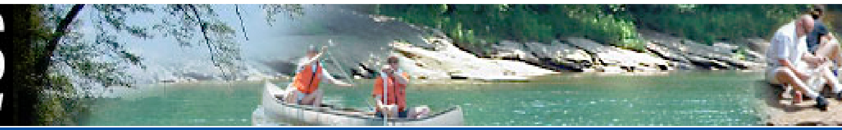


The Water Cycle: Streamflow

Gunnison River, Colorado, USA. BLM

If you read our discussion on the role the oceans play in the water cycle, you know that evaporation from the oceans is the primary way that water returns to the atmosphere from the Earth's surface. Water returns to the Earth from precipitation falling on the land, where gravity either takes it into the ground as infiltration or it begins running downhill as surface runoff. But how does much of the water get back into the oceans to keep the water cycle going? A lot of runoff ends up in creeks, streams, and rivers, flowing downhill towards the oceans. Unless the river flows into a closed lake, a rare occurrence, or is diverted for humans' uses, a common occurrence, they empty into the oceans, thus fulfilling their water-cycle duties.

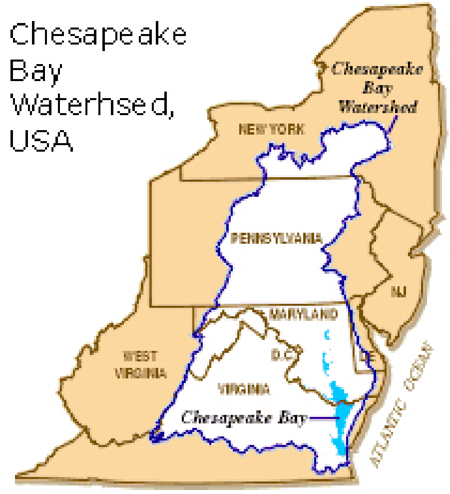
The U.S. Geological Survey (USGS) uses the term "streamflow" to refer to the amount of water flowing in a river. Although USGS usually uses the term "stream" when discussing flowing water bodies, in these pages we'll use "rivers" more often, since that is probably what you are more familiar with.

Importance of rivers

Rivers are invaluable to not only people, but to life everywhere. Not only are rivers a great place for people (and their dogs) to play, but people use river water for drinking-water supplies and irrigation water, to produce electricity, to flush away wastes (hopefully, but not always, treated wastes), to transport merchandise, and to obtain food. Rivers are major aquatic landscapes for all manners of plants and animals. Rivers even help keep the aquifers underground full of water by discharging water downward through their streambeds. And, we've already mentioned that the oceans stay full of water because rivers and runoff continually refreshes them.

Watersheds and rivers

One word can explain why any river exists on Earth—gravity. You've heard that "water seeks its own level," but really water is seeking the center of the Earth, just like everything else. In practical terms, water generally seeks to flow to the oceans, which are at sea level. So, no matter where on Earth water is, it tries to flow downhill. With the Earth being a very unlevel place, water ends up occupying the valleys and depressions in the landscape as rivers and lakes.




Urban creek at low flow and in flood.

Streamflow is always changing, from day to day and even minute to minute. Of course, the main influence on streamflow is precipitation runoff in the watershed. Rainfall causes rivers to rise, and a river can even rise if it only rains very far up in the watershed - remember that water that falls in a watershed will eventually drain by the outflow point. The size of a river is highly dependent on the size of its watershed. Large rivers have watersheds with lots of surface area; small rivers have smaller watersheds. Likewise, different size rivers react differently to storms and rainfall. Large rivers rise and fall slower and at a slower rate than small rivers. In a small watershed, a storm can cause 100 times as much water to flow by each minute as during base-periods, but the river will rise and fall possibly in a matter of minutes and hours. Large rivers may take days to rise and fall, and flooding can last for a number of days. After all, it can take days for all the water that fell hundreds of miles upstream to drain past an outflow point.

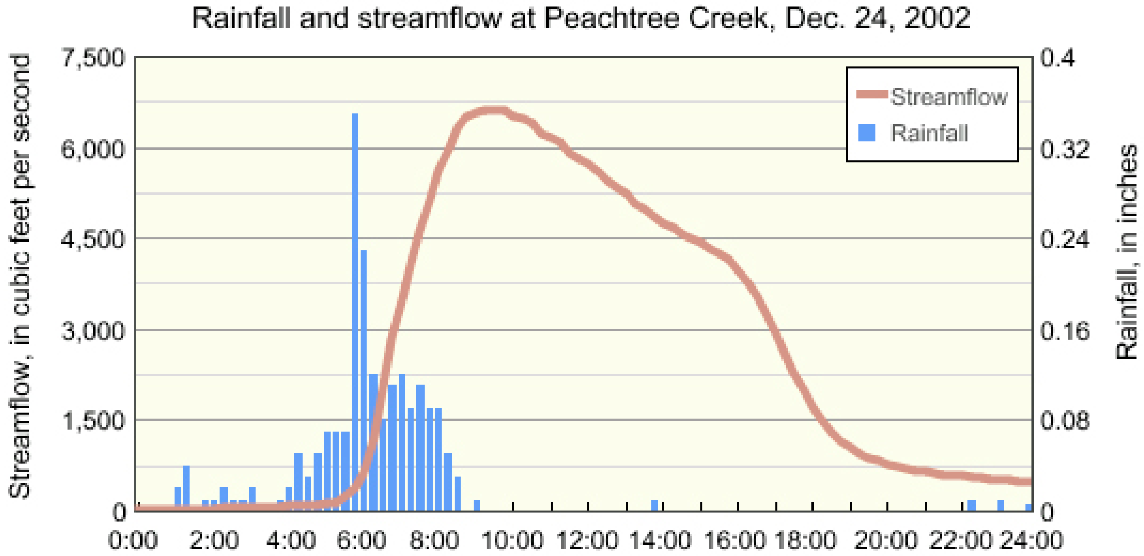
If you have ever wondered how many gallons of water falls during a storm, use our interactive rainfall calculator to find out.

Hydrologists study streamflows with hydrographs

USGS uses a hydrograph to study streamflow in rivers. A hydrograph is a chart showing, most often, river stage (height of the water above an arbitrary altitude) and streamflow (amount of water, usually in cubic feet per second). Other properties, such as rainfall and water-quality parameters can also be plotted. The hydrograph below shows rainfall and streamflow for a single day for Peachtree Creek at Atlanta, Georgia (USGS station number 02336300).

Precipitation influences streamflow

On Dec. 24, 2002, about two inches of rainfall fell in the Peachtree Creek watershed. This provides a good example to describe streamflow characteristics during a storm since the rain fell for only a few hours on that day and Peachtree Creek was at base-flow conditions before the rain started. The chart below shows rainfall, in inches, during each 15-minute increment on Dec. 24th and the continuous measure of streamflow, in cubic feet per second (ft^3/s).



The brown line in the chart shows that streamflow is much higher during the flood period than just before it. The line shows that the baseflow was about 50 ft^3/s before the river started to rise, but that just a few hours later, at 9:00 AM streamflow was over 6, 000 ft^3/s - that is about 150 times the amount of water flowing by as during baseflow conditions. This is characteristic of small streams, especially urban streams where runoff enters the river very quickly

Comparison of streamflow before and during the flood of Dec. 24, 2002
(Data are rounded)

Time		**Instantaneous streamflow**		
Time	**Stream stage, in feet**	**Cubic feet per second**	**Gallons per second**	**Streamflow, in gallons, during 15-minute interval**
Midnight	2.81	43	322	289,000
10:00	17.33	6,630	49,600	44,600,000

It is possible to estimate the total amount of water that flowed during Dec. 24, 2002, and compare it to a day when the streamflows are at base-flow conditions (stream stage of about 2.81 feet). At base flow, an estimated 27,800,000 gallons of water will flow by the Peachtree Creek measurement station in one day. Using mean streamflows for each 15-minute period during the storm of Dec. 24th, an estimated 4,290,000,000 gallons flowed by. That would be about 154 times more water than during a day of base flow.

Mechanisms that cause changes in streamflow

Rivers are always moving, which is good for everything, as stagnant water doesn't stay fresh and inviting very long. There are many factors, both natural and human-induced, that cause rivers to continuously change:

Natural mechanisms

- Runoff from rainfall and snowmelt
- Evaporation from soil and surface-water bodies
- Transpiration by vegetation
- Ground-water discharge from aquifers
- Ground-water recharge from surface-water bodies
- Sedimentation of lakes and wetlands

- Formation or dissipation of glaciers, snowfields, and permafrost

Human-induced mechanisms

- Surface-water withdrawals and transbasin diversions
- River-flow regulation for hydropower and navigation
- Construction, removal, and sedimentation of reservoirs and stormwater detention ponds
- Stream channelization and levee construction
- Drainage or restoration of wetlands
- Land-use changes such as urbanization that alter rates of erosion, infiltration, overland flow, or evapotranspiration
- Wastewater outfalls
- Irrigation wastewater return flow

Streamflow and global water distribution

Even though the water flowing in rivers is tremendously valuable to not only people but also to much of life on Earth, it makes up just a miniscule amount of Earth's water. Considering just the freshwater on Earth, streamflow in rivers only accounts for about six-one thousands of one percent (0.006%)! The first table below shows that about 0.002 percent of all Earth's water is contained in rivers, and only 0.006 percent of the world's freshwater is in rivers.

One estimate of global water distribution

Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	Percent of total freshwater	Percent of total water
Streamflow in rivers	509	2,120	0.006%	0.0002%
Total global freshwater	8,404,000	35,030,000	2.5%	--
Total global water	332,500,000	1,386,000,000	--	--

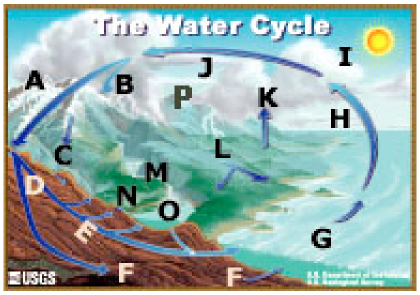
Source: Gleick, P. H., 1996: Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp.817-823.

Sources and more information

- USGS: Surface-water data for the Nation
- USGS: Real-time streamflow data
- USGS: Surface-water information

Choose a water-cycle topic

A - Storage in ice and snow
B - Precipitation
C - Snowmelt runoff to streams
D - Infiltration
E - Ground-water discharge
I - Condensation
J - Water storage in the atmosphere
K - Evapotranspiration
L - Surface runoff
M - Streamflow



F - Ground-water storage
G - Water storage in oceans
H - Evaporation
N - Springs
O - Freshwater storage
P - Sublimation

U.S. Department of the Interior | U.S. Geological Survey
URL: http://ga.water.usgs.gov/edu/watercyclestreamflow.html
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