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ABSTRACT TITLE: LBNL Sustainable Systems Scientific Focus Area: Overview

ABSTRACT: A key gap in our understanding of subsurface processes is the lack of quantification of carbon/nutrient fluxes in the subsurface, including the coupling of vertical and lateral hydrological and biogeochemical fluxes in and across deeper soils, the vadose zone, groundwater, and the hyporheic zone. These coupled fluxes could have significant implications for down-gradient water quality and ecosystem functioning. A second key challenge is quantification of microbial metabolic activity in dynamic subsurface environments. In spite of their critical role, very little is known about the manner in which subsurface microbial communities are organized, the primary determinants of how this organization evolves, and the nature of interactions between the microbes and their physical/chemical environment. New developments in sequencing and post-sequencing bioinformatics and in systems biology have rendered it more feasible to predict how microbial communities will change in response to environmental perturbations. Finally, advanced multiscale simulation capabilities that can predict how information stored in a microbial community metagenome is translated into larger system biogeochemical functioning, and how environmental forcings influence microbial metabolic activity, are entirely missing. New multiscale reactive transport simulation capabilities are needed that couple terrestrial microbial composition, competition, activity, and adaptation to biogeochemical processes and the hydrologic cycle in a manner that honors landscape characteristics, hydrological boundaries, lateral and vertical fluxes, biogeochemical transformations, and subsurface heterogeneity.

The Sustainable Systems Scientific Focus Area 2.0 Science Plan ("SFA 2.0") has been developed to advance predictive understanding of complex and multiscale terrestrial environments relevant to the DOE mission through specifically considering the scientific gaps defined above. The Grand Science Question and Grand Deliverable associated with this SFA 2.0 Science Plan are as follows:

Grand Science Question: How will climate or land-use-induced changes in hydrology and vegetation affect subsurface carbon inputs, spatial and temporal distribution of flow and transport, biogeochemical cycling, and microbial metabolic activity; how will these processes evolve over time; and what effect will these interactions have on overall watershed biogeochemical functioning?

Grand Deliverable: Development of a **G**enome-**E**nabled **Wa**tershed **S**imulation **C**apability (**GEWaSC)**, which will provide a predictive framework for understanding how genomic information stored in a subsurface microbiome affects biogeochemical watershed functioning, how watershed-scale processes affect microbial functioning, and how these interactions co-evolve.

Activities associated with the first three-year review period ("Phase I") will be primarily implemented at the Rifle, CO site. The Rifle Site provides favorable hydrogeochemical conditions and foundational understanding, datasets, models, and infrastructure that will enable us to make significant and efficient advances during the first three years of the project. At this site, we will test specific aspects of the grand challenge question and deliverable. Initiating the project at the Rifle Site will allow the SFA to develop critical capabilities and understanding before transitioning to a natural or managed ecosystem site that has additional complexity.