SPRINGS AND SEEPS
of COLONIAL NATIONAL HISTORICAL PARK

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Summary

Thirty one springs were located within the boundaries of the Colonial National Historic Park during a field reconnaissance study in May, 1996 and revisited in August, 1996. Five additional springs which feed streams flowing to the park were located outside the park boundaries. The study focused on the Yorktown unit of the park and not all streams that originate outside the park were searched for springs and seeps. The springs were found in various landscapes and elevations. Field observations indicate that water from most springs flows through a shallow aquifer system which is predominately comprised of fossil shell material. This shallow aquifer system is a really extensive and is found throughout the park and surrounding land. Springs like these are not typically found in the coastal areas of Virginia and therefore provide unique ecological environments. The original source (recharge area) of the water issuing from these springs cannot be determined by these preliminary results. It is likely that the springs are recharged within the park boundaries as well as outlying areas. The water from at least one spring indicates that some springs are associated with a more local flow system that does not flow through the shelly aquifer and therefore have recharge areas that are restricted to within park boundaries. Water from another spring shows the possibility of influences from de-icing salts in runoff from a nearby road. Additionally, water from all springs wherever measurements were possible was well oxygenated and had near neutral pH values.

Diffuse seeps of ground water were found throughout the park. The seeps are located at, or near, headwaters of streams, along valley bottoms, and alongside streams. The locations of the seeps coincide with wetland maps that were previously generated for the park and are stored in the park's geographic information system.

Several springs that were flowing in May were dry in August. More work needs to be done to quantify why these springs dry up while others remain flowing; but it is likely related to topographic position and the aquifer material. The water from the springs was generally warmer, and had slightly lower dissolved oxygen, in August than in May, indicating that the water is influenced by seasonal climatic changes. The pH and specific conductance (a measure of the amount of dissolved minerals in the water) were relatively unchanged between the May and August observations, suggesting that the overall chemistry of most springs did not change over the time period.

Water from eight selected springs was analyzed for chlorofluorocarbon compounds in order to determine modeled recharge dates. The dates from the five springs range from recent (within the past two years) recharge events to recharge that occurred in 1980.

Management of the biodiversity and ecological integrity of the park depends, in large part, on the quantity and quality of surface and ground water flowing in, and through the park. This reconnaissance study indicates that ground water which feeds streams within the park can be influenced by off-park, as well as, within-park activities. In order to effectively plan for the management of these resources, a more complete understanding of the shallow aquifer system within, and around, the park is needed. This would provide a framework from which relationships of the various local hydrologic environments to the presence and viability of specific targeted organisms (e.g. northern isopods etc.) could be developed in context with

potential influencing factors.

Introduction

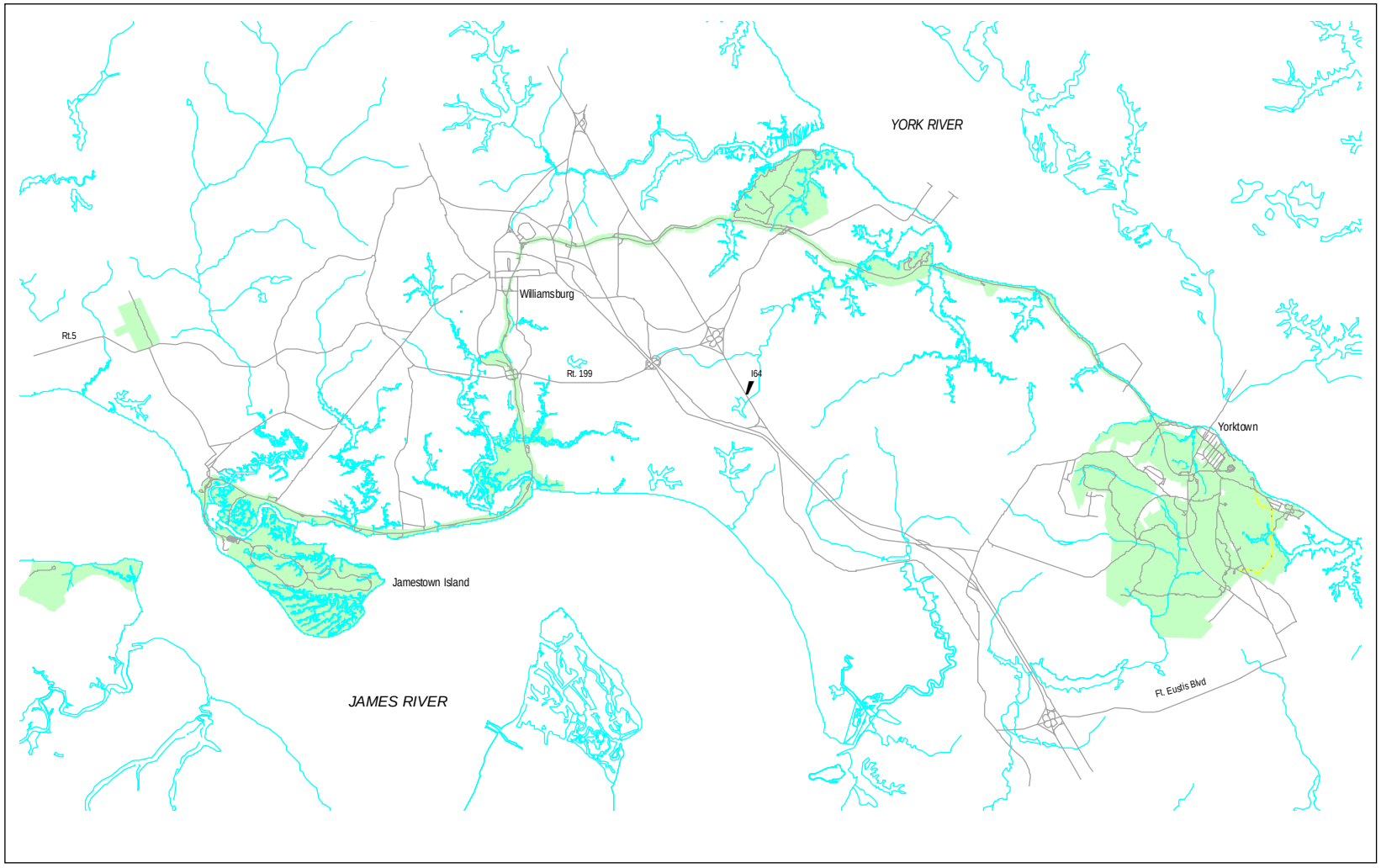
The Colonial National Historical Park is located in the Coastal Plain of Virginia near the mouth of the York River (fig. 1). A "Water-Resource Management Plan" was published for Colonial National Historical Park in 1994. Among other things, the plan includes background information on the geology and water resources of the park and states that contaminated, or altered flow of ground water could adversely affect the water resources and ecosystems of the park. For example, the Virginia Division of Natural Heritage has identified viable populations of northern spring isopods (which are listed as species of special concern in the state of Virginia) that live in springs in the park. Springs and seeps are both manifestations of ground-water discharge but are defined differently in this report. Seeps can be entire hillslopes or other large plots of land where ground water is discharging to the land surface. Springs, on the other hand, are confined to limited areas, often found where small void spaces in the aquifer coincide with land surface. The plan also indicates that little is known about the ground-water resources of the park and surrounding areas (fig. 2) at the level of detail desirable for sound management activities. The USGS submitted a proposal to the National Park Service in 1995 entitled "Investigation of Shallow Ground-Water System at Colonial National Historical Park" outlining the work that would be necessary to achieve the desired level of understanding of the ground-water system. The present study was designed to address one aspect of that original USGS proposal while maintaining a phased approach to the overall effort.

This phase of the overall effort is entitled "A Reconnaissance Study of Springs in the Colonial National Historical Park" and was designed to provide some preliminary information that would be helpful in designing and implementing the overall investigation. Locations of springs in the Yorktown unit of the park and general indicators of water chemistry from the springs were deemed important initial information for the type of hydrogeologic environment found in the park. This preliminary information would be useful in future studies that assess relations of the water resources in the park to the nearby land uses which include residential areas, highways, forests, and different underground-storage tanks (UST) and National-Priorities List (NPL)\Superfund sites. The information is also useful when assessing relations of water quality with occurrences and distributions of flora and fauna found in the park. Additionally, the information from this study can be used for investigations of the surrounding and nearby natural resources such as the Grafton Pond Sinkhole complex (fig. 2). One third of the sinkhole complex is found on park lands and it contains hydrogeologic features and associated ecological systems that are unique to this part of Virginia.

Study Areas

The springs were found in a variety of local types of landscapes (fig. 3); 1) deeply incised valleys (also called ravines), 2) headwaters of streams, 3) recent mass wastage deposits (i.e. areas where large amounts of soil and aquifer material have been moved downslope by gravity and accumulate in piles along valley walls and floors), 4) within stream channels (not at headwaters),

Figure 1. Overview of region



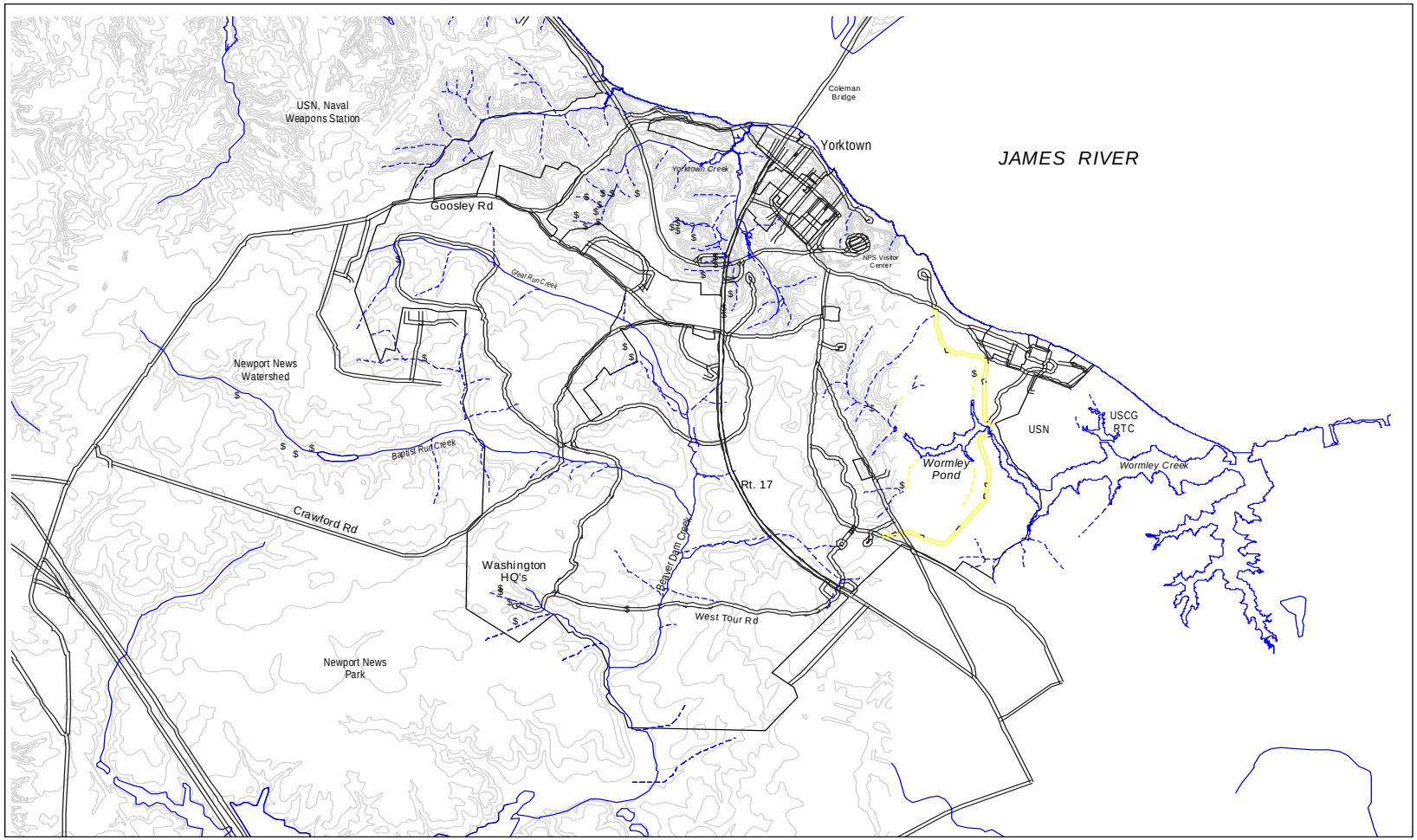
Roads
Shoreline, streams, lakes
Colonial NHP

0.5 0 0.5 1 1.5 2 Miles

Figure 1 - Overview of Region

N
W E
S

Figure 2. Yorktown



$ Springs
Shoreline, streams, lakes
Streams, intermittant
Roads
Colonial NHP, Yorktown
Topography, 10 ft

0.2 0 0.2 0.4 0.6 Miles

Figure 2. Yorktown Area

N
W E
S

and 5) local springs associated with recent rains. Most springs found in the Yorktown unit of the park were in the deeply incised valleys and generally issued where the wall and floor of the valley meet (at approximately sea level). The water from these springs subsequently forms small feeder channels that are tributaries to the main stream flowing through the valley.

Methods

Existing maps of geology, topography, locations of streams, and soils were used to determine the most likely locations to find springs within the Yorktown Battlefield unit of Colonial National Historical Park. Diffuse seeps of ground water were found throughout the park. The seeps are associated with headwaters of streams, along valley bottoms, and alongside streams. The locations of the seeps coincide with wetland maps that were previously generated for the park and are stored in the park's geographic information system. Digital map coverages of the spring locations and associated data were entered into a geographic-information system as a point coverage.

The location of each spring was recorded with a Global Positioning System and water from each spring was analyzed in May, 1996 for pH (a measure of the acidity of the water), specific conductance (a measure of the amount of dissolved substances in the water, or salinity of the water), water temperature, and the amount of oxygen dissolved in the water. This was accomplished by inserting the appropriate probe or sensor into the spring water as close as possible to the point where the spring issues from the ground, or by excavating the mouth of the spring to form a larger flow, and subsequent pool, of spring water. In some instances it was impossible to obtain an accurate measurement for dissolved oxygen due to the low flow and structure of the spring. The springs were revisited in August, 1996 and field parameters were again recorded.

Water from eight springs, selected to represent a range of spring sizes and landscape types, was sampled for chlorofluorocarbon (CFC) compounds in August in order to determine recharge dates. Details on the methodology of this technique are outlined in Busenberg and Plummer (1992). George Washington spring and three nearby springs (i.e. springs 9-12; headwaters of streams) were the first four springs sampled. Water from spring 30, also in landscape type 2 (i.e. headwaters of streams) was also sampled. Springs 27 and 28 are in landscape type 1 (i.e. deeply incised valleys) in the Yorktown Creek drainage basin and were sampled. Finally, spring 15 which is also in landscape type 1 but is in the Wormley Pond drainage, was sampled**.**

Observations and Discussion

Thirty one springs were located in the field within park boundaries in May, 1996 (fig. 1). Additionally, five more springs were located outside of the park boundaries (fig. 1). These five springs feed into drainage systems that eventually flow through the park and were not revisited in August, 1996. Springs 1-8, 15, and 17-28 are in this first landscape type (i.e. deeply incised valleys). Springs in the second landscape type (9-12 and 30-32; i.e. headwaters of streams) are usually found at higher elevations. For example springs 9-12 are at an elevation of approximately 40-50 ft above sea level. One spring (13) was associated with recent mass wastage (landscape type 3, recent mass wastage deposits) and was possibly created when the deposit covered up an

original valley spring or parts of a former small tributary. Springs associated with landscape type 4 (i.e. within stream channels) include springs 33-36. These springs are generally at elevations of 40-50 feet and were found issuing from the sides of the stream channel and, in one case, a spring could be seen bubbling up through the bottom of the stream channel. Only one spring (16) was found in landscape type 5 (i.e. local springs associated with recent rains) and is discussed in more detail later. It was hypothesized that ground water that is influenced by the more recent deposits and shallow organic soils would tend to be more acidic (have lower pH) than ground water that has been in contact with older deeper sediments. Field parameters for all springs sampled are listed in Tables 1 and 2. Spring 16 had a pH of 5.57 (neutral pH is equal to 7.0, values below 7.0 indicate acidic waters, and values above 7.0 indicate alkaline waters) thus supporting the hypothesis. Spring 16 is a different type of spring from the other springs because it is associated with the most recent shallow deposits and organic soils, and appears to be a local phenomenon. In most cases spring waters were near neutral. The maximum pH value for all springs was 7.93 at spring 27 in May and the minimum was 5.57 at spring 16 in August. Dissolved oxygen concentrations ranged from 10.4 mg/L (milligrams per liter) at spring 20 in May, to 2.5 mg/L at spring 9 in August.

The specific conductivity of the spring water in May ranged from 695 uS/cm at spring 2 to 245 uS/cm at spring 29 (excluding springs 6 and 16). The specific conductivity values are generally indicative of water that has been in contact with minerals long enough to dissolve and transport the minerals in solution. To further illustrate this point, rain water was collected during a storm in May and had a specific conductivity of 41 uS/cm. This low value is typical of rain water because the water is fresh and has not been in contact with soluble material. Generally, as the water percolates through the soils, recharges the aquifer, and flows through the aquifer, it dissolves material along the way and the specific conductivity increases. Increases in specific conductivity can be immediate if fresh water comes in contact with certain minerals such as salt. On the other hand, increases in specific conductivity can take much longer if water is flowing thorough minerals that do not dissolve as readily. For example, the anomalously low values of specific conductivity (56 uS/cm) and pH (5.57) are indicative of relatively fresh water that has recently entered and discharged from the ground water system. Therefore, this water has a short flow path from the point where it originally entered the ground to the point where it eventually exited the ground via the spring. These types of springs are usually short lived (the spring was dry in August) and, because of the short flow paths, have contributing areas that are much closer to the spring than those with more mineralized ground water discharges. Spring 6 had an anomalously high specific conductivity of 880 uS/cm which might suggest a longer contact time with aquifer material; however, the spring is relatively close to a highway where it is known that road salts are used for de-icing. It is possible that the high value at spring 6 is due to the dissolution of road salts, recharge to the aquifer, and subsequent transport of this water through the aquifer. Spring 6 was also dry in August. Consequently, higher specific conductivities, while generally indicating more mineralized ground water and longer flow paths could also be caused by a source of readily dissolvable material such as road salt.

Comparisons of field parameters for the two seasons is graphically illustrated in figures 2-5. Spring-water temperatures are generally greater in August than May and dissolved oxygen concentrations are generally lower in August than May. This observation suggests that the spring water is influenced by seasonal climatic factors. This is noteworthy because if, for example, the

spring-water temperatures and dissolved oxygen concentrations were relatively stable throughout the year, it could be surmised that the water originated from deeper flow systems. Though not quantifiable at this time, this observation is preliminary evidence of the extent of the contributing area of the springs. Springs that are sustained by deeper flow systems have larger contributing areas than springs that are sustained by shallower flow systems. The temperature and dissolved oxygen concentration could have been affected, in part, by sampling bias caused by the difficulties with obtaining an accurate reading at some of the springs. However, the observations are consistent in all springs even where the potential for this error is assumed negligible. Specific conductance remained relatively stable between the time periods for most springs suggesting that the amount of dissolved material in the water did not change with the change in season. However, it would be necessary to monitor specific conductance periodically throughout the year to verify this assertion. The values of pH are lower in August than in May in many of the springs. The differences are mostly less than a half a pH unit and probably not significant.

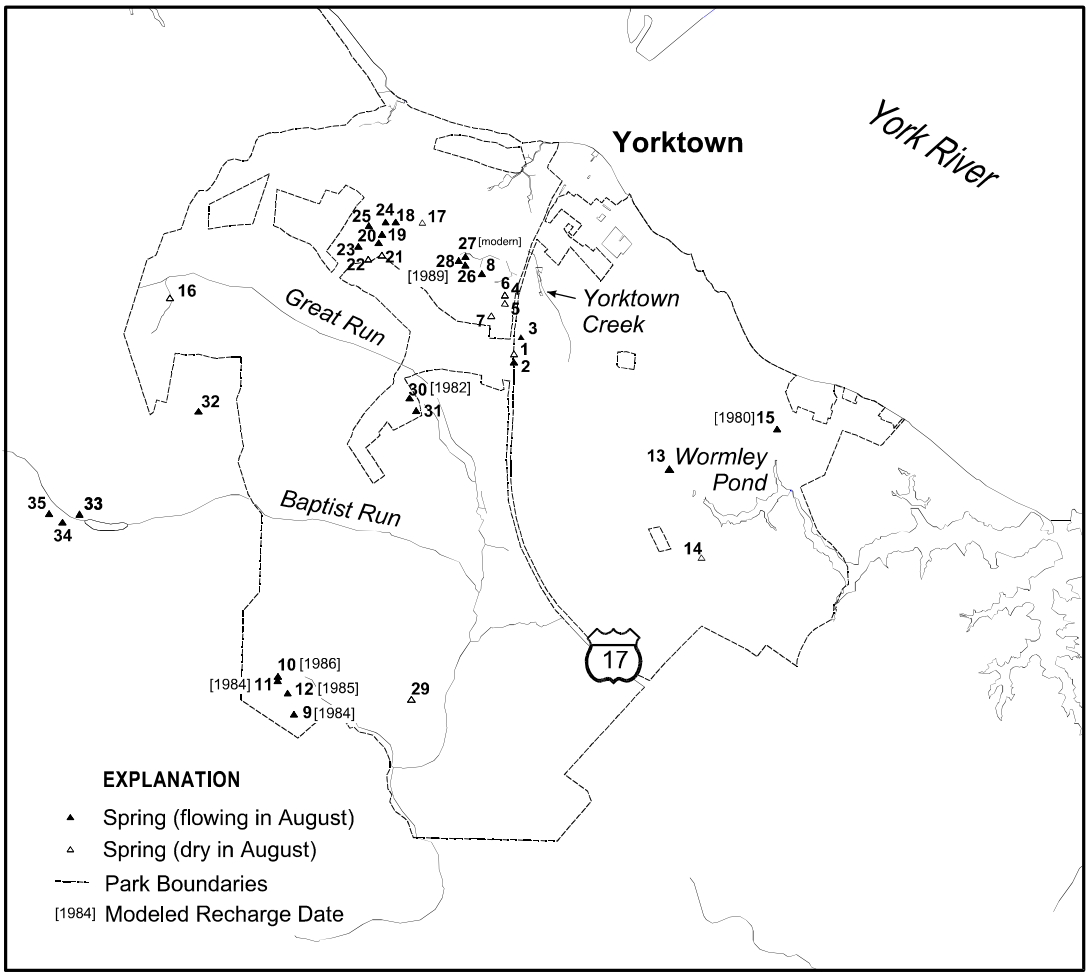


Figure 3. Locations of selected springs in Colonial National Historical Park.

Conclusions/Recommendations

Thirty-one springs were located within the boundaries of the Colonial National Historic Park during a field reconnaissance study in May, 1996 and revisited in August, 1996. Five additional springs which feed streams flowing to the park were located outside the park boundaries. Field parameters were recorded for each spring during both trips. These preliminary data establish ranges of field parameters that can be expected in the spring water. Additionally, water from eight selected springs was analyzed for chlorofluorocarbon compounds in order to determine modeled recharge ages. The age of the water ranged from recent (i.e. past two years) to 16 years old.

Before water-resource-management decisions and recommendations can be made, the ground-water-flow system and interactions with surface-water need to be described. The reconnaissance information, including locations of springs, field parameters, and recharge ages, can be used as background information to guide future investigations of the ground-water resources in the park. A follow-up study is recommended to describe the ground-water-flow system within the park. The first step of the follow-up study would be development of a geohydrologic framework for the shallow ground-water-flow system. The spring information presented in this report provides insights for designing monitoring well networks, potential recharge areas of the springs, residence times of the aquifers, and general geochemical processes. The framework would provide crucial basic information on the physical composition and geometry of the aquifer system and would be used with corresponding information such as potentiometric-surface maps to develop conceptual, or other, models of the shallow flow system. This could then be used to analyze ground-water flow from recharge to discharge locations and would provide important insights into potential contaminant sources and movement within the park. Additionally, the dynamics between the water-table and the Grafton Ponds could be ascertained with this information. For example, potentiometric-surface maps and associated water-level data from targeted wells could be used to determine the sources of water to the ponds and how they might change seasonally. These types of understandings are necessary before, or concurrent with, a study on the potential effects of surrounding land uses on the ponds.

Table 1. Field parameters collected in May, 1996 from selected springs						
uS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ^{o}C, degrees Celsius; -, no data						
Spring number	**Latitude**	**Longitude**	**pH**	**Specific conductance** (uS/cm)	**Dissolved oxygen (mg/L)**	**Water temperature (^{o}C)**
1	371332	763055	7.4	608	-	15
2	371330	763055	7.1	695	-	13
3	371336	763053	6.8	555	-	16
4	371346	763058	7.8	568	9.3	14
5	371344	763058	7.0	639	4.5	12
6	371346	763058	7.2	880	5.1	16
7	371341	763102	7.2	535	8.3	14
8	371351	763105	7.5	480	7.5	15
9	371205	763159	7.2	487	4.5	14
10	371214	763204	7.2	440	4.8	15
11	371213	763204	7.3	463	5.7	14
12	371210	763201	7.2	414	5.2	15
13	371305	763008	7.1	561	6.6	14
14	371244	762958	7.5	548	8.7	16
15	371315	762436	7.0	535	6.3	14
16	371344	763238	5.6	56	5.8	18
17	371403	763123	7.3	370	9.6	14
18	371403	763131	7.7	525	10.0	13
19	371400	763135	7.2	589	9.7	15
20	371358	763136	7.3	590	10.4	15
21	371355	763135	7.2	581	-	13
22	371354	763139	7.2	492	-	15
23	371357	763142	7.6	427	10.4	13
24	371403	763134	7.9	550	9.5	13
25	371402	763139	7.4	543	8.7	13
26	371353	763110	7.2	434	8.9	15
27	371355	763110	7.9	497	9.5	15
28	371354	763112	7.3	515	8.9	15
29	371209	763124	6.9	245	5.5	14
30	371321	763126	7.2	387	5.7	15
31	371318	763124	7.3	397	5.0	15
32	371317	763229	7.2	347	7.2	18
33	371252	763304	7.3	390	5.6	14
34	371250	763309	7.4	394	6.1	15
35	371252	763313	7.5	400	5.3	15
36	371306	763328	7.5	372	4.6	15

Table 2. Field parameters collected in August, 1996 from selected springs						
uS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ^{o}C, degrees Celsius; -, no data						
Spring number	**Latitude**	**Longitude**	**pH**	**Specific conductance (uS/cm)**	**Dissolved oxygen (mg/L)**	**Water temperature (^{o}C)**
1	371332	763055	dry	dry	dry	dry
2	371330	763055	6.7	564	-	16
3	371336	763053	6.6	560	-	16
4	371346	763058	7.1	566	3.5	15
5	371344	763058	dry	dry	dry	dry
6	371346	763058	dry	dry	dry	dry
7	371341	763102	dry	dry	dry	dry
8	371351	763105	6.7	452	7.8	16
9	371205	763159	7.3	456	2.5	16
10	371214	763204	7.2	437	2.7	15
11	371213	763204	6.7	437	2.9	15
12	371210	763201	7.4	419	2.7	14
13	371305	763008	7.0	569	6.0	16
14	371244	762958	dry	dry	dry	dry
15	371315	762436	7.0	410	4.3	19
16	371344	763238	dry	dry	dry	dry
17	371403	763123	-	-	-	-
18	371403	763131	7.5	474	8.2	18
19	371400	763135	6.8	603	8.0	17
20	371358	763136	7.0	601	-	17
21	371355	763135	dry	dry	dry	dry
22	371354	763139	dry	dry	dry	dry
23	371357	763142	7.4	445	8.4	19
24	371403	763134	7.4	580	8.8	19
25	371402	763139	7.1	550	8.3	18
26	371353	763110	6.4	422	7.9	16
27	371355	763110	6.8	478	8.7	18
28	371354	763112	6.6	456	6.6	18
29	371209	763124	dry	dry	dry	dry
30	371321	763126	7.2	403	3.8	15
31	371318	763124	7.2	402	4.2	15
32	371317	763229	-	-	-	-
33	371252	763304	-	-	-	-
34	371250	763309	-	-	-	-
35	371252	763313	-	-	-	-
36	371306	763328	-	-	-	-

Table 3. Modeled recharge dates and field parameters for selected springs				
[uS/cm, microsiemens per centimeter; mg/L, milligrams per liter]				
Spring Number	**Modeled Recharge Date**	**pH**	**Specific conductance (uS/cm)**	**Dissolve d oxygen (mg/L)**
9	1984	7.4	419	2.7
10	1986	7.3	456	2.5
11	1984	7.2	437	2.7
12	1985	6.7	437	2.9
15	1980	7.0	410	4.3
27	modern	6.8	478	8.7
28	1989	7.2	517	6.5
30	1982	7.2	403	3.8

Figure 3. Specific conductance for all springs sampled in May and August, 1996

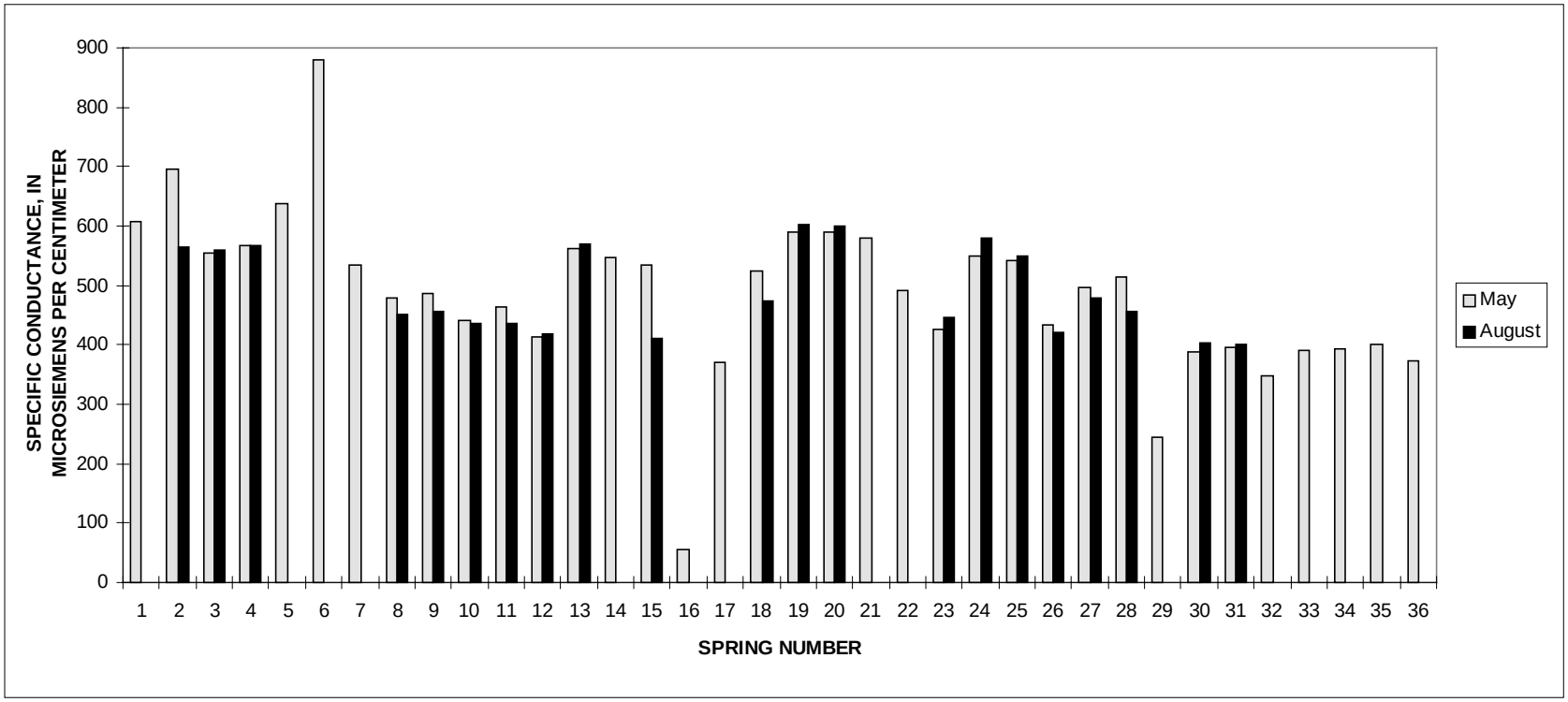


Figure 4. pH for all springs sampled in May and August, 1996

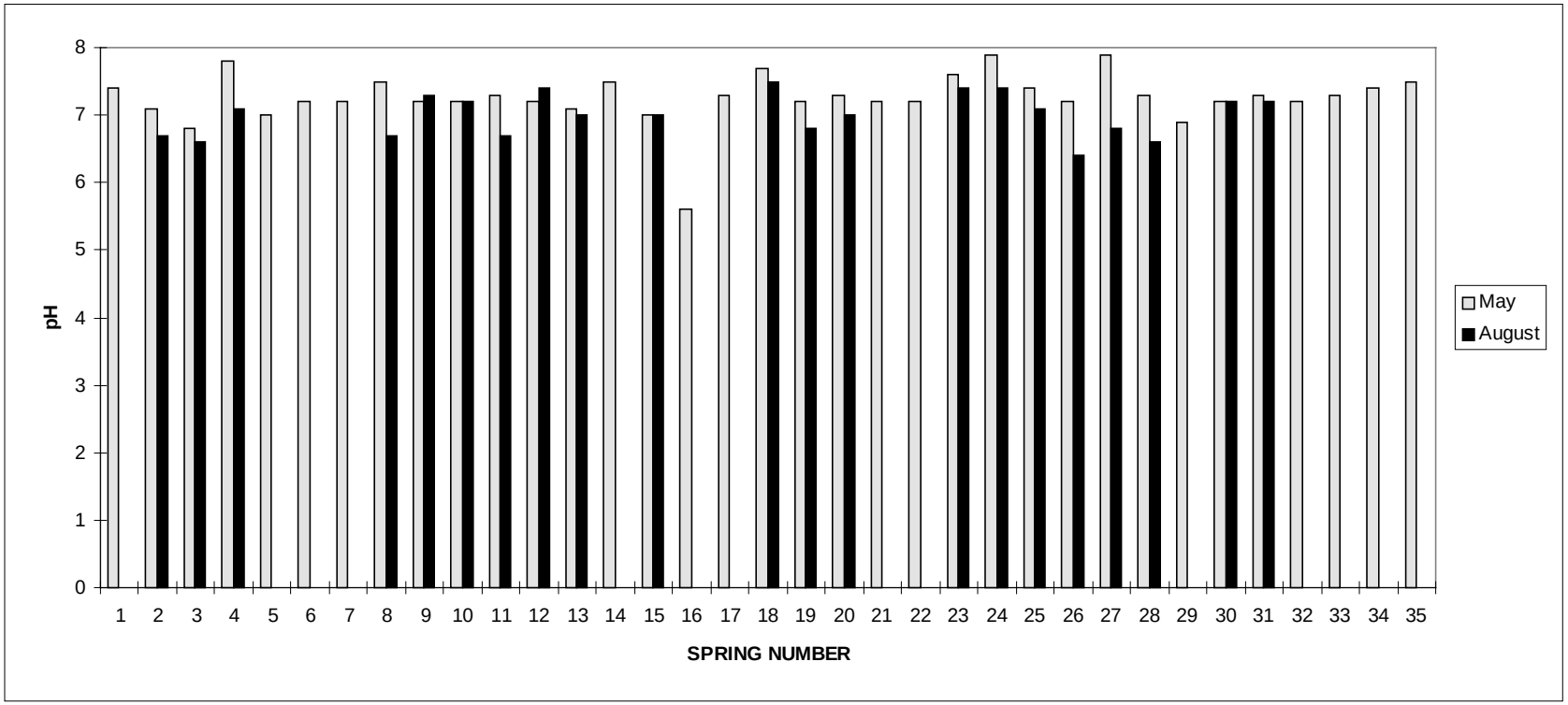


Figure 5. Water temperature for all springs sampled in May and August, 1996

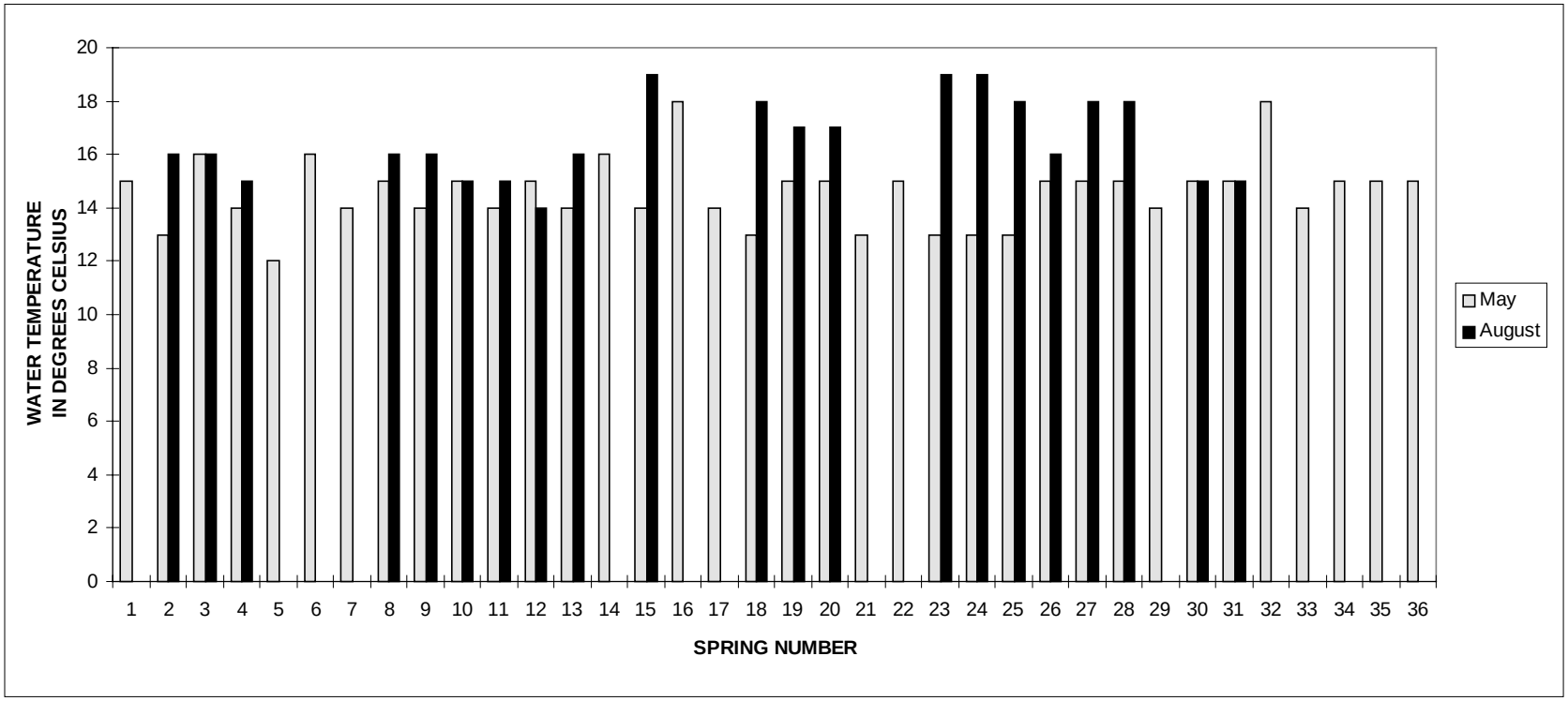
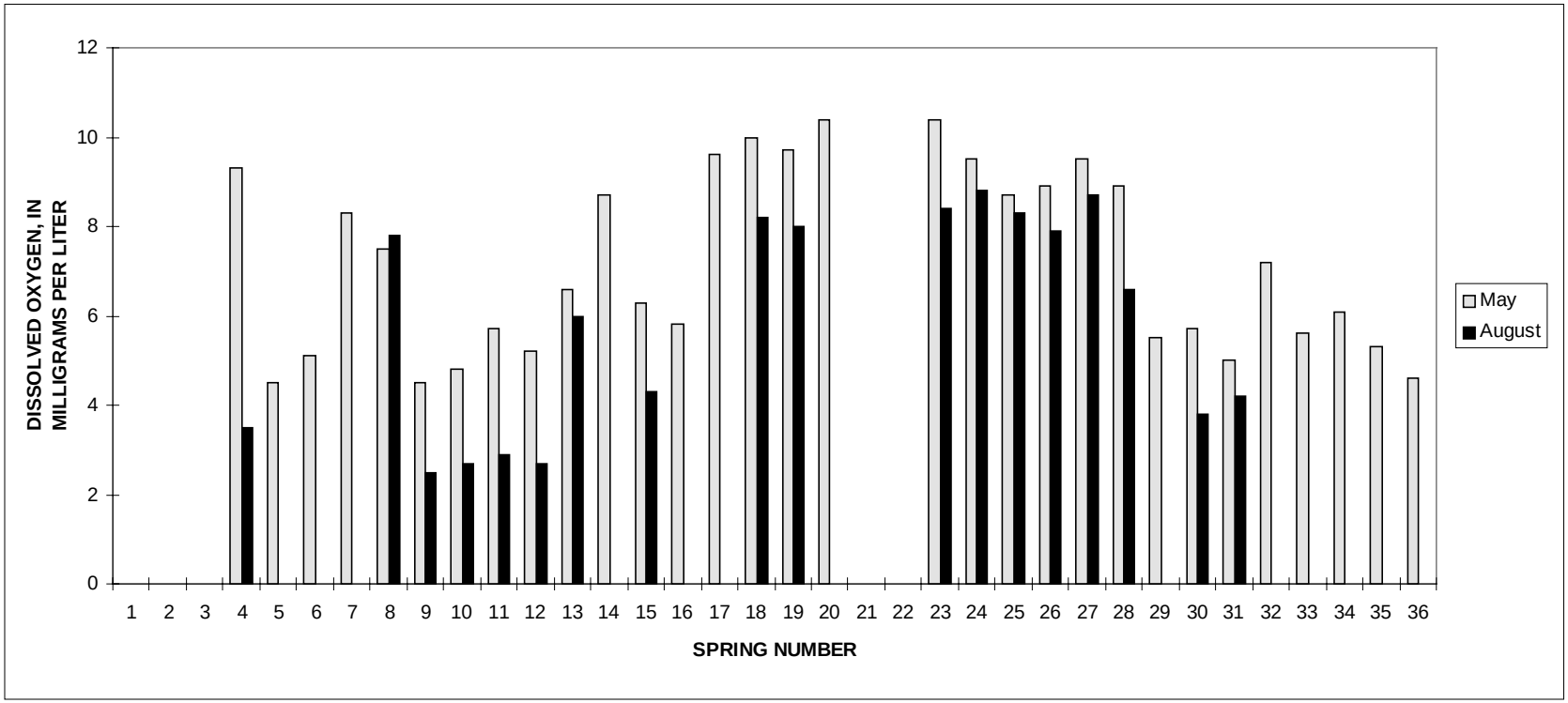


Figure 6. Dissolved oxygen for all springs sampled in May and August, 1996



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Busenberg, E., and L.N. Plummer (1992), Use of chlorofluorocarbons as hydrologic tracers and age-dating tools. The alluvium and terrace system of central Oklahoma, Water Resources Research 28, 2257-2283.