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Quality of Water Discharged From Two Agricultural Watersheds in Southwestern Iowa

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The quality of water discharged from a 157.5-ha diversified conservation-farmed watershed in southwestern Iowa was within acceptable limits for potable water except for the levels of ammonia, inorganic phosphorus, and coliform. Total coliform levels exceeded the established criteria on two occasions, and fecal coliform once during the 2-year study. Nutrient concentration was high occasionally, but the nutrient quantities discharged from the watershed were low, the effectiveness of the level-terrace system in controlling surface runoff and erosion thus being shown. Atrazine residue in the runoff and sediment was detected in only one sample. Even though several chlorinated hydrocarbon and organophosphate compounds had been applied to the watershed, none was detected in runoff or sediment. A comparison of the data from a 33.6-ha contour-farmed watershed with the data from the 157.5-ha well-planned conservation watershed showed the benefits and necessity of using some means of controlling runoff and erosion to prevent loss of agricultural chemicals that may degrade our surface waters.

Agriculture has a tremendous impact on the environment because vast land areas are managed to meet man's need for food and fiber. Advances in agricultural science and technology have made it possible for production increases per unit land area to keep pace with the growing demand for food and fiber. The use of agricultural chemicals to supply plant nutrients and to control weeds and insects has played a major role in the production increases. The dissipation of these chemicals is not clearly understood. All segments of society are challenged to assess their effects on environmental quality. Agriculture has the basic responsibility of managing extensive land resource areas to meet the food and fiber needs of man without imposing hazards on his environment.

Soil conservationists have striven for the past 40 years to keep the soil in place and out of surface water supplies by improved cropping and land and soil management practices. *Bennett* [1939] and *Williams* [1967] reported that 2.7–3.6 billion metric tons of soil was eroded annually from cropland areas. In 1971, 2.4 billion metric tons of sediment per year was estimated to have been produced by sheet-rill erosion of cropland (J. N. Holeman, personal communication, 1973). Thus the goal of keeping soil in place is far from being achieved. During the past 30 years the increased use of chemicals to supply plant nutrients and to control weeds and insects has encouraged intensification of row crop farming. Conservation practices used in conjunction with the increased row crop farming have been inadequate; consequently, runoff and erosion problems have not abated.

Until recently, soil erosion was considered to be primarily an agricultural problem because soil material was removed from crop-producing areas. However, the movement of soil and water over land surfaces has become an environmental problem because these transport media may carry chemical materials at levels hazardous to health. A research study was initiated in 1970 near Macedonia, Iowa, to determine the quality of water leaving a 157.5-ha diversified level-terraced agricultural watershed. Discharge characteristics of plant nutrients, insecticides, herbicides, and other chemical and microbiological properties of sediment and water were measured. To evaluate the influence of the level-terrace conservation practice on water, sediment, and plant nutrients discharged in surface runoff and base flow, data obtained from this watershed were compared with data obtained from a 33.6-ha contour-planted corn-cropped watershed near Treynor, Iowa. The contour-corn watershed is 17.7 km west of the level-terraced watershed. The 157.5-ha diversified level-terraced watershed will be referred to in this report as the 'level-terraced' watershed; the 33.6-ha contour-planted corn-cropped watershed will be referred to as the 'contour-corn' watershed. A 2-year summary of results obtained from these watersheds is presented.

Description of Watersheds and Management Practices

The two watersheds are located in Pottawattamie County in southwestern Iowa. The watersheds are within, and typically represent, the deep loess hills of the Missouri Valley in western Iowa and northwestern Missouri, an area characterized by a deep loess cap over glacial till. Loess depths on the watersheds range from 24 m on the ridges to less than 5 m in the valleys. Most main and upland valleys have moderately to deeply incised channels. A saturated zone above the till-loess interface causes seepage into the channels throughout the year. Soil types on the two watersheds are typic hapludolls, typic haplorthents, and cumulic hapludolls. All of these soils are fine silty mixed mesics and have moderate to moderately rapid permeability. Slopes on the two watersheds range from 2 to 13%. Each watershed is entirely tillable, but erosion is a serious problem if conservation practices are not used.

Level terraces were established on about 85% of the 157.5-ha watershed in 1962. The soil distribution on this watershed was 76% Marshall silt loam, 23% Judson silt loam, and 1% Monona silt loam. Slope distributions were: 53% of the area with 9–13% slopes, 6% with 5–8% slopes,

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and 41% with 2–4% slopes. This watershed represented agricultural practices consisting of 95% cropland and two livestock feedlots. The feedlots and a pasture adjacent to the feedlots were located near the main drainageway. Two hundred feeder cattle and two hundred hogs were kept on the feedlot and pasture areas annually. A rotational cropping system of 60% row crops and 40% hay and pasture was followed. Corn and soybean acreages each year were 46.6 and 43.3 ha, respectively. The row crop acreage was centrally located on the watershed. Conventional preplant tillage, consisting of moldboard plowing, disking, and harrowing, was performed in the spring for seedbed preparation. Cultivation for weed control was performed as needed. The corn crop was fertilized at the rate of 126.6 kg N/ha and 28 kg P/ha annually. Fertilizer was not applied to the soybean crop. Chlorinated hydrocarbon and organophosphate insecticide compounds were used as recommended for corn production. Herbicides used included atrazine, 2,4-D, propachlor, and alachlor.

Two tile drainage systems within the row crop areas drained less than 4 ha of the watershed. The water drained from these tile systems was discharged into the main drainage channel.

The contour-corn watershed used for comparison with the level-terraced watershed has been cropped continuously to corn since 1964. Distribution of soils on this watershed was 37% Marshall silty clay loam, 25% Monona silt loam, 22% Ida silt loam, and 16% Napier silt loam. Slope distributions on this watershed were: 46% of the area with 9–13% slopes, 22% with 5–8% slopes, and 32% with 2–4% slopes. The row crop cultural practices used on this watershed were similar to those used on the level-terraced watershed. Annual fertilizer application to the contour-corn watershed was 168 kg N/ha and 39.2 kg P/ha in 1969, 1970, and 1971.

FIELD SAMPLING AND LABORATORY ANALYSES

Precipitation measurements were obtained from recording rain gages located on each watershed. The main drainageways were instrumented with a broad-crested V notch weir and a water stage recorder to determine rates and amounts of streamflow discharge.

Water quality sampling for the level-terraced watershed began in May 1970 and continued through December 1971. No significant surface runoff events occurred before May 1970. During the 2-year sampling period, 211 samples were collected at the watershed outlet. The samples were collected at time intervals within each event to cover the rise, peak, and recession for the event. Each sample consisted of 500 ml of soil water suspension and was stored at 4°C to minimize chemical and microbiological conversion. Duplicate samples were collected to determine the sediment content of the runoff. Thirty-nine samples were collected during the 2-year period to determine the chemical characteristics of base flow. Base flow samples were collected monthly during periods of low base flow and weekly during periods of high base flow.

The water and sediment portions of each surface runoff sample were separated by centrifugation and/or filtering through Whatman No. 42 filter paper. The sediment included mineral soil material and organic particles. A Technicon AutoAnalyzer, using continuous flow colorimetric procedures, was used to determine soluble NO_3-N and NH_4-N contents [*Bollcter et al.*, 1961; *Henriksen and Selmer-Olsen*, 1970]. A $NaHCO_3$ extract of the sediment was made (1:20 ratio of sediment to $NaHCO_3$) to determine P associated with the sediment portion of the sample [*Olsen et al.*, 1954]. The ascorbic acid method was used to determine the P concentration of water and sediment extract [*Murphy and Riley*, 1962]. Total nitrogen associated with sediment was determined by using micro-Kjeldahl procedures as described by *Bremner* [1965]. Initially, the sediment was analyzed for NH_4-N, but it was found to be only a small percentage of the total nitrogen; therefore analyses were discontinued.

Nitrogen and phosphorus quantities were calculated by integrating concentrations with flow rate and sediment load as described by *Schuman et al.* [1973]. Nitrogen and phosphorus discharges were estimated for unsampled and partially sampled surface runoff events to determine the quantities lost annually. Unpublished data from this experiment show that quantities of soluble and sediment N and P from each storm can be estimated adequately by using the mean concentration with water or sediment volumes. Therefore quantities of N and P discharged by water or sediment during unsampled portions of surface runoff events were determined as the product of the sampled concentration mean and the unsampled volume of water or sediment. To determine quantities of N and P discharged during completely unsampled events, a concentration mean was selected from the nearest sampled runoff event. The interval between the unsampled and the sampled events was usually only a few days.

Chemical oxygen demand (COD), alkalinity, chlorine, sodium, and total and fecal coliforms were determined by methods described by the *American Public Health Association, Inc.* [1965]. Electrical conductivity was determined by the method described by *Bower and Wilcox* [1965]. Suspended solids were determined by gravimetric techniques.

A membrane-covered polarigraphic probe [*American Public Health Association, Inc.*, 1965] was used to determine dissolved oxygen content. Eighty-two field measurements of dissolved oxygen content of surface runoff were made during the 2-year period. Dissolved oxygen content of base flow was measured monthly during low base flow and weekly during high base flow.

Thirty-three 3.8-l samples collected in 1970 and four samples collected in 1971 during surface runoff events were analyzed for pesticide content. These samples represented runoff events occurring throughout the entire cropping season as well as those for noncropping seasons. Pesticide content of base flow was determined in 1970 from only fifteen 3.8-l samples. These base flow samples were collected monthly during low base flow and weekly during higher levels of base flow. The samples were analyzed for chlorinated hydrocarbons (dieldrin, DDT, DDE, etc.) and organophosphate insecticides (parathion, malathion, etc.) by chromatograph techniques [*Wiersma et al.*, 1972] and were also analyzed for atrazine. The samples were analyzed in 1970 at the U.S. Department of Agriculture, Agricultural Research Service, Plant Protection Division Laboratory, Gulfport, Mississippi, and in 1971 at the Iowa Hygienic Laboratory, Iowa City, Iowa, in cooperation with the Metropolitan Area Planning Agency, Omaha, Nebraska.

In 1970 and 1971, 293 surface runoff samples and 46 base flow samples were collected from the contour-corn watershed to determine N and P discharge characteristics. Field sampling, laboratory analyses, and calculation procedures for these determinations were the same as those described previously for the level-terraced watershed.

RESULTS AND DISCUSSION

Hydrology and Erosion

Annual precipitations on the level-terraced watershed in 1970 and 1971 were 70.4 and 67.8 cm, respectively, as compared with the long-term average of 72.3 cm at Omaha, Nebraska. Two rainfall events in 1970 and fifteen events in 1971 caused runoff of at least 0.025 cm and a peak rate of at least 0.25 cm/h (1.10 m^3/s). Thirteen smaller events were also sampled for water quality. Above-average snowfall during the winter of 1970–1971 resulted in above-average snowmelt runoff in the spring of 1971. Rainfall for May 6–18 was above average and caused 68% of the annual surface runoff in 1971. Precipitation data for 1970 and 1971 are included in Table 1.

Total annual water yields (surface runoff plus base flow) on this level-terraced watershed in 1970 and 1971 were 6.94 and 10.74 cm, respectively, compared with the average of 13.28 cm/yr for the 1964–1971 period (Table 1). Seventy-eight percent of the total 1970–1971 water yield was base flow.

The level-terraced watershed consistently received less annual precipitation than the contour-corn watershed did, as is shown in Table 1. Surface runoff from the level-terraced watershed was substantially less than that from the contour-corn watershed. *Saxton et al.* [1971] reported that level terraces on the loessial soils reduced overland flow but increased base flow, so that total water yield was not reduced. Base flow discharge did not differ greatly for the two watersheds in 1970 and 1971.

Two tile drainage systems on the level-terraced watershed drained approximately 4 ha. These two systems drained about 15.2 cm of water into the main drainageway between April 11 and July 24, 1971. There was no tile drainage in 1970.

Sediment yield data in Table 1 show that discharges from the level-terraced watershed in 1970 and 1971 were 0.36 and 1.77 metric tons/ha, respectively. In comparison, sediments discharged from the contour-corn watershed in 1970 and 1971 were 16.64 and 29.72 metric tons/ha, respectively. These comparative sediment discharges illustrate the effectiveness of the level-terraced system in controlling erosion.

Plant Nutrient Discharges

Nitrogen and phosphorus were the major plant nutrients applied as commercial fertilizers. These chemical elements are of environmental concern because they are subject to movement with water or soil. Therefore it is important to determine agriculture's contribution of these materials to water quality deterioration.

Nitrogen. Table 2 shows that the average annual nitrogen losses in surface runoff from the level-terraced watershed were 0.19, 0.63, and 4.29 kg/ha, respectively, for NO_3-N, NH_4-N, and total Kjeldahl nitrogen. In comparison the contour-corn watershed losses (Table 2) were 0.74, 0.90, and 33.24 kg/ha, respectively, for NO_3-N, NH_4-N, and Kjeldahl nitrogen. The importance of the level-terraced conservation practice in reducing N discharge is quite evident (Table 2). A similar trend is evident for nitrogen transported in base flow.

Nitrogen concentrations in surface runoff and base flow from the level-terraced watershed and the contour-corn watershed for 1970 and 1971 are shown in Table 2. The NO_3-N concentrations in surface runoff and base flow for the two watersheds did not exceed the 10-ppm upper limit set by the *Federal Water Pollution Control Administration* [1968]. However, NH_4-N concentration levels frequently exceeded the permissible 0.5-ppm limit for surface runoff and base flow on both watersheds. Nitrogen concentrations in surface runoff and base flow were generally higher for the level-terraced watershed than for the contour-corn watershed. Although the sampling program did not delineate the cropland and livestock feeding source areas on the level-terraced watershed, we believe that the livestock feeding areas greatly increased the concentration of NH_4-N and Kjeldahl nitrogen of the sediment because the feedlots were adjacent to the main drainage channel. The relatively high concentrations of NH_4-N and sediment nitrogen from the level-terraced watershed may have been caused by selective erosion associated with low flow rates; i.e., the organic material contributed from the bare and compacted feedlots during low flows yielded disproportionate amounts of NH_4-N and sediment N as compared to the remainder of the watershed.

Seven samples collected from tile effluent from April 11

TABLE 1. Annual Precipitation, Base Flow, Surface Runoff, and Sediment Loss From a Level-Terraced Watershed and a Contour-Corn Watershed in 1970 and 1971

Year	Precipitation, cm	Runoff			Sediment Yield,* metric ton/ha
		Base, cm	Surface, cm	Total, cm	
		157.5-ha Level-Terraced Watershed			
1970	70.41	5.77	1.17	6.94	0.36
1971	67.79	8.05	2.69	10.74	1.77
1970–1971 avg.	69.09	6.91	1.93	8.84	1.08
1964–1971 avg.	78.23	9.60	3.68	13.28	2.24
		33.6-ha Contour-Corn Watershed			
1970	78.28	5.97	4.52	10.49	16.64
1971	73.71	6.65	9.75	16.40	29.72
1970–1971 avg.	76.00	6.30	7.14	13.44	23.18
1964–1971 avg.	83.03	6.30	11.15	17.45	47.89

* Sediment loss by sheet-rill erosion.

TABLE 2. Discharge Characteristics of Nitrogen in Surface Runoff and Base Flow From a Level-Terraced Watershed and a Contour-Corn Watershed in 1970 and 1971

	Surface Runoff			Base Flow, Solution Nitrogen		
	Solution Nitrogen		Sediment Nitrogen, Total Kjeldahl Nitrogen*			Total Quantity of N Discharged
Year	NO_3-N	NH_4-N		NO_3-N	NH_4-N	
			Level-Terraced Watershed, kg/ha			
1970	0.16	0.24	1.50	0.35	0.35	2.60
1971	0.22	1.03	7.08	0.97	0.34	9.64
1970–1971 avg.	0.19	0.63	4.29	0.66	0.34	6.11
			Concentration for Level-Terraced Watershed, ppm			
1970	1.34†	2.02	4,188	0.60	0.60	
	0–3.18‡	0.08–4.67	3,099–5,321	0–1.68	0–2.50	
1971	0.83	3.83	4,000	1.21	0.42	
	0–5.79	0.03–26.11	1,668–12,244	0.40–2.53	0.18–0.90	
			Contour-Corn Watershed, kg/ha			
1970	0.53	0.35	25.16	1.05§	0.22§	27.31
1971	0.94	1.46	41.32	1.62	0.06	45.40
1970–1971 avg.	0.74	0.90	33.24	1.33	0.13	36.34
			Concentration for Contour-Corn Watershed, ppm			
1970	1.17†	0.77	1,511	1.77§	0.38§	
	0.10–3.18‡	0–2.30	736–3,029	0.04–3.21§	0–1.25§	
1971	0.97	1.49	1,390	2.44	0.08	
	0.07–3.98	0.02–8.22	924–6,324	0.54–6.56	0–0.50	

* Concentration values are expressed on a dry soil basis.
† Water-weighted average.
‡ Range of determinations.
§ Determined from head cut sampling.

through July 24, 1971, showed that the NO_3-N concentration ranged from 6.1 to 17.2 ppm with a water-weighted mean concentration of 10.1 ppm. The nitrate nitrogen concentration of tile effluent was consistently greater than that of base flow. Tile and base flow samples collected on May 26, 1971, showed NO_3-N concentrations of 6.1 and 1.2 ppm, respectively, and those collected on July 12, 1971, showed concentrations of 17.2 and 2.53 ppm, respectively.

Phosphorus. The phosphorus discharge data from the watershed are shown in Table 3. The average annual dis-

TABLE 3. Discharge Characteristics of Phosphorus in Surface Runoff and Base Flow From a Level-Terraced Watershed and a Contour-Corn Watershed in 1970 and 1971

	Surface Runoff			
Year	Solution Phosphorus	Sediment Phosphorus*	Base Flow, Solution Phosphorus	Total Quantity of P Discharged
		Level-Terraced Watershed, kg/ha		
1970	0.112	0.093	0.038	0.243
1971	0.272	0.329	0.047	0.648
1970–1971 avg.	0.193	0.211	0.043	0.447
		[Concentration for Level-Terraced Watershed, ppm		
1970	0.960†	259	0.066	
	0.194–1.816‡	125–868	0.004–0.194	
1971	1.012	186	0.058	
	0.008–6.946	112–1129	0.008–0.102	
		Contour-Corn Watershed, kg/ha		
1970	0.058	0.464	0.081§	0.603
1971	0.186	1.123	0.021	1.330
1970–1971 avg.	0.122	0.793	0.052	0.967
		Concentration for Contour-Corn Watershed, ppm		
1970	0.129†	28	0.135§	
	0.034–0.850‡	14–131	0.016–0.284§	
1971	0.191	38	0.032	
	0.034–0.565	17–468	0.006–0.054	

* Concentrations are expressed on a dry soil basis.
† Water-weighted average.
‡ Range of determinations.
§ Determined from gully head cut sampling.

charges of P carried by sediment, surface runoff, and base flow were 0.211, 0.193, and 0.043 kg/ha, respectively. In comparison the nutrient losses from the contour-corn watershed for sediment, surface runoff, and base flow were 0.793, 0.122, and 0.052 kg/ha/yr, respectively. These data illustrate that sediment is a prime transport medium of P and again show the benefit of level terraces. The average annual per-hectare discharges of water-soluble P were low and similar for the two watersheds.

Phosphorus concentrations in Table 3 show that levels on both watersheds frequently exceeded the 0.03-ppm lower limit considered to be favorable for profuse algal growth in impounded water. Phosphorus concentrations in water and sediment transport media were generally higher for the level-terraced watershed than for the contour-corn watershed. The location of the feedlot and pasture areas near the main drainageway and the selective erosion process associated with low flow rates probably contributed to the high phosphorus concentration in water and sediment leaving the level-terraced watershed. Field and laboratory studies in Minnesota [*Timmons et al.*, 1968; *Holt et al.*, 1970] showed that leaching of dead tissues from forage crops resulted in considerable P loss and that more than 70% was in the form of inorganic P. A large portion of this inorganic P may be adsorbed readily by sediment.

Pesticide Discharge

Chlorinated hydrocarbon and organophosphate insecticides were not detected in significant amounts in any of the surface runoff or base flow samples. Atrazine was detected at a concentration of 2.3 ppb in one surface runoff sample collected during the runoff rise for a storm on May 13, 1970. Atrazine was not detected in a sample collected 8 min later at the runoff peak of this event or in samples collected 4 hours before this event. Pesticides were not detected in any of the base flow samples collected in 1970.

Other Chemical Characteristics

Dissolved oxygen. The dissolved oxygen content of surface runoff from the level-terraced watershed was never lower than 5.8 ppm in 1970 or 7.7 ppm in 1971, as is shown in Table 4. In most cases the oxygen content of surface runoff caused by rainfall was at least 90% of the aerated standard. The dissolved oxygen content of base flow and snowmelt runoff usually exceeded that of surface runoff caused by rainfall, and all runoff was within acceptable limits [*Federal Water Pollution Control Administration*, 1968].

Microbiological and chemical characteristics. The microbiological and chemical characteristics of surface runoff and base flow indicate that water leaving the watershed is of good quality on the basis of the standards given in the report by the *Federal Water Pollution Control Administration* [1968]. Table 5 shows the ranges and averages of the data obtained for electrical conductivity, alkalinity, sodium, chloride, suspended solids, COD, and coliforms (total and fecal) for 1970. Only COD and coliform analyses were continued in 1971. In 1970 and 1971, total coliform counts were below permissible levels (10,000 most probable number/100 ml) for all but two surface runoff events (August 3, 1970, and May 10, 1971). Fecal coliforms were above permissible limits for the May 10, 1971, storm. These two storms represented major runoff events during the sampling period. The feedlot and pasture grazing area, adjacent to the drainageway, probably caused the relatively high coliform levels for these two events.

TABLE 4. Dissolved Oxygen Concentration in Surface Runoff and Base Flow From a Level-Terraced Watershed in 1970 and 1971

	Snowmelt Runoff, ppm	Rainfall Runoff, ppm	Base Flow, ppm
Aerated standard for 1970			
Average	...	9.4	10.3
Range	...	8.1–11.5	8.5–13.2
Sample for 1970			
Average	...	8.3	10.1
Range	...	5.8–11.2	5.8–12.9
Aerated standard for 1971			
Average	13.6	10.1	9.9
Range	12.8–14.0	9.2–12.3	8.1–12.9
Sample for 1971			
Average	13.6	9.3	9.9
Range	12.2–14.6	7.7–12.0	8.1–12.8

SUMMARY

A 2-year study on a diversified level-terraced watershed and a contour-planted corn-cropped watershed shows the benefit and necessity of using a well-planned conservation management system to reduce surface runoff, erosion, and discharge of agricultural chemicals capable of degrading surface water. Quantities of water, sediment, nitrogen, and phosphorus discharge from the level-terraced watershed were low because of the effective control of surface runoff and erosion.

Water-soluble NO_3-N concentration in surface runoff and base flow from the two watersheds did not exceed the 10-ppm upper limit set by the Federal Water Pollution Control Administration. Concentrations of NH_4-N and P in surface runoff and base flow from both watersheds frequently exceeded acceptable limits. Concentrations of NH_4-N and P in surface runoff were higher for the level-terraced watershed than for the contour-corn watershed. These higher concentrations were attributed to the proximity of the livestock feeding areas on the level-terraced watershed to the main drainageway.

Even though hydrocarbon and organophosphate insecticides were used on the level-terraced watershed, these materials were not found in runoff water. A low concentration of atrazine was detected in one surface runoff sample, but none was found in other samples collected during the same storm event or from other events during the 1970–1971 sampling period.

Monitoring of the surface runoff and base flow from the level-terraced watershed for dissolved oxygen, electrical conductivity, alkalinity, sodium, chloride, suspended solids, and COD showed that these constituents were within the acceptable limits. Total coliform counts were below permissible levels for all but two surface runoff events, and fecal coliform counts exceeded the acceptable level only on one occasion during the 2-year study.

TABLE 5. General Runoff Sample Characteristics From a Level-Terraced Agricultural Watershed Near Macedonia, Iowa

							Coliform	
Date	Electrical Conductivity, µmhos	Alkalinity, mg/l	Na+, ppm	Cl−, ppm	Suspended Solids, mg/l	COD, mg/l	Total, most probable number/100 ml	Fecal, most probable number/100 ml
				1970 Surface Runoff				
May 13	234	157	11.4	8.3	1250	52	...	...
	180–290	149–163	10–13.5	3.6–16.3	508–1820	18.6–94.2		
June 16	228	112	8.9	6.9	421	18.5	6	0
	190–290	95–134	8–11	3.6–11.3	128–744	12.7–31.5		
June 17	248	156	9.1	5.4	884	26.7	2	...
	230–280	108–182	8.5–10.5	3.0–11.8	532–1432	11.9–41.3		
July 27	458	184	12	11	568	2.6	182	...
	396–520	148–219	10.5–13.5	9.6–12.4	412–724	1.8–3.4		
July 28	373	145	10.4	10.5	973	4.1	141	...
	308–476	134–175	8–15	4.4–22.1	828–1352	1.8–7.8		
Aug. 2	280	99	8	11	1145	4.9	4,511	3.0
	198–414	50–208	5.5–13	3.9–23.9	792–1632	2.0–8.8		
Aug. 3	254	87	7.5	9.2	1339	6.4	13,000	2.1
	218–291	82–95	5.5–8.5	7–11.3	832–2004	3.9–9.0		
Sept. 14	286	151	11.8	11.4	303	14.6	...	...
	215–335	97–192	9.0–13.5	9.1–13.5	0–628	6.2–37.4		
Oct. 8	258	162	10.3	10.1	495	7.6	...	...
	255–260	151–167	10–11	8.7–11.8	384–568	6.3–9.1		
Nov. 9	285	196	8	5.5	539	11.2	7	1.1
	250–370	150–267	7–10	4.5–9.0	372–664	8.7–14.8		
				1970 Base Flow				
Annual	427	287	12.7	4.4		0.7	17	1.7
	380–668	205–333	9.0–15.0	3.0–8.0		0–4.6		
				1971 Surface Runoff				
Snowmelt						10.5	236	0.4
						0–27.7		
May 6						51	...	...
						16.1–129		
May 10						30.5	140,000	74,500
						4.0–130		
June 29–30						54	...	...
						20–131		
July 9						44	8,150	0.65
						14–127		

For each date the top line indicates the average, and the bottom line indicates the range.

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