USGS Mount Mansfield Stream Gages

Water Year 2013 report

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Introduction

This is the annual data report for the U.S. Geological Survey (USGS) stream gages at Ranch Brook and West Branch near Stowe, Vermont for Water Year (WY) 2013 (October 2012 through September 2013). The two gages were established in September 2000, and have been operated continuously by USGS since that time. The gaging was designed as a paired watershed study, with Ranch Brook (9.6 km^2) as the forested control watershed, and West Branch (11.7 km^2) as the developed watershed. West Branch contains nearly the entire expanse of Stowe Mountain Resort. Though the resort was well-established when the gaging began, it underwent a significant expansion during the course of the study. This report puts the WY13 streamflows in the context of the full 13-year record.

The gages are jointly funded through a cooperative agreement between the USGS and Vermont Monitoring Cooperative. They provide needed information on mountain hydrology in Vermont, and how mountain landscapes respond to development and extreme events. To our knowledge these are still the only gaged watersheds at a ski resort. The gages have supported projects on snow hydrology and water quality by University of Vermont, Sterling College, Vermont ANR, and others. In particular, Beverley Wemple and students at University of Vermont have used the gaging as a base for student projects and hands-on learning, and to attract additional funding for value-added research.

Results

WY2013 had none of the floods that characterized the 2008-2011 period, but it did have many large events (Figure 1), and overall runoff was greater than the long-term average. (Fig. 2).

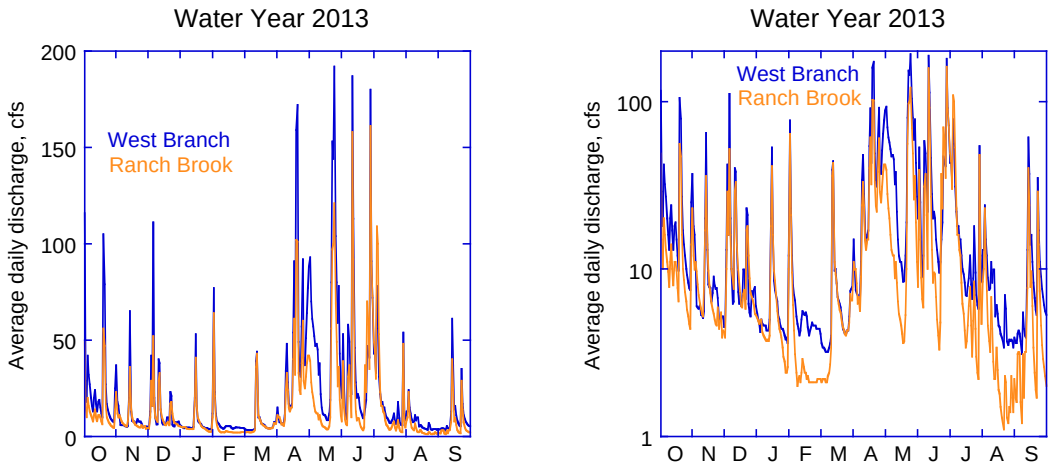

Figure 1. Streamflow at West Branch and Ranch Brook gages for Water Year 2013 (October 2012 through September 2013) in linear (left) and log (right) scales. The log scale plot illustrates the higher sustained base flow levels at West Branch.

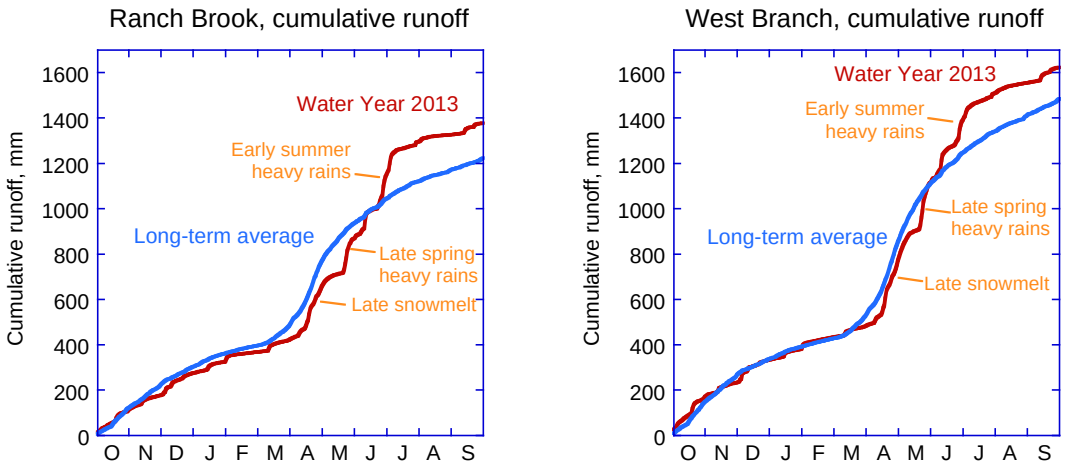

Figure 2. Cumulative runoff for Water Year 2013 at Ranch Brook (left) and West Branch (right) plotted on the long-term (2001-2013) average at each site (blue lines).

Water Year 2013 was punctuated by alternating extremes in precipitation regimes: a relatively average fall 2012 was followed by a winter that was fairly dry in the first half and snowier than average in the second half. A cold early spring led to a late snowmelt. Snowmelt was muted because April and early to mid-May were quite dry, so there were few rain-on-snow events that typically augment snowmelt. A very wet period began on May 20 with more than double typical rainfall during the next 7 weeks. The mid-July through September period was drier than average. The wet late spring and early summer period, coming on the heels of snowmelt, resulted in well over half of the annual runoff occurring in a 3-month period (Figure 2).

Throughout the 13 years of streamflow monitoring, West Branch has consistently yielded higher runoff (flow normalized to watershed area) than Ranch Brook (Wemple et al., 2007) (Figures 3 and 4). Over the long-term, the average difference has been 21% greater runoff at West Branch. After much greater differentials in WY11 and WY12, the difference in WY13 was below average at 18% (Figure 4). It is still unclear why the runoff at West Branch is so much greater and why the relative difference varies so much from year to year (Figure 4). The runoff differential peaks during the snowmelt period in April and May (Figure 3, right), partly as a consequence of the enhanced snowpack from machine-made snow, and the prolonged melt of skier-compacted snow. The low to negative differentials in late fall and early winter result from historic water extraction from West Branch for snowmaking. As yet, we have not been able to make a definitive assessment of the ski resort build-out on runoff. The assessment has been confounded by the construction of a large snowmaking storage pond, increased snowmaking, irrigation of the new golf course, and a new stormwater drainage system for the development. We are working on this assessment using a hydrologic modeling approach.

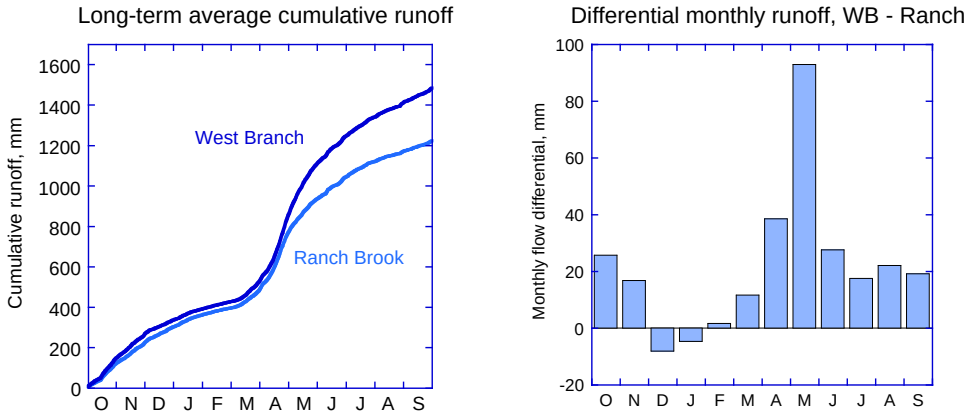

Figure 3. Long-term (Water Years 2001 to 2013) average annual cumulative runoff at West Branch and Ranch Brook (left) and differential by month (right).

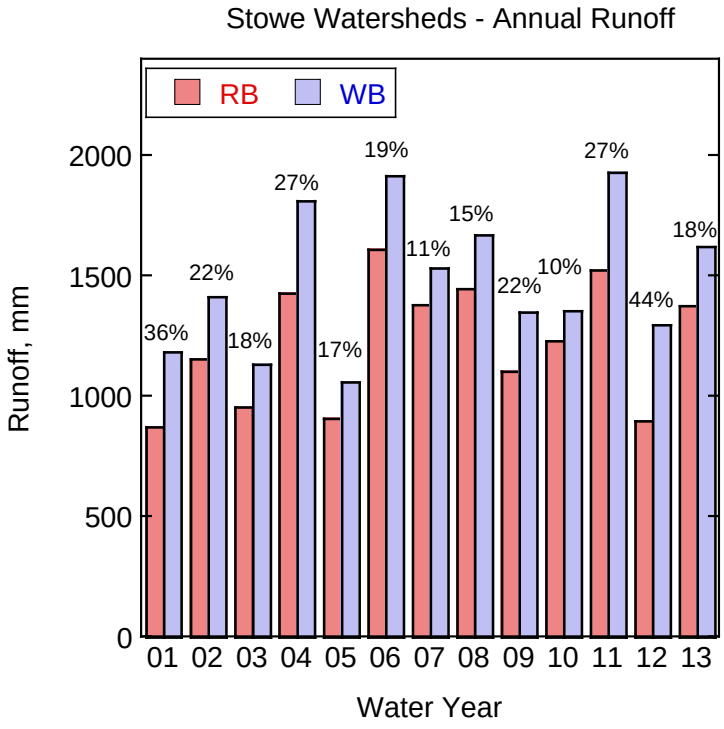

Figure 4. Annual runoff in mm at West Branch (WB) and Ranch Brook (RB) for the duration of study though the present report year. Percentage of greater runoff at WB relative to RB is given over each pair of bars.

VMC/USGS gages have attracted several student thesis projects during the 12 years. The most recent and ongoing project was led by Alejandro del Peral, a student of Beverley Wemple at U. Vermont. Beverley is continuing his work of applying the distributed soil-hydrology-vegetation model (DHSVM) (Wigmosta et al., 1994), which captures the

important soil and land surface features that drive the hyrologic processes generating streamflow. Beverley has a working version of DHSVM calibrated to the two stream watersheds, and is testing how modeled streamflow will respond to perturbations. The model provides the capability to evaluate hydrologic effects of adding and removing ski resorts from basins. Model results suggest that West Branch with full forest cover (pre-resort condition) would have been lower than today because evapotranspiration from the full forest would have been higher.

West Branch data are accessible at
http://waterdata.usgs.gov/vt/nwis/uv?site_no=04288225.
Ranch Brook data are accessible at
http://waterdata.usgs.gov/vt/nwis/uv?site_no=04288230.

References

Wemple B, Shanley J, Denner J, Ross D, Mills K., 2007. Hydrology and water quality in two mountain basins of the northeastern US: assessing baseline conditions and effects of ski area development. Hydrological Processes 21(12):1639-1650.

Wigmosta M.S., Vail L.W., Lettenmaier D.P., 1994. A distributed hydrology-vegetation model for complex terrain. Water Resources Research 30(6):1665-1680.

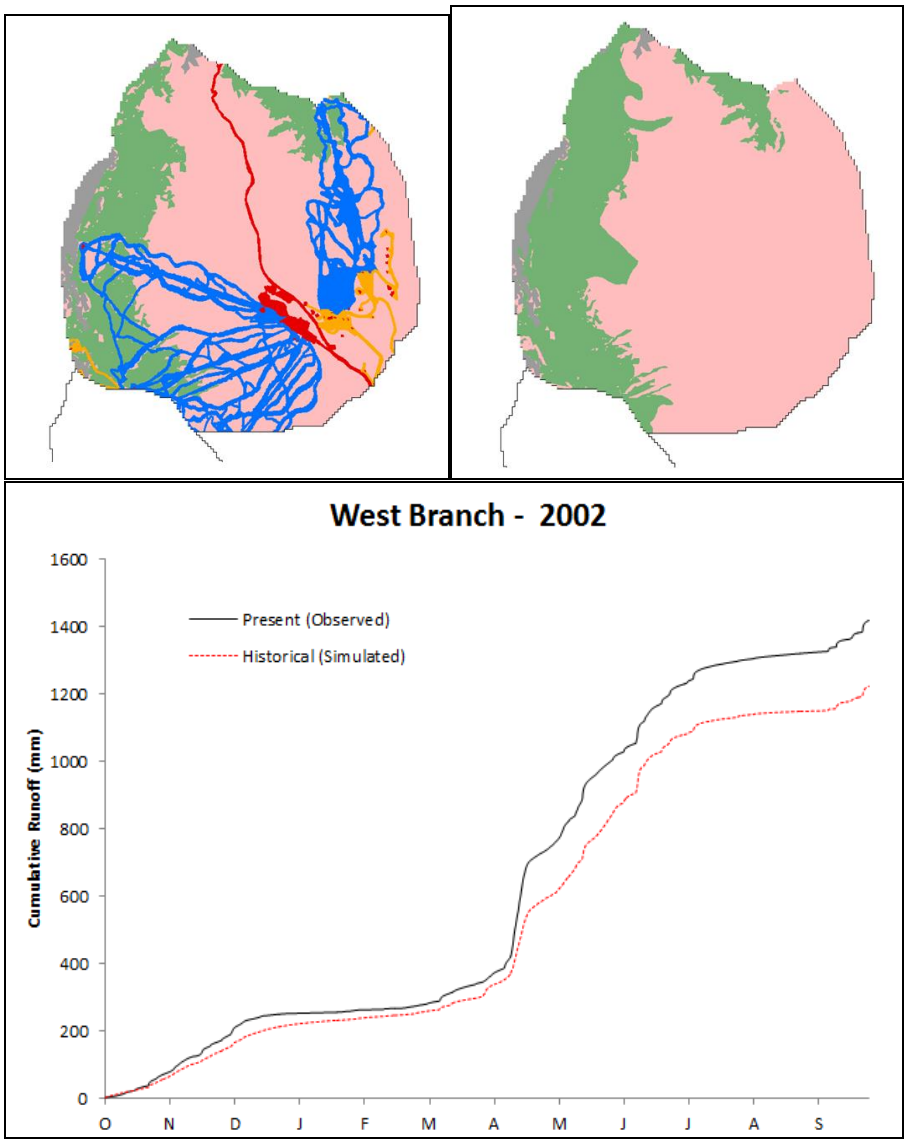

Figure 4. Simulation (red line) using DHSVM of WY2002 flow at West Branch with ski resort removed and native forest restored (depicted in maps at top) compared to observed flows (black line). These results suggest that lower evapotranspitration associated with forest removal is one driver of the high present-day flows (del Peral, M.S. thesis, in preparation).