Bathymetric Changes in Overholser Reservoir

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Depth data from both 1951 and 1982 were used to produce bathymetric maps of Lake Overholser. Volume estimates based on these maps were used to identify changes in the storage capacity of the reservoir. Losses due to sediment deposition amount to a 9% reduction in storage capacity during the 31 - year period. These losses were concentrated in the deeper southern and western sections of the lake. Comparison of the 1982 volume capacity with estimates produced in association with reservoir construction indicate a 19% reduction since impoundment in 1919.

INTRODUCTION

Lake Overholser, the second oldest Oklahoma reservoir in excess of 200 ha (1), was constructed in 1919 by the City of Oklahoma City. A 366-meter dam across the North Canadian River creates, at spillway level, a 688-ha impoundment in western Oklahoma and eastern Canadian counties. This shallow, turbid, urban reservoir is a part of Oklahoma City's municipal water supply; storage and recreation are listed as primary purposes for the impoundment (2).

Compared with most other reservoirs, Lake Overholser is unusual because a bypass canal on the east side of the impoundment regulates the amount and timing of river water additions to the reservoir (Fig. 1). When the river gates are closed, waters back up in the bypass canal and eventually flow across the rollover structure into the reservoir. Hence, unlike most Oklahoma reservoirs, Lake Overholser lacks a strong river current.

Concerns exist about the future of many Oklahoma reservoirs due to soil erosion and subsequent siltation producing losses in storage capacity. Lake Overholser shares this problem with most impoundments in Oklahoma (3). Storage capacity, initially estimated to be 2418 ha-m (4), is declining because of sediment deposition. As part of an EPA Clean Lakes Project to diagnose the feasibility of reservoir improvements, we made a new bathymetric map of Lake Overholser in 1982. This paper provides a comparison between our map and

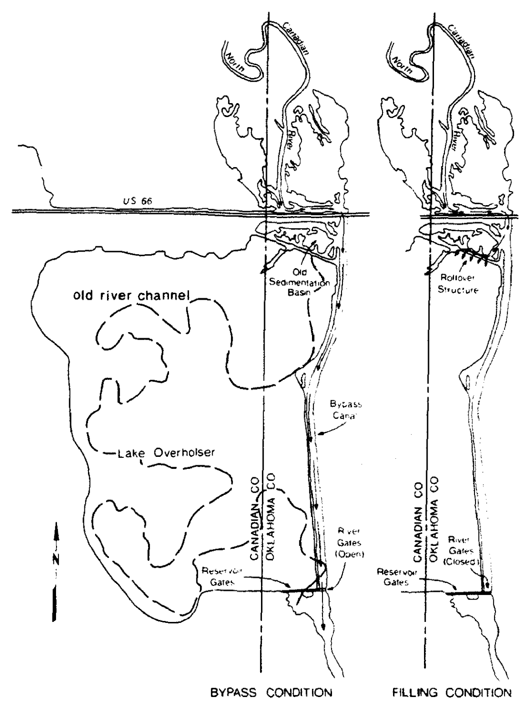

Figure 1. Overholser Reservoir reference map.

the only other source of information about the bottom configuration of the reservoir, the 1951 Hydrographic Survey Map (5). These two data sources were used to generate depth contours from which the volume of the reservoir was calculated for both years. Storage capacity differences between the two dates provide an estimate of sedimentation rate for the 31 - year period; changes in the spatial pattern of bathymetry indicate the specific geographic locations where sediment has been deposited.

DATA COLLECTION AND ANALYSIS

Depth information was collected during the summer of 1982; data from forty-four sonar transects were obtained on strip charts using a Lowrance Truline Recorder (Model No. LRG-1510B). The transects were spaced approximately 80 meters apart and oriented east-west. Depth data for specific points where a significant change in bottom topography occurred were then selected from the strip charts; locations and depths of over 1350 points were plotted on an outline map of Lake Overholser. The equipment provided depth measurements in feet; since the 1951 data were also reported in feet, the bathymetric maps were made using English units.

Preliminary bathymetric maps for Lake Overholser were generated by using SYMAP, a computer-based contour mapping routine (7). This software package produces a topographic surface through unbiased interpolation of elevation (depth) between randomly or regularly spaced data points. The SYMAP algorithim generates a line printer map of the interpolated surface using different symbols and overprint characters to indicate variations in topography. A final cartographic product depicting the bathymetry for 1982 was produced by extracting depth contours from the line printer map. A similar procedure was used to produce the bathymetric map for 1951.

Lake volume is the integrated area of strata for successive depths from the surface to the deepest point. Volume estimates for both 1951 and 1982 were determined by two standard procedures: 1) planimetry of the hypsographic or depth area curve, and 2) the frustram method (8). Both procedures require computation of the area at each contour interval; area for each stratum was measured through use of a polar planimeter. In the hypsographic curve method, areas are plotted against depth and the area of the resultant curve is measured planimetrically. The frustram method provides volume estimates (V) for each stratum through use of the equation:

$$V = (h / 3) \times (A_1 + A_2 + (A_1 \times A_2)^{1/2})$$

where h = the contour interval, A_1 = the area of the upper surface, and A_2 = the area of the lower surface. Total volume for the reservoir is determined by summation of V for the series of strata.

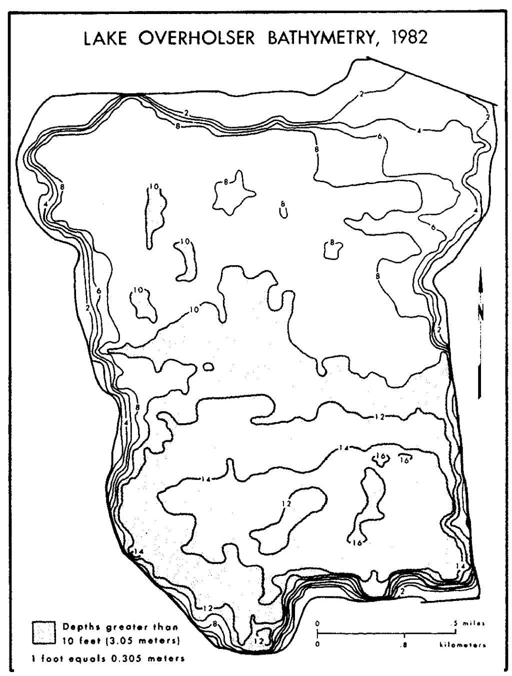

Figure 2. Lake Overholser Bathymetry, 1982.

RESULTS

The 1982 bathymetric map of Lake Overholser (Fig. 2) shows that depths are greatest in the southern end of the reservoir and along the old river channel. Maximum depths, just over 5 meters, exist along the old channel in the southern section of the lake. The northern half of the reservoir generally has depths less than three meters.

A similar geographic pattern of lake bathymetry is evident from the map produced from the 1951 survey data (Fig. 3). Shallow areas are evident in the northern half of the reservoir whereas portions of the old channel and the southern part of the lake have depths greater than three meters. A maximum depth of over 6.7 meters was found in the 1951 survey.

Estimates of volume capacity derived from analysis of the bathymetric maps using the frustram method indicate a total storage capacity of 1966 ha•m in 1982 (Table 1) whereas, 31 years earlier, the storage capacity was 2160 ha•m. Similar statistics were generated by integrating the area under the hypsographic curve (Table 1).

Sediment deposition between 1951 and 1982 in Lake Overholser has resulted in a loss of approximately 195 ha•m of storage capacity (Table 1). A substantial majority of the losses (84.6%) occurred at depths of three meters or more. In order to determine if this pattern of deep water deposition could have been predicted based on the 1951 basin shape, a chi-square analysis was performed. Expected losses

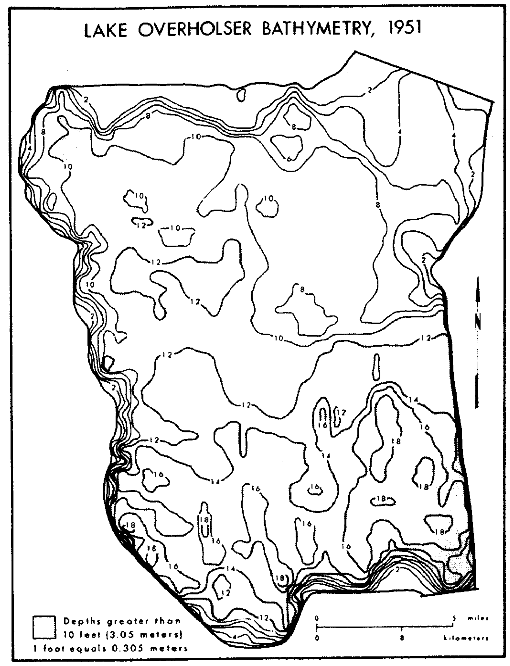

Figure 3. Lake Overholser Bathymetry, 1951.

TABLE 1. Volume capacity estimates (ha•m) by depth interval (feet) for both the frustram and hypsographic curve (in parentheses) methods. Differences between the 1951 and 1982 data indicate storage losses due to sedimentation.

Depth Interval	1951 Volume Capacity	1982 Volume Capacity	31-Year Change
0-1	205.5 (205.4)	202.3 (202.4)	3.2 (3.0)
1-2	200.3 (200.3)	195.1 (195.1)	5.2 (5.2)
2-3	195.4 (195.4)	191.4 (191.4)	4.0 (4.0)
3-4	189.4 (189.4)	185.0 (184.6)	4.4 (4.8)
4-5	183.2 (183.3)	179.2 (179.2)	4.0 (4.1)
5-6	176.4 (176.4)	174.2 (174.2)	2.2 (2.2)
6-7	170.1 (170.1)	168.7 (168.7)	1.4 (1.4)
7-8	162.6 (162.6)	161.3 (161.3)	1.3 (1.3)
8-9	146.2 (146.3)	142.0 (142.2)	4.2 (4.1)
9-10	127.2 (127.3)	107.5 (108.1)	19.7 (19.2)
10-11	109.9 (110.1)	79.6 (79.7)	30.3 (30.4)
11-12	90.8 (91.0)	65.0 (65.1)	25.8 (25.9)
12-13	71.6 (71.8)	52.6 (52.7)	19.0 (19.1)
13-14	53.7 (53.9)	38.7 (39.0)	15.0 (14.9)
14-15	36.4 (36.7)	18.4 (19.7)	18.0 (17.0)
15-16	20.5 (20.9)	4.1 (4.6)	16.4 (16.3)
16-17	12.2 (12.3)	0.5 (.7)	11.7 (11.6)
17-18	6.7 (7.0)	0 (0)	6.7 (7.0)
18-19	1.7 (1.9)	0 (0)	1.7 (1.9)
19-22	0.6 (.3)	0 (0)	0.6 (.3)
Total	2160.4 (2162.4)	1965.6 (1968.7)	194.8 (193.7)

for each depth interval were determined by subdividing the total 1951 to 1982 volume loss (195 ha•m) on the basis of the percentage of total surface area covered by each depth interval. Thus, the expected losses represent a sediment deposition process where the size of the collecting surface at any depth interval determines the amount of deposition for that interval. Results of the chi-square analysis indicate that the observed losses by depth interval were significantly different than the expected values (chi-square = 609.5, df = 19, significance = 0.0); therefore additional processes influence sediment deposition in Lake Overholser. Observed losses between 1951 and 1982 were generally less than expected in shallow areas less than three meters deep.

DISCUSSION

Geographic and statistical analyses of the losses in volume storage indicate that sedimentation has occurred primarily in the deeper southern and western sections of the impoundment; zones of greatest deposition are coincident with east-west oriented sections of the North Canadian River channel (9). A wind-and density-driven undercurrent (north-south oriented) is thought to be responsible for limiting sedimentation in the north-south sections of the old river channel (9).

Sediment deposition is occurring throughout the reservoir, but wave action is responsible for agitating and re-suspending sediment within the shallower northeastern part of the lake (10). In addition to the normal sorting that occurs when a sediment-laden stream enters a water body, wind-induced resuspension of finer-sized particles in the shallower northern portions of Lake Overholser is thought to be responsible for enhancing the spatial gradient. Qualitative analysis of geographic variations in bottom sediments indicates a pronounced north-south transition. The largest particles in the sediment load entering the impoundment (ie. fine sand or larger) remain deposited in northern sections whereas finer-sized gray muck and black ooze predominate in southern sections (9). If this pattern of depth-related sediment deposition continues, additional volume storage losses will occur primarily in the southern and western parts of the reservoir between depths of three and four meters (9).

In comparison with most reservoirs that experience sedimentation in association with a strong river current, Lake Overholser has a pattern of deposition that is markedly different. Deposition in deeper areas is resulting in a reservoir with a nearly uniform bottom depth of approximately 3 to 4 meters. Investigation of the spatial pattern of sediment deposition in Lake Carl Blackwell (11), a reservoir with direct stream inflow, indicates that deposition is primarily in the upper ends of the arms of the reservoir. Hence, habitat losses related to sedimentation are different in these two contrasting types of reservoirs.

ACKNOWLEDGMENT

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