Minnesota Pollution Control Agency

Prepared in cooperation with the
Minnesota Department of Natural Resources

Lake Carlos

Douglas County

Sentinel Lakes

Minnesota Lake ID: 21-0057
Area: 2,520 acres
Watershed Area: 156,569 acres
Ecoregion: North Central Hardwood Forest (NCHF)

Trophic State: Mesotrophic
Maximum Depth: 163 feet
Mean Depth: 45.7 feet
Mixing Status: Dimictic

Figure 1. Lake Carlos 3D depth contour

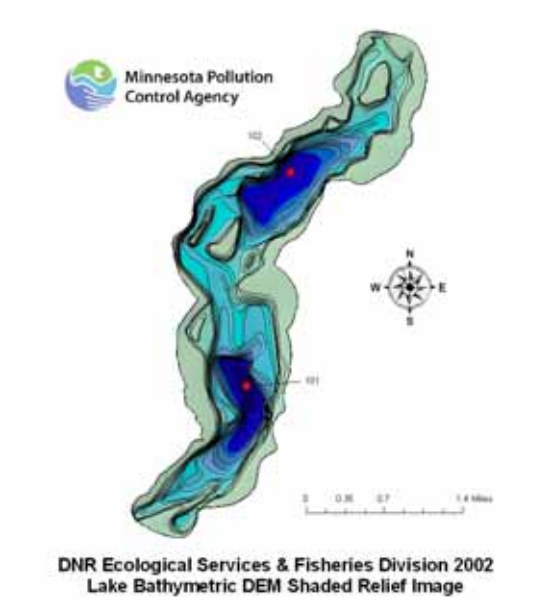

Figure 2. Lake Carlos Watershed land use

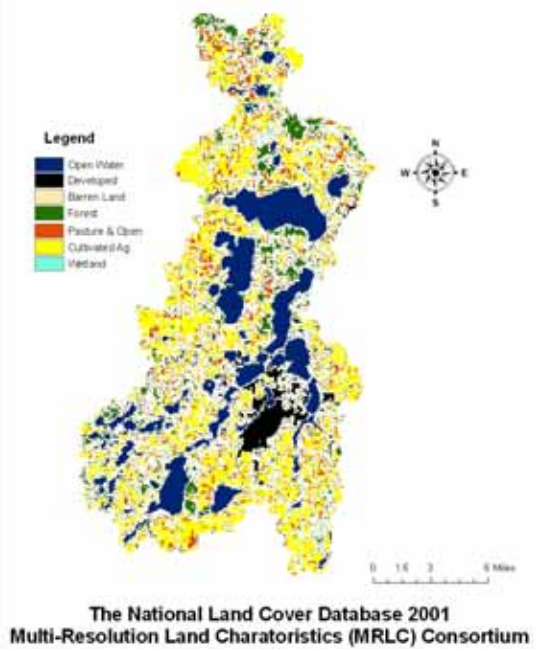

Table 1. Lake Carlos land use composition

Land use	Lake Carlos land use percentage	NCHF typical land use percentage
Developed	9	2-9
Cultivated (Ag)	30	22-50
Pasture & Open	22	11-25
Forest	16	6-25
Water & Wetland	23	14-30
Feedlots (#)	174	

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Table 2. Lake Carlos summer-mean as compared to typical range for NCHF ecoregion reference lakes MPCA data based on 1985-86 and 2008 sample collections

Parameter	Carlos 101 (S)	Carlos 102 (N)	NCHF
Number of reference lakes	-	-	43
Total Phosphorus (µg/L)	17.5	15.3	23-50
Chlorophyll mean (µg/L)	3.9	3.1	5-22
Secchi Disk (feet) (meters)	3.6	3.7	4.9-10.5 (1.5-3.2)
Total Kjeldahl Nitrogen (mg/L)		-	<0.60-1.2
Alkalinity (mg/L)	175	-	75-150
Color (Pt-Co U)	5	-	10-20
pH (SU)	7.9	7.9	8.6-8.8
Chloride (mg/L)	36	-	4-10
Total Suspended Solids (mg/L)	2.4	-	2-6
Total Suspended Inorganic Solids (mg/L)	1.8	-	1-2
Conductivity (umhos/cm)	422	421	300-400
TN:TP ratio			25:1-35:1

µg/L = micrograms per liter
mg/L = milligrams per liter
umhos/cm = micromhos per centimeter
Pt-Co-U = Platinum Cobalt Units
SU = Standard Units

Figure 3. Lake Carlos 2008 temperature and dissolved oxygen (DO) profiles and trophic status

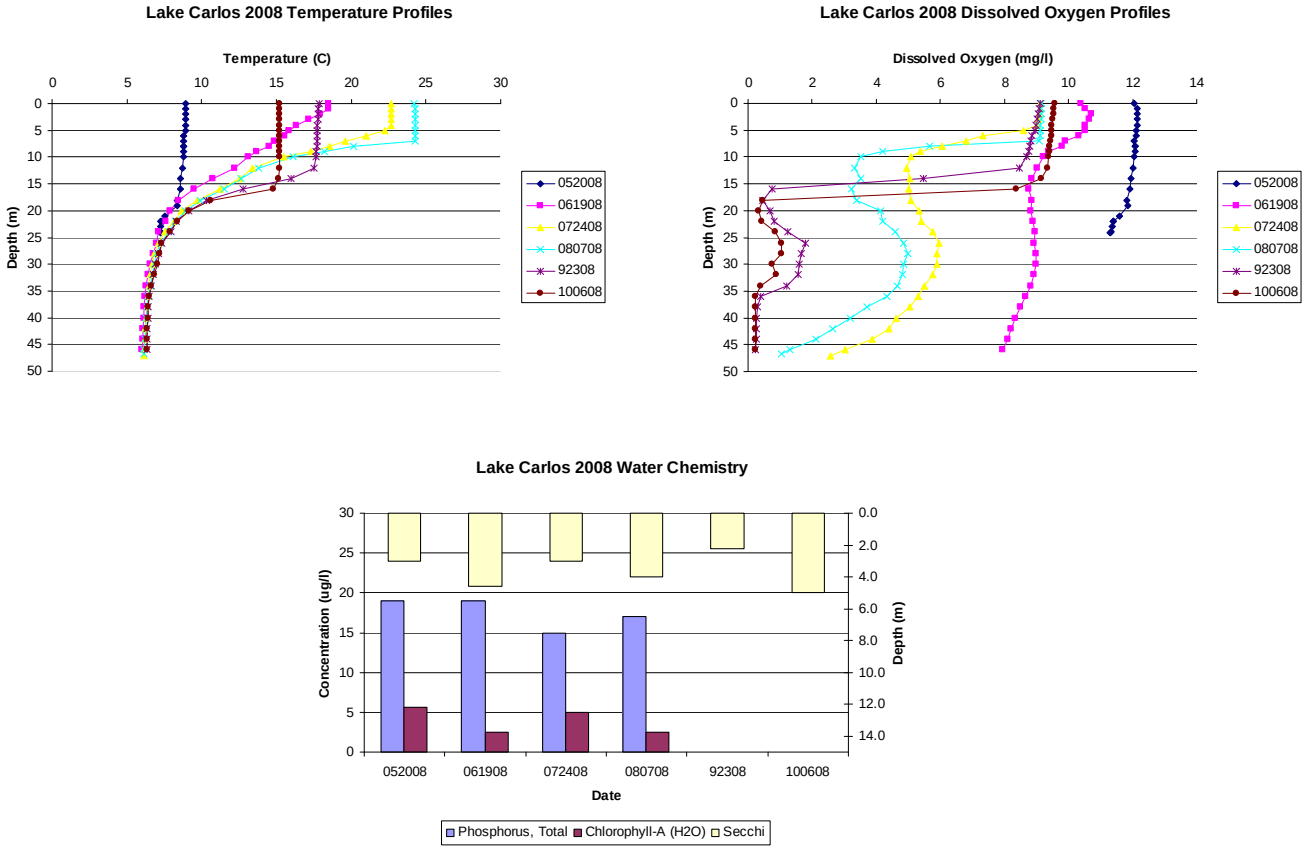
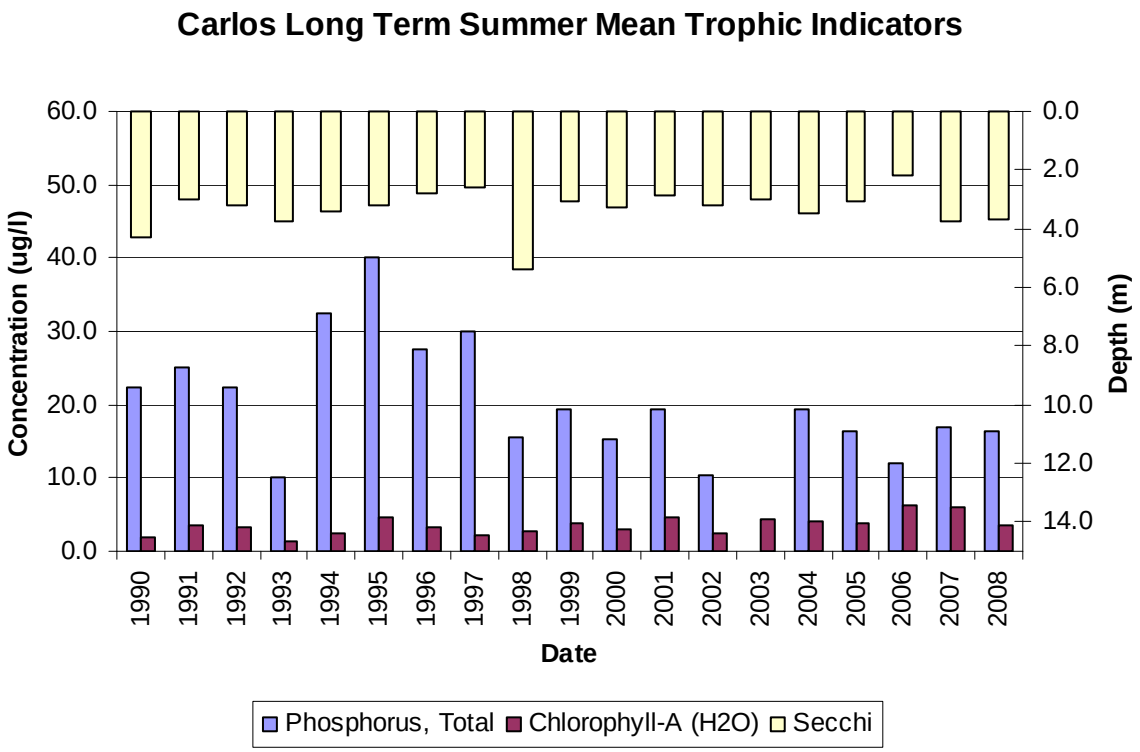


Figure 4.



Watershed, water quality, and fishery summary

Lake Carlos is a 2,520-acre basin with a maximum depth of 163 feet (Figure 1) located about five miles north of Alexandria. It is the largest and deepest lake within the Alexandria chain of lakes (Figure 2). The lake fully supports recreational uses and is popular for both angling and other water-based recreation. Boaters can access other lakes within the chain via navigable channels. Lake Carlos State Park is located along the north shore of the lake and provides camping sites, a nice swimming beach, and a boat ramp. Most of the shoreline is heavily developed with residential housing. Lake Carlos has a very large watershed (watershed: lake ratio of 62:1) that drains a typical mix of land uses (Table 1). This results in a very high water load to the lake and a potentially high nutrient load; however, its great depth and the numerous upstream lakes serve to minimize impacts from excess nutrients and help it to maintain good water quality.

Carlos was well-mixed in May and beginning to stratify by June (Figure 3). Once stratified, the thermocline was located between about 10-20 meters (m) in depth. Prior to August, DO remained at 5 mg/L, or higher, down to a depth of about 30 m; however, from August-October DO concentrations greater than 5 mg/L were limited to the upper 10-15 m. As the portion of the lake with DO > 5mg/L decreases, this can place stress on cool and coldwater fish, such as the tulibee (cisco).

In general, the water quality and clarity of Carlos are considered good (Tale 2). Secchi disk transparency averages about 3.0 meters during summer months and most water quality measurements are well within or better than the typical range for minimally impacted NCHF lakes (Table 2). Total Phosphorus (TP) peaks in May following spring turnover and declines somewhat thereafter (Figure 3). Chlorophyll-a remains relatively low throughout the summer. Carlos has extensive historic data as a result of collections by the Alexandria Area Sanitary District and previous MPCA sampling (Figure 4). Based on data since 1990, Secchi typically averages 2.5-3.5 m and no trend is evident. Since 1998, TP is rather stable at about 15-20 µg/L in most summers (Figure 4).

Table 3. Focal species captured during 2008 surveys and their size and abundance compared with other lakes in its lake class. The "biotic integrity" score for Carlos was 91.5, which is average compared with other lakes in its lake class, but presumably higher than average compared with other lakes in the Alexandria area.

Species	Stocked	Abundance	Size	Trend
Walleye	Y	Average-high	Average	Steady
Northern Pike	N	Average	Average	Steady
Yellow perch	N	Low	Large	Steady
Largemouth bass	N	High	Average	Unknown
Smallmouth bass	N	-	-	Unknown
Bluegill	N	Average	Average	Steady
Black Crappie	N	Average	Average	Steady
Rock bass	N	Low	Average	Steady
Pumpkinseed	N	Average	Average-large	Steady
White Sucker	N	High	Average-large	Steady
Cisco	N	-	-	Unknown

Table 4. Aquatic plant summary

Percent cover of aquatic plants ≤ 15ft deep	85%
Lake depth beyond which most vegetation disappeared	13.5ft
Number of common species (i.e., ≥ 10% cover)	4
Infested with non-native plants	Curly-leaf pondweed (lightly)
Frequency of Chara	62%

Narrative

Lake Carlos, despite its position in a large agricultural and urban watershed, supports a diverse and abundant game fish community, as well as several non-game species intolerant to disturbance. Cisco, a fatty cold-water forage fish are present in the lake, but the status of its population is uncertain because standard summer gillnets do not target pelagic cisco habitats. In the future, gillnet and hydroacoustic assessments will target cisco populations. Aquatic plants communities in Carlos are moderately diverse with a high abundance of Chara, an important species for juvenile and non-game fish such as yellow perch and darters. Chara is also important for maintaining high water clarity. Curly-leaf pondweed is present in the lake, but at low levels and is unlikely to increase to nuisance levels unless the productivity of the lake increases markedly.

Because of the multiple stressors that are affecting Carlos's watershed and its status as a high quality lake that supports cold, cool, and warm water species, this lake has been targeted for greater meteorological and water quality monitoring with automated sensors built and maintained by the USGS if funding is approved by LCCMR. These data will be housed in national monitoring database (National Water Inventory System) and used to adapt models to predict the future status of cold-water habitat.