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**ENVIRONMENTAL
RESTORATION
PROGRAM**

**Hydrologic Data Summary for
the White Oak Creek Watershed
at Oak Ridge National
Laboratory, Oak Ridge,
Tennessee
(January-December 1994)**

**D. M. Borders
K. S. Ziegler
D. K. Reece
J. A. Watts
B. J. Frederick
W. L. McCalla
D. J. Pridmore**

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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
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DEPARTMENT OF ENERGY

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Energy Systems Environmental Restoration Program

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Oak Ridge, Tennessee 37831-6285
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ABBREVIATIONS

IST	First Creek raingage
ATDD	Atmospheric Turbulence and Diffusion Division
BMAP	Biological Monitoring and Abatement Program
cfs	cubic feet per second
Ci	curies
CWHMP	Comprehensive Watershed Hydrologic Monitoring Program
CY	calendar year
CYRTF	Coal Yard Runoff Treatment Facility
DCP	Data Collection Platform
DOE	Department of Energy
ECE	Environmental Consulting Engineers
EMP	Environmental Monitoring Program (OECD)
EPA	Environmental Protection Agency
ERMA	Environmental Restoration Monitoring and Assessment
ER	Environmental Restoration
ESD	Environmental Sciences Division
ESP	East Seep monitoring station
ETF	Engineering Test Facility
FY	fiscal year
HEC	Hydrologic Engineering Center
HFIR	High Flux Isotope Reactor
HRT	Homogenous Reactor Test
HSG	Hydrologic Soil Group
LLW	low level waste
MB	Melton Branch
MS	monitoring station
MSL	mean sea level
MSS	multispectral scanning
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRWTF	Non-Radiological Wastewater Treatment Facility
NWT	Northwest Tributary
OECD	Office of Environmental Compliance and Documentation
OREIS	Oak Ridge Environmental Information System
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PWTP	Process Waste Treatment Plant
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	remedial investigation
SI	site investigation
SRS	sediment retention structure

STP	sewage treatment plant
SWSA	Solid Waste Storage Area
TRU	transuranics or Transuranium Processing Facility
USGS	United States Geological Survey
WAG	waste area grouping
WBE	Walker Branch East Fork
WBW	Walker Branch West Fork
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOCHW	White Oak Creek Headwater
WOD	White Oak Dam
WOL	White Oak Lake
WSP	West Seep monitoring station

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PREFACE

This Hydrologic Data Summary for the White Oak Creek Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee (January–December 1994) report (ORNL/ER-313) was prepared as part of a continuing series of annual reports documenting sources of hydrologic data for ER Program activities that use monitoring data to quantify and assess the impact from contaminant releases from ORNL waste area groupings (WAGs). This document continues the characterization of quantity and quality of water in the watershed and provides data needed for long-term assessment of the effectiveness of remedial and restoration activities. It includes data collected during the past year and summarizes data collected over several years to show trends in both spatial and temporal scales. Information provided in this document provides the basis for the results reported in the Surface Water section of the Environmental Restoration Monitoring and Assessment report.

EXECUTIVE SUMMARY

This report summarizes, for the 12-month period January through December 1994, the available dynamic hydrologic data collected on the White Oak Creek (WOC) watershed as well as information collected on surface flow systems in the surrounding vicinity that may affect the quality or quantity of surface water in the watershed. The collection of hydrologic data is one component of numerous, ongoing Oak Ridge National Laboratory (ORNL) environmental studies and monitoring programs and is intended to

1. characterize the quantity and quality of water in the surface flow system,
2. assist with the planning and assessment of remedial action activities,
3. provide long-term availability of data and quality assurance of these data, and
4. support long-term measures of contaminant fluxes at a spatial scale to provide a comprehensive picture of watershed performance that is commensurate with future remedial actions.

Characterization of the hydrology of the WOC watershed provides a better understanding of the processes that influence contaminant transport in the watershed. Identification of spatial and temporal trends in hydrologic parameters and mechanisms that affect the movement of contaminants supports the development of interim corrective measures and remedial restoration alternatives. In addition, on-going hydrologic monitoring supports long-term assessment of the effectiveness of remedial actions in limiting the transport of contaminants across Waste Area Grouping (WAG) boundaries and ultimately to the off-site environment. For these reasons, it is of paramount importance to the Environmental Restoration (ER) Program to collect and report hydrologic data, an activity that contributes to the Surface Water Program of the ER Program.

This report provides and describes sources of hydrologic data for ER activities that use monitoring data to quantify and assess the impact from releases of contaminants from ORNL WAGs. The majority of the data summarized in this report is available from the Oak Ridge Environmental Information System (OREIS). Surface-water data available within the WOC flow system include discharge and runoff and surface-water quality. Climatological data available for the Oak Ridge area include precipitation, temperature, relative humidity, wind speed and wind direction, pan evaporation, and solar radiation. Anomalies in the data and problems with monitoring and accuracy are discussed. Appendices contain daily precipitation measurements, daily discharge at surface-water monitoring stations, descriptions of surface-water monitoring stations located in the vicinity of the WOC watershed, and rating table updates for hydraulic control structures that have been recalibrated since the 1993 report.

1. INTRODUCTION

This report, prepared as part of the Environmental Restoration (ER) Program at Oak Ridge National Laboratory (ORNL), is the seventh in a series of reports that summarize the hydrologic data collected on and in the vicinity of the White Oak Creek (WOC) watershed (Fig. 1). White Oak Creek drains ORNL and receives radioactive and nonradioactive effluents (treated and untreated) from Laboratory activities as well as leachates from subsurface waste storage areas in use since the early 1940s. Sherwood and Loar (1986) summarized the available information on hydrogeological and ecological characteristics of the WOC flow system and the nature and quantity of contaminants released into and from the system. Previous annual summaries of hydrologic data (e.g., Borders et al. 1994) were prepared in response to Sherwood and Loar's recommendation that the hydrology of the WOC watershed be characterized in order to better understand trends in both temporal and spatial patterns of the watershed.

The collection of hydrologic data is an integral component of numerous ongoing ORNL environmental studies and monitoring programs and is designed to help (1) characterize the quantity and quality of water in the flow system, (2) plan and assess remedial action activities, (3) provide long-term data availability and quality assurance, and (4) support long-term measures of contaminant fluxes at a spatial scale to provide a comprehensive picture of watershed performance that is commensurate with future remedial actions. This report continues the characterization and provides the sources of data needed for long-term assessment of the effectiveness of remedial and restoration activities.

1.1 PURPOSE AND SCOPE

This report documents hydrologic data collected in the vicinity of the WOC watershed for the period January 1 through December 31, 1994. Available dynamic hydrologic data collected during 1994, along with information collected on the surface flow systems which affect the quantity or quality of surface water, are summarized. In addition to presenting data collected during the past year, we have attempted to summarize data collected over several years to show trends in both spatial and temporal scales.

1.2 SITE DESCRIPTION

The WOC watershed is located primarily in the Roane County portion of the Oak Ridge Reservation. The headwaters region of WOC, making up the northeast corner of the watershed, lies partially in Anderson County. The WOC watershed is bounded by Copper Ridge to the south, White Wing Road (State Highway 95) to the west, Chestnut Ridge to the north, and approximately the Roane/Anderson County boundary to the east. The majority of ORNL's facilities, active and inactive waste management areas, and potential sources of contaminants lie within the watershed boundaries. Therefore, most waste effluents produced as a result of ORNL operations are released into the WOC system.

WOC rises from springs on the southeast slopes of Chestnut Ridge and, with its tributaries, drains much of Bethel and Melton Valleys (which include ORNL) to the Clinch River. The waters of WOC are impounded by White Oak Dam (WOD), constructed 1.0 km (0.6 miles) upstream from the Clinch River in 1943, to form White Oak Lake (WOL) which serves as a holding pond for ORNL waste effluents. The drainage areas upstream from the Clinch River and WOD are approximately 16.8 km²

Fig. 1. Map of the White Oak Creek watershed with waste area groupings (WAGs) shown.

(6.5 miles²) and 16.0 km² (6.15 miles²), respectively (Energy Systems 1985). Elevations in the watershed range from 225.8 m (741 ft) above mean sea level (MSL) at the mouth of WOC to 413 m (1355 ft) above MSL at the top of Melton Hill, the highest point on the Oak Ridge Reservation (McMaster and Waller 1965; McMaster 1967).

Since WOL was created in 1943, a number of studies have been undertaken to determine contaminant sources, quantities of contaminants released into and retained in the lake, and the geology and hydrogeology of WOC/WOL. Table 1 summarizes some of the more important studies conducted since 1945. In some instances, the references in Table 1 represent summaries of the information; individual investigators have reported in greater detail their efforts in other reports and papers.

White Oak Dam is a low-head structure with a normal lake elevation of 227.1 m (745 ft). The reservoir is only 1.2 m (4 ft) above full-pool elevation in the Clinch River, which is 225.8 m (741 ft). Cox et al. (1991) indicated that the volume of WOL at normal pool level was approximately 43,890 m³ (1,546,330 ft³) in the summer of 1988. Flow from WOL discharges through a weir and concrete-box culvert to the lower reach of WOC. In 1983, the flow system at the dam was modified to increase flood discharge capacity to approximately 56.6 m³/s (2000 cfs). Tschantz (1987) estimated the 100-year flood peak discharge to be approximately 44.6 m³/s (1574 cfs).

Until 1992, backwater from the Clinch River created an embayment in WOC below WOD only when the Watts Bar Reservoir was near full pool level (approximately April to October). The WOC Embayment (WOCE) extends 1 km (0.6 mile) downstream from WOD to its mouth at Clinch River kilometer 33.5 (Clinch River mile 20.8). Water levels and flow in the WOCE were largely controlled by the operation of Melton Hill Dam [3.7 km (2.3 miles) upstream on the Clinch River] and summer and winter pool levels on Watts Bar Reservoir, formed by Watts Bar Dam [94 km (58.8 miles) downstream on the Tennessee River]. When the generators at Melton Hill Dam are operating, the release of water from the dam can increase the depth of water at the mouth of the embayment by over 0.3 m (1 ft) in two minutes. When the generators shut down, the water level drops almost as quickly. This rapid change in water level and pulsing of flow caused by daily peaking operations at Melton Hill Dam were contributing to the erosion of sediments from the embayment. Water levels typically vary by approximately 0.6–1.2 m (2–4 ft) per day, with monthly ranges up to 2.5 m (8 ft) or more.

A sediment retention structure (SRS), constructed at the mouth of WOC on the Clinch River, was completed in April 1992. It was constructed to reduce the scour of contaminated sediments in the WOCE. The spillway of the retention structure consists of sheet pile coffer cells constructed to an elevation of 738 ft MSL with gabions on top of the cells to elevation 743 ft MSL. This limits the winter drawdown in the embayment to an elevation greater than 738 ft MSL, resulting in a year-round embayment below WOD. The gabions form a permeable crest intended to attenuate the rapid rise and drawdown resulting from the diurnal pulsing of Melton Hill Dam.

1.3 GEOLOGY AND SOILS

Four major geologic units underlie the WOC drainage basin. All formations strike northeast at about 56° and dip southeast at angles between 30° and 40°. The Knox Group (Cambrian and Ordovician Age) underlies Chestnut and Copper ridges, which bound the WOC drainage basin to the north and south. The Knox Group, mostly composed of cherty dolomite in which sinkholes and caverns have developed, is the principal water-bearing formation in the watershed. The springs along the southeastern

Table 1. Historical changes in the surface of White Oak Lake and major events associated with significant changes in the lake

DATE	SURFACE AREA (ha)	EVENTS	REFERENCES
1941	NA	Highway fill and culvert installed by TVA	Smith (1945) as in Krumholz (1954a)
1943	14.5	(a) Sheet piling dam installed with spillway with vertical sliding gate; (b) Generation of radioactive waste at ORNL began and lake served as final settling basin (750 ft MSL)	(a) Krumholz (1954b,c); (b) Clinch River Study Steering Committee (1967)
1944	NA	Dikes at WOC km 3.3 and 3.9 washed out (7.75 in., 26 h, 3.5 in. runoff)	Setter and Kochtitsky (1950)
1945	12.2	Investigation of structural strength of dam (746.5 ft)	Oakes et al. (1982)
1948	10.3	Lake lowered to 745.5 ft to facilitate sediment sampling, normal operation from 1948 to 1955 varied from 747–749 ft	Oakes et al. (1982)
1953	NA	Lake partially drained during rotenone survey of fish populations	Oakes et al. (1982)
1955	2.8	Lake drained; radionuclides in lake sediment and water believed to be in equilibrium so lake served no useful function in retaining radioactivity but could function as an emergency storage basin	Clinch River Study Steering Committee (1967)
1956	0.4	Significant releases of ^{137}Cs probably from erosion of freshly exposed sediment after lake was drained.	Lackey (1957)
1959	NA	Gate structure renovated to prevent inflow of backwaters from Clinch River	Clinch River Study Steering Committee (1967)
1960	3.2	Dam closed, surface level raised	Kolehmainen and Nelson (1969)
1963	6.0	Completion of Melton Hill Dam	Kolehmainen and Nelson (1969)
1967	8.1	None reported	McMaster (1967)
1969	10.5	None reported	Kolehmainen and Nelson (1969)
1979	4.6	Lake level gradually dropped from 745 to 742 ft due to potential instability of the dam	Oakes et al. (1982)
1980	6.9	Construction of a berm to stabilize dam was completed	Boyle et al. (1982)
1983	6.9	Discharge channel and weir constructed, roadbed rerouted	
1988	6.9	Estimate of surface area and volume (43,900 m ³) at lake level of 745 ft	Cox et al. (1991)
1992	6.9	Sediment retention structure constructed at mouth of WOC on the Clinch River	
1994	6.9	Beaver dam discovered in upper WOL, additional 0.03 ha inundated	
1995	5.93	Estimate of surface area and volume of WOL (48,900 m ³) at lake level of 745 ft	ECE survey for WAG 2 RI (unpublished)

slopes of Chestnut Ridge are the principal sources of the base flow in the upper portion of WOC (McMaster and Waller 1965).

The Chickamauga Group (Ordovician Age) underlies Bethel Valley, where the ORNL Main Plant area, and Solid Waste Storage Areas (SWSAs) 1, 2, and 3 are located. This formation is primarily limestone, interbedded with shales, siltstones, and bedded chert. Generally, the strata are thin- to medium-bedded. Solution openings and fractures occur in the Chickamauga, but the openings are smaller than in the Knox Group.

The Conasauga Group (Cambrian Age) underlies Melton Valley, where SWSAs 4, 5, and 6, and the pits and trenches area are located. The stratigraphic sequence through the Conasauga formation is gradational, from shale at its base to bedded limestone at the top. WOL and the lower part of WOC rest on limestone or shaley limestone of the Conasauga Group.

The Rome Formation (Cambrian Age) is exposed along Haw Ridge. This formation consists of sandstone, shale, siltstone and locally, dolomite.

The Knox Group and the underlying Maynardville Limestone of the Conasauga Group form the Knox aquifer (Solomon et al. 1992), which is the source of most natural base flow in streams in the WOC basin.

The Rome Formation, the Conasauga Group and the Chickamauga Group discharge smaller quantities of water to the streams. Water is found in weathered rock of all units near land surface.

The soils of Roane County were mapped in the 1930s and the results were published in 1942 (Swann et al. 1942). Tschantz and Rghebi (1989) analyzed soil survey maps of Roane and Anderson Counties and identified approximately 40 different soil groups in the WOC watershed. The soils, most of silty or very fine loam texture, fall into three of the four major hydrologic soil groups (HSGs).

Using the U.S. Department of Agriculture Soil Conservation Service system (SCS 1965), soils categorized into the four hydrologic soil groups are denoted by the letters A, B, C, and D. Soils in the A group have high infiltration rates. They are chiefly deep, well drained sands or gravels with low runoff potential. Soils in the B group have moderate infiltration rates. They are mostly moderately deep, well drained soils of moderately fine to moderately coarse texture. Soils in group C have slow infiltration rates. They are mostly moderately deep, well-drained soils of moderately fine to moderately coarse texture. Soils in group D have very slow infiltration rates and a high runoff potential. They are chiefly clay soils with a high swelling potential, soils with a permanently high water table, soils with a clay pan at or near the surface, and shallow soils over nearly impervious materials.

Soils in the WOC watershed are clustered into six broad bands running east to west (ORNL grid) (Fig. 2). Soils are distributed in the watershed as follows: 54.1% of the watershed area is HSG B, 20.0% is HSG C, and 25.9% is HSG D. Therefore, the natural soils of the watershed, in both Bethel and Melton valleys, have relatively slow infiltration rates and tend to yield relatively high runoff. The SCS hydrologic classification of soils does not make the distinction between overland flow and storm flow that is part of the conceptual hydrologic model for the Oak Ridge Reservation (Solomon et al. 1992).

Fig. 2. White Oak Creek watershed soils classified according to hydrologic soil groups (HSGs).

1.4 CONTAMINANTS IN THE WOC WATERSHED

Water in WOL contains measurable quantities of dissolved ^3H and ^{90}Sr , which are released through the monitoring station at WOD. Controlled releases of ORNL treated and untreated effluents to WOC include those from the Process Waste Treatment Plant (PWTP), the Sewage Treatment Plant (STP), the Coal Yard Runoff Treatment Facility (CYRTF), and a variety of process waste holding ponds scattered throughout the ORNL complex. The PWTP effluent goes to the Non-Radiological Wastewater Treatment Facility (NRWTF) before being discharged into WOC. The WOC flow system also receives effluent through both surface and groundwater flow from nonpoint sources, the SWSAs and low level waste (LLW) pits and trenches. Sediments within the WOC flow system have sorbed chemical and radioactive contaminants and have accumulated in the WOC floodplain and WOL. Oakes et al. (1982) estimated that approximately $5 \times 10^6 \text{ ft}^3$ of contaminated sediment had collected in the lake bed since 1943. The sediment in the lake bed contains an estimated 650 Ci of radioactive isotopes, primarily ^{137}Cs , ^{60}Co , and ^{90}Sr . These estimates will be revised according to the results of efforts by the WAG 2 RI program to be conducted in FY 1994 and beyond. During periods of heavy runoff, dissolved radionuclides and resuspended and new suspended, contaminated sediment are released from the lake into the WOCE and the Clinch River.

1.5 STATION UPGRADE AND MAINTENANCE

The integrity of the system that monitors surface-water discharge on the WOC watershed has been deteriorating for several years due to the unmitigated deposition of sediments in stilling pools, inadequate design and lack of calibration of engineered flow measurement devices, and general lack of a consistent and comprehensive monitoring station and channel maintenance program. This section addresses the problems encountered in monitoring surface-water discharge and collecting data at sites in the WOC watershed and vicinity. Accurate, continuous discharge measurements are critical to the ER Program's goal of quantifying and characterizing contaminant discharges from waste sites at ORNL for identification, design, and assessment of future remedial actions.

In the early 1980s, the primary surface-water monitoring stations on WOC and Melton Branch (MB), above their confluence, and at WOD, were upgraded (redesigned) for improved discharge measurements and water quality sampling. At each site, the engineered hydraulic control (i.e., flow measurement structure) consists of separate low-flow and high-flow devices (i.e., weirs) for measuring discharge. The low-flow weirs were designed to accurately measure a range of flows from the minimum expected to occur at the respective site to a given flow rate considerably higher (by a factor of two or more) than wet season base flow rates. The high-flow weirs were designed to measure flows in a range from slightly less than the maximum low-flow weir discharge to maximum discharges associated with a moderate to extreme flood event of approximately 25- to 100-year return periods.

The original stage-discharge relationships for these three monitoring stations were developed from scale model tests. In 1984-85, the low-flow control devices (sharp-crested V-notch weirs on WOC and MB and a sharp-crested trapezoidal weir at WOD) were field rated by volumetric measurements made over a range of flows. These field ratings indicated that the original model calibrations were significantly in error. Until recently, the high-flow control devices (broad-crested weirs) had never been field-rated to verify or adjust the stage-discharge relationships for determining discharge. Standard theoretical derivations for each site indicate high-flow stage-discharge relationships significantly disagree with the original relationships. For example, data collected in FY 1995 by the USGS indicate that the maximum

discharge at WOD, for a stage of 2.74 m (9 ft), calculated by the original scale model relationship and the theoretical relationship, is 2005 and 1860 cfs, respectively.

Similar conditions exist at the WOC and MB monitoring stations. However, at the MB station, much greater errors in discharge measurement occur under high-flow conditions due to submergence (drowning out) of the broad-crested weir. This is caused by the channel downstream from the monitoring station becoming constricted due to natural and man-made constraints. The natural channel downstream from the weir is narrow and further constricted by dense vegetation. In addition, a concrete trunk line runs under the channel bed (perpendicular to the channel) and serves as a limiting control for possible channel improvements. At high flows, the tailwater, unable to drain freely due to inadequate channel capacity, backs up and rises above the crest of the weir, drowning out the structure. At some critical degree of submergence (the ratio between the depth of water over the weir crest on the downstream side to the depth of water above the weir crest on the upstream side), the broad-crested weir no longer performs as designed. Above this critical degree of submergence, generally accepted to be about 70% for rectangular broad-crested weirs, the upstream stage (head) over the weir begins to rise disproportionately to the discharge and the stage sensor detects an elevated stage for a given flow rate. Therefore, the monitoring station instrumentation calculates a higher flow rate than is actually occurring.

A theoretical rating has been developed at the MB monitoring station that uses the low-flow control with an extended rating for stages above the wall (weir sill) containing the sharp-crested weir. This theoretical rating provides an alternative calculation that essentially "corrects" for submergence effects. The method used for developing this extended rating is consistent with that used by the USGS in the past. The ESD Hydrology Group uses this extended rating to calculate flows at the MB monitoring station for flows which exceed the capacity of the low-flow weir (34.7 cfs). In 1994, approximately 15 discrete storm events produced peak flow rates above this value. Compared to the extended rating, the standard rating (with submergence) consistently overestimates the peak instantaneous flow rate for major storms by approximately 200%.

Stage data collected during major storm events in 1993 and 1994 have verified that the high-flow control device (broad-crested weir) at the WOC Monitoring Station (MS3) also becomes submerged periodically due to backwater from WOL and the WOC floodplain. However, this is a transient condition occurring less frequently and for relatively short intervals. An extended rating, similar to that applied to high flows at MB MS4, has been developed and utilized to "correct" discharge calculations for flows occurring under submerged conditions.

Periodic submergence of the high-flow outlet structure at WOD, due to backwater from elevated stage in the Clinch River, has been identified. This condition, if unaccounted for, can cause significant errors in discharge measurement. According to Bos (1990) the high-flow control (triangular broad-crested weir) can sustain submergence of 80% without suffering a significant reduction in flow. However, above 80%, the reduction due to submergence increases geometrically. A correction factor (or drowned-flow reduction factor) is applied to calculations during periods of high flow where submergence above 80% has occurred. In calendar year (CY) 1994, the broad-crested weir at WOD was submerged above 80% during several high-flow events. During the late March event, submergence greater than 100% occurred several times, therefore negative (reverse) flows were recorded at WOD. Figure 3 illustrates the significance of submergence on calculated discharge during this event.

Submergence of the low-flow control device (Cipolletti weir) at WOD has recently become a significant problem (see Section 1.2). The SRS, as designed, is a permeable gabion dam with a crest elevation of 226.5 m (743 ft) msl and an impermeable crest (coffer cell) at 224.9 m (738 ft) msl. Under

White Oak Dam

March 26-April 1, 1994

Fig. 3. White Oak Dam submergence conditions for March 26–April 1, 1994.

low-flow conditions, the stage behind the SRS should remain well below the gabion crest, because water should flow through the gabions. However, since its construction in the spring of 1992, the elevation of water behind the SRS, under low-flow conditions, has steadily risen due to the clogging of the SRS with sediment and aquatic vegetation and/or the deposition of sediment behind the structure. At the time this report was prepared, the low-flow weir appears to be submerged to some degree most of the time. This condition will only affect discharge measurements under low-flow conditions (≤ 14.6 cfs). However, unlike broad-crested weirs, a Cipolletti weir cannot sustain a significant degree (%) of submergence without suffering a significant reduction in accuracy (degree of error). This condition is being accounted for by applying theoretical computational corrections to all affected data. However, the conditions causing the problem should be mitigated and the correction method should be field-verified.

The high-flow measurement control devices on WOC and MB are currently being field-rated by USGS Water Resources Division staff for verification of (or adjustment to) the standard or extended stage-discharge relationships currently being used for discharge calculations at these sites. The resulting relationships will be incorporated into the data processing procedures for discharge calculations. Preliminary results indicate that the procedure (calculation method), applying an extended stage-discharge relationship, currently utilized at MB is valid. At WOC, preliminary results indicate a significant adjustment, resulting in lower flows, to the standard stage-discharge relationship. However, the results are inconsistent (and therefore inconclusive) due to inadequate measurement conditions. Initially, measurements were made by lowering a current meter down over the broad-crested weir where velocities are high (shallow depth of flow) and lateral currents are prevalent and erratic. Future measurements will be made from a foot bridge located downstream from the monitoring station. This location should provide adequate conditions for making measurements over a range of discharge conditions.

The USGS also began field-rating the high-flow control at White Oak Dam during the late winter of 1995. Measurements are made with a Neil Brown acoustic velocity meter in the section between the dam sluice gates and the high-flow control structure (triangular broad-crested weir). Conventional discharge measurement methods, including the use of a standard Price-type current meter, were inappropriate due to the configuration of the dam and hydraulic control structure and the prohibitively low velocities under a significant range of flow conditions. Preliminary results (Fig. 4) indicate a significant adjustment to the stage-discharge relationship versus the standard model rating (currently used for discharge calculations) and the theoretically derived rating. Applying the preliminary rating to CY 1994 stage data, the annual average discharge at White Oak Dam (21.1 cfs) is approximately 11% higher than the standard rating (19.0 cfs). The USGS rating will be refined and adjusted after additional measurements are collected and the standard rating will be replaced for discharge calculations henceforth. In addition, historic discrepancies in water balance and mass flux calculations will be reevaluated.

The accuracy of discharge measurements at surface-water monitoring stations in the WOC watershed is being significantly degraded due to deposition of sediment and debris during high-flow events resulting from heavy rainfalls. At the primary monitoring stations on WOC and MB, the sediment and debris have essentially filled the stilling pools. At MB (MS4), sediment is now depositing on the downstream side of the station indicating that the "stilling pool" has filled to capacity and the stream has reached an equilibrium condition. That is, the approach to the sharp-crested (low-flow) weir at this station will not worsen substantially henceforth.

At least two projects have been initiated to alleviate the problems with sediment deposition at a number of sites on the WOC watershed. One project consists of removing the deposited sediments from the stilling pools at the WOC (MS3) and MB (MS4) monitoring stations. This task calls for removal

White Oak Dam

USGS, Standard, and Theoretical Ratings

Fig. 4. White Oak Dam preliminary USGS stage-discharge relationship vs theoretical and model ratings.

of approximately 250 cubic yards of material from each site. This corresponds, approximately, to the original geometry of the approach channels as constructed in the early 1980s. This effort could be completed in the summer of 1995. A second project is tasked with upgrading four smaller tributary monitoring stations on the WOC watershed. These upgrades will be completed separately beginning with channel dredging and instrument upgrades at the Northwest Tributary (NWT) monitoring station in the summer of 1995. The other three sites are the West Seep (WSP), East Seep (ESP), and Homogeneous Reactor Test (HRT) monitoring stations. Their upgrades will be completed according to a schedule not yet determined.

1.6 FLOW FREQUENCY ANALYSES

Whereas the emphasis for most compliance monitoring is to document and compare contaminant concentrations relative to concentration limits set forth in regulations, for the ER Program the important information is contaminant flux, typically quantified over a period of 12 months. An appropriate measure of success for remedial actions is the reduction of this annual flux measured at key points in the hydrologic system. Measurement of the long-term contaminant flux is important because a decrease or increase in flux may lead to favorable or unfavorable assessments, respectively, of the consequences to potential health risks for individuals downstream from the Laboratory.

To generate a record of the annual flux, it is necessary to have complete and accurate flow measurements and flow-proportional water quality samples. In situations where contaminant concentrations are correlated to flow, it is possible to intensively sample stream water during storms and use these data, together with a correlation model and the annual streamflow hydrograph, to estimate annual fluxes. In all cases, reliable flow data are needed throughout the entire year.

Flow-frequency analyses are a standard method for evaluating the flow regime. These analyses indicate the magnitude and frequency of flows expected. However, the emphasis on monitoring is on measuring the total amount of contaminant discharged (product of flow rate, time, and concentration). High flows carry a disproportionate amount of contaminants for these small streams and tributaries. Therefore, it is important to measure the flow over a large fraction of the total flow volume rather than over a large fraction of the elapsed time. Volume-frequency analyses provide the necessary information to accomplish this strategy. Design flow ranges may be determined from a combination of these analyses to meet the Department of Energy (DOE) order 5400.1, General Environmental Protection Program and DOE order 5400.5, Radiation Protection of the Public and the Environment requiring the monitoring of contaminant releases in stream water on a regular schedule.

Flow-frequency and volume-frequency analyses were performed on continuous breakpoint data sets for five surface-water monitoring stations on the WOC watershed: WOC (MS3), MB (MS4), WOD (MS5), and the East Seep (ESP) and West Seep (WSP) monitoring stations (Fig. 5). ESP and WSP each had approximately six years (1989–1994) of continuous data available for analysis, while each of the other three had five years (1990–1994) of continuous data (Figs. 6–10). Figure 10, for WSP, shows the flow-frequency curve (flow vs frequency) and the flow volume fraction curve (flow vs volume fraction) for the 6-year data set. The data show that discharge was between 0.1 and 1 cfs approximately 50% of the time, with discharge seldom falling below 0.01 cfs (< 5% of the time) and seldom exceeding 10 cfs (< 5%). This period of record is not enough to analyze frequency to accurately determine the discharge associated with infrequent return periods. However, the data should be adequate to bracket the 95th percentile. That is, discharge at WSP is between 0.01 and 5 cfs approximately 95% of the time. Volumetrically, 95% of the flow occurs between 0.1 and 40 cfs. This is because a disproportionately

Fig. 5. Locations of surface-water monitoring stations in the vicinity of the White Oak Creek Watershed.

Fig. 6. Flow-frequency and flow-volume fraction curves for the White Oak Creek monitoring station (MS3), based on five years of 15-min discharge data.

Fig. 7. Flow-frequency and flow-volume fraction curves for the Melton Branch monitoring station (MS4), based on five years of 15-min discharge data.

Fig. 8. Flow-frequency and flow-volume fraction curves for the White Oak Dam monitoring station (MS5), based on five years of 15-min discharge data.

Fig. 9. Flow-frequency and flow-volume fraction curves for the East Seep monitoring station, based on six years of 15-min discharge data.

WEST SEEP MONITORING STATION

Fig. 10. Flow-frequency and flow-volume fraction curves for the West Seep monitoring station, based on six years of 15-min discharge data.

high percentage of total flow (volume) passes a point on a stream during a few major storms, whereas a small percentage of total flow (volume) passes under normal flow conditions. For example, flows of 0.1 cfs and less occur approximately 35% of the time, yet account for less than 5% of the total flow volume. Conversely, flows of 1 cfs and greater occur less than 15% of the time, yet account for nearly 70% of the total flow volume. Likewise, flows of 10 cfs and greater occur only about 1% of the time, yet account for approximately 20% of the total flow volume. This emphasizes the need to consider the discharge volumetrically because the percentage of contaminants passing a point in a stream more closely parallels flow volume.

2. HYDROLOGIC DATA

The collection of hydrologic data in the WOC watershed began with facility planning studies in the early 1940s. Collection of these data has developed into a long-term program of environmental research studies and monitoring activities required to cope with the Laboratory's unique waste management needs.

The hydrologic data available for the report period were derived largely from ongoing studies of the ORNL ER Program and, to a lesser extent, from the continuing effluent and environmental surveillance monitoring conducted by the Environmental Monitoring Program (EMP) of the Office of Environmental Compliance and Documentation (OECD). Much of this monitoring is associated with the National Pollutant Discharge Elimination System (NPDES) permit for ORNL operations (EPA 1986). The following sections provide information on hydrologic data available in the OREIS data base and data summaries for selected stations.

2.1 CLIMATE

Precipitation, temperature, humidity, wind speed and wind direction, solar radiation, relative humidity, and pan evaporation data are available from stations located in the vicinity of the WOC watershed (Table 2). The period of record varies from station to station. The National Oceanic and Atmospheric Administration/Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) monitoring station, located in Oak Ridge about 15.4 km (9.6 miles) north of the center of the watershed, is the closest long-term meteorological station, with records dating from 1947.

Precipitation is probably the most important climatic factor in hydrologic studies, since it establishes quantity and variations in runoff and streamflow. It also replenishes groundwater. Maximum, mean, and minimum annual precipitation for stations near ORNL during the period 1954–1983 were 190.0, 132.6, and 89.7 cm (74.8, 52.2, and 35.3 in), respectively (Webster and Bradley 1987). Monthly precipitation at the NOAA/ATDD station generally ranges from 13.46 to 15.75 cm (5.3–6.2 in.) during the wettest months (January–March), and from 7.37 to 9.65 cm (2.9–3.8 in.) during the driest months (August–October) (Borders et al. 1994). The normal (mean) precipitation for the NOAA/ATDD station, based on the 30-year (1963–1994) period of record, is 136.8 cm (53.86 in.). Table 3 shows the frequency of occurrence for precipitation at various intensities over periods of 5 minutes to 24 hours (Huff and Frederick 1984). The mean annual runoff for streams in the ORNL area is 56.6 cm (22.3 in.) (McMaster 1967). The remainder of the mean annual precipitation, about 76.2 cm (30 in.), is consumed by evapotranspiration. Precipitation in 1994 at the NOAA/ATDD monitoring station totaled 65.57 in., the seventh wettest year on record (1948–1994).

Figure 11 shows meteorological stations for which data are available through the OREIS data base system and Table 4 contains site descriptions and information on data collection methodology. The ETF station was discontinued on June 6, 1994, and the ISH and BUR stations were discontinued on January 1, 1995. Table 5 displays monthly precipitation for the period January through December 1994 at sites in the vicinity of the WOC watershed and at the NOAA/ATDD station in Oak Ridge. Daily precipitation at these sites is shown in Appendix A.

Table 2. Meteorological stations in the vicinity of the WOC watershed^a
(adapted from Boegley et al. 1985)

STATION DESCRIPTION	LOCATION	PERIOD OF RECORD	MEASUREMENTS
Knoxville (TYS) ^b	McGhee Tyson Airport	1942–Present	Precipitation, wind, temperature, temperature gradient, and humidity
Oak Ridge (NOAA/ATDD)	City	(a) 1947–Present (b) 1947–1979	(a) Precipitation, temperature, and temperature gradient; (b) wind
First Creek (1ST)	ORNL	1987–Present	Precipitation ^c
USGS 7500 Bridge (7500B)	7500 Bridge	1987–Present	Precipitation ^c
ETF	SWSA 6	1980–1994 (May)	Precipitation ^c
SW4	SWSA 4	1986–Present	Precipitation ^c , temperature, wind speed and direction, solar radiation, relative humidity, and pan evaporation ^d
ISH	Ish Creek	1982–1994	Precipitation ^c
RG1	Walker Branch	1982–Present	Precipitation ^c
RG3	Walker Branch	1982–Present	Precipitation ^c
BUR	Bear Creek Burial Ground	1985–1994	Precipitation ^c
49T	SWSA 6	1986–Present	Precipitation ^c
SW7	SWSA 7	1984–Present	Precipitation ^c

^aMeteorological measurements have been made at various times at the Y-12 Plant, the K-25 site, an early ORNL station, and the Tower Shielding Facility.

^bMeasurements also exist for the period 1871 until the station was moved to McGhee Tyson Airport.

^cPrecipitation gages are not equipped to measure snowfall.

^dRecords are discontinuous for all parameters collected at this site.

**Table 3. Rainfall vs frequency for areas up to 25.9 km² (10 miles²) in Anderson and Knox counties, Tennessee
(adapted from Huff and Frederick 1984)
Units = mm^a**

DURATION FREQUENCY (years)	MINUTES ^b					HOURS ^c				
	5	10	15	30	60	2	3	6	12	24
2	10.9	16.5	20.3	29.0	38.1	45.7	50.8	61.0	71.1	83.8
5	12.7	19.8	24.9	35.3	47.3	61.0	63.5	76.2	91.4	106.7
10	14.2	22.6	28.5	41.9	55.9	68.6	73.7	88.9	104.1	121.9
25	16.3	26.2	33.0	48.0	63.5	76.2	86.4	99.1	119.4	139.7
50	18.0	29.2	36.8	53.6	71.1	86.4	94.0	119.4	134.6	154.9
100	19.6	32.0	40.6	59.9	78.7	96.5	101.6	124.5	144.8	167.6
Probable maximum, 6-h duration: 723.9										

^a1 mm = 0.04 in.

^b2-, 100-year and 5-, 15-, and 60-min data are from maps in NWS HYDRO-35 (Frederick et al. 1977). All other "minute" data are calculated using appropriate equations from the same publication. These equations are:

10 min: $(0.59)(15 \text{ min}) + (0.41)(5 \text{ min})$

30 min: $(0.49)(60 \text{ min}) + (0.51)(15 \text{ min})$

5 year: $(0.278)(100 \text{ year}) + (0.674)(2 \text{ year})$

10 year: $(0.449)(100 \text{ year}) + (0.496)(2 \text{ year})$

25 year: $(0.669)(100 \text{ year}) + (0.293)(2 \text{ year})$

50 year: $(0.835)(100 \text{ year}) + (0.146)(2 \text{ year})$

^cInterpolated from maps in USWB TP 40 (Hershfield 1961).

Fig. 11. Meteorological stations in the White Oak Creek watershed for which data are available through the OREIS data base system.

Table 4. Precipitation measurement descriptions for stations located in the WOC watershed and the NOAA/ATDD Oak Ridge station

STATION DESCRIPTION	TYPE OF GAGE	FREQUENCY OF DATA COLLECTION	SMALLEST UNIT OF MEASURE FOR GAGE (in.)
Oak Ridge (ATDD)	Belfort Weighing Bucket & Stick	Hourly	0.01
First Creek (1ST)	Belfort Weighing Bucket	Hourly	0.01
USGS 7500 Bridge (7500B)	Electric Tipping Bucket	15 min	0.01
ETF ¹	Belfort Weighing Bucket	Hourly	0.01
SW4	Belfort Weighing Bucket	Hourly	0.01
ISH ²	Belfort Weighing Bucket	Hourly	0.01
RG1	Belfort Weighing Bucket	Hourly	0.01
RG3	Belfort Weighing Bucket	Hourly	0.01
BUR ²	Belfort Weighing Bucket	Hourly	0.01
49T	Belfort Weighing Bucket	Hourly	0.01
SW7	Belfort Weighing Bucket	Hourly	0.01

¹Station was discontinued on June 6, 1994

²Station was discontinued on January 1, 1995

**Table 5. Monthly precipitation totals at the WOC watershed and NOAA/ATDD stations
for the period January–December 1994**

Units = cm

DATE	1ST	ETF ²	SW7	49T	SW4	ISH ³	RG1	RG3	BUR ³	ATDD Actual	ATDD Normal
January 1994	15.80	16.50	14.90	15.50	15.40	15.60	15.50	15.60	15.70	15.70	8.90
February 1994	24.20	25.90	23.90	24.30	24.10	24.40	24.70	25.00	25.90	25.10	10.00
March 1994	29.00	30.10	27.20	28.10	28.60	29.00	26.20	25.10	25.60	24.30	14.40
April 1994	21.20	22.50	21.10	21.20	21.00	21.40	22.80	22.50	23.30	25.20	9.80
May 1994	8.40	10.40	7.30	9.90	8.20	8.60	7.00	7.10	7.10	7.80	8.50
June 1994	17.10		14.60	15.30	15.70	16.60	18.30	18.50	19.90	18.30	6.90
July 1994	10.20		9.30	14.80	12.60	13.30	11.00	11.70	12.90	14.20	10.30
August 1994	12.00		10.80	9.20	11.20	12.10	10.60	11.20	11.10	9.90	13.60
September 1994	6.50		5.00	6.90	6.20	5.20	7.30	7.40	7.70	5.50	13.30
October 1994	5.30		5.30	5.30	5.30	5.40	5.30	5.50	5.60	6.60	13.30
November 1994	9.10		8.60	8.40	8.70	9.00	9.60	9.10	8.00	8.50	13.80
December 1994	6.50		6.20	6.40	6.50	6.50	6.30	6.40	6.70	7.20	10.70
CY ¹ Total (cm)	165.20		154.20	165.40	163.70	167.10	164.50	165.20	170.20	168.30	133.50

¹CY - Calendar Year

²Station was discontinued on June 6, 1994

³Station was discontinued on January 1, 1995

Precipitation for the current reporting period (January–December 1994) averaged 164.5 cm (64.75 in.) for raingages in the vicinity of the WOC watershed. Precipitation measured at the NOAA/ATDD station was 168.3 cm (66.26 in), 122% of normal for the 30-year period of record. Table 5 shows precipitation at the NOAA/ATDD station was below average for 6 months and above average for 7 months of the current reporting period, resulting in an above-normal year with a surplus of approximately 29.8 cm (11.75 in) for the 12-month period. Figures 12 and 13 show the annual plots (hyetographs) of daily precipitation at the First Creek (1ST) raingage in the WOC watershed and the NOAA/ATDD station in Oak Ridge for the 12-month reporting period.

Tables 6 and 7 display maximum storm event analyses for stations 1ST and the 49 Trench Area (49T) for the cumulative period of calendar years 1990–1994. Analyses were performed at each site to determine the maximum total rainfall recorded for durations of 1, 2, 3, 6, 12, 24, 48, and 72 hours over the 5-year period. The maximum storms of short duration and high intensity, commonly associated with convective thunderstorm events, occurred during the spring and summer months, while the maximum storms of long duration occurred in the late fall and winter months. At both stations, storms of 1- to 6-h duration occurred in May and/or April while storms of 12- to 72-h duration occurred in late November and December and/or March.

2.2 SURFACE WATER

Data on surface-water discharge and quality have been and are being collected at several sites in the WOC flow system: (1) from numerous studies conducted by the ER Program, (2) as part of the EMP monitoring and compliance program associated with the NPDES permit, (3) from numerous ESD research projects, and (4) as independent research. Some water quality data are also collected periodically as part of the Biological Monitoring and Abatement Program (BMAP), which is required by the NPDES permit (Ashwood 1994).

2.2.1 Discharge

Data on streamflow in the vicinity of the WOC watershed are collected by ESD, the USGS, and EMP. Historical daily streamflow data from approximately 21 sites (Fig. 5) in the WOC system are available in the OREIS data base. Three sites—WOD (MS5), WOC (MS3), and MB (MS4)—are operated by EMP as part of the NPDES permit requirements, and six sites are currently operated by the USGS as a component of ER Program studies to isolate individual contributions from upstream hydrologic units and for application in modeling studies. An additional EMP site [WOC Headwaters (WOCHW) monitoring station] was established on WOC, upstream of all ORNL facility effluents and Bethel Valley Road, to monitor background water quality and flow in the headwaters area.

Stream discharge data are also currently being collected by ESD's Hydrology Group at ten sites. Discharge is monitored simultaneously at the four EMP stations (above) and at six additional surface-water monitoring stations independently. These include two sites (ESP and WSP) on tributaries that drain the pits and trenches area (WAG 7) northeast of WOL, one site (MS1) that drains SWSA 4 to the south into WOC, and three sites located outside the WOC watershed. These are Raccoon Creek, which drains a portion of WAG 3 into the Clinch River, west of State Highway 95 (Fig. 5), and the East and West forks of Walker Branch (WBE and WBW, respectively) (Fig. 14). Figures 15–17 show discharge hydrographs for the three major monitoring stations on WOC (MS3), MB (MS4), and WOD (MS5) for the 12-month reporting period.

NOAA/ATDD Raingage

Oak Ridge, TN

Fig. 13. Daily precipitation measured at the NOAA/ATDD raingage in Oak Ridge during the period January–December 1994.

1ST Raingage

Fig. 12. Daily precipitation measured at the First Creek (1ST) raingage in the White Oak Creek watershed during the period January–December 1994.

Table 6. Maximum storm event analysis for the 1ST station

RECORD BEGINS ON JANUARY 1, 1990 AT .00 HOURS RECORD ENDS ON DECEMBER 31, 1994 AT 24.00 HOURS			
DURATION (h)	DATE	START TIME (h)	RAINFALL (in.)
1.00	May 1, 1990	15.31	2.02
2.00	May 1, 1990	15.31	2.04
3.00	May 1, 1990	15.31	2.07
6.00	April 12, 1994	18.48	2.17
12.00	December 4, 1993	2.85	3.10
24.00	March 26, 1994	23.65	4.51
48.00	November 30, 1991	18.50	6.05
72.00	November 30, 1991	10.02	7.01

Table 7. Maximum storm event analysis for the 49T station

RECORD BEGINS ON JANUARY 1, 1990 AT .00 HOURS RECORD ENDS ON DECEMBER 31, 1994 AT 24.00 HOURS			
DURATION (h)	DATE	START TIME (h)	RAINFALL (in.)
1.00	May 1, 1990	14.61	2.02
2.00	May 1, 1990	14.61	2.2
3.00	May 1, 1990	14.61	2.22
6.00	May 1, 1990	14.61	2.24
12.00	December 4, 1993	8.62	3.09
24.00	December 3, 1993	21.35	4.47
48.00	November 30, 1991	18.1	5.88
72.00	November 30, 1991	9.62	6.79

ORNL-DWG 95M-7097R

Fig. 14. Locations of surface-water and precipitation monitoring stations in the Walker Branch Watershed.

WHITE OAK CREEK (MS3)

Fig. 15. Daily streamflow at the White Oak Creek monitoring station (MS3) for the period January–December 1994.

MELTON BRANCH (MS4)

Fig. 16. Daily streamflow at the Melton Branch monitoring station (MS4) for the period January–December 1994.

WHITE OAK DAM (MS5)

Fig. 17. Daily streamflow at the White Oak Dam monitoring station (MS5) for the period January–December 1994.

During the current reporting period, streamflow data were collected at 16 monitoring stations in and near the WOC watershed (Figs. 5 and 14). Monitoring stations HRT and T2A were discontinued with the completion of field sampling activities for the Tributary Assessment Task at the end of FY 1994.

Physical descriptions and monitoring status information on both operating and non-operating stations have been summarized in previous reports (Borders et al. 1994). Refer to Appendix B for revisions to station descriptions (changes are noted in *italics*).

Tables 8 and 9 allow comparison of flows at selected gaging stations, monthly discharge and runoff summaries for the ten ESD sites (for which data are available from the ESD Hydrology Group) and six USGS sites. The total monthly volume of runoff (natural and imported) from each station was divided by its drainage area to express monthly runoff volume in inches of water. Historically, loss of water to the atmosphere is approximately 55% of the total annual precipitation in the Oak Ridge area. The remaining 45%, on the average, occurs as runoff (or discharge). At a number of stations (GS1, GS3, and GS5) in the main plant area or downstream from plant effluents, runoff volumes are greater than precipitation totals for several months of the year (see Table 9). In addition, annual runoff volume approaches annual precipitation totals at the same stations: approximately 82% at GS1, 80% at GS3, and 69% at GS5. This highlights the magnitude and influence of imported water to monitoring stations in the WOC watershed. For comparison, two gaging stations upstream of ORNL effluents, GS2 and the WOCHW station, had runoff volumes of approximately 40% and 52%, respectively. Drainage areas for each station in the flow system are listed in Table 8 and 9, respectively. Daily flow data for these sites are listed in tables in Appendix C.

Rating tables for most of these monitoring stations are available in previous reports (Borders et al. 1991, Borders et al. 1992, Borders et al. 1993). In this report, as in the 1994 report, only those rating tables that are known to have changed have been included (Appendix D). Table 10 summarizes the status of the ratings for weirs in the vicinity of the White Oak Creek watershed.

Figure 18 shows monthly mean discharge in WOC at GS3 downstream from Haw Ridge, at MS3 on WOC upstream from the confluence with MB, and the difference between monthly discharge at the two stations. Unpublished stream surveys done by the USGS in the late 1980s indicated that the average difference between GS3 and MS3 was approximately 4.5% (Borders et al. 1994), indicating that this section of WOC is a gaining reach. Part of this difference can be attributed to the contribution from the small tributary draining the southern boundary of WAG 4. Differences in monthly discharge for the current reporting period were positive every month of 1994. The difference in discharge for the 12-month period was approximately 9.9%. This is significantly higher than previously reported and approximately equal to the relative difference in drainage area (10%) between the two sites. Differences may be expected to approach this value in wet years as runoff from the contributing area between the stations becomes more significant relative to the nearly constant process water inputs. It is reasonable that this difference was on the order of 10% because 1994 was a very wet year.

Figure 19 shows monthly mean discharge at MS3 on WOC, MS4 on MB above the confluence with WOC, MS5 at WOD, and the differences between the flow at MS5 and the sum of flows at MS3 and MS4. The occurrence of a negative sum in July, despite an appreciable contributing drainage area (1.04 mile²), highlights the need for field rating and verification of the high-flow, stage-discharge relationships at each of the three gaging stations (see Section 1.5). However, the negative difference occurred in the summer, during a month with below average precipitation, when evapotranspiration rates are higher and soil moisture deficits tend to be high, resulting in less runoff. Local inflows from ungaged

**Table 8. Monthly flow and runoff statistics for ESD stations located
in the vicinity of WOC watershed
Flow rate units=cfs**

			SITE ID									
			WOC (MS3)	MBR (MS4)	WOD (MS5)	WOCIRW	East Seep	West Seep	Raccoon Cr.	WAG 4 MS1	Walker Branch East	Walker Branch West
DRAINAGE AREA (mi ²)			3.61	1.51	6.15	8.80	0.032	0.25	0.33	0.34	0.23	0.15
1994	JANUARY	MEAN	16.8	5.93	24.8	2.56	0.11	1.13	0.8	0.17(e)	0.72	0.7
		MINIMUM	7.44	1.51	10.7	0.94	0.035	0.28	0.071	0.012	0.22	0.3
		MAXIMUM	57.2	25.7	95.4	9.77	0.38	4.77	3.97	0.64	2.97	2.21
		RUNOFF (in.)	5.37	4.53	4.64	3.69	4.04	5.22	2.81	5.65(e)	3.6	5.38
	FEBRUARY	MEAN	32	11.3	49.7	6.86	0.22	2.12	1.84	0.33	1.74	1.57
		MINIMUM	7.51	1.74	11.4	0.99	0.032	0.22	0.077	0.039	0.16	0.3
		MAXIMUM	189	76.5	382	54.6	1.35	13.9	13	2.25	13.24	10.13
		RUNOFF (in.)	9.22	7.8	8.41	8.93	7.07	8.82	5.8	10.87	7.9	10.94
	MARCH	MEAN	31	10.3	44.2	5.71	0.23	2.07	1.64	0.23	1.48(e)	1.43(e)
		MINIMUM	7.52	1.26	9.6	0.76	0.038	0.19	0.06	0.16	0.25(e)	0.34
		MAXIMUM	254	96.4	383	54.1	1.97	21.2	19.1	0.97	13.59(e)	11.65(e)
		RUNOFF (in.)	9.9	7.88	8.28	8.22	8.26	9.55	5.72	7.4	7.4(e)	10.97(e)
	APRIL	MEAN	29.2	9.82	42.8	5.98	0.2	1.9	1.18	0.23	1.65(e)	1.58
		MINIMUM	7	1.07	8.69	0.84	0.041	0.16	0.043	0.016	0.23(e)	0.5
		MAXIMUM	107	43.7	215	27.8	0.74	8.41	6.9	0.97	7.87	5.76
		RUNOFF (in.)	9.02	7.26	7.77	8.34	6.85	8.47	4	7.4	8.01(e)	11.75
	MAY	MEAN	6.95	1	7.95	0.55	0.037	0.16	0.061	0.011	0.16	0.33
		MINIMUM	5.45	0.32	5.72	0.35	0.012	0.041	0.011	0	0.09	0.26
		MAXIMUM	13.9	3.53	14.5	0.89	0.15	0.86	0.52	0.071	0.24	0.48
		RUNOFF (in.)	2.22	0.77	1.49	0.8	1.32	0.73	0.21	0.36	0.81	2.56
	JUNE	MEAN	8.56	1.74(e)	11.1	0.43	0.038	0.37	0.13	0.023	0.14	0.29
		MINIMUM	4.9	0.58	5.88	0.27	0.011	0.039	<.01	0	0.06	0.23
		MAXIMUM	38.3	12.3	65.6	1.49	0.34	2.88	2.07	0.4	1.17	0.84
		RUNOFF (in.)	2.65	1.28(e)	2.01	0.6	1.32	1.66	0.45	0.76	0.7	2.16

Table 8 (continued)

			SITE ID									
			WOC (MS3)	MBR (MS4)	WOD (MS5)	WOCHW	East Seep	West Seep	Raccoon Cr.	WAG 4 MS1	Walker Branch East	Walker Branch West
1994	JULY	MEAN	7.38	1.31	8.61	0.31	0.038(e)	0.27	0.093	0.022	0.06	0.23
		MINIMUM	6.01	0.34	6.07	0.19	<.01	0.058	0.014	0	0.03	0.2
		MAXIMUM	12.2	4.28	18.4	0.55	0.2	1.5	0.88	0.19	0.13	0.25
		RUNOFF (in.)	2.36	1	1.61	0.44	1.37(e)	1.23	0.33	0.76	0.31	1.74
	AUGUST	MEAN	7.28	0.76	8.17	0.23	0.016	0.1	0.053	<.01	0.05	0.2
		MINIMUM	5.7	0.27	6.11	0.15	<.01	0.049	0.01	0	0.02	0.18
		MAXIMUM	13.6	2.45	16.2	0.45	0.05	0.37	0.33	0.06	0.12	0.23
		RUNOFF (in.)	2.33	0.58	1.53	0.33	0.56	0.46	0.18	0.3	0.24	1.5
	SEPTEMBER	MEAN	5.74	0.41	8.1	0.15	0.014	0.06	0.028	0.012	0.03	0.18
		MINIMUM	4.53	0.18	6.97	0.11	<.01	0.012	<.01	0	0.01	0.16
		MAXIMUM	15.9	1.4	20.1	0.36	0.088	0.74	0.36	0.12	0.16	0.22
		RUNOFF (in.)	1.77	0.3	1.47	0.22	0.48	0.27	0.09	0.39	0.17	1.32
	OCTOBER	MEAN	5.23	0.52	7.28	0.14	0.021	0.051	0.022	<.01	0.05	0.17
		MINIMUM	4.43	0.18	5.28	-0.1	<.01	0.017	<.01	<.01	0.02	0.16
		MAXIMUM	12.1	1.84	15.5	0.33	0.076	0.32	0.12	0.04	0.12	0.23
		RUNOFF (in.)	1.67	0.39	1.37	0.2	0.77	0.24	0.08	0.24	0.25	1.31
	NOVEMBER	MEAN	6.72	1.25	8.04	0.31	0.027	0.15	0.14	0.023	0.08	0.19
		MINIMUM	4.11	0.3	4.64	0.12	<.01	0.03	<.01	0	0.02	0.15
		MAXIMUM	41.2	15.5	56.6	2.35	0.3	2.31	2.97	0.44	0.65	0.58
		RUNOFF (in.)	2.08	0.92	1.46	0.43	0.94	0.69	0.48	0.77	0.37	1.39
	DECEMBER	MEAN	7.76	1.69	9.76	0.61	0.031	0.25	0.16	0.028	0.15	0.24
		MINIMUM	5.66	0.77	5.93	0.24	0.01	0.069	0.02	<.01	0.05	0.17
		MAXIMUM	28.4	12.5	34.7	2.11	0.22	2.07	2.41	0.28	0.88	0.69
		RUNOFF (in.)	2.48	1.29	1.83	0.88	1.13	1.15	0.55	0.94	0.74	1.84

WOCHW=White Oak Creek Headwaters.

WOC=White Oak Creek (MS3).

MBR=Melton Branch (MS4).

WOD=White Oak Dam (MS5).

¹(e) - Estimated data.

**Table 9. Monthly flow and runoff statistics for USGS stations located
in the vicinity of WOC watershed
Flow rate units=cfs**

			SITE ID					
			GS1	GS2	GS3	GS4	GS5	GS6
DRAINAGE AREA (mi ²)			0.33	0.52	3.28	0.67	2.1	1.31
YEAR	MONTH	STATISTIC						
1994	JANUARY	MEAN	1.9	1.65(e)	16	1.77(e)	9.13	2.58(e)
		MINIMUM	0.7	0.51	6.8	0.4	3.8	0.24
		MAXIMUM	5.8	6.8	47	8.3	29	14
		RUNOFF (in.)	6.64	3.66(e)	65.90	3.05(e)	5.01	2.27(e)
	FEBRUARY	MEAN	3.38	3.33	29.1	4.34(e)	17.8	9.25
		MINIMUM	0.53	0.44	6.9	0.49	3.7	0.35
		MAXIMUM	17	21	161	30	105	73
		RUNOFF (in.)	10.67	6.66	108.00	6.75(e)	8.83	7.36
	MARCH	MEAN	3.21	3.10	26.7	4.38	15.9	7.71
		MINIMUM	0.54	0.43	7	0.53	3.5	18
		MAXIMUM	24	33	202	45	126	86
		RUNOFF (in.)	11.22	6.87	109.98	7.50	8.73	6.79
	APRIL	MEAN	3.14	2.82	27.1	3.85	16.3	7.92
		MINIMUM	0.54	0.1	7	0.32	3.6	0.16
		MAXIMUM	10	14	84	16	55	35
		RUNOFF (in.)	10.62	6.06	9.23	6.42	8.66	6.75
	MAY	MEAN	0.43	0.13(e)	6.27	0.32	3.06	0.21
		MINIMUM	0.30	0.02	5.1	0.19	2.3	0.08
		MAXIMUM	1.2	0.62	11	0.99	6.5	1.2
		RUNOFF (in.)	1.50	0.30(e)	2.2	0.56	1.68	0.19
	JUNE	MEAN	.58	0.21(e)	8.24	0.59	3.91	0.57
		MINIMUM	0.23	0.02	5.2	0.22	2.3	0.08
		MAXIMUM	3.4	2.1	30	4.4	20	7.8
		RUNOFF (in.)	1.96	0.45(e)	2.8	0.98	2.06	.48

Table 9 (continued)

			SITE ID					
			GS1	GS2	GS3	GS4	GS5	GS6
DRAINAGE AREA (mi ²)			0.33	0.52	3.28	0.67	2.1	1.31
YEAR	MONTH	STATISTIC						
1994	JULY	MEAN	0.43	0.049(e)	6.74	0.41	2.83	0.19
		MINIMUM	0.26	0	5.4	0.29	2.2	0.06
		MAXIMUM	0.95	0.54	11	0.87	5.5	0.93
		RUNOFF (in.)	1.5	0.11(e)	2.37	0.7	1.55	0.17
	AUGUST	MEAN	0.56	0.069(e)	6.65	0.4	2.84	0.24
		MINIMUM	0.28	0	5	0.22	1.9	0.04
		MAXIMUM	1.6	0.70(e)	12	0.83	6.6	1.5
		RUNOFF (in.)	1.96	0.15(e)	2.34	0.69	1.56	0.21
	SEPTEMBER	MEAN	0.37	0.001	5.25	.28	2.38	.14
		MINIMUM	0.24	0	4.2	.15	2	0.03
		MAXIMUM	1.9	0.04	14	1.4	7.1	1.2
		RUNOFF (in.)	1.25	0	2.79	0.47	1.26	.12
	OCTOBER	MEAN	0.33	0.01	4.89	0.13	2.3	0.14
		MINIMUM	0.28	0	4.1	0.08	1.9	0.04
		MAXIMUM	1.1	0.06	12	0.55	6.8	1.5
		RUNOFF (in.)	1.15	0.02	1.72	0.22	1.26	0.52
	NOVEMBER	MEAN	0.52	0.14	6.05	.31(e)	2.98	0.44
		MINIMUM	0.25	0	3.8	0.06	1.7	0.04
		MAXIMUM	4.1	2.7	33	4(e)	20	7.2
		RUNOFF (in.)	1.76	0.3	2.06	.17(e)	1.58	1.58
	DECEMBER	MEAN	0.61	0.24	6.9	.45(e)	3.51	0.44
		MINIMUM	0.27	0.04	4.6	0.16	2.1	0.07
		MAXIMUM	3	2.5	24	3.7	15	5.1
		RUNOFF (in.)	2.13	0.53	2.43	.77(e)	1.93	1.64
GS1 (USGS 03536450) = First Creek GS2 (USGS 03537100) = Melton Branch near Melton Hill GS3 (USGS 03536250) = WOC below Melton Valley Drive GS4 (USGS 03536440) = Northwest Trib near Oak Ridge GS5 (USGS 03536380) = WOC near Wheat, TN GS6 (USGS 03536320) = WOC near Melton Hill								

(e) - Estimated data.

Table 10. Summary of rating tables published in previous (1991-1993) Annual Surface Water Hydrology Reports and revisions included in the 1994 Annual Report

TABLE NO.	SITE	STATUS ¹
D.1	White Oak Dam (MS5)-low flow	NC
D.2	White Oak Dam (MS5)-high flow	NC
D.3	White Oak Creek (MS3)-low flow	NC
D.4	White Oak Creek (MS3)-high flow	NC
D.5	Melton Branch	NC
D.6	White Oak Creek Headwaters	NC
D.7	East Seep	REVISION (1994)
D.8	West Seep	NC
D.9	Raccoon Creek	NC
D.10	Ish Creek	NC
D.11	HRT monitoring station on Melton Branch tributary	NC
D.12	White Oak Creek tributary near SWSA 4	REVISION (1994)
D.13	T2A near SWSA 4 southern boundary	NC
D.14	MB2 monitoring station on Melton Branch	NC
D.15	First Creek (GS1, USGS03536450)	REVISION (1993)
D.16	Upper Melton Branch (GS2, USGS03537100)	NC
D.17	7500 Bridge (GS3, USGS03536550)	NC
D.18	Northwest Tributary (NWT) (GS4, USGS03536440)	REVISION (1993)
D.19	GS5 (USGS03536380)	NC
D.20	GS6 (USGS03536320)	NC
D.21	East Seven Tributary (GS16, USGS03537050)	NC
D.22	Center Seven H-flume (GS17, USGS03537200)	REVISION (1993)
D.23	Center Seven-V notch weir (GS17, USGS03537200)	NC
D.24	West Seven Tributary (GS18, USGS03537300)	NC
D.25	East and West Fork weirs, Walker Branch Watershed	ADDITION (1993)

¹NC=No Change; REVISION=Revised table; ADDITION=Rating Table not included in previous reports. Rating tables with status=NC are not published in this report. Refer to the 1992 report (ORNL/ER-123) and the 1993 report (ORNL/ER-166) for previously published tables.

Fig. 18. Comparison of monthly mean discharge at USGS monitoring station GS3 and ESD monitoring station MS3.

Fig. 19. Comparison of monthly mean discharge at ESD monitoring stations MS3, MS4, and MS5.

areas around the lake are also negligible at these times. In addition, sections of lower WOC above the headwaters of WOL may be losing reaches, and WOL presents a significant surface area for losses due to evaporation during hot, dry periods. Therefore, a significant portion of the negative differences may be accountable. Nevertheless, the causes of these negative differences should be verified or corrected.

Figure 20 shows monthly mean discharge at the WOCHW station north of Bethel Valley Road, at the foot of Chestnut Ridge, at GS6 downstream on WOC, south of Bethel Valley Road, and the difference between GS6 and WOCHW. Typically, during periods of high flow (wet season), discharge at GS6 is greater than at WOCHW, which is to be expected due to the increase in drainage area at GS6. However, during periods of low flow (dry season), WOCHW discharge has typically (historically) been greater than at GS6. During the three wettest months of 1994 (February–April) discharge at GS6 was greater than at WOCHW. For every other month in 1994, discharge at GS6 ranged from slightly less than to slightly greater than WOCHW discharge.

The stream reach between these two stations is a losing reach. The Knox Group, which underlies Chestnut Ridge, is the major water-bearing formation in the watershed (see Section 1.3). The Chickamauga Group underlies Bethel Valley. The Benbolt formation of the Chickamauga Group lies directly under the losing reach between GS6 and WOCHW (Borders et al. 1992). This formation is made up of limestone layers which bisect WOC and in which pronounced solution channels have formed. Flow is along the strike of these limestone layers. The WOCHW flows from the southeast slopes of Chestnut Ridge, bisects the shallow limestone layers of the Benbolt formation, and is partially intercepted.

It appears that the flow, originating as surface flow at WOCHW and ultimately being lost to the subsurface in the Benbolt formation before reaching GS6 through WOC, is reappearing as surface flow in the duck pond at Bethel Valley Road near the main portal to ORNL. A description of a water balance conducted on this reach is described in Borders et al. (1992). The fact that the difference between the duck pond outflow and inflow is greater than that portion of flow lost from WOC is typical of the geohydrologic regime. Presumably, additional water is being supplied to the duck pond from the Knox formation underlying Chestnut Ridge.

2.2.2 Flow Augmentation in the White Oak Creek Watershed

Flow in WOC in the main ORNL plant area is augmented by the disposal of water imported for plant processes, potable supplies, and sanitary use. The flow is complex because of the effects of storm drainage, leakage into and out of an extensive system of underground pipes, and the increased permeability of disturbed subsurface materials along pipe lines and within construction sites. However, the discharge data from the five USGS stations in the vicinity of the main plant permit the isolation of flow from contributing areas where the majority of plant effluents and imported water enter the surface-water system. Figure 21 shows hydrographs of monthly mean discharge at monitoring stations GS3 (7500 Bridge) on WOC downstream from the main plant area, GS4 on the NWT, GS1 on First Creek, GS5 on WOC below its confluence with Fifth Creek, and the difference between flow at GS3 and the sum of the three upstream stations. This difference, consistently above 2 cfs, includes runoff from the contributing area between the three upstream stations and GS3 (approximately 0.18 mile²), as well as, and most significantly, the three major effluent discharges regulated under the ORNL NPDES permit: the STP, the CYRTF, and the NRWTF. These three facilities collectively release, on the average, approximately 1.1 cfs. This value was derived from the NPDES permit renewal application.

Fig. 20. Comparison of monthly mean discharge at USGS monitoring station GS6 and ESD monitoring station WOCHW.

Fig. 21. Comparison of monthly mean discharge at USGS monitoring stations GS1, GS3, GS4 and GS5.

Figure 22 shows monthly mean discharge at WOC station GS5 compared to discharge at station GS6 which is outside the east gate of the main plant and upstream of most plant activities and effluents. The difference in flow between these stations includes the runoff from the contributing drainage area between the stations (approximately 0.8 mile²). This area drains Fifth Creek as well as a number of minor effluent discharges from ORNL facilities, including Category I and II outfalls, cooling water discharges, and miscellaneous source discharges. This difference (GS5-GS6) is also consistently above 2 cfs.

Flow in Melton Branch was augmented by effluent discharges of about 0.25 cfs from the High Flux Isotope Reactor (HFIR) and about 0.08 cfs from the Transuranium Processing Facility (TRU) until November 1986 when the HFIR was shut down and discharges were substantially reduced. The reactor began operating again in January 1990 and reached full power in May 1990. However, in February 1990, the NRWTF went on-line to treat dilute ORNL process waste streams. This facility now receives the waste effluents from both the TRU and HFIR, facilities which were previously routed to temporary holding ponds 7908 and 7909, and 7905, respectively, before being released to MB. Currently, MB receives blowdown from the HFIR, an unidentified process water discharge coming from the headwaters region of the tributary to MB near the HRT facility [see Borders et al. (1991) for explanation], and rainfall runoff. In addition, each summer, for at least the last four years (1990-1993), an unidentified discharge of approximately 0.5 to 1.5 cfs has occurred for approximately the month of August. This year (1994), it appears that a similar unidentified discharge of approximately 0.25 cfs occurred from October 13-November 2.

2.2.3 Outfalls to the White Oak Creek Flow System

Water is supplied to the ORNL plant site from the DOE water treatment plant at an average rate of approximately four million gallons per day (6.19 cfs). This water is then distributed to ORNL facilities through two separate systems: potable and process. Of the total amount of imported water, approximately 38% is lost to the atmosphere as evaporation via cooling towers. The remaining 62% (approximately 3.84 cfs) is subsequently discharged to the WOC surface-water system (Kasten 1986). According to Loar (1991), approximately 30% and 36% of the estimated total effluent volume to the WOC system are contributed by the cooling and process systems, respectively. Discharges from the STP, the steam plant, and leakage account for the remainder in approximately equal proportions (Kasten 1986). Process/imported water to the WOC watershed is described in detail in Borders et al. (1992).

2.2.4 Walker Branch Watershed Groundwater Loss/Gain

On large basins, where the groundwater divide might closely correlate with the surface-water divide (topographic divide), and where diversions to or from the basin by works of humans either do not occur or their volume is known, the change in basin storage over a long time period (6 months or more) is assumed to be negligible. In such cases, the difference between precipitation (inches or centimeters) on the basin and runoff from the basin (in comparable units), as determined from streamflow records, represents the sum of evaporation and transpiration from the basin.

For the basins on the Oak Ridge Reservation where streamflow records are being collected such assumptions are basically invalid, primarily because geologic and topographic divides are probably not comparable, and some of the streamflow may come from "process water" rather than rainfall. Nonetheless, a comparison of precipitation and runoff, in comparable units of depth on the basin, for periods as short as a month, and in basins without man-made diversions, is at least an indicator of

Fig. 22. Comparison of monthly mean discharge at USGS monitoring stations GS5 and GS6.

evapotranspiration and supports the concept that water is being transported from one basin to another by groundwater flow (that is, such a comparison may "prove" that the groundwater divide definitely does not correlate with the surface-water divide). The Walker Branch watershed data show this quite vividly.

There are two stream gages in the basin, one on the East Fork [59.1 ha (0.228 mile²) drainage area] and one on the West Fork [38.4 ha (0.148 mile²) drainage area]. Streamflow values are good because they are determined from a 15-min interval stage record and a well-maintained and rated weir with a large stilling pool to eliminate velocity of approach consideration. Vegetation on the two basins is very similar; the basins are small enough so that temperature and humidity are similar; and two rain gages in close proximity to the basins indicate that the precipitation on the basins is comparable. Therefore, it is reasonable to assume that evapotranspiration as a percent of precipitation should be comparable. If precipitation is the same on each basin, and if evapotranspiration as a percent of precipitation is comparable, runoff as a percent of precipitation should also be comparable. Such is definitely not the case, as indicated in Table 11.

The high percentage of runoff in the colder months are because the trees are bare and transpiration is relatively small, but for runoff to be more than 100% of precipitation, streamflow must be augmented by groundwater flow. Table 11 clearly indicates that West Fork Walker Branch streamflow is augmented by groundwater flow. The runoff percentages do not show that the augmentation is necessarily from the East basin, but comparison of East basin flows with other natural basin flows (i.e., not affected by man-made diversions) suggests that the East basin is "losing" water, and the chances are good that the "lost" water is going to the West basin. It should be recognized, however, that the comparison of East Branch flows with other basins is not as reliable as the comparison of the East and West branches in the watershed because the type and density of vegetation on the other basins is not as directly comparable.

2.2.5 Surface-water Quality

As part of the NPDES program, EMP monitors surface-water quality for both radiological and chemical constituents at a number of sites in the WOC flow system. Additional water quality data have been collected at selected sites as part of the BMAP activities and other ER Program studies.

Summaries of chemical and radiological data for in-stream monitoring sites have been presented previously in the EMP quarterly environmental data reports (e.g., Goldberg 1993) and also in the annual environmental reports for the Oak Ridge Reservation (ORR) (e.g., Kornegay et al. 1994). The EMP quarterly environmental data reports are no longer published.

Monthly discharge and concentration of selected radionuclides at the primary EMP in-stream sites is calculated from flow and concentration values and presented in the quarterly environmental data reports. In order to assess contributions of the primary radionuclides (total radiological Sr, ³H, and ¹³⁷Cs), from a human health risk/dose perspective, monthly fluxes (curies) of concern at the primary surface-water monitoring stations (WOC, MB, and WOD) have been calculated from EMP's average radionuclide concentrations and ESD's average discharges. In the past, ⁶⁰Co has also been reported, but it has been dropped from consideration because its contribution to human health risk is now negligible. These reports have been presented in previous annual hydrologic data summary reports (e.g., Borders et al. 1994). In addition, for the previous three years, these results have been presented in the annual Environmental Restoration Monitoring and Assessment (ERMA) reports (Clapp 1992, Clapp and Watts 1993, Clapp et al. 1995). This year, results for CY 1994 will be expanded in the ERMA report to

Table 11. Walker Branch watershed runoff as a percentage of precipitation

MONTH	EAST WEIR 1994	WEST WEIR 1994
January	59	92
February	82	113
March	74	109
April	90	133
May	30	93
June	10	30
July	7	39
August	6	36
September	6	46
October	12	62
November	10	38
December	29	74
CY 1994 Total	47	83

include sites on upper MB, First Creek, NWT, Fifth Creek, and process discharges to the main plant area.

Due to preliminary indications that the stage-discharge relationship at WOD will be significantly altered, the radionuclide concentrations presented in the ERMA report will reflect these changes. See Section 1.5 for a description of the WOD preliminary adjusted rating and its implications. The preliminary adjustments indicate an improvement in water and contaminant mass balance calculations for the WOC watershed. It is appropriate, in the context of the ERMA report, to incorporate these updates before the stage discharge relationship at WOD has been finalized. However, it is not appropriate to make interim adjustments to hydrologic data prior to the completion of the WOD rating. Therefore, in order to avoid inconsistency in reported data, results of monthly radionuclide discharges, for CY 1994, at the primary surface-water monitoring stations will not be presented in this report.

Raccoon Creek receives surface runoff and, presumably, groundwater recharge from the western portion of SWSA 3. All other drainage from SWSA 3 is east toward the WOC watershed. The Raccoon Creek monitoring station facility was built to complete the stream sampling network necessary to determine the extent of radionuclide migration from ORNL's SWSAs. However, composite sampling is not conducted at this site. ESD's Hydrology Group collects discharge data at this site, and some evidence of contaminants has been detected in EMP's water quality grab samples collected there.

2.2.6 Contaminants in Sediments

Studies of WOC streambed gravels as indicators of the degree and location of sources of radiological contaminants (Cerling 1985, Cerling and Spalding 1981) were continued during 1986–1987. Sobocinski et al. (1990) documented the results of studies of new sources of ^{90}Sr and ^{137}Cs in First Creek and upper WOC behind the ORNL main plant.

An aerial radiological survey was conducted during September and October of 1986 to provide detailed information on the nature and location of radiological contaminants in floodplain sediments. The study report by EG&G Energy Measurements (Fritzsche 1987) describes the survey methodology and shows detailed contours of total terrestrial gamma exposure rates and activities of ^{137}Cs , ^{60}Co , and ^{208}Th . In 1989, a gamma survey of the ORNL facilities was conducted using a helicopter flying at an altitude of 300 ft. A comprehensive survey of the ORR was conducted in April 1992 (Maurer 1992). A gamma survey was conducted by helicopter at an altitude of 250 ft. In addition to the gamma survey, multispectral (MSS) imagery was taken at night from an altitude of 4000 ft to search for seeps. MSS and color infrared were collected during the daytime at 3000 ft. Other flights flown at 6000 ft collected MSS during the daytime and specific color photographs at various locations at varying heights for different facilities. A high-altitude (43,000 ft) flight was made to survey the entire ORR. These data are being analyzed and will be included in the OREIS data base.

In August 1989, EMP extensively sampled sediment at the monitoring stations on WOC (MS3) and MB (MS4). Multiple sediment samples were collected from the stilling pool upstream from the weir at MS3, and from the stilling pool upstream from the weir and from sediments downstream from the weir at MS4. Samples were analyzed for radionuclides, metals, and polychlorinated biphenyls (PCBs), to characterize the contaminated sediments as a waste for ultimate removal and disposal at a later time. Results of these analyses can be obtained from EMP's Information Integration and Analysis Group. In 1993, sediment samples were collected from weir pools at seven surface-water monitoring stations and

at the old Intermediate Pond Site on WOC by the WAG 2/SI program for similar analyses and for verification of earlier results (Clapp et al. 1995). In addition, in January 1994, 12 sediment core samples were collected in the WOC floodplain as part of the WAG 2 Remedial Investigation (RI). The objectives of the floodplain coring were to identify and quantify radioactive and chemical contaminants in areas that may be susceptible to erosion and movement off-site and to update the ^{137}Cs inventory estimates for the floodplain.

As part of the Clinch River RFI [Resource Conservation and Recovery Act (RCRA) Facility Investigation], sediment sampling was conducted in the WOCE during the summer of 1990. Results of initial core sampling near the mouth of the embayment revealed elevated activities of ^{137}Cs for surface sediments. This finding prompted additional surface sediment and core sampling in the embayment. Subsequent sediment samples were analyzed for a wide range of contaminants including radionuclides, metals, and organics.

Preliminary risk assessments for WAG 2 (Blaylock et al. 1992) have indicated that the primary threat to human health is from direct exposure to gamma radiation. Therefore, in order to map the gamma-emitting sources in the soils and sediments in the WOC floodplain, a radiation walkover survey was conducted in the spring of 1992 (Clapp 1992). The results of the survey have been used to guide preliminary soil and sediment sampling for these gamma-emitting contaminants (primarily ^{137}Cs).

3. DATA PROCESSING AND QA/QC

3.1 DATA PROCESSING

3.1.1 Stream Discharge Data

The ESD Hydrology Group collects stream stage data at flumes and weirs. These data are measured and recorded by either of two types of monitoring systems. Some sites are equipped with electronic data loggers and submerged pressure transducers that record data on electronic data storage packs, and some are equipped with mechanical float and pulley recorders that record data by punching paper tapes. After the paper punch tapes are translated and the data storage packs are downloaded, data processing for both methods is identical.

Computer files of raw stage data are archived. The data are then reduced by removing redundancies. This reduction is done by producing files of breakpoint data with a program called EZ-BRK3 (Craig and Demaree 1992a) written for ESD by Environmental Consulting Engineers (ECE). Breakpointing is a method of data reduction whereby redundant (repetitive) values are removed, but accounted for, to compress a data set while preserving its integrity. At this point in the processing procedure, the stage data are corrected according to weekly visual inspections of staff gage readings. The stage data are then processed to produce reports of discharge data with the REPORTER program, also developed by ECE. Hydrographs of the data are produced and compared with field notes to find inaccuracies such as those caused by debris clogging flow-measurement structures, faulty equipment, and submergence. Data are corrected when possible and, if the data cannot be corrected, they are removed from the record. Estimates, by hydrograph comparison and examination of precipitation records, using data from stations in the immediate vicinity, are then made. For the MS4 site on Melton Branch, all high-flow data are adjusted, according to the extended rating, to account for submergence effects. In addition, high flow-data at MS3 and MS5 and low-flow at MS5 are checked for submergence, and discharge data are adjusted when necessary.

3.1.2 Precipitation Data

Raingage charts are collected weekly from six raingage sites equipped with Belfort Universal Recording Raingages. These charts are digitized to produce raw breakpoint data using RNF-DIG (Craig and Demaree 1992b). The breakpoint data are then converted into monthly reports of daily rainfall totals using PFREQ (Wilson 1992). The PFREQ program also has the ability to produce reports in the Terrestrial Ecology and Hydrology Model format.

Rainfall data for a site are validated by comparing the PFREQ-generated, daily rainfall totals for a site to the site's original raingage charts. Comparison of data from site to site is also done as an additional check. Original raingage charts are archived, and hardcopies of monthly reports of daily totals are retained. Computer files of the monthly reports and the breakpoint data used to create the reports are maintained by the ESD Hydrology Group.

3.1.3 Software Systems

In addition to the software packages, described in the previous section, that are used to process the streamflow and meteorological data collected by the ESD Hydrology Group, the data may also be

processed into LOTUS 1-2-3 or Statistical Analysis System files. The data, for the most part, are processed on personal computer systems. Data are stored on Bernoulli cartridges, floppy, and hard disks. Copies of the files are maintained with each notebook containing reports (listings) of the data. Copies are maintained in separate locations to protect against potential loss of data. Descriptions of the data backup and security procedures used in the ESD Hydrology Group are contained in the "Surface Water Flow and Quality Measuring Sites and Surface Water Data Processing and Interpretation" Quality Assurance plan.

3.2 DATA AVAILABILITY

3.2.1 Environmental Sciences Division

For several years, the ESD Hydrology Group has collected and processed discharge data at a number of stations in the WOC watershed and vicinity for modeling studies, independent research, and environmental restoration activities. Discharge data are available in raw-stage data format, hourly or daily discharge, and in hardcopy or computer formats. The ESD surface-water monitoring stations, for which data are available, have been described in previous reports (Borders et al. 1994). However, new stations and those with a change in monitoring status are documented in this report (Appendix B), with changes to monitoring station descriptions and additions noted in italics.

Six precipitation gages in the WOC watershed and vicinity are operated by ESD's Hydrology Group. Daily precipitation data collected at the Oak Ridge NOAA/ATDD station are available from the ESD Hydrology Group.

In addition to surface-water discharge and precipitation data, ESD's Hydrology Group collects meteorological data. Wind speed and direction, temperature, pan evaporation, solar radiation, and humidity data are available from a number of sites. However, the period of record varies from station to station, and some records are discontinuous.

Quarterly interim data reports have been published by the ESD Hydrology Group since 1992. These reports currently present daily discharge data at nine ESD and six USGS surface-water monitoring stations and daily precipitation totals at six ESD raingages located in the vicinity of the WOC watershed and the NOAA/ATDD site located in the city of Oak Ridge. The data are presented in an informal manner in order to facilitate timely dissemination to potential users with multiple data needs. All data presented in the quarterly reports are provisional and subject to revision until published in the annual hydrologic data summary report (e.g., Borders et al. 1994). Reports are released near the middle of each following quarter.

3.2.2 U. S. Department of the Interior, Geological Survey

Surface-water discharge and precipitation data are available from the USGS for a number of stations on the WOC watershed and the ORR. In addition, data on water quality, sediment, groundwater level, groundwater quality, and chemical quality of precipitation are available from the USGS for stations in Tennessee and are published in annual *Water Resources Data—Tennessee, Water Year 1994* (USGS 1995).

All USGS surface-water discharge data published in this report, and data on precipitation from the 7500 Bridge station, are available by remote access to the USGS computer system based in Nashville, Tennessee. Data are available in unit values (5 to 15 min) at selected stations and daily values for all stations. Rating tables (see Tables D.15–D.24, Appendix D in Borders et al. 1993), and the data collected for the development of the tables, are available for most surface-water monitoring stations in the system. In addition, near real-time discharge data are available from the 7500 Bridge monitoring station (GS3, USGS 03536550) connected to the USGS computer system by satellite telemetry via a data collection platform (DCP). The 7500 Bridge (GS3) station is the only station in the WOC watershed on a DCP, thereby providing near real-time data (15-min delay) under high-flow conditions. The 7500 Bridge monitoring station also has a precipitation gage connected to the DCP with the capability to provide near real-time rainfall data at 15-min intervals. These data (discharge and precipitation) are available from the OREIS data base.

3.2.3 Environmental Monitoring Program

The two primary monitoring activities of the EMP are effluent monitoring and environmental surveillance. The general activities of the EMP are presented in their annual environmental report (i.e., Kornegay et al. 1994).

3.2.4 Oak Ridge Environmental Information System

Many ORNL programs collect and report hydrologic data for a number of reasons. The OREIS is the repository of all validated data information generated by activities related to the ER Program. The Document Management Center is a repository for all published reports produced for the program and for any other pertinent publications. The Document Management Center also indexes unpublished information (e.g., project plans and field notebooks) generated by the program. The OREIS numeric data base is a central repository for technical data generated in the ER Program and data from other studies of interest. Data and the associated data management systems, prior to the OREIS system, used by the ER Program have been documented in several annual reports (e.g., Hook et al. 1990).

3.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control (QA/QC) for data collection and data processing by the ESD Hydrology Group is governed by a quality assurance plan (Clapp and Borders 1992) developed to comply with the ORNL Quality Assurance Manual. In addition, a QA/QC plan for the WAG 2 RI Plan (ORNL 1990) and the ER Program QA/QC Plan also apply to data collected in the surface-water monitoring project. Standard operating procedures for the WAG 2 investigations have also been developed and published as a controlled document for use by WAG 2 staff, with surface-water hydrology-related procedures included in Section 3200. Quality control is achieved through several steps. Procedures and guidelines have been developed covering data collection and data processing from the point of data origination in the field to final report preparation. Data verification is mentioned in the data processing section of this report.

4. SUMMARY AND RECOMMENDATIONS

The collection and reporting of quality hydrologic data are essential to fulfilling the goals of the ER monitoring program to support a mass balance approach to determining sources and sinks of contaminants in the WOC system. This process includes defining and quantifying the input of wastes from ORNL WAGs and assessing the release of contaminants from the WOC system, because surface water is the primary pathway for the release of contaminants from the WOC system to off-site areas. The data are also used for the engineering design of remedial measures, evaluation of the effectiveness of past remediation measures, and prediction of remediation performance into the future.

4.1 PROGRESS DURING THE PAST YEAR

The network of raingages on and in the vicinity of the WOC watershed is currently being evaluated to determine optimum gage placement based on the number of gages, access capability and restrictions, and spatial distribution. There are five raingages on the WOC watershed (counting the USGS gage at 7500 Bridge). Four of those gages are in Melton Valley and the fifth is near the water gap in Haw Ridge. No gages are located in the headwaters area of WOC. This area is a probable location for the placement of a new or relocated gage. One of the two gages near WOD (ETF) in WAG 6 was discontinued in June 1994 to eliminate redundancy. All gages are being evaluated for possible relocation or termination.

The majority of the raingages on the WOC watershed are weighing bucket gages with paper strip charts for recording precipitation by pen trace. The strip charts are collected weekly, digitized to produce an electronic breakpoint (data compression format) file, and then post-processed into daily records (standard output) using special purpose software. This process is very labor-intensive and does not produce a high-resolution data product.

Several tipping bucket raingages were recently purchased in order to replace the weighing bucket gages. Tipping bucket gages will significantly reduce the labor required for data processing and will produce a much higher resolution data product (hourly or 5-min). One tipping bucket gage has been installed near the First Creek (1ST) gage to test its performance and the comparability of the two gages. Several more tipping bucket gages are being calibrated as future replacement gages. Replacement of the weighing bucket gages will begin this summer (1995).

The primary disadvantage of tipping bucket raingages is that they tend to under-record during very high intensity rainfall. Apparently, the tipping "bucket" misses a significant amount of rain that should have been captured in the "bucket", while it is tipping. In order to account (and correct) for this occurrence, one or two weighing bucket gages will remain in service to provide quality assurance and a high-intensity calibration for data adjustment. The strip charts from these weighing bucket gages will not be processed on a regular basis.

Surface-water monitoring system upgrades (engineering) have been supported in recent years by staff and by availability of data (discharge frequency analyses for sizing of flow measurement structures). The Northwest Tributary monitoring station is being upgraded during the summer of 1995 with channel improvement and installation of a stilling well. Upgraded sampling and data collection instrumentation is planned. In addition, upgrades to three smaller tributary monitoring stations are planned for the near future (pending budgetary considerations). These upgrades will provide the

capability for improved accuracy of discharge and contaminant flux measurements from WAGs 3 (NWT), 7 and 9.

An extended rating was developed for the WAG 4 MS1 surface-water monitoring station to calculate discharge during periods when the trapezoidal flume is overtopped. During CY 1994, the flume at MS1 was overtopped at least eight times. These events occurred in February, March, April, and June.

The USGS determined a practical method for measuring discharge at WOD (MS5) in order to rate the high-flow control device. An acoustic velocity meter (Neil Brown meter) is being utilized to measure velocities (and hence discharge) downstream from the sluice gates. Velocities in this section are too low for the standard Price current meter but are within the applicable range of the Neil Brown meter. Preliminary tests indicate that the current rating is significantly underestimating discharge during high-flow conditions. This will affect water balance and contaminant mass flux calculations and will have important ramifications to the ER Program.

The dissemination of quality hydrologic data to multiple users and programs continues to be the primary goal of this effort. Among those requesting data in 1994 were the WAG 2 RI Seep sampling initiative and Sediment Sampling and Sediment Transport Modeling (model calibration) tasks, the ERMA report (watershed-scale flux and risk calculations), other WAGs (e.g., WAG 5 Seeps C and D performance evaluation and WAG 4 Seeps investigation for determination of the contribution of seeps to total ^{90}Sr flux and subsequent risk, etc.), Environmental Compliance for radiological analyses, and several groundwater investigations (including groundwater modeling of Melton Valley). Quarterly provisional hydrologic data reports continued to be issued in FY 1994, making data available to more users. The provisional report distribution list continued to expand. These interim data reports are intended to provide provisional hydrologic data to potential users on an informal basis in a timely manner.

4.2 RECOMMENDED IMPROVEMENTS

4.2.1 Issues within the ER Program Hydrologic Monitoring Activity

Several activities should be initiated to improve the quality and the appropriateness of the data generated for ER Program functions. The activities listed below can be accomplished by ESD's monitoring staff in concert with other ER Program groups.

- Cox et al. (1991) indicated that the volume of WOL at normal pool level was approximately 43,890 m³ (1,546,330 ft³) in the summer of 1988. This effort was effectively repeated in FY 1995 as part of the WAG 2 RI program. A bathymetric survey of WOL was conducted during the period December 1994 to February 1995 by Environmental Consulting Engineers (ECE). This survey indicated that the volume of WOL at normal pool level was approximately 48,924 m³ (1,727,987 ft³). White Oak Lake is known to collect sediments and particle-bound contaminants; therefore, the volume of the lake, in all likelihood, has not decreased, as suggested by the two studies. The WAG 2 RI program is currently investigating alternative methods of computing the lake volume from available data to provide the most accurate estimate of lake volume and recent change in lake volume.

- Recent evidence suggests that the permeability of the SRS (at the mouth of WOC) gabions are diminishing over time resulting in elevated water levels behind the structure under a range of flow conditions. These elevated water levels are causing submergence of the low-flow weir at WOD, thereby affecting the stage-discharge relationship and introducing errors in discharge measurement. Apparently, deposited sediment and aquatic vegetation are filling the void space in the gabion structure. If left unmitigated, the SRS will soon perform as a solid, impermeable dam. An evaluation of the submergence effects at WOD, due to this condition, will be conducted this summer (1995). Water surface profile simulations will be modeled for the WOCE, assuming a completely impermeable condition of the SRS, to verify the problem and determine the potential extent of submergence at WOD. This condition must be remediated or adjustments will have to be permanently incorporated into the WOD discharge calculation procedure.
- Integration of data into a Geographic Information System (GIS). Surface-water data need to be added to the same systems currently used for analyzing and reporting groundwater data. Some progress has been made in incorporating data from individual projects into MAPINFO coverages. MAPINFO is the personal computer-based GIS currently used for analyzing and reporting much of the WAG 2 and ORNL groundwater data. WAG 2 staff in ESD's Hydrology Group have some training and experience in the use of MAPINFO as a tool for mapping, analyzing, and documenting hydrologic data. Efforts are currently being made to form small working groups to coordinate these activities between the various ORNL divisions and disciplines.

4.2.2 Issues for Upper Level Management Approval

This section describes improvements that will probably require decisions and assistance by upper level management within the ER Program and ORNL if project goals are to be fully accomplished.

- The surface-water monitoring network at ORNL has been plagued in recent years by problems resulting from lack of maintenance and calibration of engineered flow measurement structures. These problems, due largely to regulatory hindrances, have fostered a general deterioration in the quality of monitoring data collected within the network. A comprehensive watershed management program must be established and rigorously implemented to restore and maintain adequate operating conditions at all sites to support an effective monitoring and assessment program for ORNL. This program should include stream channel maintenance, sediment removal, structural upgrades and site maintenance, effective construction site erosion control, mitigative measures to control sediment deposition (including engineered methods), and routine discharge calibration of weirs and flumes. Such a program would return dividends in terms of data quality and cost effectiveness (e.g., no wasted resources on a sediment removal project that takes five years to complete—see below).
- Resolution of sedimentation problems at flow monitoring sites. Sediments, which are contaminated at most sites in the WOC flow system, have filled the stilling pools upstream from weirs and are adversely affecting the accuracy of discharge measurements. Progress in this area has been very slow and tedious over the last five years. Again, as in the past several years, the summer dry season is the target for a one-time removal of deposited sediments from the major monitoring stations. If the removal effort is successfully completed this year, the situation will recur in 5–10 years without the adoption of a watershed management program to maintain adequate operating conditions at all sites in the surface-water monitoring system.

- Regulatory guidance on manual methods and engineered structures (e.g., passing sediment downstream or installation of plugs in control structures) is needed on issues pertaining to sediment removal and disposal, and on mitigation issues. Some progress has been made here through the process of NEPA documentation, however, the process has been slow, particularly where sediment is contaminated (most sites). This effort is being coordinated with ESD hydrologists, EMP, and ORNL Engineering. Alternatives are being evaluated for removal and disposal/storage of sediments.
- Resolution of tailwater problems at the MB (MS4) monitoring station. A number of measures have been employed or proposed to improve data accuracy, but they have not actually corrected the problem. An extended rating, which was developed theoretically using the upstream control above its intended range, has been used by ESD to improve the accuracy of high-flow data. This extended rating is currently being field-verified by the USGS. However, clean-out of the sediment from the stilling pool will also affect the rating and continued verification after the clean-out will be required. When verification of the stage-discharge relationship is concluded, it must be determined if the extended rating is sufficiently accurate or if the monitoring station should be redesigned to establish a permanent hydraulic control at the upstream location (current low-flow location). An alternative is to remove a section of the concrete trunk line downstream crossing the channel to improve channel capacity enough to keep the upstream control from submerging. However, this trunk line is potentially contaminated.
- Elimination of redundancy in data collection. Currently, the OECD's EMP collects flow data at numerous sites where the ER Program also collects data. In the past, some redundancy was required because different sampling systems were being used for very different purposes (e.g., continuous NPDES sampling for compliance and flood-stage-only suspended sediment sampling for the ER Program). In addition, compliance data logging and processing systems have not provided certain site-specific adjustments such as tailwater corrections, near real-time data, and finer resolution for modeling needs (i.e., hourly averages). However, the EMP has made some progress in upgrading equipment at WOD in recent months. As part of the Data Quality Objectives process, an integral part of the FY 1996 planning for the Surface Water Program, duplicative efforts will be identified and, where possible, eliminated. Some will be phased out over a short period of time. For the few stations where OECD does not have upgraded computerized data acquisition systems for monitoring flows continuously, some duplicative monitoring by the ER Program may be required. Coordination of surface-water monitoring on a watershed scale should be developed under the direction and support of the upper levels of administration within ORNL (see Section 4.2.1). An alternative that should be given serious consideration is to have the USGS maintain all surface-water monitoring stations at ORNL for discharge data collection while providing the proper interfaces for water quality data collection by compliance organizations, ER Program, and various research initiatives. The USGS is uniquely qualified to provide a high-quality, unbiased (disinterested) streamflow data product.
- Walker Branch watershed discharge (East and West forks) and precipitation data (RG1 and RG3) have been collected and processed in recent years by ESD's Hydrology Group. These data for CY 1994 are published in this report. The two discharge monitoring stations represent the longest continuous period of record of any gages on the ORR and support a long-term ecosystem research project initiated in 1967. In addition, the raingages represent two of the longest continuous records (since 1982) of precipitation on the ORR. All four gages are in danger of being discontinued at the end of FY 1995 due to lack of funding. The Walker Branch watershed provides reference

watershed information that can be transferred to other parts of the ORR to aid in developing and implementing remedial actions. The usefulness and importance of these data to the many research projects in the region and nationally far outweigh the minimal cost of continued monitoring.

4.2.3 Future Activities

The development and implementation of a comprehensive monitoring program will continue to be supported. In addition, the collection and reporting of hydrologic data will continue to support ER Program goals of identifying and characterizing sources of contamination migrating off-site via the surface-water pathway and the selection and subsequent evaluation of methods for their remediation.

Future hydrologic data summaries will continue to be produced as part of the Surface Water Program. Staff, including subcontractors, will perform the data collection, compilation, and processing, as well as maintenance and oversight of surface-water monitoring system upgrade activities. The hydrologic data will be incorporated into annual Environmental Restoration Monitoring and Assessment (ERMA) reports that provide a comprehensive picture of ER Program facilities at a watershed scale by identifying and interpreting spatial and temporal trends in contaminant movement within the WOC watershed.

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Appendix A

DAILY PRECIPITATION TOTALS FOR STATIONS IN THE WHITE OAK CREEK WATERSHED

**Table A.1. Daily precipitation (in) at the First Creek (1ST) raingage
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.14	0.00	1.44	0.00(e)	0.27	0.00	0.00	0.00	0.04	0.00	0.04	0.00
2	0.01	0.00	1.17	0.00(e)	0.00	0.50	0.00	0.05	0.00	0.00	0.00	0.00
3	0.71	0.00	0.00	0.24(e)	0.85	0.00	0.00	0.13	0.00	0.00	0.00	0.06
4	0.09	0.05	0.00	0.00(e)	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.45
5	0.00	0.31	0.00	1.02(e)	0.00	0.04	0.03	0.53	0.03	0.00	0.03	0.24
6	0.00	0.00	0.00	0.77(e)	0.00	0.24	0.00	0.00	0.11	0.00	0.02	0.00
7	0.90	0.00	0.00	0.00	0.18	0.35	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.32	0.10	0.00	0.01	0.02	0.13	0.00	0.00	0.00	0.00	0.00
9	0.00	1.15	0.84	0.00	0.00	0.30	0.08	0.00	0.00	1.19	0.48	0.00
10	0.00	2.66	0.01	1.33	0.00	0.61	0.00	0.00	0.00	0.00	0.23	1.24
11	0.86	1.24	0.00	0.60	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
12	0.37	0.00	0.00	2.16	0.00	0.00	0.37	0.00	0.00	0.23	0.00	0.00
13	0.00	0.00	0.04	0.01	0.06	0.33	0.45	0.08	0.00	0.03	0.00	0.00
14	0.05	0.00	0.00	0.00	0.17	0.00	0.00	1.28	0.00(e)	0.00	0.00	0.00
15	0.00	0.00	0.00(e)	1.99	0.35	0.45	0.43	0.00	0.00(e)	0.00	0.00	0.00
16	0.00	0.00	0.00(e)	0.00	0.00	0.37	0.60	0.40	0.00(e)	0.00	0.00	0.19
17	1.01	0.00	0.00	0.00	0.00	0.37	0.26	0.00	1.68(e)	0.00	0.00	0.07
18	0.00	0.00	0.04	0.00	0.00	0.00	0.16	0.00	0.16(e)	0.00	0.00	0.00
19	0.00	0.00	0.00(e)	0.00	0.00	0.00	0.00	0.71	0.00(e)	0.33	0.00	0.00
20	0.00	0.08	0.05(e)	0.00	0.00	0.00	0.01(e)	0.25	0.00(e)	0.00(e)	0.00	0.00
21	0.00	1.05	0.34(e)	0.00	0.00	0.09	0.04	0.44	0.00(e)	0.00(e)	0.04	0.04
22	0.00	0.52	0.00(e)	0.00	0.00	0.00	0.00	0.00	0.00	0.18(e)	0.00	0.13
23	0.00	2.16	0.00(e)	0.00	0.00	0.00	0.00	0.00	0.42	0.03(e)	0.00	0.00
24	0.00	0.00	1.50(e)	0.00	0.00	0.42	0.00	0.00	0.05	0.00(e)	0.00	0.00
25	0.92	0.00	0.16(e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00(e)	0.00	0.00
26	0.15	0.00	0.26(e)	0.00	1.41	2.59	0.53	0.00	0.05	0.01(e)	0.11	0.00
27	0.77	0.00	4.50(e)	0.21	0.00	0.04	0.54	0.00	0.00	0.00	1.27	0.00
28	0.23	0.00	0.49(e)	0.00	0.00	0.00	0.04	0.00	0.00	0.00	1.37	0.00
29	0.00		0.05(e)	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
30	0.00		0.21(e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.23(e)		0.00		0.00	0.65		0.08		0.12
TOTAL	6.21	9.54	11.43	8.33	3.30	6.72	4.02	4.72	2.54	2.08	3.59	2.54
MEAN	0.20	0.34	0.37	0.28	0.11	0.22	0.13	0.15	0.08	0.07	0.12	0.08
MAX	1.01	2.66	4.50	2.16	1.41	2.59	0.60	1.28	1.68	1.19	1.37	1.24

(e) - Data from station other than 1ST

Table A.2. Daily precipitation (in) at the Engineering Test Facility (ETF) raingage for the period January-December 1994

DAY	JAN	FEB	MAR	APR	MAY
1	0.15	0.00	1.49	0.00	0.24
2	0.01	0.00	1.24	0.00	0.00
3	0.80	0.00	0.00	0.26	0.90
4	0.06	0.05	0.00	0.00	0.00
5	0.00	0.39	0.00	1.06	0.00
6	0.00	0.00	0.00	0.99	0.00
7	0.92	0.00	0.00	0.00	0.11
8	0.00	0.28	0.13	0.00	0.04
9	0.00	1.30	0.92	0.00	0.00
10	0.00	2.69	0.01	1.83	0.00
11	0.96	1.47	0.00	0.74	0.00
12	0.34	0.00	0.00	1.95	0.00
13	0.00(e)	0.00	0.02	0.02	0.01
14	0.03(e)	0.00	0.00	0.00	0.19
15	0.00(e)	0.00	0.00	1.75	0.56
16	0.00(e)	0.00	0.00	0.00	0.00
17	1.01(e)	0.00	0.00	0.00	0.00
18	0.00(e)	0.00	0.03	0.00	0.00
19	0.00(e)	0.00	0.00	0.00	0.00
20	0.00(e)	0.05	0.03	0.00	0.00
21	0.00	1.13	0.34	0.00	0.00
22	0.00	0.53	0.00	0.00	0.00
23	0.00	2.31	0.00	0.00	0.00
24	0.00	0.00	1.56	0.00	0.00
25	1.02	0.00	0.23	0.00	0.09
26	0.17	0.00	0.29	0.00	1.97
27	0.68	0.00	4.49	0.26	0.00
28	0.36	0.00	0.54	0.00	0.00
29	0.00		0.08	0.00	0.00
30	0.00		0.25	0.00	0.00
31	0.00		0.20		0.00
TOTAL	6.51	10.20	11.85	8.86	4.11
MEAN	0.21	0.36	0.38	0.30	0.13
MAX	1.02	2.69	4.49	1.95	1.97

(e) - Data from station other than ETF

**Table A.3. Daily precipitation (in) at the SWSA 7 (SW7) raingage
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.15	0.00	1.37	0.00	0.21	0.00	0.00	0.00(e)	0.03	0.00	0.04	0.00
2	0.02	0.00	1.05	0.00	0.00	0.49	0.00	0.04(e)	0.00	0.00	0.00	0.00
3	0.67	0.00	0.00	0.23	0.86	0.00	0.00	0.13(e)	0.00	0.00	0.00	0.06
4	0.11	0.05	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.42
5	0.00	0.33	0.00	0.98	0.00	0.02	0.00	0.46	0.03	0.00	0.02	0.27
6	0.00	0.00	0.00	0.89	0.00	0.37	0.00	0.00	0.09	0.00	0.03	0.00
7	0.86	0.00	0.00	0.00	0.13	0.20	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.29	0.09	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00	0.00
9	0.00	1.08	0.80	0.00	0.00	0.24	0.11	0.00	0.00	1.22	0.27	0.00
10	0.00	2.62	0.01	1.46	0.00	0.41	0.00	0.00	0.00	0.00	0.28	1.21
11	0.80	1.22	0.00	0.63	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00
12	0.33	0.00	0.00	2.08	0.00	0.00	0.34	0.00	0.00	0.25	0.00	0.00
13	0.00	0.00	0.04	0.03	0.02	0.13	0.36	0.00	0.00	0.04	0.00	0.00
14	0.04	0.00	0.00	0.00	0.13	0.00	0.00	1.35	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	1.76	0.31	0.05	0.40	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.03	0.76	0.42	0.00	0.00	0.00	0.17
17	0.88	0.00	0.00	0.00	0.00	0.48	0.02	0.00	1.16	0.00	0.00	0.07
18	0.00	0.00	0.04	0.00	0.00	0.00	0.09	0.00	0.14	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.36	0.00	0.00
20	0.00	0.05	0.05	0.00	0.00	0.00	0.06	0.21	0.00	0.00	0.00	0.00
21	0.00	1.12	0.28	0.00	0.00	0.52	0.02	0.47	0.00	0.00	0.05	0.02
22	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.14
23	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.01	0.00	0.00
24	0.00	0.00	1.37	0.00	0.00	0.40	0.00(e)	0.00	0.07	0.00	0.00	0.00
25	0.88	0.00	0.16	0.00	0.02	0.00	0.00(e)	0.00	0.00	0.00	0.00	0.00
26	0.16	0.00	0.26	0.00	1.21	2.35	0.51(e)	0.00	0.04	0.02	0.10	0.00
27	0.64	0.00	4.26	0.25	0.00	0.02	0.52(e)	0.00	0.00	0.00	1.27	0.00
28	0.34	0.00	0.45	0.00	0.00	0.00	0.01(e)	0.00	0.00	0.00	1.32	0.00
29	0.00		0.04	0.00	0.00	0.00	0.00(e)	0.02	0.00	0.00	0.00	0.00
30	0.00		0.21	0.00	0.00	0.00	0.00(e)	0.00	0.00	0.00	0.00	0.00
31	0.00		0.21		0.00		0.00(e)	0.51		0.03		0.09
TOTAL	5.88	9.41	10.69	8.31	2.89	5.73	3.65	4.24	1.98	2.10	3.38	2.45
MEAN	0.19	0.34	0.34	0.28	0.09	0.19	0.12	0.14	0.07	0.07	0.11	0.08
MAX	0.88	2.62	4.26	2.08	1.21	2.35	0.76	1.35	1.16	1.22	1.32	1.21

(e) - Data from station other than SW7

**Table A.4. Daily precipitation (in) for the 49-Trench (49T) raingage
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.13	0.00	1.39	0.00	0.24	0.00	0.00	0.00	0.03	0.00	0.03	0.00
2	0.01	0.00	1.11	0.00	0.00	0.46	0.00	0.03	0.00	0.00	0.00	0.00
3	0.74	0.00	0.00	0.22	0.90	0.00	0.00	0.14	0.00	0.00	0.00	0.06
4	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.42
5	0.00	0.37	0.00	1.01	0.00	0.03	0.00	0.50	0.03	0.00	0.01	0.33
6	0.00	0.00	0.00	0.88	0.00	0.36	0.00	0.00	0.09	0.00	0.02	0.00
7	0.84	0.00	0.00	0.00	0.11	0.23	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.25	0.12	0.00	0.04	0.02	0.13	0.00	0.00	0.00	0.00	0.00
9	0.00	1.16	0.84	0.00	0.00	0.15	0.09	0.00	0.00	1.23	0.29	0.00
10	0.00	2.86	0.01	1.69	0.00	0.52	0.00	0.00	0.00	0.00	0.21	1.23
11	0.87	1.16	0.00	0.72	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
12	0.32	0.00	0.00	1.79	0.00	0.00	0.21	0.00	0.00	0.23	0.00	0.00
13	0.00	0.00	0.02	0.02	0.01	0.18	0.35	0.04	0.00	0.03	0.00	0.00
14	0.03	0.00	0.00	0.00	0.15	0.00	0.00	0.85	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	1.75	0.49	0.23	0.89	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.17	1.14	0.35	0.00	0.00	0.00	0.17
17	1.01	0.00	0.00	0.00	0.00	0.44	1.26	0.00	1.99	0.00	0.00	0.06
18	0.00	0.00	0.03	0.00	0.00	0.03	0.21	0.00	0.03	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.38	0.00	0.00
20	0.00	0.06	0.04	0.00	0.00	0.00	0.02	0.18	0.00	0.00	0.00	0.00
21	0.00	1.04	0.30	0.00	0.00	0.00	0.02	0.39	0.00(e)	0.00	0.02	0.02
22	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.13
23	0.00	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.05	0.00	0.00
24	0.00	0.00	1.54	0.00	0.00	0.40	0.00	0.00	0.10	0.00	0.00	0.00
25	0.93	0.00	0.21	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.16	0.00	0.27	0.00	1.88	2.70	0.53	0.00	0.03	0.00	0.10	0.00
27	0.69	0.00	4.19	0.26	0.00	0.09	0.57	0.00	0.00	0.00	1.30	0.00
28	0.30	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.00
29	0.00		0.07	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
30	0.00		0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.18		0.00		0.02	0.44		0.02		0.11
TOTAL	6.10	9.58	11.06	8.34	3.91	6.01	5.84	3.64	2.71	2.09	3.32	2.53
MEAN	0.20	0.34	0.36	0.28	0.13	0.20	0.19	0.12	0.09	0.07	0.11	0.08
MAX	1.01	2.86	4.19	1.79	1.88	2.70	1.26	0.85	1.99	1.23	1.34	1.23

(e) - Data from station other than 49T

**Table A.5. Daily precipitation (in) at the SWSA 4 (SW4) raingage
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.15	0.00	1.37	0.00	0.22	0.00	0.00	0.00	0.01	0.00	0.03	0.00
2	0.01	0.00	1.09	0.00	0.00	0.44	0.00	0.04	0.00	0.00	0.00	0.00
3	0.69	0.00	0.00	0.24	0.79	0.00	0.00	0.13	0.00	0.00	0.00	0.06
4	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.43
5	0.00	0.32	0.00	1.02	0.00	0.04	0.02	0.53	0.01	0.00	0.02	0.28
6	0.00	0.00	0.00	0.77	0.00	0.27	0.00	0.00	0.10	0.00	0.02	0.00
7	0.88	0.00	0.00	0.00	0.09	0.30	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.29	0.11	0.00	0.03	0.03	0.13	0.00	0.00	0.00	0.00	0.00
9	0.00	1.15(e)	0.81	0.00	0.00	0.21	0.06	0.00	0.00	1.19	0.36	0.00
10	0.00	2.66(e)	0.00	1.44	0.00	0.39	0.00	0.00	0.00	0.00	0.23	1.24
11	0.86	1.24(e)	0.00	0.69	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00
12	0.31	0.00(e)	0.00	2.05	0.00	0.00	0.28	0.00	0.00	0.22	0.00	0.00
13	0.00	0.00(e)	0.04	0.04	0.03	0.25	0.38	0.06	0.00	0.02	0.00	0.00
14	0.05	0.00(e)	0.00	0.00	0.14	0.00	0.00	1.06	0.00	0.00	0.00	0.00
15	0.00	0.00(e)	0.00	1.84	0.44	0.39	0.66	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00(e)	0.00	0.00	0.00	0.38	0.79	0.38	0.00	0.00	0.00	0.18
17	0.95	0.00	0.00	0.00	0.00	0.35	0.93	0.00	1.68	0.00	0.00	0.07
18	0.00	0.00	0.04	0.00	0.00	0.00	0.28	0.00	0.16	0.00	0.00	0.00
19	0.00(e)	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.40	0.00	0.00
20	0.00	0.06	0.05	0.00	0.00	0.00	0.01	0.27	0.00	0.00	0.00	0.00
21	0.00	1.04	0.34	0.00	0.00	0.01	0.03	0.46	0.00	0.00	0.05	0.03
22	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.14
23	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.03	0.00	0.00
24	0.00	0.00	1.50	0.00	0.00	0.44	0.00	0.00	0.05	0.00	0.00	0.00
25	0.95	0.00	0.16	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.16	0.00	0.26	0.00	1.49	2.65	0.51	0.00	0.04	0.01	0.12	0.00
27	0.77(e)	0.00	4.50	0.18	0.00	0.05	0.52	0.00	0.00	0.00	1.28	0.00
28	0.23(e)	0.00	0.49	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1.33	0.00
29	0.00		0.05	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
30	0.00		0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.23		0.00		0.00	0.66		0.03		0.12
TOTAL	6.08	9.50	11.25	8.27	3.24	6.20	4.97	4.40	2.46	2.08	3.44	2.55
MEAN	0.20	0.34	0.36	0.28	0.10	0.21	0.16	0.14	0.08	0.07	0.11	0.08
MAX	0.95	2.66	4.50	2.05	1.49	2.65	0.93	1.06	1.68	1.19	1.33	1.24

(e) - Data from station other than SW4

**Table A.6. Daily precipitation (in) at the Ish Creek (ISH) raingage
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.15(e)	0.00	1.41	0.00	0.22	0.00	0.00	0.00	0.02	0.00	0.04	0.00
2	0.01(e)	0.00	1.14	0.00	0.00	0.42	0.00	0.03	0.00	0.00	0.00	0.00
3	0.80(e)	0.00	0.00	0.23	0.82	0.00	0.00	0.10	0.00	0.00	0.00	0.07
4	0.06(e)	0.03	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.48
5	0.00(e)	0.30	0.00	1.09	0.00	0.04	0.00	0.60	0.03	0.00	0.03	0.23
6	0.00	0.00	0.00	0.73	0.00	0.14	0.00	0.00	0.12	0.00	0.01	0.00
7	0.90	0.00	0.00	0.00	0.17	0.43	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.30	0.12	0.00	0.00	0.04	0.17	0.00	0.00	0.00	0.00	0.00
9	0.00	1.11	0.88	0.00	0.00	0.19	0.10	0.00	0.00	1.09	0.55	0.00
10	0.00	2.80	0.01	1.44	0.00	0.68	0.00	0.00	0.00	0.00	0.22	1.27
11	0.84	1.23	0.00	0.62	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00
12	0.35	0.00	0.00	2.06	0.00	0.00	0.54	0.00	0.00	0.24	0.00	0.00
13	0.00	0.00	0.05	0.00	0.03	0.51	0.50	0.02	0.00	0.03	0.00	0.00
14	0.03	0.00	0.00	0.00	0.17	0.00	0.00	1.55	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	2.00	0.47	0.09	0.45	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.44	0.90	0.33	0.00	0.00	0.00	0.18
17	1.01(e)	0.00	0.00	0.00	0.00	0.27	0.49	0.00	1.23	0.00	0.00	0.07
18	0.00(e)	0.00	0.03	0.00	0.00	0.01	0.56	0.00	0.10	0.00	0.00	0.00
19	0.00(e)	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.37	0.00	0.00
20	0.00(e)	0.06	0.05	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
21	0.00(e)	1.07	0.25	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.04	0.02
22	0.00(e)	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.14
23	0.00	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.04	0.00	0.00
24	0.00	0.00	1.66	0.00	0.00	0.47	0.00	0.00	0.05	0.00	0.00	0.00
25	0.94	0.00	0.17	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.11	0.00	0.26	0.00(e)	1.51	2.74	0.49	0.00	0.07	0.00	0.12	0.00
27	0.66	0.00	4.41	0.26(e)	0.00	0.06	0.56	0.00	0.00	0.00	1.24	0.00
28	0.30	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.00
29	0.00		0.06	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
30	0.00		0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.16		0.00		0.10	0.80		0.17		0.11
TOTAL	6.16	9.62	11.40	8.43	3.40	6.53	5.22	4.77	2.06	2.11	3.53	2.57
MEAN	0.20	0.34	0.37	0.28	0.11	0.22	0.17	0.15	0.07	0.07	0.12	0.08
MAX	1.01	2.80	4.41	2.06	1.51	2.74	0.90	1.55	1.23	1.09	1.28	1.27

(e) - Data from station other than ISH

**Table A.7. Daily precipitation (in) at the Walker Branch Watershed (RG1)
raingage for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.14	0.00	1.40	0.00	0.18	0.00	0.00	0.00	0.04	0.00	0.02	0.00
2	0.01	0.00	1.02	0.00	0.00	0.11	0.00	0.02	0.00	0.00	0.00	0.00
3	0.72	0.00	0.00	0.28	0.81	0.00	0.00	0.07	0.00	0.00	0.00	0.04
4	0.11	0.04	0.00	0.00	0.01	0.00	0.04	0.20	0.00	0.00	0.00	0.57
5	0.00	0.26	0.00	1.00	0.00	0.00	0.00	0.59	0.02	0.00	0.03	0.13
6	0.00	0.00	0.00	0.74	0.00	0.21	0.00	0.00	0.08	0.00	0.02	0.00
7	1.00	0.00	0.00	0.00	0.22	0.48	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.27	0.07	0.00	0.03	0.29	0.14	0.00	0.00	0.00	0.00	0.00
9	0.00	1.52	0.78	0.00	0.00	0.21	0.06	0.00	0.00	1.21	0.73	0.00
10	0.00	2.74	0.00	1.42	0.00	1.05	0.00	0.00	0.00	0.00	0.27	1.22
11	0.76	1.19	0.00	0.59	0.00	0.12	0.38	0.00	0.00	0.00	0.00	0.00
12	0.35	0.00	0.00	2.38	0.00	0.00	0.26	0.00	0.00	0.22	0.00	0.00
13	0.00	0.00	0.05	0.03	0.03	0.19	0.43	0.00	0.00	0.04	0.00	0.00
14	0.02	0.00	0.00	0.00	0.14	0.00	0.00	1.05	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	2.25	0.82	0.34	0.79	0.00	0.00(e)	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.01	0.46	0.32	0.00(e)	0.00	0.00	0.18
17	0.98	0.00	0.00	0.00	0.00	0.24	0.36	0.00	2.05(e)	0.00	0.00	0.09
18	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.02(e)	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00(e)	0.39	0.00	0.00
20	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.39	0.00(e)	0.00	0.00(e)	0.00
21	0.00	1.18	0.30	0.00	0.00	0.91	0.00	0.47	0.00(e)	0.00	0.07(e)	0.00
22	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.14
23	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00
24	0.00	0.00	0.88	0.00	0.00	0.32	0.00	0.00	0.24	0.00	0.00	0.00
25	0.85	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.09	0.00	0.29	0.00	0.50	2.50	0.56	0.00	0.04	0.00	0.09	0.00
27	0.79	0.00	4.22	0.26	0.00	0.23	0.81	0.00	0.00	0.00	1.26	0.00
28	0.27	0.00	0.64	0.00	0.00	0.00	0.06	0.00	0.00	0.00	1.27	0.00
29	0.00		0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
30	0.00		0.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.20		0.00		0.00	0.59		0.06		0.12
TOTAL	6.09	9.74	10.30	8.96	2.74	7.22	4.35	4.16	2.87	2.09	3.76	2.49
MEAN	0.20	0.35	0.33	0.30	0.09	0.24	0.14	0.13	0.10	0.07	0.13	0.08
MAX	1.00	2.74	4.22	2.38	0.82	2.50	0.81	1.05	2.05	1.21	1.27	1.22

(e) - Data from station other than RG1

**Table A.8. Daily precipitation (in) at the Walker Branch Watershed (RG3)
raingage for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.15	0.00	1.40	0.00	0.19	0.00	0.00	0.00	0.03	0.00	0.02	0.00
2	0.01	0.00	1.02	0.00	0.00	0.15	0.00	0.02	0.00	0.00	0.00	0.00
3	0.73	0.00	0.00	0.29	0.81	0.00	0.00	0.07	0.00	0.00	0.00	0.06
4	0.11	0.07	0.00	0.00	0.02	0.00	0.00	0.27	0.00	0.00	0.00	0.48
5	0.00	0.22	0.00	1.01	0.00	0.00	0.00	0.62	0.02	0.00	0.03	0.22
6	0.00	0.00	0.00	0.71	0.00	0.26	0.00	0.00	0.08	0.00	0.02	0.00
7	0.95	0.00	0.00	0.00	0.27	0.54	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.35	0.07	0.00	0.01	0.31	0.16	0.00	0.00	0.00	0.00	0.00
9	0.00	1.56	0.77	0.00	0.00	0.18	0.09	0.00	0.00	1.18	0.59	0.00
10	0.00	2.65	0.00	1.44	0.00	1.07	0.00	0.00	0.00	0.00	0.30	1.21
11	0.79	1.30	0.00	0.62	0.00	0.00	0.38(e)	0.00	0.00	0.00	0.00	0.00
12	0.32	0.00	0.00	2.33	0.00	0.00	0.26(e)	0.00	0.00	0.24	0.00	0.00
13	0.00	0.00	0.04	0.02	0.04	0.16	0.43(e)	0.00	0.00	0.04	0.00	0.00
14	0.02	0.00	0.00	0.00	0.12	0.00	0.00(e)	1.25	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	2.17	0.84	0.37	0.91	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.02	0.40	0.33	0.00	0.00	0.00	0.18
17	1.03	0.00	0.00	0.00	0.00	0.20	0.34	0.00	2.05	0.00	0.00	0.09
18	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.46	0.00	0.00
20	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00
21	0.00	1.16	0.24	0.00	0.00	0.84	0.00	0.52	0.00	0.00	0.07	0.01
22	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.15
23	0.00	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00
24	0.00	0.00	0.84	0.00	0.00	0.34	0.00	0.00	0.24	0.00	0.00	0.00
25	0.82	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.14	0.00	0.26	0.00	0.51	2.57	0.73	0.00	0.05	0.00	0.11	0.00
27	0.77	0.00	4.13	0.27	0.00	0.29	0.82	0.00	0.00	0.00	1.22	0.00
28	0.29	0.00	0.51	0.00	0.00	0.00	0.08	0.00	0.00	0.00	1.24	0.00
29	0.00		0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
30	0.00		0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.19		0.00		0.00	0.57		0.08		0.13
TOTAL	6.13	9.84	9.87	8.87	2.81	7.30	4.60	4.39	2.92	2.17	3.60	2.53
MEAN	0.20	0.35	0.32	0.30	0.09	0.24	0.15	0.14	0.10	0.07	0.12	0.08
MAX	1.03	2.65	4.13	2.33	0.84	2.57	0.91	1.25	2.05	1.18	1.24	1.21

(e) - Data from station other than RG3

**Table A.9. Daily precipitation (in) at the Bear Creek Burial Ground (BUR)
raingage for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.16	0.00	1.41	0.00	0.18	0.00	0.00	0.00	0.03	0.00	0.02	0.00
2	0.01	0.00	1.03	0.00	0.00	0.13	0.00	0.03	0.00	0.00	0.00	0.00
3	0.74	0.00	0.00	0.30	0.79	0.00	0.00	0.08	0.00	0.00	0.00	0.05
4	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.48
5	0.00	0.19	0.00	1.05	0.00	0.00	0.00	0.61	0.03	0.00	0.03	0.22
6	0.00	0.00	0.00	0.72	0.00	0.20	0.00	0.00	0.08	0.00	0.04	0.00
7	1.00	0.00	0.00	0.00	0.27	0.45	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.35	0.08	0.00	0.01	0.31	0.16	0.00	0.00	0.00	0.00	0.00
9	0.00	1.63	0.76	0.00	0.00	0.23	0.04	0.00	0.00	1.22	0.63	0.00
10	0.00	2.68	0.01	1.57	0.00	1.37	0.00	0.00	0.00	0.00	0.17	1.26
11	0.83	1.36	0.00	0.61	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00
12	0.34	0.00	0.00	2.51	0.00	0.00	0.19	0.00	0.00	0.22	0.00	0.00
13	0.00	0.00	0.05	0.01	0.04	0.40	0.43(e)	0.01	0.00	0.03	0.00	0.00
14	0.02	0.00	0.00	0.00	0.14	0.00	0.00(e)	1.25	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	2.11	0.82	0.42	0.91(e)	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.03	0.40(e)	0.31	0.00	0.00	0.00	0.21
17	0.95	0.00	0.00	0.00	0.00	0.17	0.34(e)	0.00	2.27	0.00	0.00	0.08
18	0.00	0.00	0.04	0.00	0.00	0.02	0.00(e)	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00(e)	0.35	0.00	0.48	0.00	0.00
20	0.00	0.04	0.04	0.00	0.00	0.00	0.00(e)	0.31	0.00	0.00	0.00	0.00
21	0.00	1.23	0.24	0.00	0.00	0.42	0.00	0.63	0.00	0.00	0.05	0.01
22	0.00	0.49	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.15	0.00	0.17
23	0.00	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00
24	0.00(e)	0.00	0.86	0.00	0.00	0.70	0.00	0.00	0.15	0.00	0.00	0.00
25	0.82(e)	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.14(e)	0.00	0.29	0.00	0.53	2.76	0.71	0.00	0.05	0.00	0.12	0.00
27	0.77(e)	0.00	4.04	0.28	0.00	0.21	1.27	0.00	0.00	0.00	1.25	0.00
28	0.29(e)	0.00	0.67	0.00	0.00	0.00	0.16	0.00	0.00	0.00	1.19	0.00
29	0.00		0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00		0.20		0.00		0.00	0.56		0.10		0.15
TOTAL	6.17	10.19	10.07	9.18	2.78	7.82	5.06	4.38	3.04	2.20	3.50	2.63
MEAN	0.20	0.36	0.32	0.31	0.09	0.26	0.16	0.14	0.10	0.07	0.12	0.08
MAX	1.00	2.68	4.04	2.51	0.82	2.76	1.27	1.25	2.27	1.22	1.25	1.26

(e) - Data from station other than BUR

**Table A.10. Daily precipitation totals at the NOAA/ATDD in Oak Ridge
for the period January–December 1994
(units=in)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.13	0.00	1.37	0.00	0.17	0.00	0.00	0.00	0.01	0.00	0.02	0.00
2	0.08	0.00	0.89	0.00	0.00	0.15	0.00	0.00	0.02	0.00	0.00	0.00
3	0.64	0.00	0.04	0.00	0.80	0.00	0.00	0.08	0.00	0.01	0.00	0.06
4	0.12	0.02	0.00	0.00	0.00	0.00	0.21	0.07	0.00	0.00	0.00	0.53
5	0.00	0.20	0.00	1.14	0.00	0.00	0.00	0.57	0.03	0.00	0.03	0.24
6	0.00	0.00	0.00	0.70	0.00	0.18	0.00	0.00	0.08	0.00	0.04	0.00
7	1.00	0.00	0.00	0.00	0.47	0.89	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.21	0.09	0.00	0.01	0.20	0.12	0.00	0.00	0.00	0.00	0.00
9	0.00	1.45	0.77	0.00	0.00	0.31	0.03	0.00	0.00	1.35	0.24	0.00
10	0.00	2.88	0.00	1.71	0.00	0.64	0.02	0.00	0.00	0.00	0.42	1.27
11	0.77	1.19	0.00	0.69	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00
12	0.38	0.00	0.00	2.72	0.00	0.00	0.17	0.00	0.00	0.28	0.00	0.00
13	0.00	0.00	0.02	0.01	0.03	0.38	0.46	0.01	0.00	0.07	0.00	0.00
14	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.51	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	2.23	0.85	0.00	0.29	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.27	0.39	0.39	0.00	0.00	0.00	0.21
17	0.81	0.00	0.00	0.00	0.00	0.15	0.06	0.00	1.32	0.00	0.00	0.12
18	0.00	0.00	0.04	0.00	0.00	0.00	0.55	0.00	0.02	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.54	0.00	0.00
20	0.00	0.12	0.05	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00
21	0.00	1.31	0.35	0.00	0.00	0.02	0.09	0.61	0.00	0.00	0.06	0.00
22	0.00	0.50	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.19	0.00	0.22
23	0.00	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.01	0.00	0.00
24	0.02	0.00	0.81	0.00	0.00	0.94	0.00	0.00	0.21	0.00	0.00	0.00
25	0.88	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.06	0.00	0.27	0.00	0.54	3.01	0.54	0.20	0.04	0.01	0.10	0.00
27	0.83	0.00	3.71	0.30	0.00	0.00	1.93	0.22	0.01	0.00	1.18	0.00
28	40.00	0.00	0.55	0.00	0.00	0.01	0.03	0.01	0.00	0.00	1.23	0.00
29	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00		0.27		0.00		0.00	0.31		0.10		0.14
TOTAL	6.12	9.79	9.47	9.81	3.03	7.15	5.53	3.85	2.14	2.56	3.32	2.80
MEAN	0.20	0.35	0.31	.033	0.10	0.24	0.18	0.12	0.07	0.08	0.11	0.09
MAX	1.00	2.88	3.71	2.72	0.85	3.01	1.93	0.81	1.32	1.35	1.23	1.27

Appendix B

DESCRIPTIONS OF SURFACE-WATER MONITORING STATIONS IN THE WHITE OAK CREEK WATERSHED

1. White Oak Dam (WOD, X15, MS5)

Physical description: Station is at the outfall of WOL where WOC flows under State Highway 95, 1 km (0.6 mi) above the confluence with the Clinch River. Waters impounded by WOD flow through two 5.5 m (18 ft) sluice gates, through a 12.2 m (40 ft) wide channel; across a triangular, concrete, broad-crested weir (high-flow control); and finally, across a stainless steel, sharp-crested (trapezoidal) weir (low-flow control) before spilling into the White Oak Creek embayment. The notch (crest) elevations on the broad- and sharp-crested weirs are about 226.8 m (744.0 ft) and 226.6 m (743.5 ft) MSL, respectively. Normal pool elevation for WOL is about 227.1 (745 ft) MSL. Maximum lake elevation (without overtopping the gates) with the gates closed is about 228.6 m (750 ft) MSL. Crest elevation of WOD is about 230.13 m (755.05 ft) MSL at its lowest point near the longitudinal center (Tschantz, 1987).

Monitoring status: EMP collects daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Hydrology Group collects stage height data at four sensor locations, including lake level, for conversion to discharge data.

2. White Oak Creek (WOC, X14, MS3)

Physical description: Station is on WOC above the confluence with MB. Water flows into a stilling pool impounded by a concrete sill; through twin stainless steel, sharp-crested, 100° V-notch weirs contained in the sill; into a 11.0 m (36 ft) wide channel; then across a rectangular, concrete, broad-crested weir before finally spilling back into the natural channel downstream from the station. The elevations of the top of the V-notch weirs, the crests of the V-notch weirs, and the broad-crested weir are about 230.21 m, 229.45 m, and 229.21 m (755.48, 753.00, and 752.23 ft) MSL, respectively.

Monitoring status: EMP collects daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Hydrology Group collects stage height data at three sensor locations for conversion to discharge data.

3. Melton Branch (MB, X13, MS4)

Physical description: Station is on MB above the confluence with WOC. Water flows are impounded by a concrete sill, through a stainless steel, sharp-crested, 120° V-notch weir contained in the sill; into a 7.3 m (24 ft) wide channel; then across a rectangular, concrete, broad-crested weir before finally spilling into a tailwater pool downstream from the station. The elevations of the top of the V-notch weir, the crests of the V-notch weir, and the broad-crested weir are about 230.3 m, 229.6 m, and 229 m (755.90, 753.67, and 752.31 ft) MSL, respectively.

Monitoring status: EMP collects daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Hydrology Group collects stage height data at three sensor locations for conversion to discharge data.

4. White Oak Creek Headwaters (WOCHW)

Physical description: Station is in the upper reaches of WOC, north of Bethel Valley Road and upstream from any ORNL facility discharges. Therefore, this station is considered a background monitoring station for WOC. The control device is a compound, stainless steel, critical-flow flume.

Monitoring status: *Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains the instrumentation; collects punch-tapes and electronic data storage packs; processes tapes and storage packs; and generates, verifies, and stores discharge data. EMP operates a flow totalizer at this station.*

5. East Seep (ESP)

Physical description: Station is in WAG 7 on the east seep tributary to the headwaters of WOL. The control device is a stainless steel, sharp-crested, 90° V-notch weir.

Monitoring status: *Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains the instrumentation; collects punch tapes and electronic data storage packs; processes tapes and storage packs; and generates, verifies, and stores discharge data.*

6. West Seep (WSP)

Physical description: Station is in WAG 2 bordering the east slope of WAG 6 on the west seep tributary to the headwaters of WOL. The control device is a compound, stainless steel, sharp-crested, weir consisting of a 120° V-notch, low-flow section and a rectangular, high-flow section.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

7. Raccoon Creek

Physical description: Station is in the upper reaches of Raccoon Creek, approximately 0.4 km (0.25 mi) west of State Highway 95, 0.15 km (0.1 mi) south of New Zion Patrol Road, and 2.1 km (1.3 mi) upstream from the mouth at Clinch River kilometer 31.5 (mile 19.5). The control device is a stainless steel, sharp-crested weir in three sections: a 56° V-notch in the center of the channel for stages from 0 to 1.25 ft; and a vertical extension of the V-notch and two rectangular weir plates with end contractions, one on each side of the V-notch, for stages from 1.25 to 2.5 ft.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

8. Ish Creek

Physical description: Station is at the bridge on New Zion Patrol Road, 2.7 km (1.7 mi) west of State Highway 95 and 0.6 km (0.4 mi) upstream from the mouth at Clinch River kilometer 30.7 (mile 19.1). The low-flow control device is a stainless steel, critical flow flume, and the high-flow control device is the rectangular, concrete, culvert (bridge) opening.

Monitoring status: Monitoring by ESD was discontinued at the end of February 1993.

9. Melton Branch Tributary (HRT)

Physical description: Station is on the tributary to MB in the vicinity of the old Homogenous Reactor Test Facility. The control device is a stainless steel, sharp-crested, 90° V-notch weir.

Monitoring status: *Monitoring by ESD was discontinued at the end of FY 1994 (September 1994).*

10. WAG4-2 (MS1)

Physical description: Station is on the upper reaches of an unnamed tributary to White Oak Creek that runs along the southern boundary of SWSA 4. Access to the site is through SWSA 4 from Lagoon Road. The control device is a Plasti-fab, prefabricated fiberglass, 5 cm (2 in), 45° trapezoidal flume.

Monitoring status: Instrumentation includes an Omnidata Easy Logger (electronic data logger) with a submerged pressure transducer installed in the stilling pool for measuring stage. ESD's Hydrology Group maintains the instrumentation; retrieves data storage packs; and downloads and archives data.

11. WAG4-2A (T2A)

Physical description: Station is just above the mouth of an unnamed tributary to White Oak Creek that runs along the southern boundary of SWSA 4 in the vicinity of the old intermediate detention pond. The control device is a Plasti-Fab prefabricated fiberglass, 12.7 cm (5 in), 45° trapezoidal flume.

Monitoring status: *Monitoring by ESD was discontinued at the end of FY 1994 (September 1994).*

12. Melton Branch (MB2)

Physical description: Station is on MB upstream from the confluence with the HRT (Homogenous Reactor Test Facility) tributary. The control device is a 1.83 m (6 ft) wide, stainless steel, sharp-crested, trapezoidal weir.

Monitoring status: EMP operates a flow totalizer at this station.

13. Melton Branch Tributary (HRTF)

Physical description: Station is on the tributary to Melton Branch in the vicinity of the old Homogenous Reactor Test Facility upstream from the confluence with MB and downstream from station HRT (#14 below). The control device is a Manning 0.46 m (18 in), prefabricated fiberglass Palmer-Bowlus flume.

Monitoring status: No monitoring is conducted at this station. Some limited stage data were collected by ESD from August 1989 to January 1990 for an independent study on storm-flow sampling. These data are available in electronic files but have not been processed.

14. WAG 6 Tributaries (FA, FB, DA, and DB)

Physical description: Stations are on the four drainages in WAG 6 (all draining into White Oak Lake). Proceeding west to east: station FA is a 5 cm (2 in), 60° trapezoidal flume; station FB is a 15 cm (6 in) parshall flume; station DA is a 0.46 m (18 in) parshall flume; and station DB consists of 15 cm and 0.91 m (6 in and 36 in) parshall flumes in series. All flumes are prefabricated fiberglass flumes with dual 0.3 m (12 in) stilling wells for upstream (H1) and downstream (H2) head measurements.

Monitoring status: ESD's Hydrology Group collected data at all four stations for a brief period, from about late April to early June of 1990. All four stations were reinstrumented in the spring of 1992 by the Interim Corrective Measures (ICM) monitoring program for discharge data collection and water quality sampling.

15. White Oak Creek and Clinch River Confluence

Physical description: Station is at the mouth of WOC on the Clinch River at Clinch River mile 20.8. Station is a stage recorder only (no control device).

Monitoring status: *Monitoring by ESD was discontinued at the end of April 1995.*

16. First Creek (GS1, USGS #03536450)

Physical description: Station is on the First Creek tributary to WOC (above) between Burial Ground Road and the confluence with the Northwest tributary. The control device is a compound, stainless steel, critical-flow flume.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. The gage collects raw stage data at 5-min intervals for conversion to hourly average discharge values.

17. Upper Melton Branch (GS2, USGS #03537100)

Physical description: Station is in the upper reaches of MB near the proposed SWSA 7, 1.6 kilometers (1 mile) southeast of ORNL, just upstream from the HFIR complex. The control device is a "natural" concrete overflow sill with a broad, flat, triangular notch.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

18. 7500 Bridge (MS2A, GS3, USGS #03536550)

Physical description: Station is on WOC below the confluence with First Creek and Northwest Tributary where Melton Valley Drive meets Lagoon Road. The control device is a compound stainless steel sharp-crested weir consisting of a low-flow trapezoidal section, a trapezoidal transition section, and a rectangular high-flow section.

Monitoring status: USGS instrumentation includes a bubbler gage equipped with a digital punch, stage-height recorder that transmits stage data via a satellite telemetry system to the USGS data base in Nashville, TN. Stage or converted discharge data are available in near real-time for immediate access, and are also processed to produce on-line computer summaries of data. This site also has a raingage that is part of the DCP system in use. In addition, EMP operates a flow totalizer at this station.

19. Northwest Tributary (NWT, GS4, USGS #03536440)

Physical description: Station is on the Northwest tributary to WOC above the confluence with First Creek, southwest of the fish ponds behind Building 1504, ORNL. The control device is a concrete and stainless steel, short-crested triangular weir.

Monitoring status: USGS instrumentation includes a bubbler gage equipped with a digital punch, stage-height recorder. The gage collects raw stage data at 15-min intervals for conversion to hourly average discharge values. EMP operates a flow totalizer at this station.

20. White Oak Creek Parshall Flume (MS2, GS5, USGS #03536380)

Physical description: Station is at the existing MS2 concrete and stainless steel, parshall flume on WOC in the main plant area downstream from the confluence with Fifth Creek and upstream from the STP outfall.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and mounted at the upstream side of the concrete structure containing the flume, near the left bank. The gage is equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

21. Upper White Oak Creek (GS6, USGS #03536320)

Physical description: Station is on WOC east of the east gate outside the main plant area and north of the point where WOC crosses White Oak Avenue, near Building 6000, ORNL. The control is a natural bedrock outcropping in the stream.

Monitoring status: The USGS instrumentation includes a Stevens model 7001 float-type gage housed in an instrument shelter over a stilling well on the right bank of the stream. The gage is equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

22. Melton Branch Tributary (East Seven, E7C, GS16, USGS #03537050)

Physical description: Station is on the east tributary (East Seven Creek) to MB adjacent to the proposed SWSA 7. The control device is a prefabricated fiberglass H-flume.

Monitoring status: *USGS monitoring was discontinued at the end of September 1993.*

23. Melton Branch Tributary (Center Seven, C7C, GS17, USGS #03537200)

Physical description: Station is at the center of three tributaries (Center Seven Creek) to MB, adjacent to the proposed SWSA 7. The low-flow control device is a stainless steel, sharp-crested, 90° V-notch weir and the high-flow control device is a 0.76 m (2.5 ft), fiberglass H-flume.

Monitoring status: *USGS monitoring was discontinued at the end of September 1993. ESD monitoring (collection of stage data) was discontinued at the end of December 1993.*

24. Melton Branch Tributary (West Seven, W7C, GS18, USGS #03537300)

Physical description: Station is on the west tributary (West Seven Creek) to MB adjacent to the proposed SWSA 7. The control device is a combination stainless steel rectangular/90° V-notch weir.

Monitoring status: *USGS monitoring was discontinued at the end of September 1993.*

25. Walker Branch East (WBE)

Physical description: Station is on the east fork of Walker Branch about 0.9 km (0.6 mi) upstream from the mouth of Walker Branch at Clinch River and Bethel Valley Road; 0.05 km (0.03 mi) upstream from the confluence of the east and west forks of Walker Branch; and about 3.5 km (2.2 mi) northeast of the 7000 area of ORNL. The control device is a 120° V-notch stainless steel weir set in a concrete dam.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains the instrumentation; collects punch-tapes; processes the tapes; and generates, verifies, and stores discharge data.

26. Walker Branch West (WBW)

Physical description: Station is on the west fork of Walker Branch about 0.9 km (0.6 mi) upstream from the mouth of Walker Branch at Clinch River and Bethel Valley Road; 0.05 km (0.03 mi) upstream from the confluence of the east and west forks of Walker Branch; and about 3.5 km (2.2 mi) northeast of the 7000 area of ORNL. The control device is a 120° V-notch stainless steel weir set in a concrete dam.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Hydrology Group maintains the instrumentation; collects punch-tapes; processes the tapes; and generates, verifies, and stores discharge data.

Appendix C

DAILY STREAMFLOW FOR MONITORING STATIONS IN THE WHITE OAK CREEK WATERSHED

**Table C.1. Daily streamflow (cfs) at the White Oak Creek (MS3)
monitoring station for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.86	11.5	37.8	19.1	7.63	5.81	7.4	6.19	6.04	4.85	5.06	6.88
2	7.44	10.1	86.6	16.1	6.67	7.45	6.45	6.21	5.76	4.69	4.89	6.38
3	17.3	8.87	43.1	15.1	12.8	5.67	6.2	6.71	5.63	4.94	4.86	5.9
4	17.5	8.3	25	13.1	8.82	5.05	6.01	6.54	5.76	4.83	4.93	8.56
5	11.8	10.4	18.1	19	7.77	4.9	6.01	10.6	5.51	4.81	5.05	11.4
6	10.5	8.7	14.6	68.6	7.61	5.72	6.2	6.1	6.33	4.67	4.7	7.94
7	26.6	7.51	12.4	31.8	7.55	6.18	6.28	5.76	5.98	4.55	4.56	7.39
8	19.9	9.21	11.4	21.2	7.1	6.16	6.37	5.7	5.17	4.43	4.69	6.3
9	13.4	45	16.2	16.4	6.59	6.55	6.11	5.71	5.52	12.1	4.4	6.07
10	10.7	105	23.3	25.3	6.82	11.3	6.05	6.3	4.53	5.84	9.71	28.4
11	15.2	189	14.7	92.5	6.41	6.56	7.21	5.88	4.87	5.19	5.3	14.5
12	41	48.6	12.7	76.9	6.26	6.27	8.21	5.9	5	5.44	4.8	9.96
13	19.6	27.6	11.6	107	6.07	7.4	8.6	6.01	4.96	6.2	4.78	8.28
14	14.2	19.4	11.2	32.1	5.79	6.91	7.54	13.6	4.77	5.01	4.69	7.27
15	11	15.8	10.3	83.9	7.57	8.64	8.06	8.14	4.79	5.32	4.49	6.7
16	9.16	13.3	9.33	68.6	6.21	8.32	11.7	8.95	4.94	4.98	4.71	6.93
17	18.5	11.6	8.65	29.1	5.97	8.07	9.6	6.78	8.08	5.02	4.33	6.91
18	13.8	10.6	8.78	20	5.7	8.11	9.76	6.51	15.9	4.82	4.4	6.2
19	10.9	9.19	7.8	15.8	6.07	6.37	7.41	8.94	5.54	6.67	4.58	6.11
20	9.56	8.6	7.58	13.5	5.88	6.47	7.35	10.4	5.22	5.29	4.11	5.96
21	8.79	33.7	8.99	12	5.45	7.73	6.94	12.6	5.24	4.97	4.47	5.66
22	8.17	24.7	7.87	11.2	5.81	6.46	6.76	8.12	4.79	4.91	4.32	6.42
23	7.46	151	7.52	10.3	5.87	5.52	6.49	6.51	6.27	5.2	4.19	5.94
24	7.49	40	27.4	9.37	6.14	7.56	6.35	6.41	5.63	4.57	4.18	5.96
25	24.4	23.2	24.4	8.75	6.12	6.37	6.58	6.38	5.29	4.56	4.46	5.83
26	22.7	16.9	17	8.32	13.9	38.3	7.36	6.52	4.91	4.7	4.37	5.95
27	26.1	13.6	254	8.4	7.73	20.7	12.2	6.15	4.96	4.7	17.1	5.98
28	57.2	11.9	126	7.77	6.26	10.1	8	5.87	4.98	4.91	41.2	6.18
29	23.7		42.1	7.31	5.71	8.59	6.84	5.82	4.94	4.55	10.3	6.33
30	16.6		25.6	7	5.52	7.78	6.43	5.7	4.9	4.57	7.95	5.93
31	13		27.8		5.67		6.4	8.63		4.84		6.11
TOTAL	521	895	960	875	215	256	228	225	172	162	201	240
MEAN	16.8	32	31	29.2	6.95	8.56	7.38	7.28	5.74	5.23	6.72	7.76
MAX	57.2	189	254	107	13.9	38.3	12.2	13.6	15.9	12.1	41.2	28.4
MIN	7.44	7.51	7.52	7	5.45	4.9	6.01	5.7	4.53	4.43	4.11	5.66
RUNOFF (in)	5.37	9.22	9.9	9.02	2.22	2.65	2.36	2.33	1.77	1.67	2.08	2.48

**Table C.2. Daily streamflow (cfs) at the Melton Branch (MS4) monitoring station
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.11	2.44	15.2	5.67	1.3	0.6(e)	1.17	0.33	0.65	0.2	0.58	1.03
2	2.17	2.01	35.9	4.18	0.97	1(e)	1.14	0.32	0.6	0.21	0.5	0.93
3	7.19	1.94	13.8	3.9	3.34	0.8(e)	1.15	0.42	0.6	0.22	0.37	0.89
4	8.11	1.8	6.73	3.22	2.29	0.65(e)	1.18	0.63	0.57	0.21	0.39	1.57
5	3.79	3.08	4.47	4.98	1.45	0.58(e)	1.18	1.39	0.49	0.22	0.38	3.59
6	2.76	2.46	3.33	31.2	1.02	1.4(e)	1.18	0.68	0.41	0.21	0.31	2.02
7	10.9	2.12	2.66	12.7	0.91	1.28	1.25	0.61	0.32	0.18	0.3	1.19
8	7.86	2.48	2.34	6.66	0.86	1.34	1.3	0.59	0.23	0.22	0.3	0.83
9	3.66	19.3	3.82	4.56	0.89	1.22	1.31	0.55	0.31	1.84	0.31	0.77
10	2.58	47.6	10.2	10.4	0.7	2.12	1.37	0.51	0.5	0.63	0.91	12.5
11	4.05	76.5	4.55	43.7	0.62	1.24	1.63	0.55	0.44	0.39	0.47	5.28
12	20.3	13.5	3.35	33.9	0.61	1.06	1.68	0.53	0.36	0.35	0.39	2.4
13	5.76	6.5	2.88	35	0.58	1.01	1.75	0.49	0.36	0.53	0.37	1.58
14	3.58	4.2	2.55	9.03	0.72	0.98	1.57	2.34	0.35	0.58	0.35	1.24
15	2.3	3.13	2.19	29	1.2	1.2	1.92	1.2	0.4	0.63	0.35	1.06
16	1.77	2.55	1.65	20.2	0.98	1.11	3.62	1.21	0.42	0.61	0.44	1.1
17	5.88	2.36	1.5	7.66	0.77	1.27	4.28	0.81	0.32	0.61	0.6	1.26
18	5.66	2.09	1.44	5.16	0.73	1.59	3.11	0.65	1.4	0.61	0.61	1.07
19	3.26	1.88	1.35	3.88	0.7	1.02	1.47	0.83	0.39	0.76	0.58	0.98
20	1.9	1.74	1.32	2.99	0.62	0.95	1.19	1.45	0.31	0.65	0.56	0.92
21	1.7	15.3	1.63	2.46	0.53	0.92	0.78	2.45	0.18	0.57	0.59	0.84
22	1.53	8.86	1.5	2.2	0.34	1	0.48	1.02	0.22	0.57	0.56	1
23	1.51	66.4	1.26	1.97	0.32	0.91	0.42	0.56	0.39	0.64	0.54	1
24	1.6	11	14.9	1.78	0.41	1.08	0.37	0.49	0.43	0.55	0.65	1.03
25	10.6	5.95	12	1.6	0.52	1	0.35	0.45	0.34	0.53	0.68	0.98
26	11	3.99	5.44	1.46	3.53	12.3	0.36	0.38	0.3	0.52	0.73	0.94
27	11	2.96	96.4	1.52	1.37	7.88	1.58	0.27	0.3	0.51	5.36	0.94
28	25.7	2.47	38.1	1.41	0.8	1.9	0.7	0.33	0.28	0.51	15.5	0.94
29	6.75		11.2	1.17	0.71	1.39	0.49	0.39	0.26	0.55	2.36	0.82
30	4.07		6.89	1.07	0.7	1.26	0.4	0.43	0.22	0.58	1.32	0.83
31	3		9.46		0.64		0.34	0.75		0.57		0.9
TOTAL	183	316	320	294	31.1	52.1(e)	40.7	23.6	12.3	16	37.4	52.4
MEAN	5.93	11.3	10.3	9.82	1	1.74(e)	1.31	0.76	0.41	0.52	1.25	1.69
MAX	25.7	76.5	96.4	43.7	3.53	12.3	4.28	2.45	1.4	1.84	15.5	12.5
MIN	1.51	1.74	1.26	1.07	0.32	0.58	0.34	0.27	0.18	0.18	0.3	0.77
RUNOFF (in)	4.53	7.8	7.88	7.26	0.77	1.28(e)	1	0.58	0.3	0.39	0.92	1.29

(e) - Estimated data

**Table C.3. Daily streamflow (cfs) at the White Oak Dam (MS5)
monitoring station for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	11.2	13.9	38.6	23.1	9.51	5.88	8.85	6.42	8.79	7.16	5.49	8.43
2	11.1	13.6	134	22.2	8.16	7.13	7.9	6.37	8.72	7.14	5.13	7.71
3	19.2	12.7	73.5	19.7	12.4	7.75	7.19	6.8	7.56	7.18	5.04	7.21
4	31.6	11.6	35.6	17.6	13.2	6.49	6.88	6.91	7.31	7.2	5.17	8.61
5	18.1	13.2	24.2	16.9	9.29	6.35	6.6	11.6	6.97	7.6	5.17	15.3
6	14.2	13.2	18.4	107	8.27	7.51	6.49	8.1	7.38	7.52	5.03	12
7	31.4	11.6	15	57.6	7.87	7.61	6.57	6.78	7.52	7.18	4.69	9.64
8	37	11.4	13.6	30.6	8.17	8.79	6.82	6.36	7.17	7.2	4.64	8.08
9	19.8	58.4	15	22	7.29	7.59	6.83	6.13	7.17	15.5	4.68	7.5
10	14.6	131	38.3	26.3	7.14	15.9	6.85	6.22	7.19	12.4	9.59	34.7
11	15.1	382	21.3	155	7.04	9.56	7.61	6.25	7.5	8.57	6.75	29.4
12	67.1	77.9	16.5	80.8	6.84	7.88	9.2	6.11	7.65	7.94	5.55	14.1
13	31.3	38.8	14.2	215	6.7	7.75	9.7	6.28	7.6	9.19	5.37	11.8
14	19.9	24.9	13.9	47.9	6.55	8.35	9.54	9.35	7.5	8.28	5.24	10.1
15	14.7	19.3	13.6	89.9	8.31	8.8	9.17	16.2	7.52	7.99	5.04	8.69
16	12.4	15.6	12.1	130	8.53	9.21	13.8	10.4	7.61	7.85	5.15	8.4
17	21	13.5	11	42.6	7.17	9.31	14.5	8.78	9.06	7.64	5.17	8.94
18	25	13.6	10.8	27.7	6.46	10.9	18.4	7.45	20.1	6.29	5.03	7.93
19	15.3	12.5	10.2	20.6	6.39	7.81	11.1	7.27	9.79	6.94	5.12	7.36
20	13.6	11.5	9.63	16.7	6.36	7.02	8.63	13.5	8.14	7.07	4.99	7.16
21	12.6	42.6	10.6	14.1	6.01	7.14	7.92	14.2	7.65	6.01	4.98	6.67
22	11.9	33.9	11.2	13.4	5.72	7.84	7.07	9.61	7.17	5.69	5.02	6.96
23	11	262	9.6	13	5.76	6.97	6.62	7.6	7.95	6.4	4.87	7.08
24	10.7	64.7	37.3	12	5.9	7.58	6.26	6.8	8.9	5.73	5.02	6.48
25	25.8	32.6	47.3	11.1	6.14	8.66	6.07	6.57	7.74	5.41	5.3	6.22
26	44.3	22.2	26.3	10.5	14.5	25.1	6.44	7.55	7.12	5.45	5.39	6.01
27	33.7	16.8	383	10.4	14.5	65.6	13	6.13	7.03	5.32	20	5.93
28	95.4	14.2	209	10.4	7.86	14.8	9.72	6.9	7.06	5.67	56.6	6.01
29	38		58.3	9.24	6.47	11.1	7.66	6.7	7.1	5.4	15.6	6.16
30	23.1		24.4	8.69	6	9.64	6.93	7.36	7.14	5.28	10.4	5.96
31	16.9		11.7		5.86		6.53	10.5		5.52		6.17
TOTAL	767	1390	1369	1284	246	332	266	253	243	225	241	302
MEAN	24.8	49.7	44.2	42.8	7.95	11.1	8.61	8.17	8.1	7.28	8.04	9.76
MAX	95.4	382	383	215	14.5	65.6	18.4	16.2	20.1	15.5	56.6	34.7
MIN	10.7	11.4	9.6	8.69	5.72	5.88	6.07	6.11	6.97	5.28	4.64	5.93
RUNOFF(in)	4.64	8.41	8.28	7.77	1.49	2.01	1.61	1.53	1.47	1.37	1.46	1.83

**Table C.4. Daily streamflow (cfs) at the White Oak Creek Headwaters (WOCHW)
monitoring station for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.24	2.03	4.12	3.8	0.83	0.33	0.4	0.24	0.18	0.12	0.13	0.67
2	1.09	1.73	13.4	3.02	0.76	0.33	0.35	0.22	0.17	0.12	0.12	0.49
3	1.46	1.51	9.52	2.65	0.89	0.32	0.32	0.22	0.16	0.11	0.12	0.39
4	2.36	1.29	5.9	2.36	0.85	0.31	0.29	0.21	0.15	0.11	0.12	0.42
5	2.13	1.25	3.74	2.51	0.78	0.3	0.27	0.33	0.15	0.1	0.12	0.69
6	1.9	1.12	2.76	10.1	0.71	0.32	0.26	0.23	0.15	0.1	0.12	0.74
7	2.86	0.99	2.32	6.9	0.69	0.33	0.24	0.21	0.14	0.1	0.12	0.68
8	3.69	1	2.06	4.47	0.68	0.35	0.25	0.19	0.13	0.1	0.12	0.56
9	2.56	5.36	2.09	3.27	0.64	0.35	0.24	0.18	0.13	0.33	0.13	0.46
10	2.05	24.9	2.78	3.41	0.6	0.47	0.23	0.17	0.12	0.19	0.38	1.51
11	1.97	54.6	2.46	15.4	0.58	0.37	0.26	0.17	0.12	0.16	0.2	2.11
12	5.74	11.9	2.24	20.2	0.56	0.34	0.28	0.16	0.12	0.16	0.19	1.63
13	3.88	6.91	2.07	27.8	0.54	0.34	0.31	0.15	0.12	0.16	0.18	1.28
14	2.69	4.12	1.9	8.68	0.53	0.32	0.29	0.28	0.12	0.14	0.17	0.96
15	2.02	3	1.74	16.9	0.57	0.38	0.34	0.25	0.11	0.14	0.15	0.72
16	1.64	2.38	1.54	15.7	0.53	0.37	0.48	0.28	0.11	0.13	0.15	0.6
17	1.92	2.08	1.34	7.57	0.51	0.36	0.47	0.23	0.25	0.13	0.15	0.53
18	1.89	1.84	1.24	4.72	0.5	0.32	0.39	0.2	0.36	0.12	0.14	0.46
19	1.68	1.64	1.11	3.35	0.47	0.29	0.33	0.22	0.21	0.17	0.14	0.41
20	1.59	1.49	1	2.63	0.45	0.27	0.28	0.26	0.18	0.16	0.14	0.37
21	1.4	3.09	0.96	2.29	0.43	0.33	0.25	0.45	0.16	0.15	0.14	0.35
22	1.21	4.05	0.84	2.03	0.41	0.31	0.24	0.39	0.14	0.15	0.12	0.36
23	1.05	30.1	0.76	1.77	0.4	0.28	0.23	0.33	0.17	0.15	0.12	0.35
24	0.94	9.69	1.27	1.57	0.39	0.3	0.21	0.27	0.17	0.14	0.12	0.33
25	1.53	5.6	2.04	1.38	0.38	0.28	0.19	0.23	0.16	0.14	0.12	0.31
26	2.64	3.54	2.15	1.21	0.49	1.09	0.22	0.2	0.15	0.14	0.13	0.28
27	3.67	2.64	54.1	1.11	0.43	1.49	0.38	0.19	0.14	0.13	0.67	0.27
28	9.77	2.26	27.9	0.99	0.4	0.85	0.55	0.19	0.13	0.13	2.35	0.26
29	5.04		10.1	0.91	0.37	0.62	0.38	0.18	0.12	0.14	1.45	0.25
30	3.25		6.18	0.84	0.36	0.49	0.31	0.16	0.12	0.14	0.97	0.24
31	2.43		5.3		0.35		0.27	0.2		0.14		0.25
TOTAL	79.3	192	176	179	17.1	12.8	9.53	7.19	4.65	4.39	9.31	18.9
MEAN	2.56	6.86	5.71	5.98	0.55	0.43	0.31	0.23	0.15	0.14	0.31	0.61
MAX	9.77	54.6	54.1	27.8	0.89	1.49	0.55	0.45	0.36	0.33	2.35	2.11
MIN	0.94	0.99	0.76	0.84	0.35	0.27	0.19	0.15	0.11	0.1	0.12	0.24
RUNOFF (in)	3.69	8.93	8.22	8.34	0.8	0.6	0.44	0.33	0.22	0.2	0.43	0.88

**Table C.5. Daily streamflow (cfs) at the East Seep monitoring station
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.044	0.055	0.27	0.13	0.057	0.014	0.012	0.011	0.011	0.024	0.023	0.015
2	0.043	0.052	0.62	0.11	0.045	0.02	<01	0.01	0.016	0.03	0.016	0.012
3	0.13	0.05	0.25	0.092	0.11	0.014	<01	0.013	0.01	0.014	0.013	0.011
4	0.14	0.048	0.14	0.07	0.071	0.011	<01	0.012	<01	<01	0.015	0.036
5	0.083	0.081	0.1	0.13	0.047	0.012	<01	0.042	0.012	<01	0.013	0.072
6	0.063	0.061	0.093	0.49	0.037	0.026	0.01	0.012	0.019	<01	0.01	0.039
7	0.15	0.055	0.086	0.22	0.037	0.018	<01	<01	0.021	0.01	<01	0.025
8	0.073	0.065	0.08	0.13	0.037	0.021	0.012	<01	0.026	<01	0.013	0.018
9	0.04	0.36	0.12	0.1	0.033	0.017	0.018	<01	0.014	0.076	0.015	0.016
10	0.04	1	0.18	0.23	0.029	0.06	0.027	<01	<01	0.024	0.038	0.22
11	0.096	1.35	0.1	0.74	0.025	0.034	0.043	<01	<01	0.019	0.014	0.1
12	0.35	0.31	0.087	0.62	0.026	0.028	0.028	<01	<01	0.022	0.012	0.051
13	0.11	0.13	0.078	0.59	0.025	0.02	0.028	<01	<01	0.027	0.011	0.035
14	0.074	0.083	0.077	0.22	0.026	0.016	0.019	0.032	<01	0.035	0.013	0.027
15	0.045	0.055	0.073	0.58	0.054	0.025	0.057	0.016	<01	0.034	0.012	0.022
16	0.035	0.04	0.069	0.44	0.032	0.037	0.12	0.025	<01	0.025	0.011	0.027
17	0.12	0.037	0.064	0.18	0.028	0.043	0.2	0.016	0.033	0.024	0.01	0.03
18	0.1	0.039	0.064	0.13	0.024	0.045	0.18	0.013	0.088	0.016	<01	0.022
19	0.098	0.035	0.059	0.097	0.021	0.03	0.053	0.026	0.012	0.032	<01	0.018
20	0.098	0.032	0.058	0.078	0.021	0.019	0.029	0.033	<01	0.024	<01	0.015
21	0.098	0.26	0.072	0.066	0.019	0.012	0.02	0.05	<01	0.019	0.01	0.016
22	0.098	0.17	0.045	0.06	0.022	0.015	0.018	0.019	0.01	0.021	<01	0.023
23	0.077	1.17	0.038	0.053	0.019	0.011	0.021	0.012	0.021	0.023	<01	0.02
24	0.043	0.2	0.35	0.05	0.012	0.021	0.019(e)	0.012	0.015	0.017	<01	0.015
25	0.21	0.11	0.25	0.047	0.014	0.019	0.017(e)	<01	0.01	0.017	<01	0.013
26	0.2	0.089	0.14	0.045	0.15	0.34	0.02(e)	0.011	<01	0.017	0.01	0.012
27	0.17	0.073	1.97	0.058	0.041	0.14	0.12(e)	0.01	<01	0.017	0.13	0.011
28	0.38	0.068	0.97	0.048	0.023	0.037	0.025	<01	<01	0.017	0.3	0.011
29	0.12		0.24	0.041	0.019	0.025	0.015	0.014	<01	0.016	0.045	0.011
30	0.082		0.17	0.041	0.016	0.016	0.012	0.012	<01	0.017	0.023	0.01
31	0.063		0.2		0.016		0.01	0.019		0.019		0.016
TOTAL	3.47	6.09	7.11	5.89	1.14	1.14	1.17(e)	0.48	0.41	0.67	0.81	0.97
MEAN	0.11	0.22	0.23	0.2	0.037	0.038	0.038(e)	0.016	0.014	0.021	0.027	0.031
MAX	0.38	1.35	1.97	0.74	0.15	0.34	0.2	0.05	0.088	0.076	0.3	0.22
MIN	0.035	0.032	0.038	0.041	0.012	0.011	<01	<01	<01	<01	<01	0.01
RUNOFF (in)	4.04	7.07	8.26	6.85	1.32	1.32	1.37(e)	0.56	0.48	0.77	0.94	1.13

(e) - Estimated data

**Table C.6. Daily streamflow (cfs) at the West Seep monitoring station
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.29	0.33	2.83	0.95	0.22	0.043	0.55	0.071	0.066	0.022	0.037	0.12
2	0.28	0.29	7.28	0.67	0.16	0.087	0.51	0.066	0.052	0.025	0.03	0.1
3	1.22	0.25	2.54	0.59	0.5	0.068	0.45	0.072	0.043	0.023	0.03	0.087
4	1.54	0.22	1.09	0.47	0.3	0.045	0.28	0.069	0.041	0.022	0.032	0.21
5	0.68	0.41	0.66	0.83	0.2	0.04	0.063	0.25	0.035	0.02	0.031	0.57
6	0.44	0.32	0.48	5.67	0.17	0.092	0.058	0.077	0.03	0.017	0.035	0.32
7	1.8	0.29	0.38	2.17	0.16	0.073	0.058	0.063	0.026	0.018	0.03	0.21
8	1.52	0.36	0.34	1.05	0.16	0.1	0.058	0.058	0.02	0.019	0.03	0.16
9	0.65	3.53	0.66	0.7	0.14	0.071	0.058	0.058	0.018	0.32	0.09	0.13
10	0.41	11.7	1.94	1.75	0.13	0.22	0.058	0.056	0.016	0.097	0.1	2.07
11	0.72	13.8	0.84	8.41	0.11	0.094	0.087	0.054	0.014	0.044	0.055	1.03
12	3.92	2.24	0.56	7.04	0.097	0.068	0.099	0.049	0.012	0.045	0.045	0.38
13	1.09	1.08	0.45	6.2	0.081	0.067	0.13	0.049	0.012	0.068	0.042	0.25
14	0.6	0.69	0.38	2.09	0.086	0.068	0.11	0.22	0.016	0.047	0.036	0.19
15	0.39	0.49	0.32	7.02	0.21	0.1	0.27	0.11	0.012	0.04	0.036	0.15
16	0.38	0.36	0.27	4.47	0.14	0.11	0.75	0.14	0.014	0.034	0.036	0.16
17	1	0.31	0.24	2.07	0.1	0.16	1.32	0.081	0.083	0.03	0.036	0.18
18	1.01	0.27	0.23	1.15	0.093	0.16	1.5	0.063	0.74	0.03	0.036	0.15
19	0.8	0.24	0.2	0.57	0.081	0.069	0.35	0.14	0.064	0.094	0.033	0.13
20	0.8	0.23	0.19	0.46	0.079	0.056	0.17	0.21	0.039	0.072	0.031	0.11
21	0.79	2.45	0.27	0.38	0.073	0.039	0.12	0.37	0.032	0.051	0.035	0.11
22	0.77	1.54	0.23	0.33	0.063	0.42	0.094	0.15	0.036	0.049	0.031	0.14
23	0.75	13.9	0.19	0.3	0.06	0.71	0.087	0.082	0.085	0.077	0.03	0.13
24	0.31	1.78	3.65	0.28	0.045	0.74	0.078	0.065	0.085	0.05	0.03	0.11
25	1.88	0.89	2.59	0.25	0.041	0.69	0.073	0.063	0.047	0.041	0.03	0.096
26	2.12	0.56	1.21	0.22	0.86	2.88	0.077	0.059	0.035	0.039	0.037	0.085
27	1.85	0.41	21.2	0.24	0.23	1.8	0.43	0.058	0.037	0.043	0.77	0.085
28	4.77	0.35	7.36	0.21	0.1	0.81	0.14	0.056	0.035	0.039	2.31	0.076
29	1.2		2.63	0.18	0.073	0.69	0.092	0.057	0.03	0.034	0.33	0.075
30	0.66		1.56	0.16	0.056	0.6	0.081	0.055	0.035	0.036	0.17	0.069
31	0.44		1.44		0.046		0.072	0.11		0.036		0.094
TOTAL	35.1	59.3	64.2	56.9	4.88	11.2	8.26	3.09	1.81	1.58	4.61	7.75
MEAN	1.13	2.12	2.07	1.9	0.16	0.37	0.27	0.1	0.06	0.051	0.15	0.25
MAX	4.77	13.9	21.2	8.41	0.86	2.88	1.5	0.37	0.74	0.32	2.31	2.07
MIN	0.28	0.22	0.19	0.16	0.041	0.039	0.058	0.049	0.012	0.017	0.03	0.069
RUNOFF (in)	5.22	8.82	9.55	8.47	0.73	1.66	1.23	0.46	0.27	0.24	0.69	1.15

**Table C.7. Daily streamflow (cfs) at the Raccoon Creek monitoring station
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.095	0.16	2.88	0.43	0.052	0.021	0.031	0.018	0.027	0.01	0.018	0.046
2	0.11	0.12	5.69	0.27	0.041	0.021	0.037	0.018	0.018	0.013	<01	0.045
3	1.2	0.091	1.63	0.17	0.27	0.017	0.016	0.018	0.011	0.015	<01	0.038
4	0.95	0.077	0.72	0.13	0.13	0.012	0.014	0.022	0.01	0.017	<01	0.13
5	0.29	0.18	0.39	0.17	0.063	0.014	0.018	0.19	<01	<01	0.01	0.48
6	0.18	0.13	0.24	3.69	0.049	0.02	0.015	0.035	0.01	<01	0.013	0.16
7	2.08	0.096	0.18	1.19	0.043	0.026	0.016	0.023	<01	<01	<01	0.083
8	0.9	0.14	0.15	0.48	0.051	0.029	0.017	0.018	<01	<01	<01	0.063
9	0.32	3.25	0.35	0.28	0.048	0.016	0.02	0.012	<01	0.12	<01	0.052
10	0.19	10.6	1.6	0.71	0.048	0.22	0.029	0.015	<01	0.04	0.076	2.41
11	0.79	13	0.37	6.27	0.033	0.039	0.028	0.01	<01	0.02	0.029	0.48
12	3.56	2.04	0.22	3.77	0.027	0.021	0.029	0.011	0.011	0.022	0.023	0.16
13	0.72	0.92	0.17	4.62	0.024	0.017	0.05	0.012	<01	0.019	0.021	0.089
14	0.34	0.48	0.14	1.06	0.029	0.021	0.074	0.27	<01	0.022	0.019	0.062
15	0.18	0.31	0.11	6.9	0.058	0.018	0.074	0.088	<01	0.02	0.015	0.049
16	0.11	0.2	0.09	2.82	0.04	0.032	0.64	0.059	<01	0.03	0.011	0.046
17	0.97	0.14	0.076	0.9	0.024	0.045	0.29	0.031	0.013	0.033	0.011	0.064
18	0.53	0.11	0.073	0.46	0.025	0.067	0.88	0.024	0.36	0.028	<01	0.053
19	0.22	0.091	0.079	0.28	0.018	0.021	0.14	0.032	0.035	0.017	0.01	0.041
20	0.17	0.079	0.074	0.18	0.017	0.016	0.056	0.096	0.028	0.019	0.01	0.036
21	0.11	2.33	0.082	0.14	0.016	0.016	0.037	0.33	0.018	0.019	0.012	0.032
22	0.089	1.05	0.081	0.11	0.012	0.012	0.027	0.078	0.014	0.025	<01	0.034
23	0.071	12.6	0.06	0.086	0.011	<01	0.023	0.035	0.029	0.03	<01	0.041
24	0.073	1.67	2.88	0.073	0.011	0.011	0.019	0.023	0.057	0.037	<01	0.033
25	2.14	0.77	1.7	0.064	0.015	0.016	0.016	0.018	0.054	0.031	<01	0.029
26	1.36	0.43	0.64	0.058	0.52	2.07	0.02	0.018	0.027	0.021	<01	0.026
27	1.67	0.27	19.1	0.059	0.096	0.96	0.15	0.025	<01	0.014	0.7	0.024
28	3.97	0.19	7.15	0.054	0.04	0.12	0.049	0.022	<01	0.014	2.97	0.023
29	0.86		2	0.044	0.031	0.055	0.028	0.014	0.013	0.015	0.18	0.022
30	0.42		0.83	0.043	0.026	0.034	0.023	0.021	0.01	0.01	0.073	0.02
31	0.24		0.97		0.026		0.019	0.037		0.01		0.021
TOTAL	24.9	51.5	50.8	35.5	1.9	3.99	2.89	1.63	0.83	0.69	4.29	4.91
MEAN	0.8	1.84	1.64	1.18	0.061	0.13	0.093	0.053	0.028	0.022	0.14	0.16
MAX	3.97	13	19.1	6.9	0.52	2.07	0.88	0.33	0.36	0.12	2.97	2.41
MIN	0.071	0.077	0.06	0.043	0.011	<01	0.014	0.01	<01	<01	<01	0.02
RUNOFF (in)	2.81	5.8	5.72	4	0.21	0.45	0.33	0.18	0.09	0.08	0.48	0.55

**Table C.8. Daily streamflow (cfs) at the WAG 4 MS1 monitoring station
for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.064	0.082	0.43	0.12	0.02	0	<.01	<.01	0.016	<.01	<.01	0.018
2	0.067	0.068	0.98	0.092	0.011	<.01	0	<.01	0.025	<.01	<.01	0.014
3	0.18	0.058	0.37	0.087	0.052	<.01	0	<.01	<.01	<.01	<.01	0.012
4	.21(e)	0.049	0.13	0.07	0.029	0	0	<.01	<.01	<.01	<.01	0.025
5	0.13	0.079	0.067	0.16	0.017	0	0	0.026	<.01	<.01	<.01	0.06
6	0.1	0.059	0.067	0.66	0.011	<.01	0	<.01	0.012	<.01	<.01	0.034
7	0.31	0.045	0.063	0.24	<.01	<.01	0	<.01	<.01	<.01	<.01	0.024
8	0.23	0.063	0.049	0.12	<.01	<.01	0	<.01	0	<.01	<.01	0.015
9	0.13	0.5	0.11	0.089	<.01	<.01	<.01	<.01	0	0.04	<.01	0.012
10	0.1	1.63	0.19	0.28	<.01	0.011	<.01	0	0	0.013	0.014	0.28
11	0.19	2.25	0.092	0.97	<.01	<.01	<.01	0	0	<.01	<.01	0.1
12	0.54	0.38	0.071	0.97	<.01	<.01	<.01	0	0	<.01	<.01	0.046
13	0.21	0.2	0.07	0.92	<.01	<.01	<.01	0	0	0.012	<.01	0.028
14	0.13	0.13	0.062	0.16	<.01	<.01	<.01	0.019	0	0.011	<.01	0.022
15	0.084	0.1	0.056	0.77	0.021	<.01	0.015	<.01	0	0.011	<.01	0.014
16	0.063	0.084	0.046	0.4	0.013	<.01	0.077	<.01	0	<.01	<.01	0.014
17	0.16	0.064	0.039	0.15	<.01	<.01	0.16	<.01	0.023	<.01	<.01	0.015
18	0.1	0.056	0.041	0.1	<.01	<.01	0.19	0	0.12	<.01	<.01	0.011
19	0.071	0.048	0.036	0.078	<.01	<.01	0.059	<.01	0.066	0.012	<.01	0.011
20	0.04	0.039	0.036	0.059	<.01	0	0.017	0.014	0.021	<.01	<.01	0.011
21	0.022	0.33	0.046	0.046	<.01	0	0.017	0.06	<.01	<.01	<.01	0.011
22	0.012	0.21	0.039	0.039	<.01	0	0.011	0.025	<.01	<.01	<.01	0.013
23	0.012	2	0.034	0.033	<.01	0	<.01	0.014	0.027	0.012	0	0.011
24	.046(e)	0.29	0.37	0.03	<.01	<.01	<.01	0.011	<.01	0.011	<.01	<.01
25	0.38	0.15	0.28	0.027	0	<.01	<.01	0.013	<.01	<.01	<.01	<.01
26	0.26	0.1	0.15	0.023	0.071	0.4	<.01	0.012	<.01	<.01	<.01	<.01
27	0.28	0.078	4	0.025	0.014	0.18	0.056	<.01	<.01	<.01	0.1	<.01
28	0.64	0.064	1.38	0.018	<.01	0.038	0.016	<.01	<.01	<.01	0.44	<.01
29	0.2		0.28	0.017	<.01	0.018	<.01	<.01	<.01	<.01	0.069	<.01
30	0.12		0.15	0.016	0	<.01	<.01	<.01	<.01	<.01	0.034	<.01
31	.088(e)		0.21		0		<.01	0.016		<.01		<.01
TOTAL	5.16(e)	9.22	9.94	6.77	0.33	0.7	0.7	0.27	0.36	0.22	0.7	0.86
MEAN	0.17(e)	0.33	0.32	0.23	0.011	0.023	0.022	<.01	0.012	<.01	0.023	0.028
MAX	0.64	2.25	4	0.97	0.071	0.4	0.19	0.06	0.12	0.04	0.44	0.28
MIN	0.012	0.039	0.034	0.016	0	0	0	0	0	<.01	0	<.01
RUNOFF (in)	5.65(e)	10.08	10.87	7.4	0.36	0.76	0.76	0.3	0.39	0.24	0.77	0.94

(e) - Estimated data

**Table C.9. Daily streamflow (cfs) at the Walker Branch East weir (WBE)
monitoring station for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.31	0.46	0.73	0.71(e)	0.23	0.09	0.08	0.03	0.04	0.02	0.03	0.14
2	0.25	0.37	3.99	0.64(e)	0.22	0.10	0.06	0.03	0.03	0.03	0.03	0.09
3	0.22	0.30	2.76	0.56(e)	0.23	0.09	0.05	0.03	0.02	0.03	0.02	0.06
4	0.64	0.23	1.54	0.49(e)	0.24	0.07	0.05	0.03	0.02	0.03	0.03	0.07
5	0.64	0.20	1.02	0.64(e)	0.22	0.09	0.05	0.06	0.02	0.03	0.02	0.12
6	0.48	0.18	0.75	3.21	0.20	0.11	0.04	0.05	0.03	0.02	0.04	0.17
7	0.61	0.16	0.63	2.06	0.19	0.08	0.04	0.04	0.02	0.02	0.04	0.19
8	1.30	0.16	0.54	1.35	0.19	0.10	0.05	0.04	0.01	0.03	0.05	0.14
9	0.76	1.74	0.48	0.96	0.18	0.08	0.04	0.03	0.01	0.08	0.04	0.09
10	0.52	6.00	0.66	0.87	0.17	0.14	0.04	0.03	0.01	0.11	0.09	0.21
11	0.41	13.24	0.73	5.23	0.15	0.12	0.05	0.03	0.01	0.12	0.04	0.88
12	1.48	3.16	0.70	4.55	0.14	0.09	0.05	0.03	0.01	0.06	0.04	0.50
13	1.21	1.56	0.63	7.87	0.14	0.09	0.05	0.02	0.01	0.07	0.04	0.37
14	0.73	1.01	0.53	2.24	0.13	0.07	0.05	0.05	0.02	0.05	0.03	0.27
15	0.48	0.77	0.44	4.20	0.17	0.08	0.06	0.07	0.02	0.03	0.03	0.15
16	0.36	0.63	0.41	5.08	0.17	0.09	0.12	0.06	0.03	0.04	0.03	0.11
17	0.36	0.51	0.39	2.01	0.13	0.07	0.13	0.04	0.07	0.06	0.03	0.10
18	0.47	0.43	0.36	1.28	0.13	0.07	0.10	0.03	0.16	0.07	0.03	0.09
19	0.64	0.37	0.35	0.96	0.15	0.07	0.07	0.04	0.08	0.07	0.03	0.08
20	0.69	0.35	0.33	0.77	0.14	0.06	0.05	0.06	0.04	0.07	0.03	0.07
21	0.56	0.78	0.31	0.63	0.15	0.07	0.04	0.11	0.03	0.05	0.03	0.07
22	0.47	1.41	0.28	0.55	0.15	0.08	0.04	0.12	0.02	0.04	0.02	0.07
23	0.36	8.51	0.25(e)	0.47	0.15	0.06	0.04	0.07	0.04	0.06	0.02	0.07
24	0.24	2.63	0.42(e)	0.41	0.13	0.07	0.03	0.05	0.07	0.07	0.02	0.07
25	0.24	1.43	0.67(e)	0.36	0.16	0.06	0.03	0.03	0.05	0.09	0.02	0.06
26	0.81	0.95	0.71(e)	0.32	0.23	0.19	0.05	0.04	0.04	0.04	0.02	0.06
27	1.01	0.71	13.59(e)	0.29	0.16	1.17	0.10	0.04	0.05	0.04	0.13	0.06
28	2.97	0.59	6.92	0.26	0.11	0.44	0.12	0.04	0.03	0.04	0.65	0.06
29	1.51		2.49	0.25	0.11	0.30	0.12	0.06	0.02	0.02	0.39	0.06
30	0.88		1.49	0.23	0.10	0.15	0.07	0.05	0.02	0.02	0.27	0.05
31	0.61		0.70		0.09		0.04	0.05		0.02		0.05
TOTAL	22.25	48.87	45.83(e)	49.50(e)	5.01	4.31	1.92	1.48	1.02	1.55	2.30	4.55
MEAN	0.72	1.74	1.48(e)	1.65(e)	0.16	0.14	0.06	0.05	0.03	0.05	0.08	0.15
MAX	2.97	13.24	13.59(e)	7.87	0.24	1.17	0.13	0.12	0.16	0.12	0.65	0.88
MIN	0.22	0.16	.25(e)	0.23(e)	0.09	0.06	0.03	0.02	0.01	0.02	0.02	0.05
RUNOFF (in)	3.60	7.90	7.4(e)	8.01(e)	0.81	0.70	0.31	0.24	0.17	0.25	0.37	0.74

(e) - Estimated data

**Table C.10. Daily streamflow (cfs) at the Walker Branch West weir (WBW)
monitoring station for the period January-December 1994**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.40	0.60	0.83	1.26	0.48	0.26	0.25	0.20	0.18	0.16	0.16	0.21
2	0.34	0.50	2.83	1.10	0.45	0.25	0.24	0.20	0.18	0.16	0.16	0.18
3	0.36	0.43	2.38	0.98	0.47	0.25	0.23	0.20	0.18	0.17	0.16	0.18
4	0.60	0.37	1.61	0.85	0.43	0.25	0.24	0.20	0.18	0.17	0.16	0.19
5	0.67	0.36	1.20	0.80	0.39	0.25	0.24	0.22	0.18	0.17	0.16	0.23
6	0.57	0.32	0.98	2.30	0.39	0.25	0.22	0.20	0.18	0.23	0.15	0.27
7	0.64	0.30	0.83	1.85	0.38	0.26	0.22	0.20	0.18	0.16	0.15	0.26
8	1.07	0.32	0.70	1.42	0.37	0.26	0.22	0.20	0.18	0.16	0.15	0.22
9	0.81	1.31	0.65	1.15	0.36	0.25	0.22	0.20	0.18	0.21	0.15	0.20
10	0.61	4.34	0.75	1.06	0.34	0.30	0.21	0.19	0.18	0.17	0.20	0.37
11	0.52	10.13	0.79	3.53	0.34	0.26	0.23	0.19	0.18	0.16	0.16	0.69
12	1.18	3.34	0.75	3.60	0.34	0.25	0.22	0.19	0.18	0.17	0.16	0.53
13	1.15	1.96	0.71	5.76	0.32	0.25	0.23	0.19	0.17	0.16	0.16	0.39
14	0.84	1.32	0.66	2.27	0.32	0.24	0.22	0.22	0.17	0.16	0.16	0.30
15	0.61	1.00	0.60	3.26	0.35	0.25	0.24	0.20	0.17	0.16	0.15	0.22
16	0.46	0.82	0.53	3.95	0.32	0.24	0.25	0.20	0.17	0.16	0.15	0.21
17	0.48	0.67	0.46	2.09	0.31	0.24	0.25	0.19	0.22	0.16	0.15	0.20
18	0.50	0.57	0.46	1.54	0.30	0.24	0.25	0.19	0.22	0.16	0.15	0.20
19	0.50	0.50	0.42	1.26	0.29	0.23	0.24	0.19	0.18	0.17	0.15	0.19
20	0.48	0.45	0.39	1.07	0.29	0.23	0.22	0.21	0.18	0.19	0.15	0.19
21	0.42	0.75	0.39	0.92	0.29	0.27	0.21	0.23	0.17	0.20	0.15	0.18
22	0.37	1.25	0.35	0.82	0.29	0.24	0.21	0.22	0.16	0.19	0.15	0.19
23	0.33	5.65	0.34	0.72	0.28	0.23	0.21	0.20	0.18	0.16	0.15	0.20
24	0.30	2.39	0.56(e)	0.64	0.28	0.24	0.20	0.19	0.18	0.16	0.15	0.18
25	0.37	1.53	0.88(e)	0.60	0.28	0.23	0.20	0.18	0.17	0.16	0.15	0.18
26	0.75	1.14	0.92(e)	0.55	0.29	0.42	0.22	0.18	0.17	0.16	0.15	0.18
27	1.00	0.92	11.65(e)	0.52	0.27	0.84	0.23	0.18	0.17	0.16	0.23	0.18
28	2.21	0.78	5.30(e)	0.50	0.27	0.54	0.24	0.18	0.16	0.16	0.58	0.18
29	1.39	0.00	2.30(e)	0.50	0.27	0.39	0.22	0.18	0.16	0.16	0.43	0.18
30	1.00	0.00	1.62	0.50	0.26	0.27	0.21	0.18	0.16	0.16	0.32	0.17
31	0.78	0.00	1.41	0.00	0.26	0.00	0.20	0.20	0.00	0.16	0.00	0.17
TOTAL	21.68	44.10	44.21(e)	47.39	10.28	8.69	7.03	6.04	5.30	5.30	5.61	7.38
MEAN	0.70	1.57	1.43(e)	1.58	0.33	0.29	0.23	0.20	0.18	0.17	0.19	0.24
MAX	2.21	10.13	11.65(e)	5.76	0.48	0.84	0.25	0.23	0.22	0.23	0.58	0.69
MIN	0.30	0.30	0.34	0.50	0.26	0.23	0.20	0.18	0.16	0.16	0.15	0.17
RUNOFF(in)	5.38	10.94	10.97(e)	11.75	2.56	2.16	1.74	1.50	1.32	1.31	1.39	1.84

(e) - Estimated data

**Table C.11. Daily streamflow at monitoring station GS1 (USGS03536450)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.88	1.5	3.9	2.2	.55	.30	.49	.28	.52	.30	.30	.61
2	0.76	1.2	8.1	1.9	.50	.49	.43	.29	.37	.30	.29	.46
3	1.9	1.0	4.8	1.8	.96	.30	.41	.30	.27	.30	.29	.40
4	1.9	.84	3	1.5	.58	.29	.39	.32	.27	.30	.27	.73
5	1.4	.83	2.3	2.5	.50	.29	.37	.77	.27	.29	.27	1.00
6	1.2	.67	1.9	6.2	.45	.34	.38	.31	.28	.29	.27	.72
7	2.9	.53	1.6	3.5	.44	.39	.38	.30	.25	.29	.26	.64
8	2.1	.67	1.4	2.5	.42	.36	.41	.30	.24	.29	.26	.52
9	1.7	4.2	2.1	2.0	.40	.39	.40	.30	.25	1.10	.42	.43
10	1.4	12	2.2	3.3	.39	.99	.39	.31	.24	.37	.73	3.00
11	2	17	1.7	8.2	.38	.35	.47	.30	.25	.31	.32	1.60
12	3.7	5.9	1.6	10	.38	.32	.51	.44	.26	.34	.29	1.20
13	2.3	3.4	1.4	9.4	.36	.41	.57	.53	.26	.34	.27	.90
14	1.9	2.4	1.3	4.2	.36	.33	.47	1.6	.28	.31	.26	.66
15	1.4	2.1	1.2	8.5	.51	.50	.47	.86	.28	.30	.26	.51
16	1.1	1.7	1.1	7.4	.37	.55	.95	.74	.31	.29	.26	.49
17	2.1	1.5	0.88	3.8	.34	.48	.56	.52	.50	.29	.26	.48
18	1.5	1.3	0.78	2.6	.33	.46	.56	.52	1.9	.29	.26	.40
19	1.3	1.1	0.71	2.1	.32	.34	.46	.85	.42	.40	.25	.38
20	1.1	.98	0.64	1.8	.31	.35	.40	.73	.36	.31	.25	.35
21	1	3.3	0.7	1.5	.30	.42	.36	1.0	.34	.30	.26	.34
22	0.88	2.7	0.59	1.3	.30	.33	.33	.64	.33	.32	.25	.38
23	0.74	14	0.54	1.1	.30	.23	.31	.60	.44	.31	.25	.34
24	0.7	4.9	3.5(e)	.90	.30	.42	.30	.56	.39	.30	.25	.32
25	2.7	3.0	2.3	.80	.30	.27	.30	.54	.34	.29	.25	.30
26	2.3	2.3	2	.73	1.2	3.4	.32	.53	.32	.29	.27	.29
27	2.7	1.9	24	.70	.41	1.8	.73	.52	.32	.30	1.70	.29
28	5.8	1.6	12	.62	.32	.97	.38	.51	.31	.29	4.10	.28
29	3.4		5	.59	.30	.71	.30	.52	.30	.29	1.20	.28
30	2.3		3.2	.54	.30	.57	.27	.50	.30	.28	.89	.27
31	1.9		3.1		.30		.26	.83		.30		.30
TOTAL	58.96	94.52	99.54	94.18	13.18	17.35	13.33	17.32	11.17	10.28	15.46	18.87
MEAN	1.9	3.38	3.21	3.14	.43	.58	.43	.56	.37	.33	.52	.61
MAX	5.8	17	24	10	1.2	3.4	.95	1.6	1.9	1.10	4.10	3.00
MIN	0.7	.53	0.54	.54	.30	.23	.26	.28	.24	.28	.25	.27
RUNOFF (in)	6.64	10.67	11.22	10.62	1.50	1.96	1.50	1.96	1.25	1.15	1.76	2.13

(e) -Estimated data.

**Table C.12. Daily streamflow at monitoring station GS2 (USGS03537100)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.52	.73	4.3	1.6	.17	.02	.01	.00(e)	0	0	0.01	.06
2	0.51	.60	9.6	1.2	.09	.04	.00	.00(e)	0	0	0	.06
3	1.7	.52	3.8	1.1	.62	.03	.00	.01(e)	0	0	0	.05
4	2	.48	1.9	0.94	.51	.02	.00	.01(e)	0	0	0	.15
5	1.1	.82	1.4	1.4	.22	.02	.00	.20(e)	0	0	0.01	.63
6	0.78	.66	1.1	8.3	.11	.06	.00	.01(e)	0	0	0.01	.33
7	2.8	.52	.87	3.3	.08	.03	.00	.00(e)	0	0	0.01	.18
8	1.9	.64	.76	1.7	.09	.04	.00	.00(e)	0	0	0.01	.13
9	1.1	5.0	1.1	1.3	.07	.02	.00	.00(e)	0	0.06	0.01	.10
10	0.81	18	2.5	2.9	.08	.25	.00	.00(e)	0	0.02	0.05	2.50
11	1.1	21	1.2	12	.08(e)	.07	.00	.00(e)	0	0	0.03	1.10
12	5.1	3.3	.93	14	.07(e)	.02	.00	.00(e)	0	0	0.02	.43
13	1.5	1.7	.89	9.4	.07(e)	.02(e)	.01	.00(e)	0	0.01	0.01	.27
14	1.1	1.2	.76	2.6	.05(e)	.08(e)	.02	.70(e)	0	0.01	0.01	.18
15	1	.97	.66	7.8	.25(e)	.09(e)	.07	.30(e)	0	0.01	0.01	.13
16	0.99	.80	.57	6.1	.12(e)	.06(e)	.35	.10(e)	0	0.01	0.01	.14
17	1.5	.63	.52	2.2	.09(e)	.04(e)	.54	.04(e)	0	0.01	0.01	.17
18	1.6(e)	.52	.52	1.5	.08(e)	.15(e)	.13	.02(e)	0.04	0.01	0	.13
19	1.1(e)	.51	.48	1.2	.07(e)	.08(e)	.04	.00	0	0.02	0	.10
20	.95(e)	.44	.44	0.96	.07(e)	.06(e)	.01	.09	0	0.02	0	.07
21	.80(e)	3.9	.62	0.7	.06(e)	.20(e)	.00	.43	0	0.02	0.01	.06
22	.70(e)	2.2	.54	0.52	.05(e)	.09(e)	.00	.18	0	0.01	0.01	.08
23	.65(e)	20	.43	0.42	.04(e)	.03(e)	.00	.04	0	0.02	0	.08
24	.60(e)	3.1	3.8	0.34	.03(e)	.06(e)	.00	.01	0	0.02	0	.06
25	2.8	1.8	3.0	0.25	.02(e)	.06(e)	.00	.01	0	0.02	0	.06
26	2.7	1.3	1.5	0.21	.54(e)	2.0	.00	.00	0	0.01	0.01	.06
27	3.1	1.0	33	0.25	.25	2.1	.22	.00	0	0.01	0.72	.05
28	6.8	.82	11	0.23	.08	.32	.08	.00	0	0.01	2.7	.05
29	1.8		3.3	0.15	.04	.14	.03(e)	.00	0	0.01	0.31	.05
30	1.2		2.0	0.1	.02	.04	.00(e)	.00	0	0	0.11	.04
31	0.9		2.5		.02		.00(e)	.00		0.01		.05
TOTAL	51.21(e)	93.16	95.99	84.67	4.14(e)	6.24(e)	1.51(e)	2.15(e)	0.04	0.32	4.08	7.55
MEAN	1.65(e)	3.33	3.10	2.82	.13(e)	.21(e)	.049(e)	.069(e)	0.001	0.01	0.14	.24
MAX	6.8	21	33	14	.62	2.1	.54	.70(e)	0.04	0.06	2.7	2.50
MIN	0.51	.44	.43	0.1	.02	.02	.00	.00	0	0	0	.04
RUNOFF (in)	3.66(e)	6.66	6.87	6.06	.30(e)	.45(e)	.11(e)	.15(e)	0	0.02	0.3	.53

(e) - Estimated data.

**Table C.13. Daily streamflow at monitoring station GS3 (USGS03536550)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.7	11	32	20	7.7	5.4	7.0	5.4	5.2	4.60	4.50	6.10
2	7.4	9.4	66	16	6.1	7.3	6.1	5.5	4.8	4.60	4.40	5.80
3	17	8.3	39	16	11	5.7	5.9	6.0	4.7	4.70	4.40	5.60
4	17	7.5	25	13	7.9	5.2	5.6	5.9	4.8	4.60	4.40	8.10
5	12	9.7	18	20	7.0	5.2	5.7	10	4.5	4.60	4.50	11.00
6	11	8.1	15	56	7.0	6.4	5.9	5.7	5.2	4.40	4.10	7.40
7	25	6.9	13	31	6.8	6.4	6.0	5.4	5.0	4.50	4.00	6.60
8	19	8.7	11	22	6.4	7.0	6.3	5.4	4.5	4.20	4.10	5.70
9	13	38	16	17	5.8	7.1	6.0	5.3	4.9	12.00	4.50	5.70
10	11	97	21	26	6.2	11	6.1	5.8	4.2	5.60	8.80	24.00
11	15	161	15	72	5.9	6.5	7.0	5.4	4.5	4.90	4.80	14.00
12	36	45	13	84	5.8	6.1	7.9	5.5	4.7	5.20	4.30	9.50
13	20	27	12	84	5.5	7.2	8.1	5.6	4.8	5.70	4.40	7.90
14	15	19	11	33	5.4	6.8	7.2	12	4.6	4.50	4.50	6.90
15	12	16	10	71	7.3	8.4	7.5	8.1	4.7	4.70	4.20	6.30
16	9.5	13	9.2	59	5.8	8.1	10	8.6	4.8	4.40	4.40	6.50
17	19	12	8.4	30	5.6	7.1	8.2	6.5	8.1	4.30	4.10	6.40
18	14	10	8.8	21	5.3	8.1	8.4	6.2	14	4.30	4.10	5.80
19	11	9.0	7.8	17	5.5	6.0	6.6	7.7	5.6	6.10	4.20	5.70
20	9.5	8.5	7.3	14	5.3	6.3	6.6	9.8	5.1	4.80	3.80	5.40
21	8.4	30	8.9	13	5.1	7.7	6.2	11	5.2	4.50	4.20	5.00
22	7.8	24	7.4	12	5.1	6.4	5.9	7.3	4.7	4.60	3.90	5.60
23	6.9	128	7.0	10	5.2	5.5	5.5	6.0	5.9	5.00	3.90	5.00
24	6.8	39	24	9.4	5.4	7.5	5.4	5.8	5.5	4.40	3.90	4.80
25	21	25	22	8.9	5.4	6.2	5.9	5.8	4.9	4.30	4.10	4.60
26	21	17	17	8.4	11	30	6.3	5.7	4.5	4.40	4.30	4.60
27	25	14	202	8.4	6.7	21	11	5.3	4.6	4.40	16.00	4.60
28	47	12	90	7.9	5.6	9.9	7.3	5.0	4.5	4.40	33.00	4.70
29	23		39	7.1	5.2	8.2	6.0	5.2	4.5	4.10	10.00	5.00
30	16		26	7.0	5.1	7.5	5.6	5.2	4.6	4.20	7.60	4.70
31	13		27		5.2		5.6	8.0		4.50		4.90
TOTAL	497.0	814.1	828.8	814.1	194.3	247.2	208.8	206.1	157.5	151.50	181.40	213.90
MEAN	16.0	29.1	26.7	27.1	6.27	8.24	6.74	6.65	5.25	4.89	6.05	6.90
MAX	47	161	202	84	11	30	11	12	14	12.00	33.00	24.00
MIN	6.8	6.9	7.0	7.0	5.1	5.2	5.4	5.0	4.2	4.10	3.80	4.60
RUNOFF (in)	65.9	108	110	9.23	2.2	2.8	2.37	2.34	2.79	1.72	2.06	2.43

**Table C.14. Daily streamflow at monitoring station GS4 (USGS03536440)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.51	0.77	7.0(e)	2.1	0.36	0.26	0.36	0.34	0.36	.14	0.12	.40(e)
2	0.46	0.62	13(e)	1.5	0.31	0.36	0.33	0.33	0.33	.14	0.08	.30(e)
3	1.9	0.49	5.7	1.3	0.78	0.3	0.31	0.32	0.3	.14	0.08	.25(e)
4	1.8	0.5	2.9	1.1	0.59	0.26	0.3	0.34	0.29	.16	0.1	.40(e)
5	1	0.73	1.9	2.2	0.42	0.29	0.29	0.66	0.31	.13	0.07	.60(e)
6	0.74	0.65	1.4	11	0.4	0.31	0.29	0.36	0.31	.11	0.07	.50(e)
7	3.2	0.58	1.1	4.5	0.35	0.32	0.29	0.32	0.28	.14	0.06	0.33
8	2.2	0.7	0.96	2.5	0.33	0.32	0.31	0.27	0.3	.09	0.09	0.33
9	1.2	6.1	1.5	1.7	0.32	0.31	0.29	0.22	0.29	.55	0.07	0.24
10	0.83	22	3.1	3.4	0.32	0.83	0.29	0.3	0.28	.22	0.4	3.7
11	1.5	30	1.7	14	0.26	0.39	0.36	0.29	0.28	.15	0.15	1.6
12	6	6.1	1.3	16	0.25	0.31	0.41	0.31	0.3	.17	0.11	.80(e)
13	2.1	2.8	1	14	0.24	0.36	0.42	0.27	0.3	.16	0.09	.50(e)
14	1.3	1.5(e)	0.89	4.1	0.23	0.32	0.36	0.74	0.28	.15	0.12	.40(e)
15	0.89	1.1(e)	0.83	13	0.33	0.4	0.39	0.53	0.29	.09	0.13	0.3
16	.65(e)	.90(e)	0.72	10	0.26	0.41	0.87	0.54	0.15	.08	0.1	0.29
17	1.6	.75(e)	0.66	3.6	0.24	0.49	0.65	0.37	0.19	.08	0.1	0.31
18	1.2(e)	.65(e)	0.65	2	0.21	0.49	0.87	0.33	1.4	.10	0.11	0.26
19	.80(e)	.55(e)	0.59	1.5	0.2	0.33	0.55	0.47	0.24	.17	0.08	0.25
20	.60(e)	.50(e)	0.56	1.1	0.22	0.28	0.44	0.53	0.19	.12	0.08	.20(e)
21	0.53	5.0(e)	0.62	0.89	0.19	0.22	0.36	0.83	0.19	.12	0.11	.20(e)
22	0.45	4.0(e)	0.55	0.72	0.2	0.28	0.36	0.53	0.16	.10	0.08	0.26
23	0.41	24(e)	0.53	0.56	0.2	0.32	0.32	0.42	0.25	.12	.10(e)	0.21
24	0.4	4.5(e)	4.8	0.48	0.21	0.28	0.3	0.35	0.22	.10	.08(e)	0.2
25	2.9	2.5(e)	4.4	0.44	0.2	0.3	0.29	0.33	0.16	.10	.08(e)	0.18
26	2.8	1.5(e)	2.5	0.45	0.99	4.4	0.34	0.34	0.22	.08	.09(e)	.17(e)
27	3.4	1.2(e)	45	0.44	0.46	2.8	0.67	0.31	0.17	.08	1.00(e)	.16(e)
28	8.3	.90(e)	18	0.37	0.28	0.82	0.42	0.29	0.17	.11	4.00(e)	.16(e)
29	2.6		5.6	0.38	0.25	0.55	0.4	0.3	0.14	.08	1.00(e)	0.16
30	1.5		3	0.32	0.22	0.43	0.37	0.33	0.16	.08	.50(e)	0.17
31	1		3.3		0.22		0.35	0.49		.09		.17(e)
TOTAL	54.77(e)	121.6(e)	135.8	115.7	10.04	17.74	12.56	12.36	8.51	4.15	9.25(e)	13.92(e)
MEAN	1.77(e)	4.34(e)	4.38	3.85	0.32	0.59	0.41	0.4	0.28	.13	.31(e)	.45(e)
MAX	8.3	30	45	16	0.99	4.4	0.87	0.83	1.4	.55	4.00(e)	3.7
MIN	0.4	0.49	0.53	0.32	0.19	0.22	0.29	0.22	0.15	.08	0.06	0.16
RUNOFF (in)	3.05(e)	6.75(e)	7.5	6.42	0.56	0.98	0.7	0.69	0.47	.22	.17(e)	.77(e)

(e) - Estimated data.

**Table C.15. Daily streamflow at monitoring station GS5 (USGS03536380)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	4.2	6.0	20	11	4.1	2.4	2.8	2.4	2.0	2.10	2.10	3.20
2	3.9	5.1	43	9.1	3.4	3.5	2.5	2.4	2.0	2.00	2.00	2.90
3	9.7	4.5	24	8.7	6.5	2.6	2.4	2.5	2.0	2.10	2.00	2.70
4	9.8	4.1	14	7.4	3.8	2.3	2.3	2.6	2.0	2.10	2.00	4.20
5	6.8	5.3	10	13	3.4	2.3	2.3	5.1	2.0	2.20	1.90	5.20
6	5.7	4.1	8.2	36	3.4	2.9	2.3	2.5	2.3	2.10	1.90	3.50
7	15	3.7	7.1	18	3.5	3.0	2.3	2.4	2.3	2.00	1.90	3.30
8	11	4.8	6.2	12	3.2	2.9	2.3	2.3	2.1	1.90	1.90	2.90
9	7.7	26	9.5	9.8	3.1	3.3	2.3	2.4	2.0	6.80	1.80	2.70
10	6.0	62	11	17	3.0	5.6	2.3	2.4	2.0	2.80	5.00	15.00
11	9.5	105	7.9	47	2.9	2.8	2.9	2.4	2.0	2.30	2.20	7.20
12	21	28	6.8	49	2.8	2.6	3.5	2.1	2.0	2.50	2.00	5.00
13	11	16	6.3	55	2.7	3.2	3.8	1.9	2.1	2.50	1.90	4.00
14	8.0	11	5.8	19	2.6	2.8	3.0	6.6	2.1	2.10	1.90	3.50
15	6.0	8.8	5.4	45	3.7	4.2	3.0	3.0	2.1	2.00	1.80	3.20
16	4.9	7.3	4.9	38	2.9	3.6	4.6	3.8	2.1	2.00	1.80	3.40
17	10	6.4	4.5	17	2.6	3.4	3.7	2.6	2.1	2.00	1.80	3.30
18	7.0	5.6	4.4	12	2.5	3.3	3.2	2.2	4.7	2.00	1.70	2.90
19	5.6	5.0	3.9	9.5	2.4	2.5	2.7	3.9	7.1	3.00	1.70	2.80
20	5.0	4.7	3.8	7.8	2.4	2.4	2.6	4.2	2.5	2.30	1.70	2.50
21	4.6	18	4.6	6.7	2.3	3.7	2.4	5.3	2.2	2.10	1.80	2.40
22	4.3	14	3.6	6.1	2.3	2.7	2.4	3.0	2.1	2.20	1.80	2.70
23	4.0	81	3.5	5.4	2.4	2.4	2.2	2.3	2.0	2.20	1.80	2.50
24	3.8	23	12	4.9	2.4	3.2	2.2	2.1	2.9	2.10	1.80	2.40
25	13	14	11	4.6	2.4	2.4	2.3	2.0	2.5	2.00	1.80	2.30
26	12	9.9	8.4	4.2	6.1	20	2.7	2.0	2.1	2.00	1.90	2.20
27	15	7.7	126	4.4	2.8	9.7	5.5	2.0	2.0	2.00	8.80	2.20
28	29	6.7	62	3.9	2.4	4.2	3.4	1.9	2.1	2.00	20.00	2.20
29	13		23	3.7	2.4	3.6	2.7	2.1	2.1	2.00	5.00	2.10
30	9.3		15	3.6	2.3	3.2	2.5	2.0	2.1	1.90	3.60	2.10
31	7.2		16		2.3		2.4	3.5	2.1	2.00		2.40
TOTAL	283.0	497.7	491.8	488.8	95.0	116.7	87.7	87.9	71.6	71.30	89.30	108.90
MEAN	9.13	17.8	15.9	16.3	3.06	3.91	2.83	2.84	2.39	2.30	2.98	3.51
MAX	29	105	126	55	6.5	20	5.5	6.6	7.1	6.80	20.00	15.00
MIN	3.8	3.7	3.5	3.6	2.3	2.3	2.2	1.9	2.0	1.90	1.70	2.10
RUNOFF (in)	5.01	8.83	8.73	8.66	1.68	2.06	1.55	1.56	1.26	1.26	1.58	1.93

**Table C.16. Daily streamflow at monitoring station GS6 (USGS03536320)
for the period January–December 1994
(units=cfs)**

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.56	1.4	8.9	4.1	.31	0.08	.11	.07	.10	.05	.07	.14
2	0.38	1.1	24	3.0	.15	0.21	.09	.07	.07	.05	.05	.11
3	2.3	.85	12	2.6	1.2	0.09	.08	.11	.05	.05	.05	.10
4	2.8	.65	6.3	2.0	.40	0.08	.08	.12	.05	.04	.05	.69
5	1.7	.90	3.8	4.2	.22	0.08	.07	.90	.05	.04	.04	.92
6	1.3	.53	2.6	18	.18	0.26	.07	.11	.09	.04	.06	.28
7	5.2	.35	2.1	8.3	.22	0.24	.06	.08	.04	.05	.05	.18
8	3.8	.63	1.8	5.0	.18	0.24	.11	.07	.04	.05	.05	.14
9	2.2(e)	11	3.1	3.3	.14	0.33	.08	.06	.04	1.50	.05	.11
10	1.2(e)	41	3.9	6.5	.13	1	.07	.05	.03	.19	.90	5.10
11	2.5(e)	73	2.6	26	.12	0.16	.24	.04	.03	.09	.06	2.00
12	7.0(e)	16	2.1	35	.12	0.12	.40	.04	.04	.16	.05	1.10
13	1.7(e)	7.4	1.8	34	.11	0.19	.57	.04	.04	.19	.06	.57
14	1.3(e)	4.3	1.6	10	.11	0.11	.26	1.5	.05	.09	.06	.18
15	1.1(e)	2.9	1.3	26	.43	0.37	.28	.25	.05	.07	.05	.13
16	1.0(e)	2.0	1.0	22	.16	0.17	.69	.54	.06	.06	.05	.22
17	3.0(e)	1.6	.73	8.7	.11	0.31	.26	.14	.79	.06	.05	.27
18	1.5(e)	1.3	.59	5.1	.10	0.28	.15	.09	1.2	.06	.05	.15
19	1.0(e)	1.0	.36	3.4	.10	0.11	.10	.45	.14	.38	.05	.12
20	.80(e)	.76	.18	2.4	.09	0.09	.09	.62	.07	.13	.04	.11
21	0.64	5.6	.40	1.9	.09	0.96	.08	.90	.05	.08	.06	.10
22	0.56	52	.21	1.5	.08	0.19	.07	.21	.05	.13	.05	.21
23	0.35	52	.18	1.3	.08	0.11	.07	.11	.32	.13	.05	.12
24	0.24	12	3.4	1.0	.08	0.31	.06	.08	.26	.07	.04	.10
25	3.5	6.0	3.2	.78	.08	0.14	.07	.06	.10	.07	.04	.09
26	3.2	3.6	2.6	.53	.96	7.8	.18	.06	.07	.07	.07	.08
27	5.5	2.4	86	.51	.20	2.3	.93	.09	.06	.06	2.40	.08
28	14	1.8	36	.25	.12	0.37	.30	.05	.05	.06	7.20	.08
29	4.8		13	.17	.10	0.2	.12	.05	.05	.05	.97	.07
30	2.8		6.7	.16	.09	0.13	.09	.04	.04	.05	.28	.07
31	1.9		6.6		.08		.07	.41		.06		.14
TOTAL	79.8(e)	259.07	239.05	237.70	6.54	17.03	5.90	7.41	4.08	4.18	13.05	13.76
MEAN	2.58(e)	9.25	7.71	7.92	.21	0.57	.19	.24	.14	.14	.44	.44
MAX	14	73	86	35	1.2	7.8	.93	1.5	1.2	1.50	7.20	5.10
MIN	0.24	.35	18	.16	.08	0.08	.06	.04	.03	.04	.04	.07
RUNOFF (in)	2.27(e)	7.36	6.79	6.75	.19	0.48	.17	.21	.12	.52	1.58	1.64

(e) - Estimated data.

Appendix D

REVISIONS TO RATING TABLES FOR SURFACE-WATER MONITORING STATIONS IN THE WHITE OAK CREEK WATERSHED

**Table D.7 Rating table for the sharp-crested V-notch weir at the East Seep monitoring station
located on the East Seep Tributary to the headwaters of White Oak Lake**

GAGE HEIGHT ¹ (ft)	DISCHARGE (cfs)									
	-0.10	-0.09	-0.08	-0.07	-0.06	-0.05	-0.04	-0.03	-0.02	-0.01
			0.0000	0.0002	0.0005	0.0009	0.0014	0.0020	0.0027	0.0035
GAGE HEIGHT (ft)	DISCHARGE (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0044	0.0054	0.0065	0.0077	0.0091	0.0107	0.0125	0.0145	0.0169	0.0197
0.1	0.0299	0.0265	0.0305	0.0349	0.0397	0.0449	0.0505	0.0565	0.0629	0.0697
0.2	0.0769	0.0838	0.0906	0.0984	0.1062	0.1149	0.1236	0.1332	0.1427	0.1533
0.3	0.1638	0.1752	0.1866	0.1991	0.2115	0.2249	0.2383	0.2528	0.2672	0.2827
0.4	0.2981	0.3146	0.3311	0.3488	0.3664	0.3851	0.4037	0.4236	0.4434	0.4643
0.5	0.4852	0.5073	0.5294	0.5526	0.5758	0.6003	0.6247	0.6503	0.6759	0.7028
0.6	0.7296	0.7586	0.7876	0.8165	0.8455	0.8745	0.9066	0.9387	0.9709	1.0030
0.7	1.0351	1.0705	1.1059	1.1412	1.1766	1.2120	1.2507	1.2894	1.3280	1.3667
0.8	1.4054	1.4475	1.4896	1.5317	1.5738	1.6159	1.6615	1.7070	1.7526	1.7981
0.9	1.8437	1.8928	1.9419	1.9910	2.0401	2.0892	2.1419	2.1946	2.2474	2.3001

D.7 (cont.)

GAGE HEIGHT¹ (ft)	DISCHARGE (cfs)									
1.0	2.3528	2.4092	2.4656	2.5221	2.5785	2.6349	2.6951	2.7552	2.8154	2.8755
1.1	2.9357	2.9997	3.0636	3.1276	3.1915	3.2555	3.3233	3.3912	3.4590	3.5269
1.2	3.5947	3.6665	3.7383	3.8100	3.8818	3.9536	4.0294	4.1051	4.1809	4.2566
1.3	4.3324	4.4122	4.4920	4.5719	4.6517	4.7315	4.8154	4.8993	4.9833	5.0672
1.4	5.1511	5.2392	5.3273	5.4153	5.5034	5.5915	5.6838	5.7761	5.8683	5.9606
1.5	6.0529	6.1516	6.2503	6.3490	6.4477	6.5465	6.6452	6.7439	6.8426	6.9413
1.6	7.0400	7.1474	7.2549	7.3623	7.4697	7.5772	7.6846	7.7920	7.8994	8.0069
1.7	8.1143	8.2306	8.3470	8.4633	8.5797	8.6960	8.8123	8.9287	9.0450	9.1614
1.8	9.2777	9.4032	9.5286	9.6541	9.7795	9.9050	10.0304	10.1559	10.2813	10.4068
1.9	10.5322									

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¹NOTE: Gage height of weir crest is 0.00 ft, but due to a leak around the weir plate, the point of 0.00 flow is 0.08 ft below the weir crest.

Table D.12 Rating table for the trapezoidal flume at the MS1 monitoring station located on an unnamed tributary to White Oak Creek near the southern boundary of SWSA 4

GAGE HEIGHT (ft)	DISCHARGE (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0			0.001	0.001	0.002	0.004	0.006	0.008	0.011	0.014
0.1	0.018	0.023	0.027	0.033	0.038	0.045	0.052	0.059	0.067	0.075
0.2	0.084	0.094	0.104	0.115	0.126	0.138	0.150	0.163	0.177	0.191
0.3	0.206	0.222	0.238	0.254	0.272	0.290	0.308	0.327	0.347	0.368
0.4	0.389	0.410	0.433	0.456	0.480	0.504	0.529	0.555	0.581	0.608
0.5	0.636	0.664	0.693	0.723	0.753	0.785	0.816	0.849	0.882	0.916
0.6	0.951	0.986	1.02	1.06	1.10	1.13	1.17	1.21	1.25	1.29
0.7	1.34	1.38	1.42	1.47	1.51	1.56	1.60	1.65	1.70	1.74
0.8	1.79	1.84	1.89	1.94	2.00	2.05	2.10	2.16	2.21	2.27
0.9	2.32	2.38	2.44	2.50	2.56	2.62	2.68	2.74	2.81	2.87
1.0	2.93	3.00	3.06	3.13	3.20	3.27	3.34	3.41	3.48	3.55
1.1	3.63	3.74	3.85	3.97	4.08	4.20	4.32	4.45	4.58	4.70
1.2	4.84	4.97	5.11	5.25	5.39	5.53	5.68	5.83	5.98	6.14
1.3	6.30	6.46	6.62	6.79	6.96	7.13	7.31	7.49	7.67	7.86
1.4	8.04	8.24	8.43	8.63	8.83	9.03	9.24	9.45	9.66	9.88
1.5	10.1	10.3	10.6	10.8	11.0	11.3	11.5	11.7	12.0	12.2
1.6	12.5	12.8	13.0	13.3	13.6	13.8	14.1	14.4	14.7	15.0
1.7	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.8	18.1
1.8	18.4	18.8	19.1	19.5	19.8	20.2	20.5	20.9	21.3	21.7
1.9	22.0	22.4	22.8	23.2	23.6	24.0	24.4	24.8	25.2	25.7
2.0	26.1									

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