Following the success of building sustainable research infrastructure in bionanotechnology for public security and environmental safety, WVEPSCoR is seeking to build with this RII, world-class programs in two research areas of local and national importance by capitalizing on existing strengths. The research foci address fundamental science questions that align with state and NSF priorities in water resources science and gravitational wave astrophysics. Across both research foci, education, workforce development, and faculty mentoring programs engage students, the public, and faculty in research activities. Research efforts are led by WV Univ., Marshall Univ., and WV State Univ. Predominantly Undergraduate Institutions are also actively engaged in related research and workforce development activities. The proposed effort builds on recent investments by all three institutions, the state, and federal agencies in new faculty hires, shared experimental facilities, high-speed networks, and comprehensive workforce development programs. This proposal is aligned with *Vision 2015,* the state's science and technology plan.

**Intellectual Merit:** The combined science activities span the range of applied science to basic research. The common theme of both research areas is the development of tools needed to acquire and analyze large quantities of measurements and numerical simulations. Critically needed infrastructure will be built for two key, state-relevant research areas. The biologists, ecologists, environmental engineers and scientists, chemists, and geologists that will collaborate with each other through the Appalachian Freshwater Initiative (AFI) will develop analytical facilities and expertise to form a world-class research team focused on understanding and detecting ecological and biological impacts of complex mixtures of contaminants in water under varying climate change scenarios. To understand and manage the risks of environmental contamination and to ensure a future clean water supply, the AFI will develop population, physiological, and toxicological metrics and evaluate responses of aquatic, wetland, and riparian organisms to watershed-scale and localized disturbances, model fate and transport and develop means of remediating contaminants under a range of likely future climate scenarios. This research will contribute to regional and world-wide water quality enhancement and protection. The gravitational wave (GW) astrophysics component builds physical and personnel infrastructure necessary for researchers across WV to enhance their role in the worldwide effort to directly detect and characterize GWs. Detection of GWs and the characterization of GW sources will allow studies ranging from early universe cosmology to formation and evolution of galaxies to populations of compact objects in the local universe to tests of general relativity and alternative theories of gravity. Through an interdisciplinary and multi-institutional effort involving faculty from physics and astronomy, mathematics, electrical engineering, and computer science, the sensitivity of pulsar timing arrays to nanoHertz frequency gravitational waves emitted by supermassive black-hole binaries will be enhanced. This will be accomplished through addition of more millisecond pulsars to the array, development of improved algorithms for characterization of pulsars, better understanding of the source populations we wish to detect, and improvements in the sensitivity and efficiency of algorithms for detecting gravitational wave signatures. A new capacity will be built to contribute to searches for hertz to kilohertz GWs using ground-based laser interferometers. Both research foci will hire important expertise and add needed equipment to build the infrastructure needed to reach competitive goals.

**Broader Impacts:** With both research areas working collaboratively in areas of overlapping activity, this proposal will provide new opportunities for scientists, engineers, and students in academic institutions and federal research centers to collaborate. The AFI research will have significant impacts on federal and state land management policies; end users of water from the WV watershed; will engage WV students in water quality research and watershed management; it will be shared with resource managers throughout the world facing similar challenges, e.g., mining regions and urban areas and municipalities withdrawing water downstream of wastewater discharges or agricultural runoff. The GW components of this project will increase the likelihood of low-frequency GW detection while also establishing models for electromagnetic counterparts to GW events that will be of interest to the wider astrophysical community. Students trained in data mining, signal processing, and electronics design techniques required for GW detection will provide a workforce for growth of new industries in WV, e.g., high-bandwidth communications, and big data analysis. This proposal will build and strengthen international linkages and partnerships through collaborative research projects in these research areas. Both will also disseminate information arising from their research via traditional scientific means and to the public via museum/outdoor displays. A unique feature of this project is the use of hands-on science activities for K-12 students and the public to develop a pipeline of future scientists in WV and enhance participation of individuals from under-represented groups. The research discoveries, education, and workforce development programs will enhance the prosperity of the State and the nation while also developing and retaining STEM teachers.