STREAMFLOW AND WATER-QUALITY DATA FOR LITTLE SCRUBGRASS CREEK BASIN, VENANGO AND BUTLER COUNTIES, PENNSYLVANIA, DECEMBER 1987 - NOVEMBER 1988

By Kevin M. Kostelnik and Randall R. Durlin

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer metric (International system) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply Inch-Pound Unit	By	To obtain Metric Unit
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Volume	
gallon (gal)	3.785	liter (L)
	3,785	milliliter (mL)
cubic feet per second-days (ft^3/s-d)	2.447	cubic kilometers (km^3)
	Temperature	
degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius (°C)

Other Abbreviations

milligrams per liter (mg/L)
micrograms per liter (μg/L)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) -- a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929".

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ABSTRACT

Streamflow and water-quality data were collected throughout the Little Scrubgrass Creek basin, Venango and Butler Counties, Pennsylvania, from December 1987 to November 1988, to determine the prevailing quality of surface water throughout the basin. This data will assist the Pennsylvania Department of Environmental Resources during its review of coal mine permit applications. A water-quality station on Little Scrubgrass Creek near Lisbon, provided continuous-record of stream stage, pH, specific conductance, and water temperature. Monthly water-quality samples collected at this station were analyzed for total and dissolved metals, nutrients, major cations and anions, and suspended sediment concentrations. Fourteen partial-record sites, located throughout the basin, were similarly sampled four times during the period of study. Streamflow and water-quality data obtained at these sites during various base flow periods are also presented.

INTRODUCTION

Acid mine drainage, which can degrade stream water-quality, has commonly been associated with surface mining throughout the coal regions of Pennsylvania. The Pennsylvania Department of Environmental Resources (PaDER) is responsible for maintaining acceptable water quality for both surface- and ground-water systems throughout Pennsylvania. The PaDER, Bureau of Mining and Reclamation, conducts a Cumulative Hydrologic Impact Assessment (CHIA) during their appraisal of mine-permits in order to assess possible adverse environmental effects of existing and anticipated mining operations. The Bureau requires that mine-permit applications contain information on the existing water-quality conditions for areas applied.

The time frame associated with the review of coal mine-permit applications does not allow for extensive collection of water-quality and quantity data once a permit has been requested. Only a limited amount of background data can be collected and evaluated before the Bureau must respond to an application. Therefore, surface water-quality and quantity data-bases for basins within the coal regions of Pennsylvania need to be established.

Purpose and Scope

This report presents hydrologic and water-quality data for the Little Scrubgrass Creek basin. This data was collected over a range of hydrologic conditions from December 9, 1987 through November 2, 1988. An in-depth interpretative analysis of these water-quality data is not within the scope of this report.

This information will be incorporated by the Bureau, into a CHIA of the Little Scrubgrass Creek basin. This CHIA will involve a more detailed interpretative analysis of the basin's geology, biology, and cultural characteristics as well as the water-quality data in this report.

Acknowledgments

The cooperation of Robert Miller and the Westminster Highlands Church Camp are greatly appreciated for granting permission for the installation of the water-quality station on camp property for the duration of this study.

DESCRIPTION OF STUDY AREA

Location

Little Scrubgrass Creek basin is partially located in both Venango and Butler Counties and encompasses a 25.8 square-mile drainage area (fig. 1). This basin lies within the U.S. Geological Survey Hydrologic Unit 05010003. Little Scrubgrass Creek discharges into the Allegheny River about 4 miles northwest of Emlenton, PA.

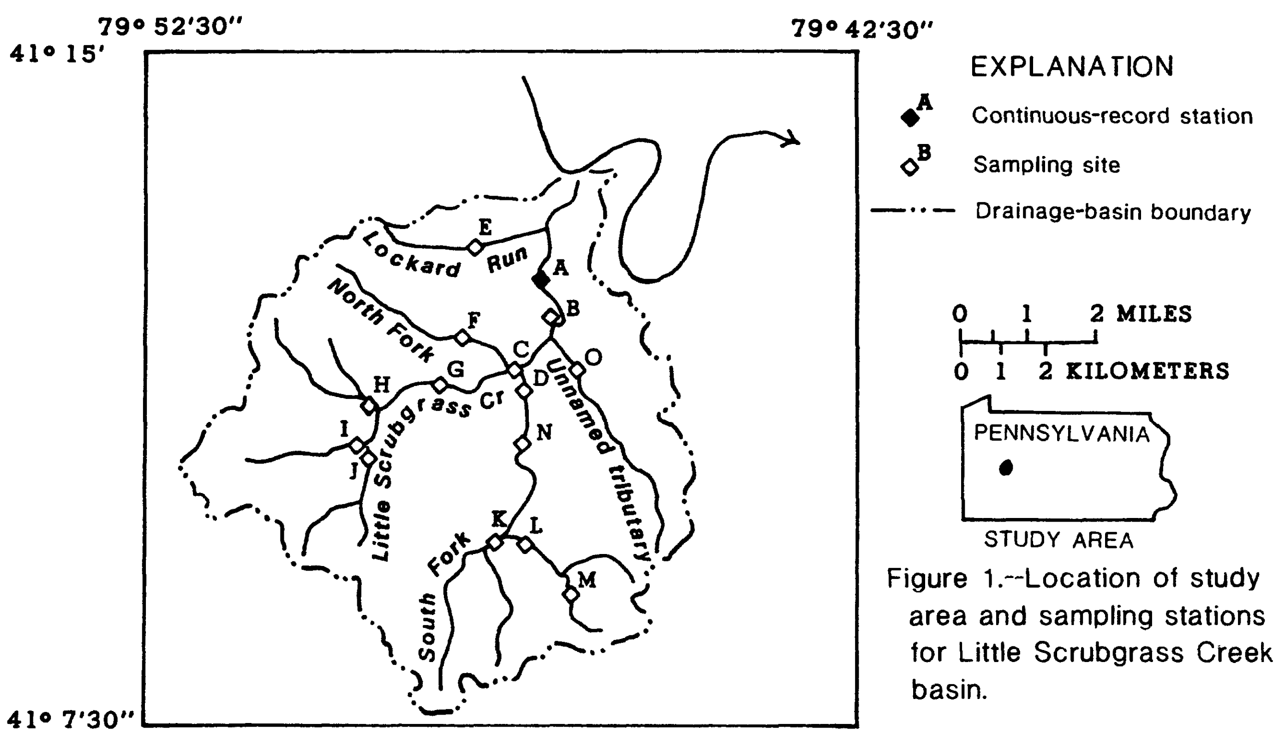

Figure 1.--Location of study area and sampling stations for Little Scrubgrass Creek basin.

Physiography and Geology

Little Scrubgrass Creek basin is located within the Appalachian Plateau Physiographic province. The underlying rock involves the Glenshaw formation of the Allegheny Group (Berg and others, 1983; 1980). Surface mining operations performed within the basin generally involve the Clarion/Brookville, Middle Kittanning, or the Lower Kittanning coal seams (Pennsylvania Department of Environmental Resources, written commun., 1988). The Upper Kittanning and Mercer coals are also present within the basin, but to a lesser extent.

A dendritic drainage pattern is well developed in the basin. The northern portion of the basin, near Little Scrubgrass Creek's point of discharge, is dominated by a deep narrow valley. The southern portion of the basin has more moderate slopes. For the overall basin, elevations above sea level range from about 880 feet near the point of discharge, to about 1,570 feet at the basin's highest points.

Air Temperature

Air temperatures for this area generally range from near 32 °F (degrees Fahrenheit) in December, January, and February, to about 100 °F in June, July, and August. Although freezing temperatures are common during the winter months, periodic warming trends tend to minimize the development of a persistent snowpack throughout the basin.

Precipitation

Precipitation amounts were obtained from a raingage located about 20 miles away from the basin at Clarion, PA. Precipitation for the 11-month study period were compared with the historic precipitation record from 1970 to 1983 (U.S. Department of Commerce, 1970-87). Although these amounts may not be exact for this basin considering the distance between the precipitation gage and basin, the overall relationship between the historic record and the study period should still be reflected by this data. Precipitation from December 1, 1987 through October 31, 1988 totaled 30.4 inches. This was 30 percent below the historic record for the same corresponding time period. A comparison of these data is shown in figure 2.

Land Use

The landcover of Little Scrubgrass Creek basin is characterized by mixed-hardwood forests interspersed with small farms and pasture lands. Surface-mining operations appeared to be the only major industrial activity in the study basin.

Mining operations, prior to 1979, affected about 9.5 percent of the total basin. Since that time 22.7 percent of the basin has been permitted for surface mining (Pennsylvania Department of Environmental Resources, oral commun., 1989). The actual extent of additional future surface mining is difficult to predict, although additional mine-permit requests are anticipated.

Interstate 80, a major east-west transportation corridor, bisects the basin at a latitude of about 40° 11'.

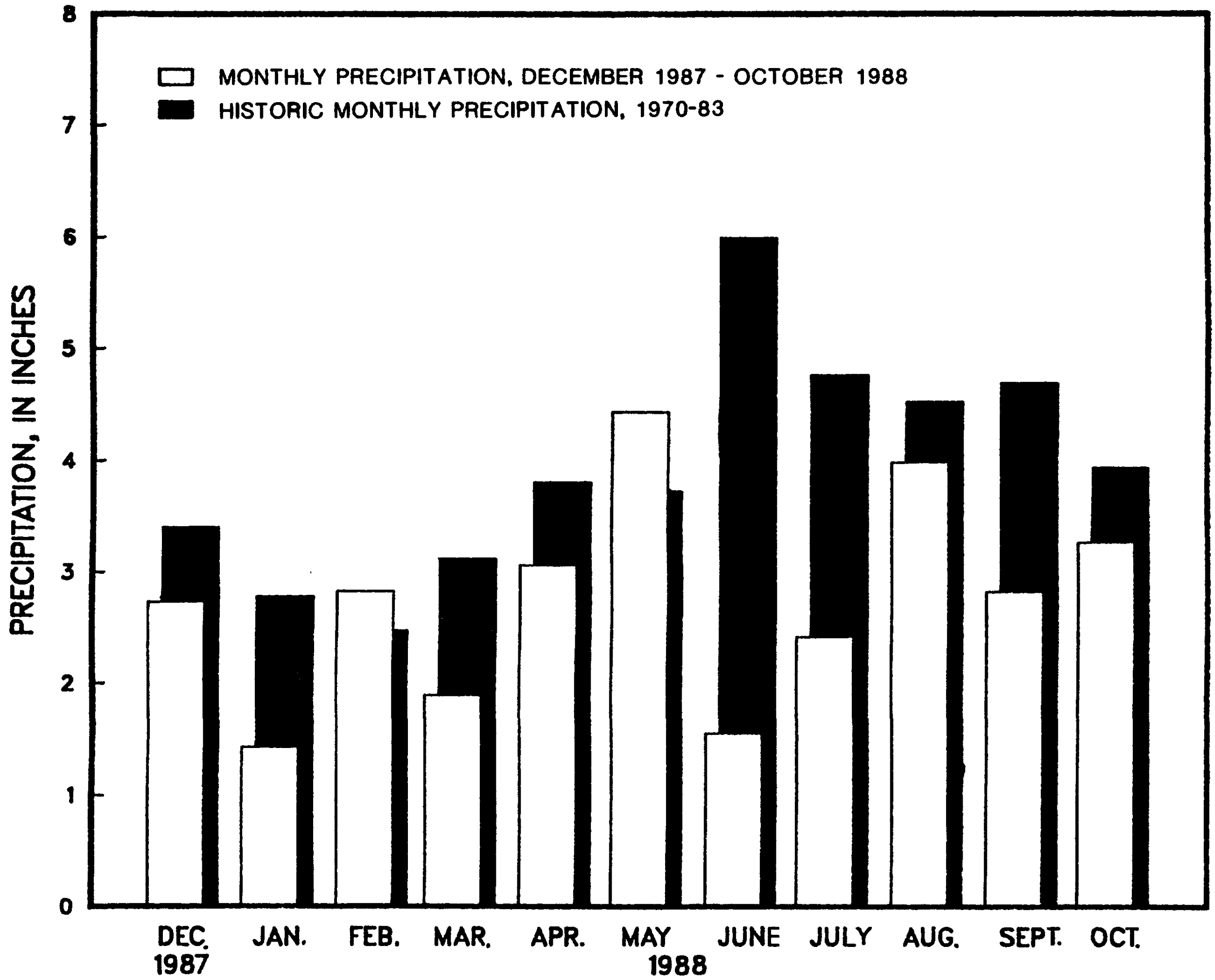

Figure 2.--Monthly precipitation for Little Scrubgrass Creek basin, December 1987 - October 1988, and mean monthly precipitation, 1970-83.

Water Use

No public water-supply systems are located within the Little Scrubgrass Creek basin. Local water sources are private wells utilizing ground water (Pennsylvania Department of Environmental Resources, written commun., 1988).

Little Scrubgrass Creek is under protected use due to its Cold Water Fishery classification by the Pennsylvania Department of Environmental Resources. The Pennsylvania Fish Commission currently stocks trout within certain reaches of Little Scrubgrass Creek (Pennsylvania Department of Environmental Resources, written commun., 1988).

METHODS AND PROCEDURES

Sampling Design

One continuous-record water-quality gaging station was installed on Little Scrubgrass Creek. This station was located several miles upstream from the mouth due to the inexcessable nature of the drainage basin at the point of discharge. Fourteen partial-record water-quality sampling sites were established throughout the basin. This sampling design provided an opportunity to assess the water quality throughout the drainage basin during a range of hydrologic conditions. The name of each sampling site, its latitude and longitude, and drainage areas, are listed in table 1. The location of each sampling site is shown on figure 1.

Table 1.--Description of sampling sites within Little Scrubgrass Creek basin
[mi^2, square mile]

	Station Name	Latitude	Longitude	Drainage area (mi^2)
A.	Little Scrubgrass Creek near Lisbon	41°12' 14"	79°46' 58"	22.6
B.	Little Scrubgrass Creek at Sutton Mill	41°11' 27"	79°47' 11"	18.5
C.	Little Scrubgrass Creek near Sutton Mill	41°11' 20"	79°47' 11"	9.85
D.	South Fork of Little Scrubgrass Creek	41°11' 19"	79°47' 09"	8.77
E.	Lockard Run north of Lisbon	41°12' 40"	79°47' 51"	1.17
F.	North Fork of Little Scrubgrass Creek	41°11' 40"	79°47' 51"	1.97
G.	Little Scrubgrass Creek north of Eakin Corner	41°11' 11"	79°48' 30"	6.57
H.	Unnamed Tributary northwest of Eakin Corner	41°10' 55"	79°49' 13"	1.80
I.	Little Scrubgrass Creek west of Eakin Corner	41°10' 34"	79°49' 20"	2.06
J.	Unnamed Tributary west of Eakin Corner	41°10' 32"	79°49' 19"	1.92
K.	South Fork branch east of Cherry Valley	41°09' 32"	79°47' 28"	3.89
L.	Carrs Run east of Cherry Valley	41°09' 34"	79°47' 25"	1.98
M.	Carrs Run northwest of Six Points	41°09' 04"	79°46' 34"	0.88
N.	South Fork branch west of Crawford Corners	41°10' 42"	79°47' 05"	8.12
O.	Unnamed Tributary east of Sutton Mill	41°11' 18"	79°46' 24"	2.58

The water-quality gaging station was instrumented to provide a continuous record of stream stage, pH, specific conductance, and water temperature. The station was visited monthly for the collection of water-quality samples and discharge measurements. This station was equipped with a Water-Stage Servo-Manometer Bubble Gage, which was coupled with an Analog Digital Recorder (ADR), to measure and record stream stage at 15-minute intervals. A U.S. Geological Survey Minimonitor recorded pH, specific conductance, and temperature at 1-hour intervals. Refer to Craig (1983), and Ficken and Scott (1983), for a discussion of the operation and maintenance of these instruments.

The partial-record stations were visited four times from December 1987 through November 1988 to collect water-quality samples and discharge measurements. The continuous-record station was also sampled during these basinwide samplings. All discharge measurements were performed according to U.S. Geological Survey procedures (Rantz and others, 1982). All water-quality samples were collected and preserved according to U.S. Geological Survey procedures (Brown and others, 1970; Skougstad and others, 1979).

The initial basinwide sampling at all stations was done on December 21-22, 1987. This sampling occurred during winter base-flow conditions. Several attempts were made to collect basinwide samples of a spring storm event but weather conditions were not cooperative. The second set of samples was collected basinwide during low base flow on June 6-7, 1988. Basinwide samples were again collected two more times during the period of study. The third sampling was conducted on July 26-27, 1988. The fourth basinwide sampling was done on August 30-31, 1988. Both of these samplings occurred during low flow conditions which persisted throughout much of the study period due to the below-normal precipitation.

Field Measurements

Field measurements associated with all water-quality sampling included pH, specific conductance, water temperature, and dissolved oxygen concentration. Alkalinity titrations of the monthly samples collected at the continuous-record station were done in the field according to standard U.S. Geological Survey methods (R.J. Pickering, U.S. Geological Survey, written commun., 1981). The alkalinity and acidity results for the partial-record sites were determined by PaDER Water Quality Laboratory titrations. Field pH was measured with an Orion Ionalyzer Model 399A pH meter[1]. A Beckman Solu-Bridge Conductivity Meter[1] was used for specific conductance measurements. Water temperature was determined with a certified mercury thermometer. Dissolved oxygen measurements were determined with a Hydrolab Meter Model 4041[1]. All field meters were calibrated daily according to the manufacturers specifications, prior to field measurements.

Sample Preparation

After collection, water-quality samples were divided into splits for various analyses. Splits intended for dissolved constituents were filtered through 0.45-micrometer cellulose nitrate membranes. Splits intended for metals analysis, both total and dissolved, were preserved with nitric acid to reduce the sample pH to 2. Splits for nutrient analyses were preserved with mercuric chloride. All samples were stored in ice until delivered to the PaDER Water Quality Laboratory, usually within 24 to 48 hours after collection. Suspended sediment samples were delivered for analysis to the U.S. Geological Survey, Pennsylvania Sediment Laboratory, Harrisburg Office.

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[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Laboratory Schedules

Two PaDER water-quality laboratory-analysis schedules were developed for this project. Monthly samples collected at the continuous-record station were submitted to the laboratory under lab schedule 432. This schedule included analyses for total and dissolved metals, base cations, major anions, and nutrients. The water-quality samples collected basinwide were submitted for laboratory analyses according to lab schedule 431. This schedule included analysis for total metals, total base cations, and total anions. The constituents and analysis techniques involved with each of these two schedules are listed in table 2.

Table 2.--Analytical techniques and laboratory schedules for water-quality samples

[mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius]

Parameter	Code	Schedule	Analysis technique	Detection limit
Acidity, total as $CaCO_3$	00435	431,432	Titrimetric	0.1 mg/L
Alkalinity, total as $CaCO_3$	00410	431,432	Titrimetric	0.1 mg/L
Aluminum, dissolved	01106	432	ICP emission	50 µg/L
Aluminum, total	01105	431,432	ICP emission	50 µg/L
Calcium, dissolved	00915	432	ICP emission	.03 mg/L
Chloride, total	00940	431,432	Ferricyanide	1 mg/L
Iron, dissolved	01046	432	ICP emission	10 µg/L
Iron, total	01045	431,432	ICP emission	10 µg/L
Magnesium, dissolved	00925	432	ICP emission	.01 mg/L
Manganese, dissolved	01056	432	ICP emission	10 µg/L
Manganese, total	01055	431,432	ICP emission	10 µg/L
Nitrite, dissolved as N	00613	432	Sulfanilamide	.01 mg/L
Nitrite + Nitrate, dis. as N	00631	432	Cadmium reduction	.02 mg/L
pH	00400	431,432	Electrometric	Standard units
Phosphorus, diss. ortho as P	00671	432	Ascorbic acid	.01 mg/L
Potassium, dissolved	00935	432	ICP emission	.135 mg/L
Sediment, suspended	80180	431,432	Filtration	1 mg/L
Sodium, total	00929	431	ICP emission	.2 mg/L
Sodium, dissolved	00930	432	ICP emission	.2 mg/L
Specific conductance	00095	431,432	Electrometric	1 µS/cm
Sulfate, total	00945	431,432	Methyl thymol blue	10 mg/L
Solids, suspended	00530	431,432	Glass-fiber	2 mg/L
Solids, dissolved	00515	431,432	Evaporation	2 mg/L
Zinc, dissolved	01090	432	ICP emission	10 µg/L
Zinc, total	01092	431,432	ICP emission	10 µg/L

Quality Assurance and Quality Control

A quality-assurance plan was developed and maintained to assure accurate and consistent laboratory results. Water-quality duplicate samples were collected and submitted for analysis throughout the study to test laboratory consistency. Duplicate water-quality samples collected under identical procedures for two additional CHIA projects during the same period of study were used so a more thorough statistical evaluation of the laboratory analyses could be performed. A Wilcoxon Two-Sample Test, was used to compare the duplicate pairs as two independent groups. Results of this test failed to indicate significant differences between groups for any of the constituents. A more precise test of duplicate repeatability was also performed. The differences between duplicate pairs were calculated for each constituent. Ideal consistency would result in a difference of zero for each constituent. A nonparametric Signed-rank Test was used to test whether the median difference of the duplicate pairs for each constituent was significantly different from zero. The results, shown in table 3, indicate that, at the 95-percent confidence level, there was no significant difference between zero and the median difference of the duplicate pairs for all constituents except sulfate. The median difference between sulfate duplicates was 2 mg/L. Although statistically significant, because one group routinely contained the larger values, this difference was not large enough to be of practical significance. Therefore, an exceptable degree of laboratory repeatability was concluded.

The routine retrieval and evaluation of preliminary laboratory results identified questionable samples and results at an early stage. Requests were submitted for the reanalysis of these samples. Depending on the constituents involved, the samples were either reanalyzed or the resulting calculations were checked and recalculated. No sample analyses were discarded due to questionable results.

Table 3.--Comparison of duplicate water-quality sample analyses

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Constituent	Detection limit		Number of samples	Median difference
Acidity, total as $CaCO_3$	0.1	mg/L	12	0
Alkalinity, total as $CaCO_3$	0.1	mg/L	13	0
Aluminum, total	50	µg/L	13	12
Calcium, dissolved	.03	mg/L	2	-2.3
Chloride, total	1	mg/L	14	0
Iron, total	10	µg/L	14	-1
Magnesium, dissolved	.01	mg/L	2	0
Manganese, total	10	µg/L	14	.5
Nitrite, dissolved as N	.01	mg/L	2	0
Nitrite + Nitrate, dissolved	.02	mg/L	2	0
Phosphorus, diss. ortho as P	.01	mg/L	2	0
Potassium, dissolved	.135	mg/L	2	.05
Sodium, total	.2	mg/L	14	-.5
Sulfate, total	10	mg/L	14	2
Solids, suspended	2	mg/L	14	-4
Solids, dissolved	2	mg/L	14	-2
Zinc, total	10	µg/L	14	0

Data Analysis

The water-quality data were reviewed and evaluated to ensure accuracy and validity of the laboratory results. These data have been rounded to the appropriate number of significant figures according to U.S. Geological Survey procedures (U.S. Department of Interior, 1976). These laboratory results, the water-quality field measurements, and stream-discharge calculations are presented in a variety of summary statistics. These statistics were performed by procedures outlined in P-STAT, Inc. (1986) and SAS, Inc. (1982). Graphical representation of the data were performed with TELAGRAF procedures (Issco, 1984).

STREAMFLOW

Monthly Discharge Records

Routine monthly discharge measurements were made at the continuous-record station on Little Scrubgrass Creek near Lisbon. Although 13 discharge measurements were available for determining the stage-discharge relation for this station, only those measurements associated with monthly water-quality samples are listed in table 4 along with their respective water-quality results.

A step-backwater analysis also was performed to help define the stage-discharge relation (Davidian, 1984). This relation was computed according to U.S. Geological Survey methods described in Rantz and others (1982). Results of these computations, were used to develop an expanded rating table for the stage-discharge relation for the period of study and are listed in Table 5. The control section, ranging from gravel to large boulders, showed no significant shift during the period of study. The reliability of this rating table for future measurements is dependent on the stability of the control area.

Table 4.--Monthly discharge measurements and water-quality samples at Little Scrubgrass Creek near Lisbon

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; µg/L, micrograms per liter; F, field analysis; <, less than; double dash indicates no data]

Date	Time	Temperature, water, field (Deg C)	Stream-Flow, instantaneous, field (ft^3/s)	Specific conductance, field (µS/cm)	Oxygen, dissolved, field (mg/L)	pH, field (standard units)	Alkalinity, total (mg/L as $CaCO_3$)	Acidity, total (mg/L as $CaCO_3$)	Solids, dissolved at 25 Deg C (mg/L)	Solids, suspended at 25 Deg C (mg/L)	Nitrogen, Nitrite dissolved (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorous ortho, dissolved (mg/L as P)	Calcium dissolved (mg/L as Ca)
DEC 1987														
09...	1115	4.0	146	380	11.7	7.6	46	0	272	78	<0.01	0.62	0.03	34
JAN 1988														
07...	1045	0.0	ICE	430	--	7.7	68	0	430	20	<0.01	0.62	<0.01	73
FEB														
03...	1100	2.0	84	300	13.0	7.2	32	0	238	56	<0.01	1.04	<0.01	38
MAR														
02...	1100	1.5	25	520	13.3	7.8	49 F	1.0 F	318	<2	<0.01	0.64	<0.01	58
APR														
05...	1230	10.5	75	340	11.1	7.7	31 F	1.7 F	1010	44	<0.01	0.70	<0.01	41
27...	1330	9.5	19	530	11.1	8.0	55 F	0	460	8	<0.01	0.32	0.01	72
MAY														
10...	0910	12.0	50	410	10.5	7.8	44	0	352	26	<0.01	0.36	0.01	59
19...	1730	14.5	100	290	10.0	7.6	38	0	16	26	--	--	--	--
JUL														
07...	1430	20.5	5.5	710	8.4	8.2	101 F	0	630	<2	<0.01	0.24	0.02	110
AUG														
11...	1000	20.0	4.3	690	8.5	7.9	72 F	0	492	10	<0.01	0.18	0.04	88
OCT														
04...	1410	12.0	4.3	675	10.4	8.1	83 F	0	444	<2	<0.01	0.10	0.01	63
NOV														
02...	1300	5.0	4.0	625	12.0	8.0	71 F	0	452	<2	<0.01	0.10	<0.01	78

Table 4.--Monthly discharge measurements and water-quality samples at Little Scrubgrass Creek near Lisbon--Continued

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; µg/L, micrograms per liter; F, field analysis; <, less than; double dash indicates no data]

Date	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Iron, total (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Manganese, total (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Zinc, total (µg/L as Zn)	Zinc, dissolved (µg/L as Zn)	Aluminum, total (µg/L as Al)	Aluminum, dissolved (µg/L as Al)	Sediment, suspended (mg/L)
DEC 1987														
09...	8.6	11	3.1	17	120	3800	83	1300	780	60	30	3000	<50	--
JAN 1988														
07...	20	13	2.2	15	70	150	29	1900	1900	30	30	<50	<50	<1
FEB														
03...	6.5	6.0	2.3	15	95	1100	94	910	760	40	40	610	60	27
MAR														
02...	16	10	2.3	15	180	410	<10	1500	1500	10	<10	190	190	4
APR														
05...	10	7.2	2.2	66	110	1900	27	960	670	160	30	680	50	9
27...	18	11	2.1	14	200	430	<10	1400	1400	20	20	190	190	3
MAY														
10...	15	13	2.3	15	140	1000	100	1100	1100	60	60	730	<50	71
19...	--	6.7	--	10	89	1800	--	820	--	70	--	550	--	32
JUL														
07...	26	14	3.0	15	260	340	16	120	65	10	<10	100	50	2
AUG														
11...	24	13	3.1	17	290	270	32	61	29	20	20	110	90	2
OCT														
04...	14	17	3.0	23	230	500	73	94	78	30	30	<50	<50	4
NOV														
02...	22	17	3.1	20	220	490	14	460	460	20	20	120	60	1

Table 5.--Stage-discharge relation for Little Scrubgrass Creek near Lisbon, February - November 1988

Gage Height (Feet)	Discharge (ft^3/s) 0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.30	3.0	3.1	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.0
.40	4.1	4.2	4.4	4.6	4.8	4.9	5.1	5.3	5.4	5.6
.50	5.8	6.0	6.3	6.5	6.8	7.0	7.3	7.6	7.8	8.1
.60	8.4	8.7	9.1	9.5	9.8	10	10	11	11	11
.70	12	12	13	13	14	14	15	15	16	16
.80	17	17	18	18	19	20	20	21	21	22
.90	23	23	24	25	25	26	27	27	28	29
1.00	30	30	31	32	33	33	34	35	36	37
1.10	37	38	39	40	41	42	43	44	44	45
1.20	46	47	48	49	50	51	52	53	54	55
1.30	56	57	59	60	61	62	63	64	65	66
1.40	68	69	70	71	72	74	75	76	77	79
1.50	80	81	83	84	85	87	88	89	91	92
1.60	94	95	97	98	100	101	103	104	106	108
1.70	109	111	112	114	116	118	119	121	123	125
1.80	126	128	130	132	134	136	137	139	141	143
1.90	145	147	149	151	153	155	157	159	161	163
2.00	166	167	169	171	173	174	176	178	180	182
2.10	183	185	187	189	191	193	195	197	198	200
2.20	202	204	206	208	210	212	214	216	218	220
2.30	222	224	226	228	230	232	234	236	239	241
2.40	243	245	247	249	251	254	256	258	260	262
2.50	265	267	269	271	273	275	277	279	281	283
2.60	285	288	290	292	294	296	298	301	303	305
2.70	307	309	312	314	316	318	321	323	325	327
2.80	330	332	334	336	339	341	343	346	348	350
2.90	353	355	358	360	362	365	367	369	372	374
3.00	377	379	382	384	387	389	391	394	396	399
3.10	401	404	407	409	412	414	417	419	422	424
3.20	427	430	432	435	437	440	443	445	448	451
3.30	453	456	459	461	464	467	469	472	475	477
3.40	480	483	486	488	491	494	497	500	503	506
3.50	508	512	515	518	521	524	527	530	533	536
3.60	539	542	545	548	552	555	558	561	564	567
3.70	571	574	577	580	583	587	590	593	596	600
3.80	603	606	610	613	616	620	623	626	630	633
3.90	636	640	643	647	650	653	657	660	664	667
4.00	671	674	678	681	685	688	692	695	699	702
4.10	706	709	713	717	720	724	727	731	735	738
4.20	742	746	749	753	757	760	764	768	772	775
4.30	779	783	787	790	794	798	802	805	809	813
4.40	817	821	825	829	832	836	840	844	848	852
4.50	856	860	864	868	872	876	880	884	888	892
4.60	896	900	904	908	912	916	920	924	928	932
4.70	937	941	945	949	953	957	962	966	970	974
4.80	978	983	987	991	995	1,000	1,005	1,010	1,015	1,021

Continuous Discharge Record

The stage of Little Scrubgrass Creek was continuously recorded near Lisbon from February 4 through November 1, 1988. Winter conditions prevented the earlier installation of this station. Daily mean discharges were computed from the continuous-record of stream stage. These values are listed in table 6 and illustrated by the hydrograph in figure 3 (Kennedy, 1983). The daily precipitation record for Clarion, for the period of study, is also illustrated in this figure. Low flows persisted at this station during the second half of the summer as a direct result of the lack of substantial precipitation from mid-May through mid-August. The minimum flow, 3.4 ft^3/s, for the period of record occurred August 17, 1988. The peak flow, 438 ft^3/s, occurred on April 3, 1988.

Ice affected the stage-discharge relation from February 4 through March 9, 1988. Discharges were estimated for this period. Estimated discharges were computed on the basis of gage height observations, high water marks, field measurements, weather records, and hydrograph comparisons.

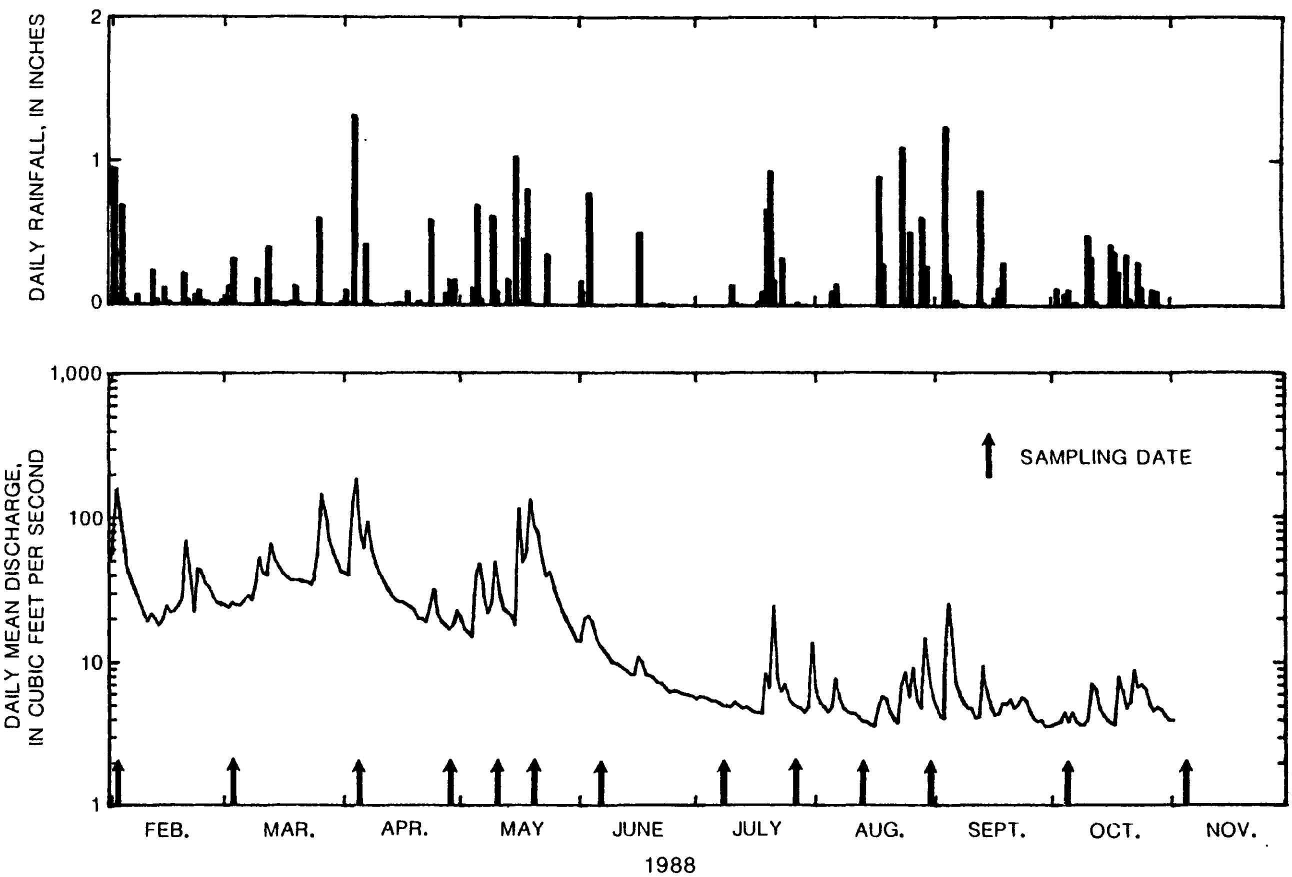

Figure 3.--Continuous stream discharge for Little Scrubgrass Creek near Lisbon and daily precipitation at Clarion, February - October, 1988.

Table 6.--Daily mean discharge of Little Scrubgrass Creek near Lisbon, from February 4, through November 1, 1988

[e, estimated; CFSM, cubic feet per second per mile; in., inches; double dash indicates no data]

DAY	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	56e	25e	41	20	14	5.6	6.2	4.9	3.7	4.0
2	160e	24e	40	17	20	5.8	5.2	4.2	3.8	--
3	100e	26e	113	16	21	5.7	4.9	4.1	3.9	--
4	60e	25e	190	15	19	5.6	4.5	26	4.5	--
5	42e	25e	78	39	15	5.4	4.9	14	3.9	--
6	35e	27e	61	48	13	5.4	7.8	7.2	4.5	--
7	30e	29e	94	28	12	5.2	5.6	5.8	3.9	--
8	26e	27e	60	22	11	5.0	4.8	5.1	3.7	--
9	22e	35e	48	26	10	5.0	4.5	4.8	3.7	--
10	19e	53	41	50	9.9	4.9	4.4	4.8	4.0	--
11	22e	41	36	29	9.5	5.3	4.4	4.1	7.2	--
12	20e	40	32	23	9.1	5.0	4.1	4.2	6.5	--
13	18e	66	29	22	8.7	4.8	3.9	9.7	4.8	--
14	20e	51	27	21	8.2	4.9	3.9	6.1	4.3	--
15	25e	46	26	18	8.2	4.7	3.7	4.8	4.0	--
16	22e	41	26	117	11	4.5	3.6	4.3	3.8	--
17	23e	39	25	48	10	4.5	4.8	4.4	3.7	--
18	25e	37	24	56	8.2	4.4	5.8	5.2	8.1	--
19	28e	37	23	135	8.1	8.6	5.5	5.1	6.3	--
20	70e	37	20	87	7.8	6.6	4.5	5.5	4.8	--
21	45e	36	20	76	7.3	25	4.0	4.8	5.3	--
22	22e	36	19	52	7.2	7.9	3.8	5.1	8.9	--
23	45e	35	24	39	6.7	6.1	6.8	5.7	6.7	--
24	43e	37	32	42	6.2	7.2	8.6	5.4	7.1	--
25	35e	54	22	32	6.3	5.5	5.7	4.6	6.5	--
26	33e	148	19	27	6.3	5.1	9.3	4.1	5.1	--
27	28e	109	18	23	6.1	4.9	5.4	3.9	4.6	--
28	26e	70	17	20	6.0	4.8	4.8	4.0	4.9	--
29	25e	58	18	18	5.9	4.5	15	3.6	4.7	--
30	--	49	23	16	5.8	4.9	8.7	3.6	4.3	--
31	--	42	--	14	--	14	5.8	--	4.0	--
TOTAL	1,125	1,405	1,246	1,196	297.5	196.8	174.9	179.1	155.2	--
MEAN	38.8	45.3	41.5	38.6	9.92	6.35	5.64	5.97	5.01	--
MAX	160	148	190	135	21	25	15	26	8.9	--
MIN	18	24	17	14	5.8	4.4	3.6	3.6	3.7	--
CFSM	1.62	1.89	1.73	1.61	.41	.26	.24	.25	.21	--
IN.	1.74	2.18	1.93	1.85	.46	.31	.27	.28	.24	--

Partial-Record Discharges

The 14 partial-record sites were visited 4 times over the course of the project. Discharge measurements were made during each visit. The scope of this study, however, did not permit for a thorough evaluation of the stage-discharge relation at each of these sites. The discharge measurements are listed in tables 11, 12, 13, and 14 along with the respective water-quality data. These data generally reflect base-flow conditions at various times of the year. Although attempts were made to collect basinwide samples during storm runoff, no suitable events were successfully sampled. The below normal precipitation to the basin for the study period limited storm flows making sampling difficult.

WATER QUALITY

Monthly Water-Quality Samples

The chemical analyses for the monthly water-quality samples collected at Little Scrubgrass Creek near Lisbon, including both field and laboratory analyses, are listed in table 4. These water-quality results appear fairly consistent throughout the study period as they generally reflect seasonal base-flow conditions. Summary statistics of these results are listed in table 7.

These monthly samples revealed the slightly alkaline nature of Little Scrubgrass Creek. The pH of these samples consistantly ranged from 7.2 to 8.2 throughout the year, although the continuous record revealed drops in pH to near 6.0. The last four water-quality samples were collected during the low flow conditions which persisted during the second half of the study period. Several of the base cations, sulfate and magnesium, exhibited slightly higher concentrations during this period. Conversely, metals, such as iron and manganese, were observed to be less concentrated during these same monthly samples.

Continuous Water-Quality Record

The station on Little Scrubgrass Creek near Lisbon recorded pH, specific conductance, and water temperature at 1-hour intervals from February 4 through November 1, 1988. These hourly data were used to calculate daily mean values, which are listed in tables 8, 9, and 10. In calculating the daily mean pH, the hourly pH values were first converted to hourly hydrogen ion concentrations to eliminate the log component of pH. Daily mean hydrogen ion concentrations were then calculated and these values were converted back to daily mean pH. The daily mean values, for the period of study, also are shown in figure 4. Periods of missing record were a result of equipment malfunctions. Water-quality data were not estimated for these missing periods.

The continuous pH remained slightly alkaline throughout the study period, although a noticable drop occurred during a February event. The specific conductance was generally several hundred microsiemens per centimeter higher during the warmer summer months than in the winter period. A steady increase was observed from May through June. This increase was inversely related to the steady decrease in stream discharge which occurred at this time. The continuous record of water temperature reflects the seasonal variation typical for this climatic region.

Table 7.--Summary of the monthly water-quality sampling of Little Scrubgrass Creek near Lisbon, from January through November 1988

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Parameter	N	Median	Mean	Minimum	Maximum	Units
Water temperature	12	10	9.3	0	20.5	Deg C
Stream discharge	11	22	47	4.0	146	ft^3/s
Specific conductance	12	475	492	290	710	µS/cm
Dissolved oxygen	11	11.1	10.9	8.4	13.3	mg/L
pH	12	7.8	7.8	7.2	8.2	pH units
Alkalinity, total	12	52	57.5	31	101	mg/L
Acidity, total	12	0	0.2	0	1.7	mg/L
Solids, dissolved	12	437	426	16	1010	mg/L
Solids, suspended	12	15	23	<2	78	mg/L
Nitrite, dissolved	11	<0.01	<0.01	<0.01	<0.01	mg/L
Nitrite-Nitrate	11	0.36	0.45	0.1	1.04	mg/L
Phosphorus, ortho	11	0.01	0.01	<0.01	0.04	mg/L
Calcium, dissolved	11	63	65	34	110	mg/L
Magnesium, dissolved	11	16	16.4	6.5	26	mg/L
Sodium, dissolved	12	12	11.6	6.0	17	mg/L
Potassium, dissolved	11	2.3	0.38	2.1	3.1	mg/L
Chloride, total	12	15	21.4	10	66	mg/L
Sulfate, total	12	160	167	70	290	mg/L
Iron, total	12	495	1015.8	150	3800	µg/L
Iron, dissolved	11	29	44.4	<10	100	µg/L
Manganese, total	12	935	885	61	1900	µg/L
Manganese, dissolved	11	760	794.7	29	1900	µg/L
Zinc, total	12	30	44.2	10	160	µg/L
Zinc, dissolved	11	30	27.3	<10	60	µg/L
Aluminum, total	12	190	531.7	<50	3000	µg/L
Aluminum, dissolved	11	50	80.9	<50	190	µg/L
Sediment, suspended	11	4	14.2	<1	71	mg/L

Table 8.--Daily mean pH of Little Scrubgrass Creek near Lisbon, from February 4, through November 1, 1988

[double dash indicates no data]

DAY	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	--	7.6	--	7.9	7.7	7.8	7.9	8.0	8.1	8.0
2	--	7.9	--	7.9	7.7	7.8	7.9	8.0	8.1	--
3	--	7.8	--	7.9	7.6	7.9	8.0	8.0	8.1	--
4	7.7	7.8	--	7.9	7.6	7.9	8.0	7.8	8.1	--
5	7.8	7.8	--	7.8	7.6	7.9	8.0	7.9	8.1	--
6	7.9	7.7	--	7.7	7.6	7.9	8.0	8.0	8.1	--
7	8.1	--	--	7.7	7.5	--	8.0	8.0	8.1	--
8	8.3	--	--	7.7	7.5	--	8.0	8.0	8.1	--
9	8.1	--	--	7.7	7.5	--	8.0	8.0	8.1	--
10	8.1	--	--	7.7	7.5	--	8.0	8.0	8.0	--
11	7.9	--	--	7.8	7.6	--	8.0	8.0	8.0	--
12	7.8	--	--	7.9	7.6	--	7.9	8.0	8.0	--
13	7.5	--	7.9	7.9	7.6	--	8.0	7.9	8.0	--
14	7.5	--	7.9	7.9	7.7	--	8.0	8.0	8.0	--
15	7.6	--	8.0	7.8	7.7	--	8.0	8.0	8.0	--
16	7.5	--	8.0	7.7	7.7	--	8.0	8.0	8.0	--
17	6.5	--	8.0	7.6	7.7	--	8.1	8.0	8.0	--
18	6.0	--	8.0	7.7	7.7	--	8.0	8.0	7.9	--
19	6.1	--	8.0	7.7	7.8	--	8.0	7.9	8.0	--
20	6.5	--	8.0	7.5	7.8	--	8.0	8.0	8.0	--
21	6.6	--	8.0	7.5	7.8	--	8.0	8.1	8.0	--
22	6.9	--	8.0	7.6	7.8	--	8.0	8.1	8.0	--
23	7.1	--	8.0	7.6	7.8	8.0	7.9	8.0	8.0	--
24	7.4	--	7.9	7.7	7.8	8.0	7.9	8.0	8.0	--
25	7.4	--	8.0	7.6	7.8	8.0	8.0	8.1	8.0	--
26	7.4	--	8.0	7.5	7.8	8.1	7.9	8.1	8.0	--
27	7.5	--	7.9	7.6	7.8	8.0	7.9	8.1	8.0	--
28	7.7	--	7.9	7.6	7.8	8.0	7.9	8.1	8.0	--
29	7.7	--	7.9	7.7	7.8	8.0	7.9	8.1	8.0	--
30	--	--	7.9	7.7	7.8	8.0	7.9	8.1	8.0	--
31	--	--	--	7.7	--	7.8	8.0	--	8.0	--
MEAN	7.4	--	8.0	7.7	7.7	7.9	8.0	8.0	8.0	--
MAX	8.3	7.9	8.0	7.9	7.8	8.1	8.1	8.1	8.1	--
MIN	6.0	7.6	7.9	7.5	7.5	7.8	7.9	7.8	7.9	--

Table 9.--Daily mean specific conductance of Little Scrubgrass Creek near Lisbon, from February 4, through November 1, 1988

[microsiemens per centimeter at 25 Deg C; double dash indicates no data]

DAY	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	--	488	339	522	537	714	697	624	673	643
2	--	495	344	527	529	715	683	645	662	--
3	--	491	329	542	523	729	689	661	659	--
4	274	495	270	550	522	726	707	540	707	--
5	309	512	328	499	540	722	700	533	669	--
6	354	494	355	377	561	723	633	571	662	--
7	395	455	334	402	599	721	698	605	674	--
8	413	457	353	430	611	708	694	623	667	--
9	439	441	384	439	628	709	696	624	687	--
10	454	396	404	382	635	716	693	643	694	--
11	475	418	419	406	655	710	691	646	640	--
12	484	429	432	434	660	720	694	661	671	--
13	504	393	434	456	659	727	689	590	644	--
14	526	391	442	471	671	729	698	616	632	--
15	514	408	450	486	671	722	691	613	644	--
16	459	420	455	315	661	734	710	639	644	--
17	478	430	460	340	653	741	657	644	646	--
18	445	434	459	355	654	727	604	656	620	--
19	435	438	462	275	673	690	674	667	657	--
20	367	439	455	302	676	729	694	654	642	--
21	378	457	476	325	682	621	701	657	642	--
22	403	462	486	354	688	643	700	653	637	--
23	405	455	465	380	697	645	675	602	633	--
24	395	429	421	396	691	684	635	624	616	--
25	421	413	433	413	698	717	657	651	624	--
26	443	284	447	432	703	719	615	651	617	--
27	458	260	498	454	711	728	661	655	626	--
28	473	280	539	480	723	726	652	674	631	--
29	480	300	537	499	713	730	601	654	627	--
30	--	317	524	513	714	732	618	671	643	--
31	--	328	--	527	--	659	609	--	643	--
MEAN	--	416	424	428	645	710	671	632	649	--
MAX	--	512	539	550	723	741	710	674	707	--
MIN	--	260	270	275	522	621	601	533	616	--

Table 10.--Daily mean water temperature of Little Scrubgrass Creek near Lisbon, from February 4, through November 1, 1988
[double dash indicates no data]

DAY	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	--	2.0	10.0	8.5	17.5	12.5	19.5	15.0	14.5	3.5
2	--	2.0	11.0	9.0	15.5	13.5	21.0	15.0	15.0	--
3	--	2.5	11.5	10.0	13.5	14.5	21.5	16.0	13.5	--
4	2.0	1.5	11.0	10.5	12.0	16.0	22.0	17.5	10.5	--
5	.5	.5	10.5	11.0	13.0	17.5	22.0	16.0	9.0	--
6	.0	1.0	11.5	12.0	16.0	18.5	21.5	13.5	8.5	--
7	.0	2.5	10.5	12.5	18.0	18.5	20.5	12.0	8.5	--
8	.0	3.5	8.5	13.5	17.5	19.5	19.5	12.0	7.5	--
9	.0	4.5	7.5	14.0	14.5	20.0	20.0	12.5	8.0	--
10	.0	4.0	8.0	13.5	12.0	19.5	20.5	14.0	8.5	--
11	.0	3.5	8.5	13.5	12.0	20.0	21.5	13.5	8.5	--
12	.0	4.5	9.5	12.5	14.5	20.5	22.5	13.5	6.5	--
13	.0	4.0	9.5	13.5	15.5	19.0	22.5	15.5	6.0	--
14	.0	2.0	9.0	13.5	17.0	20.5	22.5	13.5	5.0	--
15	.0	1.0	7.0	14.0	18.0	21.0	22.5	13.0	6.5	--
16	.0	1.0	5.0	16.0	17.5	21.0	20.5	11.5	9.0	--
17	1.0	1.5	6.5	14.5	17.0	22.0	21.0	13.5	10.5	--
18	1.5	1.5	8.5	13.5	15.5	21.0	21.5	15.5	11.5	--
19	1.5	2.0	5.5	13.5	16.0	21.0	19.5	17.0	9.0	--
20	2.0	1.5	6.0	14.0	17.0	20.5	18.5	18.0	7.5	--
21	.0	.0	7.5	14.0	19.0	19.5	16.5	16.5	6.5	--
22	.0	.5	6.5	15.0	19.5	19.5	15.0	15.0	7.5	--
23	2.5	4.0	9.5	16.0	20.0	19.0	15.0	15.5	7.5	--
24	.5	7.0	8.5	16.0	17.0	18.5	17.0	13.5	7.0	--
25	.0	8.5	8.0	12.0	18.0	18.5	17.0	13.0	6.0	--
26	.0	8.0	9.0	11.0	18.0	19.0	17.0	12.0	5.0	--
27	1.5	5.5	9.5	13.5	15.0	19.5	16.5	12.0	4.0	--
28	.5	5.5	8.5	15.0	14.5	19.5	17.5	12.5	5.0	--
29	2.0	8.5	7.0	15.5	15.0	20.5	17.5	12.5	5.0	--
30	--	10.0	7.5	17.0	13.5	21.0	16.5	13.0	4.0	--
31	--	8.5	--	17.5	--	21.0	15.0	--	2.0	--
MEAN	--	3.6	8.5	13.4	16.0	19.1	19.4	14.1	7.8	--
MAX	2.5	10.0	11.5	17.5	20.0	22.0	22.5	18.0	15.0	--
MIN	.0	.0	5.0	8.5	12.0	12.5	15.0	11.5	2.0	--

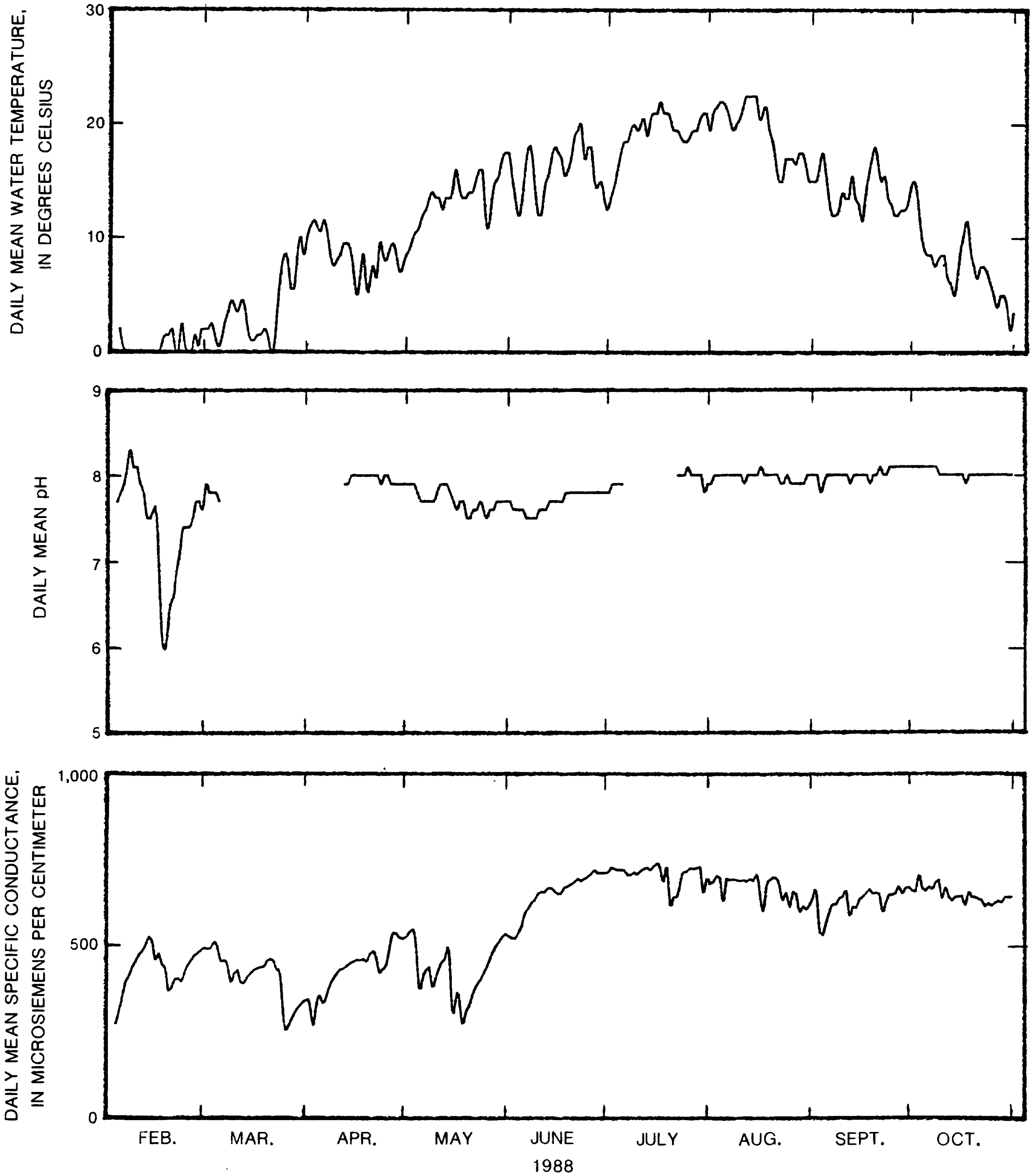

Figure 4.--Daily mean pH, specific conductance, and water temperature for Little Scrubgrass Creek near Lisbon.

Partial-Record Water Quality

Water-quality results from the four basinwide samplings are listed by event in tables 11, 12, 13, and 14. These results include both field and laboratory analyses. These water-quality samples were generally collected during base flow at various times during the 1988 water year. The first sampling event reflects winter base-flow conditions. The three other basinwide samplings were conducted during low flows which persisted throughout the second half of the study period. These dry conditions were a direct result of the below-normal precipitation conditions.

One of the most pronounced observations obtained from the basinwide base-flow samplings were the elevated manganese concentrations found at the unnamed tributary (J) west of Eakin Corner at its confluence with Little Scrubgrass Creek (I). Metal concentrations at this site were consistently high during the four basinwide samplings. Lockard Run (E) north of Lisbon exhibited the highest acidity of all the sites. Alkalinity was minimal at this tributary whereas pH values as low as 5.0 were recorded.

SUMMARY

Little Scrubgrass Creek basin, located in Venango and Butler Counties, was selected for this study because future mine-permit applications for areas within this basin were anticipated. In an effort to document existing surface water conditions, a streamflow and water-quality assessment of the entire basin was done from December 1987 to November 1988.

Precipitation to this area was 30 percent below normal for the period of study. As a result, low base-flow conditions were found to persist during much of the study period. The minimum flow for the period of study, 3.4 ft^3/s, occurred on August 17, 1988. Peak flow for the period of record, 438 ft^3/s, occurred on April 3, 1988.

The Little Scrubgrass Creek continuous water-quality record showed a consistant pH throughout most of the study period, generally ranging from 7.5 to 8.1. Specific conductance was inversely related to stream discharge, increasing and remaining high during the low flows of summer.

The basinwide samplings indicated the general conditions of the major tributaries for the Little Scrubgrass Creek basin. Several streams exhibited elevated metal concentrations or higher acidity. The complexity of a basin, including its geology, and the extent of all previous mining must be considered in great detail to improve the interpretion of the available water-quality data.

Table 11.--Results of the winter base flow sampling of Little Scrubgrass Creek basin on December 21-22, 1987

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; $\mu S/cm$, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; $\mu g/L$, micrograms per liter; double dash indicates no data]

Station	Date	Time	Temperature, water, field (Deg C)	Streamflow, instantaneous, field (ft^3/s)	Specific conductance, field ($\mu S/cm$)	Oxygen dissolved, field (mg/L)	pH, field (standard units)	Alkalinity, total (mg/L as $CaCO_3$)	Acidity, total (mg/L as $CaCO_3$)	Solids, at 105 Deg. C, dissolved (mg/L)	Solids, at 105 Deg. C, suspended (mg/L)	Sodium, total (mg/L as Na)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Iron, total ($\mu g/L$ as Fe)	Manganese, total ($\mu g/L$ as Mn)	Zinc, total ($\mu g/L$ as Zn)	Aluminum, total ($\mu g/L$ as Al)
A	122287	1245	2.0	55	363	12.8	6.9	40	0	286	4	8.8	15	120	360	1,100	20	210
B	122187	1545	3.5	56	425	--	7.7	38	0	268	6	8.4	14	120	500	1,200	40	230
C	122187	1400	3.0	30	380	--	7.4	32	0	304	10	8.6	15	140	400	1,600	40	190
D	122187	1430	4.0	24	335	--	7.5	48	0	344	10	7.4	11	100	600	480	20	330
E	122287	0850	1.5	2.9	150	12.2	5.1	6	48	122	4	1.3	3.0	60	140	1,300	80	1,200
F	122287	1010	0.5	4.5	328	12.1	6.9	42	0	298	10	11	21	100	240	630	30	260
G	122287	1111	1.5	14	495	12.6	6.9	30	0	378	8	7.4	12	210	480	3,300	70	460
H	122287	1110	2.0	3.4	900	--	7.3	48	0	766	16	17	30	340	730	1,600	30	490
I	122287	1005	1.0	5.2	270	--	7.0	16	0	230	6	3.0	6.0	90	120	1,000	60	140
J	122287	0945	2.0	3.5	780	--	7.2	38	0	770	10	4.3	4.0	360	1,000	9,900	140	1,100
K	122187	1450	4.5	9.9	375	12.3	7.6	60	0	334	12	8.0	12	110	630	620	10	220
L	122187	1500	4.5	4.9	282	12.1	7.6	46	0	288	16	6.3	6.0	90	870	370	10	350
M	122187	1625	4.0	1.8	104	12.1	7.7	10	0	44	6	3.2	6.0	27	130	99	30	120
N	122187	1315	3.5	24	330	12.3	7.3	50	0	312	12	7.2	10	100	720	560	20	320
O	122187	1635	4.0	7.4	255	--	7.3	30	0	176	10	15	25	58	530	160	<10	290

Table 12.--Results of the sampling of Little Scrubgrass Creek basin on June 6-7, 1988

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; double dash indicates no data]

Station	Date	Time	Temperature, water, field (Deg C)	Streamflow, instantaneous, field (ft^3/s)	Specific conductance, field (µS/cm)	Oxygen, dissolved, field (mg/L)	pH, field (standard units)	Alkalinity total (mg/L as $CaCO_3$)	Acidity total (mg/L as $CaCO_3$)	Solids, at 105 Deg. C, dissolved (mg/L)	Solids, at 105 Deg. C, suspended (mg/L)	Sodium, total (mg/L as Na)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Iron, total (µg/L as Fe)	Manganese, total (µg/L as Mn)	Zinc, total (µg/L as Zn)	Aluminum, total (µg/L as Al)	Sediment, suspended (mg/L)
A	060688	1940	18.0	12	564	8.9	7.8	74	0	430	16	11	14	220	490	740	30	70	5
B	060788	1155	18.0	12	682	8.5	7.8	74	0	454	12	9.2	12	240	620	1,300	40	100	6
C	060788	1045	17.0	6.8	722	9.1	7.3	52	0	514	14	9.5	12	290	640	2,400	10	60	6
D	060688	1055	17.5	5.8	580	--	8.1	110	0	376	18	9.4	11	170	540	140	40	90	8
E	060788	0930	16.0	0.33	111	8.6	5.8	6	26	72	12	1.5	3.0	44	180	1,400	50	200	8
F	060788	1115	18.0	0.66	359	7.8	7.2	50	0	260	16	9.0	16	100	410	190	10	90	5
G	060688	1410	17.5	4.6	850	8.5	7.4	56	0	626	16	7.8	10	310	220	4,700	40	80	7
H	060688	1705	21.0	1.6	1,000	7.7	7.6	72	0	804	16	12	18	440	350	1,800	10	90	7
I	060688	1540	20.0	1.4	333	8.3	7.0	22	0	236	10	4.0	6.0	120	230	740	20	70	7
J	060688	1555	19.0	1.7	1,210	8.2	7.3	74	0	964	22	5.3	4.0	560	300	17,000	100	280	4
K	060688	1530	20.5	3.2	560	8.8	7.7	122	0	402	20	8.8	10	170	570	290	20	60	7
L	060688	1615	20.0	1.0	570	8.9	7.9	130	0	376	14	8.6	8.0	170	600	380	30	80	5
M	060688	1345	20.0	0.50	220	9.2	7.4	60	0	134	18	4.1	8.0	41	430	420	50	140	7
N	060688	1715	21.0	4.6	556	9.0	8.0	112	0	150	16	9.3	10	170	560	250	<10	90	5
O	060788	1200	17.5	0.85	445	8.5	7.3	50	0	306	14	24	29	120	530	190	20	80	6

Table 13.--Results of the sampling of Little Scrubgrass Creek basin on July 26-27, 1988

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; double dash indicates no data]

Station	Date	Time	Temperature, water, field (Deg C)	Streamflow, instantaneous, field (ft^3/s)	Specific conductance, field (µS/cm)	Oxygen, dissolved field (mg/L)	pH, field (standard units)	Alkalinity, total (mg/L as $CaCO_3$)	Acidity, total (mg/L as $CaCO_3$)	Solids at 105 Deg. C, dissolved (mg/L)	Solids at 105 Deg. C, suspended (mg/L)	Sodium, total (mg/L as Na)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Iron, total (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Manganese, total (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Zinc, total (µg/L as Zn)	Aluminum, total (µg/L as AL)	Sediment, suspended (mg/L)
A	072688	1230	18.5	5.2	732	7.4	7.9	76	0	642	8	15	17	280	290	20	200	140	20	80	6
B	072688	1430	19.0	4.6	754	7.3	7.8	86	0	604	6	14	15	290	720	30	680	560	20	100	6
C	072688	1505	18.0	2.5	910	7.2	7.6	48	0	760	14	14	15	390	1,100	540	1,500	1,400	20	<50	6
D	072688	1535	20.5	2.3	598	6.8	7.6	120	0	468	8	13	13	180	320	30	66	20	10	130	3
E	072688	1615	19.0	0.07	390	7.1	5.0	6	46	304	10	2.0	2.0	170	1,200	50	7,800	7,000	440	1,800	5
F	072688	1640	20.5	0.11	527	6.4	6.1	42	0	428	6	12	18	190	260	20	370	320	30	80	5
G	072788	0900	18.0	1.9	1,070	7.7	7.4	62	0	978	8	11	12	500	370	40	6,800	5,900	30	170	14
H	072788	1000	18.5	1.0	1,160	7.0	7.4	66	0	1,090	8	6.3	11	550	660	30	27,000	9,700	110	130	24
I	072788	1045	18.5	0.41	436	7.0	7.2	36	0	336	2	7.7	10	160	170	50	310	310	10	80	13
J	072788	1105	18.5	0.73	1,440	7.5	7.2	86	0	1,430	6	6.3	4.0	790	710	160	27,000	25,000	100	680	81
K	072788	1235	20.0	1.2	610	7.2	7.8	154	0	476	4	9.2	10	170	640	60	210	170	20	60	15
L	072788	1300	19.0	0.42	664	8.0	8.0	156	0	528	4	6.6	8.0	200	690	30	550	410	20	90	20
M	072788	1345	21.5	0.10	498	7.2	7.7	178	0	570	10	4.4	7.0	87	610	30	790	670	10	240	22
N	072788	1205	21.0	2.1	608	7.2	7.7	124	0	462	14	11	12	180	620	20	210	--	30	140	12
O	072688	1340	19.0	0.35	598	7.4	7.5	56	0	434	4	34	41	180	440	50	120	--	10	100	6

Table 14.--Results of the sampling of Little Scrubgrass Creek basin on August 29-31, 1988

[Deg C, degrees Celsius; ft^3/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 Deg C; mg/L, milligrams per liter; μg/L, micrograms per liter; <, less than; double dash indicates no date]

Station	Date	Time	Temperature, water, field (Deg C)	Streamflow, Instantaneous, field (ft^3/s)	Specific conductance, field (μS/cm)	Oxygen, dissolved field (mg/L)	pH, field standard units)	Alkalinity, total (mg/L as $CaCO_3$)	Acidity total (mg/L as $CaCO_3$)	Solids at 105 Deg. C, dissolved (mg/L)	Solids at 105 Deg. C, suspended (mg/L)	Sodium, total (mg/L as Na)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Iron, total (μg/L as Fe)	Iron, dissolved (μg/L as Fe)	Manganese, total (μg/L as Mn)	Manganese dissolved (μg/L as Mn)	Zinc, total (μg/L as Zn)	Aluminum, total (μg/L as Al)
A	082988	2015	17.5	27	625	8.2	8.0	62	0	404	20	17	20	250	2,100	50	1,100	620	30	750
B	083088	0940	15.0	7.9	663	8.1	7.8	68	0	464	8	18	18	270	900	50	830	700	<10	220
C	083088	1115	15.0	4.5	790	7.5	7.5	46	0	474	4	16	22	350	820	230	1,400	420	10	190
D	083088	1040	15.5	3.8	524	8.4	8.0	88	0	314	14	17	14	170	1,000	40	170	70	<10	310
E	083088	1230	17.5	0.13	326	7.3	6.9	12	28	186	10	5.4	7.0	140	370	20	770	730	90	530
F	083088	1305	17.5	0.53	883	6.7	7.4	24	0	582	2	39	50	340	280	20	2,100	2,000	100	270
G	083088	1400	8.5	2.2	876	8.3	7.2	62	0	716	<2	12	15	410	370	20	4,200	3,800	20	130
H	083088	1435	18.0	2.4	898	7.6	7.7	68	0	722	8	11	14	420	320	30	5,500	5,300	20	150
I	083088	1530	18.0	0.36	443	7.1	7.7	38	0	296	4	6.9	8.0	180	330	60	250	250	<10	200
J	083088	1600	18.5	0.87	1,220	7.2	7.3	68	0	1,110	12	12	6.0	700	830	170	22,000	18,000	90	370
K	083188	1055	14.0	1.1	586	8.4	7.2	126	0	202	84	15	12	190	800	30	370	330	20	240
M	083188	1155	15.5	0.08	231	8.8	6.7	62	0	114	<2	2.9	5.0	54	830	370	500	--	20	350
N	083188	1005	14.0	2.4	534	9.2	7.2	100	0	350	6	14	12	170	840	20	300	290	10	190
O	083088	0910	14.5	0.74	610	8.8	7.3	54	0	402	<2	42	50	170	670	110	210	170	<10	180

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