March 15, 2013

The Honorable William F. Brinkman
Director, Office of Science
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

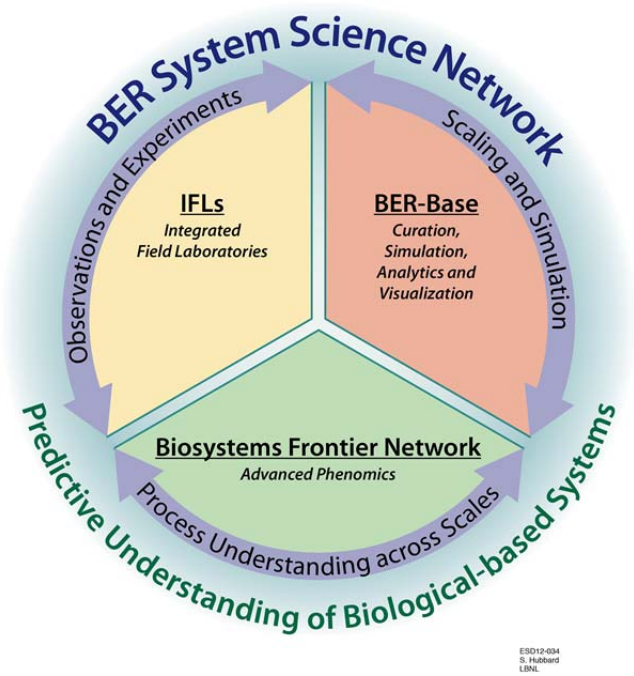
Dear Dr. Brinkman,

This letter is in response to your 'Office of Science User Facilities' charge to BERAC dated December 20, 2012. Following the concepts defined in the Grand Challenges for Biological and Environmental Research, a Long Term Vision report, BERAC developed a new concept for critical facilities needed to accomplish this vision. BERAC appointed a subcommittee that first discussed the charge and provided foundational ideas for subsequent discussion by the full committee. As we describe below, there was unanimous agreement that a new and innovative *Biological and Environmental Research System Science Network (BERS^{2}Net)* is the highest priority for a new BER facility, as its development is critical for confronting the most important challenges in energy and environmental research of our century. This facility would address the most significant impediments that presently prohibit scientists from melding climate, environmental and biological observations, as well as process knowledge and predictive capabilities in the manner needed to comprehend and develop a new class of environmental and energy solutions.

As examples, we imagine this facility will be used to:

- Improve earth system models to better predict climate change at the resolutions needed to inform optimal mitigation and adaptation strategies as well as land use practices.
- Develop approaches to enhance the plant productivity needed for food and fuel under climate-induced, stressful environments.
- Develop exciting new bioenergy resources to meet new energy and chemical needs, sharply reducing reliance on fossil fuels.
- Develop more accurate data and approaches to predict climate variability including extreme events to address energy and environmental challenges.
- Develop science-based solutions to guide the remediation, management, and sustainability of natural resources.
- Improve our understanding of how microorganisms interact with the natural environment to enable improved carbon sequestration solutions.
- Understand the complex relationship between Earth's living systems and climate and the long term impacts of climate change.

The 20th century was a period in which science was focused on the characterization of individual components of Earth systems. It is now clear that science in the 21st century must consider the complexity of the natural environment as an integrated system, which necessitates quantification of biological, geochemical, hydrological and atmospheric process interactions that occur across great time and space scales. Relevant to BER science, microbial and plant communities and their interactions regulate the fluxes of most life-critical elements, control the production of food and biofuel feedstock, and regulate the flux of water among the atmosphere,



surface, and subsurface and major greenhouse gases to the atmosphere. However, a predictive understanding of how these communities interact and function in dynamic environmental systems and their influence on landscape scale system behavior and feedbacks on the climate system is sorely lacking. Similarly, tools are not available to quantify how aerosols influence cloud formation and thus climate and feedbacks to terrestrial systems, while the linkages among these processes are mostly unexplored. New paradigms are needed to facilitate the transition of 21st century scientific research from one associated with distributed and disparate datasets, field observations, specific process knowledge, and individual models to a predictive understanding of couplings and feedbacks between natural system processes across scales – or the transition from 'parts' to 'integrated system behavior. The proposed, high-priority *Biological and Environmental Research System Science Network* is a direct extension of recommendations described in two recent BERAC reports:

- *2010 "Grand Challenges for Biological and Environmental Research: A Long Term Vision (DOE/SC-0135)*
- *2013 "BER Virtual Laboratory: Innovative Framework for Biological and Environmental Grand Challenges", Response to Dr. Brinkman's 'Innovation Charge' (DOE/SC-0156)*

The proposed *Biological and Environmental Research System Science Network* is a facility based on a "virtual laboratory" concept that allows the science community to access complex data sets and work collaboratively on solving the most challenging problems. As exemplified by President Obama's "Big Data" initiative, all areas of science are challenged by the complexity and volume of data now being collected. Specifically critical for BER is the heterogeneity and distributed nature of the datasets and models and the lack of tools that facilitate real-time data interrogation and knowledge generation needed for sustainable solutions. While several foundational components of the proposed facility are already in place in BER, there is clear need for a new facility that will allow the strategic integration of BER resources to meet the challenges of biological and environmental system science.

DOE BERS^{2}Net (Biological and Environmental Research Systems Science Network)

The goal of the proposed new facility is to develop, extend, integrate and connect the infrastructure needed to enable reliable predictions of complex natural system behavior as needed for a new class of energy and environmental solutions.

The facility would consist of three key elements that are described individually below but must be considered as essential, integrated pieces of the whole. Further details can be found in the 2013 BERAC "Virtual Laboratory" report.

1. Integrated field laboratories (IFLs): Long term, environmental research sites that allow critical biological, geochemical, hydrological and atmospheric observations across vertical (bedrock to atmosphere), geographic (across geographic regions) and temporal

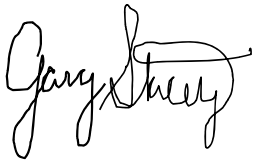
(sub-seconds to decades) scales. IFLs will build on a foundation provided by existing BER investments (e.g., ARM, AmeriFlux, NGEEs, subsurface biogeochemistry field sites).

2. Biosystems Frontier Network targeted at (a) integrating and expanding technologies for microbial and plant physiology and phenomics to gain a better understanding of organism and community phenotypic expression within complex and highly dynamic natural and managed environments; and (b) advancing biosystems engineering to enable synthetic biological solutions for environmental and energy problems. A key component of the Biosystems Frontier Network is to encourage a new level of integration and collaboration among existing BER facilities (e.g., JGI, EMSL, structural biology infrastructure) and other elements of the BERS^{2}Net.
3. BER-Base User Facility: **B**iological and **E**nvironmental **R**esearch Knowledge**base** that provides the computational curation, modeling, analytical and visualization tools needed to translate disparate and multi-scale measurements from IFLs plus process understanding from the Biosystems Frontier Network and elsewhere into new knowledge. A logarithmic expansion of KBase (which enables community investigation of systems biology), the BER-Base would enable quantification of dynamic and multi-scale interactions among: gene and protein functions in natural systems, terrestrial system behavior, and climate systems.

A specific request in your charge letter to BERAC was to rate current and proposed facilities with regard to the ability to conduct 'world-leading science' over the next decade. As made clear above, BERAC sees the current BER facilities (e.g., EMSL, JGI, ARM, structural biology infrastructure) as crucial and key pieces of the new BERS^{2}Net, which when integrated into the network should achieve synergisms that will take their current, excellent science to new levels of achievement.

Although all three elements of the *Biological and Environmental Research Systems Science Network* are required to address BER-relevant 21st century grand challenges, BERAC prioritizes BER-Base for earliest action because it is the element that requires the most extensive and rapid development and will establish standards for data systems. As described in the BERAC 'Virtual Laboratory Innovation' Report, BERAC recommends that focused community workshops are the only step needed to render the proposed BERS^{2}Net, including all three elements, as shovel ready.

Sincerely,



Chair, BERAC

cc. P. Dehmer, S. Weatherwax, D. Thomassen