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Environmental Sciences Division
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MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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ENVIRONMENTAL SCIENCES DIVISION

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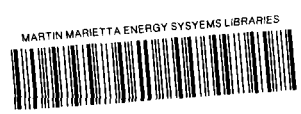

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ABSTRACT

COX, D. K., N. D. FARROW, W. C. KYKER, M. A. FAULKNER, and L. M. STUBBS. 1991. The new definitive map of White Oak Lake. ORNL/TM-11204. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 24 pp.

A map of White Oak Lake was drawn from points on the shoreline established with the use of an electronic distance-measuring theodolite and a hand-held reflecting prism. Average water depths were determined along six transects. A planimeter was used to estimate the area of each section. The volume of each section was determined by multiplying the surface area by the average depth. The total area and volume of White Oak Lake were estimated to be 6.88 ha (17.0 acres) and 43,893 m^3 (1,546,330 ft^3), respectively.

The lake's surface area has been reduced at an average rate of 0.7% per year, and its volume has been reduced at an average rate of 1.1% per year. The volume of the lake can be reliably estimated only from current depth measurements throughout the lake, not from stage heights at the dam. The lake should be remapped periodically, and an estimate of the sediment volume should be made.

1. INTRODUCTION

The evolution of White Oak Lake (WOL) is characterized by constant and sometimes rapid change in its physical and biological characteristics. Since its inception in 1943, the lake has ranged in size from a maximum of 17.9 ha (44.2 acres) to a minimum of 1.1 ha (2.8 acres). The lake was drained in 1955 and significantly lowered in 1979 to accommodate assessments relating to waterfowl usage and dam safety. For a more complete history of WOL, see Setter and Kochtitzky (1950), Loar et al. (1981), and Oakes et al. (1982).

Living processes add organic material, and heavy rains may result in rapid deposition of sediments or scouring of the lake bed. In 1979 Oakes et al. (1982) estimated a sedimentation rate of approximately 2 cm/year. Because materials continue to accumulate on the lake bed, the volume of the lake can be reliably estimated only from current depth measurements throughout the lake, not from stage heights at the dam.

The lake's area was previously estimated to be of 5.26 ha (13 acres) based on an aerial photograph taken in July 1987. This was an underestimation of the area because, at the time the photograph was taken, there was a lush growth of emergent vegetation, abundant duck weed that covered much of the lake surface, and fully leaved trees and shrubs overhanging the shore. These factors made the actual shoreline difficult to trace with a planimeter and likely produced an apparent shoreline that encompassed a smaller lake area than the actual one. Because of the uncertainty associated with the previous estimate, efforts were made to produce an updated map that includes information about water depths and volumes.

In April 1988 a new map of WOL was constructed to provide surface areas and volumes for estimating fish densities and to serve as a current benchmark against which past and future changes can be compared. The area and volume of the lake are needed for other ecological assessments as well as for hydrological, geochemical, and modeling studies that are being conducted in relation to the ORNL Remedial Action Program.

2. METHODS

A map of WOL was drawn from points on the shoreline established with the use of an electronic distance-measuring theodolite and a hand-held reflecting prism. The staff gage adjacent to the spillway on the dam read 4.96, 4.99, and 5.01, respectively, on April 7, 11, and 13, 1988, when field measurements were made. To the nearest 0.1 ft, these staff gage readings translate into a lake surface elevation of 745 ft above mean sea level.

Water depths were measured along six transects (see map, Fig. 1) by comparing the difference between the vertical height of the prism at the water surface and the vertical height of the prism when the rod rested on the surface of the sediment. The normally sharp point of the rod was fitted with a discarded washing-machine agitator to prevent significant penetration into the sediment. The rod was held steady from a boat, and the boat was kept stable by pushing forward from the stern with a pole against a taut anchor line attached to the bow. The depths were measured in early morning and late evening when the wind was light.

After the points on the shoreline and the depths along the transects were plotted and the map was drawn, the lake was divided into six main channel sections by drawing a dashed line halfway between each transect (Fig. 1). A subsection representing the small thumb-shaped cove near the dam was treated as a separate case. The area of each section was determined with the use of a planimeter. The average depth of each transect was determined by dividing the sum of the depths by the number of depth measurements plus one. This method accounts for the zero depths at the lakeshore where the water meets the bank (Platts et al. 1983). The volume of each section was determined by multiplying the surface area by the average depth (see Table 1).

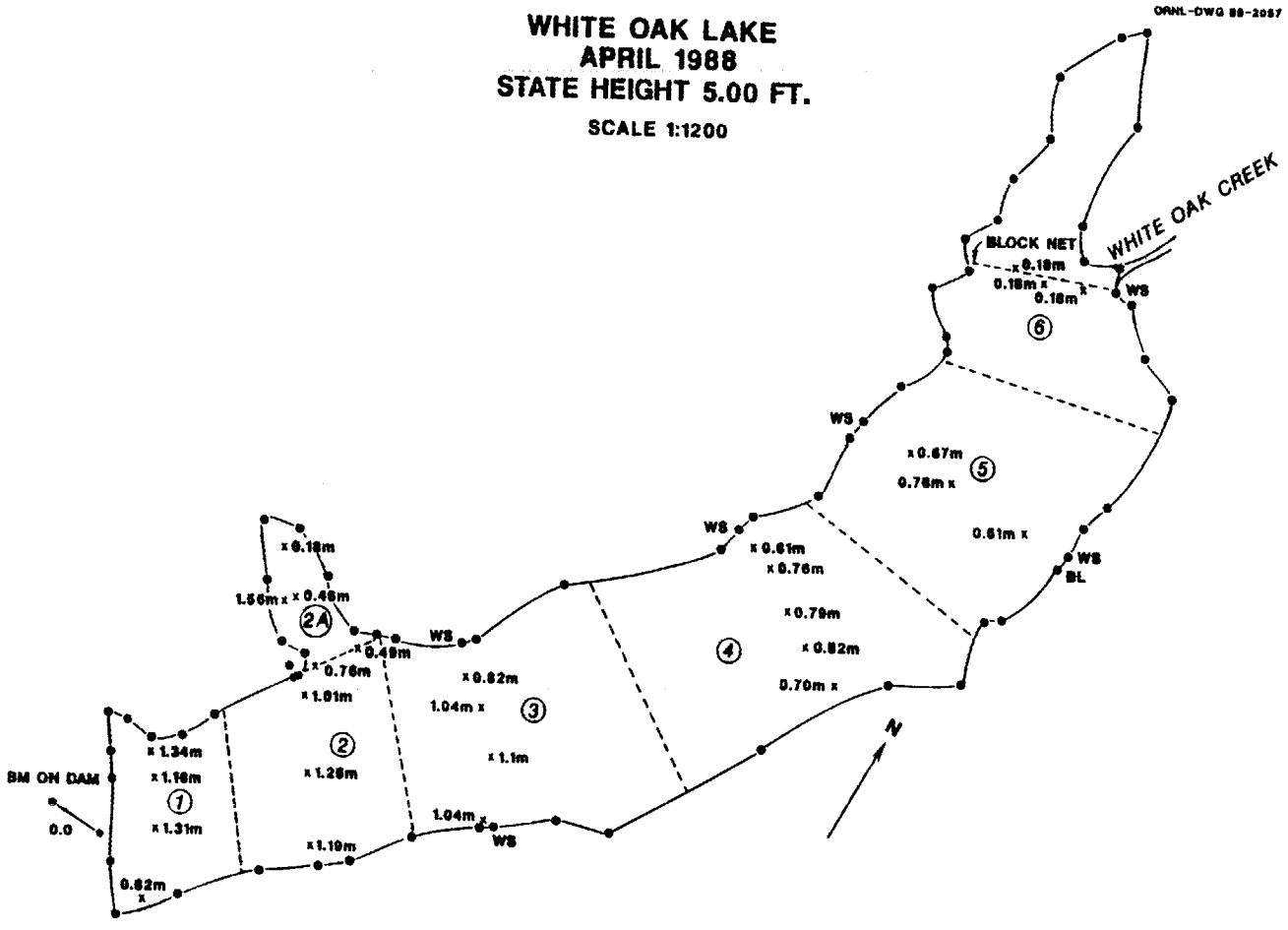

Fig. 1. White Oak Lake, April 1988 surface elevation 745 ft above mean sea level.

Table 1. Physical parameters of White Oak Lake (WOL), April 1988, elevation 745 ft (Location of sections and depth measurements are provided in map of WOL).

	Average depth		Area				Volume	
	m	ft	m^2	ft^2	ha	acre	m^3	ft^3
	0.64[a]	2.09[a]						
Sect. 1	0.93	3.04	5,366	57,743	0.53	1.33	4.991	175,539
Sect. 2	0.86	2.83	8,196	88,184	0.81	2.02	7,048	249,561
Sect. 2A	0.55	1.80	2,124	22,849	0.22	0.53	1,168	41,128
Sect. 3	0.98	3.22	13,216	142,204	1.32	3.27	12,952	457,897
Sect. 4	0.62	2.02	14,742	158,629	1.47	3.64	9,140	320,431
Sect. 5	0.51	1.67	13,704	147,460	1.37	3.39	6,989	246,258
Sect. 6	0.14	0.45	11,466	123,370	1.15	2.83	1,605	55,517
Totals			68,814	740,439	6.88	17.01	43,893	1,546,330
BN[b]	0.14	0.45	6,136	66,029	0.62	1.52	859	29,713
Survey estimate[c]	0.68[a]	2.23[a]	63,485	683,098	6.35	15.70	43,147	1,520,526

[a]Average depths calculated by dividing total volume by total area.

[b]BN = subunit of Section 6, bounded on the upper side by a block net.

[c]Parameters applicable to fish population survey conducted in May 1987.

3. RESULTS AND DISCUSSION

The new map of WOL was drawn with a smoothed line through the points established on the shoreline. The total area derived from this map was 6.88 ha (17.0 acres). These same data were entered into a HP-71B computer that utilized HP 82483A survey Package (PAC) software. The computation of area requires a defined boundary. This is accomplished simply by moving (inversing) from point to point around the perimeter, using the previous point as the back site and then closing on the original or beginning point. The area within the boundary is then calculated. This method assumes straight lines between points and was expected to yield an area slightly smaller than the hand-drawn map using smoothed lines through the points. This expectation was, in fact, the case. The survey PAC gave a total area of 16.5 acres.

An area was also calculated from a second source of data with the use of the survey PAC. These data were generated by the engineering consultants, Adams, Craft, Herz, and Walker from late 1986 to early 1987. The purpose of this survey was to place permanent reference points at 200-ft intervals around WOL and along White Oak Creek (WOC) and certain tributaries. These points were set upslope from the shoreline and would be expected to encompass a larger area. This was confirmed by a calculated value of 17.6 acres. The area determined from the hand-drawn map (17.0 acres) lies between the two survey PAC calculated values (16.5 and 17.6 acres), as expected.

A comparison of the new map with a map of the original WOL basin from Auerbach et al. (1959) shows that considerable surface area has been lost to deposition. The entire upper lake bed (see Fig. 2) has been filled in with the decaying products of organic production and alluvium transported mainly by WOC. This marshy area now extends half the distance from the back of the original lake basin to the dam. Computer graphics were used to superimpose the new 1988 map upon the Tennessee Valley Authority S-16A map (see Fig. 3). This S-16A map is the standard reference map used by the ORNL Remedial Action Program as well as ecological assessments done by others. Figure 3 shows a more

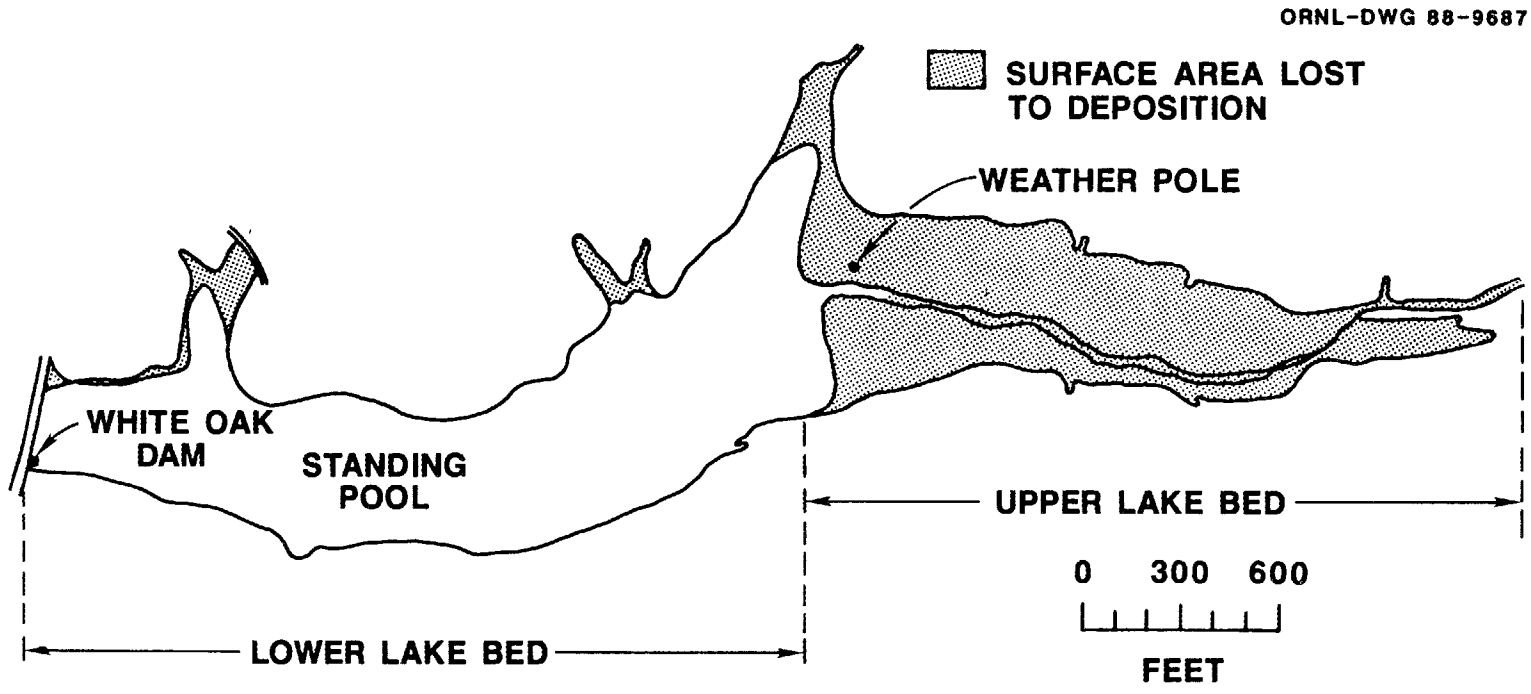

Fig. 2. Map of White Oak Lake basin at 745 ft MSL showing area lost to deposition.

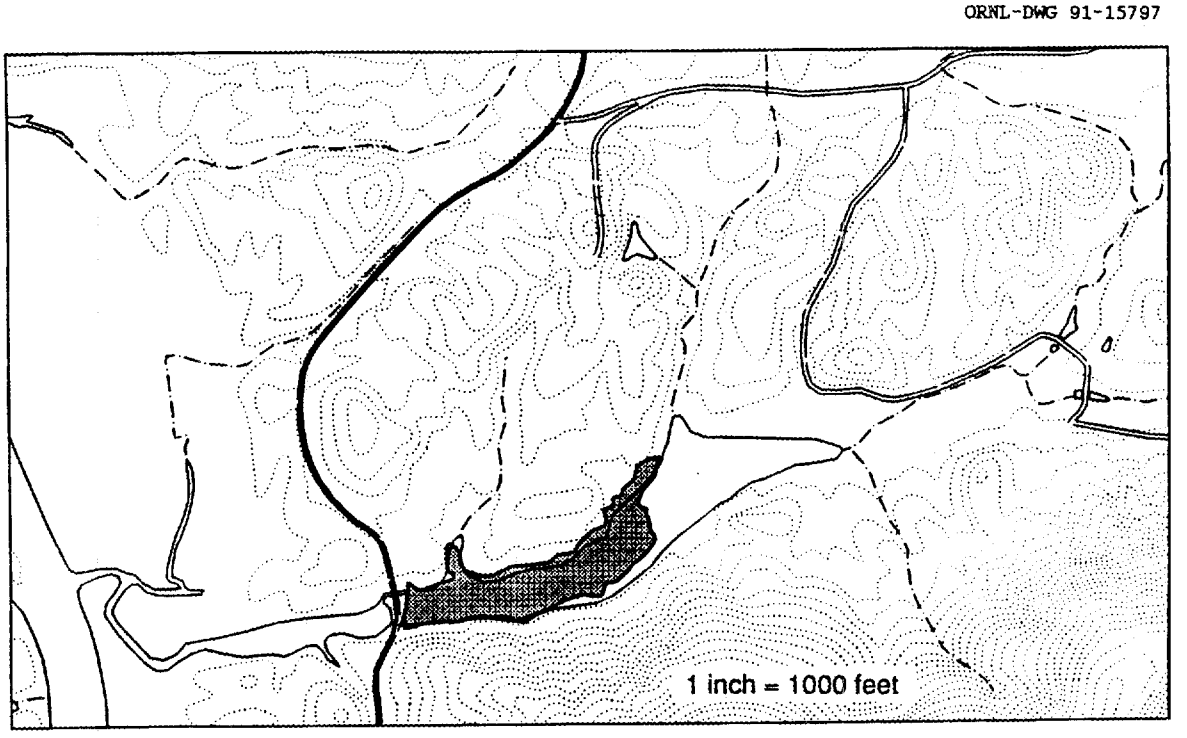

Fig. 3. The new 1988 map of White Oak Lake at 745 ft. MSL superimposed upon the Tennessee Valley Authority S-16 map.

extensive surface area lost to deposition than Figure 2, but also reflects the same general pattern of deposition in the context of a more widely used map.

An area of 24.48 acres was estimated by Oakes et al. (1982) (Table 4.1, p. 47) at the same lake surface elevation (745 ft) as that used for the 1988 map. The new map shows a surface area of 17.0 acres, indicating a 30.6% reduction in surface area over a 44-year period, or an average reduction in surface area of approximately 0.7% per year. An even greater percentage of the lake's volume has been lost over the same time period. The volume of WOL (43,893 m^3) in 1988 (Table 1) is half the original calculated volume (87,116 m^3) in 1944 (Oakes et al. 1982, Table 4.2), a 1.1% average reduction in volume per year. Should present trends in deposition rates continue, WOL could be little more than a bog area by the year 2034.

4. RECOMMENDATIONS

The lake should be remapped periodically, the frequency of remapping depending on the rate of change in the physical parameters of the lake. Major flooding and man-made perturbations, such as lake-level manipulations and construction activities, initiate rapid change. The natural processes of erosion and organic production will continue to fill the lake, steadily changing its depth and configuration. Based on its history, the lake should probably be remapped about every 3 years. If a specific need arises, the speed and accuracy of the electronic distance-measuring theodolite make it feasible to remap the lake every year.

Future remapping should include an estimate of the sediment volume. The depth of penetration of a standard rod under a standard force at intervals along several transects would provide the data necessary to estimate sediment volume. Since contaminants in WOL reside primarily in the sediments, one potential remedial action is to dredge the lake and dispose of the sediments in a manner that significantly reduces contaminant mobility and the potential for direct exposure. It is necessary to know the volume of these sediments in order to assess the feasibility of removal.

5. ACKNOWLEDGEMENT

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