GEOLOGICAL SURVEY CIRCULAR 173

WATER RESOURCES OF THE BUFFALO-NIAGARA FALLS REGION

By Charles W. Reck, and Edward T. Simmons

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GEOLOGICAL SURVEY
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Based on data collected in cooperation with the New York Department of Public Works, New York Department of Conservation, New York Power and Control Commission, and Corps of Engineers

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INTRODUCTION

An average daily flow of 125,000 million gal is available at the eastern end of Lake Erie where the Niagara River drains the inland waters northward to Lake Ontario. This quantity is sufficient to supply 70 percent of the present estimated daily use of water in the United States for all purposes except water power. The temperature and chemical characteristics of this water are suitable for most purposes. Moderate quantities of water may be obtained also from small streams and wells in the area. With such large quantities of water of good quality near at hand there should be no water shortage for the million or more people in the Buffalo-Niagara Falls area.

The economic growth of an area depends upon a satisfactory supply of water. In order to assure success and economy, the development of water resources should be based on a thorough knowledge of the quantity and quality of the water. As a nation, we can not afford to run the risk of dissipating our resources especially in times of national emergency, by building projects that are not founded on sound engineering knowledge.

The purpose of this report is to summarize and interpret all available water-resources information of the Buffalo-Niagara Falls region. This report will be useful for initial guidance in the location or expansion of water facilities for defense and nondefense industries and the municipalities upon which they are dependent. No attempt has been made to present a complete record of the hydrologic information.

Most of the facts presented herein are based on data obtained for other purposes by the U. S. Geological Survey in cooperation with the New York State Department of Public Works, Department of Conservation, Water Power and Control Commission, and the Corps of Engineers.

Much information regarding conditions in the area was obtained from the Erie County Department of Health, the Buffalo Sewer Authority, the Northwestern New York Water Authority, and the New York State Department of Health.

This report was prepared in the Water Resources Division of the U. S. Geological Survey under the immediate supervision of Arthur W. Harrington, district engineer, and Maurice L. Brashears, Jr., district geologist, and under the general direction of C. G. Paulsen, chief hydraulic engineer.

The Niagara Frontier

The Buffalo-Niagara Falls region, locally called the Niagara Frontier, is defined as that area in Erie and Niagara Counties in New York bounded on the south by Eighteenmile Creek; on the west by Lake Erie and the Niagara River; on the north by Lake Ontario; and on the east by a line just east of the village of East Aurora and the city of Lockport (see pl. 1).

Topography

The topography of the Niagara Frontier is of a relatively simple type. Three plains comprise the region - Erie, Huron, and Ontario - which form steps descending northward to Lake Ontario. The Erie and Huron plains are separated by the Onondaga escarpment, and the Huron and Ontario plains by the Niagara escarpment (see pl. 1). The Niagara escarpment, which lies north of Niagara Falls, rises abruptly 200 ft above the Ontario plain. The Ontario plain drains northward to Lake Ontario and is nearly level in most areas. The Huron plain lies about 600 ft above mean sea level. Although nearly level this plain dips southward to the Onondaga escarpment. In the vicinity of Buffalo, the Onondaga escarpment is less evident than at the eastern boundary of the area where it rises about 70 ft above the Huron plain. The Portage escarpment, the southern boundary of the Erie plain, lies outside of the area under consideration. It is moderately steep in the vicinity of Cattaraugus Creek but to the northeast it becomes ill-defined and broken by deep narrow valleys. The surface of the plains has been made uneven by the irregular deposition of rock material from glacial ice. After the retreat of the glacier, the lowland areas of Erie and Niagara Counties were covered by a lake. Lake bottom deposits of clay now determine the topographic features of the region.

Climate

The Niagara Frontier has a temperate climate and extremes in temperature are moderated by the proximity of Lake Erie and Lake Ontario. Lake Erie to the southwest lies in the direction of the prevailing winds. The U. S. Weather Bureau has maintained a weather station at Buffalo for 81 yr. The mean annual air temperature of 47.1 F as recorded in Buffalo is representative of the Niagara Frontier. The highest recorded air temperature is 99 F and the lowest -21 F. Air temperatures above 90 F and below 0 F are rare. Figure 1 shows the maximum and minimum daily and mean monthly air temperatures at Buffalo for the period 1870 to 1950. The east end of Lake Erie, some quiet portions of the Niagara River, and Lake Ontario along its shore, freeze over during the winter. The average recorded frost-free period is 140 days in the uplands and 170 days in the lowlands.

Precipitation is moderate and usually evenly distributed throughout the year (fig. 2). It ranges from about 30 in. annually in the northern part of the area to 38 in. in the southern part and averages 34.85 in. at Buffalo. During the winter arctic air crossing the lake causes local heavy snowfalls. The area has a mean annual snowfall of 6 ft, but has exceeded a total of 10 ft twice since 1899. Snowfall in excess of 1 in. occurs on the average of 22 days each year. Mean monthly snowfall at Buffalo for the period 1884 to 1950 is shown in figure 3.

Population and Industry

The population in the Niagara Frontier is about 1,100,000 of which 80 percent is classified as urban and is concentrated in the cities of Buffalo, Niagara Falls, Lackawanna, Lockport, North Tonawanda and Tonawanda.

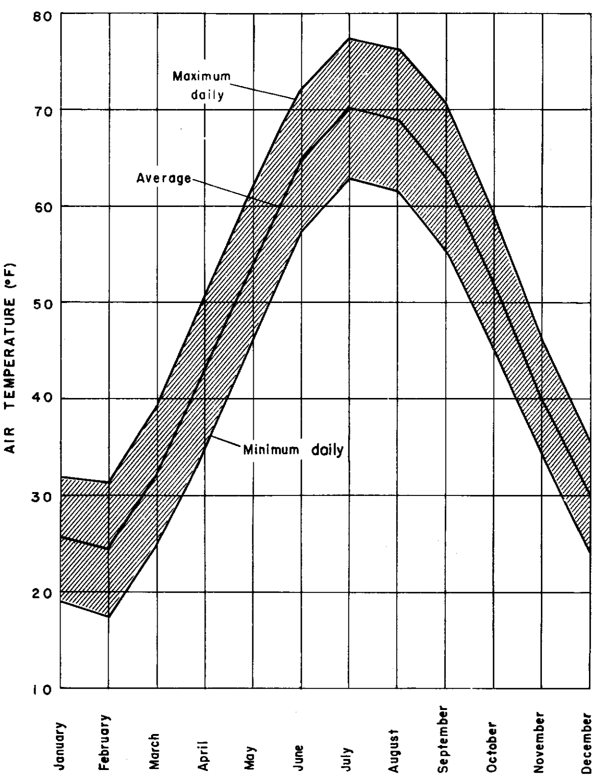

Figure 1.–Maximum and minimum daily and average monthly air temperature.

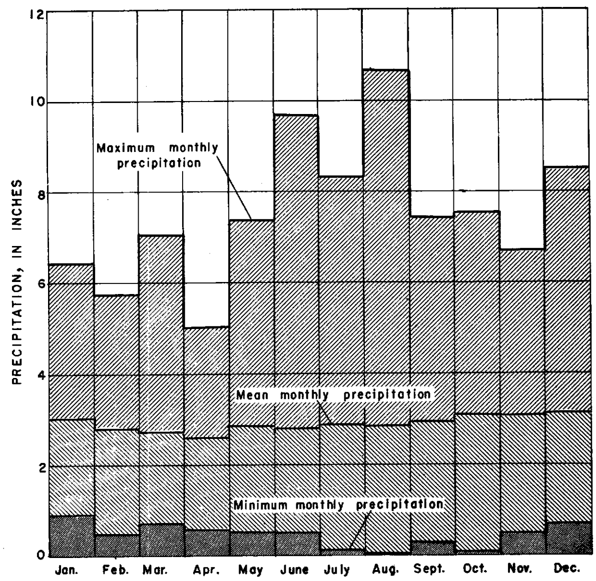

Figure 2.–Maximum, minimum, and mean monthly precipitation at Buffalo.

Cheap hydroelectric power and good transportation facilities in the Niagara Frontier have been among the prime factors in making this area one of the 10 largest industrial centers in the United States. Chemicals, abrasives, steel, pulp, and petroleum products are manufactured in large quantities. Food processing also plays an important role in the economy of the area. The port of Buffalo handles annually about 25,000,000 tons of shipping from the Great Lakes and the New York State Barge Canal. Good waterways, railroads, and highways facilitate the transportation of raw materials and finished products. The area is served by major airlines operating to the principal cities in the United States.

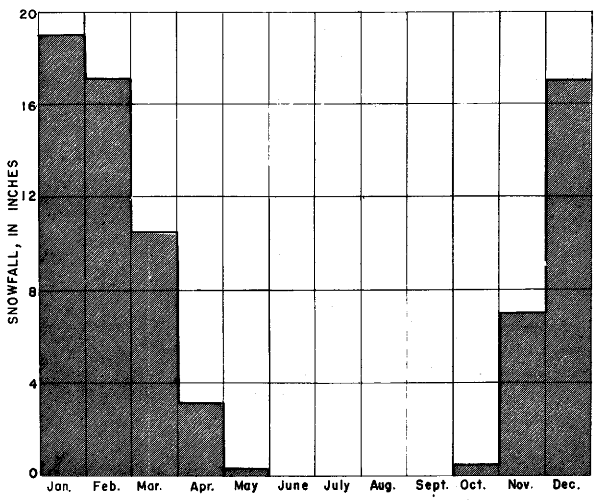

Figure 3.–Mean monthly snowfall at Buffalo.

Table 1.-Area and population of political subdivisions in the Niagara Frontier

Subdivision	Land area (sq mi)	Water area (sq mi)	Population 1950	Population density (people per sq mi)
Erie County				
Cities:				
Buffalo	39.4	10.8	580,132	14,724
Lackawanna	5.7	-	27,658	4,852
Tonowanda	3.6	.1	14,617	4,060
Villages:				
Akron	1.6	-	2,481	1,551
Alden	2.6	-	1,252	482
Angola	1.0	-	1,936	1,936
Blasdell	.9	-	3,127	3,474
Depew	4.8	-	7,217	1,504
East Aurora	2.1	-	5,962	2,839
Farnham	1.0	-	396	396
Gowanda	1.6	-	1,057	661
Hamburg	1.2	-	6,938	5,782
Kenmore	1.4	-	20,066	14,333
Lancaster	2.7	.1	8,665	3,209
North Collins	.7	-	1,325	1,893
Orchard Park	1.2	-	2,054	1,712
Sloan	.7	-	4,698	6,711
Springville	2.9	-	3,322	1,146
Williamsville	1.2	-	4,649	3,874
Towns:				
Alden	34.6	-	4,899	142
Amherst	53.5	-	33,744	631
Aurora	36.7	-	9,271	253
Boston	35.7	-	2,302	64
Brant	25.9	-	1,934	75
Cheektowaga	27.6	-	45,354	1,643
Clarence	53.8	-	6,331	118
Colden	36.1	-	1,720	48
Collins	47.7	-	6,862	144
Concord	70.4	-	5,291	75
Eden	39.9	-	4,201	105
Elma	34.6	-	4,020	116
Evans	41.8	-	7,663	183
Grand Island	32.9	2.3	3,090	94
Hamburg	41.5	-	25,067	604
Holland	36.1	-	1,728	48
Lancaster	39.9	-	18,471	463
Marilla	27.7	-	1,486	54
Newstead	51.2	-	4,653	91
North Collins	43.3	-	2,943	68
Orchard Park	38.8	-	8,491	219
Sardinia	50.7	-	1,778	35
Tonawanda	18.4	1.6	55,270	3,004
Wales	35.7	-	1,370	38
West Seneca	21.4	-	17,417	814
Erie County	1,054	15.0	899,238	853
Niagara County				
Cities:				
Lockport	7.1	-	25,133	3,540
Niagara Falls	12.7	3.2	90,872	7,155
North Tonawanda	10.0	.8	24,731	2,473
Villages:				
Lewiston	1.1	-	1,626	1,478
Middleport	.7	-	1,641	2,344
Tuscarora Indian Reservation	10.3	-	634	62
Towns:				
Cambria	40.0	-	2,346	59
Hartland	52.3	.8	2,849	54
Lewiston	39.2	-	6,921	177

Table 1.–Area and population of political subdivisions in the Niagara Frontier–Continued

Subdivision	Land area (sq mi)	Water area (sq mi)	Population 1950	Population density (people per sq mi)
Towns, Niagara County–Continued:				
Lockport	46.7	-	3,945	84
Newfane	53.0	-	5,801	109
Niagara	10.8	.1	4,729	438
Pendleton	27.8	-	1,815	65
Porter	33.5	.6	4,276	128
Royalton	70.3	-	5,297	75
Somerset	37.7	-	2,227	59
Wheatfield	28.5	.8	4,720	166
Wilson	50.2	.2	3,696	74
Niagara County	533	6	189,992	356

Agriculture in the Lake Ontario area is devoted chiefly to fruit farms, vineyards, and truck gardens. The Erie and Huron plains are used mostly for the production of hay, grain, and pasture. Poultry farming and dairying play prominent roles in the agricultural economy.

Census data for the political subdivision within Erie and Niagara Counties are given in table 1.

Natural Resources

Water, with the power and navigation it provides, is the most important natural resource of the region. Other natural resources include the soils, natural gas, gypsum and limestone. There are many producing natural gas wells in western New York, several of which are in the Niagara Frontier. The number of the gas wells increases to the south. Over 1,000,000 tons of gypsum are quarried or mined in New York State annually, and large reserves exist in the Niagara Frontier. Four of the nine active gypsum quarries and mines in the State are situated within the area. The Lockport dolomite in the Buffalo-Niagara region is a possible source of magnesium. It is exposed in beds thick enough to be quarried economically in the area east of the Niagara River.

SOURCES OF WATER

Precipitation in the form of rain, snow, ice, and dew is the immediate source of all water on the earth's surface or underground. During a typical rainstorm some water is absorbed by the ground. If the rain falls at a rate greater than that at which it can be absorbed by the earth, the excess immediately runs off and becomes part of the flow of streams. Part of the water that is absorbed is held in the soil by capillary action and eventually evaporated from the ground surface or transpired by growing plants. The remainder percolates downward and eventually becomes part of the ground water. It may remain in the ground-water reservoir for long periods but eventually it may be withdrawn through wells although most of it escapes to the lakes and streams which drain to the sea. The flow from the ground-water reservoirs constitutes most of the dry weather flow of the small streams.

The Niagara Frontier is not dependent on local precipitation for its principal water supply owing to the presence of Lake Erie and Lake Ontario. It has available the accumulated runoff from a 265,095 sq mi area above Niagara Falls and the flow from approximately 30,000 sq mi tributary to Lake Ontario. Smaller supplies may be obtained also from small streams and from the ground. The most important small streams are Buffalo Creek, Cayuga Creek, Tonawanda Creek, and Cazenovia Creek. In contrast to the surface-water supply of Lake Erie with its vast drainage basin, the ground-water supply of the area is dependent largely upon local precipitation. Minor exceptions are some artesian waters having source areas beyond the region of the report, and some recharge from the Niagara River supplying wells adjacent to the river.

SURFACE WATER

Surface water available within the area is sufficient for all present uses and foreseeable needs. The storage capacity of Lake Erie, together with that of the other Great Lakes lying above it, regulates the flow in the Niagara River and for the most part obviates the need for water-supply reservoirs. The flow of the Niagara River is much greater than the present demand. The chemical quality of the surface water throughout the area is generally favorable for most uses without costly treatment. Waste-disposal practices have had an adverse effect on the lower reaches of the smaller streams in the area and on the Tonawanda Channel of the Niagara River. The temperature of water in Lake Erie and Niagara River ranges from 34 F to 75 F. Records of water temperature in small streams are not available but during summer, when flows are at their lowest, water temperature in the streams is presumed to exceed the temperature within the lake.

Records of streamflow in the area, with the exception of that for Niagara River, are relatively short (12 yr or less). Therefore, the low-flow characteristics and the average flow for the period 1920-50 have been estimated by correlation with records of Little Tonawanda Creek at Linden where records have been collected since 1912. With the exception of Niagara River, the flow in the streams has a wide range. Floods may be expected to occur during any month of the year, but they are

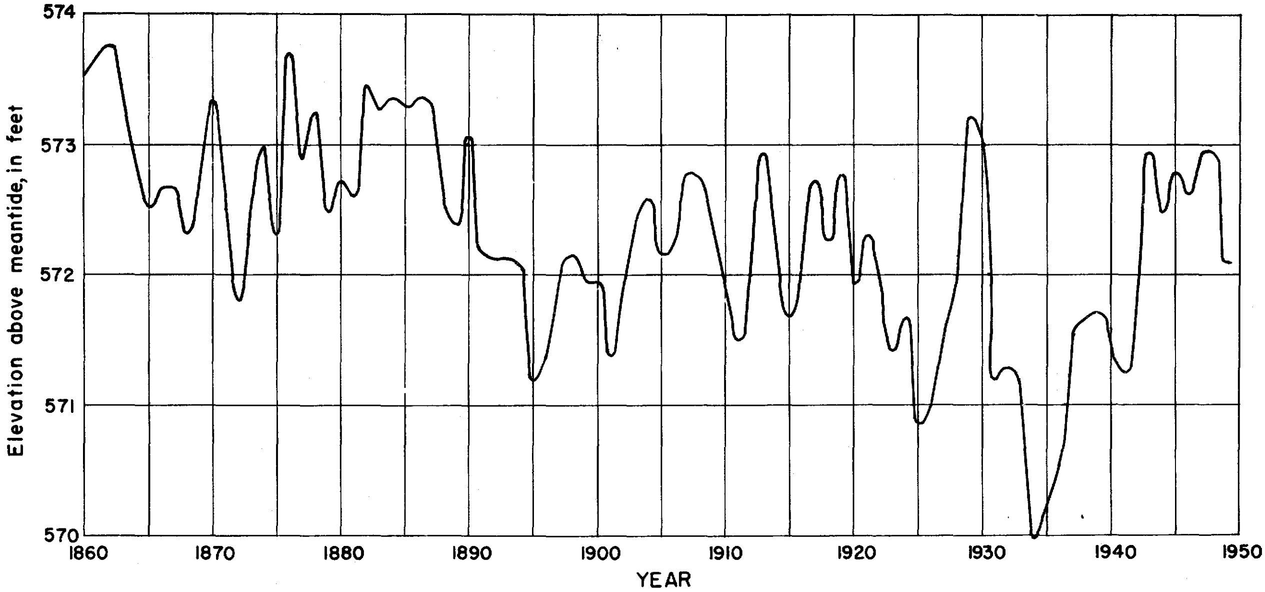

Figure 4.–Yearly mean elevation of Lake Erie (elevation above mean tide at New York City).

most likely to occur during February, March, and April.

There are several graphic methods of showing the probable flow variation. A flow-duration curve shows the percentage of time during which a specified daily discharge has been equaled or exceeded. It may be treated as a probability curve and used to estimate the probable occurrence of a specified discharge. A second method of showing the low-flow characteristics of a stream is by use of curves showing the longest period of time during which the discharge was less than a specified amount.

In addition to giving graphically the general flow characteristics of the streams, these curves are valuable for use in solving problems of plant location and operation. For example, assume that it is desired to locate a manufacturing plant on Buffalo Creek at a point where the drainage area happens to be 150 sq mi. Construction of a storage dam is not contemplated. A flow of 7.5 cfs, or 0.05 cfs per sq mi, is required to operate the plant. It is necessary to know the average number of days each year when there will be a shortage of water. Using the curve based on the estimated 1920-50 record (solid line, fig. 8) it is seen that a flow equal to or exceeding 0.05 cfs per sq mi will prevail during 98 percent of the time. The estimated curve for the period 1920-50 is used because that period included extreme droughts and floods and is considered to be more nearly representative of average conditions than the period of actual record,

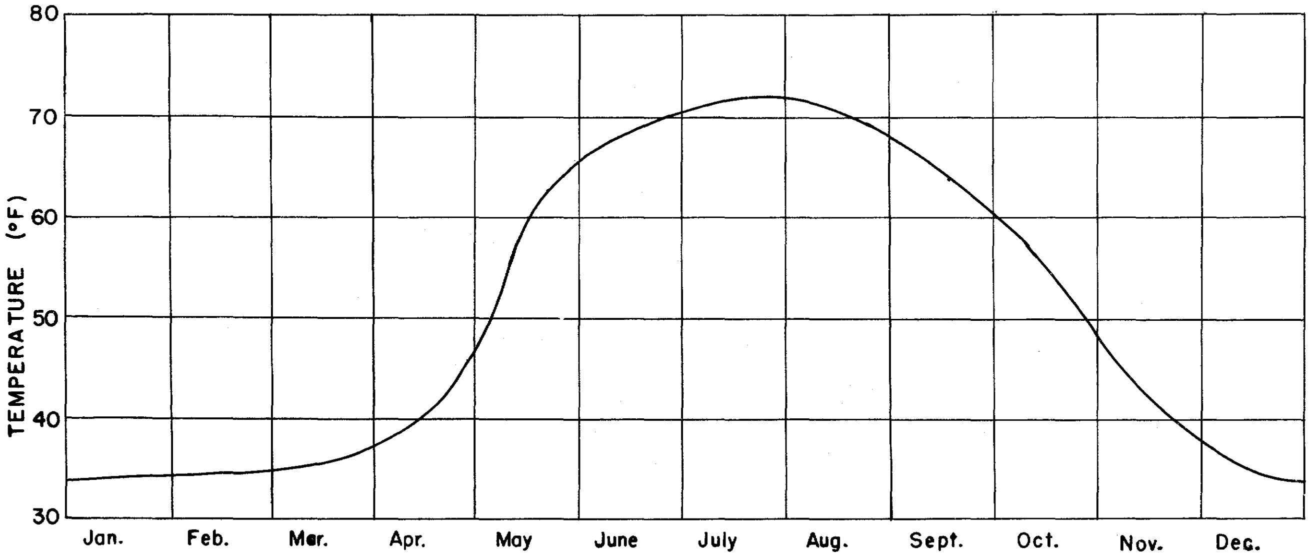

Figure 5.–Average seasonal temperature of Niagara River.

1938-50. For an average year there would be sufficient water 98 percent of 365 or 358 days, and a shortage for only 7 days.

It may be possible to operate the plant for short periods on less than 7.5 cfs. However, it is necessary to know the maximum number of consecutive days, even in unusual years, when the flow will be less than 7.5 cfs. Figure 9, based on the estimated record for the period 1920-50, shows that the flow of Buffalo Creek may be expected to be less than 0.05 cfs per sq mi for not more than 29 consecutive days.

Lake Erie

Lake Erie, shallowest of the Great Lakes, has a mean depth of 90 ft. The lake bottom in the vicinity of Buffalo slopes gradually to a depth of 30 ft about a mile off shore and to a depth of 60 ft or less, 10 miles off shore. The port area of Buffalo has been improved by harbor works which are protected by piers and revetments, and by breakwaters in the lake. The harbor areas around Buffalo are maintained by the Corps of Engineers at a nominal depth of 20 ft. The U. S. Lake Survey publishes a yearly bulletin wherein data relating to harbor use and navigational information are detailed. For water-supply purposes the lake acts as a huge and readily accessible storage reservoir.

Strong winds cause the lake level to fluctuate widely. A continuing east wind causes the lake level to drop below 570.5 ft (low-water datum), making it impossible for large ships to pass into the harbor. Since 1900 the maximum range at Buffalo during one day was 9 ft. The extreme range in lake elevations for the period 1900-50 was 13.7 ft. The records of annual stages for Lake Erie from 1870 to 1950 as recorded by the U. S. Lake Survey are shown in figure 4.

The quality of water in Lake Erie is good. Its chemical composition is essentially constant throughout the year except for localized contamination. Streams tributary to Lake Erie in the vicinity of Buffalo are highly polluted within their estuaries and present a threat to water supplies along the shore toward the Niagara River. Industrial and domestic pollution studies have been evaluated by the International Joint Commission in a report on the pollution of International boundary waters of the Niagara River. The Buffalo Sewer Authority also has studied the pollution problem and records of its findings are available.

Figure 5 shows the average seasonal temperature in the Niagara River at its head which should reflect the average temperatures of water available in Lake Erie in the area covered by this report. From information available at the Ward pumping station of the city of Buffalo, the maximum temperature during the summer months rarely exceeds 75 F.

Lake Ontario

Lake Ontario has the least surface area of any of the Great Lakes. From the Niagara River to Olcott depths of 20 ft or more are found beyond five-eighths of a mile offshore. East of Olcott the deep water is about one-fourth mile offshore. The shore along the lake is being eroded at a rate varying from 1 ft to 5 ft per year.

Like Lake Erie, Lake Ontario serves as a storage reservoir for water-supply purposes. The tributary drainage area at the head of the St. Lawrence River is about 295,000 sq mi. The average discharge of the St. Lawrence River at Ogdensburg, N. Y., is about 225,000 cfs. This discharge represents the amount of water available from Lake Ontario and from intervening tributary streams.

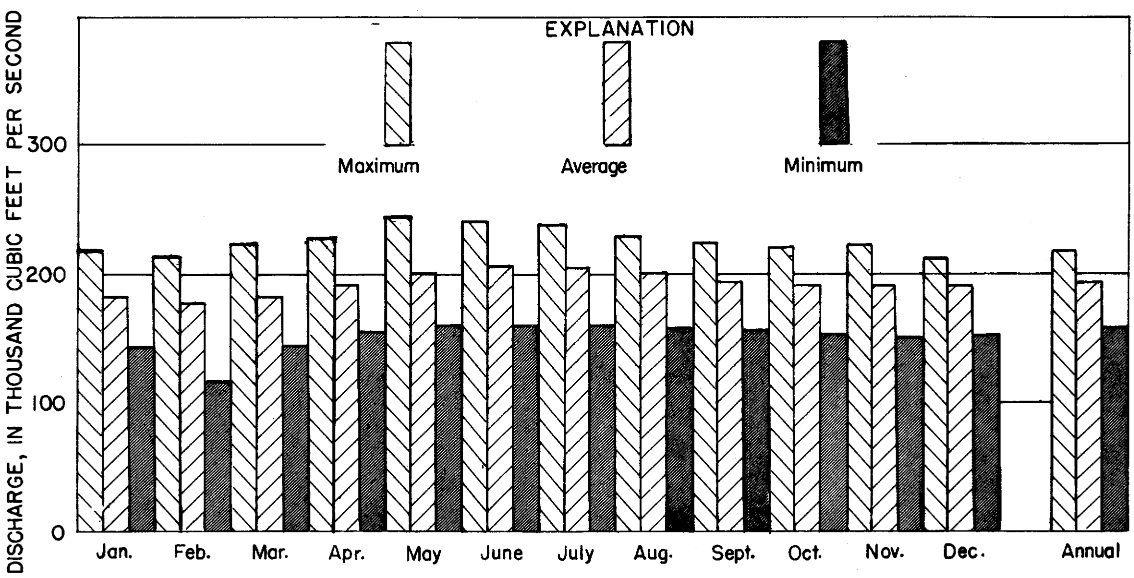

Figure 6.–Maximum, average, and minimum monthly and annual discharge Niagara River at Buffalo.

Table 2.–Chemical quality of surface water in the Niagara Frontier

(parts per million)

	1 6-20-51	2 6-20-51	3 6-20-51	4 6-20-51	5 8-8-51	6 6-20-51	7 7-26-51
Silica (SiO_2)	1.0	1.7	2.6	4.2	0.2	0.9	1.5
Total Iron (Fe)	.19	.33	.07	.33	0	.30	-
Aluminum (Al)	0	0	0	0	0	0	-
Manganese (Mn)	0	0	0	0	0	0	-
Copper (Cu)	0	0	0	0	.02	0	-
Zinc (Zn)	0	.2	0	0	0	.1	-
Calcium (Ca)	52	54	42	88	40	38	37
Magnesium (Mg)	11	10	10	15	6.4	8.3	8.9
Sodium (Na)	3.7	4.5	15	8.3	9.9	8.6	9.4
Potassium (K)	1.6	3.6	2.0	2.4	2.0	2.0	.6
Carbonate (CO_3)	0	0	0	0	0	0	0
Bicarbonate (HCO_3)	155	159	104	202	110	110	108
Sulfate (SO_4)	47	45	51	109	28	25	24
Chloride (Cl)	5.0	8.0	28	12	20	23	20
Fluoride (F)	.1	.1	.2	.4	0	0	0
Nitrate (NO_3)	1.4	.8	.8	1.1	.6	.7	.4
Phosphate (PO_4)	.3	0	.1	.1	0	0	-
Dissolved solids	218	222	234	366	164	171	177
Total hardness as $CaCO_3$	175	176	146	281	126	129	129
Color	20	15	15	25	5	10	2
pH	7.7	8.0	7.3	7.5	7.6	7.7	7.8
Specific conductance (micromhos at 25 C)	339	352	362	557	290	297	300
Temperature (F)	74	75	74	75	-	58	73
Discharge (cfs)	27	16	24	50 (estimated)	-	-	-

1 Buffalo Creek at Gardenville.
2 Cayuga Creek near Lancaster.
3 Cazenovia Creek at Ebenezer.
4 Tonawanda Creek at Millersport.
5 Treated Lake Erie water-Buffalo, N. Y.
6 Raw Lake Ontario water-Rochester, N. Y.
7 Treated Lake Erie water-Erie, Pa.

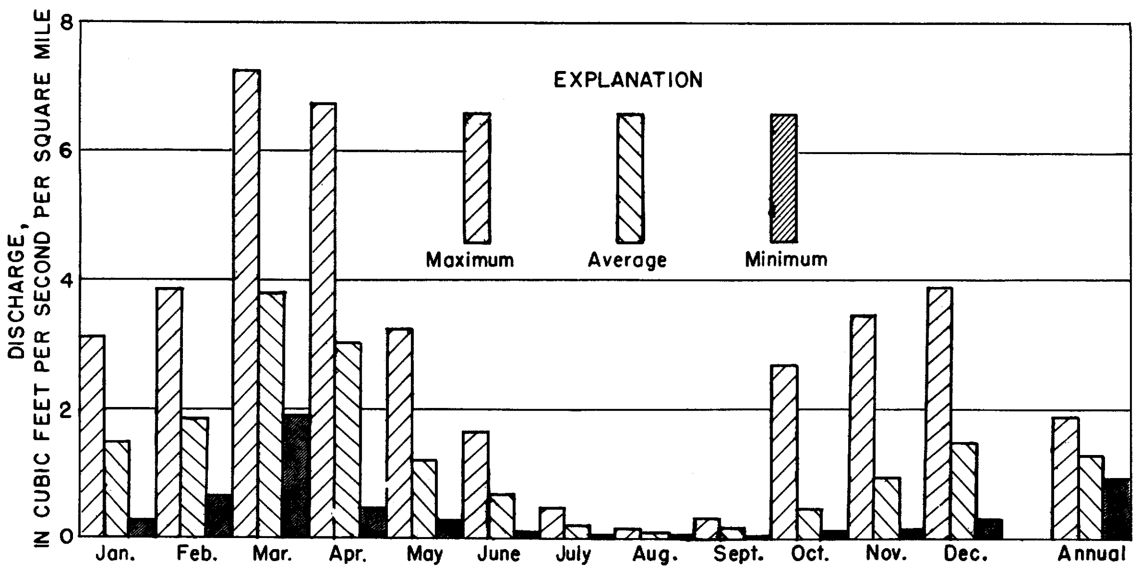

Figure 7.–Maximum, average, and minimum monthly and annual discharge Buffalo Creek at Gardenville.

The mean surface elevation is 245.8 ft. Harbors are maintained at Olcott and Wilson, N. Y. The annual U. S. Lake Survey bulletin gives detailed information about facilities relating to these harbors. Due to the greater depths of the lake, strong winds do not cause rapid changes in lake elevation.

The pollution from the Niagara River is dispersed radially into Lake Ontario. Eastward from the mouth of the Niagara River the quality of water is good, and has about the same chemical composition as water from Lake Erie. Several small streams draining the Ontario plain are dry during the summer months. The more significant streams are noted in table 3.

Niagara River

The Niagara River is the outlet of Lake Erie. From Buffalo it flows northward 33 miles where it empties into Lake Ontario. It forms the boundary between the United States and Canada. Above Buffalo it has a drainage area of 263,500 sq mi. The channel above Niagara Falls, which is 20 miles below Buffalo, is broad, ranging in width from 1,600 to 7,500 ft and contains several islands, the largest of which is Grand Island. The channel on the Canadian side of Grand Island is called the Chippewa Channel and that on the United States side is called the Tonawanda Channel. The Chippewa Channel is relatively free of

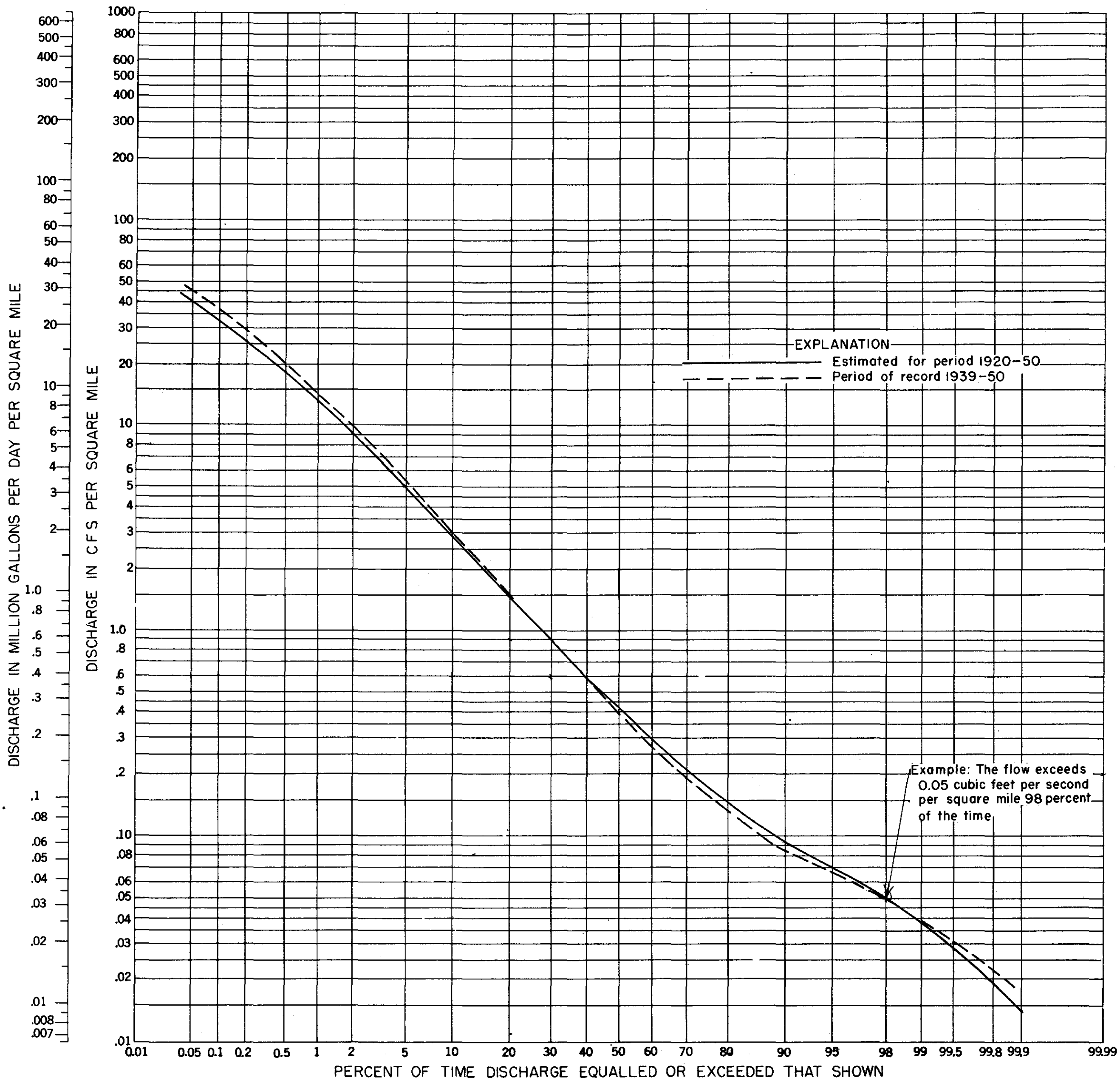

Figure 8. -Flow-duration curve for Buffalo Creek at Gardenville.

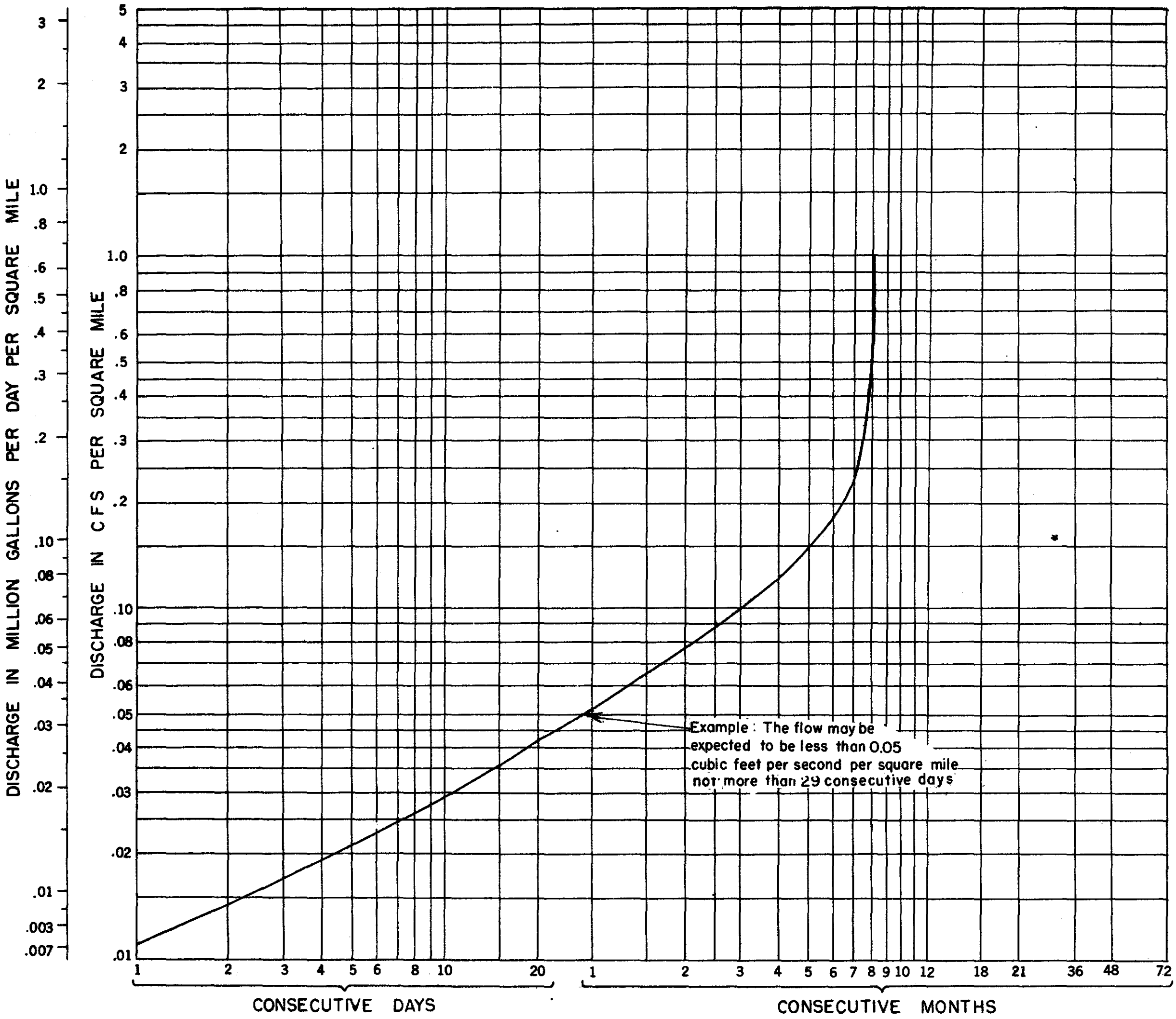

Figure 9. –Maximum period of deficient discharge Buffalo Creek at Gardenville.

pollution but the quality of water in the Tonawanda Channel is affected by pollution from the Buffalo industrialized area. The width of the channel below Niagara Falls ranges from 1,500 to 2,000 ft.

Navigation. –Navigation in the river is hazardous from the head of the river to the foot of Squaw Island. Black Rock Canal affords an alternate deep route from Lake Erie to the foot of Squaw Island where it connects to the river with a lock accommodating large vessels. Its present depth is 20 ft at low water. The river is navigable from the foot of Squaw Island to North Tonawanda (depth 20 ft) and to Hyde Park Boulevard in Niagara Falls (depth 11.4 ft) on the Tonawanda Channel and to Chippewa Island and Navy Island on the Chippewa Channel (depth 13 ft). The lower Niagara River is navigable from Lewiston, at the foot of the lower rapids, to its mouth, a distance of 7 miles. Depths range from 30 to 70 ft.

Discharge. –The Corps of Engineers has obtained a continuous record of stage and flow at Buffalo since January 1905. The average discharge during 46 yr of record (1905-50) is 194,000 cfs (not including diversions from Lakes Michigan and Erie).

The maximum monthly mean discharge for the period 1905-50 is 242,000 cfs in May 1929. The minimum monthly mean discharge is 117,000 cfs in February 1936. Figure 6 shows the maximum, average, and minimum monthly and annual discharge. The flow in Niagara River is relatively uniform because of the enormous storage in the Great Lakes above the river.

Buffalo Creek

Buffalo Creek rises near Java, Wyoming County, and flows in a northwesterly direction to its confluence with Cazenovia Creek, forming Buffalo River. It drains an area of 285 sq mi of which 128 sq mi lie in the tributary basin of Cayuga Creek. Almost all of the area is rural and lies within Erie County.

Gaging-station data. –A continuous record of stage and flow has been obtained since October 1938 at Gardenville, 2 miles upstream from Cayuga Creek. The datum of gage is 604.04 ft above mean sea level, unadjusted.

Drainage area: 145 sq mi.
Average discharge: 12 yr (1938-50) 189 cfs.
30 yr (1920-50) 187 cfs (estimated).

Monthly discharge. –The monthly discharge for the period 1938-50 ranged from 8.09 to 1,050 cfs. Figure 7 shows the maximum, average, and minimum monthly and annual discharge.

Floods. –The maximum discharge recorded since the gage was established in 1938 is 14,000 cfs on March 17, 1942. The maximum gage height recorded is 11.90 ft on March 9, 1942, when the creek stage was affected by an ice jam. The largest flood known occurred on June 21, 1937. The Corps of Engineers estimates that the peak flow was 22,000 cfs. They estimate that flood damage in the section of creek between the mouth of Cayuga Creek and U. S. Highway 20 begins at about 4,000 cfs. Floods of this magnitude may be expected to occur about three times a year.

Low flows. –The minimum discharge recorded since October 1938 is 0.7 cfs on August 22, 24, 25, 1941. The minimum gage height observed is 0.695 ft on August 28, 31, September 3, 1939 (stage affected by backwater from leaves and debris). The flow-duration curve, figure 8, and the curve showing maximum period of deficient discharge, figure 9, define the low-flow characteristics of the stream.

Quality. –There is no excessive pollution in the stream above the gaging station and temperature data have not been obtained on this stream. A chemical analysis of water from Buffalo Creek at Gardenville is given in table 2.

Reservoir sites. –The Corps of Engineers has made a study of possible reservoir sites on Buffalo Creek and has concluded that reservoirs could be constructed at East Elma and Wales with capacities up to 10,200 and 6,900 million gallons, respectively.

Cayuga Creek

Cayuga Creek rises in Wyoming County, flows in a westerly direction and joins Buffalo Creek about 2 miles above the confluence of Cazenovia and Buffalo Creeks. It drains an area of 128 sq mi, most of which lies in Erie County. Most of the area is rural although there are two incorporated villages, Depew and Lancaster, in the basin.

Gaging-station data. –A continuous record of stage and flow has been obtained since September 1938 at the flat-crested dam in Como Lake Park near Lancaster and 800 ft downstream from Little Buffalo Creek. The datum of the gage is 672.80 ft above mean sea level, unadjusted.

Drainage area: 93.3 sq mi.
Average discharge: 12 yr (1938-50) 124 cfs.
30 yr (1920-50) 120 cfs (estimated).

Monthly discharge. –The monthly discharge for the period 1938-50 ranged from 1.87 to 680 cfs. Figure 10 shows the maximum, average, and minimum monthly and annual flow of Cayuga Creek.

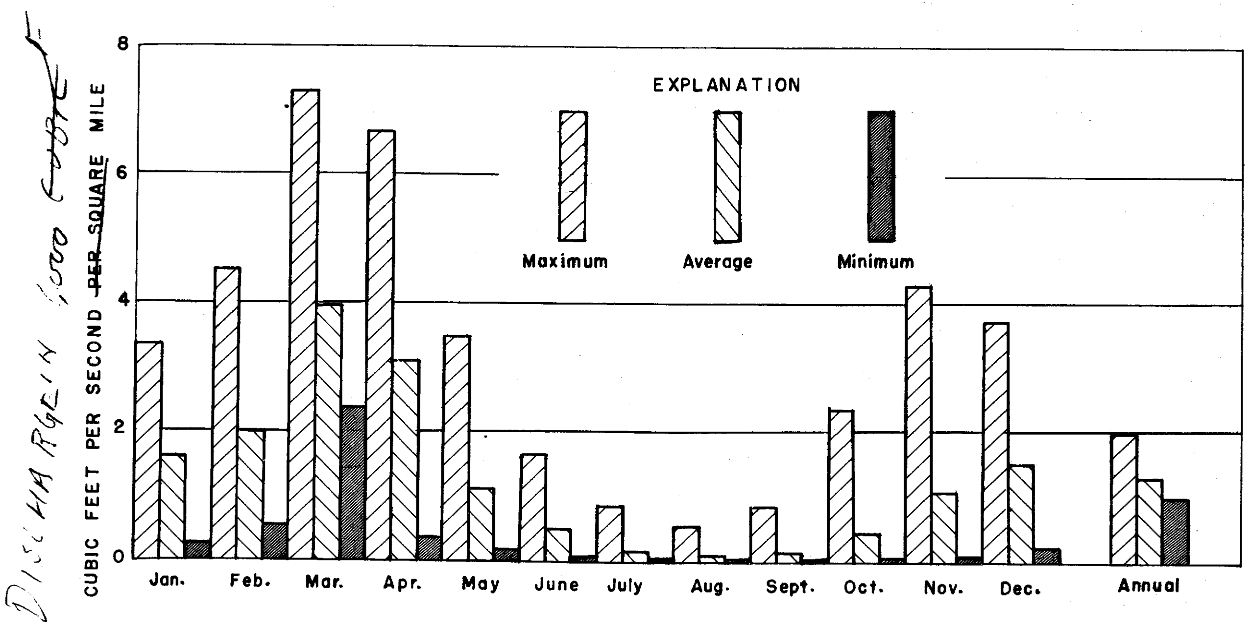

Figure 10. –Maximum, average, and minimum monthly and annual discharge Cayuga Creek near Lancaster.

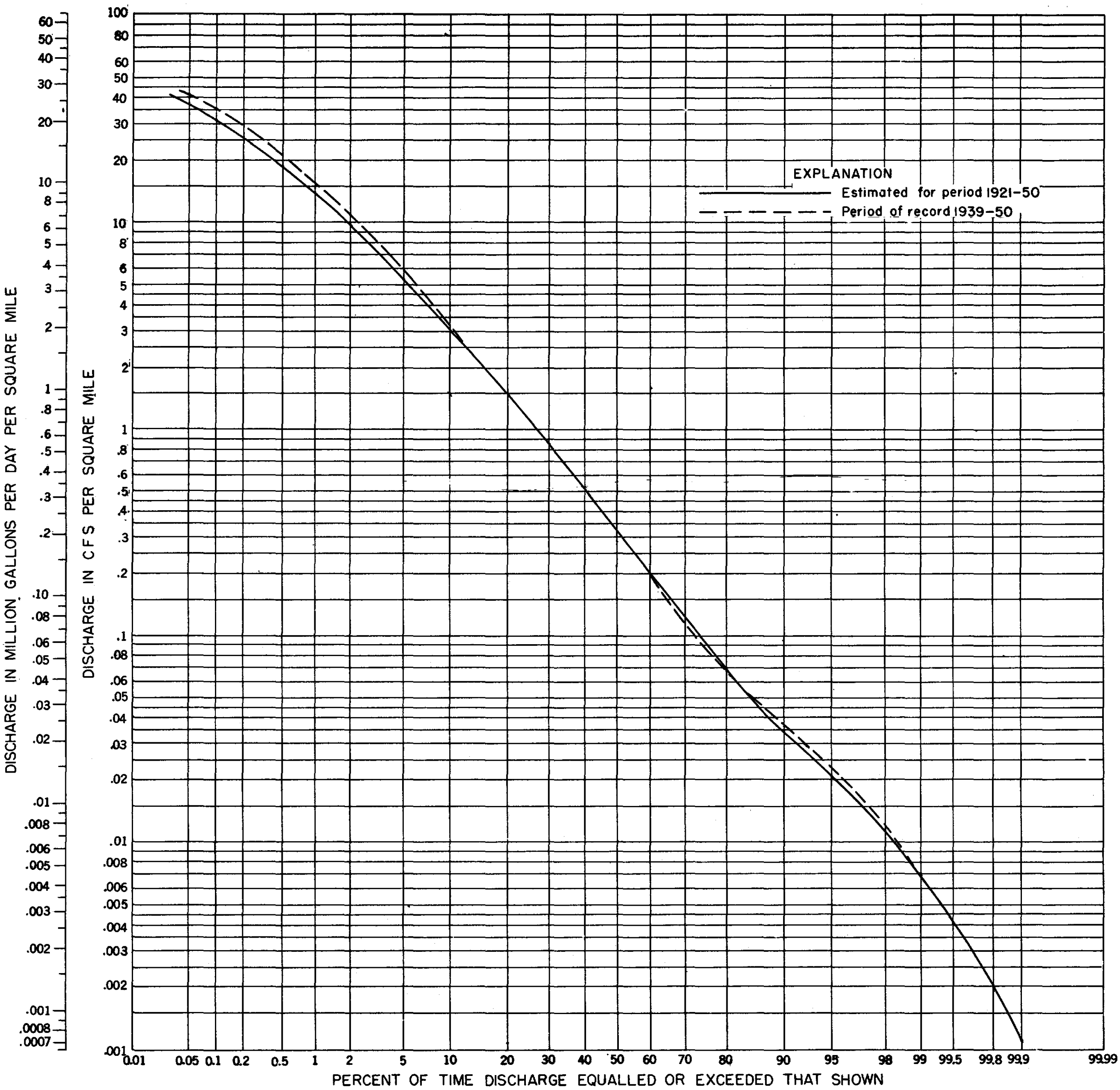

Figure 11. –Flow-duration curve for Cayuga Creek near Lancaster, N. Y.

Floods. –The maximum discharge recorded since the gage was established in 1938 is 7,480 cfs on March 17, 1942. The maximum gage height recorded is 12.36 ft on March 9, 1942 (stage affected by an ice jam). The largest flood known occurred on June 21, 1937. The Corps of Engineers estimates that the peak discharge was 18,000 cfs. Damages caused by the flood were limited mainly to areas in the village of Lancaster. Flood-protection work in the village of Lancaster has been built to forestall a repetition of the damages suffered by this flood.

Damaging floods may be expected to occur about three times a year in the section of creek between Como Park Boulevard and the mouth of the creek, and about three times in 2 yr in the section of creek between Como Park Boulevard and Penora Street.

Low flow. –The minimum daily discharge recorded since 1938 is 0.1 cfs on August 9, 1939. The flow-duration curve, figure 11, and the curve showing maximum period of deficient discharge, figure 12, show the low-flow characteristics of the stream.

Quality. –Sewage-treatment facilities of Depew and Lancaster are adequate to prevent excessive pollution. Temperature data have not been collected on this stream. A chemical analysis of water from Cayuga Creek near Lancaster is given in table 2.

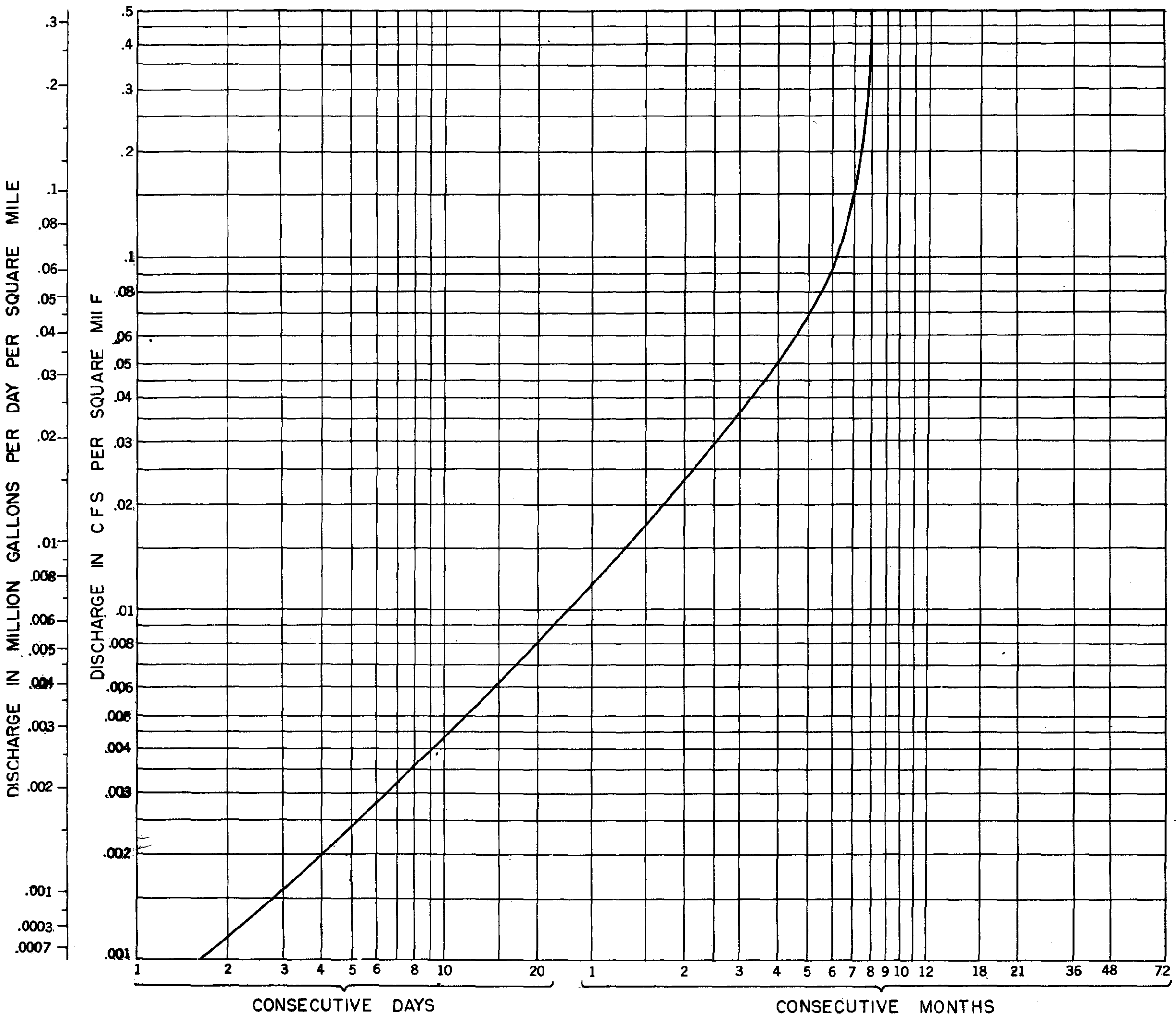

Figure 12. –Maximum period of deficient discharge for Cayuga Creek near Lancaster.

Reservoir site. –The Corps of Engineers has made a study of possible reservoir sites and concluded that a reservoir with a capacity up to 3, 300 million gallons is possible at Bennington.

Cazenovia Creek

Cazenovia Creek rises in Erie County in the town of Sardinia and flows northwesterly to its confluence with Buffalo Creek to form Buffalo River. It drains an area of 144 sq mi, all of which lies in Erie County. The village of East Aurora lies within the basin.

Gaging-station data. –A continuous record of stage and discharge has been obtained since June 1940 at the highway bridge on Ridge Road in Ebenezer. The datum of the gage is 606.86 ft above mean sea level, unadjusted.

Drainage area: 136 sq mi.
Average discharge: 10 yr (1941-50) 210 cfs.
30 yr (1920-50) 205 cfs (estimated).

Monthly discharge. –The monthly discharge for the period 1940-50 ranged from 9.76 to 1,062 cfs. Figure 13 shows the maximum, average, and minimum monthly and annual flow.

Floods. –The maximum discharge recorded for the period of record is 11,200 cfs which occurred on March 17, 1942 at a stage of 13.11 ft. The flood of June 1937 is considered to have been higher than that of March 1942, however, no data are available as to its magnitude. Flood damages during the 1937 flood were limited to agricultural areas in the basin. No damaging floods have occurred during the period of record 1940-50.

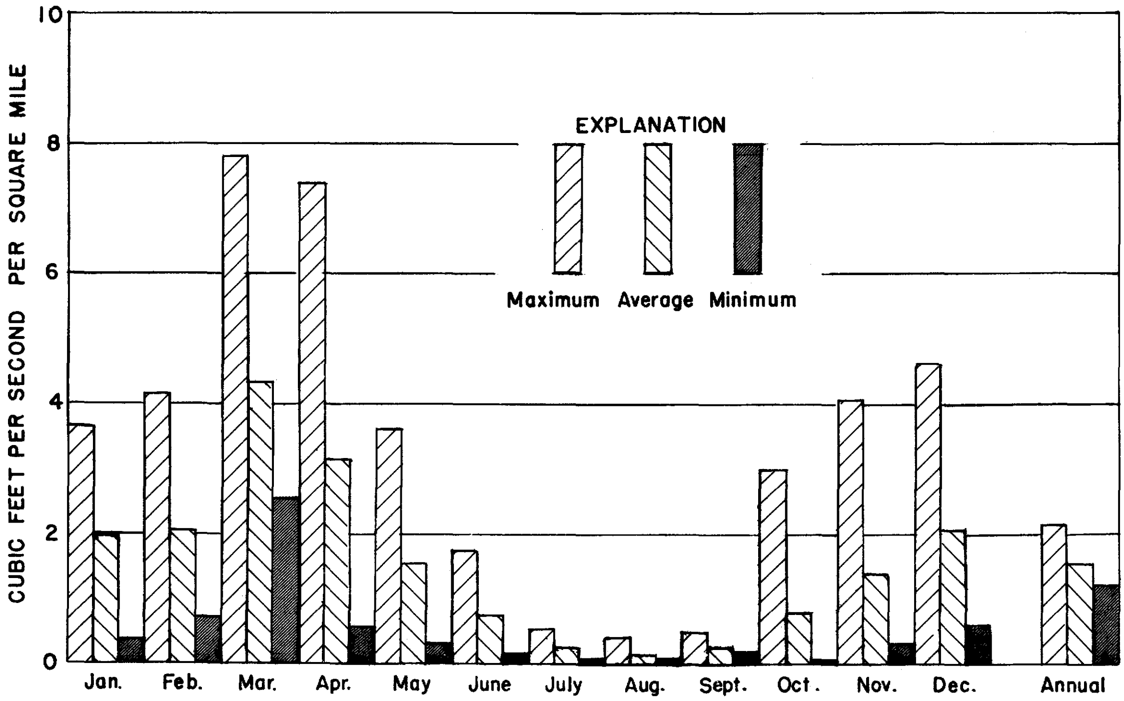

Figure 13.-Maximum, average, and minimum monthly and annual discharge Cazenovia Creek at Ebenezer.

Low flows.-The minimum discharge recorded since June 1940 is 3.3 cfs on August 17, 1949. The minimum gage height observed is 0.42 ft on August 25, 1941 and August 17, 1950. The flow-duration curve (fig. 14) and the curve showing maximum period of deficient discharge (fig. 15) define the low-flow characteristics of the stream.

Quality.-The village of East Aurora discharges its sewage into the stream after secondary treatment. Temperature data have not been collected on this stream. A chemical analysis of water from Cazenovia Creek at Ebenezer is given it table 2.

Reservoir site.-The Corps of Engineers has made a study of possible reservoir sites on Cazenovia Creek. It was concluded that a reservoir could be constructed near Spring Brook with a maximum capacity of 6,400 million gallons.

Buffalo River

Buffalo River is a navigable stream extending 6 miles upstream to the confluence of Cazenovia and Buffalo Creeks. It is maintained at a depth of 21 ft by the Corps of Engineers.

At its mouth Buffalo River drains 446 sq mi in Erie and Wyoming Counties. The maximum flow has been estimated at about 27,000 cfs and the minimum flows at times are less than 10 cfs. The mean daily discharge approximates 600 cfs. These values are based on records for the gaged areas of the three streams tributary to Buffalo River.

Flood damages on Buffalo River are rare. Since the maximum flood of June 1937, protection works have been constructed in the city of Buffalo which are expected to prevent flooding within the city limits.

Present industrial use of Buffalo River water averages 125 mgd (193 cfs). During the summer the withdrawal has approached 185 mgd (286 cfs) or about 30 times the minimum flow. Under such conditions the river acts as a large septic tank, from which water is recirculated several times daily. During these dry periods, the concentration of pollutants becomes exceptionally high and nuisance conditions are created. Sudden high discharges from the Buffalo River expel these polluted waters into the outer harbor, thus threatening water supplies along the Lake Erie shore toward the Niagara River.

Tonawanda Creek

Tonawanda Creek rises near North Java, Wyoming County, at an elevation of about 1,900 ft above mean sea level, flows north to Batavia and then northwesterly to Niagara River. It drains an area of 652 sq mi, most of which is rural. The lower $12\frac{1}{2}$ miles of the creek froms a part of the New York State Barge Canal and has a navigable depth of 12 ft.

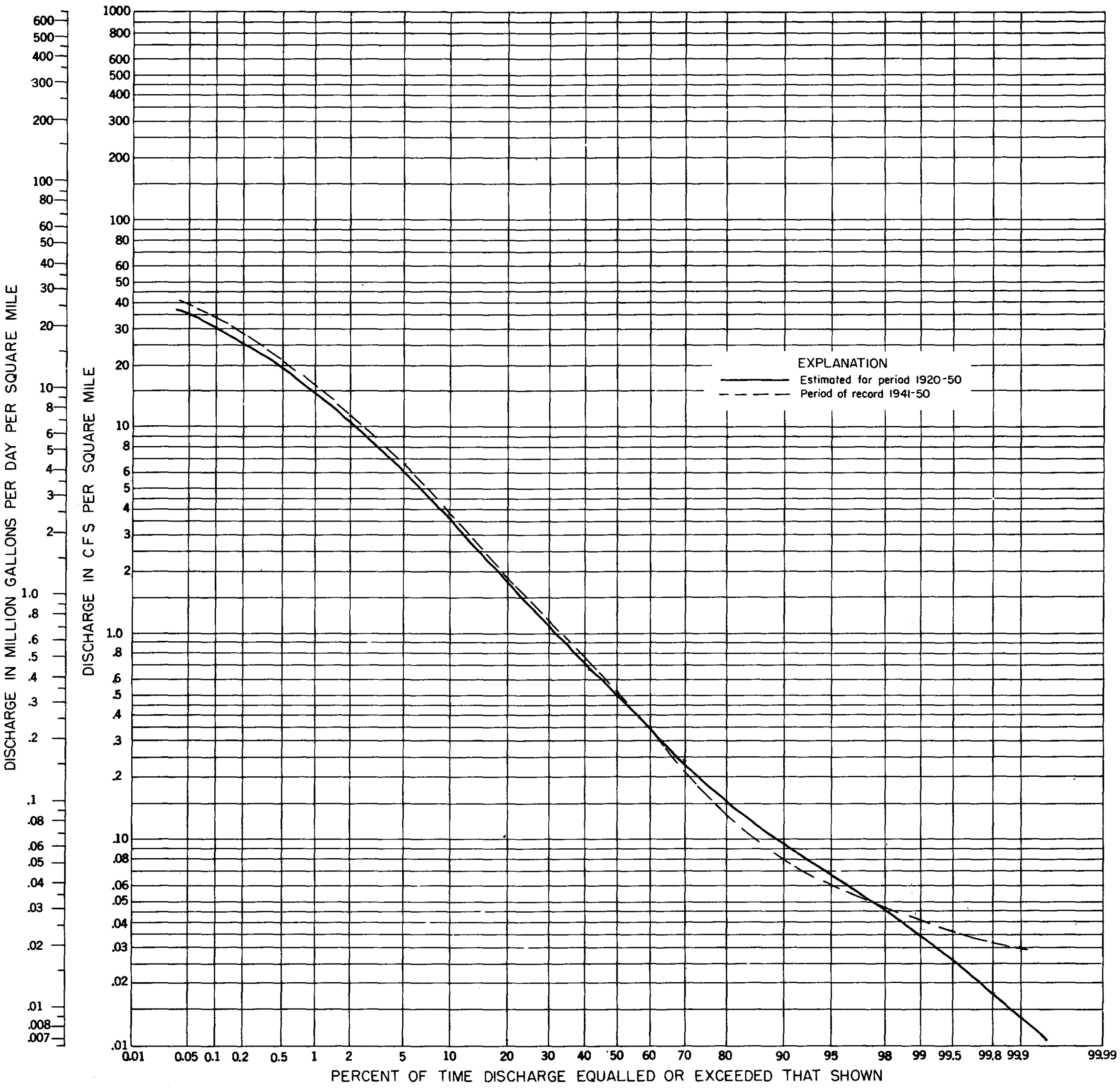

Figure 14. -Flow-duration curve for Cazenovia Creek at Ebenezer.

Gaging-station data. -Streamflow data have been collected at two sites, Batavia and Linden, in the Tonawanda Creek basin. Both of these gaging stations are outside the area covered by this report; however, they are of value in appraising the water resources of the Buffalo-Niagara region.

A continuous record of stage and discharge of Little Tonawanda Creek has been obtained since July 1912 at the highway bridge at Linden, 7 miles upstream from its mouth.

Drainage area: 22.0 sq mi.
Average discharge: 37 yr (1912-19, 1920-50) 27.4 cfs.

Batavia.—A continuous record of stage and discharge of Tonawanda Creek has been obtained since July 1944 at Batavia municipal dam 500 ft above Walnut Street bridge. Datum of gage is 876.01 ft above mean sea level (city of Batavia bench mark).

Drainage area: 172 sq mi.
Average discharge: 6 yr (1944-50) 196 cfs.
30 yr (1920-50) 200 cfs (estimated).

Monthly discharge. -The monthly discharge at Batavia for the period 1944-50 ranged from 7.91 to 1,100 cfs.

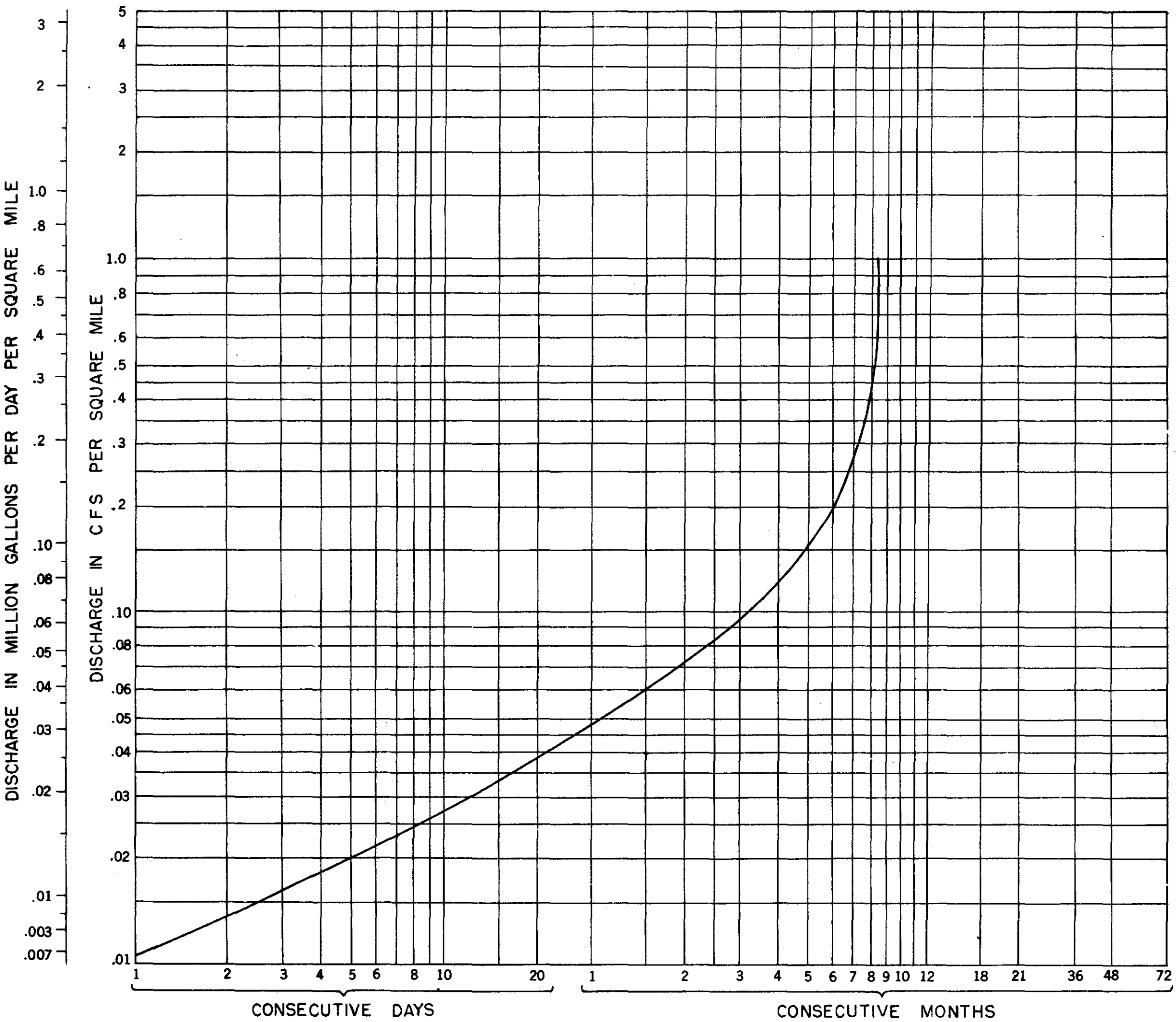

Figure 15. –Maximum period of deficient discharge for Cazenovia Creek at Ebenezer.

Flood.–The maximum discharge recorded since the Batavia gage was established in 1944 is 5,530 cfs on March 29, 1950. The maximum gage height recorded is 13.85 ft on April 6, 1947.

The Corps of Engineers estimates that the greatest discharge through Batavia was about 7,050 cfs on March 28, 1916. The flood of March 1942 reached a stage of 14.5 ft, according to Batavia City records.

Low flow.– The low-flow characteristics of Tonawanda Creek have been estimated at three sites, Batavia, Millersport, and Pendleton to mouth.

The minimum discharge recorded since July 1944 is 1.0 cfs on August 17, 1949 at Batavia. The minimum gage height recorded is 0.59 ft on July 26, 27, 1948. The low-flow characteristics of the stream are shown by the flow-duration curve (fig. 16) and the curve showing maximum period of deficient discharge (fig. 17).

Two discharge measurements were made at Millersport (drainage area 363 sq mi) during 1951. The low-flow characteristics for Tonowanda Creek at Millersport, estimated on the basis of these two measurements, are the same as those for Tonawanda Creek at Batavia (see figures 16 and 17). The average discharge is estimated to be 1.2 cfs per square mile or 440 cfs.

Pendleton to mouth.–This portion of the creek forms a part of the New York State Barge Canal. The direction of the flow in the canal is from the Niagara River to Pendleton. The flow may be shut off for short periods, but it is usually about 1,000 cfs.

Quality.–The city of Batavia and the village of Attica discharge treated sewage into Tonowanda Creek. No excessive pollution exists at Millersport. Most of the time Niagara River water flows eastward in the canalized portion of Tonawanda Creek. At times the creek will carry the pollution and contamination from the city of

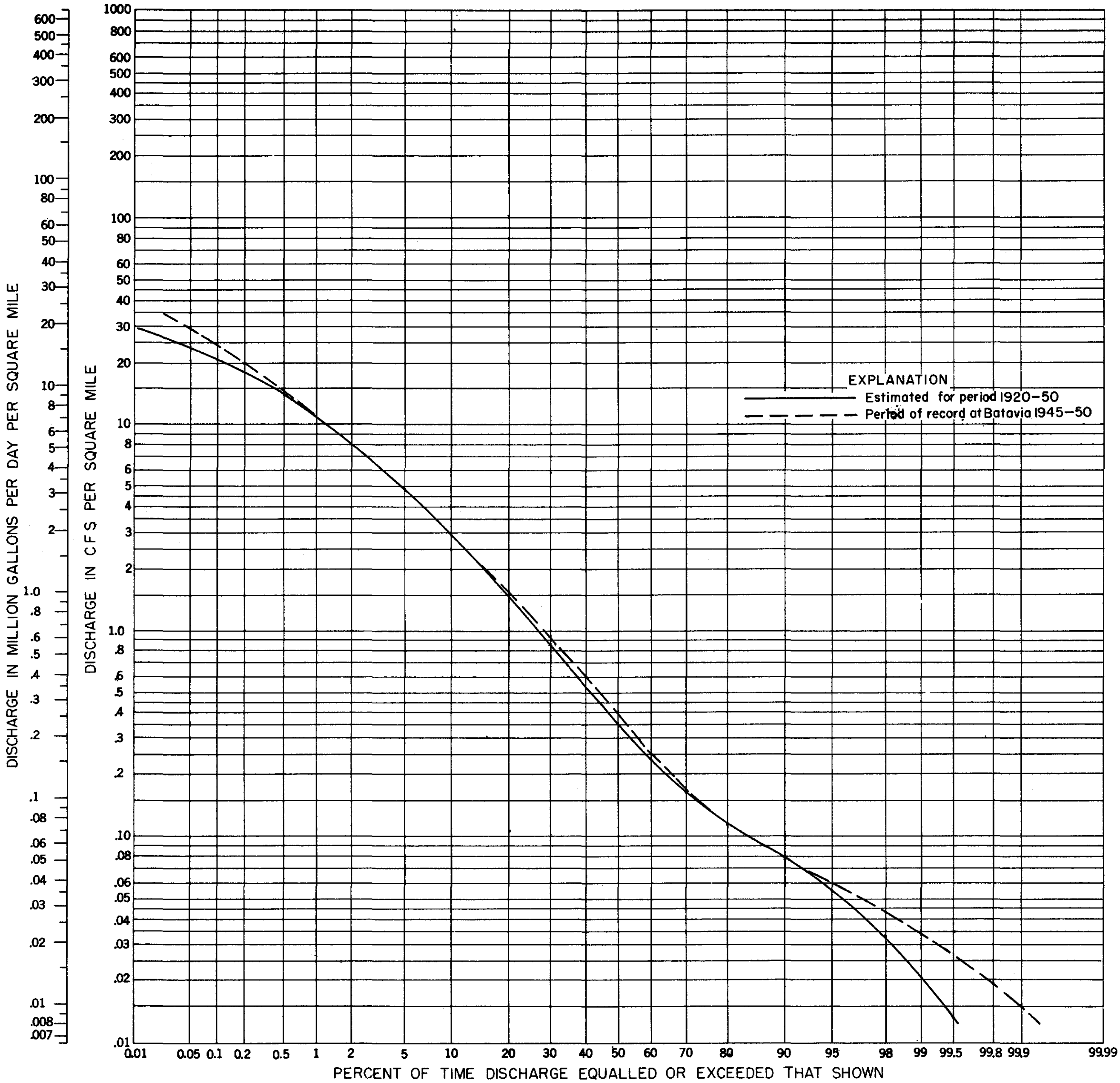

Figure 16. –Flow-duration curve for Tonawanda Creek between Batavia and Millersport.

Niagara Falls and from the Niagara River. Temperature data have not been collected on this stream. A chemical analysis of water from Tonawanda Creek at Millersport is given in table 2.

Other Streams

Drainage areas of seven ungaged streams of significance in the area are shown in table 3.

GROUND WATER

Ground water in the Buffalo-Niagara Falls region occurs both in bedrock and in unconsolidated deposits and is withdrawn in moderately large quantities by industries and municipalities. Climate and geology control the occurrence of ground water in the area. The water contained in rocks is replenished directly from rain and snowfall over the immediate area. The amount of replenishment to the water-bearing formations (called aquifers) is dependent upon several factors. Among these are the absorptive capacity of the soil and underlying rocks, topography, vegetal cover, wind, temperature, humidity, and the form, intensity, and amount of precipitation. In general, conditions in the area are favorable for the replenishment of the aquifers.

Aquifers are similar to surface reservoirs in many respects. Basic differences are the much greater size

Table 3.—Drainage areas of small streams in the Buffalo-Niagara Falls region

Stream	Drainage area (sq mi)	Remarks
Eighteenmile Creek (tributary to Lake Erie)	120	Reported to have no flow at times.
Rush Creek	11.0	Receives sewage effluent from Blasdall and Woodlawn.
Smoke Creek	32.0	Receives sewage effluent from Lackawanna plant.
Ellicott Creek	119	Receives sewage from Williamsville. Estuary to near limit of report area.
Ransom Creek	50.8	
Twelvemile Creek	45	No flow at mouth on August 7, 1951.
East Branch Twelvemile Creek	30	No flow at mouth on August 7, 1951.
Eighteenmile Creek (tributary to Lake Ontario)	82.5	Receives water from New York State Barge Canal and effluent from Lockport sewage plant.

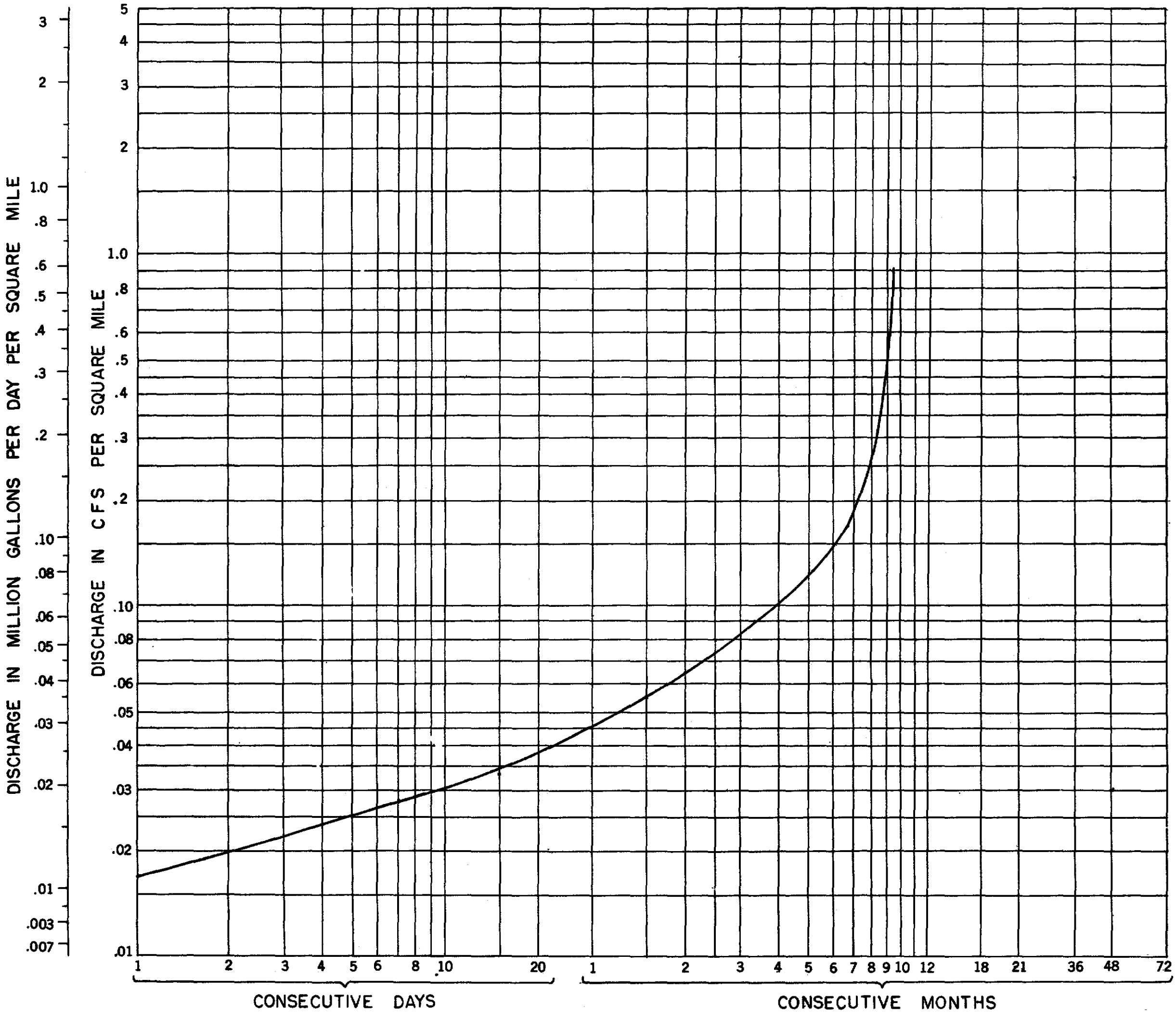

Figure 17.—Maximum period of deficient discharge for Tonawanda Creek between Batavia and Millersport.

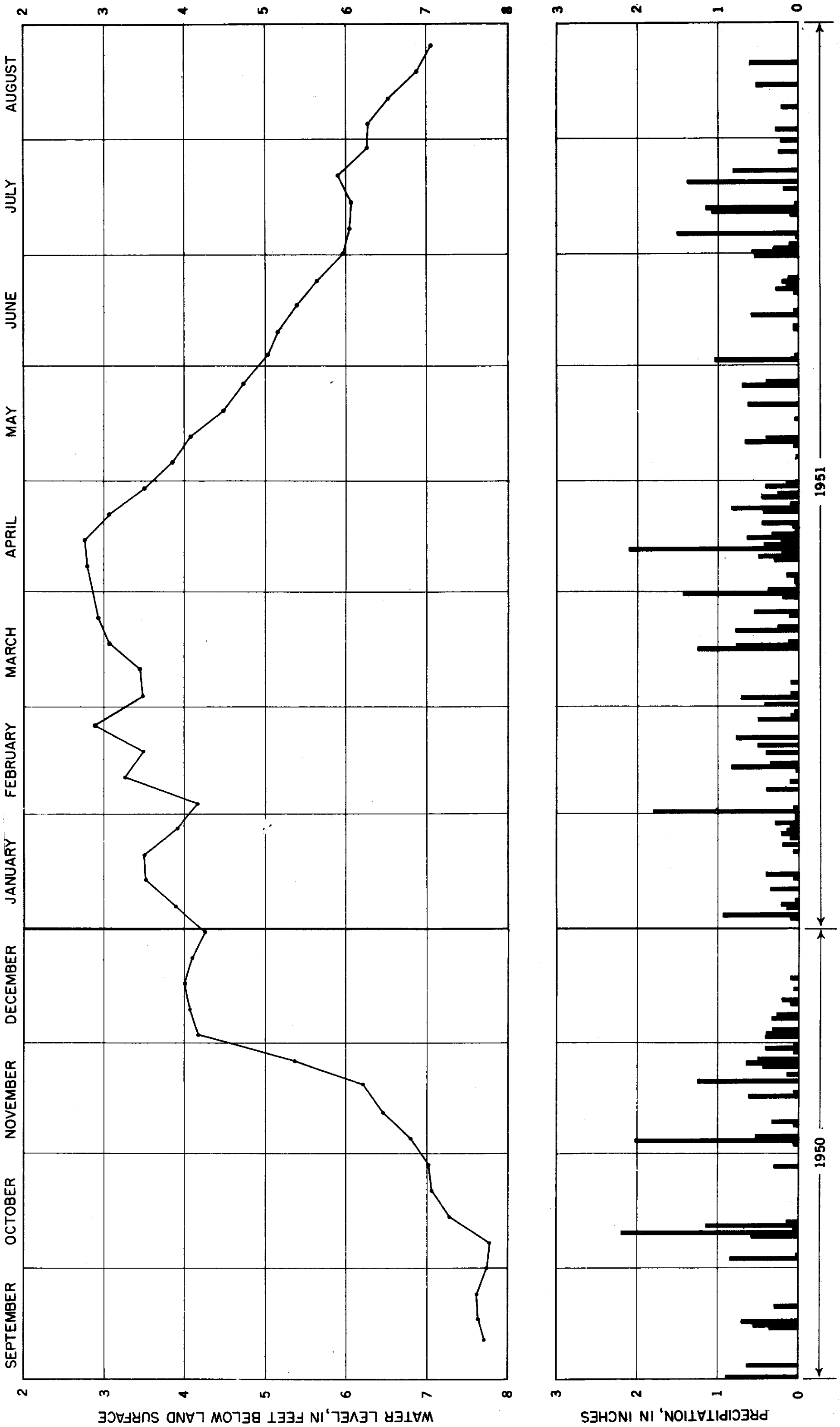

Figure 18.–Water level in observation well Ni 30 near Youngstown and daily precipitation at Lewiston, September 1950 to August 1951.

of most aquifers as compared to artificial reservoirs, and the slower rate of intake and release of the water in underground storage. The water-bearing rocks receive the water percolating down from the soil zone and release it slowly to streams and wells. The water table, or the pressure surface in confined aquifers, fluctuates in response to changes in inflow and outflow. Owing to the great extent of most aquifers and the relatively slow movement of water through them, changes in storage of more than a few feet as represented by water levels in wells generally are measured in months or years (fig. 18). Therefore, the ground acts as a great natural regulator, providing storage for precipitation and sustaining the flow of streams and springs, and the yield of wells in dry periods.

Aquifers differ in the quantity and quality of the water in storage and in their ability to yield water according to the character of the rock. These differences are related directly to the character of the rock; therefore, a knowledge of the geology of the area is essential.

Water-Bearing Formations

The consolidated rock formations (bedrock) of the Buffalo-Niagara region were deposited in shallow seas about 350 million years ago. The strata consist mostly of limestone and dolomite, shale, and sandstone. They extend in almost parallel belts from the Niagara River and Lake Erie eastward across the area. The consolidated rock beds have a slight dip to the south, the slope averaging about 28 ft per mile. The oldest formation, the Queenston shale, crops out along the south shore of Lake Ontario in the northern part of the area. Each formation to the south is younger than the formation bordering it to the north.

Each formation beginning with the Queenston shale to the north, dips beneath these younger formations and lies at progressively greater depths to the south. Thus, each formation can be penetrated by wells not only in its area of outcrop but, owing to the gentle dip, is within reach of wells in a narrow belt within the outcrop area of the next younger rocks to the south. The zones in which the principal bedrock aquifers are tapped by wells are shown on plate 1.

The unconsolidated sediments, consisting of gravel, sand, and clay, were deposited considerably later, within the past million years. These deposits are thin but cover the consolidated formations over an extensive area. Only along the base of the Portage escarpment and in isolated places do the unconsolidated deposits reach a thickness greater than 50 ft. The geologic sequence of the major rock units in the area is shown on plate 1.

Porosity and permeability are important hydrologic characteristics of a rock formation. Porosity is a measure of the volume of water that a rock formation can hold, and is expressed as a percentage by volume of the voids in a rock formation. The voids or pores formed at the time the rock was deposited are classified as primary; the joints and fractures produced by weathering and earth movements are classified as secondary. Permeability is the capacity of a rock to transmit water. Fine clay is porous, but the pores are so small that the water will not drain out. Coarse gravel may have the same porosity as the clay but the large openings permit it to drain readily. The bedrock formations in the area are generally not highly permeable except where many secondary openings occur. These openings have been further enlarged by solution in the limestone and dolomite rocks. Such enlarged openings are well developed in the Buffalo-Niagara region. No method is known for precisely determining at the surface, in advance of drilling, the location of secondary openings in bedrock and the quantity of water available. Information on existing wells, however, gives an indication of the water-bearing properties of a rock formation. A summary of these data collected in the Buffalo-Niagara region is given in plate 1. Some bedrock formations have been omitted because of their small areal extent and others have been grouped together because of similar hydrologic characteristics.

The unconsolidated rocks in the Niagara Frontier differ hydrologically from the underlying consolidated deposits. The unconsolidated deposits contain innumerable small openings or pores between grains making up the sediments. The size, number, and continuity of these openings control the quantity of water that can pass through a given deposit. If the materials consist of fine sand, clay, or silt the movement of water is slow. In coarse sand or gravel, large openings between grains permit a greater rate of flow. No known extensive gravel deposits overlie the bedrock in the Buffalo-Niagara region, although the village of East Aurora obtains ample water supplies from such deposits. The unconsolidated material overlying the bedrock elsewhere in the area consists largely of fine sand and clay and is a poor source of water. The greatest reported thickness of this material is at the southern end of Grand Island where the logs of gas borings show the thickness to be about 70 ft.

Yields of Wells

The consolidated formations in the Buffalo-Niagara region are among the largest yielding rock aquifers in New York State. Wells drilled in the Lockport dolomite, Salina formation, and Onondaga limestone yield unusually large quantities of water from secondary openings. Municipalities that use ground water depend mostly upon supplies derived from the unconsolidated material overlying the bedrock, chiefly because of the better chemical quality of the water.

The Salina formation, consisting of crystalline dolomite and dolomitic shale, is the best aquifer in the area. The average yield of 37 wells is 415 gpm (plate 1). However, this average is of little value in determining the probable yield of new wells because of the wide range in yield from this formation (25 to 3,000 gpm). Figure 19 shows the distribution of yields in this formation. The light gray to bluish Lockport dolomite and Onondaga limestone are aquifers with average yields respectively of 124 gpm and 178 gpm.

High average yields in the Salina formation and the Lockport dolomite are due, in some areas, to the infiltration of water from the Niagara River. Pumping from some wells adjacent to the river lowers the water table to below river level producing a flow of water from the river toward the wells through solution channels and other openings. For example, four wells

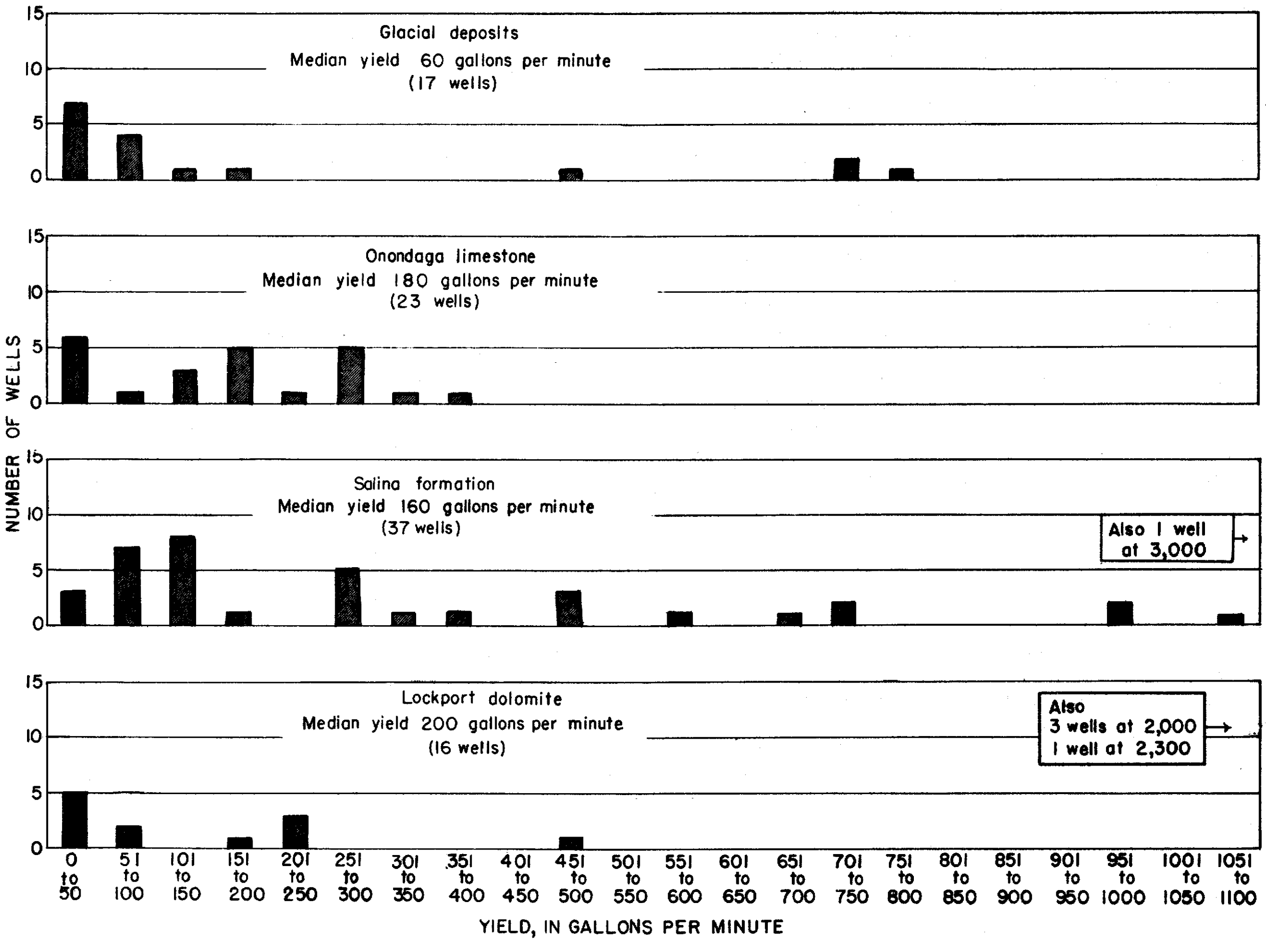

Figure 19.—Yield of wells in the Niagara Frontier.

drilled in the Lockport dolomite adjacent to the Niagara River yield to a total of 8, 300 gpm. Because these wells are not considered typical of the formation in general, they have not been included in plate 1. The graph, figure 20 compares the chemical quality of water from the Niagara River and the Lockport dolomite. The quality of water from wells adjacent to the river indicates the occurrence and approximate degree of infiltration. Figure 21 shows the variations in temperature of the Niagara River and the wells at the E. I. du Pont de Nemours plant at the city of Tonawanda. The temperature of ground water when not affected by river recharge varies only a few degrees throughout the year (fig. 21, North well field). The ground-water temperature at the E. I. du Pont de Nemours plant, however, shows a large annual variation due to the infiltration of water from the Niagara River into the aquifer.

The unconsolidated rocks are extensive, but few sand and gravel deposits yield substantial quantities of ground water. Table 4 summarizes available data on wells in the unconsolidated deposits of the region. In the village of East Aurora four wells drilled in the unconsolidated deposits yield from 500 to 800 gpm each. These are the largest yielding wells developed in the unconsolidated deposits. Attempts have been made with very little success to develop ground-water supplies from the fine sand and clay north of the city of Buffalo. One abandoned well 100 ft in depth at the Allegheny Ludlum Steel Co. yielded 37 gpm. On the north side of Grand Island, however, a well capable of yielding 250 gpm has been developed by inducing

Table 4.—Summary of data on wells in the unconsolidated rocks

Number of well records	20
Static water level (feet below land surface):	
Average	14
Range:	
Low	56
High	Flowing
Yield (gallons per minute):	
Average	209
Range:	
Low	30
High	800
Specific capacity (gallons per minute per foot of drawdown):	
Average	4.7
Range:	
Low	.9
High	12

infiltration from the Niagara River through fine sand. Outside the area to the south small areas of gravel are found. They have been developed in the towns of Eden and Collins, the yields of these wells range from 30 to 300 gpm.

Quality of Ground Water

Rain water, which is relatively free from impurities, except dissolved gases, dissolves minerals from the soil and rocks with which it comes into contact. Water percolating through decomposed organic matter, such as decaying vegetation, will absorb carbon dioxide which materially increases the solvent action of water. This solvent action of water upon the very soluble minerals in the rock of this region has resulted in a ground water of high mineral content. The consolidated rock formations contain soluble minerals such as sodium chloride, magnesium sulfate, calcium bicarbonate, magnesium bicarbonate, and calcium sulfate. A summary of the chemical quality of the ground water in the Buffalo-Niagara Falls region is given in table 5. Most of the ground water sampled in the area had over 800 ppm dissolved solids. However, some water bottling plants have succeeded in finding ground water of lower concentrations of dissolved solids by drilling shallow wells. Industries along the Niagara River also obtain ground water of lower mineral content through the induced infiltration of river water into their wells. Municipalities have developed ground-water supplies from the unconsolidated deposits of sand and gravel to obtain water of lower mineral content. Although this water is not as hard as water from the rock formations and contains less iron, it is usually necessary for the municipalities to install softeners and to provide aeration for the oxidation and removal of iron. The chemical quality of water from one well changed substantially over a period of years (see table 6). This well is now abandoned because of the unsuitable chemical quality of the water.

The Salina formation in the Buffalo-Niagara region yields water of high mineral content. Expensive treatment would be necessary to make the water suitable for many industrial processes. Waters from the Lockport dolomite and Onondaga limestone are but slightly lower in mineral content than the water from the Salina formation. The chemical quality of bedrock water in the Buffalo-Niagara area limits its use mainly to cooling and air conditioning. Water from unconsolidated sand and gravel and from the Upper Devonian shale and sandstone usually have a much lower mineral content than water from the bedrock.

Pollution

The ground water along the Niagara Frontier is generally of good sanitary quality. In some areas, especially those underlain by the Onondaga limestone, wells have been drilled by individuals and industries for the discharge of waste material. This has resulted in the pollution of large sections of this aquifer. Many of the

Table 5.–Chemical quality of ground water in the Buffalo-Niagara Falls region

(parts per million)

Formation	Period	Silica (SiO_2)	Iron (Fe)	Sulphate (SO_4)	Chloride (Cl)	Total hardness (as $CaCO_3$)	Dissolved solids
Sand and gravel deposits:	(Pleistocene)						
Number of tests		4	17	10	17	17	5
Average		12	1.0	176	90	321	898
Maximum		13	3.0	471	670	906	1,390
Minimum		10	.14	39	3	14	423
Upper Devonian sandstone: and shale							
Number of tests		1	2	2	2	2	2
Average		17	.19	173	124	602	806
Maximum		-	.33	185	144	628	841
Minimum		-	.05	160	104	576	771
Onondaga limestone:	(Devonian)						
Number of tests		4	5	6	6	7	8
Average		29	1.9	410	411	741	1,670
Maximum		74	5.6	1,160	950	1,470	2,650
Minimum		12	.03	69	32	180	428
Salina formation:	(Silurian)						
Number of tests		4	7	8	10	10	6
Average		5	.69	1,290	478	1,790	4,500
Maximum		12	36	2,780	2,500	3,010	8,450
Minimum		1	.03	116	29	444	1,900
Lockport dolomite:	(Silurian)						
Number of tests		5	5	7	6	7	6
Average		25	3.3	524	606	858	1,490
Maximum		101	16	1,320	1,200	2,180	3,230
Minimum		1.4	.03	87	18	120	299
Queenston shale:	(Ordovician)						
Number of tests		1	1	1	1	1	1
Analysis		3.0	1.0	3,620	2,100	1,570	8,920

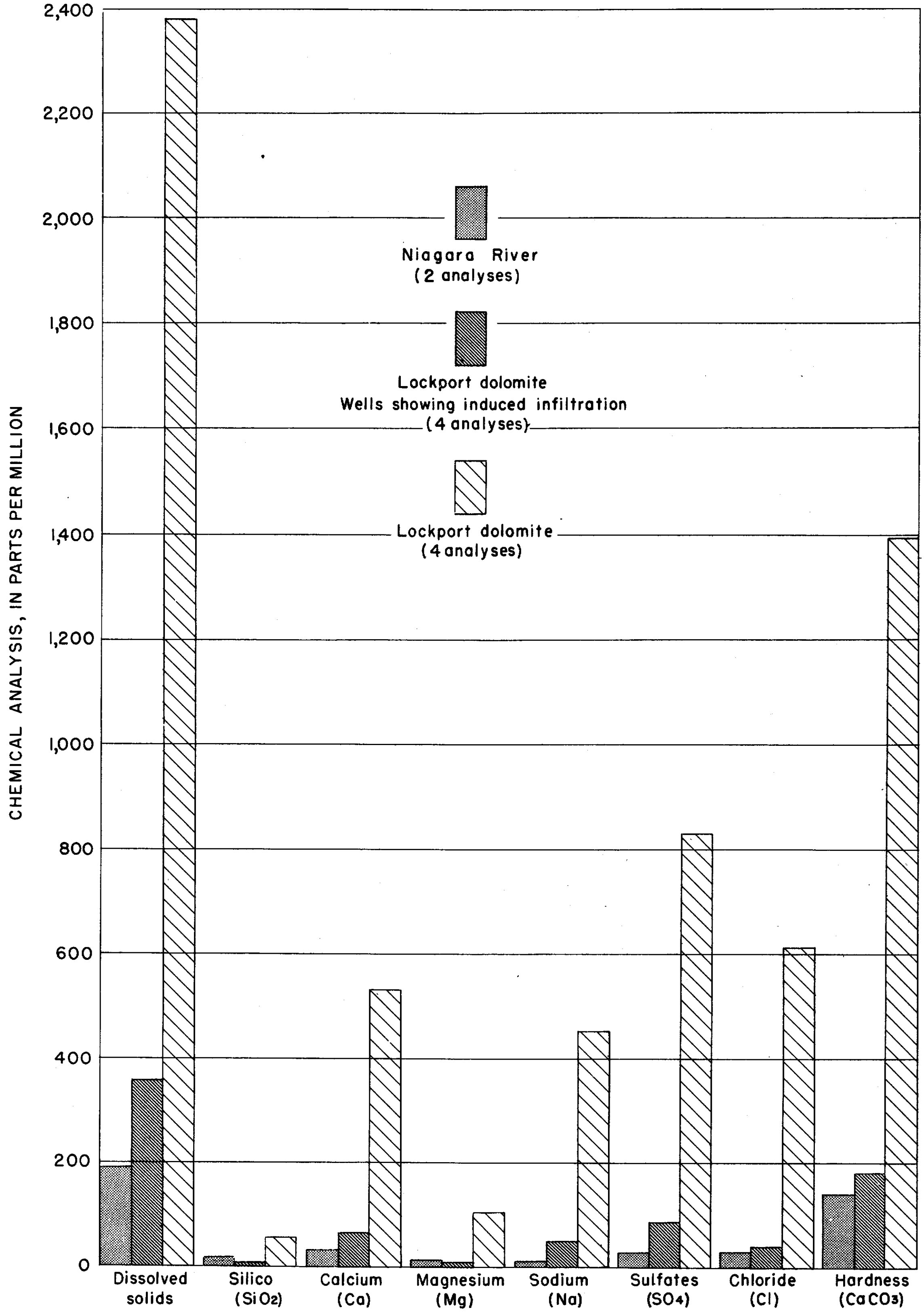

Figure 20.–Effect of induced infiltration on chemical quality of ground water in the Lockport dolomite.

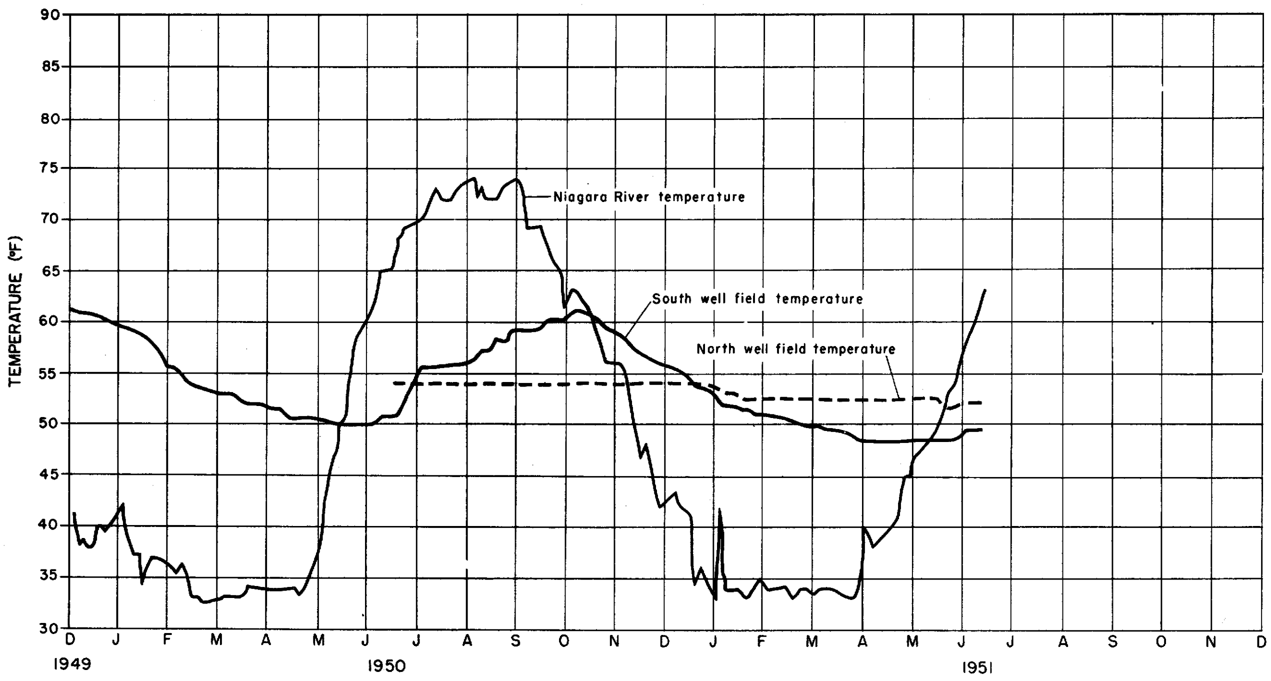

Figure 21. –Effect of induced infiltration on temperature of ground water.

wells soon become clogged losing their efficiency to absorb waste. The practice of drilling drainage wells is now discouraged by health officials.

Temperature

The temperature of water used for air-conditioning and cooling purposes is of prime importance. The temperature of surface water responds more readily to atmospheric conditions and may range from about 32 F to more than 78 F throughout a year. For this reason, ground water with its consistently moderate temperature is preferred to surface water for cooling. Of the 15 million gallons of ground water being pumped in the Buffalo-Niagara region about 80 percent is used for cooling and air conditioning. The temperature of ground water generally remains within a few degrees of the mean annual air temperature of the region, regardless of the season. The mean annual air temperature at Buffalo is 47.1 F. The average ground-water temperature as measured in the summer is 53 F. Only in shallow wells and in wells adjacent to the Niagara River and Lake Erie, where the ground-water gradient has been reversed inducing infiltraion, may the ground-water temperature be expected to vary appreciably during the year (see fig. 21).

Table 6.–Variation of the chemical quality of water from well (E1)

[East Aurora]

Year	Hardness (ppm)	Iron (ppm)	Chloride (ppm)
1931	236	-	4.8
1935	343	0.8	6.0
1938	620	1.7	430
1940	1,070	1.8	870

PUBLIC WATER SUPPLIES

Existing facilities supplying potable water to the public in the area operate at or beyond their rated capacities in most instances. Population served, average daily consumption, and rated capacities of public water-supply systems are shown in table 7.

City of Buffalo

Buffalo has adequate facilities to meet its immediate water needs. Its intake has a maximum capacity of 450 mgd and extends 1.5 miles into the Emerald channel of Lake Erie. An emergency intake obtains water from Niagara River. The Col. Francis G. Ward pumping station has a total capacity of 315 mgd. The Massachusetts Avenue pumping station is a standby unit having a capacity of 180 mgd. The two pumping stations, about one mile apart, are interconnected and with some modernization could be utilized at full capacity. The filtration plant has a rated capacity of 160 mgd with treatment consisting of chlorination, coagulation, and rapid sand filtration. A chemical analysis of the treated water is given in table 2. The distribution system serves the entire population of the city and supplies additional water to neighboring communities. Storage facilities have a total capacity of 27 million gallons.

Table 7.-Population served, average consumption and rated capacities of public water-supply systems

Public supplies	Source	Population served	Average daily consumption (mgd)	Rated capacity (mgd)
City of Buffalo	Lake Erie	577,400	130	160
City of Niagara Falls	Niagara River, Tonawanda Channel	90,900	43	40
Western New York Water Co.	Lake Erie	175,000	20	16
City of Lockport	Niagara River Tonawanda Channel	25,150	8	8
City of North Tonawanda	- do -	24,750	8	8
City of Tonawanda	- do -	14,600	6	12
Other public supplies	Ground water	-	1	-
	Small streams	-	11	-
Total		-	227	-

City of Niagara Falls

Niagara Falls has two water supply plants. Plant no. 1 obtains water from an intake extending about 1,500 ft into the Tonawanda Channel of the Niagara River. Plant no. 2 obtains water from the power canal.

Plant no. 1 has an intake capacity of about 90 mgd. Its present pumping capacity is 48 mgd, with a filter capacity of 32 mgd. At present this plant is being expanded and the intake will be extended into the Chippewa Channel of the Niagara River. By 1953 the expanded pumping and treatment plant will have a rated capacity of 90 mgd.

Plant no. 2 has a pumping capacity of 12 mgd and a filtration capacity of 8 mgd. Upon completion of the expansion program mentioned above, this plant will be abandoned.

Treatment of water consists of chlorination, coagulation, chlorine dioxide for taste and odor control, and rapid sand filtration.

The city of Niagara Falls supplies water to communities to the north on the Ontario lowland through a gravity supply system. Its storage facilities have a capacity of 750,000 gal.

Western New York Water Co.

The Western New York Water Co. is a private water company which supplies the suburban area of Buffalo with treated water. The present water facilities are overloaded. The pumping station and filtration plant are in Woodlawn, N. Y. (see pl. 1). Twin intakes, with submerged cribs under about 22 ft of water are approximately 4,000 ft offshore in Lake Erie. The pumping facilities have a capacity of 30 mgd. Treatment consists of chlorination, coagulation, activated carbon and rapid sand filtration. The rated capacity of the filtration plant is 16 mgd. Additional water is obtained from the city of Buffalo to meet peak demands beyond the capacity of the company system. This company furnishes treated water to water districts that operate and maintain their own distribution systems. The storage facilities have a capacity of 16 million gal.

City of Lockport

Lockport pumps raw water from the Tonawanda Channel of the Niagara River at North Tonawanda through 13 miles of pipeline to its filter plant in Lockport.

The pumping station in North Tonawanda has a capacity of 21 mgd. The filter plant has a rated capacity of 8 mgd. Water treatment consists of chlorination, coagulation, chlorine dioxide and activated carbon for taste control, and rapid sand filtration.

Storage facilities have a capacity of 500,000 gal.

City of Tonawanda

Tonawanda has two intakes, a 48-in. wooden pipe, a 24-in. cast iron pipe, extending into the Tonawanda Channel of the Niagara River.

The present steam-driven pumping station has a capacity of 17 mgd, but will be converted to electrically driven pumps and enlarged to a capacity of 20 mgd by late 1952. The filtration plant has a rated capacity of 12 mgd. Treatment consists of chlorination, ammoniation, coagulation, chlorine dioxide and activated carbon for taste control, and rapid sand filtration.

The storage facilities have a capacity of 500,000 gal.

City of North Tonawanda

North Tonawanda obtains water through two intakes, one wood the other steel, from the Tonawanda Channel of Niagara River. The pumping station has a total capacity of 30 mgd, of which the standby steam-driven units can pump 12 mgd.

Treatment at the filtration plant having a capacity of 8 mgd is the same as that for the city of Tonawanda. Storage facilities have a capacity of 900,000 gal.

PRESENT WATER USE

About 1,700 mgd are used for public and industrial supplies in the region. Industries are the largest

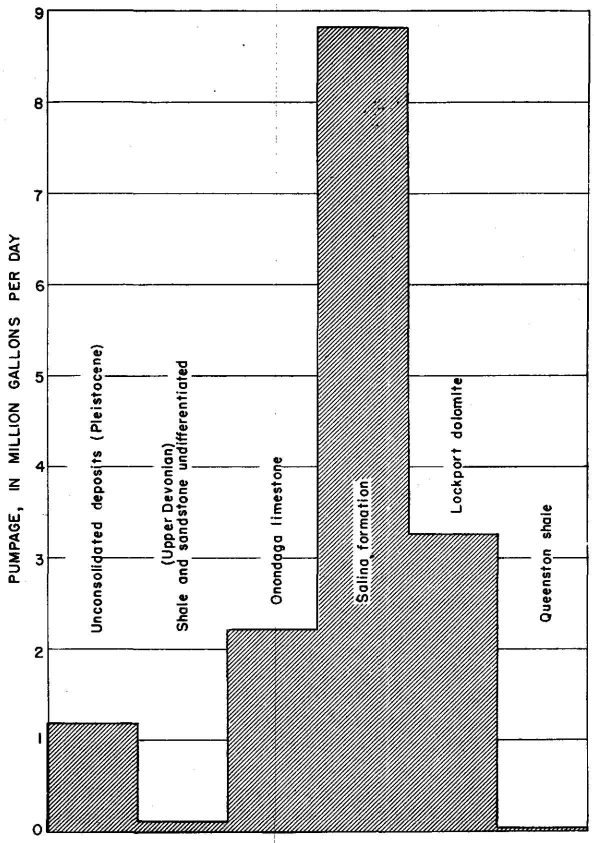

Figure 22. –Estimated average daily industrial and municipal ground-water pumpage.

users of both surface and ground water. Figure 22 shows the estimated quantity of ground water withdrawn from the various aquifers.

Public Supplies

Public water-supply systems deliver a total of 227 mgd (see table 7). Of this total, industry uses 90 mgd for process, sanitary, and cooling purposes. Industrial demand for cooling purposes increases considerably during the summer under normal production schedules. Available data on public supplies indicates that the demand fluctuates with the season from 30 percent below average in winter to 30 percent above average in summer.

Private Industrial Supplies

Industry withdraws more than 1,400 mgd from privately developed sources as indicated in the following table:

Source	Quantity withdrawn (mgd)
Upper Niagara River	1,115
Lake Erie	155
Buffalo River	125
Other streams	65
Ground water aquifers	15
Total	1,475

Water Power

The use of Niagara River water for hydraulic power production is limited by agreement between Canada and the United States. A treaty recently adopted by the two governments provides for an average diversion of about 130,000 cfs, to be shared equally between the two countries. The treaty is intended to provide for the preservation of the scenic beauty of Niagara Falls by stipulating a minimum flow of not less than 100,000 cfs during specified hours intended to correspond to day light during the tourist season and not less than 50,000 cfs at other times. The flow in New York State Barge Canal is used to develop power at Lockport.

Navigation

Diversions for navigation are made for the New York State Barge Canal and the Welland Ship Canal. The navigation season usually opens April 1 and closes December 1. The lower end of Tonawanda Creek has been deepened and the flow reversed to form the New York State Barge Canal. Operation of the Canal requires about 1,000 cfs, part of which is supplied by Tonawanda Creek and part by Niagara River. Less water passes through the canal during the nonnavigation season and it is drained for about one month each year for inspection and repairs.

An average maximum monthly flow of about 6,000 cfs is required to operate the Welland Canal. An average reduction in Niagara River flow of about 2 percent is produced by this diversion.

WATER LAWS

The development and use of water resources in New York State are under the supervision of the New York State Conservation Department and the New York State Department of Health.

The Water Power and Control Commission of the Conservation Department and the New York State Department of Public Works have jurisdiction over the construction of dams and certain other works which may change the regimen of a watercourse. The Water Power and Control Commission is empowered to allocate surface waters for public supply and requires submission of reports, surveys, and designs for all public supplies.

The New York State Department of Health, together with other state agencies, is responsible for maintaining surface waters so that they are not injurious to public health. Waste disposal systems must meet the department's requirements. Plans for such systems must be submitted prior to construction. Potable water-supply sources must meet the sanitary requirements of the Department of Helath. The Water Pollution Control Board of the Department of Health is in the process of assigning water-quality standards to all waters of New York State. Discharged waste must not pollute the receiving waters beyond the classification standards assigned by the board.

The Corps of Engineers has jurisdiction over navigable waterways. A permit for any project involving Lake Erie, Lake Ontario, the Niagara River, or other navigable watercourse except component parts of the New York State Barge Canal system must be obtained from the Corps of Engineers. The New York State Department of Public Works has jurisdiction over the Barge Canal.

Local governmental agencies in some instances have laws relating to the use of water resources under their jurisdiction.

New York State has no laws relating to the development of ground-water supplies for private or industrial use except on Long Island. However, the practice of discharging polluted or contaminated wastes underground is discouraged.

POTENTIALITIES

The Niagara Frontier can be supplied with substantial additional quantities of water for the usual cooling, processing, and domestic purposes.

The surface water sources of suitable quality are sufficient to meet future needs. Water not suitable for consumptive uses can be developed economically for cooling purposes. Added intake construction costs must be expected for the development of potable supplies by extending intake lines to the more desirable water in Lake Erie west of Buffalo, or into the Chippewa Channel of the Niagara River. The chemical quality of the water then available does not require costly treatment.

Damaging floods in the area are the exception. Flood protection works have been completed in the more critical areas.

Additional supplies of ground water are available from both the consolidated and unconsolidated rocks of the Buffalo-Niagara region. By inducing infiltration of water from the Niagara River and possibly from Lake Erie, into the ground-water aquifers, particularly the Salina formation and Lockport dolomite, still larger supplies can be developed. However, the high mineral content of water from the consolidated rocks severely limit its use to cooling and air-conditioning. For most municipalities and industrial uses, expensive treatment plants would be necessary. An advantage of inducing river infiltration is the dilution of this high mineral content of the ground water, although greater fluctuations in the temperature of the water may result.

With an adequate program of development and operation there is enough water to meet all future needs.

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