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Montana State Board of Health
and
Montana State Fish and Game Department

THREE FORKS AREA WATER QUALITY STUDY
Progress Report Number 2
October 1960 to September 1961

by Eugene B. Welch, Pollution Control
Biologist, Fish & Game Dept.

Introduction

This report summarizes data collected during the second year of a proposed three year water quality study of the Missouri River headwater streams in Montana. The description of the study area, purpose and design of the study and methods of collection and analysis of samples were thoroughly covered in Progress Report Number 1. Therefore, only changes in the sampling program and some results of the second year's data will be discussed here.

Changes in the Program

For the most part, stations and sampling procedures during the second year of the study remained the same as during the first year (Table 1). The only changes were: (1) the transfer of the Missouri River station from Trident to Toston due to insufficient mixing of the Three Forks streams at the former station; (2) the addition of chloride to the "complete" water analysis; (3) the addition of secondary stations 11, 12, 14 and 15 for complete analysis; and (4) the addition of the gravimetric analysis for total dissolved solids (TDS) or filtrable residue.

The addition of the four secondary stations for complete analysis was to obtain a more detailed picture of the Beaverhead River with respect to the origin of high sulfate concentrations during high water and the initiation of the Clark Canyon Dam project at Armstead.

The reliability of the specific conductance method of estimating total dissolved solids was questioned to some extent. To test the reliability, analysis for total dissolved solids by both the conductimetric and gravimetric methods was started for purposes of comparison.

Results

Flow data were again obtained from the Helena Office of the U. S. Geological Survey and are listed in Table 2. Water quality data collected at the primary and secondary stations are enumerated in Tables 3 and 4. Only information from the primary stations was put in graphical form (Figure 1). Plans are to make a complete comparison of the three year's data following completion of the project in September 1962. General discussion of the data will be deferred until the completion of the study.

The phenomena of sulfates reaching a high concentration during the period of peak flow, which occurred during the first year of the study, did not recur during the second year. In 1960, sulfates reached a season high concentration at all stations during peak flow when other chemical components were at a season low. As Figure 1 shows, sulfates followed the same predicted pattern as the other chemicals in 1961 and reached a low concentration during peak flow primarily due to dilution. An explanation for the sulfate pattern in 1960 cannot be offered at this time.

The conductimetric and gravimetric methods of total dissolved solids analysis were compared with a correlation analysis on 88 samples. The data are represented by a straight line relationship, the formula for which is:

$$\hat{Y} = 27.13 + 1.03\ X$$

A high degree of correlation is shown (correlation coefficient = .96) between the gravimetric and conductimetric methods of analysis. It is apparent, then, that the conductimetric method, using a National Aluminate Corporation Nalcometer, is a reliable measure of total dissolved solids, at least on the streams in the Three Forks area.

TABLE 1. Location and Description of Sampling Stations.

LOCATION	NUMBER	DESCRIPTION
East Gallatin River above the West Gallatin River	1	North on Broadway Street at Belgrade, to Dry Creek Church. Then go past church one-half mile and turn left (south). Station is first bridge crossing on this road.
West Gallatin River above the East Gallatin River	2	Sixty yards upstream from bridge crossing on Highway 10 south of Manhattan.
Gallatin River at Logan	3	One-half mile below Logan.
Gallatin River at Trident	4*	One-hundred yards above bridge crossing at Missouri Headwaters State Park.
Madison River at Indian Creek	5	South of Cameron, cross Indian Creek and turn south at first gravel road. Follow gravel road to first county bridge crossing. Station is at this bridge crossing.
Madison River at Ennis	6	Cross Madison River at Ennis and turn right (west) at first road. Sample is taken at Fish and Game Department Access Site.
Madison River at Three Forks	7*	At first bridge crossing on Highway 10 below Three Forks.
Big Hole River below the North Fork of the Big Hole River	8	At the Squaw Creek Bridge about 15 miles northeast of Wisdom. (Authors note: a new bridge has been constructed near this site since sampling began.)
Big Hole River at Melrose	9	Turn west at Melrose at the Canyon Creek-Hecla Road. Sampling station is at first bridge crossing on this road.
Big Hole River above Twin Bridges	10*	Turn right(north) at first road on Highway 91. Sampling station is at first bridge crossing on this road.
Beaverhead River at Lima	11*	Turn east at first road five miles south of Dell. Sampling Station is at first bridge crossing Beaverhead River on this road.
Beaverhead River above Dillon	12	First bridge crossing Beaverhead River on Highway 91 southeast of Dillon.

TABLE 1. (Continued)

LOCATION	NUMBER	DESCRIPTION
Beaverhead River at Twin Bridges	13*	At Bridge Crossing Beaverhead River in City of Twin Bridges.
Jefferson River below Twin Bridges	14	At first bridge crossing Jefferson River on Highway 10 north of Twin Bridges.
Jefferson River at LaHood Park	15	About one mile below (south) of LaHood Park on Highway 10.
Jefferson River above Three Forks	16*	At bridge crossing near junction of Highways 90 and 12, north of Three Forks.
Missouri River at Toston	17*	Below bridge at Toston.
Ten Mile Creek west of Helena	18*	One-half mile below bridge crossing on Highway 12 west of Helena.

*Denotes Primary Station.

Table 2. Available stream flows in cubic feet per second. Data were furnished by the office of the U.S. Geological Survey, Helena. The mean flow is recorded for July.

Gallatin River at Logan

Date	Flow
Oct. 27	600
Nov. 29	770
Dec. 28	732
Jan. 26	690
Feb. 23	732
Mar. 30	684
Apr. 28	550
May 15	465
June 13	1570
July mean	292
Aug. 3	249
Sept. 8	500

Big Hole River at Melrose

Date	Flow
Oct. 27	435
Nov. 29	375
Dec. 28	240
Jan. 26	220
Feb. 23	488
Mar. 30	604
Apr. 28	604
May 15	1050
June 13	5140
July mean	546
Aug. 3	262
Sept. 8	213

Missouri River at Toston

Date	Flow
Oct. 27	3450
Nov. 29	3500
Dec. 28	3150
Jan. 26	2500
Feb. 23	3230
Mar. 30	2960
Apr. 28	2110
May 15	1710
June 13	6630
July mean	1389
Aug. 3	800
Sept. 8	2020

Jefferson River at Sappington

Date	Flow
Oct. 27	1160
Nov. 29	1350
Dec. 28	1200
Jan. 26	800
Feb. 23	1250
Mar. 30	1310
Apr. 28	900
May 15	990
June 13	4300
July mean	593
Aug. 3	218
Sept. 8	418

Beaverhead River at Blaine (above Twin Bridges)

Date	Flow
Oct. 27	290
Nov. 29	462
Dec. 28	468
Jan. 26	361
Feb. 23	458
Mar. 30	285
Apr. 28	54
May 15	70
June 13	20
July mean	43
Aug. 3	45
Sept. 8	68

Madison River below Ennis

Date	Flow
Oct. 27	1400
Nov. 29	1190
Dec. 28	1280
Jan. 26	1120
Feb. 23	1050
Mar. 30	801
Apr. 28	664
May 15	752
June 13	1350
July mean	972
Aug. 3	976
Sept. 8	1280

Beaverhead River at Barrots (below Dillon)

Date	Flow
Oct. 27	244
Nov. 29	281
Dec. 28	281
Jan. 26	245
Feb. 23	270
Mar. 30	232
Apr. 28	161
May 15	144
June 13	336
July mean	177
Aug. 3	154
Sept. 8	144

Table 3. Tabulation of chemical data collected at secondary stations. Except for pH and temperature (°F) all results are in parts per million. TDS was determined electrically (C) and gravimetrically (G).

Station 1. East Gallatin above the West Gallatin River.

Mo.	Date	Hour	pH	T.D.S. C	T.D.S. G	Turb.	Temp.
Oct.	27	1200	8.2	222	-	1	48
May	15	1345	8.2	214	190	16	54
June	13	1300	8.4	256	245	5	60
Aug.	3	1145	8.4	222	210	0	66

Station 2. West Gallatin River above the East Gallatin River.

Mo.	Date	Hour	pH	T.D.S. C	T.D.S. G	Turb.	Temp.
Oct.	27	1140	8.0	145	-	0	48
May	15	1330	7.6	274	200	0	55
June	13	1245	7.8	86	115	5	54
Aug.	3	1115	8.0	171	190	0	61

Station 3. Gallatin River at Logan, Montana.

Oct.	27	1125	8.2	214	-	3	46
May	15	1300	8.4	222	230	5	56
June	13	1215	8.4	120	160	5	56
Aug.	3	1100	8.4	222	250	0	70

Station 5. Madison River at Indian Creek.

Oct.	27	1450	8.2	94	-	1	46
May	15	1645	8.2	188	200	0	51
June	14	0930	8.4	103	140	5	54
Aug.	3	1430	8.4	171	180	0	69

Station 6. Madison River at Ennis, Montana.

Oct.	27	1430	8.2	162	-	3	46
May	15	1615	8.2	188	200	0	56
June	14	1000	8.4	103	155	5	58
Aug.	3	1500	8.4	171	180	0	75

Station 8. Big Hole River below the North Fork of the Big Hole River.

Oct.	28	0920	7.4	90	-	4	38
May	16	1145	7.4	70	70	37	56
June	15	1130	7.6	70	140	5	64
Aug.	4	1130	8.4	68	75	2	72

Station 9. Big Hole River at Melrose, Montana.

Oct.	28	0820	7.4	103	-	0	40
May	16	1045	7.6	65	80	8	47
June	15	1030	7.8	65	110	5	60
Aug.	4	1030	8.2	137	155	0	65

Table 4. Tabulation of chemical data (complete analysis) collected at primary and some secondary stations. Except for pH and temperature (°F) all results are in parts per million. TDS results were determined electrically (C) and gravimetrically (G).

Station 4. Gallatin River at Trident, Montana.

Mo.	Day	Hour	pH	TDS C	TDS G	Turb.	Hard. $CaCO_3$	Ca	Mg	HCO_3	SO_4	Temp.	Cl
Oct.	27	1100	8.2	222	-	2	239	56	24	232	49	46	-
Nov.	29	1040	8.0	91	-	4	230	58	21	214	45	34	-
Dec.	28	1045	8.2	103	-	6	230	54	23	201	45	33	-
Jan.	26	1000	8.2	239	240	15	240	58	23	220	51	33	5
Feb.	23	1130	8.0	274	280	16	230	54	23	201	49	40	6
Mar.	30	1030	8.2	222	280	6	300	58	38	207	47	-	5
Apr.	28	1100	7.8	231	270	7	240	58	23	189	37	51	5
May	15	1230	8.4	239	230	7	210	50	21	214	25	58	9
June	13	1145	8.4	120	175	5	116	34	10	122	27	60	1
July	No samples collected.												
Aug.	3	1045	8.4	239	310	0	230	54	23	244	41	70	9
Sept.	8	1000	8.4	265	285	14	280	62	30	226	49	55	6

Station 7. Madison River at Three Forks, Montana.

Oct.	27	1045	8.0	180	-	0	125	28	13	140	29	46	-
Nov.	29	1030	8.0	197	-	37.5	140	29	17	153	29	33	-
Dec.	28	1030	8.2	197	-	3.5	140	32	15	159	25	33	-
Jan.	26	0945	8.2	222	230	7	130	30	13	159	33	33	25
Feb.	23	1120	8.0	194	210	3	110	27	10	153	16	39	22
Mar.	30	1015	8.2	180	260	4	120	27	13	146	16	-	20
Apr.	28	1035	7.8	188	230	3	140	34	14	134	25	53	15
May	15	1215	8.2	222	220	1	130	34	11	153	16	54	17
June	13	1130	8.4	145	205	5	116	25	13	125	17	64	13
July	No samples collected.												
Aug.	3	1030	8.4	171	235	5	130	29	14	140	23	72	19
Sept.	8	0950	8.2	197	225	22	140	29	17	146	25	58	25

Station 10. Big Hole River above Twin Bridges, Montana.

Oct.	27	1640	8.0	80	-	0	125	33	10	128	25	46	-
Nov.	29	1230	7.8	115	-	3	110	26	11	116	27	33	-
Dec.	28	1230	7.9	120	-	1	130	32	12	116	16	-	-
Jan.	No samples collected.												
Feb.	23	1315	7.8	111	130	5	120	26	14	110	21	36	4
Mar.	30	1115	8.0	90	140	3	100	22	11	92	21	-	19
Apr.	28	1235	7.8	86	90	3	100	21	12	85	25	56	0
May	15	1845	8.0	91	110	8	100	22	11	79	21	52	3
June	14	1200	7.8	70	104	0	36	14	0	67	12	60	0
July	No samples collected.												
Aug.	3	1640	8.4	128	180	0	130	32	12	134	23	84	4
Sept.	8	1130	8.4	180	205	3	240	42	33	128	55	59	6

Station 11. Beaverhead River at Lima, Montana

Oct.	27	1820	8.4	257	-	15	-	-	-	-	-	42	-
May	16	0900	8.2	684	730	0	520	83	76	281	317	46	34
June	14	1450	8.2	205	266	5	200	46	20	238	22	62	5
Aug.	4	0850	8.4	214	255	110	230	43	30	189	62	65	6

Station 12. Beaverhead River above Dillon, Montana

Oct.	27	1730	7.9	342	-	0	322	73	34	262	123	46	-
May	16	0815	7.8	410	440	11	320	75	32	250	136	50	15
June	14	1300	8.0	239	340	15	212	46	23	195	160	66	10
Aug.	4	0745	8.0	376	415	0	350	74	40	250	128	60	13

Table 4 (Continued)

Mo.	Day	Hour	pH	TDS C	TDS G	Turb.	Hard. $CaCO_3$	Ca	Mg	HCO_3	SO_4	Temp.	Cl
Station 13. Beaverhead River at Twin Bridges, Montana													
Oct.	27	1630	8.4	393	-	2	354	78	39	268	142	46	-
Nov.	29	1215	8.2	376	-	7.5	350	78	38	268	140	34	-
Dec.	28	1220	8.2	359	-	5	340	77	36	262	119	33	-
Jan.	26	1115	8.4	410	420	5	370	86	38	293	136	34	16
Feb.	23	1300	8.2	342	380	15	330	75	35	250	115	40	14
Mar.	30	1130	8.2	325	460	11	350	80	37	262	132	-	19
Apr.	28	1230	7.8	342	410	2	300	72	29	189	128	50	12
May	15	1830	8.4	299	320	0	240	54	25	183	99	55	12
June	14	1145	8.4	325	408	10	276	64	28	238	102	62	13
July	No samples collected.												
Aug.	3	1620	8.2	342	430	0	320	72	34	232	134	76	16
Sept.	8	1120	8.4	393	460	4	430	83	54	256	148	55	22
Station 14. Jefferson River below Twin Bridges.													
Oct.	27	1620	8.4	308	-	2	281	63	30	226	107	46	-
Nov.	29	1200	8.2	291	-	7.5	270	64	27	214	91	33	-
May	15	1815	8.2	137	140	3	120	26	14	104	29	54	5
June	14	1130	8.0	86	130	5	80	48	13	85	19	58	0
Aug.	3	1600	8.2	248	300	0	240	54	25	183	82	77	10
Station 15. Jefferson River at LaHood Park.													
Oct.	27	1015	8.2	308	-	1	270	63	27	226	99	44	-
Nov.	29	1130	8.2	274	-	6	240	61	21	207	86	33	-
May	15	1130	7.9	171	195	13	150	34	16	128	37	52	7
June	13	1030	8.0	103	150	5	96	25	14	98	21	59	0
Aug.	3	0950	8.2	274	330	0	240	58	23	226	76	71	11
Station 16. Jefferson River above Three Forks, Montana.													
Oct.	27	1000	8.0	308	-	0	270	62	28	232	103	46	-
Nov.	29	1020	8.2	274	-	5	250	61	24	207	91	33	-
Dec.	28	1000	8.3	257	-	2	280	64	29	226	91	33	-
Jan.	26	0930	8.2	333	340	5	300	69	31	244	107	33	13
Feb.	23	1115	8.0	257	310	8	250	58	26	207	86	39	12
Mar.	30	1010	8.4	231	290	10	220	51	22	177	70	-	8
Apr.	28	1015	7.8	205	230	4	190	43	20	146	66	53	6
May	15	1145	8.2	188	210	7	170	34	21	140	37	54	10
June	13	1130	8.0	120	222	5	100	27	14	98	20	60	2
July	No samples collected.												
Aug.	3	1020	8.2	299	350	0	270	58	31	226	103	73	14
Sept.	8	0940	8.2	299	380	6	350	67	44	232	103	58	16
Station 17, Missouri River at Toston, Montana.													
*Oct.	27	1110	8.2	239	-	1	229	55	22	226	49	46	-
*Nov.	No samples collected.												
*Dec.	28	1100	8.0	222	-	7	230	54	23	201	41	33	-
Jan.	26	0900	8.3	265	270	10	220	50	33	201	62	34	15
Feb.	23	1045	8.2	231	270	10	210	46	23	183	58	40	12
Mar.	30	0945	8.4	205	275	10	190	45	19	165	53	-	11
Apr.	28	1000	8.0	205	250	6	190	40	22	134	53	55	10
May	15	1045	8.4	205	200	8	170	40	17	165	33	58	11
June	13	0945	8.2	120	156	5	108	27	14	116	19	61	5
July	No samples collected.												
Aug.	3	0900	8.4	214	255	6	170	40	17	127	45	71	13
Sept.	8	0915	8.4	239	290	18	200	45	21	189	41	60	17
Station 18. Ten Mile Creek west of Helena, Montana.													
Oct.	27	0800	7.8	188	-	9	166	38	17	165	41	44	-
Nov.	29	0900	7.6	180	-	0	160	42	14	153	41	33	-
Dec.	28	0800	7.8	171	-	0	170	38	18	140	37	34	-
Jan.	26	1345	7.9	197	190	0	180	42	19	171	45	34	4
Feb.	23	0900	7.6	171	190	1	170	38	18	140	49	36	3
Mar.	30	0800	7.6	145	210	0	150	34	16	122	49	-	2
Apr.	28	1145	7.2	94	120	11	90	18	11	67	41	54	1
May	17	1745	7.2	67	90	10	60	14	6	49	27	44	2
June	14	1535	7.6	77	104	0	68	17	9	67	22	62	0
July	No samples collected.												
Aug.	4	1415	8.4	171	200	0	180	42	19	165	53	69	4
Sept.	8	1400	8.2	188	220	1	230	48	26	177	41	62	5

Figure 1. Graphic presentation of chemical results at primary stations.

Station 4. Gallatin River at Trident, Montana.

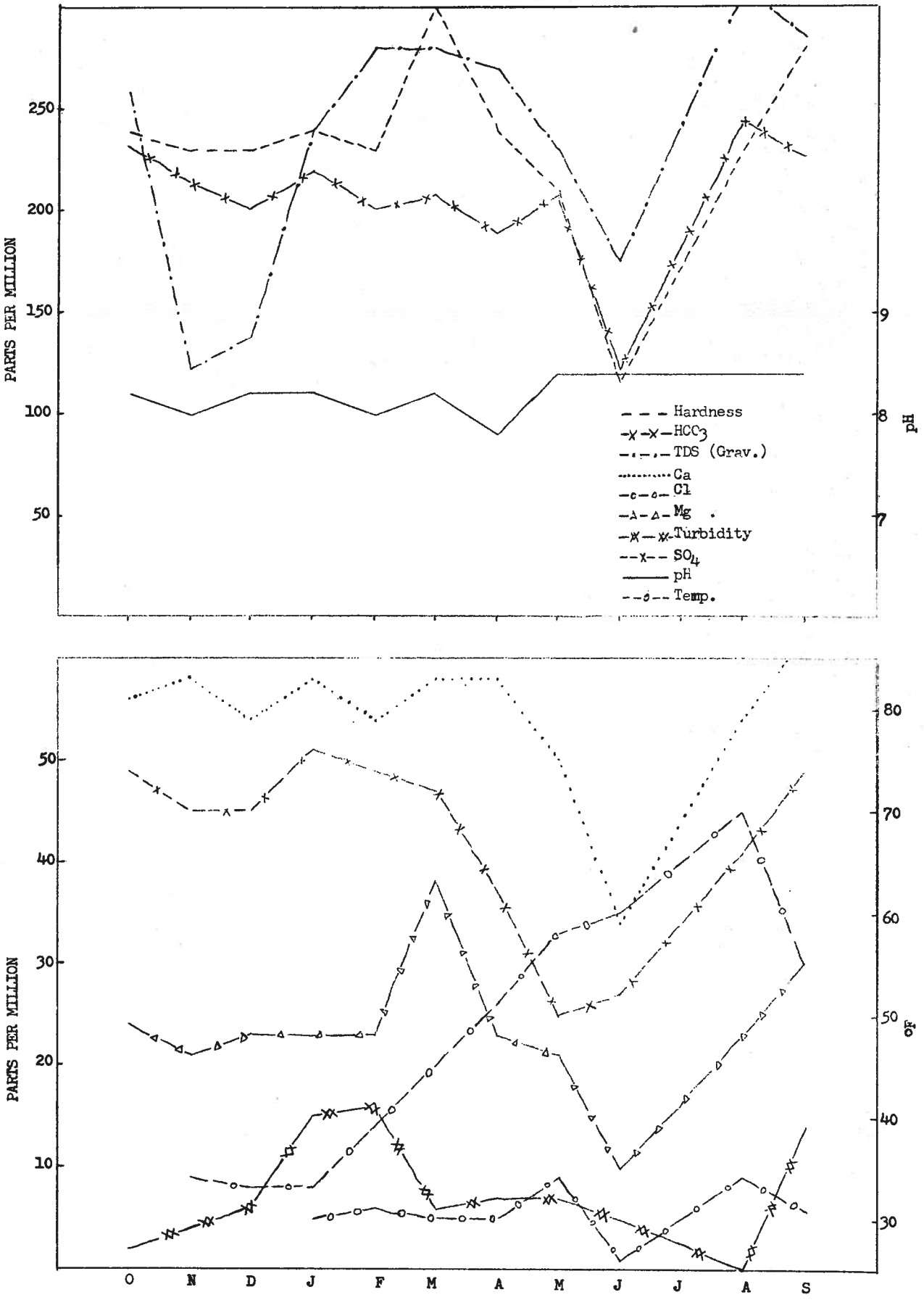


Figure 1. Continued.

Station 7. Madison River at Three Forks, Montana.

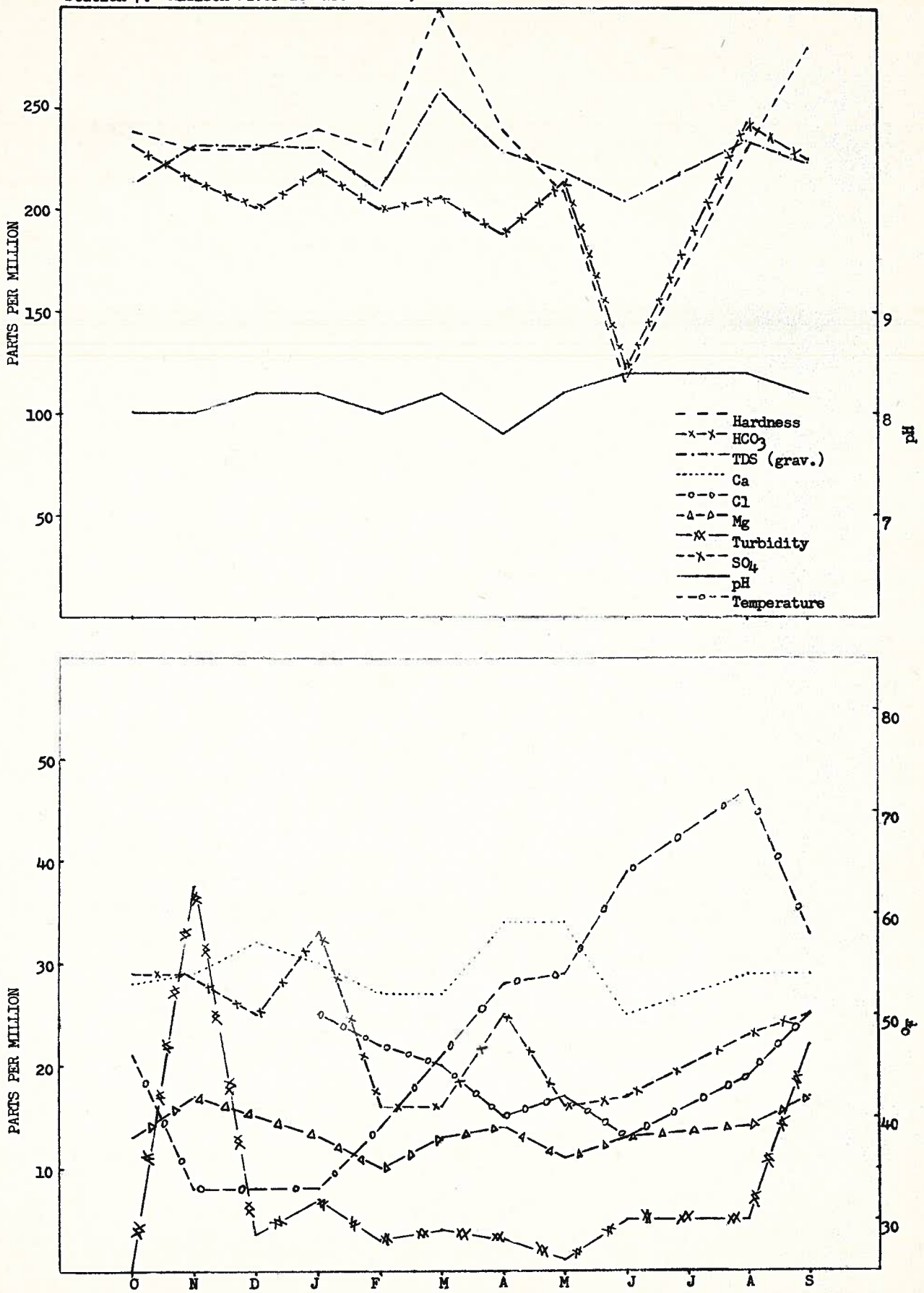
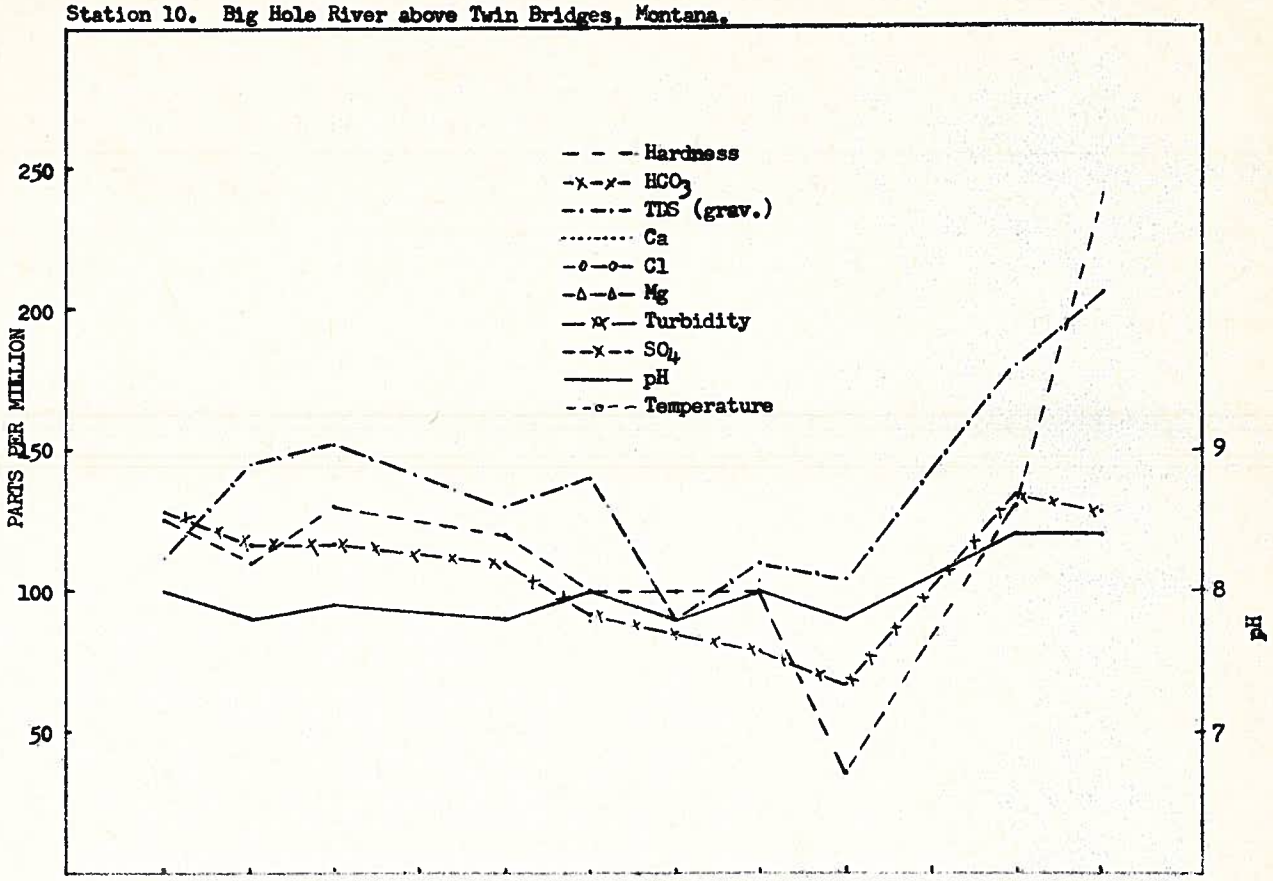


Figure 1. Continued

Station 10. Big Hole River above Twin Bridges, Montana.



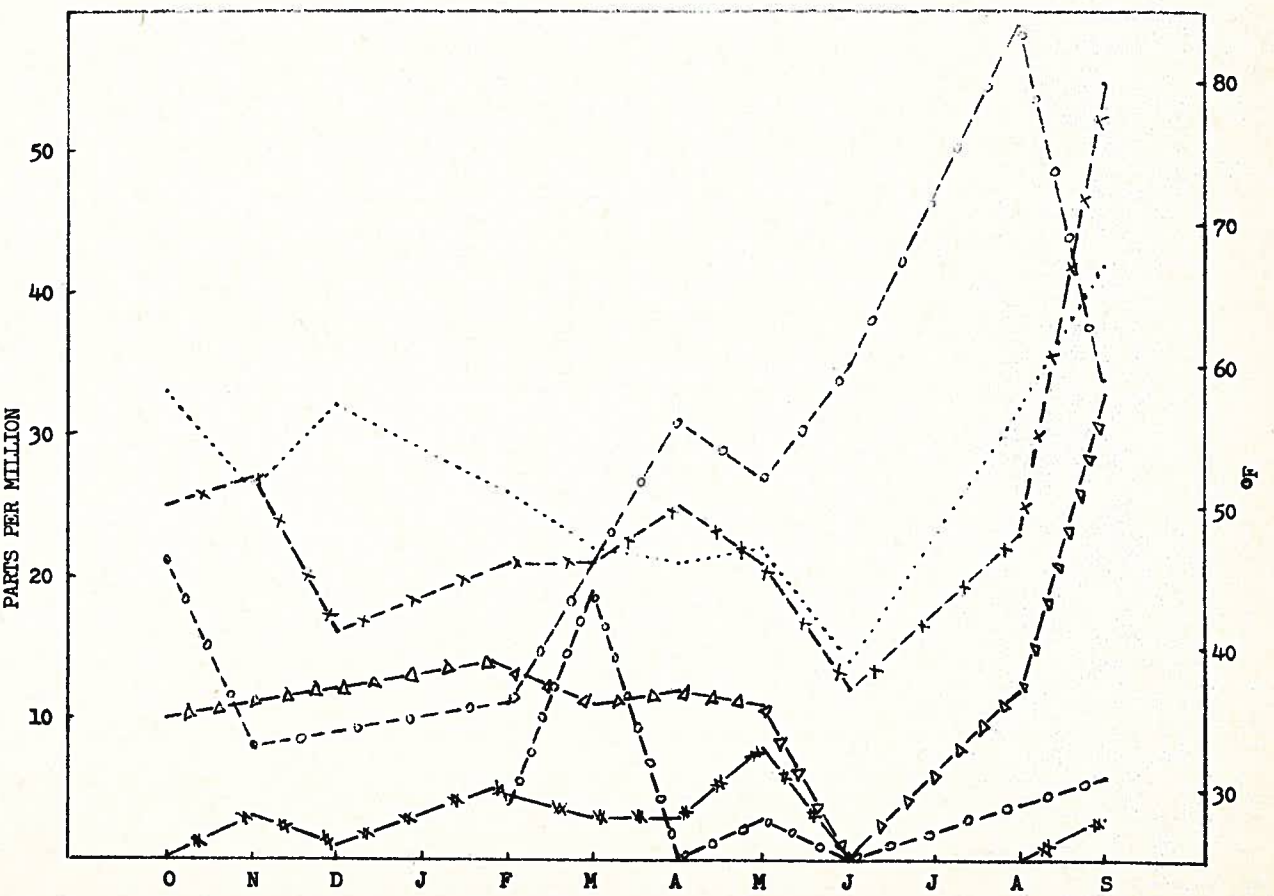


Figure 1. Continued

Station 13. Beaverhead River at Twin Bridges, Montana.

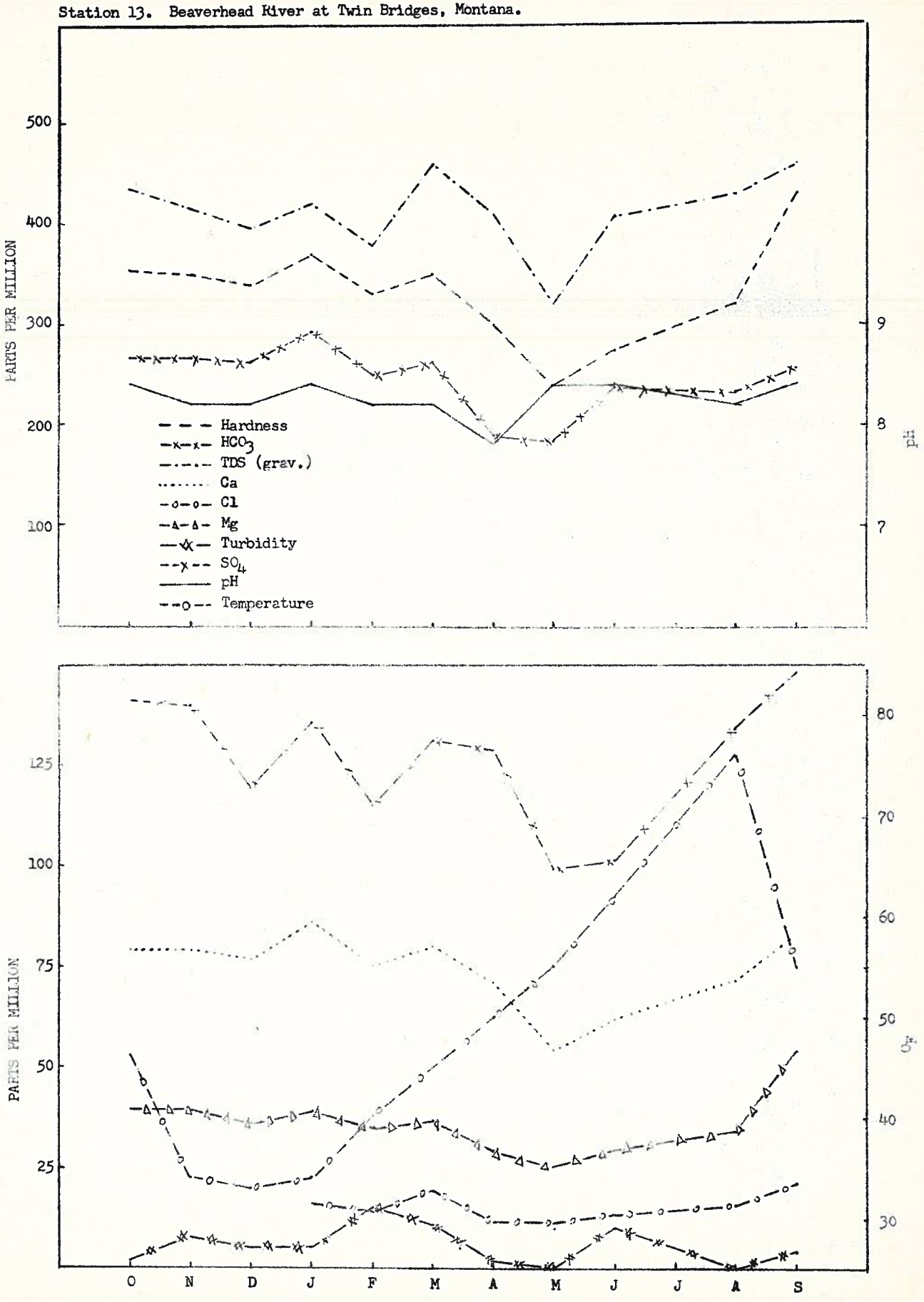


Figure 1. Continued.

Station 16. Jefferson River above Three Forks, Montana.

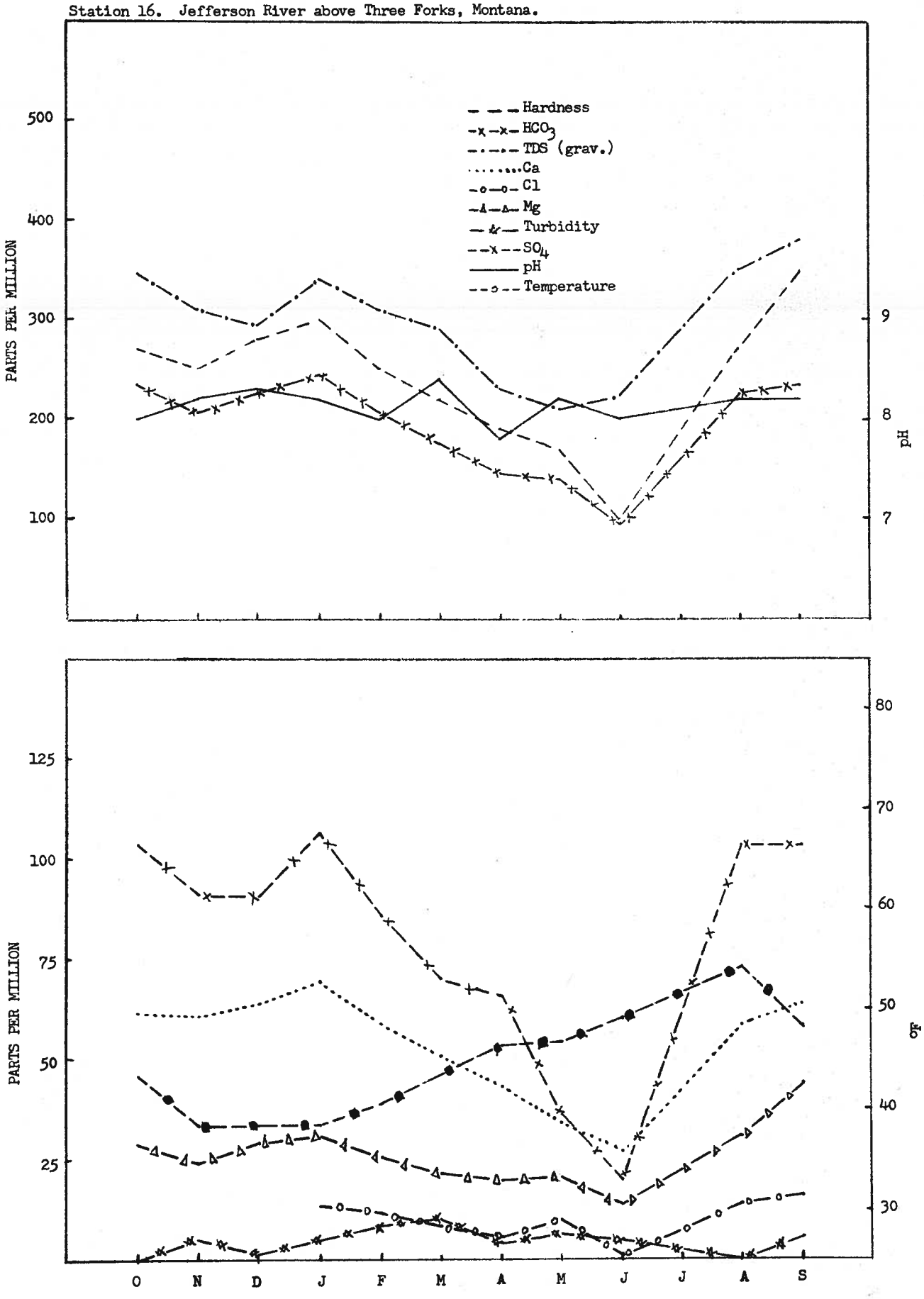


Figure 1. Continued.

Station 17. Missouri River at Toston, Montana.

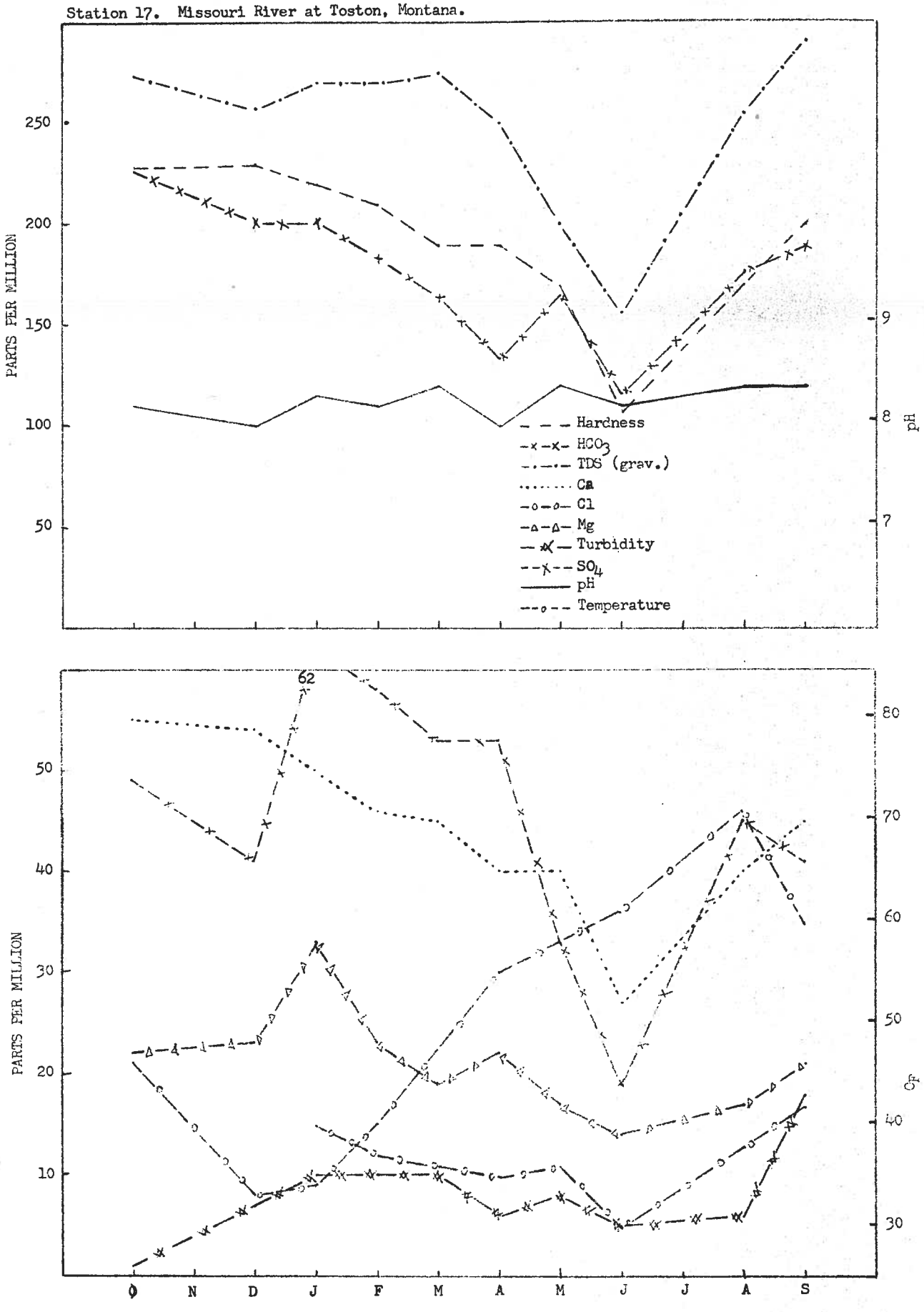


Figure 1. Continued.

Station 18. Ten Mile Creek west of Helena, Montana.