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GEOLOGICAL SURVEY

PRELIMINARY STUDY OF WASTEWATER MOVEMENT IN YELLOWSTONE NATIONAL PARK, WYOMING, OCTOBER 1976 THROUGH SEPTEMBER 1977

by Edward R. Cox

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PRELIMINARY STUDY OF WASTEWATER MOVEMENT IN YELLOWSTONE NATIONAL PARK, WYOMING, OCTOBER 1976 THROUGH SEPTEMBER 1977

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ABSTRACT

This report describes hydrologic data collected and some preliminary interpretations for a study by the U.S. Geological Survey in cooperation with the National Park Service to determine the effects on nearby lakes and streams of wastewater effluents that percolate from sewage lagoons at four sites in Yellowstone National Park. A network of observation wells has been established near the sites, and water-level and water-quality data have been collected.

Ground-water mounds have built up under the lagoons as percolation of effluents occurred. Percolating effluents mix with ground water and move down the hydraulic gradient in a direction generally perpendicular to the water-level contours. Chloride and sulfate concentrations and specific conductance of water in wells, and water-level contours indicate the most likely areas and directions of movement of percolating effluents. The most likely directions of movement are: Fishing Bridge, southwestward toward the Yellowstone River; Old Faithful, northward and northeastward toward Iron Spring Creek; Madison Junction, southeastward toward the Madison River; and Grant Village, northward toward Yellowstone Lake, northwestward, and westward.

INTRODUCTION

The National Park Service constructed new evaporation-percolation lagoons or enlarged old ones at four sewage wastewater treatment and disposal sites in Yellowstone National Park in 1974-75. A study was begun in July 1974 by the U.S. Geological Survey in cooperation with the National Park Service to establish a network of observation wells near the sites and to collect and analyze data to determine the effects on nearby lakes and streams of the wastewater effluents that percolate from the lagoons. A report summarizing the investigation from July 1974 through June 1975 was prepared and submitted to the National Park Service in 1976 as an administrative report for U.S. Government use only. A report summarizing the investigation from July 1975 through September 1976 was published as an open-file report in 1978.

The report herewith summarizes the investigation from October 1976 through September 1977. Hydrologic data and some preliminary interpretations based primarily on water-quality data for 1977 are given for the Fishing Bridge, Grant Village, Old Faithful, and Madison Junction sites in Yellowstone National Park (fig. 1). Some data collected before October 1976 and after September 1977 are included to facilitate the preliminary interpretations.

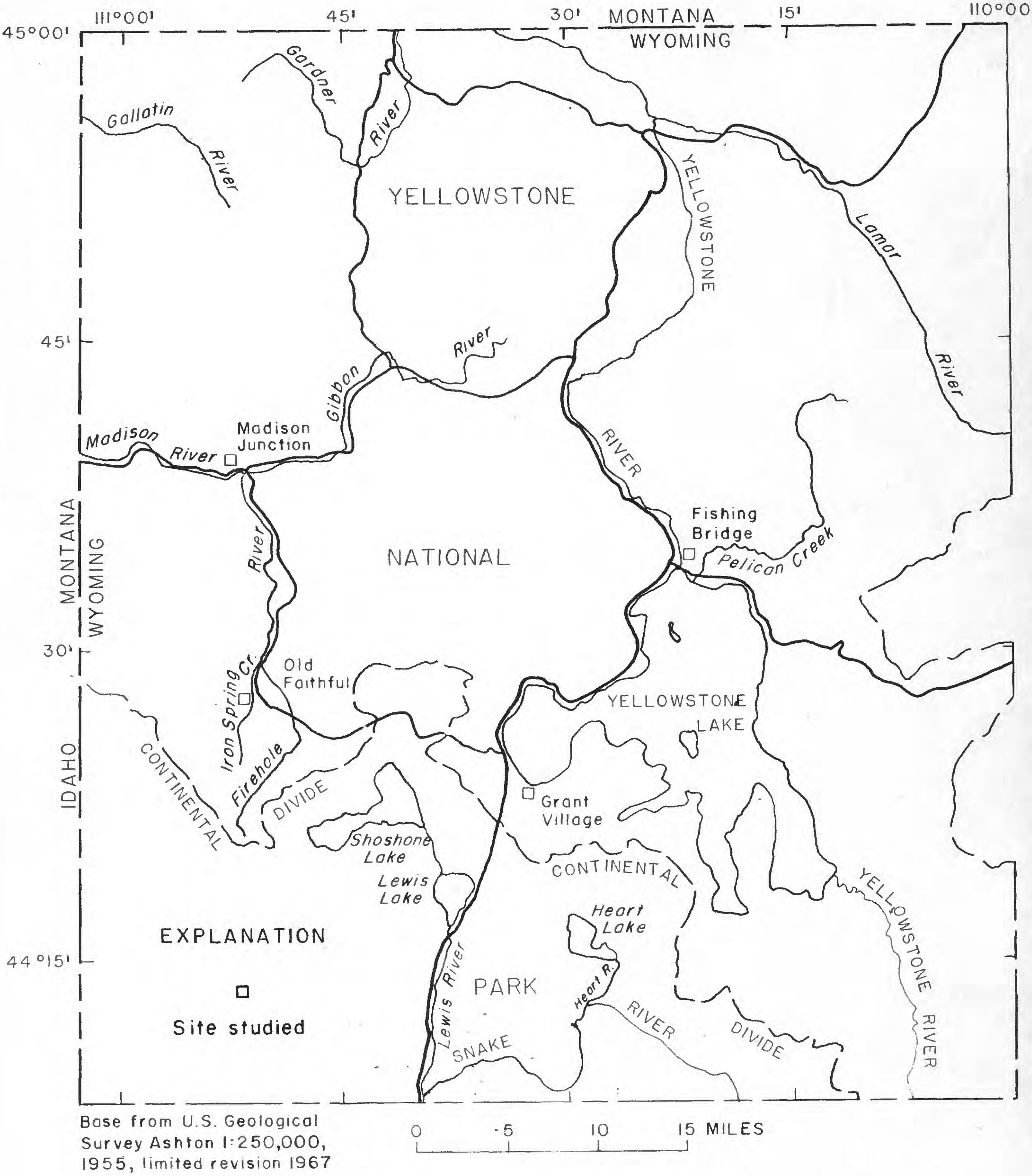

Figure 1.--Sites studied in Yellowstone National Park.

For those readers who prefer to use metric units rather than Inch-pound units, conversion factors for terms in this report are listed below:

Inch	X	25.4	= Millimeter
Foot (ft)	X	.3048	= Meter
Mile	X	1.609	= Kilometer

Forty-two test holes were bored with a power-driven auger near the sites in Yellowstone National Park in July and August 1974 to study the occurrence of ground water, the nature of the water-bearing materials, and the ground-water flow net. Three additional test holes were augered in July 1975. The test holes were completed as wells by installing 1.25-inch-diameter plastic casing. Selected intervals of the casing were perforated. One well was established by driving a well point and 1-inch-diameter steel pipe. Several wells have been destroyed, including four that were in the area of a new lagoon constructed at the Fishing Bridge site in 1976. The wells were developed by bailing, by pumping, and by blowing water from them with an air compressor. Water samples for chemical analysis were collected from the wells by bailing or by pumping.

Water levels in the wells were measured periodically. Altitudes of the wells were established by spirit leveling. Water-level contour maps were made for each site to show the configuration of the water level.

Some of the water-level measuring and some of the water-sample collecting were done by National Park Service personnel.

Abbreviations for wells are used in the text, illustrations, and tables of this report. The first two letters are abbreviations of place names near the sites studied--FB, Fishing Bridge; GV, Grant Village; OF, Old Faithful; and MJ, Madison Junction. The number is a sequential number of the wells near a particular site. A letter following the number indicates a satellite well that is located near the well having the same number. For example, well GV 3A is a well about 10 feet from well GV 3, which is the third well near Grant Village.

The Geological Survey uses a 15-digit number to identify the location of hydrologic data-collection sites. Such numbers have been assigned to sites in this report. The number is based on the universal system of latitude and longitude and a sequential number. The first six digits represent degrees, minutes, and seconds of north latitude; the next seven digits are degrees, minutes, and seconds of west longitude; the last two digits are a sequential number of sites having the same latitude and longitude.

The latitudes and longitudes were determined by using U.S. Geological Survey 1:62,500-scale topographic maps that were prepared before most of the facilities at the wastewater treatment and disposal sites were constructed. The data-collection sites have been located on larger scale maps that show the facilities, but the locations on the larger scale maps do not necessarily agree with the latitudes and longitudes determined from the topographic maps.

Hydrologic data for this study are tabulated at the back of this report. Records of wells are shown in table 1. Water levels in wells in 1976-77 are shown in table 2. Relatively complete chemical analyses of water from wells and effluents are shown in table 3. Partial chemical analyses in 1977 of water from wells are shown in table 4. Chemical constituents are expressed in milligrams per liter (mg/L) or micrograms per liter (μg/L). Temperature is measured in degrees Celsius (°C). Specific conductance is expressed in micromhos per centimeter at 25°C (μmho). Water levels in wells in 1974-75 and chemical analyses of water from selected streams in 1975-76 are listed in a previous report (Cox, 1978, tables 3-5).

MOVEMENT OF WATER AT SITES STUDIED

The Fishing Bridge and Grant Village sites did not contain sewage lagoons prior to July 1975. Data collected before that time at these sites, therefore, represent natural conditions that are useful for comparison with data collected after the lagoons were used. The Old Faithful and Madison Junction sites contained sewage lagoons prior to 1974, and data were not collected before the lagoons were used.

Ground-water mounds have built up under the lagoons as percolation of effluents occurred, and ground water probably moves short distances in all directions from the lagoons. The movement of effluents percolating from the lagoons probably is chiefly vertical in the unsaturated zone, and little lateral dispersion commonly takes place above the water table. In the saturated zone below the water table, however, lateral dispersion predominates, and the effluents move toward areas of ground-water discharge (LeGrand, 1965, p. 87-88). The effluents mix with ground water and form plumes of water that contain chemical constituents from the effluents. Each plume tends to move down the hydraulic gradient in a direction generally perpendicular to the water-level contours. The plume may either spread out as it moves through the aquifer owing to dispersion, or it may converge owing to dilution by water outside the plume.

Chemical constituents in the plume travel at different velocities. Dissolved chloride, sulfate, and nitrate tend to disperse and move faster than constituents, such as phosphorus, that may be adsorbed on the surfaces of clay, silt, and sand. Chloride, sulfate, and specific conductance are used in this report for preliminary interpretations on movement of percolating effluents. Specific conductance, which is a measure of the ability of water to conduct an electrical current, is related to the concentration of dissolved constituents.

Fishing Bridge

The Fishing Bridge site is about a mile northeast of the community of Fishing Bridge on deposits of sand, silt, clay, and gravel that partly fill the basin containing Yellowstone Lake. Wells FB 1-12 were augered and well FB 13 was driven in the vicinity of the Fishing Bridge site (fig. 2).

Two lagoons were used for disposal of effluent beginning about May 19, 1976. An additional lagoon was built north of the westernmost of the original two lagoons (fig. 2) in September and October 1976. The easternmost lagoon was used from mid-May through October 1977, and the northernmost lagoon was used from mid-June through October 1977. The westernmost lagoon was not used in 1977.

The water-level contours shown in figure 2 indicate the configuration of the water level on September 24, 1977, in the vicinity of the Fishing Bridge site. The most likely direction of movement of percolating effluent is southwestward in the area within the heavy dashed lines in figure 2.

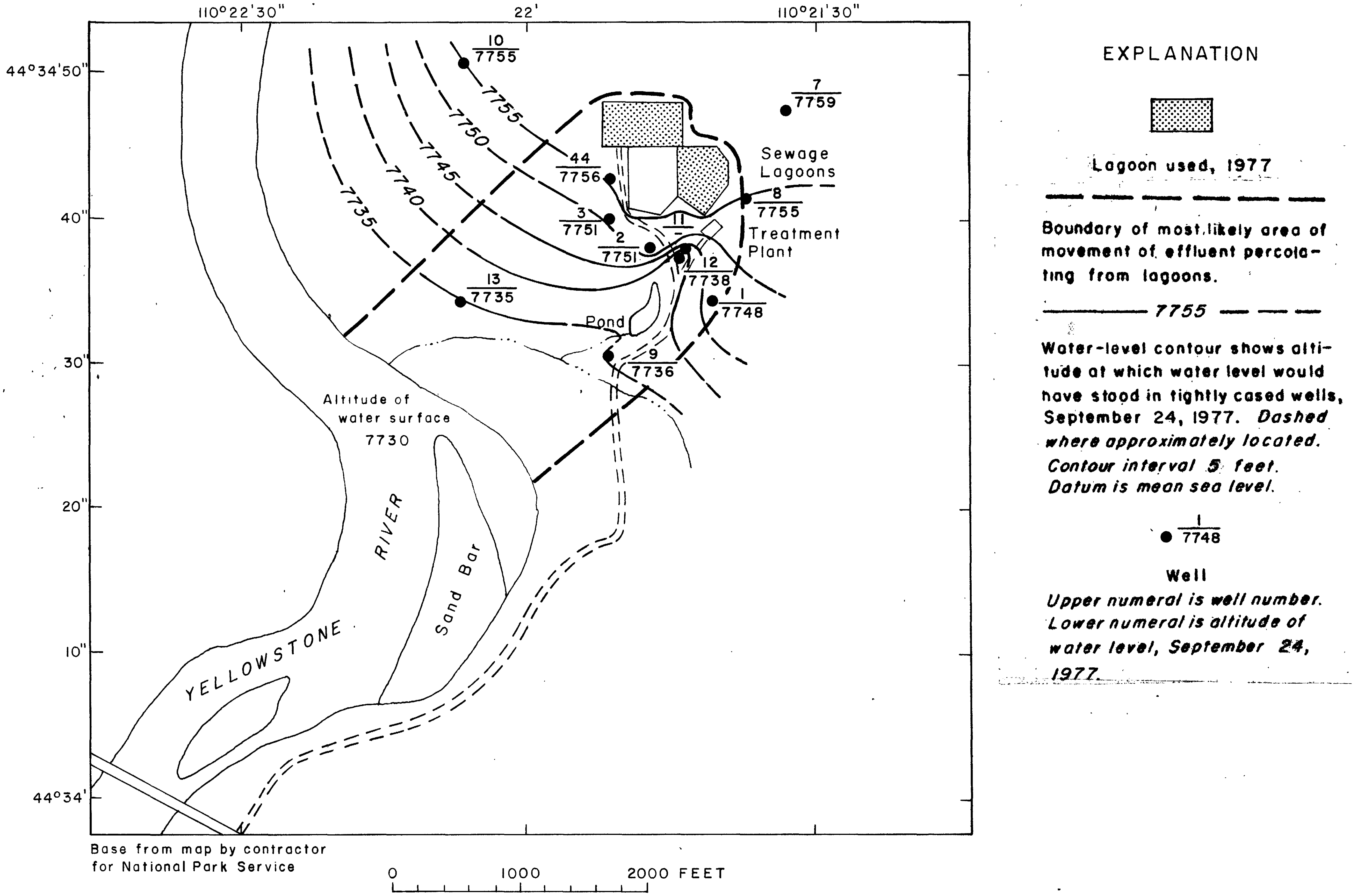

Figure 2.--Well locations and water-level contours near the Fishing Bridge sewage lagoons.

A ground-water mound built up in 1976 under and near the Fishing Bridge sewage lagoons, as indicated by changes in water levels in wells from 1975 to 1976. Water levels in wells unaffected by percolation from the lagoons were about the same during a few days of a month in 1976 as in 1975, and relatively large rises in water levels in other wells were the result of the ground-water mound near the lagoons. The rises in water levels in wells near the lagoons from June 1975 to June 1976 and from August 1975 to August 1976 were shown in a previous report (Cox, 1978, figs. 3 and 4). Most of the rises in water levels were caused by percolation of effluent from the lagoons, and contoured rises indicate the approximate shape of the mound in June 1976 and in August 1976. At both times, the mound was elongated southwest of the lagoons, which is the most likely direction of movement of effluent indicated by the configuration of the water level (fig. 2). The shape of the mound in 1977 cannot be shown in the same way because water levels were generally a few feet lower than in previous years as a result of less-than-normal precipitation and natural recharge.

The direction and extent of movement of percolating effluent is indicated by changes in chemical constituents in water in wells since the lagoons have been used. Most of the wells near the Fishing Bridge lagoons were sampled in September 1977, and the chloride and sulfate concentrations and the specific conductances are shown in figures 3, 4, and 5, respectively. Most of the wells shown on the three maps were sampled in 1974 or 1975 before the lagoons were used. Chloride concentrations were less than 2 mg/L, except in well FB 3, which had a concentration of 4.5 mg/L. Sulfate concentrations were less than 8 mg/L, except in well FB 3, which had a concentration of 10 mg/L. Specific conductances were less than 100 µmho, except in well FB 3, which had a value of 140 µmho.

Although the contours shown in figures 3, 4, and 5 are from September 1977 data, they approximate the areas of change in chemical constituents since the lagoons have been used and, therefore, indicate the direction and extent of movement of percolating effluent. The contours are elongated southwest of the lagoons, which is the most likely direction of movement of the effluent indicated by the configuration of the water level (fig. 2). The elongaged contours around the pond near well FB 9 probably resulted from chemical constituents in effluent that was discharged into the pond in August and September 1976.

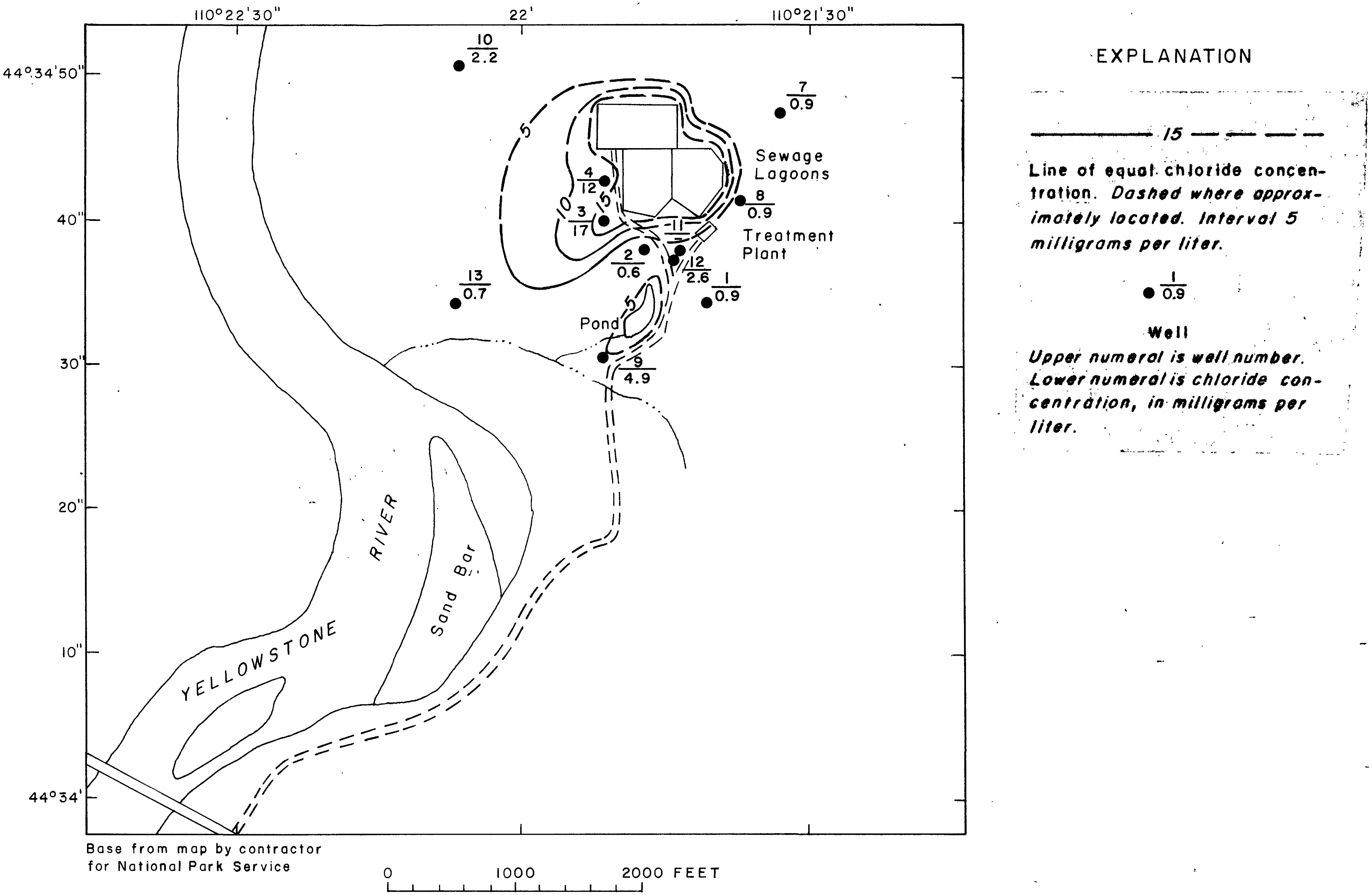

Figure 3.--Chloride concentration, September 1977, of water in wells near the Fishing Bridge sewage lagoons.

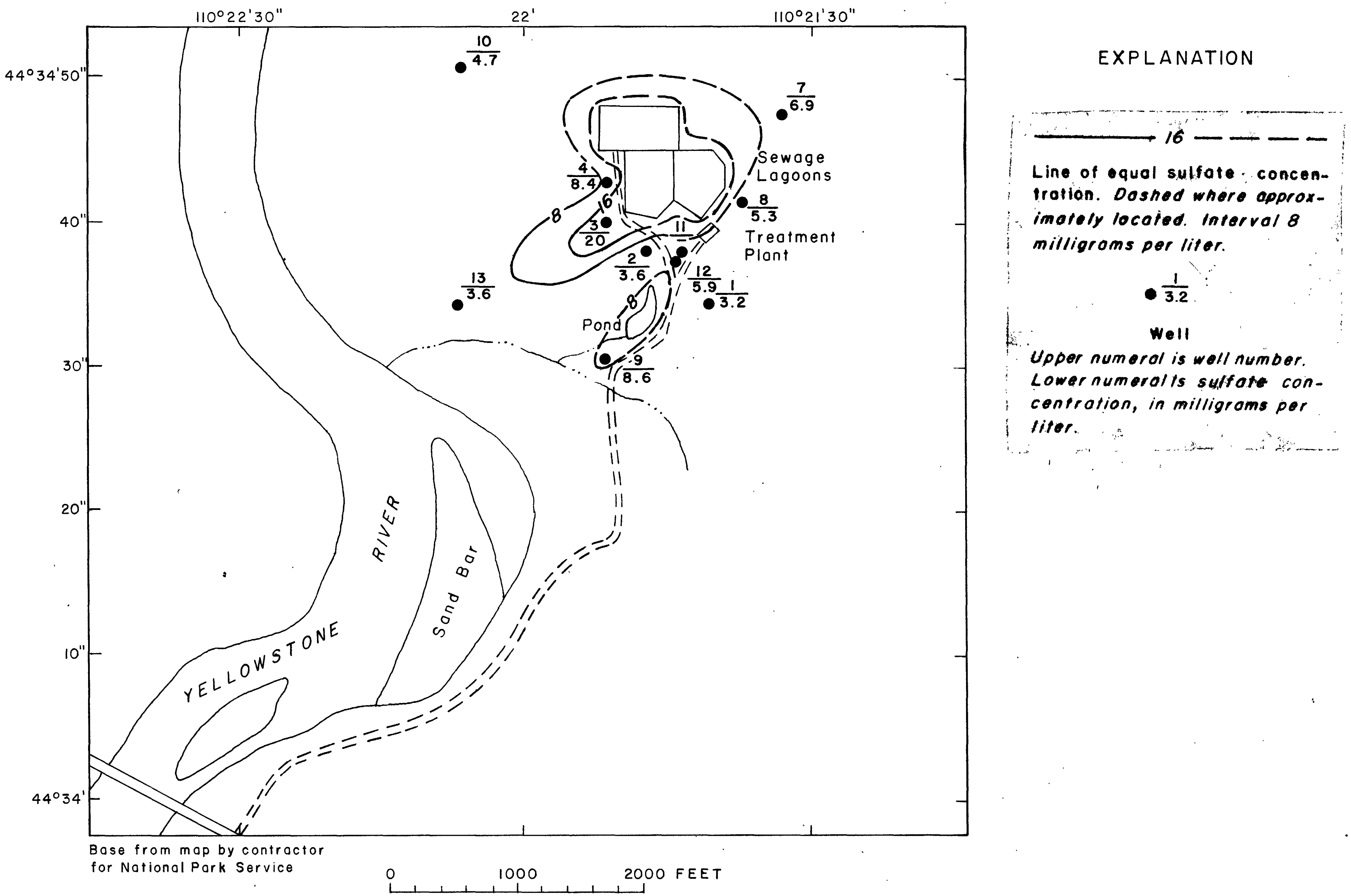

Figure 4.--Sulfate concentration, September 1977, of water in wells near the Fishing Bridge sewage lagoons.

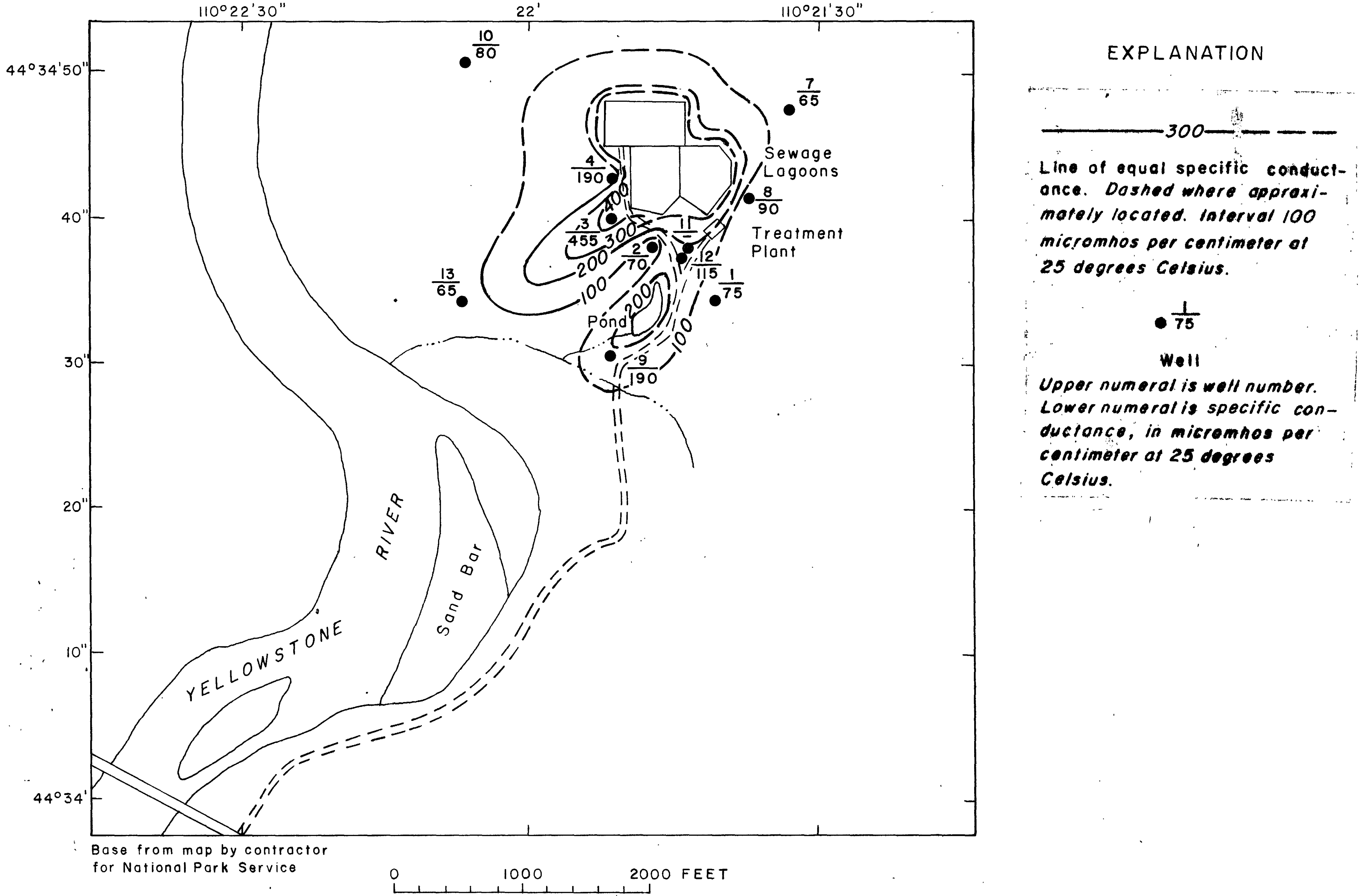

Figure 5.--Specific conductance, September 1977, of water in wells near the Fishing Bridge sewage lagoons.

Grant Village

The Grant Village site is about a mile east of Grant Village on a terrace about 100 feet above Yellowstone Lake. The site is located on deposits of sand, silt, clay, and gravel that partly fill the basin that contains Yellowstone Lake. Wells GV 1-10A were augered in the vicinity of the Grant Village site (fig. 6).

The northern lagoon of the two at the site was used for disposal of effluent in September and October 1975 and from about mid-May through October 1976. The southern lagoon was not used in 1975-76. The two lagoons were used alternately in 1977. The southern lagoon was used for disposal of effluent from May 18 to June 25, and from September 4 to October 20, 1977. The northern lagoon was used from June 25 to September 4, 1977.

The water-level contours shown in figure 6 indicate the configuration of the water level on September 21, 1977, in the vicinity of the Grant Village site. The most likely direction of movement of percolating effluent is generally between north and west in the area within the heavy dashed lines in figure 6.

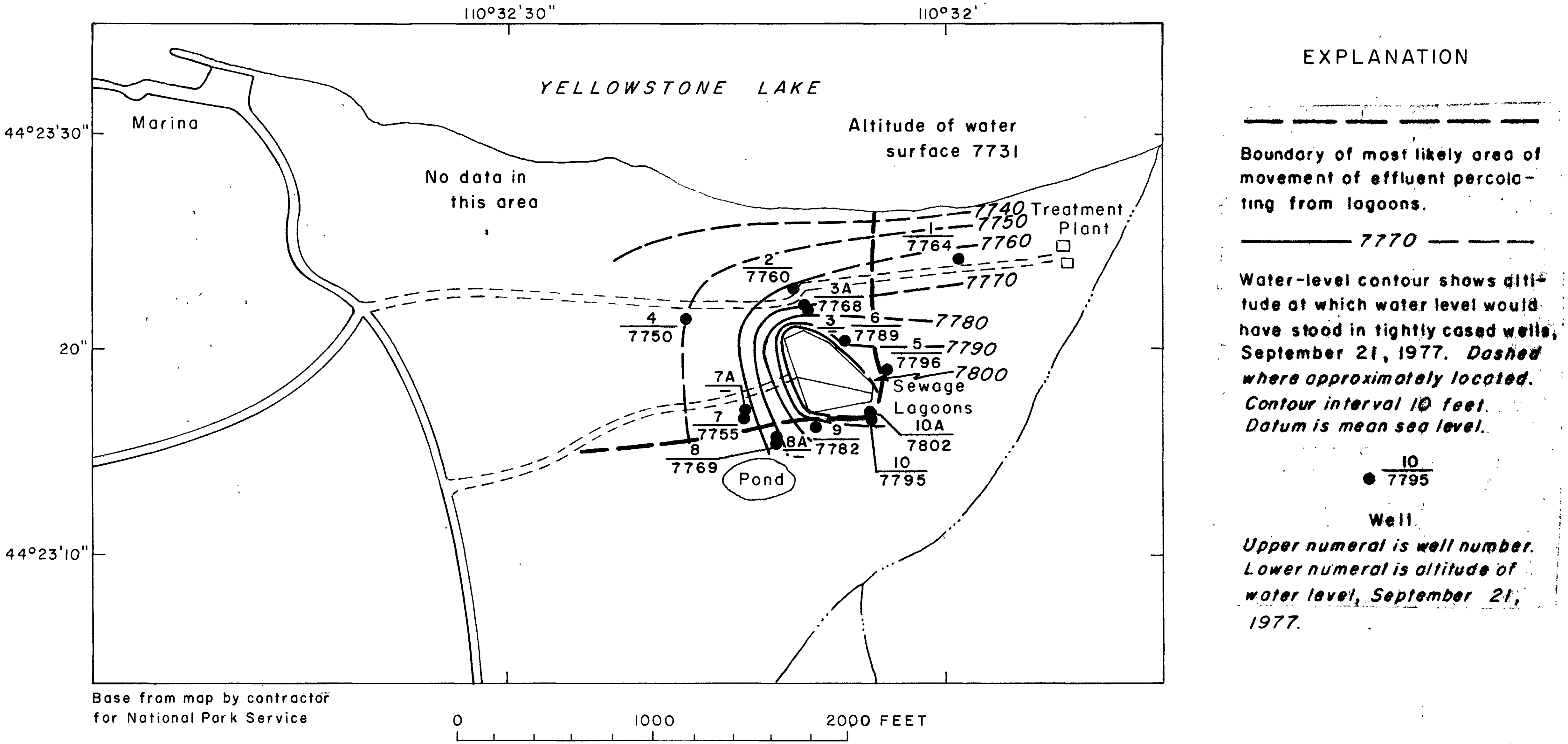

Figure 6.--Well locations and water-level contours near the Grant Village sewage lagoons.

A ground-water mound built up in 1976 under and near the northern lagoon at the Grant Village site, as indicated by changes in water levels in wells from 1975 to 1976. The rises in water levels in wells near the lagoon from July 1975 to July 1976, from September 1975 to September 1976, and from October 1975 to October 1976 were shown in a previous report (Cox, 1978, figs. 8-10). Most of the rises in water levels were caused by percolation of effluent from the northern lagoon, and contoured rises indicate the approximate shape of the mound in July 1976, in September 1976, and in October 1976. The mound was elongated almost north in July 1976, generally northwest in September 1976, and generally west in October 1976. The mound, therefore, was elongated at all three times within the most likely area of movement of effluent indicated by the configuration of the water level (fig. 6). The shape of the mound in 1977 cannot be shown similarly because water levels were generally a foot or two lower than in previous years as a result of less-than-normal precipitation and natural recharge.

The direction and extent of movement of percolating effluent is indicated by changes in chemical constituents in water in wells since the lagoons have been used. Most of the wells near the Grant Village lagoons were sampled in September 1977, and the chloride and sulfate concentrations and the specific conductances are shown in figures 7, 8, and 9 respectively. Most of the wells shown on the three maps were sampled in 1974 or 1975 before the lagoons were used. Chloride concentrations were less than 2 mg/L, except for concentrations of 3.1 mg/L in well GV 2 and 3.2 mg/L in well GV 9. Sulfate concentrations were less than 5 mg/L, except for a concentration of 5.0 mg/L in well GV 5. Specific conductances were less than 150 μmho, except for values of 280 μmho in well GV 1 and 195 μmho in well GV 5.

The contours in figures 7, 8, and 9 indicate the direction and extent of movement of percolating effluent in September 1977. The contours are elongated generally westward, which is within the most likely area of movement indicated by the configuration of the water level (fig. 6).

Similar contour maps were made using chloride and sulfate concentrations and specific conductances from samples collected July-October 1976 (figs. 10, 11, and 12). These contours are elongated generally northwestward, which is within the most likely area of movement indicated by the configuration of the water level (fig. 6).

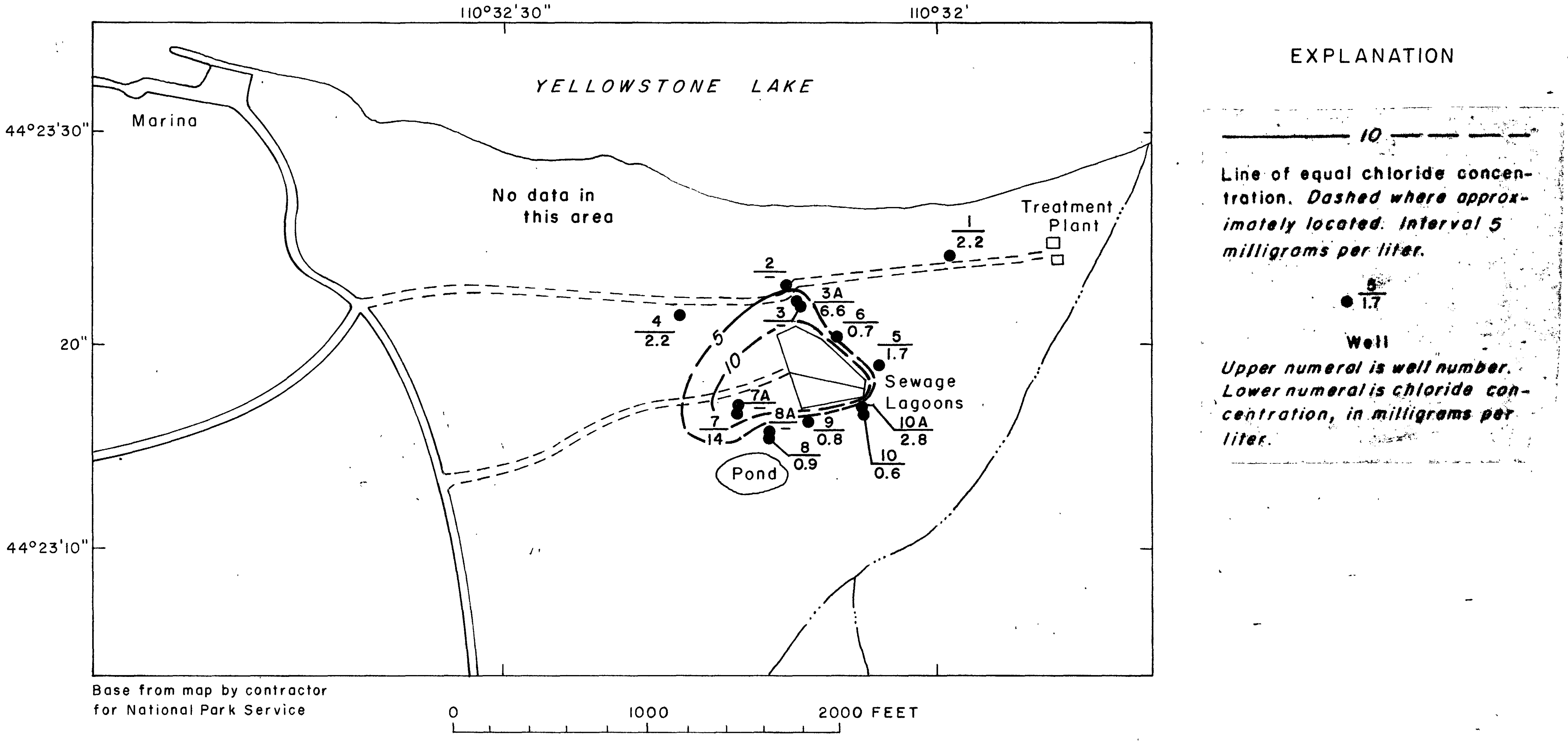

Figure 7.--Chloride concentration, September 1977, of water in wells near the Grant Village sewage lagoons.

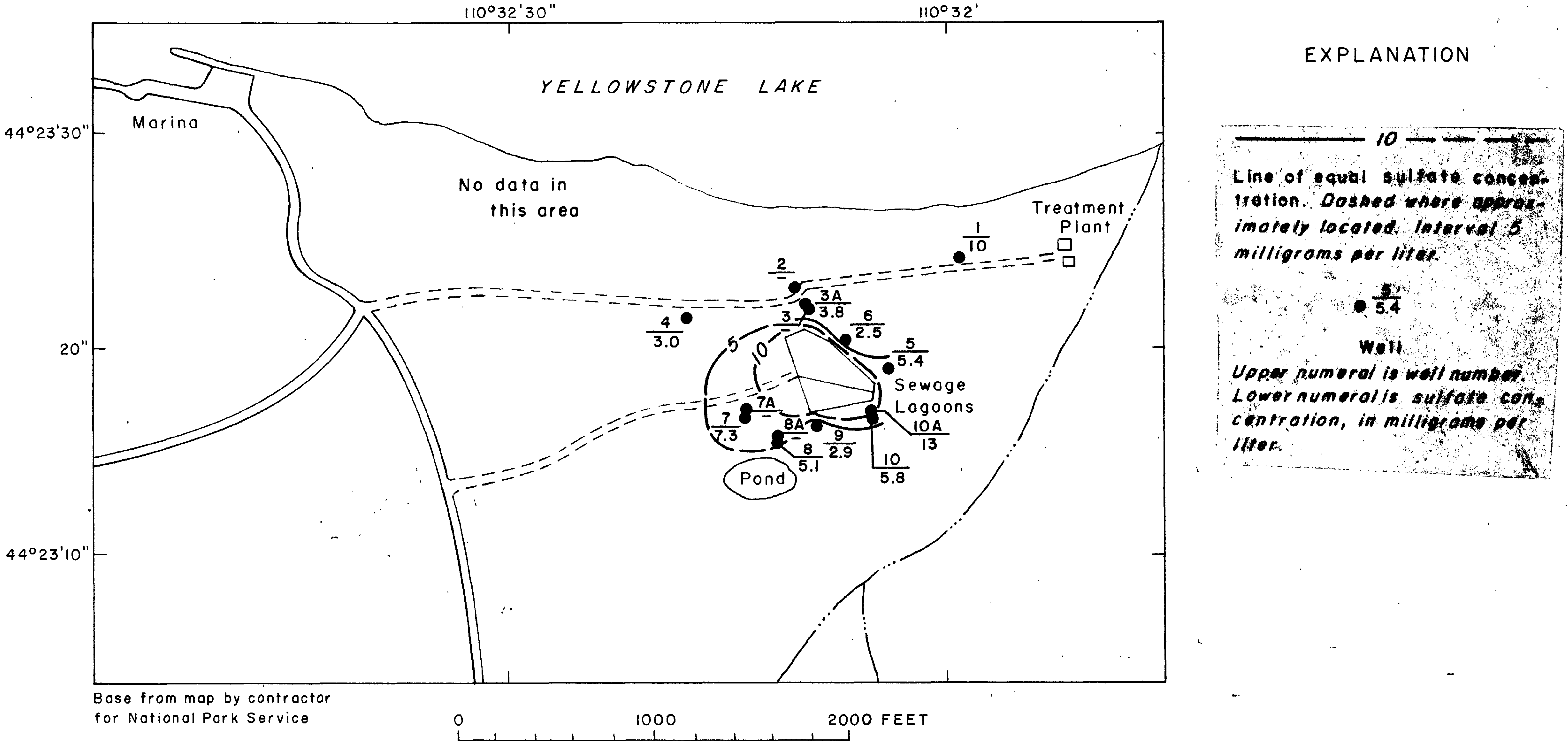

Figure 8.--Sulfate concentration, September 1977, of water in wells near the Grant Village sewage lagoons.

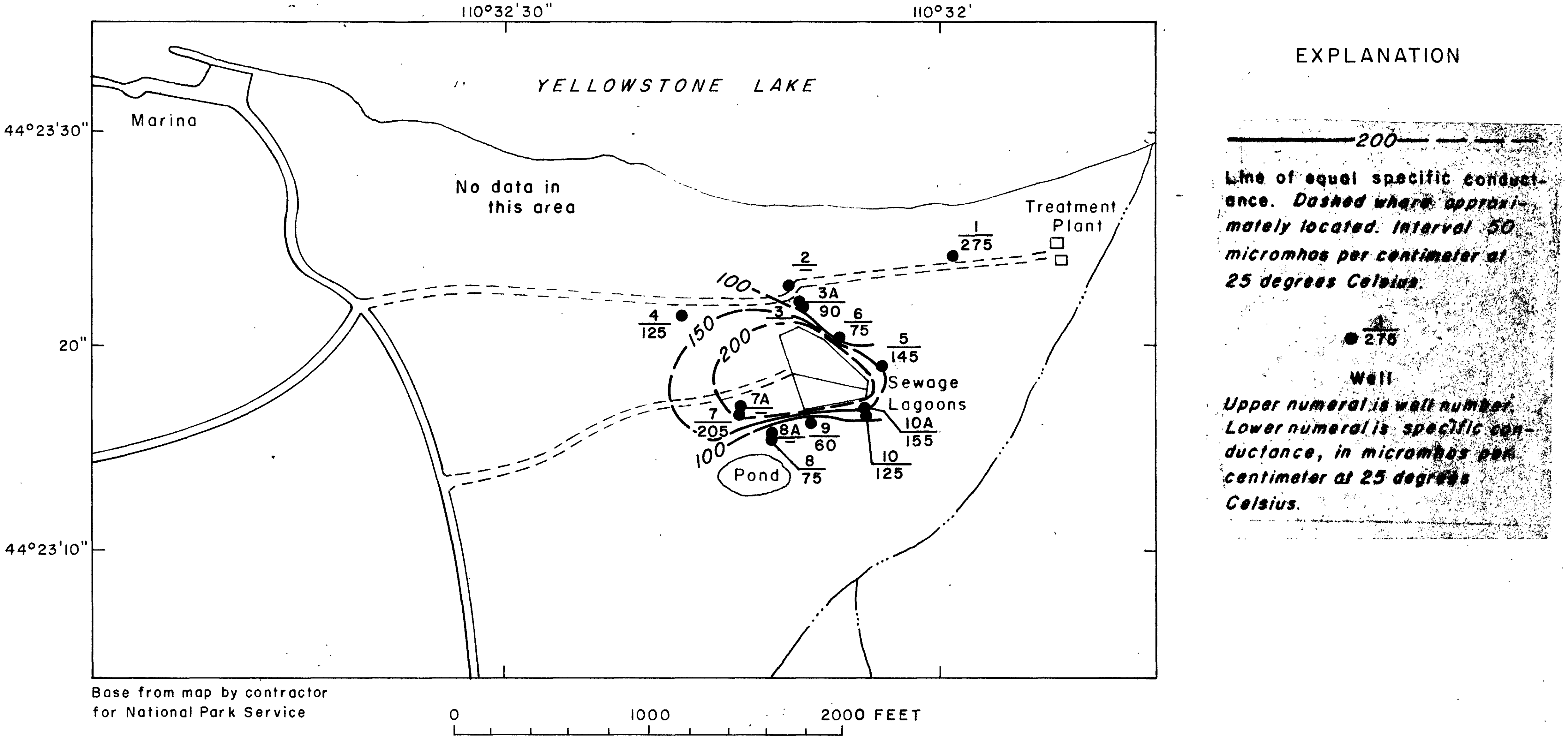

Figure 9.--Specific conductance, September 1977, of water in wells near the Grant Village sewage lagoons.

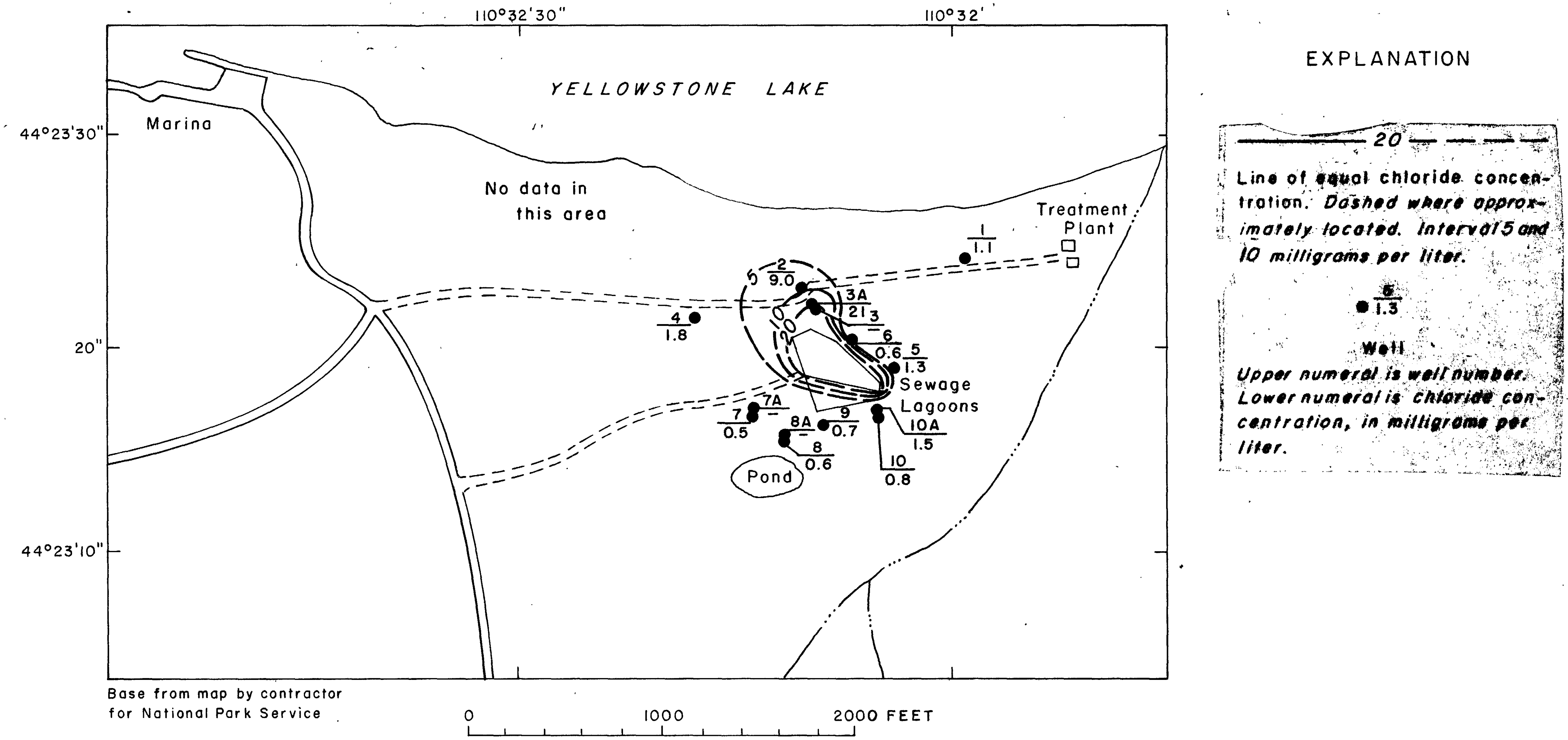

Figure 10.--Chloride concentration, July-October 1976, of water in wells near the Grant Village sewage lagoons.

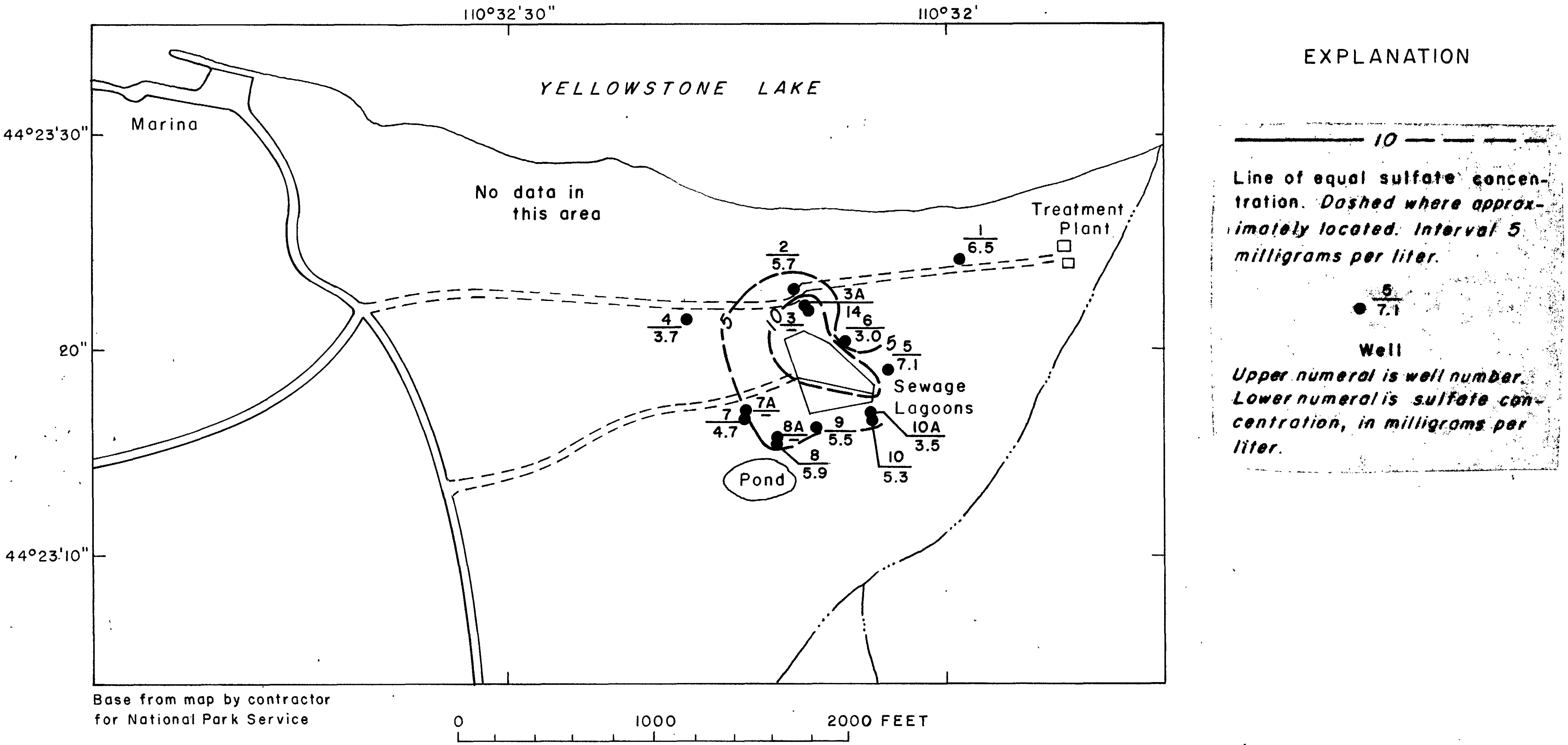

Figure 11.--Sulfate concentration, July-October 1976, of water in wells near the Grant Village sewage lagoons

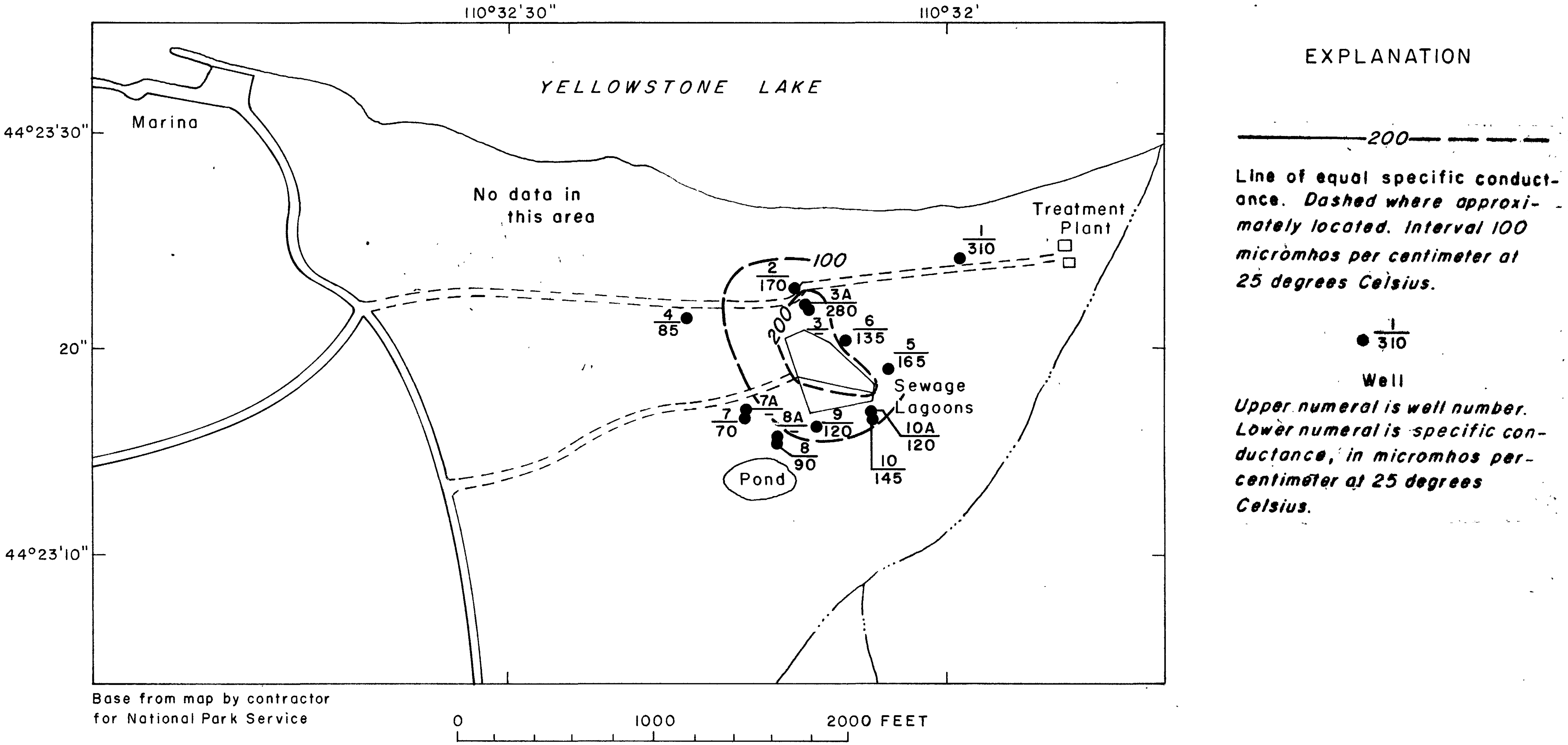

Figure 12.--Specific conductance, July-October 1976, of water in wells near the Grant Village sewage lagoons.

The northwestward movement of percolating effluent suggested by the 1976 data and the westward movement suggested by the September 1977 data may be due to the scheduling of the use of the lagoons. The northern lagoon was used in 1976, and the two lagoons were used alternately in 1977. However, the effluent may change directions as percolation occurs. The ground-water mound that built up in 1976 was elongated in a dircetion almost north in July, generally northwest in September, and generally west in October (Cox, 1978, figs. 8-10). Percolating effluent, therefore, may move northward initially, then northwestward, and finally westward as percolation continues.

Old Faithful

The Old Faithful site is about a mile west of the community of Old Faithful on kame-terrace deposits of sand and gravel about 40 feet above Iron Spring Creek. Wells OF 1-7B were augered near the Old Faithful site (fig. 13). The lagoons have been used alternately for disposal of effluent. Water levels in wells fluctuate as the lagoons are used and indicate that ground-water mounds build up under the lagoons being used.

The water-level contours shown in figure 13 indicate the configuration of the water level on September 27, 1977, in the vicinity of the Old Faithful site. The water level in well OF 1 was not used in constructing the contours because the well apparently taps a different aquifer with a considerably higher water level than the other wells. The probable path of movement of effluent percolating from the lagoon used in 1977 is within the area between the heavy dashed lines in figure 13. The configuration of the water level suggests that effluent percolating from the lagoon in 1977 probably moved northward and northeastward toward Iron Spring Creek and may have moved northwestward toward a swampy area between Iron Spring Creek and West Fork northwest of the lagoons. Effluent probably moved neither southward nor southwestward because of steep hills and bluffs that were formed by rhyolite flows and because of the aquifer with a higher water level.

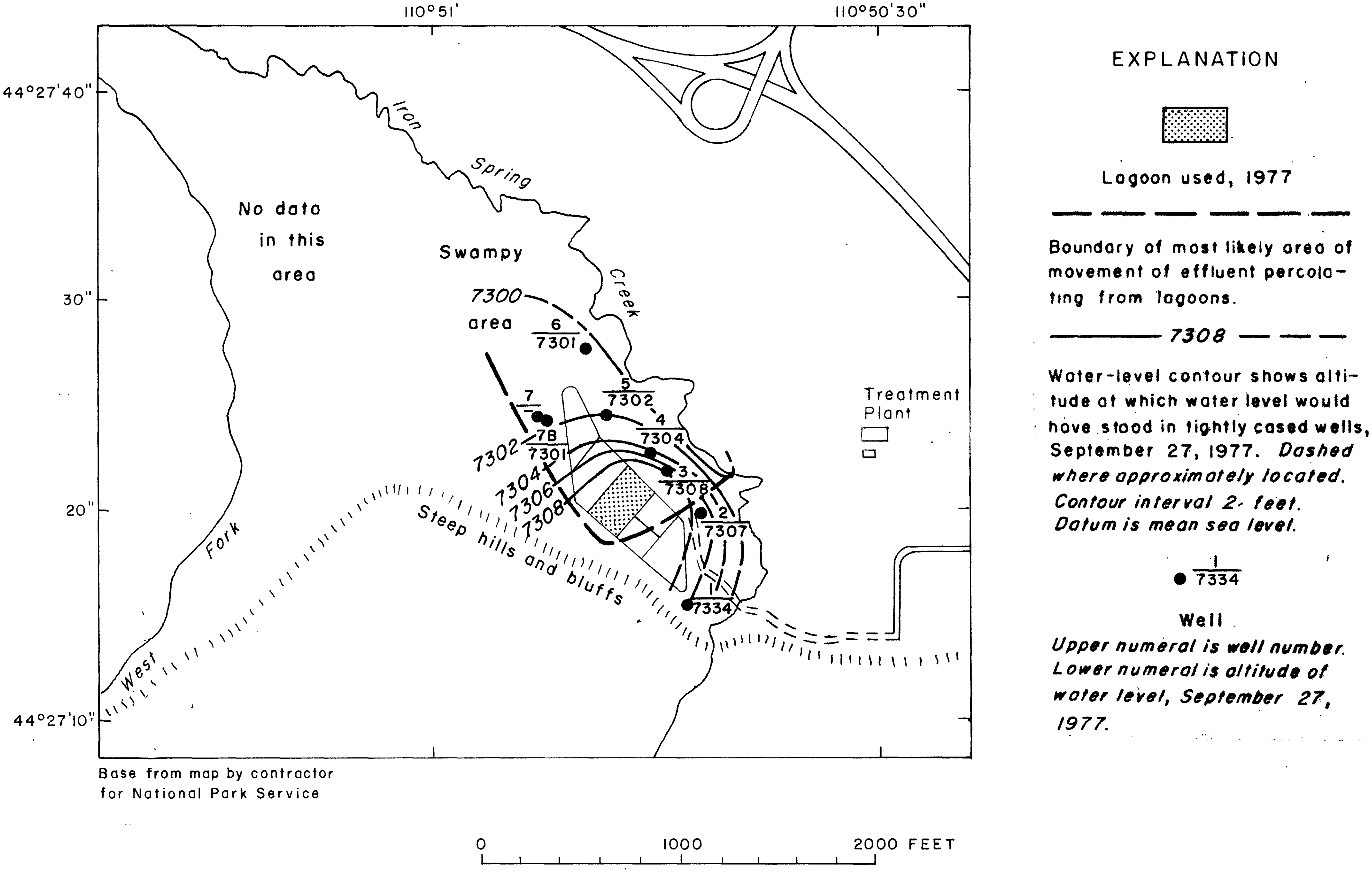

Figure 13.--Well locations and water-level contours near the Old Faithful sewage lagoons.

The direction of movement of percolating effluent is also indicated by chemical constituents in water in wells near the lagoons. Wells OF 1-6 were sampled in September 1977. The chloride concentrations ranged from 43 to 50 mg/L in wells OF 3-6 and were 3.4 and 12 mg/L in wells OF 1 and OF 2, respectively. Specific conductances ranged from 330 to 435 μmho in wells OF 3-6 and were less than 200 μmho in wells OF 1 and OF 2. The sulfate concentrations do not form a discernible pattern. The chloride concentrations and the specific conductances of water in wells OF 3-6 indicate that effluent from the lagoon used in 1977 percolated northward and northeastward to these wells.

Madison Junction

The Madison Junction site is about 0.75 mile west of Madison Junction on a terrace about 50 feet above the Madison River. The site is located on alluvial deposits of sand, silt, clay, and gravel. Colluvial deposits of cobbles and boulders are present near the site. Wells MJ 1-7 were augered near the Madison Junction site (fig. 14). The lagoons are used continuously for the storage of effluent.

The water-level contours shown in figure 14 indicate the configuration of the water level September 28, 1977, in the vicinity of the Madison Junction site. The most likely direction of movement of percolating effluent is southeastward in the area within the heavy dashed lines in figure 14.

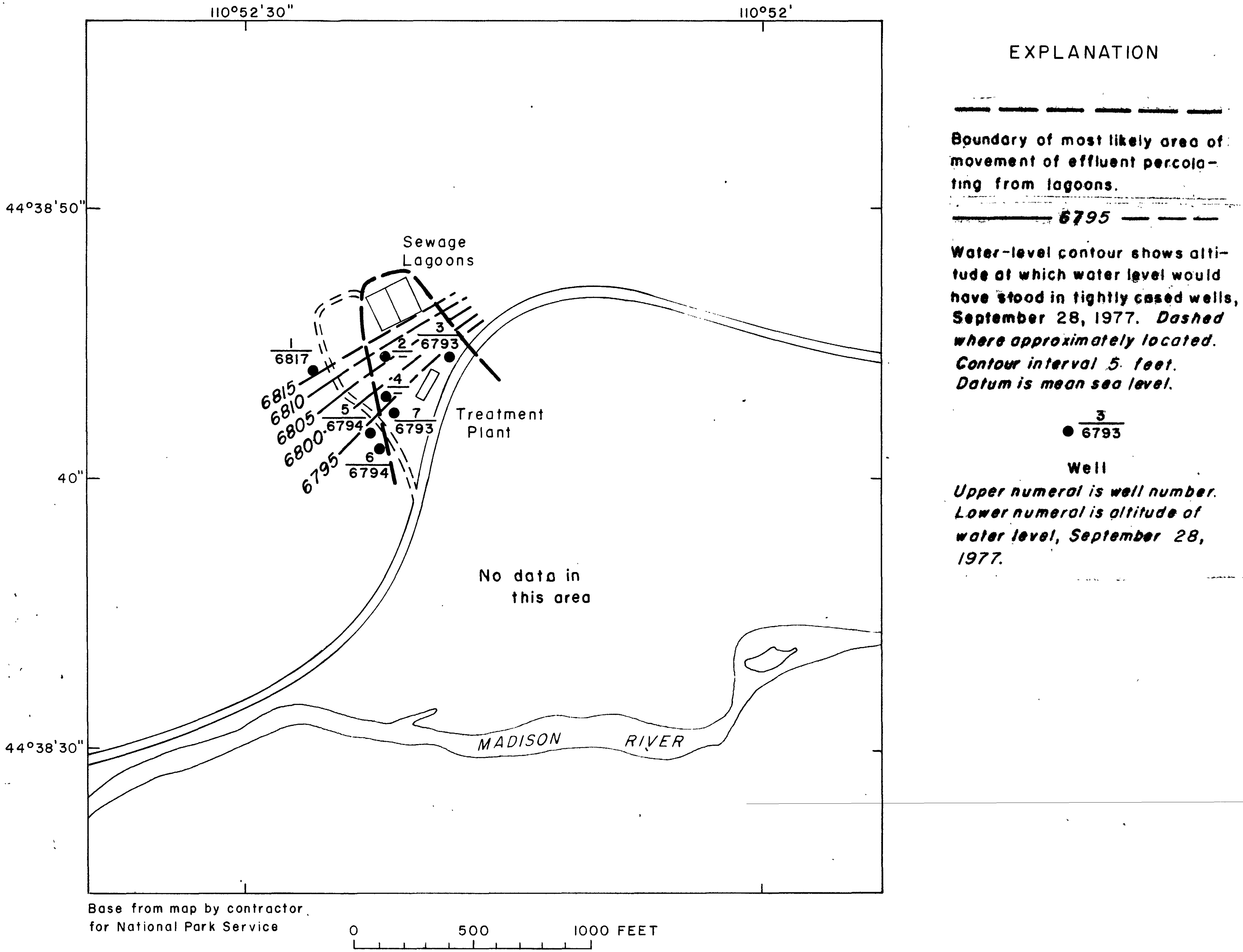

Figure 14.--Well locations and water-level contours near the Madison Junction sewage lagoons.

The direction of movement of percolating effluent is also indicated by the chloride and sulfate concentrations in water in wells near the lagoons. Wells MJ 1, MJ 3, MJ 5, MJ 6, and MJ 7 were sampled in September 1977. The chloride concentrations were 15 and 19 mg/L in wells MJ 7 and MJ 3, respectively, and were less than 3 mg/L in wells MJ 1, MJ 5, and MJ 6. The sulfate concentrations were also higher in wells MJ 3 and MJ 7 than in wells MJ 1, MJ 5, and MJ 6. The specific conductances of water in the wells ranged from 180 to 245 μmho and do not form a discernible pattern. The chloride and sulfate concentrations in wells MJ 3 and MJ 7 suggest that effluent from the lagoons percolates southeastward to these wells, which is the most likely direction of movement indicated by the configuration of the water level (fig. 14).

FUTURE WORK

The collection of hydrologic data will continue in fiscal year 1978 (starting October 1977). Water samples from the wells and nearby streams will be collected and analyzed. Water levels in the wells will be measured periodically.

SUMMARY AND CONCLUSIONS

Ground-water mounds have built up under the lagoons as percolation of effluents occurred. Percolating effluents mix with ground water and move down the hydraulic gradient in a direction generally perpendicular to the water-level contours.

Chloride and sulfate concentrations and specific conductance of water in the wells, the shape of ground-water mounds, and water-level contours indicate the most likely areas and directions of movement of percolating effluents. The most likely directions of movement are: Fishing Bridge, southwestward toward the Yellowstone River; Old Faithful, northward and northeastward toward Iron Spring Creek; Madison Junction, southeastward toward the Madison River; and Grant Village, northward toward Yellowstone Lake, northwestward, and westward.

REFERENCES CITED

Cox, E. R., 1978, Preliminary study of wastewater movement in Yellowstone National Park, Wyoming, July 1975 through September 1976: U.S. Geological Survey Open-File Report 78-227, 54 p.

LeGrand, H. E., 1965, Patterns of contaminated zones of water in the ground: Water Resources Research, v. 1, no. 1, p. 83-95.

HYDROLOGIC DATA

Table 1.--Records of wells used for studying wastewater movement in Yellowstone National Park

Well		Identification number	Well depth (ft)	Well cased (ft)	Interval perforated (ft)	Date completed	Altitude of land surface (ft above mean sea level)
FB	1	443432110214001	50	48	18-48	7-15-74	7,764.5
FB	2	443437110214601	51	51	21-51	7-15-74	7,762.2
FB	3	443440110215201	50	50	20-50	7-16-74	7,775.3
FB	4	443443110215001	50	49	19-49	7-16-74	7,774.8
FB	5	443446110214801	1/ 50	46	16-46	7-16-74	7,770.8
FB	5A	443446110214802	1/ 40	35	20-35	7-17-74	7,770.2
FB	5B	443446110214803	1/ 36	32	12-32	7-17-74	7,770.5
FB	5C	443446110214804	1/ 10	9	4- 9	7-18-74	7,770.8
FB	6	443447110213901	1/ 48	48	18-48	7-16-74	7,778.2
FB	7	443448110213101	50	47	17-47	7-16-74	7,783.0
FB	8	443441110213801	50	48	18-48	7-18-74	7,784.0
FB	9	443431110215001	51	51	21-51	7-18-74	7,743.2
FB	10	443452110220401	45	40	10-40	7-17-74	7,764.7
FB	11	443436110214301	50	49	24-49	7-10-75	7,761.4
FB	12	443435110214401	50	50	21-50	7-10-75	7,755.8
FB	13	443435110220401	6	6	5- 6	6-30-76	7,738.8
GV	1	442324110315701	59	16	11-16	7-19-74	7,773.8
GV	2	442323110321101	65	50	20-50	7-22-74	7,784.0
GV	3	442322110321001	50	50	20-50	7-26-74	7,789.7
GV	3A	442322110321002	38	38	12-38	7-29-74	7,788.6
GV	4	442321110321901	58	58	21-58	7-29-74	7,794.9
GV	5	442319110320401	65	54	38-54	7-23-74	7,819.2
GV	6	442320110320801	72	43	10-43	7-24-74	7,801.3
GV	7	442317110321601	105	105	45-105	7-25-74	7,832.0
GV	7A	442317110321602	45	40	6-40	7-25-74	7,832.2
GV	8	442315110321201	100	97	47-97	7-26-74	7,830.7
GV	8A	442315110321202	52	52	10-52	7-26-74	7,830.9

Table 1.--Records of wells used for studying wastewater movement--Continued

Well	Identification number	Well depth (ft)	Well cased (ft)	Interval perforated (ft)	Date completed	Altitude of land surface (ft above mean sea level)
GV 9	442316110320901	58	58	18-58	7-23-74	7,820.6
GV 10	442318110320301	53	53	37-53	7-22-74	7,816.3
GV 10A	442318110320302	20	20	10-20	7-23-74	7,816.7
OF 1	442717110504601	43	29	9-29	7-30-74	7,340.6
OF 2	442720110504101	50	48	18-48	7-31-74	7,337.8
OF 3	442722110504401	65	65	25-65	7-30-74	7,336.6
OF 4	442723110504601	50	49	19-49	7-30-74	7,334.9
OF 5	442724110504801	50	49	19-49	7-31-74	7,332.3
OF 6	442726110505001	35	35	15-35	8- 1-74	7,323.2
OF 7	442723110505201	35	35	10-35	7-31-74	7,309.5
Of 7A	442723110505202	1/ 13	13	5-13	8- 1-74	7,304.8
OF 7B	442723110505202	30	29	7-29	8- 1-74	7,312.6
MJ 1	443844110522501	40	35	14-35	8- 5-74	6,825.7
MJ 2	443844110522201	40	25	15-25	8- 6-74	6,823.6
MJ 3	443844110521901	60	60	20-60	8- 6-74	6,822.1
MJ 4	443843110522101	40	40	20-40	8- 5-74	6,811.0
MJ 5	443842110522201	40	40	20-40	8- 6-74	6,807.2
MJ 6	443842110522101	40	35	15-35	8- 6-74	6,805.5
MJ 7	443843110522001	50	50	18-50	7-11-75	6,809.0

1/ Well destroyed.

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement in Yellowstone National Park

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	FB 1, 443432110214001		
6- 4-76	16.42	4-27-77	16.33
6-24	15.93	6- 9	16.43
7-19	15.40	7-12	16.43
8- 3	15.43	9- 1	16.46
8-27	14.87	9-24	16.35
9-14	14.68	11- 4	16.26
10- 1	14.81		
10-18	15.00		
	FB 2, 443437110214601		
6- 4-76	11.64	4-27-77	12.68
6-24	10.44	6- 9	12.14
7-19	9.14	7-12	12.18
8- 3	8.98	9- 1	11.48
8-27	8.60	9-24	11.46
9-14	9.24	11- 4	11.26
9-21	9.38		
10- 1	9.47		
10-18	9.93		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	FB 3, 443440110215201		
6- 4-76	18.10	4-27-77	28.15
6-24	15.32	6- 9	28.52
7-19	15.07	7-12	25.83
8- 3	15.50	9- 1	24.70
8-27	16.80	9-24	24.73
9-14	18.38	11- 4	25.43
9-21	19.10		
10- 1	20.45		
10-18	22.04		
	FB 4, 443443110215001		
7-23-76	14.85	4-27-77	22.68
8- 3	15.00	6- 8	22.77
8-27	14.87	7-12	20.74
9-14	15.39	9- 1	19.59
10- 1	16.33	9-24	19.00
10-18	17.29	11- 4	19.66

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	FB 7, 443448110213101		
6- 4-76	20.70	4-27-77	23.99
6-24	21.75	6- 9	24.27
7-19	22.20	7-12	24.44
8- 3	22.25	9- 1	24.50
8-27	22.33	9-24	24.45
9-14	22.39	11- 4	24.14
10- 1	22.43		
10-18	22.52		
	FB 8, 443441110213801		
6- 4-76	28.45	4-27-77	28.43
6-24	27.76	6- 9	28.60
7-19	27.33	7-12	28.59
8- 3	27.10	9- 1	28.54
8-27	26.90	9-24	28.55
9-14	26.88	11- 4	28.96
10- 1	26.93		
10-18	27.02		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	FB 9, 443431110215001		
6- 4-76	5.53	4-27-77	6.97
6-24	4.96	6- 9	7.12
7-19	4.23	7-12	7.39
8- 3	4.05	9- 1	7.48
8-23	3.50	9-24	7.50
9-14	3.80	11- 4	7.67
10- 1	4.29		
10-15	4.67		
	FB 10, 443452110220401		
6- 4-76	5.56	4-27-77	9.44
6-24	5.76	6- 8	8.03
7-19	6.67	7-12	8.53
8- 3	7.07	9- 1	9.50
8-27	6.04	9-24	9.73
9-14	6.75	11- 4	10.13
10- 1	7.10		
10-18	7.37		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	FB 12, 443435110214401		
5- 5-76	19.03	4-27-77	18.39
6- 4	16.27	6- 9	18.35
6-24	14.47	7-12	18.51
7-19	12.08	9- 1	18.14
8- 3	11.77	9-24	18.05
8-27	9.18	11-4	18.30
9-14	12.00		
10- 1	12.98		
10-15	13.88		
	FB 13, 443435110220401		
6-30-76	1.95	4-27-77	2.05
7-19	1.74	6- 8	2.43
8- 3	1.53	7-12	3.28
8-27	1.54	9- 1	3.28
9-14	1.36	9-24	3.40
10- 1	1.36	11- 4	3.49
10-18	1.38		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
		GV 1, 442324110315701	
6- 8-76	6.29	4-28-77	12.25
7-14	6.82	6- 7	11.28
7-22	7.11	7-15	8.30
8-27	8.23	8-26	8.58
9-14	8.77	9-21	9.33
10- 1	9.26	11- 4	9.86
10-19	9.76		
		GV 2, 442323110321101	
5- 5-76	33.89	4-28-77	33.86
6- 8	21.94	6- 7	34.04
7-14	18.73	7-15	33.93
8-27	21.38	8-26	20.99
9-14	21.00	9-21	24.26
9-22	22.07	11- 4	30.73
10- 1	23.93		
10-19	28.58		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	GV 3A, 442322110321002		
6- 8-76	19.50	4-28-77	28.07
7-14	16.38	6- 7	28.38
8-27	19.81	7-15	26.55
9-14	19.55	8-26	16.65
10- 1	21.58	9-21	20.19
10-19	23.50	11-4	25.09
	GV 4, 442321110321901		
6- 8-76	49.45	4-28-77	47.65
7-14	46.65	6- 7	48.41
8-27	43.33	7-15	49.02
9-14	42.68	8-26	46.70
10- 1	42.51	9-21	44.87
10-19	42.78	11- 4	45.53

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	GV 5, 442319110320401		
6- 8-76	21.35	4-28-77	25.50
7-14	20.54	6- 7	25.01
7-20	20.65	7-15	22.40
8-27	21.65	8-26	22.48
9-14	22.07	9-21	23.21
10- 1	22.62	11- 4	23.44
10-19	23.05		
	GV 6, 442320110320801		
6- 8-76	10.53	4-28-77	17.45
7-14	8.95	6- 7	17.58
8-27	10.90	7-15	16.26
9-14	11.50	8-26	11.47
10- 1	12.34	9-21	12.17
10-19	13.22	11- 4	13.53

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	GV 7, 442317110321601		
6- 8-76	84.12	4-28-77	81.78
7-14	81.13	6- 7	82.64
8-27	76.45	7-15	82.04
9-14	75.73	8-26	77.55
9-20	75.70	9-21	76.82
10- 1	75.63	11- 4	78.29
10-19	75.91		
	GV 8, 442315110321201		
6- 8-76	61.24	4-28-77	61.10
7-14	60.67	6- 7	61.26
8-27	60.49	7-15	61.44
9-14	60.50	8-26	61.44
9-20	60.53	9-21	61.45
10- 1	60.51	11- 4	61.54
10-19	60.57		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	GV 9, 442316110320901		
6- 8-76	37.78	4-28-77	38.18
7-14	36.85	6- 7	38.42
8-27	36.66	7-15	38.28
9-14	36.80	8-26	38.54
9-22	36.87	9-21	38.70
10- 1	36.92	11- 4	38.93
10-19	37.06		
	GV 10, 442318110320301		
6- 8-76	18.60	4-28-77	21.92
7-14	18.35	6- 7	21.38
7-20	18.56	7-15	20.40
8-27	19.30	8-26	20.75
9-14	19.59	9-21	21.05
10- 1	19.85	11-4	21.17
10-19	20.10		
	GV 10A, 442318110320302		
6- 8-76	9.16	4-28-77	15.23
7-14	10.35	6- 7	14.80
7-22	10.80	7-15	14.46
8-27	11.95	8-26	14.44
9-14	12.33	9-21	14.73
10- 1	12.61	11-4	15.14
10-19	12.95		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	OF 1, 442717110504601		
6- 8-76	5.80	4-27-77	6.15
6-25	5.75	6- 8	6.23
7-24	6.00	7-25	6.30
8- 5	5.92	8-23	6.23
8-24	5.93	9-27	6.17
9-23	5.91	11- 4	6.05
10-16	6.07		
	OF 2, 442720110504101		
6- 8-76	28.53	4-27-77	30.57
6-25	28.38	6- 8	30.00
7-24	28.46	7-25	29.50
8- 5	26.93	8-23	29.55
8-24	27.37	9-27	30.38
9-23	28.36	11- 4	30.72
10-16	30.12		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	OF 3, 442722110504401		
6- 8-76	27.28	4-27-77	29.50
6-25	26.95	6- 8	28.17
7-24	28.63	7-25	27.62
8- 5	28.50	8-23	28.00
8-24	28.20	9-27	29.05
9-23	28.80	11- 4	29.85
10-16	30.01		
	OF 4, 442723110504601		
6- 8-76	30.47	4-27-77	31.48
6-25	30.76	6- 8	30.73
7-24	30.46	7-25	31.06
8- 5	30.78	9-27	30.74
8-24	31.01	11- 4	31.81
9-23	31.49		
10-16	31.60		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	OF 5, 442724110504801		
6- 8-76	28.98	4-27-77	30.55
6-25	29.20	6- 8	30.13
7-24	29.42	7-25	29.84
8- 5	29.60	8-23	29.85
8-24	29.94	9-27	30.20
9-23	30.10	11-4	30.84
10-16	30.48		
	OF 6, 442726110505001		
6- 8-76	20.69	4-27-77	22.17
6-25	20.94	6- 8	21.90
7-24	21.31	7-25	21.70
8- 5	21.45	8-23	21.73
8-24	21.75	9-27	21.97
9-23	21.86	11- 4	22.50
10-16	22.17		
	OF 7, 442723110505201		
6- 8-76	6.88	4-27-77	8.60
6-25	7.17	6- 8	8.34
7-24	7.64		
8- 5	7.75		
8-24	8.10		
9-23	8.24		
10-16	8.58		

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
	MJ 1, 443844110522501		
6-10-76	6.83	4-27-77	7.55
6-25	6.85	6- 8	7.85
7-24	7.31	7-22	8.15
8-23	7.48	8-23	8.30
9-23	7.58	9-28	8.32
10-16	7.61	10-26	8.30
	MJ 3, 443844110521901		
6-10-76	26.72	4-27-77	28.57
6-25	26.96	6- 8	28.67
7-24	28.00	7-22	28.66
8-23	28.37	8-23	28.88
9-23	28.42	9-28	28.98
10-16	28.53	10-26	29.08

Table 2.--Water levels in 1976-77 in wells used for studying wastewater movement--Continued

Date	Water level (ft below land surface)	Date	Water level (ft below land surface)
		MJ 5, 443842110522201	
6-10-76	11.35	4-27-77	13.18
6-25	11.56	6- 8	13.30
7-24	12.64	7-22	13.23
8-23	13.02	8-23	13.55
9-23	13.06	9-28	13.65
10-16	13.19	10-26	13.73
		MJ 6, 443842110522101	
6-10-76	9.78	4-27-77	11.49
6-25	10.00	6- 8	11.56
7-24	11.01	7-22	11.65
8-23	11.33	8-23	11.78
9-23	11.38	9-28	11.87
10-16	11.49	10-26	11.96
		MJ 7, 443843110522001	
6-10-76	13.59	4-27-77	15.42
6-25	13.81	6- 8	15.52
7-24	14.88	9-28	15.87
8-23	15.25	10-26	15.94
9-23	15.30		
10-16	15.42		

Table 3.--Chemical analyses of water from selected wells and effluents in Yellowstone National Park

[Analytical results in milligrams per liter (mg/L) or micrograms per liter (μg/L) except as indicated. Analyses by U. S. Geological Survey.]

Well	Identification number	Date of collection	Temperature (°C)	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (μg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Total kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved organic carbon (C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Specific conductance (μmho/cm at 25°C)	pH (units)
FB 1	443432110214001	8-29-74	7.5	32	60	8.0	2.4	3.5	1.8	37	0	5.4	2.3	0.1	0.03	0.76	0.11	37	74	30	70	7.9
		6-26-75	4.0	20	20	11	1.3	2.2	2.2	35	0	4.4	.7	.1	1.1	.25	.19	2.3	64	33	70	5.9
		7-19-76	4.5	29	10	6.3	2.0	2.0	2.3	32	0	6.9	1.8	.1	.08	.34	.12	2.7	67	24	75	6.6
		10-18-76	3.5	42	20	6.5	3.2	3.1	2.8	47	0	4.4	.6	.1	.29	.94	.11	1.0	87	29	75	6.8
		9-24-77	6.0	44	20	7.9	3.4	3.0	3.1	45	0	3.2	.9	.1	---	.88	.17	2.3	88	34	75	7.2
FB 2	443437110214601	8-26-74	8.5	47	20	6.2	3.8	3.5	3.0	48	0	4.8	1.8	.1	.24	1.0	.26	4.8	95	31	85	7.5
		10-25-74	5.0	47	50	6.5	4.0	3.8	3.2	47	0	3.5	.8	.1	.19	1.1	1.1	4.6	93	33	80	8.0
		6-24-76	5.0	46	30	5.7	3.4	3.2	2.7	45	0	3.5	1.2	.1	---	.60	.33	2.4	88	28	85	6.4
		9-21-76	5.5	44	70	6.4	3.8	3.5	2.9	46	0	6.3	.8	.1	.31	.56	.26	2.5	92	32	85	6.6
		9-24-77	4.5	45	20	5.9	3.6	2.8	2.7	40	0	3.6	.6	.1	---	.47	.17	2.0	84	30	70	7.2
FB 3	443440110215201	9-17-74	7.0	43	200	7.3	3.7	3.8	3.1	42	0	5.4	4.4	.1	.41	.61	.36	4.0	94	33	155	7.8
		6-26-75	6.0	42	70	11	5.6	3.9	4.2	57	0	10	4.5	1.1	.97	.67	.27	3.1	115	51	140	6.0
		6-24-76	6.0	44	30	15	7.4	5.6	4.4	74	0	5.3	4.3	.1	---	1.2	1.3	4.5	123	68	155	6.3
		9-21-76	13.0	48	20	21	10	9.7	7.1	99	0	18	22	.1	.17	1.5	.91	8.4	185	94	270	6.4
		9-25-77	9.5	45	20	43	19	20	9.9	250	0	20	17	.1	---	1.4	.31	6.1	297	190	455	6.7
FB 4	443443110215001	8- 3-76	5.0	40	10	14	5.5	4.4	4.4	71	0	6.8	3.2	.1	.90	1.3	.53	11	117	58	165	6.7
		10-18-76	5.0	42	10	18	7.1	4.8	4.9	101	0	7.0	4.4	.1	.76	.81	.28	3.6	141	74	165	6.8
		9-25-77	6.0	43	20	18	7.6	5.1	5.2	80	0	8.4	12	.0	---	.82	.38	2.5	139	76	190	6.8
FB 5	443446110214801	8-29-74	7.5	35	50	13	1.7	2.7	1.6	31	0	6.4	1.8	.1	.14	.63	.68	7.4	78	39	60	7.9
		7-19-76	7.0	33	20	7.6	3.3	2.8	3.5	40	0	6.3	1.8	.1	1.5	.80	.12	2.9	85	33	105	6.7

Table 3.--Chemical analyses of water from selected wells and effluents--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Total kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved organic carbon (C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Specific conductance (µmho/cm at 25°C)	pH (units)
FB 6	443447110213901	9-17-74	6.0	31	50	4.9	1.3	3.4	2.2	24	0	7.3	2.2	.2	.25	.94	.22	5.0	65	18	60	8.0
FB 7	443448110213101	8-14-75	6.0	36	0	5.8	2.0	2.5	2.5	28	0	5.1	1.3	.1	.11	1.1	.73	2.2	70	23	75	6.1
FB 8	443441110213801	10-25-74	4.0	42	20	8.4	4.8	3.8	3.3	53	0	3.8	1.1	.1	.05	.79	2.0	---	94	41	90	8.0
		7-21-76	6.5	41	20	8.9	3.9	3.6	3.3	55	0	7.5	1.4	.1	.10	.78	1.7	4.4	97	38	105	6.9
FB 9	443431110215001	9-17-74	8.5	44	20	5.9	3.4	3.4	2.4	44	0	3.9	1.9	.1	.17	.57	.13	2.5	87	29	80	7.8
		7-21-76	5.0	41	10	6.4	3.5	3.0	2.8	43	0	4.6	.8	.1	.24	.11	.13	1.0	84	30	90	6.7
		10-15-76	6.5	45	30	12	5.8	4.5	4.2	67	0	12	2.3	.1	1.4	2.0	.36	2.7	125	54	130	6.9
FB 10	443452110220401	10-25-74	5.5	34	40	9.2	4.9	4.0	3.4	59	0	5.4	.8	.1	.05	1.5	.11	---	91	43	90	7.9
		8- 3-76	6.0	31	20	6.4	2.1	2.4	2.5	37	0	5.0	.6	.1	.18	.40	.45	2.1	69	25	75	6.8
FB 12	443435110214401	10-15-76	6.5	44	20	16	5.9	4.4	3.7	72	0	5.2	4.7	.1	2.4	.75	.24	1.4	130	64	170	6.9
		9-24-77	5.0	44	30	12	5.6	3.8	3.6	65	0	5.9	2.6	.1	---	.55	.27	2.5	110	53	115	6.9
FB 13	443435110220401	9-25-77	8.5	35	30	5.8	2.6	2.9	2.5	43	0	3.6	.7	.1	---	.54	.10	2.0	74	25	65	6.5
GV 1	442324110315701	10-23-74	5.0	40	20	33	15	6.0	3.0	175	0	4.8	1.5	.3	.08	.38	.18	2.6	190	140	280	8.2
		7-22-76	11.5	33	60	36	13	4.2	1.9	167	0	6.5	1.1	.4	.11	.07	.22	44	179	140	310	7.4
GV 2	442323110321101	8-26-74	8.0	36	80	6.9	2.3	3.8	4.0	37	0	3.0	3.1	.3	.10	.76	.63	5.1	78	27	60	6.8
		9-22-76	4.5	25	20	18	3.8	4.5	3.9	53	0	5.7	9.0	.1	3.4	.94	.09	11	111	61	170	7.5
GV 3A	442322110321002	8- 7-75	4.5	19	30	3.8	1.1	1.4	1.6	12	0	2.1	.8	.1	.04	1.9	.13	4.2	36	14	40	5.8
		7-16-76	6.5	18	20	8.4	1.7	2.4	2.3	35	0	5.3	2.3	.1	1.1	1.3	.40	4.3	63	28	135	6.2
		10-19-76	5.0	23	60	26	5.5	4.6	4.4	48	0	14	21	.0	5.0	1.7	.13	1.8	144	88	280	5.7
		9-21-77	6.5	20	20	11	1.9	3.5	2.5	36	0	3.8	6.6	.0	---	1.3	.21	1.6	67	35	90	6.2

Table 3.--Chemical analyses of water from selected wells and effluents--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (g/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Total kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved organic carbon (C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Specific conductance (µmho/cm at 25°C)	pH (units)
GV 4	442321110321901	9-19-74	8.5	40	80	4.8	1.2	4.6	3.2	29	0	4.1	4.5	.2	.23	.67	.51	7.1	78	17	60	7.9
		7-16-75	7.0	41	50	5.5	.7	2.9	3.1	33	0	3.3	.7	.2	.10	1.0	1.4	14	74	17	75	5.9
		8-30-76	5.0	38	30	6.0	2.1	3.1	3.2	27	0	3.7	1.8	.1	1.2	---	.64	3.3	77	24	85	7.4
		9-21-77	5.5	42	20	9.3	3.1	3.6	4.1	56	0	3.0	2.2	.1	---	.83	.27	1.6	95	36	125	6.8
GV 5	442319110320401	10- 9-74	5.0	33	0	21	6.0	9.5	3.6	113	0	5.0	1.4	.7	.04	1.3	.42	5.0	136	77	195	8.0
		9- 9-75	6.0	36	30	18	4.4	6.1	3.3	92	0	3.5	2.0	.5	.05	2.2	.59	5.8	119	63	165	7.1
		7-20-76	5.0	38	30	19	4.1	5.5	2.7	92	0	7.1	1.3	.5	.03	1.0	.38	2.9	124	64	165	7.5
GV 6	442320110320801	10-29-74	4.5	36	20	19	3.8	3.2	2.4	63	0	2.4	13	.1	.03	1.6	1.3	2.7	111	63	85	8.3
		7-16-75	7.0	36	10	11	2.6	2.7	2.8	51	0	3.8	.7	.1	.01	.79	.43	2.0	85	38	105	6.3
		7-16-76	7.0	33	20	7.7	2.9	2.7	2.7	46	0	5.2	.7	.2	.03	.87	1.9	6.5	78	31	100	7.1
		10-19-76	5.0	34	20	9.1	3.8	2.3	2.4	52	0	3.0	.6	.1	.10	.63	.21	.5	81	38	135	7.4
		9-21-77	4.5	36	20	14	3.4	2.2	2.4	48	0	2.5	.7	.2	---	1.5	.16	3.3	85	49	75	8.1
GV 7	442317110321601	9-19-74	5.5	40	50	11	4.2	5.3	4.4	67	0	4.0	1.5	.2	.19	.53	.62	9.9	105	45	110	7.8
		8- 7-75	8.0	40	30	14	4.6	4.1	3.8	72	0	2.3	1.0	.1	.12	2.2	.75	4.4	106	54	125	6.1
		9-20-76	5.0	38	20	5.0	1.8	2.8	3.3	34	0	4.7	.5	.1	.04	.90	.25	1.1	73	20	70	6.3
		9-22-77	4.5	41	20	21	7.1	5.1	6.1	87	0	7.3	14	.1	---	1.8	.14	3.6	145	82	205	6.8
GV 8	442315110321201	10-29-74	5.0	38	10	12	3.7	3.3	2.3	61	0	5.5	2.2	.2	.05	1.1	.38	5.6	98	45	100	8.0
		8-11-75	7.5	37	30	11	3.5	3.2	3.2	55	0	3.8	1.1	.1	.06	.74	.24	1.6	90	42	115	6.5
		9-20-76	7.0	37	20	7.2	2.6	2.9	2.9	41	0	5.9	.6	.1	.04	.37	.09	1.8	80	29	90	6.6
		9-22-77	5.0	42	20	13	3.8	3.2	3.3	51	0	5.1	.9	.1	---	.53	.12	1.9	97	48	75	7.3

Table 3.--Chemical analyses of water from selected wells and effluents--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (μg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Total kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved organic carbon (C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Specific conductance (μmho/cm at 25°C)	pH (units)
GV 9	442316110320901	8-23-74	7.5	38	20	14	3.5	3.5	3.3	63	0	4.4	3.2	.1	.01	1.6	.27	6.6	101	49	85	6.9
		8-11-75	7.0	30	30	5.1	1.1	2.4	2.2	26	0	2.3	.6	.1	.01	.86	.42	1.5	57	17	50	6.8
		9-22-76	5.0	38	20	11	4.2	3.5	3.4	65	0	5.5	.7	.1	.12	1.5	.21	2.2	99	45	120	7.7
		9-22-77	4.5	37	20	6.2	2.3	2.5	2.7	36	0	2.9	.8	.1	---	.34	.07	1.7	72	25	60	7.1
GV 10	442318110320301	10-29-74	4.5	36	10	16	4.9	4.3	2.3	86	0	3.6	.8	.4	.03	.61	.37	2.2	111	60	135	8.3
		9- 9-75	7.0	34	40	16	4.7	4.4	2.0	83	0	3.5	1.4	.3	.06	1.3	.30	4.0	108	59	155	6.9
		7-20-76	7.5	37	10	15	4.7	3.6	1.7	80	0	5.3	.8	.3	.04	.84	.14	2.1	108	57	145	8.3
GV 10A	442318110320302	7-22-76	5.5	30	20	12	4.2	2.1	2.9	61	0	3.5	1.5	.1	.08	.70	.21	6.8	87	47	120	7.1
GV Effluent	442319110320601	9- 8-75	11.0	11	200	11	2.5	24	10	175	0	11	23	.5	.34	30	5.2	18	181	38	400	7.0
OF 1	442717110504601	10- 8-74	15.0	89	80	5.5	1.3	15	2.6	42	0	3.8	2.3	6.2	.03	.11	.55	.9	147	19	105	7.7
OF 2	442720110504101	8-27-74	19.0	58	80	4.0	1.1	25	6.6	6	0	20	5.8	3.0	8.5	---	1.0	7.0	164	15	180	5.6
		10-24-74	16.5	45	17,000	7.7	1.9	29	13	92	0	16	23	3.0	.09	4.5	11	7.4	201	27	290	6.9
		8-24-76	18.5	42	200	1.8	.2	35	8.3	61	0	10	36	2.8	.28	6.8	3.6	9.6	168	5	285	5.4
		9-27-77	13.0	61	60	4.9	.9	26	3.5	1	0	11	12	1.8	---	3.2	.71	3.5	122	16	175	5.8
OF 3	442722110504401	10-24-74	14.0	44	3,300	4.1	1.5	38	8.0	112	0	3.5	21	3.3	.61	10	3.6	5.8	185	16	290	6.7
		6-23-75	12.0	37	260	4.6	.9	34	5.7	71	0	2.1	21	3.2	.04	---	2.4	7.0	144	15	215	5.5
		8-25-76	16.0	43	1,700	2.8	.7	40	9.1	42	0	9.4	37	3.7	6.6	6.5	1.0	6.9	197	10	350	5.8
		9-27-77	17.0	50	610	5.4	1.1	58	14	50	0	11	47	6.2	---	13	22	6.9	218	18	435	6.8
OF 4	442723110504601	9-18-74	17.5	44	4,600	29	1.8	32	14	141	0	13	21	3.9	.13	20	8.0	4.3	233	80	400	6.9
		9-27-77	18.0	47	500	2.4	.4	63	10	46	0	9.4	50	7.1	---	12	28	7.6	212	8	415	6.7
OF 5	442724110504801	8-27-74	18.0	44	90	8.0	2.6	28	6.4	65	0	7.0	27	1.5	.23	---	7.4	9.7	158	31	250	6.5

Table 3.--Chemical analyses of water from selected wells and effluents--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Total kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved organic carbon (C) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Hardness (Ca, Mg) (mg/L)	Specific conductance (µmho/cm at 25°C)	pH (units)
OF 5	442724110504801	6-23-75	15.0	59	970	11	2.3	67	7.3	18	0	24	7.5	1.6	40	---	.20	3.2	367	37	505	4.8
		8-24-76	17.0	57	10	21	4.4	48	10	144	0	23	34	3.0	.11	5.6	7.7	21	272	71	475	6.3
		9-27-77	17.0	51	100	5.9	.7	54	7.1	24	0	19	49	6.4	---	4.2	25	8.5	205	18	330	6.1
OF 6	442726110505001	10-24-74	14.0	68	40	18	.8	35	11	63	0	11	47	.5	1.6	1.3	2.9	7.1	229	48	225	6.3
OF 7	442723110505201	9-18-74	15.0	59	2,100	11	2.2	50	13	131	0	4.9	27	3.7	.06	10	9.9	10	238	37	420	6.9
		8-25-76	15.0	58	170	7.5	1.2	41	9.9	37	0	6.0	30	2.7	11	4.4	2.7	9.7	223	24	310	5.6
OF Effluent	442722110504901	9- 8-75	24.0	45	180	4.8	1.3	43	11	189	0	9.8	28	2.4	.02	32	6.5	23	239	17	460	6.9
MJ 1	443844110522501	9-16-74	12.0	79	90	3.3	1.0	37	6.8	97	0	3.2	2.4	7.4	.10	.69	.07	2.3	188	12	200	6.8
		10-28-74	13.5	87	20	3.3	.9	36	5.6	94	0	2.9	1.8	8.0	.18	.00	.00	1.8	193	12	175	6.8
		9-28-77	14.0	80	60	3.9	.8	36	5.1	91	0	2.2	2.2	8.7	---	.47	.03	3.0	184	13	180	6.3
MJ 3	443844110521901	8-28-74	13.5	58	50	9.9	1.8	38	6.9	64	0	5.8	7.2	4.5	6.2	1.4	.11	8.6	191	32	225	6.9
		10-28-74	10.5	65	20	17	3.2	30	8.2	70	0	9.7	14	4.0	11	1.0	.23	4.3	234	56	285	6.9
		10-20-75	11.0	60	20	20	2.6	24	8.8	57	0	6.3	12	3.5	9.9	1.2	.21	3.2	209	61	255	5.4
		8-26-76	11.5	64	60	8.1	1.6	18	5.6	21	0	6.4	5.9	4.8	8.0	1.9	.31	5.4	160	27	175	5.9
		9-28-77	12.0	56	20	13	2.0	27	6.8	63	0	6.4	19	5.9	---	1.4	.13	1.9	167	41	215	6.4
MJ 4	443843110522101	8-28-74	14.5	80	190	3.8	1.9	28	5.1	56	0	4.0	3.0	11	.19	.69	.06	5.0	165	17	150	7.2
MJ 5	443842110522201	10-20-75	11.0	53	10	7.6	1.3	31	5.5	91	0	3.5	2.0	7.2	.19	.49	.15	2.7	157	24	185	6.0
		9-28-77	12.5	66	30	8.8	1.6	35	5.5	100	0	4.7	2.3	8.9	---	1.2	.16	1.3	182	29	200	6.5
MJ 6	443842110522101	9-16-74	14.0	33	160	3.4	.2	39	6.4	101	0	3.0	2.4	3.5	.09	.64	.07	3.0	141	9	200	6.9
		8-26-76	14.5	83	70	4.2	.8	41	5.8	102	0	3.3	2.3	9.5	.28	.72	.15	6.2	202	14	220	5.7
MJ 7	443943110522001	10-20-76	9.0	56	70	13	2.7	31	6.9	75	0	7.5	12	4.2	9.0	1.2	.16	2.8	210	44	170	6.0
		9-28-77	11.0	59	40	12	2.8	32	6.4	70	0	12	15	6.1	---	.95	.34	1.7	180	42	245	6.4

Table 4.--Chemical analyses in 1977 of water from selected wells in Yellowstone National Park

[Analytical results in milligrams per liter (mg/L) or micrograms per liter (µg/L) except as indicated. Analyses by U.S. Geological Survey.]

Well	Identification number	Date of collection	Temperature (°C)	Dissolved iron (Fe) (µg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Specific conductance (µmho/cm at 25°C)	pH (units)
FB 1	443432110214001	[1] 9-24-77	6.0	20	3.2	0.9	75	7.2
FB 2	443437110214601	4-27-77	7.5	30	4.1	.7	75	7.0
		7-12-77	4.5	-	5.3	1.5	80	7.0
		[1] 9-24-77	4.5	20	3.6	.6	70	7.2
		10-19-77	4.0	40	5.1	1.6	85	7.0
FB 3	443440110215201	4-27-77	10.0	10	22	16	315	6.6
		6- 9-77	11.5	150	22	11	260	6.1
		7-12-77	10.5	-	15	8.9	320	6.8
		8-16-77	11.0	-	21	11	340	6.8
		[1] 9-25-77	9.5	20	20	17	455	6.7
		10-19-77	10.0	40	19	18	535	6.9
FB 4	443443110215001	4-27-77	7.0	20	7.0	4.7	160	6.8
		8-16-77	7.0	-	8.5	4.1	160	6.6
		[1] 9-25-77	6.0	20	8.4	12	190	6.8
FB 7	443448110213101	9-15-77	5.0	50	6.9	.9	65	7.0
FB 8	443441110213801	9-15-77	5.0	50	5.3	.9	90	7.0
FB 9	443431110215001	9-15-77	6.0	70	8.6	4.9	190	6.8
FB 10	443452110220401	9-15-77	5.0	60	4.7	2.2	80	6.8
FB 12	443435110214401	6- 9-77	9.0	50	6.9	2.8	120	6.6
		[1] 9-24-77	5.0	30	5.9	2.6	115	6.9
FB 13	443435110220401	[1] 9-25-77	8.5	30	3.6	.7	65	6.5
GV 1	442324110315701	9- 7-77	8.0	210	10	2.2	275	7.4

Table 4.--Chemical analyses in 1977 of water from selected wells--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved iron (Fe) (μg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Specific conductance (μmho/cm at 25°C)	pH (units)
GV 2	442323110321101	4-28-77	7.5	30	3.4	4.8	90	6.8
		7-26-77	6.0	-	4.7	6.0	105	-
GV 3A	442322110321002	4-28-77	8.0	50	11	6.2	100	6.5
		[1] 9-21-77	6.5	20	3.8	6.6	90	6.2
GV 4	442321110321901	4-28-77	9.5	30	16	23	315	6.6
		6- 7-77	8.0	-	14	24	355	-
		[1] 9-21-77	5.5	20	3.0	2.2	125	6.8
GV 5	442319110320401	9- 7-77	7.0	130	5.4	1.7	145	7.3
GV 6	442320110320801	[1] 9-21-77	4.5	20	2.5	.7	75	8.1
GV 7	442317110321601	6- 7-77	10.0	870	9.3	2.9	185	-
		[1] 9-22-77	4.5	20	7.3	14	205	6.8
GV 8	442315110321201	7-26-77	6.0	420	5.8	-	110	-
		[1] 9-22-77	5.0	20	5.1	.9	75	7.3
GV 9	442316110320901	[1] 9-22-77	4.5	20	2.9	.8	60	7.1
GV 10	442318110320301	9- 7-77	7.0	60	5.8	.6	125	7.3
GV 10A	442318110320302	9- 7-77	6.5	-	13	2.8	155	7.5
OF 1	442717110504601	9- 7-77	17.0	40	3.7	3.4	110	7.5
OF 2	442720110504101	[1] 9-27-77	13.0	60	11	12	175	5.8
OF 3	442722110504401	6- 8-77	13.5	260	20	36	438	-
		7- 8-77	16.0	270	18	43	340	5.8
		8- 7-77	20.0	110	17	45	315	6.2
		9- 7-77	20.0	1800	17	45	380	7.0
		[1] 9-27-77	17.0	610	11	47	435	6.8
		10- 9-77	16.0	920	26	46	460	7.0

Table 4.--Chemical analyses in 1977 of water from selected wells--Continued

Well	Identification number	Date of collection	Temperature (°C)	Dissolved iron (Fe) (μg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Specific conductance (μmho/cm at 25°)	pH (units)
OF 4	442723110504601	6- 8-77	15.0	1600	22	33	245	-
		7- 9-77	16.0	230	17	41	335	5.2
		8- 7-77	20.0	130	15	45	300	6.2
		9- 7-77	21.0	490	5.2	48	465	6.9
		[1] 9-27-77	18.0	500	9.4	50	415	6.7
		10- 9-77	16.0	470	13	47	385	7.0
OF 5	442724110504801	[1] 9-27-77	17.0	100	19	49	330	6.1
OF 6	442726110505001	9- 7-77	19.5	70	20	43	385	6.6
MJ 1	443844110522501	8- 7-77	14.5	50	4.2	2.3	195	6.6
		[1] 9-28-77	14.0	60	2.2	2.2	180	6.3
MJ 3	443844110521901	6- 8-77	14.0	90	7.8	30	360	-
		7-10-77	13.0	-	5.0	32	390	6.5
		8- 7-77	15.0	60	6.0	25	325	6.5
		9- 7-77	14.5	-	4.3	21	250	6.7
		[1] 9-28-77	12.0	20	6.4	19	215	6.4
		10- 9-77	12.0	20	7.4	19	215	6.8
		11- 9-77	10.0	60	6.3	17	220	7.0
MJ 5	443842110522201	7-10-77	12.0	50	2.8	2.3	180	6.7
		[1] 9-28-77	12.5	30	4.7	2.3	200	6.5
		11- 9-77	12.0	-	4.1	2.3	205	6.9
MJ 6	443842110522101	9- 7-77	17.0	60	4.0	2.6	215	6.8
MJ 7	443843110522001	6- 8-77	14.0	60	9.1	15	275	-
		[1] 9-28-77	11.0	40	12	15	245	6.4
		10- 9-77	11.0	40	7.3	20	255	7.0

[1] More complete analysis listed in table 3.