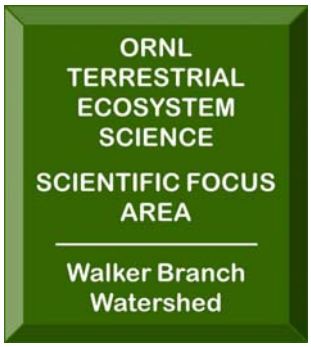
Walker Branch Watershed: 15-minute and Daily Stream Discharge and Annual Runoff



Summary:

This data set reports 15-minute and daily stream discharge, and annual runoff for the West and East Forks draining Walker Branch Watershed (WBW). The long-term Walker Branch Hydrology Monitoring project was intended to document changes in the water balance (precipitation inputs, stream discharge outputs) for the WBW over time. This data set contains three data files of stream discharge (L/s) for 15-minute and daily intervals, and annual runoff (cm). The daily and annual datasets began in 1969 in both East and West Forks, while the 15-minute datasets began in 1994 in both Forks. Data were collected through 2014 for the West Fork, and through 2012 for the East Fork.

Data Citation:

Cite this data set as follows:

Mulholland, P.J., and N.A. Griffiths. 2016. Walker Branch Watershed: 15-minute and Daily Stream Discharge and Annual Runoff. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/CDIAC/ornlsfa.007

Acknowledgement of Sponsor for Terrestrial Ecosystem Science - Scientific Focus Area (TES SFA):

This research was sponsored by the Terrestrial Ecosystem Science Program, Office of Biological and Environmental Research within the U.S. Department of Energy's Office of Science.

Data and Documentation Access:

For public access to WBW data please visit the ORNL TES-SFA Web Site:
http://tes-sfa.ornl.gov/

Walker Branch Watershed website: http://walkerbranch.ornl.gov/

Long-term monitoring of WBW is continuing through the National Ecological Observatory Network (NEON), and data are available from the NEON website: http://www.neonscience.org/.

Publications related to this data set:

Curlin, J.W., and D.J. Nelson. 1968. Walker Branch Watershed project: Objectives, facilities, and ecological characteristics. ORNL/TM-2271. Oak Ridge National Laboratory, Oak Ridge, TN.

Luxmoore, R.J. 1983. Water budget of an eastern deciduous forest stand. Soil Science Society of America Journal 47:785-791.

Luxmoore, R.J., and D.D. Huff. 1989. Water. Chapter 5, pages 164-196. In: D.W. Johnson and R.I. Van Hook, eds., Analysis of Biogeochemical Cycling Processes in Walker Branch Watershed. Springer-Verlag, New York.

Data Policy - Sharing, Access, and Use Recommendations: ORNL TES-SFA Data Policy - Data Policy and Fair-Use Statement

Related Data Sets: Historical climate, stream discharge, and stream chemistry data are available at http://tes-sfa.ornl.gov/. Environmental data from WBW are also available from the NEON website: http://www.neonscience.org/.

Walker Branch Watershed (WBW) Project Description:

Walker Branch Watershed (WBW) is a forested watershed on the Oak Ridge Reservation and has been the site of long-term environmental research since the 1960s. Hydrological, biogeochemical, and ecological studies in WBW have made important contributions to our understanding of the effects of changes in atmospheric deposition and climate variability and change in this region (see http://walkerbranch.ornl.gov/publications.shtml for complete list of publications).
Objectives of the WBW long-term observations have been to:

1. Quantify responses of an eastern upland oak forest ecosystem to inter-annual and long-term variations in climate and atmospheric deposition of sulfur and nitrogen, and
2. Provide integrated, long-term data on climate, forest vegetation, soil chemistry, and hydrologic and chemical fluxes at the catchment scale to support other focused research projects on the Oak Ridge Reservation and elsewhere in the region.

Table of Contents:

1. Data Set Overview:

This data set reports 15-minute and daily stream discharge, and annual runoff in the East and West Forks of Walker Branch Watershed from 1969-2014. The daily and annual datasets began in 1969 in both East and West Forks, while the 15-minute datasets began in 1994 in both Forks. Data were collected through 2014 for the West Fork, and through 2012 for the East Fork. The East Fork subcatchment is 59.1 ha, the West Fork subcatchment is 38.4 ha, and the total catchment area is 97.5 ha (Figure 1).

2. Data Characteristics:

Spatial Coverage:
Thia research was conducted in Walker Branch Watershed. The weirs are located at the outlet of the East and West Forks of Walker Branch (Figure 1).

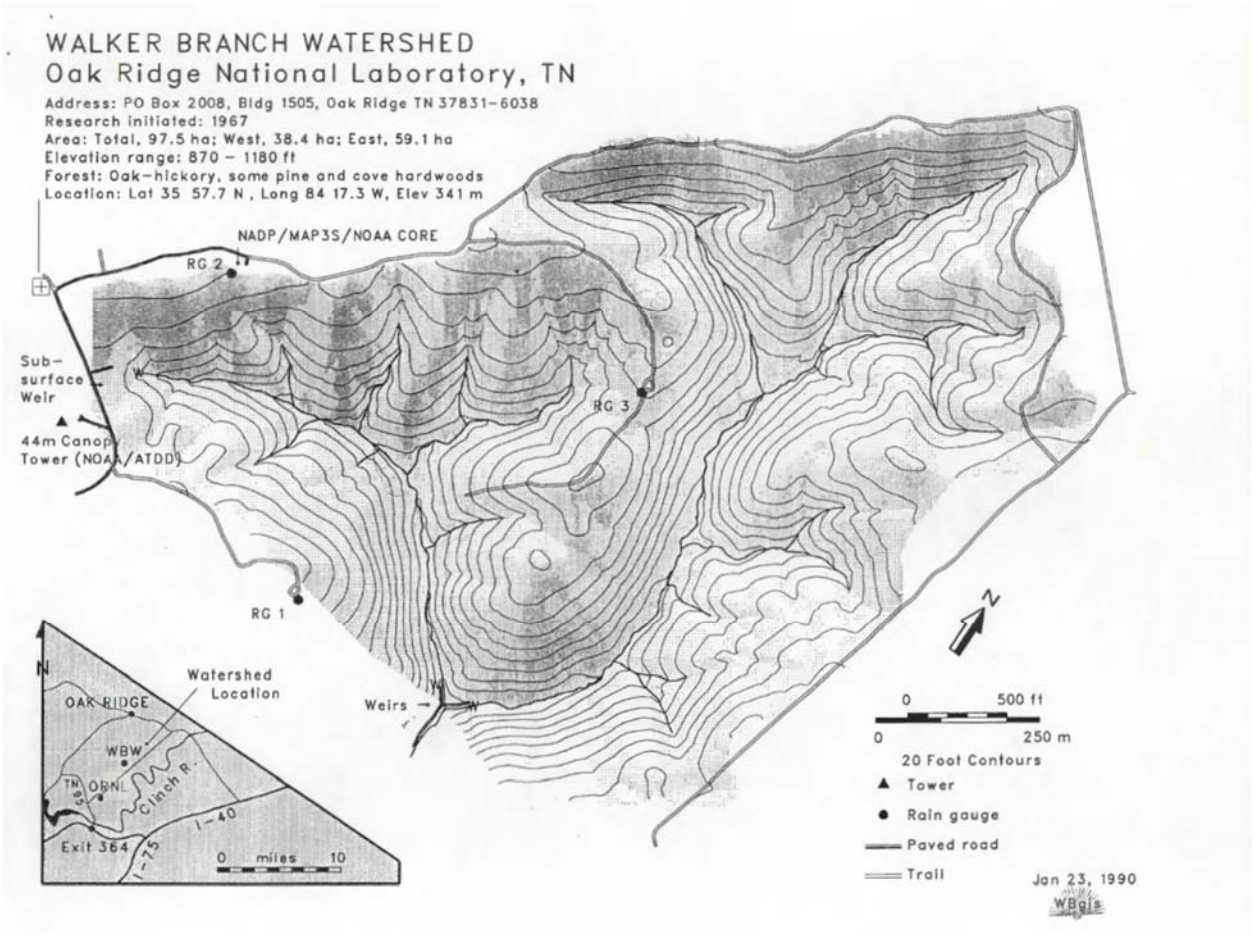


Figure 1 – Topographic map of Walker Branch Watershed showing the locations of weirs. The West Fork is on the left and the East Fork is on the right.

Site boundaries: Latitude and longitude given in decimal degrees. Source Google Earth.

Site (Region)	Longitude	Latitude	Elevation (meters amsl)	Geodetic Datum
West Fork weir pool of Walker Branch Watershed	-84.27951	35.95879	265	WGS84
East Fork weir pool of Walker Branch Watershed	-84.27922	35.95869	265	WGS84

Temporal Coverage:

Time period: The data set covers the period from January 1, 1969 to December 31, 2014.

Data File Description:

All of the data are contained in 3 comma separated (*.csv) files. Missing values are represented by -9999.

- File #1: WBW_15-minute_discharge.csv
- File #2: WBW_daily_discharge.csv
- File #3: WBW_annual_runoff.csv

Data Dictionary:

File #1: WBW_15-minute_discharge.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	TIME	HH:MM	Measurement time (EST).	
3	WF_LEVEL	ft	Stage height (water level) measured at the weir.	Water level recorder or bubble level sensor (see Methods).
4	WF_DISCHARGE	L/s	Stream discharge for the West Fork of Walker Branch.	Calculated discharge based on the dimensions of the v-notch weir.
5	EF_LEVEL	ft	Stage height (water level) measured at the weir.	Water level recorder or bubble level sensor (see Methods).
6	EF_DISCHARGE	L/s	Stream discharge for the East Fork of Walker Branch.	Calculated discharge based on the dimensions of the v-notch weir.
7	CODE		EFDA = East Fork discharge is the daily average (15-min data not available). WFDA = West Fork discharge is the daily average (15-min data not available). EFWF_EST (East and West Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). WF_EST (West Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). EF_EST (East Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). EFWT_EST (Both East and West Fork data are estimated). WF_REG (West Fork discharge estimated based on a regression with East Fork data). EF_REG (East Fork discharge estimated based on a regression with West Fork data). WF_REG2 (West Fork discharge estimated by 15-min conductivity measurements and regression between conductivity and discharge). EFWF_ISCO (values from ISCO). EF_GAP (water level logger malfunctioned periodically during measurement interval. Filled in periodic gaps in water depth data via interpolation). DUP (duplicate datapoint, possibly due to logger malfunction).	Data gap filling methods and duplicate data flags.
Historical Walker Branch datasets are available at: http://tes-sfa.ornl.gov/ and information about Walker Branch Watershed is available at: http://walkerbranch.ornl.gov/. Missing data denoted as '-9999'.				

Example Data Records:

```
DATE,TIME,WF_LEVEL,WF_DISCHARGE,EF_LEVEL,EF_DISCHARGE,CODE
19940101,0:00,-9999,11.73,-9999,10.28,-9999
19940101,0:15,-9999,11.73,-9999,10.28,-9999
19940101,0:30,-9999,11.73,-9999,10.28,-9999
19940101,0:45,-9999,11.73,-9999,9.59,-9999
19940101,1:00,-9999,11.73,-9999,9.59,-9999
….
20141231,22:45,0.40,13.29,-9999,-9999,-9999
20141231,23:00,0.40,13.29,-9999,-9999,-9999
20141231,23:15,0.40,13.29,-9999,-9999,-9999
20141231,23:30,0.40,13.29,-9999,-9999,-9999
20141231,23:45,0.40,13.29,-9999,-9999,-9999
```

File #2: WBW_daily_discharge.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	YEAR	YYYY	Measurement year.	
2	WF_DISCHARGE	L/s	Mean daily stream discharge for the West Fork of Walker Branch.	Calculated discharge based on the dimensions of the v-notch weir. Mean values recorded from 1969-1993, and mean values calculated from 1994-2014.
3	EF_DISCHARGE	L/s	Mean daily stream discharge for the East Fork of Walker Branch.	Calculated discharge based on the dimensions of the v-notch weir. Mean values recorded from 1969-1993, and mean values calculated from 1994-2014.
4	CODE		EFDA = East Fork discharge is the daily average (15-min data not available). WFDA = West Fork discharge is the daily average (15-min data not available). EFWF_EST (East and West Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). WF_EST (West Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). EF_EST (East Fork discharge estimated based on weather records and flow records for nearby site due to punch tape malfunction). EFWT_EST (Both East and West Fork data are estimated). WF_REG (West Fork discharge estimated based on a regression with East Fork data). EF_REG (East Fork discharge estimated based on a regression with West Fork data). WF_REG2 (West Fork discharge estimated by 15-min conductivity measurements and regression between conductivity and discharge). EFWF_ISCO (values from ISCO).	These codes are derived from the 15-minute data (e.g., regressions between East and West Fork data were developed using 15-minute data), but because these estimated data were used to calculate mean discharge values, the same codes appear in this dataset.
Historical Walker Branch datasets are available at: http://tes-sfa.ornl.gov/ and information about Walker Branch Watershed is available at: http://walkerbranch.ornl.gov/. Missing data denoted as '-9999'.				

Example Data Records:

```
DATE,WF_DISCHARGE,EF_DISCHARGE,CODE
19690101,5.5,2.9,-9999
19690102,5.4,2.6,-9999
19690103,5.4,2.5,-9999
19690104,5.3,2.3,-9999
19690105,5.3,2.0,-9999
….
20141227,16.9,-9999,-9999
20141228,13.8,-9999,-9999
20141229,13.6,-9999,-9999
20141230,14.1,-9999,-9999
20141231,13.6,-9999,-9999
```

File #3 name: WBW_annual_runoff.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	YEAR	YYYY	Measurement year.	
2	WF_ANN_RUNOFF	cm	Annual runoff from the West Fork.	Calculated from mean annual discharge.
3	EF_ANN_RUNOFF	cm	Annual runoff from the East Fork.	Calculated from mean annual discharge.
4	WBW_ANN_RUNOFF	cm	Annual runoff from Walker Branch Watershed.	Calculated from the East and West Fork runoff values.
Historical Walker Branch datasets are available at: http://tes-sfa.ornl.gov/ and information about Walker Branch Watershed is available at: http://walkerbranch.ornl.gov/. Missing data denoted as '-9999'.				

Example Data Records:

```
YEAR,WF_ANN_RUNOFF,EF_ANN_RUNOFF,WBW_ANN_RUNOFF
1969,63.9,32.7,45.0
1970,106.4,62.8,80.0
1971,102.9,45.9,68.3
1972,123.3,68.4,90.0
1973,159.6,96.2,121.2
….
2010,97.0,49.3,68.0
2011,140.7,83.2,105.9
2012,112.6,43.0,70.4
2013,131.9,-9999,-9999
2014,83.4,-9999,-9999
```

3. Data Application and Derivation:

The long-term Walker Branch Hydrology Monitoring project was intended to document changes in the water balance (precipitation inputs, stream discharge outputs) for the Walker Branch Watershed over time. These data were used in various publications on hydrology and biogeochemistry in Walker Branch.

4. Quality Assessment:

These data are considered at Level 2. Level 2 indicates that, in addition to the Level 1 checks, the product is a complete, externally consistent data product that has undergone interpretative and diagnostic analyses and can be shared with the public. Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures. Instrument calibrations were carried out following the manufacturer's instructions and analyses followed published procedures.

5. Data Acquisition Materials and Methods:

Site Description:
Walker Branch Watershed (WBW) is a 97.5 ha second-growth forest on the U.S. Department of Energy's Oak Ridge Reservation in east Tennessee, USA. There are two headwaters streams that drain the watershed: the West Fork drains 38.4 ha and the East Fork drains 59.1 ha (Curlin and Nelson 1968). The watershed is underlain by bedrock (Knox Dolomite) with deep soils, primarily Utisols. Vegetation is primarily oaks (*Quercus prinus, Quercus alba*), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and American beech (*Fagus grandifolia*) (Johnson 1989, Kardol et al. 2010). The climate is typical of the southern Appalachian region, with a mean annual temperature of 14.5ºC and mean annual precipitation of 135 cm (Curlin and Nelson 1968, Johnson 1989).

Stream discharge measurements:
The streams draining the two subcatchments of Walker Branch (East and West Forks) were monitored for discharge with 120-degree V-notch weirs. Discharge up to 1.18 m^3/s can be measured with the V-notch weirs, and higher discharges up to 1.86 m^3/s are monitored with a sharp-crested, rectangular cross section above the V-notch weir. The stream stage heights were monitored with a Fisher and Porter model 1542 punched-tape water-level recorder at 5-minute (until 1989) or 15-minute intervals (until 1999) with a resolution of 0.3 mm. Beginning in 1999, stream stage heights were monitored electronically at 15-min intervals with a Stevens Type A/F encoder. Beginning in 2011, stream stage heights were monitored electronically at 15-min intervals with a Campbell Compact Bubble Water Level Sensor (CS471; accuracy ±0.01 ft for measurements depths of 0 to 15 ft) attached to a CR1000 datalogger. Data were downloaded monthly, and logger data were verified with a manual hook gauge measurement.

The conversion of stage height to discharge for stage heights <2.5 ft was calculated by means of a regression equation: Discharge (L/s) = 125.37 x (stage height in feet)^2.449. The measurement uncertainty is ±5% at low flows (<0.004 m^3/s) and ±0.5% at flows > 0.125 m^3/s. Flows seldom exceed 0.7 m^3/s.

Regressions:
During logger malfunctions, discharge in one stream was sometimes calculated from a regression between the East and West Fork water levels (other gap filling methods were employed in some instances). Whether these regressions were used across all dates was not documented:
East Fork Water Level (ft) = -0.1696 + 1.3221*West Fork Water Level (ft) [$r^2 = 0.96$]

West Fork Water Level (ft) = 0.128281 + 0.756372*East Fork Water Level (ft) [$r^2 = 0.99$]

In 2011, the following equation was used:
East Fork Water Level (ft) = -0.153 + 1.2719*West Fork Water Level (ft) [$r^2 = 0.94$]

Runoff calculations:
Runoff for the East and West Forks was calculated as:
Runoff (cm) = (((Q/1000)*time)/area)*100

Where Q = mean annual discharge (in L/s), time = the number of seconds in a year, and area = area of the watershed (591,000 m^2 for the East Fork, and 384,000 m^2 for the West Fork).

Total watershed runoff was calculated as:
WB runoff = (West Fork Runoff*0.393846)+(East Fork Runoff*0.606154)

6. References:

Curlin, J. W., and D. J. Nelson. 1968. Walker Branch Watershed project: objectives, facilities, and ecological characteristics. ORNL-TM-2271. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Johnson, D. W. 1989. Site description. Pages 6-20 *in* D. W. Johnson and R. I. Van Hook (editors). Analysis of biogeochemical cycling processes in Walker Branch Watershed. Springer-Verlag, New York, New York.

Kardol, P., D. E. Todd, P. J. Hanson, and P. J. Mulholland. 2010. Long-term successional forest dynamics: species and community responses to climatic variability. Journal of Vegetation Science 21:627-642.

7. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Carbon Dioxide Information Analysis Center (CDIAC)

Data Archive Center:
Contact for Data Center Access Information:
E-mail: http://cdiacservices.ornl.gov/feedback.cfm