Overview:

Project Summary

Baseflow recession for streams is an important tool for understanding watershed hydrology and is often analyzed by the technique developed by Brutsaert and Nieber (1977). By this technique, paired observations of the rate of baseflow recession \( \frac{dQ}{dt} \) and stream discharge \( Q \) are plotted on a log-log graph, and watershed-scale aquifer properties are inferred from the cloud of data points (\( \frac{dQ}{dt} - Q \) curves). This analysis typically assumes that a spatially uniform water table profile controls baseflow recession in streams. Recent work has shown that event-scale trends in the data are not readily explained by the hydraulics of a spatially uniform water table profile. Instead, it appears that synchronous depletion of spatially distributed, heterogeneous sources of flow within a catchment may better explain recession. While there are certainly thousands of gaged watersheds, virtually none have a dense enough gage network to test this theory at the length scale of distributed flow sources. To close this knowledge gap a set of experiments using high spatial density sensor networks will be placed in medium-sized watersheds at locations throughout the U.S. The experiments focus on recession across the flow network in low order (1-3) channels that make up the majority of total channel length in most watersheds. The sensor networks will monitor two key metrics of heterogeneity in sources of baseflow: changes in the actively flowing channel network and discharge of groundwater seeps. These measurements will be supplemented with visual mapping of the active stream network, thermal imaging of groundwater inputs to streams, and soil moisture measurements. This project will provide evidence to support the debate over the fundamental theory of what really controls recession.

Intellectual Merit:

Resolving the debate over streamflow recession interpretation can provide fundamental insights into macro-scale watershed function and help overcome current limitations to understanding watershed-scale function posed by a bottom-up, reductionist approach. This reinterpretation of the information content within \( \frac{dQ}{dt} - Q \) curves suggests that recession data may provide valuable insights into the role of heterogeneous source areas and antecedent moisture on recession. This contrasts with the traditional notion that recession data only provides information on the hydraulic properties of an assumed uniform aquifer. Further, the new approach is supported by linear reservoir model approach that holds promise. This ability to use \( \frac{dQ}{dt} - Q \) curves as an empirical measure of watershed-scale spatial heterogeneity has direct value to ongoing research to predict discharge in ungauged basins, to investigate watershed scale storage-discharge relationships, to understand the travel time distribution of solutes through watersheds, and to predict the location of biogeochemical hot spots and hot moments.

Broader Impacts:

For water managers, this work will help improve estimates of low-flows on streams during sustained dry periods and help project future impacts on ecology and water resources, a critical concern due to climate change. For high school and middle school students, this project will develop lessons involving sensor design and hydrologic measurements that will be incorporated into established STEM educational programs that reach several hundred students in the Syracuse, NY region. For the scientific community, this work will provide widely distributed data sets that should be of use to numerous disciplines while also providing an opportunity for synthesis among established hydrologic research sites. Finally, this work will provide training for undergraduate researchers and graduate students.