Evaluation of Water Resources in the Reedsport Area, Oregon

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations
Open-File Report 80-444

Prepared in cooperation with the
City of Reedsport

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By Joseph F. Rinella, F. J. Frank, and A. R. Leonard

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1980

UNITED STATES DEPARTMENT OF THE INTERIOR
CECIL D. ANDRUS, Secretary
GEOLOGICAL SURVEY
H. William Menard, Director

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[Plate is in pocket]

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CONVERSION FACTORS FOR INCH-POUND SYSTEM AND INTERNATIONAL SYSTEM OF UNITS (SI)

[For use of those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below]

To convert from	To	Multiply by
Length		
inch (in.)	millimeter (mm)	25.4
foot (ft)	meter (m)	0.3048
mile (mi)	kilometer (km)	1.609
Area		
acre	square meter (m^2)	4,047
	hectometer (hm^2)	0.4047
square mile (mi^2)	square kilometer (km^2)	2.59
Volume		
gallon (gal)	liter (L)	3.785
million gallons (Mgal)	cubic meters (m^3)	3,785
cubic foot (ft^3)	cubic meter (m^3)	0.02832
acre-foot (acre-ft)	cubic meter (m^3)	1,233
Specific combinations		
cubic foot per second (ft^3/s)	cubic meter per second (m^3/s)	0.02832
foot per day (ft/d)	meter per day (m/d)	0.3048
foot squared per day (ft^2/s)	meter squared per day (m^2/d)	0.0929
gallon per minute (gal/min)	liter per second (L/s)	0.06309
gallon per minute per foot [(gal/min)/ft]	liter per second per meter [(L/s)/m]	0.2070
million gallons per day (Mgal/d)	cubic meters per day (m^3/d)	3,785
acre-foot per year (acre-ft/yr)	cubic meter per year (m^3/yr)	1,233
Temperature		
degree Fahrenheit (°F)	degree Celsius (°C)	5/9 after subtracting 32 from °F value

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ABSTRACT

The water supply for the Reedsport area is obtained from Clear Lake, a 310-acre coastal lake that contains 16,600 acre-feet of water at full-pool level. The lake receives about 6,000 acre-feet of water annually from runoff and direct precipitation, and it loses about 600 acre-feet by evaporation. The 2,100 acre-feet diverted annually for public supply is about two-thirds of the "usable storage capacity" of the lake volume above the water-supply outlet pipe. Clear Lake is classified as a warm monomictic lake; that is, it is thermally stratified except during winter. The water of Clear Lake is of the sodium chloride type and is low in dissolved solids and nutrients. The water is considered to be of good quality for public supply, on the basis of biological and chemical constituents analyzed, which include trace elements, pesticides, and organic material.

The only ground-water source with potential to supply the needs of the Reedsport area is the dune sand-marine aquifer between U.S. Highway 101 and the coast. That aquifer consists largely of medium- to fine-grained sand with a variable saturated thickness of at least 90 feet. The aquifer is estimated to contain at least 12 billion gallons of water and to receive annual recharge from precipitation equivalent to 10 million gallons per day. Wells in the most productive part of the aquifer could be expected to yield a few hundred gallons per minute. The only identified water-quality problem is excessive iron reported in water from some wells.

Either Clear Lake or the major aquifer could supply the Reedsport area's anticipated year 2000 need of about 2.4 million gallons per day.

INTRODUCTION

Reedsport is a city with a population of about 4,600, located on the Umpqua River estuary a few miles upstream from its mouth (pl. 1). Industry and tourism are expanding in the area, resulting in an increased demand for water. Water supplies for Reedsport, Winchester Bay, and Gardiner are obtained from Clear Lake, which is about 2 mi southeast of the mouth of the Umpqua River and 5 mi southwest of Reedsport (pl. 1). During the summer of 1977, a drought year, water use in Reedsport was restricted because of lowered lake levels.

The sand-dune and beach deposits along the Pacific coast near Clear Lake are potential sources of large quantities of ground water. The annual recharge to the sand-dune deposits in the Coos Bay area has been estimated to average about 39 in. (Robison, 1973, p. 20). The recharge rate of the dune deposits near Clear Lake probably is similar, and this water discharges to the Pacific Ocean unused.

The purposes of this study are (1) to evaluate the extent, thickness, movement, availability, and quality of ground water in the sand dunes and in the principal alluvial deposits near Reedsport; and (2) to evaluate the variation in quality and quantity of Clear Lake water as it relates to the present and future use of the lake as a source of public water supplies.

Wells and springs are assigned a number based on their location according to the rectangular system for subdivision of public lands. In successive order, the numerals represent the township, range, and section. Thus, well 22S/13W-16dab is in township 22 south, range 13 west, section 16. A graphic illustration of this method of well location is shown in figure 1. The letters following the section number show the location within the section, the first letter designating the quarter section (160 acres), the second letter the quarter-quarter section (40 acres), and the third letter the quarter-quarter-quarter section (10 acres). Where two or more wells are in the same 10-acre subdivision, serial numbers are added after the third letter. For a spring, a lower case (s) is appended to the final letter.

This investigation was made partly to provide information needed by Reedsport and Douglas County for land-use planning. Most of the ground-water data were supplied by well owners, drillers, and water users. The cooperation and assistance of these people is appreciated, particularly those owners who permitted access to wells so that additional data could be obtained. We also wish to express appreciation to Ed Wynes and other employees of Reedsport for their assistance with the test-hole drilling, logging, and sampling. City officials also permitted access to Clear Lake so that water-quality data could be obtained and surveys made to determine lake depths and volume.

GEOGRAPHIC SETTING

Physiography

The city of Reedsport is situated on a narrow terrace mostly between Scholfield Creek and the Umpqua River. The principal physiographic features of the area are the Umpqua River estuary, the coastal sand dunes, and the rolling forested uplands inland from the dunes.

The mouth of the Umpqua River is at Winchester Bay, about 5 mi west of Reedsport and approximately 8 river miles downstream from the city. Downstream from the city, the estuary is from one-half to about a mile wide, has a maximum depth of about 20 ft, and is characterized by numerous broad tidal flats and marshy islands. At Reedsport, the Umpqua and Smith Rivers and Scholfield Creek are tidal and their waters are a brackish mixture of seawater and freshwater runoff.

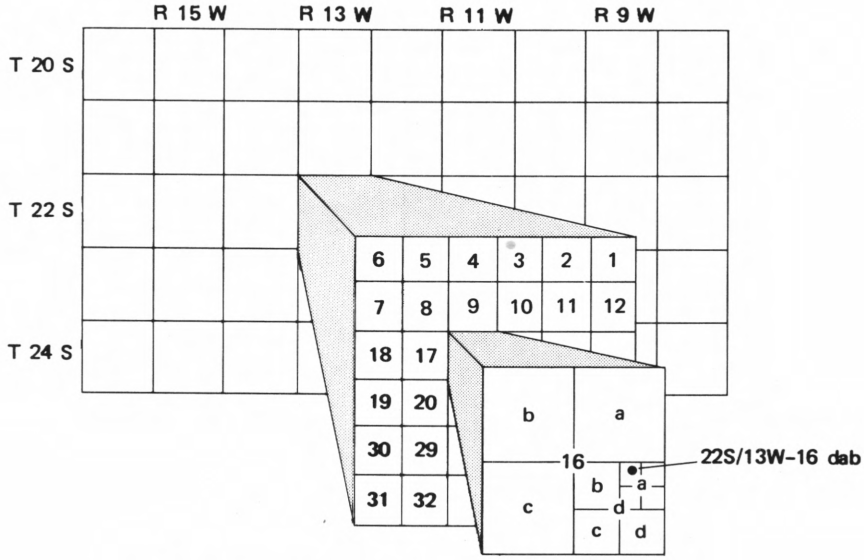


Figure 1.—Well- and spring-numbering system

The coastal dunes south of the mouth of the Umpqua River are among the highest, most striking dunes along the Oregon coast. The dune tract extends inland 1/2 to 2 mi from the coast. The highest altitude of about 500 ft is near the eastern edge of the dunes. The eastern part of the dunes is partly forested, but the main area consists largely of bare, shifting sand with typical alternating dune ridges and deflation plains. In the southeastern part of sec. 24 and the northeastern part of sec. 25, T. 22 S., R. 13 W. (pl. 1), dunes border the west side of Clear Lake.

Most of the area south of the Umpqua River is a well-dissected forested upland with hills and ridges as much as several hundred feet in altitude. The northern half of T. 22 S., R. 12 W., is drained by Scholfield and Winchester Creeks, but streams in the southern part flow into a series of coastal lakes. Clear Lake, the northwesternmost and highest lake (surface altitude, 229 ft), is described in detail in a later section of this report. It drains through Lake Edna and Clear Creek into Eel Lake (see pl. 1). Clear, Eel, and Tenmile Lakes all are part of an old stream system partly blocked by the coastal dunes and now discharging through Tenmile Creek in northwestern Coos County (Cooper, 1958, p. 102-103).

Climatic Features

The area has a temperate marine climate characterized by mild temperatures, wet winters, and dry summers. January is the coldest month with an average temperature of about 43°F, and August is warmest with an average temperature of 60°F. The annual average is about 52°F. Average daily fluctuations in winter commonly are only about 10°, but in summer they may be 20° to 30°F. The average annual precipitation for Reedsport is 77 in., with more than 70 percent occurring during the period November-March. January is normally the wettest month of the year, with an average of 13 in. of precipitation.

GEOLOGIC UNITS AND THEIR WATER-YIELDING POTENTIAL

Unconsolidated Deposits

Unconsolidated deposits, all of Quaternary age, include the alluvium, dune sand, and fluvial and marine terrace deposits.

Alluvium

The alluvium consists of narrow bands of stream-deposited material bordering the Umpqua River and in the valleys of Scholfield and Winchester Creeks. Along those creeks the alluvium consists largely of silt and fine sand derived from erosion of the local bedrock. Alluvium adjacent to the Umpqua River also is largely fine grained but contains beds of cobbles and gravel and, locally, peat and mud. A few miles upstream from Reedsport, gravel is being mined by dredging from the Umpqua River channel. The maximum thickness of the alluvium is not known, but it is probably about 50 ft.

In some places, permeable sand and gravel beds within the alluvium may yield quantities of water adequate for domestic or stock supplies. However, because of the preponderance of fine-grained material, the alluvium is not likely to yield large quantities of water anywhere in the project area. The most favorable area for beds of high permeability is adjacent to the Umpqua River, but high-yielding wells there probably would induce the infiltration of brackish water from the estuary. Hence, the alluvium should be considered a potential source of only small supplies of water.

Dune Sand

Dune sand covers much of the area west of U.S. Highway 101 in the south half of T. 22 S., R. 13 W. (pl. 1). This dune tract is a northward extension of the Coos Bay dune tract which extends southward nearly 20 mi to Coos Bay. Dune features are similar to those of other such tracts along the Oregon coast. A narrow foredune parallels the beach, and a deflation plain lies to the east of it. The deflation plain has been described as a surface from which wind has removed sand to about the level of the summer water table. Much of the area east of the deflation plain consists of a series of southeast-trending oblique dune ridges which rise in altitude in the inland direction (Cooper, 1958, p. 98). The east edge of the dune tract, which in places reaches an altitude of 500 ft, is forested and stabilized.

The dune sand consists of a mass of fine- to medium-grained sand without pronounced bedding or variations in lithology. In the subsurface, it is not readily distinguishable from sand of the underlying marine terrace deposits. Test holes drilled near the coast as part of this project indicate a thickness of 70 to 80 ft for the dune sand, possibly including the marine terrace deposits (fig. 2). Thickness of the dune sand may be nearly 200 ft where the dunes are highest (Cooper, 1958).

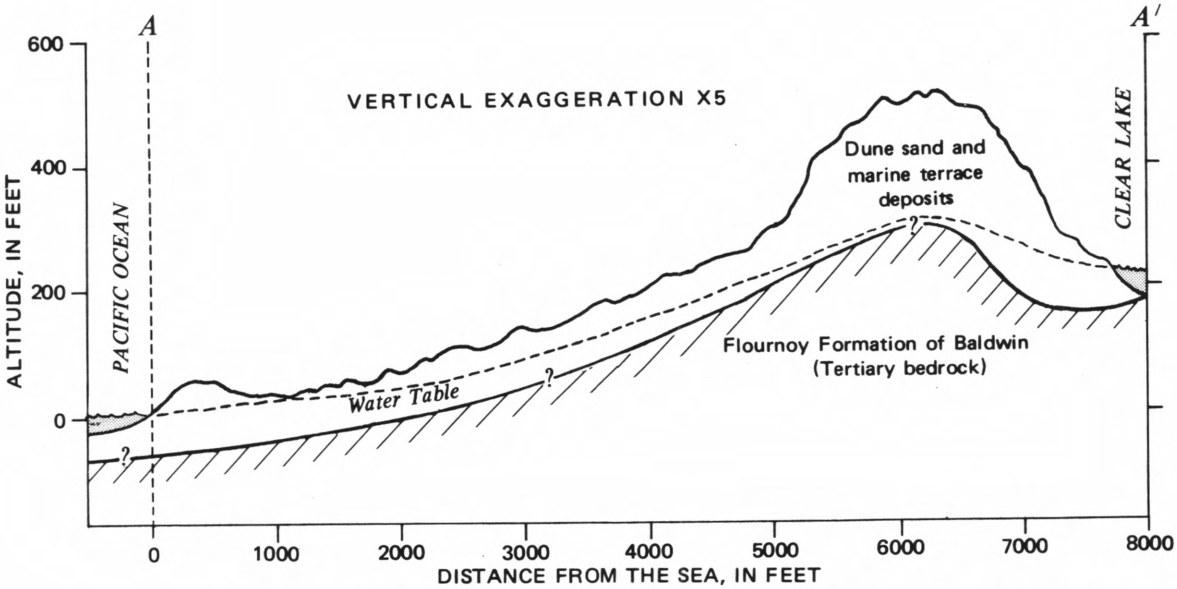


Figure 2.—Generalized section through dune area at *A* to *A'* of Plate 1.

The composite ground-water potential of the dune sand and marine terrace deposits is discussed under "Marine terrace deposits," which follows.

Marine Terrace Deposits

Consolidated, poorly stratified sand of marine origin underlies the entire dune tract and extends an unknown distance seaward. These deposits are referred to as marine terrace deposits, and their upper surface is a terrace that dips beneath the sea to the west and rises beneath the dunes to the east (Cooper, 1958, p. 97). The marine terrace deposits, which were the primary source for the dune sand, are impossible to differentiate from dune sand in drillers' logs or drill cuttings, and geophysical logs indicate only faint stratification.

Robison (1973, pl. 1) has suggested that terrace deposits in the Coos Bay dune area a few miles to the south constitute the bulk of the sandy material lying beneath the dunes. His cross sections indicate that these deposits have a thickness of about 70 to about 170 ft, with the greatest thickness to the south. In the Reedsport area, the marine terrace deposits probably do not exceed 100 ft in thickness.

The dune sand and underlying marine terrace deposits together are an aquifer that could be the source of large quantities of ground water. These deposits are highly permeable, absorb as recharge a large part of the precipitation that falls on their surface, and probably contain no natural deleterious material or source of pollution that might impair the quality of their water.

Assuming that about half the annual precipitation, or 40 in. per year, goes into ground-water recharge in the dune area, each square mile would receive about 700 million gallons per year. Because the dune tract has no surface drainage, all this water would move seaward and be discharged into the ocean. Part of this water might be "captured" for use, with a line of wells parallel to the coast. The wells would need to be inland far enough that pumping would not induce seawater to migrate into the aquifer system.

The specific capacity of four test wells drilled near the coast averaged about 6 (gal/min)/ft of drawdown. The saturated thickness was about 80 ft of a total thickness of 90 ft (tables 1 and 2). On that basis, wells might be constructed that would yield as much as 250 gal/min with little chance of inducing seawater into the freshwater aquifer. More comprehensive pumping tests would be needed to determine the most suitable pumping rate, distance between wells, and specifications for well construction.

Ground water also could be developed from the dune sand-marine terrace aquifer near U.S. Highway 101 south of Clear Lake. The differences between levels of Clear Lake and other nearby lakes show that Clear Lake may discharge considerable water by seepage into the unconsolidated deposits along the south and southwest margins of the lake. About 80 ft of saturated material was noted in a test well drilled through the aquifer about 1,000 ft south of the lake (well 22S/13W-25dad). The specific capacity of that well, estimated from a short pumping test, was about 8 (gal/min)/ft of drawdown. However, the reported specific capacity of well 22S/13W-36aaa1, about half a mile south of the test well, was 20 (gal/min)/ft. These tests indicate that wells in that area should be capable of yielding several hundred gallons per minute. Because leakage from the lake would provide a continuing source of recharge, in addition to that from precipitation, a well field producing a few million gallons per day might be developed in that area. Additional testing of existing wells would be a prerequisite to such development. Care also would be needed in locating production wells in that area in order to minimize adverse hydrologic boundary effects of the wells of the narrow bedrock valley in which the aquifer occurs.

Fluvial Terrace Deposits

Semiconsolidated deposits of old stream alluvium underlie a small terrace on which the western part of Reedsport is situated (pl. 1). These deposits are predominantly silt, fine sand, and clay, but the basal part consists of 10 to 20 ft of sand and gravel. (See log of well 21S/12W-28ddd, table 2.) The eroded surface of this terrace lies at an altitude of 40 to 80 ft. Thickness of the deposits is at least 200 ft, and the base of the deposits extends to 150 ft below mean sea level at well 21S/12W-28ddd.

Table 1.--Records of selected wells and springs in the Reedsport area

Well number: See page 2 for description of well- and spring-numbering system.
Type of well: Dr, drilled.
Finish: B, open bottom (not perforated or screened); S, screened: P, perforated.
Altitude: Altitude of land surface at well, in feet above National Geodetic Vertical Datum of 1929, interpolated from topographic maps.
Water level: Depths to water, given in feet and decimals, were measured by the Geological Survey; those in whole feet were reported by others or estimated.
Specific conductance of water: Field determination, in micromhos per centimeter, at 25°C.
Type of pump: C, centrifugal; J, jet; S, submersible; N, none.
Well performance: Yield in gallons per minute, and drawdown in feet below static water level, reported by owner, operator, driller, or pump company.
Use: D, domestic; N, none.
Remarks: Ca, chemical analysis of water in table 8; remarks on adequacy, dependability, and general quality are reported by owners, tenants, drillers, or others. P or B, pumped or bailed, for period indicated. L, driller's log of well in table 2.

Well or spring number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish, and interval (feet)	Character of material	Altitude (feet)	Water level		Specific conductance of water	Type of pump and hp	Well performance		Use	Remarks
										Feet below datum	Date			Yield (gal/min)	Drawdown (feet)		
21S/12W-27ccd(s)	Ray Holladay	--	--	--	--	--	--	--	70	--	8- 3-78	110	N	--	--	N	Temp 55°F. Former domestic supply.
28ddd	do.	Dr	1956	208	6	200	P, 195-200	Sand and gravel	40	19.64	do.	580	J, 2.5	66.5	--	D	P 1 hr, Ca. Water supply for 10 families. L.
33dbb	J. K. Hubbard	Dr	1966	125	6	124	B	do.	45	16	7-22-66	120	S, 5	30	20	D	B 5 hr. L.
22S/11W-5aac(s)	P. Washburn	--	--	--	--	--	--	Sandstone	240	--	8- 3-78	100	N	5	--	D	Temp 55°F. Flows by gravity in 1½-in. pipe to trailer house.
5bda(s)	W. Warren	--	--	--	--	--	--	do.	160	--	8- 4-78	110	C, 1/3	5	--	D	Temp 59°F. Pump and gravity flow to trailer house.
22S/12W-3aca	John Waggoner	Dr	1971	136	6	48.5	P, 29.5-49.5	Sand and gravel	80	28.64	8-31-78	127	S, 1.5	16	106	D	B 1/2 hr. L.
3acb	do.	Dr	1957	107	6	90	B	Sand	70	23	6-17-57	--	J, 0.5	40	10	N	B. Water not used because of poor quality. L.
4dac	Leonard Larson	Dr	1963	250	6	20	B	Sandstone	160	68	8-29-78	--	S, 0.5	4	182	N	B 1 hr. Yield inadequate.
22S/13W-14dda	City of Reedsport	Dr	1978	72	6	72	B	Sand	30	23.98	10-12-78	--	N	--	--	N	Test well; no screen; "tight" formation. L.
25dad	do.	Dr	1978	119	6	109	S, 109-119	do.	275	37.49	10-24-78	95	N	46	5.83	N	P 1½ hr, Ca. Test well. L.
26dbd	do.	Dr	1978	83	6	71	S, 73-83	do.	18	8.11	10-25-78	67	N	46	5.11	N	Do.
35aca	do.	Dr	1978	76	6	64	S, 66-76	do.	17	8.68	do.	75	N	46	6.76	N	P 1¼ hr, Ca. Test well. L.
35dcc	do.	Dr	1978	64	6	57	S, 54-64	do.	22	6.10	10-24-78	85	N	46	11.06	N	Do.
36aaa1	Donald St.Clair	Dr	1962	50	6	44	--	do.	235	33.86	8-10-78	95	S, 1	40	2.00	D	B 1 hr.
36aaa2	Frank Hunter	Dr	1962	69	6	65	S, 64.5-69	do.	235	28.15	do.	151	J, 0.75	40	12.00	D	B 2 hr. L.
36aaa3	Donald Whelpley	Dr	1978	100	6 4	60 100	P, 60-100	Sandstone	240	38	2-15-78	152	S, 1.5	12	23	D	P 4 hr. L.

Table 2.--Drillers' logs of selected wells

Materials	Thickness (feet)	Depth (feet)
21S/12W-28ddd. Ray Holladay. Altitude 40 ft. Drilled by Charles Panschow, 1956. Casing: 6-in. diam to 200 ft; lower 5 ft slotted		
Clay, red	25	25
Sand and silt	165	190
Sand and gravel	18	208
21S/12W-33dbb. J. K. Hubbard. Altitude 45 ft. Drilled by Charles Panschow, 1966. Casing: 6-in. diam to 124 ft; unperforated		
Clay, yellow	28	28
Clay, gray, and sand	70	98
Clay, brown and gray	8	106
Clay, gray	11	117
Sand and gravel, gray, water-bearing	10	127
22S/12W-3aca. John Waggoner. Altitude 80 ft. Drilled by Charles Panschow, 1971. Casing: 6-in. diam to 136 ft; perforated 29½ to 49½ ft		
Clay, brown	4	4
Clay, light-brown, and some sand	8	12
Clay, gray, and some sand and weeds	19	31
Clay, gray, and fine gravel	4	35
Clay, yellow, and fine gravel and sand	14	49
Sandstone, gray	14	63
Sandstone, gray, and shale	12	75
Sandstone, gray, and clay	27½	102½
Sandstone, gray	8½	111
Sandstone, gray, and shale	12	123
Sandstone, gray	2	125
Sandstone, gray, and shale	8	133
22S/12W-3acb. John Waggoner. Altitude 70 ft. Drilled by Ralph H. Steiber, 1957. Casing: 6-in. diam to 70 ft; unperforated		
Soil, brown, silty	4	4
Clay, yellow	24	28
Clay, black, silty	18	46
Clay, blue	24	70
Mud, blue, and tree bark	9	79
Sand and gravel, hard	1	80
Sandstone, blue, medium-hard	26	106
Sand, water-bearing	1	107
22S/13W-14dda. City of Reedsport. Altitude 30 ft. Drilled by Aqua-Tech Well Construction Co., Inc., 1978. Casing: 6-in. diam to 72 ft; unperforated		
Sand, brown, medium-fine	38	38
Sand, brown, medium-fine, tightly packed	34	72
22S/13W-25dad. City of Reedsport. Altitude 275 ft. Drilled by Aqua-Tech Well Construction Co., Inc., 1978. Casing: 6-in. diam to 109 ft; 4-in. screen 109-119 ft		
Sand, fine to medium, light-brown	38	38
Sand, fine to medium, brown; contains thin silty clay streaks	81	119
22S/13W-26dbd. City of Reedsport. Altitude 18 ft. Drilled by Aqua-Tech Well Construction Co., Inc., 1978. Casing: 6-in. diam to 71 ft; screened 73-83 ft		
Sand, brown, medium-fine	83	83
22S/13W-35aca. City of Reedsport. Altitude 17 ft. Drilled by Aqua-Tech Well Construction Co., Inc., 1978. Casing: 6-in. diam to 64 ft; screened 66-76 ft		
Sand, brown, medium-fine	76	76
22S/13W-35dcc. City of Reedsport. Altitude 22 ft. Drilled by Aqua-Tech Well Construction Co., Inc., 1978. Casing: 6-in. diam to 57 ft, screened 54-64 ft		
Sand, brown, medium-fine	64	64
22S/13W-36aaa2. Frank Hunter. Altitude 235 ft. Drilled by Steibers Well Drilling, 1961. Casing: 6-in. diam to 65 ft; screened 64½ to 69 ft		
Sand, medium, with brown clay	20	20
Sand, gray, medium	49	69
22S/13W-36aaa3. Donald Whelpley. Altitude 240 ft. Drilled by Corvallis Drilling Co., Inc., 1978. Casing: 6-in. diam to 60 ft, 4-in. diam to 100 ft; perforated 60-100 ft		
Loam, sandy	12	12
Sand, light-brown	11	23
Sand, white	25	48
Silt and wood	10	58
Sandstone, weathered	42	100

Well 21S/12W-28ddd was tested at 66 gal/min, which is an indication of the water-yielding potential of the terrace deposits. However, both the volume of the deposits and of the water contained in them are small. In addition, the deposits lie close to the Umpqua estuary, so that heavy pumping could cause infiltration of brackish water. Some additional water probably could be developed from these deposits in the northeastern part of sec. 4, T. 22 S., R. 12 W., if they contain water-bearing gravel there. These deposits, however, are not likely to be capable of supplying more than a small part of the water needed for Reedsport.

Consolidated Tertiary Rocks (Flournoy Formation)

Bedrock in the Reedsport area has been mapped by Beaulieu and Baldwin (Beaulieu and Hughes, 1975) as the marine Flournoy Formation of Baldwin (1974). The Flournoy underlies the entire area and is exposed in a broad area south and west of Reedsport (pl. 1). The formation consists of several thousand feet of siltstone interbedded with thin layers of arkosic, micaceous sandstone. The sandstone beds commonly are 3 to 5 ft thick, well cemented, and resistant to erosion. The siltstone units are more erodible and form the rounded hills of the study area. West of a north-trending anticline through the middle of R. 12 W., beds in the Flournoy dip westward; east of that line the dip is eastward.

The Flournoy is relatively impermeable and wells developed in the formation generally have meager yields. At favorable sites, yields adequate for domestic supplies can be developed, but the unit has no potential as a source of municipal, industrial, or irrigation water.

CLEAR LAKE

Physical Description

Clear Lake occupies the valley of the ancestral headwaters of Clear Creek, part of which was dammed by sand-dune encroachment (Cooper, 1958). Some of the dune sand also has slumped into the southern part of the lake. The Clear Creek basin was logged during the early 1940's and is now covered by brush and second-growth forest that frame the shoreline. Additional logging occurred in 1976. Virtually no emergent growth was observed in the lake except for very dense vegetation in small swamps adjacent to the inflow streams. A segment of U.S. Highway 101 lies within the watershed and follows the western shoreline of the lake.

Clear Lake is dendritic (branching) in form, and its dimensions are given in table 3. The hillsides bordering the lake have slopes comparable to the near-shore parts of the lake. The maximum depth (119 ft) at full pool is near the confluence of the two northern branches. The shallower parts are along the south and southwest edges of the lake, where sand from the encroaching dune has slumped into the lake (Cooper, 1958). Figure 3 shows depth contours of Clear Lake, and table 4 shows lake volumes at various depth intervals.

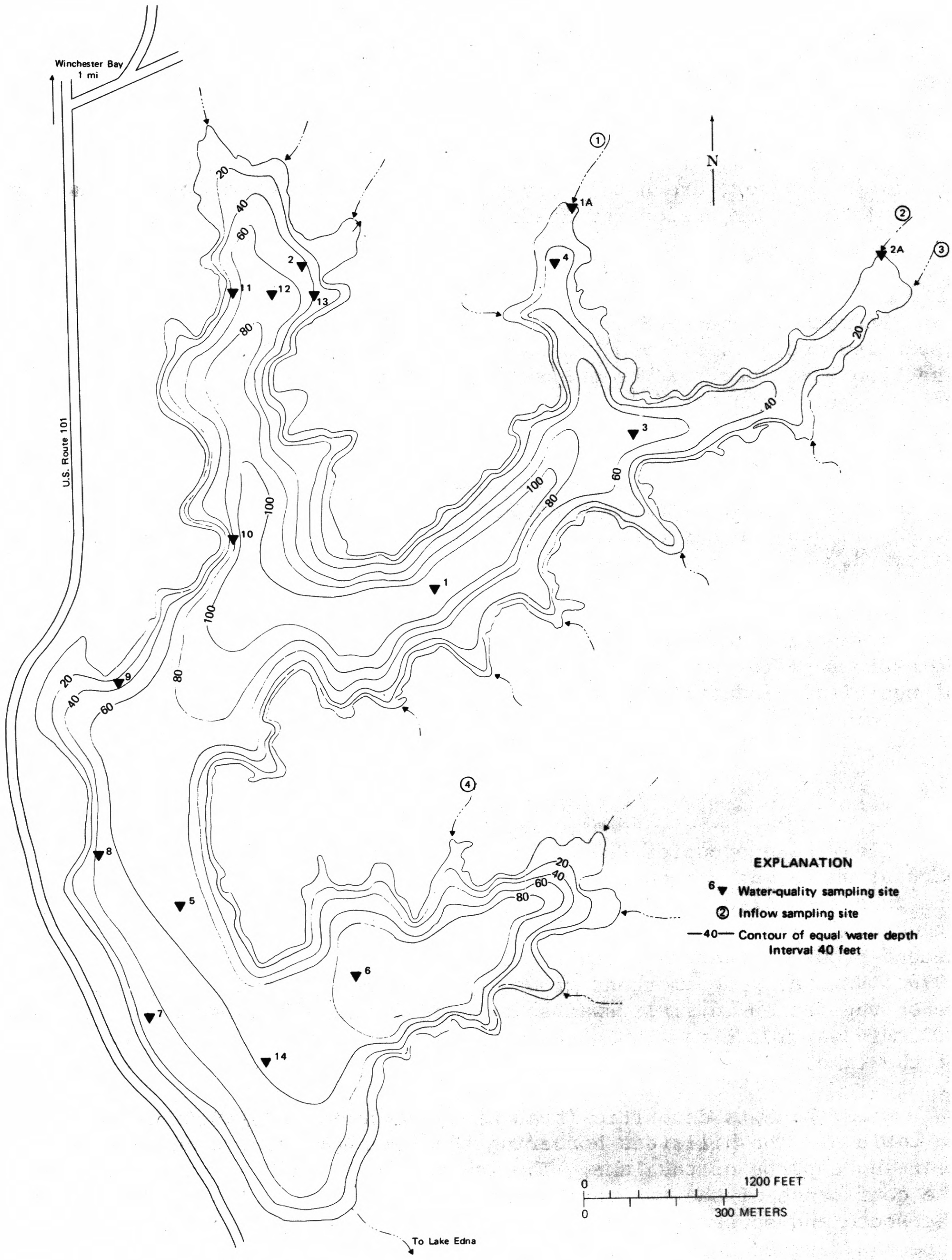


Figure 3.—Depth-contour map of Clear Lake.

Table 3.--Physical data for Clear Lake at full-pool level

Location (township, range)	T.22 S., R.12 W.
Altitude (water surface)	229 ft
Total drainage area (lake surface included)	1,290 acres
Area of lake	310 acres
Volume	16,600 acre-ft
Depth, maximum	119 ft
Depth, mean	54 ft
Shoreline length	46,000 ft

Table 4.--Volume of Clear Lake, by depth intervals

Depth interval (feet)	Volume (acre-feet)	Percentage of total volume
0-10	3,000	18.0
10-20	2,700	16.2
20-30	2,500	15.0
30-40	2,200	13.2
40-60	3,400	20.5
60-80	1,900	11.4
80-100	800	4.8
100-119	140	.9
Total (rounded)	16,600	100.0

Hydrology

Clear Lake receives water from numerous intermittent streams that flow into the coves along the lake perimeter. The lake discharges into Lake Edna through a short stream channel at the south.

During a normal year, Clear Lake receives 70 percent of its input by surface-water runoff and ground-water inflow and 30 percent by direct precipitation onto the lake surface. About 10 percent of the annual inflow is lost from the lake by evaporation. The ratio of total drainage area to lake surface is 4.2:1, and the volume of water in Clear Lake at full-pool level is about 2.7 times the average annual inflow.

The main surface-water inflows are from the north and east, where the basin is underlain by the Flournoy Formation of Baldwin (1974). The mean annual runoff from that area is estimated to be equivalent to 50 in. of precipitation, but ground-water inflow from the area is very small (Pacific Northwest River Basins Commission, 1970). Inflow to Clear Lake from the western dunes by way of ground-water seepage through the permeable sand is estimated to be equivalent to 50 in. of annual precipitation. An approximate monthly water balance for Clear Lake during a normal year is shown in table 5. Average monthly water use (column F) was calculated by averaging the

Table 5.--Estimated monthly water budget for Clear Lake

	A	B	C	D	E (C+D-B)	F	G (E-F)	H	I
	Normal precipitation 1/ (inches)	Lake evaporation 2/	Monthly runoff into lake 3/	Direct precipitation onto lake surface	Monthly contribution less evaporation	Average monthly municipal water-supply use 4/	Net water input	Maximum usable storage to level of intake pipe 5/	Minimum surface-water and ground-water outflow
		Acre-feet							
January	13.18	0	700	340	1,040	240	800	3,200	800
February	9.53	25	500	250	725	140	585	3,200	585
March	9.32	25	490	240	705	120	585	3,200	585
April	5.31	80	280	140	340	120	220	3,200	220
May	3.61	80	190	90	200	140	60	3,200	60
June	1.95	80	100	50	70	180	-110	3,090	0
July	.61	100	30	20	-50	250	-300	2,790	0
August	.98	100	50	30	-20	220	-240	2,550	0
September	2.30	80	120	60	100	210	-110	2,440	0
October	6.63	25	350	170	495	110	385	2,825	0
November	11.30	15	600	290	875	180	695	3,200	320
December	12.46	15	660	320	965	190	775	3,200	775
Total (rounded)	77.00	600	4,000	2,000	5,400	2,100	3,300		3,300

1/ National Oceanic and Atmospheric Administration (1977).
2/ Adapted from Robison (1973) and U.S. Department of Commerce (1959).
3/ Estimated 50 in. of runoff per year; monthly values assume no net change in soil-moisture content (Pacific Northwest River Basins Commission, 1970).
4/ Average municipal water use for 1976 through 1978 (Reedsport City Engineer, written commun.).
5/ Assumes no ground-water loss; also assumes that Clear Lake is at full-pool level in January.

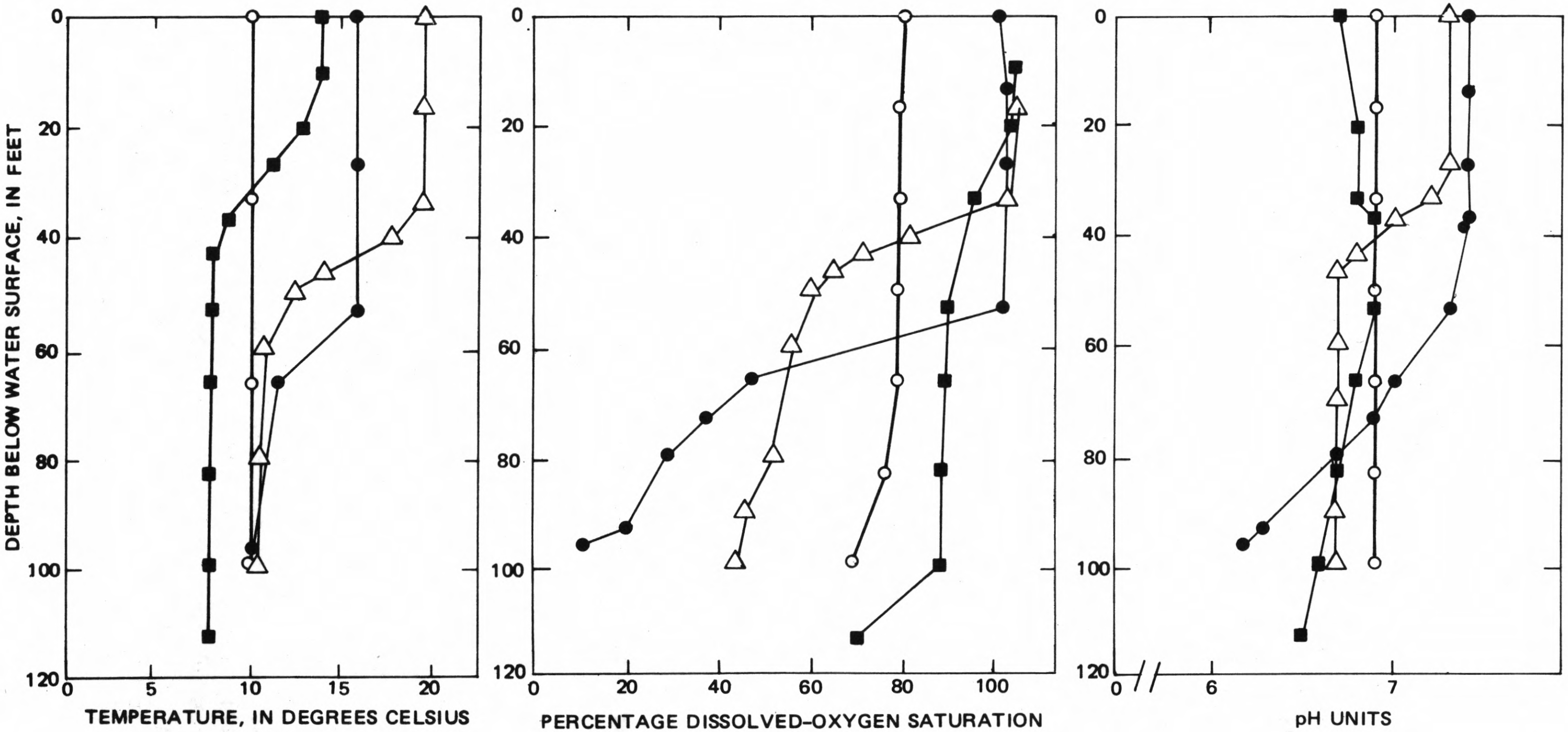
monthly metered water diversions into the municipal water-supply lines during 1976-78. Water use may be overestimated due to an unknown volume of water leaking from the municipal pipeline. The net water input (column G) is the difference between direct water inputs from runoff and precipitation (columns C and D), less lake evaporation (column B), and municipal water use (column F), assuming no ground-water outflow.

The maximum usable storage supply at full-pool level is about 3,200 acre-ft. During the month of January, Clear Lake was assumed to be at full-pool level, which is 10.9 ft above the bottom of the municipal intake pipe. The lake levels, however, are commonly lower than can be estimated by a water budget, and some water probably is discharged by ground-water seepage through the permeable sand near the outlet, as suggested in the ground-water discussion (p. 6). Therefore, the actual usable storage is generally less than the maximum usable storage. The minimum monthly surface- and ground-water outflow (column I) is based on the assumption that any water input to the lake at full-pool capacity will leave the lake either as surface-water outflow or ground-water seepage. The volumes in table 5 are approximate; for a more comprehensive water budget, ground-water and surface-water hydrology should be studied in greater detail.

Thermal Structure

In Reedsport, January is normally the coldest month of the year, with an average ambient air temperature of 43.5°F and average daily fluctuations of only about 9°F. Lake-water temperatures are seldom less than 4°C. The above information and in-situ temperature profiles (fig. 4) indicate that in a normal year Clear Lake can be classified as a warm monomictic lake. Warm monomictic lakes typically have one period of circulation or turnover in winter and stratification of temperature during summer. Figure 4 shows in-situ depth profiles of temperatures recorded during the period late October 1977-early May 1979.

Thermal stratification begins to develop in early spring as ambient temperatures and solar radiation warm the lake surface. (See fig. 4, May 2, 1979.) By late spring and summer, surface warming results in thermal stratification in which the less dense warm water overlies the denser cool water. The upper warm layer, the epilimnion, is thermally uniform due to mixing by the wind. The lower cold layer, the hypolimnion, is also thermally uniform and is separated from the epilimnion by the metalimnion, a layer of water that rapidly decreases in temperature with depth. (See fig. 4, September 7, 1978.) During the autumn months, the surface layers are cooled gradually until they reach the temperature of the deeper water. As the near-surface water continues to cool, it becomes denser and gradually sinks and mixes with the lower water. The water temperature then becomes uniform and the lake reaches a homogeneous state. (See fig. 4, November 28, 1978, when the lake reached a uniform temperature of 10°C). As the air warms in spring, the water near the surface also begins to warm and the entire cycle is repeated.



EXPLANATION

Date and time of measurements		Lake stage above bottom of municipal intake pipe (ft)
● 10-27-77	(1630 hrs)	2.9
△ 9-7-78	(0915 hrs)	9.3
○ 11-28-78	(0830 hrs)	8.6
■ 5-2-79	(0845 hrs)	10.5

Figure 4.—Profiles showing temperature, percentage dissolved-oxygen saturation, and pH at site 1, Clear Lake.

The seasonal temperature range in Clear Lake affects various water-treatment processes for municipal water supplies. For instance, higher chlorine dosages would be required as temperatures decrease (U.S. Environmental Protection Agency, 1976B).

WATER QUALITY

Surface and ground water in the Reedsport area generally are low in hardness and dissolved solids and, on the basis of constituents analyzed, are of good quality for most uses.

Explanation of Data

Dissolved solids refers to the substances dissolved in water. In this report, concentrations of dissolved solids are reported in milligrams per liter. For example, at common levels of concentration, 1 mg/L (milligram per liter) is equivalent to 1 pound of substance per million pounds of water, or 8.33 pounds per million gallons of water.

The total concentration of substances dissolved in water may be expressed in units of dissolved solids or related to specific-conductance values. Specific conductance is a measure of the ability of water to conduct electrical current and is expressed in micromhos per centimeter at 25°C. The average relation between dissolved solids and specific conductance is that the concentration of dissolved solids in milligrams per liter is approximately two-thirds of the specific-conductance value.

Ground Water

Chemical analyses were made of ground-water samples collected from five test wells in the dunes aquifer and from one well in the fluvial terrace deposits. Results of these analyses are given in table 6.

On the basis of the chemical constituents analyzed, the ground water tested is considered to be of good quality for public supplies, except for the excessive iron concentration of 0.49 mg/L in test well 22S/13W-35dcc. Water from the dune sand-marine terrace aquifer had a dissolved-solids concentration of less than 100 mg/L, was soft, and was low in all dissolved constituents. The water from well 21S/12W-28ddd, in the fluvial terrace deposits, had a substantially greater dissolved-solids concentration principally due to sodium chloride (table 5). That well is only a short distance from the Umpqua River estuary; hence, the sodium chloride may indicate some infiltration of brackish water from the estuary. The chloride concentration, however, does not exceed the drinking-water-criterion level established by the U.S. Environmental Protection Agency (1976B).

Table 6.--Chemical analyses of ground water in the Reedsport area

Location number	Water-bearing unit[1/]	Depth of well (feet)	Date of collection (1978)	Milligrams per liter: Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite + nitrate (as N)	Phosphate, ortho (as P)	Boron (B)	Arsenic (As)	Dissolved solids, calculated from determined constituents	Hardness (as $CaCO_3$)	Noncarbonate hardness (as $CaCO_3$)	Sodium-adsorption-ratio (SAR)	Specific conductance (micromhos/cm at 25°C)	pH (units)	Temperature °C	Temperature °F
21S/12W-28ddd	Qft	208	Oct.	32	0.13	8.2	3.6	120	2.3	--	2.9	98	0.6	0.04	0.18	0.53	0.000	358	35	0	8.8	490	7.0	12.0	54
22S/13W-14dda[2/]	Qds	25	Oct. 3	--	.05	--	--	--	--	9	--	32	--	--	--	--	--	--	--	--	--	100	6.2	--	--
22S/13W-25dad	Qds	109	Oct. 24	17	.14	7.9	3.3	9.8	1.1	--	5.7	22	.0	3.1	.01	.03	.000	79	33	12	.7	130	7.0	12.0	54
22S/13W-26dbd[2/]	Qds	12	Sept. 28	--	.11	--	--	--	--	11	--	32	--	--	--	--	--	--	--	--	--	130	6.3	16.0	61
Do.	Qds	83	Oct. 25	18	.06	2.4	1.3	8.7	.9	13	4.8	9.5	.0	.26	.04	.02	.000	52	11	0	1.1	70	7.0	12.0	54
22S/13W-35aca[2/]	Qds	14	Sept. 26	--	.08	--	--	--	--	9	--	22	--	--	--	--	--	--	--	--	--	100	6.3	15.0	59
Do.	Qds	76	Oct. 25	8.9	.21	3.7	2.0	8.9	1.4	20	3.6	12	.0	.05	.02	.03	.000	59	17	1	.9	70	7.0	11.5	53
22S/13W-35dcc[2/]	Qds	10	Sept. 21	--	.04	--	--	--	--	9	--	11	--	--	--	--	--	--	--	--	--	72	6.4	--	--
Do.	Qds	64	Oct. 24	20	.49	11	1.9	10	1.1	22	3.1	23	.0	.08	.02	.04	.000	81	35	17	.7	80	7.0	12.0	54

1/ See plate 1 for identification of symbols.

2/ Partial analysis of bailed sample collected during drilling.

Quality of Water in Clear Lake

Figure 3 shows locations where water was sampled for selected chemical and biological constituents in Clear Lake, its outflow, and selected inflows. Clear Lake water was analyzed for dissolved oxygen (DO), major ions, nutrients, trace elements, sediment, color, turbidity, indicator bacteria, and phytoplankton (suspended algae).

The chemical, biological, and sediment analyses were made by standard analytical methods (Skougstad and others, 1978; Greeson and others, 1977; and Guy, 1969, respectively).

Suspended Sediment and Selected Optical Properties

Suspended sediment is a measure of the organic and inorganic particulates suspended in water. Suspended sediment may result from biological productivity (algal growth) within a lake and from erosion along the shoreline and in the contributing watershed.

Table 7 presents data on suspended-sediment concentrations, turbidity, and color of water sampled at various sites and times in Clear Lake. Generally, the suspended-sediment concentrations within the lake appear to be seasonally constant and quite low, even at the greater depths.

The inflow concentrations of suspended sediment may correlate with total daily rainfall within the Clear Lake watershed. On September 6, 1978, total daily precipitation was 0.09 in. compared to 0.40 in. on November 28, 1978, and no precipitation on May 2, 1979. As the total daily precipitation increased, the suspended-sediment concentrations of the inflows increased (see table 7). The lake-water samples did not show a corresponding increase in suspended-sediment concentration, probably because the inflow sediments were deposited in the heavily vegetated swamps lying between the inflow sampling locations and the lake.

On May 2, 1979, outflow sediments appeared to be mostly sand that was probably re-entrained from the predominantly sand bottom adjacent to the outlet.

Suspended-sediment concentration in a lake may be monitored by measuring turbidity and secchi-disk transparency levels. The secchi-disk transparency reading reflects the effects of both turbidity and color on light penetration within a water body. The 1-percent light-transmittance level within a lake is about 2½ to 5 times the depth of the secchi-disk transparency level. The secchi-disk depths on October 27, 1977, November 28, 1978, and May 2, 1979, were 22.8, 15.5, and 25.5 ft, respectively, indicating relatively clear water. The estimated percentage of cloud cover on these days at the time of measurement was 15, 100, and 5 percent, respectively.

For health considerations, the EPA (Environmental Protection Agency) has established a maximum limit of 1 turbidity unit for drinking water entering a public distribution system. This limit is based on the determination that increased suspended material provides increased surface areas for attachment of

Table 7.--Suspended sediment, turbidity, and color analyses of Clear Lake water

[Lake samples were collected in a modified Van Dorn bottle. D.I., depth-integrated sample; NTU, nephelometric turbidity units]

Site or location	Date	Time	Depth of collection (feet)	Suspended sediment concentration (mg/L)	Percentage suspended sediment finer than 0.062 mm	Turbidity (NTU)	Color (platinum-cobalt units)
Site 1	9- 6-78	1700	8	2	--	<1	5
Do.	do.	1705	28	2	--	<1	5
Do.	do.	1708	43	2	--	<1	5
Do.	do.	1710	85	1	--	<1	5
Do.	do.	1715	102	3	73	1	5
Do.	9- 7-78	0930	102	4	81	1	5
Do.	11-28-78	1128	66	1	--	2	5
Do.	do.	1135	98	2	--	1	5
Do.	5- 2-79	0915	7	1	--	1	0
Do.	do.	0925	30	2	--	2	0
Do.	do.	0940	80	2	--	1	0
Site 2	9- 6-78	1805	7	2	--	--	5
Do.	9- 7-78	1010	10	1	--	<1	5
Do.	do.	1005	30	3	--	<1	5
Do.	11-28-78	1145	10	0	--	1	5
Inflow 1	11-28-78	1430	D.I.	47	73	12	100
Do.	5- 2-79	1530	D.I.	7	--	5	10
Inflow 2	9- 8-78	1610	D.I.	15	--	2	60
Do.	11-28-78	1500	D.I.	55	48	9	85
Do.	5- 2-79	1445	D.I.	8	--	2	10
Inflow 3	9- 8-78	1535	D.I.	47	53	5	75
Do.	11-28-78	1530	D.I.	124	52	18	130
Do.	5- 2-79	1430	D.I.	20	--	6	5
Outflow	5- 2-79	1400	D.I.	6	--	5	0

micro-organisms and, thus, chlorine disinfectant does not make effective contact with the organisms (U.S. Environmental Protection Agency, 1976B, p. 210). Generally, the lake turbidities were 1 nephelometric turbidity unit (NTU) or less at all depths. In two of the 14 lake-water samples, the maximum limit was exceeded by 1 NTU.

The color in Clear Lake water and inflows is mainly caused by the naturally occurring organic matter in runoff from the forested watershed. As discussed on page 22, the inflows are quite high in total organic carbon.

For esthetics, color of an untreated domestic water supply is not to exceed 75 color units on the platinum-cobalt scale (U.S. Environmental Protection Agency, 1976B). In Clear Lake, the water color was 5 units or less.

Dissolved Oxygen and pH

Dissolved-oxygen (DO) concentrations and pH generally are indicators of the chemical and biological processes occurring in a lake. Sources of DO in lake water are aeration aided by wave action and the photosynthetic activity of algae and plants. In the presence of sunlight, algae consume carbon dioxide and various nutrients to synthesize carbohydrates, proteins, and fats (Reid and Wood, 1976); a byproduct of this reaction is oxygen. Oxygen is removed from lake water by algal respiration and by the bacterial or chemical oxidation of organic and inorganic matter. The consumption of carbon dioxide during photosynthesis increases the pH, whereas the generation of carbon dioxide during respiration and oxidation of organics decreases the pH.

Hourly observations of selected water-quality characteristics were recorded at a 6-ft depth at site 2 (table 12, at end of report) from 1600 hr on September 6 through 1530 hr on September 7, 1978. The in-situ multiparameter probe was then lowered to a 30-ft depth for the remainder of the hourly measurements through 1700 hr on September 8. DO, pH, specific conductance, and water temperature were nearly identical at the 6- and 30-ft depths throughout the day. The data show little fluctuation in temperature and specific conductance during the 3-day period. Under partly cloudy conditions on September 6 and 7, DO remained at slightly more than 100-percent saturation and the pH ranged from 7.0 to 7.3, indicating that photosynthesis was probably occurring to a limited extent. Under 100-percent cloud-cover conditions on September 8, DO dropped slightly below saturation and pH dropped to 6.9, probably as a result of respiration and the oxidation of organic matter.

Figure 4 shows vertical DO and pH profiles in Clear Lake at site 1. DO and pH were also monitored at sites 2, 3, 5, 6, and 14, and their profiles were similar to those shown for site. 1.

Clear Lake DO profiles are characteristic of nutrient-enriched (eutrophic) conditions. During summer, the DO curve exhibits an oxygen deficit in the lower part of the water column (hypolimnion) and a sharp transition through the metalimnion. (See fig. 4, September 7, 1978.) The oxygen deficit at the greater depths probably is due to the bacterial oxidation of organic matter with a subsequent production of carbon dioxide and resultant lowering of pH. (The source of the organic matter is discussed later in this report.) Oxidation most likely occurs within the water column as well as at the mud-water interface. Saturated DO levels in the upper warm-water zone (epilimnion) during spring, summer, and fall were probably maintained by reaeration and photosynthetic activity. The strongly developed metalimnion tends to act as a barrier that prevents mixing between the well-oxygenated upper warm-water zone and the oxygen-depleted lower cold-water zone. After the winter turnover (fig. 4, November 28, 1978), oxygen increased in the lower water zone as a result of mixing with the upper-level water.

Clear Lake water is well within the suggested pH ranges of 5 to 9 for domestic water and 4.5 to 9.0 for irrigation water (U.S. Environmental Protection Agency, 1976B).

Chemical Constituents

Nitrogen, phosphorus, and organic carbon.--Nitrogen and phosphorus are considered to be major plant nutrients because their concentrations are often exhausted by phytoplankton (free-floating algae), thus limiting further growth (Britton and others, 1975). A plentiful supply of these nutrients, especially in the dissolved inorganic forms, may result in an abundant accumulation of aquatic plants which, in turn, can result in added cost for treatment of municipal water supplies.

Table 8 shows the seasonal variation in nitrogen and phosphorus concentrations at various depths in Clear Lake. Clear Lake water can be classified as meso-oligotrophic, which includes mean concentrations of total phosphorus (as P) between 0.005 and 0.01 mg/L, orthophosphate (as P) between 0.001 and 0.005 mg/L, and inorganic nitrogen (nitrite plus nitrate as N) between 0.2 and and 0.3 mg/L (Bortleson and others, 1974). Eutrophic (enriched) waters are characterized by abundant accumulations of nutrients that support dense plant growth, and oligotrophic (unenriched) waters are characterized by low accumulations of nutrients that support sparse growth. Meso-oligotrophic waters are characterized by a moderate supply of nutrients.

Critical minimum concentrations of nitrogen and phosphorus necessary to support nuisance plant growths in Wisconsin lakes have been found to be 0.30 mg/L for inorganic nitrogen and 0.01 mg/L for inorganic phosphorus. These critical concentrations were determined in the springtime, when nutrient concentrations commonly are at a maximum at the start of a growing season (National Academy of Sciences and National Academy of Engineering, 1972). On May 2, 1979, Clear Lake nutrient concentrations were less than the observed critical concentrations for Wisconsin lakes.

Table 8 also shows the seasonal inflow concentrations of nutrients. The three major inflows sampled during each visit were upstream from heavily vegetated swamps that occur between discrete inflow channels and open-lake water. On May 2, 1979, nutrients were collected from the swamps at inflow sites 1A and 2A. The 70-percent reduction of dissolved nitrite plus nitrate and a small reduction of orthophosphate between inflow site 2 and its adjacent midswamp sampling site 2A (table 8) indicates consumption of nutrients by the aquatic vegetation in the swamp. Nutrient concentrations (inorganic nitrogen and inorganic phosphorus) did not change significantly from upstream inflow site 1 to midswamp site 1A; however, dissolved orthophosphate was not detected at either site, suggesting that phosphorus may have been the limiting nutrient.

The low nutrient concentrations observed in the open-lake water may be explained by (1) consumption of nutrients within the swamps by rooted aquatic vegetation, or by algae (table 8, inflow sites 2 and 2A); (2) settling of the nutrients into the bottom sediments (table 8); (3) dilution by rain falling on the lake surface, and (4) consumption of nutrients by algae in the lake.

Table 8.--Selected chemical analyses of Clear Lake water and bottom sediments

[D.I., depth-integrated sample; < , less than]

Site or location	Date	Time (2400 hours)	Discharge (ft3/s)	Depth of collection (feet)	Dissolved constituents													Total constituents					Specific conductance (micromhos/cm at 25°C)	pH (units)
					Milligrams per liter																			
					Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Alkalinity (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite + nitrate (as N)	Orthophosphate (as P)	Dissolved solids residue at 180°C	Hardness (as $CaCO_3$)	Nitrogen (as N)	Kjeldahl nitrogen (as N)	Nitrite + nitrate (as N)	Phosphorus (as P)	Total organic carbon (TOC)		
Site 1	10-27-77	1630	--	23	6.8	2.9	1.8	12	1.0	15	2.1	17	0.0	0.00	0.00	60	15	0.25	0.24	0.01	0.00	2.2	83	7.4
Site 2	9- 7-78	1000	--	9	7.2	--	1.9	14	1.0	12	4.4	17	.0	--	--	44	--	--	--	--	--	--	82	7.0
Site 1	do.	1400	--	16	--	--	--	--	--	12	--	--	--	.03	.00	--	--	.20	.17	.03	.01	1/2.9	82	7.1
Do.	do.	1325	--	98	8.8	3.8	2.0	15	1.0	12	6.0	15	.0	.27	.00	60	18	.49	.22	.27	.01	1.7	81	6.8
Site 2	11-28-78	1145	--	10	7.7	2.5	2.0	12	1.1	13	4.3	16	.3	.10	.01	54	14	.39	.29	.10	.01	2.3	87	6.9
Site 1	do.	1128	--	66	--	--	--	--	--	--	--	--	--	.13	.01	--	--	.62	.49	.13	.01	2.1	87	6.9
Do.	do.	1135	--	98	--	--	--	--	--	--	--	--	--	.11	.00	--	--	.37	.26	.11	.00	2.0	88	6.9
Site 4	do.	1445	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2/	--	--	2/	2/	--	--
Site 1	5- 2-79	0915	--	7	7.0	2.8	1.9	10	.9	13	3.6	12	.1	.19	.00	60	15	3/.36	.14	.22	.01	2.5	84	6.7
Do.	do.	0940	--	80	7.1	2.4	1.9	10	1.0	13	3.6	13	.0	.19	.00	56	14	3/.38	.15	.23	.01	5.4	85	6.7
Inflow 1	9- 7-78	1630	0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow 2	do.	1600	<.5	D.I.	--	--	--	--	--	--	--	--	--	.57	.01	--	--	.93	.36	.57	.02	--	--	--
Inflow 3	do.	1530	<.5	D.I.	--	--	--	--	--	--	--	--	--	.63	.01	--	--	1.56	.93	.63	.05	--	--	--
Inflow 1	11-28-78	1430	.5	D.I.	--	--	--	--	--	--	--	--	--	.42	--	--	--	.92	.50	.42	.06	25	--	--
Inflow 2	do.	1500	.8	D.I.	--	--	--	--	--	--	--	--	--	2.3	--	--	--	3.1	.82	2.3	.06	20	--	--
Inflow 3	do.	1530	.6	D.I.	--	--	--	--	--	--	--	--	--	2.5	.10	--	--	4.2	1.7	2.5	.11	35	--	--
Inflow 1	5- 2-79	1530	--	D.I.	--	--	--	--	--	--	--	--	--	.15	.00	--	--	.34	.19	.15	.01	3.6	97	--
Inflow 1A 4/	do.	1545	--	D.I.	--	--	--	--	--	--	--	--	--	.16	.00	--	--	.42	.26	.16	.01	4.0	--	--
Inflow 2	do.	1445	.2	D.I.	--	--	--	--	--	--	--	--	--	.63	.01	--	--	.85	.18	.67	.01	4.3	87	--
Inflow 2A 4/	do.	1500	--	D.I.	--	--	--	--	--	--	--	--	--	.19	.00	--	--	1.0	.81	.22	.00	2.9	--	--
Inflow 3	do.	1430	.1	D.I.	--	--	--	--	--	--	--	--	--	.79	.01	--	--	1.1	.30	.84	.02	5.1	99	--
Outflow	9- 8-78	1130	<.1	D.I.	--	--	--	--	--	--	--	--	--	.02	.00	--	--	.12	.10	.02	.00	2.8	--	--
Do.	5- 2-79	1400	1.0	D.I.	--	--	--	--	--	--	--	--	--	.19	.00	--	--	.44	.23	.21	.00	2.4	--	--

1/ Suspended organic carbon and dissolved organic carbon are 0.3 and 2.6 mg/L, respectively.
2/ Bottom sediments contain 4.2 mg/g total nitrogen (as N), 0.13 mg/g total phosphorus (as P), and 95 mg/g total organic carbon (TOC).
3/ Total ammonia (as N) is 0.01 mg/L.
4/ Sample collected downstream from inflow channel in swamp adjacent to lake.

Decaying vegetation in the inflows is the major direct source of the nitrogen, phosphorus, and relatively high total organic carbon (TOC) concentrations observed.

TOC concentrations are a measure of the living and dead organic matter from basin runoff and algal production within the lake. The TOC may exert an oxygen demand after settling on the lake bottom or while in the water column by undergoing bacterial oxidation to carbon dioxide and water. Decomposing vegetative matter from the inflows accounts for the high nitrogen and TOC in the bottom sediments.

Major chemical constituents.--Table 8 shows the seasonal variation of major chemical constituents at various depths in Clear Lake. The most common ions in Clear Lake water are sodium and chloride, which constitute 40 to 70 percent of the dissolved solids. Clear Lake water can be classified as low in hardness, alkalinity, and dissolved solids.

Trace chemical constituents.--Table 9 shows the concentrations of selected trace elements, pesticides and other organics, and radiochemical constituents at three depths in Clear Lake and in the bottom sediments. The data show that neither the Maximum Contaminant Levels permitted by the Safe Drinking Water Act (U.S. Environmental Protection Agency, 1975 and 1976A) nor the criterion levels recommended by the U.S. Environmental Protection Agency (1976B) for domestic water supplies were exceeded. Pesticides were not detected in the water column nor in the bottom sediments; levels of detection are indicated by the number of digits shown in table 9.

Biological Features

Methods for determining the trophic state of a lake include chemical analyses of lake water (as discussed in the previous sections) and the analyses of suspended-algae communities (Reid and Wood, 1976). Nutrient-poor lakes typically support low densities of suspended algae (<5,000 cells/mL) and a large variety of species. Nutrient-enriched lakes generally support high densities of suspended algae (>15,000 cells/mL), with a small variety of species that frequently undergo intense algal blooms.

Suspended-algae abundance in Clear Lake was measured directly by cell count per unit volume of lake water and indirectly by chlorophyll a and b determinations. Light- and dark-bottle tests provided data on algal productivity, which is dependent on algal abundance (American Public Health Association and others, 1975). Seasonal potential for algal growth in Clear Lake was estimated by bioassays in which the growth of a selected test alga was observed in filtered Clear Lake water under laboratory conditions.

Suspended-algae abundance and composition.--Table 13 shows the observed algal species and cell counts at various depths in Clear Lake at site 1 and in the swamps at inflow sites 1A and 2A. Algal cell counts decreased as water temperature decreased. The lake-water cell counts ranged from 480 cells per milliliter in September 1978 to 63 cells per milliliter in November 1978. A cell count of 480 cells per milliliter is one-tenth the maximum cell count generally observed in nutrient-poor lakes. Cell counts could have been higher

Table 9.--Trace constituents in Clear Lake water and bottom sediments and maximum levels established for drinking water

[n.e., criteria for maximum allowable level has not been established; --, no data collected]

Total chemical constituent	Maximum allowable level in drinking water	Clear Lake Concentration found in water column, 9-7-78 Site 2 9-foot depth (ug/L)	Site 2 30-foot depth (ug/L)	Site 1 98-foot depth (ug/L)	Concentration found in bottom sediments, 11-28-78 Site 4 30-foot depth (ug/g)
Inorganic constituents					
Arsenic	1/50	0	1	1	14
Barium	1/1,000	200	200	200	100
Cadmium	1/10	--	--	0	0
Inorganic carbon	n.e.	--	--	--	200
Chromium	1/50	10	0	0	20
Copper	2/1,000	7	--	--	--
Iron (dissolved)	2/300	20	30	80	--
Lead (dissolved)	50	0	0	0	--
Lead	n.e.	0	0	0	0
Mercury 1/	1/2.0	.0	.0	.0	.04
Selenium	1/10	0	0	0	0
Silver	2/50	0	0	0	2
Zinc	2/5,000	10	--	--	--
Pesticides and other organics					
Aldrin	2/n.e.	.00	.00	.00	.0000
Chlordane	2/n.e.	.0	.0	.0	.000
DDD	n.e.	.00	.00	.00	.0000
DDE	n.e.	.00	.00	.00	.0000
DDT	2/n.e.	.00	.00	.00	.0000
Detergent	n.e.	<100	--	--	--
Dieldrin	2/n.e.	.00	.00	.00	.0000
Endosulfan	n.e.	.00	.00	.00	.0000
Endrin	1/.2	.00	.00	.00	.0000
Heptachlor epoxide	n.e.	.00	.00	.00	.0000
Heptachlor	2/n.e.	.00	.00	.00	.0000
Lindane	1/4.0	.00	.00	.00	.0000
Methoxychlor	1/100	.00	.00	.00	.0000
Mirex	n.e.	.00	.00	.00	.0000
Oil and grease	2/n.e.	<100	--	--	--
PCB	2/n.e.	.0	.0	.0	.000
PCN	n.e.	.0	.0	.0	--
Perthane	n.e.	.00	.00	.00	.0000
Silvex	1/10	.00	--	.00	.000
Toxaphene	1/5	.0	.0	.0	.000
2,4-D	1/100	.00	--	.00	.000
2, 4-DP	n.e.	.00	--	.00	.000
2, 4, 5-T	n.e.	.00	--	.00	.000
Radiochemical constituents (picocuries/L)					
Radium-226	3/5.0	<.1	--	--	--
Strontium-90 (dissolved)	3/8.0	.4	--	--	--
Strontium-90	3/8.0	1.5	--	--	--
Tritium	3/20,000	<300	--	--	--
Gross alpha	3/15	<.4	--	--	--

1/ U.S. Environmental Protection Agency (1975).
2/ U.S. Environmental Protection Agency (1976B).
3/ U.S. Environmental Protection Agency (1976A).

between samplings, because algal populations can undergo dynamic changes in population densities within short time intervals. However, the observed seasonal consistency of the same dominant species throughout the year suggests that (1) the established species equilibrium does not have extreme population pulses, and (2) low cell counts are seasonally characteristic in Clear Lake water.

The two codominant species of algae present throughout the year in Clear Lake water are Anacystis sp. and Cyclotella meneghiniana. Cyclotella meneghiniana is a centric diatom that has been associated with nutrient-poor lakes. Anacystis is a blue-green alga that has been associated with nutrient-enriched lakes (Wetzel, 1975; Hutchinson, 1967), but also has the ability to take up phosphorus from nutrient-poor water, store it, and distribute it to its daughter cells (McHugh, 1972). Therefore, Anacystis often tend to dominate summer algal populations in nutrient-enriched water as phosphorus concentrations become limiting. The low phosphorus concentrations in Clear Lake throughout the year give Anacystis an advantage in nutrient consumption and also discourage algal competition. Other algae observed in Clear Lake water that are generally indicative of unenriched or moderately enriched water are Chroococcus turgidus, Oocystic sp., Tabellaria fenestrata, and Dinobryon divergens (McHugh, 1972). Generally, the composition of suspended algal species identified in Clear Lake is consistent with the chemical data, indicating unenriched to moderately enriched lake conditions.

Two additional methods for estimating the trophic state of lakes are the determination of chlorophyll a and b (pigments found in chlorophyll-bearing plants) and adenosine triphosphate (ATP, a specific organic constituent found in living plant and animal tissues) concentrations. Table 10 shows analyses of biological constituents in Clear Lake. A summertime analysis of chlorophyll in Clear Lake was 0.13 ug/L, indicating nutrient-poor water. In November 1978 and May 1979, chlorophyll a and b concentrations were below the lowest detectable limit. ATP concentrations provided a measure of the living biomass (suspended algae and microscopic animal life) in Clear Lake water. Because chlorophyll was not detected on May 2, 1979, the predominant source of the ATP probably was not from plant life, but rather from the microscopic animal life.

The light- and dark-bottle test measures primary productivity, which is defined as the rate at which suspended algae (chlorophyll-bearing plants) convert inorganic carbon to an organic carbon (American Public Health Association and others, 1975). Table 10 presents primary productivity data collected from Clear Lake. The net productivity and respiration data indicate a low production of oxygen by photosynthesis and low consumption of oxygen by respiration, which is consistent with the low algal cell counts in the lake.

The algal growth potential (AGP) of Clear Lake was determined in bioassays for which the growth of the test alga, Selenastrum capricornutum, was monitored in filtered Clear Lake water. The growth response of this alga is not necessarily identical to that of indigenous species of algae in Clear Lake; however, growth-response trends are probably similar. The AGP test differentiates between nutrient concentrations identified by a chemical analysis and those forms of nutrients that are actually available for algal growth

Table 10.--Selected biological characteristics of Clear Lake

Site	Date	Time (2400 hours)	Depth (feet)	Suspended algal analyses: Light- and dark-bottle test: Primary productivity: Gross (mg O_2/m^3/hr)	Net	Respiration	Algal growth potential (mg/L)	Adenosine triphosphate (ug/L)	Chlorophyll a	Chlorophyll b	Algal count (cells/mL)
1	10-27-77	1630	23	--	--	--	--	--	--	--	250
1	9- 7-78	1625	3	--	--	--	--	--	--	--	480
1	do.	1640	16	--	--	--	0.4	--	0.13	0.00	450
1	do.	1630	98	--	--	--	.4	--	--	--	--
2	do.	1100-1700	2	0	-33	33	--	--	--	--	--
2	do.	1100-1700	12	17	-8	25	--	--	--	--	--
2	do.	1100-1700	22	8	0	8	--	--	--	--	--
2	do.	1100-1700	32	0	0	0	--	--	--	--	--
1	11-28-78	1550	3	--	--	--	--	--	--	--	69
1	do.	1600	10	--	--	--	--	0.0	.00	.00	63
1	do.	1610	66	--	--	--	.5	--	--	--	--
2	do.	1050-1615	3	0	-16	16	--	--	--	--	--
2	do.	1050-1615	30	0	-9	9	--	--	--	--	--
1	5- 2-79	0910	3	--	--	--	--	--	--	--	77
1	do.	0915	7	--	--	--	.3	--	.00	.00	--
1	do.	0915	7	--	--	--	1/ .4	--	--	--	--
1	do.	0915	7	--	--	--	2/ 6.0	--	--	--	--
1	do.	1600	7	--	--	--	--	.2	--	--	--
1	do.	0920	13	--	--	--	--	--	--	--	130
1	do.	0940	80	--	--	--	.3	--	--	--	--
2	do.	1000-1630	3	0	-3	3	--	--	--	--	--
2	do.	1000-1630	12	65	6	59	--	--	--	--	--
2	do.	1000-1630	24	11	-11	22	--	--	--	--	--
Inflow 1	do.	1545	--	--	--	--	--	--	--	--	380
Inflow 2	do.	1500	--	--	--	--	--	--	--	--	8,200

1/ Nitrogen spiked.

2/ Phosphorus spiked.

(Miller and others, 1978). The AGP of a nutrient-spiked water sample indicates which nutrient may be limiting for algal growth (Miller and others, 1978).

Table 10 shows AGP determinations for filtered Clear Lake water, including nutrient-spiked water samples. The AGP of unspiked samples ranged from 0.3 to 0.5 mg/L for both epilimnetic and hypolimnetic waters. The low algal cell counts and low AGP values indicate that Clear Lake is moderately productive (Miller and others, 1974). Moderately productive waters have been associated with slightly nutrient-enriched to moderately nutrient-enriched water-quality conditions (Miller and others, 1974).

On May 2, 1979, two water samples were collected, filtered, and nutrient spiked, one with nitrogen (as $NaNO_3$) and the other with phosphorus (as K_2HPO_4)--1 mg of nitrogen per liter and 0.05 mg of phosphorus per liter in the respective samples. The addition of nitrogen did not stimulate algal growth, whereas the addition of phosphorus increased the AGP to 6.0 mg/L, which is typical of moderately high productivity that has been associated with highly nutrient-enriched lake conditions (Miller and others, 1974). Clear Lake appears to be phosphorus limited, with high enough levels of nitrogen to create highly nutrient-enriched conditions if phosphorus loadings were increased.

<u>Bacteriological reconnaissance</u>.--The transmission of disease-producing microscopic organisms can be directly associated with fecal contamination from warmblooded animals (U.S. Environmental Protection Agency, 1976B). The primary bacterial indicator used in drinking water standards as a guideline to determine the disease-producing potential of drinking water is total coliform bacteria. Other, more specific, indicators for identifying fecal contamination include fecal coliform (a subunit of total coliform) and fecal streptococci.

Indicator bacteria may be found in the gut of warmblooded animals, but they are also associated with soils, vegetation, and insects. Because of the nonfecal sources of the bacteria, the occurrence of the indicator bacteria does not conclusively indicate the presence of fecal contamination. Indicator bacteria are not necessarily disease-producing; however, their presence is often associated with disease-producing organisms. Unless the source of the indicator bacteria has been determined by species identification to be nonfecal, the presence of total coliform, fecal coliform, and fecal streptococci indicates a potential health hazard.

Table 11 lists selected bacterial concentrations in Clear Lake water, selected inflows, and the lake outflow. The samples were collected a few inches below the water surface at the various sites. The higher fecal coliform and fecal streptococci concentrations in the inflows were probably due to animal droppings observed in those areas. Having limited survival time outside the gut of warmblooded animals, the fecal coliform and fecal streptococci died off, as shown by the low colony counts observed within the lake. Some dilution of bacterial concentrations would also occur from direct precipitation onto the lake surface. The predominant source of the total coliform was probably the soils and vegetation in the watershed.

Table 11.--Selected bacterial concentrations in Clear Lake water

[K indicates nonideal colony count]

Sampling site or location	Date	Time (2400 hours)	Total coliform	Fecal coliform	Fecal streptococci
			Colonies per 100 mL		
Site 1	10-27-77	1630	--	K2	--
Do.	9- 6-78	1715	> 8,000	< 1	K6
Do.	5- 2-79	1600	K19	< 1	K1
Site 2	10-27-77	1645	--	K2	K6
Do.	9- 6-78	1805	> 8,000	< 1	140
Do.	5- 2-79	1630	K5	K1	K1
Site 7	9- 7-78	1430	65,000	69	K1
Do.	11-28-78	1545	< 400	< 1	K1
Site 8	11-28-78	1550	< 400	< 1	< 1
Site 9	11-28-78	1555	< 400	< 1	< 1
Site 10	11-28-78	1600	< 400	3	< 1
Site 11	11-28-78	1615	< 400	< 4	K4
Site 12	11-28-78	1620	< 400	K1	K2
Site 13	11-28-78	1625	< 400	K1	< 1
Inflow 1	11-28-78	1430	5,500	100	140
Do.	5- 2-79	1530	220	< 1	K2
Inflow 2	9- 8-78	1600	K5,400	K260	260
Do.	11-28-78	1500	K1,400	K440	48
Do.	5- 2-79	1445	260	65	K2
Inflow 3	9- 8-78	1530	K1,000	33	130
Do.	11-28-78	1530	8,300	220	150
Do.	5- 2-79	1430	2,400	K80	K3
Inflow 4	9- 8-78	1400	22,000	110	< 2,500
Outflow	9- 7-78	1445	K50,000	K210	K320
Do.	5- 2-79	1400	K72	K4	K8

Table 11 shows that the bacterial populations are intermittent and transient in the lake water and inflows. The occurrence of indicator bacteria in the lake suggests that Clear Lake water would need chlorination if it is to be used for drinking.

WATER USE AND OUTLOOK FOR THE FUTURE

Reedsport maintains records of diversions from Clear Lake; however, the data are unrepresentative because of a leak of unknown volume from the pipeline that was repaired in February 1978. The Clear Lake water system presently serves a population of about 6,200, with estimated annual use of 2,100 acre-ft (1.9 Mgal/d; table 5, column F) and a maximum monthly demand of about 310 acre-ft (3.3 Mgal/d). This indicates an average daily per capita use of about 300 gal.

The population of Douglas County is estimated to increase 34 percent by the year 2000 (Oregon State Center for Population Research and Census, oral commun., May 1979). Assuming the same percentage of increase for the Reedsport area, Clear Lake may be serving an estimated population of 8,000, requiring an estimated annual diversion of 2,700 acre-ft (2.4 Mgal/d) to supply the average daily per capita use of 300 gal.

Clear Lake

Presently, Reedsport's municipal water-supply intake pipe is 10.9 ft below water surface at full-pool level. With the pipe at this level, the maximum usable storage capacity is 3,200 acre-ft. The total maximum usable storage capacity would be increased to 5,700 acre-ft by lowering the intake pipe, but pumping may be required. Lake Edna, whose water quality should be similar to that of Clear Lake, has a total volume of 1,300 acre-ft at full-pool level. An intake pipe placed at the 16-ft depth in Lake Edna would provide an additional maximum usable storage of 600 acre-ft; but, because Lake Edna is more than 30 ft lower than Clear Lake, the water would have to be pumped. Before lake levels are drastically lowered, however, an analysis of the potential for shoreline erosion is needed.

Table 5 shows that during a year of normal rainfall and municipal water consumption (average of 1976 through 1978), Clear Lake would provide an adequate supply for the city with the intake pipe at its present level. In 1978, precipitation at Clear Lake was 64 in., which was 13 in. less than normal. The lowest daily lake level during 1978 occurred in November, at 9 ft above the intake pipe. Even with precipitation in 1978 at 17 percent below normal and with the intake pipe at 10.9 ft below full-pool level, lake storage capacity was more than adequate for Reedsport's needs.

In 1976 and 1977, total annual rainfall was 33 in. and 12 in. below normal, respectively. By late summer of 1977, the lake stage was about 3 ft above the bottom of the intake pipe and would have been lower if a water-conservation program had not been imposed for the Reedsport area in the spring of 1977. If a similar period of low rainfall were to occur in the year 2000, the level of the intake pipe would have to be lowered to meet water-supply demands, or water use would have to be curtailed.

The quality of Clear Lake water in the future should remain adequate for municipal use if the policy of permitting only limited land-use activity in the watershed is continued. If phosphorus loadings are increased either by increased erosion or from some unforeseen source, rapid eutrophication may result. An alternate water source might be considered for an emergency, such as an accidental toxic spill along U.S. Highway 101 bordering the west side of the lake.

Supplemental Ground Water

The dune sand-marine terrace aquifer is the only geologic unit in the Reedsport area with the potential to supply large quantities of ground water. Its 4-mi^2 area between the Umpqua River and the Coos County line receives at least 3 billion gallons per year as recharge from precipitation and a substantial but unknown quantity by seepage from adjacent lakes. Conservatively, total recharge to the aquifer is estimated to be equivalent to more than 10 Mgal/d, more than five times Reedsport's 1978 use.

Assuming an average saturated thickness of 70 ft and a specific yield of 20 percent for the dune sand-marine terrace aquifer, the more than 4-mi^2 area contains at least 12 billion gallons of water. Hence, both the annual replenishment rate and the total volume of water stored in this aquifer system indicate that the aquifer is adequate to supply the area's anticipated water needs in year 2000.

On a practical basis, the volume of ground water that can be developed from the dune aquifer would depend on the rate at which individual wells could be pumped and on well spacing. As indicated earlier, pumping tests more comprehensive than those made for this investigation would be necessary to determine those factors. At a pumping rate of 250 gal/min, three wells pumping continuously would be required for each million gallons pumped per day. Possibly wells pumping twice that rate could be developed southwest of Clear Lake, in sec. 25, T. 22 S., R. 13 W. The aquifer in that area occupies a narrow bedrock valley about half a mile wide. For best results, well sites should be located closer to the lake than to either valley wall. Such locations would allow the wells to intercept seepage from the lake and to avoid adverse boundary effects of the valley walls.

The only identified ground-water-quality problem is excessive iron reported in water from several privately owned wells south of Clear Lake. More information is needed to identify the depth zone where excessive iron occurs and also its lateral extent.

A new pipeline, several miles long, would be required to develop ground water in the dunes, either from the coastal area or southwest of Clear Lake.

CONCLUSIONS

Clear Lake and ground water in the Reedsport area can be classified as low in hardness and dissolved solids. On the basis of the constituents analyzed, the water is of good quality for municipal use.

Ground water.--The dune sand-marine terrace aquifer contains adequate water to supply the Reedsport area's needs in the year 2000. As a prerequisite to planning ground-water development, additional hydrologic data should be obtained from the aquifer so that the efficient spacing, pumping rates, and design of wells can be determined. Additional information needed includes (1) daily, seasonal, and long-term fluctuations of ground-water levels; (2) an analysis of water-level responses to tidal and lake-level changes and to precipitation; and (3) data on the areal extent of water with excessive iron concentrations and any seasonal variation in iron concentration.

Clear Lake.--During a year of normal rainfall, Clear Lake can meet present water-supply demands with the municipal intake pipe set at its present depth of 10.9 ft below full-pool level. An additional 2,500 acre-ft of usable storage could be obtained by lowering the intake pipe to 20 ft below full-pool level; the consequences of increased erosion, however, should be investigated before drastically lowering the lake levels. The lowering of lake levels should not significantly alter the suitability of the lake water for domestic use, because the quality of water in the epilimnion and hypolimnion met drinking water standards and criterion levels.

Chemical and biological data indicate that Clear Lake can be classified as a moderately nutrient-enriched lake. Clear Lake, however, has the potential to rapidly become eutrophic if phosphorus loadings were increased above present levels.

Table 12.--Water-quality data collected hourly from Clear Lake

Site 2
Date: September 6-8, 1978
Weather and remarks: Partly cloudy on 9-6 and 9-7, with light precipitation on 9-7. One hundred percent cloud cover on 9-8, with light precipitation.

Time (2400 hours)	Water temperature (°C)	Specific conductance (micromhos/cm at 25°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	pH (units)	Solar radiation (calories/cm²/min)
			6-foot depth			
Sept. 6						
1600	19.6	83	9.6	104	7.2	0.92
1700	19.6	83	9.6	104	7.2	.68
1800	19.6	83	9.7	105	7.2	.08
1900	19.6	83	9.7	105	7.2	.02
2000	19.6	84	9.7	105	7.2	.00
2100	19.6	84	9.7	105	7.1	.00
2200	19.6	84	9.8	106	7.0	.00
2300	19.6	84	9.8	106	7.0	.00
Sept. 7						
0000	19.6	84	9.8	106	7.0	.00
0100	19.6	83	9.7	105	7.0	.00
0200	19.6	82	9.6	104	7.1	.00
0300	19.4	82	9.5	102	7.1	.00
0400	19.4	82	9.5	102	7.1	.00
0500	19.4	82	9.6	103	7.0	.00
0600	19.4	82	9.5	102	7.1	.00
0700	19.4	82	9.5	102	7.1	.05
0800	19.4	82	9.6	103	7.0	.15
0900	19.4	82	9.6	103	7.0	.15
1000	19.2	82	9.5	102	7.0	.50
1100	19.4	82	9.5	102	7.0	.60
1200	19.6	83	9.5	103	7.0	1.2
1300	19.6	83	9.6	104	7.0	.90
1400	19.6	83	9.6	104	7.1	.98
1500	19.6	83	9.6	104	7.2	.68
			30-foot depth			
1600	19.6	82	9.5	103	7.2	.72
1700	19.6	82	9.5	103	7.2	.50
1800	19.8	81	9.5	103	7.2	.15
1900	19.7	82	9.5	103	7.2	.05
2000	19.6	82	9.5	103	7.3	.00

Table 12.--Water-quality data collected hourly from Clear Lake--Continued

Time (2400 hours)	Water temperature (°C)	Specific conductance (micromhos/cm at 25°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	pH (units)	Solar radiation (calories/cm²/min)
	30-foot depth--Continued					
Sept. 7						
2100	19.6	83	9.5	103	7.2	0.00
2200	19.6	83	9.5	103	7.3	.00
2300	19.6	83	9.4	102	7.2	.00
Sept. 8						
0000	19.6	83	9.5	103	7.3	.00
0100	19.6	83	9.4	102	7.1	.00
0200	19.6	84	9.3	101	7.1	.00
0300	19.6	84	9.3	101	7.1	.00
0400	19.6	84	9.3	101	7.1	.00
0500	19.6	84	9.2	100	7.1	.00
0600	19.6	84	9.2	100	7.1	.00
0700	19.4	85	9.2	99	7.1	.00
0800	19.4	85	9.2	99	7.0	.05
0900	19.4	85	9.2	99	7.0	.15
1000	19.4	85	9.2	99	7.0	.15
1100	19.4	85	9.2	99	6.9	.15
1200	19.4	85	9.2	99	6.9	.10
1300	19.2	86	9.2	99	6.9	.15
1400	19.2	86	9.0	97	6.9	.15
1500	19.2	86	9.0	97	6.9	.12
1600	19.2	86	9.0	97	6.9	1.8
1700	19.2	86	9.1	98	6.9	.08

Table 13.--Taxa and cell count of suspended algae from Clear Lake

[Common name is indicated in parentheses after division, class, order, or family. Cell count is in organisms per milliliter; percent is percent of total organisms in sample]

DIVISION / CLASS / Order / Family / Genus species	Sampling site: Site 1														Inflow 1A		Inflow 2A	
Date	10-27-78		9-7-78		9-7-78		11-28-78		11-28-78		5-2-79		5-2-79		5-2-79		5-2-79	
Depth	1 foot		3 feet		16 feet		3 feet		10 feet		3 feet		13 feet		1 foot		1 foot	
	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent	Cell count	Percent
CHLOROPHYTA (Green algae)																		
CHLOROPHYCEAE																		
Volvocales																		
Chlamydomonadaceae																		
Chlamydomonas-like	--	--	13	2.7	23	5.0	1	1.4	2	3.2	1	1.3	6	4.7	16	4.2	--	--
Chlorococcales																		
Coelastraceae																		
Coelastrum microporum	--	--	--	--	--	--	--	--	1	1.6	--	--	--	--	--	--	--	--
Oocystaceae																		
Ankistrodesmus falcatus	--	--	--	--	--	--	--	--	--	--	--	--	2	1.6	--	--	--	--
Oocystis sp.	2	0.8	--	--	13	2.9	--	--	--	--	3	3.9	7	5.5	--	--	--	--
Quadrigula sp.	--	--	3	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scenedesmaceae																		
Crucigenia quadrata	4	1.6	--	--	--	--	1	1.4	3	4.7	1	1.3	--	--	--	--	--	--
Scenedesmus hystrix	--	--	3	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zygnematales																		
Desmidiaceae (Placoderm desmids)																		
Staurastrum sp.	--	--	3	.6	3	.7	--	--	--	--	--	--	--	--	--	--	--	--
Misc. green algae	2	.8	--	--	--	--	--	--	--	--	2	2.6	--	--	8	2.0	--	--
Misc. green algae C	--	--	30	6.2	10	2.1	1	1.4	--	--	--	--	--	--	--	--	--	--
Misc. green algae E	--	--	13	2.7	10	2.1	--	--	1	1.6	--	--	--	--	--	--	--	--
Misc. green algae F	--	--	--	--	10	2.1	--	--	--	--	--	--	--	--	--	--	--	--
Misc. green algae G	--	--	7	1.4	10	2.1	4	6.0	1	1.6	--	--	--	--	--	--	--	--
Misc. green algae J	--	--	--	--	--	--	--	--	2	3.2	--	--	--	--	--	--	--	--
EUGLENOPHYTA (Euglenoids)																		
EUGLENOPHYCEAE																		
Euglenales																		
Euglenaceae																		
Trachelomonas sp.	--	--	--	--	--	--	--	--	--	--	1	1.3	2	1.6	--	--	--	--
CRYPTOPHYTA (Cryptomonads)																		
CRYPTOPHYCEAE																		
Cryptomonidales																		
Cryptomonodaceae																		
Cryptomonas erosa	--	--	37	7.6	36	7.9	1	1.4	--	--	--	--	--	--	--	--	--	--
Cryptomonas sp.	--	--	17	3.5	19	4.3	--	--	--	--	--	--	--	--	--	--	--	--
PYRRHOPHYTA (Fire algae)																		
DINOPHYCEAE (Dinoflagellates)																		
Peridiniales																		
Peridiniaceae																		
Peridinium cinctum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	.8	--	--
Ceratiaceae																		
Ceratium hirundinella	--	--	3	.6	3	.7	--	--	--	--	--	--	--	--	--	--	--	--
CHRYSOPHYTA																		
CHRYSOPHYCEAE (Yellow-brown algae)																		
Chrysomonadales																		
Ochromonadaceae																		
Dinobryon divergens	--	--	--	--	--	--	3	4.4	4	6.3	--	--	--	--	--	--	--	--
D. sertularia	--	--	--	--	--	--	--	--	--	--	--	--	4	3.1	--	--	--	--

Table 13.--Taxa and cell count of suspended algae from Clear Lake-- Continued

DIVISION / CLASS / Order / Family / Genus species	Site 1														Inflow 1A		Inflow 2A	
Dat	10-27-78		9-7-78		9-7-78		11-28-78		11-28-78		5-2-79		5-2-79		5-2-79		5-2-79	
Depth	1 foot		3 feet		16 feet		3 feet		10 feet		3 feet		13 feet		1 foot		1 foot	
	Cell Count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent	Cell count	Per-cent
BACILLARIOPHYCEAE (Diatoms)																		
Centrales (Centric diatoms)																		
Coscinodiscaceae																		
Cyclotella meneghiniana	128	50.6	101	20.8	110	24.4	12	17.5	19	30.1	23	29.9	30	23.6	49	12.9	37	0.5
C. stelligera	--	--	--	--	--	--	--	--	1	1.6	--	--	--	--	--	--	--	--
Melosira distans	--	--	--	--	--	--	--	--	--	--	1	1.3	3	2.4	--	--	--	--
Pennales (Pennate diatoms)																		
Tabellariaceae																		
Tabellaria fenestrata	--	--	--	--	--	--	--	--	1	1.6	1	1.3	1	.8	27	7.1	149	1.8
T. flocculosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	1.3	186	2.3
Diatomaceae																		
Diatoma tenue elongatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	409	5.0
Fragilariaceae																		
Fragilaria capucina	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
F. construens	--	--	30	6.2	--	--	1	1.4	1	1.6	--	--	--	--	--	--	--	--
F. vaucheria	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	111	1.4
Synedra radians	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	.8	--	--
S. rumpens	--	--	--	--	--	--	--	--	--	--	--	--	1	.8	62	16.3	74	.8
S. ulna	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	.8	74	.8
S. sp.	--	--	--	--	--	--	1	1.4	--	--	1	1.3	--	--	--	--	--	--
S. spp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	22	5.8	--	--
Eunotiaceae																		
Eunotia incisa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	260	3.2
E. naegelii	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35	9.2	111	1.4
E. sp.	--	--	--	--	--	--	1	1.4	--	--	--	--	--	--	14	3.7	--	--
E. spp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	223	2.7
Achnanthaceae																		
Achnanthes lanceolota	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
A. linearis	6	2.4	--	--	10	2.1	3	4.4	2	3.2	1	1.3	--	--	--	--	446	5.5
A. microcephala	--	--	--	--	--	--	--	--	--	--	--	--	2	1.6	--	--	37	.5
A. minutissima	17	6.7	3	.6	16	3.6	--	--	2	3.2	7	9.1	3	2.4	57	15.0	4,829	59.1
A. stewartii	--	--	--	--	--	--	--	--	--	--	--	--	1	.8	--	--	37	.5
Cocconeis placentula	--	--	--	--	--	--	1	1.4	--	--	1	1.3	--	--	--	--	111	1.4
Naviculaceae (Naviculoid)																		
Anomoeoneis vitrea	15	5.9	7	1.4	6	1.4	3	4.4	1	1.6	5	6.5	8	6.3	--	--	37	.5
Caloneis ventricosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
Frustulia rhomboides	--	--	--	--	--	--	--	--	1	1.6	1	1.3	--	--	--	--	--	--
Gyrosigma sp.	--	--	--	--	--	--	--	--	1	1.6	--	--	1	.8	--	--	--	--
Navicula cryptocephala	--	--	--	--	--	--	--	--	--	--	2	2.6	5	3.9	--	--	--	--
N. minima	--	--	--	--	--	--	--	--	1	1.6	--	--	--	--	--	--	74	.8
N. radiosa parva	--	--	--	--	--	--	1	1.4	--	--	--	--	--	--	--	--	--	--
N. sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
Neidium iridis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
Pinnularia sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	74	.8
Gomphonemataceae																		
Gomphonema angustatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	2.0	149	1.8
G. parvulum	2	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G. subclavatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	111	1.4
G. sp.	--	--	--	--	--	--	--	--	--	--	1	1.3	--	--	--	--	--	--

Table 13.--Taxa and cell count of suspended algae from Clear Lake--Continued

DIVISION / CLASS / Order / Family / Genus species	Site 1, 10-27-78, 1 foot: Cell count	Per-cent	Site 1, 9-7-78, 3 feet: Cell count	Per-cent	Site 1, 9-7-78, 16 feet: Cell count	Per-cent	Site 1, 11-28-78, 3 feet: Cell count	Per-cent	Site 1, 11-28-78, 10 feet: Cell count	Per-cent	Site 1, 5-2-79, 3 feet: Cell count	Per-cent	Site 1, 5-2-79, 13 feet: Cell count	Per-cent	Inflow 1A, 5-2-79, 1 foot: Cell count	Per-cent	Inflow 2A, 5-2-79, 1 foot: Cell count	Per-cent
Cymbellaceae																		
Amphora ovalis	2	0.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cymbella angustata	2	.8	--	--	--	--	1	1.4	--	--	1	1.3	1	0.8	3	0.8	--	--
C. cesatii	--	--	--	--	--	--	--	--	--	--	1	1.3	3	2.4	--	--	--	--
C. lunata	--	--	--	--	--	--	--	--	--	--	1	1.3	--	--	--	--	--	--
C. minuta	--	--	--	--	--	--	--	--	--	--	1	1.3	--	--	--	--	74	0.8
Nitzschiaceae																		
Nitzschia amphibia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	.8	--	--
N. dissipata	2	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	74	.8
N. palea	2	.8	--	--	--	--	--	--	--	--	1	1.3	1	.8	--	--	--	--
N. sp.	--	--	--	--	--	--	1	1.4	--	--	1	1.3	--	--	3	.8	--	--
Misc. pennate diatoms	6	2.4	--	--	--	--	--	--	--	--	1	1.3	4	3.1	38	10	260	3.2
CYANOPHYTA (Blue-green algae)																		
CYANOPHYCEAE																		
Chroococcales																		
Chroococcaceae																		
Anacystis sp.	48	18.9	155	32.0	129	28.6	32	46.5	18	28.5	18	23.3	42	33.0	22	5.7	--	--
Coccochloris turgidus	2	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C. sp.	13	5.1	30	6.2	16	3.6	1	1.4	1	1.6	--	--	--	--	--	--	--	--
Hormogonales (Filamentous blue-green algae)																		
Nostocaceae																		
Anabaena sp.	--	--	10	2.1	--	--	--	--	--	--	--	--	--	--	--	--	37	.5
Misc. blue-green algae D	--	--	10	2.1	29	6.4	--	--	--	--	--	--	--	--	--	--	--	--
Misc. blue-green algae H	--	--	10	2.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	253	100.0	485	100.0	453	100.0	69	100.0	63	100.0	77	100.0	127	100.0	381	100.0	8,169	100.0

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