AR-NP-017124-A001
Revision 0

PROBABILISTIC FLOOD HAZARD ASSESSMENT

FOR

OAK RIDGE NATIONAL LABORATORY

September 25, 2003

Prepared by the
TENNESSEE VALLEY AUTHORITY
for the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6058
managed by
UT-Battelle, LLC
for the
U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-00OR22725

REVISION LOG		
Revision	**Description**	**Date**
0	Initial Issue	9/25/2003

EXECUTIVE SUMMARY

The Department of Energy (DOE) Order 420.1A, *Facility Safety*, requires that site-specific natural phenomena hazard assessments be conducted for DOE sites, and in addition requires the assessments to be reviewed as a minimum every ten years, or updated whenever new information becomes available. The last site-specific flooding hazard assessment for the Oak Ridge National Laboratory (ORNL) was performed in 1991 by the Tennessee Valley Authority (TVA). Since then, new information and new methodologies have been developed. This report provides the results of the latest updated flood hazard assessments, using the new information and methodologies, for ORNL.

This report supercedes the flooding assessment provided in ES/CNPE-95/1, Flood Analyses for Department of Energy, Y-12,m ORNL, and K-25 Plants, December 1991.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1401

September 25, 2003

Mr. Mark W. Kohring
Nuclear & Facility Safety Services
Operational Safety Services Division
Building 4500 South, Room H-260
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6127

Dear Mr. Kohring:

We are pleased to provide you with 12 copies of the report "Probabilistic Flood Hazard Assessment", funded under terms of procurement subcontract number 4000022021, dated March 12, 2003, between Oak Ridge National Laboratory (ORNL) and the Tennessee Valley Authority (TVA), and managed by UT-Battelle, LLC. Also enclosed is a digital disk containing data files and support material. This completes the study.

This is to certify that the report meets the requirements of all tasks noted in the *Statement of Work* section of the subcontract, and that all work has been accomplished in accordance with sound and accepted engineering practice.

If you have any questions, you may contact Steve Allen in Knoxville at (865) 632-6851.

Sincerely,

Greg Lowe

Gregory W. Lowe, P.E.
Senior Manager
River Scheduling

Enclosures

APPENDIX A

TENNESSEE VALLEY AUTHORITY
River System Operations & Environment
River Scheduling

Probabilistic Flood Hazard Assessment For Oak Ridge National Laboratory

Submitted to:
Oak Ridge National Laboratory
Nuclear & Facility Safety Services
Operational Safety Services Division

Knoxville, Tennessee
September 2003

TABLE OF CONTENTS

List of Exhibits

GENERAL INFORMATION

Authority

The flood analyses described in this report were conducted between March and September, 2003 for the Operational Safety Services Division of Oak Ridge National Laboratory (ORNL), by the Tennessee Valley Authority (TVA) Office of River System Operations & Environment. This study was performed under procurement subcontract number 4000022021 dated March 12, 2003, titled *Probabilistic Flood Hazard Assessment*, and managed by UT-Battelle, LLC. The subcontract operates under contract Number DE-AC05-00OR22725 with the United States Department of Energy (DOE) and TVA. A copy of this agreement is provided in Appendix C.

Purpose

At the request of the Nuclear & Facility Safety Services group of the ORNL Operational Safety Services Division, the study was performed to meet the requirements of DOE O 420.1A, *Facility Safety*, and DOE-STD-1023-95, *Natural Phenomena Assessment Criteria*, UT-Battelle. These requirements specify a site-specific flood hazard assessment at least every ten years. The results shown in this report update and supersede those at the same ORNL locations provided in the December 1991 report, Flood Analysis for Department of Energy, Y-12, ORNL, and K-25 Plants, performed by TVA.

This study defines the potential and local rainfall depth and duration data for the watersheds occupied by ORNL, and determines potential peak water surface elevations for four streams subject to flooding; Whiteoak Creek (also known at ORNL as White Oak Creek), Melton Branch, an unnamed tributary to Melton Branch which crosses Melton Valley Access Road near its mouth, and the Clinch River. Determination of flood levels on the Clinch River includes current operation guidelines followed by TVA for dams both upstream and downstream, and also considers the postulated failure of Norris Dam during both extreme rainfall and seismic events.

In April 2003 TVA performed, as a part of this work, a pre-study assessment of the 1991 TVA report as it pertains to streams and floodplains in the ORNL vicinity (provided in Appendix B). As noted in the assessment, this current study is intended to incorporate five major areas of change that could alter results described in the 1991 report:

1. Additional hydrologic record has been established in the 12 years since the earlier analysis and watershed changes have occurred that may affect runoff from large rainfall events.

2. Physical changes have occurred along the streams, including new and replacement bridges and weirs, which affect streamflow and computed flood elevations.
3. Hydrometeorological and flood frequency national standards have been upgraded.
4. Many improvements have been made to flood hydraulic models and analysis methods, and the national standard hydraulic model for flood studies has been upgraded.
5. Dam modifications have been made to meet new dam safety criteria, and TVA's 1991 Lake Improvement Plan has brought about changes in reservoir operation guidelines and philosophy.

Scope

In contrast to the 1991 TVA analysis, this report is limited in scope to those streams and watershed areas affecting the land and facilities managed and operated by ORNL.

For the Clinch River, peak flood elevations were computed for conditions resulting from the 25-year, 100-year, 500-year, 2,000-year, 10,000-year, 100,000-year, maximum probable (MPF), and probable maximum floods (PMF) without the failure of Norris Dam. For the postulated Norris Dam failure scenario, flood elevations were computed for failure conditions resulting from the one-half probable maximum flood (½PMF), and for failure occurring in non-flood conditions. The reach of Clinch River affecting ORNL extends from the vicinity of stream mile 18, below Jones Island, upstream to approximately stream mile 34, in Gallaher Bend. This reach includes Melton Hill Dam at mile 23.1.

For Whiteoak Creek, Melton Branch, and the tributary to Melton Branch peak flood elevations were computed for conditions resulting from the 25-year, 100-year, 500-year, 2,000-year, 10,000-year, 100,000-year, MPF, and PMF floods. This flood information was determined for the same stream reaches provided in the 1991 report, which are described below. Note that with the help of more precise watershed mapping than was available in 1991, stream mileage and associated landmark locations have been adjusted. Tables comparing 1991 stream miles with 2003 stream miles are provided in Appendix A.

Whiteoak Creek was restudied from its mouth at Clinch River mile 20.83, below the Tennessee Highway 95 bridge, upstream to approximate stream mile 4.1, on the southeastern slope of Chestnut Ridge and about 2,200 feet north of Bethel Valley Road.

Melton Branch was restudied from its mouth at Whiteoak Creek mile 1.55, above Whiteoak Lake, upstream to approximate stream mile 2.3 on the south side of Melton Valley Drive near its intersection with Melton Valley Access Road.

The tributary to Melton Branch was restudied from its mouth at Melton Branch mile 1.77 upstream approximately 900 feet to the east (upstream) side of Melton Valley Access Road.

For the ORNL watershed, local rainfall depth and duration relationships were computed for conditions resulting from the 25-year; 100-year; 500-year; 2,000-year; 10,000-year; and 100,000-year rainfall; as well as the maximum probable (MPP) and probable maximum precipitation (PMP). As in the 1991 report, the rainfall-frequency estimates were determined for 5-, 10-, 15-, and 30-minutes durations, and also for durations ranging from 1 to 6 hours.

ENGINEERING METHODS

HYDROLOGIC ANALYSIS

For this report, hydrologic analysis refers to the development of flood discharge estimates from predicted rainfall to be applied to the hydraulic models. The methods used to develop flood discharge estimates varied by size of the flood event and by size, that is, drainage area of the stream involved. These are summarized below.

Small Drainage Area Streams at ORNL

Peak discharge-frequency estimates for 25-year, 100-year and 500-year events on Whiteoak Creek, Melton Branch and its tributary were computed with regression equations developed from current stream gage records. The adopted flood discharges were developed based on the relationship of drainage area to annual peak discharge for 19 stream gages in the region surrounding Oak Ridge. This set of gages differs from that used in the 1991 study, which used regression equations developed earlier for a Knox County flood insurance study. Noting that several observed flood events in the past decade had been assigned a flood frequency of nearly a 100-year event, it was decided that the Knox County equations were under-predicting peak discharges for the ridge-and-valley type of topography in the Oak Ridge area. To create a more representative set of stream gages, three gages on streams in the Smoky Mountains were eliminated and three gages located near Oak Ridge were added to the stream gage set.

To develop the regional relationships, discharge-frequency curves for each of the chosen stream gage locations were computed using U.S. Water Resources Council Bulletin 17B (U.S. Department of Interior, September 1981), and adjusted for historic flood information where applicable. The frequency distribution utilized for the analysis is a log-Pearson type III. The computed discharge from the Bulletin 17B analysis for each desired recurrence interval up to the 500-year event was tabulated for all gage locations and a least-squares regression was performed on drainage area to produce the adopted regression equations. For the 2,000- and 10,000-year events, the computed discharge-frequency curve from Bulletin 17B was extrapolated on the log-Pearson plot, and then the same procedure was used to develop the regional relationships for these larger events. Table 1 below summarizes the adopted regression equations.

TABLE 1. ADOPTED REGIONAL RELATIONSHIPS	
$Q_{25} =$	$404 \times DA^{0.718}$
$Q_{100} =$	$620 \times DA^{0.732}$
$Q_{500} =$	$1017 \times DA^{0.742}$
$Q_{2000} =$	$1478 \times DA^{0.753}$
$Q_{10000} =$	$2331 \times DA^{0.745}$

These adopted regional relationships were compared to the applicable U.S. Geological Survey (USGS) relationships for Tennessee, Area 1 (U.S. Geological Survey, 1993). Discharge estimates from the USGS equations ranged up to 50 percent less than the relationships developed for this study, with greater differences for larger events. The USGS equations produce lower discharges for the same reason as the Knox County equations; the gages used represented a variety of topographic conditions, including gages in the Blue Ridge, Smoky Mountain and Cumberland Plateau regions. The list of stream gages used to develop the adopted discharge-frequency relationships for this study is found in Table 2.

TABLE 2. STREAM GAGES

Gage Location	Gage Number	Drainage Area, Square Miles	Period of Record
Nails Creek near Knoxville, TN	03498700	0.36	1954 - 1985
Melton Branch near Oak Ridge, TN	03537500	1.48	1955 - 1964
Baker Creek Tributary near Binfield, TN	03519610	2.1	1966 - 1996
Willow Fork near Halls Cross Roads, TN	03535180	3.23	1967 - 1996
Whiteoak Creek below Melton Valley Drive near Oak Ridge, TN	03636550	3.28	1985 - 2001
Millican Creek near Douglas Dam, TN	03469010	4.2	1942 - 1962
Bear Creek at State Highway 95 near Oak Ridge, TN	03538270	4.34	1985 - 2000
Caney Creek near Kingston, TN	03538130	5.55	1961 - 1985
Buffalo Creek near Norris, TN	03534500	7.82	1947 - 1982
Island Creek at Vonore, TN	03519600	11.2	1954 - 1976
First Creek at Mineral Springs Ave, Knoxville, TN	03496000	11.9	1945 - 1963

Chestuee Creek above Englewood, TN	03565040	14.8	1945 - 1957
Baker Creek near Greenback, TN	03519640	16	1965 - 1996
East Fork Poplar Creek near Oak Ridge, TN	03538250	19.5	1960 - 1988
Bat Creek near Vonore, TN	03519700	30.7	1954 - 1976
Poplar Creek near Oliver Springs, TN	03538200	55.9	1954 - 1985
Oostanaula Creek near Sanford, TN	03565500	57	1955 – 1989
Sweetwater Creek near Loudon, TN	03520100	62.2	1954 – 1982
Bullrun Creek near Halls Crossroads, TN	03535000	68.5	1957 – 1986

Unit hydrographs were developed during the 1991 study to compute the MPF (also known as TVA MPF) and the PMF for Whiteoak Creek and Melton Branch using procedures developed at TVA (Newton and Vinyard, September 1967). These were developed for each stream individually from the maximum flood hydrographs recorded at gaging stations at several locations on these streams. Equations relating the unit graph peak discharge to the drainage area size were then developed from the computed unit graphs for various ungaged locations on the streams. Peak MPF and PMF flood discharges were derived from these equations.

An analysis of rainfall events occurring after 1991 showed no significant change in unit hydrograph shape for the more recent storms compared to those used to generate the unit hydrographs; therefore the same MPF and PMF relationships developed for the 1991 study were adopted for this study.

In the 1991 report under Rainfall Data the exceedance probabilities of the MPF and PMF events are carefully examined and the conclusion is shown to be 5×10^{-5} (20,000-year flood) and 1×10^{-6} (1 million-year flood) for the MPF and PMF, respectively. Therefore, the 100,000-year event has a return period lying between the MPF and PMF. Peak MPF and PMF discharges were estimated for several locations on each stream, and these were then plotted on log-Pearson III paper to allow interpolation of peak discharges for the 100,000-year event at those same locations.

Clinch River in the ORNL Vicinity

Since 1991 TVA has made no changes in the operation guidelines or philosophy for scheduled releases to Clinch River below Norris Dam or in the operation of Melton Hill Dam. For flood events up to the 500-year, therefore, the same discharges used to compute flood levels in 1991 were used for this analysis.

Because changes (noted below) have occurred that affect estimated discharges for large floods such as the MPF and PMF, a discharge frequency plot was developed at each cross section to interpolate the estimated discharges for the 2,000- and 10,000-year floods between the 500-year and MPF events.

Unsteady flow techniques were used on the Clinch River to determine MPF and PMF elevations, as well as on the Tennessee River, which controls flood elevations on the lower reaches of the Clinch River. TVA's Simulated Open Channel Hydraulics (SOCH) model, based on unsteady flow analysis techniques developed at TVA, (Garrison, Granju, and Price, September 1969) was used in both 1991 and this current study to analyze flow characteristics for the Clinch and Tennessee Rivers. In its current version SOCH is an integrated hydrologic and hydraulic model which eliminates separate approximation of the inflow hydrographs, as was done in 1991. Because of this integration, it is difficult to differentiate details of discharge determination from elevation computation. Therefore, this discussion will cover both hydrologic and hydraulic analyses for the Clinch River.

In addition to the model upgrade itself, the Clinch and Tennessee River models have been modified since the 1991 study to include the use of updated reservoir median starting elevations for summer and spring conditions, and to reflect the inclusion of safety modifications that have been completed over the last decade at several dams in the region to meet upgraded dam safety criteria.

Also, in 1991 TVA changed operating philosophy for the Tennessee River and several tributaries with implementation of the Lake Improvement Plan (Tennessee Valley Authority, December 1990). These changes had a significant impact on median starting elevations for the summer and spring storms used to analyze Clinch River MPF and PMF events. Additional years of experience in reservoir operation since 1991 also is a component of the median level changes noted. Table 3 summarizes the median level changes. The period identified as "latest median" is 1972 to 2002.

TABLE 3. CHANGES IN MEDIAN ELEVATIONS FOR TWO STORMS

TVA Dam	Spring Storm, March 15		Summer Storm, July 15	
	Original Median	Latest Median	Original Median	Latest Median
South Holston	1713.0	1713.0	1719.8	1723.1
Watauga	1848.0	1948.0	1945.4	1952.3
Cherokee	1942.0	1943.0	1960.3	1963.3
Douglas	958.0	960.0	989.2	991.9
Fontana	1643.0	1648.0	1685.2	1696.1
Norris	998.0	999.0	1009.0	1012.9

In March 1998 TVA modified the Clinch River SOCH model to incorporate the physical modifications that were made to meet upgraded dam safety guidelines (Tennessee Valley Authority, March 1998). Table 4 summarizes the dam modifications that could affect MPF and PMF flooding on the Clinch River.

TABLE 4. DAM SAFETY MODIFICATIONS AT TVA DAMS, 1990 - 1995

TVA Dam	Action Taken
Watauga	Dam raised 10 feet by rock fill
Boone	Dam raised 8.5 feet with earth fill
Douglas	Main dam raised 13.5 feet with concrete, raised 8 saddle dams, dam post-tensioned
Cherokee	Dam raised 7.5 feet with concrete wall to reduce potential erosion at the junction of the earth embankment with the concrete dam
Fontana	Dam post-tensioned
Fort Loudoun	Dam raised 3.25 feet with concrete wall
Tellico	2000-foot uncontrolled ogee spillway added at saddle dam number 1 at elevation 817
Melton Hill	Dam post-tensioned
Watts Bar	Left rim saddle dam and east embankment raised 10 feet with earth fill

For the MPF and the PMF analyses, several storm and flood scenarios were evaluated and sub-watersheds modeled separately. Each scenario produced different elevations in the ORNL vicinity. Generally, where there was overlap in the storm coverage, a storm centered over the Norris and Melton Hill watersheds produced higher elevations than one centered over a larger drainage area, because the intensity of a storm over a larger area is expected to be less than that of a smaller storm. Therefore, at locations where analyses overlapped, the higher elevation was chosen.

Table 5 summarizes storm scenarios and sub-watersheds modeled.

TABLE 5. SUMMARY OF STORM AND FLOOD SCENARIOS USED FOR CLINCH RIVER MPF AND PMF ANALYSES		
MPF	Controlling storm downstream of Melton Hill on March 15 and spring reservoir elevations. [21,400 square mile watershed (above Chattanooga)]	(applies to Clinch River below Melton Hill Dam)
	Same controlling storm with July 15 summer reservoir elevations. Sub-watersheds modeled: • Norris watershed MPF • Melton Hill watershed MPF	(applies to Clinch River upstream of Melton Hill Dam)
PMF	Controlling storm downstream of Melton Hill on March 15 and spring reservoir elevations. [7,980 square mile watershed (above Chattanooga excluding 5 upstream dams -- Norris, Cherokee, Douglas, Hiwassee, and Fontana)]	(applies to Clinch River below Melton Hill Dam)
	Same controlling storm with July 15 summer reservoir elevations. Sub-watersheds modeled: • Norris watershed PMF • Melton Hill watershed PMF	(applies to Clinch River upstream of Melton Hill Dam)

HYDRAULIC ANALYSIS

For this report, hydraulic analysis refers to the computation of water surface elevations during those events for which flood discharge estimates have been developed. The hydraulic analysis of large flood events on the Clinch River was part of the integrated SOCH model work and is discussed above in the section, Clinch River in the ORNL Vicinity.

Small Drainage Area Streams at ORNL

For the 1991 study TVA used HEC-2, a widely used flood hydraulic model developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, May 1991). Since 1991 HEC-2 has been replaced by the River Analysis System, also known as HEC-RAS (U.S. Army Corps of Engineers, September 1998). The HEC-RAS floodplain geometry is developed from land surveys and measurements of floodplains and structures, such as bridges and culverts, along with estimates of floodplain floodflow parameters. The program then simulates gradually varied open channel flood flow, and evaluates the impacts that hydraulic structures have on flood elevations. HEC-RAS is now widely used and is recommended by the Federal Emergency Management Agency (FEMA) for community flood insurance studies and floodplain maps. HEC-RAS analysis methods for pipe culverts, piers, weirs, and other hydraulic structures commonly found on small drainage area streams is greatly improved over HEC-2, and provides a wide variety of choices for the modeling engineer in matching observed structure shapes and conditions.

An inspection of the full study reach of Whiteoak Creek, Melton Branch, and its tributary was made on March 27, 2003. Current floodplain conditions were noted at each location found in the existing HEC-2 models, as well as at other locations determined to be significant for hydraulic modeling. Several new or altered bridges and weirs were observed. Land surveys and measurements of these new structures were carried out by Barge, Waggoner, Sumner, and Cannon, Inc. in June and July 2003. This new information was incorporated into the HEC-RAS models to supplement the 1991 and 1979 land surveyed data used again at those locations where no significant changes had occurred.

Digital topographic maps developed in the 1990's by ORNL and TVA and archived by Q-Systems, Inc. (Q-Systems, August 2002) were obtained and used to determine distances between cross sections. The close contour intervals and up-to-date features on these maps were used to extend surveyed cross sections used in 1991 to the full limits of the large-flood floodplains, and to add to the model the blockage effects of buildings at their true locations.

With better maps than those used in 1991 a more precise stationing of stream lengths was possible. As a result, the true locations of many hydraulic structures in terms of stream mileage from the mouth changed from the 1991 designation. Also, better mapping allowed several 1991 surveyed cross sections to be more accurately placed in the model by matching survey features with the same features shown on the maps. A survey data summary and table of comparisons between 1991 mileage and 2003 updated mileage can be found in Appendix A.

The developed discharge estimates were then used in each stream model to determine flood elevations for each flood event. The models were calibrated by analyzing flow characteristics at culverts and weirs and comparing flood profiles for the different flood events. As additional calibration, discharge estimates were developed for 2- and 10-year floods so those flood profiles could be compared to observed flood marks and debris deposited by a small spring 2003 flood. A final field inspection was conducted on July 21, 2003 to verify new surveys and to assist calibration of the final models.

Compared to the 1991 analyses of Whiteoak Creek and Melton Branch, the flood models produced higher elevations at most locations for frequency floods up to the 500-year. The higher elevations can mostly be attributed to higher estimated discharges for these flood events, to capabilities of the HEC-RAS program which allowed more precise descriptions of bridge parameters and floodplain roughness factors, and to accurate placement of buildings and other floodplain blockages shown on the digital maps. At some locations, such as the new bridges and weirs near the confluence of Whiteoak Creek and Melton Branch, and along the reach from Third Street to White Oak Avenue the models produced 100-year elevation increases of as much as one to two feet, and occasionally more.

For larger flood events, results at most locations showed lower flood elevations than those computed in 1991. Current estimated discharges for these events were not significantly higher than in 1991, and HEC-RAS allowed a better description than was available with HEC-2 for the extended floodplain areas that would be impacted by these large floods.

On the tributary to Melton Branch significantly higher flood elevations at Melton Valley Access Road can be attributed to inadequacy of the very small culvert under the road that was not properly addressed in the HEC-2 model. Also, the more accurate digital maps showed the mouth of the tributary to be several hundred feet upstream of the location shown on the USGS topographic sheet used in 1991.

Clinch River in the ORNL Vicinity

For the smaller floods, the 25-year through the 500-year events, two Clinch River HEC-RAS models (below and above Melton Hill Dam) were created by importing the same stream and floodplain geometry used in the 1991 HEC-2 study model and also found in the unsteady flow SOCH model. Discharges and starting elevations also were the same as those used in the 1991 study. Because no policy or guidelines changes have been implemented for the Clinch River below Norris Dam, and no land use changes were observed that would affect flood modeling, no changes were made to the Clinch model.

For the intermediate flood events, the 2,000- and 10,000-year floods, the discharges developed by interpolation were used in the same HEC-RAS models. Starting elevations for these flood models were determined by similar interpolation methods as used to develop estimated discharges.

As noted in detail above, MPF and PMF flood elevations on the Clinch River were computed with the integrated SOCH model. MPF and PMF elevations and discharges, and the interpolated 100,000-year discharges, were then used with a rating curve to determine 100,000-year flood elevations.

A comparison of flood elevation results from the current and 1991 studies showed few significant differences in Melton Hill Reservoir for large flood events. In the reach below Melton Hill Dam small elevation increases resulted from the new study. As noted above, there was no change in computed elevations of frequency floods up to the 500-year.

DAM FAILURE FLOOD ANALYSIS

In the 1991 study, both Norris and Melton Hill Dams (separately) were postulated to fail concurrent with the one-half PMF (½PMF) and seismically in non-flood conditions. Resulting flood elevations in the Clinch River near ORNL from the Norris Dam failure were shown to be much higher than those from the Melton Hill Dam failure alone. The Melton Hill Dam failure alone scenarios were not reevaluated in this current study.

In 1998, to determine changing impacts on flood elevations and response times at nuclear plants, TVA reanalyzed postulated dam failures throughout the system, incorporating the dam safety modifications at the dams and philosophy changes in reservoir operation (Tennessee Valley Authority, March 1998). As in earlier studies, this reanalysis used unsteady flow techniques with the SOCH model. Although no dam modifications or operational changes have taken place at Norris Dam, updated hydrologic record and median elevations produced dam failure profiles on the Clinch River that differ from those published in the 1991 report. Also dam safety modifications at Tellico and Watts Bar Dams, which now allow these dams to safely pass the PMF, affected computed Clinch River flood elevations below Melton Hill Dam. Compared to the 1991 study, results showed somewhat higher flood elevations below Melton Hill, while they are significantly lower above the dam. These significantly lower elevations also reflect the 1998 assumption that Norris Dam failure in both ½PMF and non-flood events would overtop and fail Melton Hill Dam.

As noted in the 1991 study, in furnishing this information TVA neither implies nor concedes that its dams are inadequate to withstand great floods and/or earthquakes that may be reasonably expected to occur. In compliance with federal guidelines on dam safety, TVA carries out regular inspections and maintenance, conducts simulation exercises, and has fully developed emergency action plans for each dam to address potential safety issues.

RAINFALL ANALYSIS

The National Oceanic and Atmospheric Administration (NOAA) is currently in the process of re-computing and updating the rainfall depth information presented in Technical Paper 40 (TP-40) (U.S. Department of Commerce, Weather Bureau, May 1961), Technical Memorandum Hydro-35 (TM Hydro-35) (National Weather Service, June 1977), and several other related publications. This new report will benefit from the evaluation of about 25 to 40 years of additional rainfall data, and is due to be published in late 2003 or 2004. However, with the new report not yet available, rainfall depth-duration relationships were developed using the published reports described below.

Rainfall-frequency estimates for durations from 5 to 60 minutes and return periods up to 100 years were obtained from the NWS manual TM Hydro-35. Estimates for durations and return periods longer than one hour greater than 100 years, respectively, were obtained from publication TP-40. MPP and PMP estimates were obtained from the NOAA / TVA Hydrometeorological Report No. 56 (U.S. Department of Commerce, October 1986). All intermediate values were either interpolated or calculated from equations found in the publications.

Figures 1 and 2 provide a summary of the local area rainfall depth-duration-frequency data.

Figure 1

Rainfall Depth-Duration Frequency
ORNL, Oak Ridge, Tennessee

Duration	25-yr	100-yr	500-yr	2000-yr	10000-yr	100,000-yr	TVA MPP	PMP
5-minute	0.64	0.77	1.0	1.3	1.7	2.4	1.9	3.2
10-minute	1.05	1.28	1.7	2.4	3.2	4.3	3.5	5.4
15-minute	1.34	1.63	2.35	3.2	4.3	5.9	4.8	7.4
30-minute	1.92	2.37	3.3	4.5	6.4	9.1	7.2	11.8

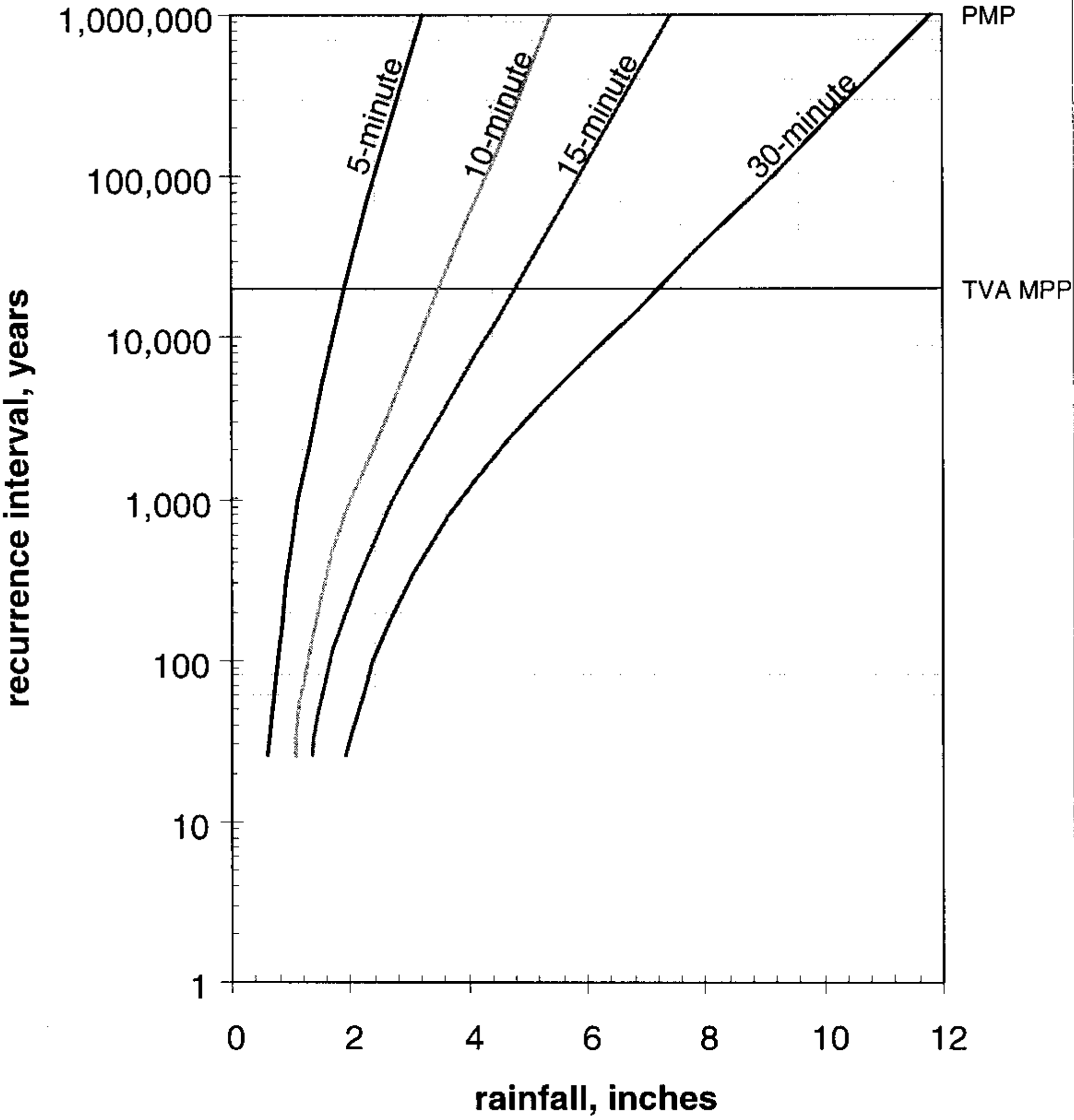
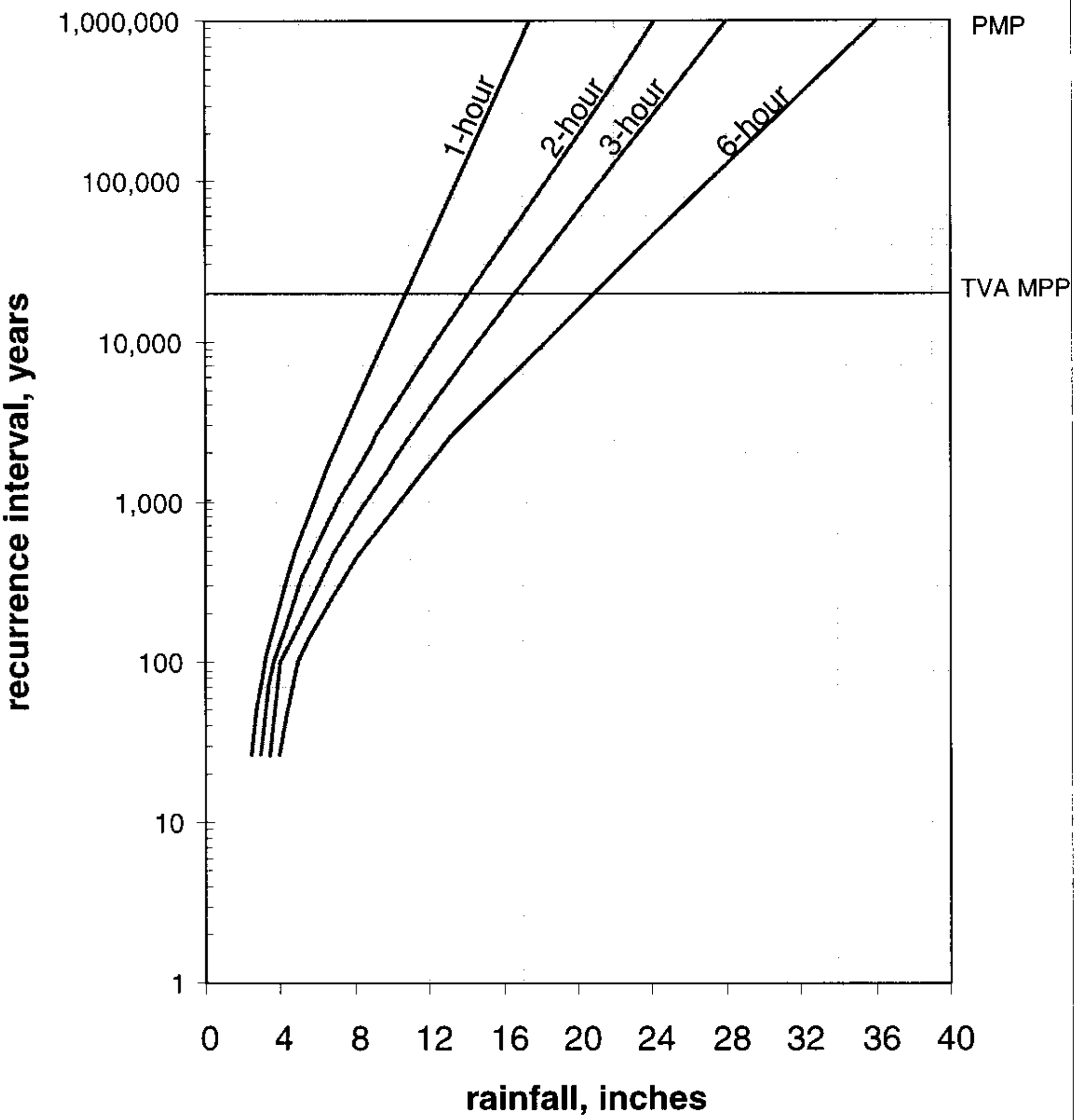


Figure 2

Rainfall Depth-Duration Frequency
ORNL, Oak Ridge, Tennessee

Duration	25-yr	100-yr	500-yr	2000-yr	10000-yr	100,000-yr	TVA MPP	PMP
1-hour	2.53	3.15	4.7	6.8	9.5	13.4	10.6	17.4
2-hour	3.00	3.75	5.7	8.5	12.4	18.3	14.1	24.2
3-hour	3.4	4.0	6.9	10.2	14.7	21.2	16.6	28.0
6-hour	3.95	4.9	8.2	12.3	18.1	27.0	20.8	36.0



Whiteoak Creek
Flood Elevations for Specified Events
(feet, MSL, NGVD)

Stream Mile		Location Description	25-Year Flood	100-Year Flood	500-Year Flood	2,000-Year Flood	10,000-Year Flood	Maximum Probable Flood (MPF)	100,000-Year Flood	Probable Maximum Flood (PMF)
0.40			750.1 *	753.9 *	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
0.55	ds	Tennessee Highway 95 and Whiteoak Dam	750.1 *	753.9 *	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
	us		751.8	754.1	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
0.78		in Whiteoak Lake	751.9	754.1	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
1.18		in wetland	751.9	754.2	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
1.38			752.1	754.3	757.8 *	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
1.62	ds	vehicle bridge and double "V" weir	755.1	756.0	757.9	760.7 *	763.3 *	763.8 *	772.0 *	780.1 *
	us		759.6	761.3	762.5	764.2	764.4	765.6	772.0 *	780.1 *
1.90		berm on west bank	761.1	762.5	764.4	766.7	768.1	769.9	772.0 *	780.1 *
2.22	ds	trapezoidal weir	770.2	772.0	774.4	775.4	777.1	778.6	779.7	781.7
	us		773.3	774.1	774.9	775.7	778.1	779.6	780.4	782.2
2.25	ds	Melton Valley Drive	773.6	774.5	775.7	777.0	779.1	781.0	782.3	784.4
	us		774.8	777.6	780.8	782.1	783.3	784.7	785.8	787.3
2.59	ds	Third Street	777.7	779.3	782.0	783.6	785.4	787.7	789.4	792.0
	us		778.3	780.3	782.6	783.9	785.6	787.9	789.6	792.1
2.70	ds	Parshall flume	780.4	781.9	783.8	785.0	786.6	788.6	789.6	793.0
	us		780.9	782.1	783.9	785.1	786.8	788.9	790.2	794.5
2.80	ds	pedestrian bridge	782.3	783.6	785.5	787.0	789.2	792.6	794.7	796.5
	us		782.4	783.8	786.9	787.8	789.4	792.7	794.7	796.6
2.84	ds	pedestrian entrance to HTML	783.9	785.0	787.2	788.1	789.6	792.7	794.8	796.5
	us		785.2	786.4	788.3	790:3	791.1	793.4	795.9	797.6
2.88	ds	vehicle bridge to HTML	786.0	787.2	788.9	790.6	791.7	794.0	796.2	798.0
	us		787.3	788.7	790.1	791.0	792.7	795.1	797.3	799.3
2.92	ds	vehicle bridge to building 4509	788.0	789.4	790.8	791.8	793.3	795.8	797.8	799.9
	us		789.0	790.0	791.2	792.0	793.5	795.9	798.0	800.1

Whiteoak Creek
Flood Elevations for Specified Events
(feet, MSL, NGVD)

Stream Mile		Location Description	25-Year Flood	100-Year Flood	500-Year Flood	2,000-Year Flood	10,000-Year Flood	Maximum Probable Flood (MPF)	100,000-Year Flood	Probable Maximum Flood (PMF)
3.03	ds	pedestrian bridge	791.9	793.0	794.3	795.7	797.4	800.4	801.6	802.7
	us		793.8	796.2	797.2	798.0	799.5	802.3	803.5	805.0
3.08	ds	vehicle bridge to building 5505	794.9	796.7	797.9	798.9	800.5	803.1	804.5	806.2
	us		795.1	797.0	798.8	799.7	802.9	804.1	805.4	807.1
3.16	ds	pedestrian bridge	797.0	798.1	799.8	800.9	803.2	804.8	806.0	807.6
	us		798.6	799.7	800.6	801.7	803.4	805.1	806.3	807.9
3.22	ds	arch vehicle bridge	800.0	800.8	801.8	803.0	805.3	806.7	807.7	808.8
	us		801.3	803.6	804.6	806.0	806.9	809.2	810.2	811.6
3.27	ds	vehicle bridge to building 6011	802.2	804.1	805.3	806.5	807.7	809.9	811.0	812.6
	us		804.8	805.2	805.8	806.6	807.8	810.1	811.1	812.6
3.36	ds	White Oak Avenue	807.0	808.0	808.9	809.5	810.4	812.2	813.2	814.7
	us		810.4	811.0	811.7	812.3	813.1	814.7	815.5	816.7
3.63	ds	Melton Valley Access Road	819.3	820.8	821.8	822.4	823.4	825.6	826.8	828.2
	us		825.8	826.3	826.9	827.4	828.1	829.4	830.1	831.0
3.71	ds	Bethel Valley Road	825.8	826.3	827.0	827.5	828.2	829.8	830.6	831.7
	us		828.9	829.3	829.7	830.0	830.5	831.4	831.9	832.5
3.94			838.0	838.9	840.0	840.7	841.8	844.0	845.0	846.4
4.13		at power line right-of-way	853.6	854.1	854.6	855.1	855.8	857.8	858.9	860.5

* Controlling backwater elevations from Clinch River

ds and us refer to downstream and upstream at structures

Exhibit 1

Melton Branch
Flood Elevations for Specified Events
(feet, MSL, NGVD)

Stream Mile		Location Description	25-Year Flood	100-Year Flood	500-Year Flood	2,000-Year Flood	10,000-Year Flood	Maximum Probable Flood (MPF)	100,000-Year Flood	Probable Maximum Flood (PMF)
0.12	ds	vehicle bridge and single "V" weir	754.5	755.6 *	757.8 **	760.7 **	763.3 **	763.8 **	772.0 **	780.1 **
	us		758.1	758.4	759.5	760.7 **	763.3 **	763.8 **	772.0 **	780.1 **
0.41			764.1	765.1	766.0	766.8	768.0	769.5	772.0 **	780.1 **
0.71	ds	trapezoidal weir	776.3	776.9	777.6	778.3	779.1	780.4	781.4	782.8
	us		776.4	777.0	777.7	778.3	779.2	780.5	781.5	782.9
0.72	ds	field road culverts	776.5	777.1	777.8	778.5	779.4	780.7	781.7	783.1
	us		778.1	778.4	778.8	779.2	779.7	780.9	781.9	783.3
0.96			784.1	785.0	785.7	786.5	787.7	789.5	790.7	792.4
1.22	ds	concrete flume	794.8	795.3	795.8	796.5	797.5	799.7	800.9	802.5
	us		795.0	795.5	796.1	796.8	797.8	800.1	801.3	802.9
1.58	ds	concrete weir	804.9	805.6	806.2	806.9	808.0	810.3	811.4	812.6
	us		805.3	805.7	806.3	807.0	808.0	810.4	811.5	812.6
1.78		above Tributary	817.2	817.6	817.9	818.1	818.6	820.0	820.6	821.6
2.13			839.4	839.5	839.8	840.0	840.4	841.7	841.8	842.6
2.30		near Melton Valley Road	867.7	867.9	868.2	868.7	869.2	871.3	871.8	872.7

* Controlling backwater elevations from Whiteoak Creek

** Controlling backwater elevations from Whiteoak Creek and Clinch River

ds and us refer to downstream and upstream at structures

Exhibit 2

Melton Branch Tributary
Flood Elevations for Specified Events
(feet, MSL, NGVD)

Stream Mile		Location Description	25-Year Flood	100-Year Flood	500-Year Flood	2,000-Year Flood	10,000-Year Flood	Maximum Probable Flood (MPF)	100,000-Year Flood	Probable Maximum Flood (PMF)
0.02		near mouth	816.8	817.2	817.7	818.1	818.8	819.8	820.0 *	821.0 *
0.16	ds	Melton Valley Access Road	831.2	831.4	831.7	831.9	832.4	833.6	834.6	835.3
	us		837.3	837.5	837.7	837.8	838.5	840.4	840.9	841.6

* Controlling backwater elevations from Melton Branch

ds and us refer to downstream and upstream at the road

Exhibit 3

Clinch River
Flood Elevations for Specified Events
(feet, MSL, NGVD)

Stream Mile		Location Description	25-Year Flood	100-Year Flood	500-Year Flood	2,000-Year Flood	10,000-Year Flood	Maximum Probable Flood (MPF)	100,000-Year Flood	Probable Maximum Flood (PMF)
16.8		near Caney Creek	747.9	751.0	754.2	756.0	758.6	760.5 *	768.9 *	778.7 *
18.9		near Hood Ridge	749.2	752.8	756.5	759.0	760.8	761.4 *	770.9 *	779.5 *
21.0		near Whiteoak Creek	750.2	754.0	757.9	760.8	763.5	764.0	772.1	780.2 *
23.1	ds	Melton Hill Dam	751.4	755.3	759.2	762.1	764.8	766.5	772.9	780.8 *
	us		796.0	796.0	796.0	796.0	797.3	799.3	803.6	809.6
25.2		near Hope Creek	796.0	796.1	796.1	796.2	797.5	799.5	803.8	810.1
27.3		near Hickory Creek Bend	796.1	796.1	796.2	796.3	797.6	799.6	803.9	810.3
29.4		near county boundaries	796.1	796.2	796.3	796.4	797.8	799.8	804.0	810.7
31.5		near Bearden Creek	796.1	796.2	796.4	796.5	797.9	800.0	804.2	811.0
33.6		near Gallaher Bend	796.2	796.3	796.5	796.7	798.1	800.3	804.4	811.6

* Controlling backwater elevations from Tennessee River

ds and us refer to downstream (tailwater) and upstream (headwater) at Melton Hill Dam

Clinch River
Flood Elevations for Specified Events
Elevation (feet, MSL, NGVD)

Stream Mile		Location Description	Norris Dam Failure Coincident with 1/2 Probable Maximum Flood (½PMF)	Norris Dam Failure in Non-Flood Conditions
16.8		near Caney Creek	800.2	790.8
18.9		near Hood Ridge	807.1	797.3
21.0		near Whiteoak Creek	812.5	802.4
23.1	ds	Melton Hill Dam	813.0	803.8
	us		813.0	804.0
27.46		in Hickory Creek Bend	820.7	811.1
31.82		near Bearden Creek	827.5	817.8
36.18		near Conner Creek	830.7	820.7

ds and us refer to downstream (tailwater) and upstream (headwater) at Melton Hill Dam

Exhibit 5

REFERENCES

Garrison, J. M., J. P. Granju, and J. T. Price. (September 1969) "Unsteady Flow Simulation in Rivers and Reservoirs." Journal of the Hydraulics Division, American Society of Civil Engineers, Volume 95, Number HY5. Proceedings paper 6771, pages 1559-1576.

Newton, Donald W., and Vinyard, J. W. (September 1967) "Computer-Determined Unit Hydrographs from Floods." Journal of the Hydraulics Division, American Society of Civil Engineers, Volume 93, Number HY5.

Q-Systems, Inc. (August 2002) Composite Coverage, Oak Ridge Reservation GIS Raster and Vector Data. Prepared for OREIS Base Mapping Project. Last Updated: August 21, 2002. Oak Ridge, Tennessee

Tennessee Valley Authority. (December 1990) Tennessee River and Reservoir System Operation Planning Review. Final Environmental Impact Statement. Report TVA/RDG/EQU-91/1. Knoxville, Tennessee.

Tennessee Valley Authority, Division of Water Resources. (December 1991) Flood Analysis for Department of Energy, Y-12, ORNL, and K-25 Plants. Knoxville, Tennessee.

Tennessee Valley Authority, Office of TVA Nuclear. (March 1998) Flood Reassessment for the Effects of Dam Safety Modifications. Archive Reference ID 300991. Unpublished Calculations. Chattanooga, Tennessee.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. (September 1998) HEC-RAS River Analysis System, Version 2.2. Davis, California.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. (May 1991) HEC-2 Water Surface Profiles, Generalized Computer Program, Version 4.6.2. Davis, California.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, and Tennessee Valley Authority. (October 1986) Probable Maximum and TVA Precipitation Estimates with Areal Distribution for Tennessee River Drainages Less Than 3,000 Mi^2 in Area. Hydrometeorological Report No. 56. Silver Springs, Maryland.

National Weather Service. (June 1977) Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States, NOAA Technical Memorandum NWS HYDRO-35. Silver Springs, Maryland.

U.S. Department of Commerce, Weather Bureau. (May 1961) Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. Technical Paper Number 40. Washington, D.C.

U.S. Department of the Interior, Geological Survey. (September 1981) Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee, Interagency Advisory Committee on Water Data. Washington, D.C.

U.S. Geological Survey. (1993) Flood Frequency of Streams in Rural Basins of Tennessee. Water Resources Investigations Report 92-4165. Nashville, Tennessee.

APPENDIX A

Stream Stations, Surveys, and Maps

WHITEOAK (WHITE OAK) CREEK - STREAM STATIONS AND SURVEYS				
Stationing (miles above mouth)		Stream Location	Land Surveys	
2003	1991		section ID	Date and Surveyor
0.40	0.45	below TN Hwy 95	1A	May 1979, DOE
0.55	0.60	TN Hwy 95 and Whiteoak Dam	1C	May 1979, DOE
0.78	0.83	in Whiteoak Lake	2	May 1979, DOE
1.18	1.18	in wetland	3	May 1979, DOE
1.38	1.40	in wetland	4	May 1979, DOE
1.55	1.55	mouth of Melton Branch		
1.62	1.62	vehicle bridge and double "V" weir	5A, 5C	May 1979, DOE
			1.62	July 2003, BWS&C
1.90		berm on west bank	1.89	July 2003, BWS&C
2.22	2.18	trapezoidal weir	6A, 6C	May 1979, DOE
			2.18	July 2003, BWS&C
2.25	2.21	Melton Valley Drive	6C, 7B	May 1979, DOE
2.59	2.55	Third Street	8	May 1979, DOE
2.70	2.66	Parshall flume	2	January 1991, ETE X-10
			2.54	July 2003, BWS&C
2.80	2.74	pedestrian bridge	9	July 2003, BWS&C
2.84	2.78	pedestrian entrance to HTML	3	January 1991, ETE X-10
2.88	2.82	vehicle bridge to HTML	4	January 1991, ETE X-10
2.92	2.87	vehicle bridge to building 4509	10	May 1979, DOE
3.03	2.96	pedestrian bridge	5	January 1991, ETE X-10
			2.96	July 2003, BWS&C
3.08	2.99	vehicle bridge to building 5505	11	May 1979, DOE
3.16	3.06	pedestrian bridge	6	January 1991, ETE X-10
			3.05	July 2003, BWS&C
3.22	3.12	arch vehicle bridge	7	January 1991, ETE X-10
			3.12	July 2003, BWS&C
3.27	3.16	vehicle bridge to building 6011	12	May 1979, DOE
3.36	3.24	White Oak Avenue	13	May 1979, DOE
			3.24	July 2003, BWS&C
3.63	3.47	Melton Valley Access Road	14	May 1979, DOE
3.71	3.55	Bethel Valley Road	15	May 1979, DOE
3.94	3.78	near telephone lines	16	May 1979, DOE
4.13	4.00	at power line right-of-way	17	May 1979, DOE

MELTON BRANCH - STREAM STATIONS AND SURVEYS				
Stationing (miles above mouth)		Stream Location	Land Surveys	
2003	1991		section ID	Date and Surveyor
0.12	0.11	vehicle bridge and singe "V" weir	1	February 1991, MMES
			0.11	July 2003, BWS&C
0.41	0.39	in creek bend	2	February 1991, MMES
0.71		trapezoidal weir	3	February 1991, MMES
0.72	0.67	field road culverts	3	February 1991, MMES
0.96	0.85	near HFIR	4	February 1991, MMES
1.22	1.12	concrete flume	5	February 1991, MMES
1.58	1.48	concrete weir	6	February 1991, MMES
1.77	1.51	mouth of unnamed tributary		
1.78	1.67	above confluence of tributary	7	February 1991, MMES
2.13	1.93	in hollow	8	February 1991, MMES
2.30	2.05	below Melton Valley Drive	9	February 1991, MMES

UNNAMED TRIBUTARY TO MELTON BRANCH - STREAM STATIONS AND SURVEYS				
Stationing (miles above mouth)		Stream Location	Land Surveys	
2003	1991		section ID	Date and Surveyor
0.01	0.11	above confluence of tributary (same as section 7 above)	7	February 1991, MMES
0.16	0.37	Melton Valley Access Road	10	February 1991, MMES

DIGITAL MAP DATA SUMMARY
Digital maps Stateplane projection, NAD83 horizontal datum, NGVD29 vertical datum. Aerial Photography, initially April 10 and 11, 1993 @ 7,200 feet above ground. Aerial Photography, second fly over on April 2 and 3, 1998 @ 7,200 feet above ground. Resulting digital map by National Map Accuracy Standards; 1:2,400 scale, or 1" = 200'.

APPENDIX B

April 2003 Pre-study Assessment of the 1991 Report

Current (2003) Assessment of the December 1991 TVA Report "Flood Analyses for Department of Energy Y-12, ORNL, and K-25 Plants" as it Pertains to Streams and Floodplains in the ORNL Vicinity.

Tennessee Valley Authority (TVA)
April 2003

Summary and Conclusion

As a part of the flood hazard assessment currently underway to meet DOE Facility Safety requirements TVA has carefully examined the 1991 report and the supporting flood models and hydrologic methods used. In addition, a field inspection was carried out on March 27, 2003 to observe changes since 1991 in land use and natural cover, recent construction possibly affecting riparian conditions, and any new stream blockages, bridges, or weirs not noted in the previous study. Although some changes had occurred in all categories, best management practices seem to have been followed such that increases in flood potential have been minimized.

There have been many improvements in analysis methods since publication of the 1991 report, especially in hydraulic flood modeling. Also, those floods which have occurred in the past 12 years have increased the accuracy of flood frequency estimation by extending the observed period of record. This improved technology will have a positive effect on accuracy of the current study and enhance the understandability of results. However, this better definition of flood hazard does not imply a significant change in the magnitude of risk to ORNL facilities. In combination with the field observations noted above, the current assessment is not expected to reveal any findings that significantly differ from those previously published. Therefore, in general, the 1991 study remains a valid assessment of flood risk at ORNL.

Additional Hydrologic Record and Watershed Changes

Discharge estimates were developed in 1991 for frequency floods up to the 500-year using regional relationships based on stream gages in the vicinity. The flood experience over the last decade at these gages will affect recomputed estimates. Updated gage data will also affect the statistical procedures used for estimation of other larger floods.

No urbanization adjustments were made in the Whiteoak Creek and Melton Branch parts of the 1991 study to account for buildings, roads, and other impervious areas because the percentage of these was small compared to the whole watershed. More recent site clearing and other changes resulting from construction could affect updated discharges, although current management practices using retention should minimize the significance. As a percentage of the total Whiteoak Creek watershed, imperviousness is still a small parameter.

As translated through modeling into flood elevations and risk, the updated discharge estimates will probably not produce significant differences. Flood elevations in the 1991 report, therefore, can still be considered generally valid but in need of updating due to elapsed time and moderately changed watershed characteristics.

Changing Standards in Flood Frequency and Dam Safety Analyses

The discharge estimation procedure described above was based on regression equations developed by TVA using accepted procedures outlined in the U.S. Water Resources Council Bulletin 17B. In the last decade the national trend has been to move away from uniquely developed regression equations and instead use similar equations developed by the U.S. Geological Service (USGS) and published for watersheds nationwide. In 1991 results from these USGS equations were compared with the TVA equations and found to be similar, but discharge estimates from the TVA developed equations ranged from 0 to 30 percent less than the USGS relationships for Tennessee. That comparison will again be made and the conclusion could result in adopting USGS relationships. In terms of flood elevations and risk it is expected that the USGS relationships would produce values slightly higher than those published in 1991, although actual study findings could prove differently.

Updates of the United States rainfall atlases are currently underway by the National Weather Service (NWS). These atlases are used in both rainfall frequency analysis and runoff prediction. According to the NWS web site completed atlases for eastern basins are not expected within the time period of 2003 study. Results in western basins have generally shown an upward trend in the frequency of extreme precipitation. When available for eastern basins, this information could likely be used to produce somewhat higher flood elevation predictions for the ORNL vicinity, but those will not be part of the current update.

There has been a considerable amount of research and analysis of dam failure case studies in the last decade with a focus on better modeling procedures to improve on both the prediction time and damage reduction associated with the downstream flood wave. The overwhelming majority of the case studies, however, involve earthen embankments and not high concrete dams such as Norris. Although computer modeling of dam failure and flood waves has been greatly enhanced since 1991, and output information is easier to use, there will likely be no change in postulated dam-failure flood elevations from those published in the 1991.

Flood Hydraulic Models and Current Stream Condition Observations

Although state of the art in 1991 for this type of flood investigation, the U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center has now upgraded their HEC-2 Water

Surface Profiles computer program to a version known as HEC-RAS. USACE no longer supports HEC-2. The HEC-2 flood models for Whiteoak Creek and Melton Branch will be imported into the HEC-RAS program and then modified with current field observations and updated discharge estimates. Minor differences in elevation usually result from this conversion alone. But HEC-RAS provides the modeler with a much wider array of hydraulic choices than those available in HEC-2, such as different types of weirs and flumes, culvert shapes, bridge configurations and surface materials. Therefore, a considerably more accurate hydraulic model will result from using HEC-RAS, but until completed both the magnitude and direction of resulting elevation differences is not known.

In analyzing the existing HEC-2 hydraulic model for Whiteoak Creek some minor but additive errors in stream distances were noted. The effect was to increase the total stream length in the model by about 6% above the true stream length at ORNL. These errors are likely a result of physical measurements on hard copy maps that were not as precise as the maps available for the current study. Along with digital maps and more accurate flood models now available, TVA has developed procedures to avoid such mapping errors. Distance error in a hydraulic model in the positive (excess) direction usually results in higher predicted flood elevations because friction effects are overestimated. However, for a 6% distance error on Whiteoak Creek the elevation increase at most locations would be just hundredths of a foot. Therefore, this error far from invalidates published flood elevations.

As a final point with respect to hydraulics, regular removal of debris and silt deposits within bridges, and the occasional removal of woody growth on stream banks could produce noticeable flood reductions. At many stream locations these flood reduction measures could totally compensate for any elevation increases resulting from watershed changes or other activities in the floodplain.

Stephen C. Allen, PE
TVA River Operations

ORNL 1991 report assessment.doc 4/4/2003 sca