

Simulation of Water-Quality Data at
Selected Stream Sites in the
Missouri River Basin, Montana

(U.S.) Geological Survey
Helena, MT

Sep 80

QE
75
.U58w
no.80-76
1980

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

NTIS[®]

LIBRARY

JUN 02 1981

Bureau of Reclamation
Denver, Colorado

SURPLUS
RECLAMATION LIBRARY
DO NOT REMOVE



BUREAU OF RECLAMATION DENVER LIBRARY



92057434

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

REPORT DOCUMENTATION PAGE		1. REPORT NO. USGS/WRD/WRI-80/0771	2.	3. Recipient's Accession No. PB81 125023	
4. Title and Subtitle SIMULATION OF WATER-QUALITY DATA AT SELECTED STREAM SITES IN THE MISSOURI RIVER BASIN, MONTANA (Final report)				5. Report Date September 1980	
7. Author(s) J. R. Knapton and M. A. Jacobson				8. Performing Organization Rept. No. USGS/WRI 80-76	
9. Performing Organization Name and Address U.S. Geological Survey, Water Resources Division 428 Federal Building, Drawer 10076 Helena, Montana 59601				10. Project/Task/Work Unit No.	
				11. Contract(C) or Grant(G) No. (C) (G)	
12. Sponsoring Organization Name and Address U.S. Geological Survey, Water Resources Division 428 Federal Building, Drawer 10076 Helena, Montana 59601				13. Type of Report & Period Covered Final	
				14.	
15. Supplementary Notes					
16. Abstract (Limit: 200 words) Modification of sampling programs at some water-quality stations in the Missouri River basin in Montana has eliminated the means by which solute loads have been directly obtained in past years. To compensate for this loss, water-quality and streamflow data were statistically analyzed and solute loads were simulated using computer techniques. Functional relationships existing between specific conductance and solute concentration for monthly samples were used to develop linear regression models. The models were then used to simulate daily solute concentrations using daily specific conductance as the independent variable. Once simulated, the solute concentrations, in milligrams per liter, were transformed into daily solute loads, in tons, using mean daily streamflow records. Computer output was formatted into tables listing simulated mean monthly solute concentrations, in milligrams per liter, and the monthly and annual solute loads, in tons, for water years 1975-78.					
17. Document Analysis a. Descriptors Missouri River, Montana, water quality, model studies					
b. Identifiers/Open-Ended Terms Specific conductance, simulated solute concentrations, simulated solute loads					
c. COSATI Field/Group I					
18. Availability Statement No restriction on distribution Prepared for NTIS by U.S. Geological Survey, WRD			19. Security Class (This Report) Security Class (This Page)		21. No. of Pages 37
					22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly N11S-35)
Department of Commerce

SIMULATION OF WATER-QUALITY DATA AT SELECTED
STREAM SITES IN THE MISSOURI RIVER BASIN, MONTANA

By J. R. Knapton and M. A. Jacobson

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 80-76



Helena, Montana
September 1980

I. a

CONTENTS

	Page
Metric conversion table	IV
Abstract.	1
Introduction.	1
Purpose	2
Scope	2
Historical significance of solute transport	3
Functional relationships between variables.	4
Discussion of functional relationships.	9
Simulation of data.	10
Conclusions	11
References.	11
Supplemental information.	12

ILLUSTRATIONS

Figure 1. Map showing location of stations in the Missouri River basin of Montana where water-quality data were simulated.	2
2. Graph showing relationship of dissolved solids to specific conductance for the Yellowstone River near Livingston, water years 1976-78	5

TABLES

Table 1. Station descriptions.	13
2. Most recent regressions using specific conductance (independent variable) and dissolved constituents (dependent variable)	6
3. Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78.	17
4. Comparison, in percent, of simulated solute loads to measured solute loads at eight stations for the 1974 water year	10

METRIC CONVERSION TABLE

The following factors can be used to convert inch-pound units in this report to the International System (SI) of metric units.

<u>Multiply inch-pound unit</u>	<u>By</u>	<u>To obtain SI unit</u>
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
cubic foot (ft ³)	28.32	liter (L)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
pound (lb)	453.6	gram (g)
ton (short)	0.9072	metric ton (tonne)
temperature, degrees Celsius (°C) = 0.556 (°F-32)		

SIMULATION OF WATER-QUALITY DATA AT SELECTED
STREAM SITES IN THE MISSOURI RIVER BASIN, MONTANA

by

J. R. Knapton and M. A. Jacobson

ABSTRACT

Modification of sampling programs at some water-quality stations in the Missouri River basin in Montana has eliminated the means by which solute loads have been directly obtained in past years. To compensate for this loss, water-quality and streamflow data were statistically analyzed and solute loads were simulated using computer techniques.

Functional relationships existing between specific conductance and solute concentration for monthly samples were used to develop linear regression models. The models were then used to simulate daily solute concentrations using daily specific conductance as the independent variable. Once simulated, the solute concentrations, in milligrams per liter, were transformed into daily solute loads, in tons, using mean daily streamflow records.

Computer output was formatted into tables listing simulated mean monthly solute concentrations, in milligrams per liter, and the monthly and annual solute loads, in tons, for water years 1975-78.

INTRODUCTION

Demands for water-resources information in the upper Missouri River basin are becoming more numerous as a result of conflicting water-use priorities. Water-use planners and managers require more information than is now available to make predictions with the necessary degree of accuracy. Major solutes, principal factors in assessing water quality, are of importance in nearly all water-use proposals for the region. Major-solute data have been collected at stream locations for more than 40 years and are available in tabular form as solute concentrations and solute loads. Recently, however, the emphasis in water-quality work has shifted, placing greater priority on constituents that are thought to be of more imminent threat to the environment than the major solutes. The net result is a considerable reduction in solute-load information in recent data reports (U.S. Geological Survey, issued annually). The load data are sometimes recoverable through simulation, using other water-quality and streamflow data that are being collected.

Purpose

The purpose of this report is to present simulated solute-load information for selected water-quality stations in the Missouri River basin of Montana (fig. 1, and table 1 in the Supplemental Information section at back of report) and to document the means by which simulation was done. Until September 1974, these load data were obtained directly from analyses of discharge-weighted composite samples; the data were published by the U.S. Geological Survey (issued annually). After September 1974, sample compositing was discontinued and solute-load information was obtained through simulation. The simulated data, which were not published in the annual report, are presented herein.

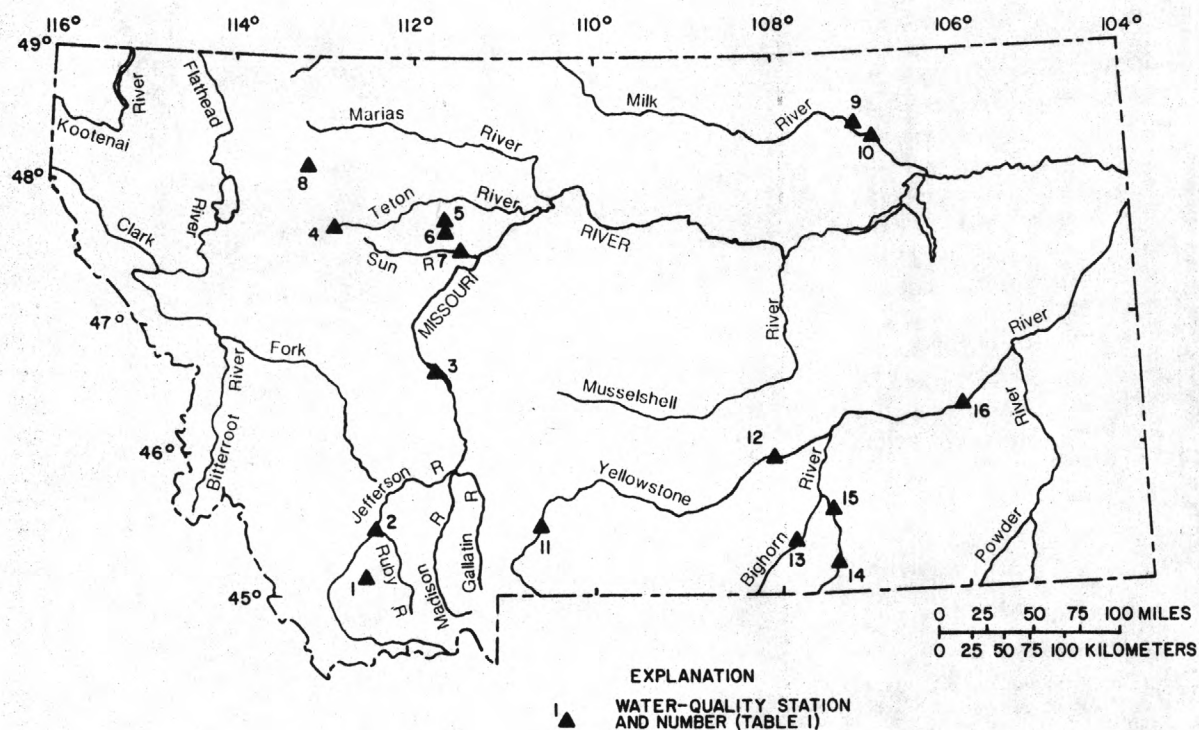


Figure 1.--Location of stations in the Missouri River basin of Montana where water-quality data were simulated.

Scope

Water-quality data in this report have been simulated for 16 stations in the Missouri River basin of Montana. The stations are operated by the U.S. Geological Survey at the request of other agencies of the Department of the

Interior. The data obtained fulfill certain water-quality needs of the requesting agencies. The Montana stations are part of the commonly referred to Missouri River Basin Network, which is but one of several water-quality networks functioning in the basin. Some of the Montana stations have been operated under the network program for many years, others are relatively new, and some have been discontinued as data needs were met. The data in this report are for October 1974 through September 1978 (water years 1975-78).

HISTORICAL SIGNIFICANCE OF SOLUTE TRANSPORT

Historically, much of the impetus for inorganic water-chemistry work done by the U.S. Geological Survey was for the purpose of determining solute transport in streams--primarily the loading of major solutes throughout the annual flow periods (Rainwater and Thatcher, 1960). Knowledge of spatial solute transport of a stream is essential to most water-quality evaluations such as: (1) Determining the geologic processes of erosion of rocks and soil and modification of land forms, (2) determining the quantity of pollutants entering a stream or the capacity of the stream to assimilate a quantity of waste material, (3) determining the salt balance on irrigated lands, (4) determining the magnitude of evapotranspiration on land or in streams or reservoirs, and (5) determining the potential quality of water if impounded.

Until September 1974, solute loads were obtained from composite results of daily samples and stream-discharge data. Products of solute concentrations from composite samples and the mean discharge for the composite period multiplied by a constant provided the load, as indicated by equation 1:

$$L = Q \times C \times K \quad (1)$$

where L = load for composite period, in tons;
 Q = mean discharge for composite period,
 in cubic feet per second;
 C = solute concentration for composite sample,
 in milligrams per liter, and
 $K = \frac{86,400 \text{ seconds per day} \times 62.4 \text{ pounds per cubic foot}}{2,000 \text{ pounds per ton} \times 1,000,000 \text{ milligrams per liter}} = 0.0027$

Composites were prepared by combining volumes from each of the daily samples that were proportional to the mean daily discharge. The daily sample was considered to contain solute concentrations that represented the mean for the day. Generally, composite periods ranged from 10 to 30 days and were determined by a measure of specific conductance of individual samples--a marked change in specific conductance of daily samples determined a break in composite periods. Obviously, a separate analysis of each daily sample would eliminate the necessity to composite and likely improve the accuracy of load determination; however, analytical costs make this method prohibitive.

For some types of water-quality studies compositing of samples is not desirable. Records obtained from sample composites commonly mask conditions

that are only obvious from the analyses of individual samples. Temporal concentrations are most commonly the criteria used in classifying Montana waters and form the basis for many water-quality programs presently operated in Montana. In recent years greater emphasis has been placed on the analysis of individual samples, often at the expense of sample composites.

This modification in sampling, of course, eliminated compositing as a means for determining solute transport. Because of changing program objectives at many sampling sites, solute transport is of little benefit to the cooperator. At other stream locations where solute transport is deemed important, statistical analysis of streamflow and water-quality data by means of computer techniques permits the simulation of solute loading without sacrificing temporal sampling. In addition to daily streamflow, water-quality requirements for simulation include daily specific conductance and monthly sampling for solute concentration.

FUNCTIONAL RELATIONSHIPS BETWEEN VARIABLES

Functional relationships commonly exist between various physical, chemical, and biological properties of a stream. Examination of the data using statistical techniques is a way of determining the strengths of such relationships. Although solute concentrations can be related to a number of factors, one of the best correlations is frequently with specific conductance.

Because specific conductance of water is dependent on the ions in solution to conduct an electric current, a direct relationship (fig. 2) exists with the sum of the dissolved solutes (dissolved solids) as well as with those individual solutes that are present. Correlations are generally best with dissolved solids and tend to decrease with those solutes that become less dominant. Other factors inherent in solutions such as the degree of ionization also affect the correlations. For example, silica, which is practically nonionic at the pH of most natural waters (6.0 - 8.5), generally has little correlation with specific conductance.

Scatter diagrams similar to figure 2 were plotted by computer for constituent concentration against specific conductance at each station. The plotted data were visually inspected to determine if linear relationships could be expected. In this study, the relationship between solute concentration and specific conductance is described by using a simple linear regression as follows:

$$C = a + bS, \quad (2)$$

where C = solute concentration in milligrams per liter (dependent variable),
a = regression constant (y intercept),
b = regression coefficient (slope), and
S = specific conductance in micromhos per centimeter (independent variable) .

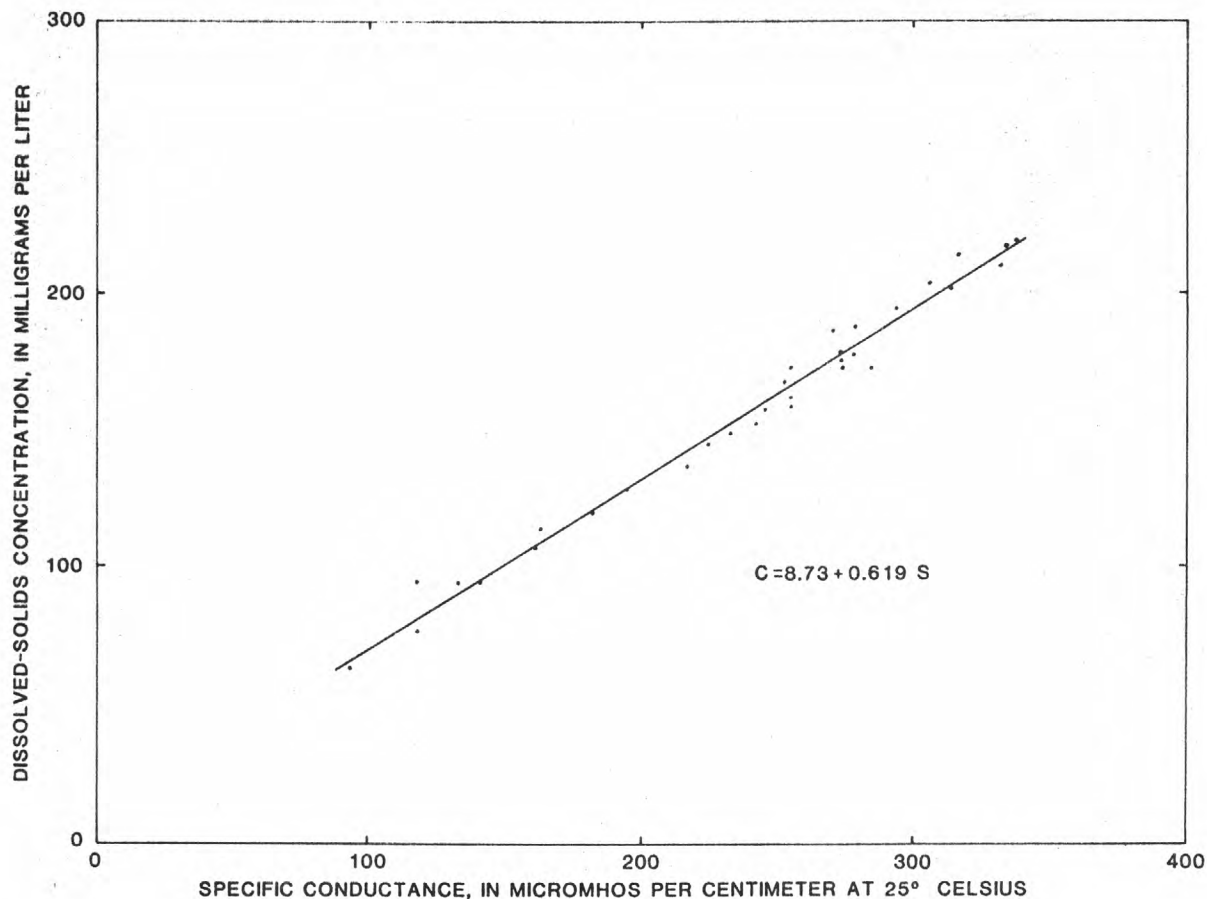


Figure 2.--Relationship of dissolved solids to specific conductance for the Yellowstone River near Livingston, water years 1976-78. The regression equation is of the same form as equation 2.

Regression summaries for individual solutes at each station are listed in table 2. For this study the practice has been, when possible, to develop new regression equations periodically, using analytical data from the past 3 years of sampling record (30-40 paired values). In a few instances for new stations, less than 3 years of record was used. The regression constant and regression coefficient in table 2, developed through programs given by Bar, Goodnight, Sell, and Helwig (1976), were used in simulating the 1978 water-year data. The equations used for previous years are not shown.

The strengths of functional relationships listed in the regression summaries are indicated by the correlation coefficient, the standard error of estimate, and the level of significance of the correlation coefficient. The correlation coefficient is a measure of the goodness of fit that the equation actually assumed to the data and ranges from -1 to +1. No relationship exists if the correlation coefficient is zero, whereas a perfect linear relationship exists if

Table 2.--Most recent regressions using specific conductance (independent variable) and dissolved constituents (dependent variable)

Variable	Sample size	Regression constant	Regression coefficient	Correlation coefficient	Standard error of estimate	Correlation coefficient level of significance	Period of record used	Range of specific conductance (µmho/cm at 25°C)
Station 1 Beaverhead River at Barretts, Mont (06016000)								
Calcium	32	- 0.534	0.117	+0.896	2.59	0.0001	1976-78	297-645
Magnesium	32	- 3.16	.0458	+ .855	1.25	.0001	1976-78	297-645
Sodium	32	5.69	.0305	+ .637	1.65	.0001	1976-78	297-645
Bicarbonate and carbonate	32	78.3	.287	+ .597	17.3	.0003	1976-78	297-645
Sulfate	32	- 83.6	.314	+ .826	9.59	.0001	1976-78	297-645
Chloride	32	- 2.20	.0258	+ .528	1.86	.0019	1976-78	297-645
Dissolved solids	32	- 24.1	.674	+ .921	12.7	.0001	1976-78	297-645
Station 2 Beaverhead River near Twin Bridges, Mont (06018500)								
Calcium	31	17.6	.0866	+ .858	3.62	.0001	1976-78	488-882
Magnesium	31	- 3.12	.0461	+ .918	1.39	.0001	1976-78	488-882
Sodium	31	- 13.0	.0640	+ .881	2.40	.0001	1976-78	488-882
Bicarbonate and carbonate	31	108	.256	+ .730	16.7	.0001	1976-78	488-882
Sulfate	31	- 32.0	.214	+ .881	8.03	.0001	1976-78	488-882
Chloride	31	- 13.7	.0467	+ .865	1.89	.0001	1976-78	488-882
Dissolved solids	31	26.4	.600	+ .959	72.4	.0001	1976-78	488-882
Station 3 Missouri River below Canyon Ferry Dam, near Helena, Mont (06058502)								
Calcium	36	2.03	.101	+ .789	3.31	.0001	1976-78	242-442
Magnesium	36	- 2.88	.0405	+ .924	.706	.0001	1976-78	242-442
Sodium	36	- 6.66	.0687	+ .912	1.30	.0001	1976-78	242-442
Bicarbonate and carbonate	36	4.48	.439	+ .956	5.64	.0001	1976-78	242-442
Sulfate	36	- 14.8	.145	+ .910	2.79	.0001	1976-78	242-442
Chloride	36	- 6.90	.0455	+ .819	1.34	.0001	1976-78	242-442
Dissolved solids	36	- 16.7	.659	+ .965	7.57	.0001	1976-78	242-442
Station 4 Sun River below diversion dam, near Augusta, Mont (06080900)								
Calcium	31	.803	.145	+ .965	3.08	.0001	1976-78	183-504
Magnesium	31	- 2.64	.0458	+ .969	.917	.0001	1976-78	183-504
Sodium	31	.601	.00395	+ .691	.324	.0001	1976-78	183-504
Bicarbonate and carbonate	31	84.2	.231	+ .880	9.80	.0001	1976-78	183-504
Sulfate	31	- 70.9	.341	+ .965	7.32	.0001	1976-78	183-504
Chloride	31	---	---	+ .0694	.271	.7107	1976-78	183-504
Dissolved solids	31	- 26.6	.658	+ .976	11.5	.0001	1976-78	183-504
Station 5 Muddy Creek near Vaughn, Mont (06088300)								
Calcium	36	35.9	.0269	+ .972	5.49	.0001	1976-78	544-6400
Magnesium	36	3.57	.0607	+ .992	6.66	.0001	1976-78	544-6400
Sodium	36	- 75.9	.146	+ .990	17.3	.0001	1976-78	544-6400
Bicarbonate and carbonate	36	---	---	+ .324	63.5	.0542	1976-78	544-6400
Sulfate	35	-318	.570	+ .989	71.0	.0001	1976-78	544-6400
Chloride	35	- 7.18	.0162	+ .984	2.45	.0001	1976-78	544-6400
Dissolved solids	35	-200	.853	+ .996	65.8	.0001	1976-78	544-6400
Station 6 Muddy Creek at Vaughn, Mont (06088500)								
Calcium	36	32.7	.0327	+ .929	5.58	.0001	1976-78	519-5630
Magnesium	36	1.33	.0595	+ .965	6.91	.0001	1976-78	519-5630
Sodium	36	- 42.5	.117	+ .986	8.55	.0001	1976-78	519-5630
Bicarbonate and carbonate	36	218	.0970	+ .584	57.7	.0002	1976-78	519-5630
Sulfate	36	-161	.441	+ .983	35.7	.0001	1976-78	519-5630
Chloride	36	- 6.40	.0151	+ .946	2.21	.0001	1976-78	519-5630
Dissolved solids	36	- 74.4	.740	+ .996	28.7	.0001	1976-78	519-5630

Table 2.--Most recent regressions using specific conductance (independent variable) and dissolved constituents (dependent variable)

Variable	Sample size	Regression constant	Regression coefficient	Correlation coefficient	Standard error of estimate	Correlation coefficient level of significance	Period of record used	Range of specific conductance (µmho/cm at 25°C)
Station 7 Sun River near Vaughn, Mont (06089000)								
Calcium	36	26.3	.0491	+ .916	4.93	.0001	1976-78	278-2610
Magnesium	36	- 2.58	.0565	+ .960	3.77	.0001	1976-78	278-2610
Sodium	36	28.8	.100	+ .973	5.48	.0001	1976-78	278-2610
Bicarbonate and carbonate	36	138	.154	+ .768	29.3	.0001	1976-78	278-2610
Sulfate	36	-109	.405	+ .982	18.0	.0001	1976-78	278-2610
Chloride	35	4.33	.0125	+ .895	1.44	.0001	1976-78	278-2610
Dissolved solids	35	- 46.5	.708	+ .995	15.7	.0001	1976-78	278-2610
Station 8 Birch Creek near Valier, Mont (06098100)								
Calcium	11	8.35	.0673	+ .744	6.78	.0086	1978	372-1260
Magnesium	11	2.33	.0375	+ .814	3.00	.0023	1978	372-1260
Sodium	11	- 27.9	.135	+ .775	12.4	.0051	1978	372-1260
Bicarbonate and carbonate	11	55.1	.352	+ .920	16.8	.0001	1978	372-1260
Sulfate	11	-113	.365	+ .924	17.0	.0001	1978	372-1260
Chloride	11	---	---	+ .135	1.15	.6920	1978	372-1260
Dissolved solids	11	- 85.7	.771	+ .956	26.7	.0001	1978	372-1260
Station 9 Milk River at Juneberg Bridge, near Saco, Mont (06164510)								
Calcium	10	8.61	.0532	+ .984	5.30	.0001	1978	280-2220
Magnesium	10	- 2.08	.0331	+ .988	2.86	.0001	1978	280-2220
Sodium	10	- 29.8	.154	+ .974	19.6	.0001	1978	280-2220
Bicarbonate and carbonate	10	58.4	.230	+ .963	34.9	.0001	1978	280-2220
Sulfate	10	- 76.2	.359	+ .976	43.7	.0001	1978	280-2220
Chloride	10	- 3.40	.0204	+ .751	9.77	.0123	1978	280-2220
Dissolved solids	10	- 62.6	.737	+ .979	84.6	.0001	1978	280-2220
Station 10 Milk River at Tampico, Mont (06172310)								
Calcium	21	- 1.36	.0623	+ .968	6.83	.0001	1976-77	317-2170
Magnesium	21	- 2.23	.0313	+ .990	1.91	.0001	1976-77	317-2170
Sodium	21	- 22.4	.143	+ .982	11.6	.0001	1976-77	317-2170
Bicarbonate and carbonate	21	32.2	.240	+ .946	34.9	.0001	1976-77	317-2170
Sulfate	21	- 72.0	.361	+ .986	26.3	.0001	1976-77	317-2170
Chloride	21	- 7.41	.0236	+ .941	3.60	.0001	1976-77	317-2170
Dissolved solids	21	- 79.1	.742	+ .997	23.7	.0001	1976-77	317-2170
Station 11 Yellowstone River near Livingston, Mont (06192500)								
Calcium	32	2.40	.0780	+ .984	1.06	.0001	1976-78	83-366
Magnesium	32	.773	.0249	+ .966	.495	.0001	1976-78	83-366
Sodium	32	- 1.28	.0755	+ .981	1.13	.0001	1976-78	83-366
Bicarbonate and carbonate	32	16.1	.326	+ .980	4.97	.0001	1976-78	83-366
Sulfate	32	- 6.65	.150	+ .969	2.83	.0001	1976-78	83-366
Chloride	32	- 2.73	.0482	+ .930	1.43	.0001	1976-78	83-366
Dissolved solids	32	8.73	.619	+ .992	6.01	.0001	1976-78	83-366
Station 12 Fly Creek at Pompeys Pillar, Mont (06217750)								
Calcium	36	36.9	.0429	+ .903	18.6	.0001	1976-78	657-4250
Magnesium	36	1.44	.0408	+ .973	8.81	.0001	1976-78	657-4250
Sodium	36	- 70.1	.160	+ .980	29.8	.0001	1976-78	657-4250
Bicarbonate and carbonate	36	146	.0928	+ .865	49.1	.0001	1976-78	657-4250
Sulfate	36	-164	.515	+ .987	75.4	.0001	1976-78	657-4250
Chloride	36	- 6.29	.0114	+ .813	7.46	.0001	1976-78	657-4250
Dissolved solids	36	-111	.816	+ .993	88.5	.0001	1976-78	657-4250

Table 2.--Most recent regressions using specific conductance (independent variable) and dissolved constituents (dependent variable)

Variable	Sample size	Regression constant	Regression coefficient	Correlation coefficient	Standard error of estimate	Correlation coefficient level of significance	Period of record used	Range of specific conductance (µmho/cm at 25°C)
Station 13 Bighorn River near St. Xavier, Mont (06287000)								
Calcium	36	- 3.28	.0929	+ .956	4.36	.0001	1976-78	544-3670
Magnesium	36	- 7.49	.0390	+ .965	1.64	.0001	1976-78	544-3670
Sodium	36	- 8.63	.0981	+ .970	3.74	.0001	1976-78	544-3670
Bicarbonate	36	56.9	.167	+ .940	9.31	.0001	1976-78	544-3670
and carbonate								
Sulfate	36	- 68.0	.395	+ .980	12.3	.0001	1976-78	544-3670
Chloride	36	- 6.45	.0204	+ .892	1.58	.0001	1976-78	544-3670
Dissolved solids	36	- 50.8	.729	+ .987	18.5	.0001	1976-78	544-3670
Station 14 Little Bighorn River below Pass Creek, near Wyola, Mont (06290500)								
Calcium	10	36.8	.0509	+ .739	3.95	.0147	1976	337-821
Magnesium	10	1.45	.0435	+ .879	2.01	.0008	1976	337-821
Sodium	10	- 31.0	.0905	+ .798	5.80	.0056	1976	337-821
Bicarbonate	10	---	---	+ .560	14.4	.0923	1976	337-821
and carbonate								
Sulfate	10	-135	.440	+ .923	15.6	.0001	1976	337-821
Chloride	10	- 2.17	.00646	+ .845	.348	.0021	1976	337-821
Dissolved solids	10	- 43.7	.701	+ .952	19.2	.0001	1976	337-821
Station 15 Little Bighorn River near Hardin, Mont (06294000)								
Calcium	33	30.6	.0511	+ .591	11.2	.0003	1976-78	421-1340
Magnesium	33	2.70	.0434	+ .949	2.33	.0001	1976-78	421-1340
Sodium	33	- 45.5	.121	+ .879	10.6	.0001	1976-78	421-1340
Bicarbonate	33	129	.174	+ .641	33.5	.0001	1976-78	421-1340
and carbonate								
Sulfate	33	-106	.398	+ .933	24.6	.0001	1976-78	421-1340
Chloride	33	- .531	.00537	+ .723	.824	.0001	1976-78	421-1340
Dissolved solids	33	- 47.6	.709	+ .988	18.1	.0001	1976-78	421-1340
Station 16 Yellowstone River near Miles City, Mont (06296120)								
Calcium	36	5.47	.0759	+ .948	4.17	.0001	1976-78	238-1040
Magnesium	36	.0511	.0323	+ .971	1.30	.0001	1976-78	238-1040
Sodium	36	- 4.29	.0907	+ .967	3.91	.0001	1976-78	238-1040
Bicarbonate	37	56.6	.182	+ .894	15.7	.0001	1976-78	238-1040
and carbonate								
Sulfate	36	- 39.2	.342	+ .976	12.6	.0001	1976-78	238-1040
Chloride	36	- .586	.0144	+ .894	1.18	.0001	1976-78	238-1040
Dissolved solids	36	1.93	.648	+ .988	16.8	.0001	1976-78	238-1040

the correlation coefficient is -1 or +1. The standard error of estimate is the average squared deviation of the predicted values from the measured values. The level of significance of the correlation coefficient indicates the probability of getting a sample with a correlation coefficient greater than the observed value if the population correlation really was zero. The probability value for the level of significance is listed in table 2. Some investigators believe that if the test achieves the 0.05 level or smaller, the particular null hypothesis should be rejected. For this study, the null hypothesis was represented by a correlation coefficient that was equal to zero. Although 0.05 is an arbitrary number, it was used in this investigation as a limit in determining the reliability of the regression equations. In instances where the level of significance exceeded 0.05, the regression constant and regression coefficient were eliminated from table 2 and later simulation was not attempted. Even though these regression parameters were eliminated from the table, the remaining regression parameters were retained in an attempt to show the degree of weakness of the relationships.

DISCUSSION OF FUNCTIONAL RELATIONSHIPS

The scatter diagrams generally indicated that linear regression equations described the data through the entire range. Regression equations from logarithmic transformations (log base 10) showed little improvement and in most instances were weaker than those developed using untransformed data. Relationships between stream discharge as an independent variable and constituent concentrations also were examined. They were seldom as strong as the regression equations developed when using specific conductance as the independent variable. Streamflow regulation upstream from many of the stations probably accounted for the lack of correlation with stream discharge. The presence of regulation moderates natural flows and disrupts expected relationships between discharge and dissolved constituents.

Of all the equations, dissolved solids most frequently had the strongest correlations with specific conductance at individual stations. Dissolved solids generally were followed by the more dominant ions of magnesium, sodium, sulfate, and calcium. Although bicarbonate and carbonate accounted for large percentages of the anion sums, they commonly showed weaker correlations than the above ions. The weakest correlations were found to be with chloride where small concentration ranges were masked by the more dominant ions.

Like all regression models, caution needs to be exercised in the application of regression constants and regression coefficients of table 2. Simulation of data values should be within the range of the data base used to develop the equations. Large negative and positive y intercepts for some of the equations demonstrate the inadequacy for estimating values below the lower limits of the data base. Similar errors due to nonlinearity between the dependent and independent variables may exist above the upper limits of the data base.

SIMULATION OF DATA

A computer program has been developed for simulating chemical quality of streamflow. The program uses mean daily records of specific conductance and stream discharge in conjunction with the appropriate regression model from table 2 (Williams, 1975). One-time daily samples for specific conductance are used to represent the mean daily specific conductance. Although specific conductance sometimes varies throughout the day, these fluctuations tend to be smoothed and become less significant in the monthly and annual summaries. A continuous-streamflow record is processed to provide mean daily discharge values.

Solute concentrations were simulated using regression models (eq. 2) in which the independent variable S is the mean daily specific conductance. Once simulated, the solute concentrations, in milligrams per liter, were further transformed into daily solute loads using a computation similar to that shown in equation 1. The summation of the appropriate periods of daily solute loads provided monthly and annual loads. The program output was formatted and listed in table 3 (see Supplemental Information section at back of report), which gives simulated mean monthly concentrations, in milligrams per liter, and monthly and annual solute loads, in tons. Daily concentrations and loads were omitted for the purpose of brevity.

For the 1974 water year both the actual measurement, by means of sample compositing, and the simulation were used to determine loads at eight stations. This procedure enabled a comparison to be made of the two methods and is a measure of the validity of simulation. The constituents and their variability at the stations when the 1974 simulated annual loads were compared with the 1974 measured annual loads are listed in table 4. The range of difference, in percent, indicates the greatest negative and positive comparative differences for each constituent at the eight stations. The level of significance was

Table 4.--Comparison, in percent, of simulated solute loads
to measured solute loads at eight stations for the
1974 water year

Constituent	Range of difference, in percent	Level of significance
Calcium	-4.1 to +13.6	0.96
Magnesium	-7.2 to +6.9	.96
Sodium	-4.4 to +7.6	.72
Bicarbonate-carbonate	-1.6 to +13.5	.88
Sulfate	-13.7 to +7.1	.96
Chloride	-0.7 to +15.4	.88
Dissolved solids	-2.8 to +7.9	.88

computed by the Mann-Whitney U test (Ott, 1977); it represents the probability of the simulated value being equal to the measured value. Although a certain amount of variability is shown between the measured and simulated constituent loads, the results show that simulation of constituent loads can reasonably approach the results obtained by actual measurement.

CONCLUSIONS

Simulation of solute loads in streams, using linear regression models developed for the major solutes with specific conductance as an independent variable, is an alternative to obtaining solute-load information through discharge-weighted compositing of daily water samples. Regression statistics given in this report show strengths of the models and provide an indication of the validity of simulated solute loads. The statistics generally confirm that reliable solute loads can be simulated for dissolved solids, magnesium, sodium, sulfate, and calcium at the network stations. However, in using regression models to obtain solute loads for bicarbonate-carbonate and chloride, discretion needs to be exercised. These two solutes showed weak correlations at certain stations.

REFERENCES

- Bar, A. J., Goodnight, J. H., Sell J. P., and Helwig, J. T., 1976, A user's guide to SAS: Statistical Analysis System Institute, Inc., 329 p.
- Ott, Lyman, 1977, An introduction to statistical methods and data analysis: Duxbury Press, North Seituete, Mass., 730 p.
- Rainwater, F. H., and Thatcher, L. L., 1960, Methods for collection and analysis of water samples: U.S. Geological Survey Water-Supply Paper 1454, 301 p.
- U.S. Geological Survey, issued annually, Water resources data for Montana: U.S. Geological Survey water-data report.
- Williams, O. O., 1975, Daily values data entry and computation (program H475), sec. A, of National Water Data Storage and Retrieval System, Hutchinson, N. E., compiler: U.S. Geological Survey WATSTORE User's Guide, v. 1, chap. IV, Open-File Report 75-426, p. A-1 - A-93.

SUPPLEMENTAL INFORMATION

Table 1.--Station descriptions

[Number to left of station name is the same as shown on fig. 1; number to right is formal Geological Survey station number]

Station 1 BEAVERHEAD RIVER AT BARRETTS, MONT (06016000)

LOCATION.--Lat 45°06'59", long 112°44'59", in SW1/4SE1/4 sec. 19, T. 8 S., R. 9 W., Beaverhead County, on left bank 1 mi (2 km) upstream from Barretts, 2 mi (3 km) downstream from Grasshopper Creek, and 8.9 mi (14.3 km) southwest of Dillon. Samples collected 1.0 mi (1.6 km) downstream from gaging station. PERIOD OF SIMULATED RECORD.--1975-78.

Station 2 BEAVERHEAD RIVER NEAR TWIN BRIDGES, MONT (06018500)

LOCATION.--Lat 45°23'01", long 112°27'07", in SW1/4NW1/4SE1/4 sec. 22, T. 5 S., R. 7 W., Madison County, on left bank at downstream side of bridge on State Highway 41, 11.5 mi (18.5 km) upstream from Ruby River, 12.7 mi (20.4 km) southwest of Twin Bridges, and 14.5 mi (23.3 km) northeast of Dillon. PERIOD OF SIMULATED RECORD.--1975-78.

Station 3 MISSOURI RIVER BELOW CANYON FERRY DAM, NEAR HELENA, MONT (06058502)

LOCATION.--Lat 46°38'58", long 111°43'39", in NW1/4SE1/4SE1/4 sec. 4, T. 10 N., R. 1 W., Lewis and Clark County, just downstream from generator outlet at Canyon Ferry Dam, 15 mi (24 km) east of Helena, and at mile 2,242.8 (3,608.7 km). PERIOD OF SIMULATED RECORD.--1975-78.

Station 4 SUN RIVER BELOW DIVERSION DAM, NEAR AUGUSTA, MONT (06080900)

LOCATION.--Lat 47°37'10", long 112°41'28", near center of east line of sec. 36, T. 22 N., R. 9 W., Lewis and Clark County, Lewis and Clark National Forest, on road bridge 1.0 mi (1.6 km) downstream from diversion dam, 16.5 mi (26.5 km) northwest of Augusta, and at mile 95.6 (153.8 km). PERIOD OF SIMULATED RECORD.--1975-78.

Station 5 MUDDY CREEK NEAR VAUGHN, MONT (06088300)

LOCATION.--Lat 47°37'30", long 111°38'05", NW1/4NE1/4 sec. 32, T. 22 N., R. 1 E., Cascade County, on left bank 200 ft (61 m) downstream from bridge on county road and 6.2 mi (10.0 km) northwest of Vaughn. PERIOD OF SIMULATED RECORD.--1975-78.

Table 1.--Station descriptions--Continued

Station 6 MUDDY CREEK AT VAUGHN, MONT (06088500)

LOCATION.--Lat 47°33'42", long 111°32'33", near center of S1/2NE1/4 sec. 24, T. 21 N., R. 1 E., Cascade County, on right bank about 30 ft (9.1 m) upstream from old highway bridge at Vaughn, 1.5 mi (2.4 km) upstream from mouth.
PERIOD OF SIMULATED RECORD.--1975-78.

Station 7 SUN RIVER NEAR VAUGHN, MONT (06089000)

LOCATION.--Lat 47°31'37", long 111°29'05", in NW1/4SE1/4SW1/4 sec. 33, T. 21 N., R. 2 E., Cascade County, on right bank 3.7 mi (6.0 km) downstream from Muddy Creek, 3.6 mi (5.8 km) southeast of Vaughn, and at mile 14.6 (23.5 km).
PERIOD OF SIMULATED RECORD.--1975-78.

Station 8 BIRCH CREEK NEAR VALIER, MONT (06098100)

LOCATION.--Lat 48°21'29", long 112°20'13", in SW1/4NE1/4SE1/4 sec. 14, T. 30 N., R. 6 W., Pondera County, Blackfoot Indian Reservation, on left bank, 240 ft (73 m) downstream from bridge on State Highway 358, 4.2 mi (6.8 km) downstream from Dupuyer Creek, 5.5 mi (8.8 km) northwest of Valier, and 12.7 mi (20.4 km) upstream from mouth.
PERIOD OF SIMULATED RECORD.--1978.

Station 9 MILK RIVER AT JUNEBOG BRIDGE, NEAR SACO, MONT (06164510)

LOCATION.--Lat 48°30'32", long 107°13'02", in NE1/4NE1/4 sec. 30, T. 32 N., R. 35 E., Phillips County, on left bank 25 ft (8 m) upstream from Junebog bridge on Phillips County road, 1.5 mi (2.4 km) downstream from Frenchman River, and 6.9 mi (11.1 km) northeast of Saco.
PERIOD OF SIMULATED RECORD.--1978.

Station 10 MILK RIVER AT TAMPICO, MONT (06172310)

LOCATION.--Lat 48°18'29", long 106°49'19", in SW1/4SW1/4SW1/4 sec. 32, T. 30 N., R. 38 E., Valley County, at county bridge 0.8 mi (1.3 km) downstream from Buggy Creek, and 0.3 mi (0.5 km) northeast of Tampico.
PERIOD OF SIMULATED RECORD.--1975-77.

Table 1.--Station descriptions--Continued

Station 11 YELLOWSTONE RIVER NEAR LIVINGSTON, MONT (06192500)

LOCATION.--Lat 45°35'50", long 110°33'55", in NE1/4NW1/4NW1/4 sec. 12, T. 3 S., R. 9 E., Park County, on right bank 50 ft (15 m) downstream from bridge on former U.S. Highway 89, 2 mi (3 km) downstream from Suce Creek, 4 mi (6 km) south of Livingston, and at mile 481.3 (774.4 km).

PERIOD OF SIMULATED RECORD.--1975-78.

Station 12 FLY CREEK AT POMPEYS PILLAR, MONT (06217750)

LOCATION.--Lat 45°59'33", long 107°57'07", in NW1/4SE1/4 sec. 23, T. 3 N., R. 30 E., Yellowstone County, on right bank at county bridge at Pompeys Pillar and 0.5 mi (0.8 km) upstream from mouth.

PERIOD OF SIMULATED RECORD.--1975-78.

Station 13 BIGHORN RIVER NEAR ST. XAVIER, MONT (06287000)

LOCATION.--Lat 45°19'00", long 107°55'05", in NW1/4NE1/4 sec. 16, T. 6 S., R. 31 E., Big Horn County, on right bank 800 ft (244 m) downstream from Yellowtail afterbay dam, 1,500 ft (460 m) downstream from Lime Kiln Creek, and 14 mi (23 km) southwest of St. Xavier.

PERIOD OF SIMULATED RECORD.--1975-78.

Station 14 LITTLE BIGHORN RIVER BELOW PASS CREEK, NEAR WYOLA, MONT (06290500)

LOCATION.--Lat 45°10'38", long 107°23'36", in W1/2SW1/4 sec. 35, T. 7 S., R. 35 E., Big Horn County, on right bank 3.5 mi (5.6 km) north of Wyola and 6 mi (10 km) downstream from Pass Creek.

PERIOD OF SIMULATED RECORD.--1975, 1977.

Station 15 LITTLE BIGHORN RIVER NEAR HARDIN, MONT (06294000)

LOCATION.--Lat 45°44'10", long 107°33'24", in NW1/4SW1/4NW1/4 sec. 20, T. 1 S., R. 34 E., Big Horn County, on right bank 15 ft (4.6 m) downstream from bridge on Sarpy road, 0.2 mi (0.3 km) upstream from terminal wasteway of Agency Canal, 0.6 mi (1.0 km) upstream from mouth, and 2.3 mi (3.7 km) east of Hardin.

PERIOD OF SIMULATED RECORD.--1975-78.

Table 1.--Station descriptions--Continued

Station 16 YELLOWSTONE RIVER NEAR MILES CITY, MONT (06296120)

LOCATION.--Lat $46^{\circ}23'51''$, long $105^{\circ}53'36''$, in SE1/4SW1/4 sec. 31, T. 8 N., R. 47 E., Custer County, at Keogh Bridge, 1.6 mi (2.6 km) upstream from Tongue River, 2.0 mi (3.2 km) west of Miles City, and at mile 183.1 (294.6 km).
PERIOD OF SIMULATED RECORD.--1975-76, 1978.

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78

[All constituents are dissolved]

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1975 WATER YEAR														
Station 1 Beaverhead River at Barretts, Mont (06016000)														
Oct	63	1280	23	461	24	490	250	5130	86	1740	12	235	355	7210
Nov	61	677	22	245	23	261	250	2760	81	905	11	125	343	3830
Dec	63	705	23	253	24	267	250	2770	88	982	12	129	355	3960
Jan	67	709	24	254	25	268	260	2760	94	996	12	130	373	3970
Feb	66	658	24	236	25	249	260	2570	93	923	12	121	371	3690
Mar	64	825	23	297	24	314	260	3270	89	1140	12	152	361	4640
Apr	61	905	22	327	24	348	250	3670	83	1220	11	166	347	5120
May	53	2050	20	755	21	818	230	8940	65	2510	9.8	378	305	11800
June	52	4780	19	1770	21	1920	230	21200	62	5720	9.5	882	297	27600
July	54	5430	20	2000	21	2160	230	23500	67	6720	9.9	1000	309	31100
Aug	56	6210	21	2270	22	2440	240	26200	72	7920	10	1140	321	35400
Sept	60	5160	22	1870	23	2000	250	21200	79	6840	11	950	338	29300
Annual		29389		10738		11535		123970		37616		5408		167620
Station 2 Beaverhead River near Twin Bridges, Mont (06018500)														
Oct	76	1820	30	709	34	814	300	7160	120	2840	19	462	458	11000
Nov	71	2050	26	763	30	855	280	8010	100	3020	16	474	413	11900
Dec	72	1820	27	688	31	776	280	7100	110	2770	17	430	426	10700
Jan	73	1650	28	628	32	710	290	6440	110	2510	18	396	433	9770
Feb	72	1560	27	587	31	666	280	6070	110	2380	17	371	427	9180
Mar	71	1910	27	718	30	799	280	7460	110	2870	17	441	417	11100
Apr	71	2290	27	855	30	962	280	8920	110	3380	17	532	418	13400
May	68	3240	24	1140	27	1250	260	12600	95	4420	14	652	382	18100
June	72	2390	27	899	31	1020	280	9310	110	3570	17	565	426	14100
July	71	5010	27	1870	30	2090	280	19600	110	7390	16	1160	413	29200
Aug	69	5160	25	1890	28	2080	270	20200	99	7390	15	1140	396	29700
Sept	70	4990	26	1820	29	2040	270	19400	100	7200	15	1100	402	28800
Annual		33890		12567		14062		132270		49740		7723		196950
Station 3 Missouri River below Canyon Ferry Dam, near Helena, Mont (06058502)														
Oct	34	12300	9.8	3540	16	5730	150	54200	33	11900	7.9	2860	198	71800
Nov	35	10100	10	2890	17	4830	150	43400	34	9860	8.3	2400	204	58900
Dec	35	14900	10	4220	17	7130	150	63300	34	14500	8.3	3520	205	86500
Jan	37	17700	11	5280	17	8410	160	77300	36	17500	8.9	4280	213	103000
Feb	39	18100	12	5400	19	8630	170	77000	40	18200	9.7	4480	228	105000
Mar	41	20700	12	6080	20	10100	170	86500	42	21100	10	5100	237	120000
Apr	41	19800	12	5760	20	9600	170	82700	42	20100	10	4900	238	114000
May	41	21300	12	6250	20	10400	180	90400	42	21800	11	5430	241	124000
June	41	28800	12	11400	20	18800	170	163000	42	39400	10	9650	238	224000
July	35	47200	10	13700	16	22200	150	204000	34	46100	8.2	11200	203	274000
Aug	30	16400	8.4	4560	14	7410	130	71600	28	14900	6.5	3520	175	94800
Sept	32	13700	9.0	3880	15	6380	140	59700	30	12800	7.1	3060	184	79700
Annual		241000		72960		119620		1073100		248160		60400		1455700
Station 4 Sun River below Diversion Dam, near Augusta, Mont (06080900)														
Oct	51	369	13	96.2	2.1	15.1	170	1220	54	382	---	---	210	1520
Nov	49	589	13	154	2.0	24.4	160	1980	50	591	---	---	203	2430
Dec	50	563	13	147	2.1	23.3	170	1870	53	587	---	---	208	2330
Jan	53	490	14	132	2.2	20.1	170	1590	62	568	---	---	224	2060
Feb	57	474	16	129	2.4	19.5	180	1490	69	573	---	---	243	2010
Mar	57	519	15	139	2.4	21.2	180	1630	69	622	---	---	241	2180
Apr	57	464	15	125	2.3	19.0	180	1450	69	559	---	---	241	1960
May	48	3090	12	790	2.0	130	160	10700	47	2810	---	---	196	12600
June	32	15900	7.2	3600	1.4	686	130	63200	9.4	4250	---	---	118	58900
July	29	4040	6.5	900	1.3	176	120	17100	4.0	464	---	---	107	14900
Aug	38	633	9.3	154	1.6	26.8	140	2350	24	396	---	---	149	2480
Sept	47	388	12	99.5	1.9	16.1	160	1320	44	366	---	---	191	1590
Annual		27519		6465.7		1177.5		105900		12168				104960

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1975 WATER YEAR--Continued													
Station 5 Muddy Creek near Vaughn, Mont (06088300)													
Oct	52	334	54	346	62	394	---	230	1430	6.1	38.8	564	3600
Nov	52	228	57	249	68	299	---	250	1090	6.7	29.4	599	2620
Dec	57	183	65	208	83	263	---	310	972	8.1	25.9	694	2220
Jan	57	145	66	166	83	209	---	310	773	8.2	20.6	698	1760
Feb	56	102	64	115	81	145	---	300	530	8.0	14.3	684	1230
Mar	62	179	77	222	110	302	---	390	1130	10	29.4	832	2400
Apr	63	791	79	990	110	1360	---	410	5050	11	133	859	10700
May	64	1340	81	1650	110	2210	---	420	8250	11	216	881	17800
June	51	1160	53	1250	60	1480	---	210	5390	5.9	146	548	13100
July	49	1130	48	1110	51	1210	---	180	4300	5.0	118	493	11500
Aug	48	1610	45	1500	45	1490	---	160	5180	4.5	148	458	15200
Sept	53	658	56	693	65	803	---	230	2910	6.3	79.0	580	7240
Annual		7860		8499		10165			37005		998.4		89370
Station 6 Muddy Creek at Vaughn, Mont (06088500)													
Oct	56	601	50	544	55	587	290	200	2190	4.9	53.0	530	5720
Nov	59	339	57	326	68	384	310	260	1440	6.3	35.0	616	3500
Dec	63	210	65	217	83	277	320	320	1050	7.7	25.6	712	2370
Jan	64	173	68	182	89	238	330	340	900	8.2	21.9	742	2000
Feb	63	116	66	121	85	155	320	320	588	7.8	14.3	721	1320
Mar	68	222	75	247	100	339	340	390	1290	9.6	31.6	837	2740
Apr	69	1040	78	1190	110	1700	350	420	6490	10	158	874	13400
May	71	1690	81	1910	110	2670	350	440	10200	11	246	905	21300
June	55	1630	50	1570	53	1860	290	200	7060	4.8	169	520	16900
July	53	1640	46	1470	47	1570	290	170	5800	4.2	141	480	15400
Aug	52	2130	44	1780	42	1700	280	160	6300	3.7	151	449	18300
Sept	57	731	54	915	62	1040	300	230	3920	5.6	94.7	576	9740
Annual		10522		10472		12520			47228		1141.1		112690
Station 7 Sun River near Vaughn, Mont (06089000)													
Oct	61	1680	43	1170	51	1390	260	210	5860	4.8	132	512	14100
Nov	58	1630	39	1080	45	1250	260	190	5280	4.2	118	469	13100
Dec	59	1370	40	907	47	1050	250	200	4390	4.4	99.2	481	11000
Jan	58	1050	40	714	47	838	250	200	3540	4.4	79.4	476	8610
Feb	58	864	38	563	43	643	250	180	2680	4.1	60.8	458	6820
Mar	59	1060	40	711	46	827	250	190	3480	4.4	78.1	479	8570
Apr	71	2880	57	2260	74	2910	300	310	12300	7.0	277	678	27000
May	59	8370	40	5360	46	6000	250	190	25400	4.4	569	478	64900
June	41	25200	15	9750	6.4	4900	190	25	19600	5	434	191	122000
July	48	9810	25	4300	23	2940	220	94	12000	2.1	271	307	53400
Aug	58	5000	38	3320	44	3830	250	190	16100	4.1	361	462	40100
Sept	61	2890	43	2000	51	2370	260	220	9980	4.9	224	516	24000
Annual		61804		32135		28948			120610		2703.5		393600
Station 10 Milk River at Tampico, Mont (06172310)													
Oct	51	771	25	379	100	3220	220	240	3680	15	224	564	8580
Nov	56	1550	28	771	120	3540	240	280	7510	17	469	636	17400
Dec	77	1380	41	733	180	5420	330	410	7330	28	495	910	16300
Jan	76	1080	41	573	170	5360	330	410	5720	28	388	901	12800
Feb	78	506	42	670	180	4970	340	420	2700	29	184	932	6030
Mar	76	795	41	421	170	5380	330	410	4210	27	285	905	9430
Apr	48	6180	23	2620	97	2910	210	230	23800	14	1130	532	61200
May	37	13900	17	6220	68	2090	160	160	58200	8.1	2940	384	143000
June	45	5950	21	2840	89	2650	200	210	27100	12	1570	489	64500
July	41	3670	19	1660	78	2430	180	180	15300	10	797	437	37900
Aug	47	2930	23	1410	93	2890	200	280	13600	13	816	513	32100
Sept	49	1610	24	781	99	2980	210	230	7590	14	457	542	17700
Annual		40322		19078		43840			176550		9755		426940

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1975 WATER YEAR--Continued														
Station 11 Yellowstone River near Livingston, Mont (06192500)														
Oct	21	3860	7.3	1350	19	3600	96	18100	38	7070	7.5	1400	167	31000
Nov	21	3020	7.8	1100	21	2990	100	14000	43	6030	7.7	1080	177	24900
Dec	23	2690	8.7	1020	24	2810	100	12200	51	5930	7.9	939	192	22600
Jan	24	2290	9.9	929	28	2600	110	10400	61	5740	8.3	781	213	20000
Feb	25	2130	9.9	858	28	2430	110	9530	62	5370	8.3	718	215	18600
Mar	23	2590	8.9	999	25	2770	110	11800	52	5880	8.0	901	196	22000
Apr	22	2530	8.2	941	22	2560	100	11500	46	5300	7.8	895	183	21000
May	19	4830	6.1	1390	16	3360	90	23500	27	4950	7.2	1920	145	35300
June	12	13500	1.6	1670	1.1	1060	65	72400	.0	.00	5.9	6540	66	72800
July	12	15000	1.6	1680	1.4	570	65	80000	.0	.00	5.9	7270	67	78100
Aug	16	6670	4.0	1650	8.8	3620	79	33400	.0	.00	6.6	2800	109	45700
Sept	19	4690	6.2	1520	16	3940	91	22500	29	6980	7.2	1780	148	36400
Annual		63800		15107		32310		319330		53520		27024		428400
Station 12 Fly Creek at Pompeys Pillar, Mont (06217750)														
Oct	110	90.0	85	69.3	300	247	370	304	920	750	17	14.1	1640	1340
Nov	130	92.6	100	74.9	370	271	420	311	1150	844	21	15.3	1980	1460
Dec	140	66.1	120	56.6	450	206	480	221	1350	627	24	11.2	2350	1090
Jan	120	126	93	92.8	330	322	390	439	1030	993	19	19.7	1800	1790
Feb	130	154	110	119	400	422	440	528	1220	1290	22	24.6	2130	2300
Mar	75	415	52	228	180	671	270	1580	540	2070	11	55.8	1000	4340
Apr	120	261	95	202	340	717	400	897	1050	2190	20	42.4	1840	3910
May	130	355	100	277	370	988	420	1210	1140	3020	21	56.9	1980	5350
June	62	274	37	160	120	497	230	1020	350	1520	8.7	38.1	701	3060
July	91	137	67	101	230	349	320	482	710	1070	14	21.5	1280	1940
Aug	69	185	44	118	140	381	250	676	440	1170	10	26.6	851	2260
Sept	60	218	35	124	110	376	220	817	330	1150	8.2	29.7	660	2370
Annual		2373.7		1622.6		5447		8485		16694		355.9		31210
Station 13 Bighorn River near St. Xavier, Mont (06287000)														
Oct	66	20400	22	6650	69	21100	190	58000	240	72300	9.7	2980	512	157000
Nov	68	19600	22	6410	70	20400	190	55500	240	69900	9.9	2870	523	151000
Dec	70	21700	23	7140	73	22700	200	61200	250	77800	10	3190	540	168000
Jan	65	20900	21	6810	68	21600	190	59200	230	74100	9.5	3040	504	161000
Feb	69	19600	23	6440	73	20500	200	55200	250	69800	10	2880	538	152000
Mar	76	21400	26	7150	81	22800	210	59800	280	78000	12	3240	596	167000
Apr	78	21600	26	7220	84	23100	220	59800	290	79300	12	3250	614	169000
May	77	33300	26	11100	82	35400	210	93000	280	122000	12	5030	599	260000
June	74	41700	25	13900	78	44100	210	118000	270	152000	11	6170	576	325000
July	60	40900	20	13300	61	41700	170	118000	210	143000	8.6	5840	460	314000
Aug	49	23500	15	7370	48	22900	150	7040	160	78300	6.6	3140	367	176000
Sept	61	19200	20	6260	63	19700	180	55300	220	67700	8.8	2760	472	148000
Annual		303800		99750		316000		863400		1084200		44390		2348000
Station 14 Little Bighorn River below Pass Creek, near Wyola, Mont (06290500)														
Oct	64	816	27	347	25	318	---	---	120	1600	1.7	22.0	371	4770
Nov	64	800	28	343	25	316	---	---	130	1600	1.8	21.8	378	4710
Dec	63	668	27	284	24	254	---	---	120	1300	1.7	17.9	367	3890
Jan	64	869	27	367	25	330	---	---	130	1680	1.7	23.2	376	5050
Feb	67	617	29	267	28	254	---	---	140	1280	1.8	17.0	397	3680
Mar	68	1260	30	536	29	492	---	---	150	2490	1.9	34.1	410	7370
Apr	71	1590	31	698	32	701	---	---	160	3470	2.1	45.4	436	9680
May	65	3950	28	1680	26	1520	---	---	130	7770	1.8	106	382	23000
June	49	5470	18	2000	10	1060	---	---	58	6080	1.1	115	246	26900
July	49	2960	18	1060	9.7	487	---	---	55	2890	1.0	60.4	240	14200
Aug	59	1160	24	478	20	389	---	---	100	2020	1.5	29.4	332	6510
Sept	67	890	29	385	28	368	---	---	140	1840	1.8	24.6	398	5310
Annual		21050		8445		6489				34020		516.8		115070

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1975 WATER YEAR--Continued														
Station 15 Little Bighorn River near Hardin, Mont (06294000)														
Oct	61	1020	33	545	47	790	250	4210	180	3000	3.3	54.1	460	7660
Nov	63	1270	35	701	54	1060	260	5250	200	4000	3.6	71.4	493	9890
Dec	64	1070	35	594	54	904	260	4440	200	3410	3.6	60.9	500	8390
Jan	62	1790	33	913	49	1220	260	7460	180	4700	3.3	85.8	468	12700
Feb	68	1460	40	840	65	1360	280	5980	240	5030	4.3	89.7	566	12000
Mar	64	3780	36	1910	55	2490	260	15800	210	9700	3.7	176	506	26500
Apr	74	3410	46	2080	80	3600	300	13900	290	13100	5.2	234	657	29900
May	69	8790	41	5170	68	8510	280	35800	250	31500	4.5	560	584	73500
June	54	8420	26	3910	29	4230	230	35900	120	17500	2.2	320	352	53300
July	51	5560	23	2370	22	2000	220	23800	94	8940	1.7	166	307	31600
Aug	59	1870	30	961	41	1290	250	7810	160	5000	2.8	90.1	420	13300
Sept	61	1100	33	591	48	854	260	4570	180	3250	3.3	58.7	463	8270
Annual		39540		20585		28308		164920		109130		1966.7		287010
Station 16 Yellowstone River near Miles City, Mont (06296120)														
Oct	55	39000	20	13900	53	38100	180	125000	180	125000	8.4	5990	413	295000
Nov	59	43500	21	15700	58	43300	190	138000	190	143000	9.1	6750	447	333000
Dec	61	35000	22	12700	61	35300	190	110000	200	117000	9.4	5470	465	269000
Jan	60	33400	22	12000	60	33300	190	106000	200	110000	9.3	5190	457	255000
Feb	61	30000	22	10900	62	30200	190	94500	210	100000	9.6	4690	473	231000
Mar	61	46600	22	16900	61	46900	190	147000	200	155000	9.5	7280	469	359000
Apr	66	52900	24	19500	68	54300	200	164000	230	182000	11	8410	515	412000
May	59	117000	22	42300	59	116000	190	370000	200	385000	9.2	18100	455	893000
June	38	117000	13	39000	32	98000	130	418000	98	297000	5.4	16700	267	820000
July	31	107000	9.6	33500	23	77000	120	410000	64	214000	4.1	14300	202	698000
Aug	42	53900	14	18400	37	47700	150	188000	120	147000	6.2	7900	303	388000
Sept	52	37400	19	13300	50	35900	170	122000	160	117000	7.9	5700	391	281000
Annual		712700		248100		656000		2392500		2092000		106480		5234000
1976 WATER YEAR														
Station 1 Beaverhead River at Barrett, Mont (06016000)														
Oct	56	3370	21	1230	22	1320	240	14200	72	4320	10	626	321	19300
Nov	52	2640	19	971	21	1060	230	11600	63	3190	9.7	491	299	15200
Dec	60	2910	22	1060	23	1120	250	12000	79	3840	11	530	337	16500
Jan	61	2620	22	946	23	1000	250	10700	81	3500	11	472	344	14800
Feb	62	2100	22	753	24	804	250	8500	84	2830	11	378	350	11800
Mar	59	2100	22	759	23	811	250	8670	78	2750	11	381	336	11900
Apr	51	2050	19	760	21	827	230	9110	61	2420	9.4	378	294	11800
May	47	3780	17	1410	19	1550	220	17800	51	4140	8.6	699	272	22100
June	47	4090	18	1530	19	1670	220	18900	53	4560	8.7	756	275	23900
July	50	4280	19	1590	20	1720	230	19300	59	5050	9.3	791	291	24800
Aug	54	4260	20	1580	21	1680	230	18400	66	5240	9.9	783	308	24400
Sept	55	2740	20	1000	22	1090	240	11700	69	3440	10	497	314	15700
Annual		36940		13580		14652		160880		45280		6782		212200
Station 2 Beaverhead River near Twin Bridges, Mont (06018500)														
Oct	70	5100	26	1870	28	2090	270	19900	99	7300	15	1130	400	29400
Nov	67	4650	24	1660	26	1810	260	18100	93	6430	14	971	378	26200
Dec	67	4680	24	1670	26	1830	260	18300	93	6480	14	972	379	26500
Jan	67	4070	24	1450	27	1610	260	15800	93	5640	14	846	380	23000
Feb	68	3240	24	1160	27	1280	260	12500	94	4510	14	676	383	18300
Mar	66	3460	23	1220	25	1320	260	13500	90	4670	13	693	370	19300
Apr	64	4100	22	1400	23	1490	250	15900	83	5270	12	759	350	22400
May	61	4700	21	1570	21	1630	240	18100	75	5760	11	810	328	25100
June	70	2940	26	1080	29	1210	280	11600	100	4240	16	661	408	17000
July	71	2380	26	885	30	1000	280	9280	110	3520	16	550	415	13900
Aug	72	3430	27	1290	31	1460	280	13400	110	5100	17	810	421	20100
Sept	68	4120	25	1500	28	1660	270	16100	97	5820	15	898	390	23500
Annual		46870		16755		18390		182480		64740		9776		264700

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1976 WATER YEAR--Continued													
Station 3 Missouri River below Canyon Ferry Dam, near Helena, Mont (06058502)													
Oct	34	16200	9.7	4650	16	7660	150	71500	32	15600	7.8	3750	195 94000
Nov	36	22300	10	6240	17	10500	150	94800	35	21700	8.4	5260	206 129000
Dec	36	21000	10	5930	17	9970	150	89600	35	20500	8.5	4980	207 121000
Jan	36	18200	11	5360	17	8660	160	80300	36	17900	8.7	4380	211 106000
Feb	38	17800	11	5160	18	8500	160	75300	38	17700	9.2	4340	219 103000
Mar	40	25500	12	7510	19	12300	170	109000	40	25600	9.8	6300	229 147000
Apr	41	36000	12	10600	20	17500	170	150000	42	36700	10	8830	237 209000
May	40	45100	12	13100	19	21600	170	192000	40	45500	10	11300	231 261000
June	33	31800	9.3	8990	15	14700	140	139000	31	30000	7.4	7160	189 184000
July	28	16600	7.7	4550	13	7390	130	75200	25	14700	5.8	3410	163 96100
Aug	28	13500	7.5	3670	12	5870	120	59100	24	11700	5.6	2720	160 78100
Sept	31	13800	8.5	3850	14	6250	130	60900	28	12500	6.5	2970	176 79800
Annual		277800		79610		130900		1196700		270100		65400	1608000
Station 4 Sun River below Diversion Dam, near Augusta, Mont (06080900)													
Oct	48	882	13	227	2.0	36.7	160	3040	47	817	---	---	196 3590
Nov	43	1640	11	413	1.8	68.2	150	5720	36	1370	---	---	175 6600
Dec	48	1150	13	302	2.0	47.9	160	3980	47	1100	---	---	197 4710
Jan	51	887	13	232	2.1	36.6	170	2960	55	949	---	---	212 3690
Feb	52	799	14	211	2.2	33.0	170	2630	57	865	---	---	218 3330
Mar	52	815	14	216	2.1	33.4	170	2700	56	878	---	---	216 3380
Apr	45	2660	12	692	1.9	11.3	160	9360	41	2250	---	---	185 10800
May	36	10500	8.6	2510	1.5	44.9	140	41000	19	5140	---	---	138 40500
June	29	3940	6.4	875	1.3	17.3	120	16600	2.9	369	---	---	105 14400
July	30	1020	6.8	229	1.3	44.3	130	4230	6.2	163	---	---	112 3760
Aug	37	721	8.9	175	1.6	30.8	140	2720	22	428	---	---	143 2820
Sept	39	655	9.8	162	1.7	27.6	140	2390	28	461	---	---	156 2600
Annual		25669		6244		1093.5		97330		14790			100180
Station 5 Muddy Creek near Vaughn, Mont (06088300)													
Oct	67	847	88	1150	120	1660	---	---	470	6290	12	162	960 12600
Nov	65	324	84	418	120	581	---	---	440	2190	11	57.2	909 4550
Dec	76	298	110	425	160	634	---	---	620	2440	16	62.7	1200 4720
Jan	71	270	98	378	140	555	---	---	540	2110	14	54.2	1080 4160
Feb	77	232	110	333	170	504	---	---	640	1930	17	49.7	1240 3720
Mar	81	424	120	637	180	981	---	---	710	3780	18	96.8	1340 7130
Apr	87	350	140	598	210	988	---	---	810	3820	21	96.0	1510 6800
May	70	501	95	645	140	902	---	---	520	3390	14	89.0	1050 7050
June	45	923	39	779	34	666	---	---	110	2200	3.3	66.0	383 7710
July	46	1050	41	914	37	826	---	---	130	2820	3.7	82.1	405 9140
Aug	46	1060	42	951	39	887	---	---	130	3030	3.9	87.6	418 9560
Sept	46	620	40	545	37	494	---	---	130	1680	3.6	48.6	403 5440
Annual		6899		7773		9678				35680		951.9	82580
Station 6 Muddy Creek at Vaughn, Mont (06088500)													
Oct	72	1030	84	1230	120	1800	360	4990	460	6900	11	168	946 13900
Nov	71	417	81	480	120	679	350	2060	440	2600	11	63.1	911 5380
Dec	81	350	100	437	160	662	390	1680	600	2550	14	62.0	1160 4980
Jan	79	332	98	417	150	634	380	1590	570	2440	14	59.5	1120 4750
Feb	84	280	110	359	170	554	400	1330	640	2120	16	51.6	1240 4110
Mar	88	493	120	656	180	1040	420	2320	710	4000	17	97.8	1340 7570
Apr	90	358	120	521	200	881	420	1630	740	3350	18	82.5	1400 6120
May	79	667	97	756	150	1060	380	3300	560	4030	14	98.6	1110 8440
June	49	1370	36	1020	27	750	270	7570	98	2710	2.3	64.1	358 10100
July	50	1420	40	1130	35	966	270	7710	130	3540	3.0	84.9	404 11300
Aug	52	1560	43	1280	40	1190	280	8380	150	4400	3.6	106	441 13100
Sept	50	963	40	768	35	666	270	5220	130	2450	3.1	58.3	406 7760
Annual		9240		9054		10882		47780		41090		996.4	97510

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78

	Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1976 WATER YEAR--Continued														
Station 7 Sun River near Vaughn, Mont (06089000)														
Oct	71	4170	56	3300	73	4300	290	17200	310	18100	6.9	411	671	39600
Nov	55	3440	34	2140	36	2340	240	15100	160	9820	3.5	220	415	25900
Dec	62	3760	43	2630	52	3140	260	16000	220	13200	4.9	297	518	31600
Jan	63	1820	45	1300	54	1580	270	7720	230	6700	5.1	149	536	15600
Feb	62	2410	43	1670	53	2010	260	10300	220	8460	5.0	190	524	20200
Mar	68	2640	52	2030	66	2570	280	11000	280	10900	6.3	244	622	24300
Apr	55	4060	35	2480	38	2670	240	17700	160	11300	3.6	252	421	30200
May	43	15100	17	5710	9.7	2660	200	71100	39	10500	.9	237	215	71900
June	44	7530	19	2940	13	1550	200	35000	52	6110	1.2	138	238	37000
July	53	3410	31	1970	33	2010	230	15000	140	8410	3.1	188	380	24000
Aug	55	3390	34	2100	37	2310	240	14800	160	9660	3.5	217	414	25600
Sept	55	2550	33	1560	36	1680	240	11200	150	7040	3.4	158	404	18900
Annual		54280		29830		28820		242120		120200		2701		364800
Station 10 Milk River at Tampico, Mont (06172310)														
Oct	62	1580	32	813	140	3410	270	6810	320	8000	20	519	718	18200
Nov	45	2560	21	1220	88	5020	200	11200	210	11700	12	676	486	27700
Dec	65	1940	34	1010	140	4300	280	8380	330	9960	22	645	750	22500
Jan	73	1660	39	880	160	3740	310	7170	390	8780	26	590	861	19700
Feb	37	1230	17	551	67	2230	160	5420	150	5140	8.0	268	381	12700
Mar	40	5720	19	2130	76	8030	180	25600	180	17200	9.5	527	423	50900
Apr	38	3430	17	1490	71	6010	170	15100	160	13800	8.6	685	398	34600
May	62	293	32	146	130	607	270	1260	310	1410	20	87.6	709	3280
June	59	2200	30	1100	130	4630	260	9550	300	10800	19	679	676	24800
July	50	3010	24	1460	100	6100	220	13100	230	14100	14	854	548	33200
Aug	45	1190	22	560	89	2320	200	5200	210	5340	12	309	492	12800
Sept	46	553	22	263	92	1090	200	2430	210	2530	13	148	503	6000
Annual		25366		11623		47487		111220		109760		5987.6		266380
Station 11 Yellowstone River near Livingston, Mont (06192500)														
Oct	20	3990	6.2	1250	16	3090	91	18200	27	5350	7.6	1510	148	29700
Nov	21	3520	6.7	1090	17	2730	96	15900	30	4860	8.3	1360	159	26200
Dec	23	3350	7.1	1040	18	2640	100	14800	32	4720	9.0	1320	169	24900
Jan	22	2840	6.8	884	17	2220	98	12800	30	3940	8.5	1100	161	21100
Feb	23	2710	7.2	840	18	2140	100	11800	33	3860	9.3	1080	173	20100
Mar	23	2780	7.1	860	18	2200	100	12300	32	3930	9.0	1090	170	20600
Apr	21	3370	6.6	1050	17	2630	95	15200	29	4630	8.1	1300	157	25100
May	13	9800	4.2	3130	9.2	6550	63	48400	14	8610	4.0	2590	97	72300
June	9.7	12600	3.2	4080	6.1	7840	49	64000	6.9	8660	2.2	2750	71	92200
July	12	9650	3.8	3090	8.1	6480	58	47400	11	8710	3.3	2590	88	71000
Aug	16	6140	5.0	1930	12	4510	74	28700	19	7200	5.3	2060	117	45500
Sept	19	4600	5.9	1430	14	3500	86	21000	25	5990	7.0	1690	140	34100
Annual		65350		20674		46530		310500		70460		20440		482800
Station 12 Fly Creek at Pompeys Pillar, Mont (06217750)														
Oct	93	157	69	104	240	342	320	568	740	1050	15	23.1	1330	1990
Nov	130	90.1	100	73.6	380	268	430	304	1150	820	21	15.0	2010	1430
Dec	140	84.0	110	68.7	420	253	460	277	1280	780	23	14.0	2220	1340
Jan	150	113	120	96.7	450	352	480	378	1380	1080	25	19.3	2390	1870
Feb	130	108	110	88.6	400	322	450	362	1240	991	22	18.0	2140	1720
Mar	150	90.4	130	77.4	460	281	490	300	1390	861	25	15.3	2410	1490
Apr	150	93.6	130	79.5	470	291	500	307	1450	892	26	15.7	2500	1530
May	100	180	76	119	270	398	350	607	830	1220	16	26.6	1490	2310
June	67	234	42	139	140	434	250	871	420	1340	9.7	32.9	813	2660
July	68	200	43	122	140	386	250	735	430	1180	9.8	28.3	825	2330
Aug	68	160	43	100	140	323	250	588	430	989	9.8	22.9	833	1920
Sept	60	226	35	131	110	400	220	849	330	1230	8.2	31.2	659	2490
Annual		1736.1		1199.5		4050		6189		12433		262.3		23080

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1976 WATER YEAR--Continued														
Station 13 Bighorn River near St. Xavier, Mont (06287000)														
Oct	64	16900	21	5500	67	17500	180	48300	230	59800	9.4	2460	496	130000
Nov	66	22500	21	7330	68	23300	190	63800	230	79900	9.6	3280	508	174000
Dec	66	22600	22	7390	69	23500	190	64500	240	80700	9.7	3310	511	175000
Jan	63	21800	21	7100	65	22500	180	62600	220	77300	9.2	3160	487	168000
Feb	65	22400	21	7340	68	23200	190	63600	230	79600	9.5	3260	503	173000
Mar	70	28200	23	9280	74	29600	200	80000	250	102000	10	4140	545	219000
Apr	73	28600	24	9520	77	30200	200	80200	270	104000	11	4310	570	223000
May	78	34500	26	11500	83	36800	220	96600	290	127000	12	5330	610	271000
June	69	32800	23	10800	72	34200	190	92300	250	117000	10	4860	534	254000
July	56	17900	18	5760	56	17900	160	52300	190	61400	7.8	2490	423	136000
Aug	51	11200	16	3540	50	11000	150	33200	170	37500	6.9	1510	382	84100
Sept	49	10300	15	3240	48	10100	150	31000	160	34000	6.5	1380	366	77400
Annual		269700		88300		279800		768400		960200		39490		2084500
Station 15 Little Bighorn River near Hardin, Mont (06294000)														
Oct	64	1410	35	779	53	1180	---	---	200	4450	3.6	79.7	496	11000
Nov	63	935	35	511	53	762	---	---	200	2880	3.6	51.8	494	7200
Dec	69	1210	41	711	67	1170	---	---	250	4330	4.4	77.4	578	10100
Jan	70	1650	42	987	70	1650	---	---	260	6100	4.6	108	598	14100
Feb	77	2580	49	1630	86	2940	---	---	320	10700	5.6	189	700	23500
Mar	78	2220	50	1410	91	2570	---	---	330	9270	5.9	165	725	20400
Apr	78	1820	49	1160	90	2110	---	---	320	7600	5.8	135	714	16800
May	67	2710	38	1500	61	2240	---	---	230	8440	4.1	152	543	21100
June	52	4170	24	1900	24	1960	---	---	100	8200	1.8	150	319	25800
July	54	1610	26	745	30	785	---	---	120	3240	2.2	59.4	354	10100
Aug	61	680	33	363	48	518	---	---	180	1980	3.3	35.6	462	5080
Sept	63	843	35	461	53	685	---	---	200	2580	3.6	46.6	492	6480
Annual		21838		12157		18570			69770		1249.5			171660
Station 16 Yellowstone River near Miles City, Mont (06296120)														
Oct	55	40300	20	14500	54	39600	180	130000	180	129000	8.5	6220	419	306000
Nov	54	40800	20	14600	53	39900	180	132000	170	130000	8.4	6290	411	309000
Dec	58	42700	21	15400	57	42500	180	136000	190	140000	9.0	6620	441	326000
Jan	58	38300	21	13800	58	38000	190	122000	190	124000	9.0	5930	443	293000
Feb	60	45300	22	16500	61	45400	190	143000	200	151000	9.4	7060	465	348000
Mar	65	49100	24	17900	67	50200	200	152000	220	168000	10	7670	505	381000
Apr	61	53900	22	19600	61	54300	190	170000	200	180000	9.5	8420	470	415000
May	42	89000	14	29900	37	76300	150	313000	120	236000	6.2	12800	302	631000
June	32	91800	9.9	29200	23	68400	120	349000	66	194000	4.2	12400	207	607000
July	29	54400	9.1	16900	21	38400	110	214000	58	105000	3.9	7250	191	353000
Aug	41	36000	14	12200	35	31100	140	125000	110	95200	5.9	5210	289	256000
Sept	46	30400	16	10600	43	28000	160	103000	140	89100	6.9	4540	340	223000
Annual		612000		211100		552100		2089000		1741300		90410		4448000
1977 WATER YEAR														
Station 1 Beaverhead River at Barretts, Mont (06016000)														
Oct	57	2650	19	889	21	964	220	10300	71	3320	10	466	310	14400
Nov	58	2690	20	907	21	970	230	10400	75	3450	10	476	317	14700
Dec	61	2430	21	823	22	866	230	9240	83	3280	11	437	335	13300
Jan	63	1800	21	609	22	637	230	6730	87	2510	11	315	343	9840
Feb	63	1370	21	462	22	483	240	5120	87	1900	11	239	343	7470
Mar	63	1120	21	379	22	399	240	4230	86	1550	11	197	341	6120
Apr	61	1110	21	377	22	398	230	4220	82	1500	11	199	331	6080
May	65	2420	22	819	23	851	240	8930	93	3460	12	427	355	13200
June	62	3300	21	1130	22	1190	240	12500	86	4540	11	579	340	18000
July	65	3640	22	1230	23	1290	240	13400	93	5210	12	647	356	19900
Aug	64	2830	22	959	23	1010	240	10500	90	4000	11	509	349	15500
Sept	66	1150	22	390	23	403	240	4200	95	1660	12	203	359	6280
Annual		26510		8974		9461		99770		36380		4694		144790

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78

	Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1977 WATER YEAR--Continued														
Station 2 Beaverhead River near Twin Bridges, Mont (06018500)														
Oct	71	4910	24	1670	25	1750	270	18600	95	6470	14	984	389	26900
Nov	69	4530	23	1520	24	1570	260	17100	89	5870	13	873	375	24600
Dec	70	3920	24	1320	25	1380	270	14700	94	5200	14	786	386	21500
Jan	72	2840	25	983	26	1030	270	10600	98	3870	15	595	399	15700
Feb	72	2330	25	809	26	843	270	8740	98	3180	15	485	398	12900
Mar	72	2360	25	815	26	861	270	8780	98	3200	15	495	400	13000
Apr	74	2220	26	767	28	820	270	8260	100	3080	16	469	410	12300
May	80	1150	29	420	32	462	290	4150	120	1750	19	278	458	6580
June	85	1010	32	377	36	422	300	3600	140	1610	22	259	491	5830
July	87	832	33	315	37	354	310	2930	140	1350	23	219	506	4820
Aug	87	1020	33	386	37	434	310	3600	140	1660	23	268	507	5900
Sept	80	1600	29	586	32	647	290	5780	120	2470	19	388	469	9140
Annual		28722		9968		10573		106840		39810		6099		159170
Station 3 Missouri River below Canyon Ferry Dam, near Helena, Mont (06058502)														
Oct	35	15100	9.8	4240	15	6580	150	63700	32	13800	7.5	3240	196	84500
Nov	36	15800	10	4420	16	6990	150	66400	33	14600	7.8	3430	200	88500
Dec	35	15900	10	4500	16	7120	150	67600	33	14800	7.7	3450	199	89500
Jan	38	17000	11	5050	17	7780	160	72300	36	16400	8.6	3890	214	96800
Feb	38	15600	12	4700	18	7220	160	66400	38	15400	8.9	3650	219	89600
Mar	40	18900	12	5770	19	9060	170	80800	41	19400	9.8	4620	233	110000
Apr	41	19200	13	6080	20	9310	180	83700	43	20000	10	4710	241	113000
May	41	15700	13	4950	20	7630	180	68400	43	16400	10	3840	241	92000
June	41	11800	13	3740	20	5690	180	50400	42	12100	10	2880	238	68400
July	41	14900	13	4730	20	7260	180	64500	43	15500	10	3650	240	87400
Aug	41	19300	13	6160	20	9270	170	82200	42	20000	10	4750	237	113000
Sept	40	12400	12	3790	19	5920	170	53000	41	12700	9.7	3020	232	72300
Annual		191600		58130		89830		819400		191100		45130		1105000
Station 4 Sun River below Diversion Dam, near Augusta, Mont (06080900)														
Oct	48	553	12	144	1.9	22.3	160	1850	40	468	---	---	188	2180
Nov	55	430	15	115	2.1	16.4	170	1350	58	445	---	---	222	1720
Dec	57	432	15	116	2.1	16.3	180	1340	62	470	---	---	230	1750
Jan	60	419	16	114	2.2	15.5	180	1270	68	474	---	---	242	1700
Feb	69	249	19	69.2	2.4	8.72	200	715	89	322	---	---	283	1030
Mar	64	219	18	60.4	2.3	7.91	190	644	78	270	---	---	261	899
Apr	56	270	15	73.3	2.1	10.3	170	833	59	289	---	---	225	1090
May	46	1120	12	290	1.9	45.7	160	3820	37	905	---	---	180	4400
June	37	696	9.0	169	1.7	31.3	140	2630	16	311	---	---	139	2630
July	42	258	11	65.1	1.8	11.0	150	924	27	169	---	---	161	996
Aug	54	526	15	140	2.1	20.2	170	1650	56	543	---	---	219	2120
Sept	55	306	15	82.1	2.1	11.5	170	959	60	334	---	---	223	1240
Annual		5478		1438.1		217.13		17985		5000				21755
Station 5 Muddy Creek near Vaughn, Mont (06088300)														
Oct	61	417	61	411	66	433	---	---	240	1530	8.3	54.8	621	4140
Nov	66	321	71	347	91	439	---	---	330	1600	11	53.5	766	3730
Dec	68	285	77	320	100	427	---	---	380	1580	13	52.3	840	3500
Jan	68	216	76	242	100	326	---	---	380	1200	12	39.6	834	2660
Feb	75	227	90	272	140	413	---	---	520	1540	17	49.6	1050	3140
Mar	77	185	97	232	150	366	---	---	580	1380	18	43.8	1130	2710
Apr	84	325	110	453	190	801	---	---	720	3050	22	94.1	1340	5540
May	62	445	63	417	71	379	---	---	250	1310	8.8	49.2	650	4020
June	54	555	46	450	29	234	---	---	88	674	4.1	35.4	403	3830
July	53	1020	44	829	24	426	---	---	71	1240	3.5	64.7	375	7050
Aug	58	665	54	613	48	539	---	---	170	1830	6.3	70.8	518	5870
Sept	62	352	62	354	69	389	---	---	250	1390	8.7	48.9	640	3620
Annual		5013		4940		5172				18324		656.7		49810

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1977 WATER YEAR--Continued														
Station 6 Muddy Creek at Vaughn, Mont (06088500)														
Oct	64	598	58	528	69	605	310	2940	260	2290	7.8	67.6	634	5720
Nov	71	393	70	388	93	514	330	1860	350	1940	11	59.7	787	4350
Dec	74	352	77	361	110	497	340	1630	400	1880	13	59.4	867	4090
Jan	75	248	77	256	110	359	340	1140	410	1350	13	42.5	877	2910
Feb	80	252	86	270	130	395	360	1140	480	1490	15	47.2	1000	3120
Mar	84	194	94	215	140	323	370	856	540	1220	17	39.2	1090	2500
Apr	93	396	110	492	180	804	400	1650	660	3010	22	99.4	1300	5840
May	61	747	53	621	59	646	310	3770	220	2440	6.5	69.4	569	6580
June	57	805	45	626	42	574	290	4170	160	2160	4.4	58.4	467	6470
July	47	1300	45	1020	42	930	290	6740	160	3520	4.3	94.9	465	10500
Aug	61	999	52	855	57	934	300	4970	220	3510	6.3	102	559	9150
Sept	64	536	57	478	66	556	310	2650	250	2090	7.5	62.3	617	5190
Annual		6820		6110		7137		33516		26900		802		66420
Station 7 Sun River near Vaughn, Mont (06089000)														
Oct	64	2320	41	1480	47	1710	260	9400	200	7210	5.1	185	498	18000
Nov	66	1790	43	1170	52	1390	270	7230	220	5870	5.7	152	528	14200
Dec	69	1470	47	997	58	1230	280	5880	240	5120	6.4	136	569	12100
Jan	72	1290	51	911	65	1170	290	5150	270	4850	7.3	131	617	11100
Feb	73	1250	52	883	67	1140	290	4940	280	4720	7.5	128	630	10800
Mar	75	1130	55	827	73	1100	300	4450	300	4520	8.2	124	672	10100
Apr	87	1370	69	1120	99	1660	330	5210	400	6720	11	191	852	13900
May	68	1750	46	1160	57	1400	280	7100	240	5860	6.3	154	566	14200
June	64	1500	41	956	48	1100	260	6120	200	4670	5.2	119	499	11600
July	64	2200	41	1410	48	1650	260	8940	200	6930	5.2	179	503	17200
Aug	70	2090	48	1450	60	1820	280	8340	250	7590	6.7	203	588	17700
Sept	72	1280	51	901	65	1150	290	5070	270	4790	7.3	129	621	11000
Annual		19440		13265		16520		77830		68850		1831		161900
Station 10 Milk River at Tampico, Mont (06172310)														
Oct	64	593	31	287	130	1160	290	2650	300	2750	17	159	691	6370
Nov	76	1130	37	549	150	2260	330	4940	370	5410	22	319	829	12300
Dec	99	1110	49	550	210	2310	430	4760	500	5630	31	343	1110	12500
Jan	100	993	50	492	220	2090	400	4250	520	5050	32	309	1140	11200
Feb	95	1190	47	584	200	2470	410	5110	480	5930	29	359	1060	13200
Mar	76	1050	37	512	150	2130	330	4620	370	5080	22	302	826	11500
Apr	97	42.1	48	20.7	200	87.6	410	181	490	211	30	12.8	1080	469
May	100	475	51	234	220	976	440	2090	530	2330	32	138	1160	5250
June	89	87.0	43	42.4	180	178	380	372	440	431	26	26.0	981	959
July	96	67.1	47	32.9	200	139	410	287	480	336	29	20.4	1070	746
Aug	97	76.9	48	37.6	200	156	420	337	490	372	30	22.1	1090	844
Sept	86	315	42	154	180	646	370	1360	420	1550	25	93.4	946	3470
Annual		7129.1		3495.6		14602.6		30957		35080		2103.7		78808
Station 11 Yellowstone River near Livingston, Mont (06192500)														
Oct	21	4130	6.7	1310	16	3200	95	18700	28	1630	8.3	5580	154	30500
Nov	22	3210	7.1	1020	17	2490	100	14400	31	1300	9.1	4420	165	23700
Dec	24	2920	7.7	928	19	2290	110	13100	34	1210	10	4110	178	21600
Jan	27	2810	8.4	897	21	2230	120	12600	34	1200	11	4090	196	20900
Feb	27	2480	8.5	790	21	1960	120	11200	39	1060	11	3600	198	18400
Mar	26	2730	8.4	870	21	2160	120	12400	38	1150	11	3960	195	20200
Apr	22	3620	6.9	1140	17	2750	98	16300	30	1390	8.7	4800	161	26500
May	15	5460	4.7	1720	11	3980	68	25300	17	1770	4.8	6190	107	39700
June	12	8000	3.9	2500	8.6	5480	58	37800	13	2130	3.5	7730	88.9	57400
July	18	5100	5.8	1630	14	3880	84	23400	24	1900	6.8	6560	134	37700
Aug	21	3780	6.7	1210	16	2940	96	17100	29	1500	8.4	5150	156	28000
Sept	23	3380	7.3	1080	18	2630	100	15100	32	1390	9.4	4720	170	25100
Annual		47620		15095		35990		217400		17630		60910		349700

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

	Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1977 WATER YEAR--Continued														
<u>Station 12 Fly Creek at Pompeys Pillar, Mont (06217750)</u>														
Oct	120	142	83	91.3	260	270	340	400	870	922	18	18.7	1550	1670
Nov	140	68.1	99	47.4	330	157	380	181	1100	526	23	11.0	1900	908
Dec	140	70.4	100	50.5	340	170	370	188	1100	565	24	11.9	1940	971
Jan	150	45.4	110	33.1	380	114	410	123	1300	378	26	7.91	2140	642
Feb	160	73.9	110	52.0	390	184	420	194	1300	609	28	12.9	2220	1040
Mar	170	62.3	130	45.3	450	161	450	161	1500	528	31	11.3	2490	896
Apr	160	198	120	139	420	456	430	537	1400	1540	29	31.9	2330	2650
May	110	306	67	182	190	474	300	890	670	1690	13	32.6	1210	3180
June	85	313	48	169	110	359	250	946	410	1380	7.6	24.5	806	2780
July	99	216	60	131	160	350	290	626	380	1240	11	23.9	1070	2310
Aug	93	250	55	147	140	374	270	731	510	1350	9.8	25.9	967	2560
Sept	92	326	54	189	140	464	270	962	500	1700	9.5	32.1	943	3250
Annual		2071.1		1277.6		3533		5939		12428		244.61		22857
<u>Station 13 Bighorn River near St. Xavier, Mont (0628700)</u>														
Oct	70	17800	23	5930	70	17600	190	48300	240	61700	9.8	2490	527	133000
Nov	72	25700	24	8670	72	25500	200	69800	250	89700	10	3640	543	193000
Dec	74	23400	25	7950	73	23200	200	63300	260	81800	11	3410	555	176000
Jan	67	21900	23	7290	67	21800	190	60000	230	75900	9.1	2950	508	165000
Feb	71	16100	24	5410	70	16000	190	43600	250	56100	9.9	2250	532	121000
Mar	76	14100	26	4790	75	13900	200	37800	260	49000	11	2070	568	106000
Apr	87	11700	30	4030	85	11400	230	30300	310	41200	14	1870	653	87500
May	91	13300	32	4620	89	13000	240	34100	320	47100	15	2180	683	99200
June	87	13600	30	4730	86	13400	230	35100	310	48100	14	2230	656	102000
July	81	14400	28	4940	80	14200	210	37900	290	50500	13	2220	611	108000
Aug	81	12700	28	4360	80	12500	210	33300	290	44800	13	1980	610	95400
Sept	77	10600	26	3610	76	10500	210	28300	270	37400	11	1570	577	79900
Annual		195300		66330		193000		521800		683300		28860		1466000
<u>Station 14 Little Bighorn River below Pass Creek, near Wyola, Mont (06290500)</u>														
Oct	64	758	25	297	20	238	---	---	110	1260	1.8	20.8	344	4070
Nov	65	638	26	252	21	206	---	---	110	1070	1.8	17.6	353	3450
Dec	67	700	27	280	23	239	---	---	120	1260	1.9	19.6	367	3850
Jan	69	736	28	299	25	267	---	---	130	1390	2.0	21.3	388	4140
Feb	70	729	29	301	26	275	---	---	140	1440	2.1	21.6	400	4170
Mar	75	872	32	370	31	363	---	---	160	1850	2.3	26.5	442	5150
Apr	72	1620	30	672	28	622	---	---	150	3200	2.1	47.8	416	9290
May	52	2860	18	965	8.0	409	---	---	47	2430	1.2	63.0	234	12700
June	53	1930	19	668	9.4	313	---	---	54	1820	1.2	43.8	247	8810
July	61	778	24	297	18	216	---	---	93	1150	1.6	20.6	320	4030
Aug	66	602	26	240	22	199	---	---	120	1050	1.8	16.8	359	3290
Sept	65	589	26	234	21	193	---	---	110	1010	1.8	16.3	356	3210
Annual		12812		4875		3540				18930		335.7		66160
<u>Station 15 Little Bighorn River near Hardin, Mont (06294000)</u>														
Oct	67	1230	33	604	40	727	260	4720	170	3110	3.2	58.2	451	8240
Nov	70	954	35	479	47	632	270	3630	190	2600	3.5	47.5	492	6640
Dec	73	1340	38	690	54	988	280	5040	220	3950	3.9	70.7	531	9740
Jan	75	1130	39	590	57	863	280	4270	230	3420	4.0	60.9	550	8330
Feb	77	1660	41	888	63	1420	290	6200	250	5450	4.3	94.9	583	12800
Mar	82	2040	45	1110	76	1880	300	7570	290	7110	4.9	122	654	16300
Apr	79	4630	42	2470	67	3900	290	17300	260	15100	4.5	263	607	35500
May	60	3720	27	1670	21	1240	240	14700	110	6680	2.3	139	346	21200
June	58	2740	26	1200	16	706	230	10800	95	4310	2.0	94.3	318	14800
July	68	743	33	364	41	434	260	2850	170	1860	3.2	34.8	455	4950
Aug	69	740	34	368	44	466	260	2820	180	1950	3.4	36.0	471	5060
Sept	67	725	33	355	38	418	260	2810	170	1810	3.1	33.8	443	4810
Annual		21652		10788		13674		82710		57350		1055.1		148370

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

	Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1978 WATER YEAR														
<u>Station 1 Beaverhead River at Barretts, Mont (06016000)</u>														
Oct	64	990	22	340	23	347	240	3700	90	1390	12	185	343	5370
Nov	68	1020	24	356	24	355	250	3720	100	1510	13	196	372	5600
Dec	68	1260	24	439	24	436	250	4560	100	1870	13	241	372	6880
Jan	68	1210	24	421	24	421	250	4410	99	1780	13	233	370	6640
Feb	69	1200	24	419	24	418	250	4370	100	1760	13	228	376	6560
Mar	65	1500	23	519	23	528	240	5570	92	2090	12	281	354	8150
Apr	59	1660	20	572	21	598	230	6350	76	2150	11	310	320	9010
May	59	4230	20	1440	21	1530	220	16100	76	5430	11	780	318	22900
June	56	4760	19	1620	21	1760	220	18500	69	5860	10	868	304	25800
July	56	3570	19	1220	21	1300	220	13800	69	4380	10	662	303	19200
Aug	61	3590	21	1240	22	1290	230	13500	82	4790	11	661	330	19400
Sept	62	1860	21	639	22	666	230	7000	84	2540	12	348	336	10100
Annual		26850		9225		9649		101580		35550		4993		145610
<u>Station 2 Beaverhead River near Twin Bridges, Mont (06018500)</u>														
Oct	77	2340	28	860	31	933	280	8650	110	3460	18	550	433	13200
Nov	76	2320	28	851	30	914	280	8570	110	3400	18	535	429	13100
Dec	76	2390	28	881	30	949	280	8870	110	3550	18	557	429	13600
Jan	75	2200	27	798	29	855	280	8200	110	3230	17	501	421	12400
Feb	75	2130	27	772	29	831	280	7950	110	3130	17	486	424	12000
Mar	71	2650	25	940	26	978	260	9890	99	3700	15	558	395	14800
Apr	71	2320	25	820	26	861	270	8720	99	3230	15	486	395	12900
May	73	2870	27	1030	28	1090	270	10800	110	4130	16	630	412	16100
June	78	1580	29	591	32	645	290	5800	120	2380	19	389	446	9030
July	81	1490	30	563	33	621	290	5450	120	2280	20	376	462	8580
Aug	82	1850	31	701	34	775	300	6730	130	2840	21	470	472	10700
Sept	76	3070	28	1130	30	1210	280	11300	110	4540	18	725	433	17400
Annual		27210		9937		10662		100930		39870		6263		153810
<u>Station 3 Missouri River Below Canyon Ferry Dam, near Helena, Mont (06068502)</u>														
Oct	42	18000	13	5620	20	8850	180	75900	42	18200	11	4720	241	104000
Nov	43	18600	13	5770	21	9080	180	78500	43	18800	11	4900	247	108000
Dec	43	19800	13	6160	21	9720	180	83800	43	20100	11	5230	247	115000
Jan	44	20900	14	6640	22	10400	190	88700	45	21500	12	5690	254	122000
Feb	44	21600	14	6850	22	10800	190	91200	46	22300	12	5910	259	126000
Mar	46	24900	15	7990	23	12500	190	105000	48	26000	13	7000	267	146000
Apr	46	23800	15	7650	23	11900	190	99900	48	24800	13	6640	267	139000
May	43	24900	13	7860	21	12200	180	105000	43	25400	12	6700	247	145000
June	39	26000	12	8080	19	12400	170	110000	39	25500	9.8	6520	226	150000
July	36	23000	11	6910	17	10500	150	96700	34	21800	8.5	5410	206	131000
Aug	34	16700	9.7	4820	15	7310	140	70400	30	15000	7.2	3600	188	93500
Sept	34	13900	9.8	4050	15	6090	140	58700	31	12600	7.3	3030	189	78300
Annual		252100		78400		121750		1063800		252000		65350		1457800
<u>Station 4 Sun River below Diversion Dam, near Augusta, Mont (06080900)</u>														
Oct	59	303	16	81.5	2.2	11.2	180	918	67	341	---	---	239	1220
Nov	61	287	16	77.1	2.2	10.5	180	848	70	335	---	---	246	1160
Dec	64	434	17	117	2.3	15.6	190	1260	77	527	---	---	260	1770
Jan	64	435	17	118	2.3	15.7	190	1280	77	530	---	---	260	1780
Feb	65	401	18	110	2.3	14.4	190	1170	80	495	---	---	264	1640
Mar	64	522	17	142	2.3	18.7	190	1510	78	635	---	---	261	2130
Apr	54	1100	14	290	2.1	41.9	170	3510	55	1080	---	---	216	4390
May	41	6620	10	1620	1.7	273	150	24200	23.6	3520	---	---	156	25000
June	31	6200	6.8	1380	1.4	285	130	26500	.6	125	---	---	110	22100
July	30	2730	6.6	572	1.4	123	130	11700	.0	.00	---	---	105	9230
Aug	37	848	8.7	200	1.6	36.5	140	3340	13.4	276	---	---	136	3140
Sept	44	486	11	123	1.8	19.4	150	1690	30.5	334	---	---	169	1870
Annual		20366		4830.6		864.9		77926		8198				75430

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

	Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids	
	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)
1978 WATER YEAR--Continued														
Station 5 Muddy Creek near Vaughn, Mont (06088300)														
Oct	66	301	72	328	89	405	---	---	320	1480	11	51.2	761	3460
Nov	67	228	74	251	94	317	---	---	350	1160	12	39.6	792	2670
Dec	70	191	80	221	110	302	---	---	410	1120	14	36.8	887	2420
Jan	66	148	71	161	87	196	---	---	320	714	11	24.7	750	1690
Feb	66	142	72	154	88	190	---	---	320	689	11	23.9	755	1630
Mar	69	1250	79	1260	110	1370	---	---	390	4850	13	177	859	12800
Apr	86	294	110	395	190	663	---	---	740	2530	23	77.9	1370	4710
May	75	661	91	766	130	1050	---	---	500	3890	16	128	1020	8410
June	58	705	53	666	44	601	---	---	150	2080	6.2	80.1	498	6390
July	55	1600	47	1360	28	819	---	---	86	2540	4.3	127	405	11800
Aug	53	1240	42	976	16	368	---	---	39	912	3.0	70.0	334	7820
Sept	57	791	51	723	39	585	---	---	130	1970	5.6	81.7	472	6730
Annual		7551		7261		6866				23935		919.9		70530
Station 6 Muddy Creek at Vaughn, Mont (06088500)														
Oct	69	461	68	452	88	583	330	2180	330	2210	11	70.5	753	5020
Nov	73	277	74	280	100	378	340	1290	380	1420	12	45.6	828	3130
Dec	77	231	82	245	120	344	350	1050	440	1300	14	41.9	925	2780
Jan	71	182	71	182	94	241	330	845	360	907	11	29.0	794	2030
Feb	71	175	71	174	93	229	330	818	350	866	11	27.6	786	1940
Mar	71	1540	71	1420	94	1720	330	7450	360	6500	11	202	795	15500
Apr	94	386	110	458	170	718	400	1640	660	2710	22	89.1	1300	5350
May	84	884	97	939	140	1290	370	4020	540	4840	18	157	1100	10500
June	58	997	46	838	45	881	290	4980	170	3320	5.0	99.2	483	8860
July	56	1890	43	1470	40	1360	290	9690	150	5150	4.2	146	447	15200
Aug	53	1720	39	1240	30	973	280	9020	110	3700	3.0	97.6	387	12500
Sept	48	1070	48	886	48	909	290	5390	180	3440	5.3	103	500	9360
Annual		9813		8584		9626		48373		36363		1108.5		92170
Station 7 Sun River near Vaughn, Mont (06089000)														
Oct	76	1480	54	1060	71	1400	290	5730	300	5830	8.2	161	663	13000
Nov	77	1270	56	919	74	1220	300	4890	310	5080	8.6	142	682	11300
Dec	71	1100	50	776	65	1010	280	4280	270	4190	7.4	115	611	9500
Jan	68	995	45	663	56	820	270	3960	230	3400	6.2	91.2	552	8100
Feb	67	1040	44	686	54	837	260	4080	220	3490	6.0	93.1	537	8350
Mar	72	3950	50	2710	64	3420	280	15500	270	14200	7.3	387	611	33100
Apr	70	2170	47	1460	59	1820	270	8530	250	7630	6.7	205	576	17900
May	49	8910	23	4110	17	2730	210	38200	75	12400	1.4	203	276	48800
June	45	9710	19	3980	9.2	1750	200	42600	45	8790	.4	58.0	222	46800
July	51	6460	26	3440	22	2720	220	29500	96	12000	2.0	238	311	41100
Aug	57	3370	33	1950	35	2030	240	13900	150	8680	3.6	212	403	23600
Sept	62	2820	39	1770	44	2050	250	11300	190	8660	4.8	224	472	21600
Annual		43775		23524		21806		182470		94350		2129.3		283150
Station 8 Birch Creek near Valier, Mont (06098100)														
Oct	57	138	29	71.2	69	167	310	749	150	361	---	---	468	1140
Nov	56	159	29	82.0	67	190	300	865	150	408	---	---	458	1300
Dec	57	182	29	93.8	69	221	310	986	150	476	---	---	469	1500
Jan	54	159	28	81.5	63	186	290	861	130	388	---	---	434	1280
Feb	52	144	26	73.9	59	163	280	787	120	334	---	---	409	1140
Mar	48	682	24	339	52	647	260	3720	100	1140	---	---	369	4870
Apr	68	242	35	126	91	326	370	1300	210	752	---	---	594	2130
May	62	227	32	118	80	293	340	1230	180	659	---	---	533	1950
June	51	222	26	113	58	252	280	1210	120	517	---	---	406	1760
July	51	415	26	210	58	449	280	2260	120	889	---	---	404	3190
Aug	50	232	26	119	56	257	270	1270	110	517	---	---	391	1810
Sept	53	303	28	156	63	358	290	1640	130	748	---	---	430	2450
Annual		3105		1583.4		3509		16878		7189				24520

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1978 WATER YEAR--Continued														
Station 9 Milk River at Juneburg Bridge near Saco, Mont (06164510)														
Oct	91	514	49	277	210	1180	420	2340	480	2720	28	160	1080	6120
Nov	100	501	57	275	250	1190	470	2270	560	2730	33	160	1250	6070
Dec	110	498	62	277	270	1210	510	2260	620	2780	37	162	1370	6120
Jan	110	567	59	312	260	1340	480	2560	590	3100	34	182	1300	6870
Feb	96	423	52	229	220	983	440	1910	520	2260	30	132	1150	5050
Mar	81	4250	43	1630	180	4840	370	21400	420	10300	25	717	948	34100
Apr	34	14400	14	5170	44	14000	170	72200	96	29300	6.4	2130	292	108000
May	48	7010	23	3260	85	12300	230	33300	190	27600	12	1710	487	70500
June	60	2820	30	1390	120	5510	280	13200	270	12500	16	754	651	30200
July	56	3110	27	1510	110	5870	260	14600	240	13300	15	811	586	32700
Aug	55	2050	27	994	100	3880	260	9660	240	8820	14	535	579	21600
Sept	47	3210	22	1460	81	5360	220	15300	180	12000	11	750	465	31300
Annual		39353		1678		57663		191000		127470		8203		358630
Station 11 Yellowstone River near Livingston, Mont (06192500)														
Oct	23	3560	7.4	1130	19	2920	100	15600	34	5130	10	1550	174	26700
Nov	25	2930	8.0	936	21	2420	110	13000	37	4340	11	1320	189	22100
Dec	27	2680	8.7	856	23	2240	120	11800	41	4050	13	1240	206	20300
Jan	28	2620	9.1	836	24	2190	120	11400	43	3990	13	1230	215	19800
Feb	28	2190	9.0	703	24	1840	120	9530	43	3340	13	1020	213	16600
Mar	25	2790	7.9	892	20	2300	110	12500	36	4090	11	1240	186	21000
Apr	22	3700	7.0	1190	18	2990	98	16500	31	5230	9.4	1580	164	27700
May	15	7600	4.8	2440	11	5460	69	35100	18	8670	5.1	2450	110	55100
June	10	13900	3.3	4440	6.5	8530	50	66300	8.8	11400	2.2	2830	72	96300
July	12	11900	3.9	3840	8.0	7910	56	56400	12	11500	3.2	3100	85	84600
Aug	16	6790	5.1	2170	12	5010	73	30900	20	8210	5.6	2380	116	49400
Sept	19	5020	6.1	1610	15	3900	86	22500	25	6670	7.6	1980	141	37000
Annual		61680		21043		47710		301530		76620		21920		476600
Station 12 Fly Creek at Pompeys Pillar, Mont (06217750)														
Oct	140	89.1	94	61.6	290	192	360	234	1000	655	19	12.7	1740	1140
Nov	140	67.4	100	48.1	320	155	370	179	1100	526	22	10.4	1880	906
Dec	150	64.5	110	47.6	360	153	400	167	1200	519	25	10.4	2090	883
Jan	150	56.0	110	40.3	340	127	380	145	1200	436	23	8.63	1970	743
Feb	140	56.9	96	39.7	300	124	360	150	1000	418	20	8.32	1770	735
Mar	120	543	80	293	240	652	330	1610	830	2510	16	37.9	1460	4970
Apr	160	165	120	120	400	391	420	427	1400	1340	28	26.5	2310	2260
May	120	4200	82	2580	240	6730	330	12000	850	24700	16	431	1490	45200
June	160	421	120	305	400	985	420	1100	1400	3330	27	66.2	2300	5720
July	90	341	52	197	130	486	260	990	480	1800	7.9	29.7	906	3410
Aug	83	277	45	149	100	328	250	824	390	1260	5.9	18.8	760	2500
Sept	98	446	60	268	160	694	280	1280	570	2520	9.9	43.1	1050	4700
Annual		6726.9		4149.3		11017		19106		40014		703.65		13167
Station 13 Bighorn River near St. Xavier, Mont (06287000)														
Oct	80	8110	27	2780	79	8030	200	20900	280	28900	12	1190	599	61100
Nov	91	7990	32	2810	90	7950	230	19900	330	29300	14	1250	687	60400
Dec	92	14400	32	5100	92	14400	230	36100	340	53200	15	2270	697	110000
Jan	97	18700	35	6680	97	18700	240	45800	360	69400	16	3000	741	142000
Feb	100	22700	37	8390	100	22900	250	56500	380	87200	17	3830	780	177000
Mar	99	30500	36	11100	99	30500	250	75200	370	114000	16	5030	764	235000
Apr	99	29200	35	10500	99	29200	240	71000	360	108000	16	4730	747	222000
May	96	25400	34	9060	96	25400	240	62100	360	94000	15	4060	730	193000
June	90	54700	32	19200	90	54600	220	136000	330	200000	14	8590	682	414000
July	78	66700	27	22700	77	66200	200	173000	280	237000	11	9820	585	502000
Aug	51	27800	15	8380	48	26500	160	84300	160	89300	5.4	2980	373	204000
Sept	62	17700	20	5680	60	17100	170	49500	210	59800	7.9	2240	463	131000
Annual		323900		112380		321480		830300		1170100		48990		2451500

Table 3.--Simulated mean concentrations (C) in milligrams per liter and constituent loads (L) in tons for water years 1975-78--Continued

Calcium		Magnesium		Sodium		Bicarbonate and carbonate		Sulfate		Chloride		Dissolved solids		
(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	(C)	(L)	
1978 WATER YEAR														
Station 15 Little Bighorn River near Hardin, Mont (06294000)														
Oct	68	945	35	479	44	604	260	3580	190	2580	3.4	47.6	475	6580
Nov	72	896	38	472	53	657	270	3350	220	2690	3.9	47.7	529	6570
Dec	76	914	41	497	62	743	280	3410	250	2970	4.2	50.9	581	6980
Jan	75	775	41	419	61	622	280	2890	240	2490	4.2	42.9	573	5900
Feb	73	778	39	415	56	591	280	2920	230	2400	4.0	42.1	545	5790
Mar	76	2630	41	1450	61	2220	280	9800	240	8770	4.2	149	574	20400
Apr	83	2480	47	1380	78	2190	310	9190	300	8590	4.9	143	673	19600
May	75	17500	40	9280	59	13200	280	65200	240	53500	4.1	938	562	129000
June	62	9100	30	4300	30	4200	240	34800	140	20200	2.8	406	394	56800
July	61	3580	29	1640	27	1400	230	13600	130	7230	2.7	151	376	21300
Aug	67	1510	34	761	42	931	250	5700	180	4050	3.3	74.8	463	10400
Sept	77	1700	42	937	63	1460	280	6290	250	5750	4.3	97.2	590	13300
Annual		42808		22031		28818		160730		121220		2190.2		302620
Station 16 Yellowstone River near Miles City, Mont (06296120)														
Oct	55	27100	21	10400	55	27100	180	86700	190	91800	8.9	4350	428	210000
Nov	61	22300	24	8650	62	22700	190	70200	210	77000	9.9	3650	473	175000
Dec	68	29500	27	11500	70	30400	210	89500	240	105000	11	4890	532	231000
Jan	74	32000	29	12600	77	33500	220	95200	270	117000	12	5370	585	254000
Feb	75	39100	30	15500	80	41300	230	117000	280	143000	13	6530	600	311000
Mar	68	64600	27	25200	70	66500	210	197000	240	228000	11	10600	535	508000
Apr	69	58200	27	22900	72	60400	210	177000	250	208000	11	9600	546	460000
May	63	136000	25	52900	64	138000	200	421000	220	474000	10	22000	491	1060000
June	43	130000	16	48000	41	122000	150	448000	130	385000	6.5	19600	323	970000
July	40	113000	15	41600	37	103000	140	396000	120	327000	6.0	16700	297	832000
Aug	46	54200	17	20400	44	51800	150	181000	140	168000	7.1	8340	346	410000
Sept	55	53900	21	20600	55	53700	180	172000	180	180000	8.8	8620	423	416000
Annual		759900		290250		750400		2451600		2503800		120250		5837000

12/12/22