Rep. No. 62

ORNL-562

[redacted]

WASTE DISPOSAL

MASTER COPY

CLASSIFICATION CANCELLED
(DOE Review Order)
DATE JUN 29 1979

[redacted]
DECLASSIFICATION OFFICER
OAK RIDGE NATIONAL LABORATORY
AUTHORITY DELEGATED BY ERDA 6-15-77

THIS DOCUMENT HAS PREVIOUSLY DECLASSIFIED AND IS EXEMPT FROM DOE 1979 REVIEW ORDER PER DOE LETTER, 10-15-79, R.T. DUFF, OOC

R. S. BAKER, ORNL/CO 7/21/80
INITIALS DATE

STUDIES OF THE WHITE OAK CREEK DRAINAGE SYSTEM

I. DRAINAGE AREA OF THE CREEK AND CAPACITY OF WHITE OAK LAKE

DECLASSIFIED

For Latest Instructions See
E. J. Murphy, 11-1-96
M. Vickery
For M. T. Bray, Supervisor
Laboratory Records Dept.
ORNL

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS DIVISION
UNION CARBIDE AND CARBON CORPORATION
UCC
POST OFFICE BOX P
OAK RIDGE, TENNESSEE

This document has been approved for release to the public by:

David Hamm 8/2/96
Technical Information Officer, ORNL Site — Date

ORNL 562
This document consists of 16 pages. Copy 50 of 142, Series A.

Contract No. W-7405, eng 26

HEALTH PHYSICS DIVISION

STUDIES OF THE WHITE OAK CREEK DRAINAGE SYSTEM

I. DRAINAGE AREA OF THE CREEK AND CAPACITY OF WHITE OAK LAKE

L. R. Setter
O. W. Kochtitzky

Date Issued: JAN 30 1950

OAK RIDGE NATIONAL LABORATORY
operated by
CARBIDE AND CARBON CHEMICALS DIVISION
Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

STUDIES OF THE WHITE OAK CREEK DRAINAGE SYSTEM

I. DRAINAGE AREA OF THE CREEK AND CAPACITY OF WHITE OAK LAKE

L. R. Setter[1] and O. W. Kochtitzky[2]

Description

White Oak Creek (Figure 1), a tributary of the Clinch River at mile Cl. 20.8, receives partially treated liquid wastes of ORNL (both industrial and domestic) from various outfalls located between 2.34 and 3.0 miles above its mouth. Until September, 1944 when they were washed out during a storm there were two earthen dikes (mile 2.27 and 2.0) which caused the creek to overflow and pond in two marshy areas. Since that time the creek flows unimpeded into the small impoundment known as White Oak Lake which was created in the fall of 1943 by damming the creek at mile 0.6.

At the site of the present dam the TVA had in 1941 placed a 16' x 12' concrete culvert and an earth fill for a highway crossing of the creek.[3] Closure of the opening to impound a lake for retention and dilution of the wastes was accomplished in the fall of 1943 by placing interlocking steel piling on the upstream side of the culvert. The overflow elevation of the piling was set at 750.0 ft. (mean sea level datum).

---

(1) Principal Chemist, Environmental Health Center, U.S.P.H.S. (formerly Senior Sanitary Engineer, TVA, on loan to ORNL.)

(2) Public Health Engineer, TVA, on loan to ORNL.

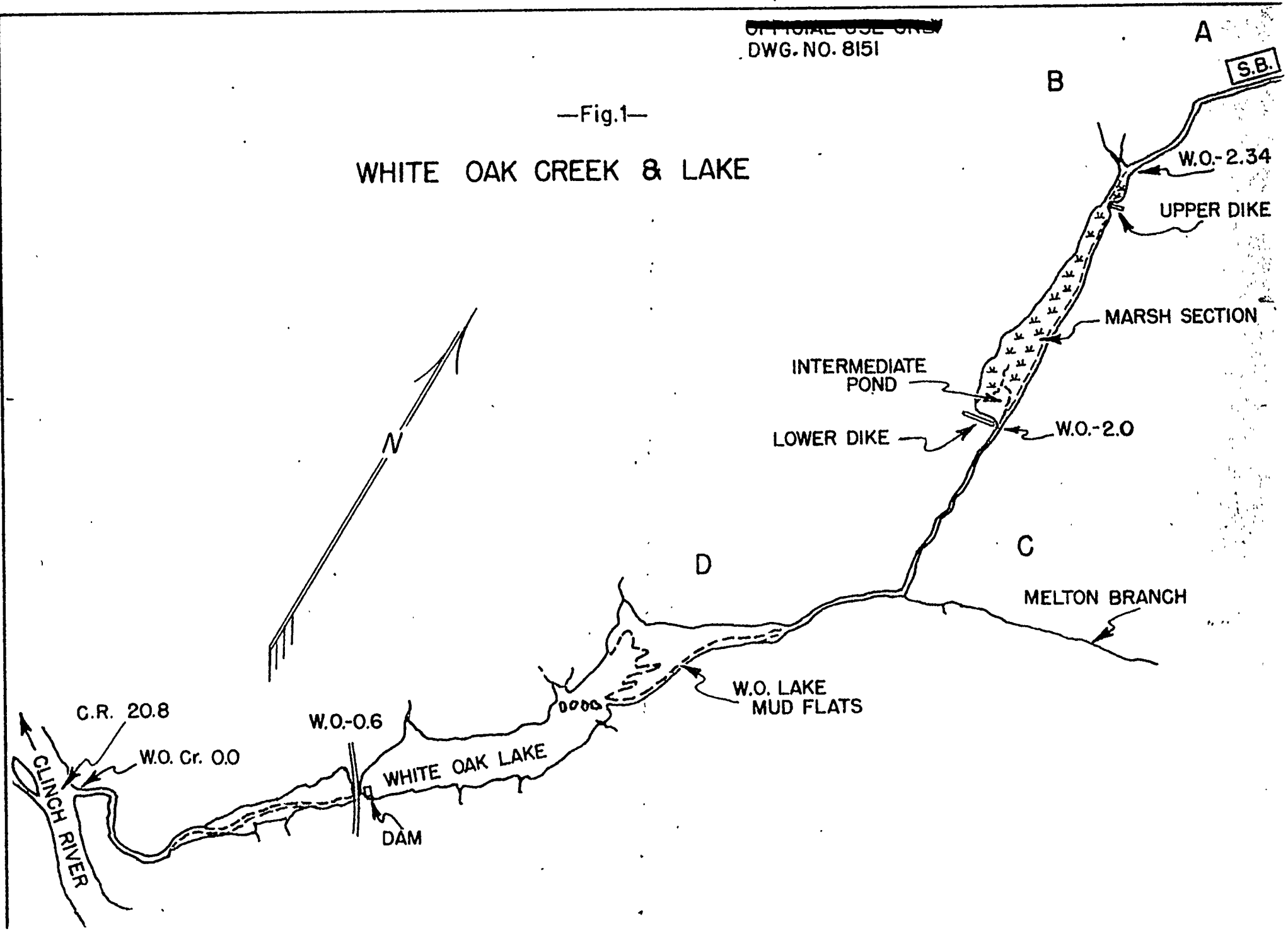
(3) Most of the information about initial construction and operation of the dam is from Report CL-455 dated February 24, 1945 by Marvin S. Smith, Chief of Project Division, Clinton Laboratories.

OFFICIAL USE ONLY

DWG. NO. 8151

—Fig.1—

WHITE OAK CREEK & LAKE



In this cofferdam a sluice gate 4' x 4' with invert at elevation 734.07 and a control gate 4' wide and 6' high with invert at elevation 744.0 were provided. Normal discharges are controlled by the upper gate. When flow is such as to exceed the capacity of that gate the lake level may rise and the cofferdam of piling acts as an overflow section. On September 29, 1944 the lake rose to elevation 753.63, the highest elevation that has been experienced. This elevation resulted in a 3.63 foot head over the cofferdam. The dam, improvised from a highway fill, satisfactorily withstood this flood which was only one foot below the roadway elevation.

Discharge schedules for the dam are established by the Area Monitoring Group of the Health Physics Division, ORNL. Since June, 1948 the lake level has been as low as elevation 745.3 to facilitate mud sampling and as high as 751 and over, during flood stage. Normal operation might be considered as between elevations 747 and 749. Pictures of the earth dam, cofferdam, screen, discharge gate, and appurtenances are given in Figures 2 and 3.

Below White Oak Dam the creek constitutes an embayment of Watts Bar Reservoir which enters the Clinch River arm of that reservoir at mile Cl. 20.8. At full pool level (elevation 741) backwater from Watts Bar Dam at mile Te. 529.9 extends up the Clinch River to mile Cl. 28.5 and up White Oak Creek to White Oak Dam. However, at this elevation about half the White Oak embayment is less than 6 ft. deep and the remainder, the lower end where it is very narrow, is less than 11 ft. deep. From mile Cl. 23.5 upstream the depth decreases from 11 ft. to 6 ft. With drawdown of Watts Bar Reservoir, which may go as low as elevation 735, these depths would

OFFICIAL USE ONLY
PHOTO 872

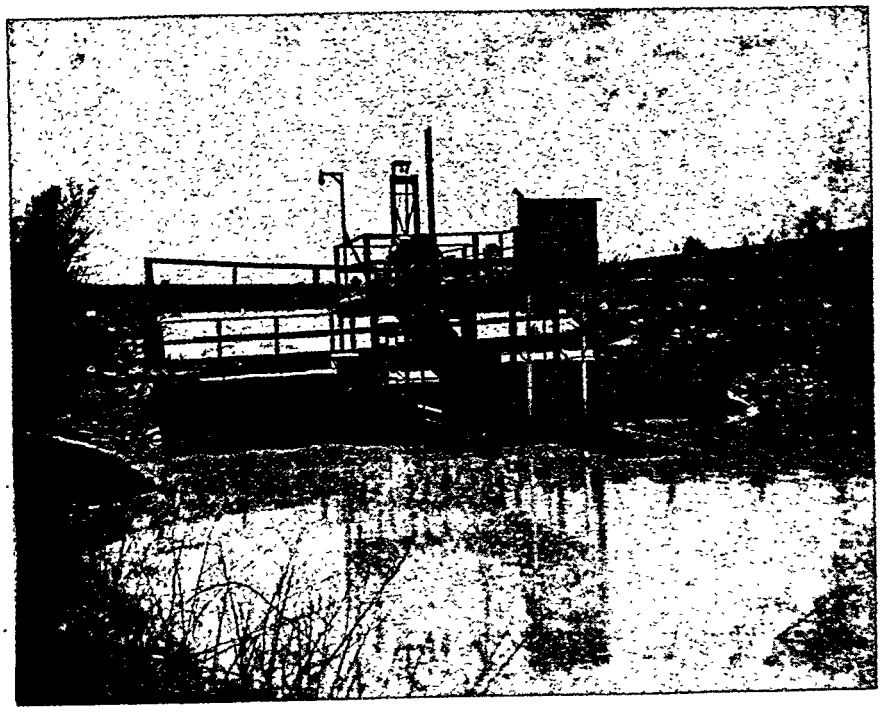


Figure 2

White Oak Dam
Looking downstream from lake and showing highway fill, cofferdam, upper gate, and screen.

[redacted]
PHOTO 871

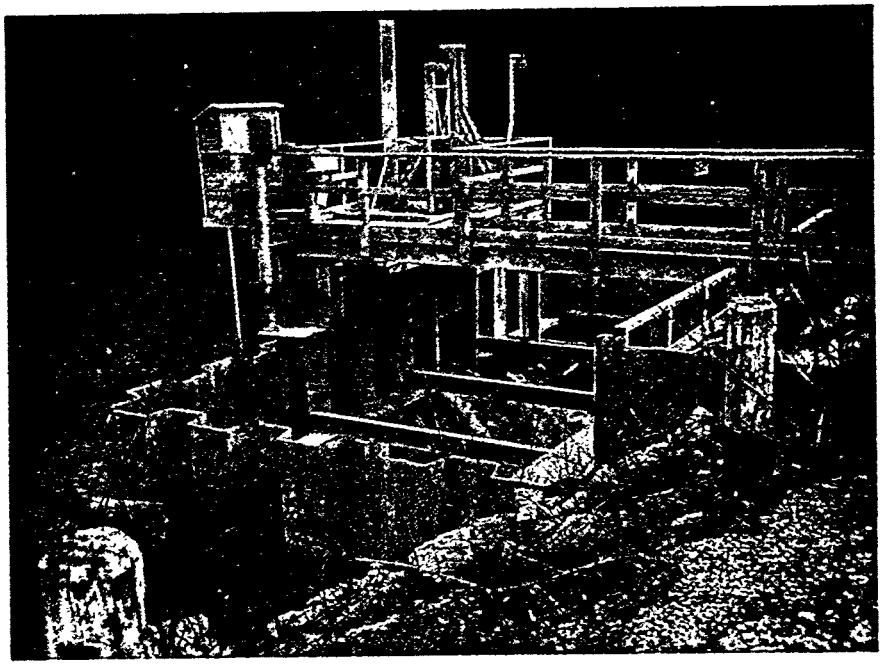


Figure 3

White Oak Dam
Taken from roadway along crest of dam and showing interlocking steel piling and discharge through upper gate.

be correspondingly reduced. Thus, it may be seen that both the creek and the river at the mouth of the creek may more nearly resemble surface streams than impoundages, particularly when the influence of stream flow regulation at Norris Dam is considered.

The principal tributaries to the Clinch River between White Oak Creek at mile Cl. 20.8 and its confluence with the Tennessee River at Te. 567.7 are Poplar Creek at Cl. 12.0 and the Emory River at Cl. 4.4.

Domestic water supplies having their source between Oak Ridge National Laboratory and Chattanooga are K-25 Plant at mile Cl. 13.3, Harriman on the Emory River at mile Em. 12.8, Watts Bar Dam at mile Te. 529.9 and Chattanooga at mile Te. ~~464.2~~ 465.3. Harriman is included in this list of water supplies which might be affected by ORNL discharge since the TVA has found that due to density currents the cold water of the Clinch River often flows upstream along the bottom of the Emory River for a distance of 14 miles. Although the city has a new intake near the head of backwater it may sometimes, because of low flow in the Emory, be forced to draw from water stored in Watts Bar Reservoir.

Drainage Area

Topographic sheet 130 NE (Bethel Valley Quadrangle, U.S.G.S., contour interval 20 ft.) was used to determine the surface drainage area above White Oak Dam. For ease of planimetering, the area was divided into four letter sections as indicated on Figure 1 and the areas were measured as follows:

Section A (E. fork of White Oak Cr.)	1424.4 Acres
Section B (W. fork of White Oak Cr.)	688.4 Acres
Section C (Melton Branch)	946.0 Acres
Section D(remainder below E. and W. forks)	832.0 Acres
Total	3890.8 Acres
or	6.07 sq. mi.

White Oak drainage area is bounded on the south by Copper Ridge, its highest peak being elevation 1356, and on the north by Chestnut Ridge, with a corresponding peak elevation of 1160. The distance from the dam to the most remote point on the drainage area is 4.5 miles; however, the meandering of the creek gives it a length of five miles or more. On the drainage area there is no cultivated land, and the cover by vegetation is virtually complete, ranging from grasses in the plant area to brush and trees on the ridges. Runoff from the drainage area would vary widely ranging from 100% for building roofs and paved areas down to possibly less than 20% but depending greatly upon the intensity and duration of rainfall.

Reference to hydrological records[4] indicates that small drainage areas of approximately the size of this one may experience flood runoff in excess of 2000 cfs per square mile. Thus, runoff of 12,000 cfs may occur in White Oak Creek. A sustained flow of 12,000 cfs would equal 43.2 million cubic feet per hour. (One inch runoff from the drainage area equals 14.1 million cubic feet).

---

(4) "Engineering Data," TVA Technical Monograph #55, p. 2-7.

White Oak Lake Volume

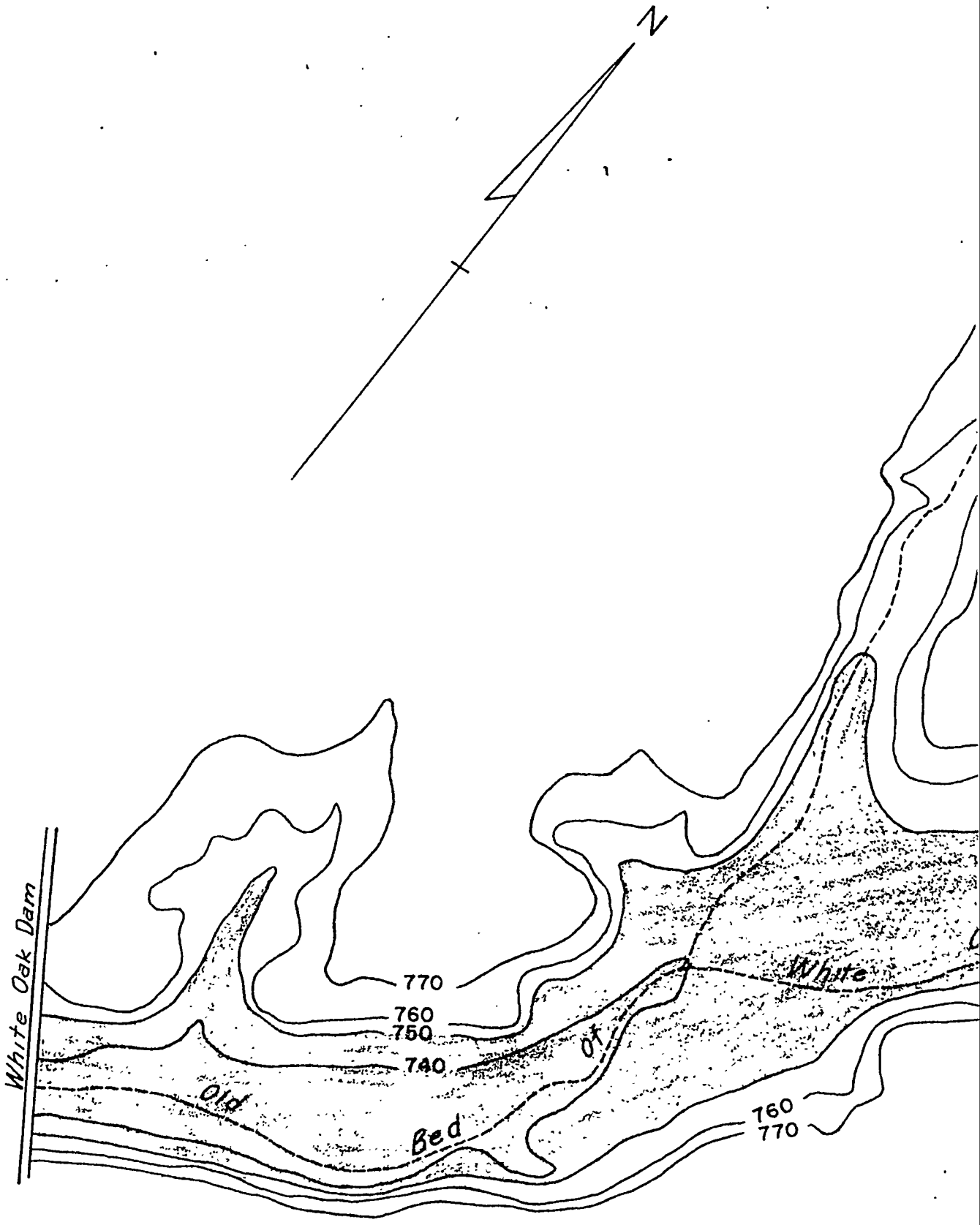
Estimates were made of the volume of the lake at certain elevations in order to calculate detention periods for wastes and waters flowing into it and to determine ultimate capacity should the dam ever be raised to provide higher pool levels.

A contour map, Figure 4, was prepared by enlargement from the U.S.G.S. Bethel Valley Quadrangle. Observations made during an extensive mud sampling program in 1948 were used for locating the 750 ft. contour (20 ft. contour interval only on the quadrangle). Drawing No. E 3410, ORNL Project C 393 MP was used for obtaining the 770 ft. contour in the upper section of the area. In the lower section the 770 ft. contour was sketched in as the mid-point between the 760 and 780 ft. contours.

The area below each contour was determined by Setter on the quadrangle sheet and by C. P. Straub on the enlarged map. The volumes calculated by using the areas from the two procedures checked very closely and are shown on Figure 5. Volumes at various elevations taken from this curve indicate the following approximate capacities:

Elevation	Volume Million Cubic Feet
750	15
760	48
765	78

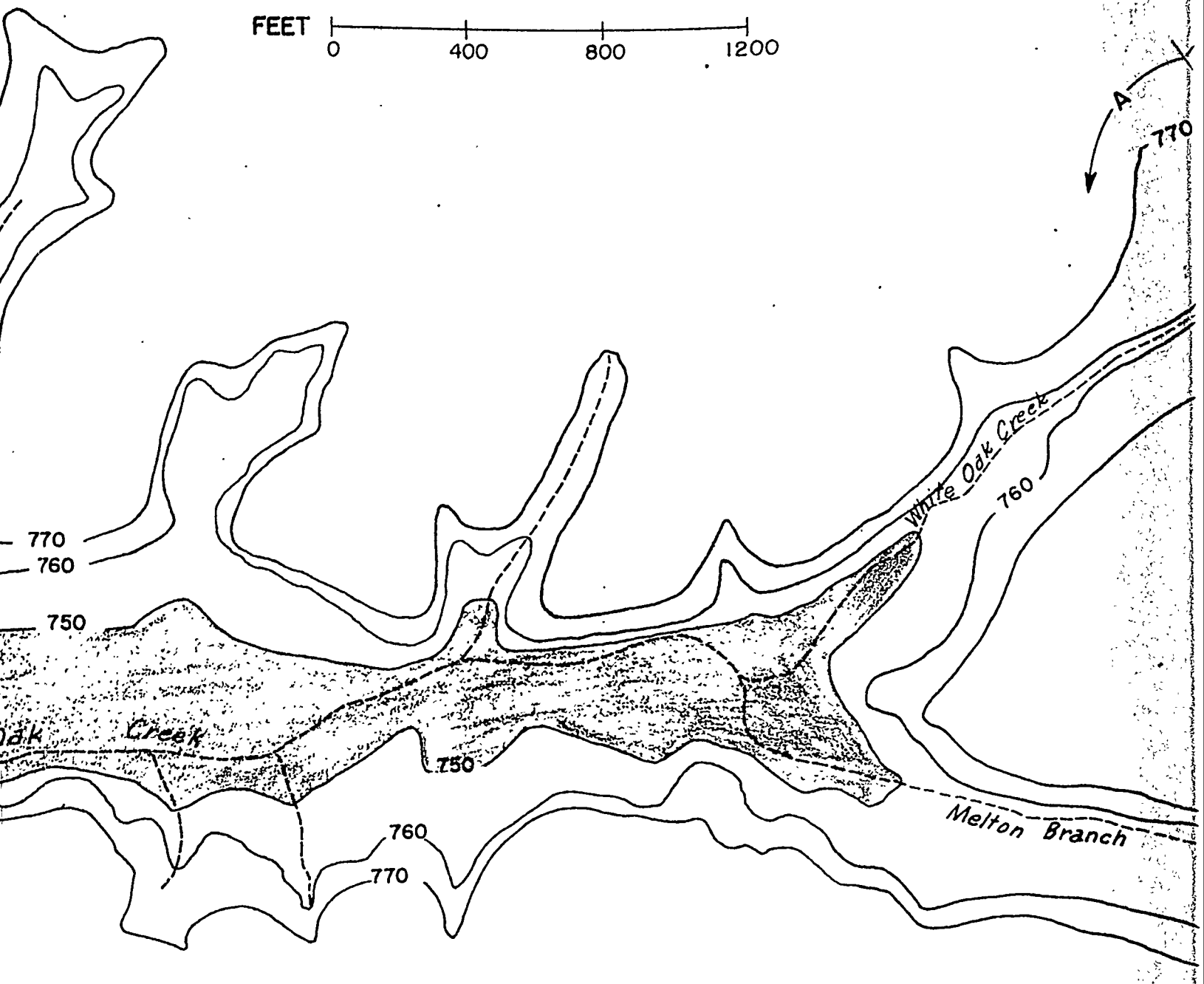
At elevation 765 the volume would be 5.2 times the present volume at elevation 750 and backwater would extend up the creek almost to the location of the upper dike; that is, to a point 0.1 mile below the confluence of


N
White Oak Dam
770
760
750
740
Old
Bed
760
770

LEGEND :

A_ ESTIMATE BASED ON USGS TOPO SHEET 130 NE (TENN.)
CONTOURS 760' & 780'

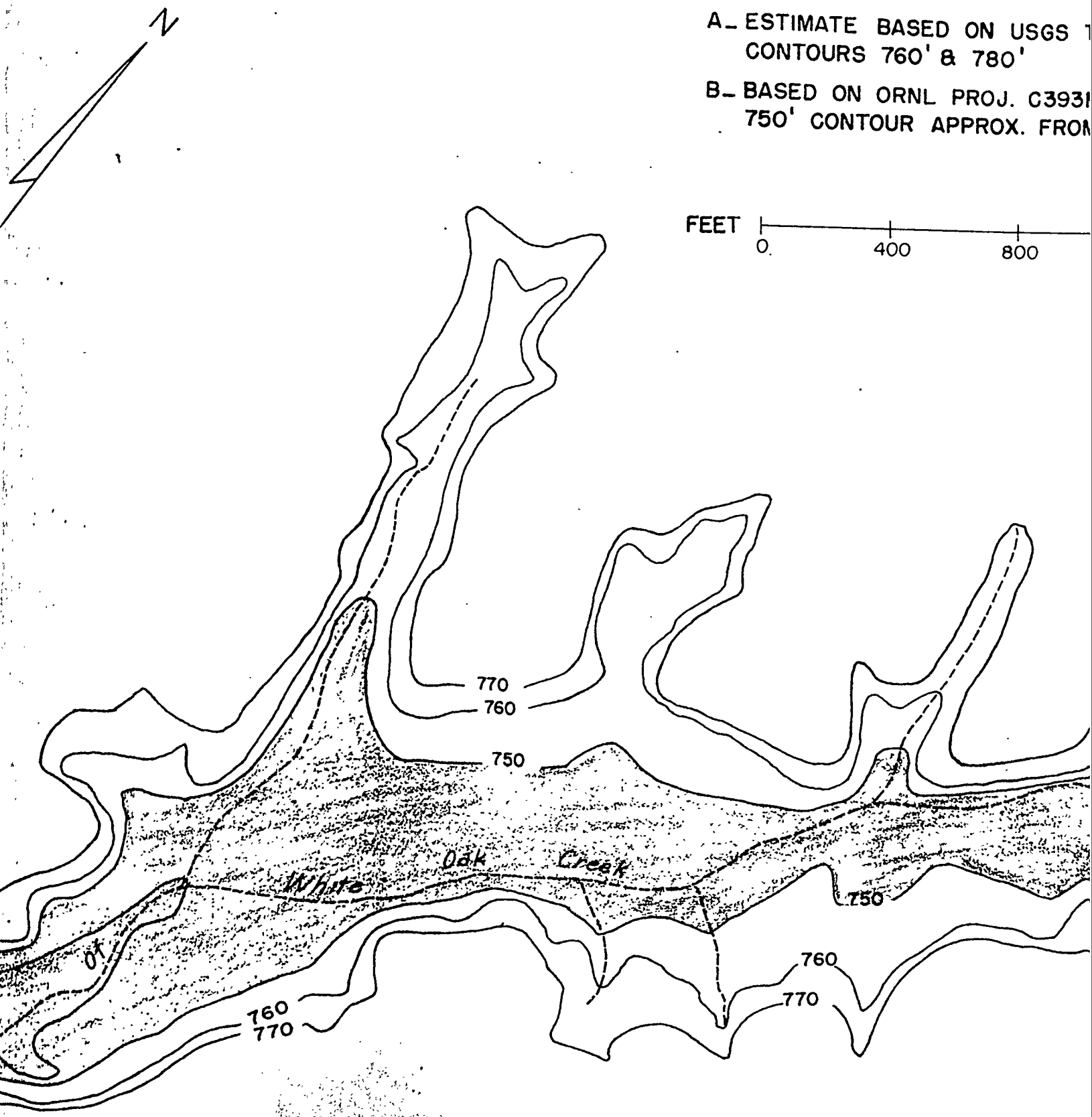
B_ BASED ON ORNL PROJ. C393MP DWG NO. E3410.
750' CONTOUR APPROX. FROM GROWTHS ALONG SHORELINE.



LEGEND :

A_ ESTIMATE BASED ON USGS T
CONTOURS 760' & 780'

B_ BASED ON ORNL PROJ. C393I
750' CONTOUR APPROX. FROM

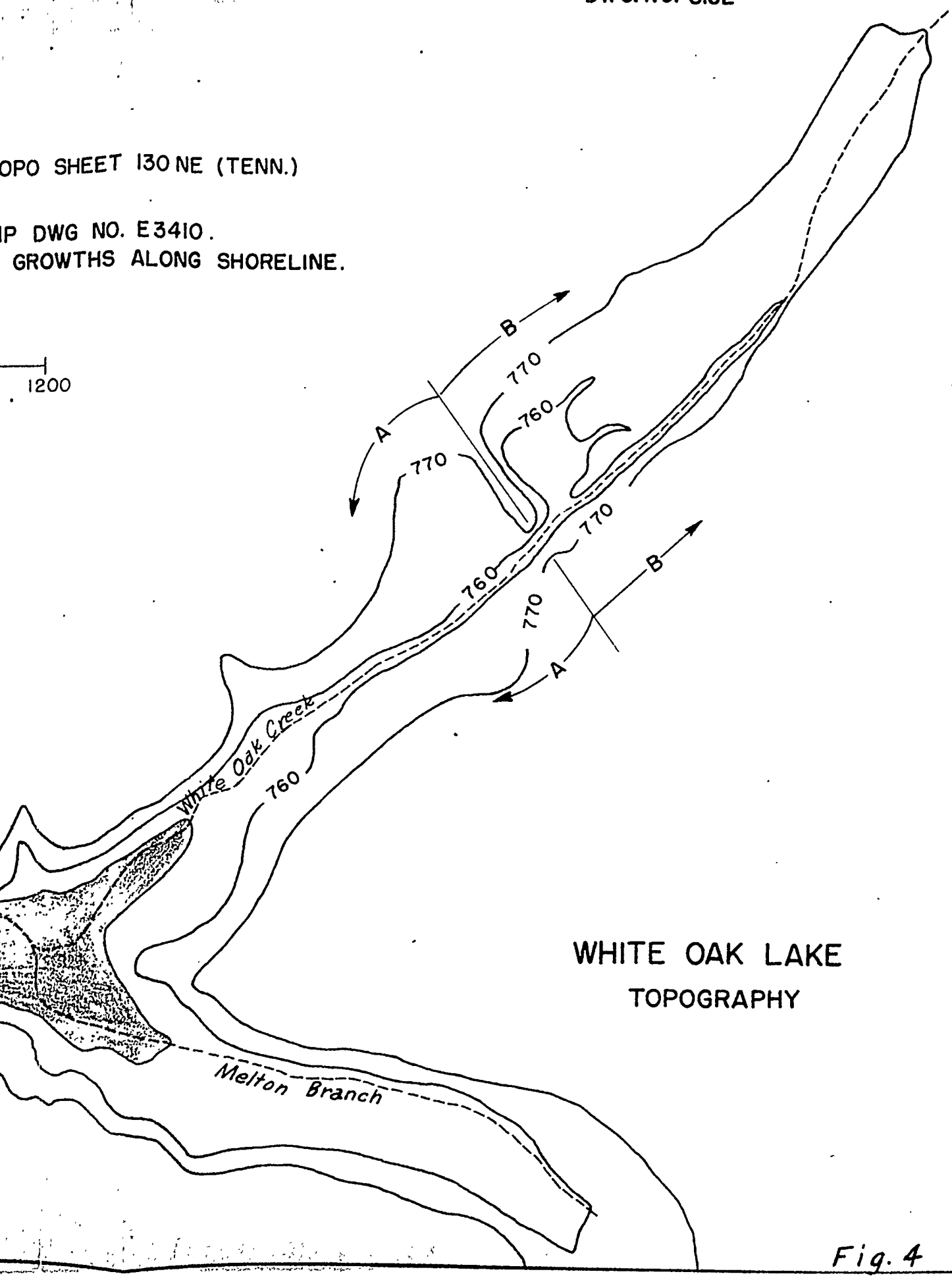


[redacted]
DWG. NO. 8152

OPO SHEET 130 NE (TENN.)

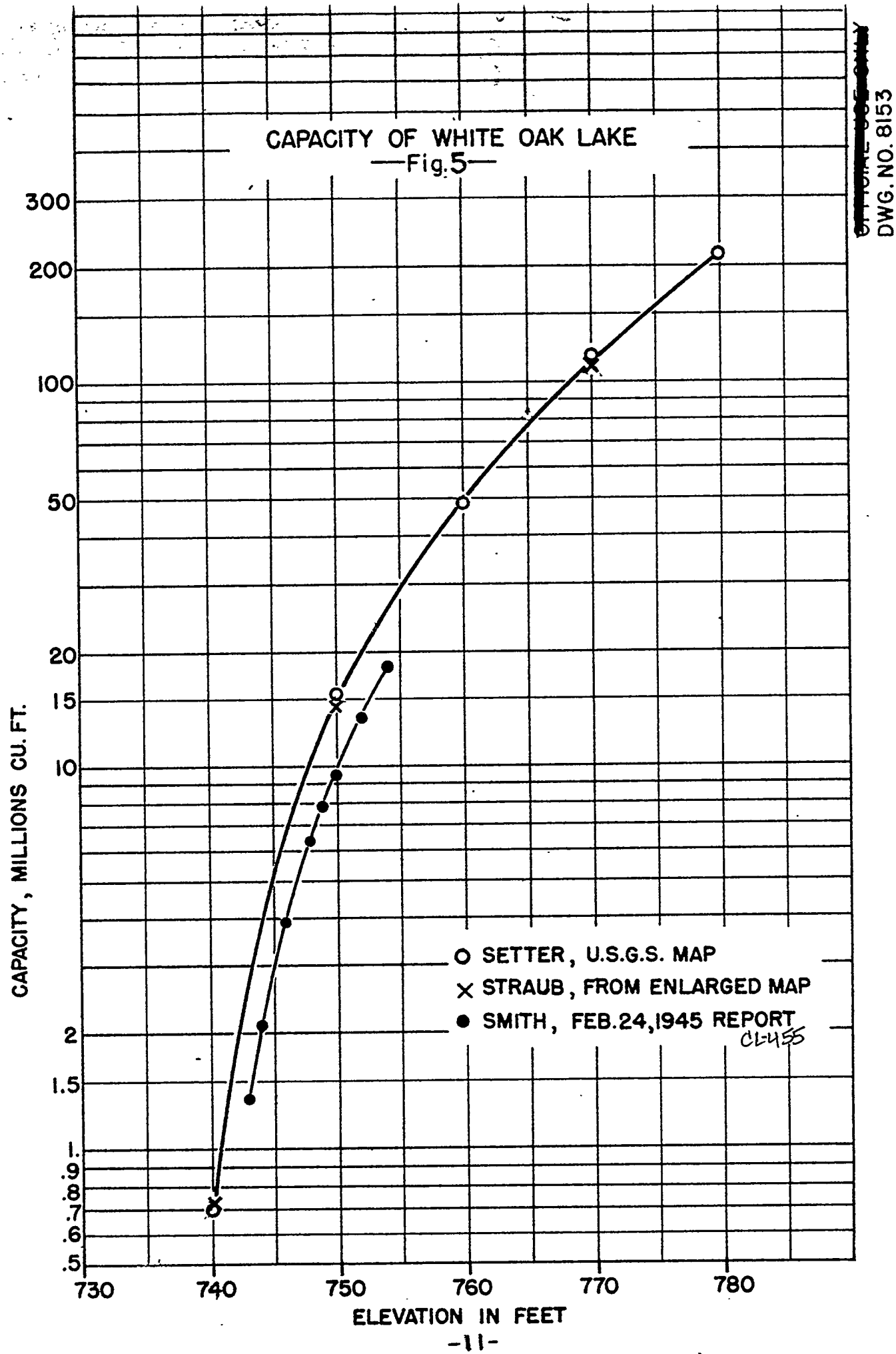
IP DWG NO. E3410.
GROWTHS ALONG SHORELINE.

1200



WHITE OAK LAKE
TOPOGRAPHY

Fig. 4


CAPACITY OF WHITE OAK LAKE
—Fig. 5—
DWG. NO. 8153
CAPACITY, MILLIONS CU. FT.
300
200
100
50
20
15
10
2
1.5
1.
.9
.8
.7
.6
.5
730
740
750
760
770
780
ELEVATION IN FEET
O SETTER, U.S.G.S. MAP
× STRAUB, FROM ENLARGED MAP
● SMITH, FEB. 24, 1945 REPORT
CL-455

the East and West Forks of White Oak Creek.

The capacity of White Oak Lake at various operating levels experienced during 1948, as determined from Figure 5, are given below:

Pool Elevation	Equivalent Gate Setting	Capacity Millions Cubic Feet
744	6.13	4.3
745	5.13	5.5
746	4.13	7.0
747	3.13	8.8
748	2.13	10.8
749	1.13	12.8
750	0.13	15.0
751	-	17.2
752	-	20.0
753	-	22.0

The capacities below elevation 750 are somewhat greater than those calculated by Marvin Smith[3] which are also plotted on Figure 5. If Mr. Smith had more extensive topography or cross-sections for use in his calculations than were available to the Waste Disposal Research Section, his values may be more accurate. With the information available in Waste Disposal Research files and a measurement of depth made by Area Monitoring on September 23, 1949, volumes were computed from the enlarged map by O. W. Kochtitzky and were found to check very closely the values of Setter and Straub.

Discussion

The average flow from Norris Reservoir drainage area for the 9 years between 1936 and 1944 was 1.23 cfs per square mile.[5] This

---

[5] "Engineering Data," TVA Technical Monograph No. 55, p. 23 - 9 and 10.

figure applied to the White Oak Creek drainage area above the dam would give an anticipated average flow of 7.5 cfs.

Runoff equivalent to one inch on the drainage basin will produce 14.1 million cubic feet of water. Unusual flood flows may, for short periods of time, discharge at rates as high as 40 million cubic feet of water per hour.(6)

At flows of 7.5 cfs the storage capacity in the lake would equal 13.6 days at elevation 747 or 23.1 days at elevation 750. Dry weather flows of 1 to 3 cfs might have theoretical detention of almost three months in the lake but actually periodic rains produce flash runoff which can flush out the lake in a few hours.

Rapid purging of the lake following intense localized rainfall may result in "slugs" of radioactivity entering the Clinch River while the flow in it is very low. There are three possible ways to alleviate such a situation.

1. Reducing the quantity of liquid wastes to the drainage system to the extent that the radioactivity in the system would never be sufficient to cause the concentration in the river to exceed tolerance even if the entire lake volume were displaced. The evaporator, which was completed and put into operation during the summer of 1949, has reduced the concentration of wastes materially and additional waste

(6) "Engineering Data," TVA Technical Monograph No. 55, p. 2-7.

treatment may be effective in further limiting the amounts of radioactivity contained in the water of White Oak Lake. Sudden purging of the lake by storm flows will continue to stir up from the bottom and carry over the dam radioactive sediment which otherwise would remain undisturbed on the bottom.

2. Providing adequate flow in the Clinch River at all times for satisfactory dilution. It would be impractical if not impossible to maintain such a flow at all times since the primary river regulation is for the TVA integrated programs of navigation, flood control, and power production. A controlled release from Norris Dam might not reach the mouth of White Oak Creek until after the slug for which dilution might be needed had already reached the river.

3. Providing adequate storage capacity for impounding wastes during accidental spills and runoff from flash floods. In this report it has been attempted to estimate the increase in storage capacity that would be provided in White Oak Lake in the event the height of the dam were to be increased. At elevation 760 the capacity would correspond to 2-1/3 inches more runoff than at elevation 750. Elevation 765 would provide capacity for almost 4-1/2 inches more runoff than elevation 750. The storm of September 29, 1944 with ~~5.15~~ 7.75 inches of rainfall produced 3.5 inches of runoff in 26 hours.

Summary

The White Oak Creek Drainage System is described as the last step in treatment and control of radioactive wastes from the Oak Ridge National Laboratory before discharge into the Clinch River and Watts Bar Reservoir. Wastes, diluted with runoff from six square miles of drainage area, are impounded in a lake having a capacity (at the top of the cofferdam) of about fifteen million cubic feet.

While the pool level is ordinarily maintained at such an elevation as to leave approximately half of the capacity available for storing accidental spills or flash runoff, experience (September 29, 1944) has shown that intense rainfall may in 26 hours produce sufficient runoff to finish filling the lake and then displace the entire volume almost three times.

Waste discharges to White Oak Creek and the amount of radioactivity contained in the water of the lake may be reduced or controlled by waste treatment or storage with regulated release. An increase in the storage capacity of the lake would serve to minimize the flushing out of material already present in the lake in the form of sediment. The amount of increase possible would depend on engineering studies of the feasibility and cost of structures necessary to provide it.

Acknowledgement

Most of the work of assembling data, making calculations, and preparing this report was done by L. R. Setter, Senior Sanitary Engineer, Tennessee Valley Authority, on loan to Oak Ridge National Laboratory and now with Environmental Health Center, U. S. Public Health Service.

Acknowledgment was given in the report to Marvin Smith, formerly of Clinton Laboratories, and Conrad P. Straub, Sanitary Engineer, U. S. Public Health Service, on loan to Oak Ridge National Laboratory, for calculations of the lake capacity.

Editing and slight revisions resulting from more recent information were made by O. W. Kochtitzky, Public Health Engineer, Tennessee Valley Authority, on loan to Oak Ridge National Laboratory.

C. File

ORNL 562
SUPPLEMENT

This document consists of 2 pages.
Copy 50 of 160. Series A

ERRATUM

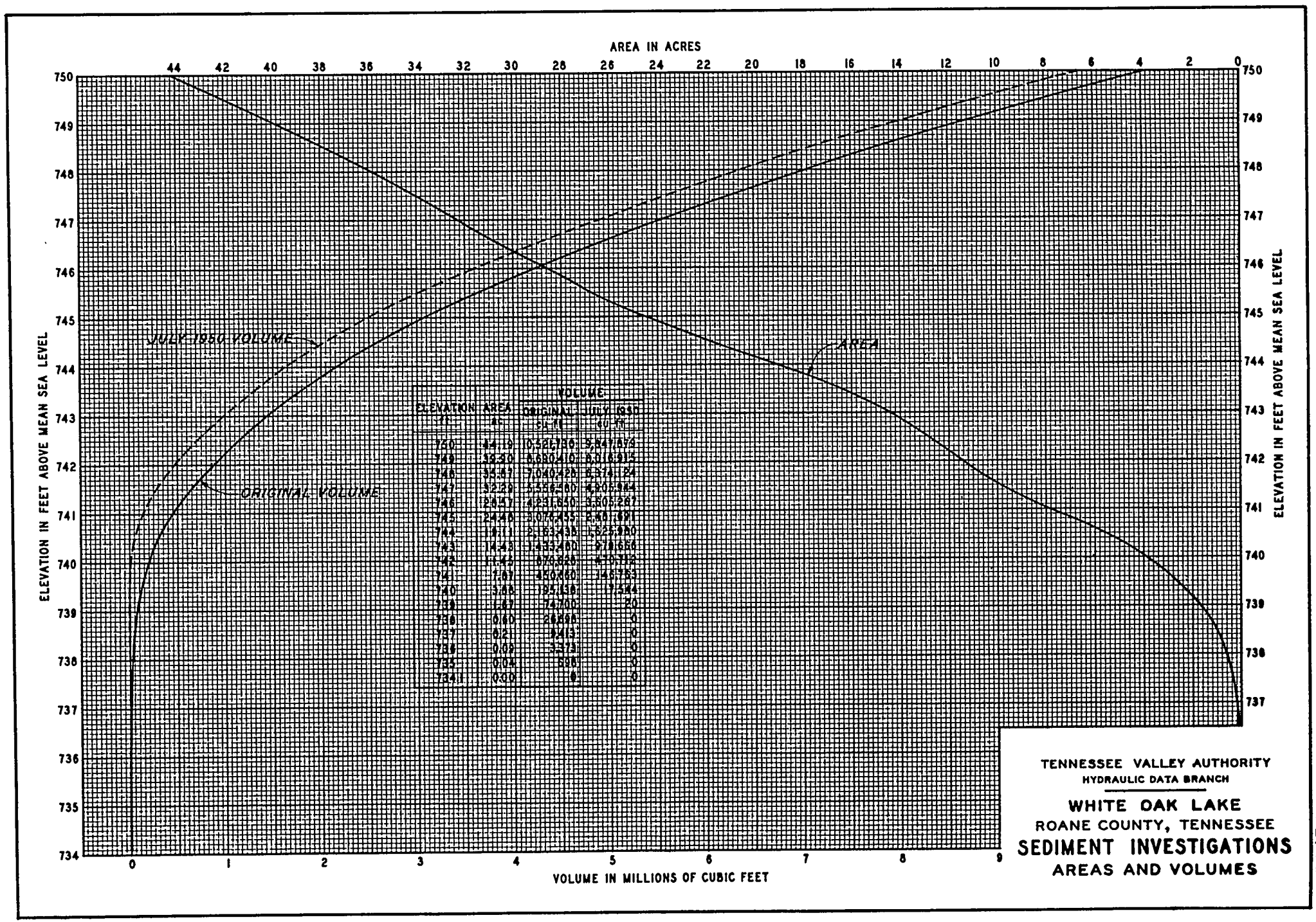
P. 7, paragraph 3, line 4 should read ".....Chattanooga at mile Te 465.3".

ADDENDA

P. 8, paragraph 2 - Construction activities in the new research area during the last half of 1950 and throughout 1951 and the installation of Burial Ground No. 4 resulted in the destruction of vegetative cover in these areas. Run-off from these areas carries considerable silt into the drainage system. Furthermore, the opening up of the Haw Gap by clearing trees and underbrush from the creek and banks and improving channel alignment permits more rapid run-off from Bethel Valley.

P. 9, et seq. White Oak Lake Volume

During July 1950 a survey was made by the Hydraulic Data Branch, TVA, to determine the extent and location of silt deposits in White Oak Lake. Soundings and probings were made at 10 feet intervals along ranges spaced 100 feet apart from the dam to the head of the Lake. The relationships of volume and area to elevation are given in the attached chart which is Plate 16 in the TVA report. The original volume was determined to be 10,521,730 cubic feet (at full pool elevation 750) and the reduction by 673,852 cubic feet of sediment left a net volume of 9,847,878 cubic feet in July 1950 (a reduction of 6.4% in 6 3/4 years). The volumes for different elevations correspond rather closely to the values taken from Report C.L. - 455 (Marvin Smith, Feb. 24, 1945) and plotted on Dwg. 8153, but are substantially different from those calculated by Setter, Straub, and Kochtitzky.



ELEVATION	AREA	VOLUME	
		ORIGINAL	JULY 1950
(FT)	(AC)	(CU FT)	(CU FT)
750	44.19	10,521,136	9,847,878
749	39.30	8,680,416	8,016,915
748	35.87	7,040,428	6,374,124
747	32.29	5,356,560	4,805,964
746	28.51	4,231,850	3,805,267
745	24.46	3,076,455	2,801,691
744	19.11	2,163,438	1,825,580
743	14.43	1,433,460	978,656
742	11.43	676,828	470,712
741	7.87	450,860	346,753
740	3.68	195,138	71,544
739	1.67	74,700	20
738	0.60	26,598	0
737	0.21	8,413	0
736	0.09	3,373	0
735	0.04	806	0
734.1	0.00	0	0