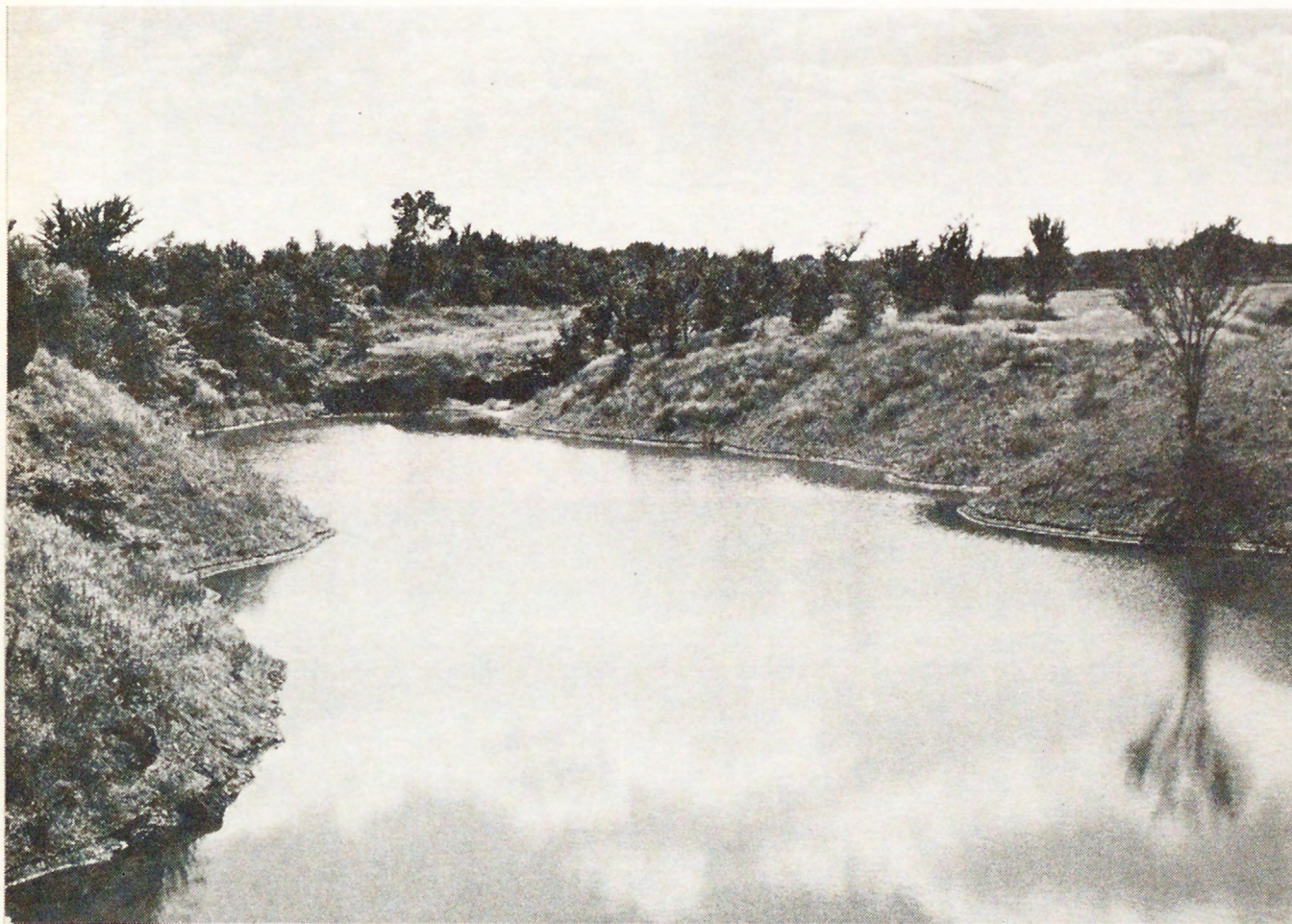


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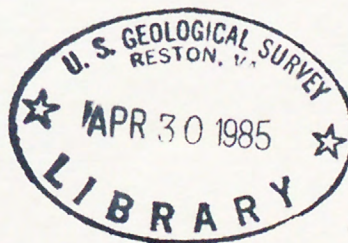
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PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER IN COAL-MINE PONDS, EASTERN OKLAHOMA, JUNE TO NOVEMBER 1977-81



U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 84-446



Prepared in cooperation with the
OKLAHOMA GEOLOGICAL SURVEY

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PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER IN COAL-MINE PONDS, EASTERN OKLAHOMA, JUNE TO NOVEMBER 1977-81

By Larry J. Slack and Stephen P. Blumer

Open-file report
(Geological Survey
(U.S.))

U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 84-446



Prepared in cooperation with the
OKLAHOMA GEOLOGICAL SURVEY

Oklahoma City, Oklahoma
1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For the convenience of readers who may want to use International System of Units (SI), the data may be converted by using the following factors:

Multiply inch-pound units	By	To obtain SI units
acres	0.4047	square hectometers
acre-feet	1233.	cubic meters
feet	0.3048	meters
miles	1.609	kilometers
Temperature		
degrees Fahrenheit (°F)	$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$	degrees Celsius (°C)
Specific conductance		
micromhos per centimeter at 25° Celsius (micromhos)	1.000	microsiemens per centimeter at 25° Celsius

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER
IN COAL-MINE PONDS, EASTERN OKLAHOMA,
JUNE TO NOVEMBER 1977-81

By

Larry J. Slack and Stephen P. Blumer

ABSTRACT

Water at 102 sites in 59 coal-mine ponds in eastern Oklahoma was sampled, at least twice, during June to November 1977-81 to determine temperature, specific conductance, dissolved oxygen, pH, and dissolved sulfate, chloride, iron, and manganese--as part of a study of the hydrology of the Oklahoma coal field. These determinations show that during June to October, water in ponds deeper than about 10 feet was stratified; ponds which had little or no change of temperature with depth generally were shallow or were sampled in early November. Temperature, dissolved oxygen, and pH usually decreased with depth, whereas specific conductance usually increased with depth. Concentrations of dissolved sulfate, chloride, iron, and manganese varied from site to site. Specific conductance, which is a measure of dissolved solids in the water, ranged from 93 to 4,800 micromhos per centimeter at 25 degrees Celsius. Some physical and chemical characteristics of the mine-pond water are related to the coal bed adjacent to the pond. Mean specific-conductance values and dissolved-sulfate concentrations were greatest in ponds associated with mining of the Dawson, Weir-Pittsburg, and Secor coals. Mean dissolved-iron concentrations were greatest in ponds associated with mining of the Dawson, Secor, and Hartshorne coals. Mean dissolved-manganese concentrations were greatest in ponds associated with mining of the Dawson, Weir-Pittsburg, and Secor coals, but greatly exceeded secondary drinking-water limits regardless of coal bed mined.

INTRODUCTION

The coal-mine ponds in eastern Oklahoma have a total area of about 4,000 acres (Johnson, 1974). The average measured depth of the ponds is about 25 feet; thus, the ponds provide storage for about 100,000 acre-feet of water. These ponds provide habitat for a variety of aquatic and semi-aquatic wildlife. Many of the ponds have been stocked with fish, and some are used for boating and swimming. Water from some of the ponds is used for stock, irrigation, and municipal supply.

Currently (1983), Red Oak (Latimer County) is the only city in the study area to use mine-pond water as a source for drinking water for a community system. Keota (Haskell County) and Gans (Sequoyah County) have used mine-pond water for their community system but, because of inconsistent quantity, no longer do. An undetermined number of individual households use mine-pond water for domestic supply.

The origin of the coal-mine ponds, especially those formed prior to 1974, is illustrated by figure 1 and the following generalized description summarized from Johnson (1974). First, a trench or box cut is made through the overburden to expose the coal which is then removed. As each parallel cut is made, the overburden is placed as spoil material into the previously excavated cut. Successive cuts are mined until the overburden thickness becomes so great that the coal can no longer be mined profitably. The final cut leaves an open trench bound by the last spoil pile on one side and the highwall on the other. Coal-mine ponds are formed by precipitation, ground-water seepage, and surface-water inflow partly filling the last cut and other depressions.

Prior to passage of Oklahoma's Open Cut Land Reclamation Act (effective January 1, 1968) and Mining Lands Reclamation Act (June 1971), most mined lands were left as shown in part (c) of figure 1. In areas mined since the passage of the reclamation acts, the ridges of spoil are graded, the topsoil replaced, and the area revegetated by seeding or planting. Revegetation is most successful when the revegetated area is not used for pasture until the plants have become well established.

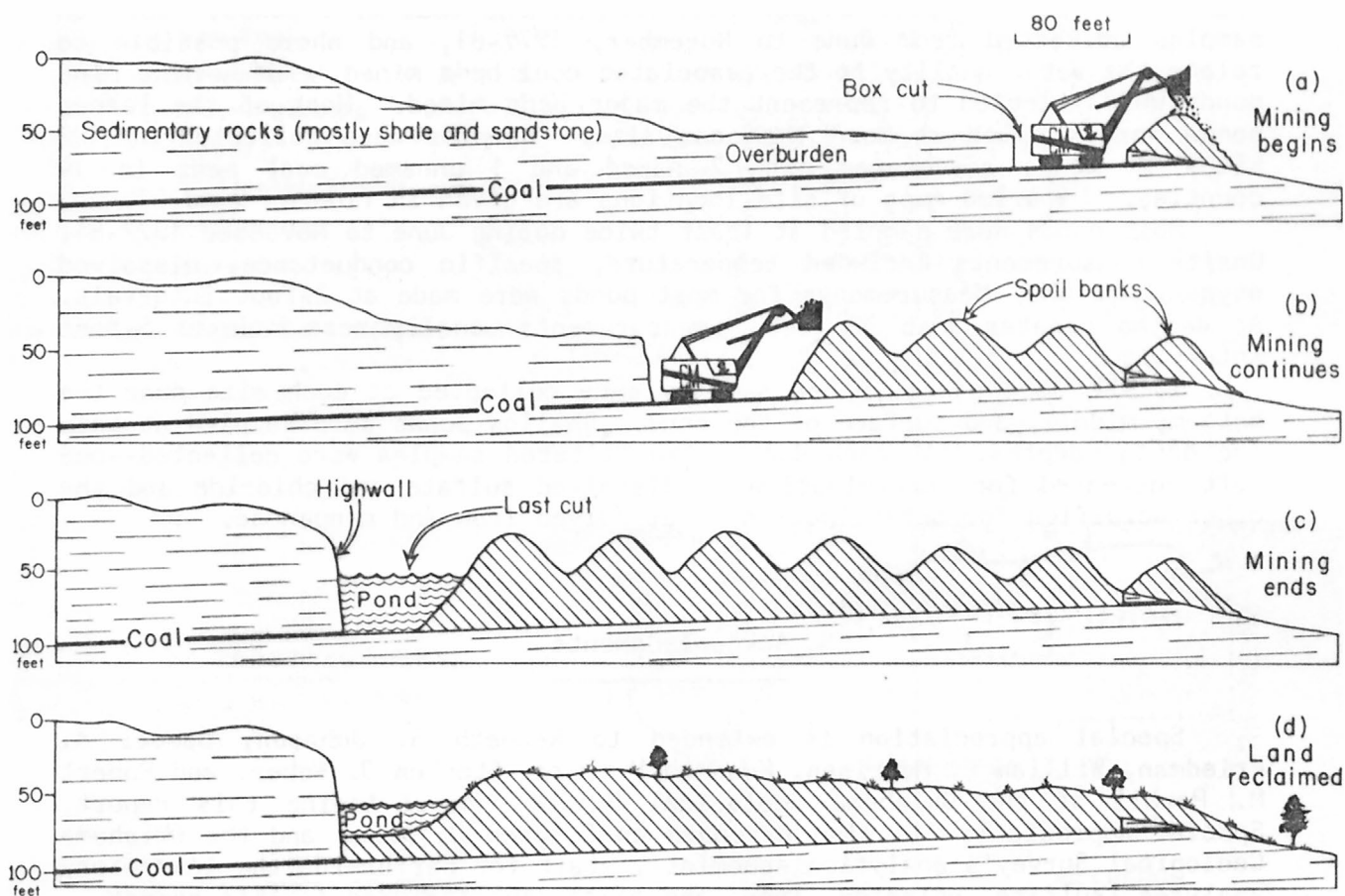


Figure 1.--Schematic sections showing stages of surface mining for coal
(from Johnson, 1974).

Purpose and Scope

In 1977, the U.S. Geological Survey, in cooperation with the Oklahoma Geological Survey, began collecting data on coal-mine ponds as part of a regional study of the hydrology of the eastern Oklahoma coal field (fig. 2). The purpose of this report is to describe the physical and chemical characteristics of water in the eastern Oklahoma coal-mine ponds, based on samples collected from June to November, 1977-81, and where possible to relate the water quality to the associated coal beds mined. Fifty-nine mine ponds were selected to represent the major beds mined. Most of the larger ponds were sampled at more than one site. Samples were collected at 102 sites in ponds associated with 7 named and 1 unnamed coal beds in 14 counties. Detailed maps of site locations are given in figures 9 to 57.

Most ponds were sampled at least twice during June to November 1977-81. Onsite measurements included temperature, specific conductance, dissolved oxygen, and pH. Measurements for most ponds were made at 2-foot intervals. At depths greater than 30 feet, measurements usually were made at 5-foot intervals.

In the deep ponds, water samples were collected at each site near the bottom, middle, and surface of the pond. Shallow ponds were sampled at only one or two depths. At each depth, two filtered samples were collected--one left untreated for determination of dissolved sulfate and chloride and the other acidified for determination of dissolved iron and manganese.

Acknowledgments

Special appreciation is extended to Kenneth S. Johnson, Samuel A. Friedman, William E. Harrison, Kenneth V. Luza, Stephen J. Weber, and Robert M. Powell of the Oklahoma Geological Survey for reviewing this report. Special appreciation is also extended to Stephen J. Weber and the Oklahoma Geological Survey's analytical-chemistry staff for performing the laboratory analyses (sulfate, chloride, iron, and manganese) included in this report.

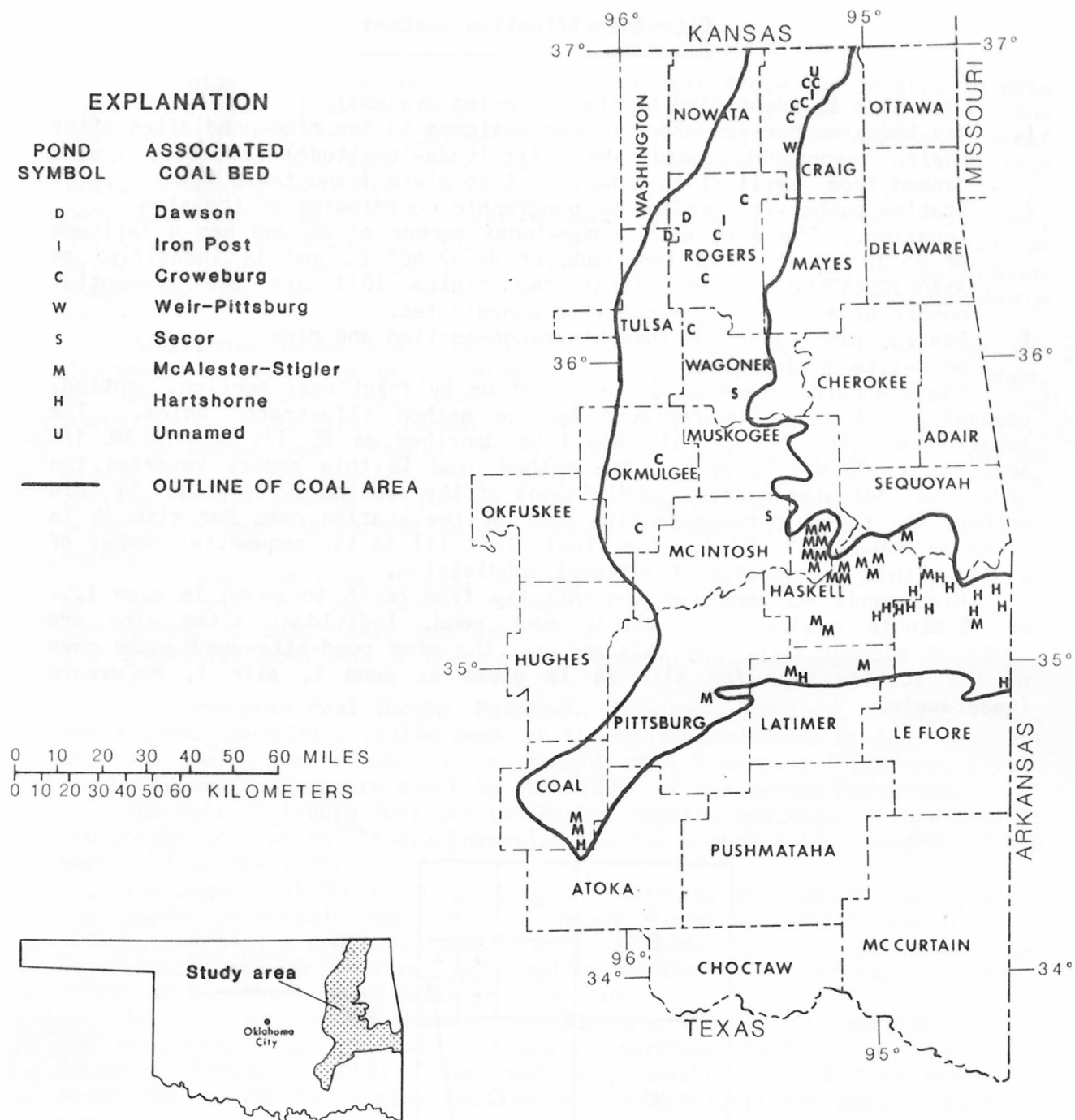


Figure 2.--Study area, location of coal-mine ponds, and associated coal beds.

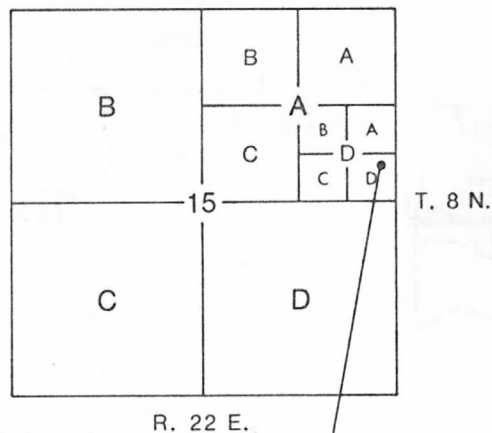
Site-Identification Systems

Each site is identified by the following systems:

1. Map-index number--an order number assigned to the mine-pond sites after their geographic-coordinate (latitude-longitude) numbers were ranked from smallest to largest. (See plate 1 and table 1.)
2. Station number--determined by geographic coordinates at the site location. The site with a map-index number of 24 and has a latitude of $35^{\circ}10'03''$ N. and longitude of $94^{\circ}57'50''$ E. and is identified as 351003094575001. The final two digits (01) are the sequential number of a site at the specific coordinates.
3. Station name--based on township-range-section and mine pond-site-quadrangle.

The standard method of giving location by fractional section, section, township, and range is replaced by the method illustrated below. The location of site 24 normally would be described as SE 1/4 SE 1/4 NE 1/4 sec. 15, T. 08 N., R. 22 E. The method used in this report reverses the order and indicates quarter subdivisions of the section by letters. By this method, the township-range-section part of the station name for site 24 is given as 08N-22E-15 ADD 1. The final digit (1) is the sequential number of a site within the smallest fractional subdivision.

Mine ponds are numbered sequentially from north to south in each 7.5- or 15-minute quadrangle. Within each pond, individual sites also are numbered sequentially. By this method, the mine pond-site-quadrangle part of the station name for site 24 is given as pond 1, site 1, McCurtain (quadrangle).



08N-22E-15 ADD 1

STRATIGRAPHY OF STUDY AREA

The mine ponds sampled in the Oklahoma coal field are located in pits associated with bituminous coal beds of Pennsylvanian age (fig. 3). The northeastern part of the Oklahoma coal field is in the "northeast shelf area"--that contains sandstone, shale, and limestone, and the Dawson, Iron Post, Croweburg, Weir-Pittsburg, and Secor coals. Shelf-area rocks contain more limestone than the coal-bearing rocks of the Arkoma basin (Friedman, 1978a). The southern part of the coal field is in the Arkoma basin--an eroded structural and depositional basin that contains sandstone, siltstone, shale, and the Secor, McAlester (Stigler), and Upper and Lower Hartshorne coals.

Additional named coals occur in Oklahoma but are omitted from the discussion because none of the mine ponds sampled are in contact with them. At least 20 named coals and several unnamed coals have been mined commercially in eastern Oklahoma during the last 100 years (Friedman, 1983).

The Dawson coal (Rogers, Tulsa, and Washington Counties) is in the middle part of the Seminole Formation. The Dawson coal has a mean sulfur content of 4.6 percent (Friedman, 1974). The Dawson, Weir-Pittsburg, and Secor coals have the largest sulfur content of the seven named coals in this study.

The Iron Post coal (Craig, Nowata, and Rogers Counties) is the upper principal coal of the Senora Formation which consists of a series of sandstones, shales, coal, and usually a limestone capping the formation. The Iron Post coal has a mean sulfur content of 4.0 percent (Friedman, 1974).

The Croweburg coal (Craig, McIntosh, Okfuskee, Okmulgee, Rogers, Tulsa, and Wagoner Counties), unlike most of the other coal beds in the northeast Oklahoma shelf, has a mean sulfur content of 1.9 percent (Friedman, 1974). The Croweburg coal occurs about in the middle of the Senora Formation.

The Weir-Pittsburg coal (Craig, Mayes, Rogers, and Wagoner Counties) is the lowest coal of the Senora Formation and has a mean sulfur content of 4.8 percent (Friedman, 1974).

The Secor coal (McIntosh, Muskogee, Pittsburg, and Wagoner Counties) is the upper principal coal of the Boggy Formation which consists of alternating shales and sandstones with local beds of blocky red clay. The Secor coal has the greatest mean sulfur content, 4.9 percent (Friedman, 1974), of the seven named coals in this study.

The Stigler coal of Haskell and Muskogee Counties is correlated with the McAlester coal of Coal, Pittsburg, northern Latimer, and Le Flore Counties (Friedman, 1983). The coal bed, usually 3 to 5 feet thick, is found 350 to 400 feet below the top of the McAlester Formation, which is composed dominantly of shale and sandstone. The McAlester (Stigler) coal has a mean sulfur content of 1.8 percent (Friedman, 1974). The McAlester (Stigler) coal generally has many of the same impurities as the Hartshorne coal.

The Hartshorne coal, commonly 3 to 5 feet thick, has been mined in Atoka, Coal, Pittsburg, Latimer, Haskell, Le Flore, and Sequoyah Counties. In Atoka, Coal, and Pittsburg Counties, the bed is divided into the Upper and Lower Hartshorne coals (fig. 3). The Upper Hartshorne coal is at the top of the Hartshorne Sandstone, with the Lower Hartshorne coal about 25 feet lower. East of Pittsburg County, the coals converge and in northernmost Haskell, Sequoyah, and Le Flore Counties are no longer distinguished as two separate beds. Hartshorne coal with thin layers of shale and pyrite has a mean sulfur content of 1.8 percent (Friedman, 1974).

SYSTEM	SERIES (age)	GROUP	FORMATION (Thickness in feet)	COAL
PENNSYLVANIAN	MISSOURIAN	SKIATOOK		
			Checkerboard Limestone 1 - 5	
			Seminole Formation 10 - 240	DAWSON
	DESMOINESIAN	MARMATON	Holdenville Shale 40 - 250	
			Lenapah Limestone 50	
			Nowata Shale 110	
			Oologah Limestone 30	Lexington
			Labette Shale 120	
			Fort Scott Limestone 0 - 35	
		CABANISS	Senora Formation 150 - 900	IRON POST Bevier
				CROWEBURG Fleming
				MINERAL (MORRIS?) Tebo (ERAM?)
				WEIR-PITTSBURG
		KREBS	Stuart Shale 0 - 375	
			Thurman Sandstone 0 - 250	
			Boggy Formation 125 - 2,140	SECOR
			Savanna Formation 180 - 2,500	Drywood ROWE (LOWER WITTEVILLE)
				CAVANAL
			McAlester Formation 140 - 2,830	Upper McAlester MC ALESTER (STIGLER)
			Hartshorne Sandstone 3 - 316	HARTSHORNE { UPPER LOWER

(Modified from Friedman, 1974)

Figure 3.--Generalized geologic column showing sequence of coal beds of Pennsylvanian age in Oklahoma. Coal beds containing identified coal resources are shown in capitals.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER IN COAL-MINE PONDS

The physical and chemical characteristics of the coal-mine pond water determined for this study included water temperature, specific conductance, dissolved oxygen, pH, and dissolved sulfate, chloride, iron, and manganese. Variations in degree of mixing of the water in the ponds caused a wide range of measured values for these properties and constituents from site to site within a pond and with depth at a single site. Profiles of temperature, specific conductance, dissolved oxygen, and pH for each sampling site and date are included in figures 58 to 159. Statistical data (maximum, minimum, mean, and number of determinations) for selected physical and chemical characteristics for each of the 102 sites are summarized in tables 1-4. Statistical data (number of analyses, standard deviation, and percentile) for selected characteristics for all 102 sites combined are presented in table 5.

Dissolved sulfate and chloride are reported in milligrams per liter (mg/L) and dissolved iron and manganese are reported in micrograms per liter (μ g/L). One milligram per liter is equal to 1,000 micrograms per liter.

Temperature

In the summer months, surface water heated by the sun was less dense and did not mix well with the underlying colder, more dense water. Lack of mixing, especially in the ponds deeper than about 10 feet, resulted in thermal stratification of the water. A cooling trend with increased depth was determined for most of the ponds. However, below a depth of about 30 feet the temperature usually showed no further change with depth.

From June to October, many Oklahoma coal-mine ponds were poorly mixed, and surface temperatures were as much as 23.5° Celsius greater than bottom temperatures. This variation in temperature with depth was greatest in the ponds deeper than about 10 feet sampled during July and August. For example, the pond at site 24 was 42 feet deep and had a surface to bottom temperature difference of about 17° Celsius in July 1977 and 19° Celsius in August 1979. The pond at site 5 was 50 feet deep and had a temperature difference of 23.5° Celsius. Typical temperatures of a 20-foot deep pond ranged from about 30° Celsius at the surface to about 15° Celsius at the bottom, as at sites 25 and 35. (See figures 62, 81, 82, and 92.)

Ponds that had little or no change of temperature with depth generally were shallow or were sampled in early November when cooling surface temperatures cause the pond to become well mixed.

Table 1.--Maximum values for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site.
(micromhos, micromhos per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter.)

Map- Index number (pl. 1)	Station Number	Station Name (Township - range - section and mine pond - site - quadrangle)	Specific conductance (micromhos)	pH (units)	Sulfate (mg/L)	Chloride (mg/L)	Iron (µg/L)	Manganese (µg/L)
1	342353096135301	02S-10E-11 BCB 2 POND 2 SITE 2 LEHIGH	400	7.3	33	3.0	80	2000
2	342358096135701	02S-10E-11 BCB 1 POND 2 SITE 1 LEHIGH	400	7.5	84	6.0	3600	3800
3	342807096133301	01S-10E-14 CAB 1 POND 1 SITE 1 LEHIGH	510	8.3	140	6.0	20	180
4	343106096133801	01N-10E-35 BBD 1 POND 1 SITE 1 COALGATE	190	7.6	19	2.0	3400	4500
5	345403094271301	05N-27E-16 DDC 1 POND 1 SITE 1 BATES	1810	9.0	60	9.0	70	4900
6	345440095404701	05N-15E-14 DDD 1 POND 1 SITE 1 KREBS	1650	7.2	16	3.0	490	2000
7	345506095190001	05N-19E-08 CAC 1 POND 1 SITE 1 WILBURTON	1070	6.8	59	85	50	50
8	345636095185601	06N-19E-32 DDD 1 POND 3 SITE 1 WILBURTON	990	8.9	260	4.0	60	350
9	345641095190301	06N-19E-32 DDB 1 POND 2 SITE 1 WILBURTON	785	8.9	260	4.0	10	10
10	345911095035101	06N-21E-14 CCD 1 POND 1 SITE 1 RED OAK NE	540	8.7	76	9.0	1900	5400
11	345915095033401	06N-21E-14 DCB 1 POND 1 SITE 2 RED OAK NE	300	8.2	28	4.0	60	110
12	345921095031801	06N-21E-14 DDB 1 POND 1 SITE 3 RED OAK NE	490	8.5	60	6.0	160	3100
13	350643095130001	07N-20E-05 ABC 1 POND 1 SITE 2 KINTA	466	8.2	63	3.2	40	130
14	350645095123401	07N-20E-05 AAD 1 POND 1 SITE 3 KINTA	517	8.3	63	2.4	310	2600
15	350645095124701	07N-20E-05 AAC 1 POND 1 SITE 1 KINTA	497	8.3	63	3.0	40	20
16	350702094350201	08N-26E-32 CCC 1 POND 1 SITE 1 POTEAU EAST	450	9.4	130	2.0	90	2200
17	350805095141701	08N-20E-30 CAC 2 POND 2 SITE 2 SANS BOIS	753	8.4	180	12	180	620
18	350805095142101	08N-20E-30 CAC 1 POND 2 SITE 1 SANS BOIS	794	8.4	180	10	110	400
19	350907094355001	08N-26E-19 DAB 1 POND 3 SITE 3 SPIRO	480	8.6	34	12	1500	70
20	350907094585001	08N-22E-22 CBB 1 POND 3 SITE 1 MCCURTAIN	1180	8.6	180	13	110	1900
21	350911094470901	08N-24E-16 CCD 1 POND 3 SITE 1 BOKOSHE	210	7.3	28	3.0	7100	6000
22	350913094351801	08N-26E-20 DDB 1 POND 3 SITE 1 SPIRO	480	8.5	30	13	1700	400
23	350918094352701	08N-26E-20 ACA 1 POND 3 SITE 2 SPIRO	480	8.5	29	13	360	30
24	351003094575001	08N-22E-15 ADD 1 POND 1 SITE 1 MCCURTAIN	4440	8.3	1600	56	1100	8000
25	351037094553001	08N-23E-07 CCA 1 POND 2 SITE 1 MCCURTAIN	1140	8.4	1100	10	40	720
26	351049094290701	08N-27E-08 CBB 1 POND 1 SITE 1 HACKETT	685	7.4	300	3.0	20	140
27	351130094520301	08N-23E-03 CDA 1 POND 1 SITE 1 BOKOSHE	970	8.4	250	7.0	490	13600
28	351230094340201	09N-26E-32 DAA 1 POND 2 SITE 1 SPIRO	215	8.1	12	4.0	8100	3400
29	351247094494801	09N-23E-36 BCB 1 POND 2 SITE 1 BOKOSHE	970	8.0	250	6.0	6600	4900
30	351343094300701	09N-26E-25 ABD 1 POND 1 SITE 1 SPIRO	375	8.3	50	11	600	10000
31	351436094420901	09N-25E-19 BAC 1 POND 1 SITE 1 PANAMA	4800	8.4	350	5.0	160	3300
32	351454095113301	09N-20E-16 DCB 1 POND 1 SITE 1 SANS BOIS	335	7.9	25	3.0	40	4100
33	351517095095801	09N-20E-14 BCC 1 POND 3 SITE 2 STIGLER WEST	450	8.8	40	7.0	760	5000
34	351517095121501	09N-20E-17 ADD 1 POND 2 SITE 2 STIGLER WEST	615	8.6	68	4.0	40	310
35	351518095095001	09N-20E-14 BCA 1 POND 3 SITE 1 STIGLER WEST	340	8.8	39	13	90	3300
36	351522095122201	09N-20E-17 ADB 1 POND 2 SITE 1 STIGLER WEST	685	8.5	78	4.0	30	6500
37	351602094435201	09N-24E-11 DBA 1 POND 1 SITE 1 MULBROW SW	1700	8.3	700	8.0	80	6100
38	351612094480301	09N-24E-07 ADB 1 POND 1 SITE 1 R.S.KERR DAM	1620	8.3	600	8.0	30	110
39	351632095003401	09N-22E-06 DDD 1 POND 2 SITE 1 STIGLER EAST	191	7.2	11	6.3	1800	5700
40	351925095034701	10N-21E-22 DAD 1 POND 1 SITE 1 STIGLER EAST	1380	8.3	550	8.0	2200	4400
41	352001094583101	10N-22E-16 DDD 1 POND 1 SITE 1 KEOTA	380	8.0	48	22	60	20
42	352001094583501	10N-22E-16 DDC 1 POND 1 SITE 2 KEOTA	475	8.0	48	21	180	4000
43	352001094583901	10N-22E-16 DDC 2 POND 1 SITE 3 KEOTA	360	7.9	49	20	90	10
44	352054095142601	10N-19E-12 DDD 1 POND 1 SITE 3 STIGLER WEST	940	8.0	190	13	640	6400
45	352100095142301	10N-19E-12 DDA 2 POND 1 SITE 2 STIGLER WEST	1080	8.4	220	2.0	940	22000
46	352105095142301	10N-19E-12 DDA 1 POND 1 SITE 1 STIGLER WEST	490	8.0	130	5.0	50	140
47	352222095150501	10N-19E-01 BDB 1 POND 1 SITE 1 PORUM	970	8.3	230	3.0	20	20
48	352231095145001	10N-19E-01 ABC 1 POND 3 SITE 2 HOLT MOUNTAIN	1030	8.2	310	3.0	580	3700
49	352237095143601	10N-19E-01 ABC 1 POND 3 SITE 1 HOLT MOUNTAIN	1400	8.2	430	3.0	1300	8700
50	352513094523201	11N-23E-16 DCC 1 POND 1 SITE 1 VIAN	944	8.2	340	7.0	60	1400

Table 1.--Maximum values for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site --continued.

Map- Index number (pl. 1)	Station Number	Station name (Township - range - section and mine pond - site - quadrangle)	Specific conductance (micromhos)	pH (units)	Sulfate (mg/L)	Chloride (mg/L)	Iron (ug/L)	Manganese (ug/L)
51	352518095134601	11N-20E-18 DCC 1 POND 2 SITE 2 HOLT MOUNTAIN	2550	8.8	1500	12	50	510
52	352519094522501	11N-23E-16 DCA 1 POND 1 SITE 2 SALLISAW	991	8.4	350	4.7	20	300
53	352519095135001	11N-20E-18 CDD 2 POND 2 SITE 3 HOLT MOUNTAIN	900	8.1	300	3.7	--	--
54	352520095135301	11N-20E-18 CDD 1 POND 2 SITE 1 HOLT MOUNTAIN	2580	8.9	640	17	60	540
55	352521095140601	11N-20E-18 CCA 1 POND 1 SITE 2 HOLT MOUNTAIN	2200	8.6	770	6.0	530	10000
56	352521095142101	11N-19E-13 DDA 1 POND 1 SITE 1 HOLT MOUNTAIN	1550	8.6	730	6.0	90	20
57	352522095135601	11N-20E-18 CDB 1 POND 1 SITE 3 HOLT MOUNTAIN	1540	8.6	730	12	120	880
58	352611095150401	11N-19E-12 CDC 1 POND 1 SITE 3 WARNER	1230	8.5	630	7.0	50	3800
59	352612095152001	11N-19E-12 CCB 1 POND 1 SITE 1 WARNER	1210	8.5	540	22	40	1200
60	352617095151101	11N-19E-12 CCA 1 POND 1 SITE 2 WARNER	1850	8.8	570	5.9	140	400
61	352619095572301	11N-13E-08 CAD 1 POND 2 SITE 1 HENRYETTA	753	6.3	410	5.7	20	4200
62	352628095572601	11N-13E-08 CAB 1 POND 2 SITE 2 HENRYETTA	757	6.3	400	5.2	10	4200
63	352825095251901	12N-18E-32 ACA 2 POND 3 SITE 3 WARNER NW	3220	3.3	2200	9.8	4800	55000
64	352830095251501	12N-18E-32 ACA 1 POND 3 SITE 2 WARNER NW	3240	3.3	2200	6.6	4900	55000
65	352834095251001	12N-18E-32 AAC 1 POND 3 SITE 1 WARNER NW	3240	3.3	2200	8.1	5000	56000
66	353805095522501	13N-13E-01 ADA 1 POND 1 SITE 2 OKMULGEE NE	630	8.1	190	22	10	600
67	353811095522601	13N-13E-01 AAD 1 POND 1 SITE 1 OKMULGEE NE	657	7.9	200	22	10	1600
68	355323095330101	16N-17E-06 CCA 1 POND 1 SITE 1 RED BIRD	1840	8.1	1000	6.4	80	2400
69	355323095330601	16N-17E-06 CCB 1 POND 1 SITE 2 RED BIRD	1950	7.9	1100	4.1	80	16000
70	360526095435401	19N-15E-29 DCD 1 POND 1 SITE 3 ONETA	3690	8.2	2300	14	2600	6600
71	360533095440101	19N-15E-29 DCC 1 POND 1 SITE 2 ONETA	3730	8.2	2200	17	2700	11000
72	360552095435801	19N-15E-29 ACC 1 POND 1 SITE 1 ONETA	3460	8.3	2100	11	460	2600
73	361544095395101	21N-15E-36 BAB 1 POND 1 SITE 1 SAGEEYAH	506	8.2	99	3.8	90	1300
74	361549095394601	21N-15E-36 BAB 2 POND 1 SITE 2 SAGEEYAH	466	8.3	90	5.1	160	2200
75	362249095495501	22N-14E-17 DDD 1 POND 2 SITE 3 COLLINSVILLE NE	2520	8.1	900	230	2200	12000
76	362253095500201	22N-14E-17 DDB 2 POND 2 SITE 2 COLLINSVILLE NE	3000	8.1	1100	240	8700	13000
77	362257095495501	22N-14E-17 DDB 1 POND 2 SITE 1 COLLINSVILLE NE	2860	8.0	840	230	10000	13000
78	362333095365201	22N-16E-16 BBB 2 POND 2 SITE 1 FOYIL	917	8.4	310	29	40	400
79	362337095364601	22N-16E-16 BBB 1 POND 2 SITE 2 FOYIL	793	8.2	250	4.6	40	80
80	362618095352801	23N-16E-27 CDC 1 POND 1 SITE 3 FOYIL	554	7.9	160	8.2	70	850
81	362635095352701	23N-16E-27 CAA 1 POND 1 SITE 1 FOYIL	598	8.0	160	7.0	480	1600
82	362636095352801	23N-16E-27 CAC 1 POND 1 SITE 2 FOYIL	587	8.0	160	8.3	460	1800
83	362718095450201	23N-15E-19 CDA 1 POND 1 SITE 2 COLLINSVILLE NE	2020	8.2	1100	11	40	4400
84	362725095445801	23N-15E-19 CAD 1 POND 1 SITE 1 OOLOGAH	1730	8.2	950	6.7	40	760
85	363039095292401	24N-17E-33 DDD 1 POND 3 SITE 1 CHELSEA	552	8.4	220	6.4	30	70
86	363049095293201	24N-17E-33 DDC 1 POND 3 SITE 2 CHELSEA	559	8.4	210	6.7	40	70
87	363049095293801	24N-17E-33 DCD 1 POND 3 SITE 3 CHELSEA	588	8.3	230	6.5	40	1700
88	364109095183301	26N-19E-31 DDC 1 POND 2 SITE 2 ESTELLA	3080	7.6	2000	14	120	15000
89	364119095183101	26N-19E-31 DAC 1 POND 2 SITE 3 ESTELLA	2590	7.6	1700	12	40	2900
90	364125095182301	26N-19E-31 DAA 1 POND 2 SITE 1 ESTELLA	2710	7.7	1700	9.9	110	2200
91	364756095174101	27N-19E-29 ABB 1 POND 2 SITE 1 CENTRALIA	430	8.9	77	4.0	4200	1500
92	364756095174801	27N-19E-29 BAA 1 POND 2 SITE 2 CENTRALIA	440	8.5	72	5.0	400	1200
93	364831095172101	27N-19E-20 ADD 1 POND 1 SITE 3 CENTRALIA	3000	8.3	180	5.0	60	1100
94	364835095171801	27N-19E-20 ADA 1 POND 1 SITE 2 CENTRALIA	690	8.2	190	4.1	60	680
95	364841095171901	27N-19E-20 AAD 1 POND 1 SITE 1 CENTRALIA	695	9.1	180	5.1	200	90
96	364951095132801	27N-19E-12 DCC 2 POND 2 SITE 1 PYRAMID CORNERS	715	8.4	210	2.9	1000	4700
97	365119095124701	27N-20E-06 BBD 1 POND 1 SITE 1 PYRAMID CORNERS	1520	6.3	900	10	80	1200
98	365418095123701	28N-20E-18 CDB 1 POND 2 SITE 3 WELCH NW	970	7.9	440	5.0	120	590
99	365418095124201	28N-20E-18 CCA 2 POND 3 SITE 1 WELCH NW	700	8.3	230	13	60	60
100	365421095124001	28N-20E-18 CCA 1 POND 2 SITE 2 WELCH NW	960	8.1	450	5.7	130	1500
101	365424095124201	28N-20E-18 CBD 1 POND 2 SITE 1 WELCH NW	955	8.4	390	6.0	220	770
102	365549095121701	28N-20E-07 ABB 1 POND 1 SITE 1 WELCH NW	1500	8.2	690	9.1	610	15000

Table 2.--Minimum values for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site.
(micromhos, micromhos per centimeter at 25° Celsius; mg/L, milligrams per liter, µg/L, micrograms per liter.)

Map- Index number (pl. 1)	Station Number	Station Name (Township - range - section and mlne pond - site - quadrangle)	Specific conductance (micromhos)	pH (units)	Sulfate (mg/L)	Chloride (mg/L)	Iron (µg/L)	Manganese (µg/L)
1	342353096135301	02S-10E-11 BCB 2 POND 2 SITE 2 LEHIGH	180	6.3	28	3.0	10	20
2	342358096135701	02S-10E-11 BCB 1 POND 2 SITE 1 LEHIGH	160	6.6	11	3.0	10	10
3	342807096133301	01S-10E-14 CAB 1 POND 1 SITE 1 LEHIGH	460	7.3	130	6.0	10	10
4	343106096133801	01N-10E-35 BBD 1 POND 1 SITE 1 COALGATE	110	6.4	3.7	2.0	10	15
5	345403094271301	05N-27E-16 DDC 1 POND 1 SITE 1 BATES	200	7.3	7.6	4.0	10	5
6	345440095404701	05N-15E-14 DDD 1 POND 1 SITE 1 KREBS	120	6.8	5.1	2.0	50	20
7	345506095190001	05N-19E-08 CAC 1 POND 1 SITE 1 WILBURTON	1060	6.7	58	85	10	10
8	345636095185601	06N-19E-32 DDD 1 POND 3 SITE 1 WILBURTON	735	7.0	230	4.0	10	10
9	345641095190301	06N-19E-32 DDB 1 POND 2 SITE 1 WILBURTON	700	7.6	230	2.0	10	10
10	345911095035101	06N-21E-14 CCD 1 POND 1 SITE 1 RED OAK NE	150	6.6	16	4.0	10	10
11	345915095033401	06N-21E-14 DCB 1 POND 1 SITE 2 RED OAK NE	150	7.0	20	4.0	10	10
12	345921095031801	06N-21E-14 DDB 1 POND 1 SITE 3 RED OAK NE	150	6.3	9.0	3.0	10	10
13	350643095130001	07N-20E-05 ABC 1 POND 1 SITE 2 KINTA	455	7.6	62	3.1	30	20
14	350645095123401	07N-20E-05 AAD 1 POND 1 SITE 3 KINTA	445	6.8	51	2.3	10	40
15	350645095124701	07N-20E-05 AAC 1 POND 1 SITE 1 KINTA	446	7.5	63	2.9	20	10
16	350702094350201	08N-26E-32 CCC 1 POND 1 SITE 1 POTEAU EAST	305	7.3	60	1.0	10	5
17	350805095141701	08N-20E-30 CAC 2 POND 2 SITE 2 SANS BOIS	637	7.8	170	2.6	40	400
18	350805095142101	08N-20E-30 CAC 1 POND 2 SITE 1 SANS BOIS	645	7.5	160	3.0	30	10
19	350907094355001	08N-26E-19 DAB 1 POND 3 SITE 3 SPIRO	440	7.3	29	12	1300	20
20	350907094585001	08N-22E-22 CBB 1 POND 3 SITE 1 MCCURTAIN	610	6.9	140	8.0	10	5
21	350911094470901	08N-24E-16 CCD 1 POND 3 SITE 1 BOKOSHE	115	6.7	13	3.0	110	15
22	350913094351801	08N-26E-20 DDB 1 POND 3 SITE 1 SPIRO	370	7.4	20	5.0	10	20
23	350918094352701	08N-26E-20 ACA 1 POND 3 SITE 2 SPIRO	430	7.4	24	11	80	10
24	351003094575001	08N-22E-15 ADD 1 POND 1 SITE 1 MCCURTAIN	1260	7.2	380	8.0	20	5
25	351037094553001	08N-23E-07 CCA 1 POND 2 SITE 1 MCCURTAIN	980	7.1	360	7.0	20	5
26	351049094290701	08N-27E-08 CBB 1 POND 1 SITE 1 HACKETT	680	6.7	300	2.0	10	20
27	351130094520301	08N-23E-03 CDA 1 POND 1 SITE 1 BOKOSHE	490	6.7	140	3.0	20	20
28	351230094340201	09N-26E-32 DAA 1 POND 2 SITE 1 SPIRO	93	6.5	5.0	2.0	90	40
29	351247094494801	09N-23E-36 BCB 1 POND 2 SITE 1 BOKOSHE	230	6.7	40	2.0	30	5
30	351343094300701	09N-26E-25 ABD 1 POND 1 SITE 1 SPIRO	190	6.8	23	1.0	20	10
31	351436094420901	09N-25E-19 BAC 1 POND 1 SITE 1 PANAMA	780	7.1	280	1.0	10	10
32	351454095113301	09N-20E-16 DCB 1 POND 1 SITE 1 SANS BOIS	170	7.0	17	3.0	10	10
33	351517095095801	09N-20E-14 BCC 1 POND 3 SITE 2 STIGLER WEST	230	7.0	17	3.0	40	10
34	351517095121501	09N-20E-17 ADD 1 POND 2 SITE 2 STIGLER WEST	410	7.6	52	2.0	20	10
35	351518095095001	09N-20E-14 BCA 1 POND 3 SITE 1 STIGLER WEST	220	7.1	17	3.0	30	90
36	351522095122201	09N-20E-17 ADB 1 POND 2 SITE 1 STIGLER WEST	420	7.3	52	4.0	20	110
37	351602094435201	09N-24E-11 DBA 1 POND 1 SITE 1 MULBROW SW	1000	7.1	510	1.0	10	5
38	351612094480301	09N-24E-07 ADB 1 POND 1 SITE 1 R.S.KERR DAM	1140	7.3	520	4.0	20	5
39	351632095003401	09N-22E-06 DDD 1 POND 2 SITE 1 STIGLER EAST	114	7.1	7.6	5.0	40	80
40	351925095034701	10N-21E-22 DAD 1 POND 1 SITE 1 STIGLER EAST	1060	7.4	420	2.0	20	5
41	352001094583101	10N-22E-16 DDD 1 POND 1 SITE 1 KEOTA	360	7.7	45	19	60	20
42	352001094583501	10N-22E-16 DDC 1 POND 1 SITE 2 KEOTA	365	6.9	46	20	80	20
43	352001094583901	10N-22E-16 DDC 2 POND 1 SITE 3 KEOTA	355	7.7	48	20	40	10
44	352054095142601	10N-19E-12 DDD 1 POND 1 SITE 3 STIGLER WEST	360	6.6	93	1.0	20	10
45	352100095142301	10N-19E-12 DDA 2 POND 1 SITE 2 STIGLER WEST	350	6.6	94	0.1	10	10
46	352105095142301	10N-19E-12 DDA 1 POND 1 SITE 1 STIGLER WEST	350	6.6	93	0.1	10	10
47	352222095150501	10N-19E-01 BDB 1 POND 1 SITE 1 PORUM	730	6.1	190	1.0	20	10
48	352231095145001	10N-19E-01 ABC 1 POND 3 SITE 2 HOLT MOUNTAIN	657	5.1	190	1.0	10	5
49	352237095143601	10N-19E-01 ABC 1 POND 3 SITE 1 HOLT MOUNTAIN	647	6.5	180	1.0	10	20
50	352513094523201	11N-23E-16 DCC 1 POND 1 SITE 1 VIAN	894	7.4	330	4.5	30	20

Table 2.--Minimum values for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site --continued.

Map- Index number (pl. 1)	Station Number	Station Name (Township - range - section and mine pond - site - quadrangle)	Specific conductance (micromhos)	pH (units)	Sulfate (mg/L)	Chloride (mg/L)	Iron (ug/L)	Manganese (ug/L)
51	352518095134601	11N-20E-18 DCC 1 POND 2 SITE 2 HOLT MOUNTAIN	666	6.6	260	3.6	10	20
52	352519094522501	11N-23E-16 DCA 1 POND 1 SITE 2 SALLISAW	903	7.2	340	4.4	20	10
53	352519095135001	11N-20E-18 CDD 2 POND 2 SITE 3 HOLT MOUNTAIN	890	7.8	300	3.5	--	--
54	352520095135301	11N-20E-18 CDD 1 POND 2 SITE 1 HOLT MOUNTAIN	711	6.6	260	2.8	20	20
55	352521095140601	11N-20E-18 CCA 1 POND 1 SITE 2 HOLT MOUNTAIN	1040	6.5	7.7	1.0	10	10
56	352521095142101	11N-19E-13 DDA 1 POND 1 SITE 1 HOLT MOUNTAIN	1040	6.6	670	4.0	10	10
57	352522095135601	11N-20E-18 CDB 1 POND 1 SITE 3 HOLT MOUNTAIN	1040	6.6	330	2.0	10	8
58	352611095150401	11N-19E-12 CDC 1 POND 1 SITE 3 WARNER	1010	6.5	440	2.0	10	10
59	352612095152001	11N-19E-12 CCB 1 POND 1 SITE 1 WARNER	1000	6.8	440	3.0	20	10
60	352617095151101	11N-19E-12 CCA 1 POND 1 SITE 2 WARNER	1000	6.5	440	2.0	10	8
61	352619095572301	11N-13E-08 CAD 1 POND 2 SITE 1 HENRYETTA	750	6.1	400	5.0	10	4200
62	352628095572601	11N-13E-08 CAB 1 POND 2 SITE 2 HENRYETTA	755	6.1	400	4.2	10	4100
63	352825095251901	12N-18E-32 ACA 2 POND 3 SITE 3 WARNER NW	3210	3.2	2000	7.5	4800	54000
64	352830095251501	12N-18E-32 ACA 1 POND 3 SITE 2 WARNER NW	3220	3.2	2200	6.2	4800	54000
65	352834095251001	12N-18E-32 AAC 1 POND 3 SITE 1 WARNER NW	3220	3.2	2100	7.8	5000	55000
66	353805095522501	13N-13E-01 ADA 1 POND 1 SITE 2 OKMULGEE NE	624	7.6	190	22	10	100
67	353811095522601	13N-13E-01 AAD 1 POND 1 SITE 1 OKMULGEE NE	583	7.4	190	22	10	30
68	355323095330101	16N-17E-06 CCA 1 POND 1 SITE 1 RED BIRD	1820	7.7	1000	1.0	50	1600
69	355323095330601	16N-17E-06 CCB 1 POND 1 SITE 2 RED BIRD	1870	7.3	1000	0.7	80	3200
70	360526095435401	19N-15E-29 DCD 1 POND 1 SITE 3 ONETA	3330	7.0	2000	14	80	20
71	360533095440101	19N-15E-29 DCC 1 POND 1 SITE 2 ONETA	3340	7.1	2000	13	50	20
72	360552095435801	19N-15E-29 ACC 1 POND 1 SITE 1 ONETA	3290	7.3	2000	5.9	130	1200
73	361544095395101	21N-15E-36 BAB 1 POND 1 SITE 1 SAGEEYAH	454	7.1	95	3.7	70	820
74	361549095394601	21N-15E-36 BAB 2 POND 1 SITE 2 SAGEEYAH	433	7.2	74	4.9	50	20
75	362249095495501	22N-14E-17 DDD 1 POND 2 SITE 3 COLLINSVILLE NE	2090	7.1	770	220	50	400
76	362253095500201	22N-14E-17 DDB 2 POND 2 SITE 2 COLLINSVILLE NE	2150	7.0	790	220	60	320
77	362257095495501	22N-14E-17 DDB 1 POND 2 SITE 1 COLLINSVILLE NE	2150	7.0	780	220	120	320
78	362333095365201	22N-16E-16 BBB 2 POND 2 SITE 1 FOYIL	700	7.4	250	4.2	10	0
79	362337095364601	22N-16E-16 BBB 1 POND 2 SITE 2 FOYIL	790	7.8	250	4.6	40	80
80	362618095352801	23N-16E-27 CDC 1 POND 1 SITE 3 FOYIL	533	7.2	130	7.1	10	20
81	362635095352701	23N-16E-27 CAA 1 POND 1 SITE 1 FOYIL	490	7.1	110	6.1	40	40
82	362636095352801	23N-16E-27 CAC 1 POND 1 SITE 2 FOYIL	494	7.1	110	6.1	40	90
83	362718095450201	23N-15E-19 CDA 1 POND 1 SITE 2 COLLINSVILLE NE	1710	7.4	960	6.5	30	50
84	362725095445801	23N-15E-19 CAD 1 POND 1 SITE 1 ODOLOGAH	1600	7.3	870	5.5	10	20
85	363039095292401	24N-17E-33 DDD 1 POND 3 SITE 1 CHELSEA	530	7.5	200	6.1	20	30
86	363049095293201	24N-17E-33 DDC 1 POND 3 SITE 2 CHELSEA	535	7.5	200	6.5	20	40
87	363049095293801	24N-17E-33 DCD 1 POND 3 SITE 3 CHELSEA	537	7.5	210	5.4	30	80
88	364109095183301	26N-19E-31 DDC 1 POND 2 SITE 2 ESTELLA	2520	6.6	1700	13	60	2000
89	364119095183101	26N-19E-31 DAC 1 POND 2 SITE 3 ESTELLA	2500	7.3	1700	6.9	40	1900
90	364125095182301	26N-19E-31 DAA 1 POND 2 SITE 1 ESTELLA	2510	7.2	1600	8.1	60	1600
91	364756095174101	27N-19E-29 ABB 1 POND 2 SITE 1 CENTRALIA	329	6.6	64	3.1	30	10
92	364756095174801	27N-19E-29 BAA 1 POND 2 SITE 2 CENTRALIA	333	6.5	61	2.6	10	5
93	364831095172101	27N-19E-20 ADD 1 POND 1 SITE 3 CENTRALIA	491	7.3	140	4.0	10	5
94	364835095171801	27N-19E-20 ADA 1 POND 1 SITE 2 CENTRALIA	502	7.6	140	3.5	10	20
95	364841095171901	27N-19E-20 AAD 1 POND 1 SITE 1 CENTRALIA	499	7.5	140	3.0	30	20
96	364951095132801	27N-19E-12 DCC 2 POND 2 SITE 1 PYRAMID CORNERS	561	7.5	170	2.2	80	60
97	365119095124701	27N-20E-06 BBD 1 POND 1 SITE 1 PYRAMID CORNERS	1480	6.3	900	10	80	1200
98	365418095123701	28N-20E-18 CDB 1 POND 2 SITE 3 WELCH NW	738	7.4	360	3.6	10	200
99	365418095124201	28N-20E-18 CCA 2 POND 3 SITE 1 WELCH NW	404	7.8	150	7.1	10	15
100	365421095124001	28N-20E-18 CCA 1 POND 2 SITE 2 WELCH NW	758	6.5	380	2.4	20	80
101	365424095124201	28N-20E-18 CBD 1 POND 2 SITE 1 WELCH NW	747	6.9	370	4.7	20	270
102	365549095121701	28N-20E-07 ABB 1 POND 1 SITE 1 WELCH NW	460	6.3	130	2.5	20	1

Table 3.--Mean values for specific conductance and concentrations of dissolved sulfate, chloride, iron, and manganese for each site.
(micromhos, micromhos per centimeter at 25°Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter.)

Map-index number (pl. 1)	Station Number	Station Name (Township - range - section and mine pond - site - quadrangle)	Specific conductance (micromhos)	Sulfate (mg/L)	Chloride (mg/L)	Iron (µg/L)	Manganese (µg/L)
1	342353096135301	02S-10E-11 BCB 2 POND 2 SITE 2 LEHIGH	230	30	3.0	40	1000
2	342358096135701	02S-10E-11 BCB 1 POND 2 SITE 1 LEHIGH	243	41	4.2	1400	1400
3	342807096133301	01S-10E-14 CAB 1 POND 1 SITE 1 LEHIGH	492	140	6.0	20	95
4	343106096133801	01N-10E-35 BBD 1 POND 1 SITE 1 COALGATE	140	11	2.0	820	1300
5	345403094271301	05N-27E-16 DDC 1 POND 1 SITE 1 BATES	513	44	6.3	40	1000
6	345440095404701	05N-15E-14 DDD 1 POND 1 SITE 1 KREBS	654	9.7	2.7	220	770
7	345506095190001	05N-19E-08 CAC 1 POND 1 SITE 1 WILBURTON	1060	58	85	30	30
8	345636095185601	06N-19E-32 DDD 1 POND 3 SITE 1 WILBURTON	824	240	4.0	30	120
9	345641095190301	06N-19E-32 DOB 1 POND 2 SITE 1 WILBURTON	744	240	3.5	10	10
10	345911095035101	06N-21E-14 CCD 1 POND 1 SITE 1 RED OAK NE	318	45	6.4	420	1900
11	345915095033401	06N-21E-14 DCB 1 POND 1 SITE 2 RED OAK NE	206	24	4.0	40	60
12	345921095031801	06N-21E-14 DOB 1 POND 1 SITE 3 RED OAK NE	287	30	4.8	70	1100
13	350643095130001	07N-20E-05 ABC 1 POND 1 SITE 2 KINTA	459	62	3.1	40	75
14	350645095123401	07N-20E-05 AAD 1 POND 1 SITE 3 KINTA	487	57	2.4	160	1300
15	350645095124701	07N-20E-05 AAC 1 POND 1 SITE 1 KINTA	462	63	3.0	30	15
16	350702094350201	08N-26E-32 CCC 1 POND 1 SITE 1 POTEAU EAST	344	80	1.5	50	590
17	350805095141701	08N-20E-30 CAC 2 POND 2 SITE 2 SANS BOIS	701	180	7.3	110	510
18	350805095142101	08N-20E-30 CAC 1 POND 2 SITE 1 SANS BOIS	733	170	6.7	70	180
19	350907094355001	08N-26E-19 DAB 1 POND 3 SITE 3 SPIRO	460	32	12	1400	45
20	350907094585001	08N-22E-22 CBB 1 POND 3 SITE 1 MCCURTAIN	704	160	9.8	30	580
21	350911094470901	08N-24E-16 CCD 1 POND 3 SITE 1 BOKOSHE	156	20	3.0	3600	3000
22	350913094351801	08N-26E-20 DOB 1 POND 3 SITE 1 SPIRO	422	26	10	700	140
23	350918094352701	08N-26E-20 ACA 1 POND 3 SITE 2 SPIRO	445	26	12	210	20
24	351003094575001	08N-22E-15 ADD 1 POND 1 SITE 1 MCCURTAIN	2280	1100	21	220	2000
25	351037094553001	08N-23E-07 CCA 1 POND 2 SITE 1 MCCURTAIN	1070	510	9.2	30	240
26	351049094290701	08N-27E-08 CBB 1 POND 1 SITE 1 HACKETT	683	300	2.5	20	80
27	351130094520301	08N-23E-03 CDA 1 POND 1 SITE 1 BOKOSHE	760	200	5.5	150	5000
28	351230094340201	09N-26E-32 DAA 1 POND 2 SITE 1 SPIRO	144	8.8	3.4	3100	1600
29	351247094494801	09N-23E-36 BCB 1 POND 2 SITE 1 BOKOSHE	538	100	4.0	3100	2300
30	351343094300701	09N-26E-25 ABD 1 POND 1 SITE 1 SPIRO	280	36	7.0	320	3100
31	351436094420901	09N-25E-19 BAC 1 POND 1 SITE 1 PANAMA	3240	310	2.4	60	1000
32	351454095113301	09N-20E-16 DCB 1 POND 1 SITE 1 SANS BOIS	210	20	3.0	30	1100
33	351517095095801	09N-20E-14 BCC 1 POND 3 SITE 2 STIGLER WEST	306	30	4.3	280	1900
34	351517095121501	09N-20E-17 ADD 1 POND 2 SITE 2 STIGLER WEST	478	60	3.0	30	160
35	351518095095001	09N-20E-14 BCA 1 POND 3 SITE 1 STIGLER WEST	269	28	5.4	50	1700
36	351522095122201	09N-20E-17 ADB 1 POND 2 SITE 1 STIGLER WEST	546	65	4.0	20	3300
37	351602094435201	09N-24E-11 DBA 1 POND 1 SITE 1 MULBROW SW	1160	560	3.2	50	1300
38	351612094480301	09N-24E-07 ADB 1 POND 1 SITE 1 R.S. KERR DAM	1330	570	4.8	30	34
39	351632095003401	09N-22E-06 DDD 1 POND 2 SITE 1 STIGLER EAST	142	9.3	5.6	920	2900
40	351925095034701	10N-21E-22 DAD 1 POND 1 SITE 1 STIGLER EAST	1210	470	3.8	470	1000
41	352001094583101	10N-22E-16 DDD 1 POND 1 SITE 1 KEOTA	372	46	20	60	20
42	352001094583501	10N-22E-16 DDC 1 POND 1 SITE 2 KEOTA	396	47	21	130	1400
43	352001094583901	10N-22E-16 DDC 2 POND 1 SITE 3 KEOTA	359	48	20	60	10
44	352054095142601	10N-19E-12 DDD 1 POND 1 SITE 3 STIGLER WEST	494	140	3.6	150	2100
45	352100095142301	10N-19E-12 DDA 2 POND 1 SITE 2 STIGLER WEST	595	160	1.4	150	7100
46	352105095142301	10N-19E-12 DDA 1 POND 1 SITE 1 STIGLER WEST	424	110	1.5	30	46
47	352222095150501	10N-19E-01 DOB 1 POND 1 SITE 1 PORUM	910	210	2.0	20	15
48	352231095145001	10N-19E-01 ABC 1 POND 3 SITE 2 HOLT MOUNTAIN	809	230	2.0	160	650
49	352237095143601	10N-19E-01 ABC 1 POND 3 SITE 1 HOLT MOUNTAIN	951	320	2.2	190	1600
50	352513094523201	11N-23E-16 DCC 1 POND 1 SITE 1 VIAN	923	340	5.8	40	710

Table 3.--Mean values for specific conductance and concentrations of dissolved sulfate, chloride, iron, and manganese for each site.--continued.

Map- Index number (pl. 1)	Station Number	Station Name (Township - range - section and mine pond - site - quadrangle)	Specific conductance (micromhos)	Sulfate (mg/L)	Chloride (mg/L)	Iron (ug/L)	Manganese (ug/L)
51	352518095134601	11N-20E-18 DCC 1 POND 2 SITE 2 HOLT MOUNTAIN	1150	780	5.9	30	270
52	352519094522501	11N-23E-16 DCA 1 POND 1 SITE 2 SALLISAW	949	340	4.6	20	160
53	352519095135001	11N-20E-18 CDD 2 POND 2 SITE 3 HOLT MOUNTAIN	897	300	3.6	--	--
54	352520095135301	11N-20E-18 CDD 1 POND 2 SITE 1 HOLT MOUNTAIN	1200	410	7.6	40	270
55	352521095140601	11N-20E-18 CCA 1 POND 1 SITE 2 HOLT MOUNTAIN	1500	650	4.0	90	1400
56	352521095142101	11N-19E-13 DDA 1 POND 1 SITE 1 HOLT MOUNTAIN	1230	700	4.8	30	18
57	352522095135601	11N-20E-18 CDB 1 POND 1 SITE 3 HOLT MOUNTAIN	1260	620	4.8	50	260
58	352611095150401	11N-19E-12 CDC 1 POND 1 SITE 3 WARNER	1150	530	3.8	30	820
59	352612095152001	11N-19E-12 CCB 1 POND 1 SITE 1 WARNER	1080	500	7.6	30	260
60	352617095151101	11N-19E-12 CCA 1 POND 1 SITE 2 WARNER	1330	510	4.2	40	110
61	352619095572301	11N-13E-08 CAD 1 POND 2 SITE 1 HENRYETTA	752	400	5.4	20	4200
62	352628095572601	11N-13E-08 CAB 1 POND 2 SITE 2 HENRYETTA	756	400	4.7	10	4200
63	352825095251901	12N-18E-32 ACA 2 POND 3 SITE 3 WARNER NW	3210	2100	8.6	4800	54500
64	352830095251501	12N-18E-32 ACA 1 POND 3 SITE 2 WARNER NW	3230	2200	6.4	4800	54500
65	352834095251001	12N-18E-32 AAC 1 POND 3 SITE 1 WARNER NW	3230	2200	8.0	5000	55500
66	353805095522501	13N-13E-01 ADA 1 POND 1 SITE 2 OKMULGEE NE	626	190	22	10	350
67	353811095522601	13N-13E-01 AAD 1 POND 1 SITE 1 OKMULGEE NE	609	200	22	10	820
68	355323095330101	16N-17E-06 CCA 1 POND 1 SITE 1 RED BIRD	1840	1000	3.7	60	2000
69	355323095330601	16N-17E-06 CCB 1 POND 1 SITE 2 RED BIRD	1900	1000	2.4	80	9600
70	360526095435401	19N-15E-29 DCD 1 POND 1 SITE 3 ONETA	3440	2200	14	1300	3300
71	360533095440101	19N-15E-29 DCC 1 POND 1 SITE 2 ONETA	3490	2100	16	930	3700
72	360552095435801	19N-15E-29 ACC 1 POND 1 SITE 1 ONETA	3340	2000	8.4	300	1900
73	361544095395101	21N-15E-36 BAB 1 POND 1 SITE 1 SAGEEYAH	476	97	3.8	80	1100
74	361549095394601	21N-15E-36 BAB 2 POND 1 SITE 2 SAGEEYAH	452	82	5.0	100	1100
75	362249095495501	22N-14E-17 DDD 1 POND 2 SITE 3 COLLINSVILLE NE	2200	840	220	1100	6200
76	362253095500201	22N-14E-17 DOB 2 POND 2 SITE 2 COLLINSVILLE NE	2360	940	230	4400	6700
77	362257095495501	22N-14E-17 DOB 1 POND 2 SITE 1 COLLINSVILLE NE	2360	810	220	5100	6700
78	362333095365201	22N-16E-16 BBB 2 POND 2 SITE 1 FOYIL	798	280	16	30	240
79	362337095364601	22N-16E-16 BBB 1 POND 2 SITE 2 FOYIL	791	250	4.6	40	80
80	362618095352801	23N-16E-27 CDC 1 POND 1 SITE 3 FOYIL	546	140	7.6	40	440
81	362635095352701	23N-16E-27 CAA 1 POND 1 SITE 1 FOYIL	557	140	6.6	260	820
82	362636095352801	23N-16E-27 CAC 1 POND 1 SITE 2 FOYIL	557	140	7.2	250	940
83	362718095450201	23N-15E-19 CDA 1 POND 1 SITE 2 COLLINSVILLE NE	1820	1000	9.1	30	1500
84	362725095445801	23N-15E-19 CAD 1 POND 1 SITE 1 OLOGAH	1640	920	6.2	30	270
85	363039095292401	24N-17E-33 DDD 1 POND 3 SITE 1 CHELSEA	538	210	6.2	20	50
86	363049095293201	24N-17E-33 DDC 1 POND 3 SITE 2 CHELSEA	544	200	6.6	30	55
87	363049095293801	24N-17E-33 DCD 1 POND 3 SITE 3 CHELSEA	562	220	6.0	40	890
88	364109095183301	26N-19E-31 DDC 1 POND 2 SITE 2 ESTELLA	2700	1800	13	80	6800
89	364119095183101	26N-19E-31 DAC 1 POND 2 SITE 3 ESTELLA	2530	1700	9.4	40	2400
90	364125095182301	26N-19E-31 DAA 1 POND 2 SITE 1 ESTELLA	2580	1600	9.0	80	1900
91	364756095174101	27N-19E-29 ABB 1 POND 2 SITE 1 CENTRALIA	378	70	3.7	900	360
92	364756095174801	27N-19E-29 BAA 1 POND 2 SITE 2 CENTRALIA	373	70	4.0	140	210
93	364831095172101	27N-19E-20 ADD 1 POND 1 SITE 3 CENTRALIA	1820	160	4.5	30	240
94	364835095171801	27N-19E-20 ADA 1 POND 1 SITE 2 CENTRALIA	580	170	3.9	30	140
95	364841095171901	27N-19E-20 AAD 1 POND 1 SITE 1 CENTRALIA	584	160	3.8	120	55
96	364951095132801	27N-19E-12 DCC 2 POND 2 SITE 1 PYRAMID CORNERS	628	190	2.6	540	2400
97	365119095124701	27N-20E-06 BBD 1 POND 1 SITE 1 PYRAMID CORNERS	1500	900	10	80	1200
98	365418095123701	28N-20E-18 CDB 1 POND 2 SITE 3 WELCH NW	862	390	4.0	40	360
99	365418095124201	28N-20E-18 CCA 2 POND 3 SITE 1 WELCH NW	582	190	10	40	37
100	365421095124001	28N-20E-18 CCA 1 POND 2 SITE 2 WELCH NW	864	410	4.1	60	460
101	365424095124201	28N-20E-18 CBD 1 POND 2 SITE 1 WELCH NW	835	380	5.2	90	430
102	365549095121701	28N-20E-07 ABB 1 POND 1 SITE 1 WELCH NW	804	250	4.9	120	2600

Table 4.--Number of determinations for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site.

Map-index number (pl. 1)	Station Number	Station name (Township - range - section and mine pond - site - quadrangle)	Number of Determinations					
			Specific conductance	pH	Sulfate	Chloride	Iron	Manganese
1	342353096135301	02S-10E-11 BCB 2 POND 2 SITE 2 LEHIGH	9	9	2	2	2	2
2	342358096135701	02S-10E-11 BCB 1 POND 2 SITE 1 LEHIGH	13	13	5	5	5	5
3	342807096133301	01S-10E-14 CAB 1 POND 1 SITE 1 LEHIGH	6	4	2	2	2	2
4	343106096133801	01N-10E-35 BBD 1 POND 1 SITE 1 COALGATE	17	17	5	5	5	5
5	345403094271301	05N-27E-16 DDC 1 POND 1 SITE 1 BATES	22	22	6	6	6	6
6	345440095404701	05N-15E-14 DDD 1 POND 1 SITE 1 KREBS	18	6	3	3	3	3
7	345506095190001	05N-19E-08 CAC 1 POND 1 SITE 1 WILBURTON	2	2	2	2	2	2
8	345636095185601	06N-19E-32 DDD 1 POND 3 SITE 1 WILBURTON	12	12	3	3	3	3
9	345641095190301	06N-19E-32 DDB 1 POND 2 SITE 1 WILBURTON	9	9	4	4	4	4
10	345911095035101	06N-21E-14 CCD 1 POND 1 SITE 1 RED OAK NE	19	19	5	5	5	5
11	345915095033401	06N-21E-14 DCB 1 POND 1 SITE 2 RED OAK NE	6	6	2	2	2	2
12	345921095031801	06N-21E-14 DDB 1 POND 1 SITE 3 RED OAK NE	20	20	5	5	5	5
13	350643095130001	07N-20E-05 ABC 1 POND 1 SITE 2 KINTA	8	8	2	2	2	2
14	350645095123401	07N-20E-05 AAD 1 POND 1 SITE 3 KINTA	10	10	2	2	2	2
15	350645095124701	07N-20E-05 AAC 1 POND 1 SITE 1 KINTA	8	8	2	2	2	2
16	350702094350201	08N-26E-32 CCC 1 POND 1 SITE 1 POTEAU EAST	13	13	4	4	4	4
17	350805095141701	08N-20E-30 CAC 2 POND 2 SITE 2 SANS BOIS	9	9	2	2	2	2
18	350805095142101	08N-20E-30 CAC 1 POND 2 SITE 1 SANS BOIS	9	9	3	3	3	3
19	350907094355001	08N-26E-19 DAB 1 POND 3 SITE 3 SPIRO	9	9	2	2	2	2
20	350907094585001	08N-22E-22 CBB 1 POND 3 SITE 1 MCCURTAIN	28	25	8	8	8	8
21	350911094470901	08N-24E-16 CCD 1 POND 3 SITE 1 BOKOSHE	7	7	2	2	2	2
22	350913094351801	08N-26E-20 BDB 1 POND 3 SITE 1 SPIRO	25	25	5	5	5	5
23	350918094352701	08N-26E-20 ACA 1 POND 3 SITE 2 SPIRO	17	17	3	3	3	3
24	351003094575001	08N-22E-15 ADD 1 POND 1 SITE 1 MCCURTAIN	19	19	6	6	6	6
25	351037094553001	08N-23E-07 CCA 1 POND 2 SITE 1 MCCURTAIN	15	15	5	5	4	3
26	351049094290701	08N-27E-08 CBB 1 POND 1 SITE 1 HACKETT	6	6	2	2	2	2
27	351130094520301	08N-23E-03 CDA 1 POND 1 SITE 1 BOKOSHE	17	17	4	4	4	4
28	351230094340201	09N-26E-32 DAA 1 POND 2 SITE 1 SPIRO	17	17	5	5	5	5
29	351247094494801	09N-23E-36 BCB 1 POND 2 SITE 1 BOKOSHE	20	20	4	4	4	4
30	351343094300701	09N-26E-25 ABD 1 POND 1 SITE 1 SPIRO	14	14	5	5	5	5
31	351436094420901	09N-25E-19 BAC 1 POND 1 SITE 1 PANAMA	27	8	5	5	5	5
32	351454095113301	09N-20E-16 DCB 1 POND 1 SITE 1 SANS BOIS	12	11	4	4	4	4
33	351517095095801	09N-20E-14 BCC 1 POND 3 SITE 2 STIGLER WEST	12	12	3	3	3	3
34	351517095121501	09N-20E-17 ADD 1 POND 2 SITE 2 STIGLER WEST	3	3	2	2	2	2
35	351518095095001	09N-20E-14 BCA 1 POND 3 SITE 1 STIGLER WEST	16	16	5	5	5	5
36	351522095122201	09N-20E-17 ADB 1 POND 2 SITE 1 STIGLER WEST	7	7	2	2	2	2
37	351602094435201	09N-24E-11 DBA 1 POND 1 SITE 1 MULBROW SW	16	17	5	5	5	5
38	351612094480301	09N-24E-07 ADB 1 POND 1 SITE 1 R.S. KERR DAM	13	13	5	5	5	5
39	351632095003401	09N-22E-06 DDD 1 POND 2 SITE 1 STIGLER EAST	8	2	2	2	2	2
40	351925095034701	10N-21E-22 DAD 1 POND 1 SITE 1 STIGLER EAST	20	20	5	5	5	5
41	352001094583101	10N-22E-16 DDD 1 POND 1 SITE 1 KEOTA	5	5	2	2	2	2
42	352001094583501	10N-22E-16 DDC 1 POND 1 SITE 2 KEOTA	5	5	3	3	3	3
43	352001094583901	10N-22E-16 DDC 2 POND 1 SITE 3 KEOTA	5	5	2	2	2	2
44	352054095142601	10N-19E-12 DDD 1 POND 1 SITE 3 STIGLER WEST	33	33	5	5	5	5
45	352100095142301	10N-19E-12 DDA 2 POND 1 SITE 2 STIGLER WEST	43	43	13	13	10	10
46	352105095142301	10N-19E-12 DDA 1 POND 1 SITE 1 STIGLER WEST	16	16	5	5	5	5
47	352222095150501	10N-19E-01 BDB 1 POND 1 SITE 1 PORUM	4	4	2	2	2	2
48	352231095145001	10N-19E-01 ABC 1 POND 3 SITE 2 HOLT MOUNTAIN	20	19	6	6	6	6
49	352237095143601	10N-19E-01 ABC 1 POND 3 SITE 1 HOLT MOUNTAIN	31	31	10	10	8	8
50	352513094523201	11N-23E-16 DCC 1 POND 1 SITE 1 VIAN	10	10	2	2	2	2

Table 4.--Number of determinations for specific conductance, pH, and concentrations of dissolved sulfate, chloride, iron, and manganese for each site --continued.

Map-index number (pl. 1)	Station Number	Station name (Township - range - section and mine pond - site - quadrangle)	Number of Determinations					
			Specific conductance	pH	Sulfate	Chloride	Iron	Manganese
51	352518095134601	11N-20E-18 DCC 1 POND 2 SITE 2 HOLT MOUNTAIN	9	10	4	4	4	4
52	352519094522501	11N-23E-16 DCA 1 POND 1 SITE 2 SALLISAW	8	8	2	2	2	2
53	352519095135001	11N-20E-18 CDD 2 POND 2 SITE 3 HOLT MOUNTAIN	4	4	2	2	0	0
54	352520095135301	11N-20E-18 CDD 1 POND 2 SITE 1 HOLT MOUNTAIN	8	9	3	3	3	3
55	352521095140601	11N-20E-18 CCA 1 POND 1 SITE 2 HOLT MOUNTAIN	31	36	12	12	9	9
56	352521095142101	11N-19E-13 DDA 1 POND 1 SITE 1 HOLT MOUNTAIN	13	16	5	5	5	5
57	352522095135601	11N-20E-18 CDB 1 POND 1 SITE 3 HOLT MOUNTAIN	14	18	5	5	5	5
58	352611095150401	11N-19E-12 CDC 1 POND 1 SITE 3 WARNER	24	26	6	6	6	6
59	352612095152001	11N-19E-12 CCB 1 POND 1 SITE 1 WARNER	15	21	6	6	6	6
60	352617095151101	11N-19E-12 CCA 1 POND 1 SITE 2 WARNER	29	35	11	11	8	8
61	352619095572301	11N-13E-08 CAD 1 POND 2 SITE 1 HENRYETTA	5	5	2	2	2	2
62	352628095572601	11N-13E-08 CAB 1 POND 2 SITE 2 HENRYETTA	6	6	2	2	2	2
63	352825095251901	12N-18E-32 ACA 2 POND 3 SITE 3 WARNER NW	3	3	2	2	2	2
64	352830095251501	12N-18E-32 ACA 1 POND 3 SITE 2 WARNER NW	4	4	2	2	2	2
65	352834095251001	12N-18E-32 AAC 1 POND 3 SITE 1 WARNER NW	4	4	2	2	2	2
66	353805095522501	13N-13E-01 ADA 1 POND 1 SITE 2 OKMULGEE NE	4	4	2	2	2	2
67	353811095522601	13N-13E-01 AAD 1 POND 1 SITE 1 OKMULGEE NE	4	4	2	2	2	2
68	355323095330101	16N-17E-06 CCA 1 POND 1 SITE 1 RED BIRD	7	4	2	2	2	2
69	355323095330601	16N-17E-06 CCB 1 POND 1 SITE 2 RED BIRD	6	6	2	2	2	2
70	360526095435401	19N-15E-29 DCD 1 POND 1 SITE 3 ONETA	10	10	2	2	2	2
71	360533095440101	19N-15E-29 DCC 1 POND 1 SITE 2 ONETA	8	8	3	3	3	3
72	360552095435801	19N-15E-29 ACC 1 POND 1 SITE 1 ONETA	7	7	2	2	2	2
73	361544095395101	21N-15E-36 BAB 1 POND 1 SITE 1 SAGEEYAH	7	7	2	2	2	2
74	361549095394601	21N-15E-36 BAB 2 POND 1 SITE 2 SAGEEYAH	8	8	2	2	2	2
75	362249095495501	22N-14E-17 DDD 1 POND 2 SITE 3 COLLINSVILLE NE	6	6	2	2	2	2
76	362253095500201	22N-14E-17 DDB 2 POND 2 SITE 2 COLLINSVILLE NE	7	7	2	2	2	2
77	362257095495501	22N-14E-17 DDB 1 POND 2 SITE 1 COLLINSVILLE NE	7	7	2	2	2	2
78	362333095365201	22N-16E-16 BBB 2 POND 2 SITE 1 FOYIL	19	18	6	6	3	3
79	362337095364601	22N-16E-16 BBB 1 POND 2 SITE 2 FOYIL	7	7	1	1	1	1
80	362618095352801	23N-16E-27 CDC 1 POND 1 SITE 3 FOYIL	5	5	2	2	2	2
81	362635095352701	23N-16E-27 CAA 1 POND 1 SITE 1 FOYIL	7	7	2	2	2	2
82	362636095352801	23N-16E-27 CAC 1 POND 1 SITE 2 FOYIL	6	6	2	2	2	2
83	362718095450201	23N-15E-19 CDA 1 POND 1 SITE 2 COLLINSVILLE NE	11	11	3	3	3	3
84	362725095445801	23N-15E-19 CAD 1 POND 1 SITE 1 OOLOGAH	7	7	6	6	6	6
85	363039095292401	24N-17E-33 DDD 1 POND 3 SITE 1 CHELSEA	6	6	2	2	2	2
86	363049095293201	24N-17E-33 DDC 1 POND 3 SITE 2 CHELSEA	7	7	2	2	2	2
87	363049095293801	24N-17E-33 DCD 1 POND 3 SITE 3 CHELSEA	11	11	2	2	2	2
88	364109095183301	26N-19E-31 DDC 1 POND 2 SITE 2 ESTELLA	9	9	3	3	3	3
89	364119095183101	26N-19E-31 DAC 1 POND 2 SITE 3 ESTELLA	7	7	2	2	2	2
90	364125095182301	26N-19E-31 DAA 1 POND 2 SITE 1 ESTELLA	10	10	2	2	2	2
91	364756095174101	27N-19E-29 ABB 1 POND 2 SITE 1 CENTRALIA	22	22	5	5	5	5
92	364756095174801	27N-19E-29 BAA 1 POND 2 SITE 2 CENTRALIA	21	21	6	6	6	6
93	364831095172101	27N-19E-20 ADD 1 POND 1 SITE 3 CENTRALIA	23	15	5	5	5	5
94	364835095171801	27N-19E-20 ADA 1 POND 1 SITE 2 CENTRALIA	26	21	8	8	6	6
95	364841095171901	27N-19E-20 AAD 1 POND 1 SITE 1 CENTRALIA	15	12	3	3	2	2
96	364951095132801	27N-19E-12 DCC 2 POND 2 SITE 1 PYRAMID CORNERS	6	6	2	2	2	2
97	365119095124701	27N-20E-06 BBD 1 POND 1 SITE 1 PYRAMID CORNERS	4	4	1	1	1	1
98	365418095123701	28N-20E-18 CDB 1 POND 2 SITE 3 WELCH NW	17	13	5	5	5	5
99	365418095124201	28N-20E-18 CCA 2 POND 3 SITE 1 WELCH NW	5	3	2	2	2	2
100	365421095124001	28N-20E-18 CCA 1 POND 2 SITE 2 WELCH NW	36	28	9	5	6	6
101	365424095124201	28N-20E-18 CBD 1 POND 2 SITE 1 WELCH NW	19	14	4	3	4	4
102	365549095121701	28N-20E-07 ABB 1 POND 1 SITE 1 WELCH NW	24	19	11	11	8	8

Table 5.--Number of analyses, standard deviation, and percentile for selected physical and chemical characteristics of water from 102 mine-pond sites

(micromhos, micromhos per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter)

Physical or chemical characteristics	Recommended drinking-water limit ¹	Number of analyses	Standard deviation	Percentile						
				Minimum		Median				Maximum
				0	10th	25th	50th	75th	90th	100th
Specific conductance (micromhos)	---	1,292	835	93	260	440	700	1,090	2,090	4,800
pH (units)	6.5-8.5	1,233	0.7	3.2	6.7	7.2	7.6	8.1	8.4	9.4
Sulfate (mg/L)	250	383	470	3.7	26	70	210	500	940	2,300
Chloride (mg/L)	250	378	29	0.1	2.0	3.0	4.0	7.1	13	240
Iron, dissolved (µg/L)	300	357	1,300	10	10	20	40	90	640	10,000
Manganese, dissolved (µg/L)	50	356	7,500	0	10	20	80	1,400	4,500	56,000

¹U.S. Environmental Protection Agency, 1979

Specific Conductance

Specific conductance is a measure of the ability of a water to conduct an electrical current. Specific conductance is the reciprocal of the resistance, in ohms, measured between opposite faces of a cube with dimensions of 1 centimeter of an aqueous solution and is expressed in micromhos per centimeter at 25° Celsius.

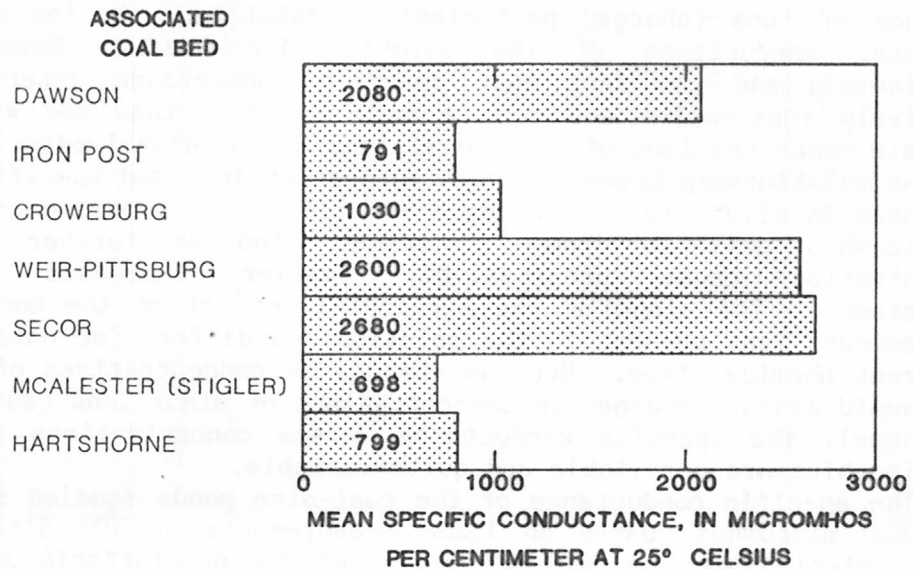
The ability of water to conduct an electrical current depends on the presence of ions (charged particles) in solution. As ion concentrations increase, conductance of the solution increases. Because of this relationship and the fact that specific conductance determinations are relatively inexpensive and can be made quickly, they are widely used to estimate concentrations of individual ions and of dissolved solids in water.

The relationship between concentrations of ions and specific conductance is linear in dilute solution. As a solution becomes more concentrated, the relationship deviates from a straight line as further increases in concentration cause progressively smaller increases in specific conductance. The slope of the straight-line part of the curve depends on the dominant ions present in the solution and differs for natural waters of different chemical type. Because changes in concentrations of the dominant ions would obscure changes in concentrations of minor ions (such as iron and manganese), the specific conductance versus concentrations of minor ions relationships are unreliable and quite variable.

The specific conductance of the coal-mine ponds studied ranged from 93 to 4,800 micromhos, based on 1,292 measurements at 102 sites (table 5). This variation may be partly attributed to precipitation. Periods of increased precipitation dilute the ponds, resulting in a decrease in specific conductance. Sulfate is the principal ion in mine-pond water. Consequently, the specific conductance of mine-pond water varies from pond to pond in direct proportion to sulfate concentration.

The largest mean specific conductances were in ponds resulting from mining of the Dawson, Weir-Pittsburg, and Secor coals, which have mean sulfur contents of 4.6 to 4.9 percent--the greatest for the seven named coals in this report. The smallest specific conductances were for ponds associated with the McAlester (Stigler) coal. The mean specific conductances, in micromhos, of the mine ponds associated with each of the coal beds are: Dawson, 2,080; Iron Post, 791; Croweburg, 1,030; Weir-Pittsburg, 2,600; Secor, 2,680; McAlester (Stigler), 698; and Hartshorne, 799. (See figure 4 and the pH and Dissolved Sulfate sections.)

The specific conductance generally increased with depth for about 40 percent of the ponds, regardless of the coal bed that was mined, indicating ionic concentration in those ponds also increased with depth. The greatest variation in specific conductance with depth was at site 24 with a specific conductance of 2,760 micromhos at the surface (depth equaled 1 foot) and 4,440 micromhos at the bottom (depth equaled 42 feet) in July 1977. (See figure 81.)



**Figure 4.--Mean specific conductance in coal-mine pond
water associated with each coal bed.**

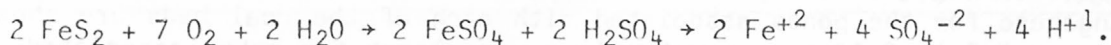
Dissolved Oxygen

The dissolved-oxygen concentration of the coal-mine ponds usually decreased with depth during June to early October. Thermal stratification resulted in warmer, less dense water at the surface, insulating the colder, more dense water below preventing it from coming in contact with atmospheric oxygen. The largest decreases in dissolved oxygen with depth occurred at site 8 and site 57 (August 1979) with differences of 12.4 and 11.8 mg/L, respectively, from the surface to the bottom. By November, usually little or no variation in dissolved-oxygen concentration with depth was detected. (See figures 65 and 114.)

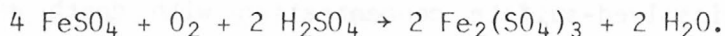
pH

The pH of a solution is the negative base-10 log of the hydrogen-ion activity and is approximately equal to the hydrogen-ion (H^{+1}) concentration expressed in moles per liter. The pH of pure water at 25° Celsius is 7.0. In natural water, the pH usually is within the range of 6.0 to 8.5, depending upon equilibria reactions of species in the water (Hem, 1970).

In coal-mine ponds, pH is governed by oxidation of sulfide minerals and subsequent buffering by carbonate minerals. Iron sulfide minerals, usually pyrite (FeS_2) and marcasite (FeS_2), exposed in spoil piles and high walls of strip pits, react with oxygen (O_2) and water (H_2O) to release sulfuric acid (H_2SO_4) and ferrous sulfate ($FeSO_4$), with a corresponding decrease in pH of the solution:



The iron is then oxidized from the ferrous (Fe^{+2}) to the ferric (Fe^{+3}) state:



Hydrolysis occurs and the ferric sulfate [$Fe_2(SO_4)_3$] is converted to ferric hydroxide [$Fe(OH)_3$], a reddish-brown precipitate commonly called "yellow boy," and more sulfuric acid.

The oxidation reactions are bacterially mediated and complex (Stumm and Morgan, 1981; and Drever, 1982). The rate-determining (slowest) step is the oxidation of ferrous iron (Fe^{+2}) to ferric iron (Fe^{+3}). Even at a pH of 3, the preceding reaction has a half-time of about 1,000 days (Stumm and Morgan, 1981).

The net result, whether the pyrite is oxidized directly by oxygen or is dissolved and then oxidized, is that two molecular weights (or four equivalent weights) of sulfuric acid are released for each molecular weight of the original pyrite. If the concentration of sulfuric acid (as H^{+} in milliequivalents per liter) is greater than carbonate and bicarbonate, the solution is acidic ($pH < 7$). However, if concentrations of carbonate and bicarbonate (in milliequivalents per liter) are greater than that of the hydrogen ions, the solution is alkaline or basic ($pH > 7$).

If the pH in coal-mine ponds were only dependent upon the equilibria reactions of sulfate and ferrous iron, pH also could be correlated to the coal bed mined and the impurities present, especially pyrite. However, in the Oklahoma coal region, the median pH for the ponds associated with the Dawson, Iron Post, Croweburg, Weir-Pittsburg, McAlester (Stigler), and Hartshorne coals showed little variation, 7.4 to 7.8 (table 6). The only significant difference was for the ponds associated with the Secor coal.

Sites 63, 64, and 65 (pond 1, Warner NW quadrangle, fig. 44) had a pH of 3.2 to 3.3 in June 1980. Sites 68 and 69 (pond 1, Red Bird quadrangle, fig. 46) had a pH of 7.3 to 8.1 in June 1980. Both the Warner and Red Bird ponds were identified as being associated with the Secor coal. The median pH for the ponds associated with the Secor coal was 3.3. Excluding the Warner pond, the median pH for the ponds associated with the Secor coal was 7.7, virtually the same as for the ponds associated with all other coal beds. The pH of water in the coal-mine ponds generally decreased with depth.

Dissolved Sulfate

Pyrite (FeS_2) contains most of the sulfur in Oklahoma coals (Friedman, 1974). The anaerobic conditions under which the coal was deposited was a favorable environment for the formation of pyrite. When the pyrite is later exposed to aerated water it is oxidized, producing sulfate ions in the water. (See also section on pH.)

Mean dissolved-sulfate concentrations were greatest for the water in ponds associated with the Dawson, Weir-Pittsburg, and Secor coal beds which, of the seven named coals, also had the greatest percent sulfur content. (Plots of the mean concentrations of dissolved sulfate, chloride, iron, and manganese for the ponds associated with each of the coal beds are shown in figures 5-8.) Sulfate concentrations were least for water associated with McAlester (Stigler) and Hartshorne coals. Pond water associated with the Dawson, Weir-Pittsburg, and Secor coal beds had mean dissolved-sulfate concentrations of 900; 1,700; and 1,700 mg/L, respectively. The greatest increase in dissolved-sulfate concentration with depth was 1,200 mg/L at site 51.

More than 25 percent of the sulfate concentrations in water-quality samples from the mine-pond sites exceeded the 250-mg/L limit in the Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1979). The sulfate concentrations ranged from 3.7 to 2,300 mg/L. The median sulfate concentration was 210 mg/L. (See table 5.)

Sulfate affects the taste of water and may produce laxative effects on some people but acclimation generally is rapid. Waters with large concentrations of sulfate used to irrigate crops grown on clayey soils may decrease soil permeability but the sulfate itself has little effect on most plants.

Table 6.--Minimum, median, maximum, and number of pH determinations of mine-pond water for each associated coal bed

Associated coal bed	pH of mine-pond water			
	Minimum	Median	Maximum	Number
				of determinations
Dawson	7.0	7.7	8.2	38
Iron Post	6.3	7.4	8.0	22
Croweburg	6.1	7.8	9.1	263
Weir-Pittsburg	6.6	7.5	7.7	26
Secor	3.2	3.3	8.1	21
Secor ¹	7.3	7.7	8.1	10
McAlester (Stigler)	5.1	7.6	9.4	588
Hartshorne	6.3	7.5	9.0	262

¹ Excluding the pH values for Warner Pond.

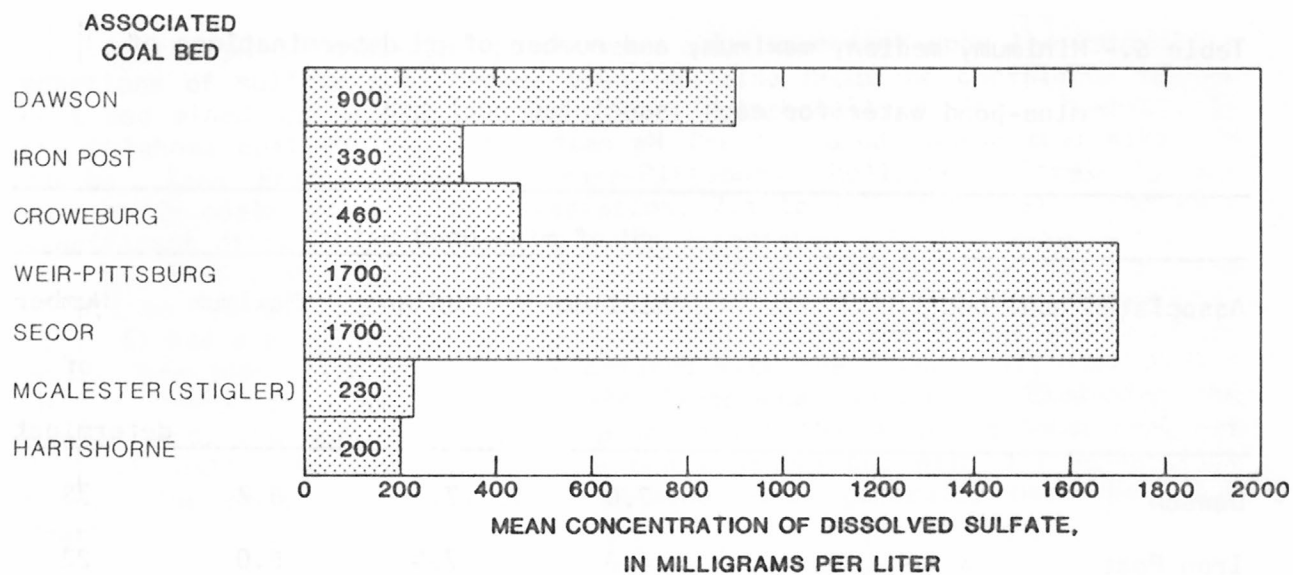


Figure 5.--Mean dissolved-sulfate concentration in coal-mine pond water associated with each coal bed.

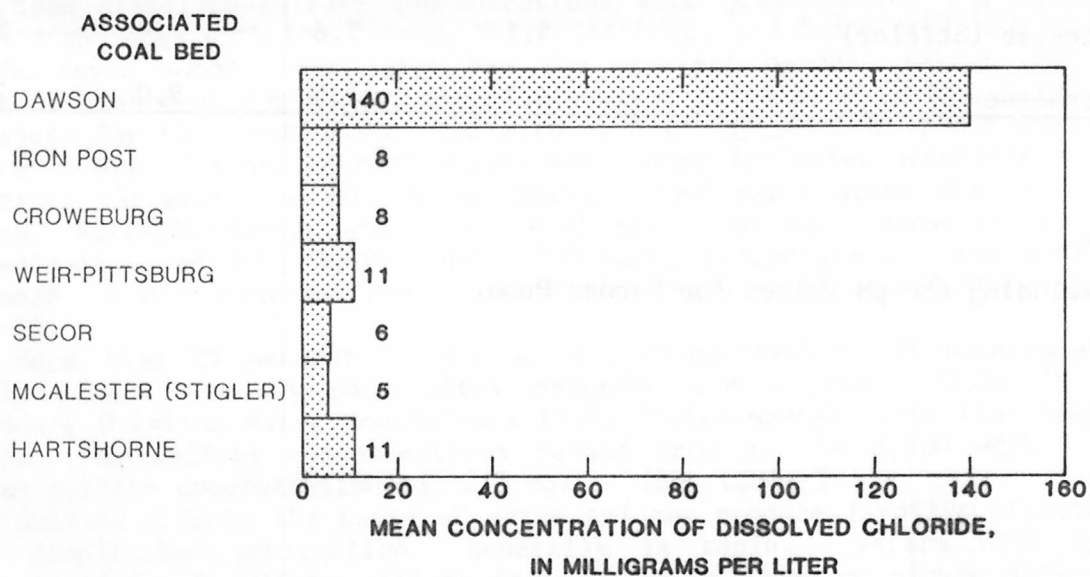


Figure 6.--Mean dissolved-chloride concentration in coal-mine pond water associated with each coal bed.

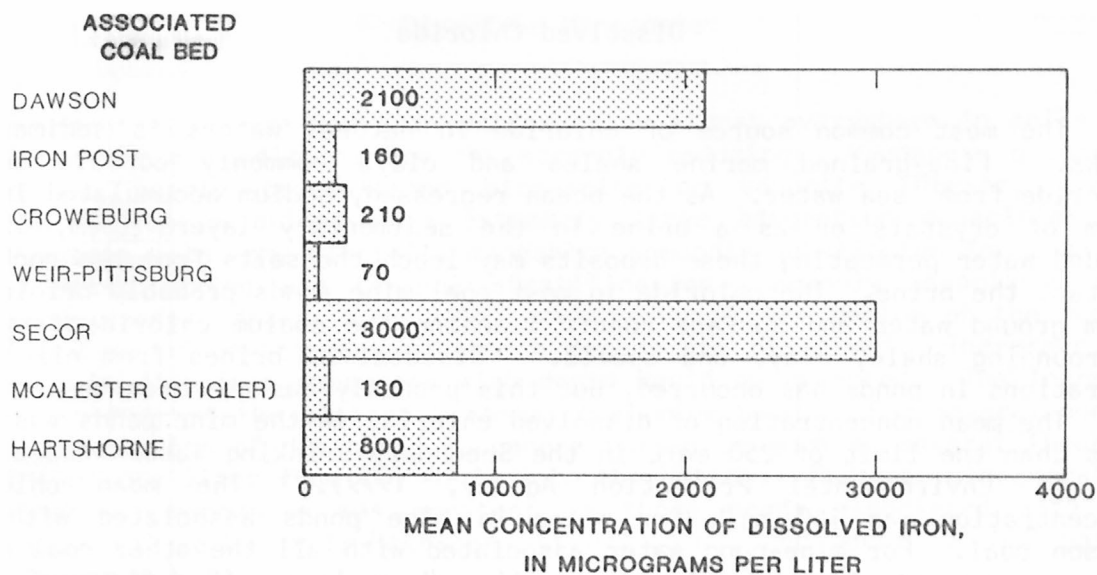


Figure 7.--Mean dissolved-iron concentration in coal-mine pond water associated with each coal bed.

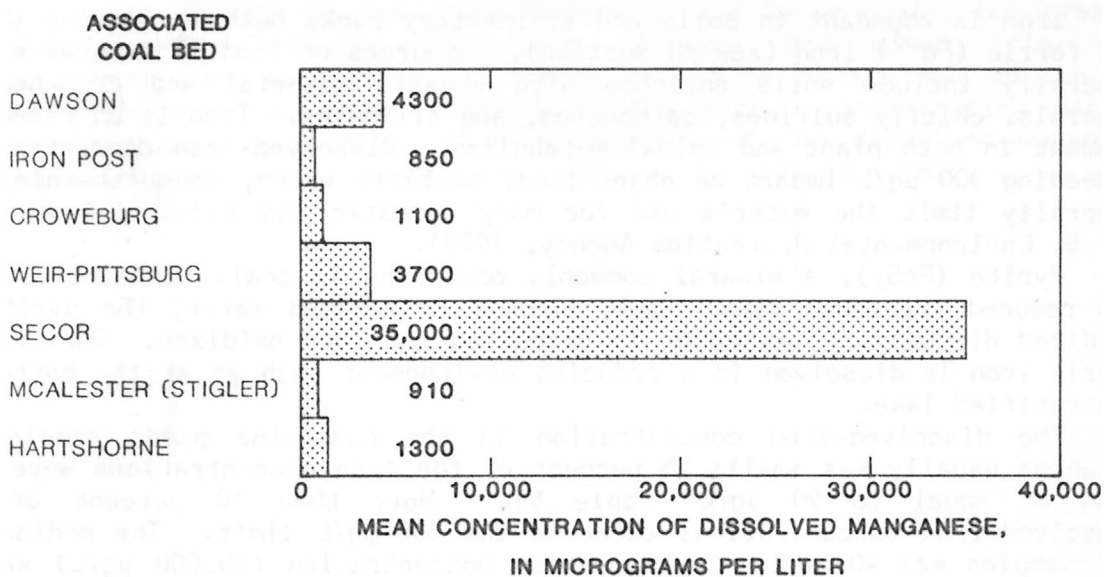


Figure 8.--Mean dissolved-manganese concentration in coal-mine pond water associated with each coal bed.

Dissolved Chloride

The most common source of chloride in natural waters is sedimentary rocks. Fine-grained marine shales and clays commonly contain sodium chloride from sea water. As the ocean regressed, sodium accumulated in the form of crystals or as a brine in the sedimentary layers (Hem, 1970). Ground water permeating these deposits may leach the salts from the rocks or contact the brine. The chloride in most coal-mine ponds probably originated from ground water and surface runoff leaching the sodium chloride from the surrounding shale, clay, and spoils. Disposal of brines from oil field operations in ponds has occurred, but this probably has not been too common.

The mean concentration of dissolved chloride in the mine ponds was much less than the limit of 250 mg/L in the Secondary Drinking Water Regulations (U. S. Environmental Protection Agency, 1979). The mean chloride concentration was 140 mg/L for water in mine ponds associated with the Dawson coal. For mine-pond water associated with all the other coal beds, the mean concentration of chloride was 11 mg/L or less. (See figure 6.)

The chloride concentration ranged from 0.1 to 240 mg/L for all 378 analyses of samples collected at the 102 mine-pond sites. For 90 percent of the analyses the chloride concentration was less than or equal to 13 mg/L. The median was 4.0 mg/L. (See table 5.)

Dissolved Iron

Iron is abundant in soils and sedimentary rocks both as ferrous (Fe^{+2}) and ferric (Fe^{+3}) iron (see pH section). Sources of iron in natural waters generally include soils enriched with organic material and iron-bearing minerals, chiefly sulfides, carbonates, and silicates. Iron is an essential element in both plant and animal metabolism. Dissolved-iron concentrations exceeding 300 $\mu\text{g/L}$ impart an objectional taste to water, cause staining and generally limit the water's use for many domestic and industrial purposes (U. S. Environmental Protection Agency, 1979).

Pyrite (FeS_2), a mineral commonly occurring in coal, contains iron in its reduced (ferrous) form. When exposed to aerated water, the pyrite is oxidized directly by oxygen or is dissolved and then oxidized. Conversely, ferric iron is dissolved in a reducing environment such as at the bottom of a stratified lake.

The dissolved-iron concentration in the coal-mine ponds sampled in Oklahoma usually was small; 75 percent of the iron concentrations were less than or equal to 90 $\mu\text{g/L}$ (table 5). More than 10 percent of the dissolved-iron concentrations exceeded the 300- $\mu\text{g/L}$ limit. The median for 357 samples was 40 $\mu\text{g/L}$. The greatest concentration (10,000 $\mu\text{g/L}$) was at site 77 (Dawson coal bed).

The mean concentration of dissolved iron was greatest in those ponds associated with the Dawson, Secor, and Hartshorne coal beds (fig. 7). The mean dissolved-iron concentration for sampled ponds associated with the Dawson was 2,100 $\mu\text{g/L}$; Secor, 3,000 $\mu\text{g/L}$; and Hartshorne, 800 $\mu\text{g/L}$. The mean iron concentrations for the Iron Post, Croweburg, Weir-Pittsburg, and McAlester (Stigler) coals were all less than the 300- $\mu\text{g/L}$ secondary limit for drinking water (U. S. Environmental Protection Agency, 1979).

Dissolved Manganese

Hydrous manganese and iron oxides exist almost everywhere in soils and sediments where conditions are not strongly reducing. Manganese generally occurs as poorly crystallized birnessite or todorite (Drever, 1982). Hydrous manganese oxides have extremely large adsorption capacities for heavy metals. In many minerals, manganese commonly substitutes for iron.

Limited mixing and thermal stratification, commonly associated with coal-mine ponds, creates a reducing environment at the bottom of the ponds. In this type of environment manganese oxides are dissolved. Therefore, an increase in dissolved manganese with depth would be expected. The increase occurs in many of the eastern Oklahoma coal-mine ponds. For several ponds, the concentration of dissolved manganese varied as much as several thousand micrograms per liter from the surface to the bottom. The mean concentration of dissolved manganese was greatest in those ponds associated with the Dawson (4,300 $\mu\text{g/L}$), Weir-Pittsburg (3,700 $\mu\text{g/L}$), and Secor (35,000 $\mu\text{g/L}$). (See figure 8.)

Dissolved-manganese concentrations exceeding the 50- $\mu\text{g/L}$ limit in the Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1979) impart an objectional taste to water, cause staining and limit the water's use for many domestic and industrial purposes. Manganese is readily removed by aeration or filtering and does not have any significant effect on most irrigated crops.

The mean dissolved-manganese concentrations were least for water associated with the Iron Post and McAlester (Stigler) coals and greatest for water associated with Dawson, Weir-Pittsburg, and Secor coals, but greatly exceeded secondary limits regardless of coal bed mined (fig. 8). Dissolved-manganese concentrations ranged from 0 to 56,000 $\mu\text{g/L}$ in the 356 water-quality samples. (See table 5.) The median concentration was 80 $\mu\text{g/L}$. Consequently, greater than 50 percent of the dissolved-manganese concentrations in the mine-pond water exceeded the 50- $\mu\text{g/L}$ limit.

SUMMARY AND CONCLUSIONS

Water at 102 sites in 59 coal-mine ponds in eastern Oklahoma was sampled, generally at least twice, during June to November 1977-81 to determine temperature, specific conductance, dissolved oxygen, pH, and dissolved sulfate, chloride, iron, and manganese. These determinations indicate that during June to October, water in the deeper ponds was stratified; temperature, dissolved oxygen, and pH usually decreased with depth, whereas specific conductance usually increased with depth. The variation of temperature with depth was greatest during July and August. Ponds which had little or no change of temperature with depth generally were shallow or were sampled in early November.

Concentrations of dissolved sulfate, chloride, iron, and manganese varied with depth and from site to site. Specific conductance ranged from 93 to 4,800 micromhos per centimeter at 25° Celsius. The physical and chemical characteristics of the pond water are related to the coal bed in which the pond is located. Mean specific-conductance values and concentrations of dissolved sulfate were greatest for the water in ponds associated with the Dawson, Weir-Pittsburg, and Secor coals. Mean concentrations of dissolved iron were greatest in the ponds associated with mining of the Dawson, Secor, and Hartshorne coals.

More than 25 percent of the dissolved-sulfate concentrations, more than 10 percent of the dissolved-iron concentrations, and more than 50 percent of the dissolved-manganese concentrations in the water-quality samples exceeded the limit in the Secondary Drinking Water Regulations. The pH of the mine-pond water generally is in the range for most natural waters.

SELECTED REFERENCES

- American Public Health Association and others, 1976, Standard methods for the examination of water and wastewater (14th ed.): New York, 1,193 p.
- Averitt, Paul, 1970, Stripping-coal resources of the United States-January 1970: U.S. Geological Survey Bulletin 1322, 34 p.
- Barnes, Ivan, and Clarke, F. E., 1964, Geochemistry of ground water in mine drainage problems: U.S. Geological Survey Professional Paper 473-A, 6 p.
- Bevans, H. E., 1980, A procedure for predicting concentrations of dissolved solids and sulfate ion in streams draining areas strip mined for coal: U.S. Geological Survey Water-Resources Investigations Open-File Report 80-764, 17 p.
- Branson, C. C., and Hoffman, G. G., 1965, Geology of Craig County; Part 1 of Geology and oil and gas resources of Craig County, Oklahoma: Oklahoma Geological Survey Bulletin 99, p. 7-58.
- Brinlee, R. C., 1975, Soil survey of Haskell County, Oklahoma: U.S. Department of Agriculture, Soil Conservation Service, 78 p.
- Campbell, M. R., 1917 (1922), The coal fields of the United States: U.S. Geological Survey Professional Paper 100-A, p. 1-33.
- Dane, C. H., Rothrock, H. E., and Williams, J. S., 1938, Geology and fuel resources of the southern part of the Oklahoma coal field. Part 3. The Quinton-Scipio district, Pittsburg, Haskell, and Latimer Counties: U.S. Geological Survey Bulletin 874-C, p. 151-253.
- Doerr, A. H., 1961, Coal mining and landscape modification in Oklahoma: Oklahoma Geological Survey Circular 54, 48 p.
- Drever, J. I., 1982, The geochemistry of natural waters: Englewood Cliffs, N.J., Prentice-Hall, Inc., 388 p.
- Dunham, R. J., and Trumbull, J. V. A., 1955, Geology and coal resources of the Henryetta mining district, Okmulgee County, Oklahoma: U.S. Geological Survey Bulletin 1015-F, p. 183-225.
- Friedman, S. A., 1974, Investigation of the coal reserves in the Ozarks sections of Oklahoma and their potential uses; Final report to the Ozarks Regional Commission, July 1974: Oklahoma Geological Survey, Special Publication 74-2 (5th Printing 1981), 117 p.
- _____, 1978a, Field description and characterization of coals sampled by the Oklahoma Geological Survey, 1971-1976, in Dutcher, R. R., ed., Field description of coal: American Society for Testing Materials Special Technical Publication 661, p. 58-63.
- _____, 1978b, Desmoinesian coal deposits in part of the Arkoma Basin, eastern Oklahoma: Oklahoma City Geological Society Guidebook for Field Trip 2 of the American Association of Petroleum Geologists annual national meeting, 62 p.
- _____, 1982a, Map of eastern Oklahoma showing areas of potentially strippable coal: Oklahoma Geological Survey Map GM-23, scale 1:125,000, 4 sheets.
- _____, 1982b, Map of eastern Oklahoma showing locations of active mines in 1977-1979: Oklahoma Geological Survey Map GM-24 (scale 1:500,000).
- _____, 1982c, Determination of reserves of methane from coal beds for use in rural communities in eastern Oklahoma: Oklahoma Geological Survey Special Publication 82-3, 32 p.
- _____, 1983, Oklahoma, in 1983 Keystone Coal Industry Manual: New York, McGraw-Hill Mining Publications, p. 593-597.
- Gray, Fenton, and Galloway, H. M., 1959, Soils of Oklahoma: Stillwater, Oklahoma State University Experiment Station, 65 p.

- Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.
- Hendricks, T. A., 1937, Geology and fuel resources of the southern part of Oklahoma coal field; Part 1, The McAlester district, Pittsburg, Atoka, and Latimer Counties: U.S. Geological Survey Bulletin 874-A, p. 1-90.
- _____, 1939, Geology and fuel resources of the southern part of the Oklahoma coal field; Part 4, The Howe-Wilburton district, Latimer and Le Flore Counties: U.S. Geological Survey Bulletin 874-D, p. 255-298.
- Innocchione, A. T., and Puglio, D. G., 1979, Methane content and geology of the Hartshorne coalbed in Haskell and Le Flore Counties, Oklahoma: U.S. Bureau of Mines Report of Investigations 8407, 14 p.
- Johnson, K. S., 1974, Maps and description of disturbed and reclaimed surface mined coal lands in eastern Oklahoma, showing acreage disturbed and reclaimed through June 1973: Oklahoma Geological Survey Map GM-17, scale 1:125,000, 3 sheets, 21 p. text.
- Johnson, K. S., Brandon, C. C., Curtis, N. M., Jr., Ham, H. E., Marcher, M. V., and Roberts, J. F., 1972, Geology and earth resources of Oklahoma: Oklahoma Geological Survey Educational Publication 1, 8 p.
- Johnson, K. S., Kidd, C. M., and Butler, R. C., 1981, Bibliography of abandoned coal-mine lands in Oklahoma: Oklahoma Geological Survey Special Publication 81-2, 84 p.
- King, D. L., Simmler, J. J., Decker, C. S., and Ogg, C. W., 1974, Acid strip mine lake recovery: Journal of Water Pollution Control Federation, v. 46, no. 10, p. 2301-2315.
- Knetchel, M. M., 1937, Geology and fuel resources of the southern part of the Oklahoma coal field; Part 2, The Lehigh district, Coal, Atoka, and Pittsburg Counties: U.S. Geological Survey Bulletin 874-B, p. 91-149.
- _____, 1949, Geology and coal and natural gas resources of northern Le Flore County, Oklahoma: Oklahoma Geological Survey Bulletin 68, 76 p.
- McKee, J. E., and Wolf, H. W., eds., 1963, Water quality criteria (2d ed.): Sacramento, The Resources Agency of California, State Water Quality Control Board, Pub. no. 3-A, 548 p.
- Marcher, M. V., 1969, Reconnaissance of the water resources of the Fort Smith quadrangle, east-central Oklahoma: Oklahoma Geological Survey Hydrologic Atlas 1, scale 1:125,000, 4 sheets.
- Marcher, M. V., and Bergman, D. L., 1983, Reconnaissance of the resources of the McAlester quadrangle, southeastern Oklahoma: Oklahoma Geological Survey Hydrologic Atlas 9, scale 1:250,000, 4 sheets.
- Marcher, M. V., Bergman, D. L., Stoner, J. D., and Blumer, S. P., 1981, Preliminary appraisal of the hydrology of the Blocker area, Pittsburg County, Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 81-1187, 48 p.
- _____, 1983a, Preliminary appraisal of the hydrology of the Rock Island area, Le Flore County, Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 83-4013, 35 p.
- _____, 1983b, Preliminary appraisal of the hydrology of the Red Oak area, Latimer and Le Flore Counties, Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 83-4166, 38 p.
- Marcher, M. V., and Bingham, R. H., 1971, Reconnaissance of the water resources of the Tulsa quadrangle, northeastern Oklahoma: Oklahoma Geological Survey Hydrologic Atlas 2, scale 1:250,000, 4 sheets.

- Marcher, M. V., Huntzinger, T. L., Stoner, J. D., and Blumer, S. P., 1983, Preliminary appraisal of the hydrology of the Stigler area, Haskell County, Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 82-4099, 37 p.
- Marcher, M. V., and others, 1983, Hydrology of Area 40, Western Region, Interior Coal Province, Kansas, Oklahoma, and Missouri: U.S. Geological Survey Water-Resources Investigations Open-File Report 83-266, (in press).
- National Academy of Sciences and National Academy of Engineering, 1972 (1974), Water quality criteria 1972: Washington, D.C., U.S. Government Printing Office, 594 p.
- Oakes, M. C., 1944, Broken Arrow coal and associated strata, western Rogers, Wagoner, and southeastern Tulsa Counties, Oklahoma: Oklahoma Geological Survey Circular 24, 40 p.
- _____, 1952, Geology and mineral resources of Tulsa County, Oklahoma: Oklahoma Geological Survey Bulletin 69, 234 p.
- _____, 1977, Geology and mineral resources (exclusive of petroleum) of Muskogee County, Oklahoma: Oklahoma Geological Survey Bulletin 122, 78 p.
- Oakes, M. C., and Knechtel, M. M., 1948, Geology and mineral resources of Haskell County, Oklahoma: Oklahoma Geological Survey Bulletin 67, 134 p.
- Oakes, M. C., and Koontz, T., 1967, Geology and petroleum of McIntosh County, Oklahoma: Oklahoma Geological Survey Bulletin 111, 88 p.
- Oakes, M. C., and Motts, W. S., 1963, Geology and water resources of Okmulgee County, Oklahoma: Oklahoma Geological Survey Bulletin 91, 164 p.
- Oklahoma Conservation Commission, 1983, Oklahoma abandoned mine land reclamation plan: Oklahoma City, 307 p.
- Oklahoma Session Laws, 1971, Mining lands reclamation act, House-bill 1492, p. 855-862, Chapter 332, par. 721-738.
- Oklahoma State Department of Health, 1982, Public water supply report: Environmental Health Services, 4 vols.
- Oklahoma Water Resources Board, 1969, Appraisal of the water and related land resources of Oklahoma; Regions Five and Six: Oklahoma Water Resources Board Publication 27, 159 p.
- _____, 1970, Appraisal of the water and related land resources of Oklahoma. Region Seven: Oklahoma Water Resources Board Publication 29, 141 p.
- _____, 1971, Appraisal of the water and related land resources of Oklahoma. Eight: Oklahoma Water Resources Board Publication 34, 141 p.
- _____, 1971b, Appraisal of the water and related land resources of Oklahoma. Region Nine: Oklahoma Water Resources Board Publication 36, 149 p.
- _____, 1979a, Oklahoma's water quality standards, 1979: Oklahoma Water Resources Board Publication 101, 94 p.
- _____, 1979b, Rules, regulations, and modes of procedure, 1979 revision: Oklahoma Water Resources Board Publication 90, 73 p.
- _____, 1980, Rural water systems in Oklahoma: Oklahoma Water Resources Board Publication 98, 160 p.
- Russell, D. T., 1960 Geology of northern Latimer County, Oklahoma: Oklahoma Geological Survey Circular 50, 57 p.
- Sawyer, C. N., and McCarty, P. L., 1978, Chemistry for environmental engineering (3d ed.): New York, McGraw-Hill, 532 p.
- Shannon, C. W., and Cooper, C. L., 1924, Coal in Oklahoma: Oklahoma Geological Survey Bulletin 4, 110 p.

- Slack, L. J., 1983, Hydrology of an abandoned coal-mining area near McCurtain, Haskell County, Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 83-4202, 117 p.
- Stumm, Werner, and Morgan, J. J., 1981, Aquatic chemistry--an introduction emphasizing chemical equilibria in natural waters (2d ed.): New York, John Wiley and Sons, 780 p.
- Trumbull, J. V. A., 1957, Coal resources of Oklahoma: U.S. Geological Survey Bulletin 1042-J, p. 307-382.
- U.S. Bureau of Mines, 1971, Strippable reserves of bituminous coal and lignite in the United States: U.S. Bureau of Mines Information Circular 8531, 148 p.
- U.S. Department of the Interior, 1977, Guidelines for reclamation of study areas: Bureau of Land Management, EMRIA Handbook, 1977, 83 p.
- U.S. Environmental Protection Agency, 1976a, National interim primary drinking water regulations: Office of Water Supply, EPA-570/9-76-003, 159 p.
- _____, 1976b, Quality criteria for water, 1976: Washington, D.C., U.S. Government Printing Office, 256 p.
- _____, 1979, National secondary drinking water regulations: Office of Drinking Water, EPA-570/9-76-000, 37 p.
- U.S. Office of Surface Mining, Reclamation and Enforcement, 1979, Surface coal mining and reclamation operations-permanent regulatory program: Federal Register, v. 44, no. 50, Book 3, p. 15311-15463.

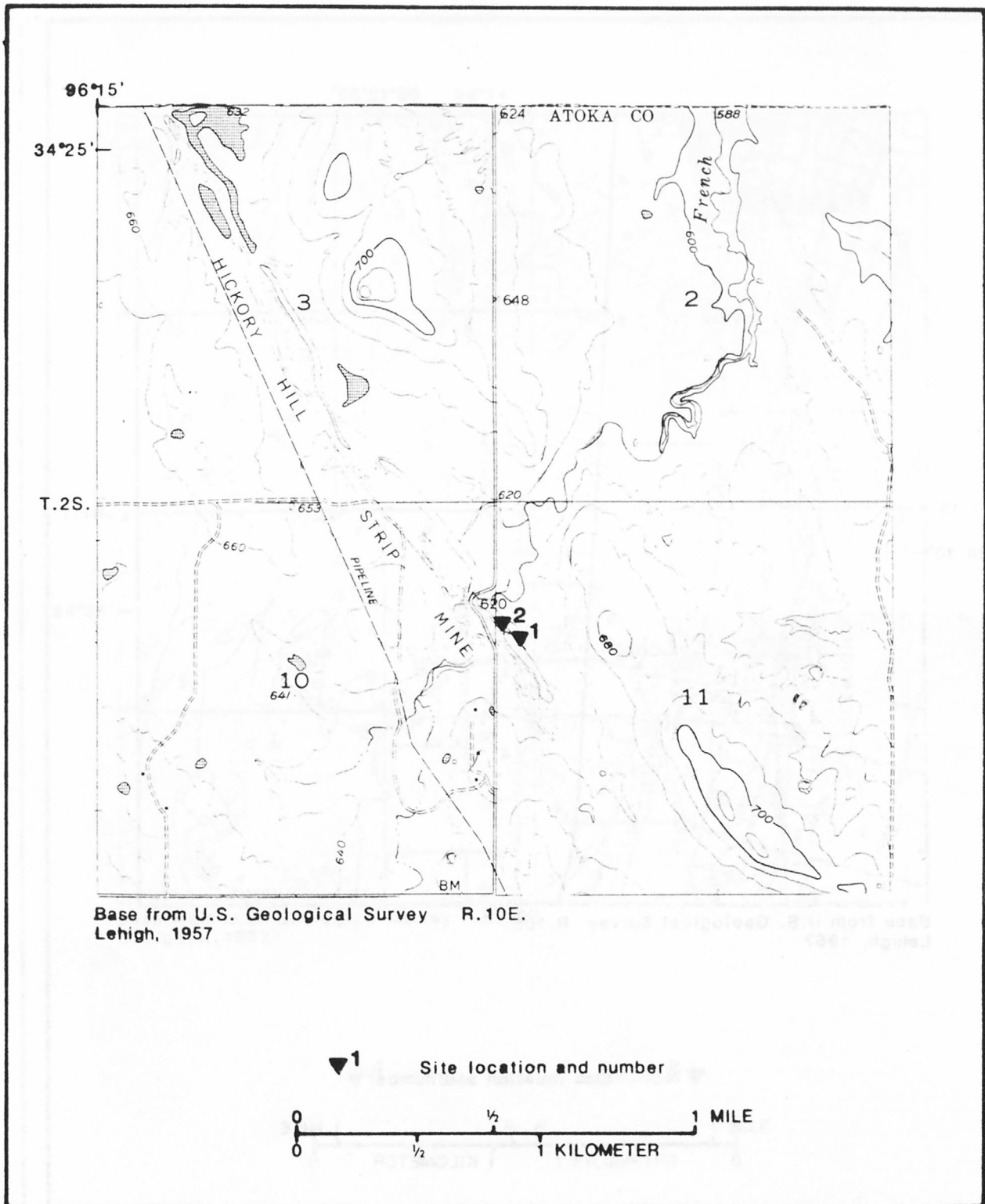


Figure 9.--Sites 1-2.

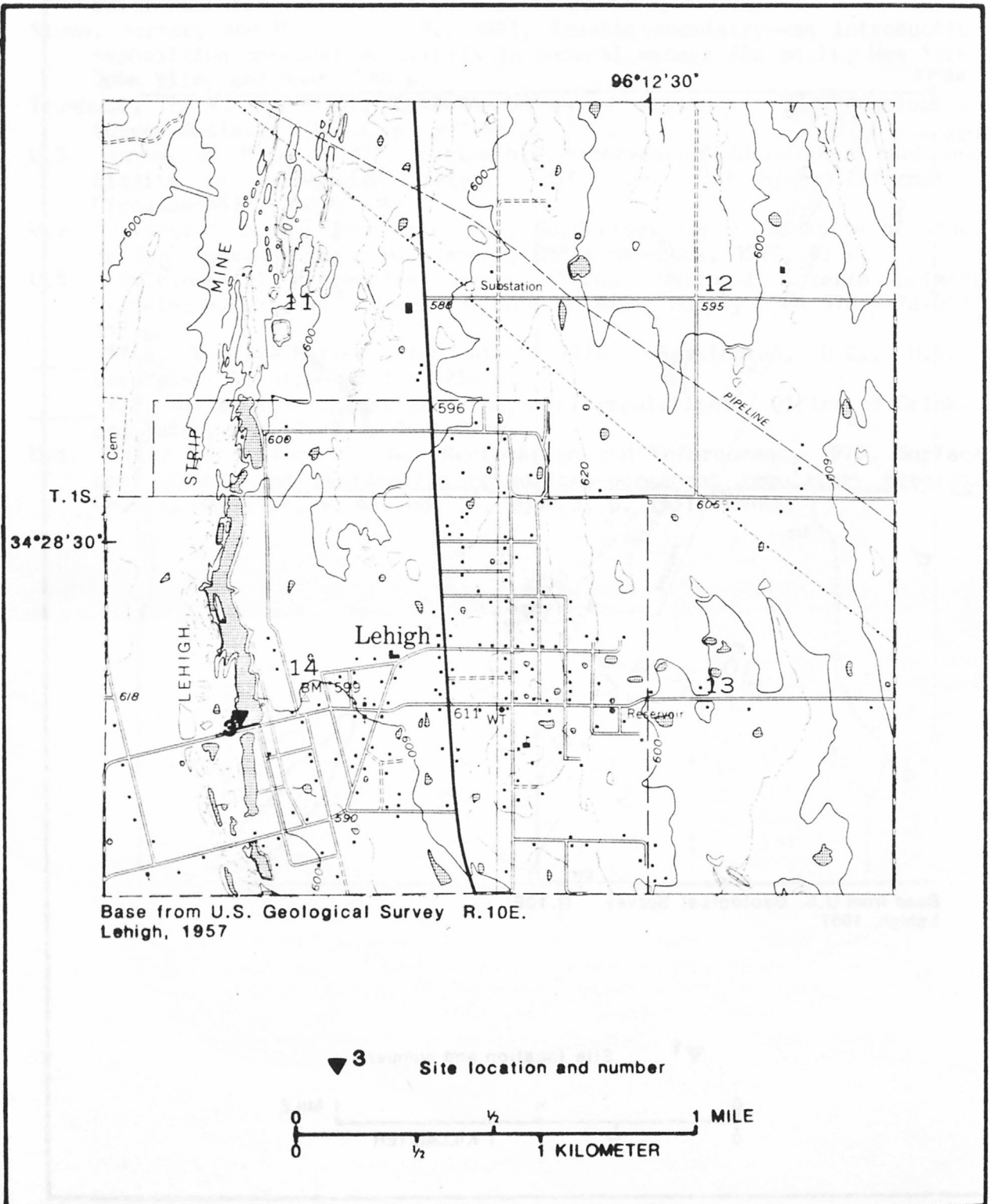


Figure 10.--Site 3.

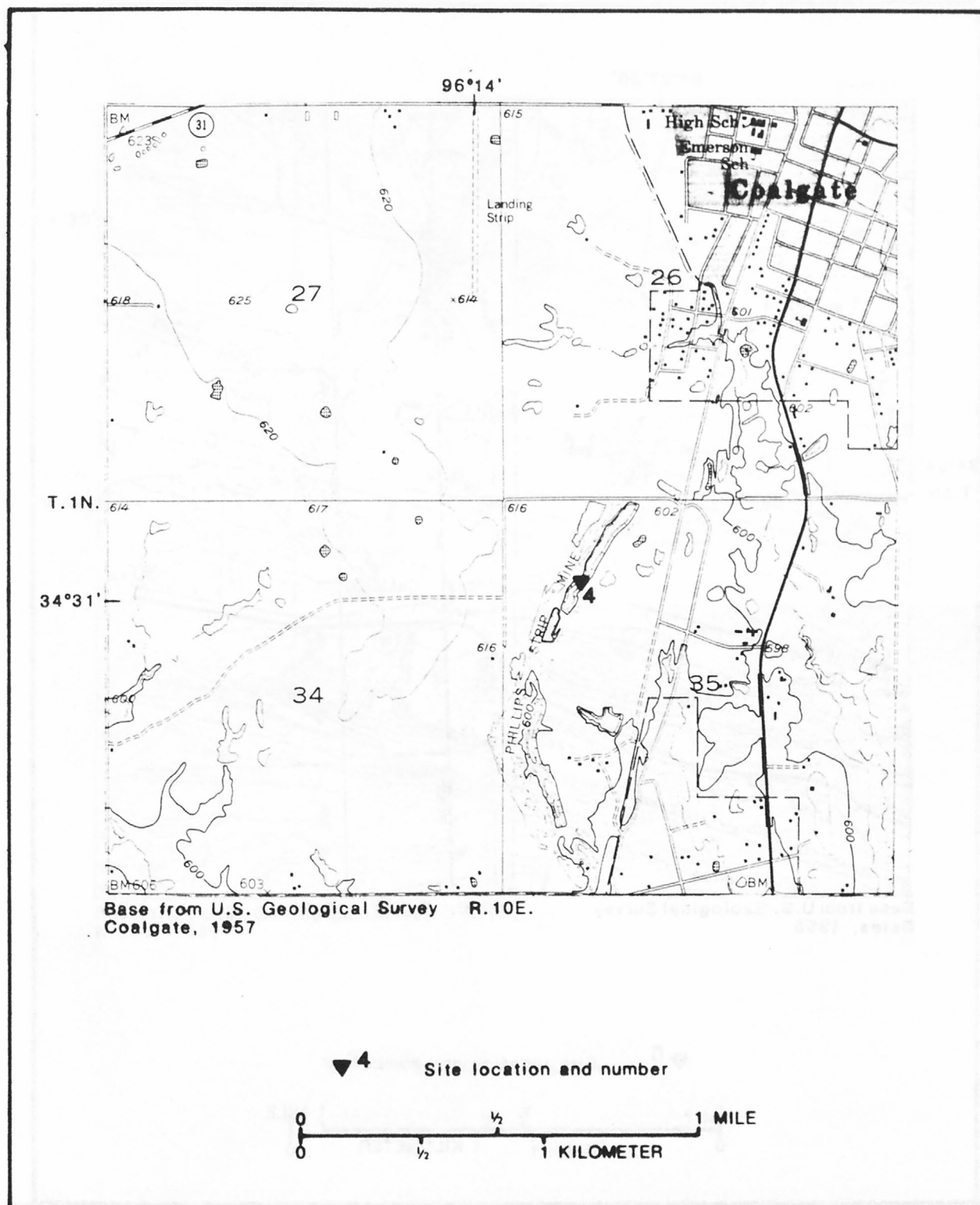
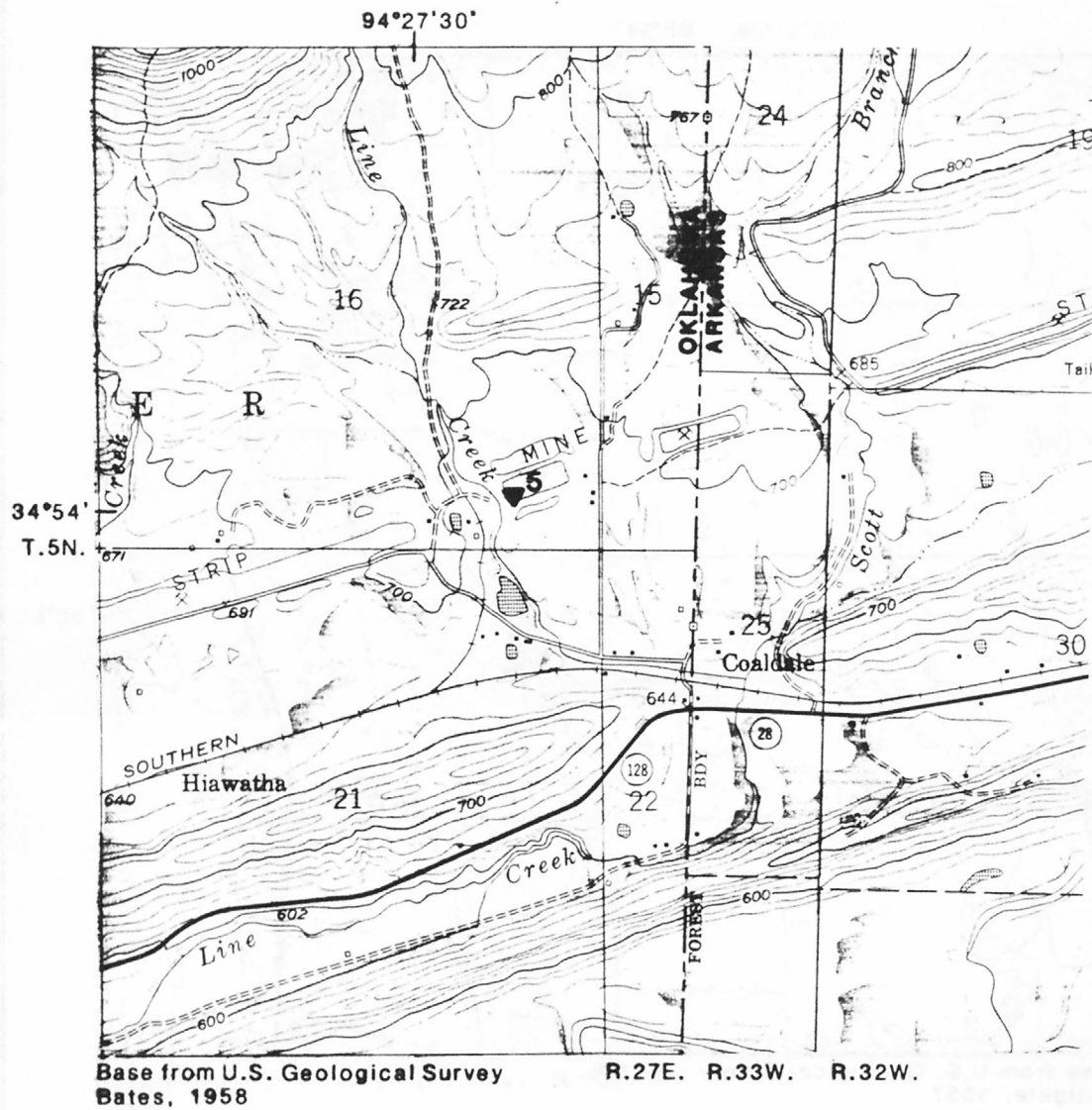


Figure 11.--Site 4.



▼ 5 Site location and number

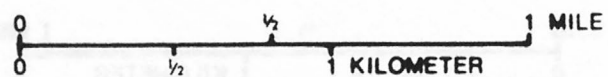
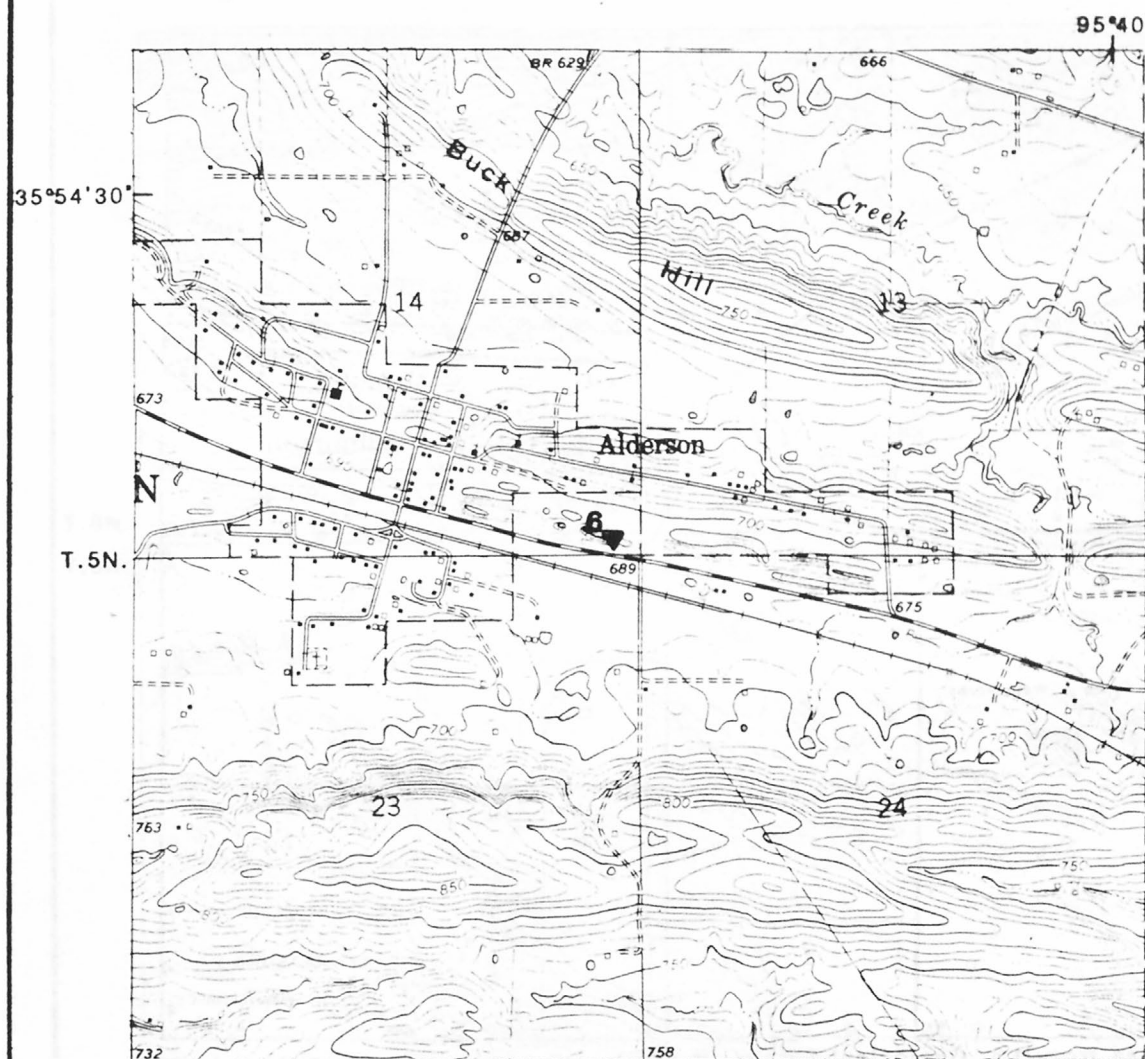


Figure 12.--Site 5.



Base from U.S. Geological Survey R.15E.
Krebs, 1967



Site location and number

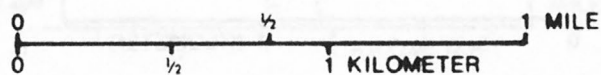


Figure 13.--Site 6.

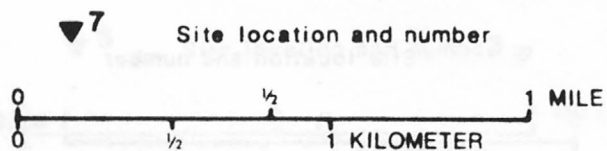
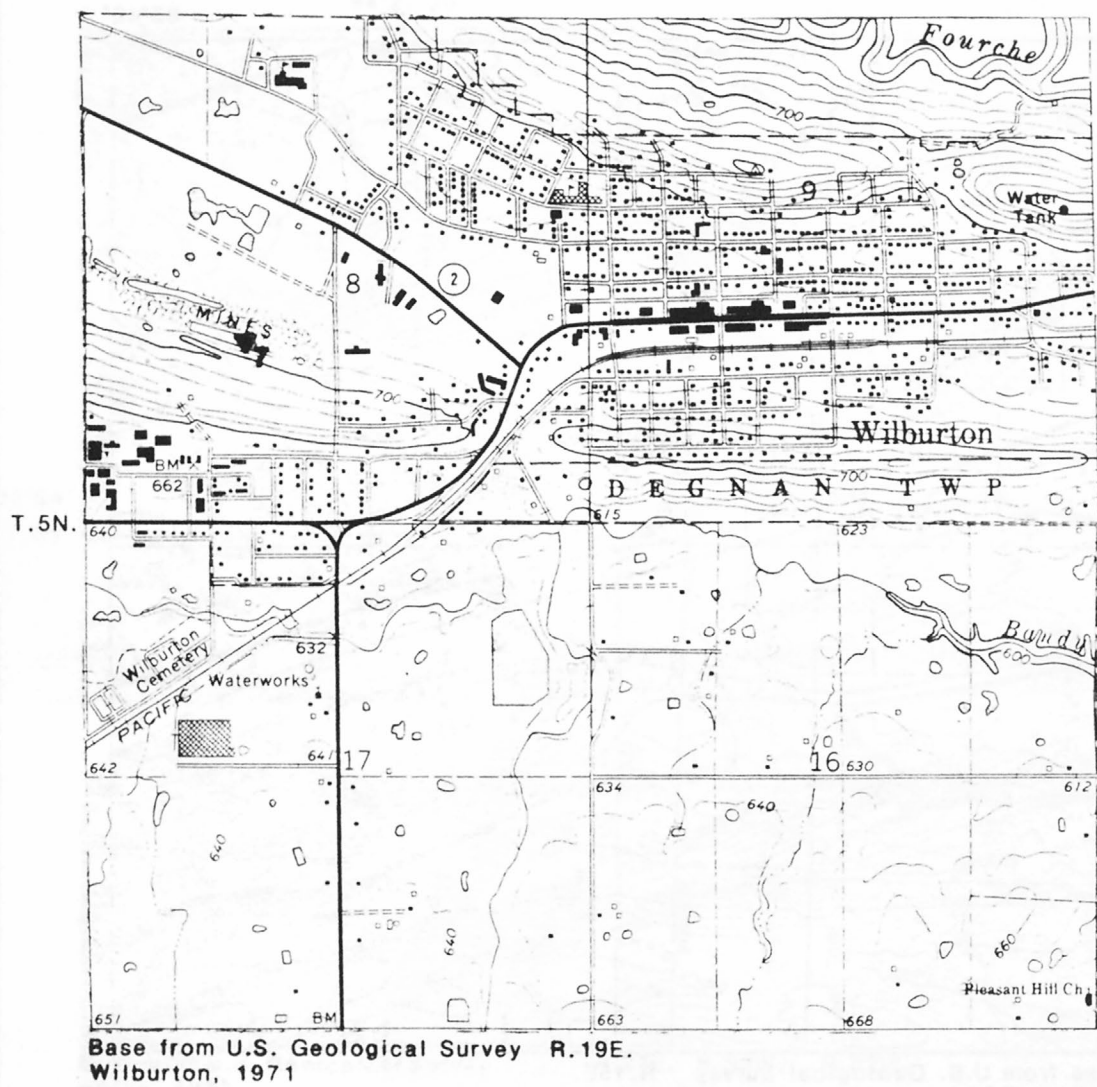
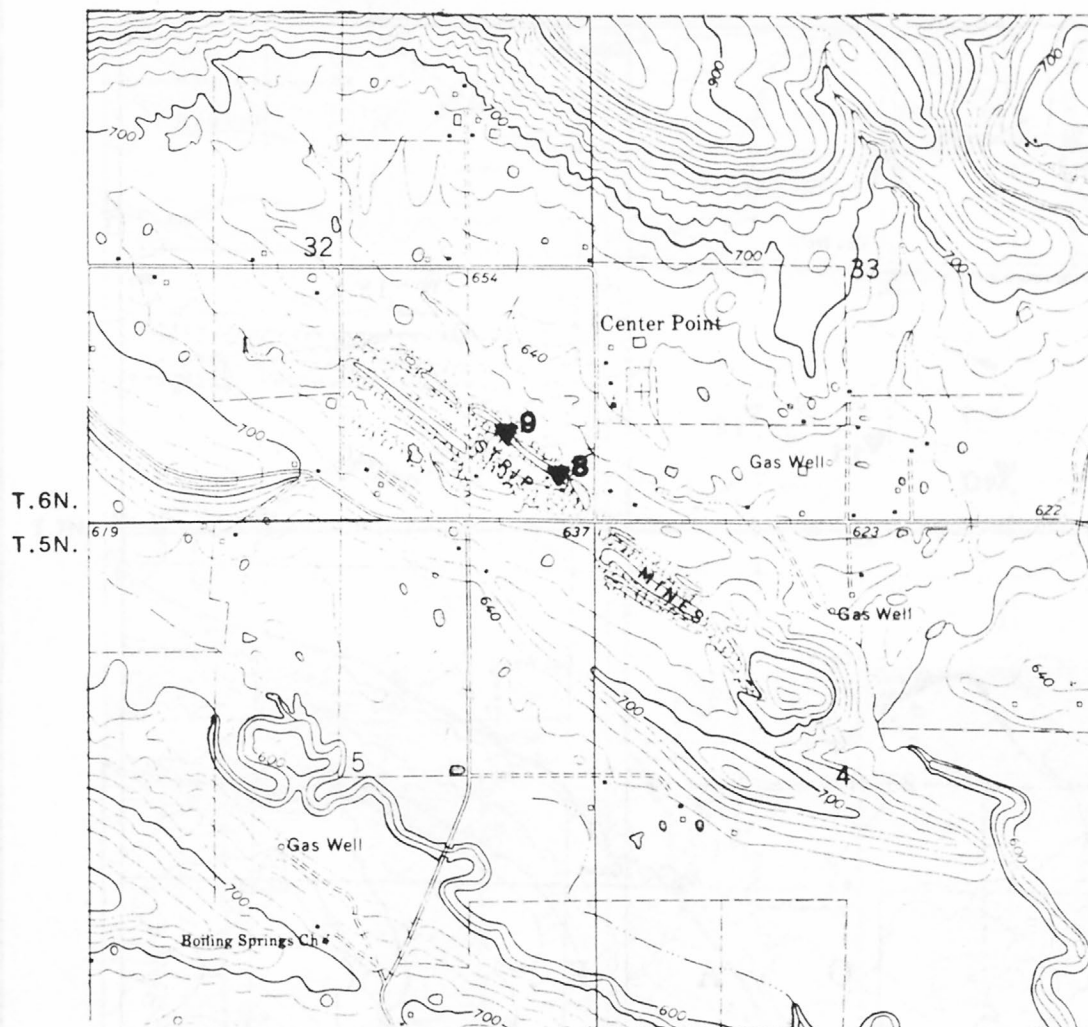


Figure 14.--Site 7.



Base from U.S. Geological Survey R.19E.
Wilburton, 1971

▼ 8 Site location and number

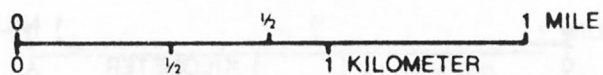
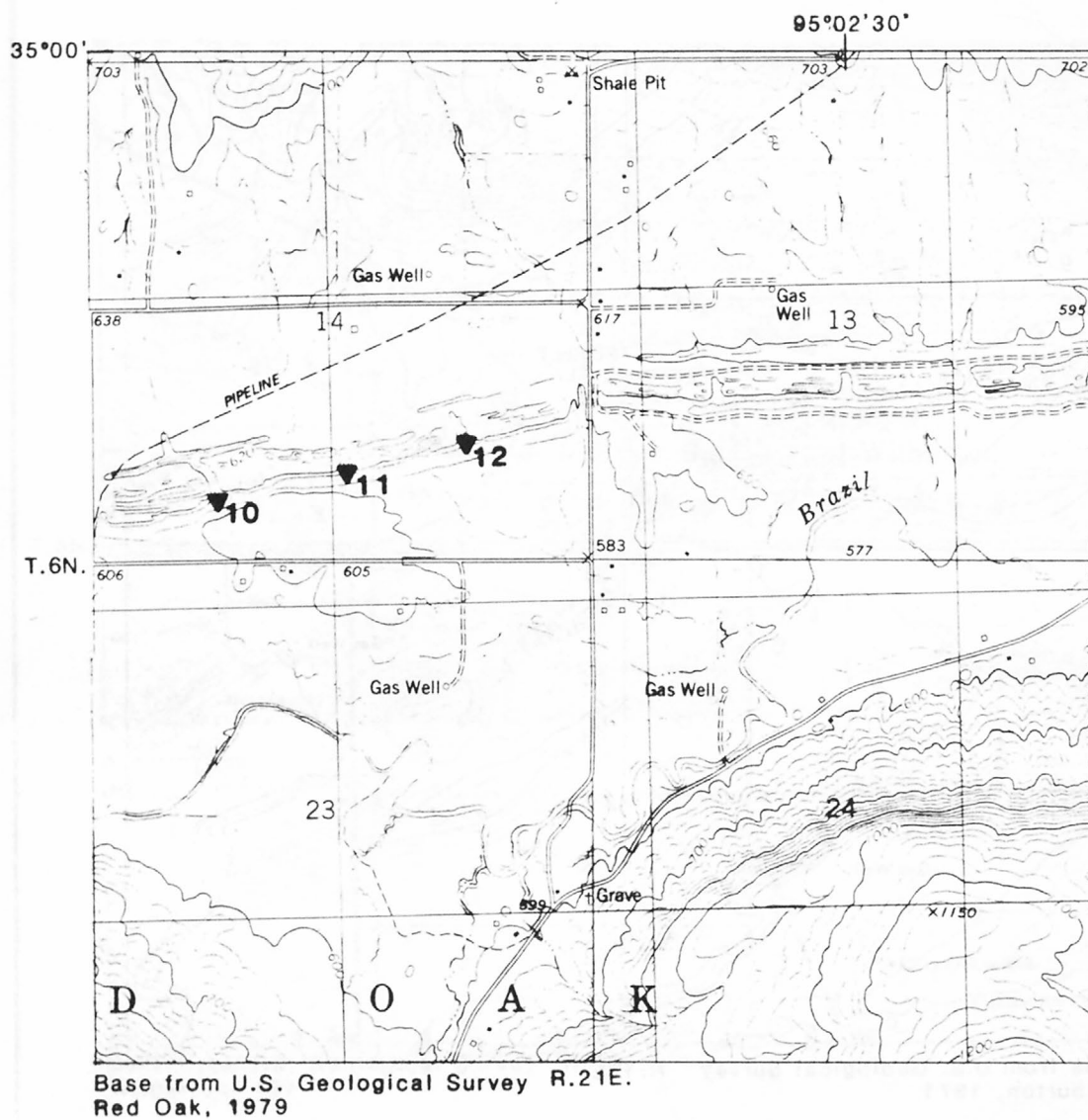


Figure 15.--Sites 8-9.



▼ 10 Site location and number

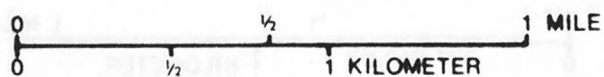
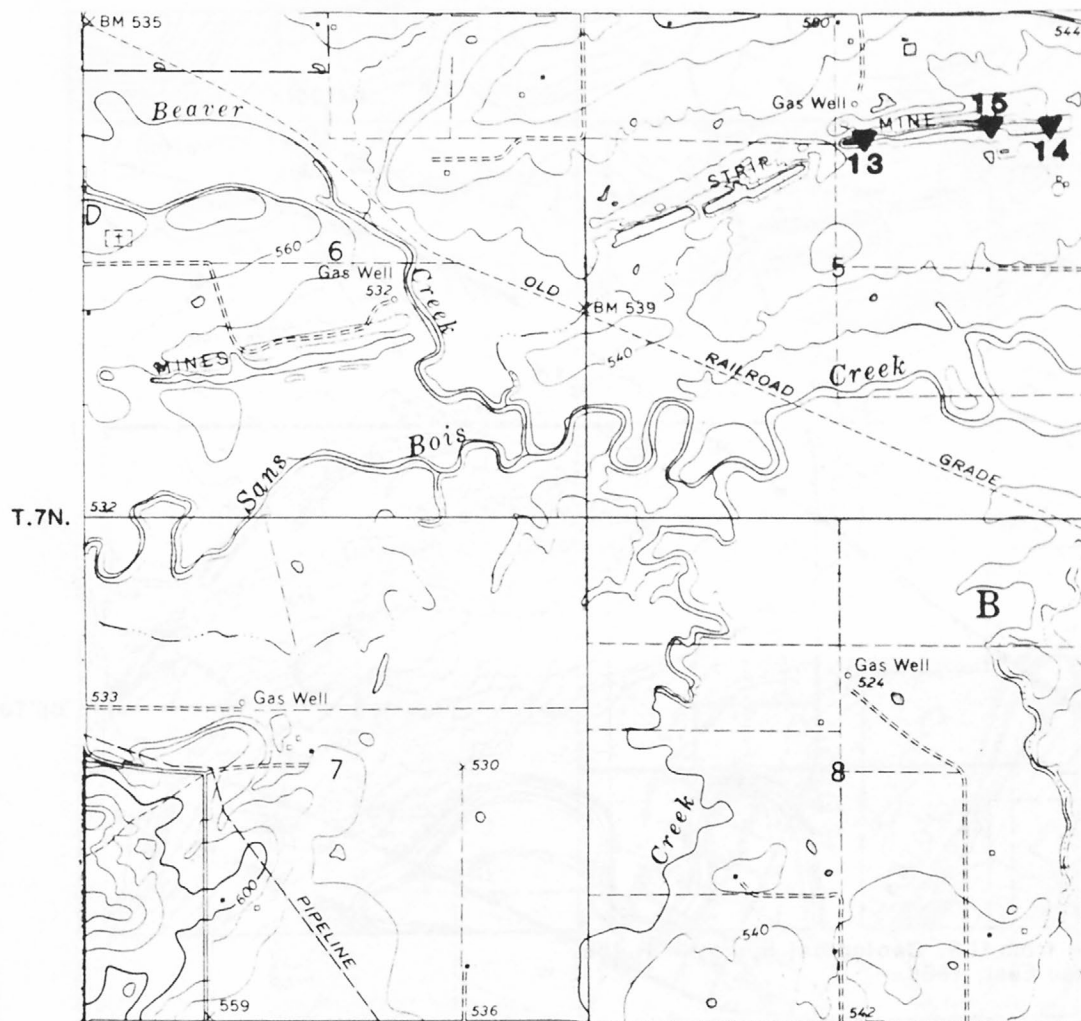


Figure 16.--Sites 10-12.



Base from U.S. Geological Survey
Kinta, 1969

R.20E.

▼13 Site location and number

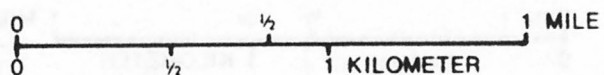
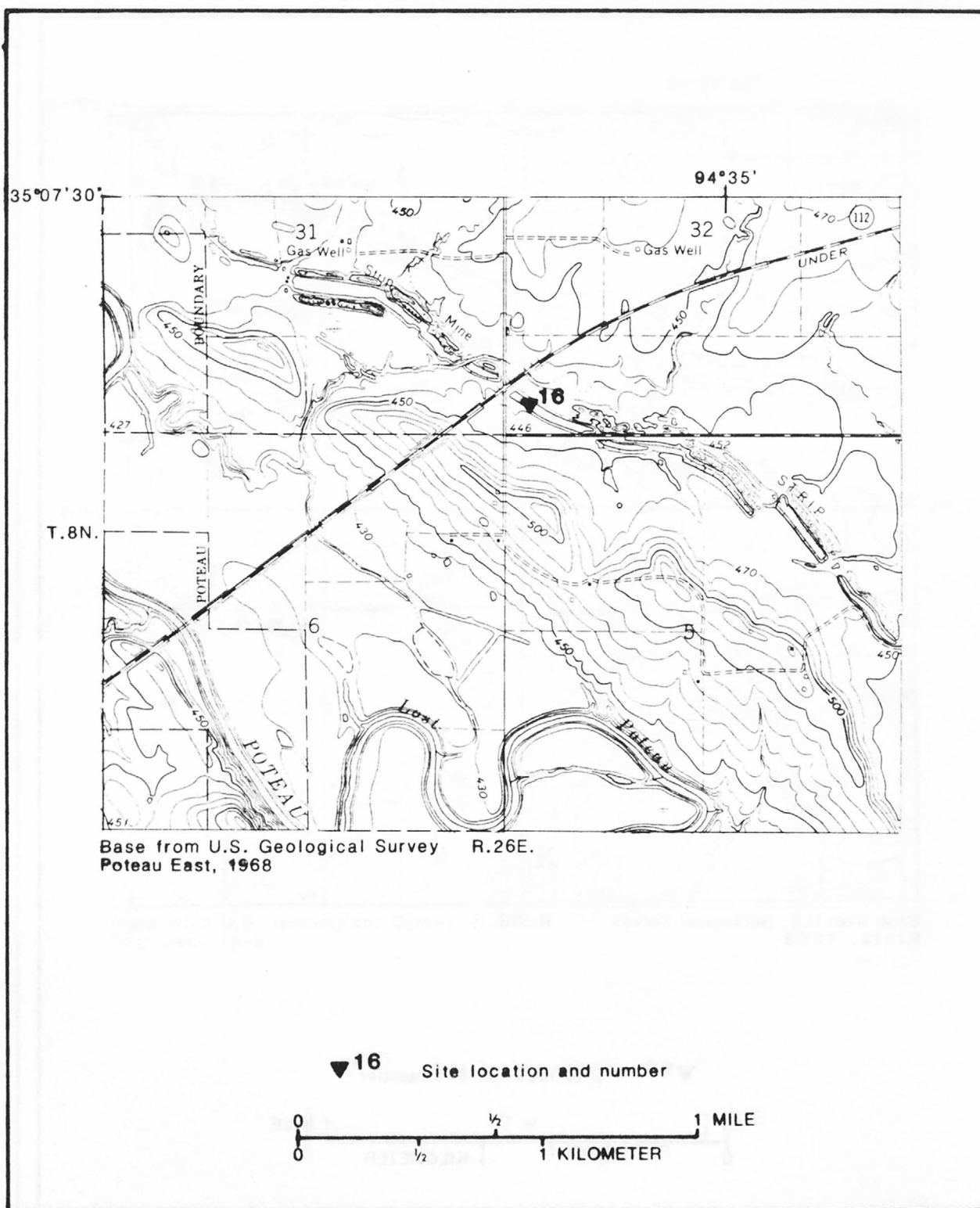
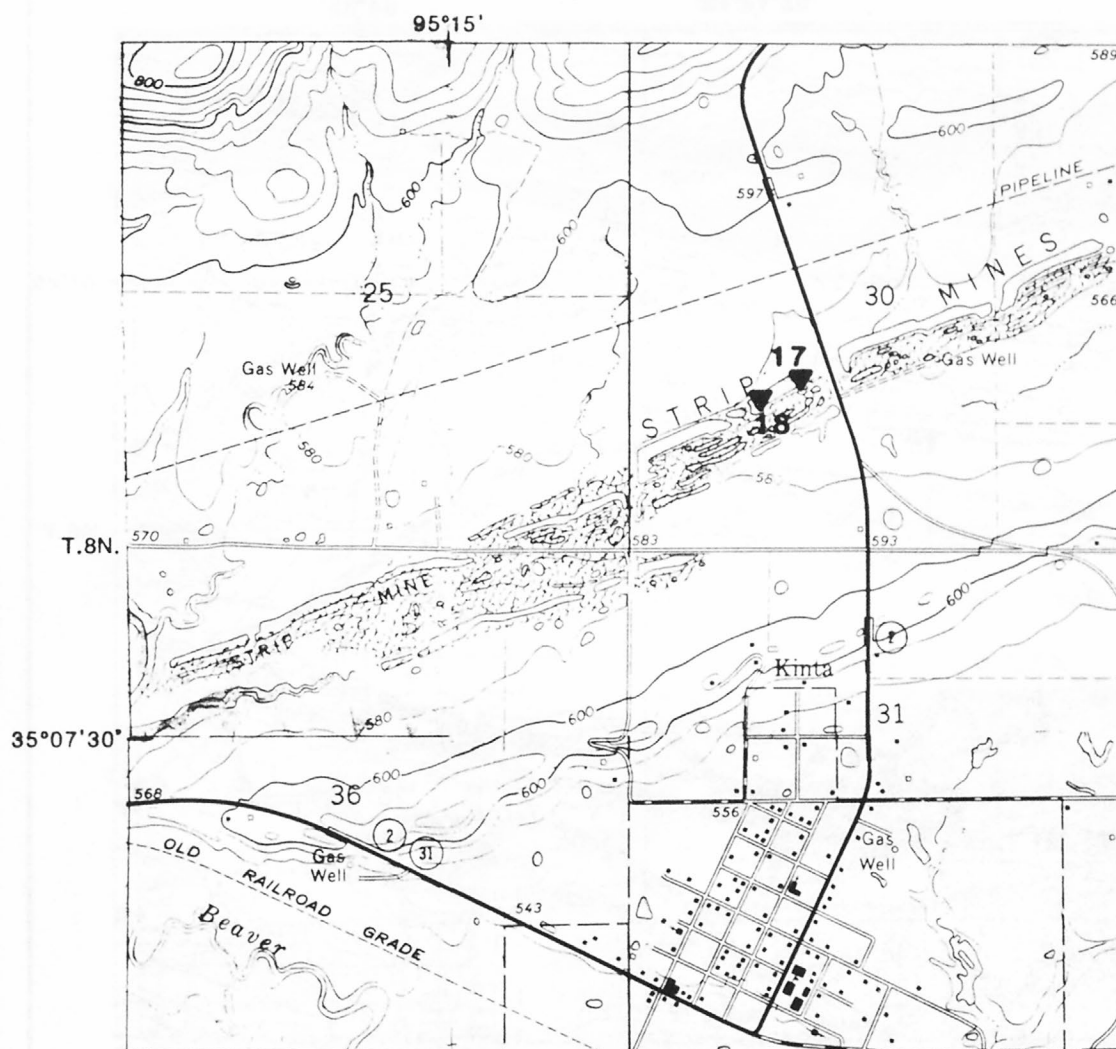


Figure 17.--Sites 13-15.





Base from U.S. Geological Survey R.19E. R.20E.
 Kinta, 1969
 Quinton North, 1969
 Quinton South, 1969
 Sans Bois, 1969

▼17 Site location and number

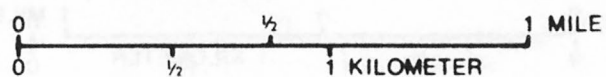
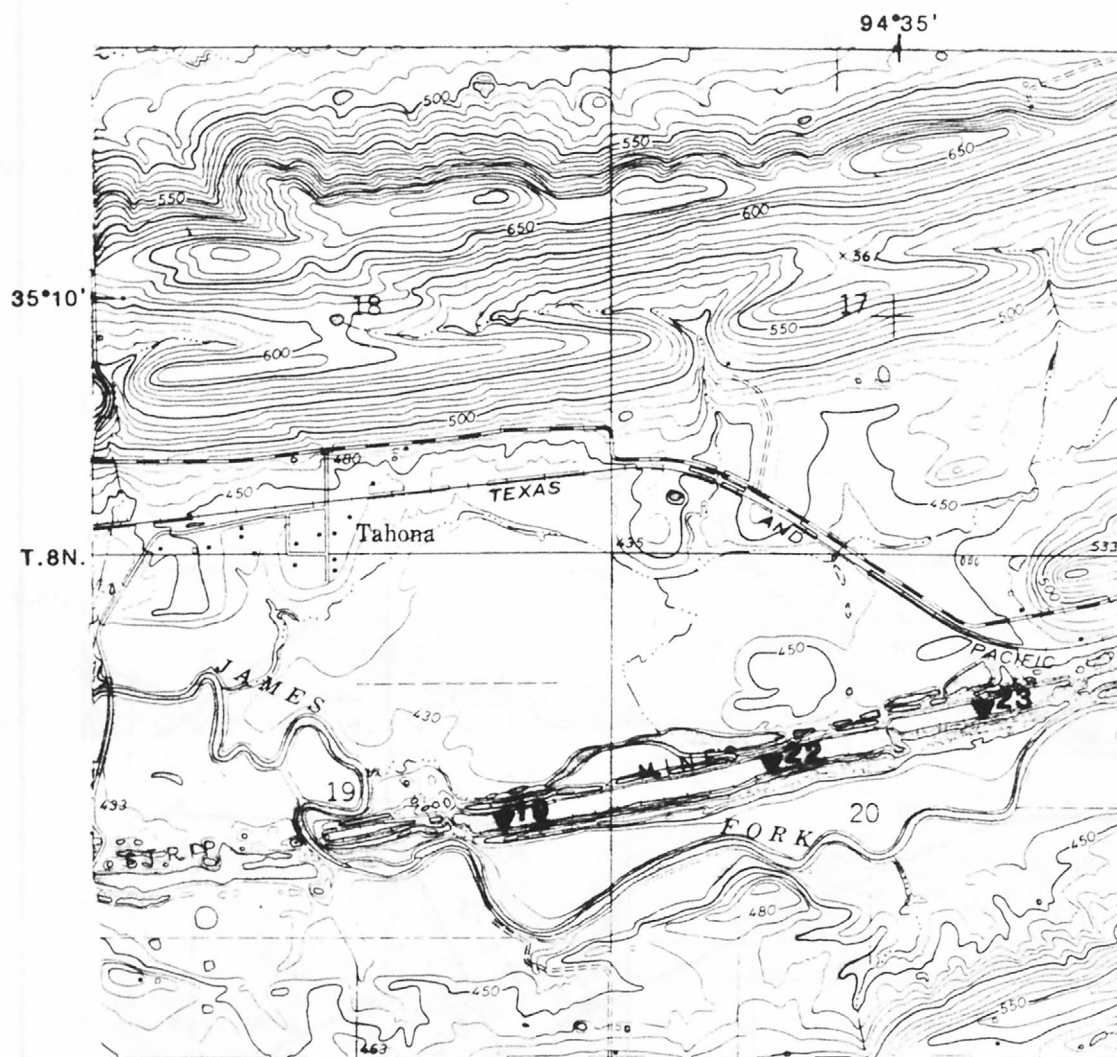


Figure 19.--Sites 17-18.



Base from U.S. Geological Survey R.26E.
Spiro, 1968

▼ 19 Site location and number

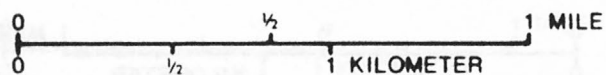
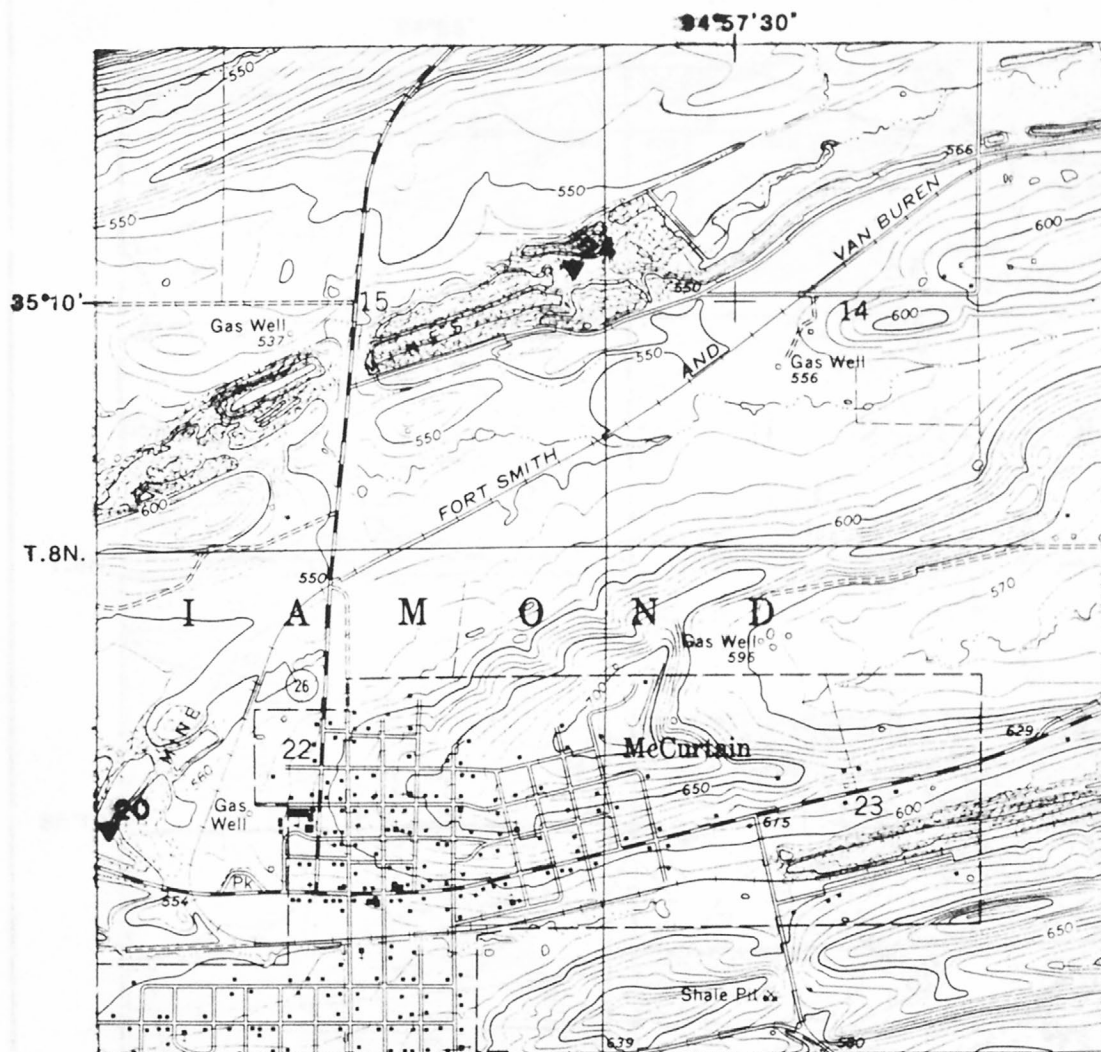


Figure 20.--Sites 19 and 22-23.



Base from U.S. Geological Survey \bullet 22E.
 McCurtain, 1968

▼ 24 Site location and number

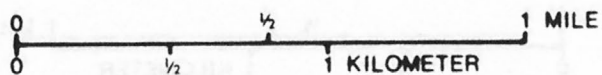
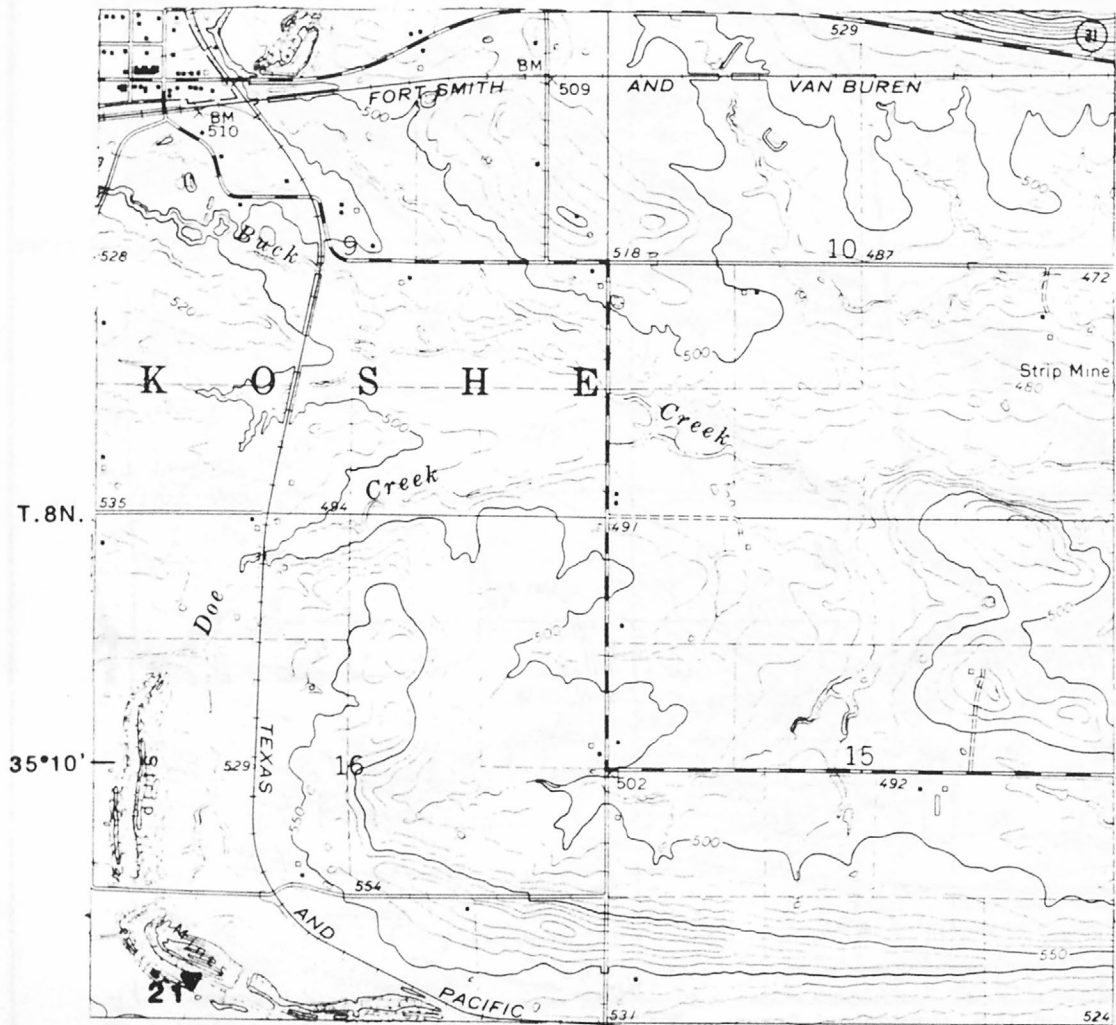


Figure 21.--Sites 20 and 24.



Base from U.S. Geological Survey R.24E.
Bokoshe, 1968

▼²¹ Site location and number

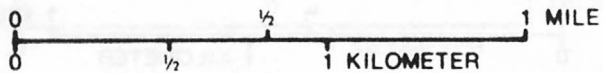
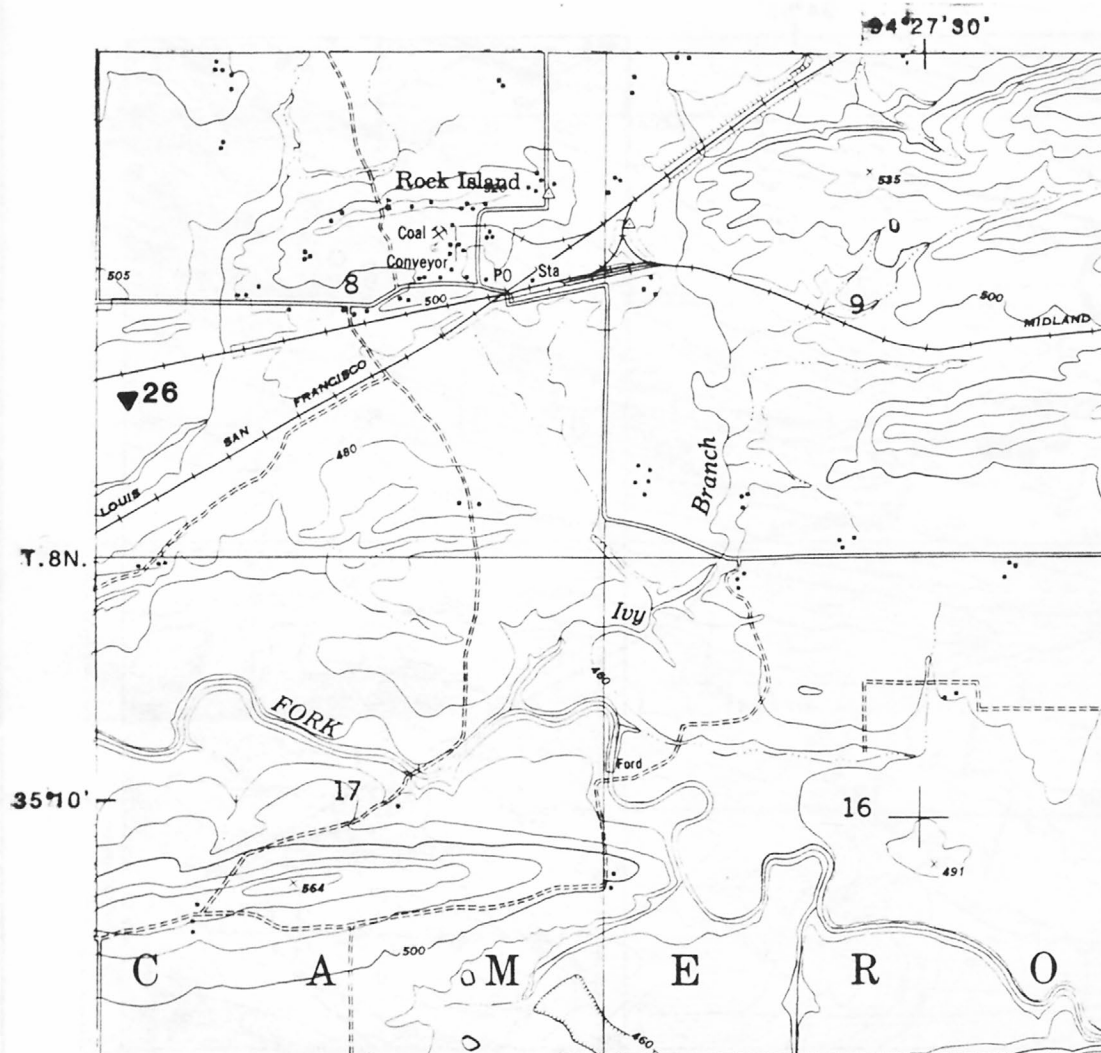


Figure 22.--Site 21.



Base from U.S. Geological Survey R. 27E.
Hackett, 1948

▼26 Site location and number

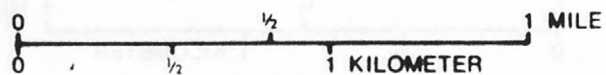
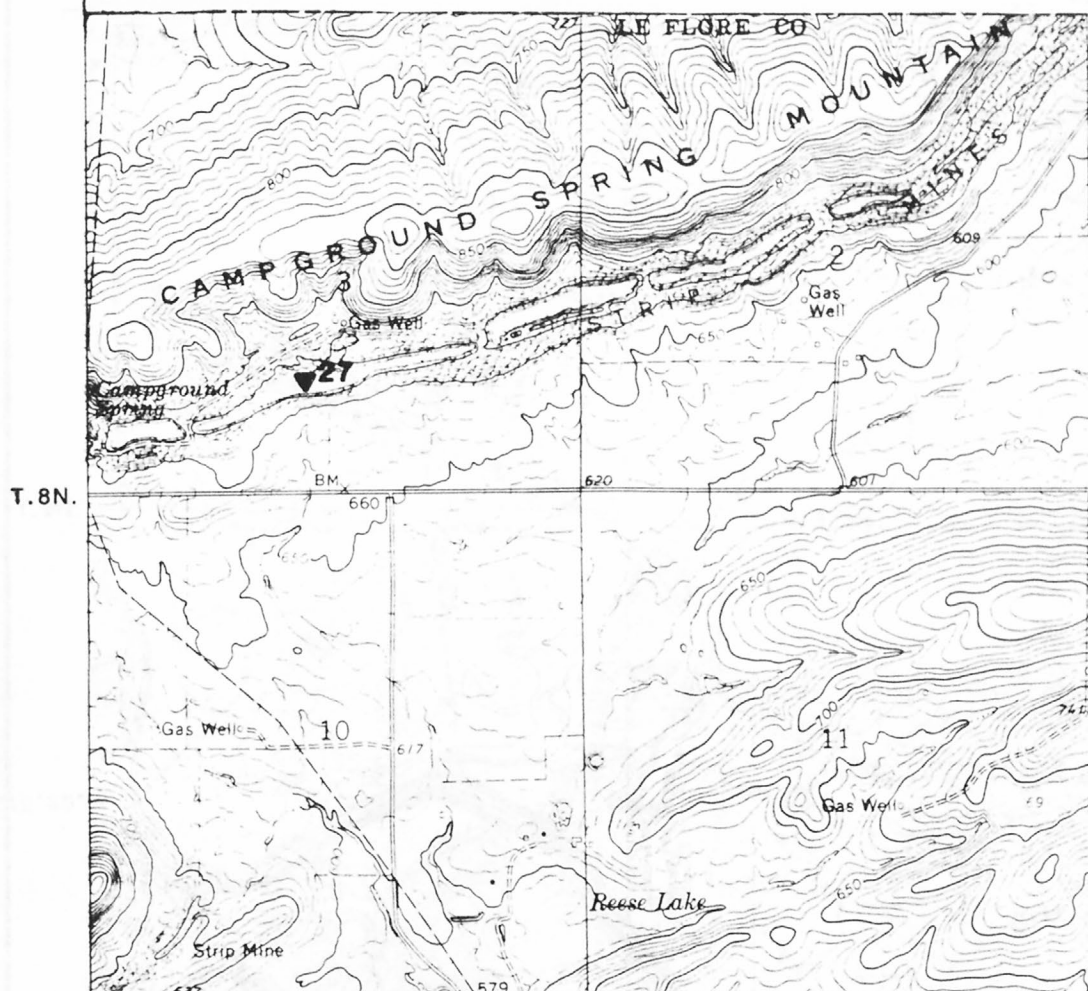


Figure 24.--Site 26.



Base from U.S. Geological Survey R.23E.
Bokoshe, 1968

▼ 27

Site location and number

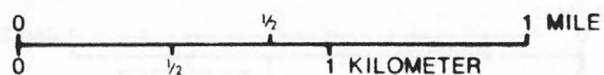


Figure 25.--Site 27.

Figure 26.--Site 28.

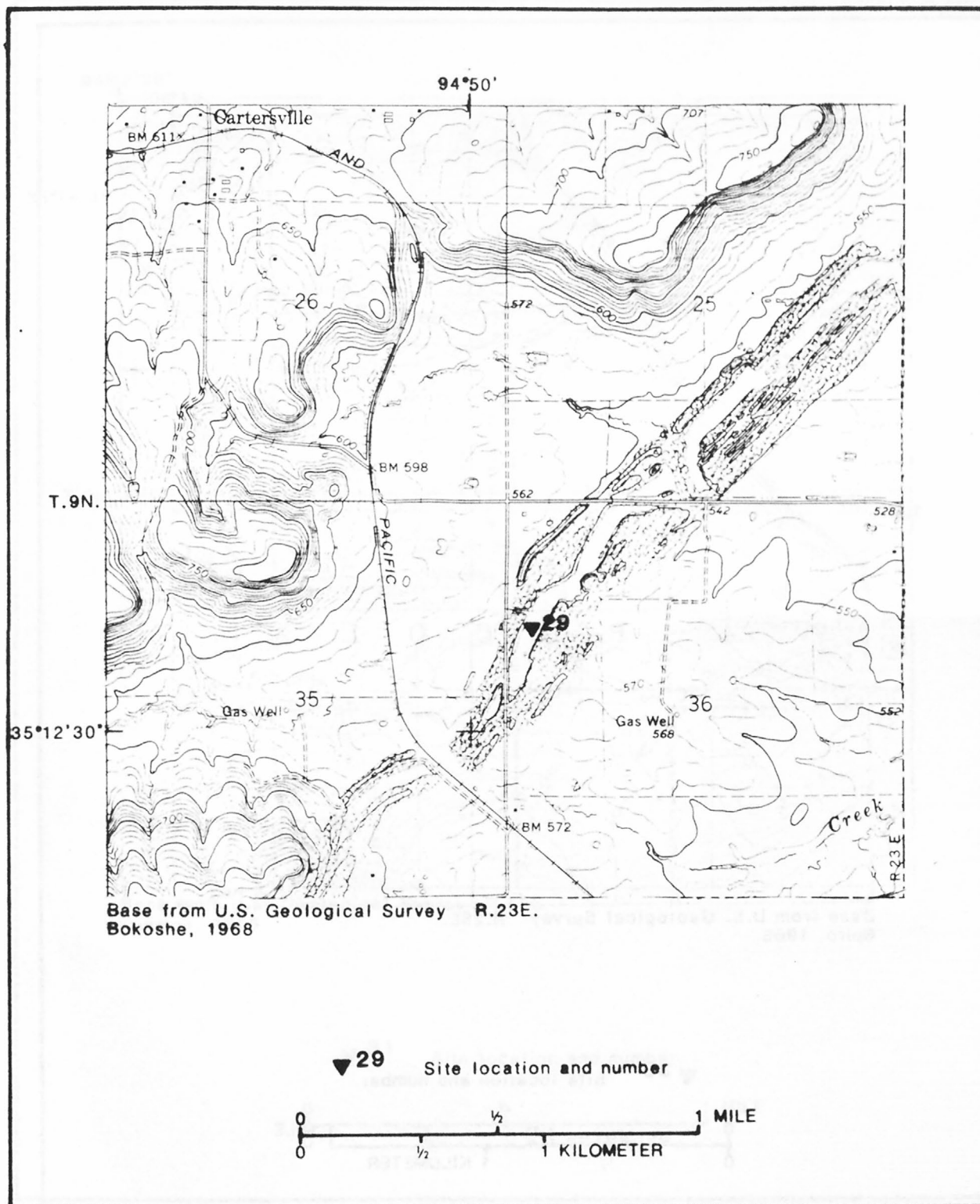
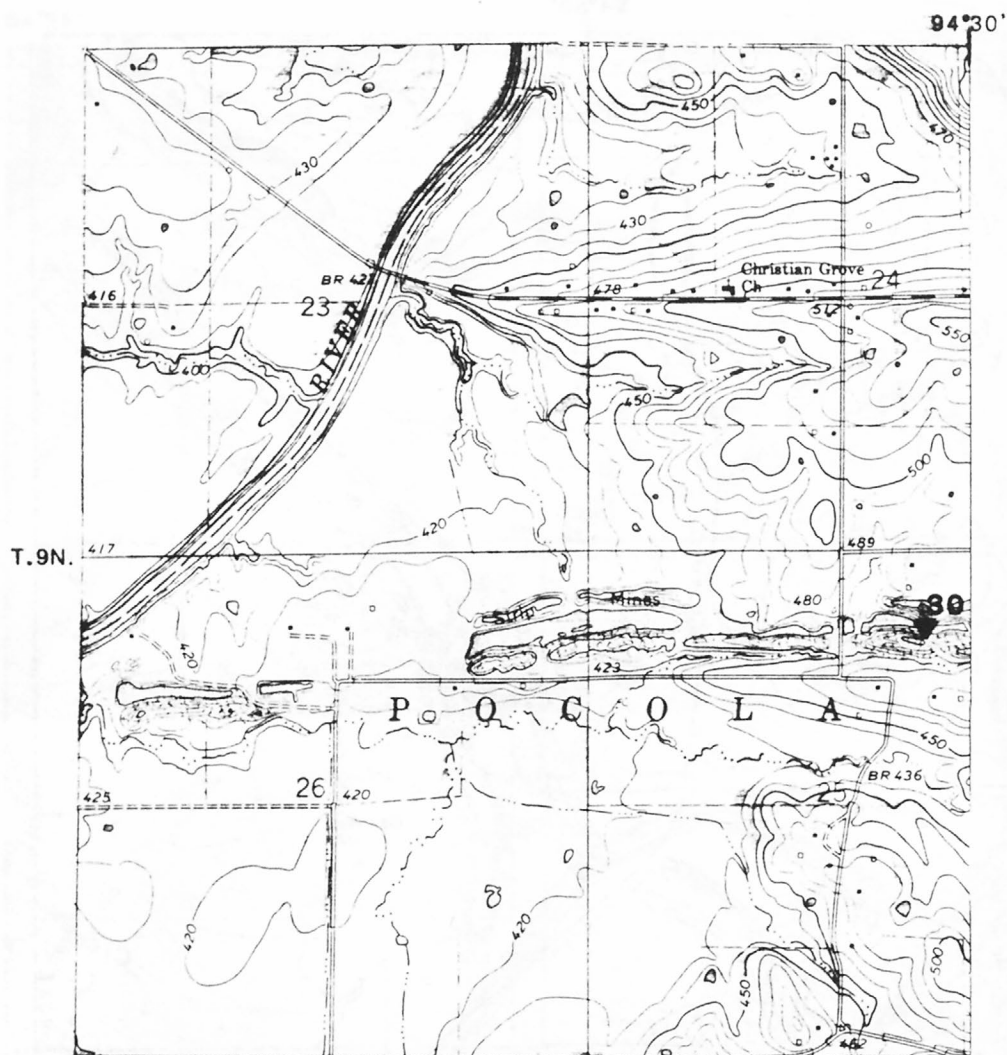


Figure 27.--Site 29.



Base from U.S. Geological Survey R.26E.
Spiro, 1968

▼ 30

Site location and number

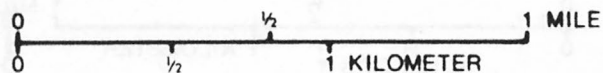


Figure 28.---Site 30.

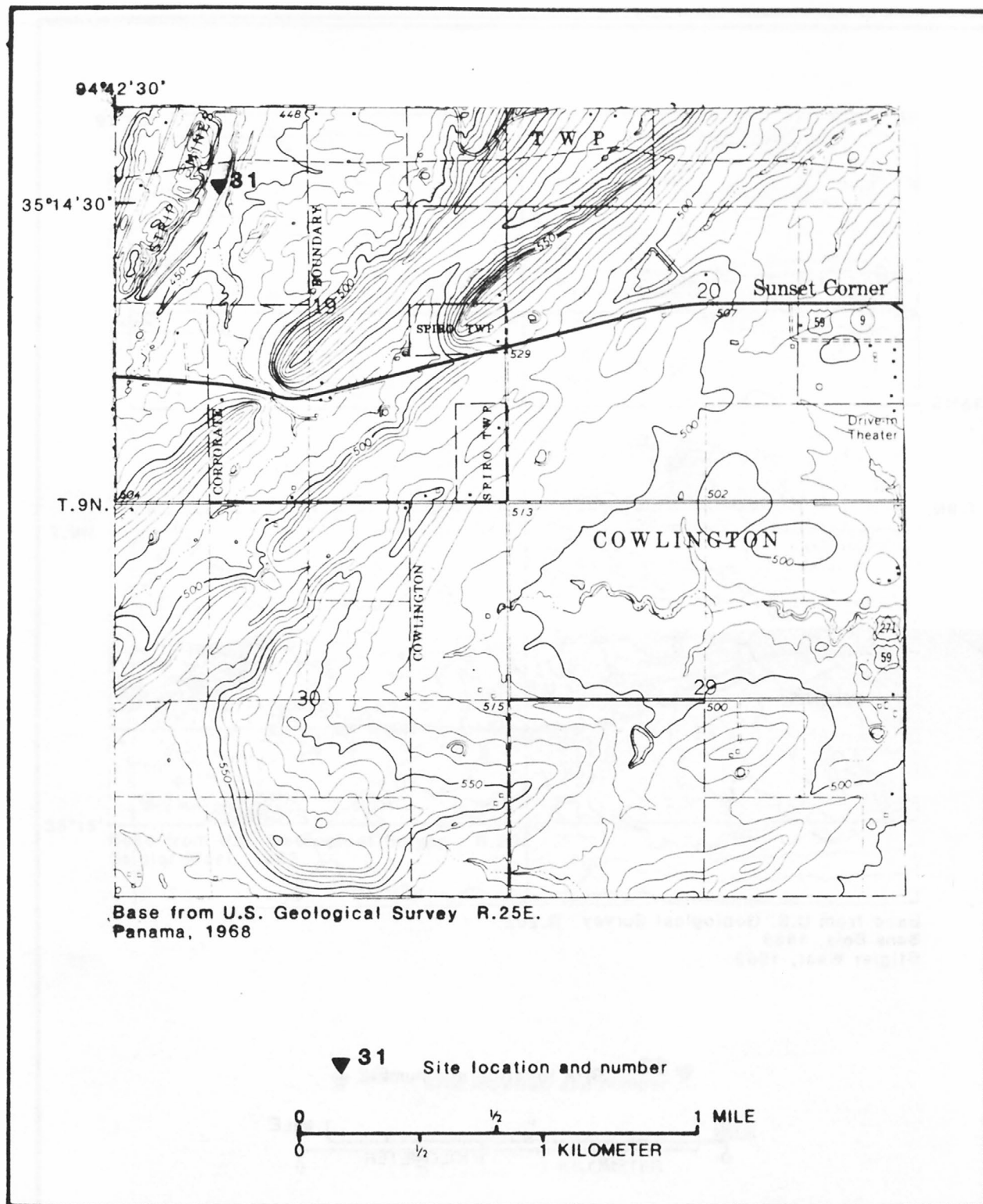
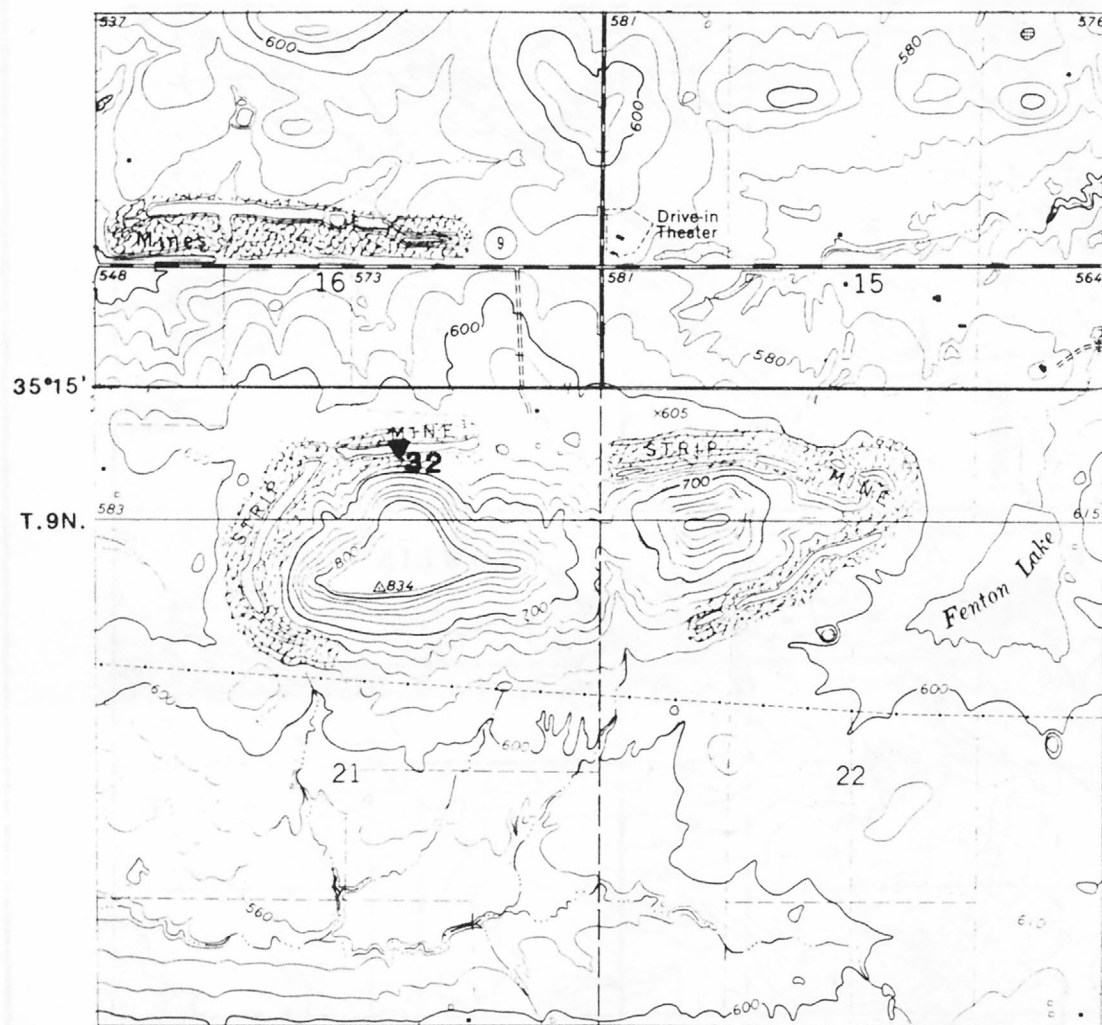


Figure 29.--Site 31.



Base from U.S. Geological Survey R.20E.
 Sans Bois, 1969
 Stigler West, 1962

▼ 32 Site location and number

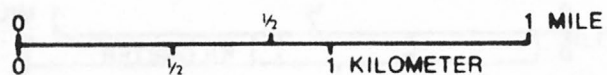
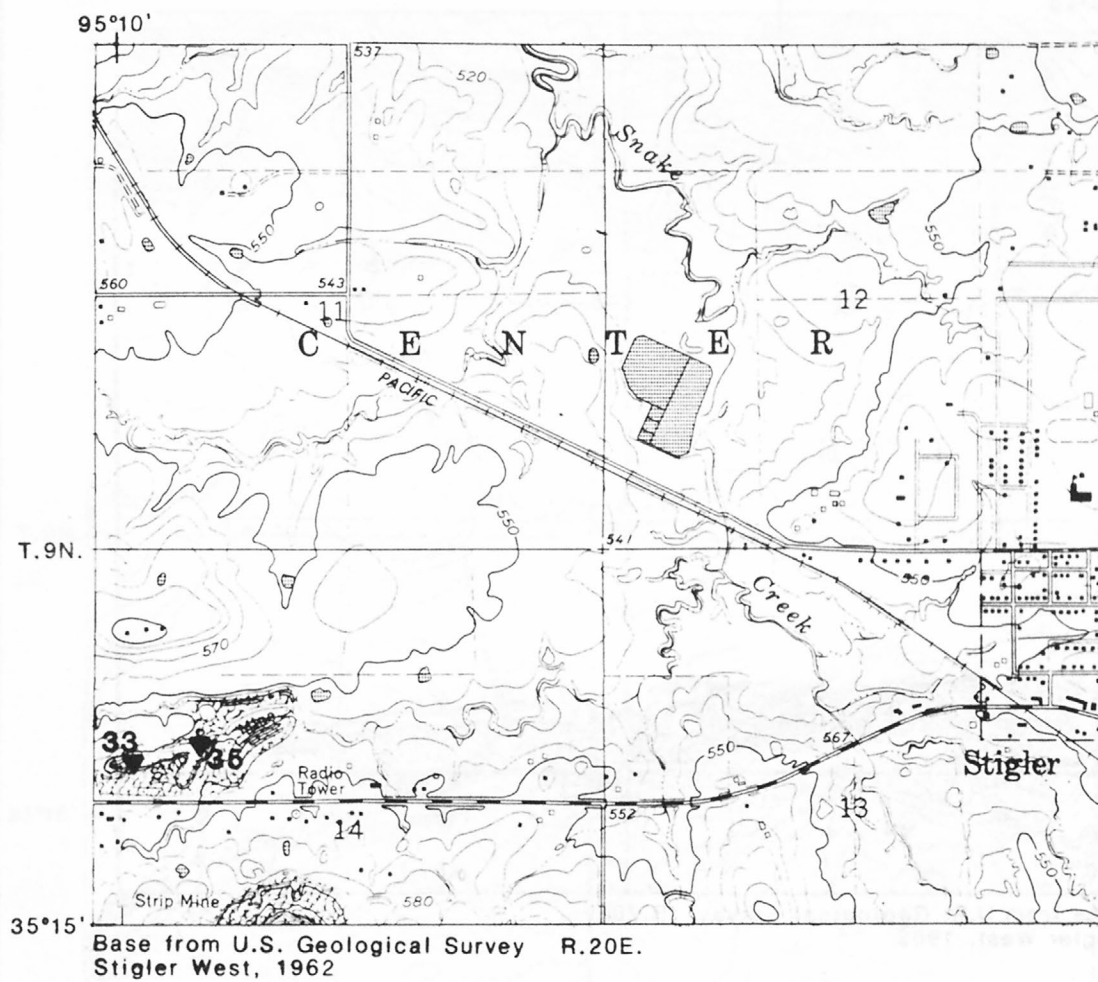


Figure 30.--Site 32.



▼ 33 Site location and number

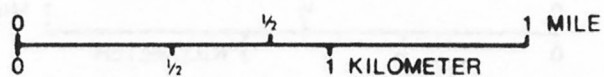
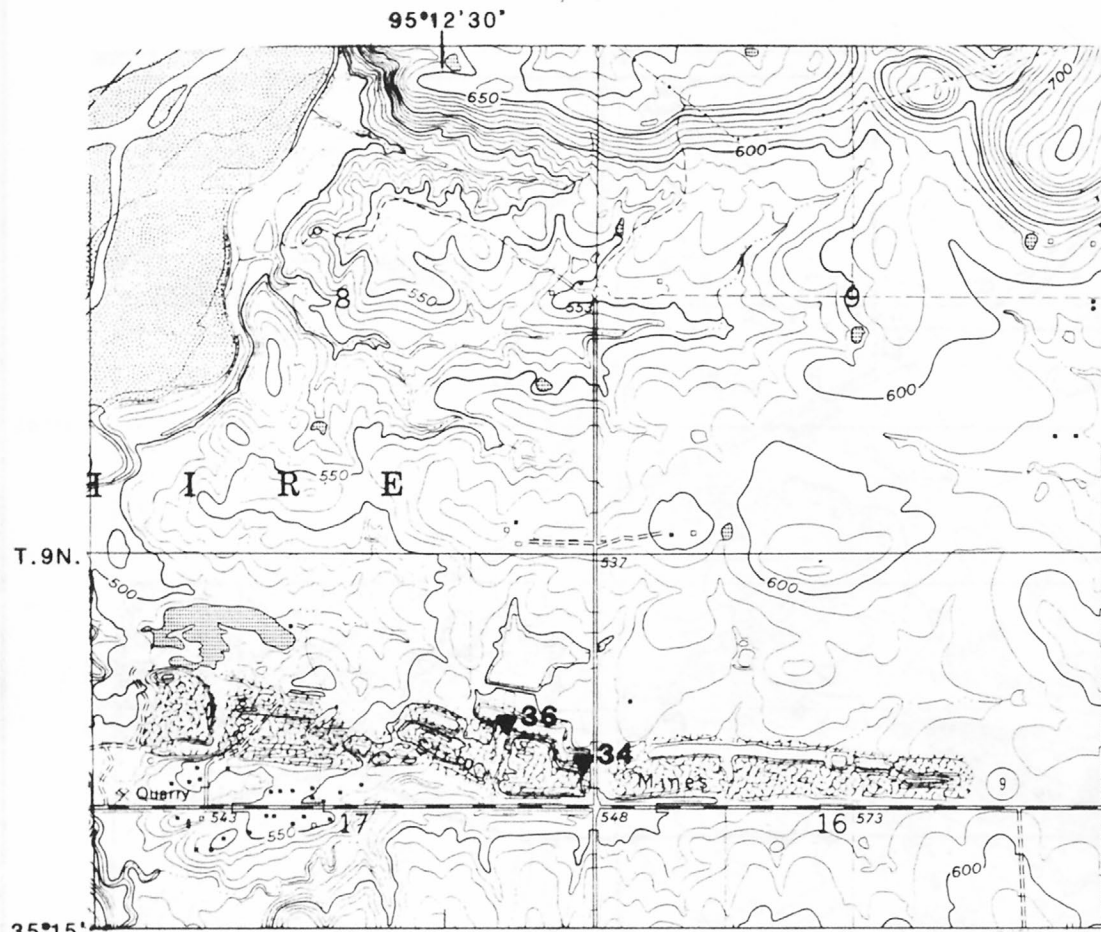


Figure 31.--Sites 33 and 35.



Base from U.S. Geological Survey R.20E.
Stigler West, 1962



Site location and number

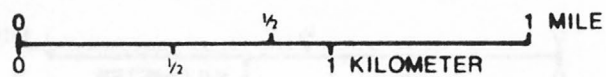
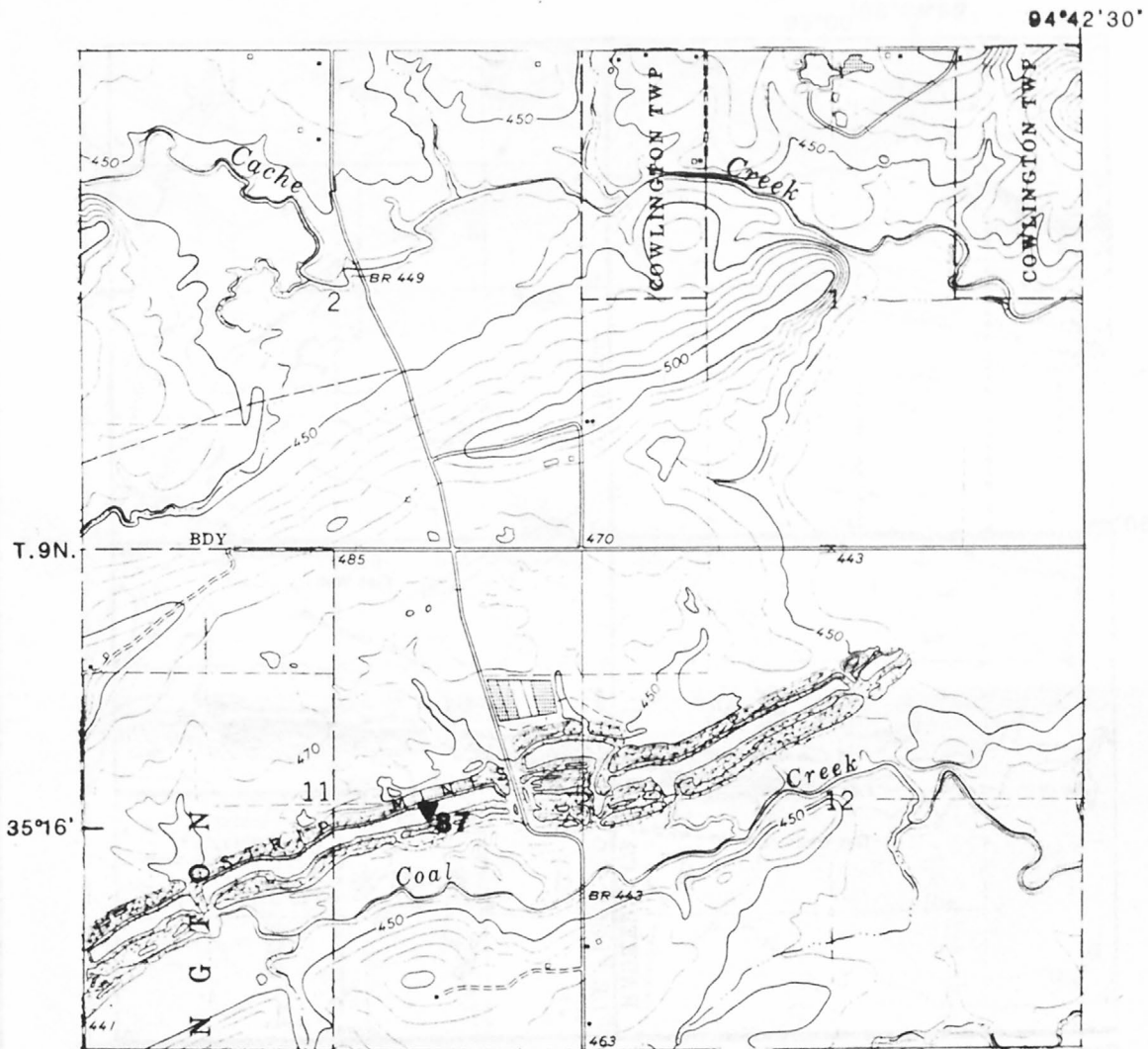


Figure 32.--Sites 34 and 36.



Base from U.S. Geological Survey R.24E.
Muldrow SW, 1966

▼ 37 Site location and number

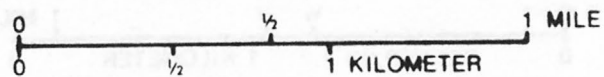


Figure 33.--Site 37.

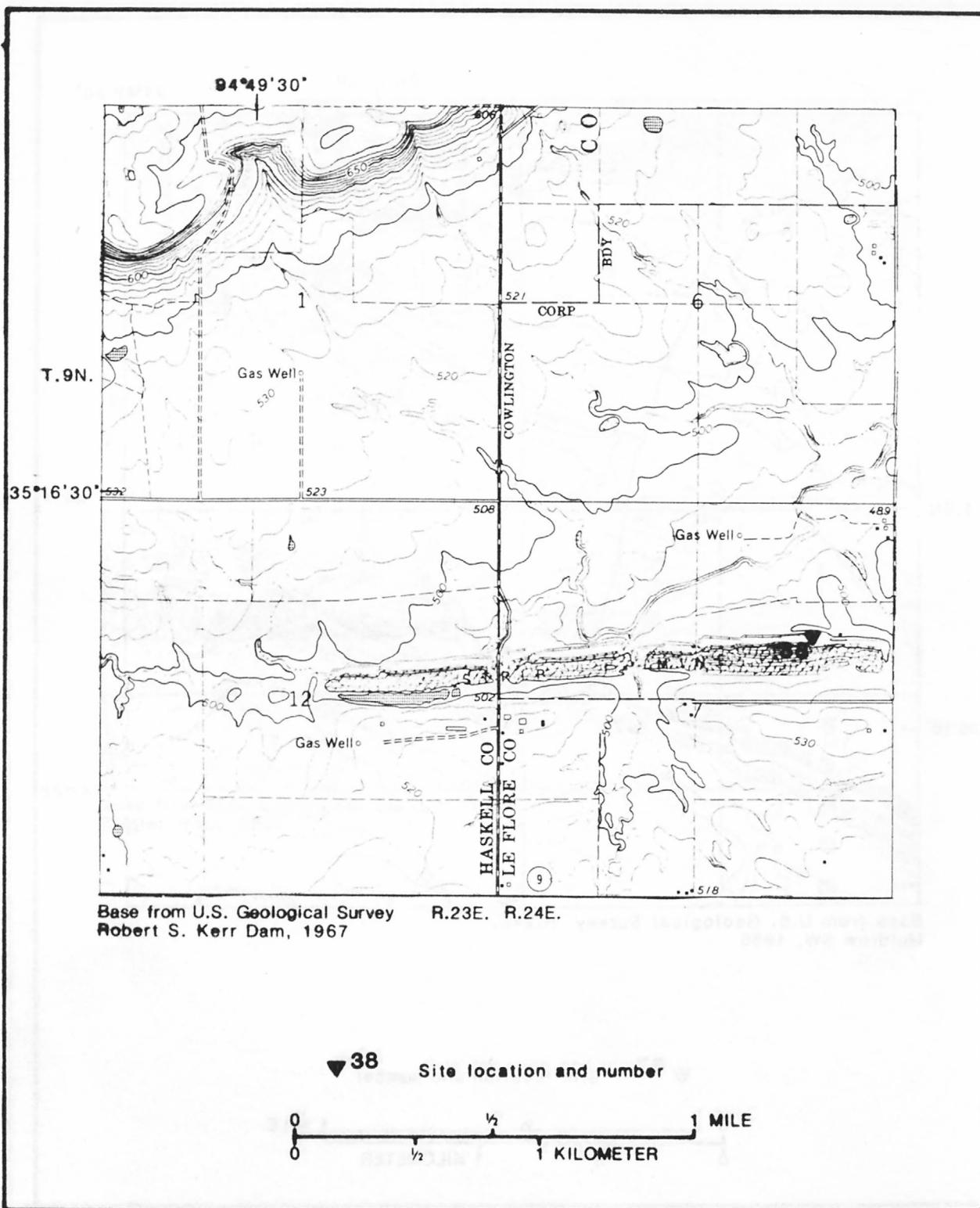
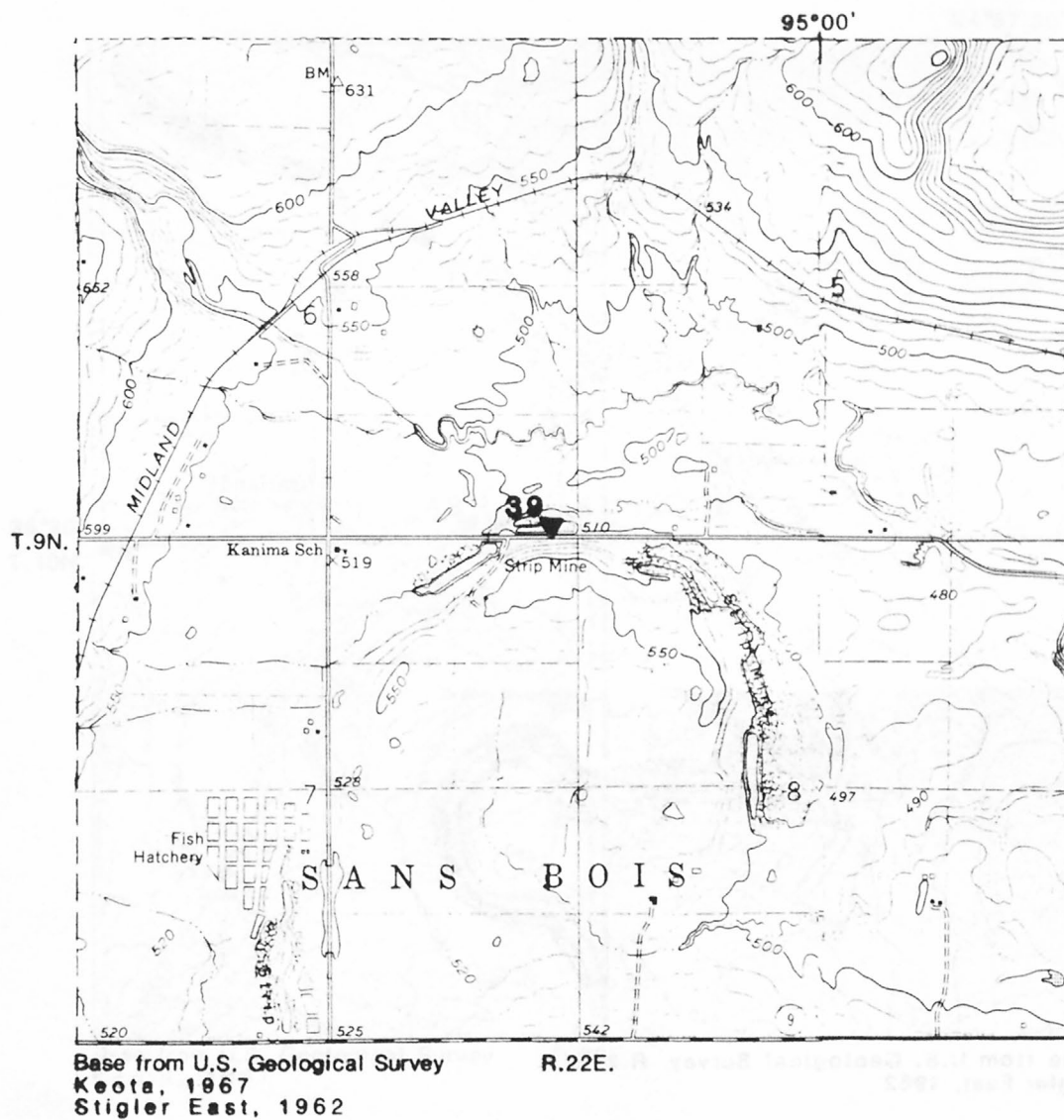


Figure 34.--Site 38.



▼39 Site location and number

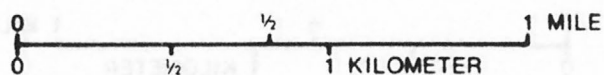
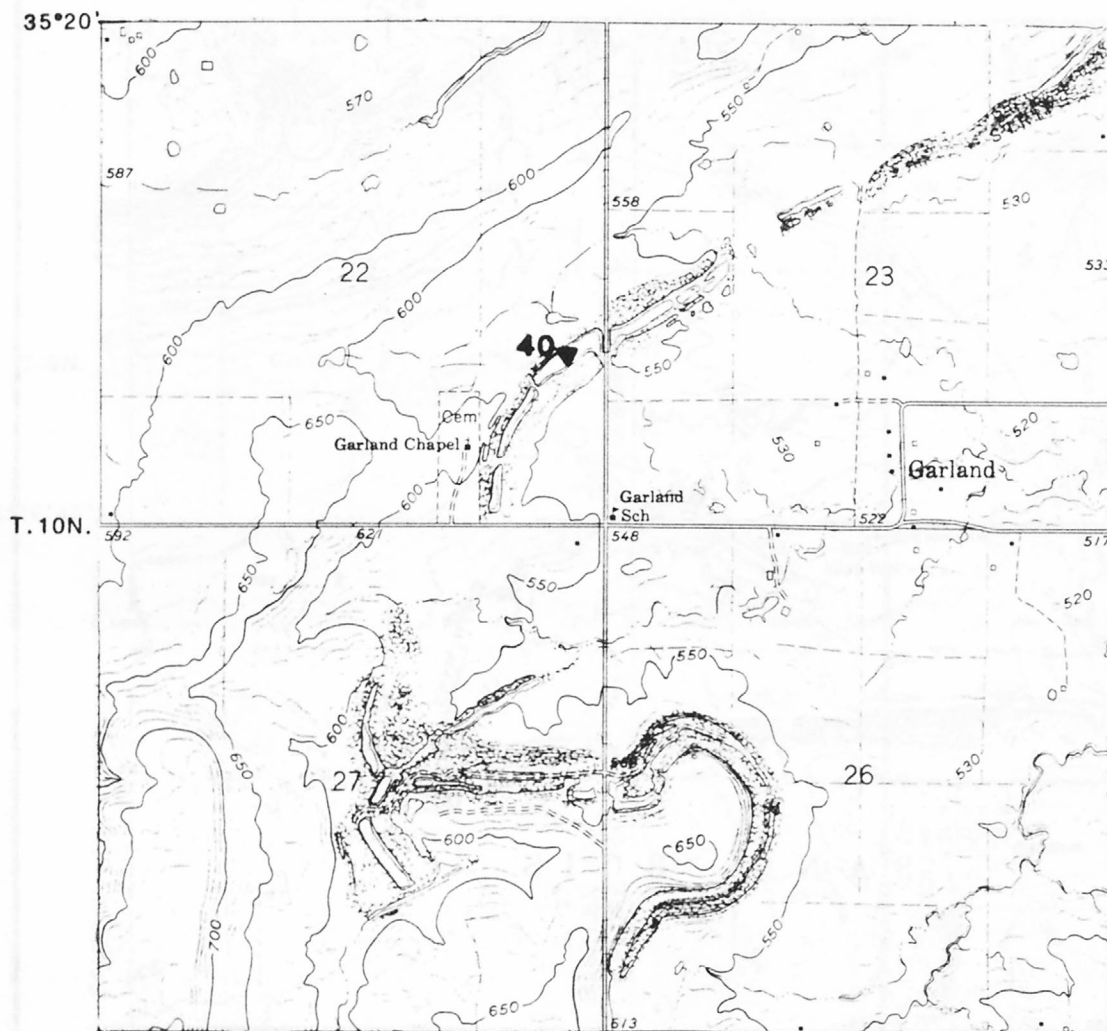


Figure 35.--Site 39.



Base from U.S. Geological Survey R.21E.
Stigler East, 1962

▼ 40 Site location and number

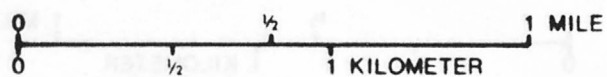


Figure 36.--Site 40.

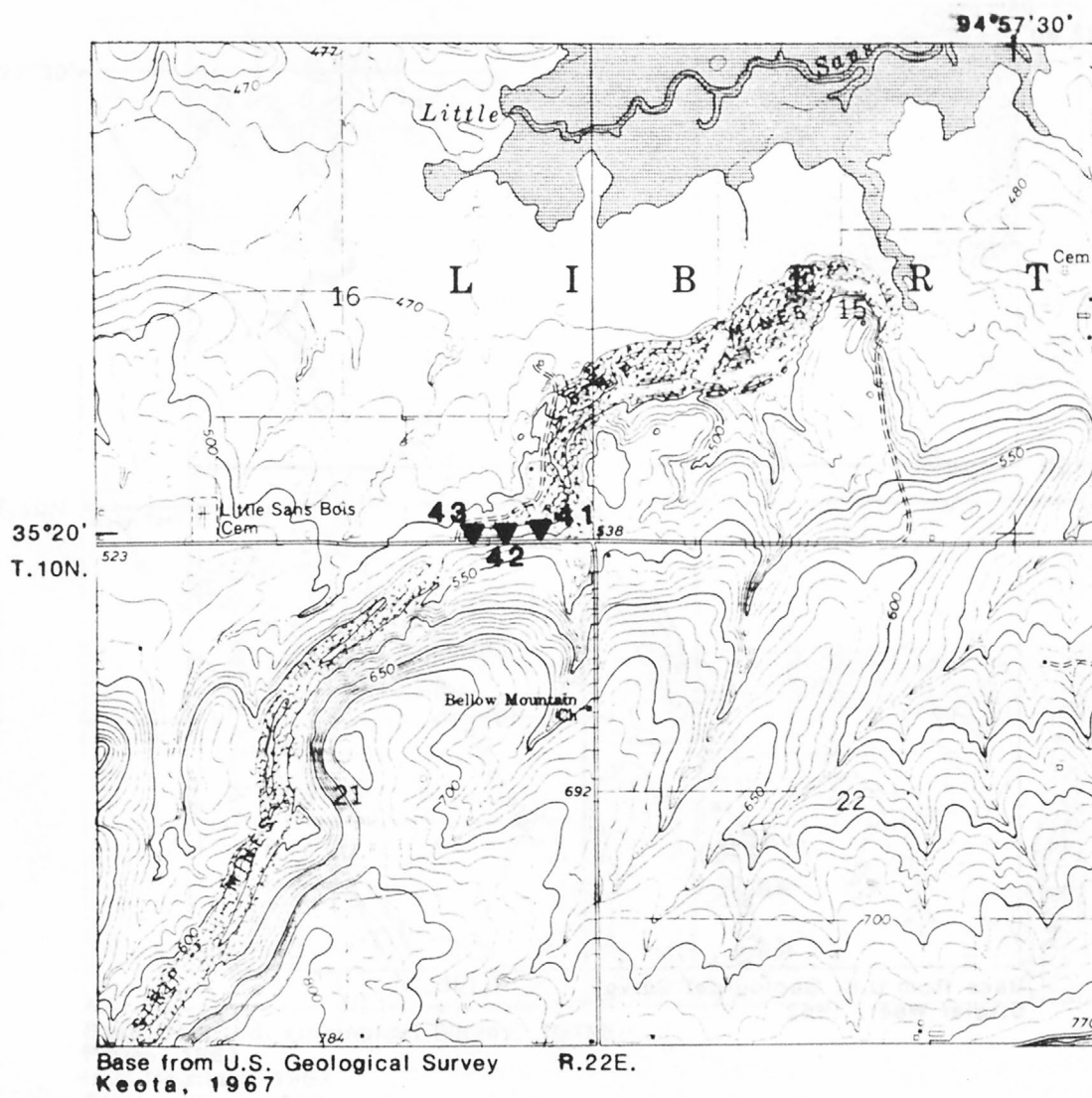
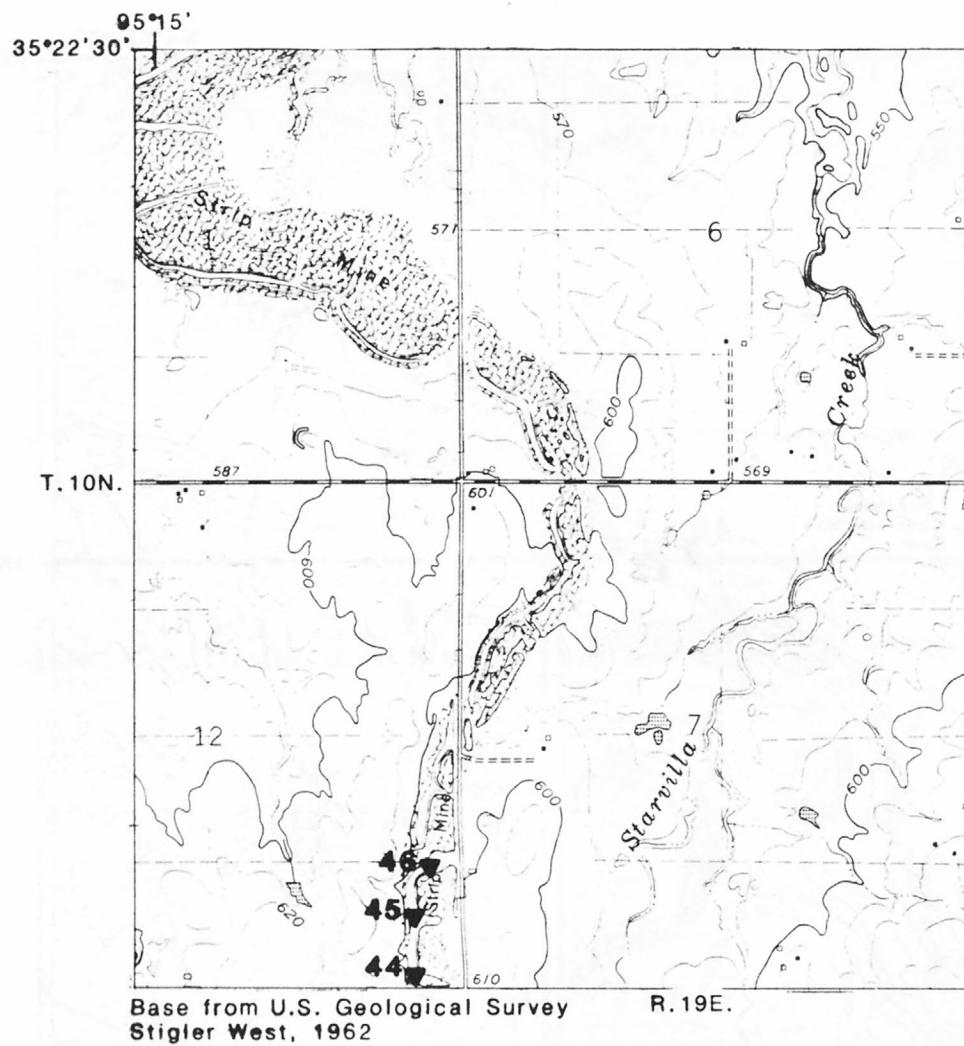


Figure 37.--Sites 41-43.



▼ 44 Site location and number

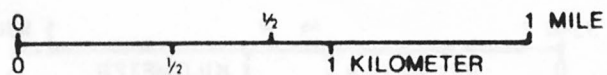


Figure 38.--Sites 44-46.

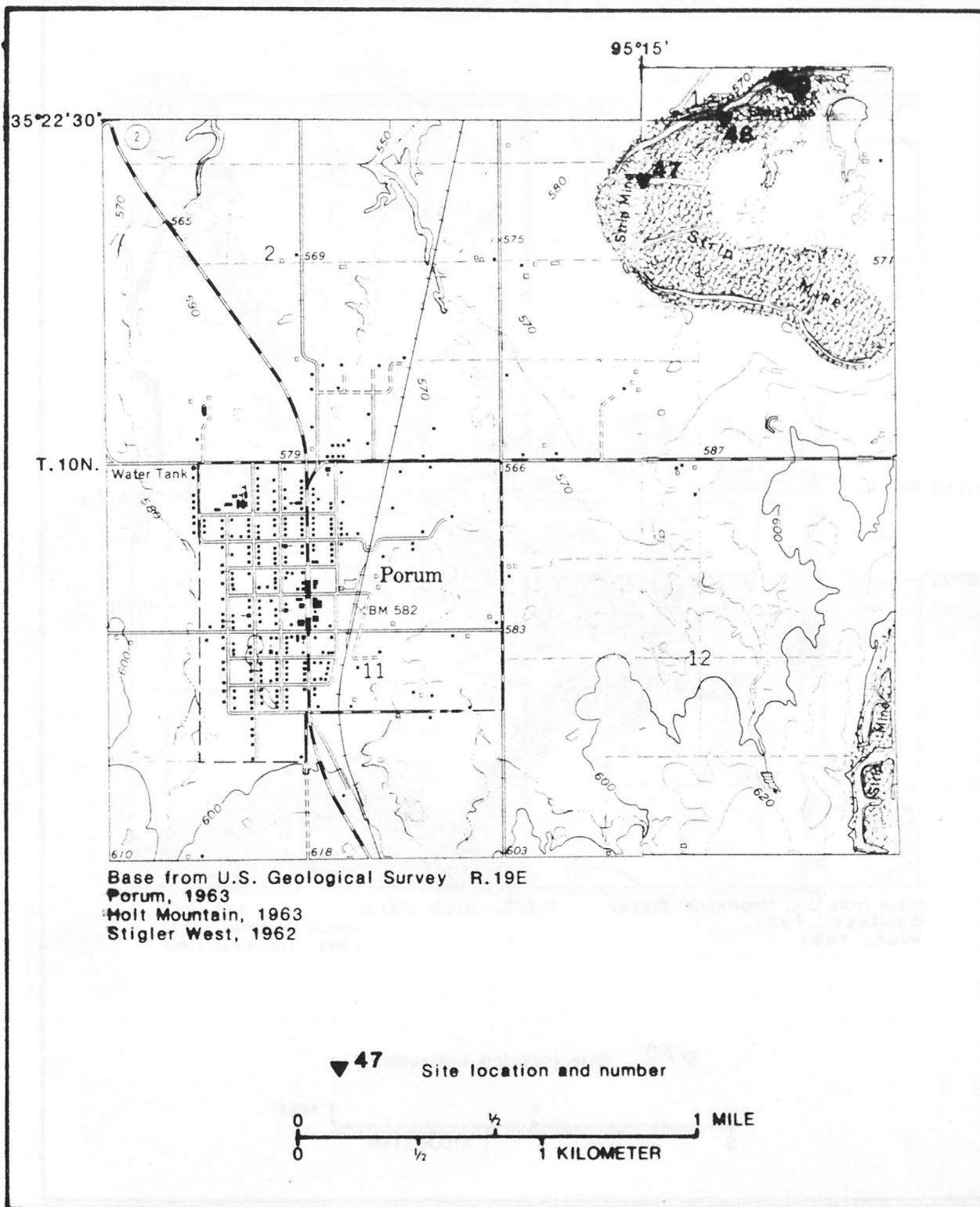
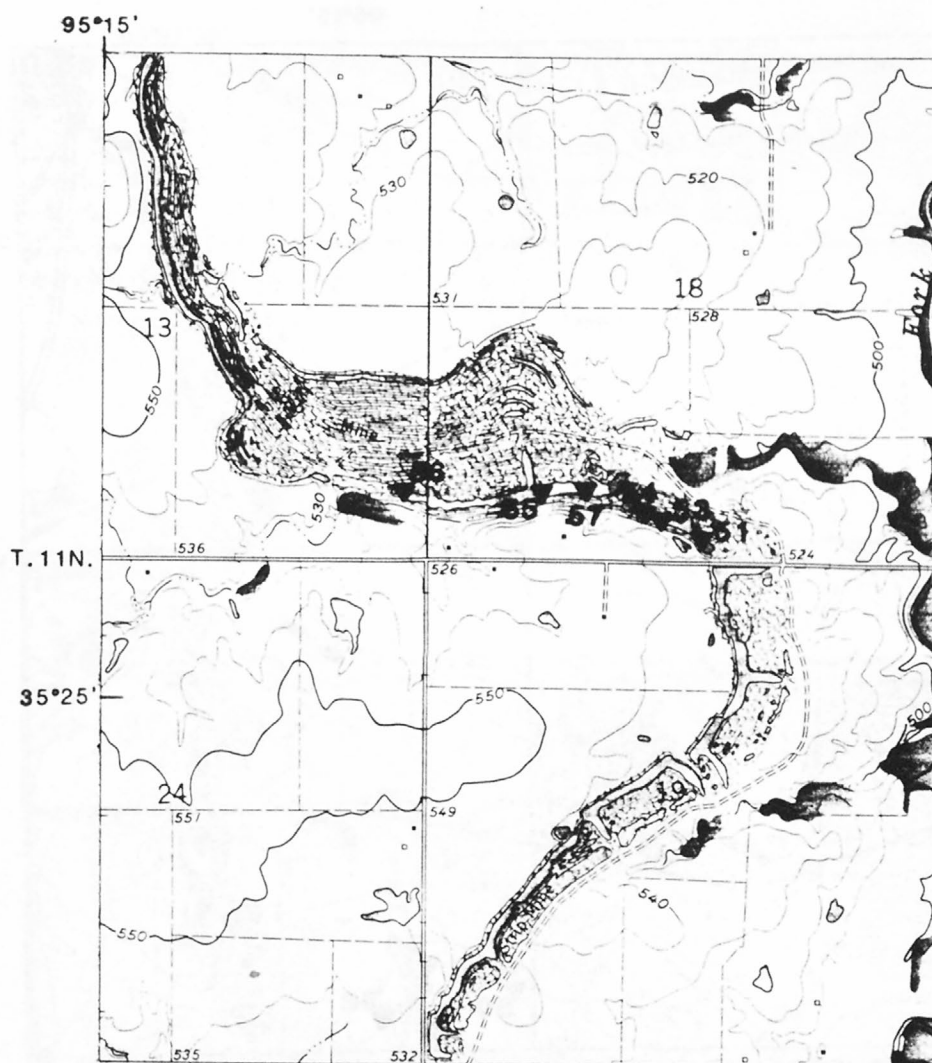


Figure 39.--Sites 47-49.



Base from
U.S. Geological Survey
Holt Mountain, 1963

▼ 51 Site location and number

0 1/2 1 MILE
0 1/2 1 KILOMETER

Figure 41.--Sites 51 and 53-57.

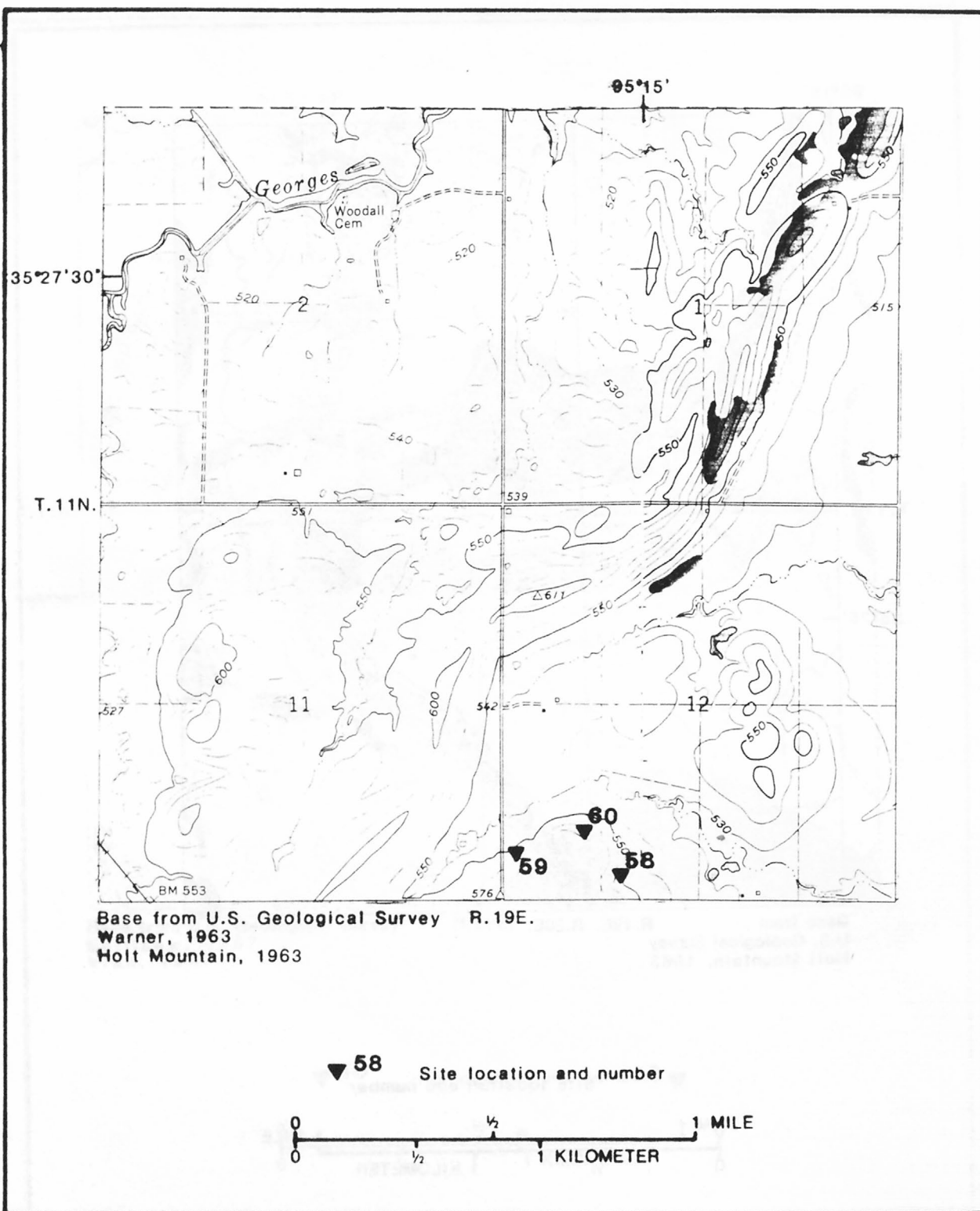


Figure 42.—Sites 58–60.

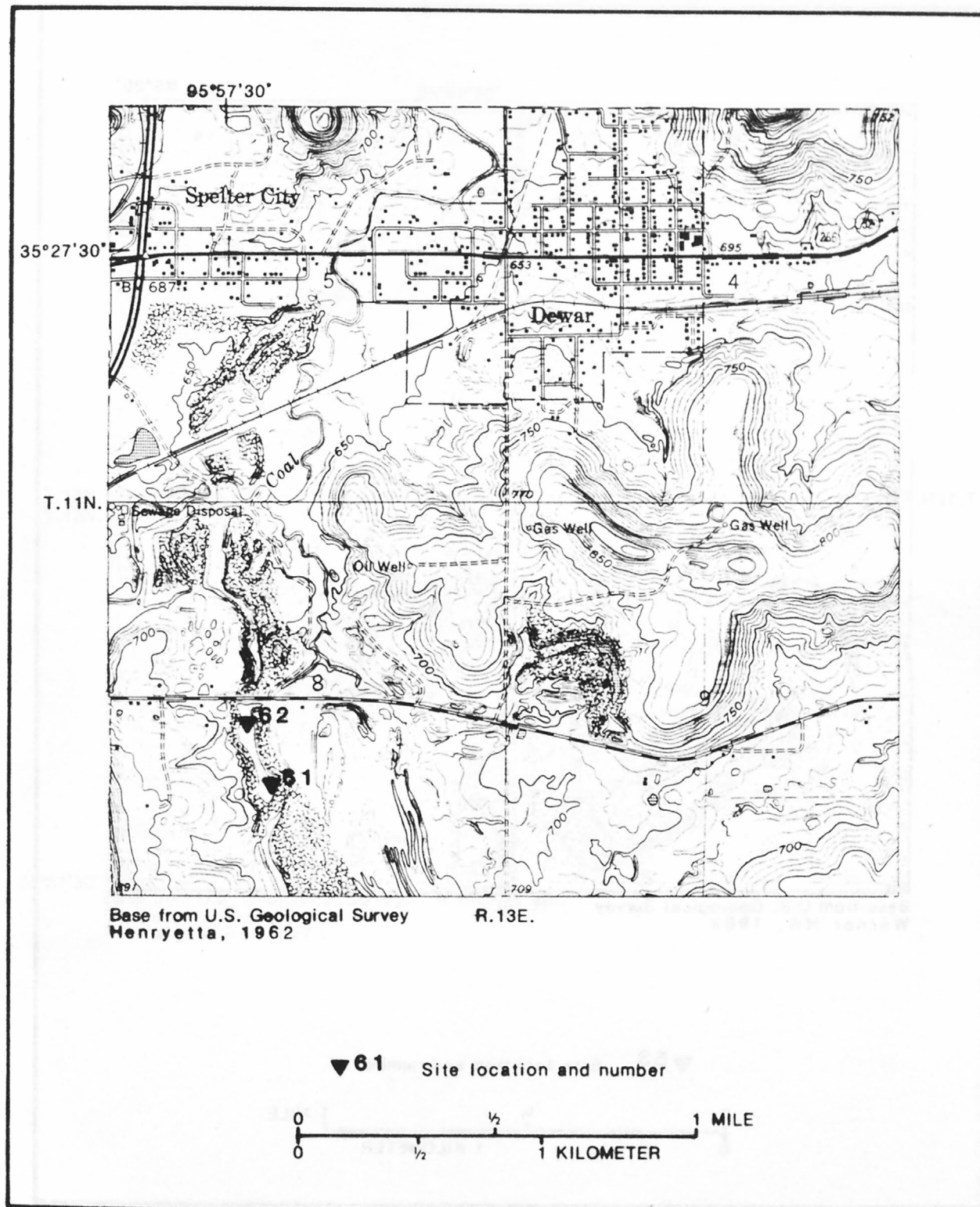
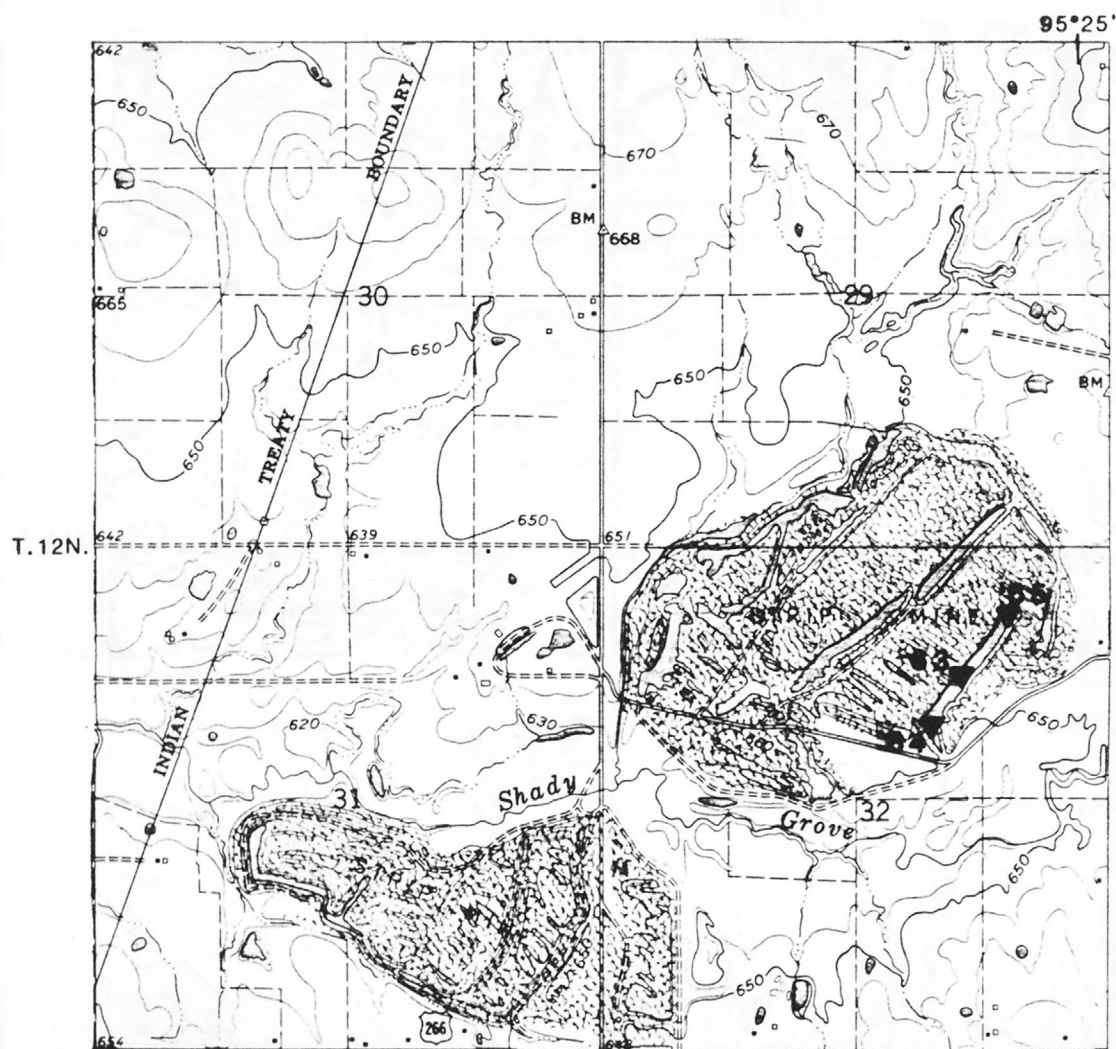


Figure 43.—Sites 61–62.



Base from U.S. Geological Survey R.18E.
Warner NW, 1963

▼ 63 Site location and number

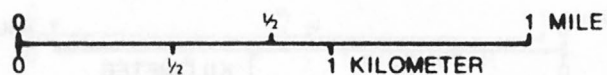


Figure 44.—Sites 63-65.

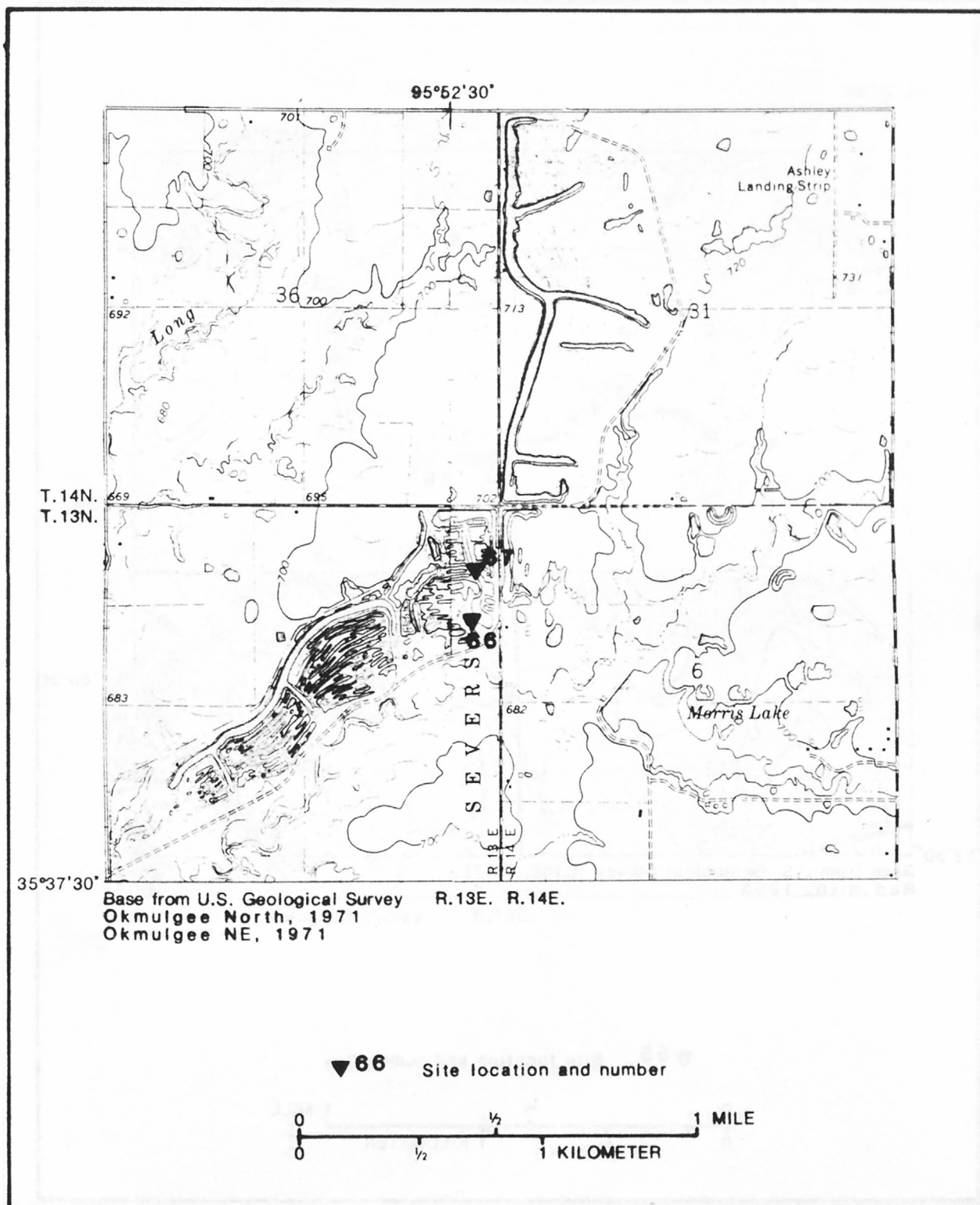
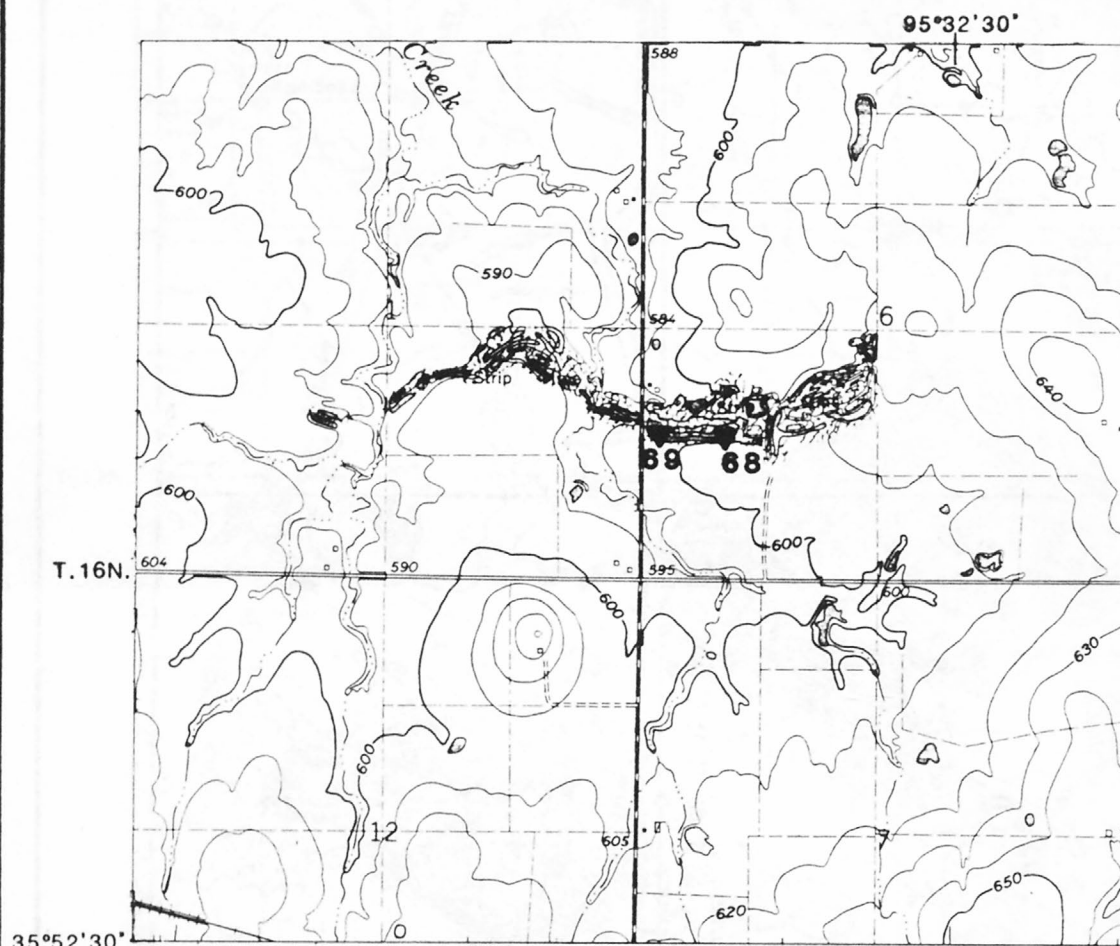


Figure 45.—Sites 66–67.



▼ 68 Site location and number

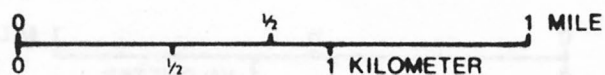
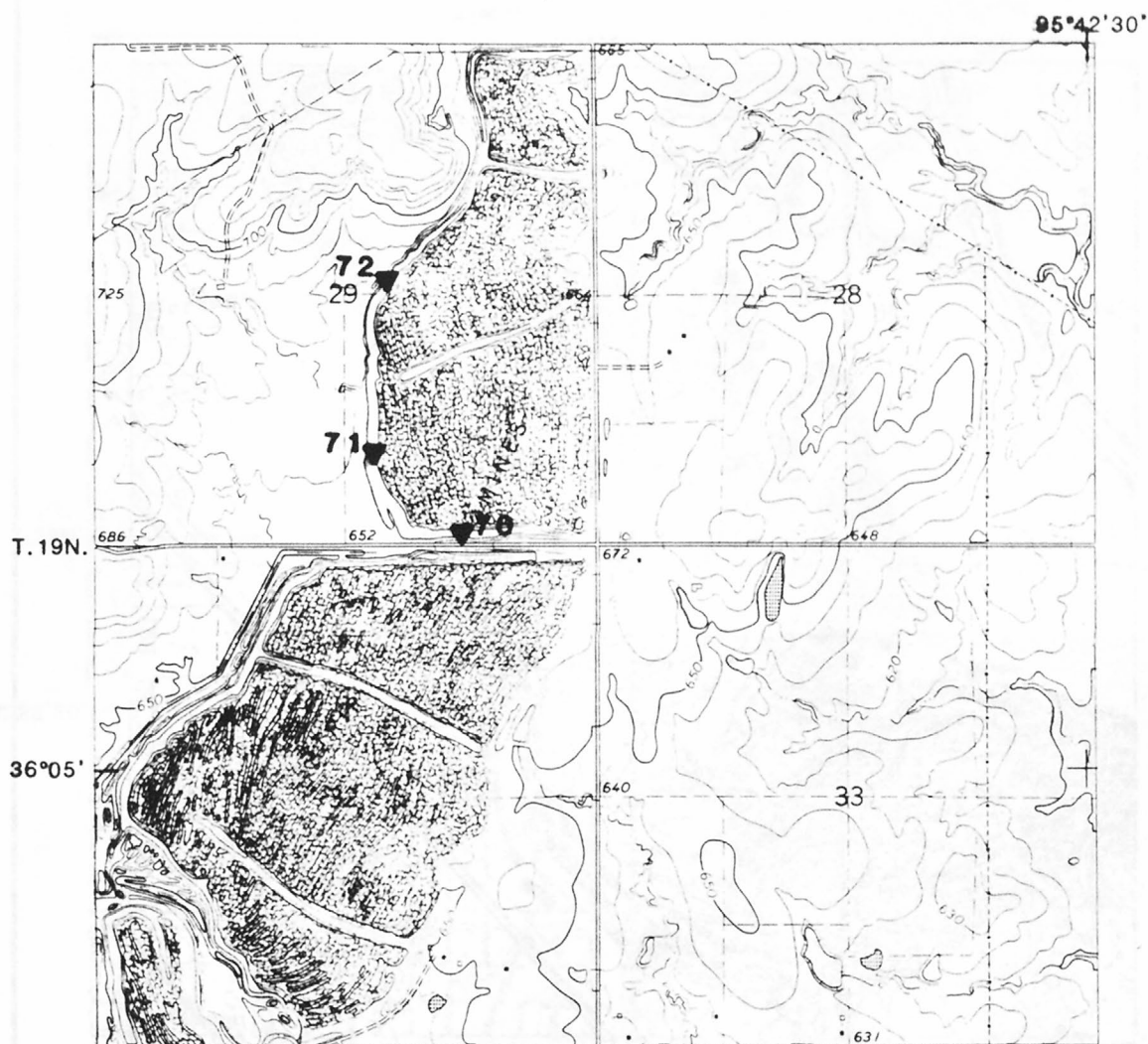


Figure 46.—Sites 68-69.



Base from U.S. Geological Survey
Oneta, 1963

R.15E.



Site location and number

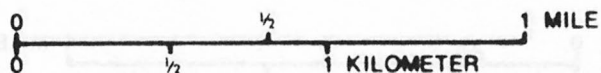
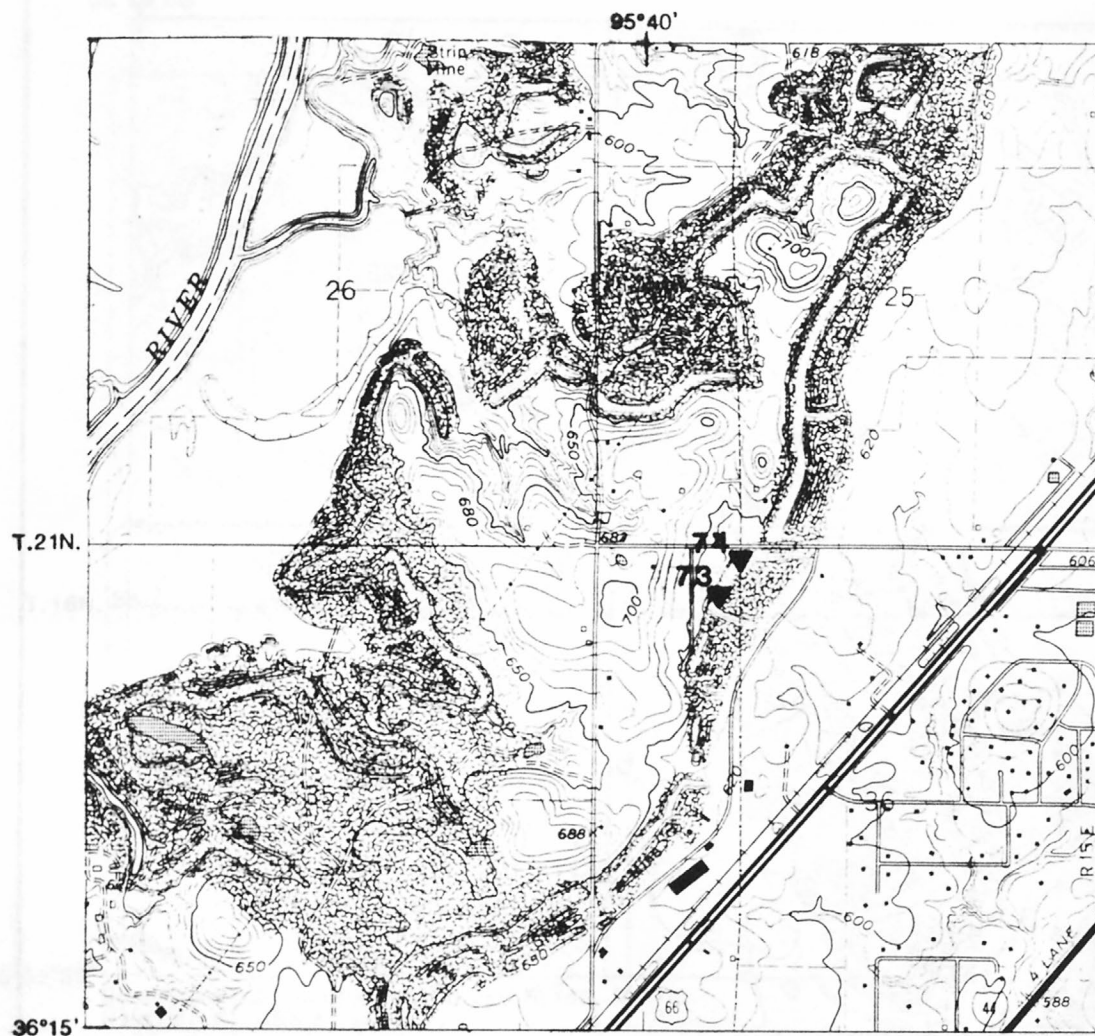


Figure 47.—Sites 70-72.



Base from U.S. Geological Survey
Bageyah, 1963

R.15E.



73

Site location and number

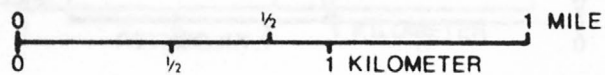
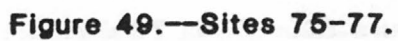
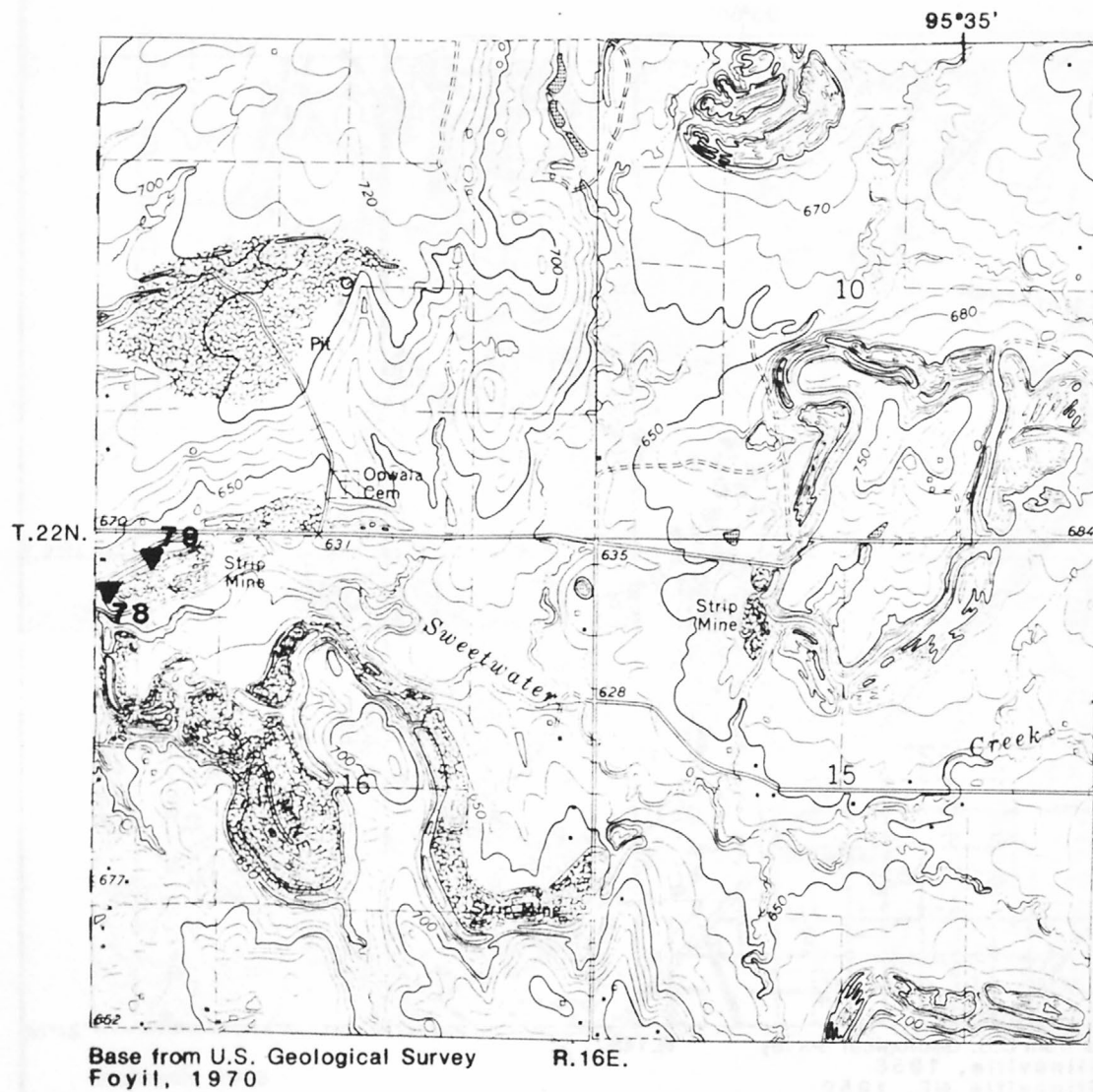


Figure 48.—Sites 73-74.

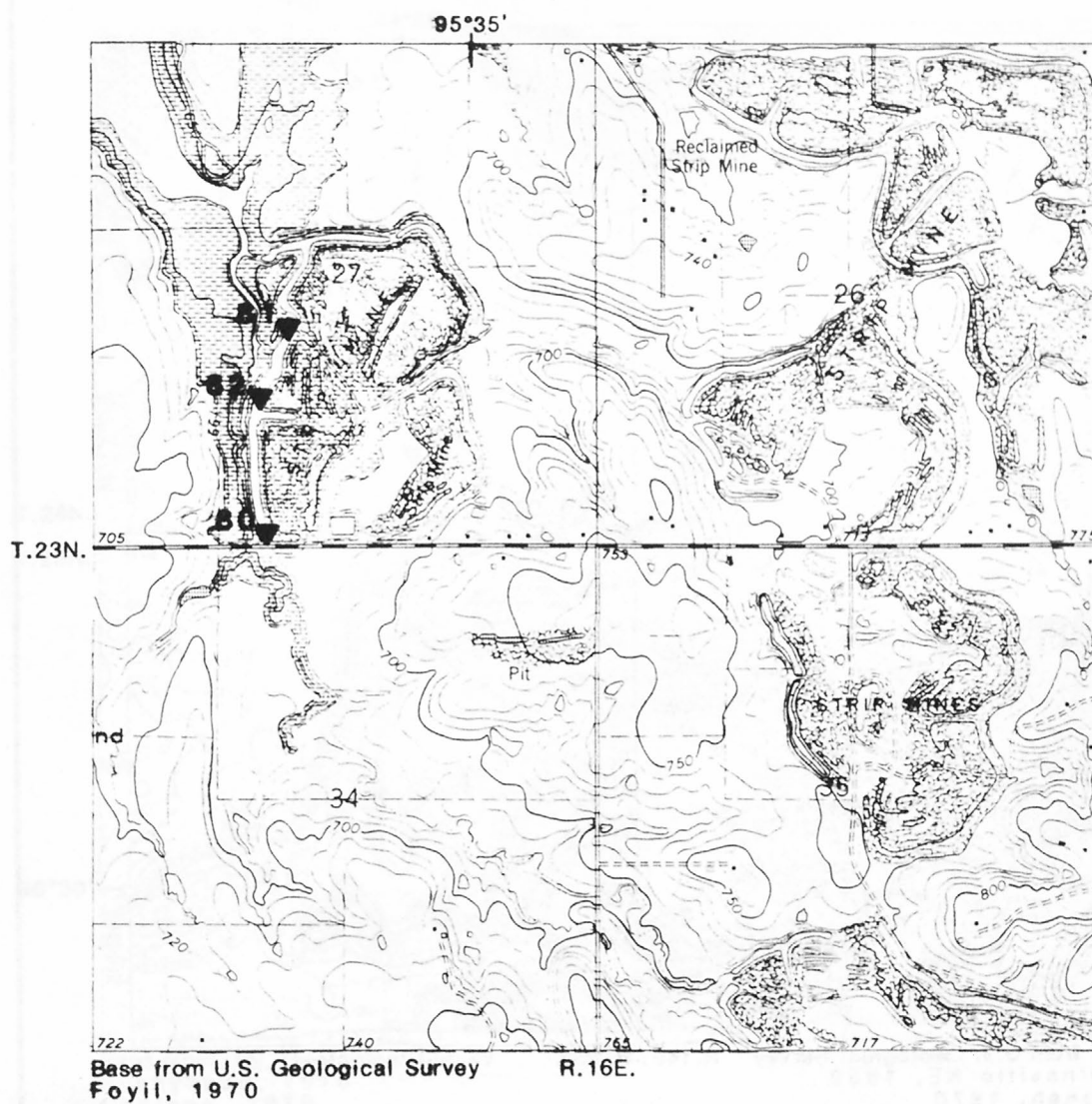




▼78 Site location and number

0 1/2 1 MILE
0 1/2 1 KILOMETER

Figure 50.—Sites 78-79.



▼80 Site location and number

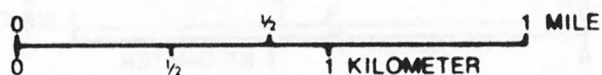


Figure 51.—Sites 80-82.

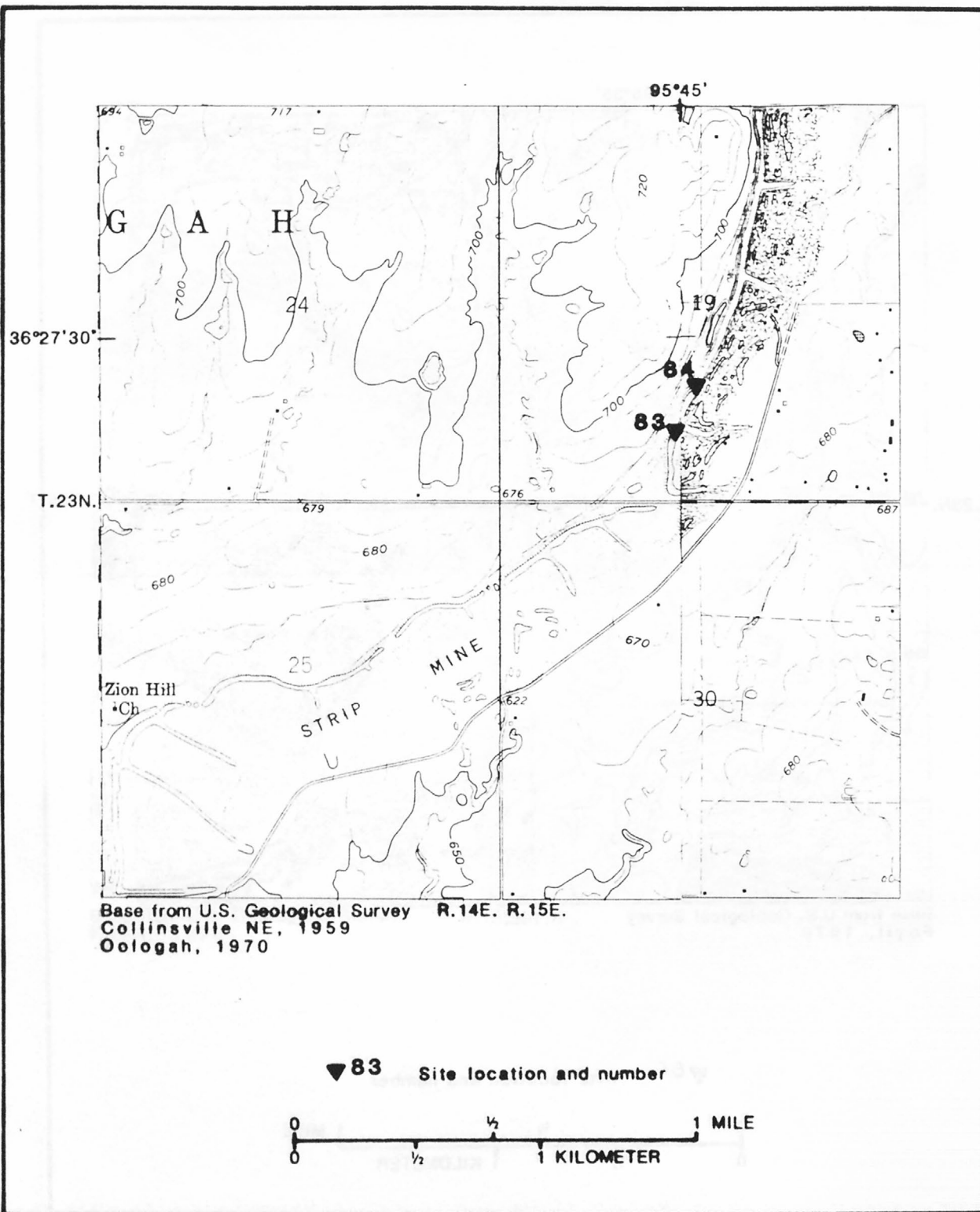
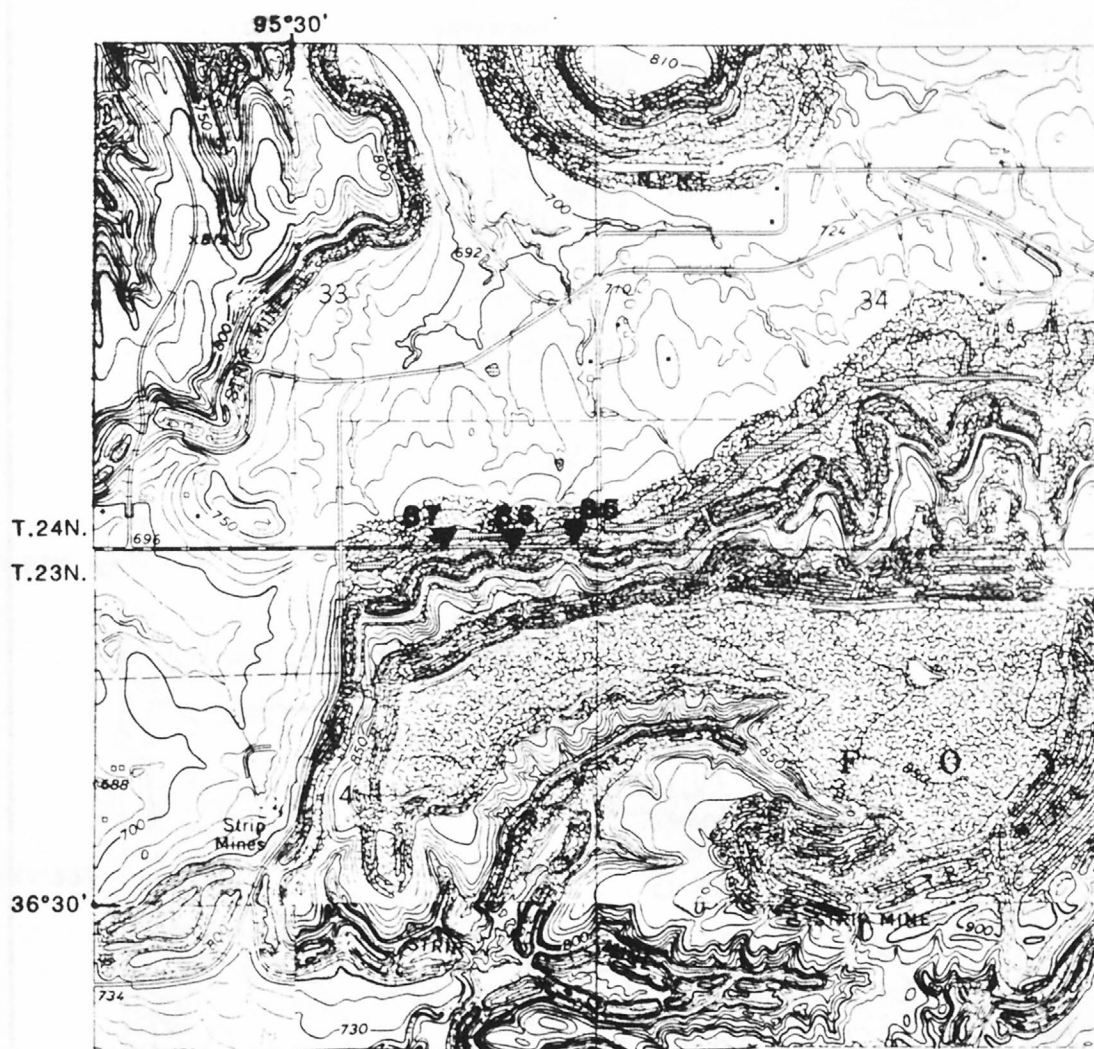


Figure 52.—Sites 83-84.



Base from U.S. Geological Survey R.17E.
 Bushyhead, 1970
 Chelsea, 1970
 Foyil, 1970
 Winganon, 1970

▼ 85 Site location and number

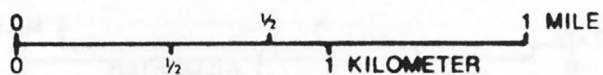
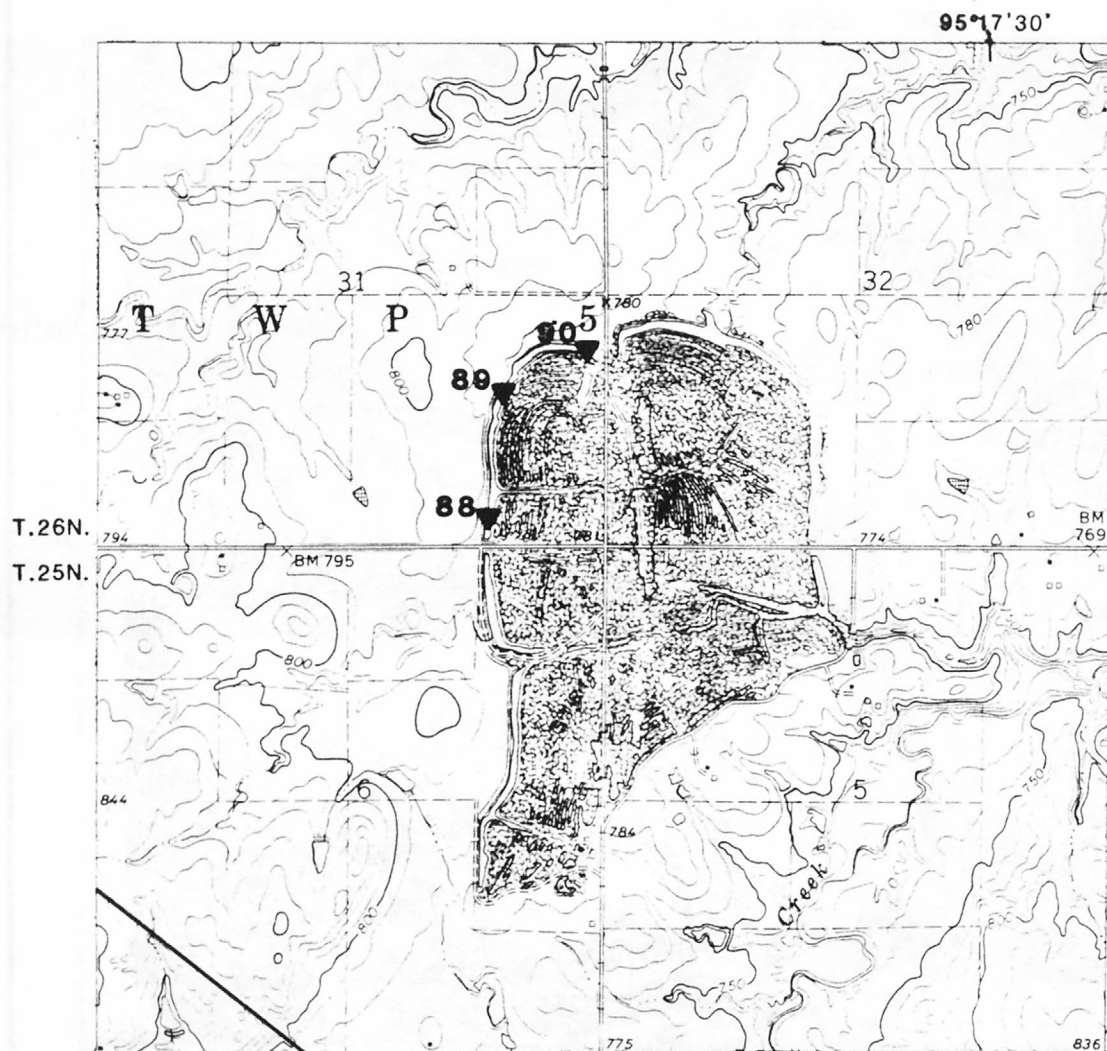


Figure 53.—Sites 85-87.



Base from U.S. Geological Survey R.19E.
Estella, 1972

▼ 88 Site location and number

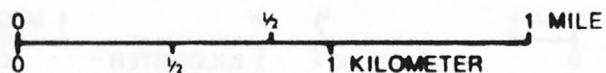


Figure 54.—Sites 88-90.

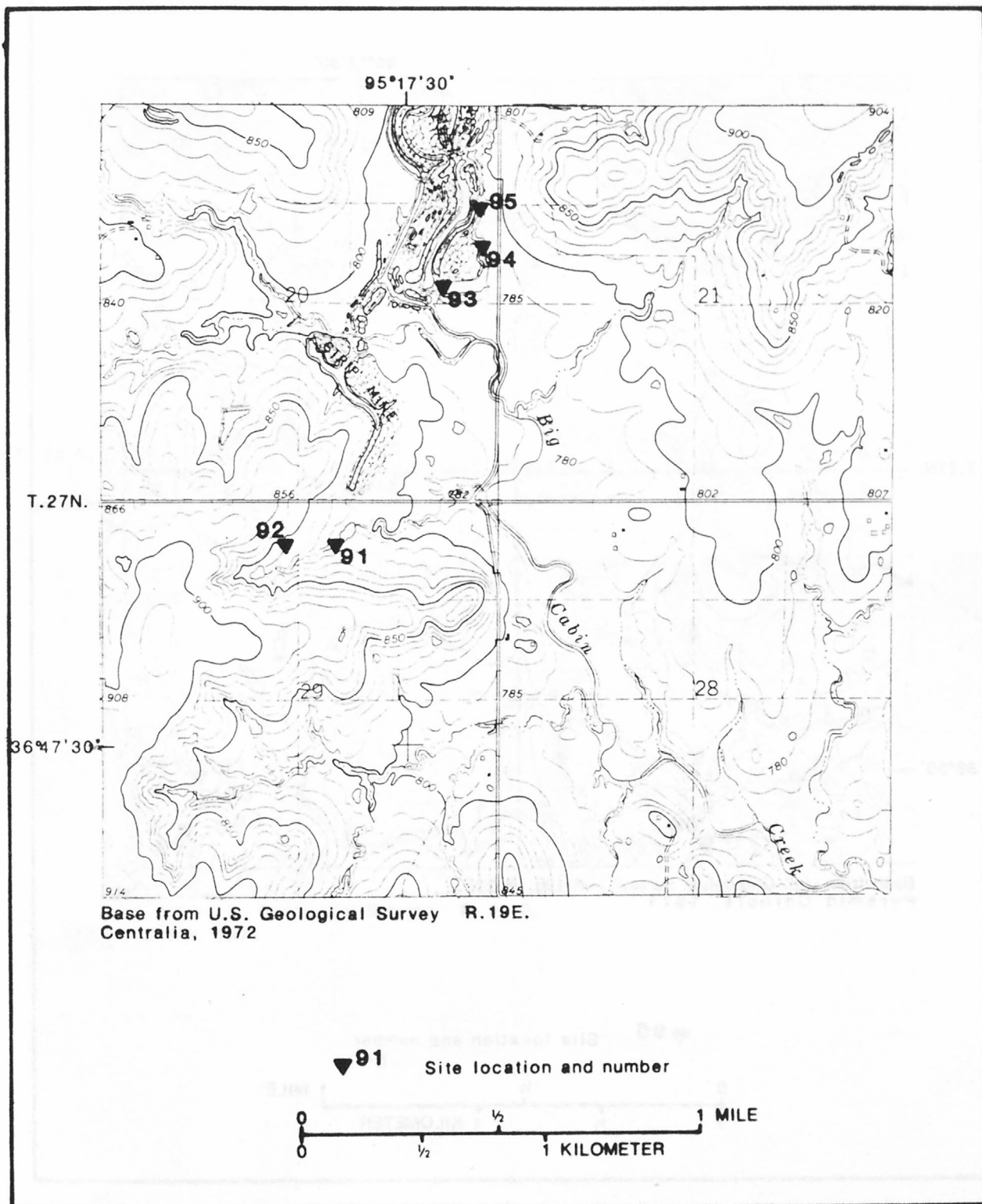
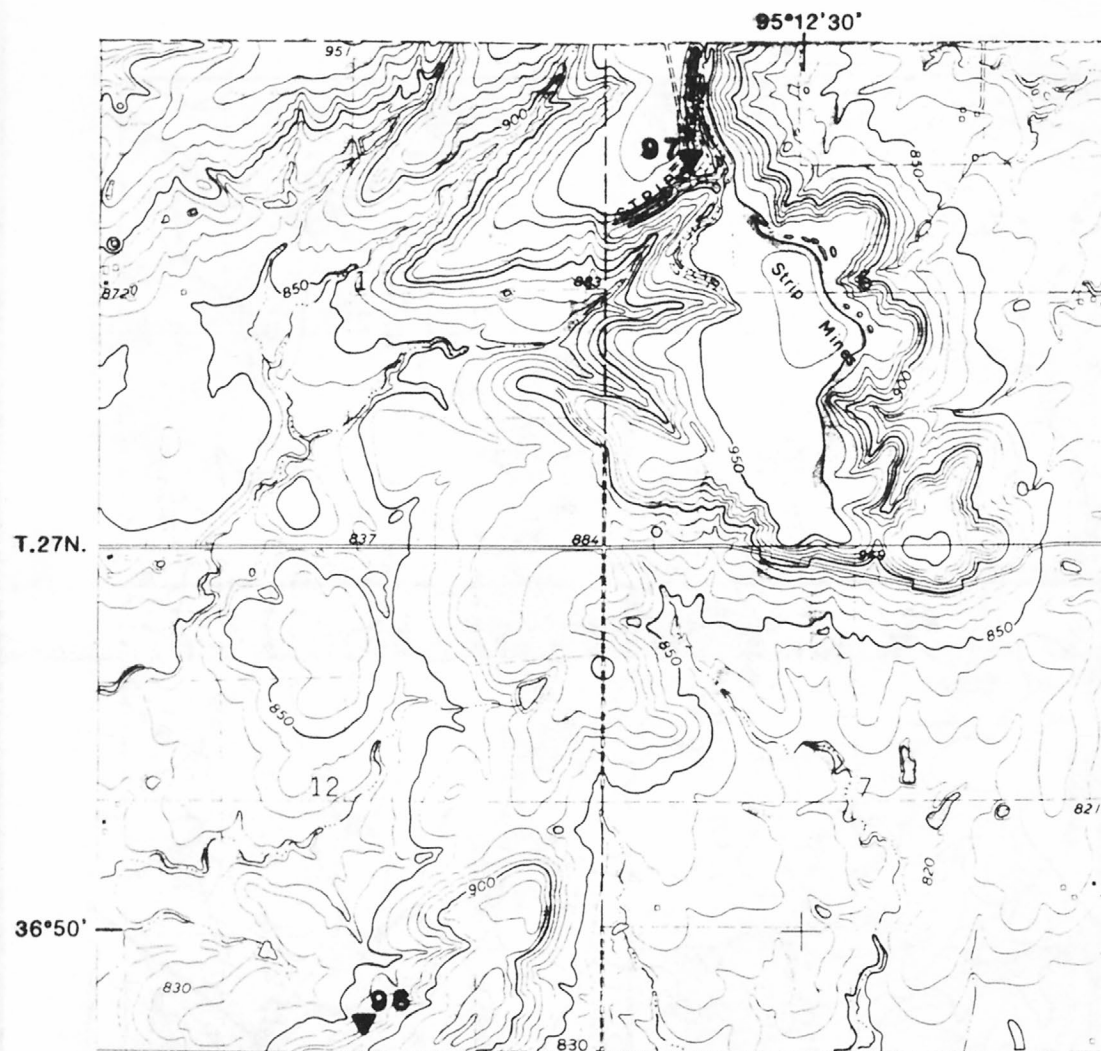


Figure 55.—Sites 91-95.



Base from U.S. Geological Survey R.19E. R.20E.
Pyramid Corners, 1971

▼ 96 Site location and number

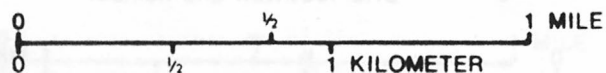


Figure 56.—Sites 96-97.

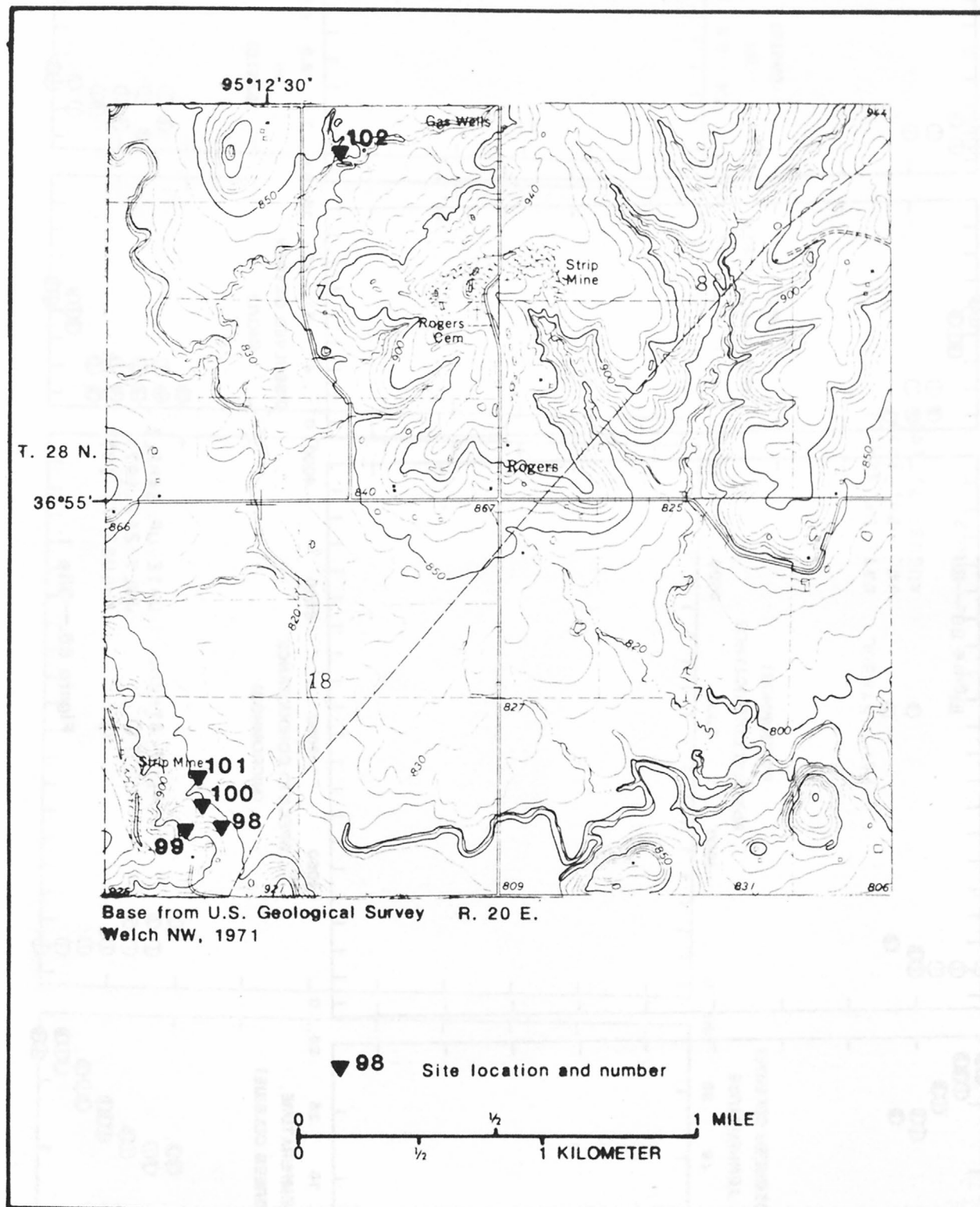
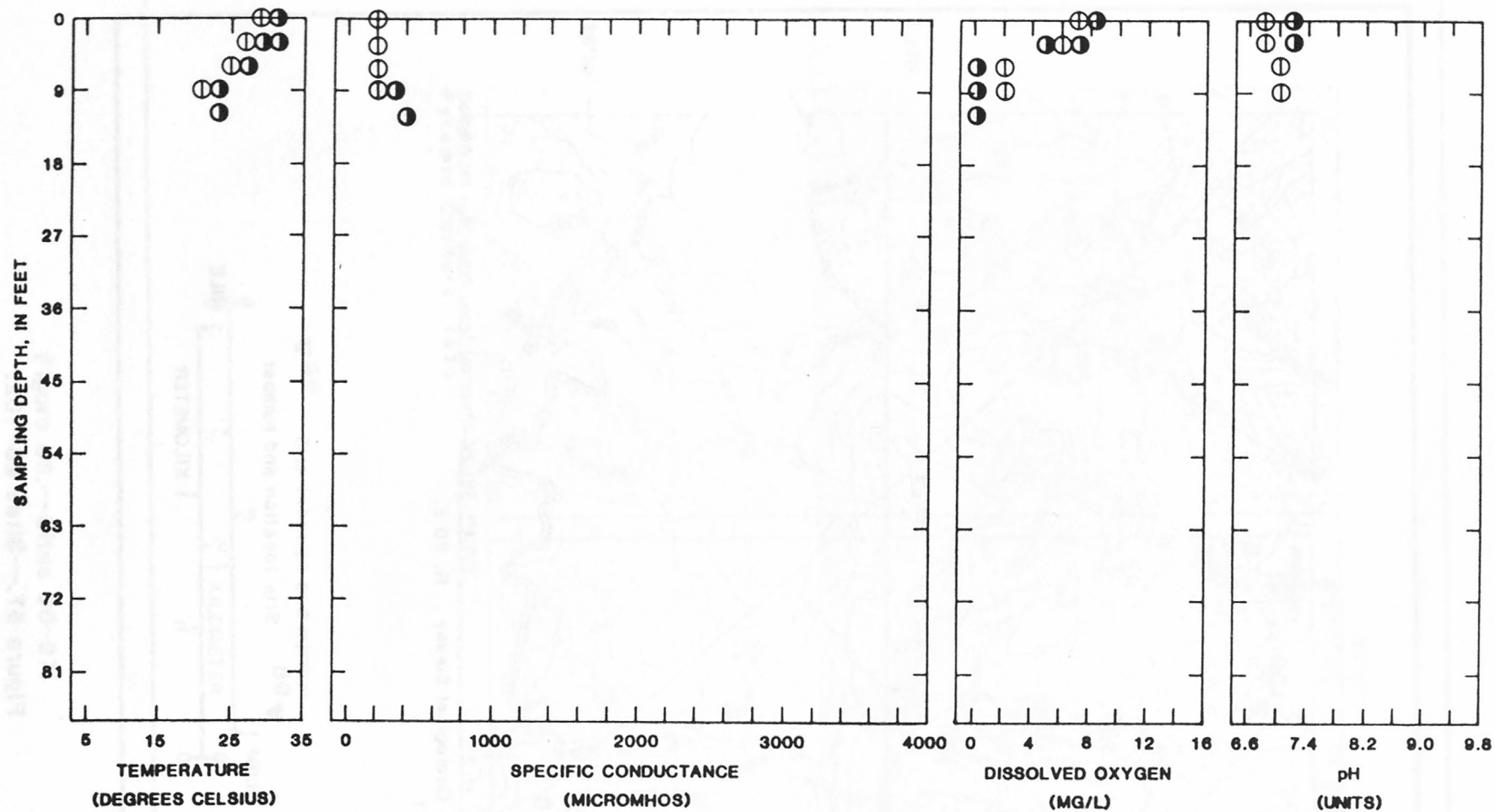
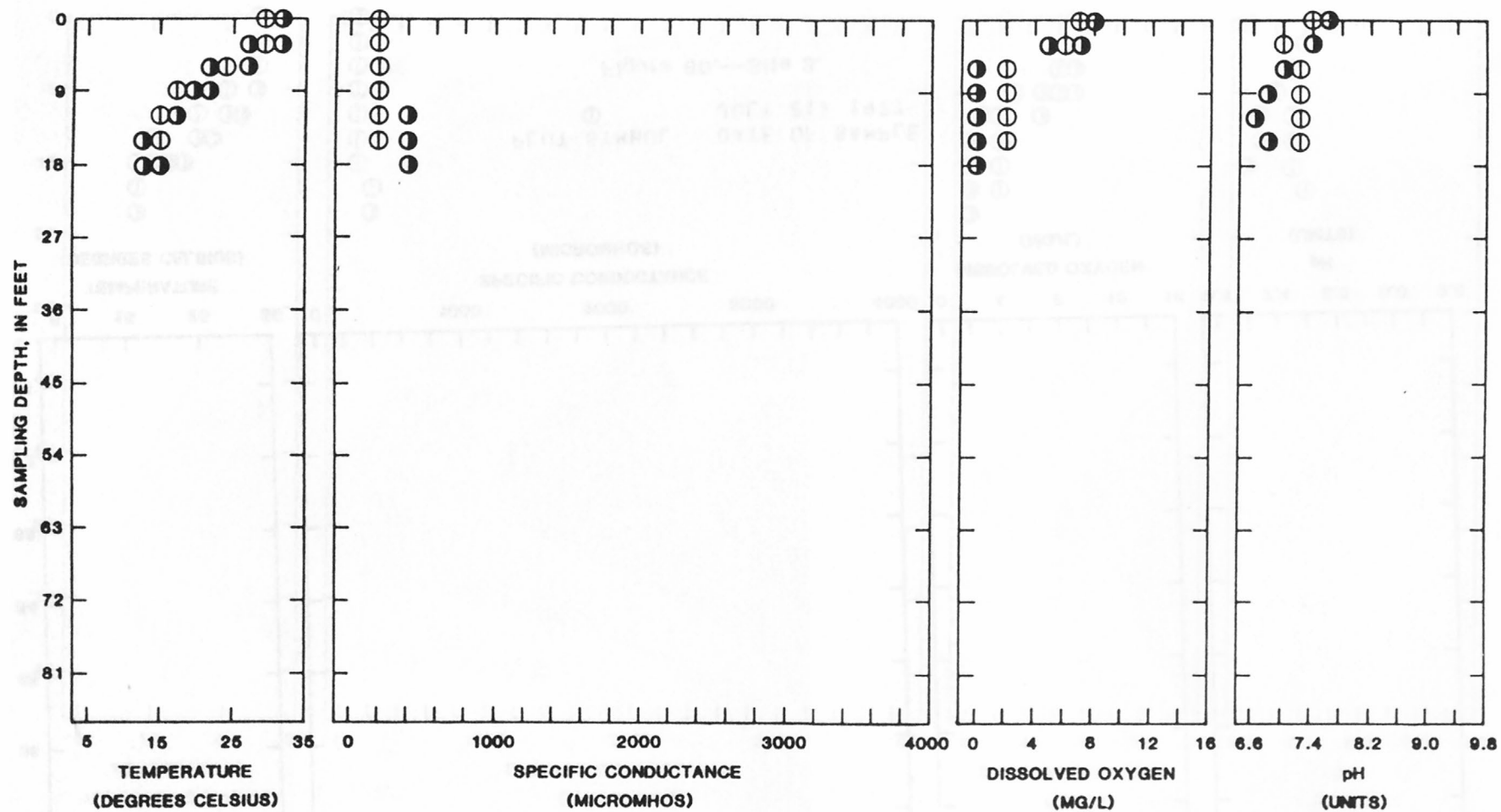


Figure 57.—Sites 98-102.



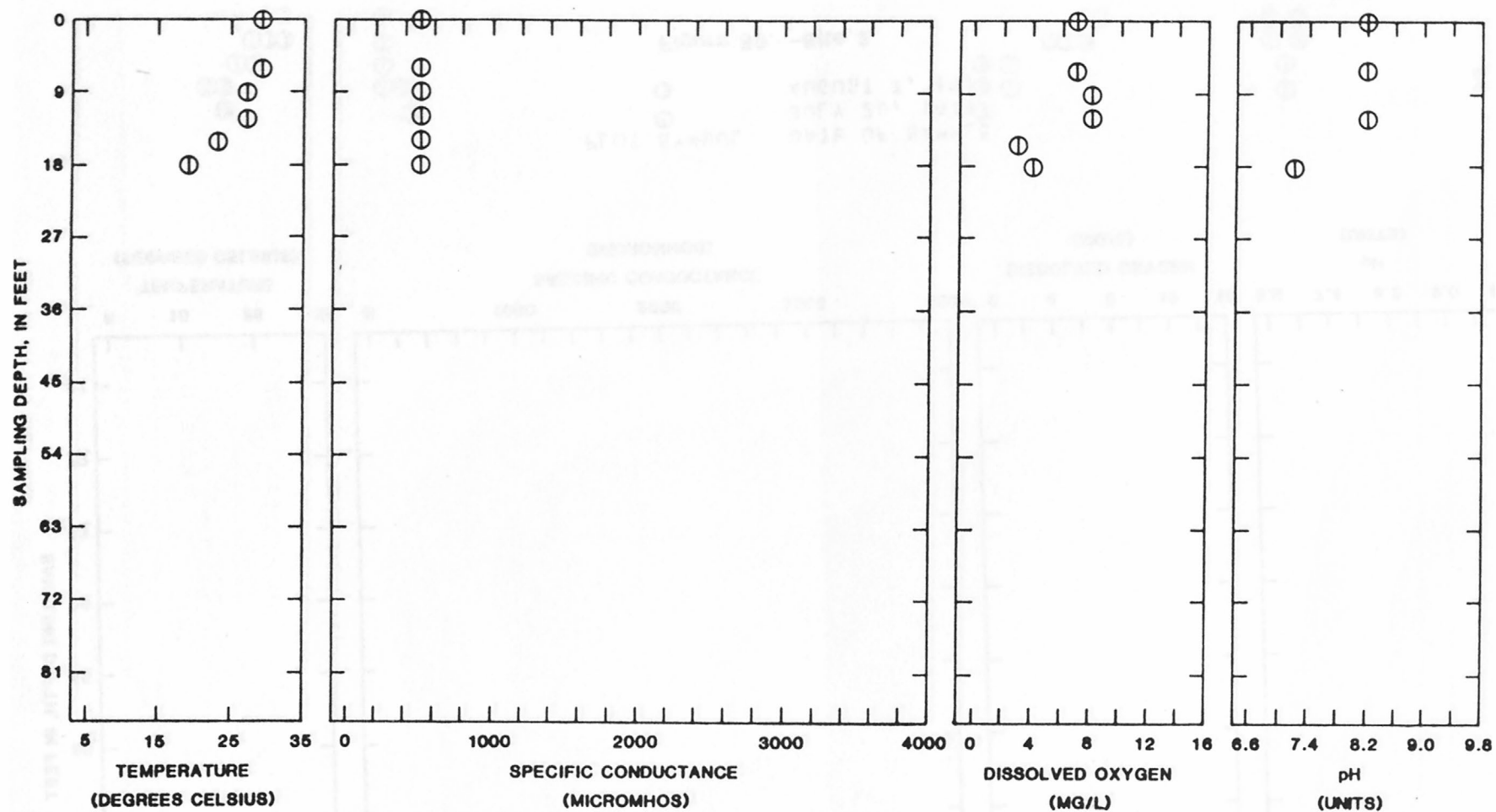
PLUT SYMBOL DATE OF SAMPLE
 ○ JULY 20, 1977
 ● AUGUST 7, 1979

Figure 58.--Site 1.



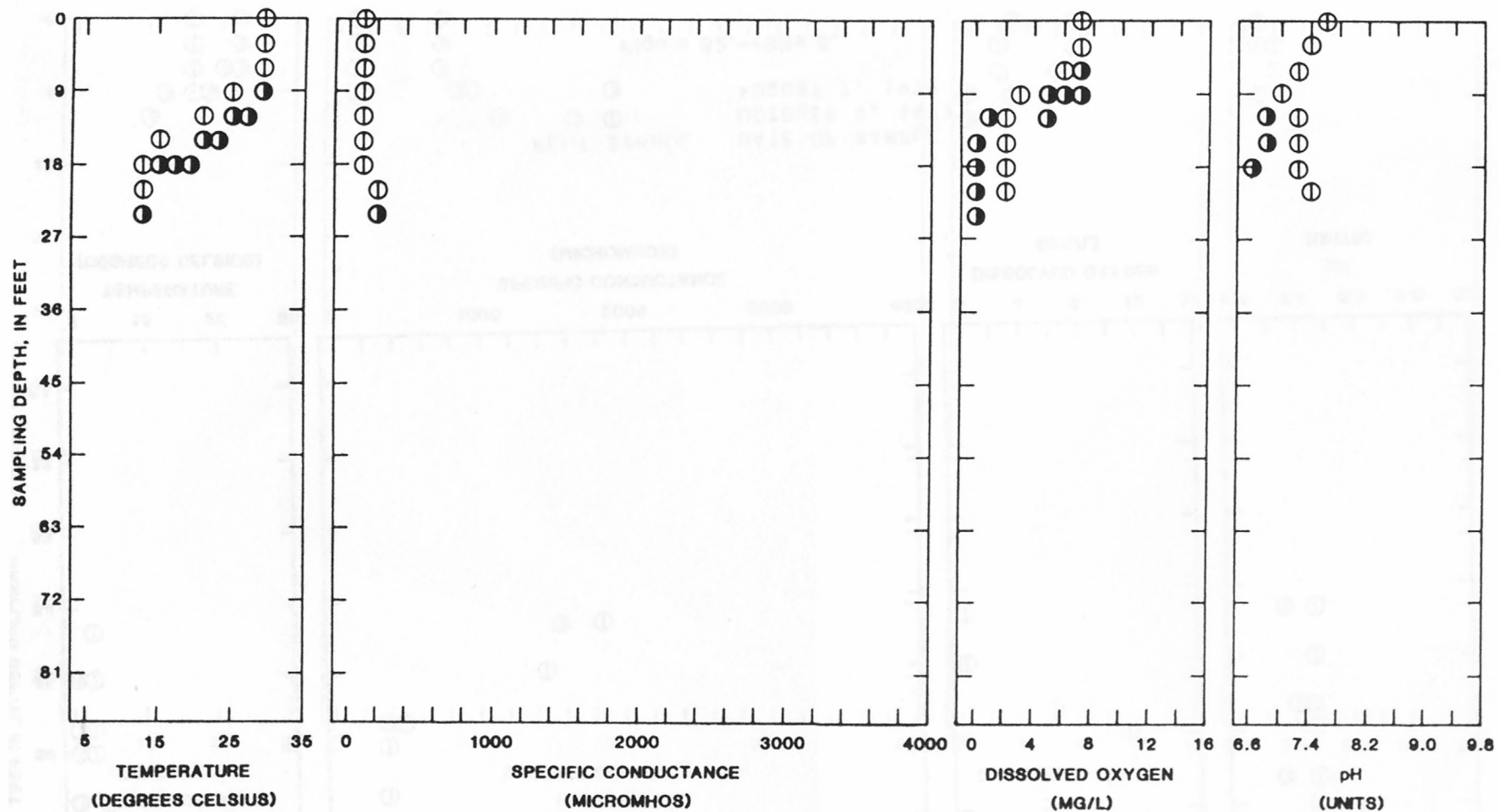
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 20, 1977
 ● AUGUST 7, 1979

Figure 59.--Site 2.



PLUT SYMBOL DATE OF SAMPLE
① JULY 21, 1977

Figure 60.--Site 3.



PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 20, 1977
 ● AUGUST 7, 1979

Figure 61.--Site 4.

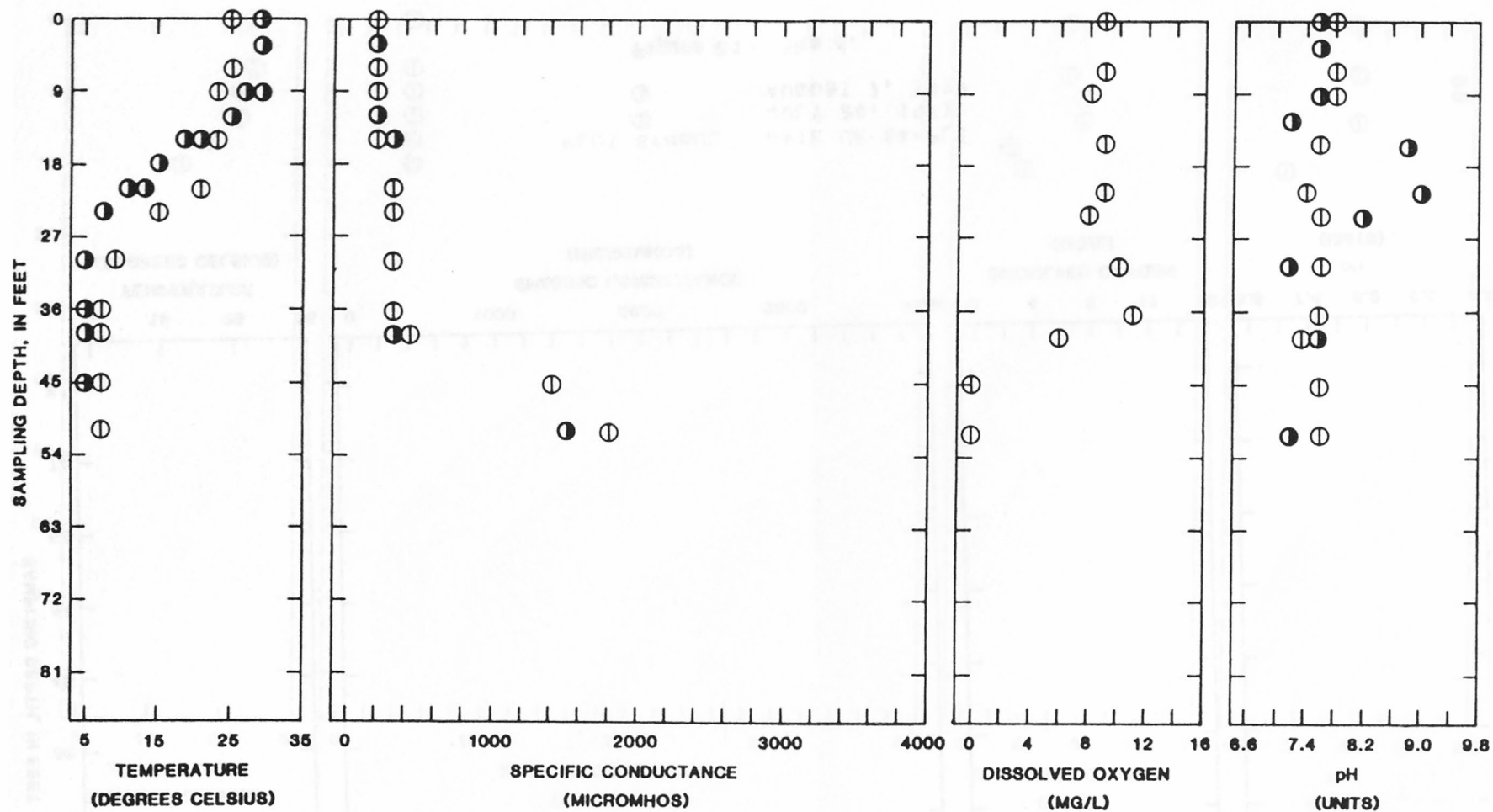
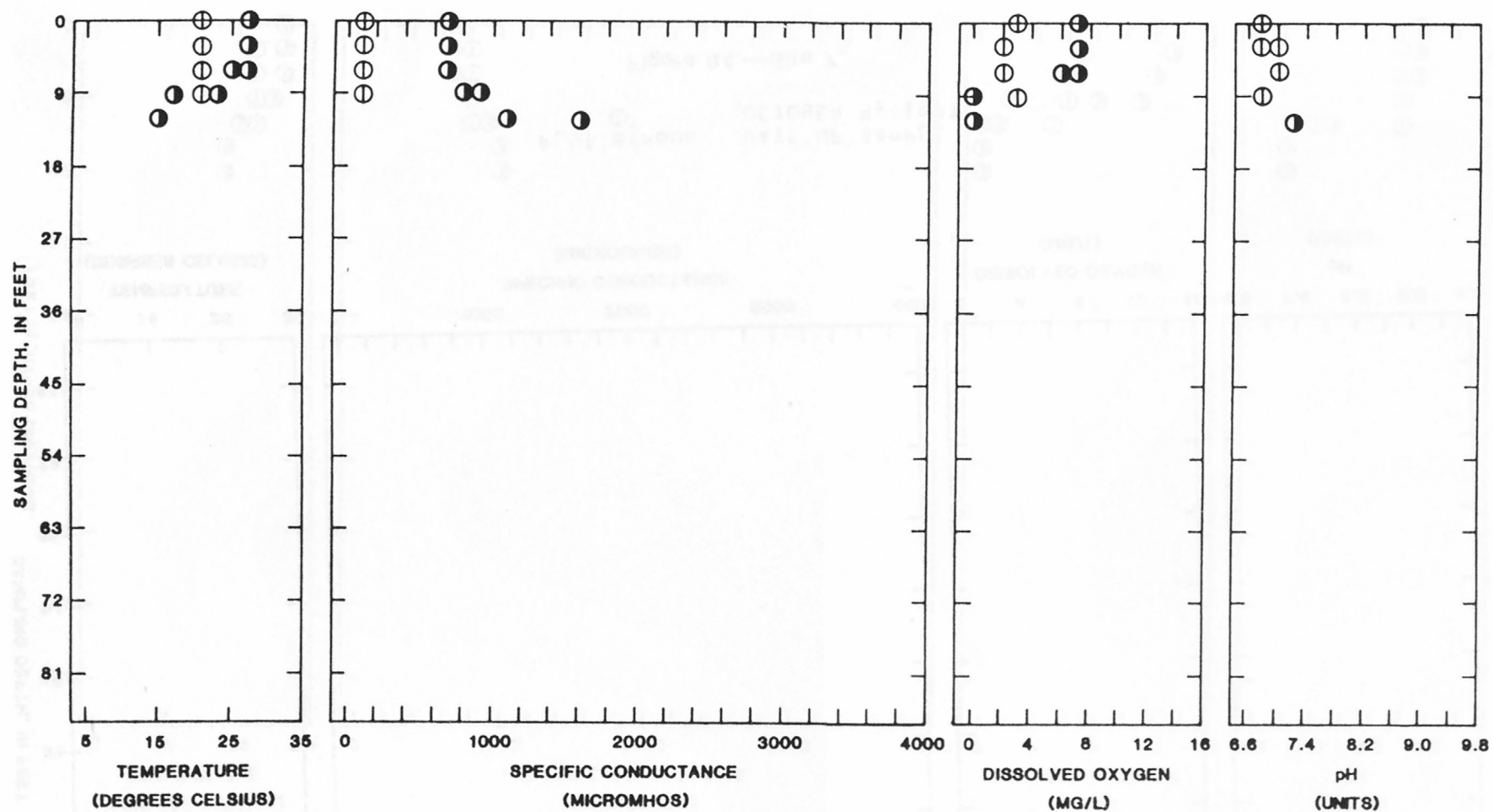
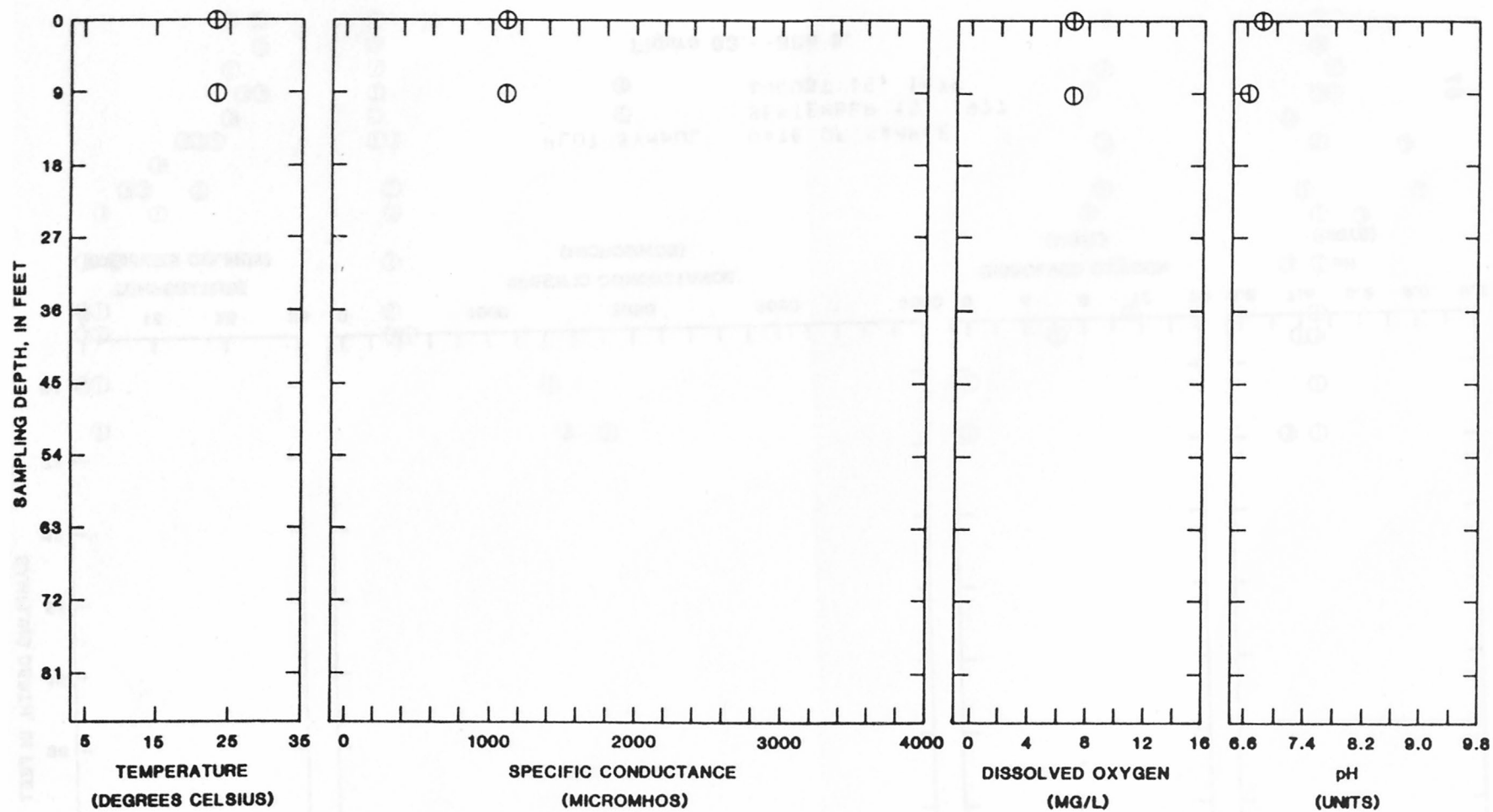


Figure 62.--Site 5.



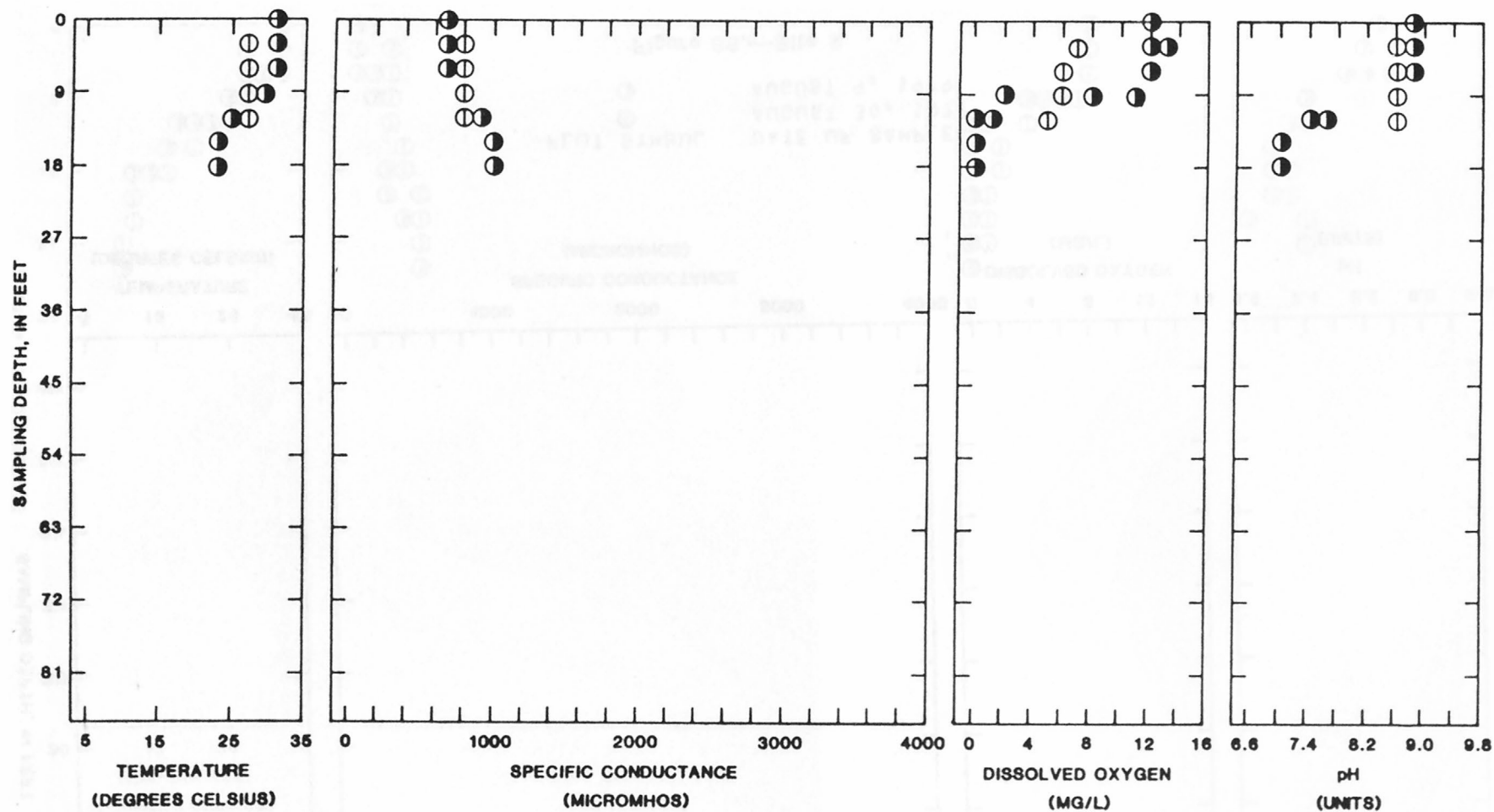
PLOT SYMBOL DATE OF SAMPLE
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 ● AUGUST 15, 1979

Figure 63.--Site 6.



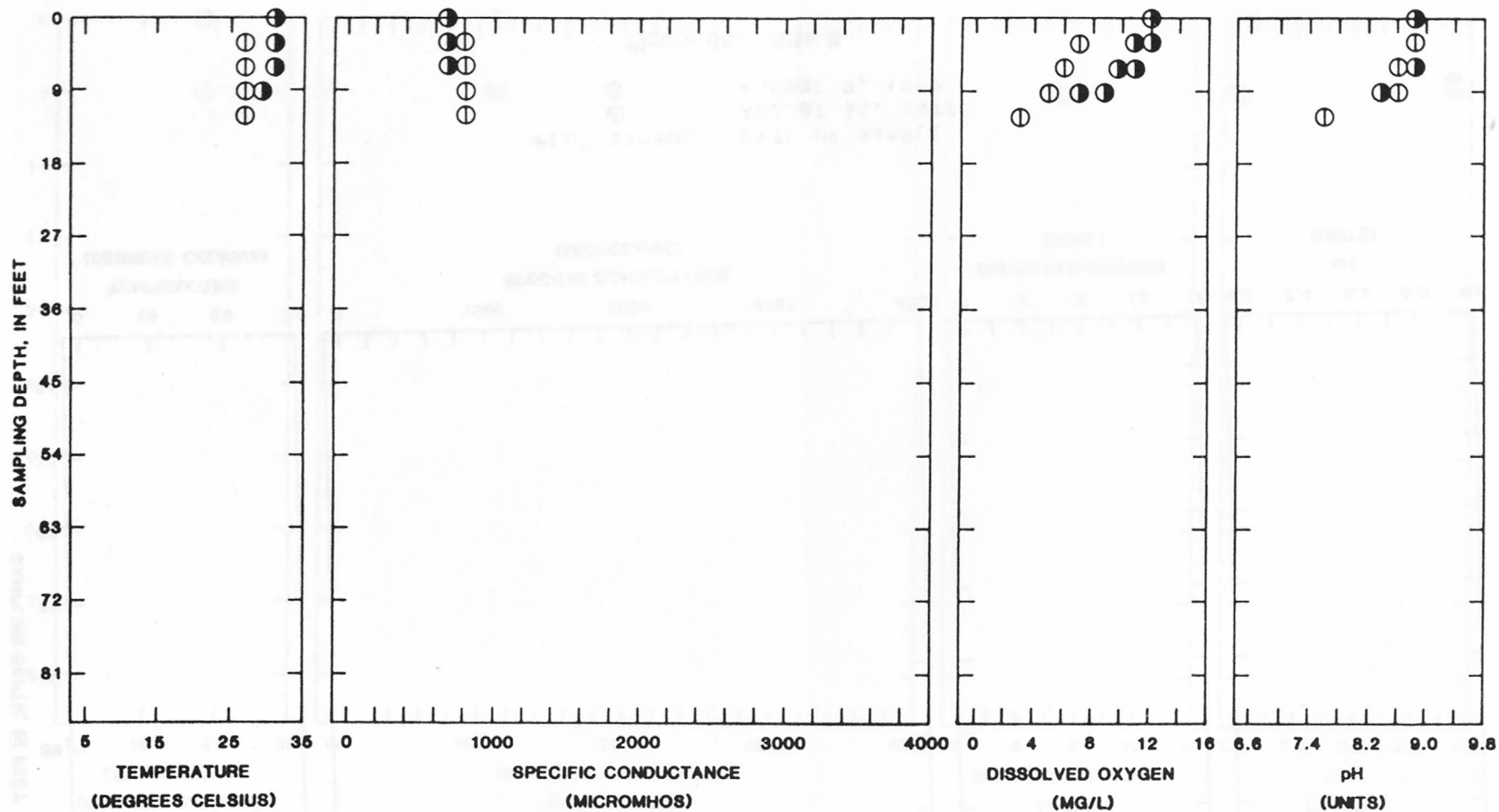
PLT SYMBOL DATE OF SAMPLE
⊕ OCTOBER 5, 1977

Figure 64.--Site 7.



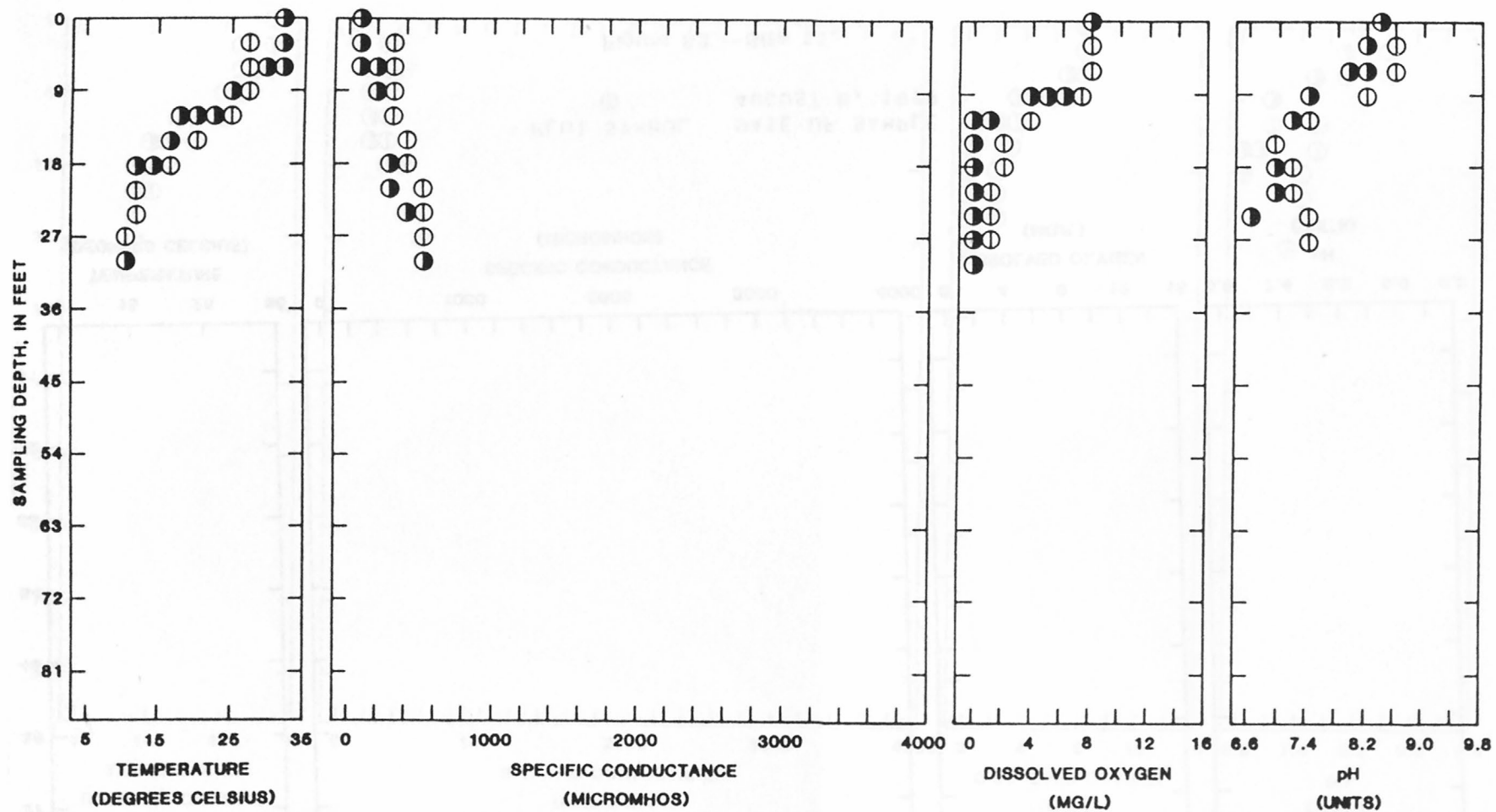
PLOT SYMBOL DATE OF SAMPLE
 ○ AUGUST 30, 1977
 ● AUGUST 9, 1979

Figure 65.--Site 8.



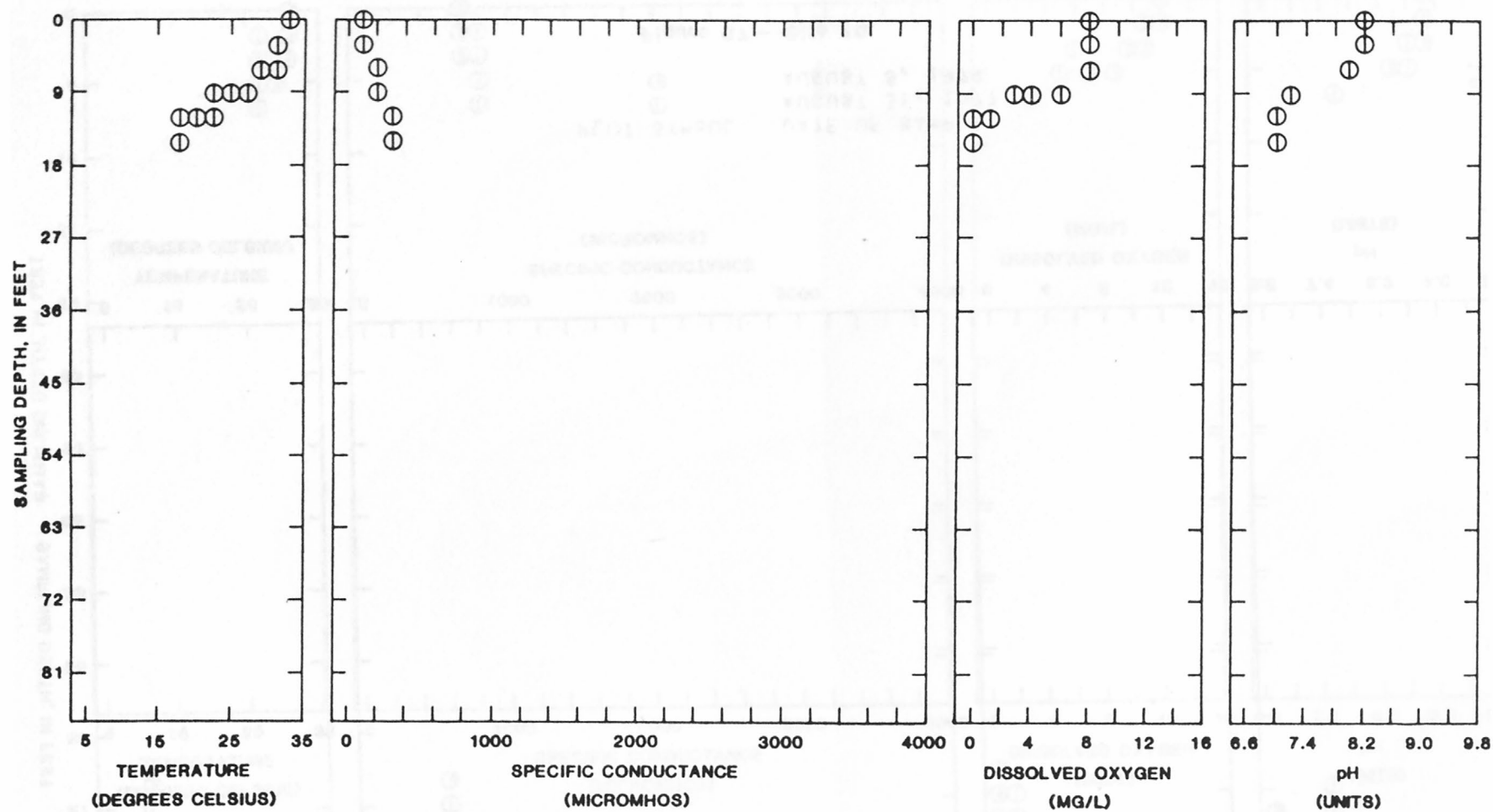
PLT SYMBOL DATE OF SAMPLE
 ○ AUGUST 30, 1977
 ● AUGUST 9, 1979

Figure 66.--Site 9.



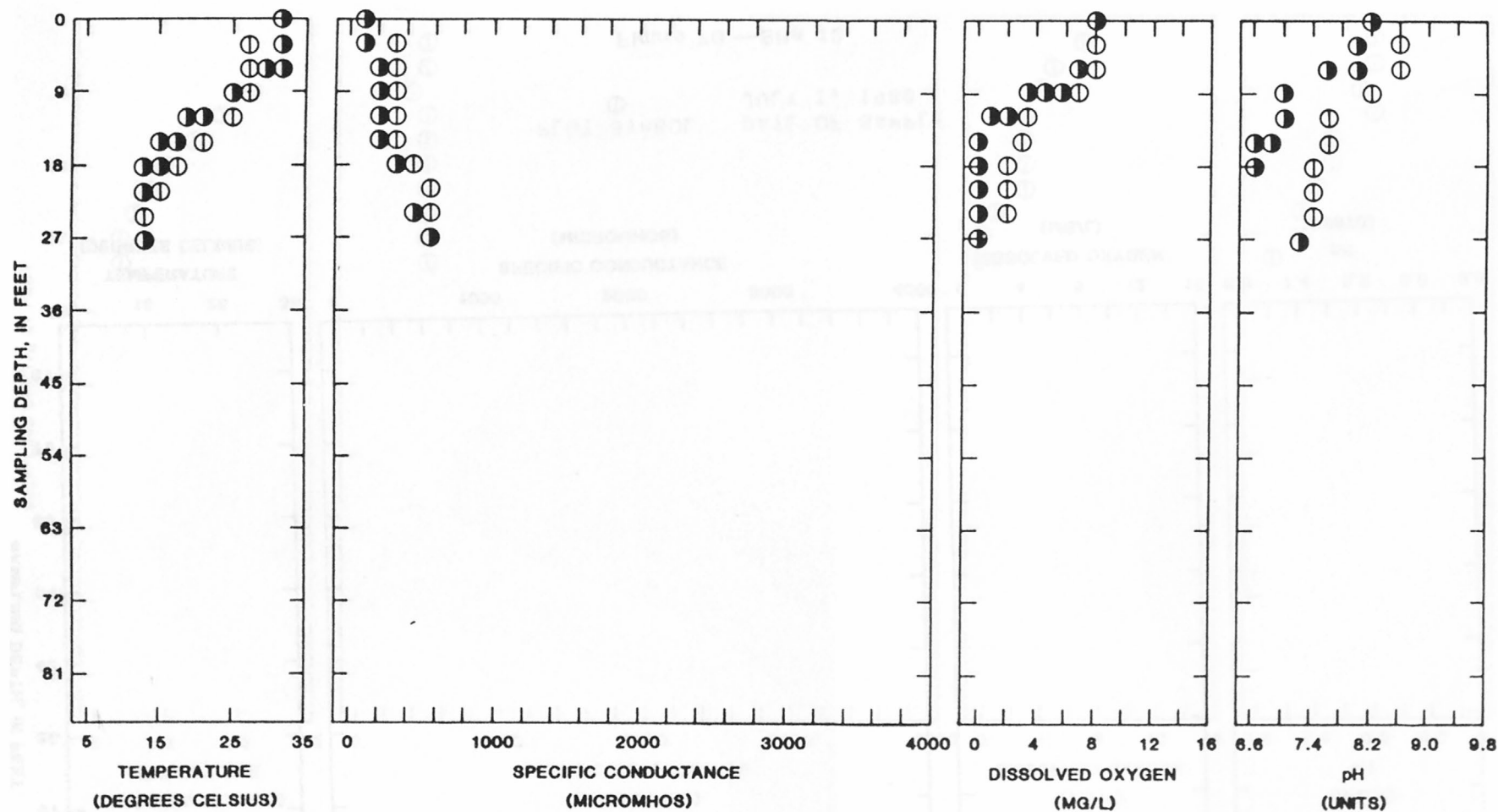
PLOT SYMBOL DATE OF SAMPLE
 ○ AUGUST 31, 1977
 ● AUGUST 8, 1979

Figure 67.--Site 10.



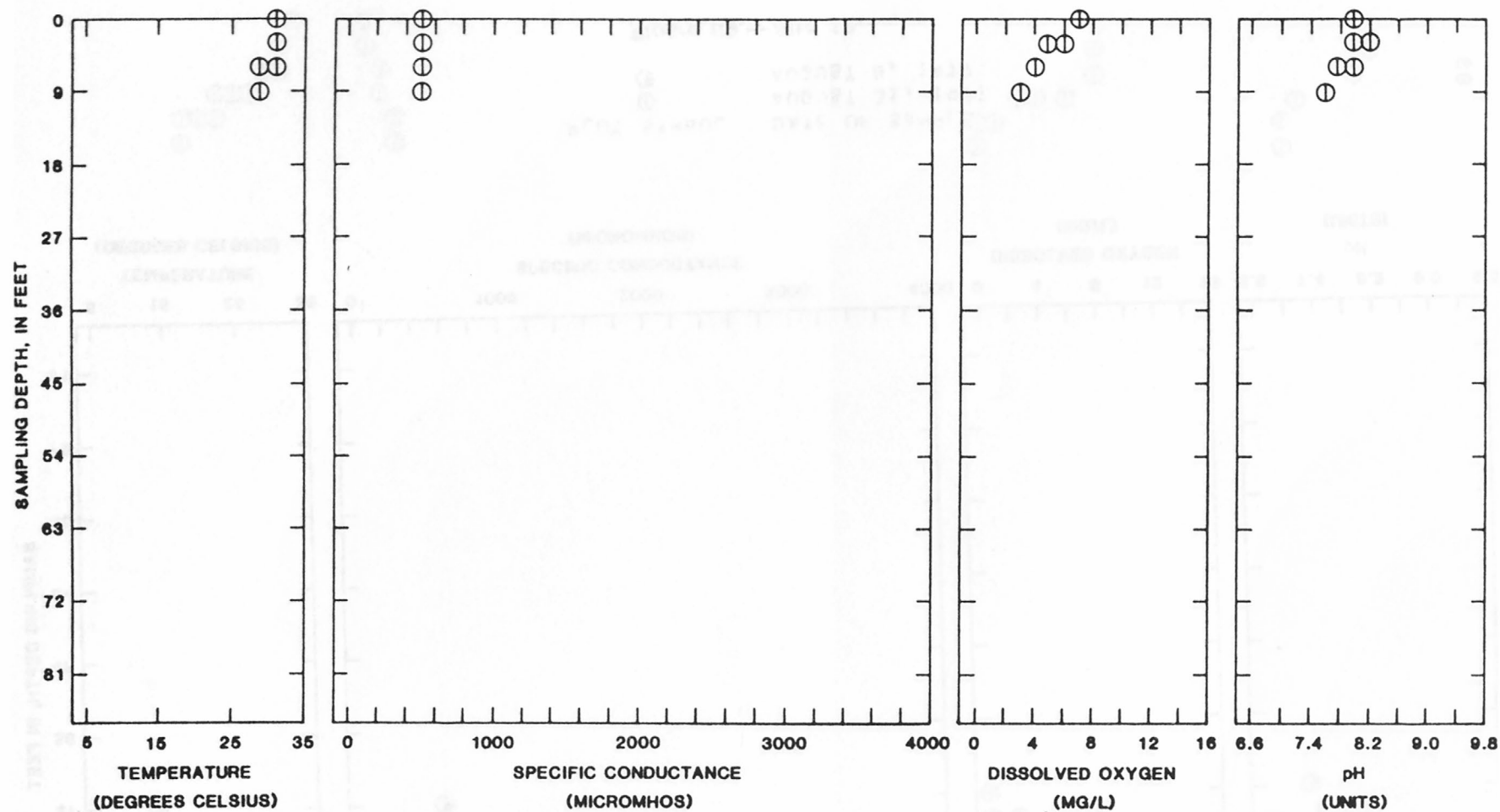
PLUT SYMBOL DATE OF SAMPLE
① AUGUST 8, 1979

Figure 68.--Site 11.



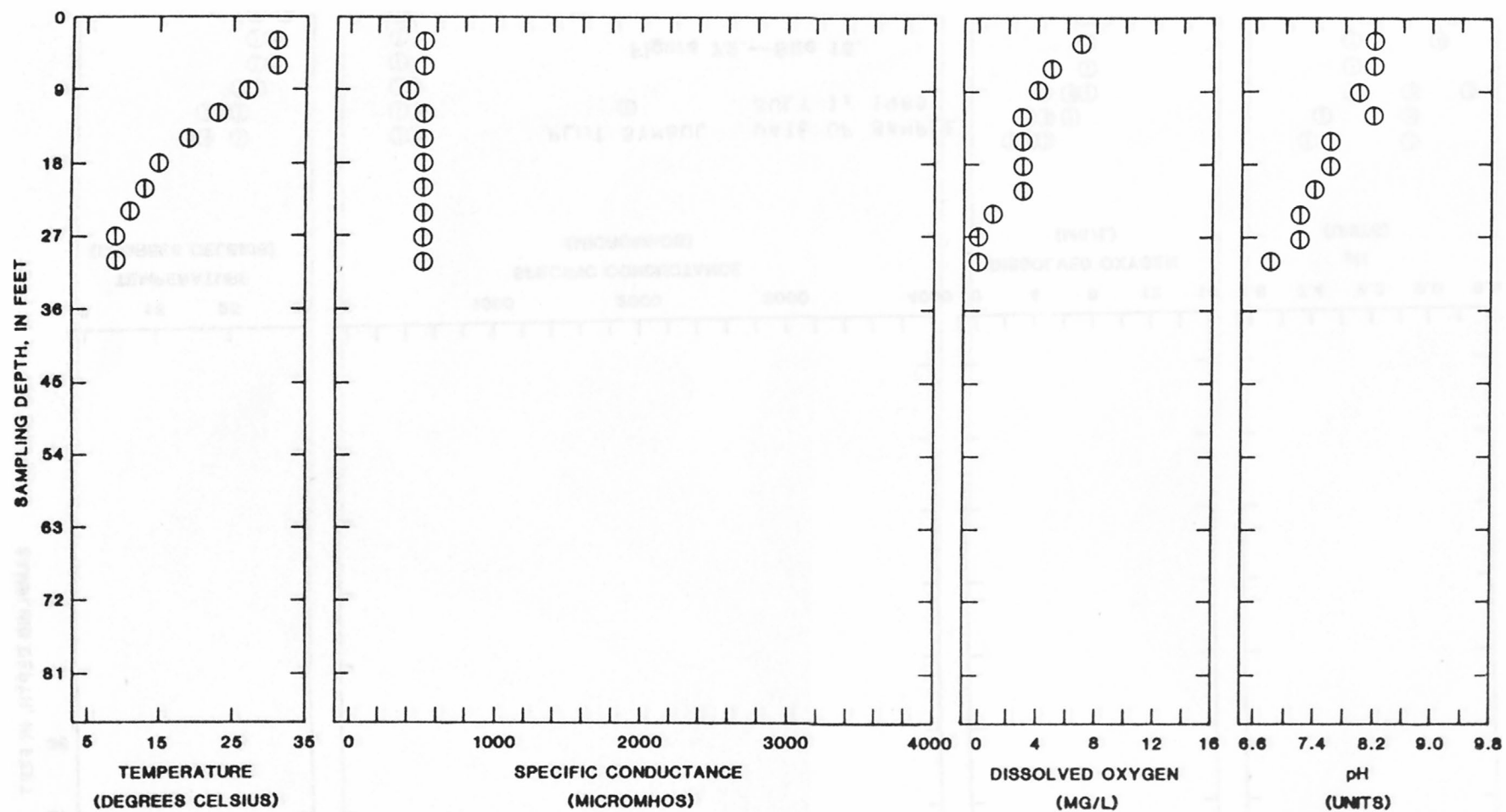
○	DATE OF SAMPLE
○	AUGUST 31, 1977
●	AUGUST 8, 1979

Figure 69.--Site 12.



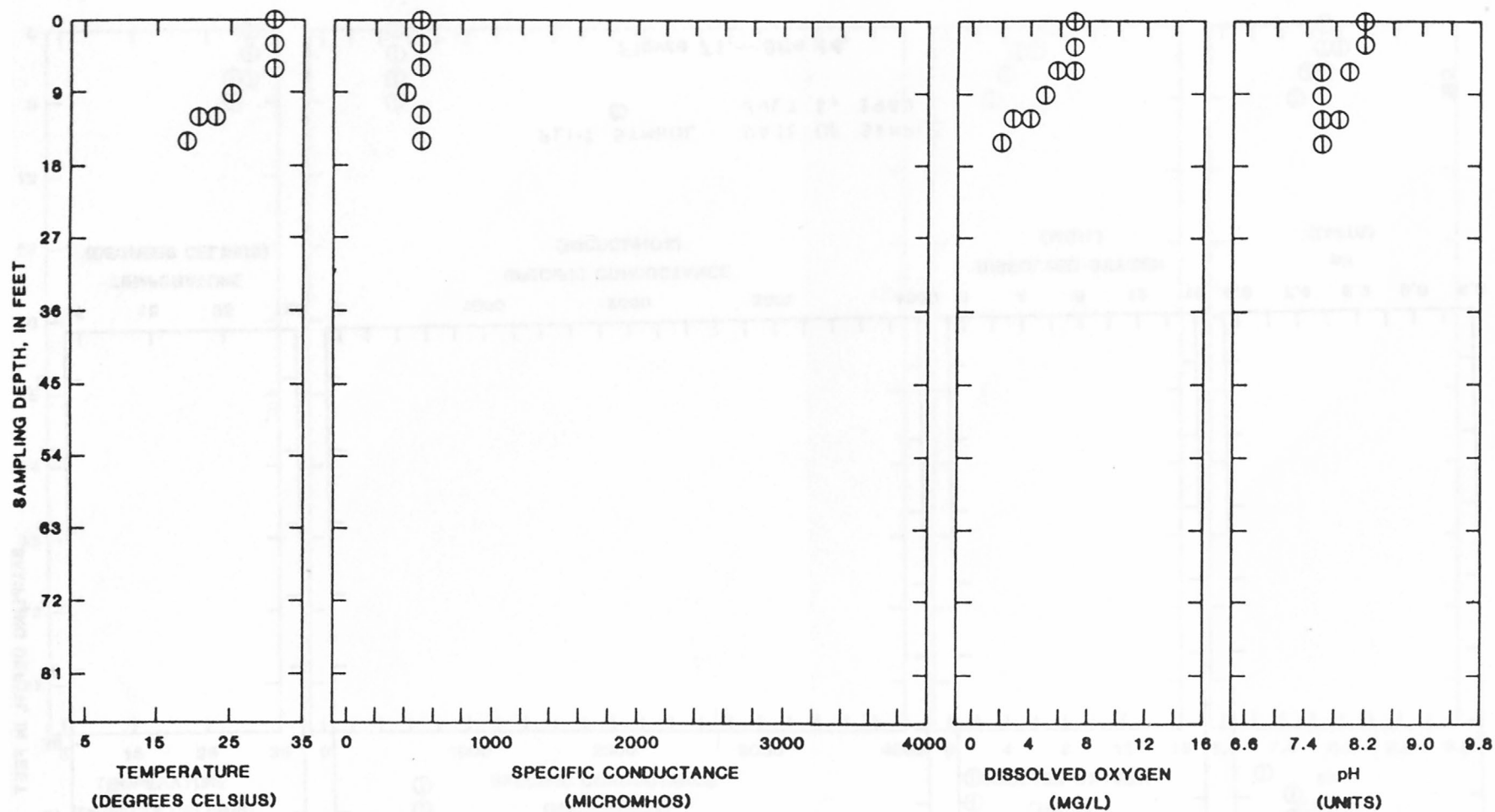
PLUT SYMBOL DATE OF SAMPLE
⊕ JULY 1, 1980

Figure 70.--Site 13.



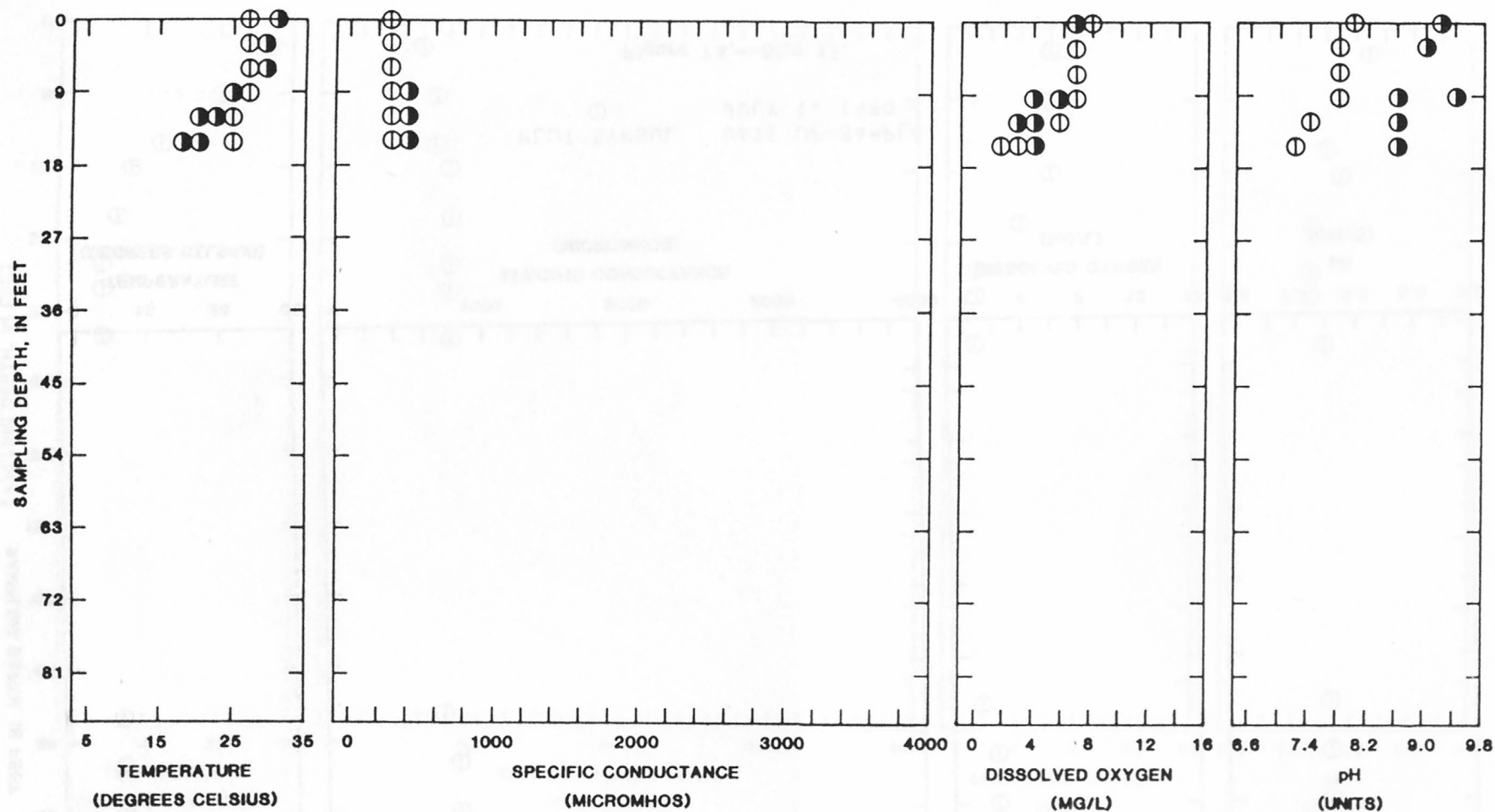
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 1, 1980

Figure 71.--Site 14.



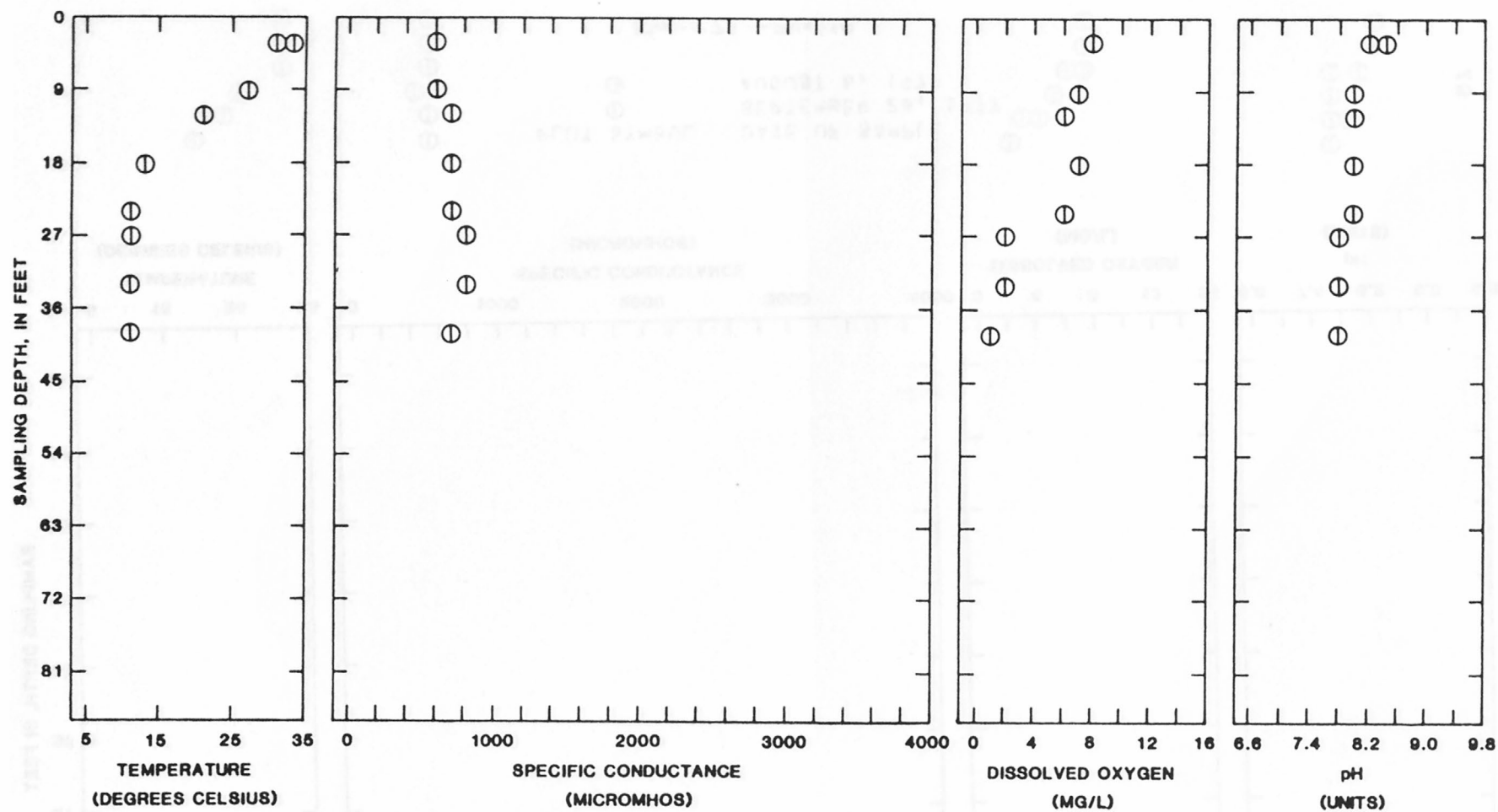
PLUT SYMBOL DATE OF SAMPLE
⊙ JULY 1, 1980

Figure 72.--Site 15.



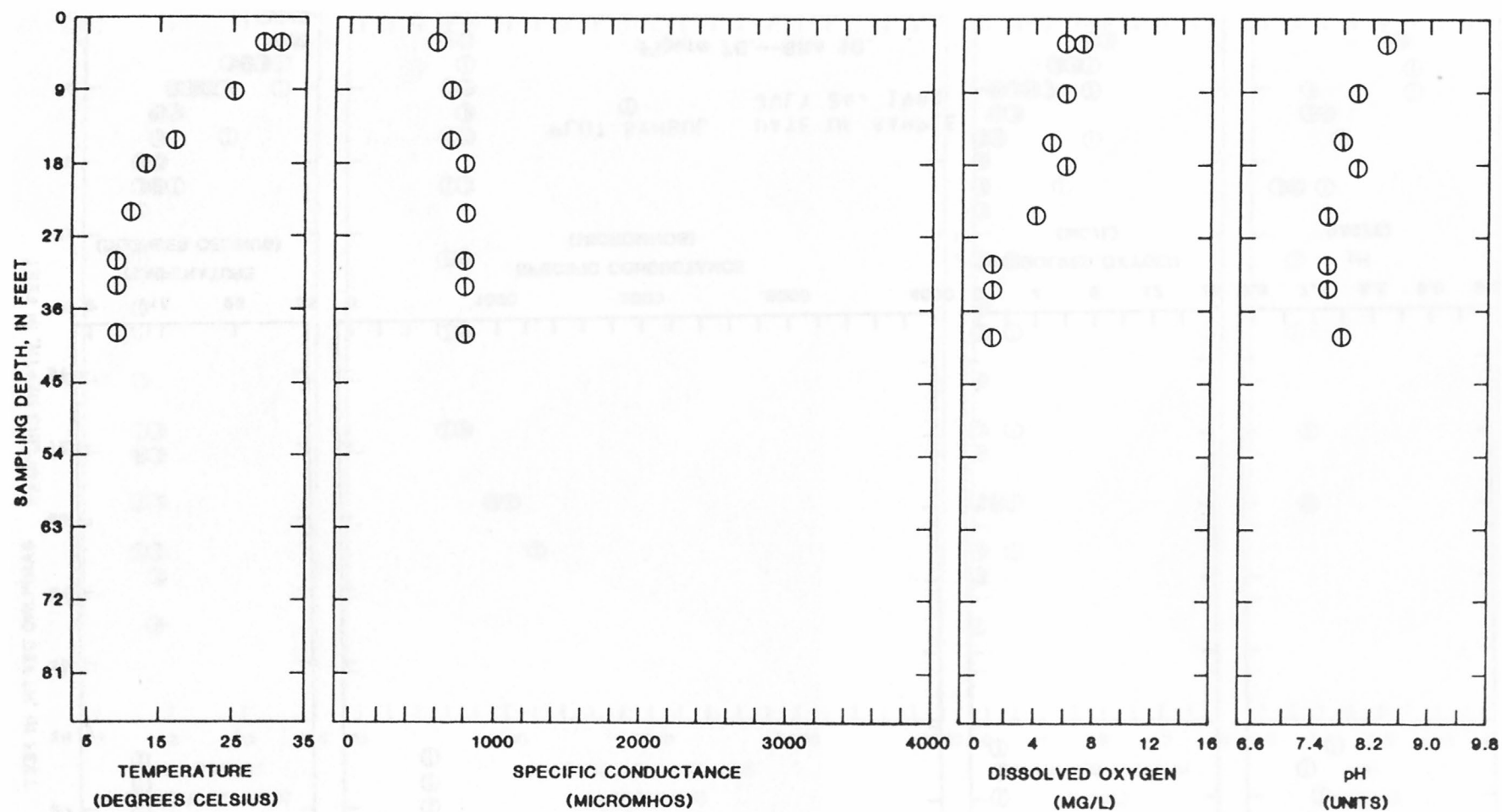
PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 28, 1977
 ● AUGUST 6, 1979

Figure 73.--Site 16.



PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 1, 1980

Figure 74.--Site 17.



PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 1, 1980

Figure 75.--Site 18.

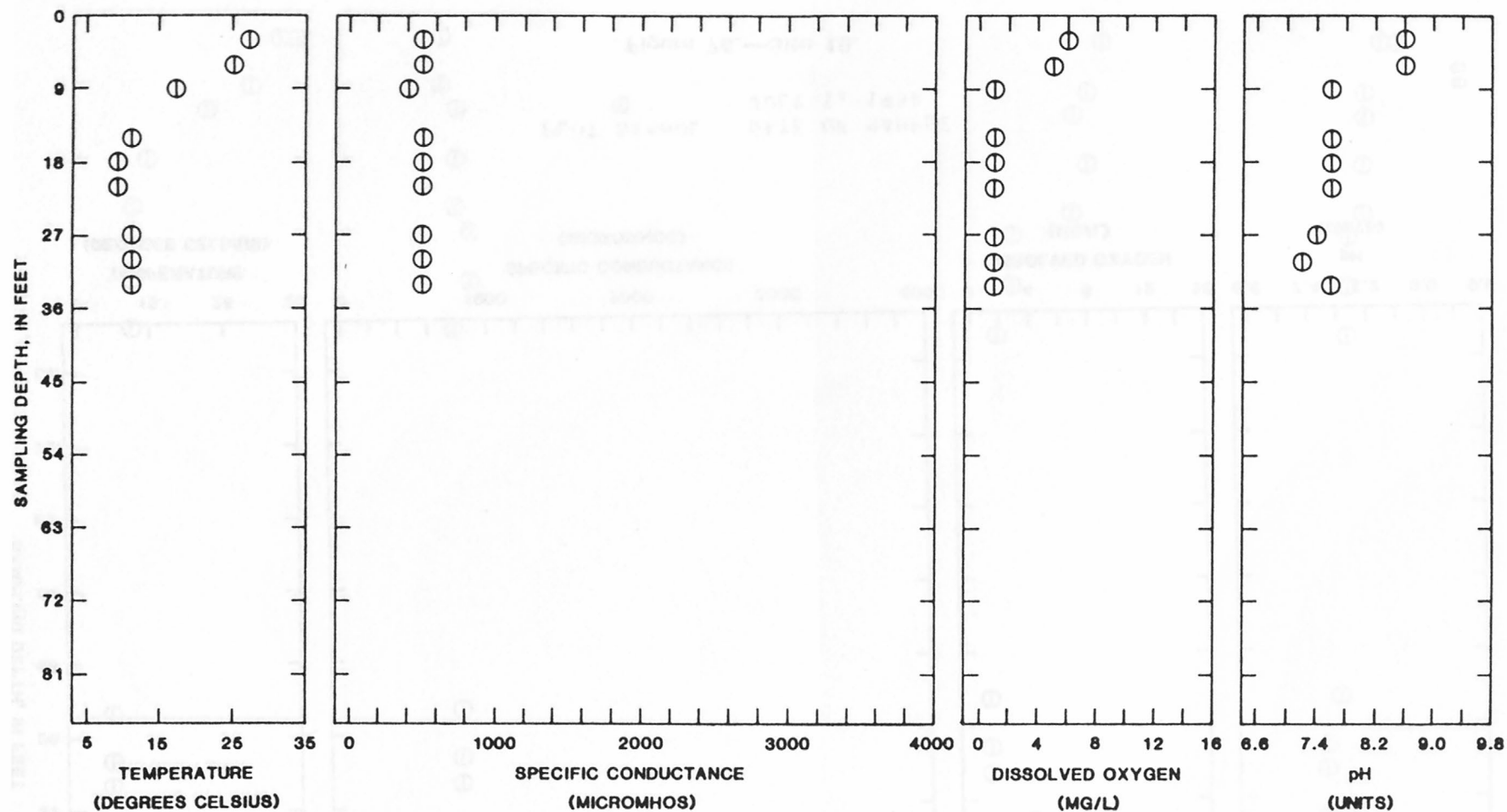
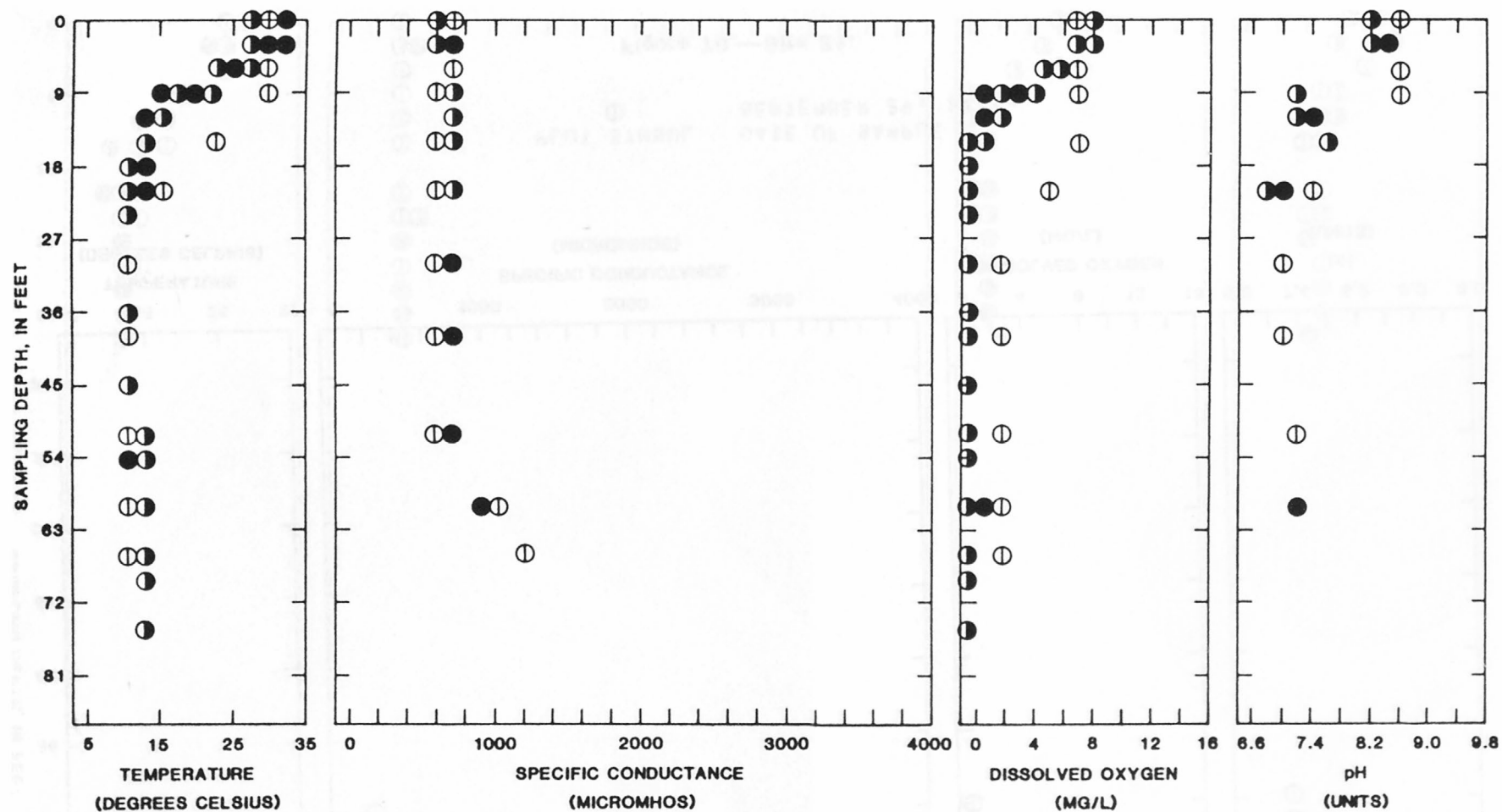
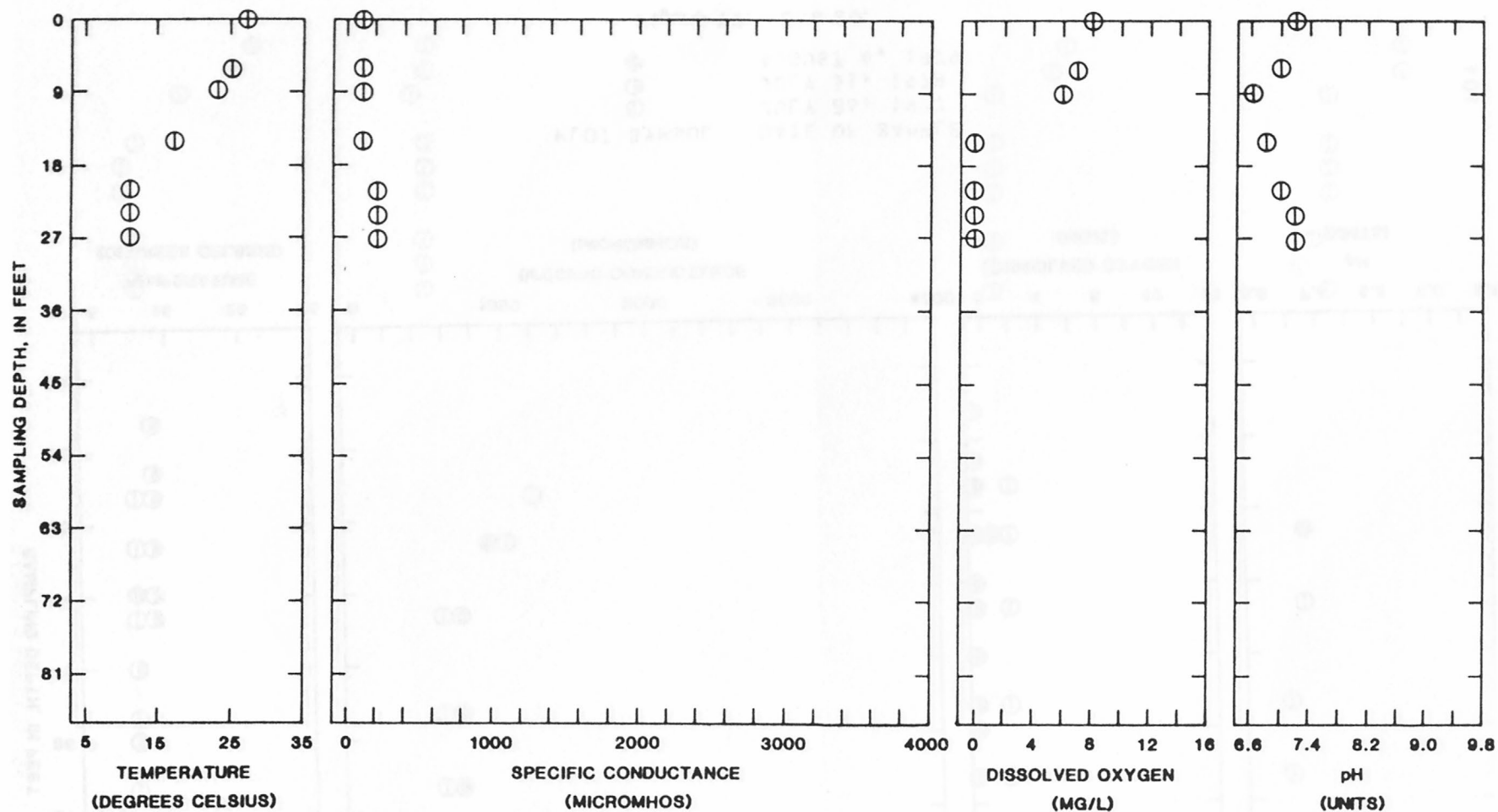


Figure 76.--Site 19.



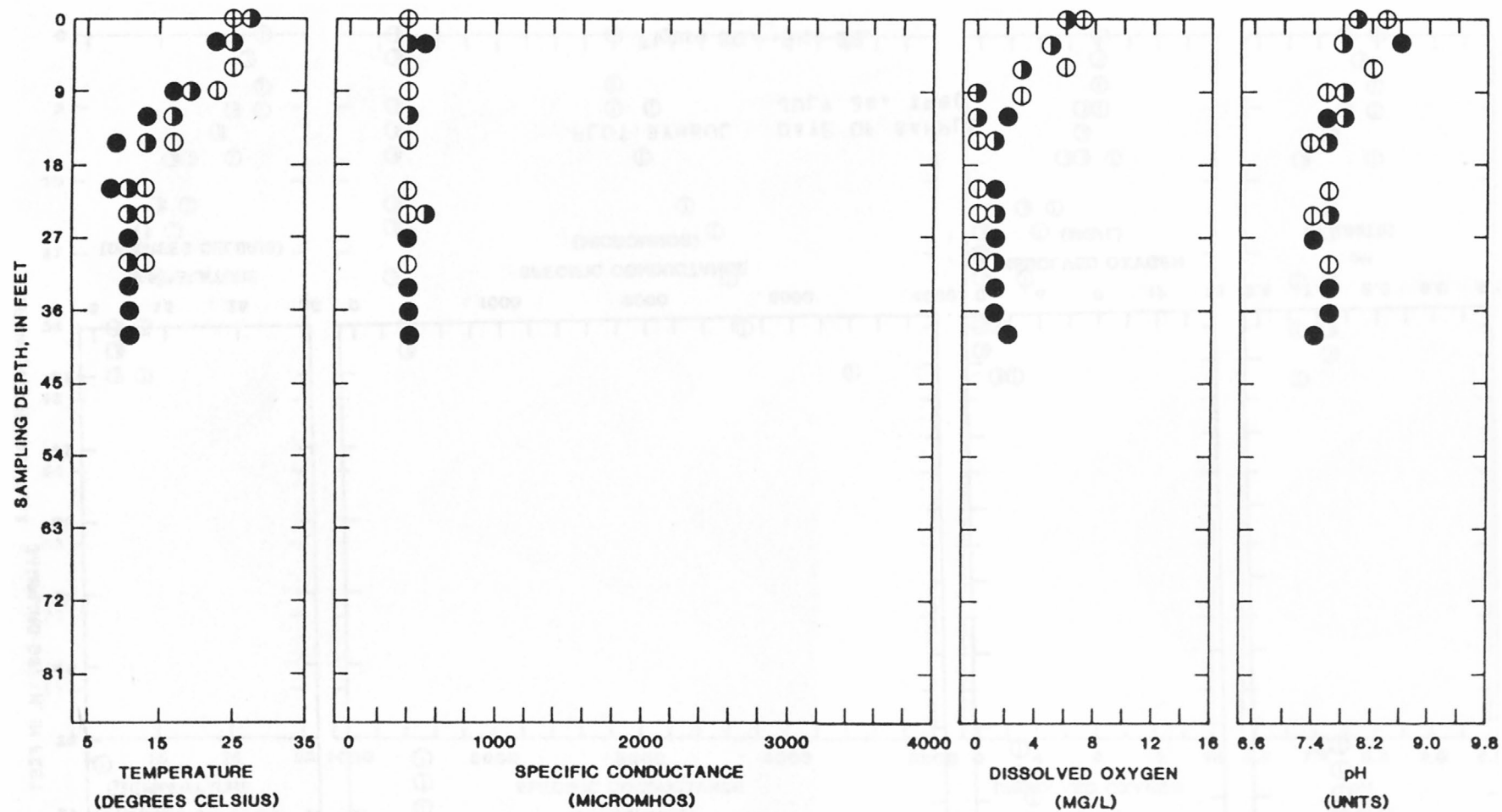
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 26, 1977
 ◐ JULY 31, 1979
 ● AUGUST 6, 1979

Figure 77.--Site 20.



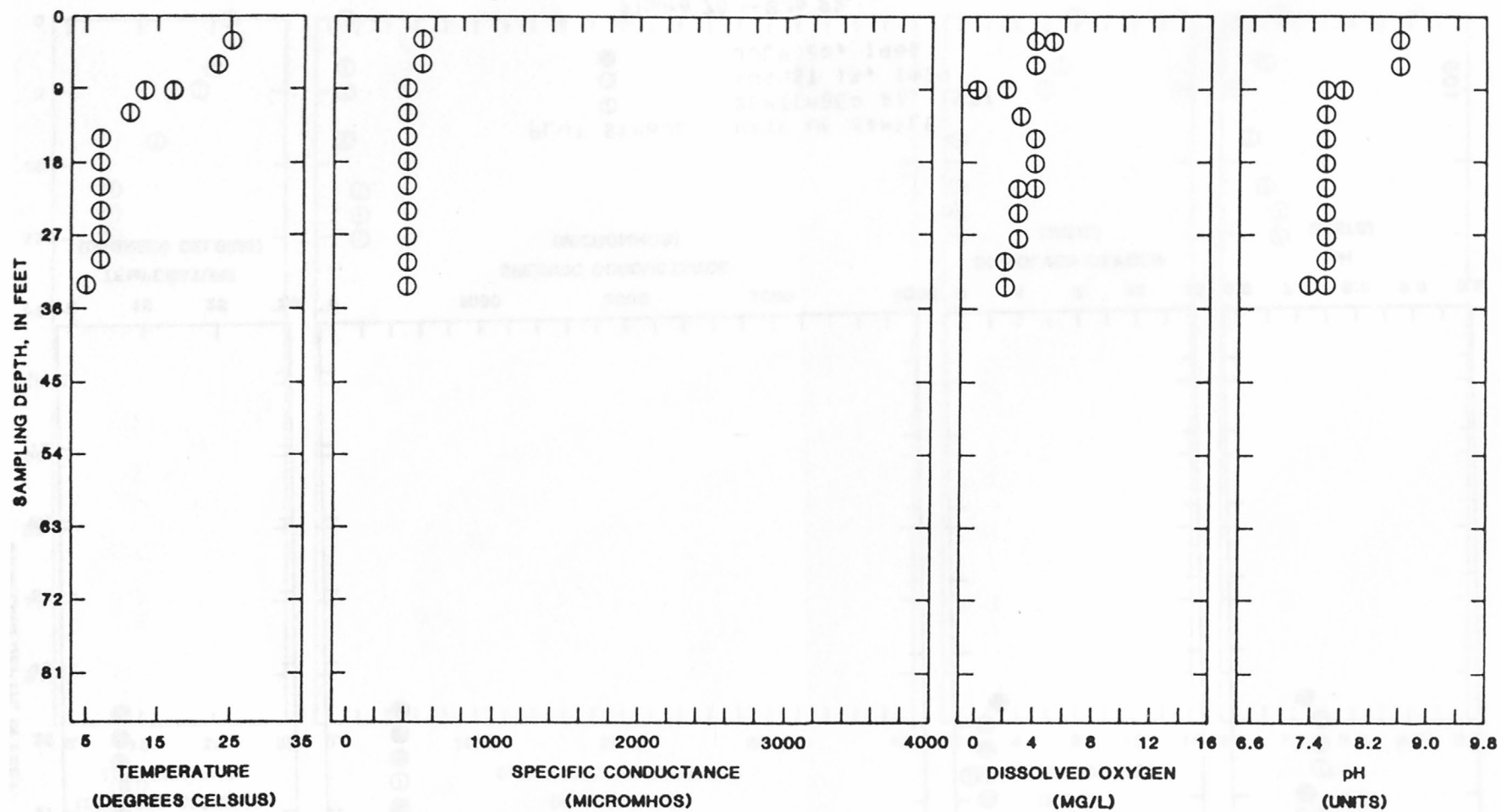
PLOT SYMBOL DATE OF SAMPLE
 ⊕ SEPTEMBER 29, 1977

Figure 78.--Site 21.



PLT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 27, 1977
 ◐ AUGUST 15, 1979
 ● JULY 24, 1980

Figure 79.--Site 22.



PLUT SYMBOL DATE OF SAMPLE
 ○ JULY 24, 1980

Figure 80.--Site 23.

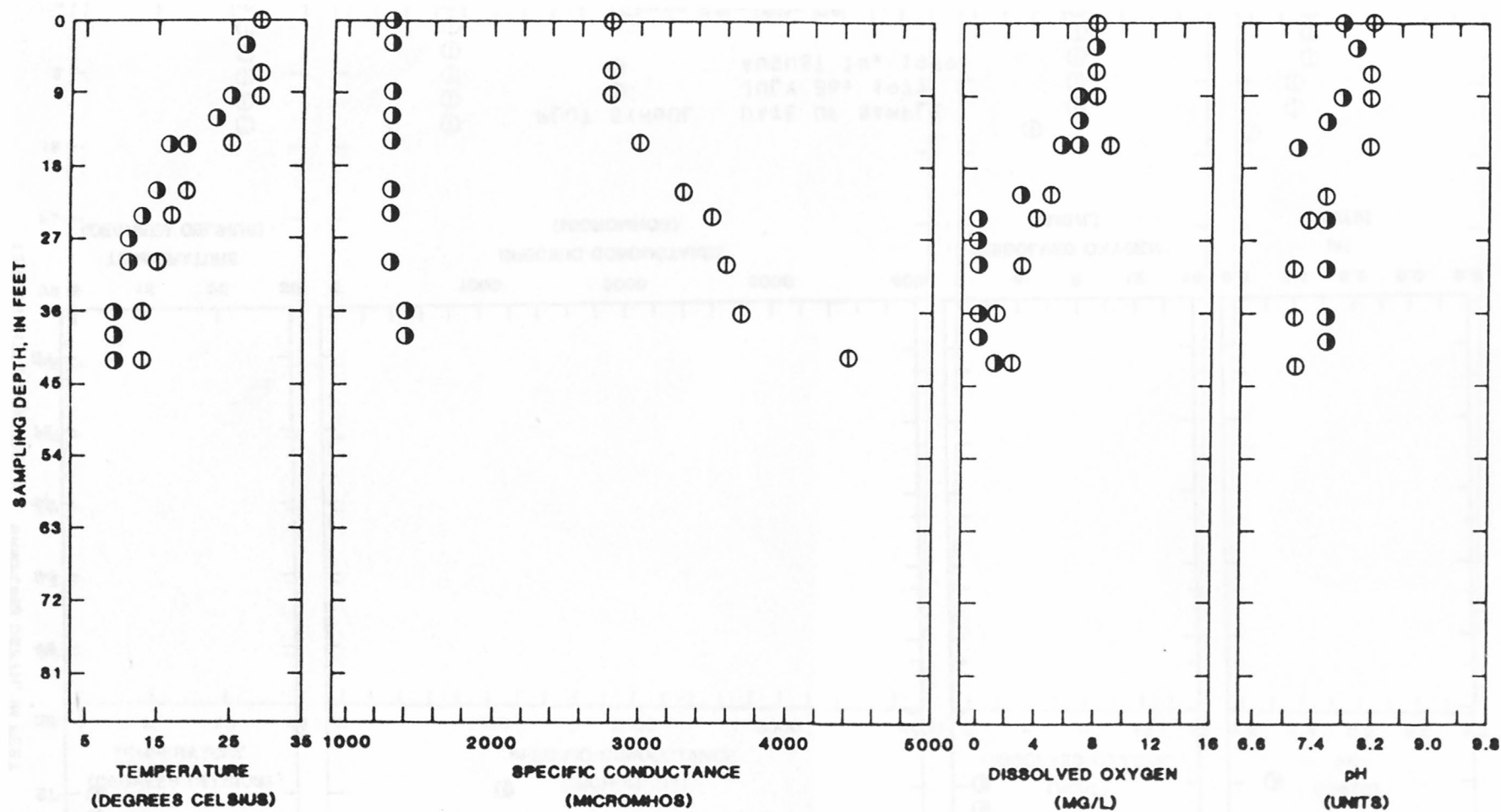


Figure 81.--Site 24.

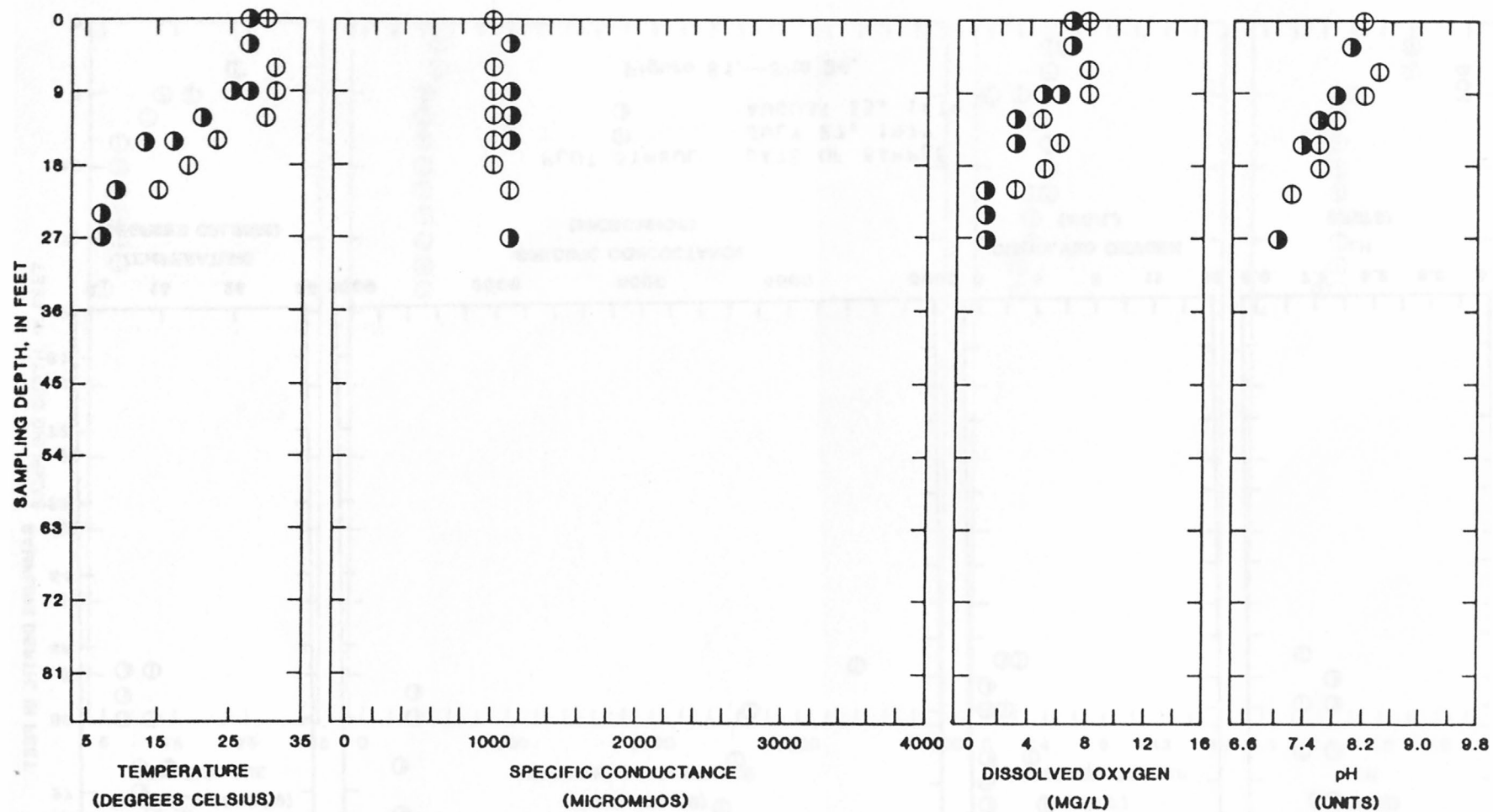
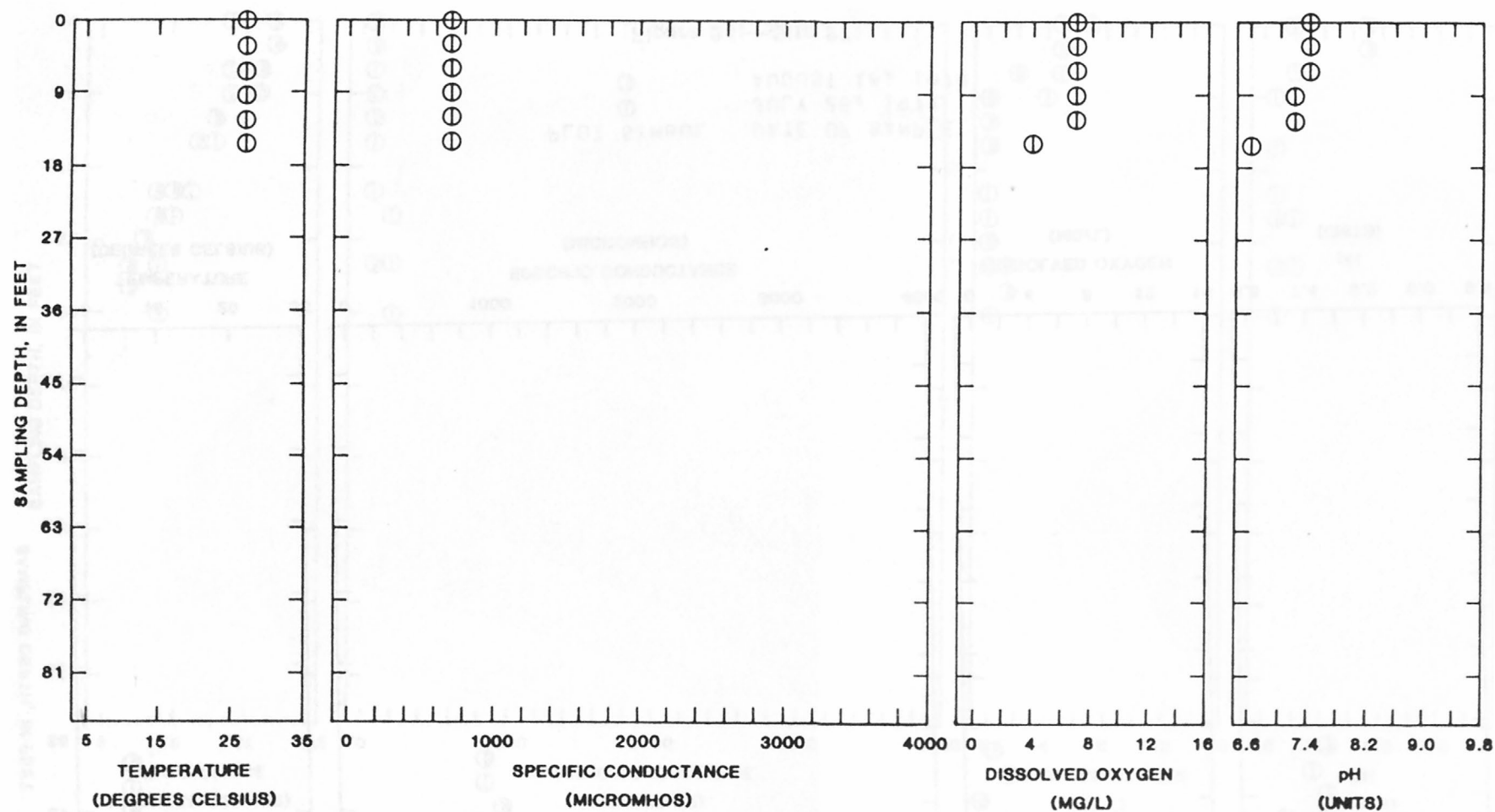


Figure 82.--Site 25.



PLOT SYMBOL DATE OF SAMPLE
 ⊕ SEPTEMBER 28, 1977

Figure 83.--Site 26.

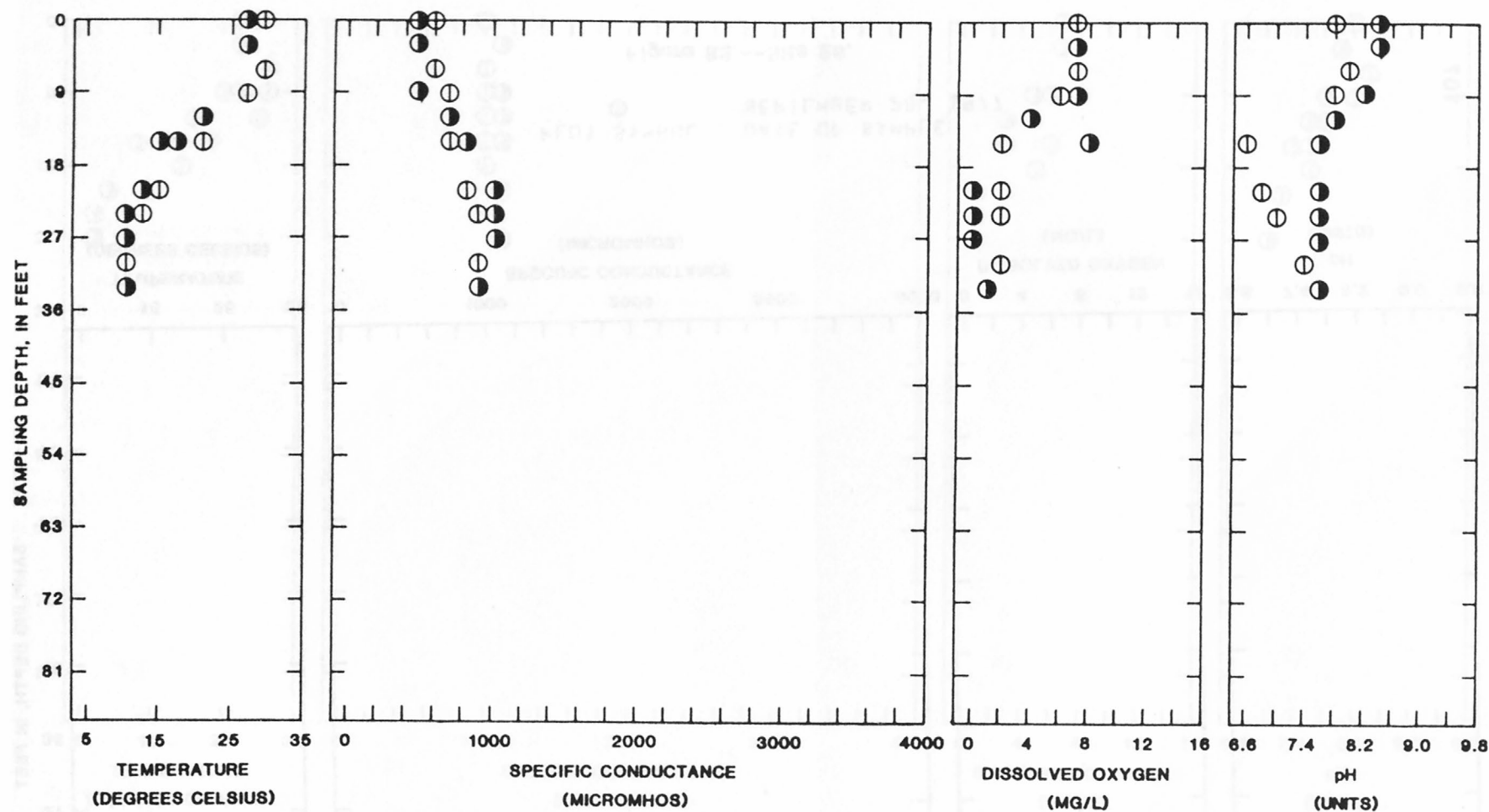
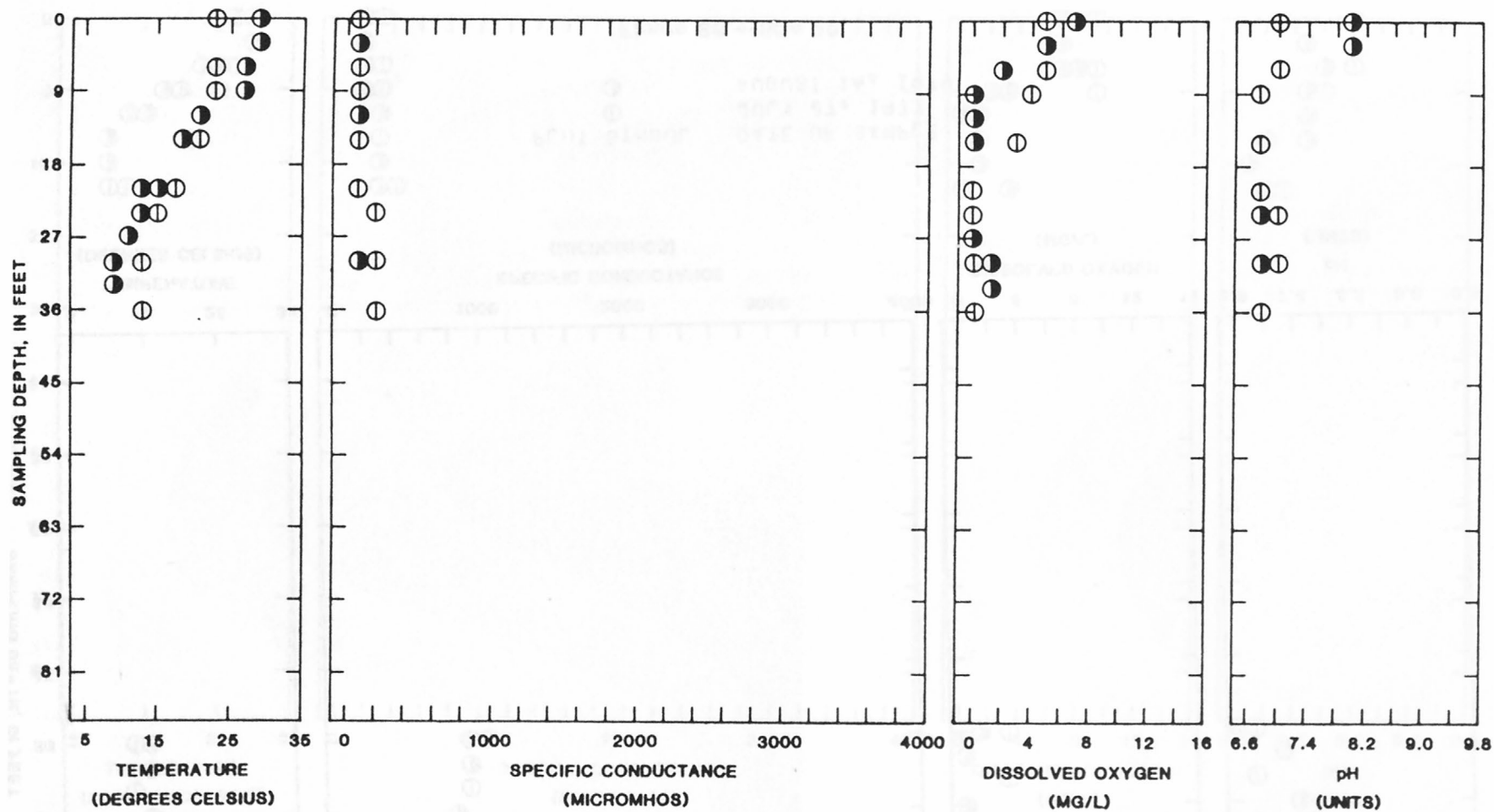


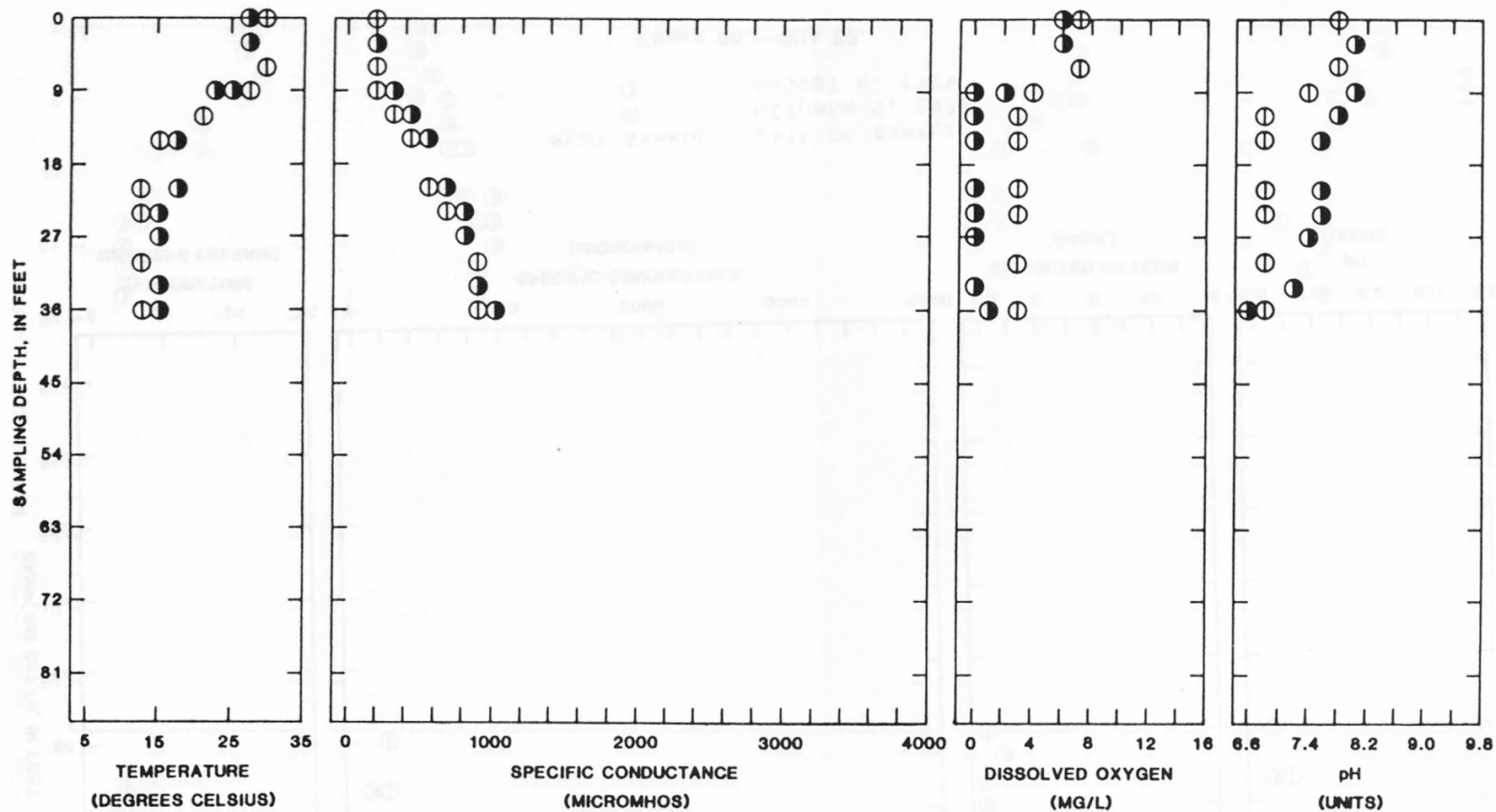
Figure 84.--Site 27.



PLOT SYMBOL
 ○
 ●

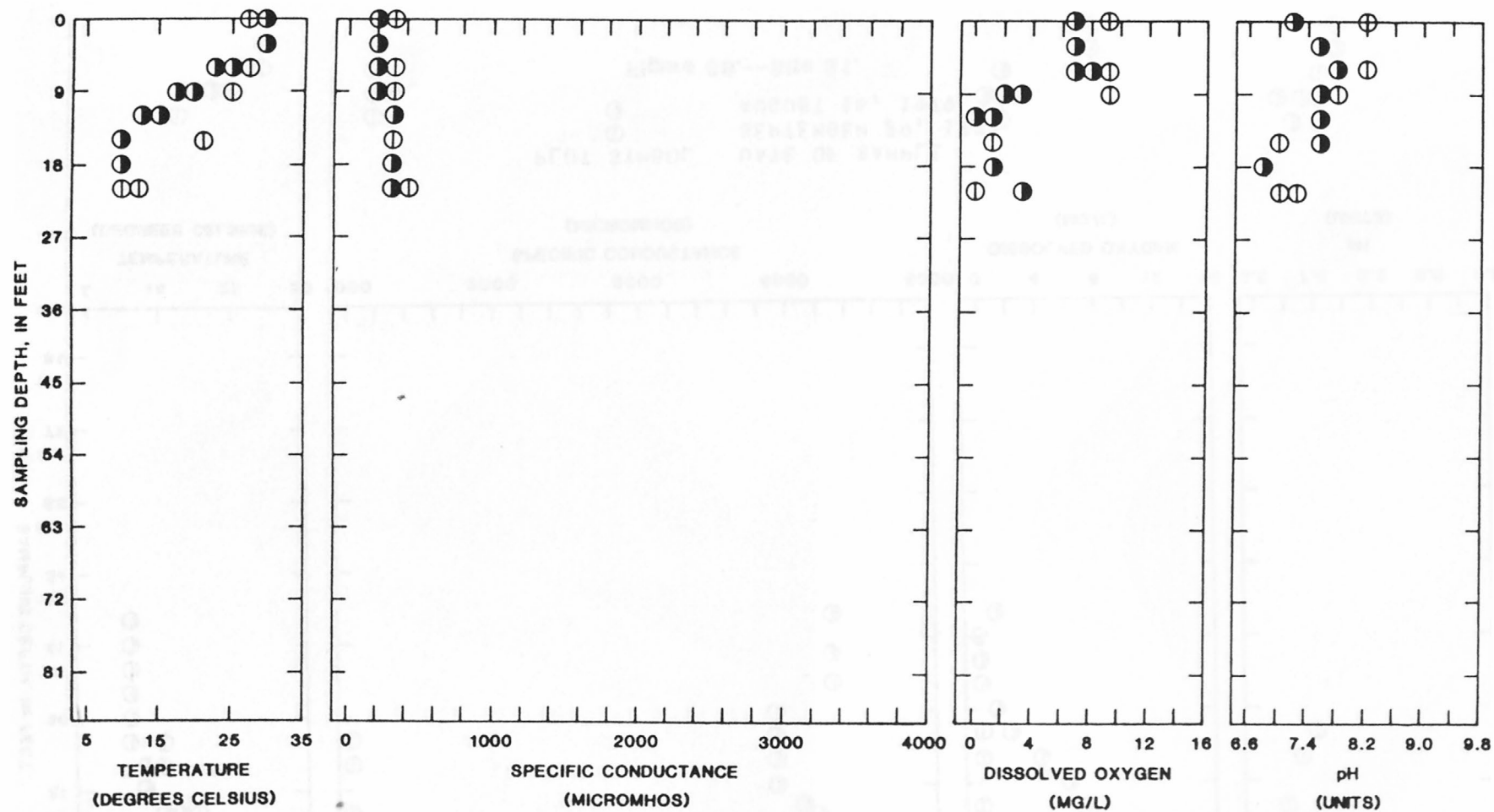
DATE OF SAMPLE
 OCTOBER 5, 1977
 AUGUST 8, 1979

Figure 85.--Site 28.



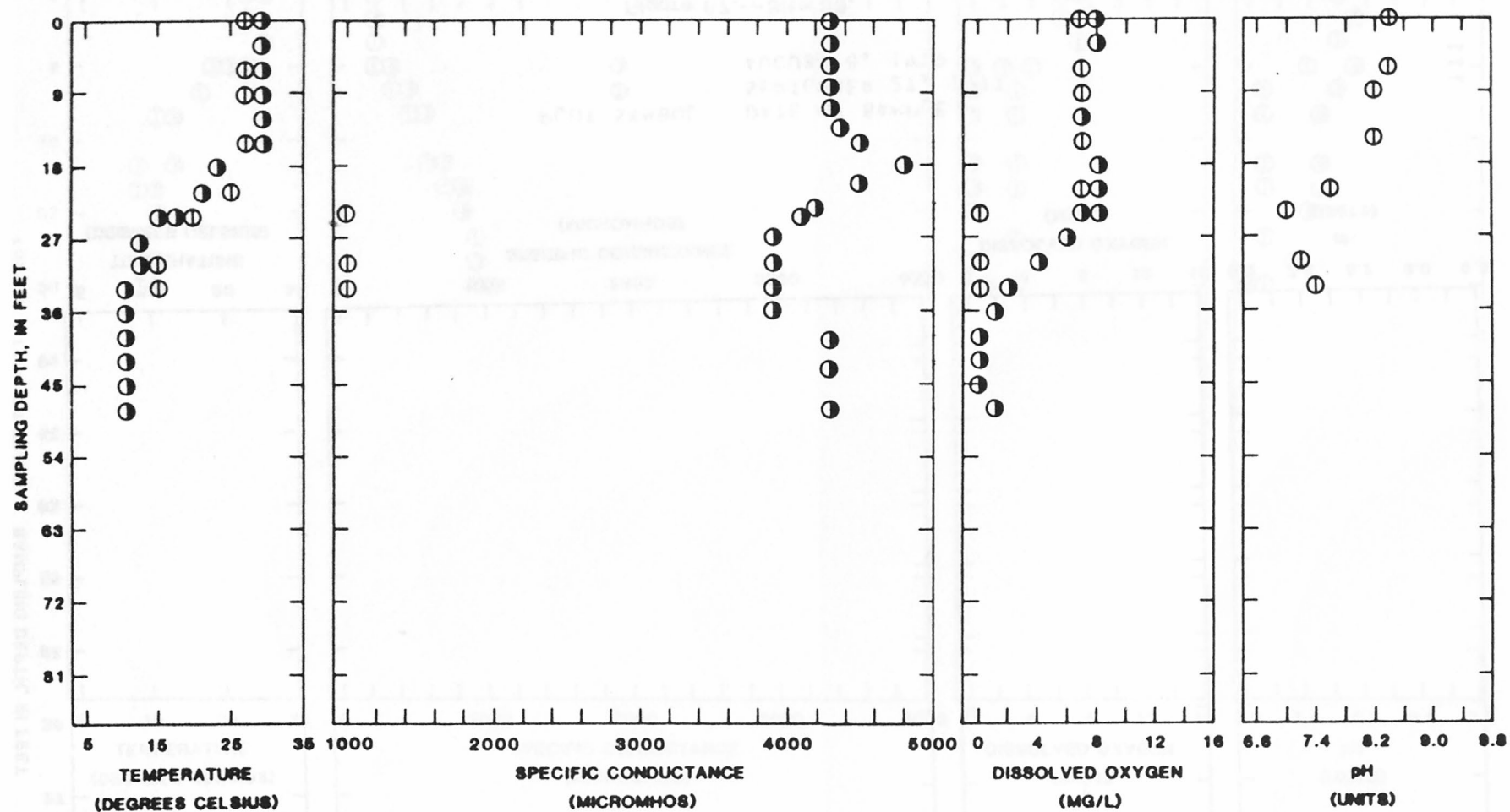
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 27, 1977
 ● AUGUST 16, 1979

Figure 86.--Site 29.



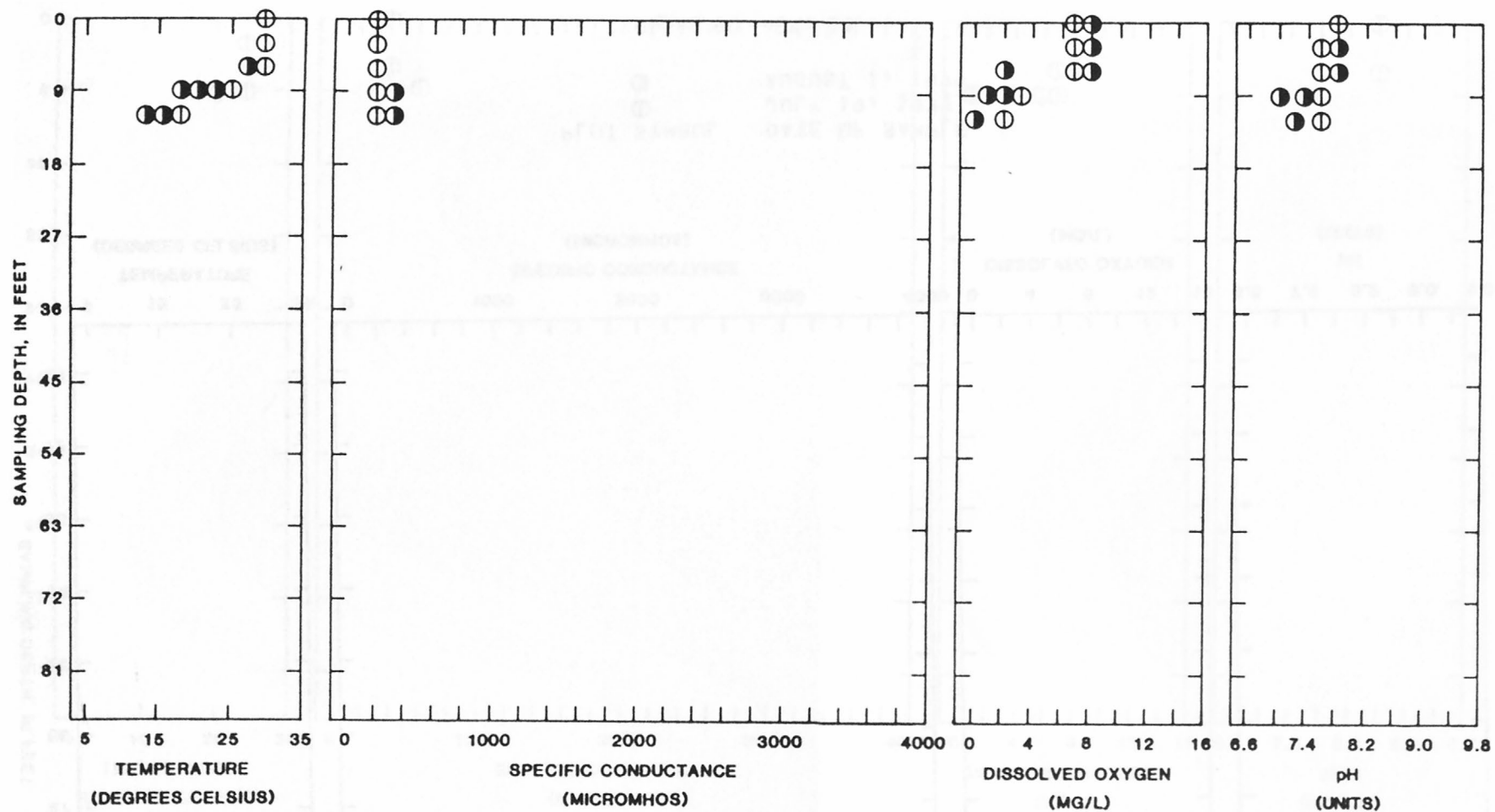
PLOT SYMBOL DATE OF SAMPLE
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 ● AUGUST 8, 1979

Figure 87.--Site 30.



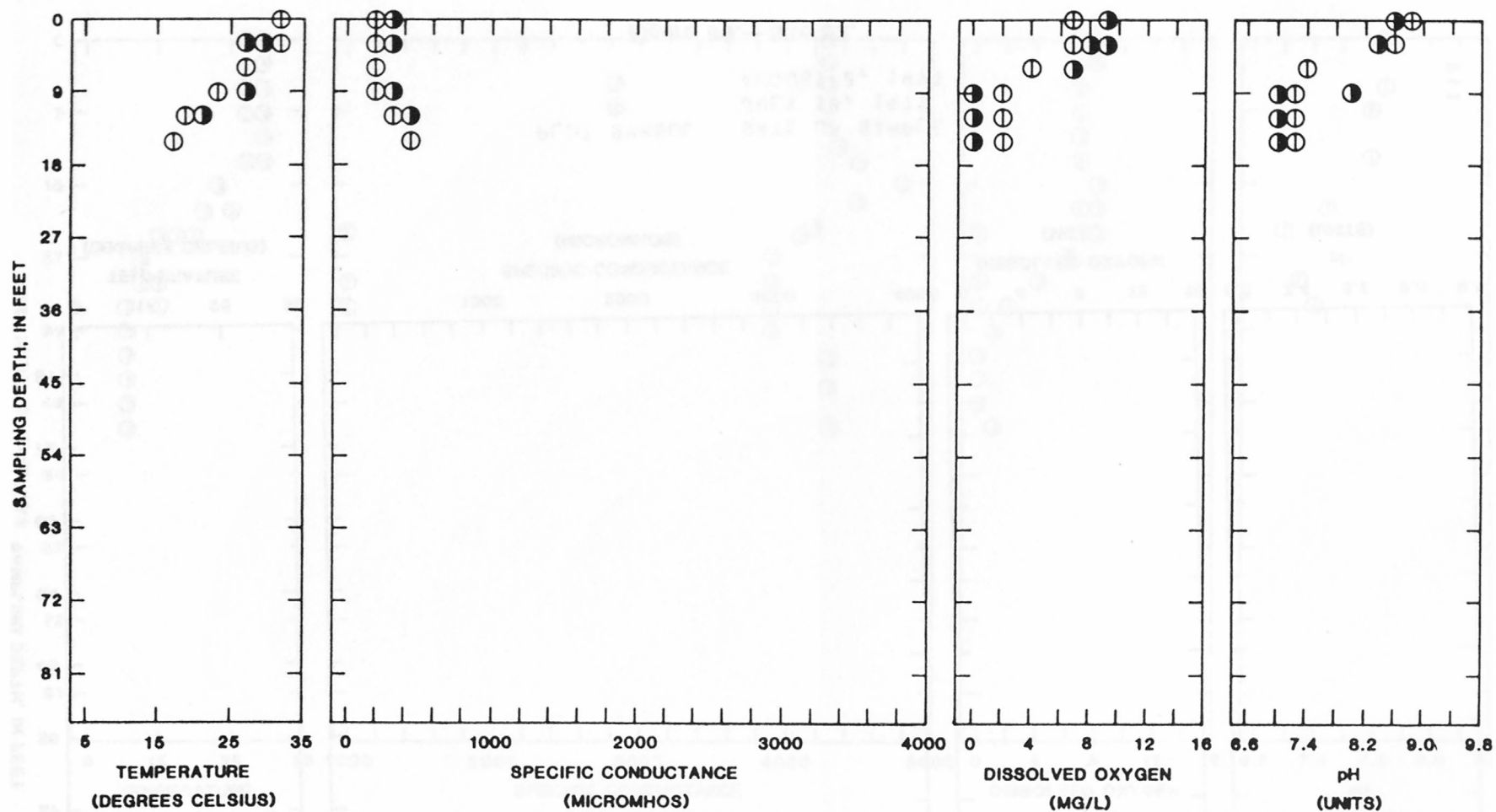
PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 29, 1977
 ● AUGUST 16, 1979

Figure 88.--Site 31.



PLUT SYMBOL DATE OF SAMPLE
 ○ JULY 19, 1977
 ● AUGUST 2, 1979

Figure 89.--Site 32.



PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 19, 1977
 ● AUGUST 1, 1979

Figure 90.--Site 33.

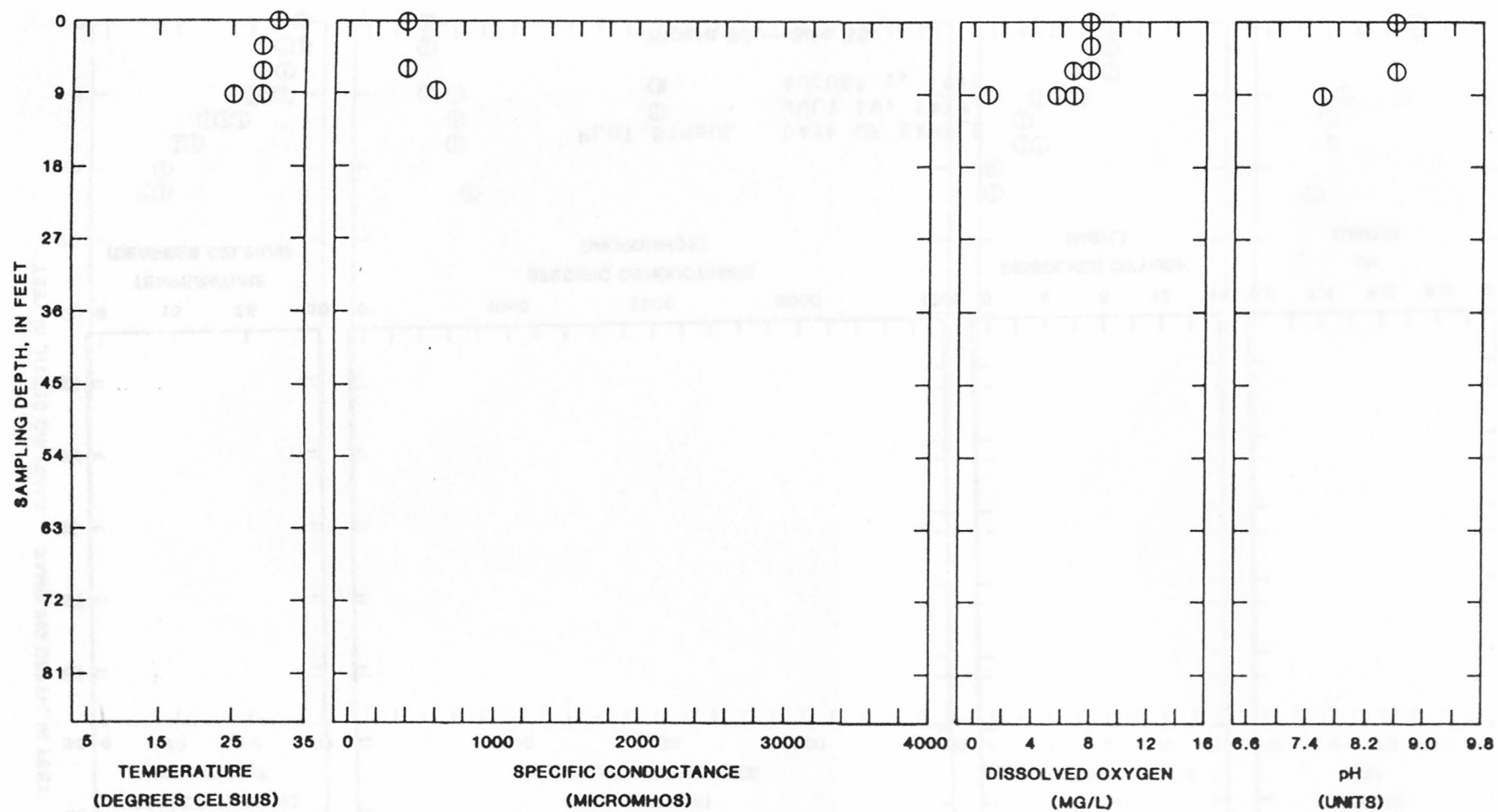
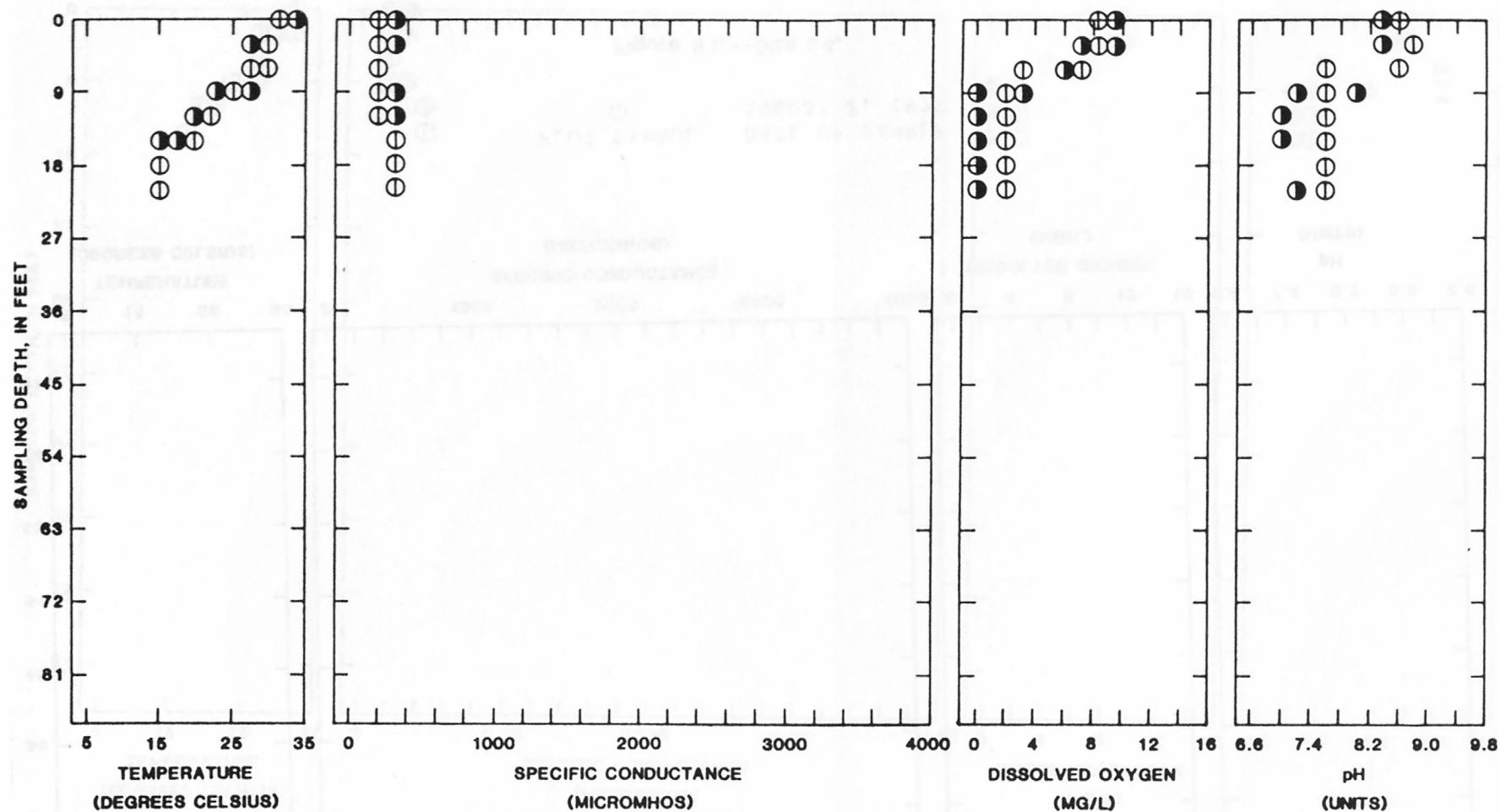
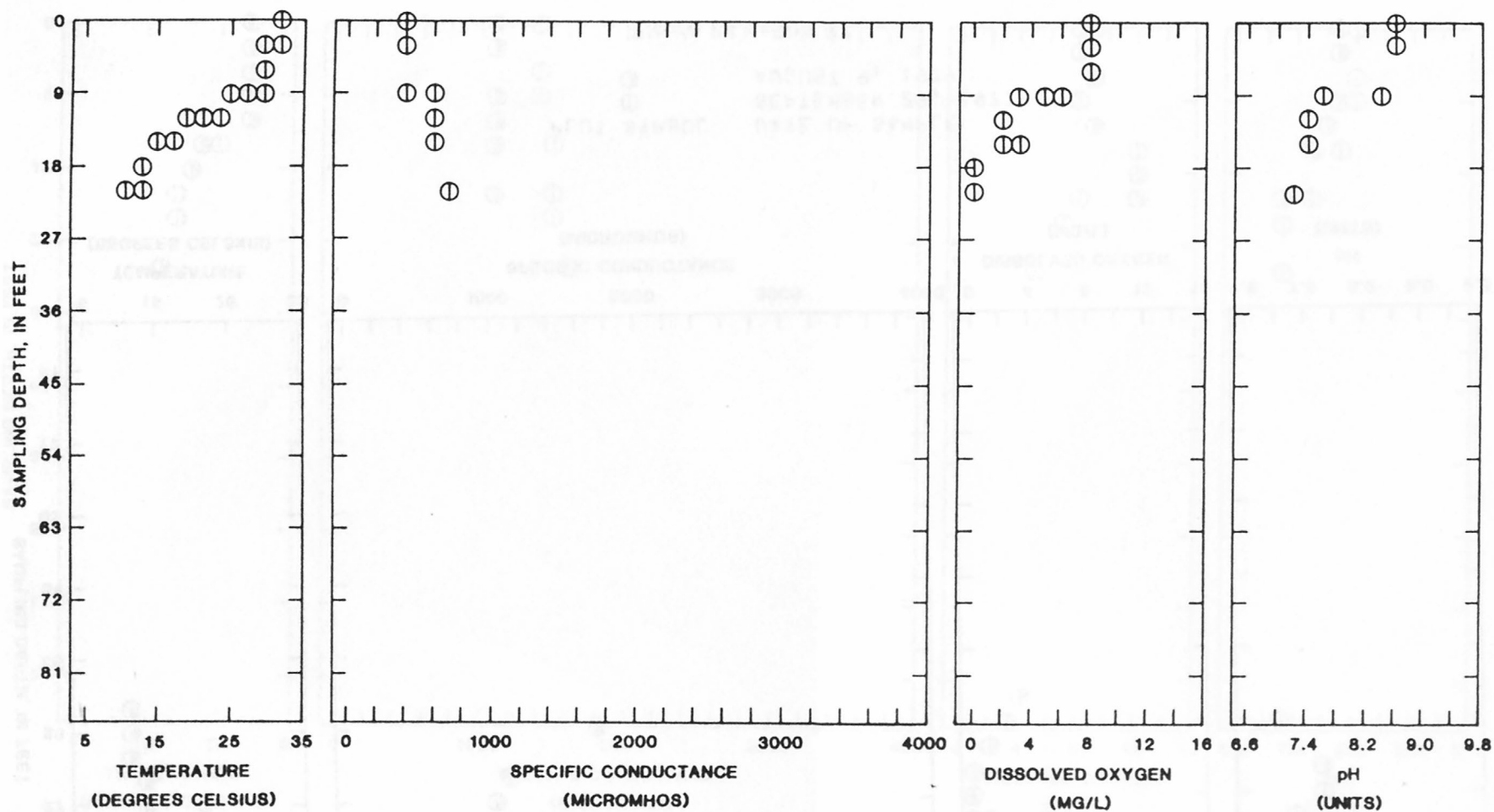


Figure 91.--Site 34.



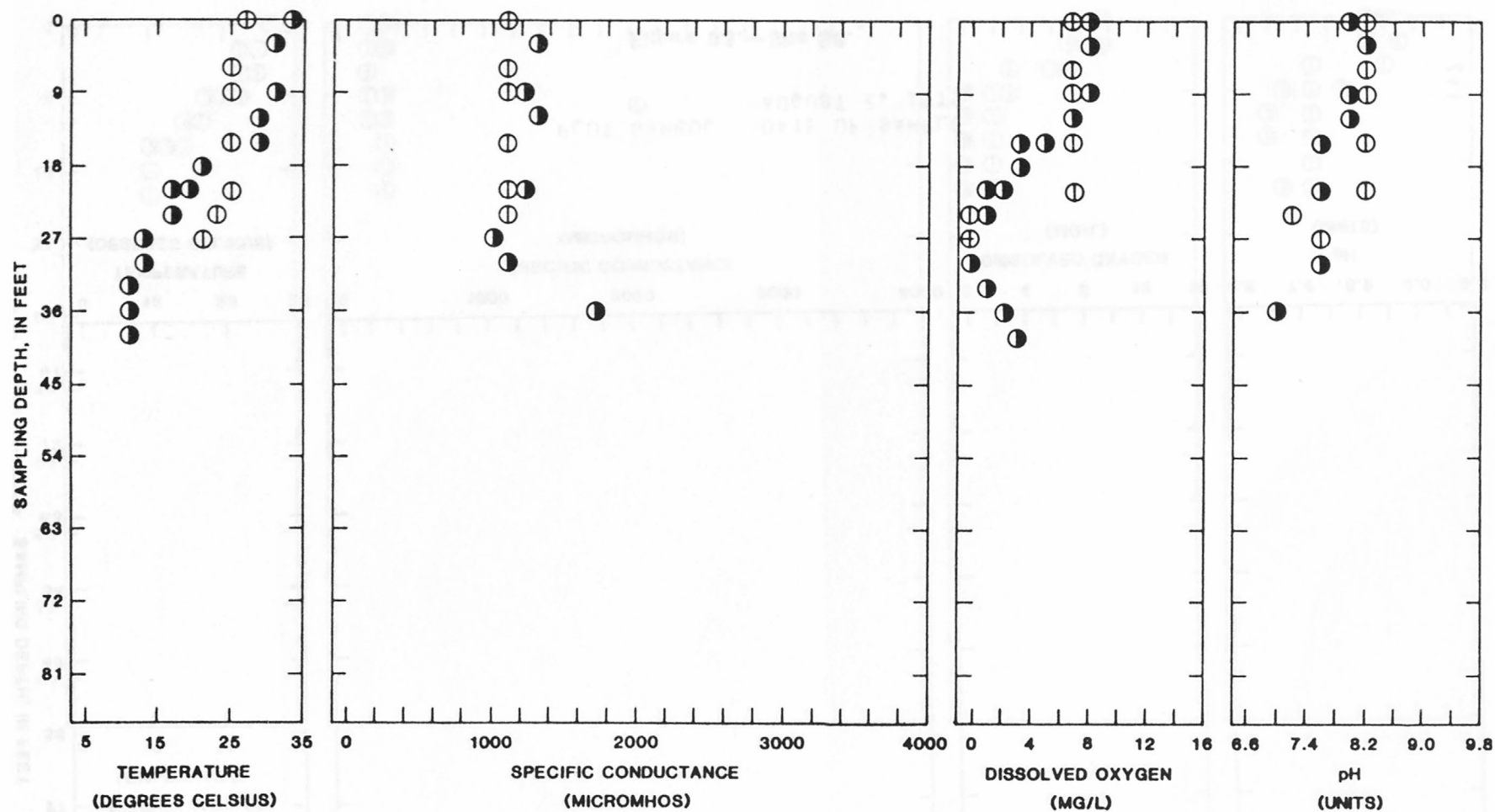
PLUT SYMBOL DATE OF SAMPLE
 ○ JULY 19, 1977
 ● AUGUST 1, 1979

Figure 92.--Site 35.



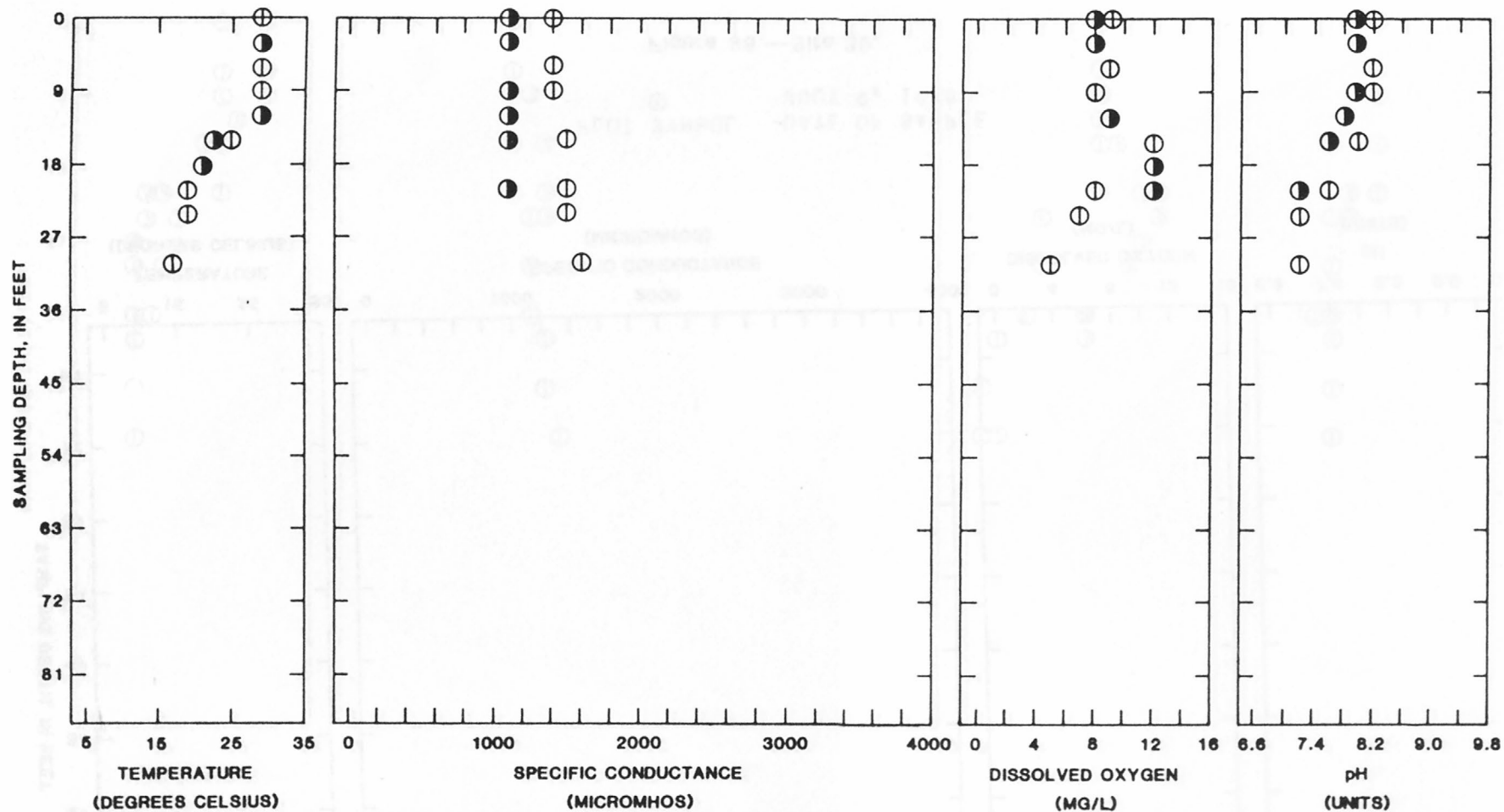
PLOT SYMBOL DATE OF SAMPLE
 ○ AUGUST 2, 1979

Figure 93.—Site 36.



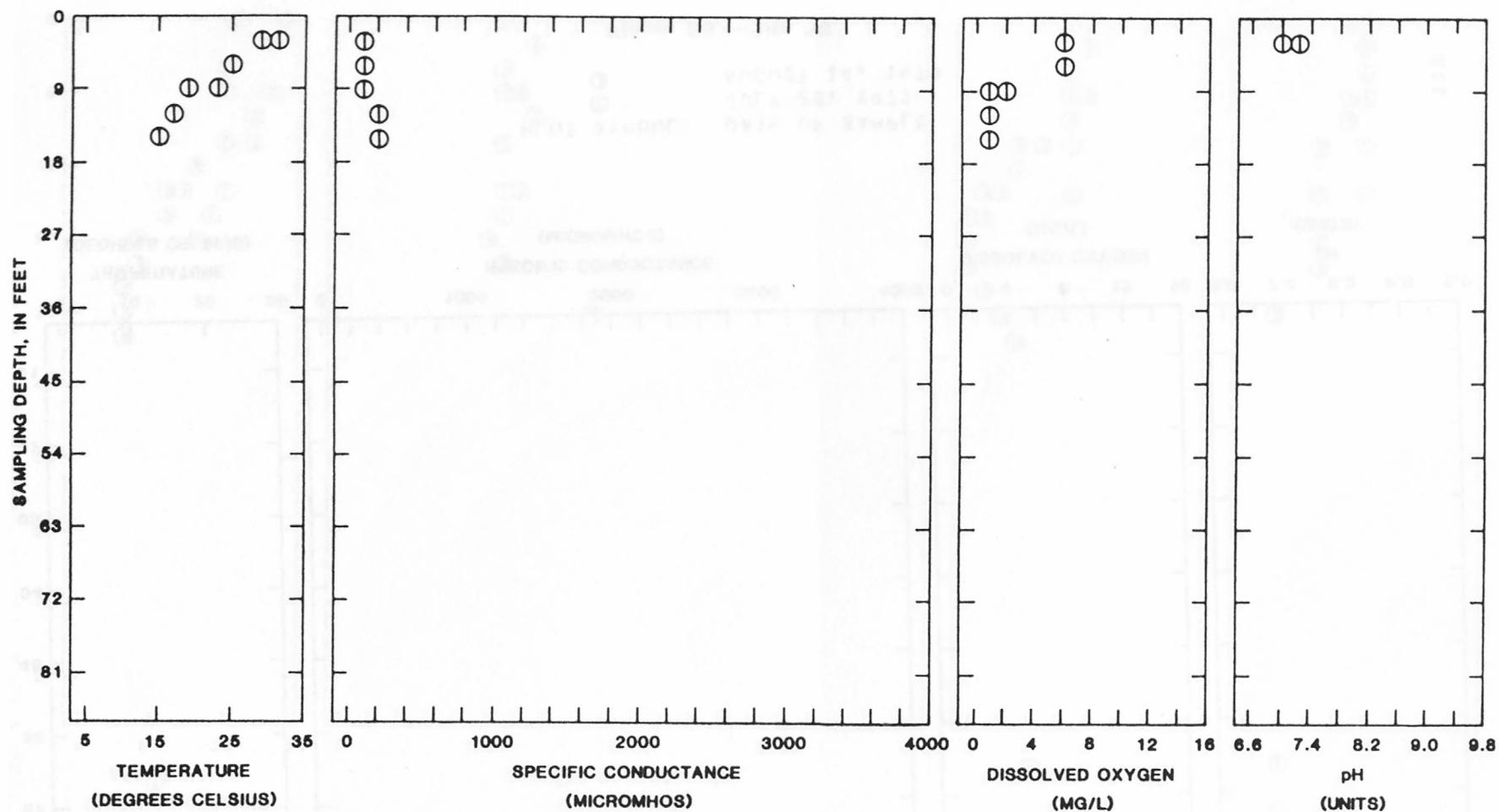
PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 29, 1977
 ● AUGUST 9, 1979

Figure 94.--Site 37.



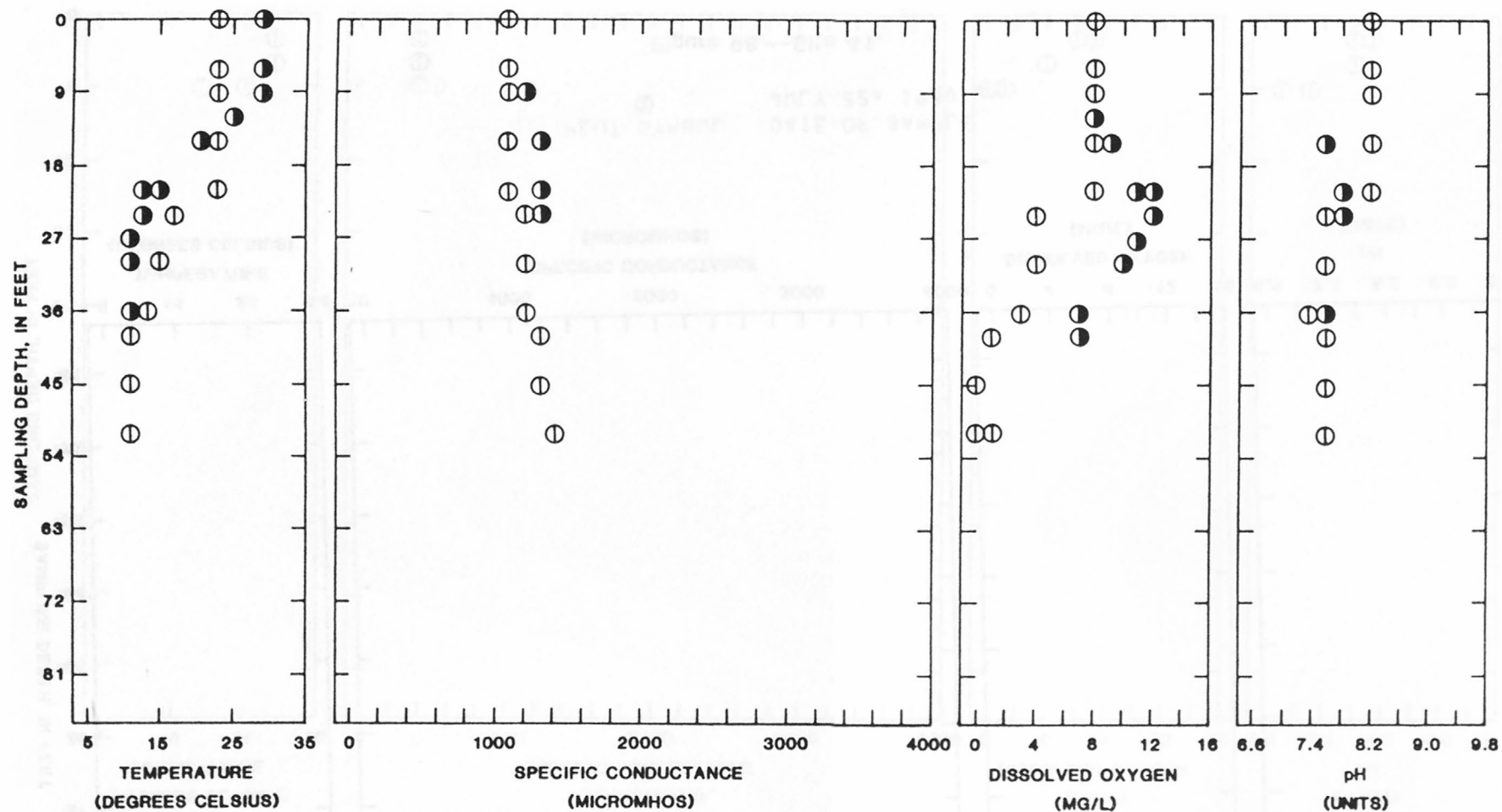
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 28, 1977
 ● AUGUST 14, 1979

Figure 95.--Site 38.



PLOT SYMBOL DATE OF SAMPLE
⊙ JULY 9, 1980

Figure 96.--Site 39.



PLOT SYMBOL DATE OF SAMPLE
 ○ OCTOBER 6, 1977
 ● AUGUST 1, 1979

Figure 97.--Site 40.

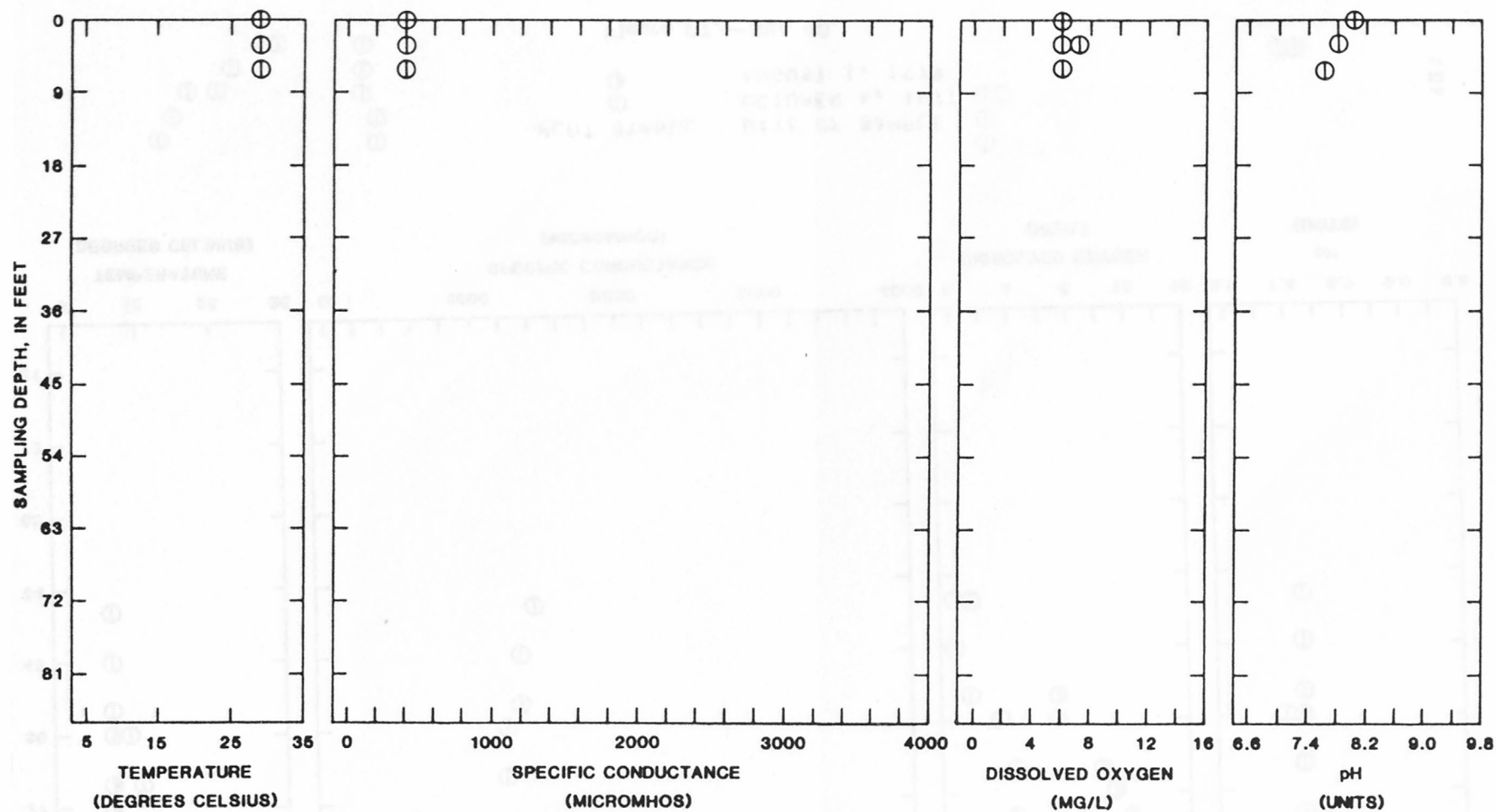
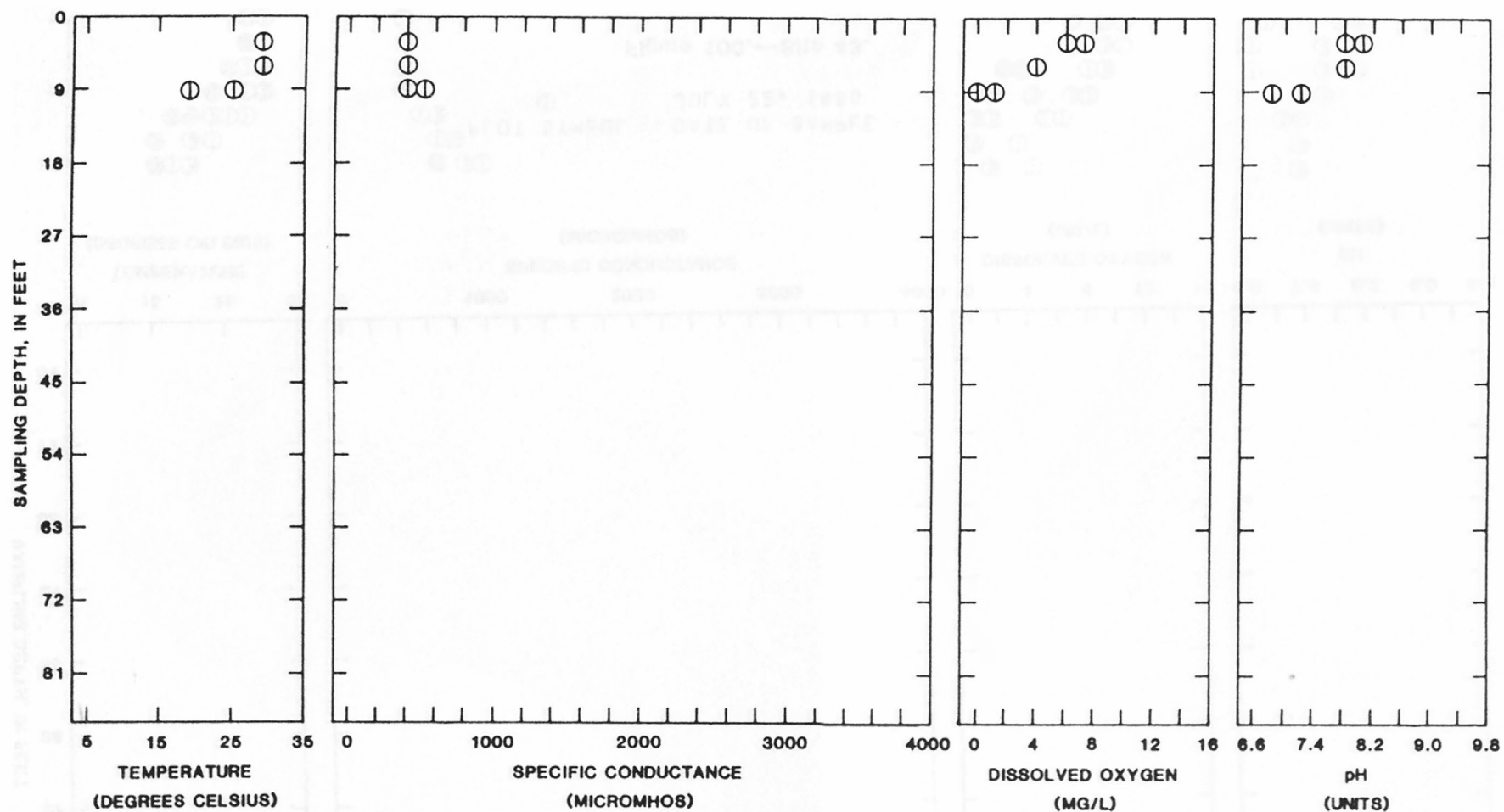
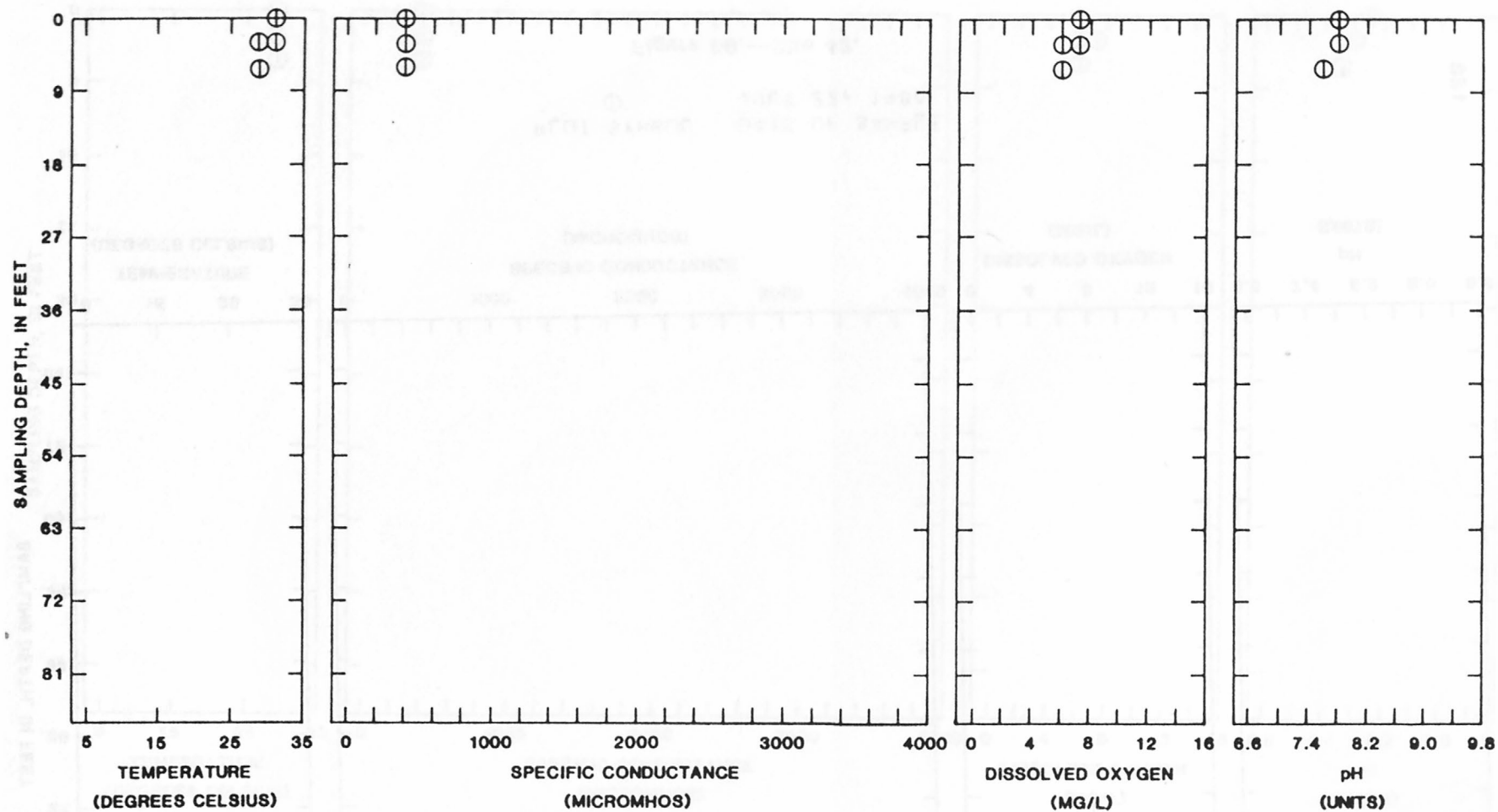


Figure 98.--Site 41.



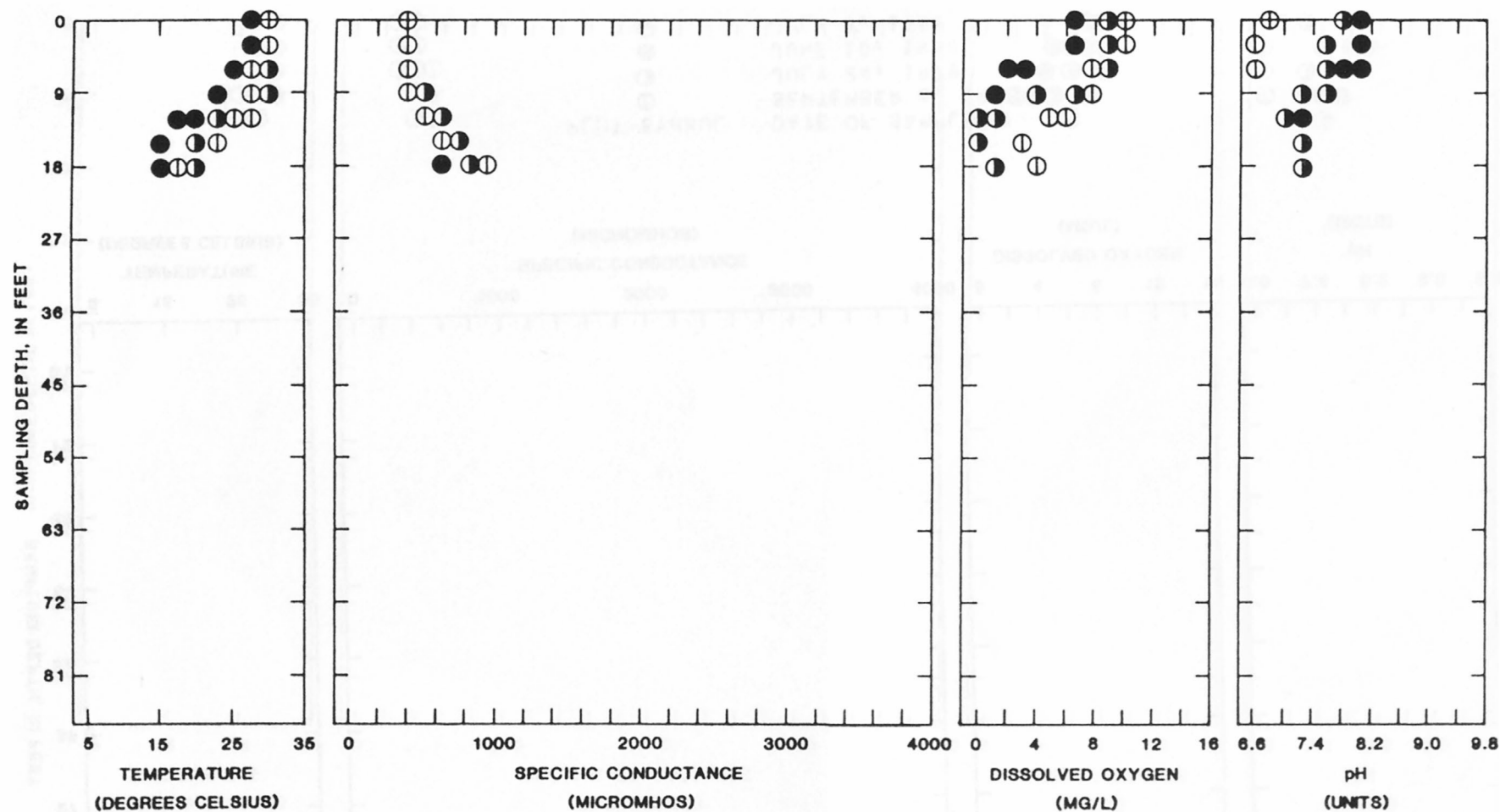
PLOT SYMBOL DATE OF SAMPLE
 ○ JULY 22, 1980

Figure 99.--Site 42.



PLOT SYMBOL DATE OF SAMPLE
⊗ JULY 22, 1980

Figure 100.--Site 43.



PLUT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 6, 1978
 ⊙ JULY 23, 1979
 ● JUNE 10, 1980

Figure 101.--Site 44.

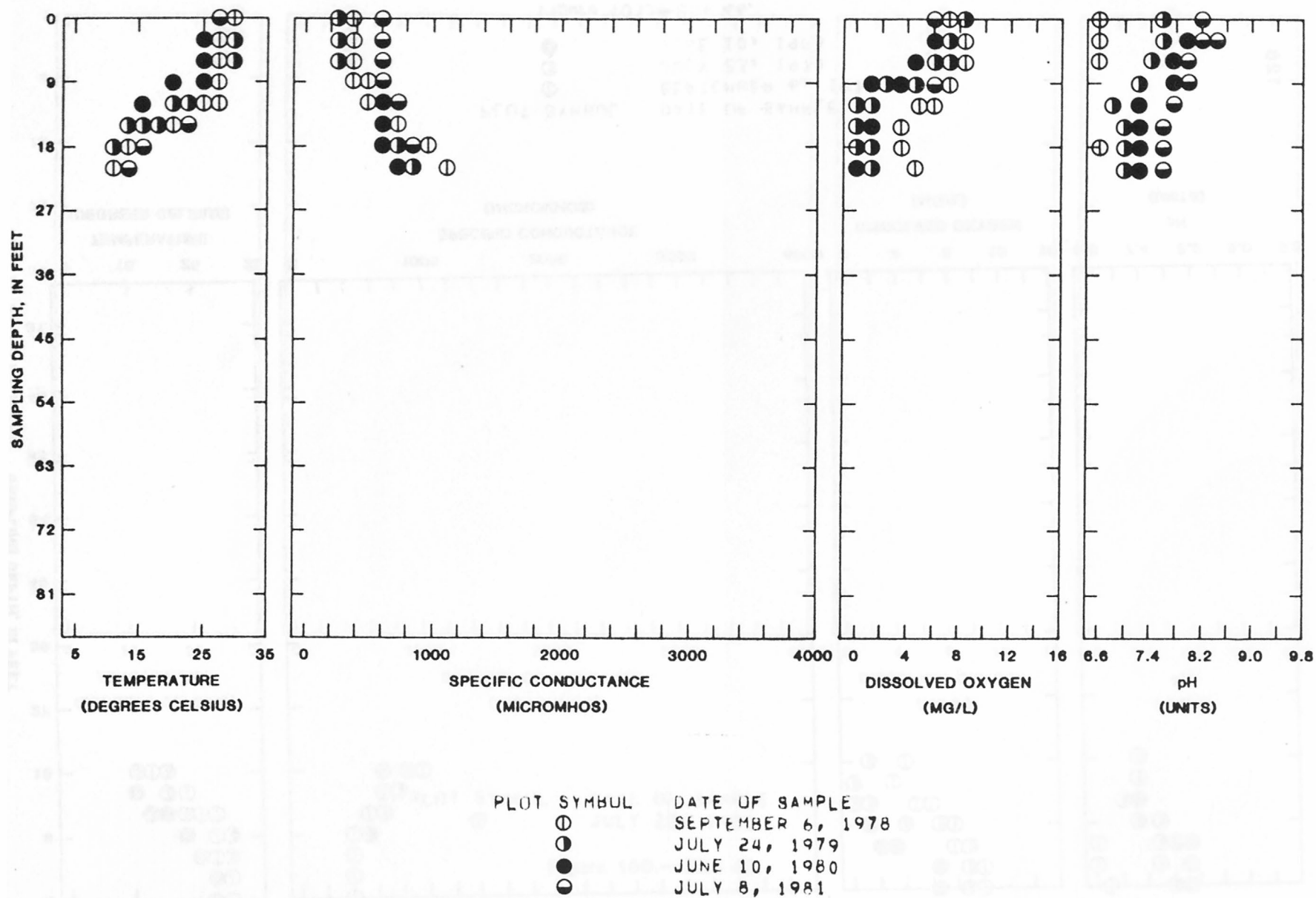
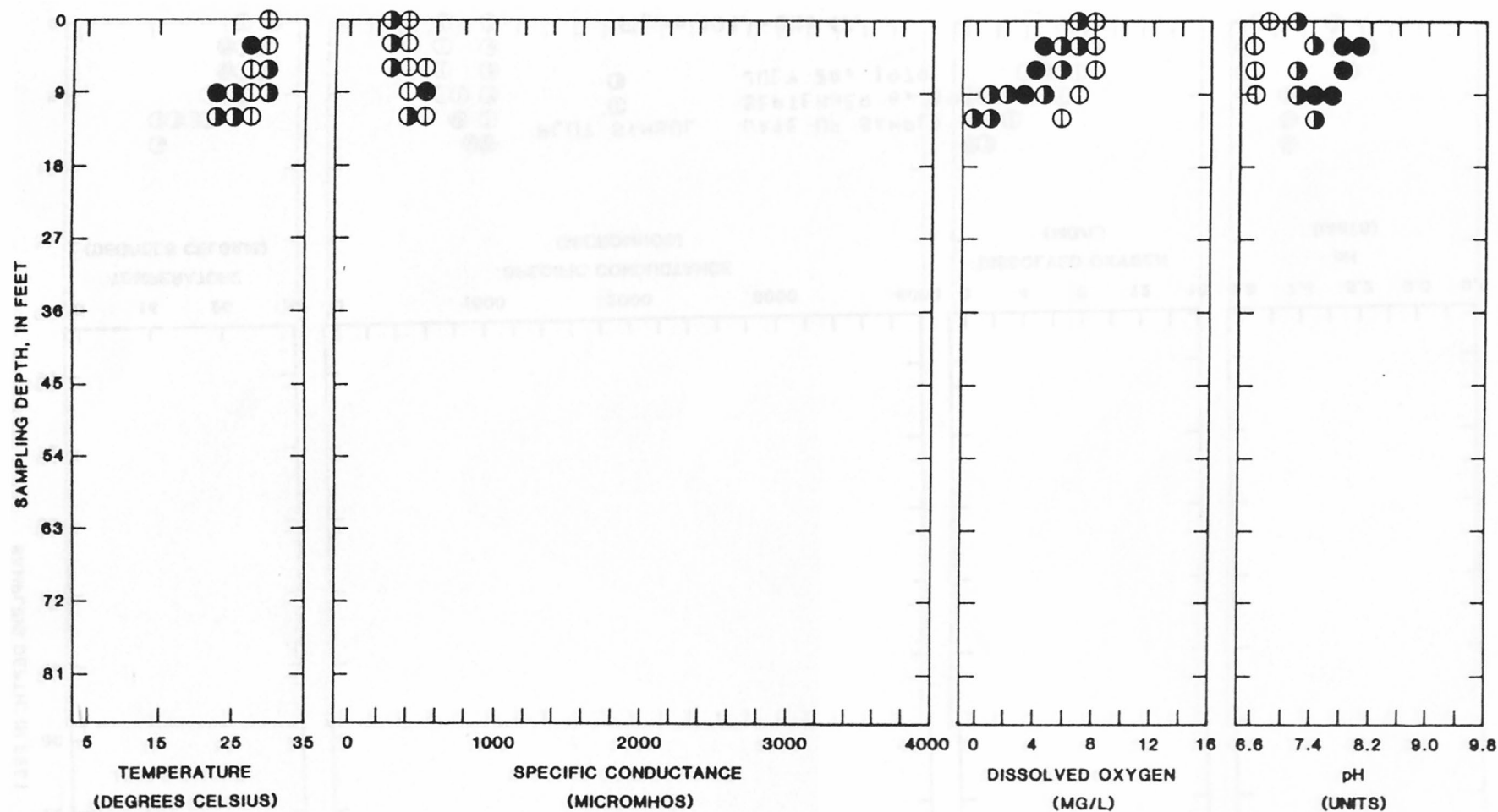
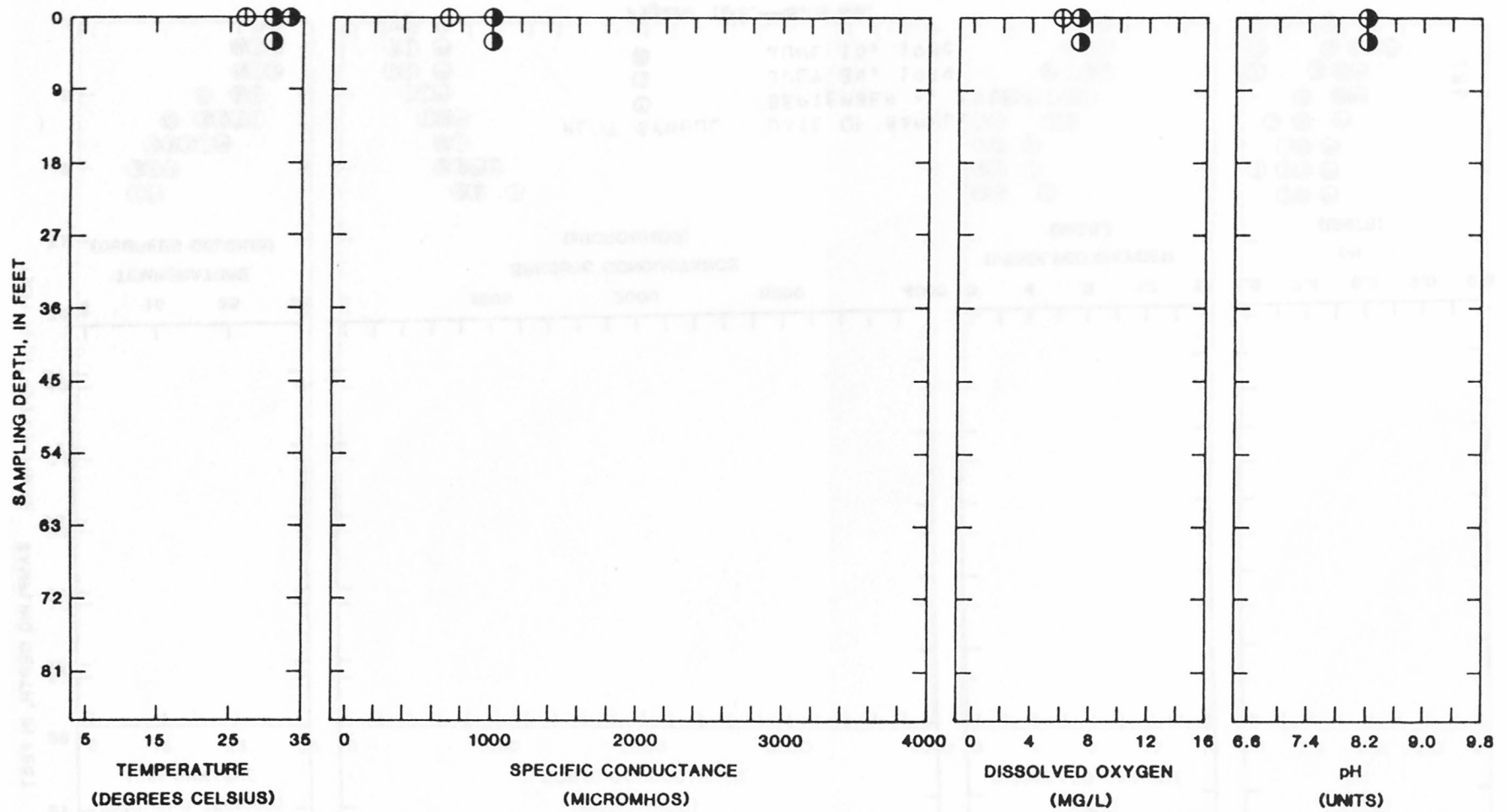


Figure 102.--Site 45.



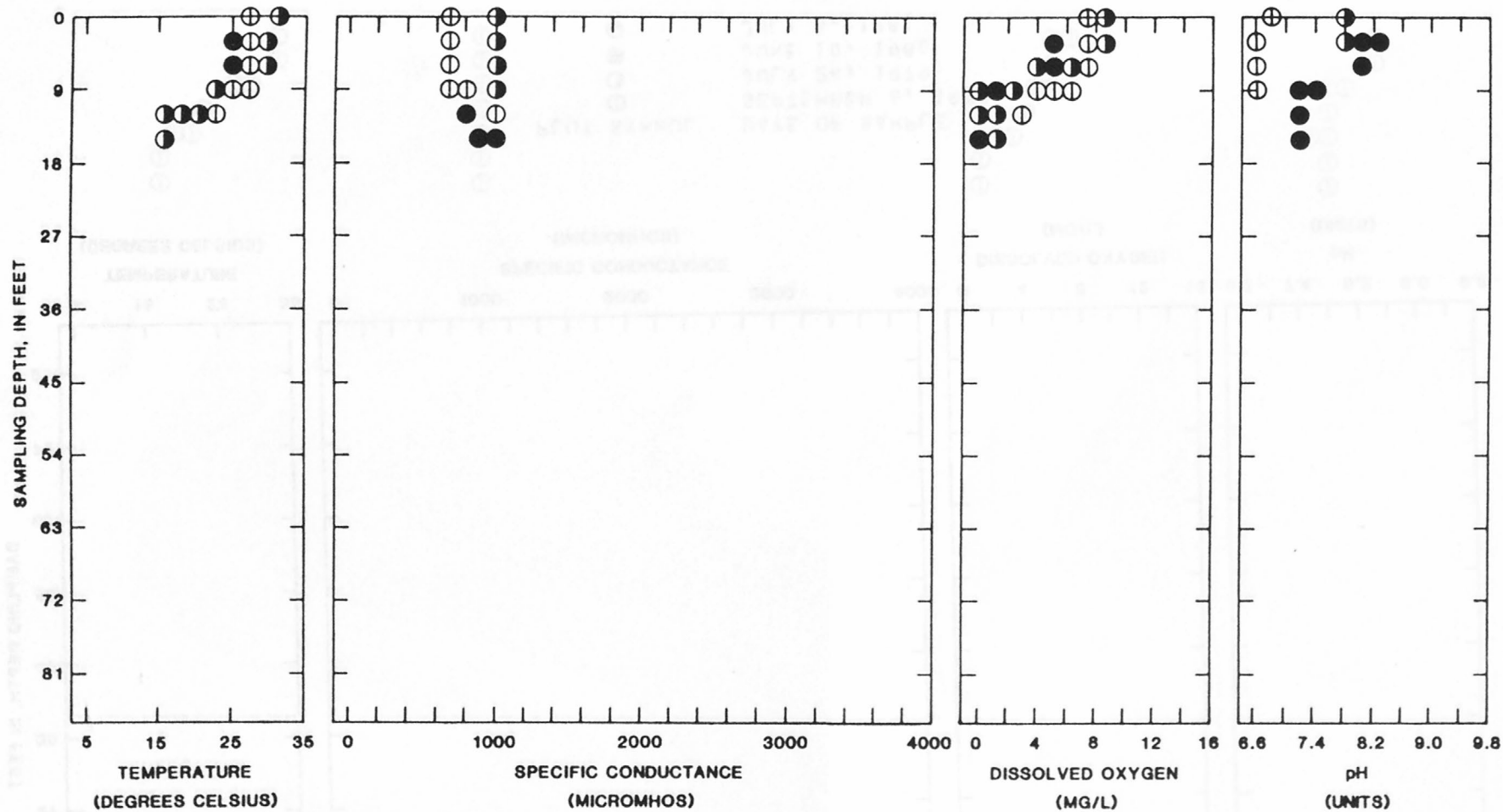
PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 6, 1978
 ◐ JULY 24, 1979
 ● JUNE 10, 1980

Figure 103.--Site 46.



PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 6, 1978
 ● JULY 24, 1979

Figure 104.--Site 47.



PLUT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 6, 1978
 ◐ JULY 24, 1979
 ● JUNE 10, 1980

Figure 105.--Site 48.

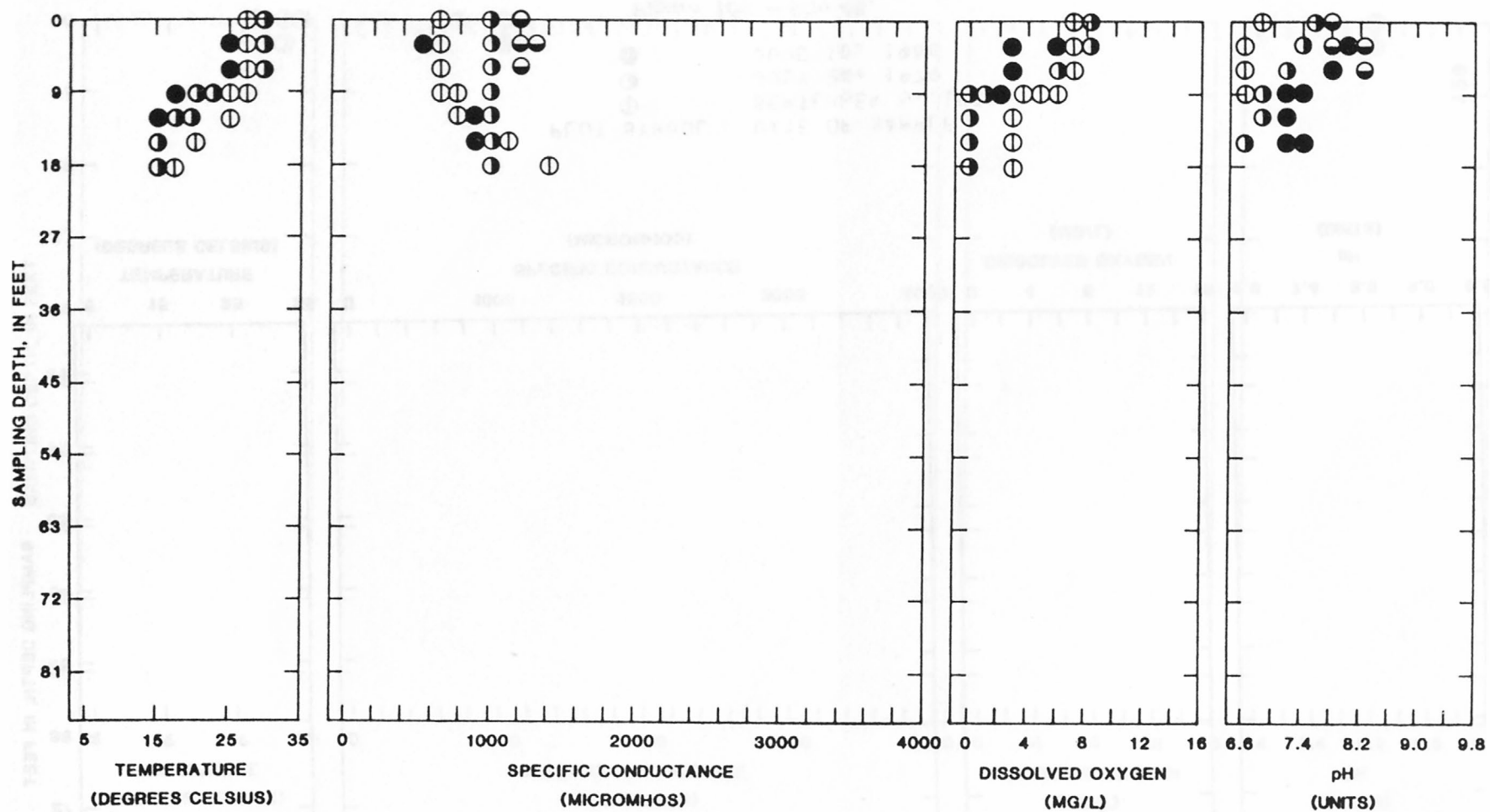


Figure 106.--Site 49.

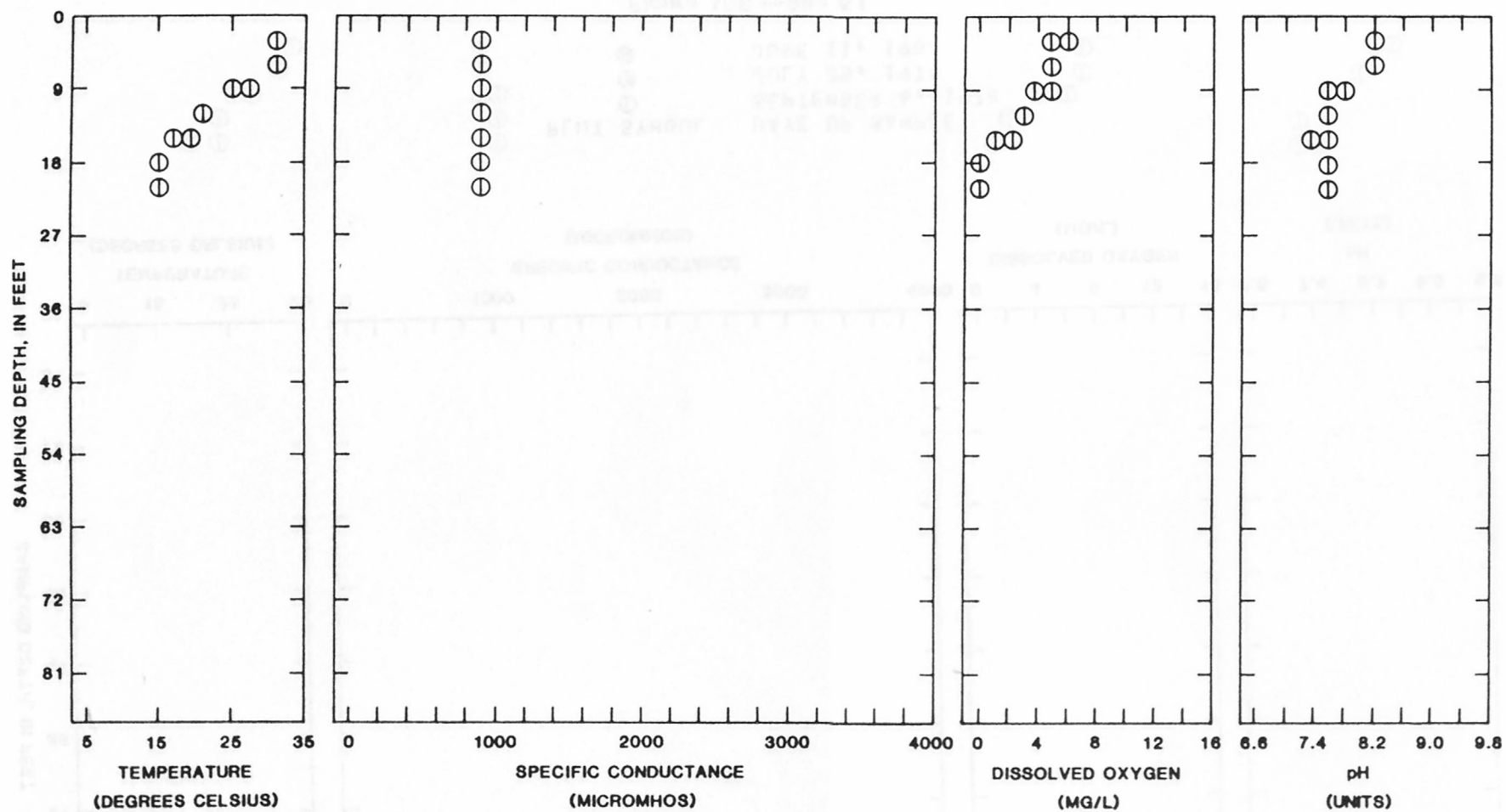
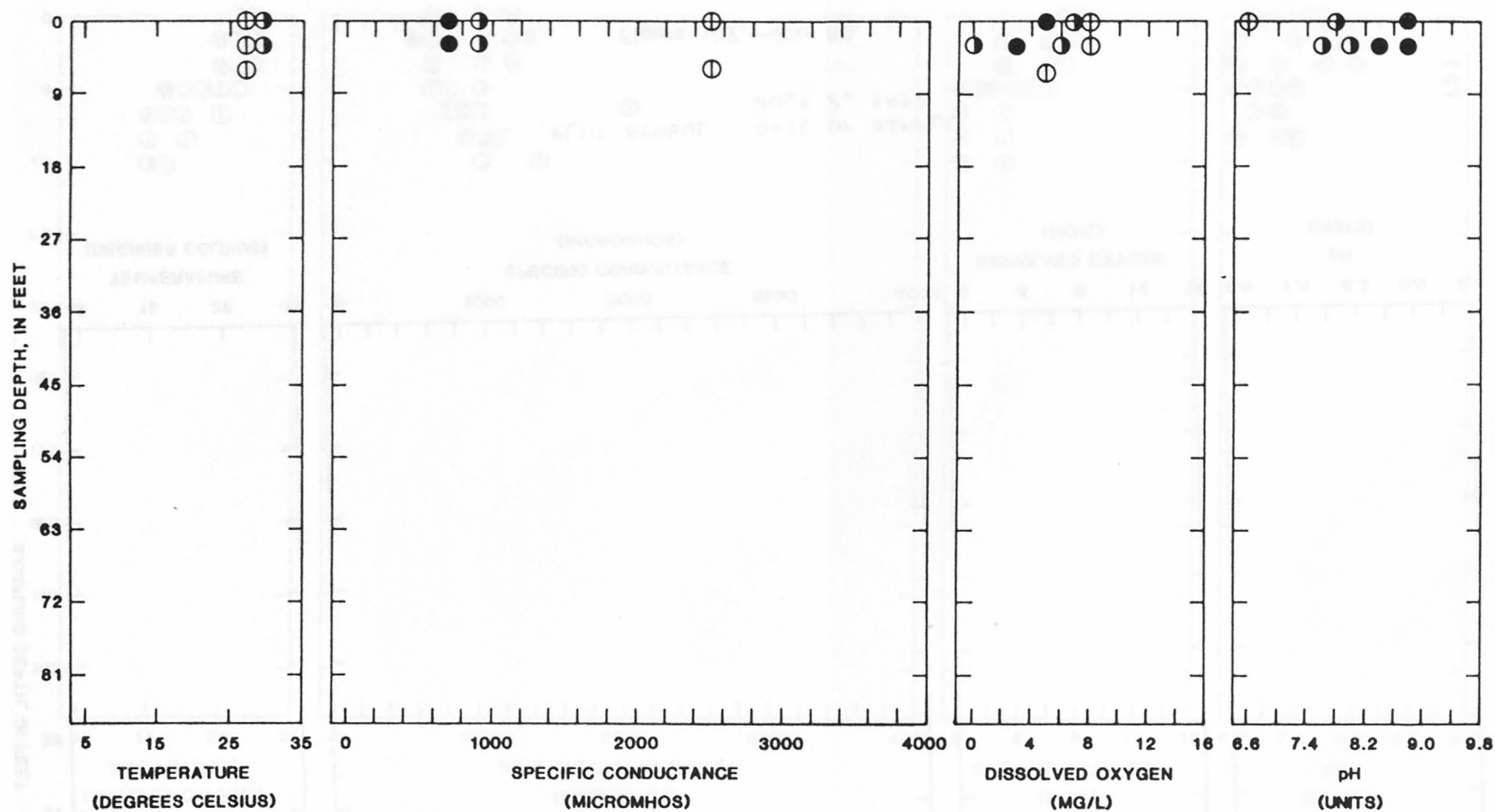
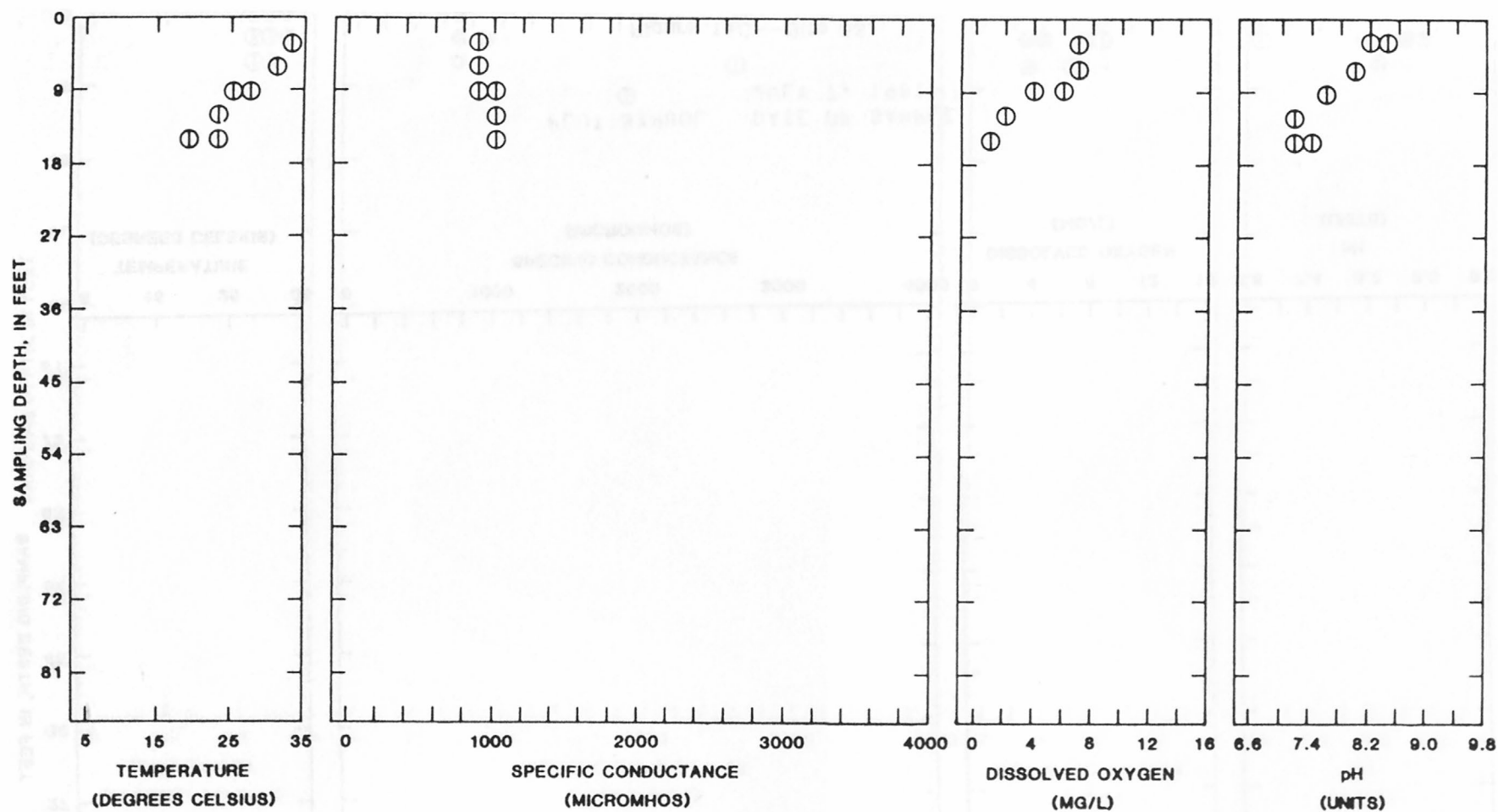


Figure 107.--Site 50.



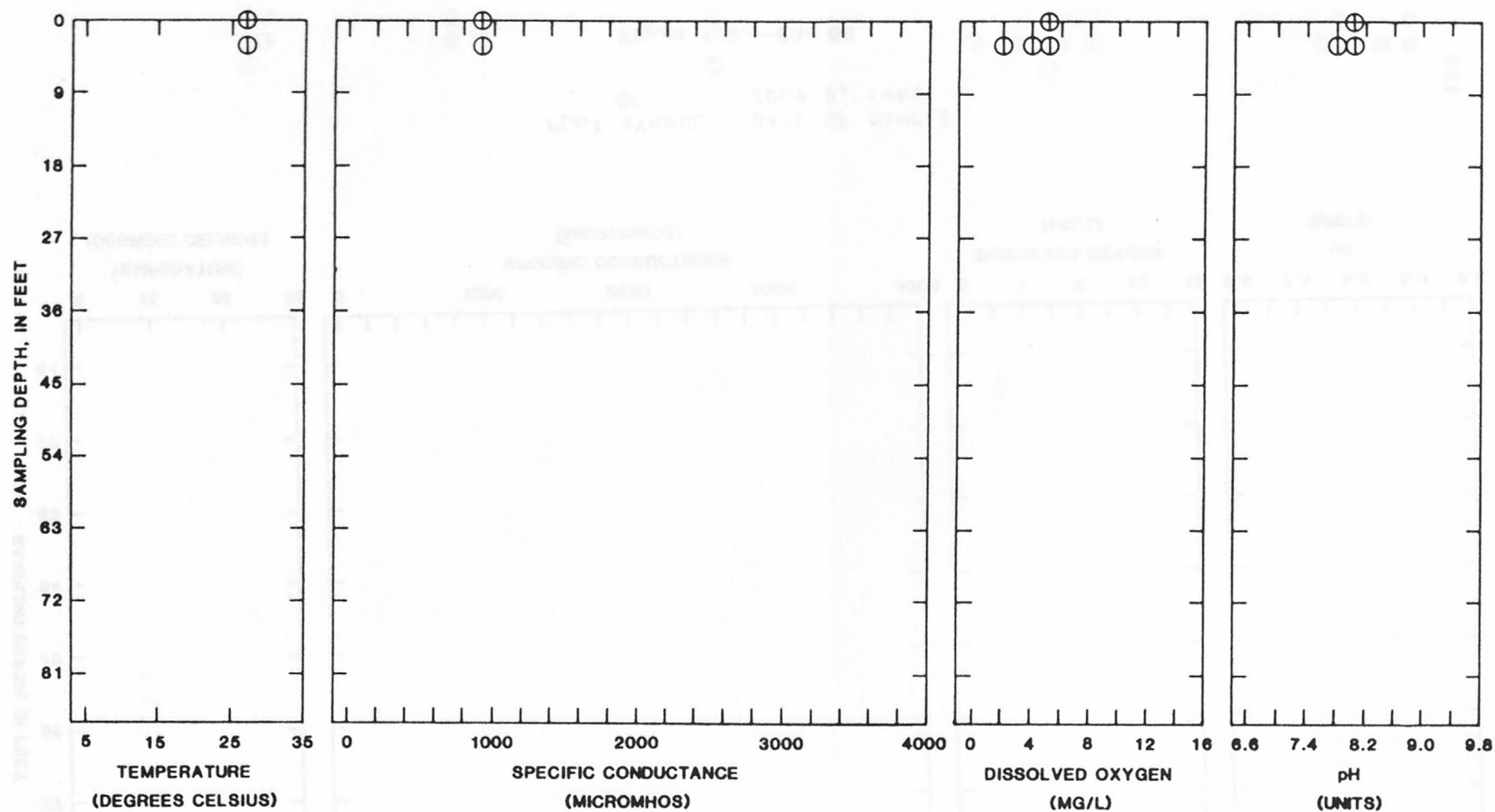
PLUT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 6, 1978
 ◐ JULY 25, 1979
 ● JUNE 11, 1980

Figure 108.--Site 51.



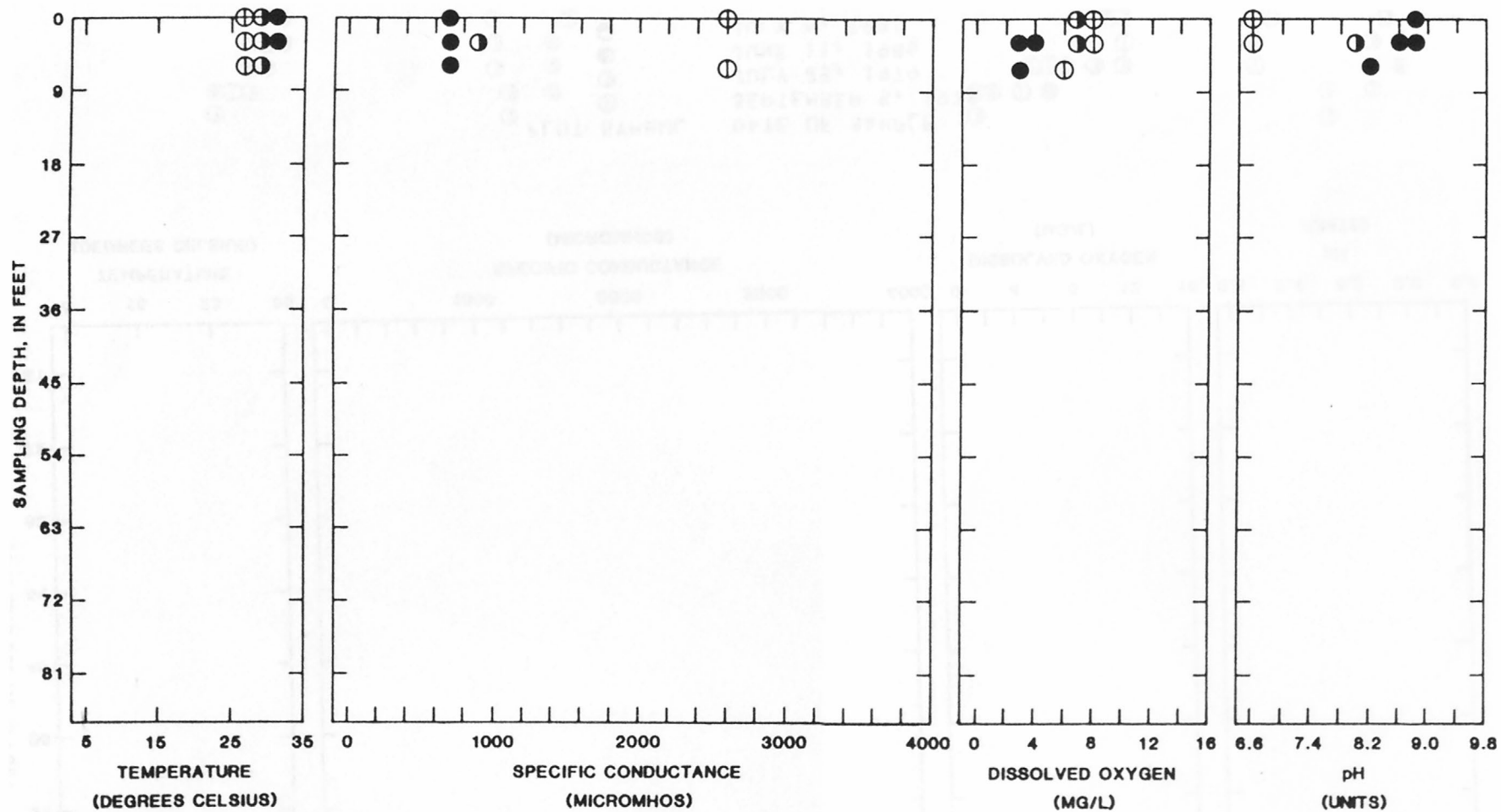
PLOT SYMBOL DATE OF SAMPLE
 ⊕ JULY 2, 1980

Figure 109.--Site 52.



PLUT SYMBOL DATE OF SAMPLE
⊕ JULY 7, 1981

Figure 110.--Site 53.



○	DATE OF SAMPLE
◐	SEPTEMBER 6, 1978
◑	JULY 25, 1979
●	JUNE 11, 1980

Figure 111.--Site 54.

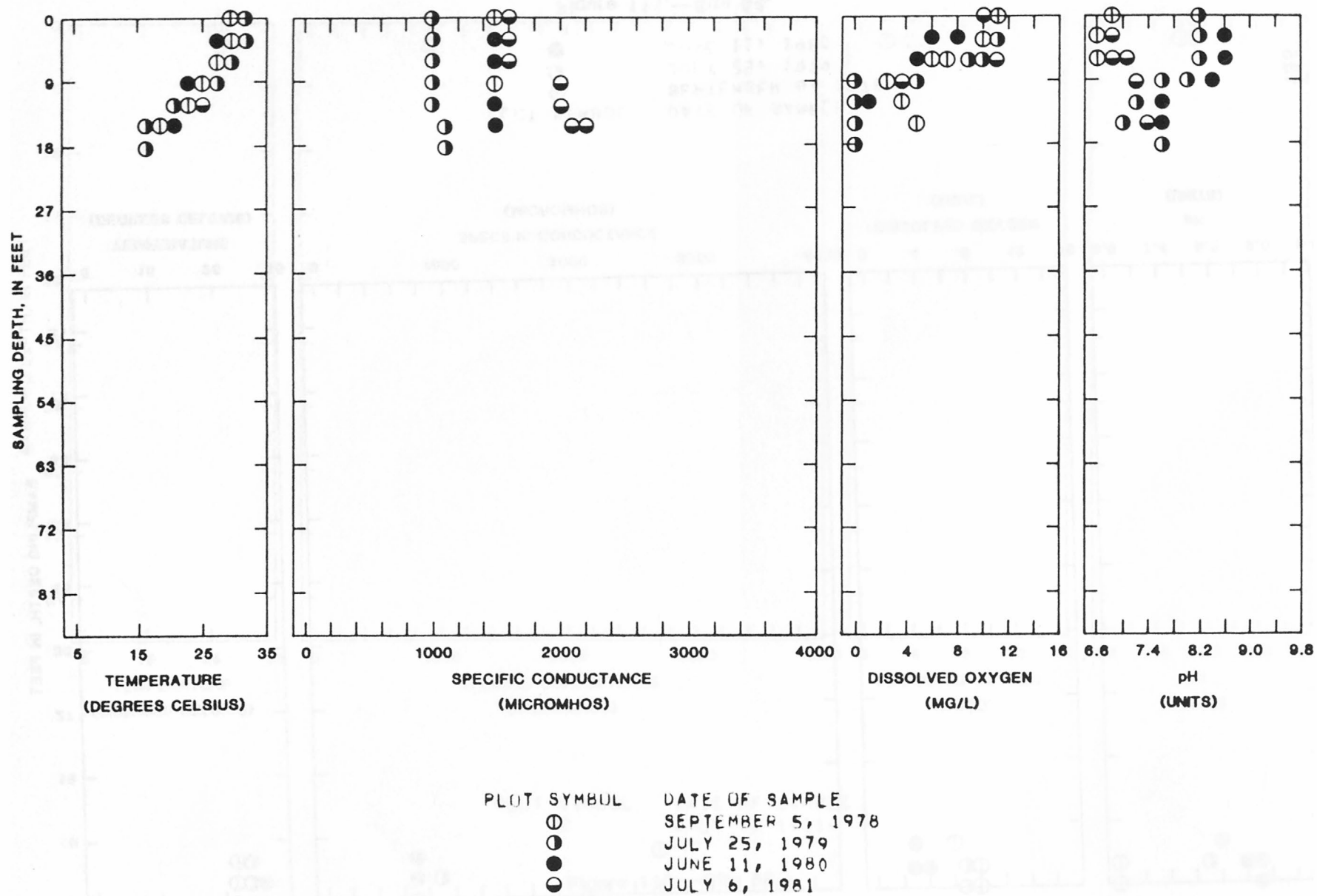


Figure 112.--Site 55.

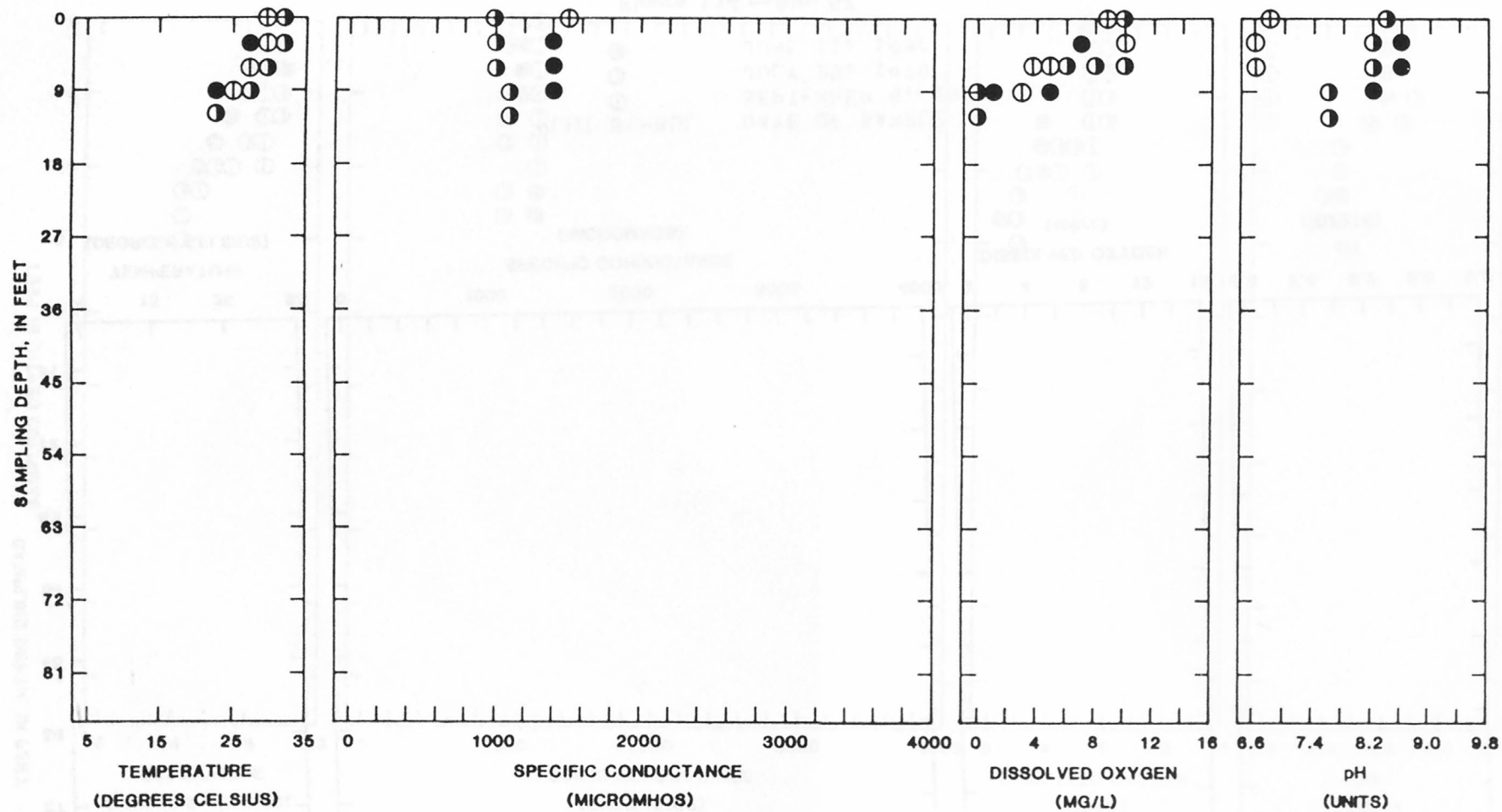
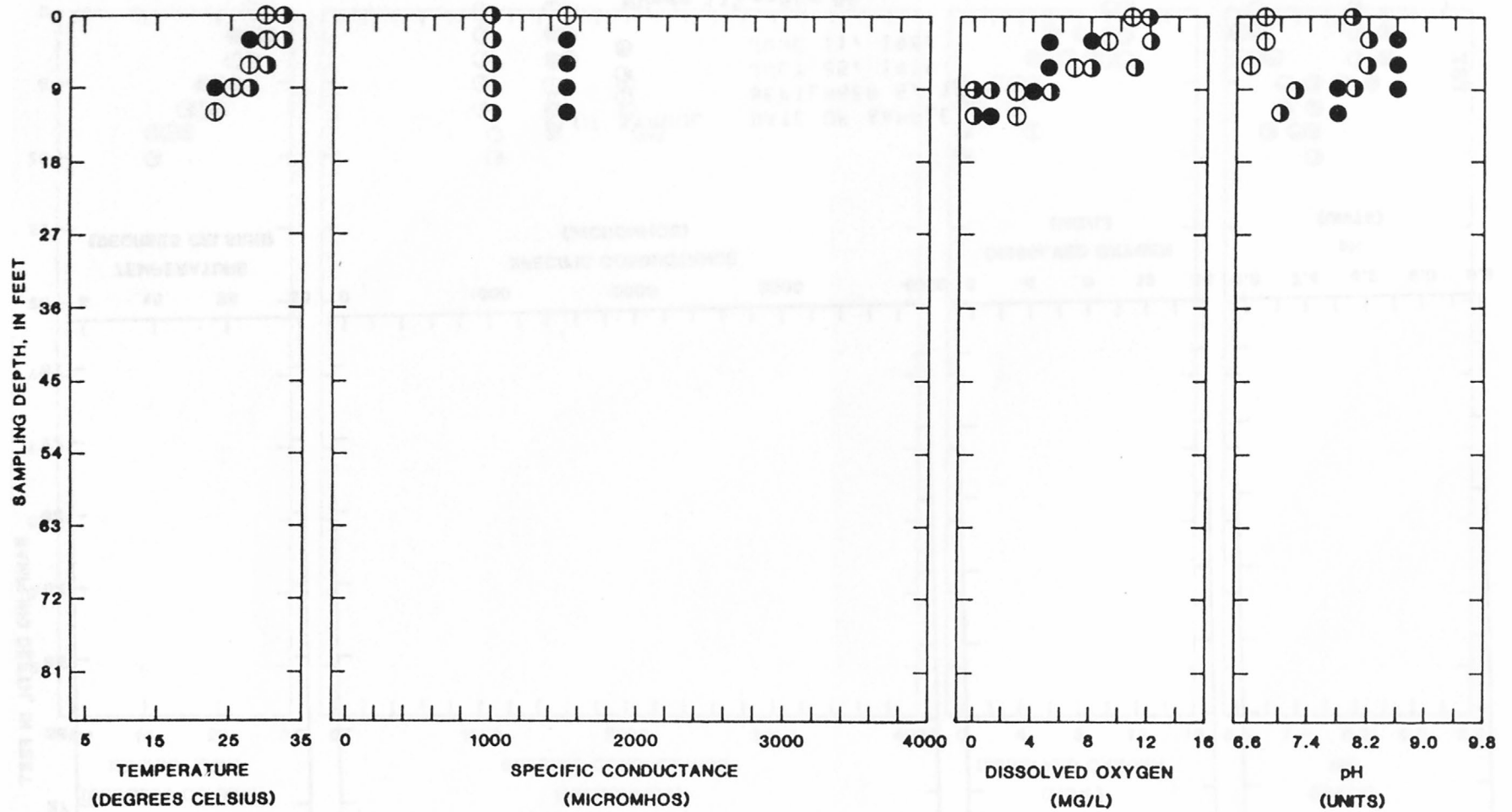
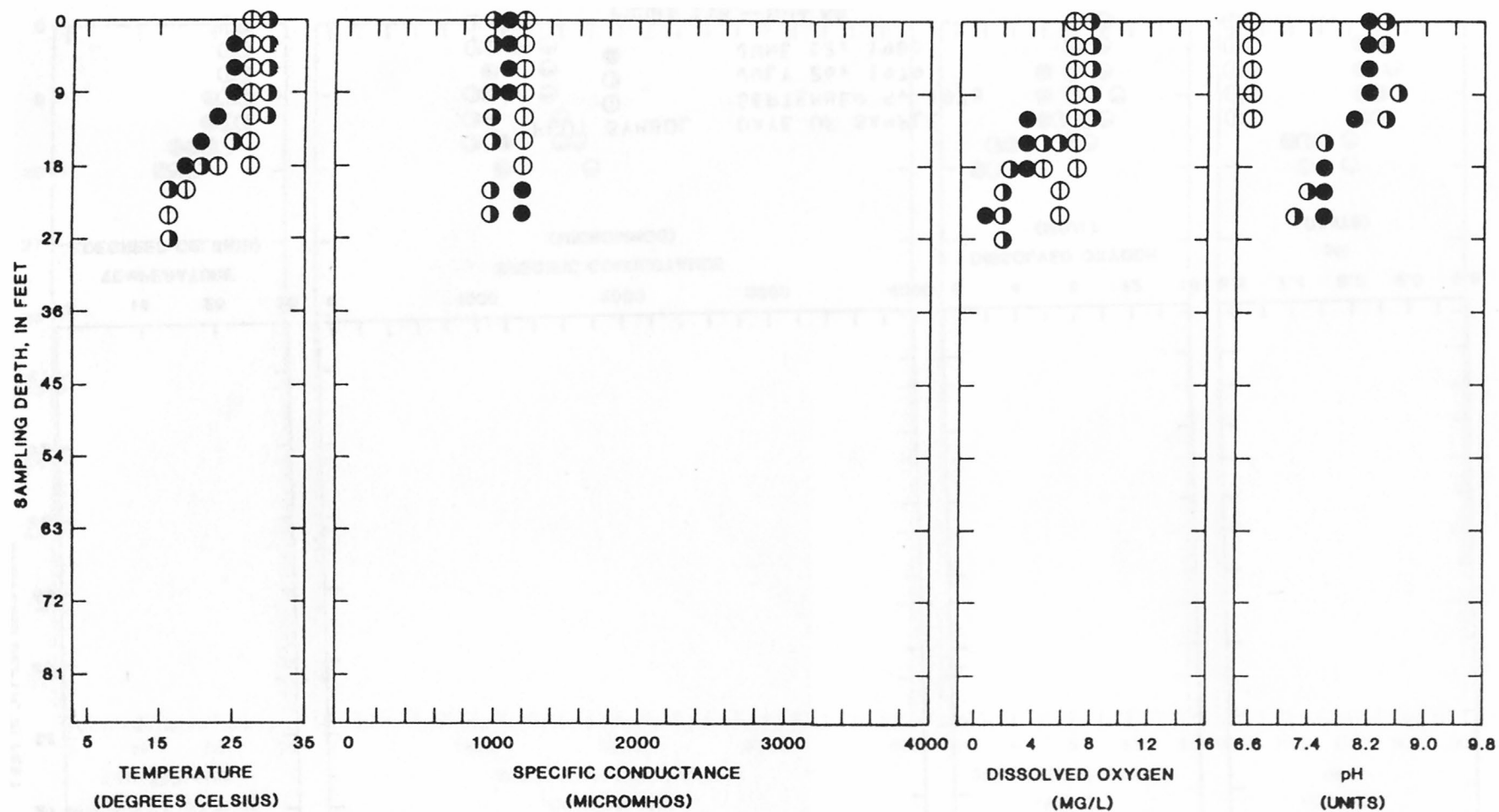


Figure 113.--Site 56.



PLT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 5, 1978
 ◐ JULY 25, 1979
 ● JUNE 11, 1980

Figure 114.--Site 57.



PLOT SYMBOL DATE OF SAMPLE
 ○ SEPTEMBER 5, 1978
 ◐ JULY 26, 1979
 ● JUNE 11, 1980

Figure 115.--Site 58.

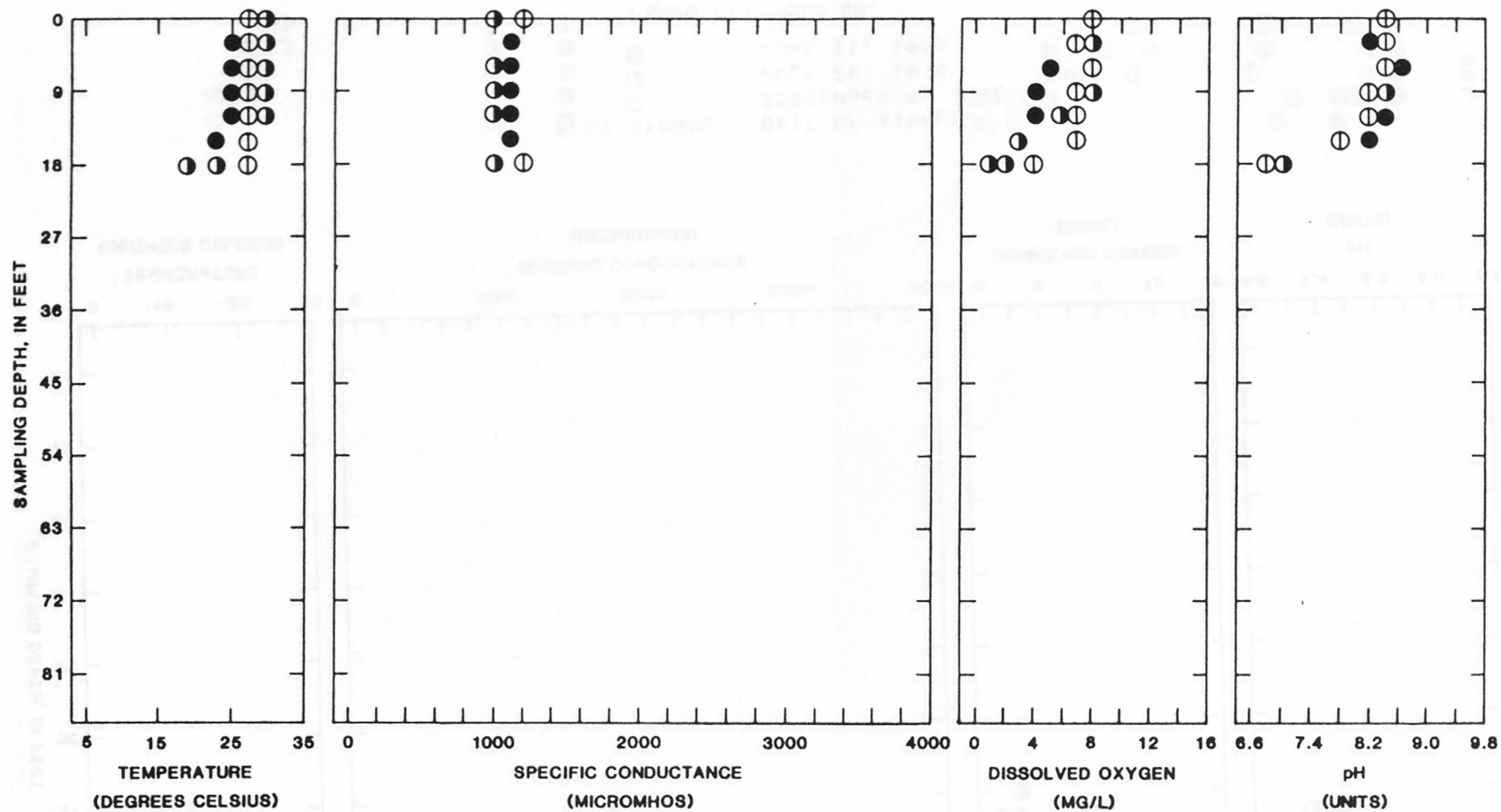


Figure 116.--Site 59.

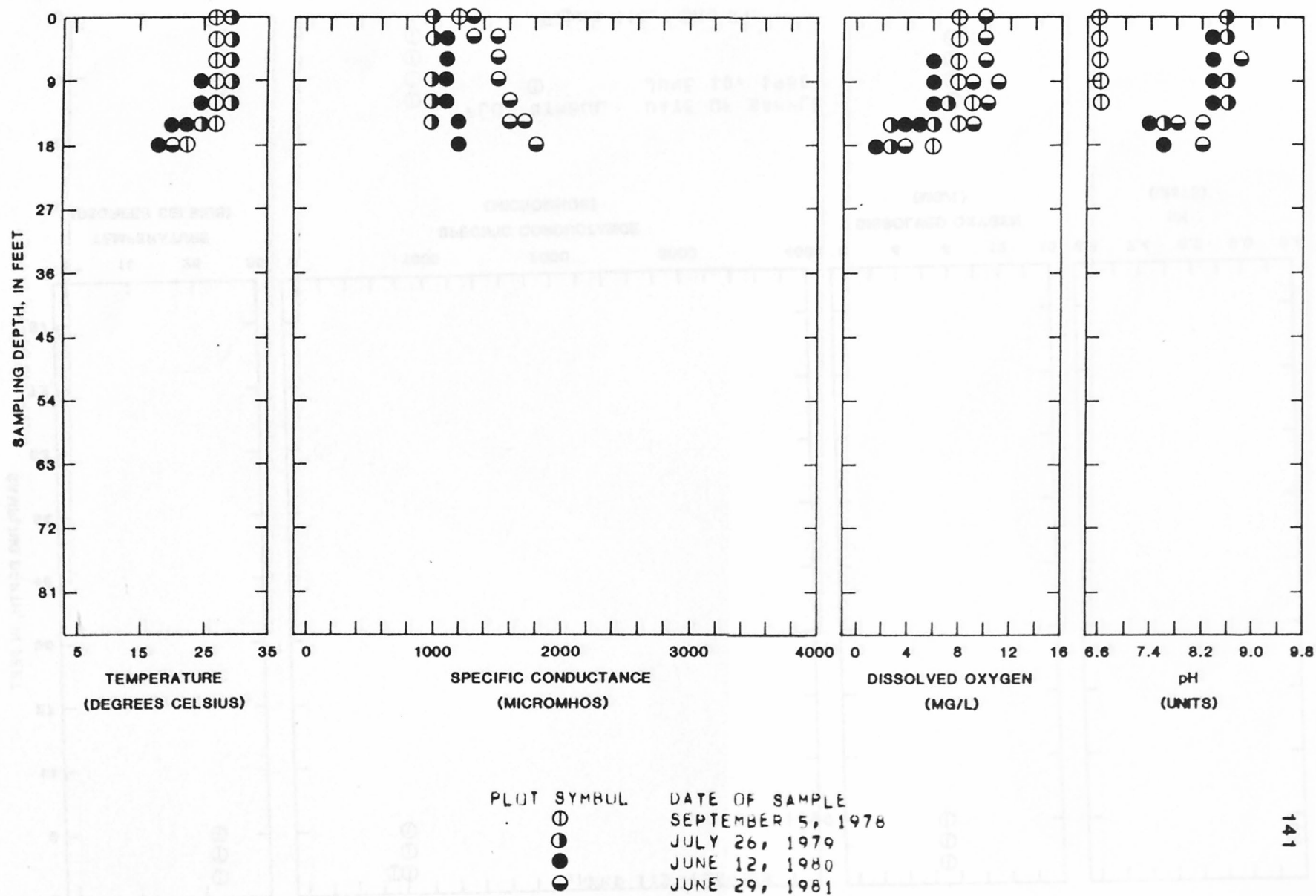
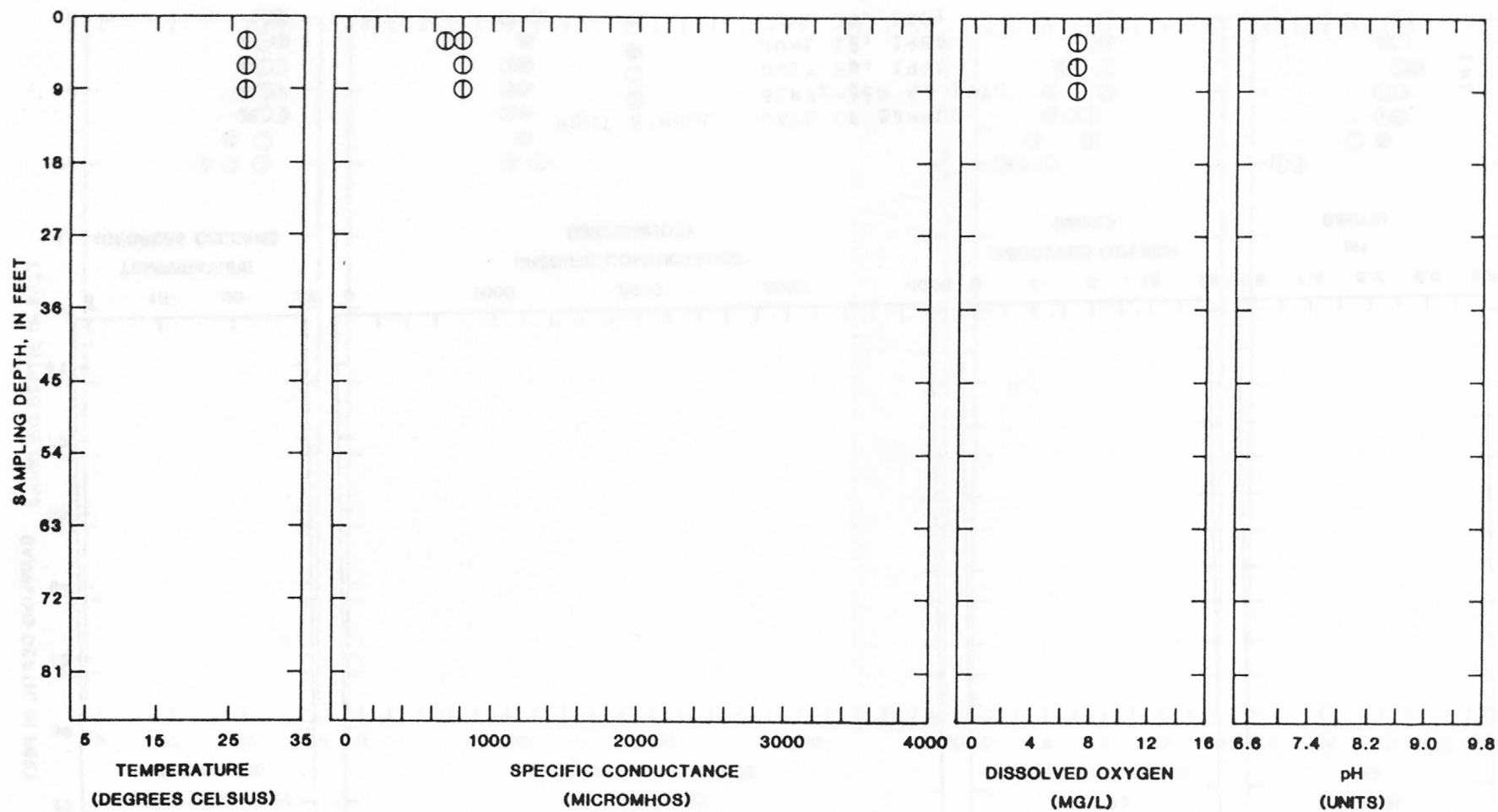
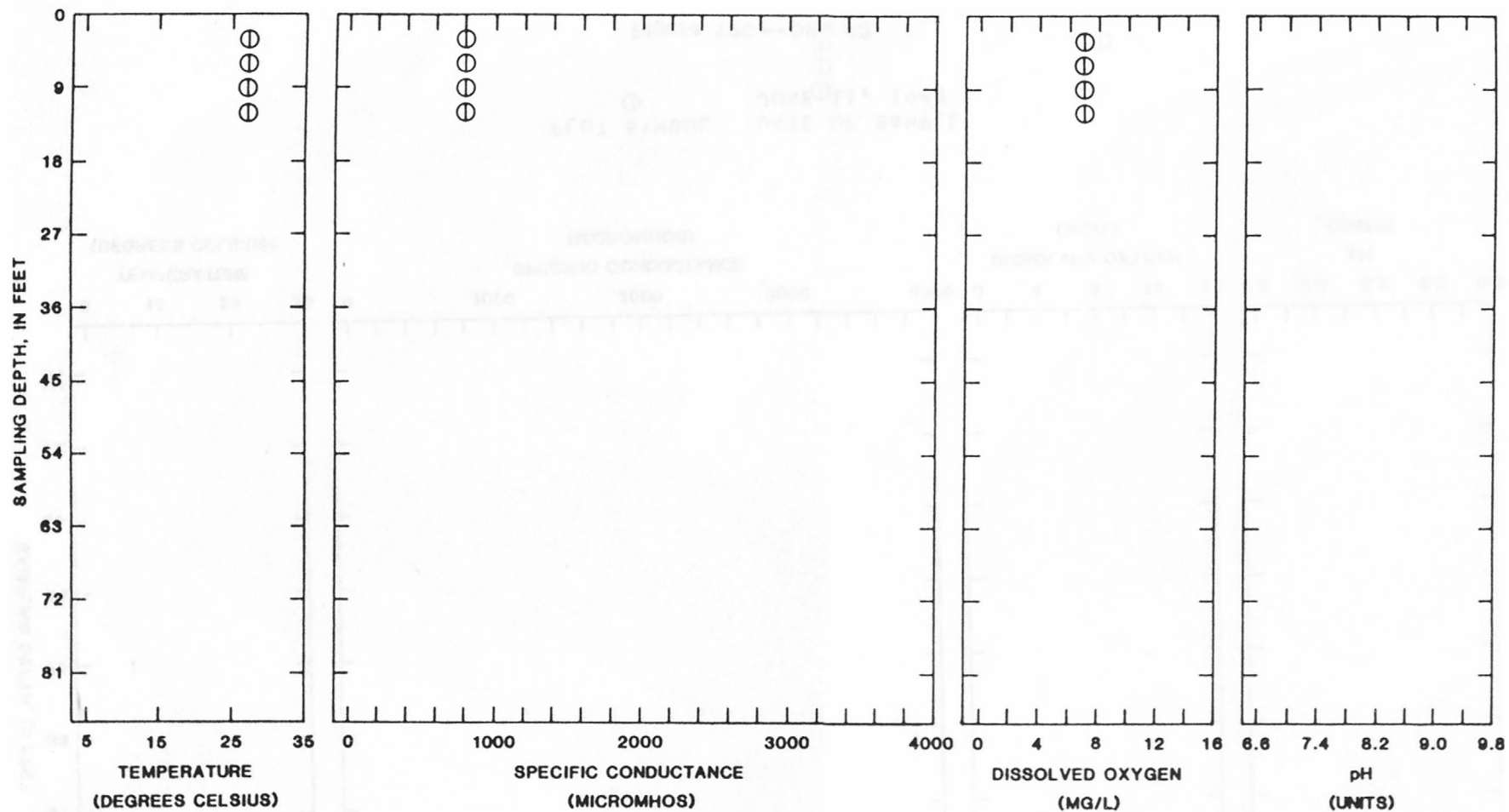


Figure 117.--Site 60.



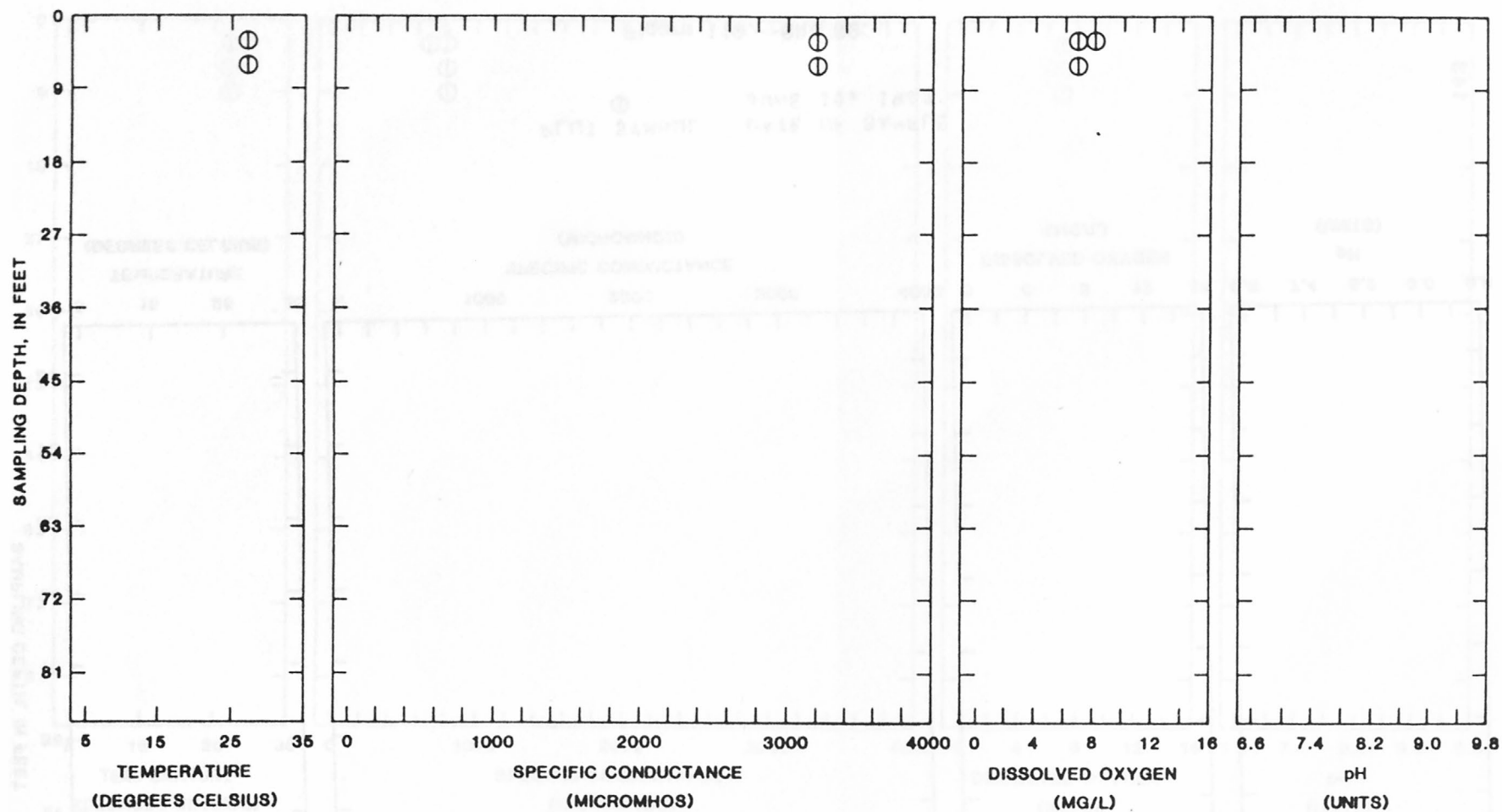
PLT SYMBOL DATE OF SAMPLE
⊙ JUNE 10, 1980

Figure 118.--Site 61.



PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 10, 1980

Figure 119.--Site 62.



PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 11, 1980

Figure 120.--Site 63.

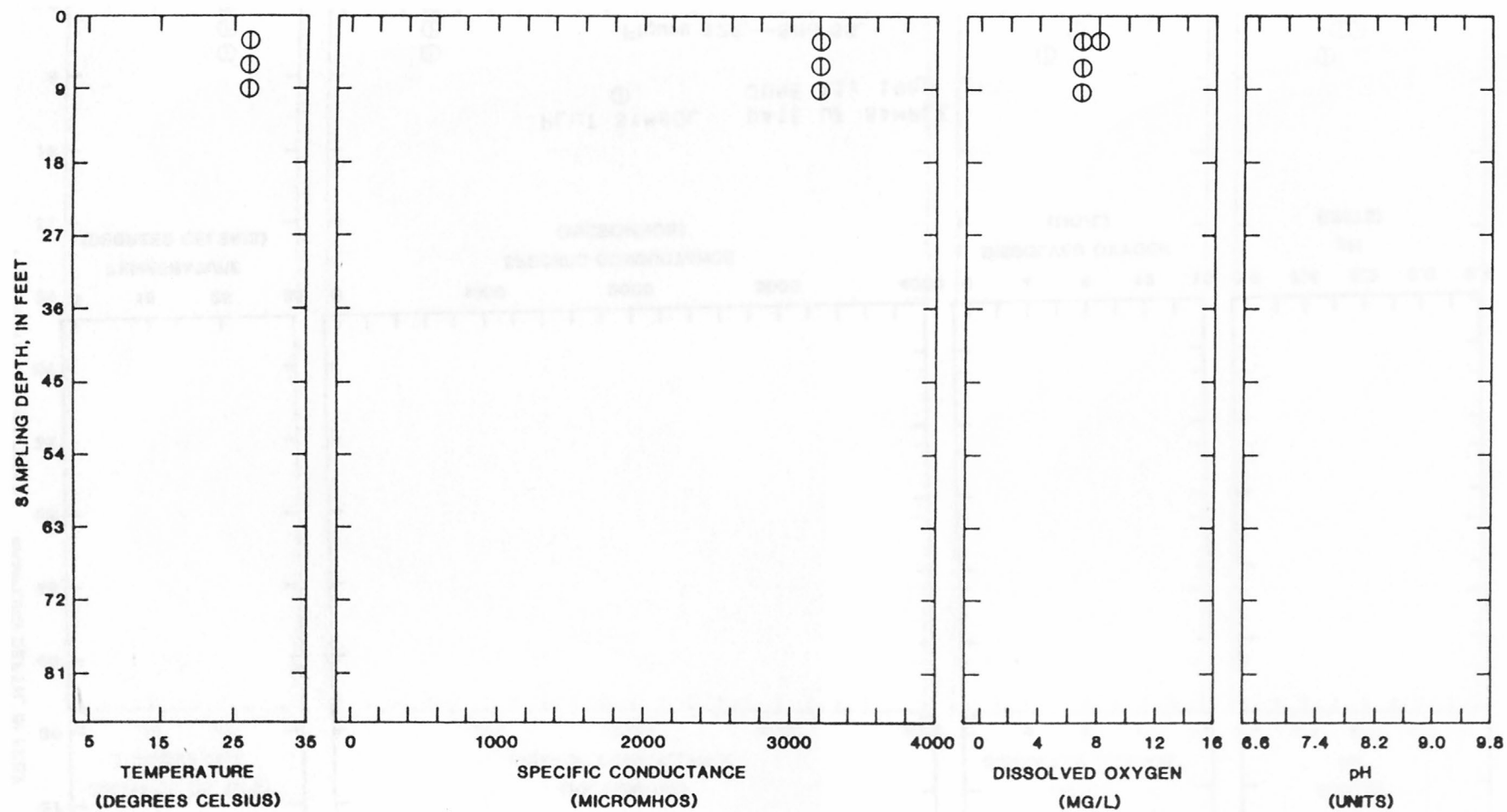
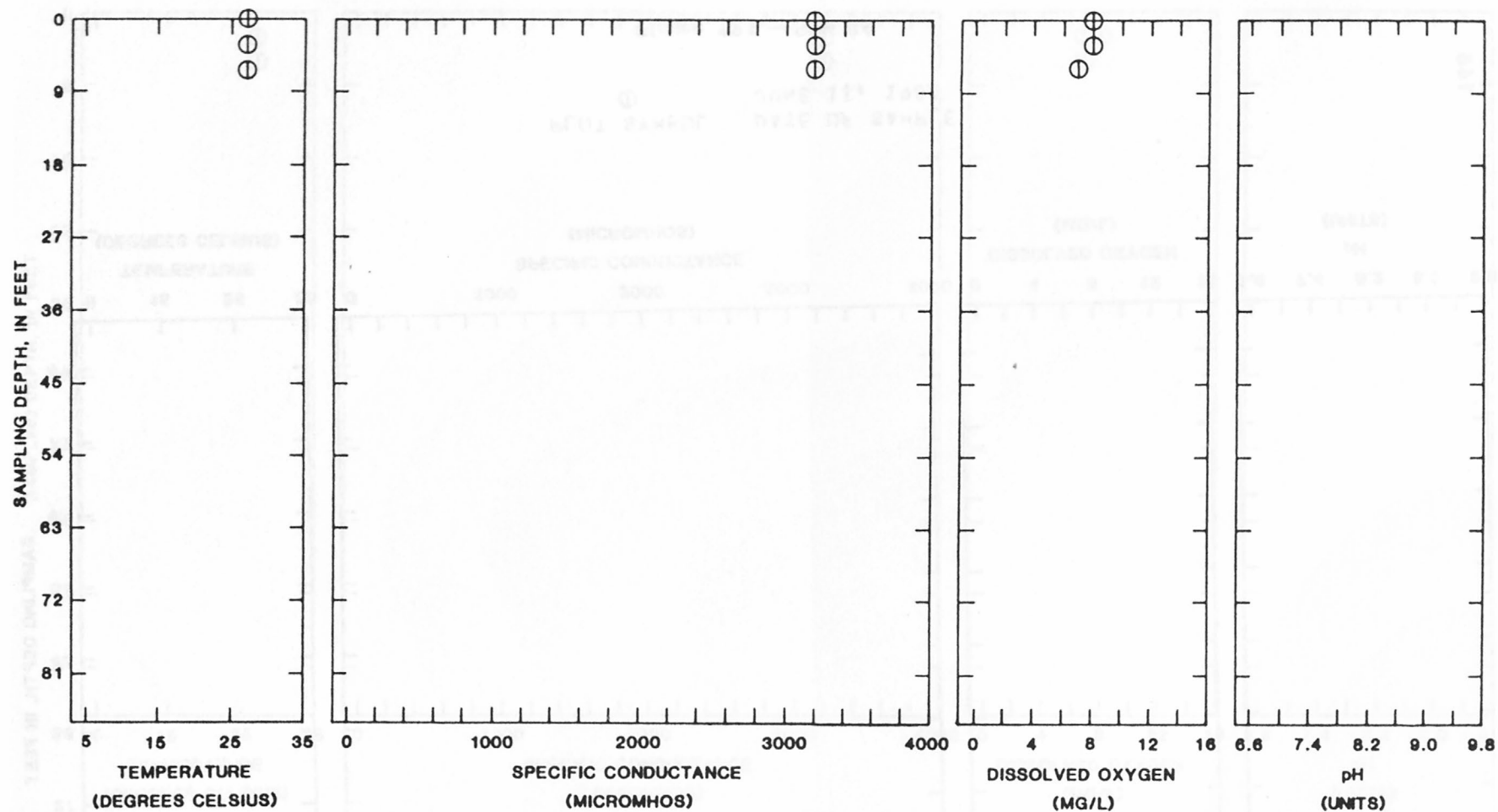
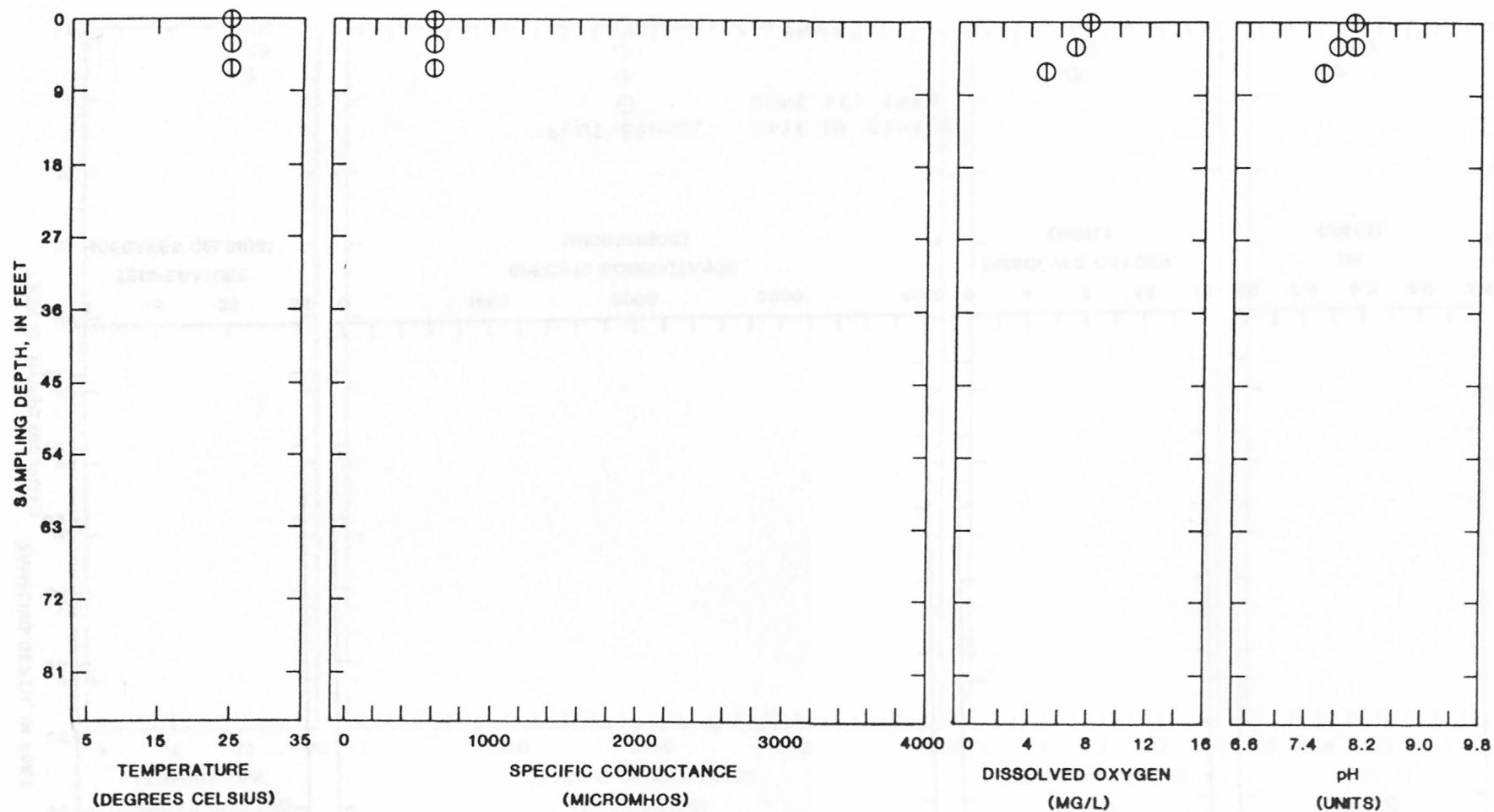


Figure 121.--Site 64.



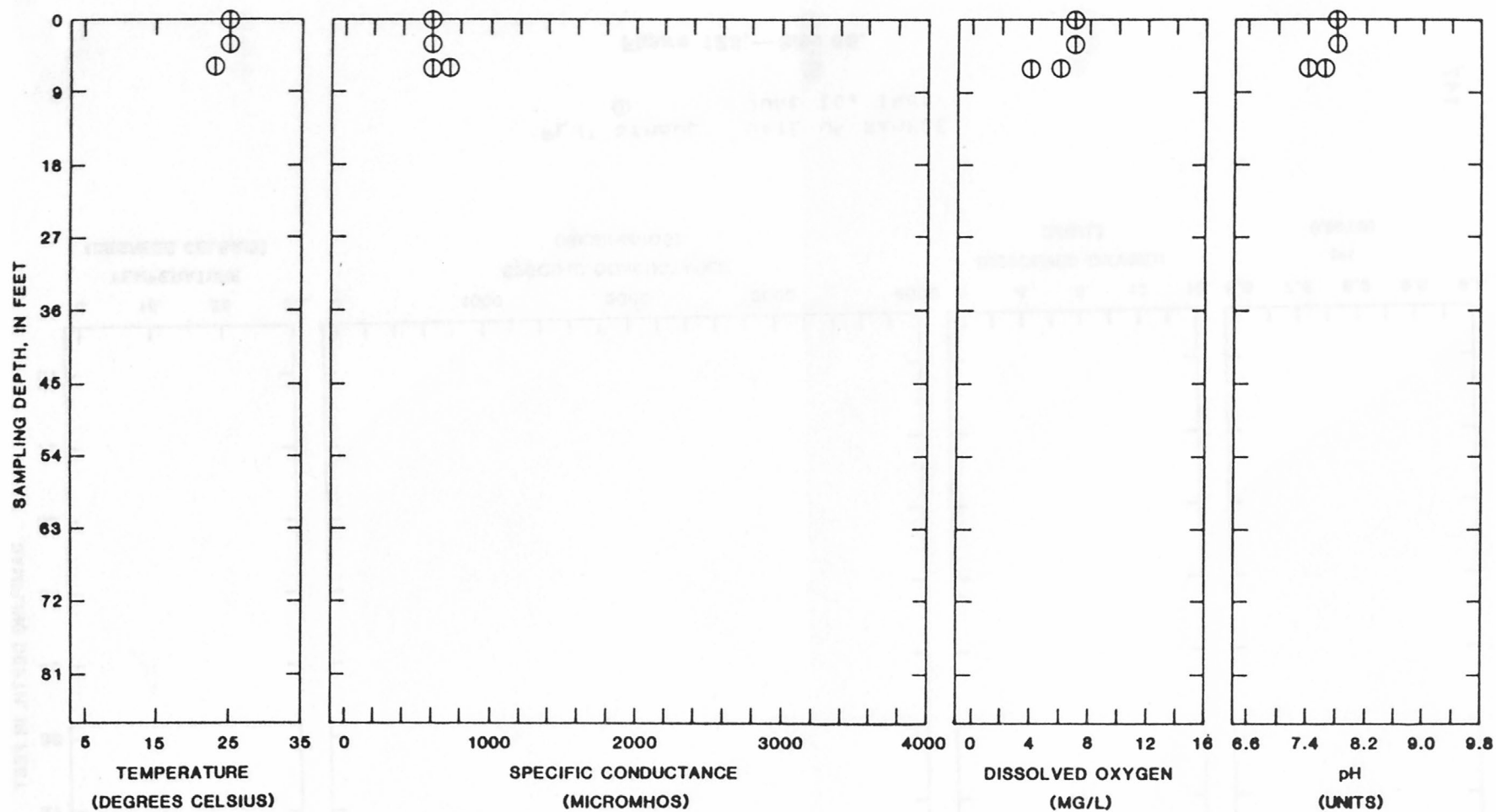
PLUT SYMBOL DATE OF SAMPLE
⊕ JUNE 11, 1960

Figure 122.--Site 65.



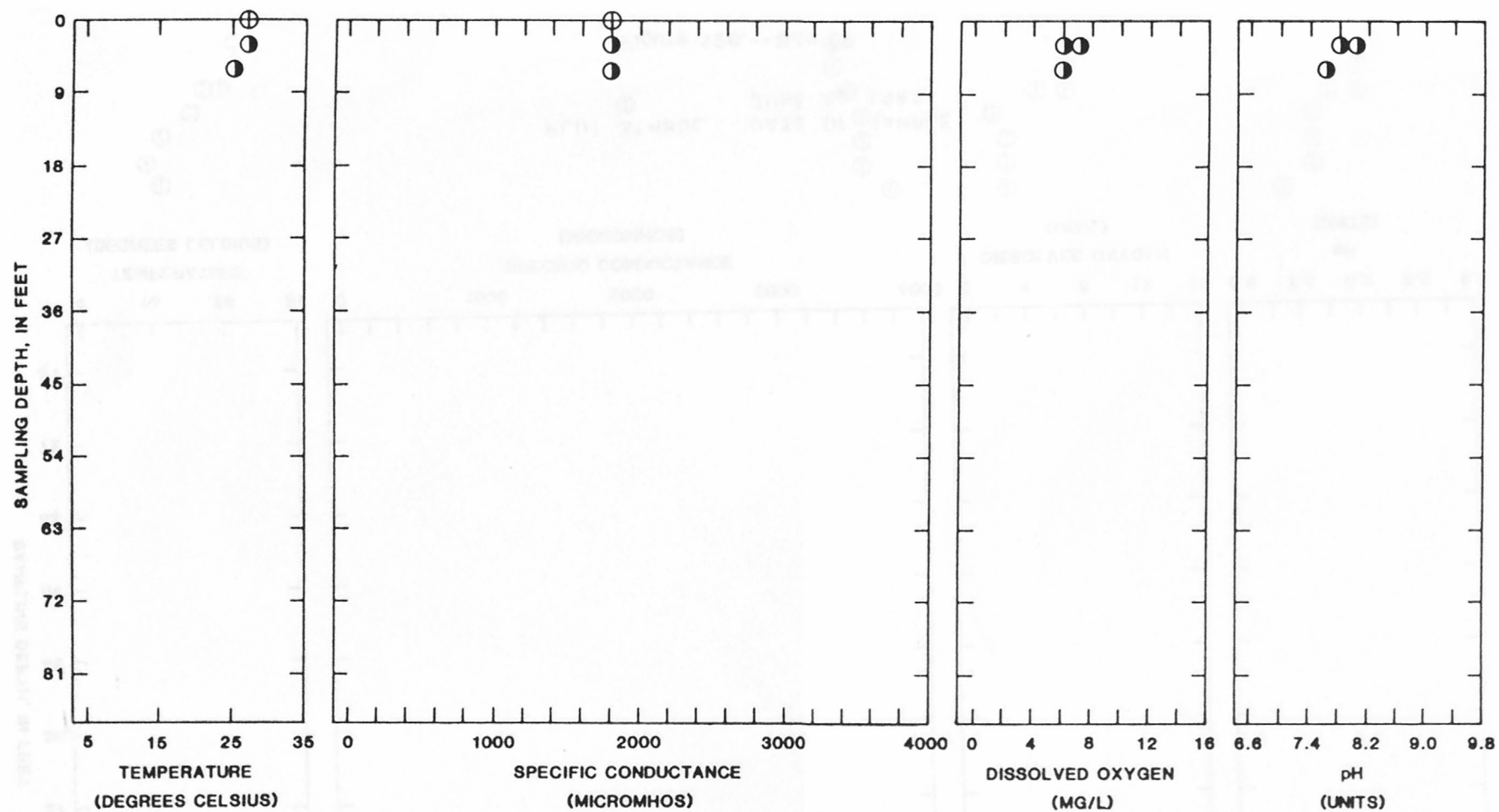
PLOT SYMBOL DATE OF SAMPLE
⊗ JUNE 10, 1980

Figure 123.--Site 66.



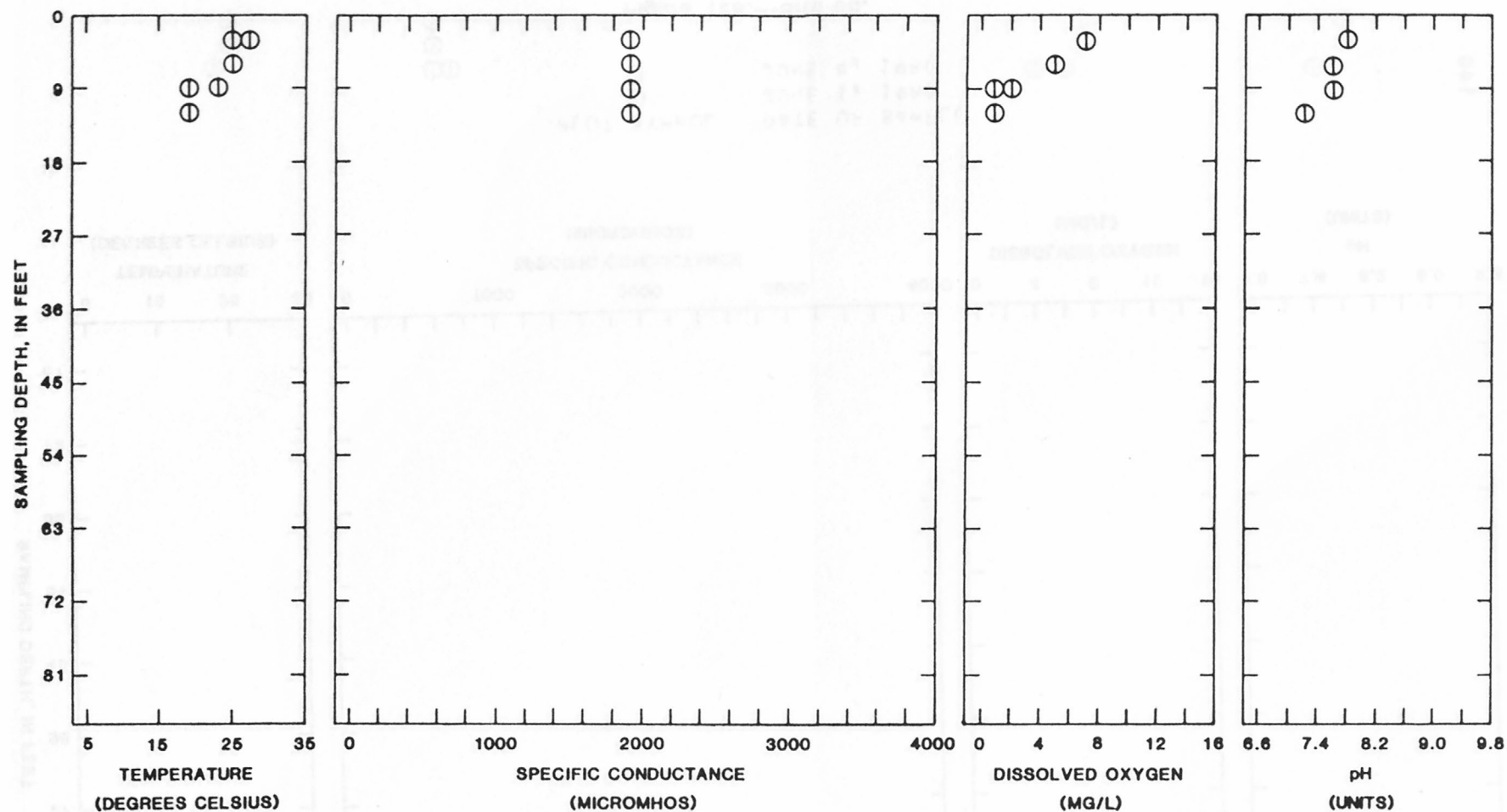
PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 10, 1980

Figure 124.--Site 67.



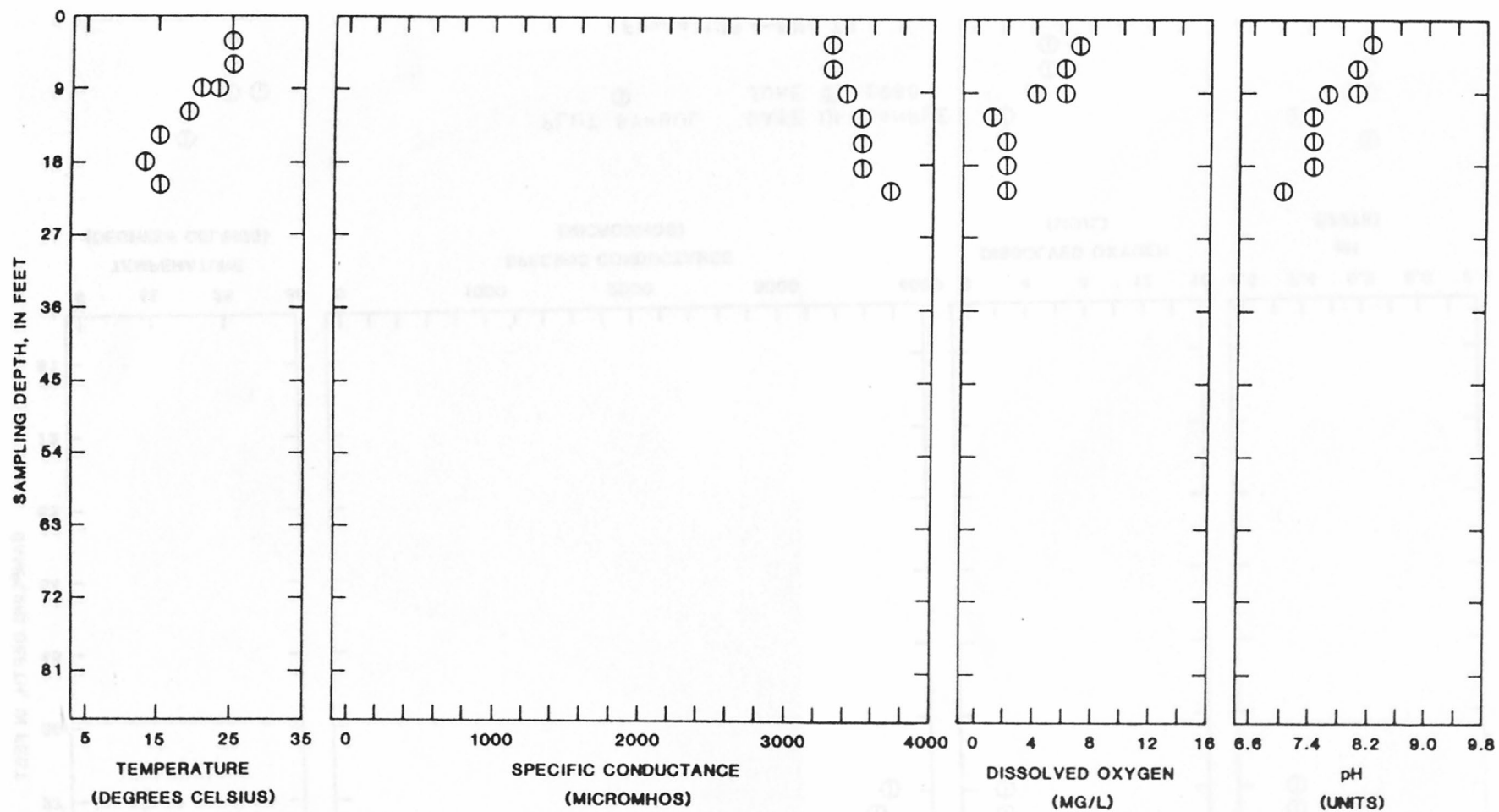
PLOT SYMBOL	DATE OF SAMPLE
○	JUNE 1, 1980
●	JUNE 4, 1980

Figure 125.--Site 68.



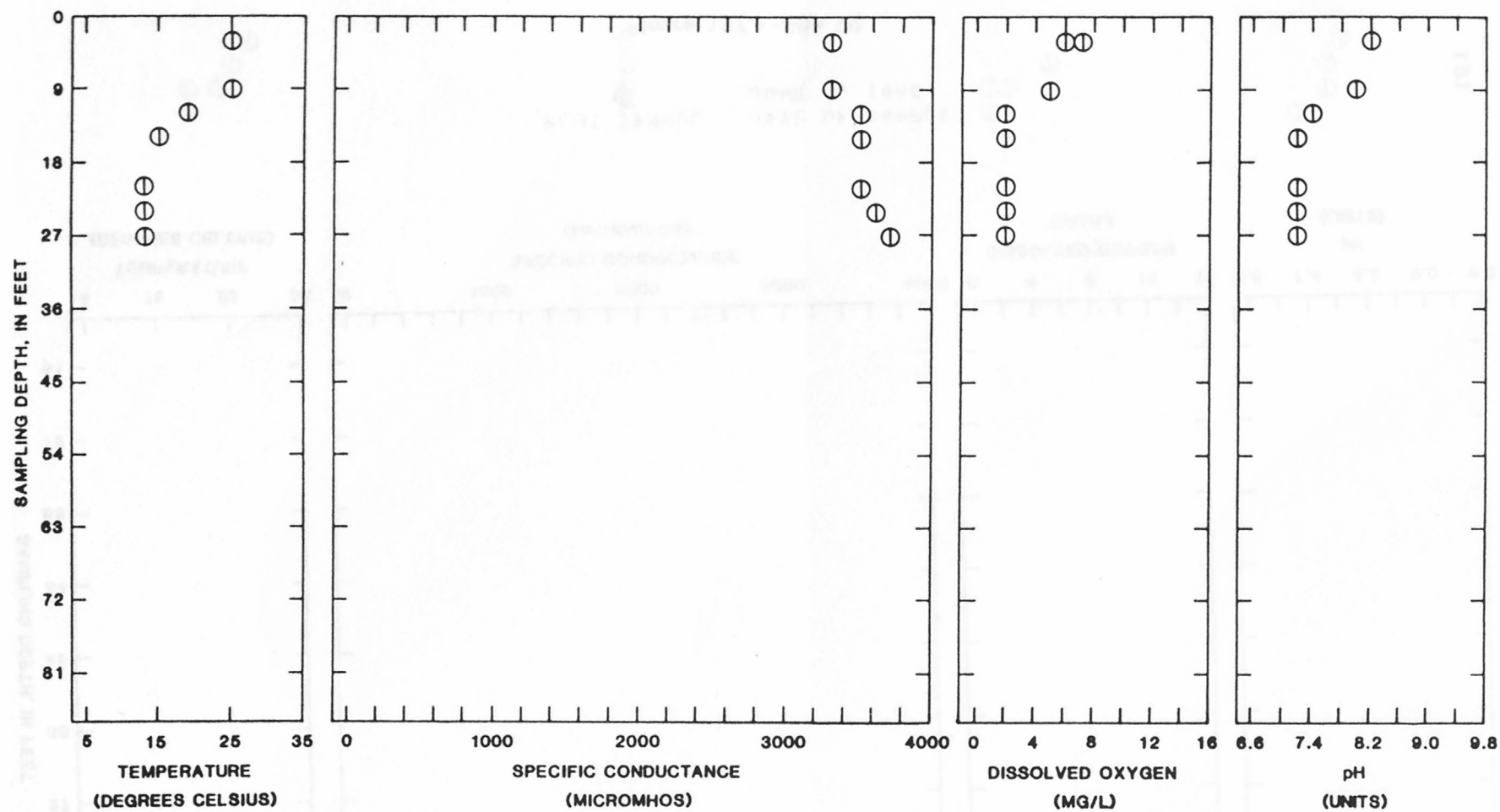
PLOT SYMBOL DATE OF SAMPLE
○ JUNE 4, 1980

Figure 126.--Site 69.



PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 4, 1980

Figure 127.--Site 70.



⊙ DATE OF SAMPLE
JUNE 4, 1980

Figure 128.--Site 71.

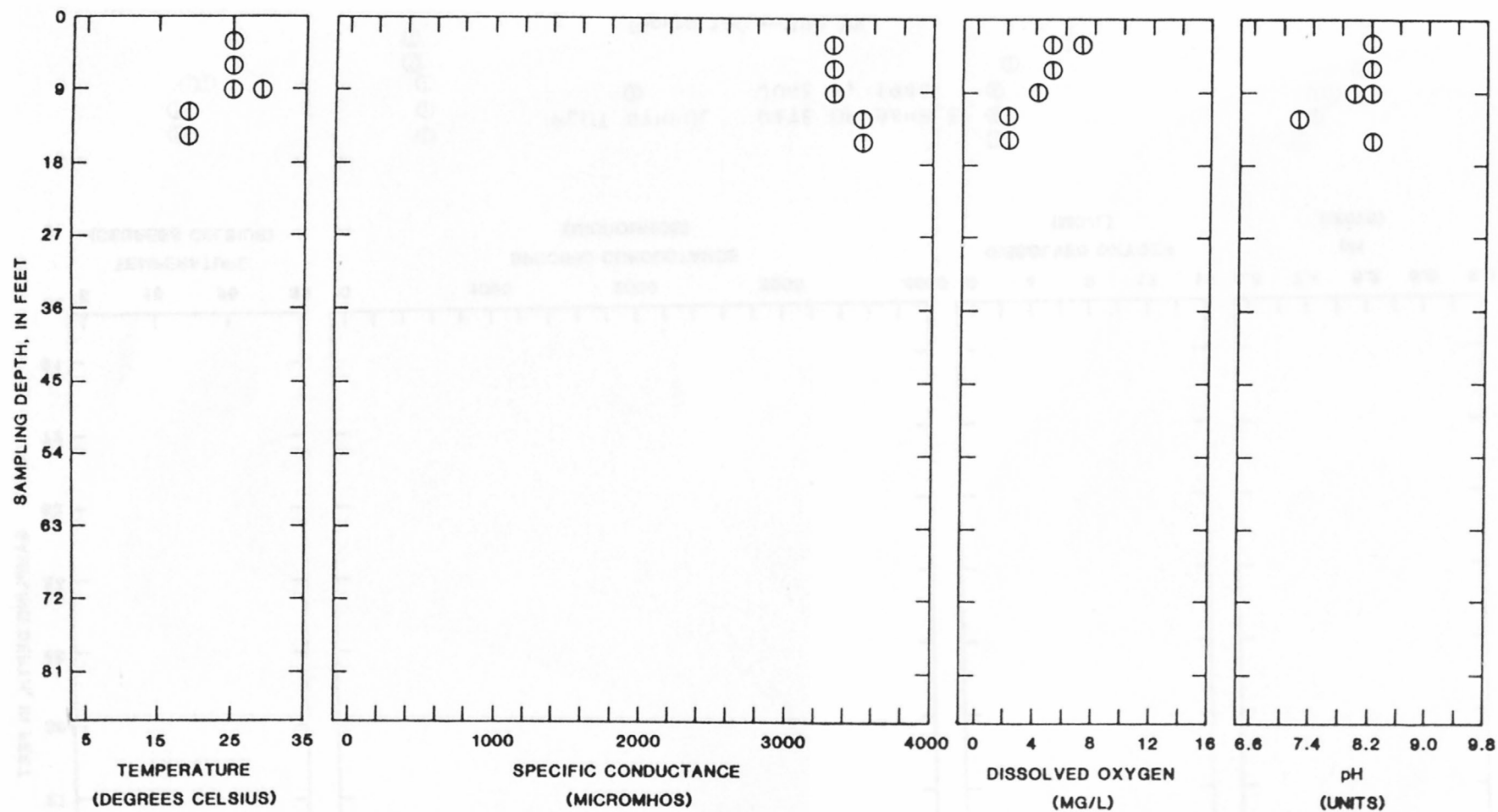


Figure 129.--Site 72.

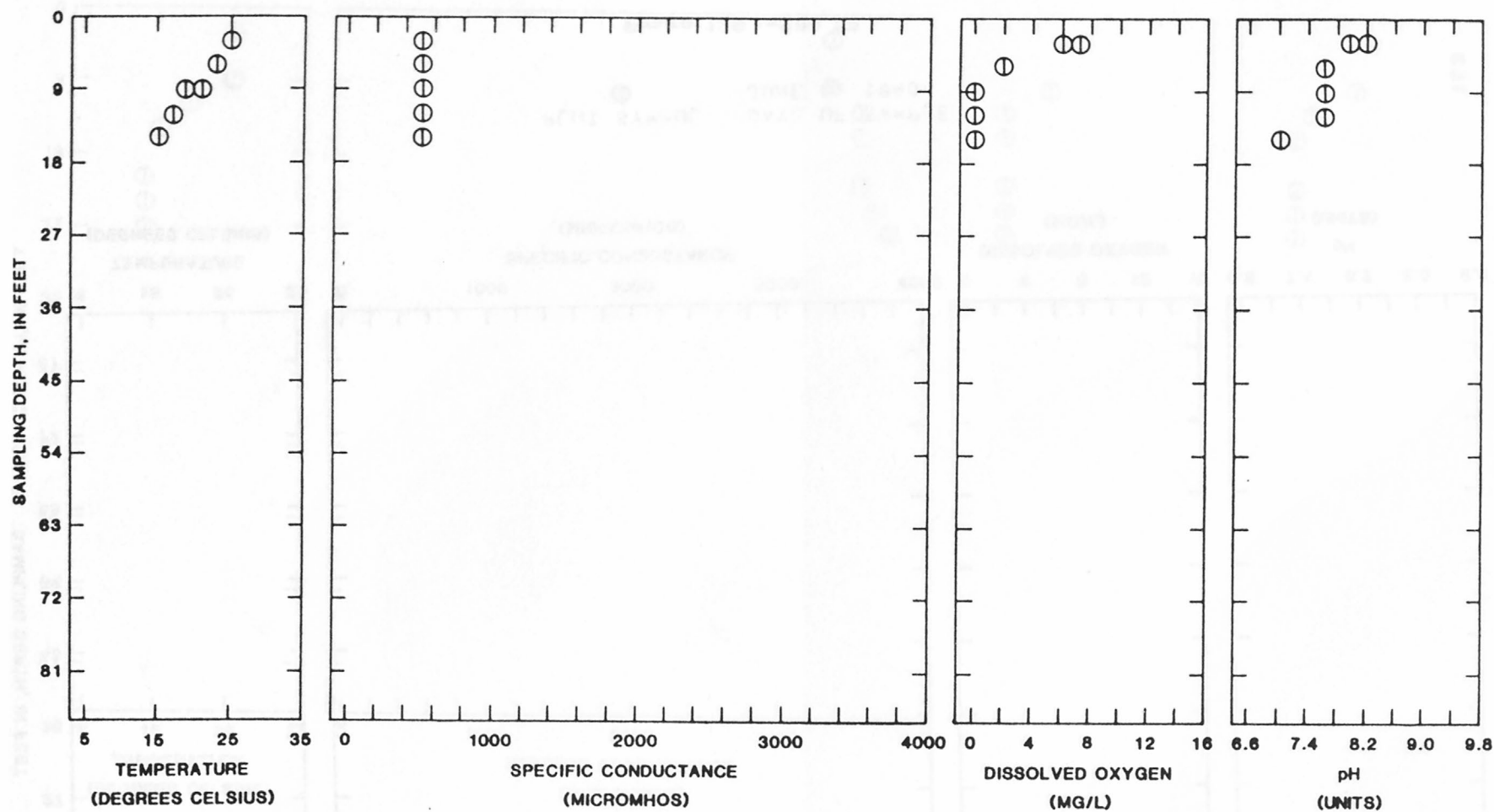
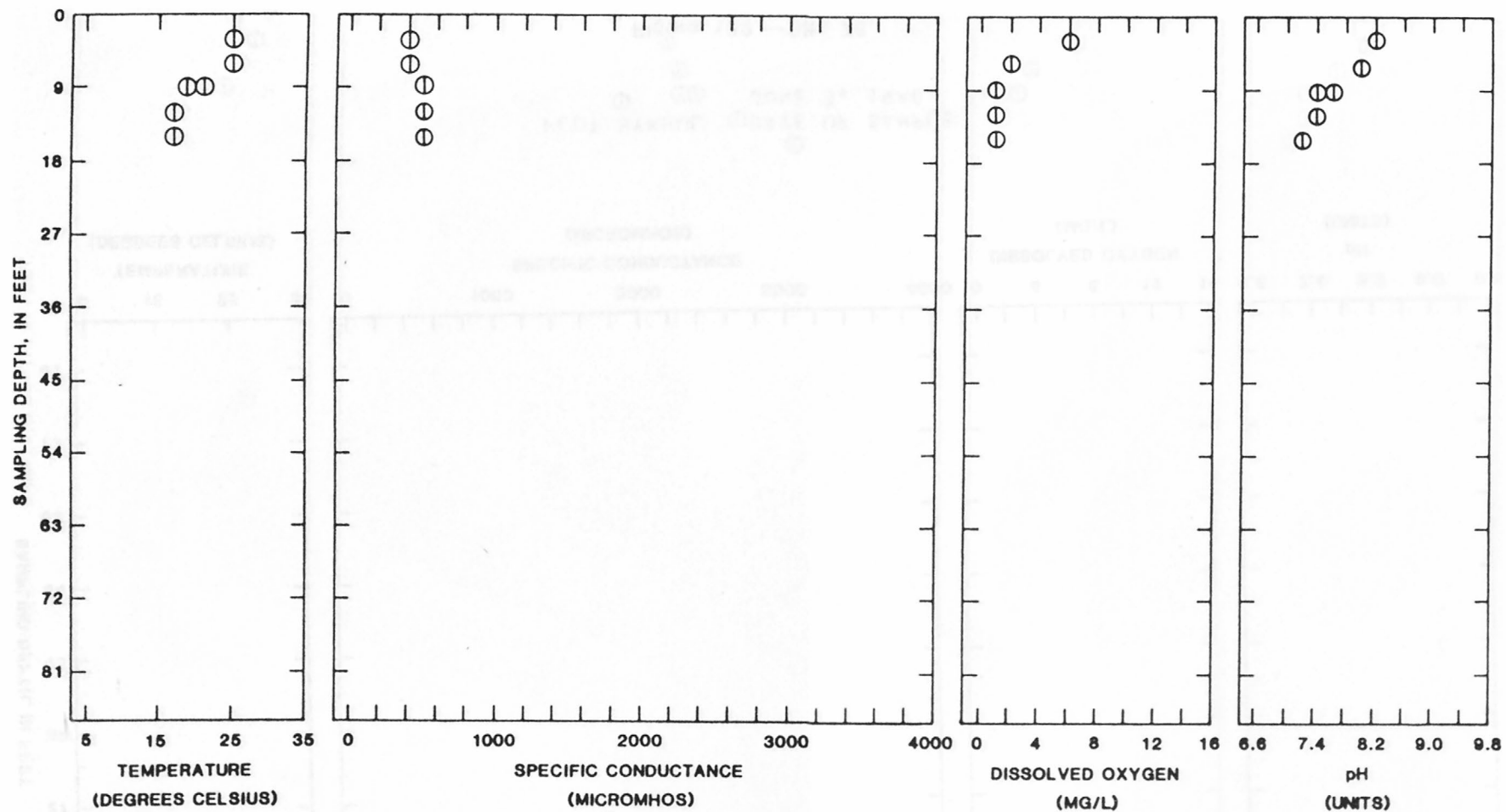
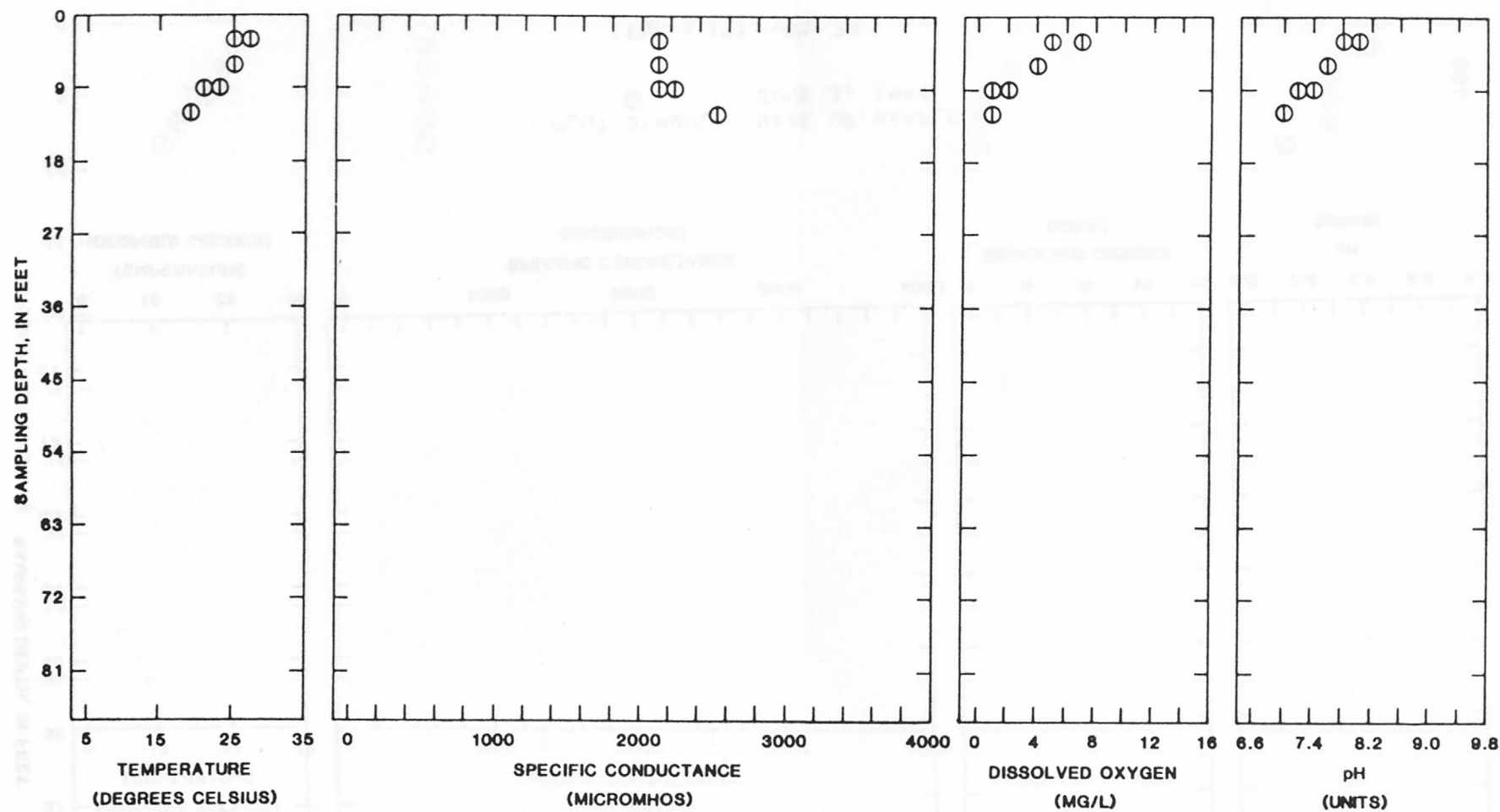


Figure 130.--Site 73.



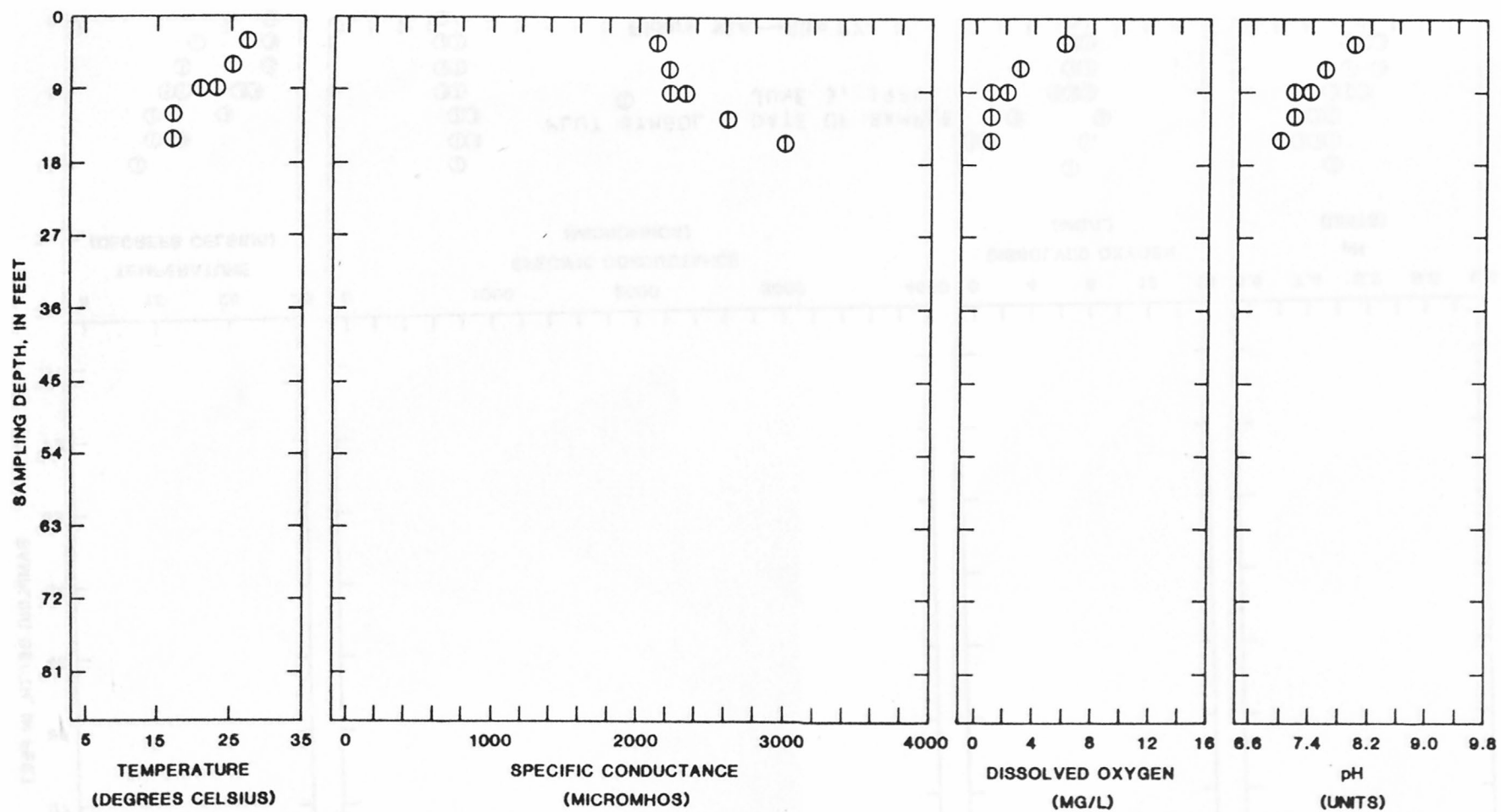
PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 3, 1980

Figure 131.--Site 74.



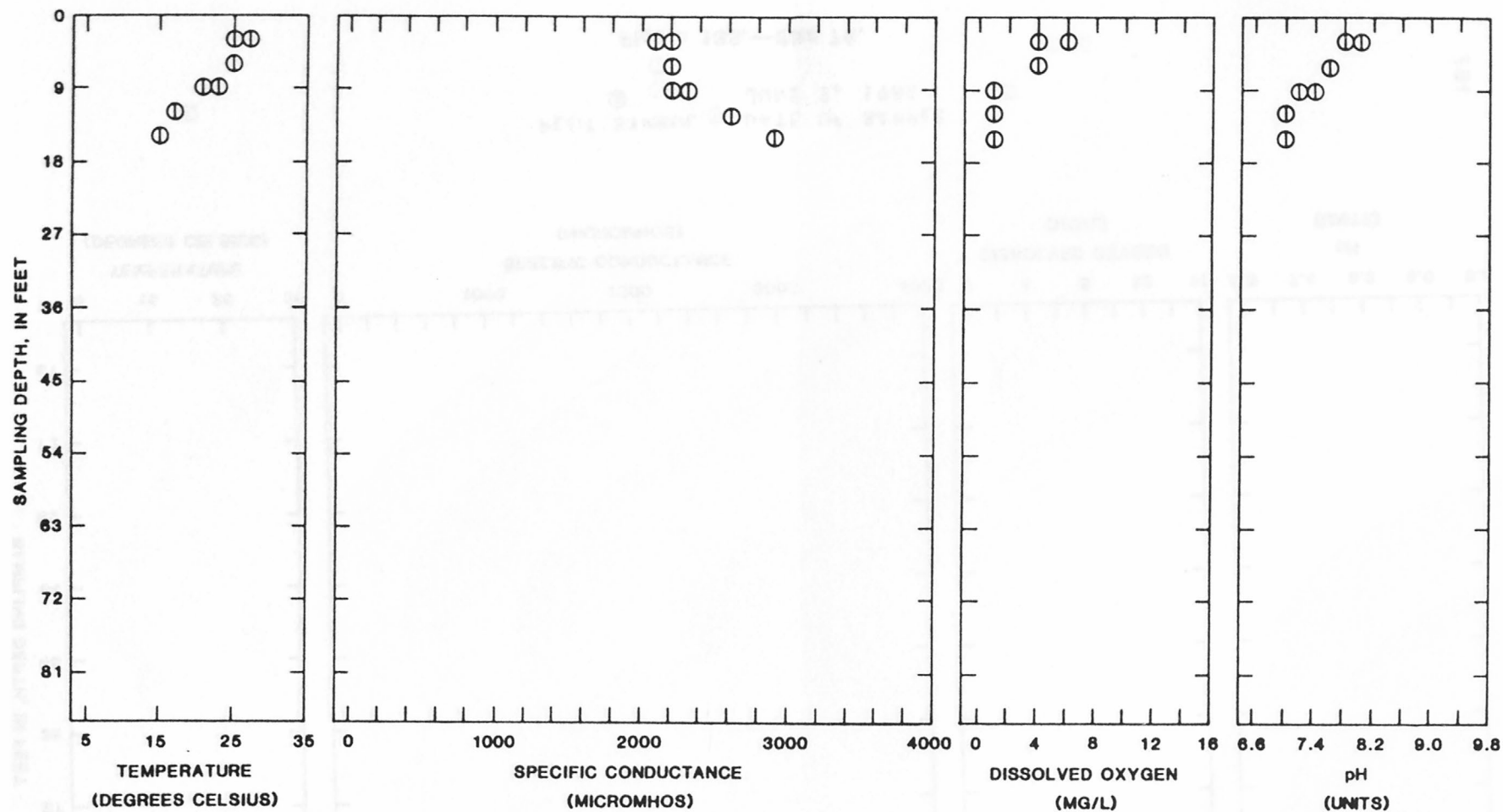
PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 3, 1980

Figure 132.—Site 75.



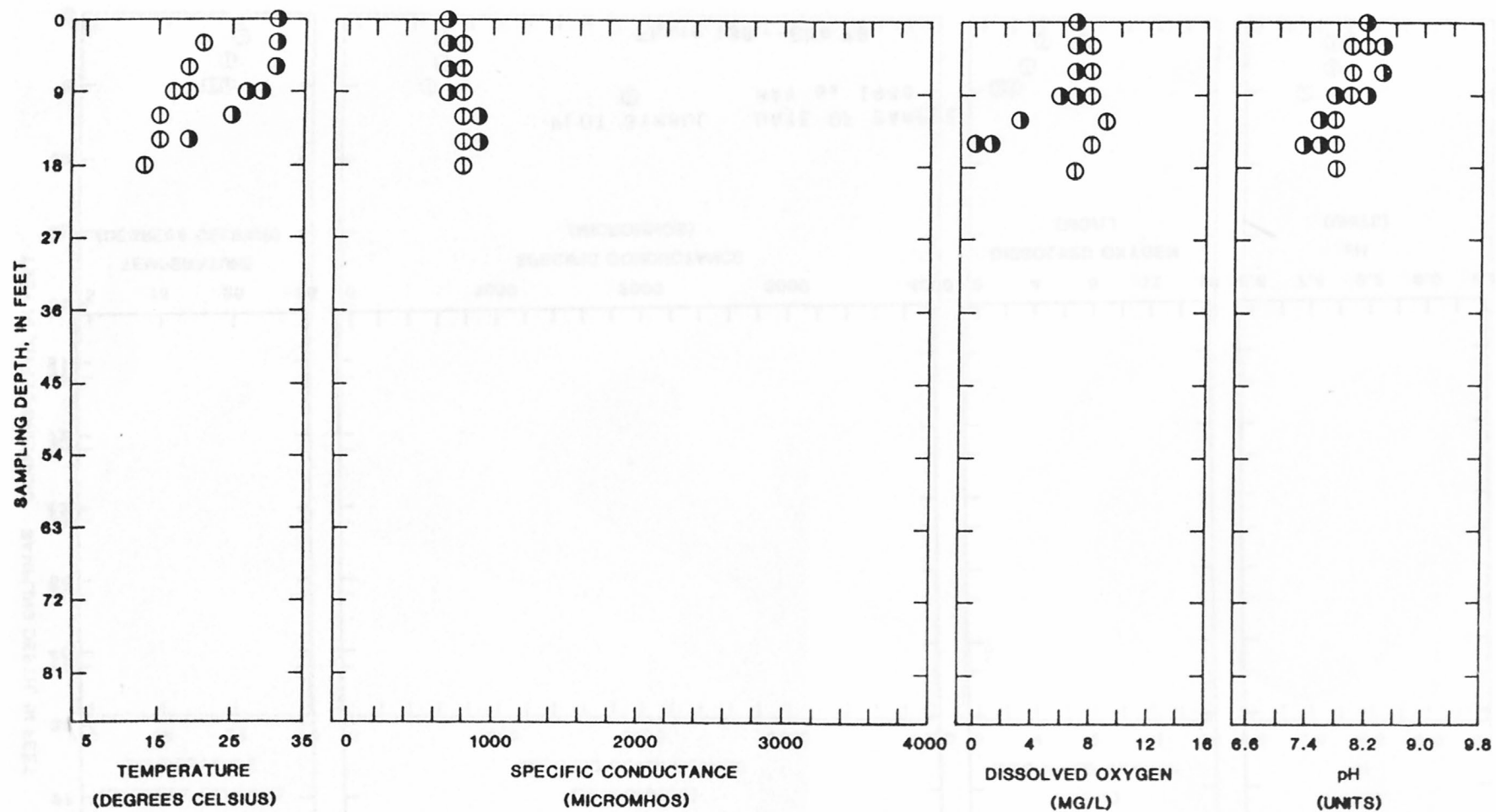
PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 3, 1980

Figure 133.--Site 76.



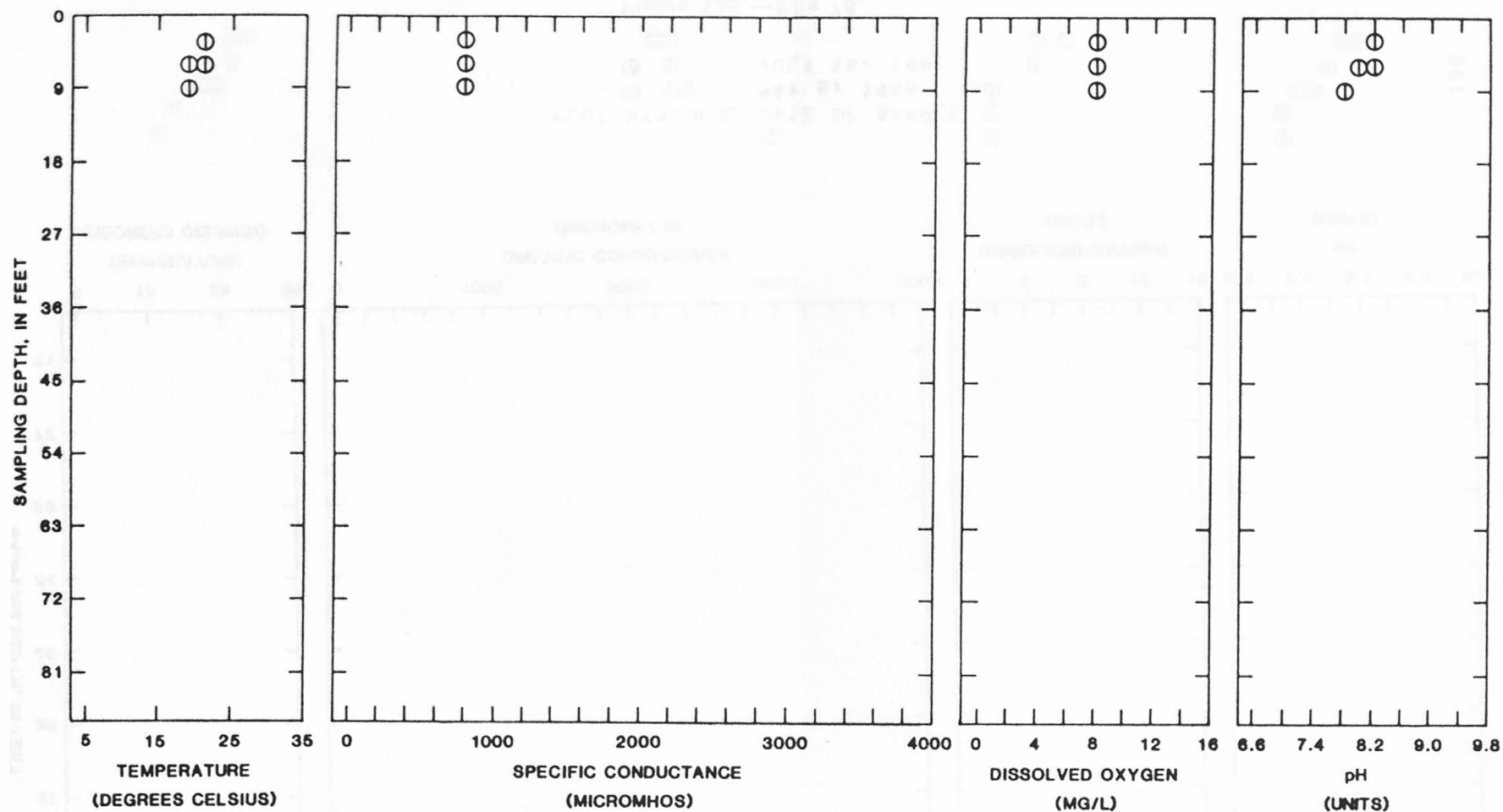
PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 3, 1980

Figure 134.--Site 77.



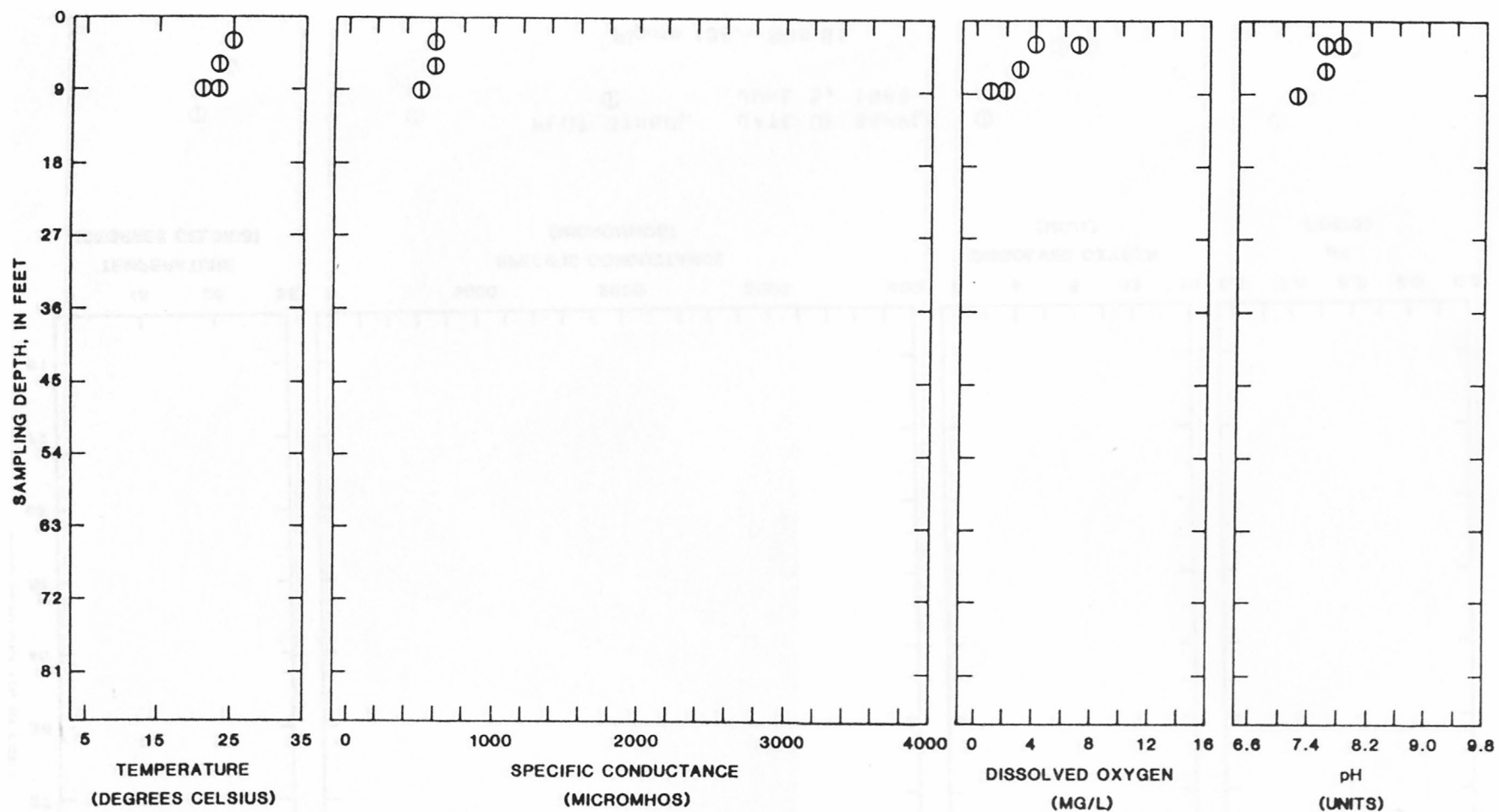
PLOT SYMBOL DATE OF SAMPLE
 ○ MAY 6, 1980
 ● JULY 14, 1981

Figure 135.--Site 78.



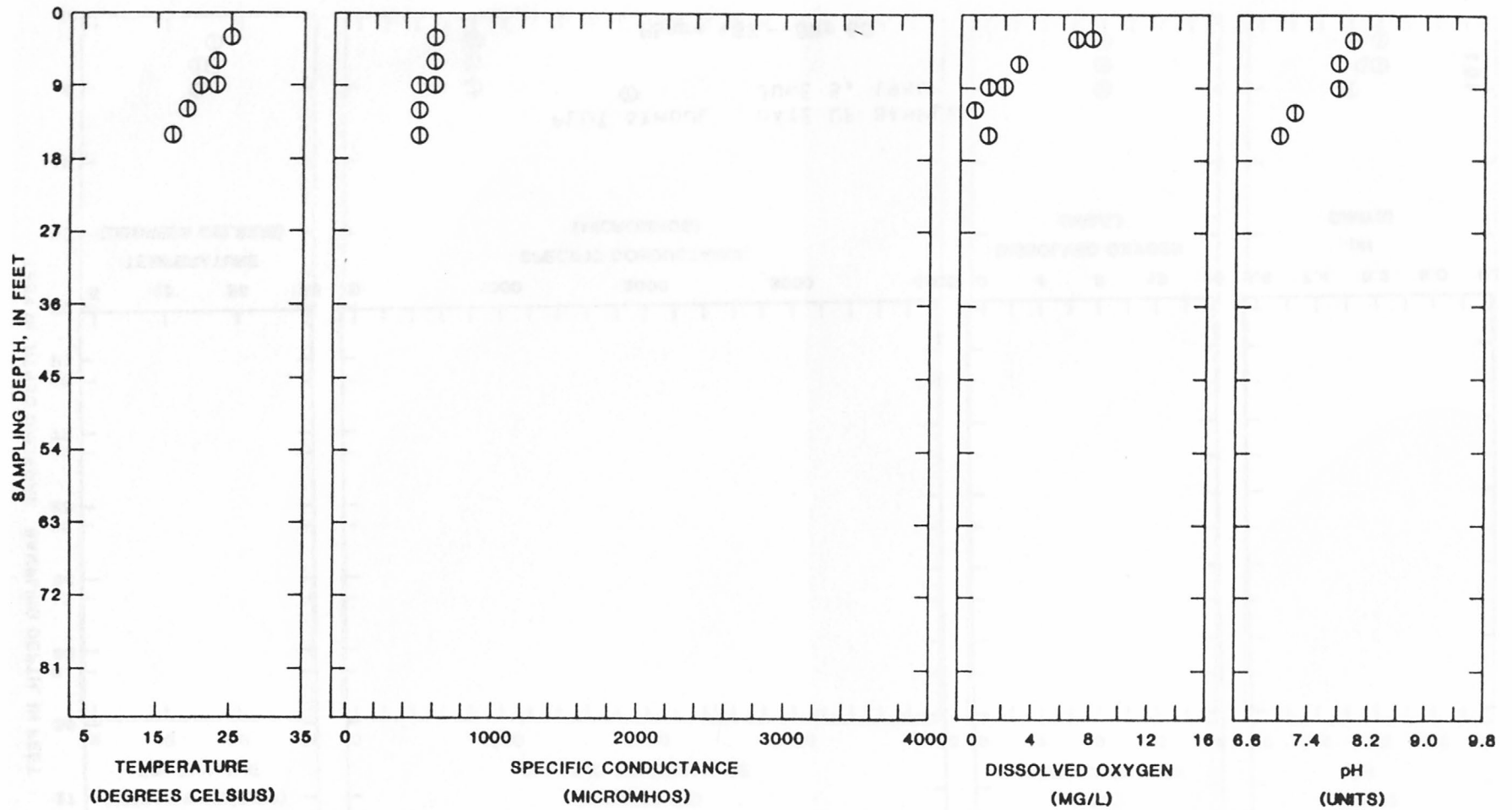
PLOT SYMBOL DATE OF SAMPLE
⊙ MAY 6, 1980

Figure 136.--Site 79.



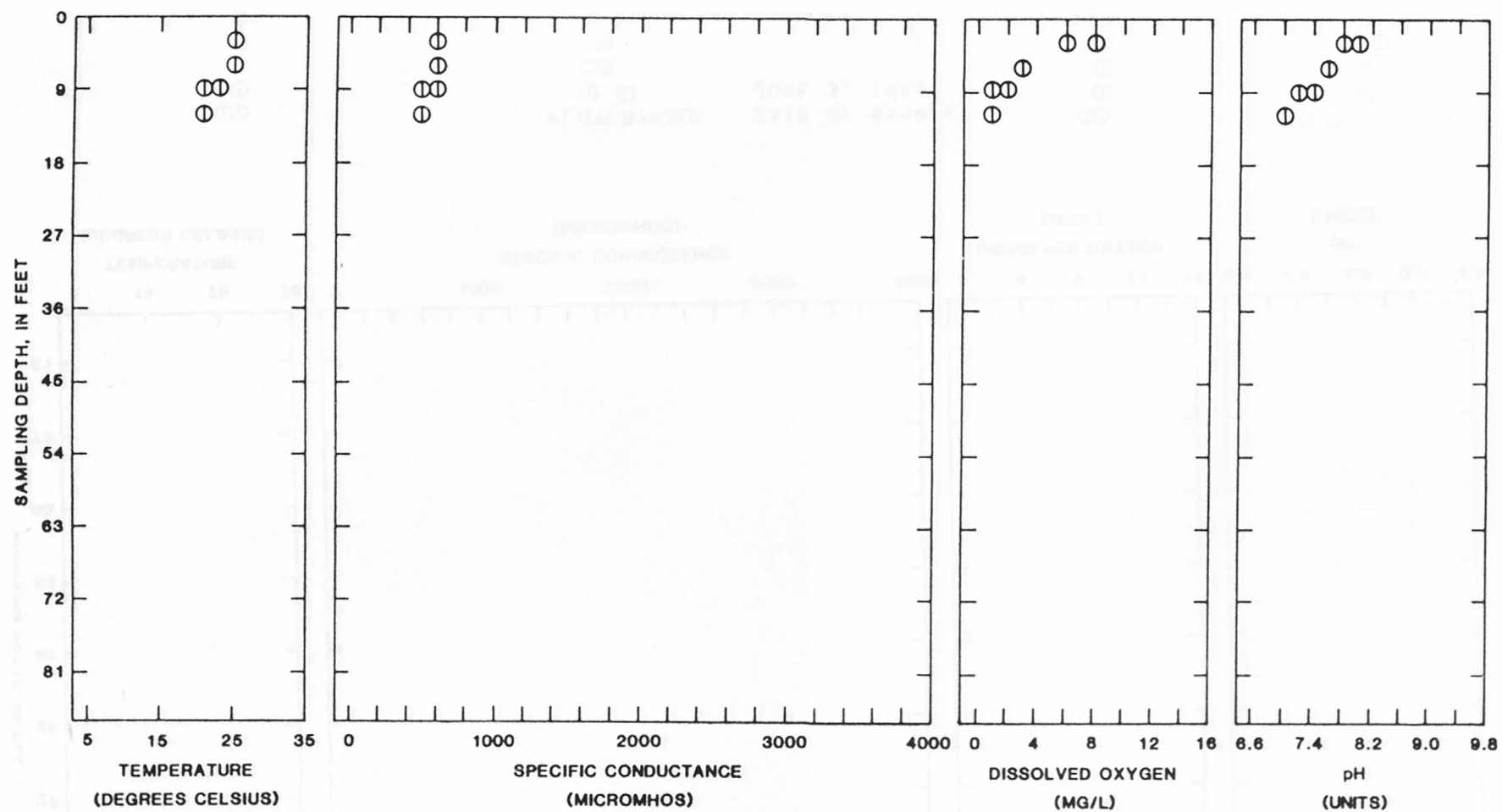
PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 5, 1980

Figure 137.--Site 80.



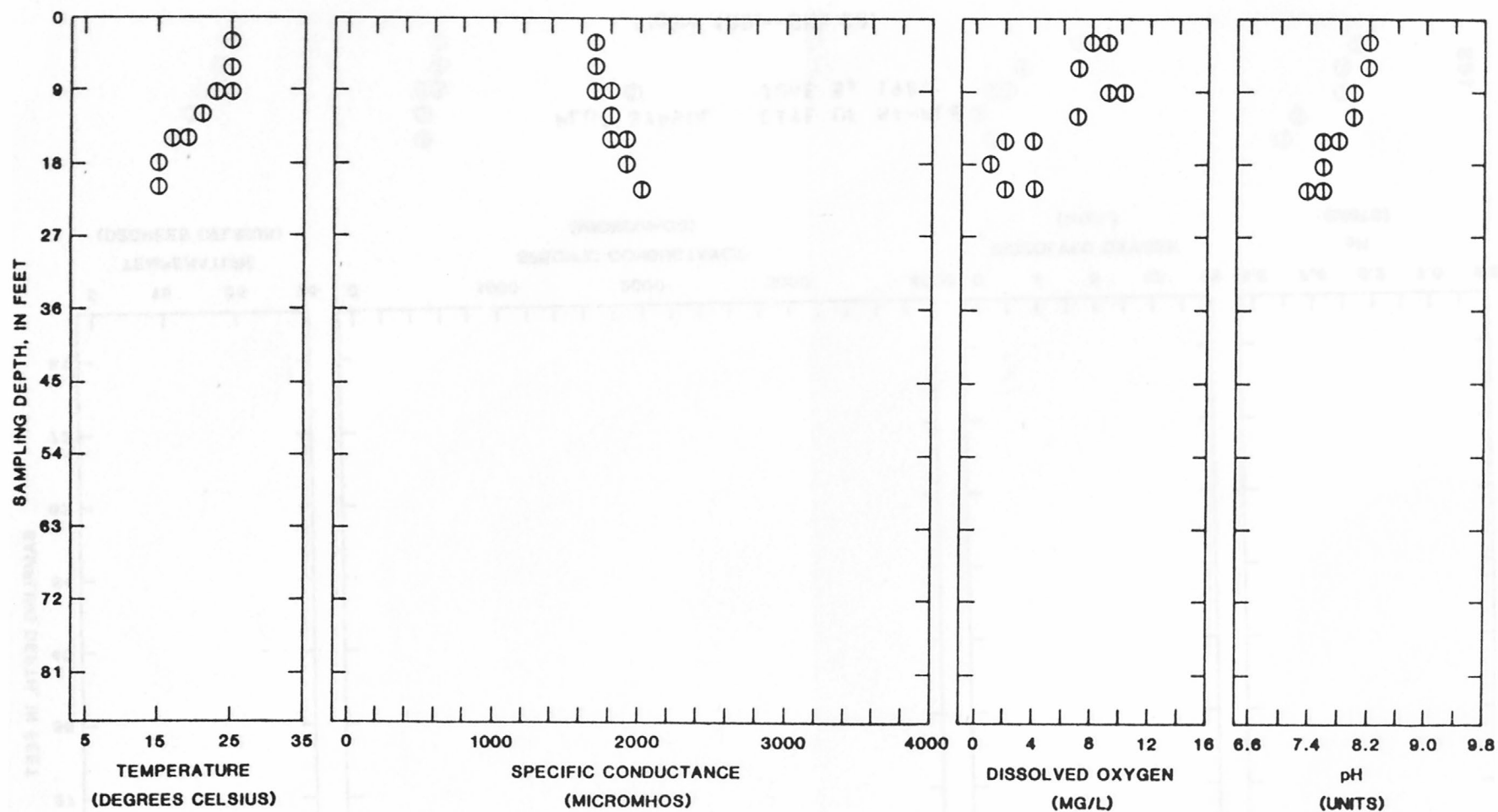
PLOT SYMBOL DATE OF SAMPLE
○ JUNE 5, 1980

Figure 138.--Site 81.



PLUT SYMBOL DATE OF SAMPLE
○ JUNE 5, 1980

Figure 139.--Site 82.



PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 3, 1980

Figure 140.--Site 83.

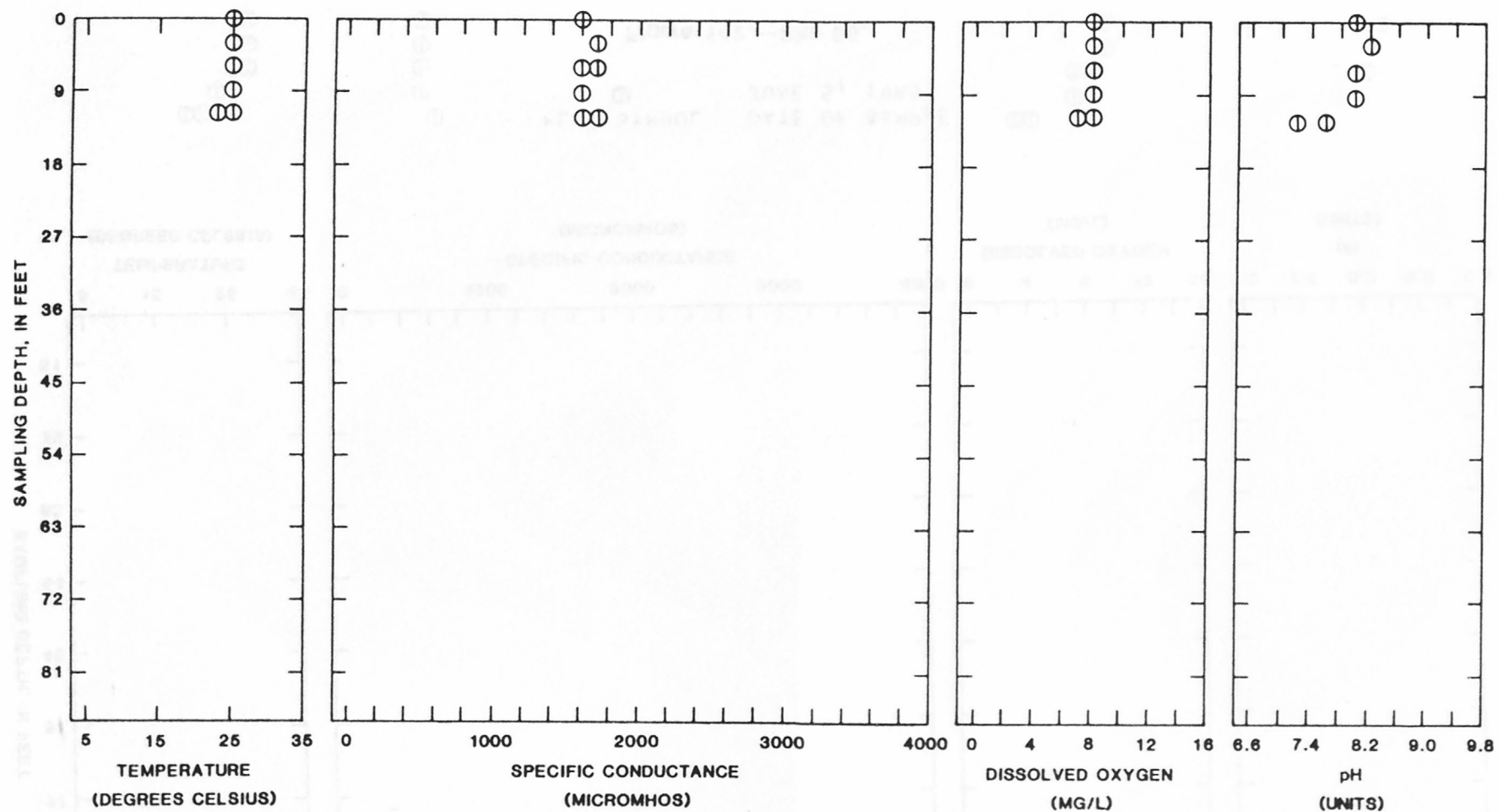
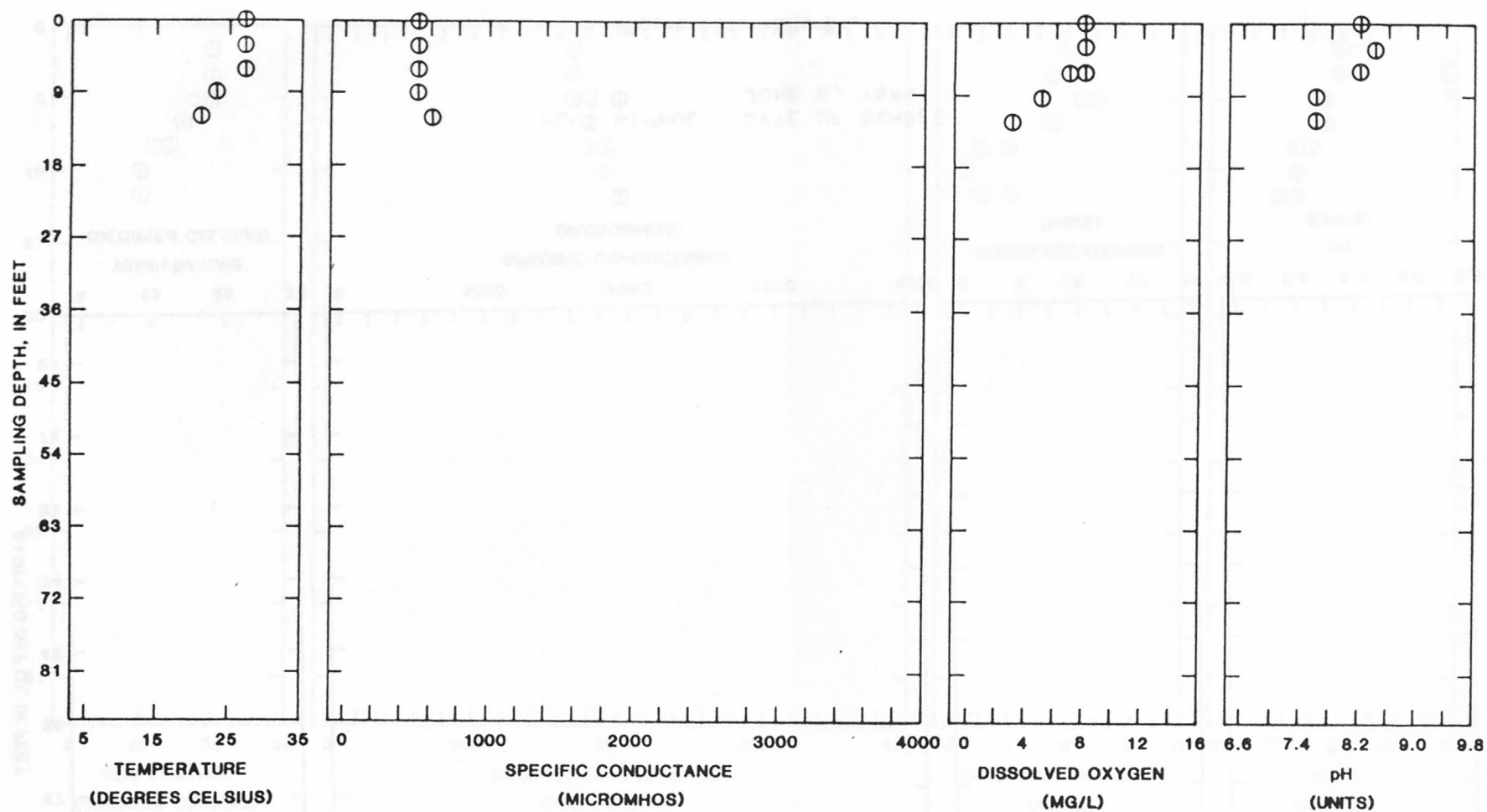


Figure 141.—Site 84.



PLOT SYMBOL DATE OF SAMPLE
⊗ JUNE 5, 1980

Figure 142.--Site 85.

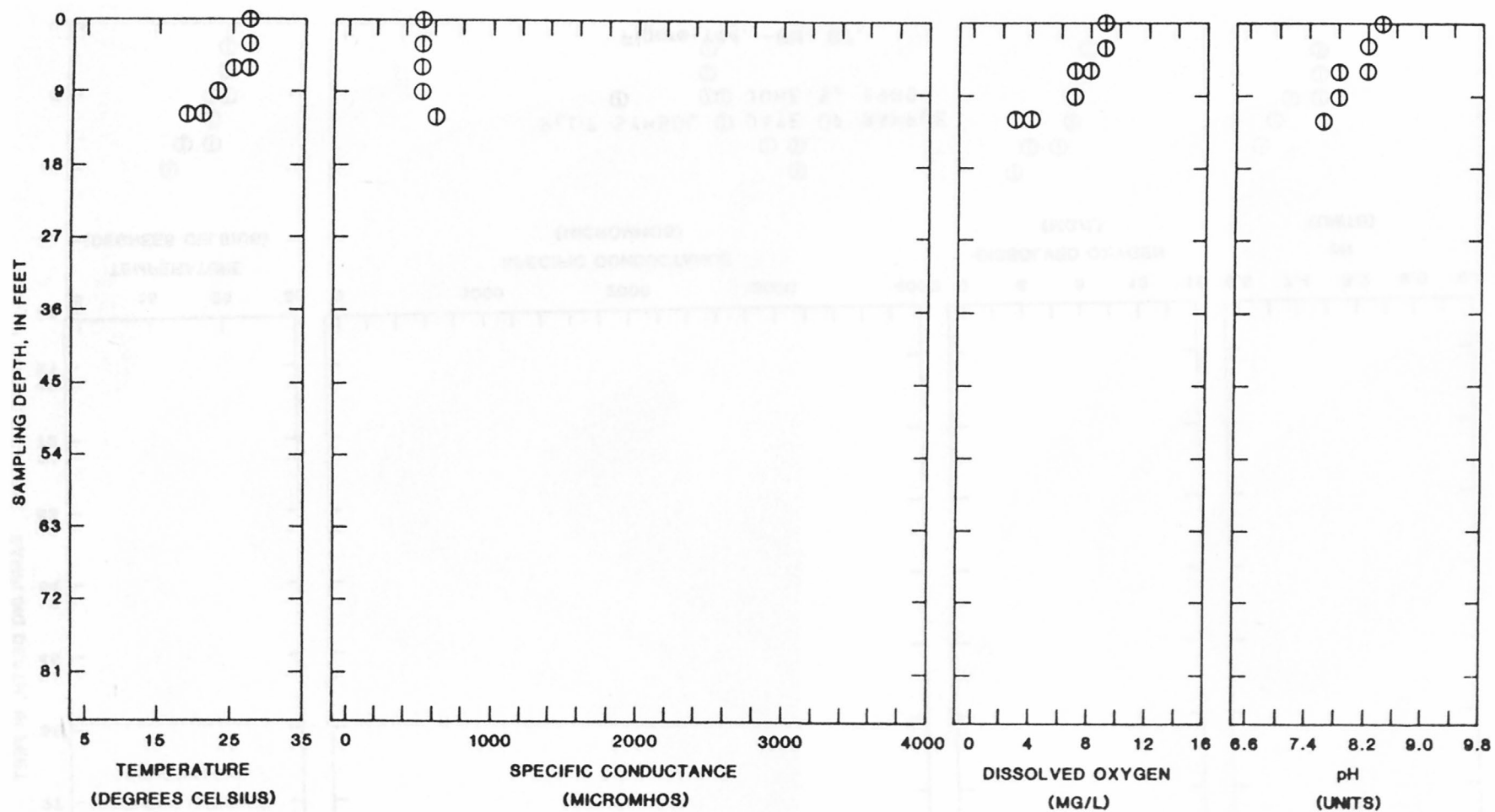
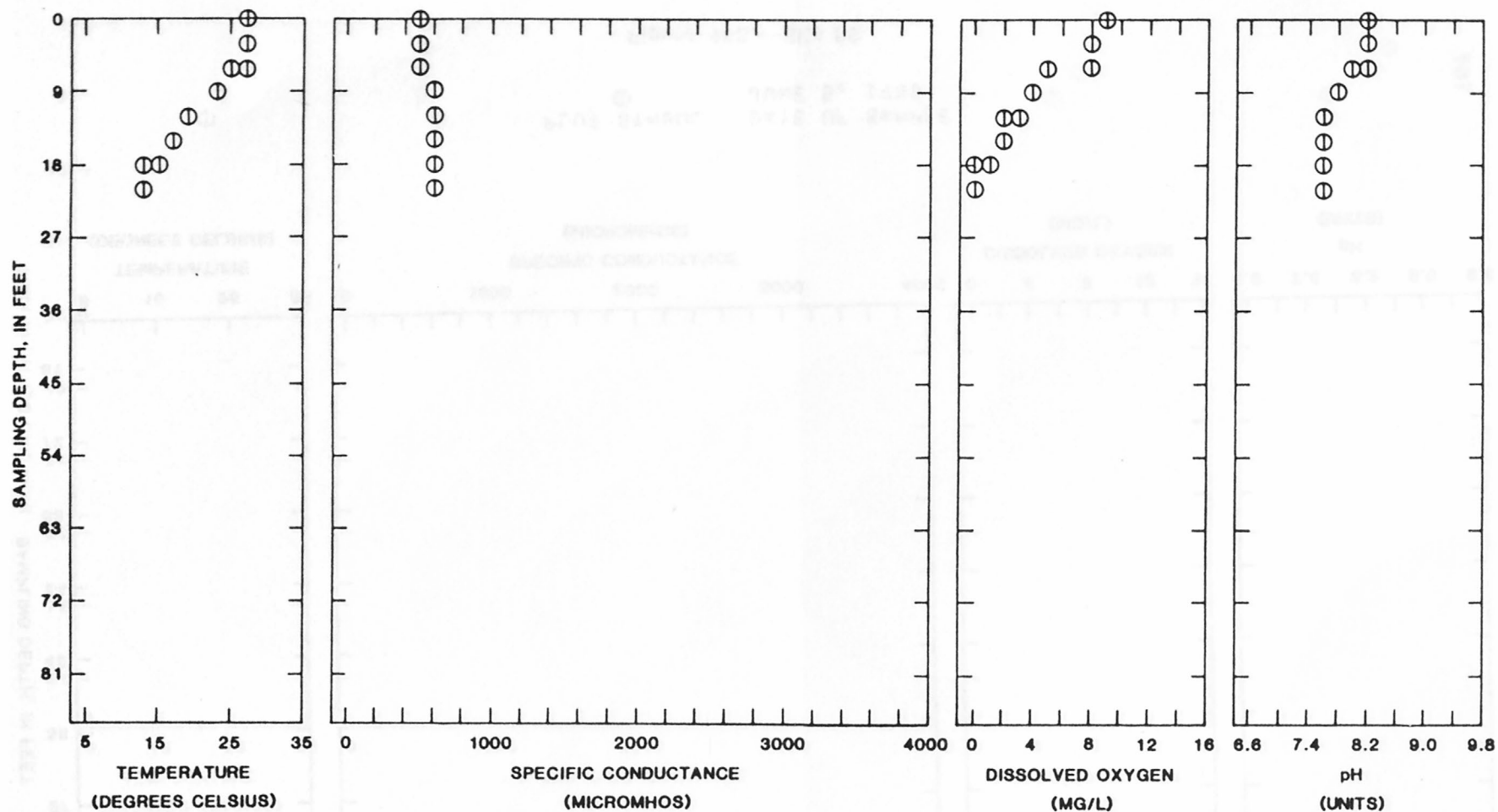
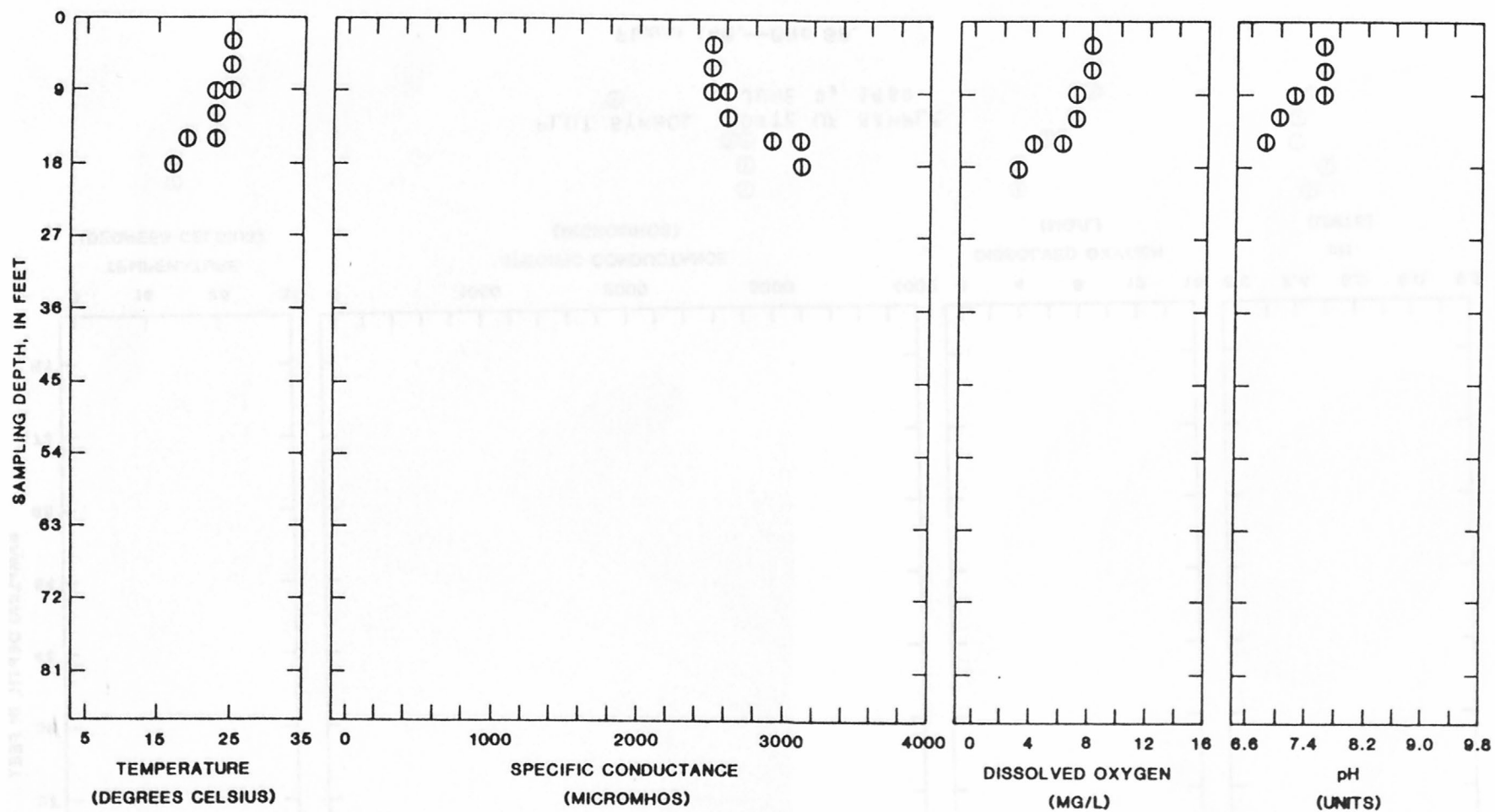


Figure 143.--Site 86.



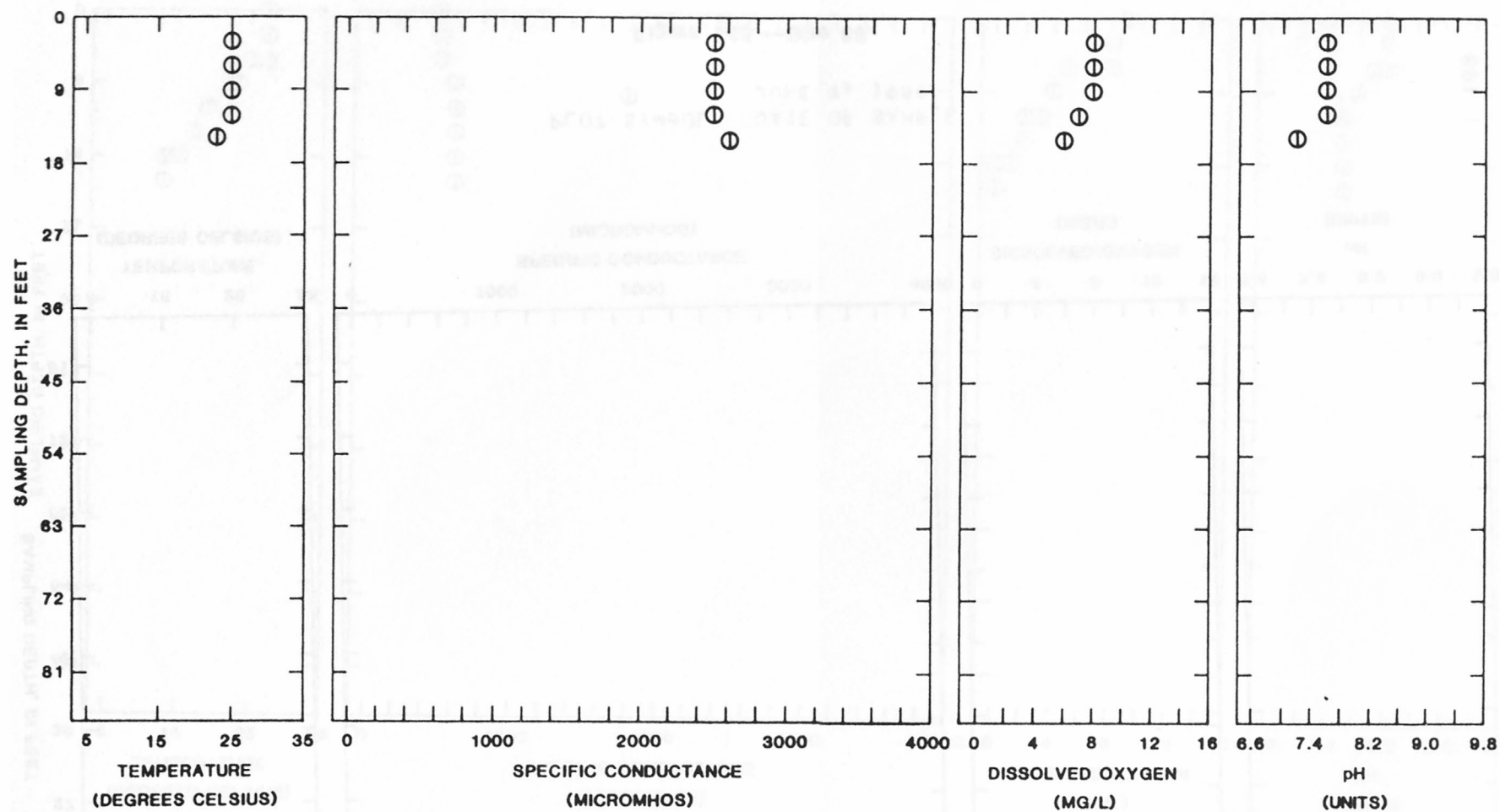
PLUT SYMBOL DATE OF SAMPLE
⊙ JUNE 5, 1980

Figure 144.--Site 87.



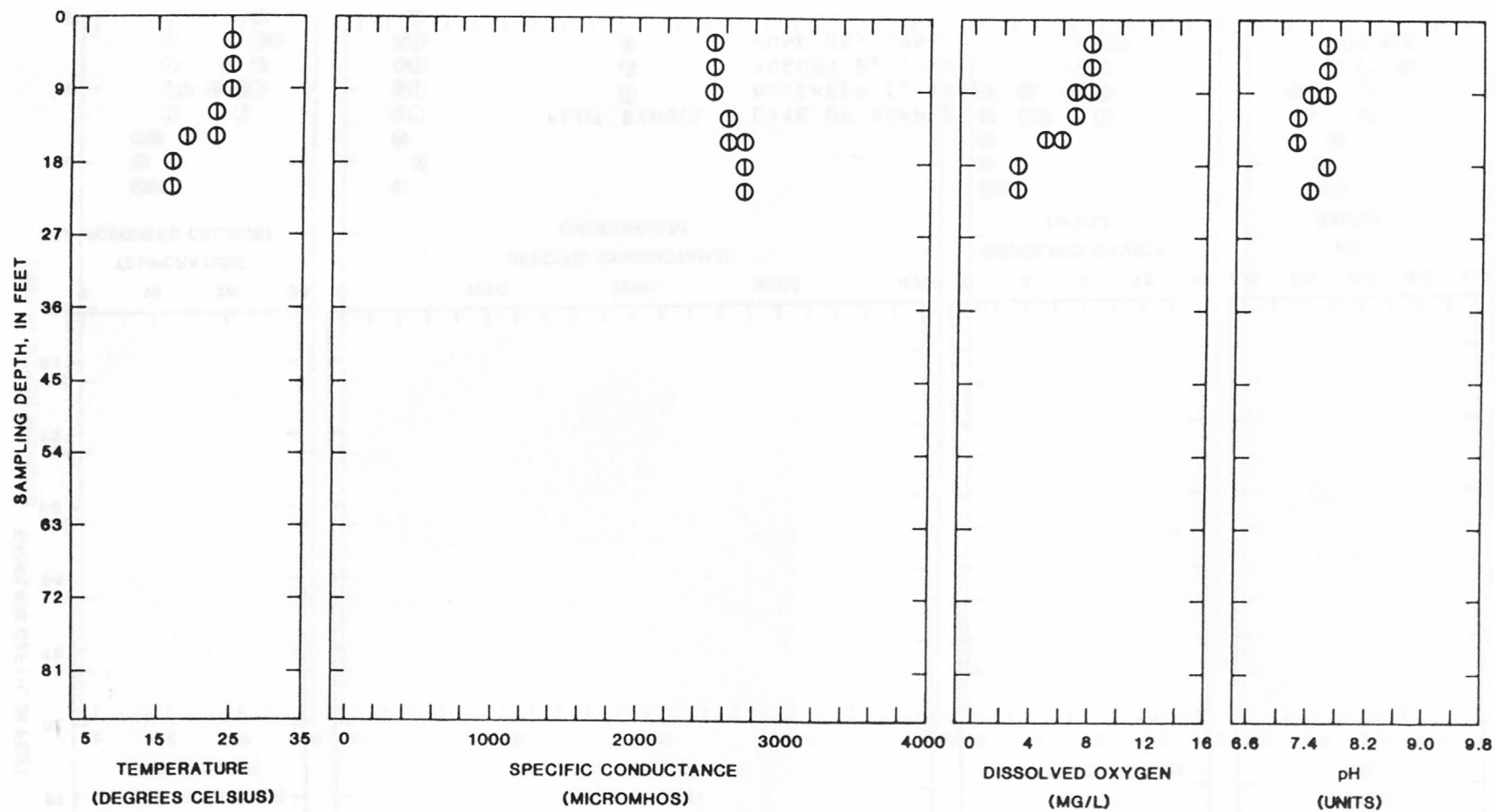
PLOT SYMBOL DATE OF SAMPLE
 ○ JUNE 4, 1980

Figure 145.--Site 88.



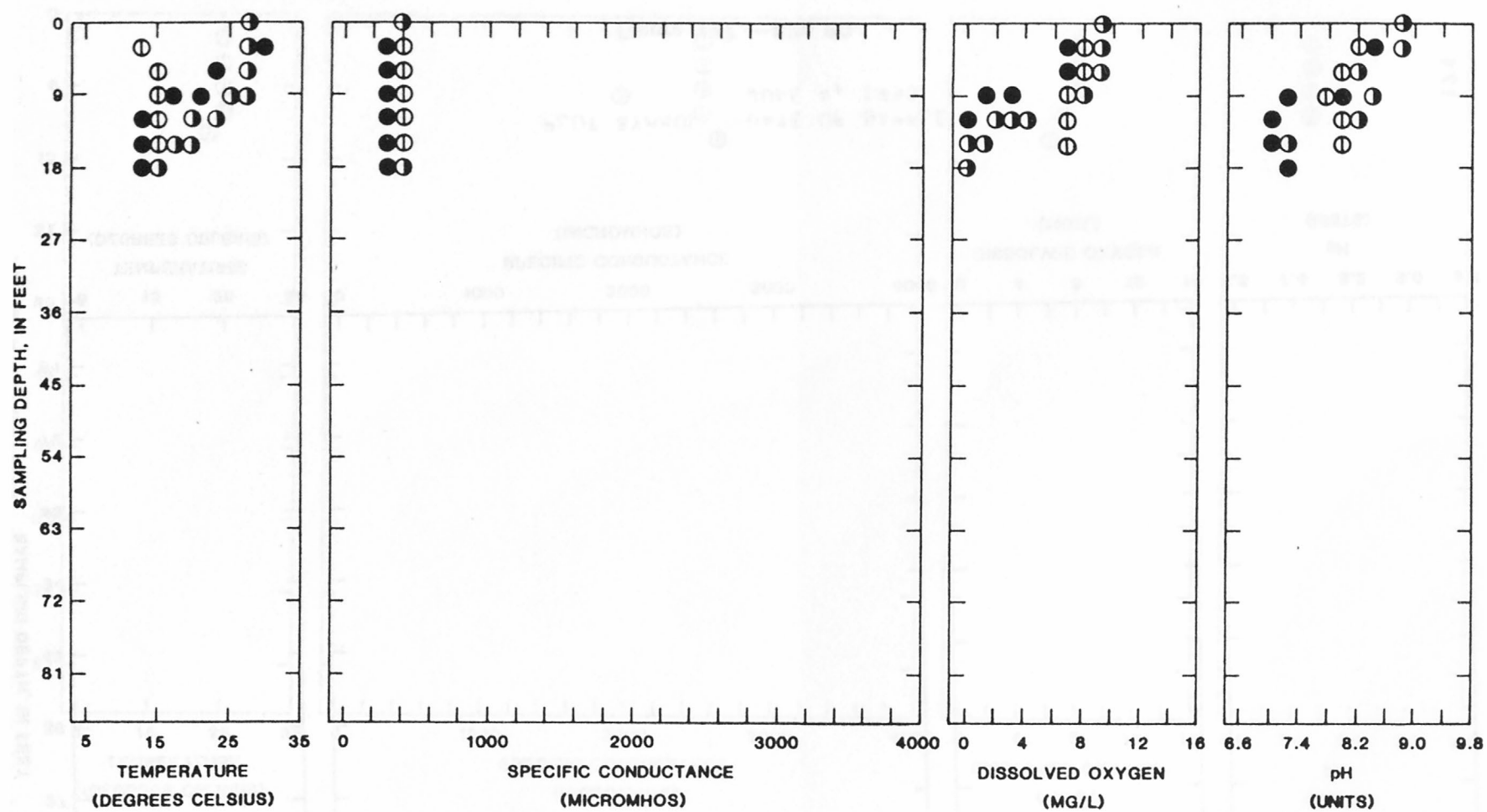
PLOT SYMBOL DATE OF SAMPLE
⊙ JUNE 4, 1980

Figure 146.--Site 89.



PLOT SYMBOL DATE OF SAMPLE
 ⊙ JUNE 4, 1980

Figure 147.--Site 90.



PLOT SYMBOL . DATE OF SAMPLE
 ○ NOVEMBER 1, 1978
 ◐ AUGUST 2, 1979
 ● JUNE 25, 1980

Figure 148.--Site 91.

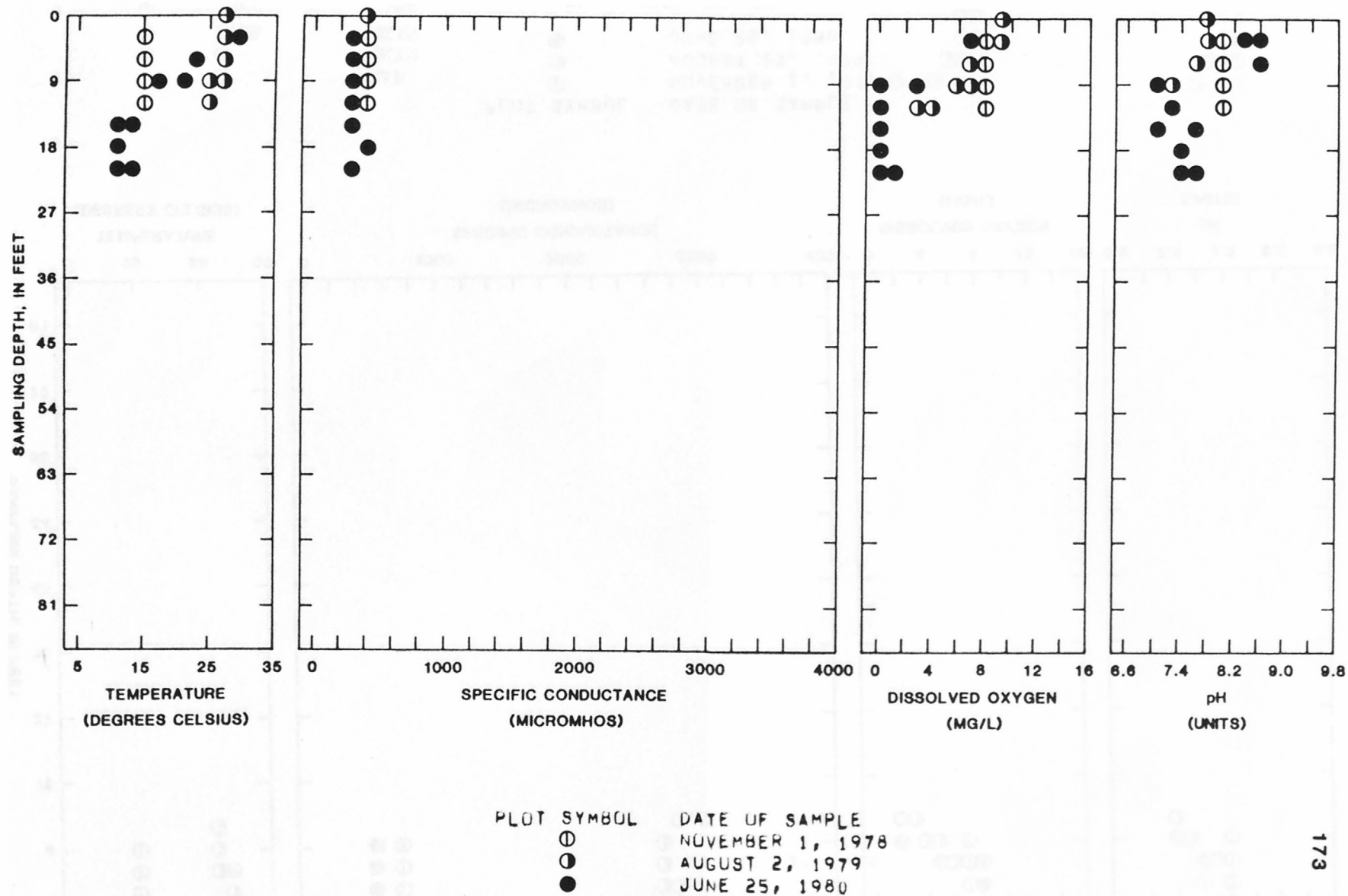


Figure 149.--Site 92.

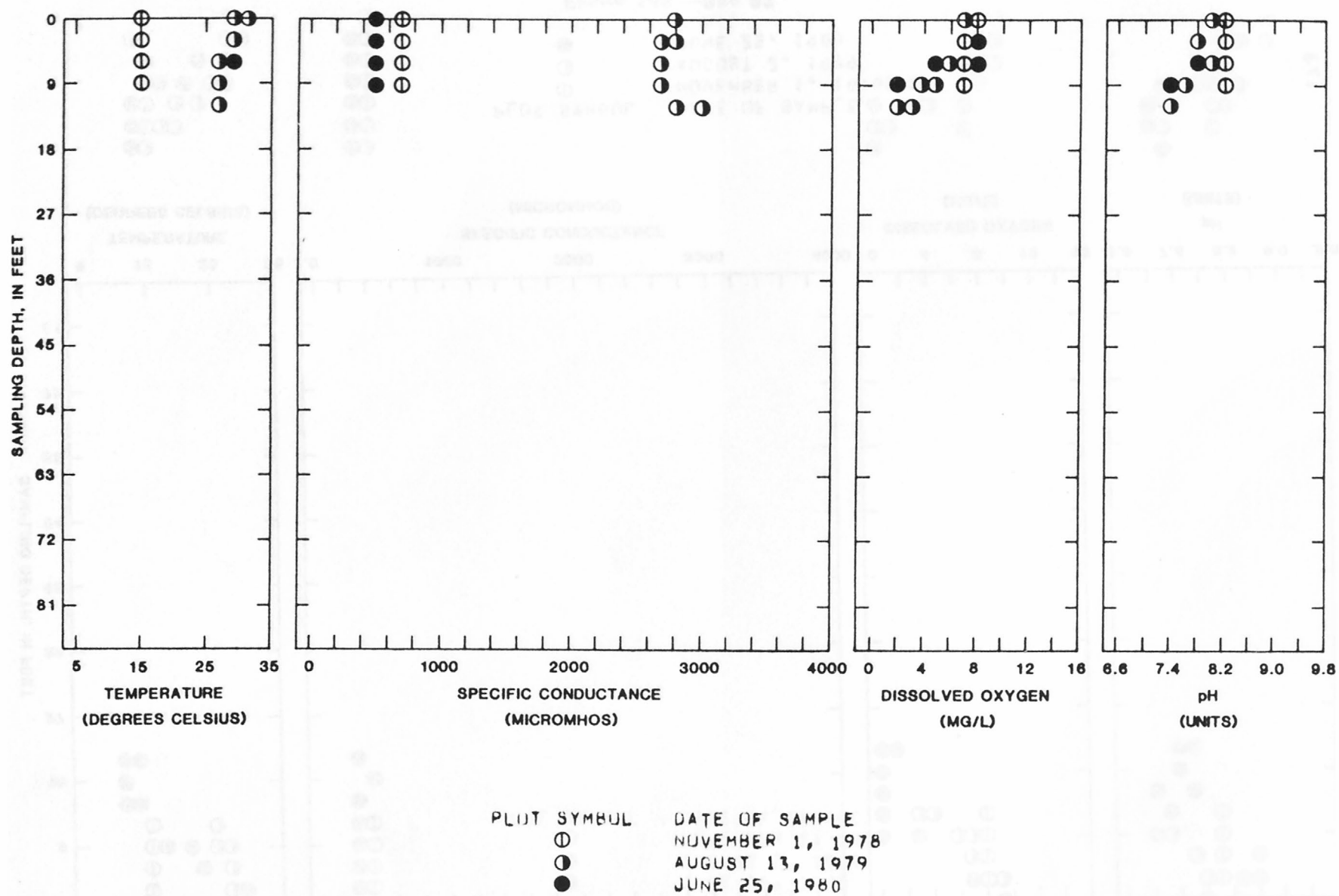
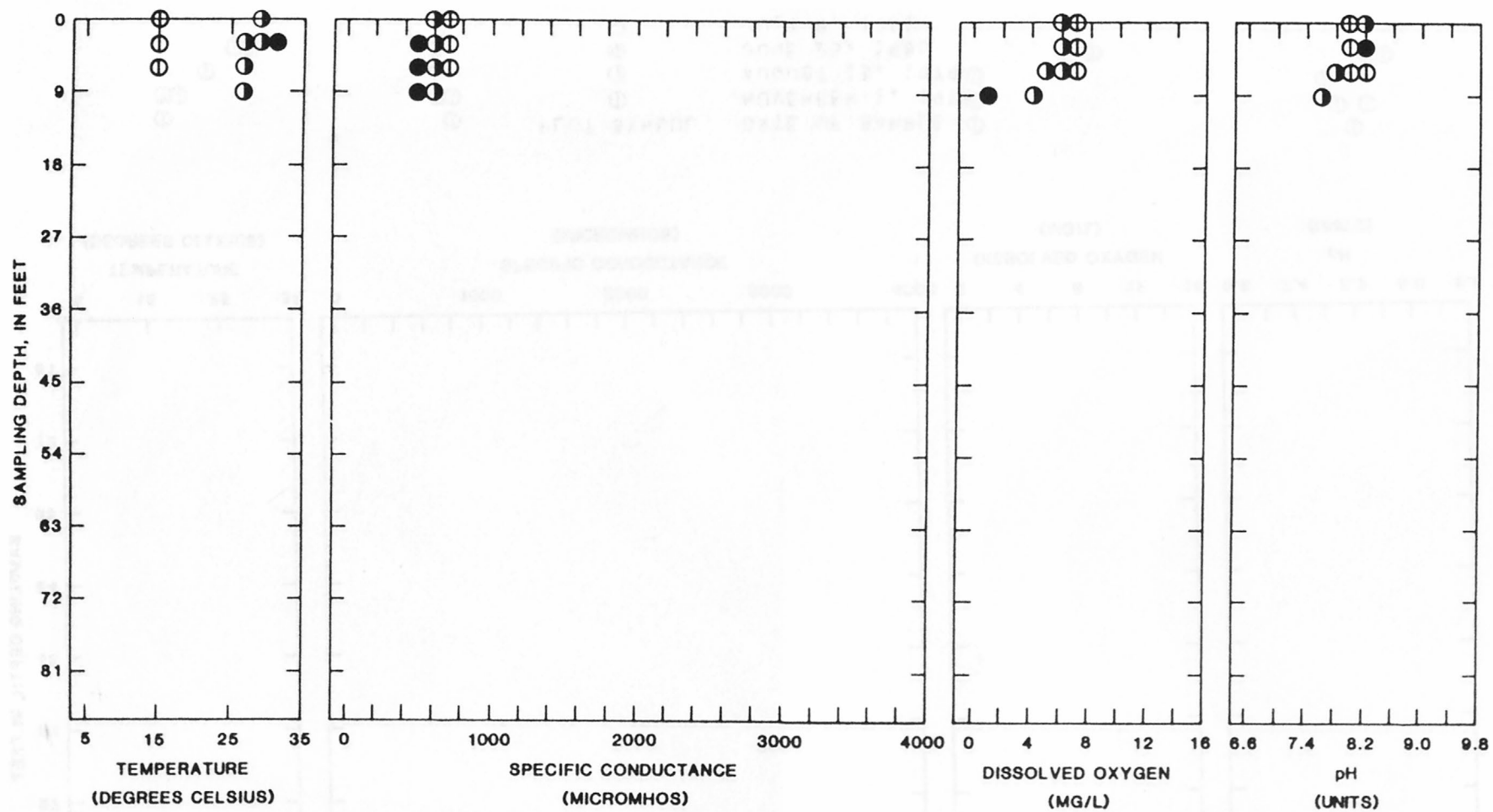


Figure 150.--Site 93.



PLUT SYMBOL DATE OF SAMPLE
 ○ NOVEMBER 1, 1978
 ◐ AUGUST 13, 1979
 ● JUNE 25, 1980
 ⊙ JULY 9, 1981

Figure 151.--Site 94.

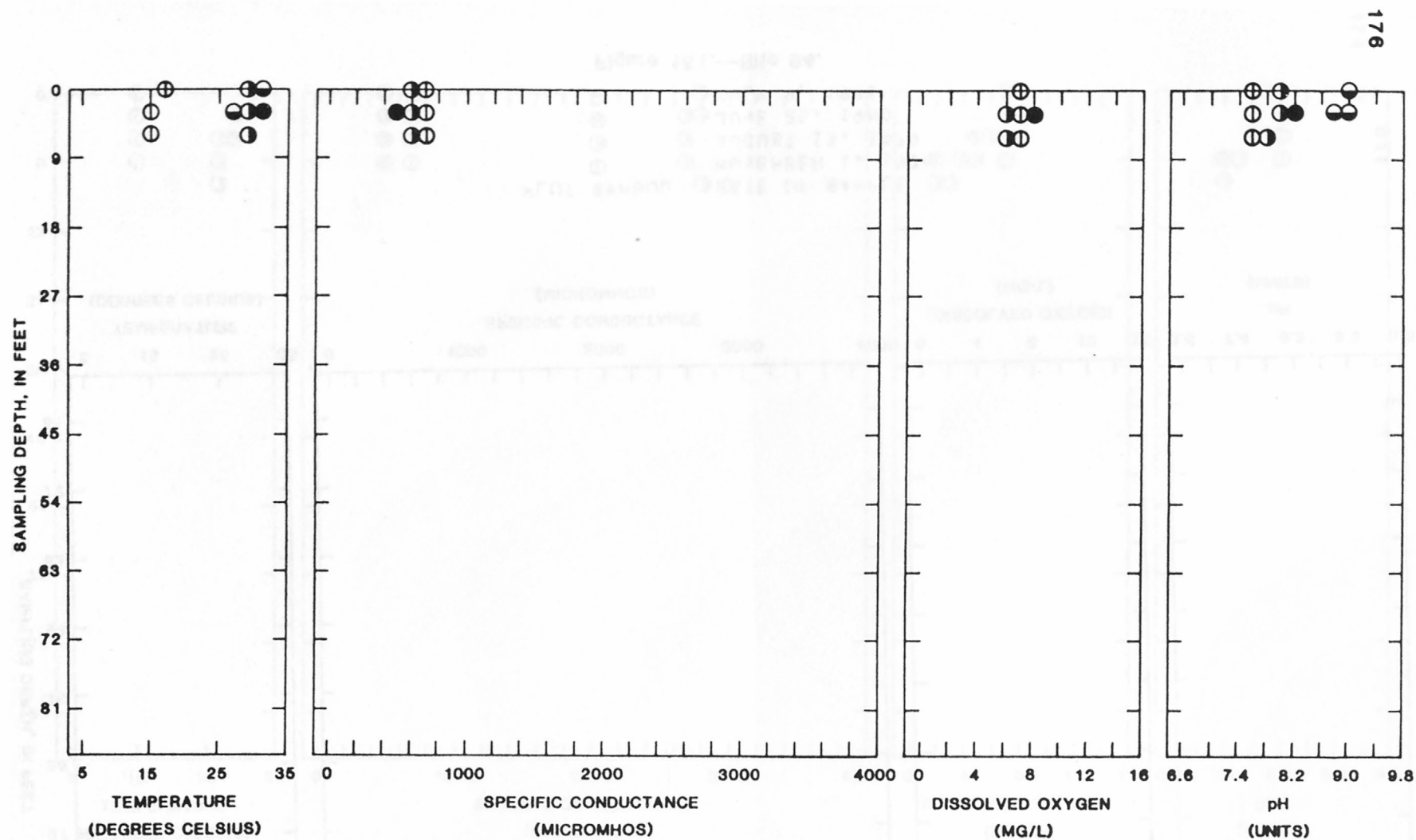
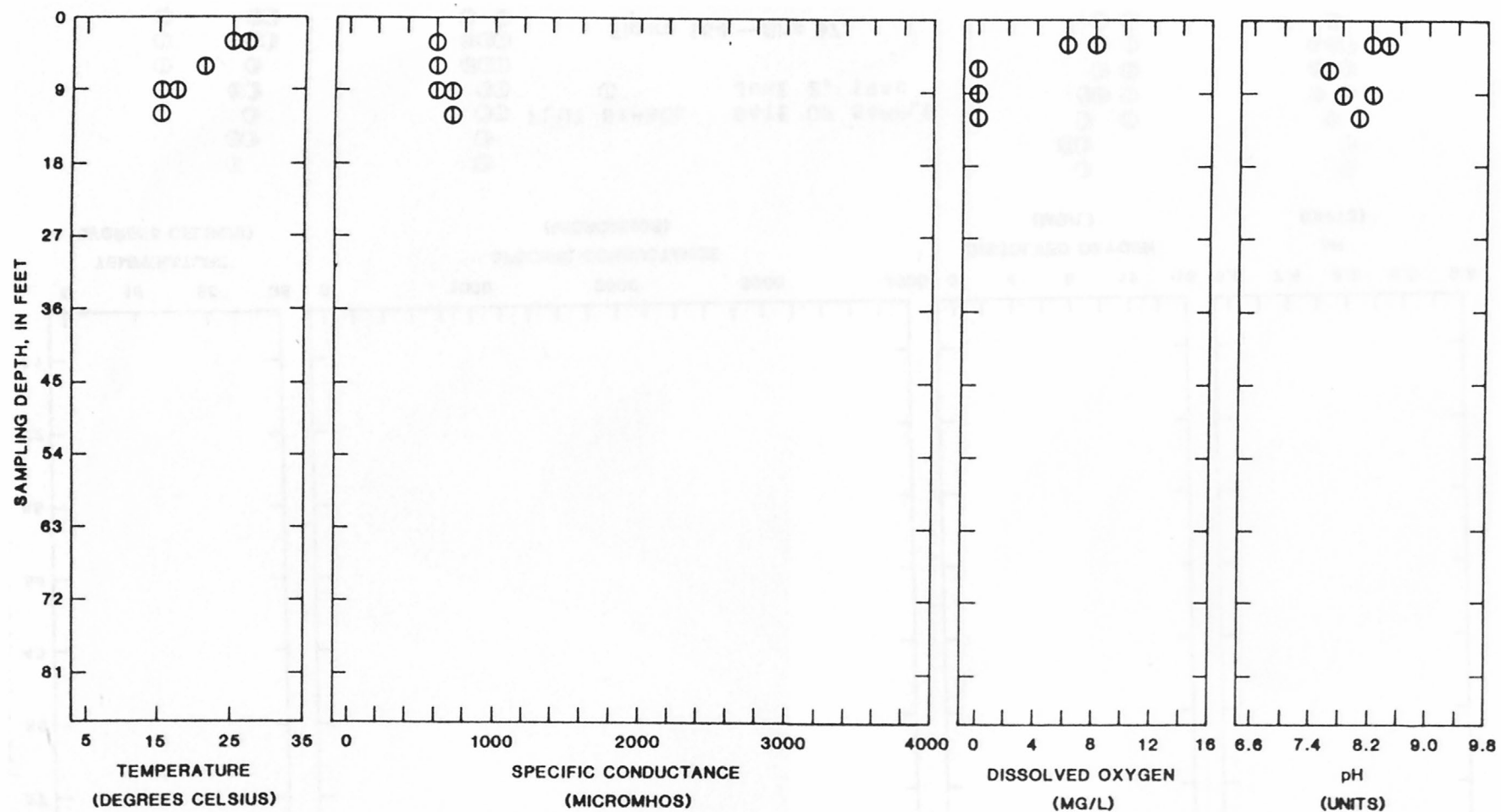


Figure 152.—Site 95.



PLOT SYMBOL DATE OF SAMPLE
 ⊙ JUNE 24, 1980

Figure 153.--Site 96.

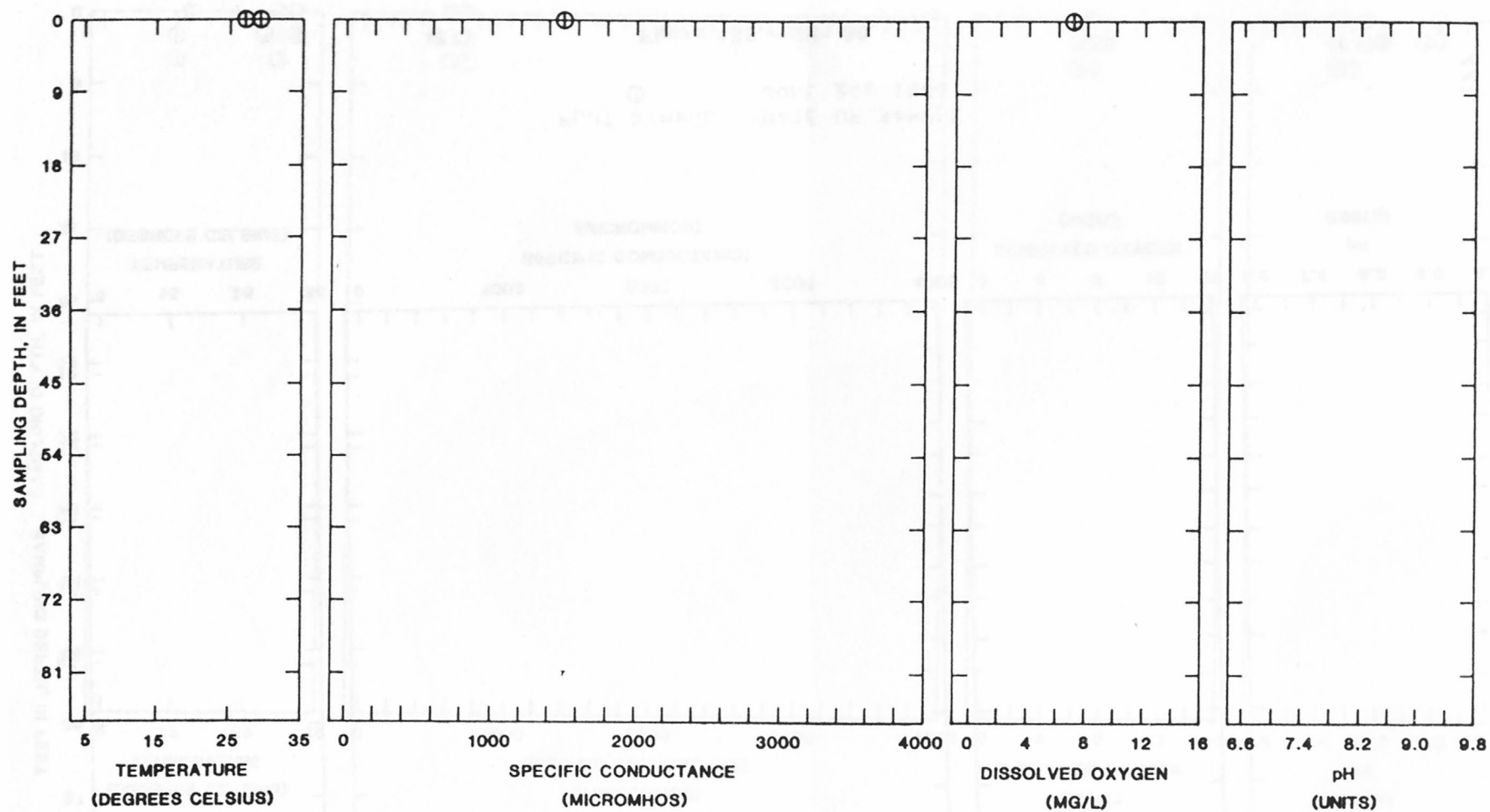


Figure 154.--Site 97.

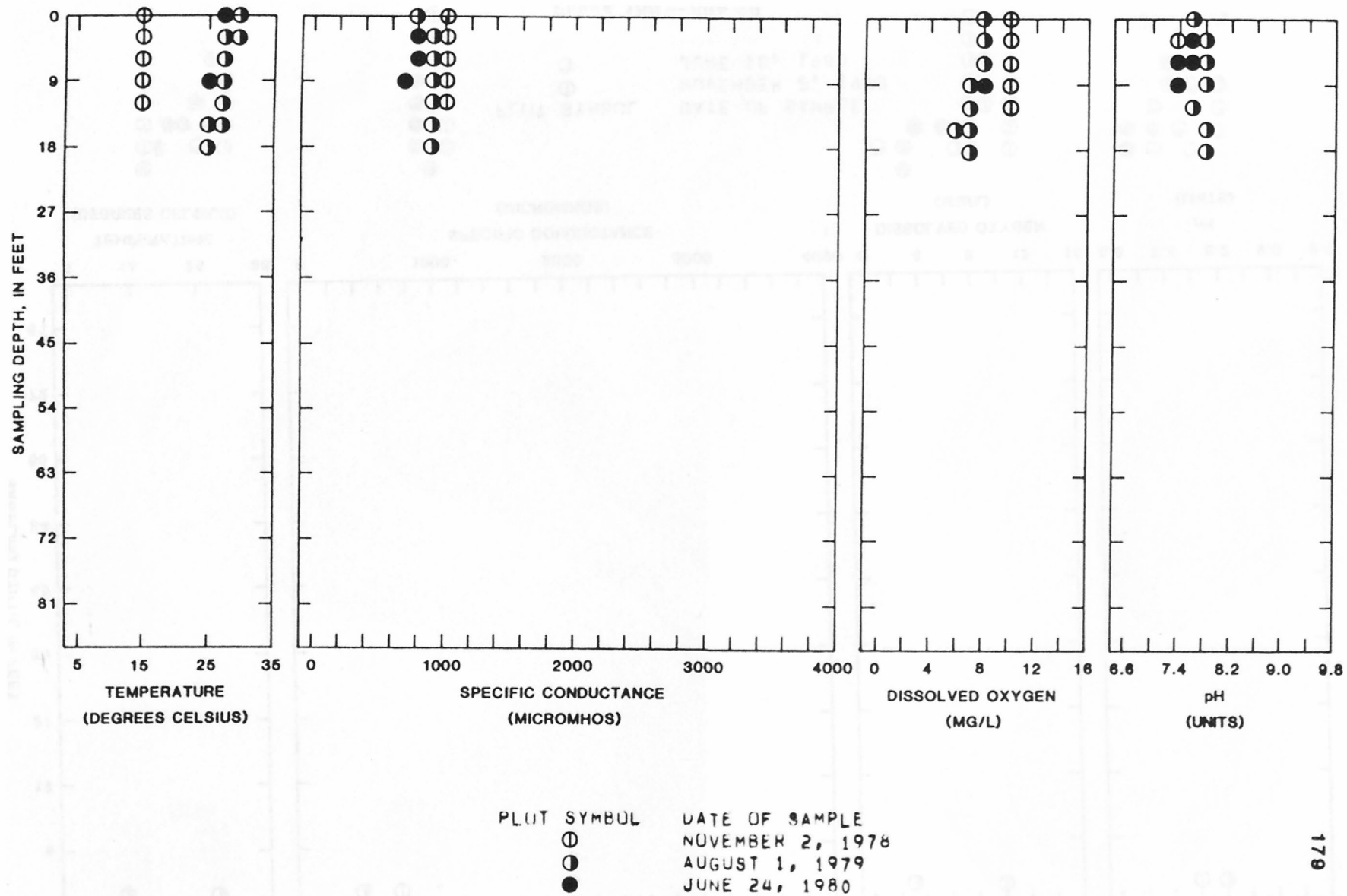
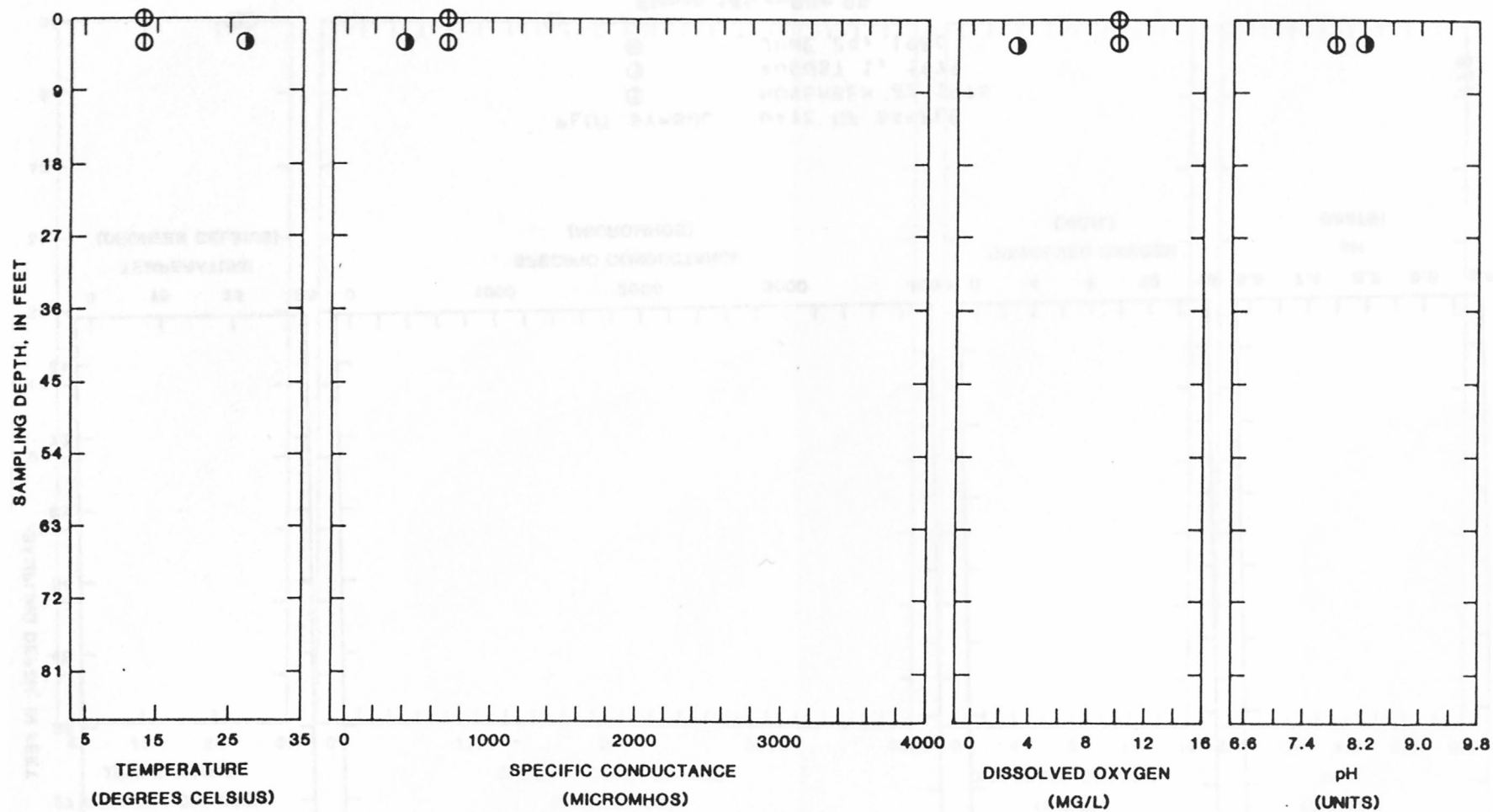
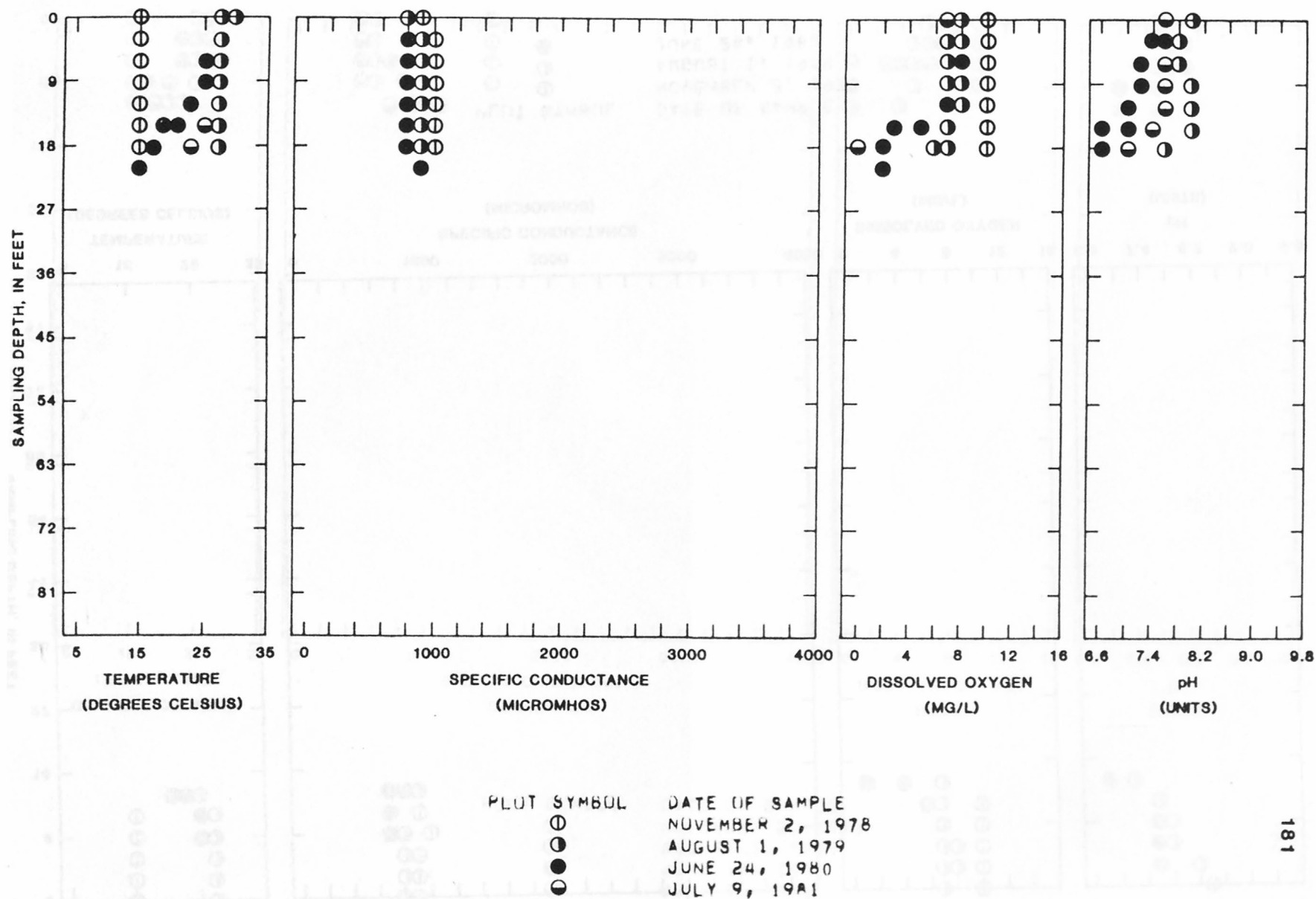


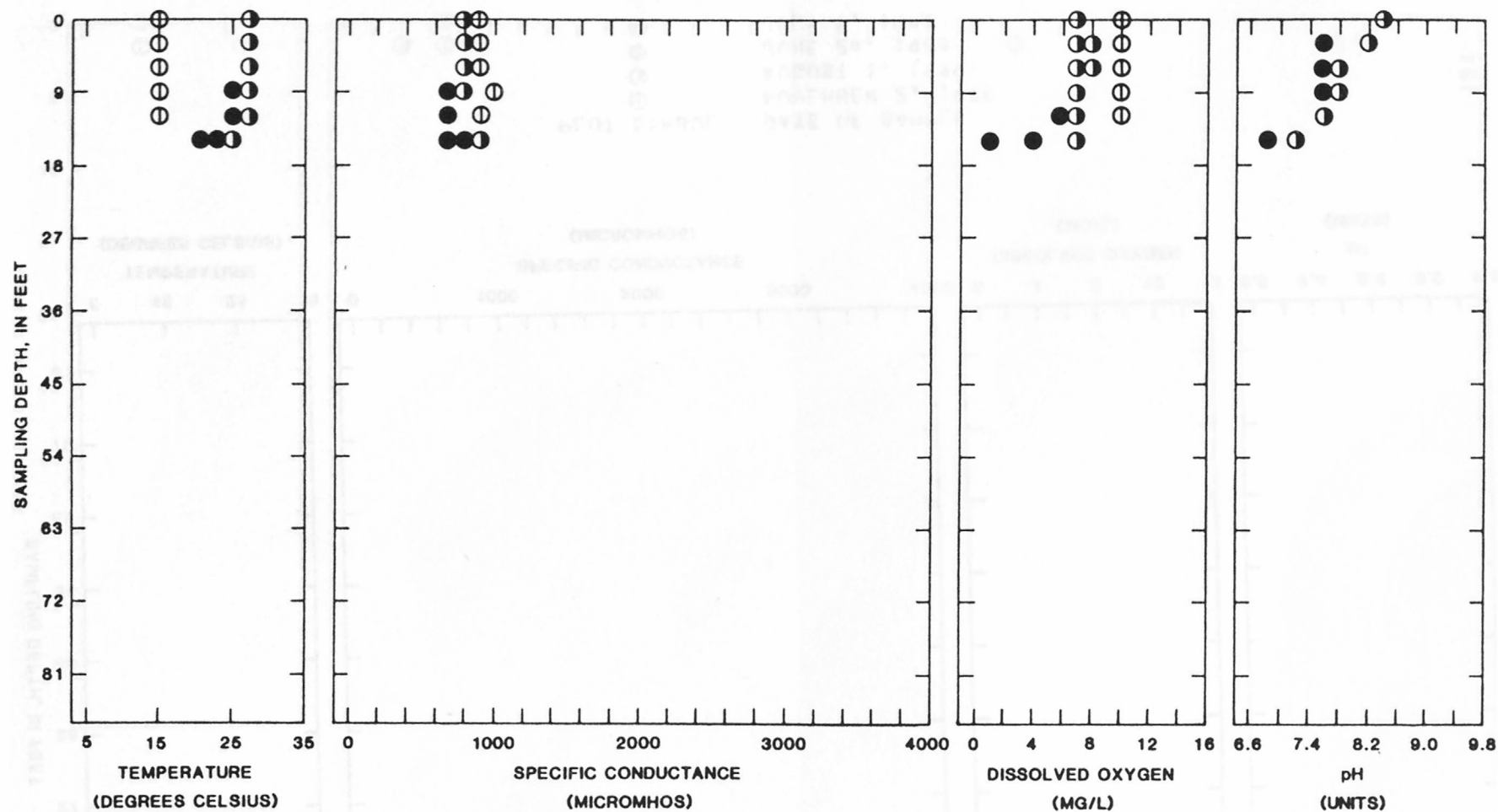
Figure 155.--Site 98.



PLOT SYMBOL DATE OF SAMPLE
 ○ NOVEMBER 2, 1978
 ● JUNE 18, 1980

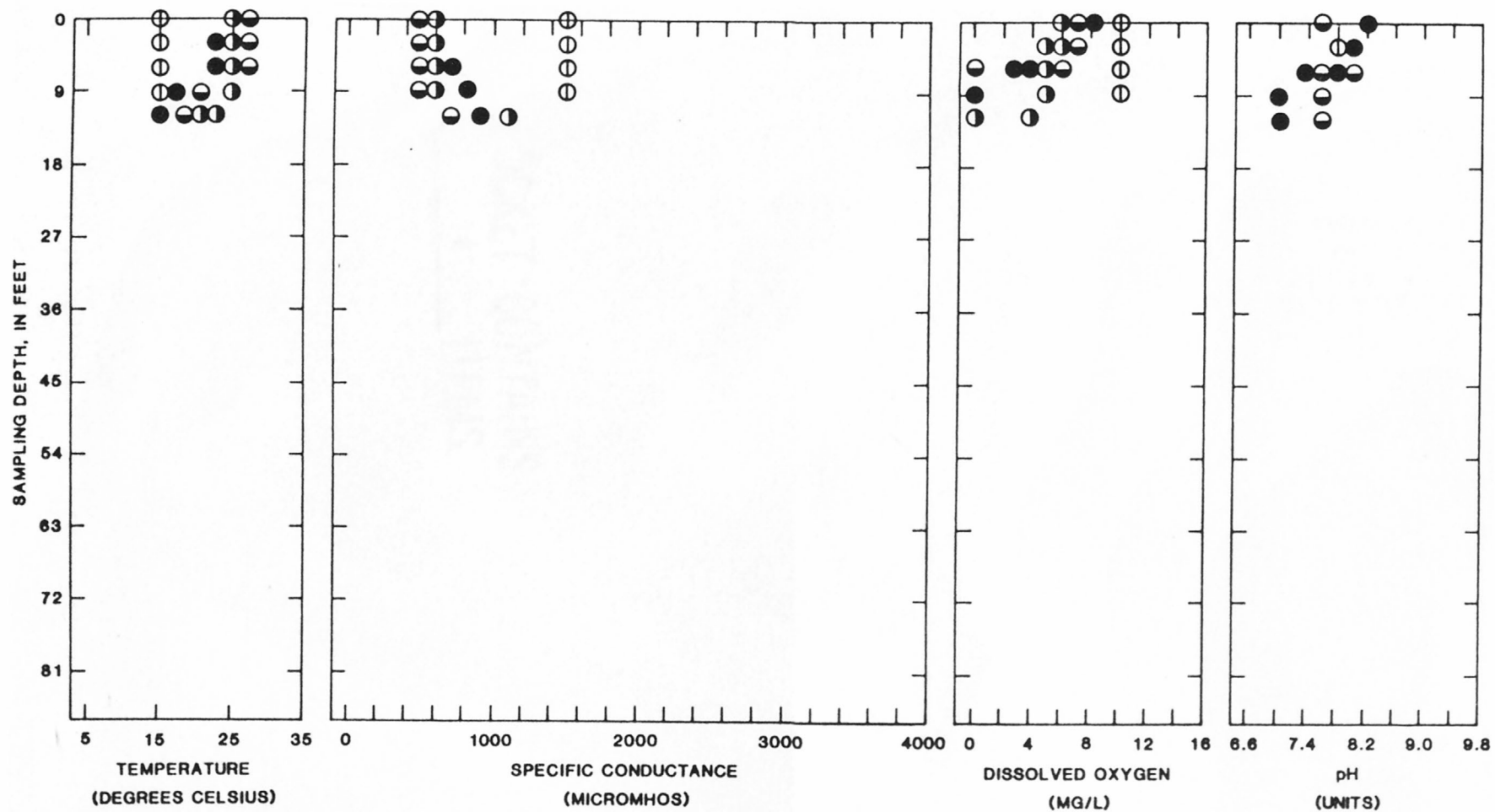
Figure 156.--Site 99.





PLUT SYMBOL DATE OF SAMPLE
 ○ NOVEMBER 2, 1978
 ◐ AUGUST 1, 1979
 ● JUNE 24, 1980

Figure 158.—Site 101.



PLOT SYMBOL DATE OF SAMPLE
 ○ NOVEMBER 2, 1978
 ◐ AUGUST 1, 1979
 ● JUNE 18, 1980
 ○ JULY 9, 1981

Figure 159.--Site 102.

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