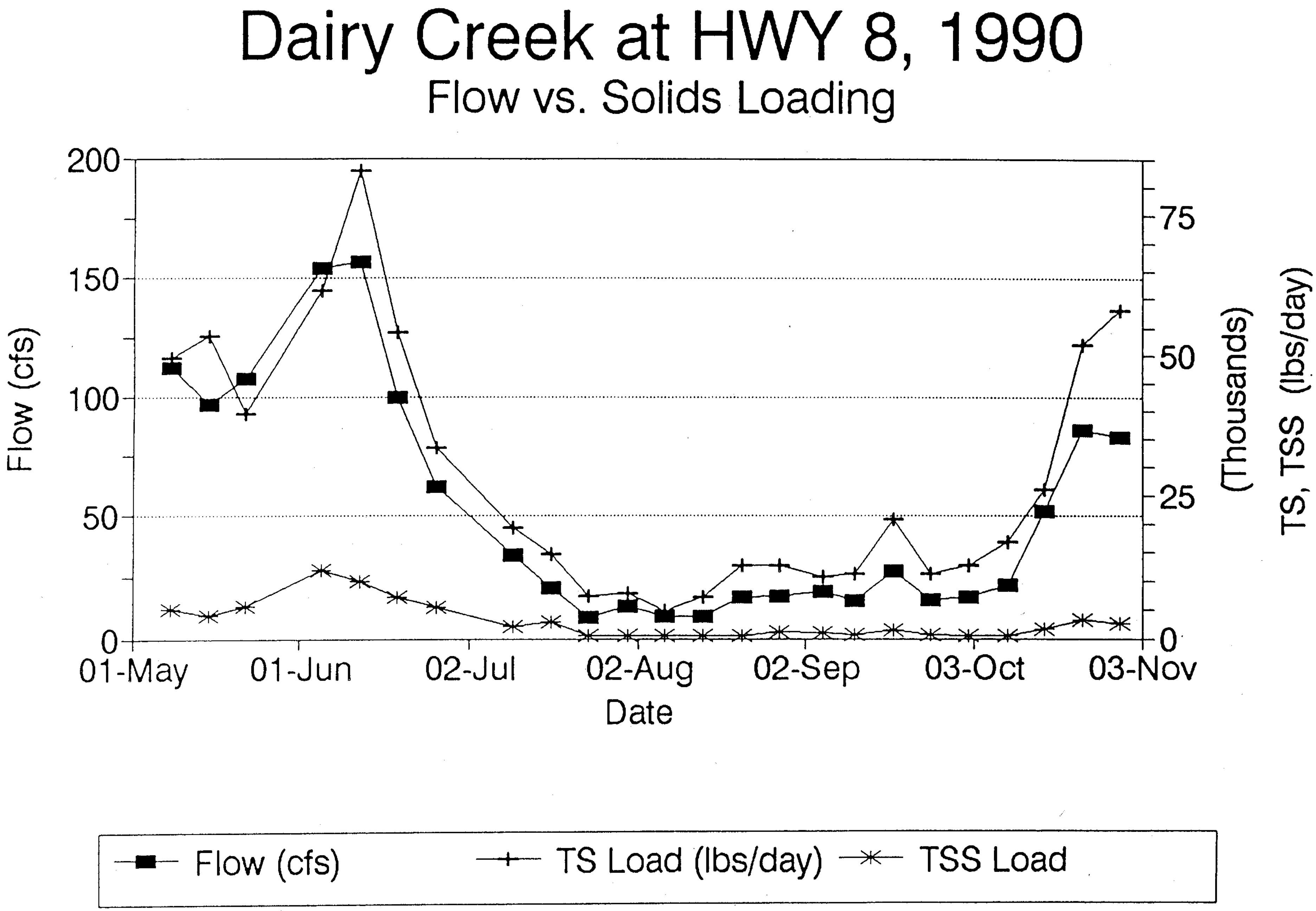

Dairy Creek at HWY 8, 1990
Flow vs. Solids Loading
200
150
100
50
0
Flow (cfs)
75
50
25
0
(Thousands)
TS, TSS (lbs/day)
01-May
01-Jun
02-Jul
02-Aug
02-Sep
03-Oct
03-Nov
Date
Flow (cfs)
TS Load (lbs/day)
TSS Load

Figure 27

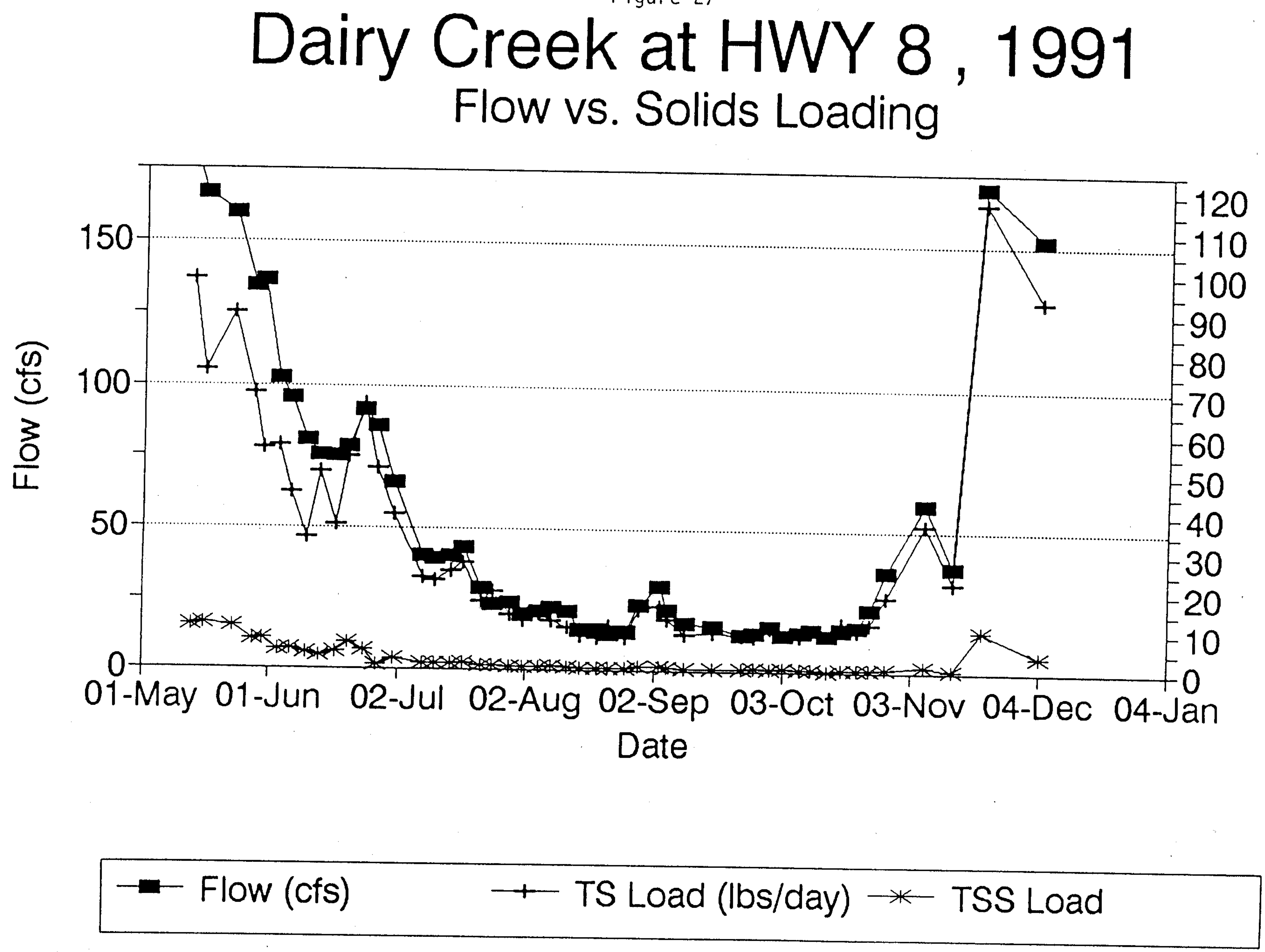

Dairy Creek at HWY 8 , 1991
Flow vs. Solids Loading
Flow (cfs)
150
100
50
0
120
110
100
90
80
70
60
50
40
30
20
10
0
(Thousands)
TS, TSS (lbs/day)
01-May
01-Jun
02-Jul
02-Aug
02-Sep
03-Oct
03-Nov
04-Dec
04-Jan
Date
Flow (cfs)
TS Load (lbs/day)
TSS Load

Figure 28

Dairy Creek at HWY 8, 1990
Flow vs. Phosphate Loading

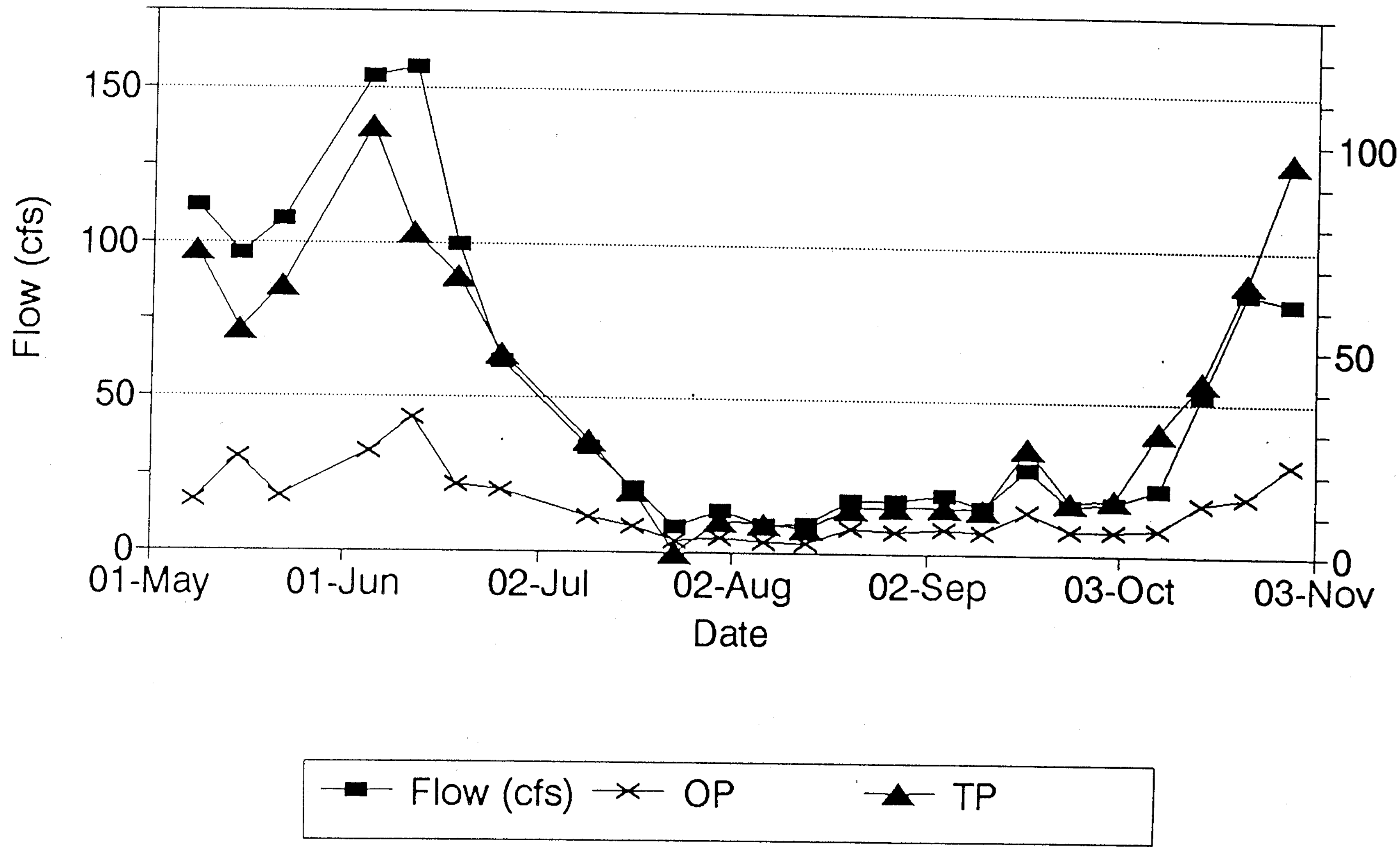


Figure 29

Dairy Creek at HWY 8, 1991

Flow v.s Phosphate Loading

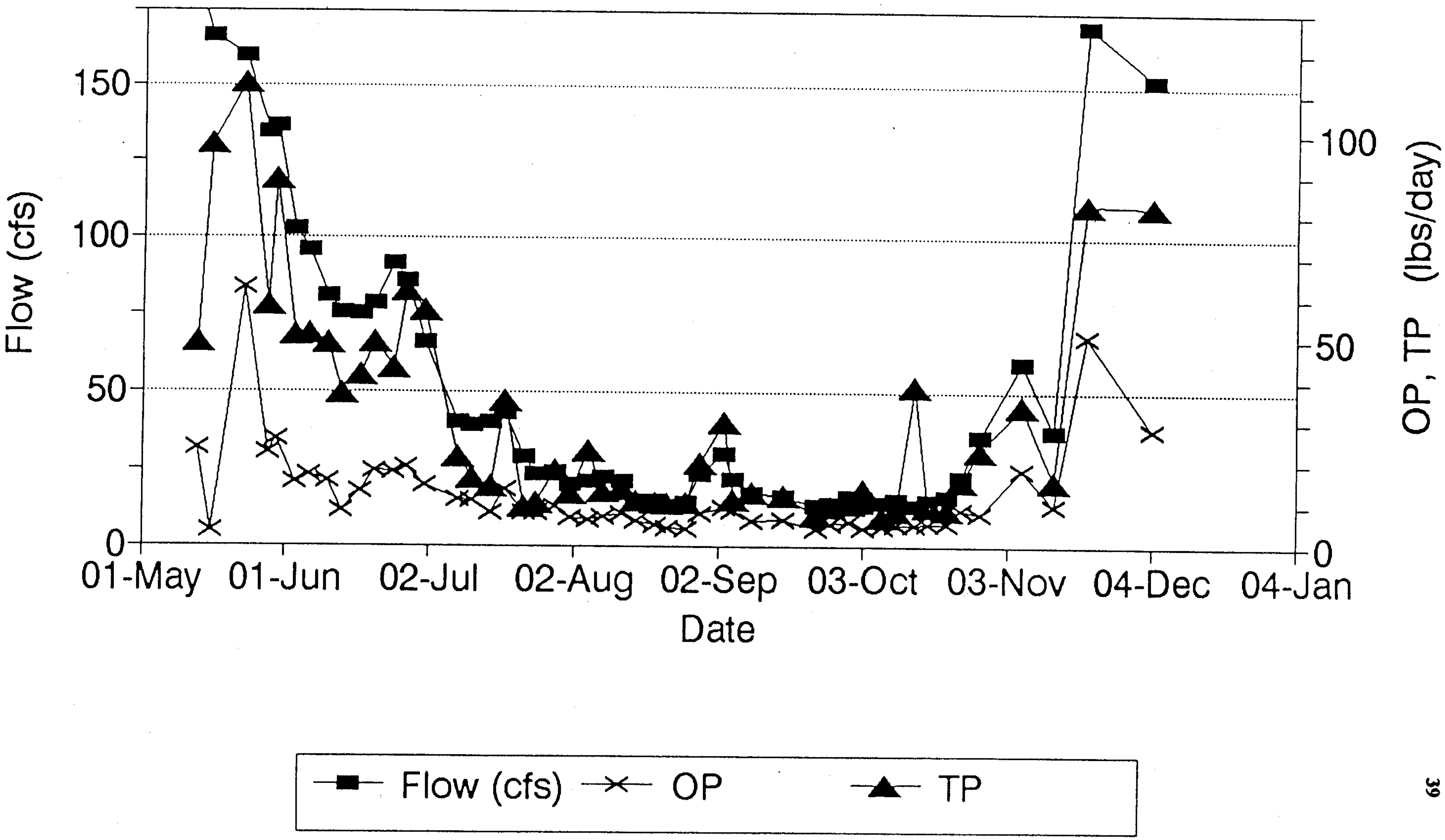


Figure 30

Dairy Creek at HWY 8, 1990

Flow vs. Nitrogen Loading

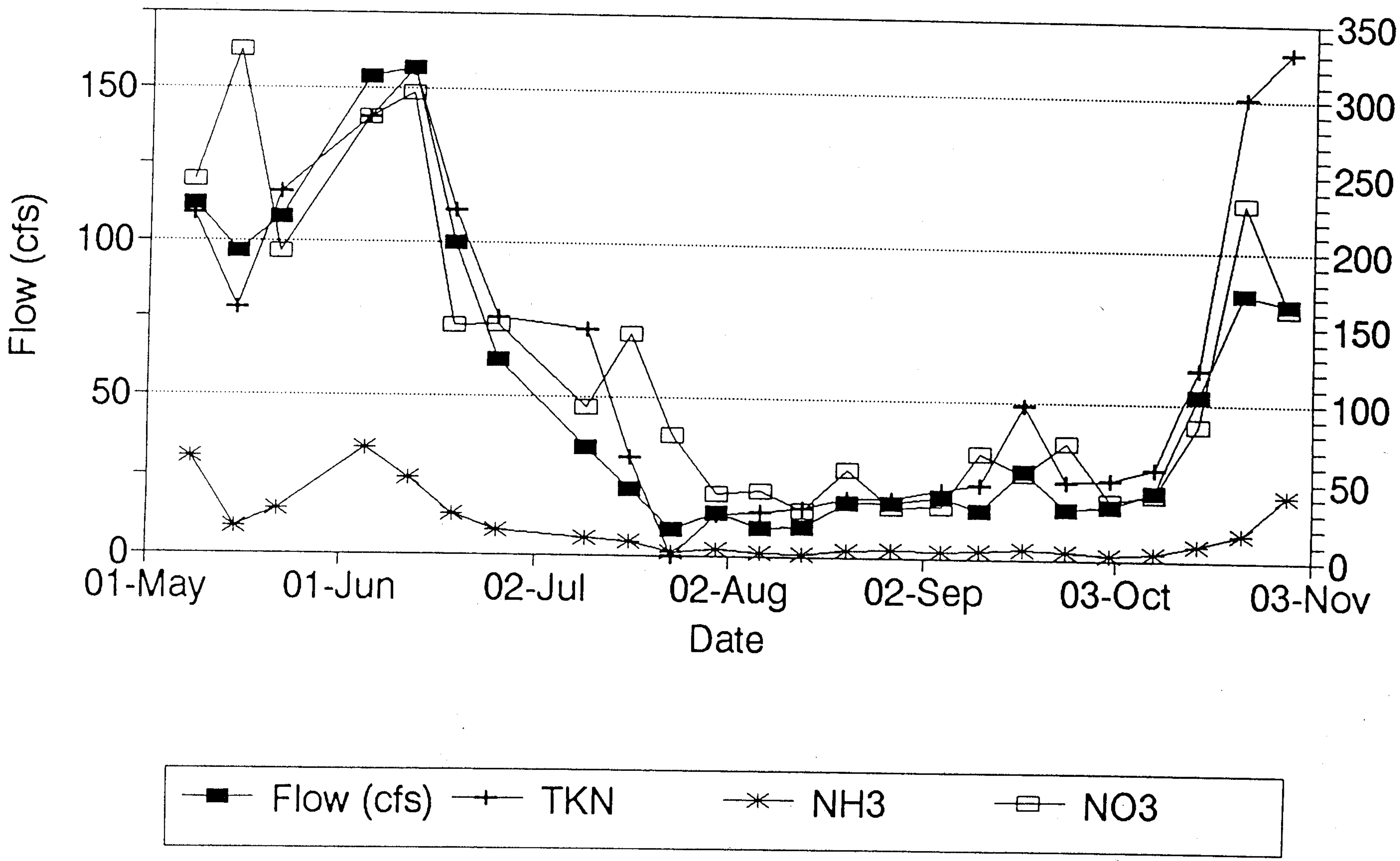


Figure 31

Dairy Creek at HWY 8, 1991

Flow vs. Nitrogen Loading

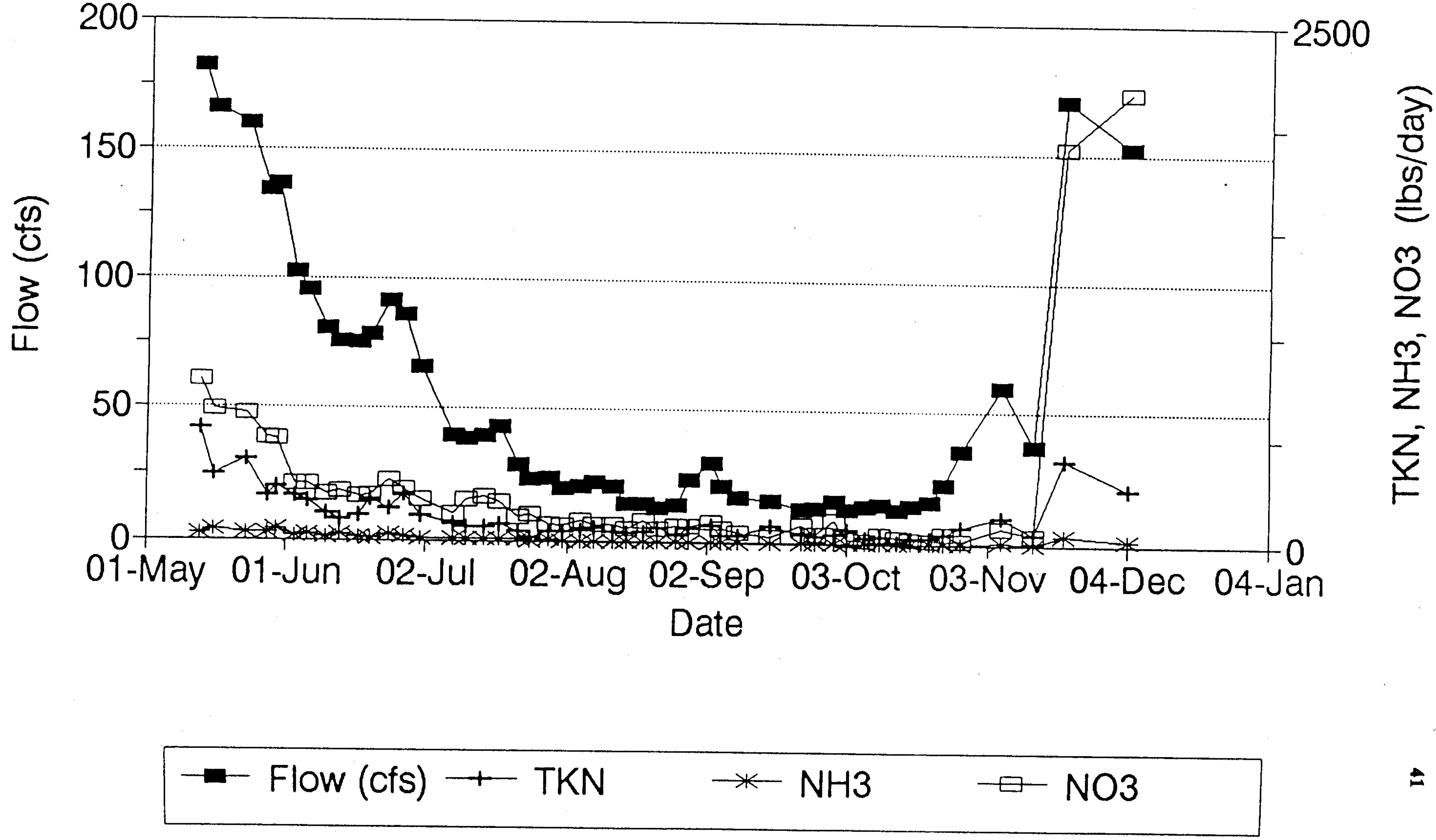
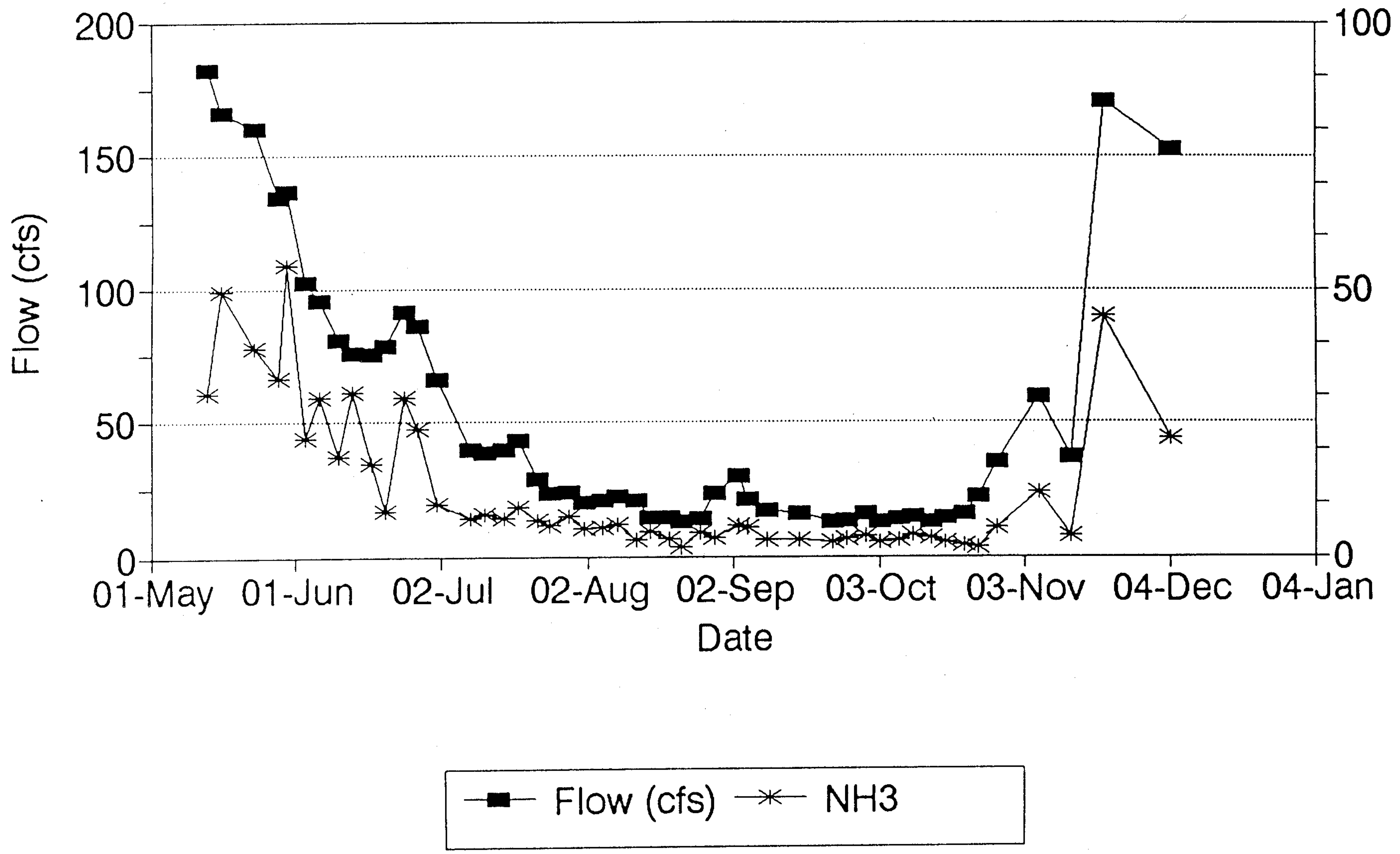


Figure 32

Dairy Creek at HWY 8, 1991

Flow vs. NH3 Loading



APPENDIX I - WATER QUALITY DATA DAIRY CREEK, 1990

WEST FK
3817063

YYMMD	GAUGE H	TS	TDS	TSS	NH3-N	TKN	NO2NO3-	T-PO4-P	S-OPO4-P
900523	999999	96	88.4	7.6	0.065	0.5	0.2	0.098	0.034
900606	999999	96	87	9	0.078	0.4	0.3	0.073	0.011
900620	999999	114	105	8.66	0.049	0.19	0.19	0.091	0.024
900711	999999	110	93	17	0.057	0.26	0.263	0.094	0.029
900718	999999	108	102	5.76	0.064	0.34	0.473	0.1	0.047
900801	999999	136	119	17.1	0.06	0.43	0.729	0.11	0.022
900815	999999	120	110	10.2	0.035	0.46	0.333	0.107	0.038
900829	999999	96	88.6	7.4	0.053	0.5	0.218	0.089	0.04
900912	999999	114	108	5.76	0.082	0.4	0.241	0.125	0.048
900926	999999	138	125	13.1	0.133	0.8	0.151	0.148	0.054
901010	999999	120	115	5.4	0.083	0.5	0.11	0.13	0.035
901024	999999	130	122	8.44	0.048	0.4	0.518	0.13	0.022

WEST FK
3817020

YYMMDD	GAUGE_	TS	TDS	TSS	NH3-N	TKN	NO2NO3-	T-PO4-P	S-OPO4-P
900523	3	96	84.5	11.5	0.037	0.43	0.352	0.09	0.026
900606	2.6	104	93	10.8	0.049	0.46	0.442	0.08	0.021
900620	2	124	109	15.3	0.049	0.27	0.279	0.092	0.03
900711	1.6	130	102	27.8	0.068	0.35	0.408	0.102	0.039
900718	1.6	134	114	20.3	0.096	0.555	0.771	0.125	0.052
900801	1.6	140	121	18.9	0.067	0.61	0.541	0.147	0.031
900815	2	154	126	27.8	0.032	1.11	0.135	0.191	0.031
900829	1.17	128	103	25.2	0.11	1.22	0.223	0.135	0.04
900912	1.88	142	129	12.6	0.11	0.54	0.206	0.125	0.048
900926	1.44	134	120	13.8	0.093	0.54	0.198	0.139	0.051
901010	1.48	138	107	31	0.039	0.61	0.12	0.14	0.038
901024	1.87	130	120	10.2	0.037	0.45	0.54	0.14	0.025

MCKAY CK
3816020

YYMMDD	GAUGE_H	FLOW-INT	TS	TDS	TSS	NH3-N	TKN	NO2NO3-	T-PO4-P	S-OPO4-P
900507	999999	999999	76	71.8	4.22	0.04	0.3	0.491	0.05	0.029
900514	999999	999999	106	102	4.3	0.06	0.25	0.44	0.07	0.038
900523	999999	999999	100	95.5	4.5	0.05	0.4	0.352	0.084	0.033
900529	999999	999999	82	72.9	9.06	0.079	0.5	0.41	0.11	0.009
900606	3.98	1.76	88	81.8	6.18	0.038	0.31	0.453	0.069	0.022
900611	999999	999999	78	70	7.84	0.056	0.28	0.45	0.08	0.022
900620	999999	999999	104	98.8	5.2	0.038	0.2	0.339	0.102	0.032
900625	4.62	11.84	88	77.8	10.2	0.044	0.25	0.361	0.08	0.037
900711	999999	999999	124	112	12	0.069	0.29	0.406	0.098	0.071
900718	4.4	7.1	122	117	5.2	0.062	0.32	0.469	0.12	0.1
900723	4.08	2.62	118	110	7.96	0.067	0.4	0.337	0.129	0.1
900801	4	1.9	144	138	6.04	0.06	0.46	0.301	0.16	0.077
900806	4	1.9	134	125	8.88	0.055	0.55	0.188	0.139	0.061
900815	3.94	1.47	174	165	8.72	0.037	0.86	0.273	0.202	0.06
900820	4.16	3.51	150	132	18.1	0.051	0.54	0.291	0.141	0.064
900829	4.19	3.86	120	113	6.76	0.058	0.5	0.177	0.122	0.074
900904	4.18	3.74	104	98	5.56	0.056	0.45	0.386	0.148	0.098
900912	4.09	2.72	134	129	5.04	0.065	0.38	0.298	0.158	0.088
900917	4.44	7.86	122	114	7.96	0.079	1.09	0.379	0.18	0.11
900926	4.08	2.62	128	122	6.12	0.074	0.42	0.232	0.16	0.079
901001	4.12	3.04	128	125	3.36	0.045	0.25	0.176	0.121	0.087
901010	4.32	5.72	120	117	3.16	0.042	0.42	0.11	0.152	0.067
901015	4.49	8.84	108	105	2.84	0.035	0.525	0.092	0.18	0.063
901024	4.59	11.09	130	126	3.88	0.063	0.36	0.5	0.17	0.035
901029	4.45	8.06	110	106	3.68	0.451	0.95	0.788	0.17	0.05

East Fork Dairy Cr at Fern Flat Road
3818168

YYMMDD	GAUGE_	TS	TDS	TSS	NH3-	TKN	NO2NO3-	T-PO4-P	S-OPO4-P
900523	999999	70	67.9	2.1	0.02	0.27	0.398	0.06	0.036
900606	999999	82	71.9	10.1	0.042	0.32	0.453	0.061	0.029
900620	999999	118	99	5.08	0.023	0.14	0.311	0.078	0.032
900711	999999	82	76	5.66	0.026	0.15	0.43	0.07	0.036
900718	999999	78	74.3	3.66	0.049	0.2	0.43	0.061	0.043
900801	999999	92	88	4.04	0.035	0.26	0.391	0.08	0.034
900815	999999	82	78.3	3.68	0.014	0.22	0.379	0.08	0.043
900829	999999	70	66.4	3.56	0.014	0.2	0.311	0.052	0.057
900912	999999	76	75	1.08	0.017	0.15	0.277	0.06	0.035
900926	999999	104	71	32.7	0.024	0.35	0.262	0.08	0.034
901010	999999	196	80	116	0.019	0.98	0.247	0.192	0.028
901024	999999	110	105	4.96	0.022	0.17	0.589	0.09	0.023

Dairy Creek at HWY 8
3815021

YYMMDD	GAUGE_H	FLOW-INT	TS	TDS	TSS	NH3-N	TKN	NO2NO3-	T-PO4-P	S-OPO4-P
900102	999999		154	139	14.9	0.2		2.13	0.16	0.037
900205	999999		82	74.3	7.7	0.067		2.67	0.116	0.03
900305	999999		96	74.5	21.5	0.048		1.23	0.065	0.022
900402	999999		112	93.2	18.8	0.078		0.893	0.084	0.019
900508	3.3	112	82	73.3	8.66	0.1	0.36	0.397	0.12	0.02
900515	3.05	97	102	94	8.1	0.033	0.3	0.623	0.102	0.043
900522	3.25	108	68	58.2	9.82	0.048	0.4	0.333	0.11	0.023
900530	4.66	190	104	89	15	0.092	0.53	0.456	0.104	0.04
900605	4	154	74	59.4	14.6	0.08	0.34	0.339	0.123	0.029
900612	4.05	157	98	86.1	11.9	0.056	0.37	0.352	0.091	0.038
900619	3.1	100	100	86	13.8	0.047	0.41	0.269	0.123	0.03
900626	2.4	62.2	100	83.5	16.5	0.045	0.45	0.435	0.142	0.045
900710	1.82	34.2	104	92.7	11.3	0.057	0.78	0.506	0.146	0.045
900717	1.5	21.1	130	102	27.5	0.078	0.54	1.24	0.131	0.055
900724	8.8	8.8	158	148	10.5	0.04	M	1.6	0.12	0.063
900731	1.3	13.5	110	103	6.6	0.063	0.37	0.547	0.108	0.049
900807	1.17	9.15	100	90	9.96	0.044	0.58	0.841	0.14	0.052
900814	1.18	9.5	142	131	10.9	0.032	0.6	0.575	0.12	0.041
900821	1.41	17.5	134	128	6.44	0.044	0.4	0.587	0.114	0.063
900828	1.41	17.6	134	122	12	0.049	0.4	0.336	0.12	0.057
900905	1.45	19.1	106	97	8.88	0.043	0.42	0.316	0.112	0.058
900911	1.36	15.7	134	125	8.96	0.06	0.55	0.788	0.13	0.064
900918	1.66	28	136	126	9.72	0.041	0.65	0.362	0.173	0.069
900925	1.37	16.1	130	121	9.24	0.064	0.57	0.846	0.15	0.065
901002	1.39	17	140	134	6.08	0.032	0.55	0.407	0.149	0.061
901009	1.52	21.8	142	137	5.36	0.032	0.49	0.351	0.256	0.055
901016	2.21	52.5	92	85.9	6.08	0.034	0.43	0.302	0.15	0.044
901023	2.85	86	112	105	7.08	0.037	0.65	0.5	0.144	0.031
901030	2.8	83	130	124	5.72	0.093	0.74	0.363	0.215	0.05
901105	999999		106	104	1.76	0.018	0.47	0.561	0.1	0.037
901112	999999		126	125	1.44	0.036		0.255	0.102	0.044
901210	999999		116	102	14.4	0.067		2.75	0.094	0.019

APPENDIX II - WATER QUALITY DATA DAIRY CREEK, 1991

LOCCOD WEST FK DAIRY CK
3817063

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
60691	*	*	100	94	6.36	0.038	0.004	0.29	0.29	0.294	0.03	0.022
62091	*	*	98	90	8.48	0.031	0.005	0.273	0.35	0.278	0.055	0.029
62791	*	*	88	83	5.08	0.067	0.008	0.262	0.49	0.27	0.087	0.027
71191	5.1	1.8	104	101	2.76	0.072	0.005	0.273	0.48	0.278	0.093	0.034
72591	*	*	86	82	3.52	0.133	0.018	0.569	0.725	0.587	0.117	0.059
80891	5.8	1.66	112	98	14.5	0.148	0.005	0.558	0.77	0.563	0.2	0.07
82291	*	*	150	143	6.72	0.075	0.005	0.557	0.35	0.562	0.112	0.047
90591	4.2	1.58	102	97	5.28	0.065	0.007	0.289	0.55	0.296	0.08	0.052
91991	2.7	1.46	94	86	7.84	0.072	0.007	0.23	*	0.237	0.105	0.063
100391	3.5	1.55	104	100	3.92	0.109	0.012	0.246	0.65	0.258	0.193	0.049
101791	3.6	1.56	138	131	7.28	0.135	0.008	0.147	*	0.155	0.176	0.56

LOCCOD WEST FK DAIRY CK
3817020

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
50991		3.7	106	90.8	15.2	0.052	0.01	0.571	0.5	0.581	0.122	0.029
52391		*	98	83.5	14.5	0.043	0.004	0.48	0.41	0.484	0.105	0.026
60691	31.6	2.28	114	111	3.04	0.053	0.006	0.329	0.28	0.335	0.046	0.03
62091	27.5	2.1	114	101	13.3	0.028	0.004	0.346	0.28	0.35	0.05	0.033
62791	29.1	2.17	100	89	10.9	0.058	0.009	0.353	0.4	0.362	0.073	0.025
71191	11.8	1.47	104	92	12	0.09	0.01	0.419	0.3	0.429	0.09	0.036
72591	8	1.2	104	91	12.7	0.07	0.013	0.521	0.4	0.534	0.083	0.059
80891	7.7	1.17	96	90	6.24	0.073	0.008	0.893	0.36	0.901	0.09	0.042
82291	4	*0.64	216	182	34.4	0.061	0.026	0.478	1.57	0.504	0.241	0.054
90591	7.8	1.18	140	114	26.4	0.087	0.014	0.193	1.15	0.207	0.2	0.065
91991	5	*0.8	150	72	77.7	0.011	0.04	0.158	*	0.198	0.342	0.064
100391	8.8	1.29	114	100	14.3	0.065	0.026	0.533	0.5	0.559	0.23	0.058
101791	12.06	1.48	140	132	8.12	0.033	0.009	0.26	*	0.269	0.157	0.055
103191	20.53	1.81	100	98	2.36	0.039	0.002	0.162	*	0.164	0.11	0.028

LOCCOD EAST FK DAIRY CK
3818014

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
50991		3.4	92	78.3	13.7	0.029	0.005	0.61	0.3	0.615	0.066	0.022
52391	60	2.78	84	73	11	0.042	0.001	0.458	0.25	0.459	0.062	0.016
60691	43.18	2.31	108	106	2	0.055	0.004	0.465	0.22	0.469	0.022	0.021
62091	35.85	2.09	90	78	12.2	0.017	0.004	0.411	0.38	0.415	0.099	0.027
62791	35.21	2.07	98	87	11.1	0.047	0.008	0.499	0.27	0.507	0.048	0.025
71191	17.61	1.48	82	74	8	0.052	0.005	0.87	0.26	0.875	0.064	0.043
72591	17.34	1.47	76	68	7.88	0.049	0.008	0.679	0.15	0.687	0.044	0.038
80891	12.91	1.3	58	56	1.84	0.048	0.001	0.376	0.2	0.377	0.05	0.033
82291	9.11	1.14	148	142	5.88	0.021	0.004	0.396	0.2	0.4	0.062	0.041
90591	11.94	1.26	86	80	6.36	0.051	0.005	0.272	0.3	0.277	0.068	0.05
91991	8.65	1.12	66	61	5.12	0.037	0.008	0.147	*	0.155	0.094	0.046
100391	8.88	1.13	66	59	6.68	0.017	0.007	0.175	0.16	0.182	0.17	0.03
101791	8.19	1.1	104	102	1.84	0.026	0.005	0.128	*	0.133	0.134	0.031
103191	12.67	1.29	76	76	0.02	0.033	0.002	0.201	*	0.203	0.048	0.02

LOCCOD DAIRY CK @HWY8
3815021

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
10791			114	110	4.36	0.115			0.4	1.59	0.086	0.05
20491			142	99.8	42.2	0.094			0.61	3.48	0.152	0.032
30491			178	124	54.5	0.164			0.78	3.14	0.3	0.044
40191			92	67.2	24.8	0.042			0.22	1.65	0.06	0.021
50691	200	4.81	102	90.1	11.9	0.05	0.001	1.07	0.54	0.87	•	0.026
50991	250	5.54	112	98.5	13.5	0.036	•	•	0.515	0.731	0.09	0.027
51391	210	4.5	100	88.6	11.4	0.031	0.007	0.767	0.535	0.774	0.05	0.024
51691	87	4.26	84	71.2	12.8	0.055	•	•	0.345	0.689	0.108	0.004
52091	260	• 5.61	96	84.9	11.1	0.074	0.014	0.773	0.42	0.787	0.145	0.033
52391	84.6	4.16	104	91.5	12.5	0.045	•	•	0.44	0.695	0.13	0.072
52891	134.7	3.75	96	85.5	10.5	0.046	0.008	0.661	0.29	0.669	0.08	0.031
53091	75.5	3.78	76	65	10.6	0.074	•	•	0.35	0.652	0.12	0.035
60391	105	3.2	102	94	8.44	0.04	0.006	0.48	0.38	0.486	0.092	0.028
60691	95.9	3.08	86	76	9.68	0.057	•	•	0.36	0.518	0.099	0.033
61091	81	2.8	76	66	9.76	0.043	0.008	0.501	0.29	0.509	0.112	0.036
61391	76	2.71	122	113	8.8	0.075	•	•	0.25	0.58	0.09	0.021
61791	78	2.7	90	79	11.4	0.043	0.007	0.513	0.3	0.52	0.101	0.033
62091	78.7	2.76	126	110	15.8	0.02	•	•	0.46	0.506	0.116	0.043
62491	91.5	3	136	127	9.48	0.06	0.009	0.577	0.32	0.586	0.087	0.036
62791	86.1	2.9	110	107	2.8	0.051	•	•	0.48	0.525	0.133	0.041
70191	66	2.51	110	102	7.96	0.027	0.006	0.545	0.34	0.551	0.159	0.041
70891	40	1.96	108	101	6.6	0.033	0.005	0.609	0.38	0.614	0.1	0.052
71191	39.2	1.94	108	101	6.96	0.037	•	•	0.34	0.931	0.078	0.052
71591	40	1.95	116	109	6.64	0.032	0.012	0.956	0.31	0.968	0.067	0.038
71891	43.2	2.03	116	109	7.16	0.039	•	•	0.35	0.819	0.15	0.059
72291	29	1.69	112	104	8.44	0.043	0.006	0.746	0.3	0.752	0.06	0.052
72591	23.4	1.55	158	149	8.88	0.046	•	•	0.18	1.02	0.083	0.064
72991	24	1.57	108	101	7.4	0.059	0.012	0.65	0.4	0.662	0.143	0.073
80191	20.4	1.47	116	110	6.32	0.046	•	•	0.46	0.713	0.113	0.061
80591	21	1.48	126	118	8.12	0.047	0.006	0.898	0.47	0.904	0.203	0.056
80891	22.6	1.53	106	97	9.04	0.049	•	•	0.55	0.694	0.109	0.057
81291	21	1.48	98	91	6.84	0.028	0.005	0.709	0.44	0.714	0.119	0.069
81591	14.8	1.31	110	103	6.68	0.057	•	•	0.505	0.797	0.138	0.077
81991	14.8	1.31	104	97	6.8	0.043	0.006	1.24	0.595	1.25	0.133	0.061
82291	13.2	1.26	162	153	8.68	0.023	•	•	0.97	0.873	0.144	0.062
82691	14.2	1.29	110	103	6.92	0.056	0.006	0.983	0.5	0.989	0.138	0.052
82991	23.4	1.55	122	113	8.52	0.028	•	•	0.55	0.598	0.159	0.062
90391	30	1.71	102	95	7.28	0.036	0.039	0.549	0.5	0.588	0.184	0.057
90591	21.5	1.5	114	106	7.92	0.048	•	•	0.32	0.584	0.098	0.073
90991	17	1.38	104	97	7.12	0.032	0.007	0.525	0.4	0.532	0.14	0.067
91691	16	1.34	114	108	6.48	0.034	0.001	0.338	0.99	0.339	0.143	0.074
92391	13	1.26	130	123	7.28	0.04	0.011	1.3	0.65	1.31	0.105	0.056
92691	13.5	1.27	120	111	9.36	0.045	•	•	0.535	0.628	0.131	0.073
93091	16	1.34	128	120	7.68	0.046	0.012	1.25	0.5	1.26	0.119	0.067
100391	13.2	1.26	134	121	13.2	0.039	•	•	1.02	0.303	0.19	0.061
100791	14	1.27	122	117	5.44	0.042	0.007	0.242	0.4	0.249	0.092	0.061
101091	15.2	1.32	122	118	4.28	0.05	•	•	0.42	0.553	0.102	0.063
101491	13	1.26	136	132	3.6	0.051	0.008	0.421	0.18	0.429	0.551	0.073
101791	15.9	1.31	156	150	5.6	0.036	•	•	0.36	0.294	0.12	0.065
102191	16	1.35	120	114	5.56	0.025	0.003	0.206	0.35	0.209	0.101	0.061
102491	22.6	1.53	100	96	4.08	0.014	•	•	0.4	0.415	0.13	0.072
102891	35.4	1.85	100	96	4.24	0.029	0.004	0.092	0.42	0.096	0.12	0.041
110691	59.5	2.38	116	111	4.84	0.038			0.41	0.235	0.106	0.057
111191	37.5	1.9	112	109	2.64	0.019			0.26	0.219	0.078	0.049
112091	170.3	4.32	128	116	11.5	0.049			0.44	2.07	0.09	0.055
112691	280	• 5.8	110	94	16.4	0.074			0.98	2.99	0.13	0.033
120491	152.5	4.04	114	109	5.12	0.027			0.32	2.64	0.1	0.034
121191		9.02	136	116	19.8	0.04			0.55	4.73	0.086	0.032
121891		5.29	98	93	5.28	0.044			0.35	3.33	0.062	0.029
10292		5.51	148	133	14.8	0.074			0.43	3.66	0.106	0.038
10892		8.64	120	102	18	0.042			0.4	2.96	0.092	0.031
11592		7.21	92	74	18	0.03			0.39	3.37	0.07	0.028
12292		7.07	110	96	13.7	0.051			0.41	3.3	0.072	0.028
21292		8.2	122	95	27.2					2.62		0.025
21992	•					0.119				3.01		0.052

LOCCOD EAST FK DAIRY CK
3818084

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
60691	*	*	86	81	4.76	0.031	0.002	0.407	0.12	0.409	0.042	0.018
62091	*	*	90	81	9.16	0.028	0.002	0.355	0.22	0.357	0.034	0.024
62791	*	*	76	66	10.2	0.027	0.005	0.329	0.24	0.334	0.035	0.022
71191	*	*	84	80	3.68	0.044	0.004	0.259	0.31	0.263	0.056	0.027
72591	*	*	54	53	1.38	0.036	0.006	0.264	0.4	0.27	0.08	0.032
80891	14.1	1.29	70	57	12.9	0.047	0.001	0.171	0.15	0.172	0.06	0.029
82291	*	*	118	110	8.36	0.023	0.003	0.23	0.2	0.233	0.073	0.03
90591	*	1.49	84	76	7.96	0.029	0.004	0.201	0.2	0.205	0.054	0.043
91991	8.4	1.1	72	61	10.7	0.035	0.007	0.23	*	0.237	0.069	0.044
100391	7.5	1.01	110	49	61.1	0.027	0.007	0.16	0.25	0.167	0.189	0.024
101791	*	1.16	114	97	17.4	0.038	0.004	0.156	*	0.16	0.122	0.032
103191	10.3	1.21	94	74	20.2	0.033	0.002	0.217	*	0.219	0.06	0.016

LOCCOD MCKAY CK
3816160

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
71191	*	*	84	83	0.6	0.045	0.002	0.349	0.28	0.351	0.05	0.02
72591	*	*	66	66	0.48	0.038	0.005	0.025	0.37	0.33	0.013	0.027
80891	1.94	1.94	64	63	0.74	0.052	0.001	0.209	0.1	0.21	0.02	0.02
82291	*	*	170	166	4.4	0.046	0.004	0.25	0.57	0.254	0.2	0.099
90591	1.89	1.89	80	76	3.64	0.027	0.039	0.22	0.1	0.259	0.027	0.034
91991	1.83	1.83	72	69	2.94	0.02	0.005	0.204	*	0.209	0.061	0.031
100391	1.83	1.83	82	65	16.7	0.015	0.004	0.198	0.2	0.202	0.157	0.018
101791	1.82	1.82	106	103	2.96	0.024	0.004	0.149	*	0.153	0.155	0.022
103191	1.9	1.9	80	78	1.74	0.029	0.002	0.259	*	0.261	0.068	0.011

LOCCOD MCKAY CK
3816020

MMDDYY	FLOW-INT CFS	GAUGE_H FEET	TS MG/L	TDS MG/L	TSS MG/L	NH3-N MG/L	NO2-N MG/L	NO3-N MG/L	TKN MG/L	NO2NO3- MG/L	T-PO4-P MG/L	S-OPO4-P MG/L
50991	56.43	5.7	106	103	2.92	0.092	0.009	0.95	0.41	0.959	0.068	0.023
52391	46.7	5.47	96	92.1	3.94	0.045	0.005	0.972	0.38	0.977	0.059	0.02
60691	19.2	4.82	124	122	1.68	0.035	0.005	0.593	0.28	0.598	0.056	0.027
62091	14.9	4.68	124	112	12.1	0.028	0.008	0.419	0.25	0.427	0.034	0.043
62791	16.6	4.74	100	97	2.72	0.078	0.014	0.61	0.37	0.624	0.108	0.04
71191	6.9	4.35	118	112	5.88	0.044	0.006	0.697	0.32	0.703	0.079	0.054
72591	4.2	4.19	108	103	5.04	0.059	0.006	0.313	0.29	0.319	0.1	0.072
80891	3.5	4.14	110	107	3.12	0.055	0.001	0.29	0.34	0.291	0.12	0.076
82291	1.9	4	134	129	4.8	0.025	0.001	0.268	0.2	0.269	0.04	0.037
90591	4.2	4.19	118	114	4.4	0.059	0.004	0.132	0.5	0.136	0.124	0.077
91991	1.97	4.01	130	127	2.8	0.331	0.013	0.054	*	0.067	0.253	0.125
100391	1.9	4	112	109	3.48	0.049	0.016	0.319	0.3	0.335	0.211	0.07
101791	3	4.1	148	147	1.4	0.033	0.013	0.17	*	0.183	0.215	0.075
103191	12.88	4.66	108	107	1.08	0.036	0.003	0.198	*	0.201	0.106	0.038