HYDROGEOLOGIC AND WATER-QUALITY DATA FROM WELL CLUSTERS NEAR THE WASTEWATER-TREATMENT PLANT, U.S. MARINE CORPS AIR STATION, CHERRY POINT, NORTH CAROLINA

By Louis C. Murray, Jr., and Charles C. Daniel, III

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HYDROGEOLOGIC AND WATER-QUALITY DATA FROM WELL CLUSTERS NEAR THE WASTEWATER-TREATMENT PLANT, U.S. MARINE CORPS AIR STATION, CHERRY POINT, NORTH CAROLINA

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ABSTRACT

Hydrogeologic and ground-water quality data were collected near the wastewater-treatment plant and associated polishing lagoons at the Marine Corps Air Station, Cherry Point, North Carolina, in 1988. Between March and May 1988, two observation wells were installed upgradient and six wells were installed downgradient of the polishing lagoons and sampled for organic and inorganic U.S. Environmental Protection Agency priority pollutants. Placement of the well screens allowed sampling from both the upper and lower parts of the surficial aquifer. Natural gamma-ray geophysical logs were run in the four deepest wells. Lithologic logs were prepared from split-spoon samples collected during the drilling operations. Laboratory hydraulic conductivity tests were conducted on samples of fine-grained material recovered from the two confining units that separate the surficial aquifer and the drinking-water supply aquifer; values ranged from 0.011 to 0.014 foot per day ($4x10^{-6}$ to $5x10^{-6}$ centimeters per second). Static water levels were recorded on April 25, 1988.

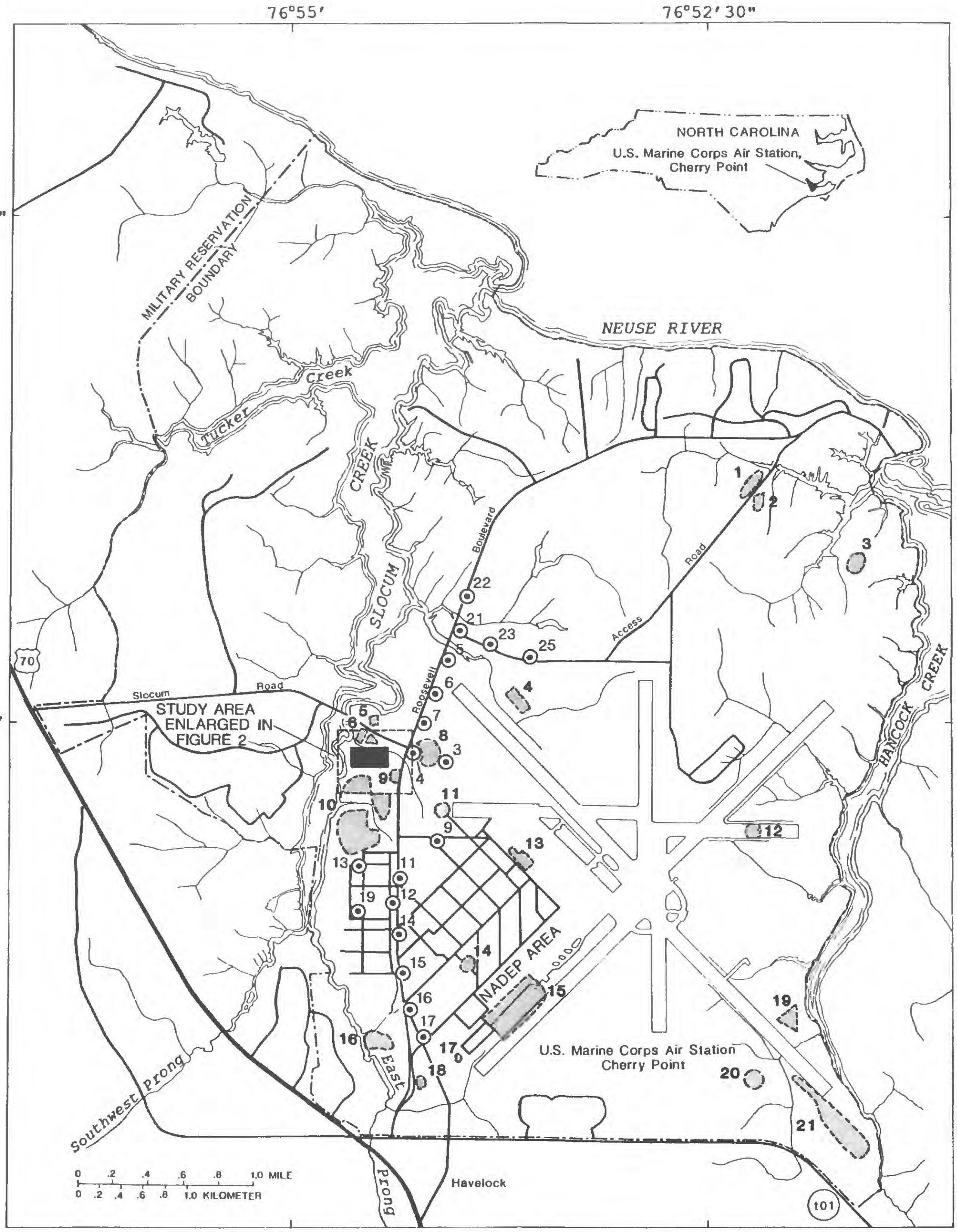
Relatively low concentrations of purgeable organic compounds (up to 2.2 micrograms per liter for dichlorodifluoromethane), acid and base/neutral extractable compounds (up to 58 micrograms per liter for bis(2-ethylhexyl) phthalate), or pesticides (up to 0.03 micrograms per liter for diazinon and methyl parathion) were detected in water samples collected from all of the wells. Trace metals were detected in concentrations above minimum detectable limits in all of the wells and were found to be higher in water samples collected from the downgradient wells (up to 320 micrograms per liter for zinc) than in water samples from the upgradient wells.

INTRODUCTION

The U.S. Marine Corps Air Station, Cherry Point, North Carolina, was established in 1941 on the south shore of the Neuse River (fig. 1). Since that time, the Air Station has become a major flight training and military aircraft rework center for the Department of the Navy. Along with this growth and industrial activity has come an increased demand for water. At the same time, wastes of many varieties have been disposed of at selected sites on the Air Station; additionally, there have been spills of chemicals and petroleum products (fig. 1). The Air Station currently uses between 3.5 and 4.5 million gallons of water per day (Mgal/d), all of which is pumped from wells located on Air Station property.

Increased demand for water and concerns about possible ground-water contamination have led to a multiphase study by the U.S. Geological Survey (USGS) in cooperation with the Department of the Navy, U.S. Marine Corps, to evaluate the water resources of the Air Station. The first phase of the study, which began in April 1986, investigated all potable water-supply wells for chemical contamination and developed a preliminary hydrogeologic framework for the area. That study resulted in a report by Lloyd and Daniel (1988) indicating that a relatively small amount of contamination originating at or near land surface had migrated into the water-supply aquifer.

One area of ground-water contamination identified by Lloyd and Daniel (1988) is near the intersection of Slocum Road and Roosevelt Boulevard. This is also an area noted for a number of spill and dump sites, including the largest landfill (fig. 1, site 10) on the Air Station. Just north of this landfill is the municipal wastewater-treatment plant (fig. 2), which includes two large polishing lagoons. For a number of years prior to August 1987, rinse and wash water from the metal-plating plant at the Naval Aviation Depot (NADEP) flowed from the NADEP industrial wastewater-treatment plant to the municipal wastewater-treatment plant. The effluent was discharged through the polishing lagoons and ultimately into Slocum Creek. Because the water from the NADEP may have contained metals and other chemicals that may have reached the lagoons, it is possible that ground water beneath the lagoons is contaminated.



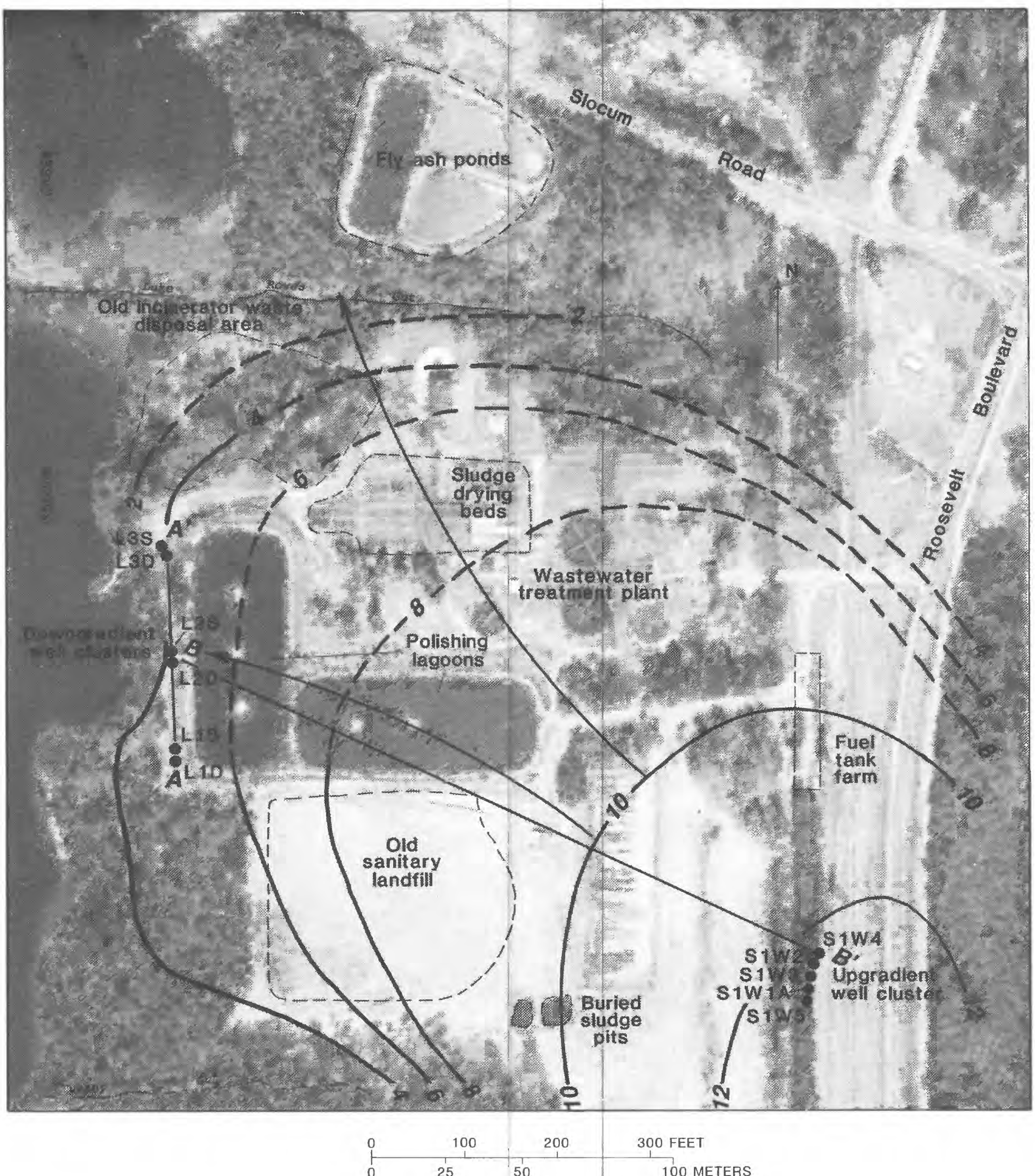
EXPLANATION

5 — WASTE DISPOSAL OR SPILL SITE--Number is that assigned for Naval Assessment and Control of Installation Pollutants study (Putnam and others, 1982)

WASTE WATER TREATMENT PLANT AND POLISHING LAGOONS AREA--See figure 2 for details

22 — DRINKING-WATER SUPPLY WELL AND NUMBER--Data for wells are given in Lloyd and Daniel (1988)

Figure 1.--Location of study area at the U.S. Marine Corps Air Station, Cherry Point, North Carolina.



EXPLANATION

—— 6 - - - WATER-TABLE CONTOUR (FROM COBLE AND SHARPLESS, 1983)--Shows altitude of water table. Dashed where approximately located. Contour interval 2 feet. Datum is sea level

——→ DIRECTION OF GROUND-WATER MOVEMENT (FROM COBLE AND SHARPLESS, 1983)

A —— A' LINE OF HYDROGEOLOGIC SECTION

L3S ● OBSERVATION WELL AND NUMBER

Figure 2.--Aerial view of study area and locations of well clusters.

Purpose and Scope

This report presents hydrogeologic and water-quality data collected within the area of the wastewater-treatment plant and polishing lagoons. The data, collected from four well clusters installed in March 1988, include lithologic descriptions, geophysical logs, water levels, laboratory tests for hydraulic conductivity, grain-size analysis, and results of water-quality analyses. These data were used to construct hydrogeologic sections.

Water samples collected from the wells in April 1988 were analyzed for organic compounds (table 1) and inorganic trace elements (table 2) classified as priority pollutants by the U.S. Environmental Protection Agency (EPA). Analyses were also performed for physical properties and inorganic constituents (table 2) that included major ions and nutrients. Field measurements included specific conductance, alkalinity, temperature, and pH.

Site Description

A typical section of the upper 300 feet (ft) of the aquifers and confining units at the Air Station is shown in figure 3 (Murray and Keoughan, 1990). The surficial aquifer is composed of the sand and silty sand of the Pleistocene Flanner Beach Formation. A confining unit of silty to clayey sand of the Pleistocene James City Formation, hereafter referred to as the upper confining unit, separates the surficial and Yorktown aquifers. The Yorktown aquifer is comprised of the sands and slightly silty sands of the Pliocene Yorktown Formation and is underlain by a confining unit of phosphatic silty sand to sandy clay in the Miocene Pungo River Formation, hereafter referred to as the lower confining unit. The Castle Hayne aquifer supplies drinking water to the Air Station and is composed of the sand, sandy limestone, and limestone beds of the Oligocene River Bend Formation and the Eocene Castle Hayne Formation. Figure 3 also shows the relation of these units to the natural gamma-ray log. These relations were used to construct hydrogeologic sections presented later in this report.

Table 1.--*Organic compounds analyzed*

[Substances are classified as priority pollutants by U.S. Environmental Protection Agency (1976, 1984a, 1984b, and 1986)]

Purgeable organic compounds		
Dichlorobromomethane	Methyl chloride	1,2-Dichlorobenzene
Carbon tetrachloride	Methyene chloride	1,3-Dichlorobenzene
1,2-Dichloroethane	Tetrachloroethylene	1,4-Dichlorobenzene
1,2-(cis) Dichloroethene	Trichlorofluoromethane	2-Chloroethyl vinyl ether
Bromoform	1,1-Dichloroethane	Dichlorodifluoromethane
Chlorodibromomethane	1,1-Dichloroethylene	1,3-(trans) Chloropropene
Chloroform	1,1,1-Trichloroethane	1,3-(cis) Chloropropene
Toluene	1,1,2-Trichloroethane	1,2-Dibromoethylene
Benzene	1,1,2,2-Tetrachloroethane	Vinyl chloride
Chlorobenzene	1,2-Dichloropropane	Trichloroethylene
Chloroethane	1,2-(trans) Dichloroethene	Styrene
Ethylbenzene	1,3-Dichloropropene	Xylene
Methyl bromide		
Acid and base/neutral extractable organic compounds		
Acenaphthylene	N-nitrosodi-n-propylamine	2,4-Dimethylphenol
Acenaphthene	N-Nitrosodiphenylamine	2,4-Dinitrotoluene
Anthracene	N-Nitrosodimethylamine	2,4-Dinitrophenol
Benzo(b)fluoranthene	Nitrobenzene	2,4,6-Trichlorophenol
Benzo(k)fluoranthene	Parachlorometa cresol	2,6-Dinitrotoluene
Benzo(a)pyrene	Phenanthrene	3,3-Dichlorobenzidine
Delta benzene hexachloride	Pyrene	4-Bromophenyl phenyl ether
Bis(2-chloroethyl) ether	Benzo(g,h,i) perylene	4-Chlorophenyl phenyl ether
Bis(2-chloroisopropyl) ether	Benzo(a)anthracene	4-Nitrophenol
Bis(2-chloroisopropyl) ether	1,2-Dichlorobenzene	4,6-Dinitro-ortho-cresol
N-butyl benzyl phthalate	1,2,4-Trichlorobenzene	Phenol (C6H-5OH)
Chrysene	1,2,5,6-Dibenzanthracene	Naphthalene
Diethyl phthalate	1,3-Dichlorobenzene	Pentachlorophenol
Dimethyl phthalate	1,4-Dichlorobenzene	Bis(2-ethylhexyl) phthalate
Fluoranthene	2-Chloronaphthalene	Di-n-butyl phthalate
Fluorene	2-Chlorophenol	Benzidine
Hexachloropentadiene	2-Nitrophenol	Naphthalenes, polychlor
Hexachloroethane	Di-n-octyl phthalate	Hexachlorobenzene
Indeno (1,2,3-c,d)pyrene	2,4-Dichlorophenol	Hexachlorobutadiene
Isophorone		
Pesticides/PCB's		
Endosulfan sulfate	Lindane	Aroclor 1242 PCB
beta-Endosulfan	Chlordane	Aroclor 1248 PCB
alpha-Endosulfan	Dieldrin	Aroclor 1254 PCB
Endrin aldehyde	Endrin	Aroclor 1260 PCB
Aroclor 1016 PCB	Ethion	Malathion
4,4'-DDT	Toxaphene	Parathion
4,4'-DDD	Heptachlor	Diazinon
4,4'-DDE	Heptachlor epoxide	Methyl parathion
Aldrin	Arochlor 1221 PCB	Trithion
alpha-Benzene hexachloride	Arochlor	Methyl trithion
beta-Benzene hexachloride		

Table 2.--*Physical properties and inorganic constituents analyzed*

[°C, degrees Celsius]

Physical properties and characteristics		
Alkalinity	Turbidity	Residue dissolved at 180 °C
Color	Total organic carbon	Specific conductance
Methyl blue active substance	pH	Temperature
Hardness		
Major dissolved ions and nutrients		
Calcium	Potassium	Nitrate
Chloride	Silica	Ammonia nitrogen
Fluoride	Sodium	Organic nitrogen
Iron	Sulfate	Orthophosphate
Magnesium	Nitrite	
Trace elements		
Antimony, total[1]	Cobalt, dissolved[2]	Mercury, total recoverable[1]
Arsenic, total[1]	Copper, total recoverable[1]	Nickel, total recoverable[1]
Beryllium, total recoverable[1]	Copper, dissolved[1]	Nickel, dissolved[1]
Barium, dissolved[2]	Cyanide, total[1]	Selenium, total[1]
Boron, dissolved	Lead, total recoverable[1]	Silver, total recoverable[1]
Cadmium, total recoverable[1]	Lead, dissolved[1]	Tin, total recoverable[2]
Chromium, total recoverable[1]	Manganese, dissolved[1]	Zinc, total recoverable[1]
Chromium, dissolved[1]		

[1]Priority pollutant (U.S. Environmental Protection Agency, 1976 and 1986).
[2]Required by U.S. Environmental Protection Agency for ground-water samples from Resource Conservation and Recovery Act sites (U.S. Environmental Protection Agency, 1987).

The study area encompasses the Air Station wastewater-treatment plant and associated polishing lagoons, part of the old sanitary landfill, a fuel tank farm, and other areas previously used as waste-disposal sites at the Base (fig. 2). These other disposal areas include a site where wastes were previously incinerated and disposed of and a site previously used to dispose of fly ash and cinders from an old power plant. Two closed sludge pits, located south of the polishing lagoons, were used to dispose of industrial sludge generated by the NADEP and the Air Station prior to January 1983. Further details on the types and amounts of wastes disposed of at these sites and at the old sanitary landfill are available in reports by Schnabel Engineering Associates, Inc., (1981); Putnam and others (1982); and NUS Corporation (1984).

Land surface across the study area slopes from east to west toward Slocum Creek. Altitudes range from 25 ft above sea level near Roosevelt

Boulevard to approximately 1 ft above sea level at Slocum Creek. A considerable part of the surficial soils across the study area has been disturbed by construction of the wastewater-treatment plant and waste-disposal sites. Ground water in the surficial aquifer moves in a northwesterly direction across the study area toward Slocum Creek, with localized flow toward Luke Rowes Gut and Turkey Gut (Coble and Sharpless, 1983).

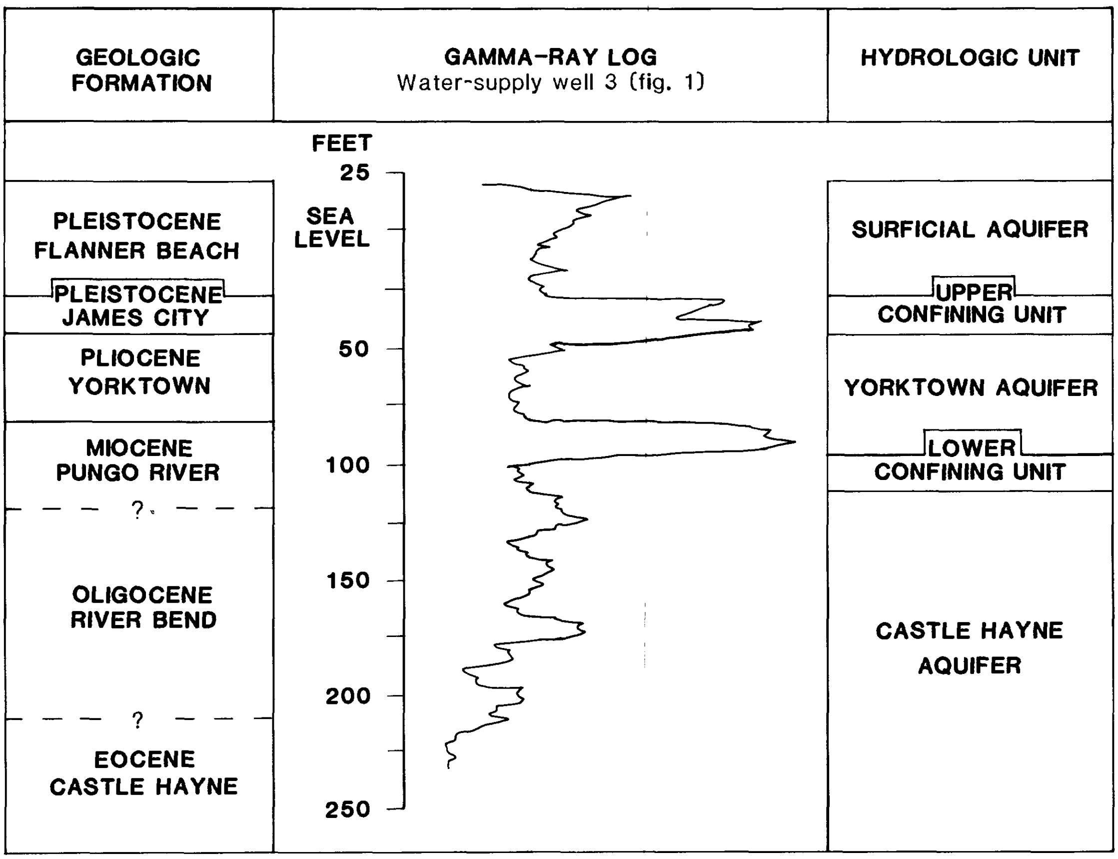


Figure 3.--Relation between geologic formations, hydrologic units, and the gamma-ray log at the U.S. Marine Corps Air Station, Cherry Point, North Carolina.

Previous Studies

Lloyd and Daniel (1988) made a preliminary identification and appraisal of the distribution of the aquifers and confining units that underlie the Air Station. The hydrogeologic nomenclature used in their report has since been revised (Murray and Keoughan, 1990).

Several previous studies have been conducted within the study area (figs. 1 and 2). Schnabel Engineering Associates, Inc., (1981) conducted a soil and hydrogeologic investigation of the old landfill area. Their report includes data on soil lithology, water levels, and results from field and laboratory hydraulic conductivity tests and grain-size analyses.

Soil and Materials Engineers, Inc., (1983) concentrated their investigation near the perimeters of the two buried sludge pits and collected soil samples between 10 and 15 ft below land surface for chemical analyses. Results indicated the presence of several purgeable organic compounds (up to 2,590 parts per billion (ppb) of chloroform) and trace metals (up to 9.7 parts per million (ppm) of lead) in these samples.

Coble and Sharpless (1983) showed that the potential exists for ground-water contaminant movement from the buried sludge pits to Slocum Creek and into the underlying aquifers. Their report includes a water-table contour map, potentiometric water levels from selected water-supply wells, a hydrogeologic section, and estimated soil physical properties.

NUS Corporation (1984, 1985, and 1986) installed monitoring well networks at numerous waste-disposal sites scattered across the Air Station in an effort to evaluate the effects of these sites on shallow ground-water quality. Individual investigations were conducted at the sanitary landfill site, the incinerator waste-disposal site, and at the fly ash disposal site (fig. 2). Results included chemical analyses of ground water, surface water, soils, and sediments.

A later NUS Corporation report (1987) presents results from a soil and hydrogeologic investigation of the sanitary landfill area with emphasis on the sludge pits. The study included a hydrogeologic framework, water levels, well records, lithologic soil logs, and results of laboratory measurements of the physical properties of soil. In addition, values of hydraulic conductivity and transmissivity of the surficial aquifer were estimated from pumping tests, slug tests, and laboratory tests conducted during the investigation.

Acknowledgments

This report was prepared in cooperation with the Department of the Navy, U.S. Marine Corps Air Station, Cherry Point, North Carolina. The authors extend their appreciation to R.D. Nelson, David Criswell, and Gary Edwards of the office of Natural Resources and Environmental Affairs, U.S. Marine Corps Air Station, Cherry Point, North Carolina, for their key roles in planning and coordinating this study.

DATA COLLECTION

Well Drilling and Construction

Eight wells (S1W4, S1W5, L1D, L1S, L2D, L2S, L3D, and L3S) were installed for this study at four cluster sites (2 wells per site) by the USGS in March 1988. The sites were selected to provide sampling access to the surficial aquifer upgradient and downgradient of the polishing lagoons with respect to the ground-water flow direction in the surficial aquifer (fig. 2). The upgradient wells were constructed near Roosevelt Boulevard, while the three downgradient clusters were installed in a north-south orientation between Slocum Creek and the westernmost polishing lagoon. Well screens at each of the four cluster sites were placed in the upper and lower parts of the surficial aquifer to allow for stratified sampling. The two wells constructed at the upgradient site, S1W4 and S1W5, were placed near three other USGS wells (S1W1A, S1W2, S1W3) previously installed in May 1987 as part of a larger, ongoing ground-water supply study at the Air Station. Wells S1W2 and S1W3 are screened in the surficial aquifer, while S1W1A is screened in the underlying Yorktown aquifer.

For this study, well S1W2 was used to collect ground-water samples from the lower part of the surficial aquifer at the upgradient site. Ground water from the upper part of the surficial aquifer was sampled at well S1W5. Well S1W4 was drilled into the Yorktown aquifer for collecting soil samples for lithologic analysis. No water samples were collected from well S1W4.

At the downgradient cluster sites, wells L1S, L2S, and L3S are screened in the upper part of the surficial aquifer, while wells L1D, L2D, and L3D are screened in the lower part of the surficial aquifer. Other monitoring wells installed within the study area during previous investigations are not shown in figure 2 but are located and discussed in other reports (NUS Corporation, 1984, 1986, and 1987).

Wells S1W1A and S1W4 were drilled with the mud-rotary method. The nine surficial aquifer wells were drilled with a hollow-stem auger. All bits, drill rods, auger stems, well casings, and screens were steam-cleaned prior to drilling and well construction. Well records providing data on well depths, screened intervals, casing materials, and installation dates are shown in table 3. With the exception of S1W1A and S1W4, all of the wells conform to the specifications depicted in figure 4. Construction specifications for wells S1W1A and S1W4 are shown in figure 5. In well S1W4, the 2-inch (in.) diameter well screen was secured to the top of a 20-ft polyvinyl chloride (PVC) riser section so that the bottom of the screen was at 68 ft below land surface. This was necessary because the borehole for well S1W4 was drilled to 104 ft below land surface to collect soil samples at the top of the lower confining unit for laboratory hydraulic conductivity tests.

Continuous split-spoon soil samples extracted during the drilling operations at S1W4, L1D, L2D, and L3D were used to prepare lithologic logs. Three core samples containing fine-grained sediments from the upper and the lower confining units at S1W4 were sent to Soil and Materials Engineers, Inc., (Raleigh, North Carolina) for measurement of hydraulic conductivity and grain-size analyses. Natural gamma-ray logs were run in wells S1W1A, L1D, L2D, and L3D.

Once construction was completed, altitudes (in feet above sea level) were measured for each well at the top of the 2-in. casing, top of the 6-in. protective casing, and ground surface. Water-level altitudes were measured on April 25, 1988. Results are summarized in table 4.

Table 3.--*Description of study area cluster wells*

[Map well number: Number that is assigned to identify the well and its location on figure 2. USGS identification number: Number is composed of latitude and longitude of well suffixed with a two-digit sequence number. Cooperator well number: Number which has been assigned by the U.S. Marine Corps to coincide with the installation restoration program well numbering system; NA, no number has been assigned. Upgradient or downgradient well: Designates whether the monitoring well was installed at a location upgradient or downgradient of the wastewater lagoons with respect to the direction of ground-water flow in the surficial aquifer. SS, stainless steel casing; PVC, polyvinyl chloride casing. Y, Yorktown aquifer; S, surficial aquifer; (upper) and (lower), designates portion of the water table aquifer in which the screen was set. Yes, water-quality data are available; No, water-quality data are not available. G, geophysical gamma-ray log available; L, lithologic log data available. --, no data available]

Map well number	USGS identification number	Cooperator well number	Date of installation	Upgradient or downgradient well	Total well depth (feet below land surface)	Casing Type	Casing Diameter (inches)	Casing Depth (feet)	Screen opening From (feet)	Screen opening To (feet)	Aquifer	Water-quality analysis	Geophysical or lithologic log
S1W1A	345442076542501	10GW26	May 1987	Upgradient	76.0	SS	2	76.0	66.0	76.0	Y	Yes	G
S1W2	345442076542502	10GW25	May 1987	Upgradient	38	SS	2	38	28	38	S (lower)	Yes	--
S1W3	345442076542503	NA	May 1987	Upgradient	38	PVC	2	38	28	38	S (lower)	Yes	--
S1W4	345442076542504	NA	March 1988	Upgradient	88	PVC	2	88	58	68	Y	No	L
S1W5	345442076542505	NA	March 1988	Upgradient	28	SS	2	28	18	28	S (upper)	Yes	--
L1D	345441076544001	10GW27	March 1988	Downgradient	30	SS	2	30	20	30	S (lower)	Yes	G,L
L1S	345441076544002	10GW28	March 1988	Downgradient	19.5	SS	2	19.5	9.5	19.5	S (upper)	Yes	--
L2D	345443076544001	10GW29	March 1988	Downgradient	30	SS	2	30	20	30	S (lower)	Yes	G,L
L2S	345443076544002	10GW30	March 1988	Downgradient	19.5	SS	2	19.5	9.5	19.5	S (upper)	Yes	--
L3D	345445076544001	10GW31	March 1988	Downgradient	24	SS	2	24	14	24	S (lower)	Yes	G,L
L3S	345445076544002	10GW32	March 1988	Downgradient	14	SS	2	14	4	14	S (upper)	Yes	--

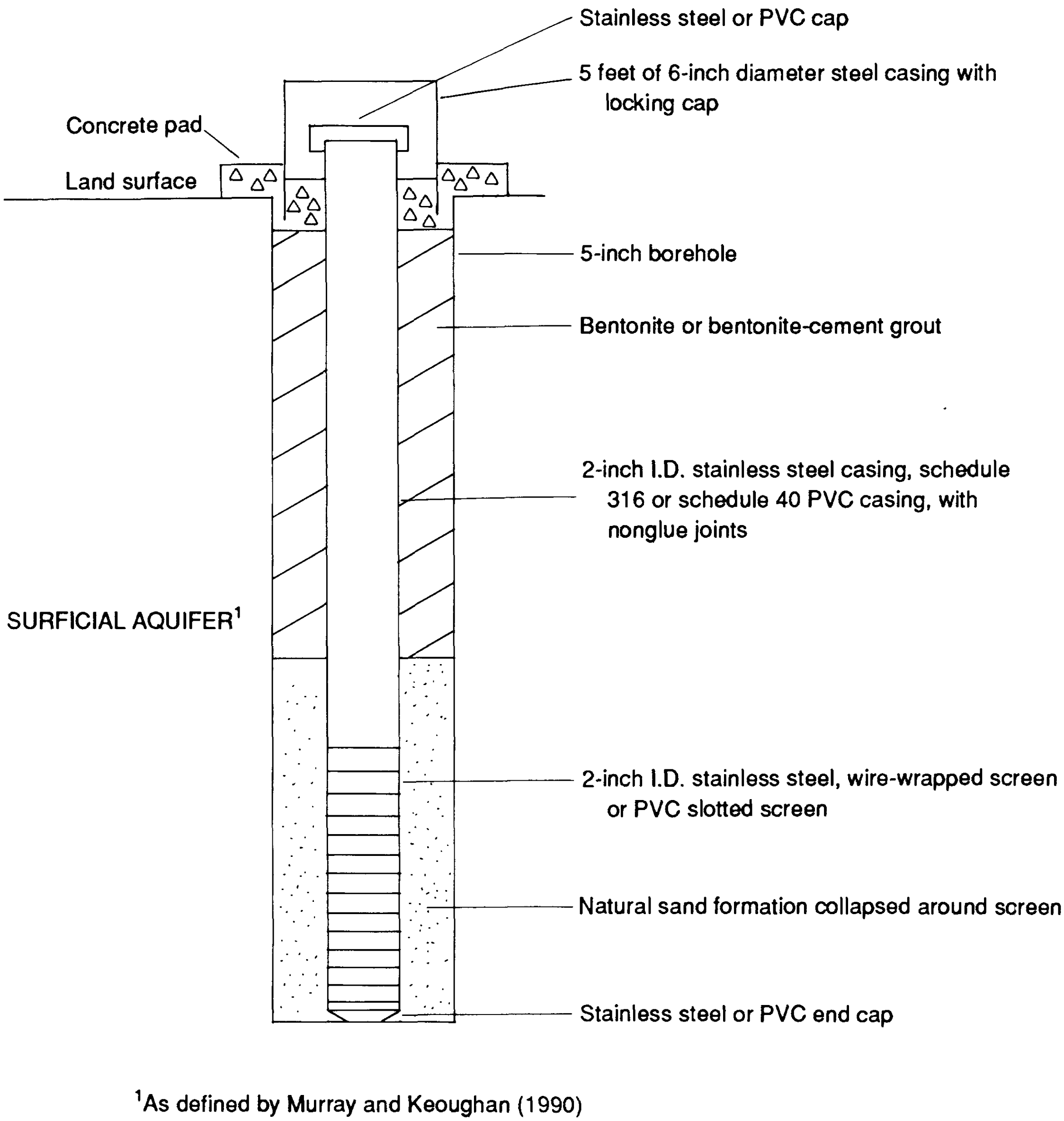
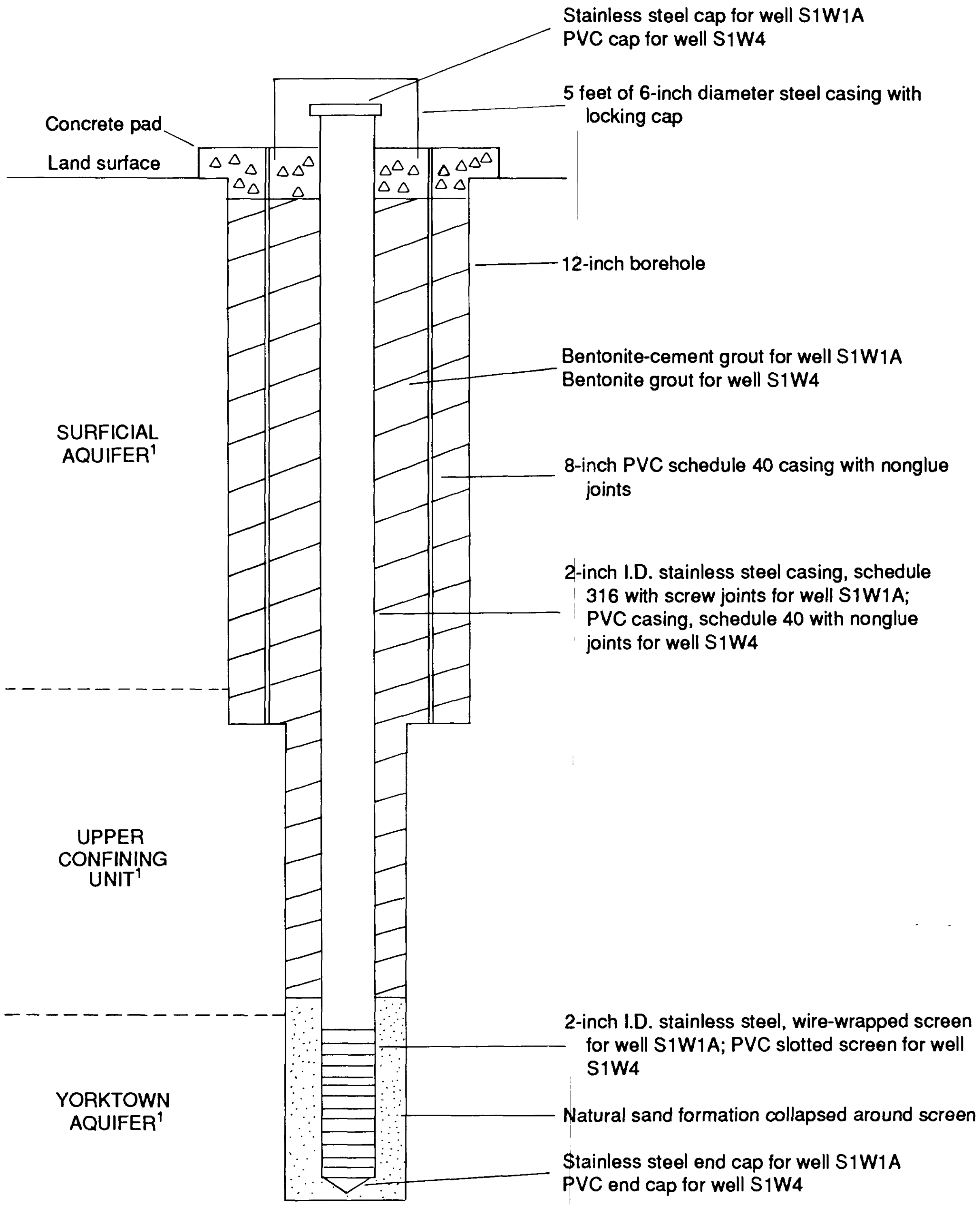


Figure 4.--Well construction specifications for monitoring wells S1W2, S1W3, S1W5, L1D, L1S, L2D, L2S, L3D, and L3S.

The eight wells constructed in March 1988 were all developed prior to collecting water-quality samples. At least three casing volumes of water were pumped from each well. During pumpage, the effluent was measured for temperature, pH, and conductivity. Pumpage was terminated once the discharge was clear and the conductivity and pH readings were stable.



[1]As defined by Murray and Keoughan (1990)

Figure 5.--Well construction specifications for monitoring wells S1W4 and S1W1A.

Table 4.--*Cluster well and water-level altitudes, April 25, 1988*

[All altitudes determined from existing benchmarks located near the wastewater lagoon site. Water-level altitudes determined with use of a steel tape]

Map well number (figure 2)	Altitude (feet above sea level)			
	Land surface	Top of 2-inch casing	Top of 6-inch protective casing	Static water level in well
S1W1A	23.53	24.79	25.14	6.16
S1W2	23.50	25.16	25.36	9.66
S1W3	23.52	24.90	25.29	9.67
S1W4	23.28	25.35	25.78	6.23
S1W5	23.66	25.51	25.89	9.94
L1D	14.60	16.92	17.25	4.77
L1S	14.60	16.74	17.05	4.77
L2D	12.54	14.60	14.87	3.81
L2S	12.54	14.94	15.22	3.75
L3D	8.04	10.54	10.75	3.25
L3S	8.04	10.01	10.52	3.08

Ground-Water Sampling

Between April 6 and 13, 1988, ground-water samples were collected from wells S1W2, S1W5, L1D, L1S, L2D, L2S, L3D, and L3S and submitted to laboratories for analyses of the organic compounds and inorganic constituents listed in tables 1 and 2. A duplicate sample was taken from well L2S for quality-assurance and quality-control purposes. Procedures used to collect the ground-water samples are described by Lloyd and Daniel (1988).

Samples collected for analyses of purgeable organic compounds, physical properties and characteristics, nutrients, major cations and anions, trace metals, and other selected inorganics were sent to the USGS laboratory in Arvada, Colorado. Samples collected for analyses of acid and base/neutral extractable organic compounds and pesticides were sent to the Tennessee Valley Authority (TVA) laboratory in Chattanooga, Tennessee.

Analyses for major cations and anions, physical properties and field determinations, nutrients, and trace elements were made according to the methods of Fishman and Friedman (1985). Methods used for analyses of dissolved organic carbon, methylene blue active substance (MBAS), purgeable organic compounds, acid and base/neutral extractable organic compounds, pesticides, and PCB's are described by Wershaw and others (1987). The procedures for purgeable organic compounds and acid and base/neutral extractable organic compounds described by Wershaw and others (1987) are consistent with EPA Methods 624 and 625 (U.S. Environmental Protection Agency, 1984a and 1984b).

Quality-control procedures utilized by the laboratories to ensure the accuracy of analytical results are described by Wershaw and others (1987) and Fishman and Friedman (1985). To monitor the possibility of contamination that might be introduced by or during sampling and shipment, shipment blanks (empty sample containers) were included in the sampling process and shipped along with the samples to the laboratory. At the laboratory, these bottles were rinsed out with deionized water and the rinse water then analyzed.

HYDROGEOLOGIC DATA

Lithologic and Geophysical Logs

Generalized lithologic logs depicting textural changes with depth and the corresponding natural gamma-ray logs for wells L1D, L2D, and L3D are shown on hydrogeologic section A-A' (figure 6). Figure 7 depicts the east-west hydrogeologic cross section B-B' and includes wells L2D and S1W4. The gamma-ray log for S1W1A in hydrogeologic section B-B' is shown alongside the lithologic log for S1W4; these two wells are separated by approximately 50 ft. Detailed lithologic logs used to prepare figures 6 and 7 are found in table 10 beginning on page 31 of this report and provide a sample-by-sample soil description and Munsell chart color coding. The number of blow counts required to drive the sampler each 2-ft interval for boreholes S1W4, L2D, and L3D is given in table 5.

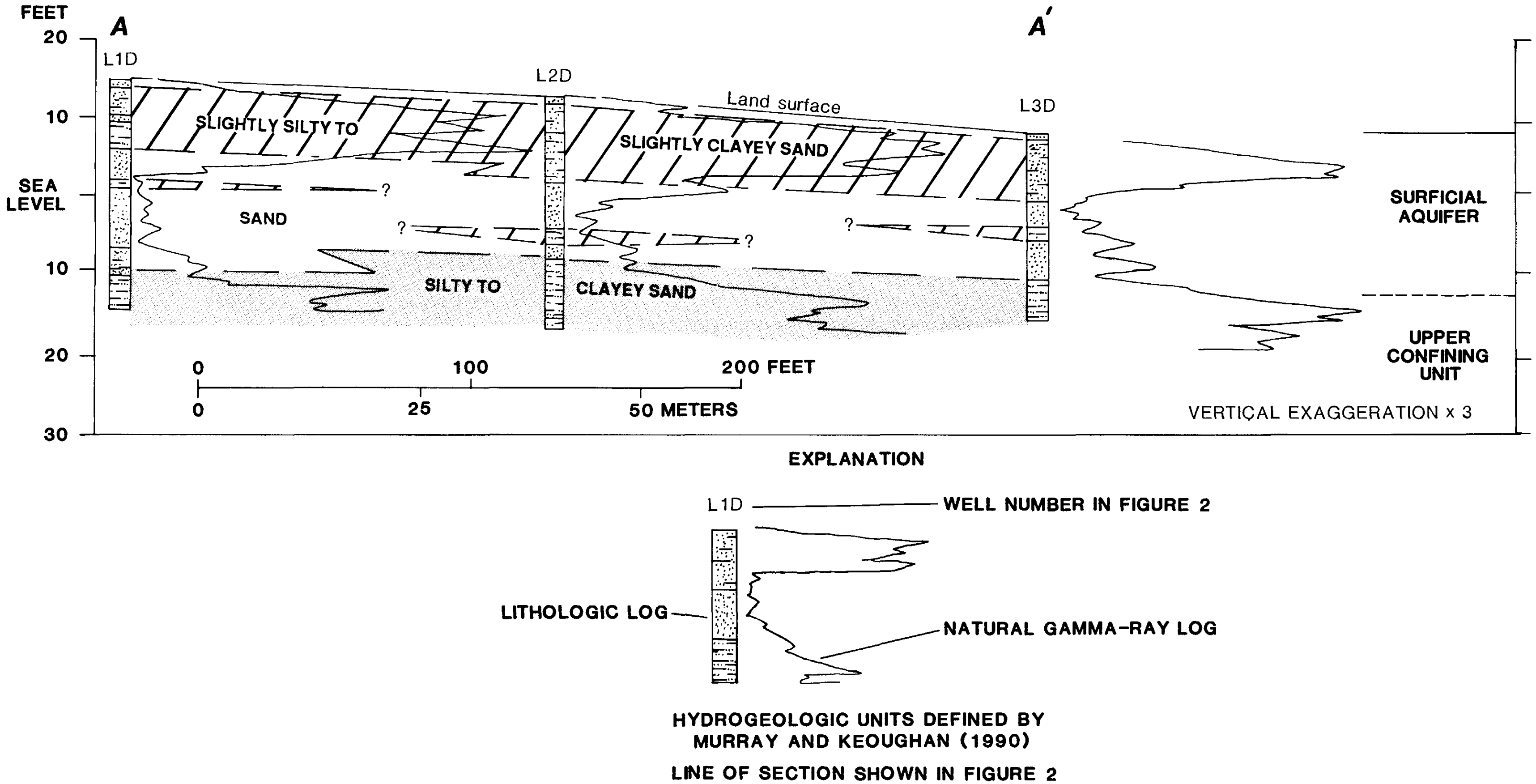


Figure 6.--Generalized lithologic logs and natural gamma-ray logs for section A-A'.

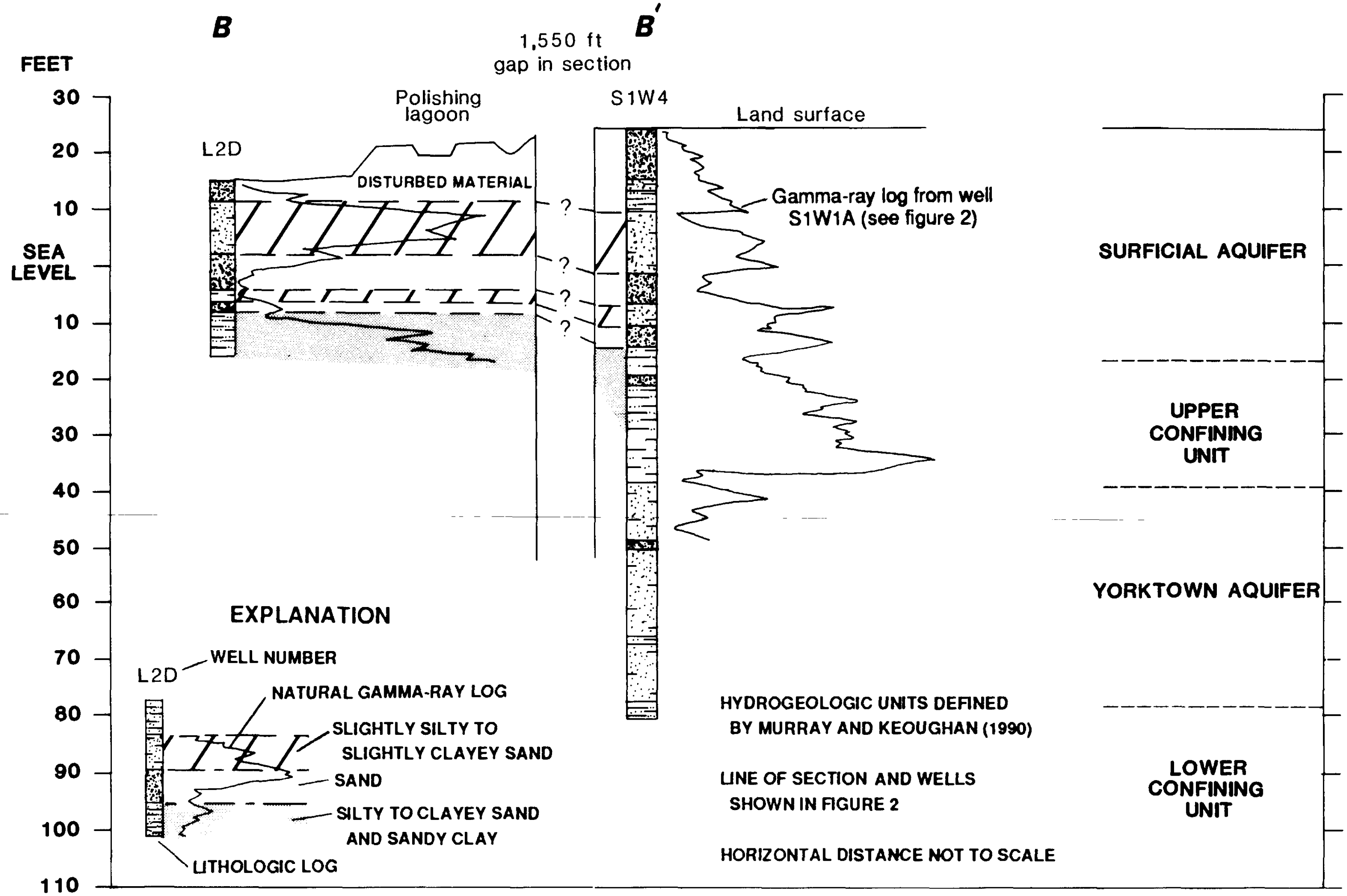


Figure 7.--Generalized lithologic logs and natural gamma-ray logs for section B-B'.

Table 5.--*Blow counts versus depth for S1W4, L2D, and L3D boreholes (Values were not recorded for L1D)*

Sampling interval (feet below land surface)	Blow count[1]		
	S1W4 borehole	L2D borehole	L3D borehole
0-2	22	11	37
2-4	21	20	34
4-6	34	21	15
6-8	26	22	26
8-10	16	13	12
10-12	9	28	19
12-14	21	14	21
14-16	15	37	12
16-18	12	38	11
18-20	11	12	10
20-22	27	24	14
22-24	30	25	20
24-26	24	27	(Boring terminated)
26-28	21	25	
28-30	24	29	
30-32	14	(Boring terminated)	
32-34	28		
34-36	43		
36-38	49		
38-40	20		
40-42	24		
42-44	30		
44-46	31		
46-48	48		
48-50	42		
50-52	39		
52-54	26		
54-56	68		
56-58	48		
58-60	33		
60-62	89		
62-64	73		
64-66	45		
66-68	47		
68-70	35		
70-72	138		
75-76	144		
80-81	197		
82-83	167		
89-90	131		
100-102	63		
104	(Boring terminated)		

[1]The blow count number was recorded for each interval during drilling of the borehole; each value indicates the number of blows from a 140-pound hammer dropped approximately 30 inches required to drive the split-spoon sampler each 2-foot interval to the indicated depth.

Sediments examined with a microscope and estimated to contain less than 5 percent silt and clay-sized grains are called "sands" on the hydrogeologic sections. Sediments estimated to contain 5 to 10 percent of silt and clay-sized grains are called "slightly silty to slightly clayey sands," and the sediments estimated to contain greater than 10 percent silt and clay-sized material are called "silty to clayey sands" to "sandy clays."

Water Levels

Water-level elevations measured in wells L1D, L1S, L2D, L2S, L3D, and L3S on April 25, 1988, are shown in figure 8. Placement of well screens relative to the generalized subsurface lithology defined in figure 6 are also shown. Similarly, water levels and screen placements through section B-B' are shown in figure 9.

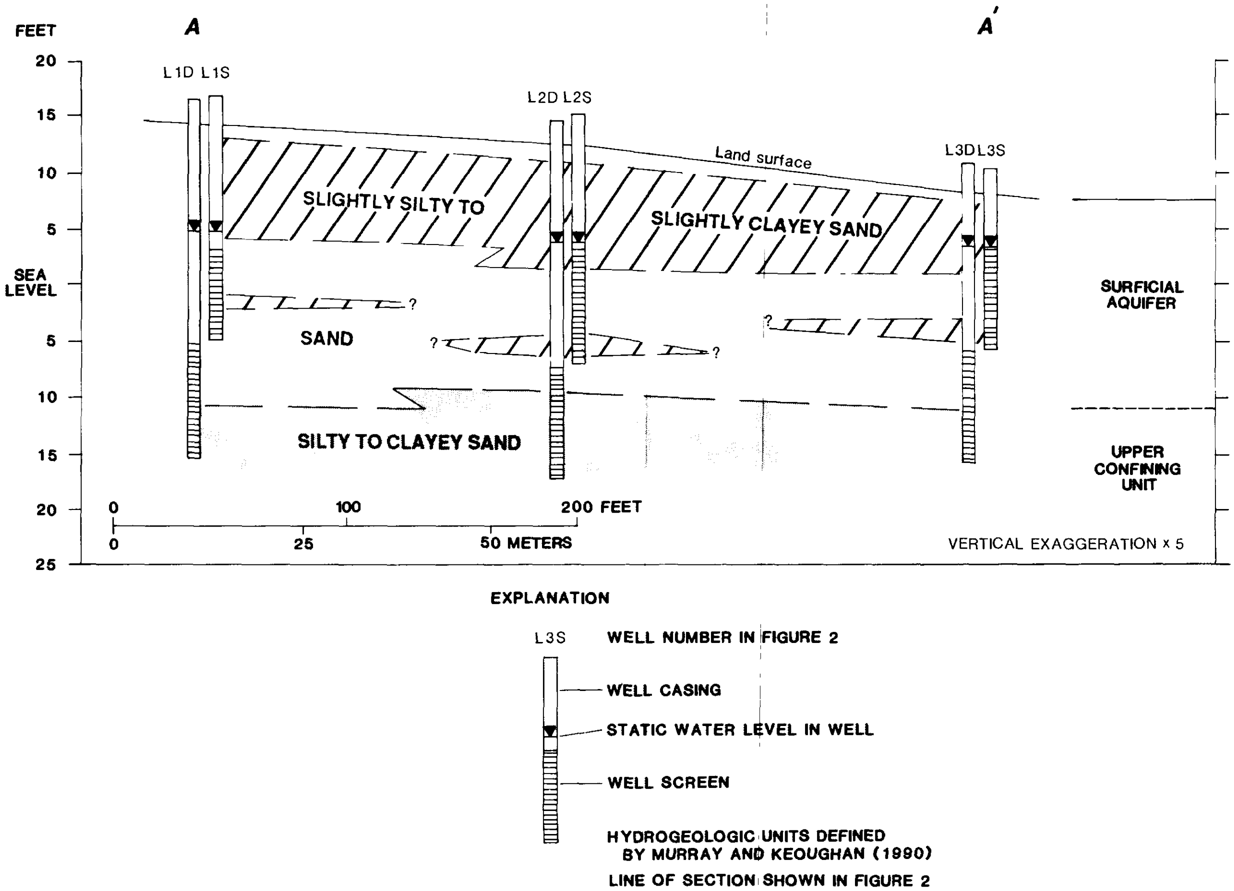


Figure 8.--North-south section A-A' depicting placement of cluster wells and static water levels on April 25, 1988.

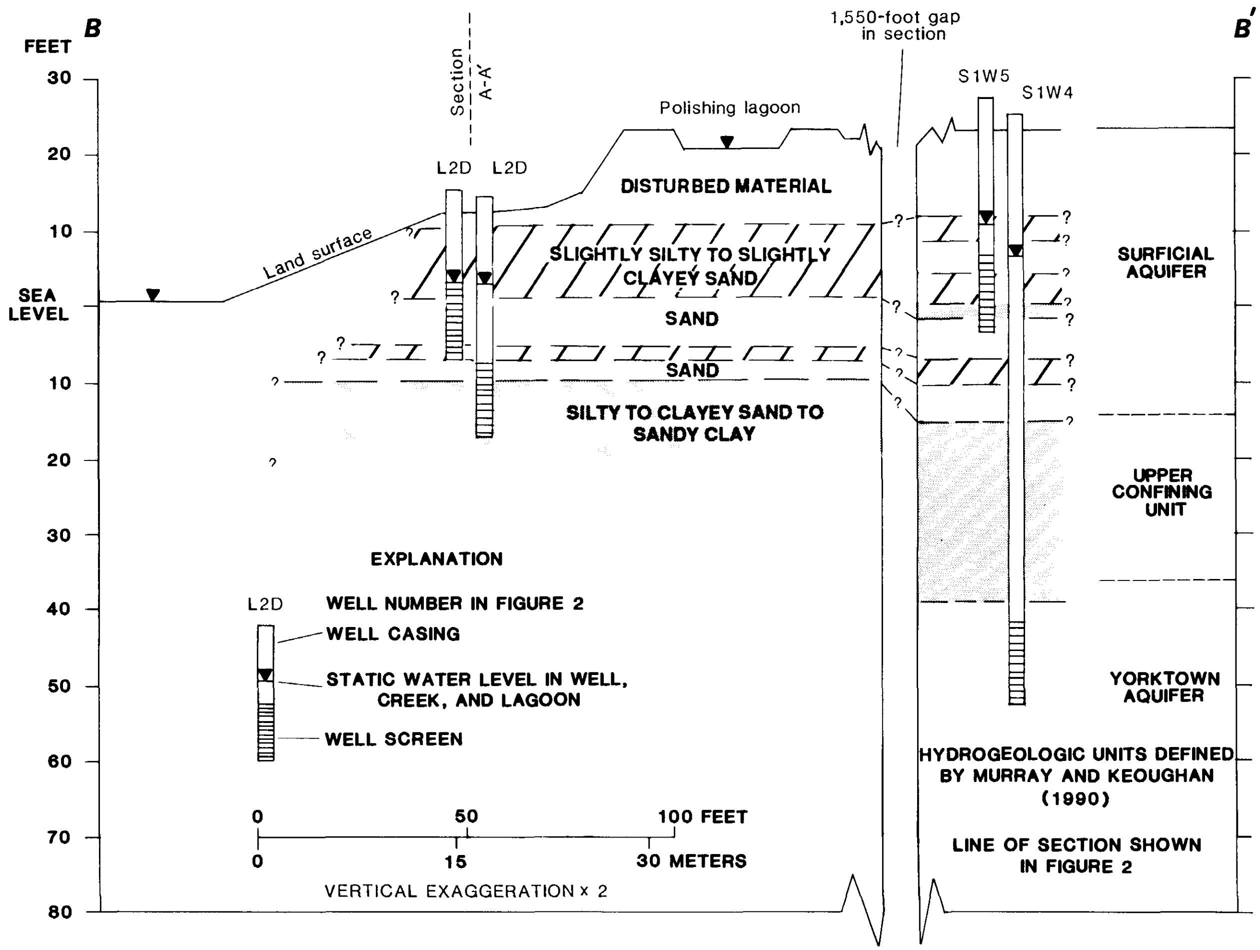


Figure 9.--East-west section B-B' depicting placement of cluster wells and static water levels on April 25, 1988.

Sediment Analyses

Results of the hydraulic conductivity tests and grain-size analyses conducted on the samples from S1W4 at the Soil and Materials Engineers, Inc., testing laboratory are summarized in table 6. Hydraulic conductivity testing procedures used by Soil and Materials Engineers, Inc., are described in the U.S. Army Corps of Engineers Manual (1970), EM-1110-2-1906, Appendix VII, "Permeability Tests." Basically, these procedures describe a falling-head, flexible-well test that uses backpressure to presaturate the sample. Grain-size and hydrometer analyses were performed in accordance with procedures described by the American Society of Testing and Materials Manual (1972), Designation D-422, "Particle Size Analysis of Solids." Grain-size distribution curves for the tested samples are shown in figure 10.

Table 6.--*Results of hydraulic conductivity tests and grain-size analyses of soil samples from borehole S1W4*

[cm/s, centimeter per second; ft/d, foot per day; g/cm^3, grams per cubic centimeter. Grain-size distribution curves are shown in figure 10.]

Sample location (in feet below land surface)	Hydraulic conductivity (cm/s)	(ft/d)	Specific gravity (g/cm^3)	Grain-size composition (percent by weight) Clay	Silt	Sand	Gravel
48-50	5×10^{-6}	0.014	2.61	15	20	65	0
58-60	4×10^{-6}	.011	2.62	13	16	67	4
102-104	4×10^{-6}	.011	2.70	12	31	57	0

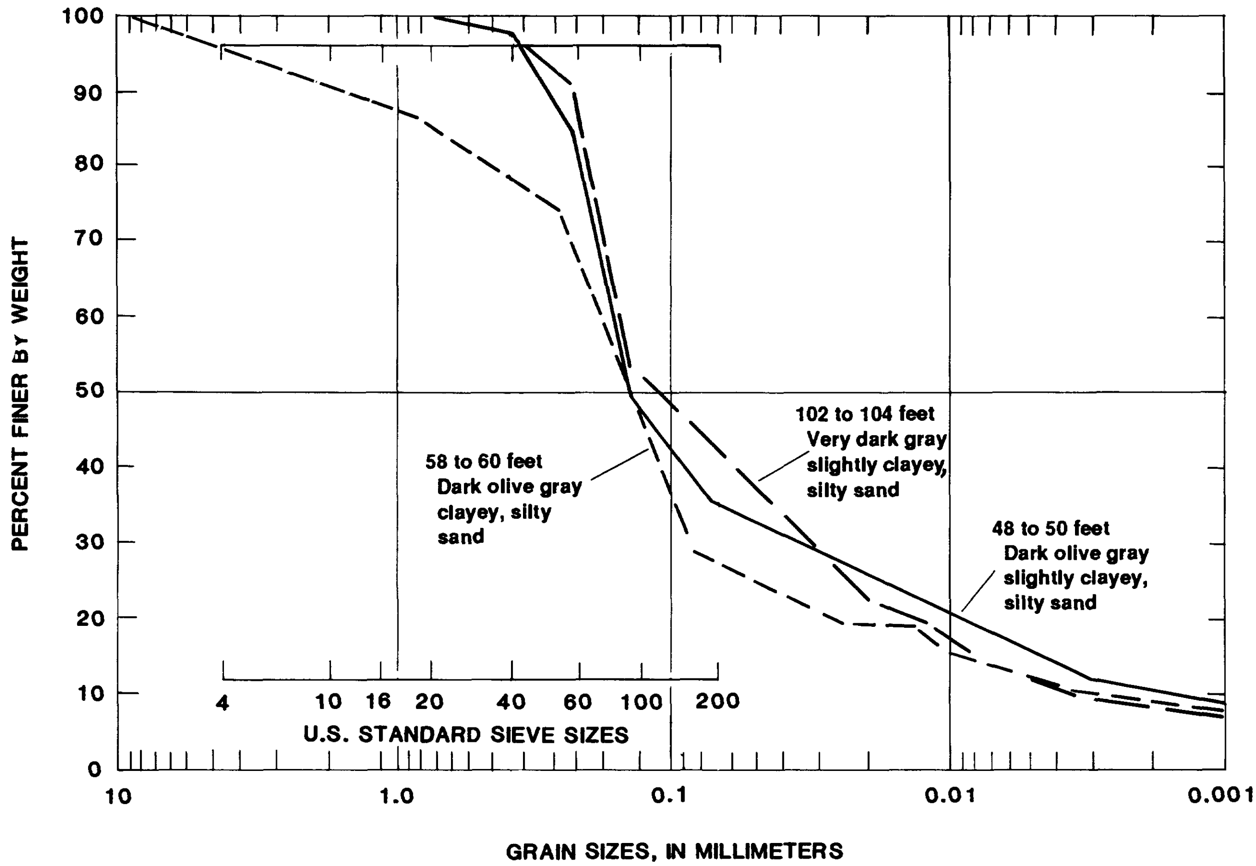


Figure 10.--Grain-size distribution curves for S1W4 sediment core samples.

WATER-QUALITY DATA

The complete water-quality data for each sampled cluster well are presented in table 11 beginning on page 41. A summary of both organic and inorganic EPA priority pollutants, concentrations of which were found at or in excess of minimum detectable limits, are given in tables 7 and 8, respectively. Analyses for total recoverable trace metals (table 8) were performed on unfiltered samples, while the dissolved concentrations were determined from filtered samples.

A National Bureau of Standards library search conducted by the USGS laboratory tentatively identified nonpriority pollutant purgeable organic compounds (table 9). Library searches were made using spectral data available for nearly 39,000 known organic compounds. A library search was also conducted by the TVA laboratory for nonpriority acid and base/neutral extractable organic compounds, but none were found.

Table 7.--*Organic compounds found at or above minimum detectable levels in water from cluster wells*

[Substances are classified as priority pollutants by U.S. Environmental Protection Agency (1976, 1984a, 1984b, and 1986). All concentrations are given in micrograms per liter. --, constituent concentration below minimum detectable limit.]

Minimum detectable limit[1]	Constituent	Well number: S1W2	S1W5	L1S	L1D	L2S	L2S (duplicate)	L2D	L3S	L3D	Blank (L2D)
	Purgeable organics										
0.2	Benzene	--	--	--	0.3	0.2	--	0.2	--	0.4	--
.2	Chlorobenzene	0.3	--	0.2	.2	.2	--	--	--	--	--
.2	Chlorodibromomethane	.4	--	--	--	--	--	--	--	--	--
.2	Chloroform	.2	--	--	--	--	--	--	--	--	--
.2	Dichlorobromomethane	--	--	--	.3	--	--	--	--	--	--
.2	Dichlorodifluoromethane	--	--	2.2	--	--	--	--	--	--	--
.2	1,1-Dichloroethane	--	--	--	.4	--	0.2	1.2	0.5	1.6	--
.2	1,2-Dichloroethane	--	--	--	.6	--	--	--	--	--	--
.2	1,2-(cis)-Dichloroethene	--	--	.2	.4	.2	.3	1	.5	.6	--
.2	1,2-Dichloropropane	.3	--	--	--	--	--	--	--	--	--
.2	1,3-Dichloropropene	--	--	--	.8	--	--	--	--	--	--
.2	(trans)1,3-Dichloropropene	--	--	--	.3	--	--	--	--	--	--
.2	Methylene chloride	.5	--	--	--	--	--	--	--	--	--
.2	Trichloroethylene	--	--	--	.4	--	--	.3	--	--	--
.2	1,1,1-Trichloroethane	1.8	0.7	.6	1	--	--	1.6	.9	.6	--
.2	1,1,2,2-Trichloroethane	--	--	--	.4	--	--	--	--	--	--
.2	Tetrachloroethylene	--	--	--	--	--	--	.2	--	--	--
.2	1,2-Dichlorobenzene	--	--	.4	.8	.3	.4	.4	--	--	--
.2	1,3-Dichlorobenzene	--	--	.2	.5	.5	.2	--	--	--	--
.2	1,4-Dichlorobenzene	--	--	.5	1	.4	.3	.2	--	--	--
.2	~~(cis)1,3-Dichloropropene~~	--	--	--	.5	--	--	--	--	--	--
	Extractables										
5	Nitrobenzene	--	--	--	--	--	--	--	--	7	--
5	Bis(2-ethylhexyl) phthalate	--	--	58	--	--	--	--	55	--	43
10	Dioctyl phthalate	--	--	--	--	--	11	--	--	--	--
5	2-Nitrophenol	--	--	6	--	--	--	--	--	--	--
5	Phenanthrene	--	--	--	--	--	--	--	15	--	--
	Pesticides										
.01	Malathion	.01	--	--	--	--	--	--	--	--	--
.01	Diazinon	--	--	.03	.02	.03	.03	--	--	--	--
.01	Methyl parathion	--	--	.03	--	--	.02	--	--	--	--
.01	Parathion	--	--	.01	--	--	.01	--	.01	.01	--
.01	Methyl trithion	--	--	.02	.02	--	--	--	--	--	--

[1]Minimum detectable limits (Feltz and others, eds., 1985).

Table 8.--*Metals and other selected inorganic constituents found at or above minimum detectable levels in water from cluster wells*

[All concentrations are given in micrograms per liter; --, constituent concentration below minimum detectable limit.]

Minimum detectable limit[1]	Constituent	Well number: S1W2	S1W5	L1S	L1D	L2S	L2S (duplicate)	L2D	L3S	L3D
1.0	Arsenic, total[2]	5	--	24	5	36	28.0	22	2.0	22
1	Antimony, total[2]	2	--	4	5	1	--	2	8	1
2	Barium, dissolved[3]	15	12	62	63	64	73	38	60	43
10	Boron, dissolved	10	10	140	120	120	120	50	120	110
1	Cadmium, total recoverable[2]	--	--	--	1	--	--	5	2	--
5	Chromium, total recoverable[2]	28	9	110	58	140	130	77	61	3
3	Cobalt, dissolved[3]	--	--	40	60	20	20	20	240	6
1	Copper, dissolved[2]	--	1	--	--	--	--	--	--	--
1	Copper, total recoverable[2]	15	5	13	7	15	19	14	200	4
3	Iron, dissolved	4	96	18,000	16,000	29,000	29,000	12,000	76,000	32,000
5	Lead, total recoverable[2]	--	--	10	--	20	21	--	--	7
.10	Mercury, total recoverable[2]	--	--	--	--	--	.1	--	.50	--
1	Nickel, dissolved[2]	4	4	13	16	13	14	37	--	34
1	Nickel, total recoverable[2]	22	11	52	32	30	42	52	36	43
1	Silver, total recoverable[2]	1	1	--	--	--	--	--	4	--
1	Vanadium, dissolved[3]	--	--	--	2	--	--	--	38	--
3	Zinc, total recoverable[2]	40	20	200	130	220	210	100	320	20
1	Manganese, dissolved	37	25	460	4,700	540	530	1,800	2,500	3,000
1	Tin, total recoverable[3]	--	--	--	--	--	--	--	25	--

[1]Minimum detectable limits (Feltz and others, eds., 1985).
[2]Priority pollutants (U.S. Environmental Protection Agency, 1976 and 1986).
[3]Required by U.S. Environmental Protection Agency for ground-water samples from Resource Conservation and Recovery Act sites (U.S. Environmental Protection Agency, 1987).

Table 9.--*Nonpriority pollutant organic compounds detected in water samples from cluster wells*

[Compounds were identified through a National Bureau of Standards library search of approximately 39,000 available spectra. µg/L, micrograms per liter]

Well number	Tentatively identified nonpriority pollutant organic compounds	Concentration (µg/L)
S1W2	1,3-Dichloropropane	1.0
S1W5	No compounds detected	
L1S	Chlorodifluoromethane	1.5
	Unidentified compound	Trace
	Unidentified compound	Trace
	C_3HF (?)	.2
	Chlorofluorocarbon	Trace
	C_6H_{12} (two isomers)	Trace
	Carbon disulfide	.2
	$C_{10}H_{20}$	3
	Unidentified compound	Trace
L1D	Light hydrocarbon	.2
	$C_{10}H_{20}$	.5
	Unidentified compound	Trace
L2S	C_3NF (?)	Trace
	C_7H_{14}	.3
L2S (duplicate)	C_7H_{14}	Trace
L2D	Unidentified compound	.2
	Unidentified compound	.2
L3S	Carbon disulfide	.2
	Unidentified compound	.2
L3D	No compounds detected	

None of the purgeable organic compounds listed in table 1 were detected at or above detectable limits in the blank sample analyzed by the USGS laboratory in Denver. One extractable organic compound, bis(2-ethylhexyl) phthalate, was detected at a concentration of 43 micrograms per liter (µg/L) in the blank sample analyzed by the TVA laboratory in Chattanooga.

SUMMARY

For a number of years until August 1987, rinse and wash water from the metal-plating plant at the Cherry Point Marine Corps Air Station (MCAS), North Carolina, flowed from the industrial wastewater-treatment plant to the municipal wastewater-treatment plant. The effluent was discharged through polishing lagoons and ultimately into Slocum Creek, a tributary of the Neuse River. Since the industrial wastewater may have contained metals and other chemicals that may have reached the lagoons, it is possible that ground water beneath the lagoons is contaminated.

To provide the data needed to assess the degree of contamination of the ground water, hydrogeologic and water-quality data were collected between March and May 1988 at eight wells completed in the surficial aquifer both upgradient and downgradient from the wastewater-treatment plant and polishing lagoons. The wells were sampled for organic and inorganic U.S. Environmental Protection Agency priority pollutants. The well screens were placed to allow sampling from both the upper and lower parts of the surficial aquifer. Lithologic logs were prepared from sediment samples collected during the drilling operations. Laboratory hydraulic conductivity tests conducted on fine-grained material recovered from two confining units that underlie the surficial aquifer yielded values that ranged from 0.011 to 0.014 foot per day (4×10^{-6} to 5×10^{-6} centimeters per second). Natural gamma-ray logs from the four deepest wells, together with the lithologic logs, were used to prepare hydrogeologic sections across the study area. Static water levels were recorded on April 25, 1988.

Relatively low concentrations of purgeable organic compounds (up to 2.2 μg/L for dichlorodifluoromethane), acid and base/neutral extractable compounds (up to 58 μg/L for bis(2-ethylhexyl) phthalate), or pesticides (up to 0.03 μg/L for diazinon and methyl parathion) were detected in water samples collected from all of the wells. Trace metals were detected in concentrations above minimum detectable limits in all of the wells and were found to be higher in water samples collected from the downgradient wells (up to 320 μg/L for zinc) than in water samples from the upgradient wells.

REFERENCES

Annual Book of the American Society of Testing and Materials Standards, Designation: D-422-63, 1972.

Coble, R.W., and Sharpless, N.B., 1983, Reconnaissance study of potential ground-water contamination at waste-disposal sites, Marine Corps Air Station, Cherry Point, North Carolina, U.S. Geological Survey Administrative Report, 21 p.

Feltz, H.R., Duncan, S.S., and Zepp, A., eds., 1985, 1986-87-88 National water quality laboratory services catalog: U.S. Geological Survey Open-File Report 86-232.

Fishman, M.J., and Friedman, L.C., eds., 1985, Methods for determination of inorganic substances in water and fluvial sediments--Techniques of water-resources investigations of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 85-495, 709 p.

Lloyd, O.B., and Daniel, C.C., III, 1988, Hydrogeologic setting, water levels, and quality of water from supply wells at the U.S. Marine Corps Air Station, Cherry Point, North Carolina: U.S. Geological Survey, Water-Resources Investigations Report 88-4034, 76 p.

Munsell Soil Color Chart, 1990, Baltimore, Maryland, Munsell Color, 7 charts.

Murray, L.C., Jr., and Keoughan, K.M., 1990, Hydrogeologic, water-level, and water-quality data from monitoring wells at the U.S. Marine Corps Air Station, Cherry Point, North Carolina: U.S. Geological Survey Water-Resources Investigations Report 89-4200, 86 p.

NUS Corporation, 1984, Confirmation study to determine existence and possible migration of specific chemicals in situ at the Marine Corps Air Station, Cherry Point, North Carolina, Step 1A--Verification study work plan: Pittsburgh, Pa., Naval Facilities Engineering Command Contract N62470-84-B-6886, NUS Corporation Report (November 1984), Pennsylvania.

----- 1985, Confirmation study to determine existence and possible migration of specific chemicals in situ at the Marine Corps Air Station, Cherry Point, North Carolina, Round 1 sampling analytical results: Pittsburgh, Pa., Naval Facilities Engineering Command Contract N62470-84-B-6886, NUS Corporation Report (February 1985), Pennsylvania.

----- 1986, Confirmation study to determine existence and possible migration of specific chemicals in situ at the Marine Corps Air Station, Cherry Point, North Carolina, Round 2 sampling analytical results: Pittsburgh, Pa., Naval Facilities Engineering Command Contract N62470-84-B-6886, NUS Corporation Report (February 1986), Pennsylvania.

----- 1987, Report on hydrogeology, contaminants detected and corrective action/recommendations for the former surface impoundments [at the Marine Corps Air Station, Cherry Point, North Carolina] (Appendix 2-8): Pittsburgh, Pa., Naval Facilities Engineering Command Contract N62470-84-B-6886, NUS Corporation Report (January 1987), Pennsylvania.

Putnam, Hugh, Sullivan, James, Hein, Michael, Adams, William, and Fellows, Charles, 1982, Initial assessment study of Marine Corps Air Station, Cherry Point, North Carolina: Gainesville, Fla., Naval Energy and Environmental Support Activity, Contract NEESA 13-009, Water and Air Research, Inc., Florida.

Schnabel Engineering Associates, Inc., 1981, Hydrogeologic and geotechnical engineering analysis, putrescible waste landfills, Marine Corps Air Station, Cherry Point, North Carolina: Richmond, Va., Schnabel Engineering Associates Report, Contract NC 81399, Virginia.

Soil and Materials Engineers, Inc., 1983, Sludge disposal area investigation report, Marine Corps Air Station, Cherry Point, North Carolina: Soil and Materials Engineers, Inc., Report, Job no. 051-83-097-A.

U.S. Army Corps of Engineers Manual, EM-1110-2-1906, Appendix VII, November 30, 1970.

U.S. Environmental Protection Agency, 1976, Quality criteria for water: Washington, D.C., U.S. Government Printing Office, 256 p.

----- 1984a, Drinking water rules and regulations: Method 624--purgeables: Federal Register, October 26, 1984, v. 49, no. 209, p. 141-152.

----- 1984b, Drinking water rules and regulations: Method 625--base/neutrals and acids: Federal Register, October 26, 1984, v. 49, no. 209, p. 153-174.

----- 1986, Quality criteria for water: Office of Water Regulations and Standards, EPA 440/5-86-001, 310 p.

----- 1987, List of hazardous constituents for ground-water monitoring: Federal Register, July 1987, v. 52, no. 131, p. 25942-25953.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., eds., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.

Table 10.--*Lithologic logs for selected cluster wells*

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4	
Soil	0-1
SAND, quartz, fine, well sorted, angular, very pale orange (10 YR 8/2), twigs present at base, no fossils observed	1-10
Sandy CLAY; medium gray (N5); few sand interlaminations and lenses; sand fine, well sorted, subangular to angular, dark yellowish orange (10 YR 6/6)	10-12.5
Sandy CLAY, light gray (N5)	12.5-12.7
SAND and SILT, top 5 inches is coarse silt to fine sand; sand is moderately sorted, subangular to angular, very pale orange (10 YR 8/2), some dark iron oxide staining present; bottom 6 inches is sand, fine, moderately sorted, subangular to angular, very pale orange (10 YR 8/2)	12.7-13.6
No sample recovery	13.6-14
SAND, fine, moderately sorted, subangular to angular, very pale orange, (10 YR 8/2); clay interlaminations and clasts, dark yellowish orange (10 YR 6/6)	14-15
No sample recovery	15-16
SAND, fine, moderately sorted, subangular, very pale orange (10 YR 8/2); mottled with clay lenses and a few clay clasts, medium gray (N5); twigs at base	16-16.8
No sample recovery	16.8-18
SAND, fine, very pale orange (10 YR 8/2); with small clay lenses, dark yellowish orange (10 YR 6/6)	18-19.8
No sample recovery	19.8-20.5
SAND, fine, well sorted, angular, medium gray (N5); 5 percent silt present	20.5-21.6
No sample recovery	21.6-22.7

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
Clayey SAND; sand fine, quartz, well sorted, angular, medium gray (N5) to medium dark gray (N4); bottom 4 inches is sand, quartz, bimodal with 65 percent very fine to fine and 35 percent medium, subrounded to angular, yellowish gray (5 Y 8/1)	22.7-23.5
No sample recovery	23.5-24
Silty SAND, top 3 inches fine sand, quartz, dark yellowish orange (10 YR 6/6); 1-inch layer of clay, dark gray (N3); bottom 8 inches is sand, coarse, moderately sorted, subrounded to subangular, medium dark gray (N4); with clay lenses	24-25
No sample recovery	25-26
SAND, quartz, medium, moderately sorted, subrounded; very light gray (N8) to medium light gray (N6)	26-27.8
No sample recovery	27.8-28
SAND, quartz, fine, well sorted, angular; very pale orange (10 YR 8/2); sparse very coarse subrounded quartz grains; twigs at base	28-29.4
No sample recovery	29.4-30
SAND, top 5 inches fine to medium, poorly sorted, subangular to angular; very light gray (N8); middle 6 inches is slightly granular sand, bimodal with 70 percent medium (0.5 mm) subrounded sand and 30 percent coarse to very coarse subrounded to rounded sand; medium gray (N5); phosphatic pebbles, shell fragments; bottom 1 inch increases in silt	30-31.3
No sample recovery	31.3-33
Pebbly silty SAND; sand medium size, poorly sorted, angular, olive gray (5 Y 4/1); 20 percent pebbles, glauconite, phosphate and quartz pebbles, subrounded; shell fragments, angular; 15 percent silt; thin black carbonized lenses	33-33.75

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
No sample recovery	33.75-34
Slightly silty SAND, sand fraction is 90 percent and contains 90 percent quartz and 10 percent phosphatic sand, medium sand size, well sorted, subangular to angular, olive gray (5 Y 6/1), 5 to 10 percent silt and clay, phosphate and quartz pebbles, thin black carbonized lenses	34-34.5
Pebbly SAND; sand fraction is 90 percent and contains 95 percent quartz; 3 percent phosphate, and 2 percent shell fragments; coarse sand size (0.6 mm), poorly sorted, rounded to subrounded; gravel fraction is 10 percent and contains quartz, shell fragments, and phosphate pebbles; light gray (N8) to light olive gray (5 Y 6/1); dark carbonaceous layers	34.5-35.4
SAND; 95 percent quartz and rare phosphate, glauconite, and sand-sized shell fragments; bimodal, 65 percent medium (0.25 mm) and 35 percent coarse (0.7 mm) sand; moderately sorted, subround to subangular; very light gray (N8); rare pebble-sized shell fragments	35.4-35.8 36-37
Pebbly slightly silty SAND; 80 percent sand, medium, light olive gray (5 Y 6/1) to medium light gray (N6); 10 percent silt and clay; 10 percent quartz and phosphate pebbles, shell fragments	37-37.75
No sample recovery	37.75-38
Pebbly SAND; 85 percent sand, medium, very light gray (N8); 15 percent quartz and phosphate pebbles, shell fragments	38-39
Sandy CLAY with 30 percent silt size and 40 percent clay size; 30 percent sand fraction is 30 percent and contains 95 percent quartz and 5 percent phosphate, sand fine, moderately sorted, subangular, olive gray (5 Y 4/1) to dark greenish gray (5 GY 4/1); rare mica flakes	39-40 40.6-41.8

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
Silty SAND; sand fraction is 70 percent and contains 90 percent quartz and 10 percent phosphatic sand, fine sand, poorly sorted, angular; dark greenish gray (5 GY 4/1); 30 percent silt and clay	41.8-44.4
Silty SAND; sand fraction is 70-80 percent and contains 95 percent quartz and 5 percent phosphatic sand, fine sand, moderately sorted, angular, dark greenish gray (5 GY 4/1); 20-30 percent silt and clay	44.4-46 46.4-48 48-49.4 50.8-52
SAND; 90 percent quartz, 6 percent phosphate, and 4 percent sand-sized shell fragments; fine to coarse sand, very poorly sorted, subrounded, light olive gray (5 Y 6/1); phosphate pebbles, shell fragments	52-53
Slightly silty SAND; sand fraction is 90 percent and contains 95 percent quartz and 5 percent phosphatic sand, fine sand, well sorted, subangular; dark greenish gray (5 GY 4/1); 10 percent silt and clay; quartz and phosphate pebbles	53-54
No sample recovery	54-54.25
Silty SAND; sand fraction is 80 percent and contains 90 percent quartz, 10 percent phosphatic and glauconitic sand; fine sand, moderately sorted, angular; dark greenish gray (5 GY 4/1); 20 percent silt and clay	54.25-58
Silty SAND to sandy SILT; 40-50 percent silt and clay; 50-60 percent sand contains 95 percent quartz; 5 percent phosphatic and glauconitic sand; dark greenish gray (5 GY 4/1); phosphate pebbles	58-59.75
No sample recovery	59.75-60.25
Silty SAND; sand fraction is 70 percent and contains 95 percent quartz, 5 percent phosphatic and glauconitic sand; fine sand, moderately sorted, angular; greenish gray (5 GY 6/1); 30 percent silt and clay; abundant weathering and leached shells; phosphate pebbles	60.25-62

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
Pebbly silty SAND; sand fraction is 70-80 percent and contains 95 percent quartz, 5 percent shell fragments and phosphatic sand; coarse sand, moderately sorted, subrounded, olive gray (5 Y 4/1); 20-30 percent silt; 10 percent quartz and phosphate pebbles; shell fragments; mica flakes, possible wood chips; bottom 4 inches increases in percent silt and decreases in pebbles	62-64
Silty SAND to sandy SILT; sand fraction is 60 percent and contains 90 percent quartz and 10 percent phosphatic sand, fine to medium sand, well sorted, subangular; light olive gray (5 Y 6/1); 40 percent silt and clay	64-66.25
Slighty silty SAND; sand fraction is 90 percent and contains 95 percent quartz and 5 percent phosphate; medium sand, moderately sorted, subrounded; light olive gray (5 Y 6/1); 10 percent silt and clay; rare quartz and phosphate pebbles	66.25-67.75
No sample recovery	67.75-68
Pebbly SAND; sand fraction is 80 percent and contains 95 percent quartz and 5 percent phosphate; very coarse sand, well sorted, rounded to subrounded; yellowish gray (5 Y 8/1); 20 percent gravel fraction contains shell fragments, quartz and phosphate pebbles	68-69
Slightly pebbly, slightly silty SAND; sand fraction is 90 percent and contains 95 percent quartz, 4 percent phosphate and 1 percent shell fragments; medium sand, very well sorted, subrounded to subangular; light olive gray (5 Y 4/1); 5 percent silt; 5 percent rounded phosphate and quartz pebbles; weathered and leached out shells; base increases in grain size to coarse and very coarse slightly silty sand	69-69.75
No sample recovery	69.75-70

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
Silty SAND; sand fraction is 75 percent and contains 95 percent quartz and 5 percent phosphatic sand; fine sand, moderately sorted, subrounded to subangular; yellowish gray (5 Y 8/1); 20 percent silt; 5 percent quartz and phosphate pebbles; rare shell fragments	70-71
No sample recovery--refusal from semi-cemented sediments	71-75
Slightly pebbly silty SAND; sand fraction is 75 percent and contains 95 percent quartz and 5 percent phosphatic sand; medium sand size, moderately sorted, subangular to subrounded; light olive gray (5 Y 6/1); 20 percent silt; 5 percent phosphate and quartz pebbles, shell fragments	75-75.8
No sample recovery--refusal from semi-cemented sediments	75.8-80
Slightly silty SAND, slightly cemented; sand fraction is 90 percent and contains 95 percent quartz and 5 percent phosphatic sand; medium sand size, very well sorted, subrounded to subangular; light olive gray (5 Y 6/1); 10 percent silt; layer of quartz and phosphate pebbles and shell fragments at 80.25 to 80.4 feet	80-81
No sample recovery--refusal from semi-cemented sediments	81-82
Slightly silty SAND, slightly cemented; sand fraction is 90 percent and contains 95 percent quartz, 5 percent phosphatic and glauconitic sand; medium sand size, moderately sorted, rounded to subround; light olive gray (5 Y 6/1); 10 percent silt; phosphatized fish teeth	82-83
Rotary drill through lenses of semi-cemented sediments	83-89
Silty SAND, cemented with 30 percent silt; sand fraction is 70 percent and contains 80 percent quartz, 15 percent shell fragments, and 5 percent phosphatic sand; coarse sand size, poorly sorted, subrounded; light olive gray (5 Y 6/1)	89-91

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well S1W4--Continued	
Rotary drill through sediments	91-100
SAND; quartz and rare phosphatic sand, fine to medium, moderately sorted, subangular to angular; light olive gray (5 Y 6/1); 10 percent of sand fraction is coarse to very coarse sand; 5 percent silt; mica flakes	100-101
Silty SAND; 40 percent silt; sand fraction is 55 percent and contains 90 percent quartz and 10 percent phosphatic sand, moderately sorted, angular; dark greenish gray (5 GY 4/1); 5 percent quartz and phosphate pebbles; weathered and leached out shells	101-101.25 102-104
Boring terminated at 104 feet below land surface.	
Well L1D	
Soil	0-1
Slightly silty fine quartz SAND, well sorted, angular, pale yellowish orange (10 YR 8/6)	1-2
SAND, fine-grained quartz, well sorted, angular dark yellowish orange (10 YR 6/6) to very pale orange (10 YR 8/2)	2-3.5
Silty to clayey fine SAND, moderately sorted, angular, dark yellowish orange (10 YR 6/6)	3.5-5.5
SAND, fine-grained quartz, subangular to angular, moderately sorted, very pale orange (10 YR 8/2) mottled with clayey fine sand lenses and clasts, dark yellowish orange (10 YR 6/6)	5.5-10.5
SAND, fine-grained quartz, well sorted, angular, grayish orange (10 YR 7/4) to pale yellowish orange (10 YR 8/6)	10.5-12
SAND, fine- to medium-grained quartz, subrounded to angular, grayish orange (10 YR 7/4)	12-14.5

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well L1D--Continued	
Slightly clayey SAND, medium grained, dark yellowish orange (10 YR 6/6), with light brown clayey sand clasts and some large quartz grains and medium-grained sand	14.5-16
SAND, pale yellowish orange (10 YR 8/6), medium to coarse grained	16-17.5
SAND, dark yellowish orange (10 YR 6/6), medium grained	17.5-18
SAND, pale orange (10 YR 8/2) medium grained	18-19
Slightly silty fine SAND, pale olive (10 YR 6/2), with dark yellowish orange (10 YR 6/6) lenses of clayey fine sand	19-22
SAND, medium- to coarse-grained quartz, olive gray (5Y 3/2), with some clayey clasts	22-23
Slightly silty SAND, fine- to medium-grained quartz, olive gray (5Y 3/2)	23-24
Wash	24-25
Silty to clayey fine SAND, olive gray (5Y 3/2), with grayish black (N2) clayey clasts and some phosphate grains and quartz pebbles	25-26
No recovery	26-28
Wash	28-29
Silty fine SAND, olive gray (5Y 3/2) with some phosphate grains	29-30

Boring terminated at 30 feet below land surface.

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well L2D	
Soil	0-1
Slightly silty fine SAND, well sorted, angular, pale yellowish orange (10 YR 8/6)	1-3
Clayey fine SAND, moderately sorted, angular, dark yellowish orange (10 YR 6/6)	3-6
Slightly silty fine SAND, moderately sorted, very pale orange (10 YR 8/2) mottled with clayey fine sand lenses and clasts, dark yellowish orange (10 YR 6/6)	6-10
Slightly silty fine SAND, very pale orange (10 YR 8/2)	10-12.5
SAND, fine to medium grained, angular, pale yellowish orange (10 YR 8/6)	12.5-14
SAND, medium grained, subangular, very pale orange (10 YR 8/6)	14-18
Slightly clayey SAND, medium grained, dark yellowish orange (10 YR 6/6)	18-20.5
SAND, fine to medium grained with phosphate grains and quartz pebbles, olive gray (5 Y 3/2) to light gray (N7)	20.5-22.5
Silty SAND, fine to medium grained, olive gray (5 Y 3/2) with some phosphate grains and quartz pebbles	22.5-23.5
Slightly silty fine SAND, olive gray (5 Y 3/2) with some phosphate grains	23.5-24
Silty SAND, fine to medium grained, olive gray (5 Y 3/2) with grayish black (N 2) clayey sand clasts and some phosphate grains and quartz pebbles	24-26.5
Silty SAND, fine to medium grained, olive gray (5 Y 3/2) with some phosphate grains and quartz pebbles	26.5-30

Boring terminated at 30 feet below land surface.

Table 10.--*Lithologic logs for selected cluster wells*--Continued

[Estimates of grain-size fractions, sediment composition, and fossil content are based on microscopic examinations by a U.S. Geological Survey geologist. Color Code Description: Example--(10 YR 8/2) Sand, fine, moderately sorted very pale orange. See Munsell Chart. mm, millimeter]

Description	Depth below land surface (feet)
Well L3D	
Soil	0-1
Silty SAND, moderately sorted, angular, dark yellowish orange (10 YR 6/6)	1-2
Slightly silty SAND, subangular to angular, moderately sorted, very pale orange (10 YR 8/2) mottled with clayey fine sand lenses and clasts, dark yellowish orange (10 YR 8/6)	2-8
SAND, fine- to medium-grained quartz, well sorted, angular, pale yellowish orange (10 YR 8/6)	8-9.5
SAND, fine to medium grained, moderately sorted, angular, dark yellowish orange (10 YR 6/6)	9.5-10
SAND, medium-grained quartz, subangular to angular well sorted, very pale orange (10 YR 8/2)	10-11.5
Clayey SAND, olive gray (5Y 3/2)	11.5-11.75
SAND, medium grained, subangular, very pale orange (10 YR 8/2)	11.75-12
Slightly silty fine- to medium-grained SAND, moderately sorted, very pale orange (10 YR 8/2)	12-14
SAND, fine to medium grained, very pale orange (10 YR 8/2)	14-16.5
SAND, medium- to coarse-grained quartz, moderately sorted, subrounded to subangular, pale yellowish orange (10 YR 8/6)	16.5-17
SAND, fine to medium grained, very pale orange (10 YR 8/2)	17-18
Silty to clayey fine SAND, olive gray (5Y 3/2) with dark gray (N3) clayey clasts and lenses	18-20
Silty fine SAND, olive gray (5Y 3/2), with some phosphate grains and quartz pebbles	20-24

Boring terminated at 24 feet below land surface.

Table 11.--*Chemical analyses of water from cluster wells*

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Sample collection		Field temperature water (°C)	Turbidity (NTU)	Color (platinum-cobalt units)	Field specific conductance (µS/cm)	Lab specific conductance (µS/cm)	Field pH (standard units)	Lab pH (standard units)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, nitrite, dissolved (mg/L as N)
	Date	Time									
S1W2	04/06/88	1400	20.0	210	35	320	280	7.20	7.30	0.021	0.004
S1W5	04/06/88	1200	20.1	37	2	95	51	5.00	5.20	0.016	.002
L1D	04/07/88	1100	19.5	160	17	585	630	6.65	6.90	24.0	.004
L1S	04/07/88	1300	20.0	220	940	580	618	6.45	6.60	28.0	.005
L2D	04/12/88	1000	19.6	260	15	640	585	6.50	6.70	2.30	.010
L2S	04/12/88	1100	19.7	750	12	580	511	6.55	6.60	20.0	.005
L2S (Duplicate)	04/12/88	1200	19.7	810	22	565	514	6.45	6.60	20.0	.009
L3D	04/13/88	1200	20.0	200	14	495	472	6.10	6.40	3.90	.006
L3S	04/13/88	1300	19.8	4,000	45	400	367	5.75	5.70	3.30	.012
Blank	04/12/88	1500	--	--	--	--	--	--	--	--	--

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; μS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; μg/L, microgram per liter; NA, not analyzed.]

Well number	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, $NO_2 + NO_3$, dissolved (mg/L as N)	Nitrogen, nitrate, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Carbon organic, dissolved (mg/L as C)	Cyanide, total (mg/L as CN)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
S1W2	0.50	0.154	0.150	0.156	0.9	<0.010	140	51.0	2.3	4.4	1.2
S1W5	<.20	.493	.491	.003	1.0	<.010	9	1.4	1.4	4.5	1.0
L1D	24	.016	--	<.001	8.6	<.010	120	39	5.1	49	7.0
L1S	30	<.010	--	<.001	12	<.010	100	32	5.2	49	9.4
L2D	2.3	.012	.002	<.001	1.8	<.010	200	75	3.3	3.7	2.1
L2S	22	<.010	--	<.001	7.4	<.010	73	19	6.2	47	6.7
L2S (Duplicate)	20	.010	--	<.001	3.7	<.010	73	19	6.2	47	6.7
L3D	3.2	.012	.006	<.001	3.0	<.010	130	46	3.9	28	5.0
L3S	3.6	.125	.113	<.001	5.6	<.010	57	17	3.5	31	3.8
Blank	--	--	--	--	--	--	--	--	--	--	--

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Arsenic, total (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, total recoverable (µg/L as Be)	Boron, dissolved (µg/L as B)	Cadmium, total recoverable (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Chromium, total recoverable (µg/L as Cr)
S1W2	4.8	20.0	0.30	12.0	5	15	<10	10	<1	<5	28
S1W5	5.1	8.4	.10	11	<1	12	<10	10	<1	<5	9
L1D	53	12	.20	9.9	5	63	<10	120	1	<5	58
L1S	48	85	.20	9.4	24	62	<10	140	<1	<5	110
L2D	47	14	.20	26	22	38	<10	50	5	<5	77
L2S	48	20	.20	7.0	36	64	<10	120	<1	<5	140
L2S (Duplicate)	49	20	.20	6.9	28	73	<10	120	<1	<5	130
L3D	38	27	.20	21	22	43	<10	110	<1	<5	3
L3S	32	80	.20	15	2	60	<10	120	2	<5	61
Blank	--	--	--	--	--	--	--	--	--	--	--

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Cobalt, dis-solved (µg/L as Co)	Copper, dis-solved (µg/L as Cu)	Copper, total recov-erable (µg/L as Cu)	Iron, dis-solved (µg/L as Fe)	Lead dis-solved (µg/L as Pb)	Lead, total recov-erable (µg/L as Pb)	Manga-nese, dis-solved (µg/L as Mn)	Nickel, dis-solved (µg/L as Ni)	Nickel, total recov-erable (µg/L as Ni)	Silver, total recov-erable (µg/L as Ag)	Tin, total recov-erable (µg/L as Sn)
S1W2	<3	<1	15	4	<5	<5	37	4	22	1	<1
S1W5	<3	1	5	96	<5	<5	25	4	11	1	<1
L1D	60	<1	7	16,000	<5	<5	4,700	16	32	<1	<1
L1S	40	<1	13	18,000	<5	10	460	13	52	<1	<1
L2D	20	<1	14	12,000	<5	<5	1,800	37	52	<1	<1
L2S	20	<1	15	29,000	<5	20	540	13	30	<1	<1
L2S (Duplicate)	20	<1	19	29,000	<5	21	530	14	42	<1	<1
L3D	6	<1	4	32,000	<5	7	3,000	34	43	<1	<1
L3S	240	<1	200	76,000	<5	<5	2,500	<1	36	4	25
Blank	--	--	--	--	--	--	--	--	--	--	--

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Vanadium, dissolved (µg/L as V)	Zinc, total recoverable (µg/L as Zn)	Antimony, total (µg/L as Sb)	Selenium, total (µg/L as Se)	Dichlorobromomethane, total (µg/L)	Carbon tetrachloride, total (µg/L)	1,2-Dichloroethane, total (µg/L)	1,2-(cis) dichloroethene, total (µg/L)	Bromoform, total (µg/L)	Chlorodibromomethane, total (µg/L)	Chloroform, total (µg/L)	Toluene, total (µg/L)
S1W2	<1	40	2	<1	<0.20	<0.20	<0.20	<0.20	<0.20	0.40	0.20	<0.20
S1W5	<1	20	<1	<1	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20
L1D	2	130	5	<1	.30	<.20	.60	.40	<.20	<.20	<.20	<.20
L1S	<1	200	4	<1	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.20
L2D	<1	100	2	<1	<.20	<.20	<.20	1.0	<.20	<.20	<.20	<.20
L2S	<1	220	1	<1	<.20	<.20	<.20	.20	<.20	<.20	<.20	<.20
L2S (Duplicate)	<1	210	<1	<1	<.20	<.20	<.20	.30	<.20	<.20	<.20	<.20
L3D	<1	20	1	<1	<.20	<.20	<.20	.60	<.20	<.20	<.20	<.20
L3S	38	320	8	<1	<.20	<.20	<.20	.50	<.20	<.20	<.20	<.20
Blank	--	--	--	--	<.20	<.20	<.20	<.20	<.20	<.20	<.20	<.20

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	N-Butyl benzyl phthalate, total (µg/L)	Chlorobenzene, total (µg/L)	Chloroethane, total (µg/L)	Chrysene, total (µg/L)	Diethyl phthalate, total (µg/L)	Dimethyl phthalate, total (µg/L)	Endosulfan sulfate, total (µg/L)	Endosulfan beta, total (µg/L)	Endosulfan alpha, total (µg/L)	Endrin aldehyde, total (µg/L)	Ethylbenzene, total (µg/L)
S1W2	<5.0	0.30	<0.20	<10.0	<5.0	<5.0	<0.01	<0.01	<0.01	<0.01	<0.20
S1W5	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L1D	<5.0	.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L1S	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L2D	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L2S	<5.0	.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L2S (Duplicate)	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L3D	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
L3S	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20
Blank	<5.0	<.20	<.20	<10.0	<5.0	<5.0	<.01	<.01	<.01	<.01	<.20

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Benzene, total (µg/L)	Ace-naphthy-lene, total (µg/L)	Ace-naph-thene, total (µg/L)	Anthra-cene, total (µg/L)	Benzo(b) fluoran-thene, total (µg/L)	Benzo(k) fluoran-thene, total (µg/L)	Benzo(a) pyrene, total (µg/L)	delta Benzene hexa-chlo-ride, total (µg/L)	bis(2-Chloro-ethyl) ether, total (µg/L)	bis(2-Chloro-ethoxy) methane, total (µg/L)	bis(2-Chloro-iso-prophyl) ether, total (µg/L)
S1W2	<0.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<0.01	<5.0	<5.0	<5.0
S1W5	<.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L1D	.30	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L1S	<.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L2D	.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L2S	.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L2S (Duplicate)	<.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L3D	.40	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
L3S	<.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0
Blank	<.20	<5.0	<5.0	<5.0	<10.0	<10.0	<10.0	<.01	<5.0	<5.0	<5.0

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Fluor-anthene, total (µg/L)	Fluor-ene, total (µg/L)	Hexa-chloro-cyclo-pent-adiene, total (µg/L)	Hexa-chloro-ethane, total (µg/L)	Indeno-(1,2,3-c,d) pyrene, total (µg/L)	Iso-phorone, total (µg/L)	Methyl bromide, total (µg/L)	Methyl chlo-ride, total (µg/L)	Methy-lene chlo-ride, total (µg/L)	N-Nitro-sodi-n-propyl-amine, total (µg/L)	N-Nitro-sodi-phenyl-amine, total (µg/L)
S1W2	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<0.20	<0.20	0.50	<5.0	<5.0
S1W5	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L1D	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L1S	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L2D	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L2S	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L2S (Duplicate)	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L3D	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
L3S	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0
Blank	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<.20	<.20	<.20	<5.0	<5.0

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	N-Nitrosodimethylamine, total (µg/L)	Nitrobenzene, total (µg/L)	para-Chloro-meta-cresol, total (µg/L)	Phenanthrene, total (µg/L)	Pyrene, total (µg/L)	Tetrachloroethylene, total (µg/L)	Trichlorofluoromethane, total (µg/L)	1,1-Dichloroethane, total (µg/L)	1,1-Dichloroethylene, total (µg/L)	1,1,1-trichloroethane, total (µg/L)	1,1,2-trichloroethane, total (µg/L)
S1W2	<5.0	<5.0	<30.0	<5.0	<5.0	<0.20	<0.20	<0.20	<0.20	1.8	<0.20
S1W5	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	<.20	<.20	.70	<.20
L1D	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	.40	<.20	1.0	<.20
L1S	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	<.20	<.20	.60	<.20
L2D	<5.0	<5.0	<30.0	<5.0	<5.0	.20	<.20	1.2	<.20	1.6	<.20
L2S	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	<.20	<.20	<.20	<.20
L2S (Duplicate)	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	.20	<.20	<.20	<.20
L3D	<5.0	7.0	<30.0	<5.0	<5.0	<.20	<.20	1.6	<.20	.60	<.20
L3S	<5.0	<5.0	<30.0	15.0	<5.0	<.20	<.20	.50	<.20	.90	<.20
Blank	<5.0	<5.0	<30.0	<5.0	<5.0	<.20	<.20	<.20	<.20	<.20	<.20

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	1,1,2,2-Tetra-chloro-ethane, total (µg/L)	Benzo-(g,h,i)-peryl-ene, total (µg/L)	Benzo(a)-anthra-cene, total (µg/L)	1,2-Di-chloro-benzene, total (µg/L)	1,2-Di-chloro-propane, total (µg/L)	1,2-trans-Di-chloro-ethene, total (µg/L)	1,2,4-Tri-chloro-benzene, total (µg/L)	1,2,5,6-Dibenzo-anthra-cene, total (µg/L)	1,3-Di-chloro-propene, total (µg/L)	1,3-Di-chloro-benzene, total (µg/L)	1,4-Di-chloro-benzene, total (µg/L)
S1W2	<0.20	<10.0	<5.0	<0.20	0.30	<0.20	<5.0	<10.0	<0.20	<0.20	<0.20
S1W5	<.20	<10.0	<5.0	<.20	<.20	<.20	<5.0	<10.0	<.20	<.20	<.20
L1D	.40	<10.0	<5.0	.80	<.20	<.20	<5.0	<10.0	.80	.50	1.0
L1S	<.20	<10.0	<5.0	.40	<.20	<.20	<5.0	<10.0	<.20	.20	.50
L2D	<.20	<10.0	<5.0	.40	<.20	<.20	<5.0	<10.0	<.20	<.20	.20
L2S	<.20	<10.0	<5.0	.30	<.20	<.20	<5.0	<10.0	<.20	.50	.40
L2S (Duplicate)	<.20	<10.0	<5.0	.40	<.20	<.20	<5.0	<10.0	<.20	.20	.30
L3D	<.20	<10.0	<5.0	<.20	<.20	<.20	<5.0	<10.0	<.20	<.20	<.20
L3S	<.20	<10.0	<5.0	<.20	<.20	<.20	<5.0	<10.0	<.20	<.20	<.20
Blank	<.20	<10.0	<5.0	<5.0	<.20	<.20	<5.0	<10.0	<.20	<5.0	<5.0

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	2-Chloroethyl vinyl ether, total (µg/L)	2-Chloronaphthalene, total (µg/L)	2-Chlorophenol, total (µg/L)	2-Nitrophenol, total (µg/L)	Di-n-octyl phthalate, total (µg/L)	2,4-Dichlorophenol, total (µg/L)	2,4-Dimethylphenol total (µg/L)	2,4-Dinitrotoluene, total (µg/L)	2,4-Dinitrophenol, total (µg/L)	2,4,6-Trichlorophenol, total (µg/L)	2,6-Dinitrotoluene, total (µg/L)
S1W2	<0.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
S1W5	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L1D	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L1S	<.20	<5.0	<5.0	6.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L2D	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L2S	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L2S (Duplicate)	<.20	<5.0	<5.0	<5.0	11.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L3D	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
L3S	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0
Blank	<.20	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<20.0	<20.0	<5.0

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	3,3'-Dichlorobenzidine, total (µg/L)	4-Bromophenyl phenyl ether, total (µg/L)	4-Chlorophenyl phenyl ether, total (µg/L)	4-Nitrophenol, total (µg/L)	4,6-Dinitro-ortho-cresol, total (µg/L)	Dichlorodifluoromethane, total (µg/L)	Aroclor 1016 PCB, total (µg/L)	Phenol (C6H5OH), total (µg/L)	Naphthalene, total (µg/L)	1,3-trans-Dichloropropene, total (µg/L)	Cis-1,3-Dichloropropene, total (µg/L)
S1W2	<25.0	<5.0	<5.0	<30.0	<30.0	<0.20	<0.1	<5.0	<5.0	<0.20	<0.20
S1W5	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
L1D	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	.30	.50
L1S	<25.0	<5.0	<5.0	<30.0	<30.0	2.2	<.1	<5.0	<5.0	<.20	<.20
L2D	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
L2S	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
L2S (Duplicate)	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
L3D	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
L3S	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20
Blank	<25.0	<5.0	<5.0	<30.0	<30.0	<.20	<.1	<5.0	<5.0	<.20	<.20

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	Methylene blue active substance (mg/L)	Pentachlorophenol, total (µg/L)	1,2-Dibromoethylene, total (µg/L)	bis(2-ethylhexyl) phthalate, total (µg/L)	Di-n-butyl phthalate, total (µg/L)	Benzidine, total (µg/L)	Vinyl chloride, total (µg/L)	Trichloroethylene, total (µg/L)	Naphthalenes, polychloride, total (µg/)	4,4'-DDT, total (µg/L)	4,4'-DDD, total (µg/L)
S1W2	<0.01	<30.0	<0.2	<5.0	<5.0	<50.0	<0.20	<0.2	<0.01	<0.01	<0.01
S1W5	.01	<30.0	<.2	<5.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
L1D	.01	<30.0	<.2	<5.0	<5.0	<50.0	<.20	.4	<.01	<.01	<.01
L1S	.48	<30.0	<.2	58.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
L2D	--	<30.0	<.2	<5.0	<5.0	<50.0	<.20	.3	<.01	<.01	<.01
L2S	.76	<30.0	<.2	<5.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
L2S (Duplicate)	.70	<30.0	<.2	<5.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
L3D	.18	<30.0	<.2	<5.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
L3S	.06	<30.0	<.2	55.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01
Blank	<.01	<30.0	<.2	43.0	<5.0	<50.0	<.20	<.2	<.01	<.01	<.01

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; µg/L, microgram per liter; NA, not analyzed.]

Well number	4,4'-DDE, total (µg/L)	Aldrin, total (µg/L)	alpha-Benzene hexa-chlor-ide, total (µg/L)	beta-Benzene hexa-chlor-ide, total (µg/L)	Lindane, total (µg/L)	Chlor-dane, total (µg/L)	Di-eldrin, total (µg/L)	Endrin, total (µg/L)	Ethion, total (µg/L)	Toxa-phene, total (µg/L)	Hepta-chlor, total (µg/L)
S1W2	<0.01	<0.010	<0.01	<0.01	<0.010	<0.0	<0.010	<0.010	<0.01	<0.5	<0.010
S1W5	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L1D	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L1S	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L2D	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L2S	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L2S (Duplicate)	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L3D	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
L3S	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010
Blank	<.01	<.010	<.01	<.01	<.010	<.0	<.010	<.010	<.01	<.5	<.010

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; μS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; μg/L, microgram per liter; NA, not analyzed.]

Well number	Heptachlor epoxide, total (μg/L)	Aroclor 1221 PCB, total (μg/L)	Aroclor 1232 PCB, total (μg/L)	Aroclor 1242 PCB, total (μg/L)	Aroclor 1248 PCB, total (μg/L)	Aroclor 1254 PCB, total (μg/L)	Aroclor 1260 PCB, total (μg/L)	Malathion, total (μg/L)	Parathion, total (μg/L)	Diazinon, total (μg/L)
S1W2	<0.010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.01	<0.01	<0.01
S1W5	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	<.01	<.01
L1D	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	<.01	.02
L1S	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	.01	.03
L2D	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	<.01	<.01
L2S	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	<.01	.03
L2S (Duplicate)	<.010	<.1	<.1	<.1	<.0	<.1	<.1	<.01	.01	.03
L3D	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	.01	<.01
L3S	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	.01	<.01
Blank	<.010	<.1	<.1	<.1	<.1	<.1	<.1	<.01	<.01	<.01

Table 11.--*Chemical analyses of water from cluster wells*--Continued

[Well number: Number used to identify U.S. Geological Survey wells shown in figure 2. °C, degree Celsius; NTU, nephelometric turbidity unit; μS/cm, microsiemens per centimeter; mg/L, milligram per liter; --, not applicable; <, constituent concentration is less than detection limit, as given by indicated value; μg/L, microgram per liter; NA, not analyzed.]

Well number	Methyl para-thion, total (μg/L)	Hexa-chloro-benzene, total (μg/L)	Chloro-buta-diene, total (μg/L)	Tri-thion, total (μg/L)	Methyl tri-thion, total (μg/L)	Solids, residue at 180 °C, dis-solved (mg/L)	Mercury, total recov-erable (μg/L as Hg)	Styrene, total (μg/L)	Xylene, total water whole total recoverable (μg/L)	Lab Alka-linity (mg/L as $CaCO_3$)
S1W2	<0.01	<5.0	<5.0	<0.01	<0.01	170	<0.10	<0.2	<0.2	113.0
S1W5	<.01	<5.0	<5.0	<.01	<.01	34	<.10	<.2	<.2	2.0
L1D	<.01	<5.0	<5.0	<.01	.02	283	NA	<.2	<.2	223
L1S	.03	<5.0	<5.0	<.01	.02	318	<.10	<.2	<.2	146
L2D	<.01	<5.0	<5.0	<.01	<.01	346	<.10	<.2	<.2	209
L2S	<.01	<5.0	<5.0	<.01	<.01	240	<.10	<.2	<.2	146
L2S (Duplicate)	.02	<5.0	<5.0	<.01	<.01	236	.10	<.2	<.2	148
L3D	<.01	<5.0	<5.0	<.01	<.01	269	<.10	<.2	<.2	124
L3S	<.01	<5.0	<5.0	<.01	<.01	274	.50	<.2	<.2	36
Blank	<.01	<5.0	<5.0	<.01	<.01	--	--	<.2	<.2	--

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