

PROGRAM REVIEW AND GUIDANCE FOR UTAH EPSCoR RII TRACK-1

AAAS EXTERNAL REVIEW PANEL REPORT

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Introduction

This report includes the findings and recommendations by a review panel convened by the American Association for the Advancement of Science (AAAS) in March, 2016. The Utah Experimental Program to Stimulate Competitive Research (Utah EPSCoR or “innovative Urban Transitions and Arid-region Hydrosustainability – iUTAH”) asked the AAAS Research Competitiveness Program to provide a summative review and sustainability guidance on its Research Infrastructure Improvement (RII-Track-1) award¹. The Track-1 award is a \$20 million, five-year cooperative agreement (2012-2017) with the National Science Foundation. External reviews are part of the developed work plan for NSF-funded EPSCoR programs and are intended to provide evaluation and guidance to the state EPSCoR leadership to help ensure overall success of the program.

iUTAH: Utah’s NSF EPSCoR Track-1 Program

iUTAH’s broader program goals are to improve water-related science and technology infrastructure in Utah; improve the state’s research competitiveness; and further develop the workforce in areas of research, education, and practice – thereby promoting sustainable economic development. It aims to meet these goals by water-quality and water-quantity monitoring and modeling in three watersheds, extend and support cyber-infrastructure, develop human-capital diversity, and engage with decision-making and policy processes at the state level and beyond. This effort consists of a state-wide collaboration with ten Utah institutions of higher education². Utah State University (USU), University of Utah (UU), and Brigham Young University (BYU) are the co-leads for the three research focus areas (RFAs) of the program, each having multi-faceted aims:

RFA1: Improve Utah’s capacity to monitor and understand the ecologic/climatic/hydrologic (ecohydrologic) system of the Wasatch Range Metropolitan Area (WRMA). This goal will be achieved by improving watershed-scale measurement capacities. This instrumentation will be used to conduct research aimed at gaining a better understanding of the biophysical processes that influence Utah’s water resources.

¹ Utah EPSCoR has previously been awarded an NSF EPSCoR RII-Track 2 award and NSF EPSCoR C-2 cyberinfrastructure award. The current report is focused solely on Track-1 activities.

² The following partners comprise iUTAH, representing a range of institutions: University of Utah (UU) and Utah State University (USU) - public PhD-granting research universities; Utah Valley University, Southern Utah University, Weber State University, Dixie State University - metro-regional universities; Snow and Salt Lake Community Colleges; USU regional campuses (Roosevelt, Vernal, Tooele, Brigham City, USU Eastern-Price, USU Eastern-Blanding). Brigham Young University (BYU) is the state’s only private, PhD-granting university and Westminster College is the only private liberal arts college.

RFA 2: Improve the capacity of Utah’s science community to gather and analyze social and engineering system data on coupled water systems. Additionally, understand the interactions between urban form, environmental change, built water infrastructure, and decision-making in terms of water use; and also model the impact of alternative infrastructure designs and policy options on water use behaviors, the water cycle, water quality, and interconnected social and environmental systems.

RFA 3: Describe the water system as a whole, by defining and including the linkages between biophysical and social dynamics, using results from RFAs 1 and 2. Finally, facilitate interactions with stakeholders and linkages among disparate datasets and models to improve capacity to study the complexity of local water issues.

AAAS 2016 Review and Site Visit

The AAAS panel was charged with performing an external, summative assessment of the overall iUTAH program using the information provided through other evaluation processes, along with stakeholder interviews during a site visit. The purpose of the 2016 AAAS Site Visit and Review is to understand and document the progress made to-date (winter 2016) in all project areas, advise on the implementation of the final year of the Track-1 award, and recommend potential strategies for sustainability. In addition, iUTAH requested specific feedback on the following areas: 1) research strategies to maximize opportunities for competitive federal funding; 2) continued development and expansion of collaboration across participating institutions in the realms of research, education, and workforce development; and 3) the legacy of iUTAH and outcomes of the project most likely to have substantive impacts beyond Utah’s boundaries.

To address these issues, AAAS recruited 3 experts with collective expertise in water resources and climate change science, engineering, decision support, and visualization to review the iUTAH project. Each of these experts also served on the 2014 AAAS review of the iUTAH program. The 2016 panel was led by an AAAS senior staff member with expertise in program evaluation: panelists’ names and their affiliations are provided on the cover page. In preparation for this review, the AAAS panel read iUTAH’s: original proposal to the NSF; Strategic Plan; Annual Reports to the NSF (Years 1-3); External Advisory Board (EAB) reports (Years 0-3); NSF Reverse Site Visit Reports and iUTAH’s responses (Years 2 and 4); plans and policies; and other materials provided on-site. The AAAS panel convened at the University of Utah’s campus in Salt Lake City, Utah from March 6-8, 2016. Over the course of the site visit, the panel interviewed the iUTAH leadership team and participants (see Appendix A for the 2016 AAAS Site Visit Agenda). The panel then debriefed the iUTAH leadership team with its initial findings.

The AAAS review is designed to complement the work of other evaluation processes under the oversight of the iUTAH leadership team. The goal of the AAAS review is to analyze the

information available, interpret it in the national context, assess progress toward program goals, and most importantly, make recommendations on guiding the program as a consequence. A principal audience of this review is the UT EPSCoR leadership team, yet this report is designed to serve as a tool for managing the program, and the AAAS panel findings are summarized in such a way that they can be communicated to all stakeholders: the project participants (both scientists and management), the participating universities, colleges, and community colleges (because the environment they provide is critical to success), the state committee and other interested parties within the state government and private sector, and the National Science Foundation.

This report summarizes the AAAS panel's findings related to iUTAH management activities, scientific and technical directions, educational, outreach, and diversity activities, and supporting infrastructure and policies, and provides specific recommendations to iUTAH on strategies for future success. iUTAH's administrative leadership and project management strategies, research priorities and goals, and education, outreach, and diversity activities are discussed in terms of priorities for Year 5 of the project, and sustainability.

I. Administrative Leadership and Project Management

The AAAS panel interacted with the following members of iUTAH leadership, individually and as a group: PI Michelle Baker; Co-PIs and RFA Co-Leads Zach Aanderud, Doug Jackson-Smith, and Court Strong; Co-PI and Facilities Lead Jim Ehleringer; EOD Director Mark Brunson; and iUTAH Assistant Director and Project Administrator Andreas Leidolf; as well as Utah EPSCoR State Director Paul Brooks, members of the Utah EPSCoR State Committee (Tamara Goetz [Utah Governor's Office for Economic Development], Alan Harker [Associate Vice President, BYU], and Mark McLellan [VPR, Utah State University]), and Cynthia Furse, Associate VPR, University of Utah. In addition, the panel had interactions with Chris Keleher, Assistant Director, Recovery Programs Office, Utah Department of Natural Resources. We perceived a high degree of collegiality, professional support, and interdisciplinary integration. We found clear evidence of teamwork, shared purpose, and vision for completion of the Track-1 award. The leadership team's discussion of the future sustainability of the program demonstrates acute awareness of the challenges and opportunities that lie ahead. Here we present the panel's findings and make recommendations on overall project coordination and management.

Award Implementation and Management to-date and in Year-5:

Strengths:

The current iUTAH leadership team has successfully made the transition from the 2014 departure of the-then PI, Todd Crowl, and State Director, Rita Teutonico. The 2014 AAAS panel had flagged this as a potentially difficult transition; that is, the need to ensure continuity of the

science program while also keeping on track relations with iUTAH's diverse stakeholders. The current AAAS panel finds that the transition has been achieved smoothly, related in part to the fact that most of the other co-PIs as well as many of the faculty participants had been involved in developing the iUTAH concept. As we comment below, the science program is making excellent strides and appears to be set to meet established objectives during the coming, final year of the EPSCoR award. The leadership team is to be commended for successful integration of research and outreach, with the expectation that the program's outcomes will continue to provide value to the State.

Challenges:

Despite the successful leadership transition, the panel did identify two main challenges for iUTAH leadership and project management. First, the EPSCoR State Committee appears to have been in hiatus since 2014. There was some evidence that lack of attention to the role and function of the State EPSCoR Committee has hampered communication and integration with non-university stakeholders, some of whom the AAAS panel had the opportunity to interact with. The AAAS panel was assured that the current, recently appointed state director, with past experience in interdisciplinary science and outreach programs, had sized up the challenges and is assertively taking on State Committee functions.

Second, and related to the State Committee and outreach challenge just mentioned, iUTAH leadership has yet to convincingly address the post-award sustainability challenges. Several options were discussed, among them creation of an institute or center, federal grants to sustain iUTAH as a program, and diversification of scientific focus (e.g., on "air" as related to climate, air-quality, dust, etc.). We comment on these separately, below, in the context of sustainability. Overall, uncertainty in the sustainability plan, particularly on the part of the PI and RFA leads, poses a distraction for the science and outreach completion activities.

iUTAH Sustainability:

Strengths:

Collaboration of the state's three R1 universities with a diverse range of PUIs places iUTAH in an advantageous position to seek state and university resources for continued funding. iUTAH continues to serve as an integrating platform for successful science and outreach to provide impact and help meet the state's needs in respect to water resources.

Challenges:

Sustainability beyond the current Track-1 award poses significant challenges that the iUTAH team is well aware of. The AAAS panel and the leadership team discussed multiple future possibilities and all agreed on the need to prioritize those elements of the program that are the most successful, including the monitoring network, cyberinfrastructure, the GIRF, outreach with municipalities, water providers, and users, and the collaboration with the PUIs (see the panel's comments on science integration, below).

Raising the state's water resource challenges to the level of political decision-making and securing commitments for continued funding can be difficult. iUTAH is well positioned to address and convey to decision-makers issues related to climate change, projected growth, and water-quality processes – all of which the AAAS panel agrees are core components of iUTAH. In the final year of the current award, a major overarching communication challenge is to convey the relevance of iUTAH's research for future development pathways in the state. Here, the project team and State Committee, as well as representatives of the R1s and PUIs, all have roles to play. As commented above, completion and integration of the science plan should be led by the PI. This, in turn, should form the basis for continued outreach to disseminate and publicize iUTAH. Finally, raising water-related challenges and opportunities to the state level should form a central objective of the State Committee and senior representatives of the R1s and PUIs.

There was considerable discussion generated by iUTAH leadership on the idea to establish a center or institute to continue iUTAH's work. The AAAS panel's view is that such an approach would need to be based on a commitment from the three R1s of support for a core staff and some faculty time-release. Yet our discussions with State Committee members did not suggest that such support would be forthcoming. This makes the prospect of seeking State Legislature support more difficult, particularly at a time when the EPSCoR State Committee has been in hiatus. Even if institutional or Legislature support were real possibilities, it is not clear to the panel that creating an institute would necessarily add value for future scientific work. Running a center and supporting it financially can be fulltime responsibilities, with inevitable setbacks even when progress is positive. The focus on forming an institute could distract from other value-added components of the remaining iUTAH work, including outreach and stakeholder engagement.

Recommendations

Year-5 Administrative Leadership and Project Management Priorities:

The iUTAH leadership should remain focused on successfully completing the science program by vigorously implementing remaining RFA 1, 2, and 3 activities, and crucially, integrating these (which incidentally is an RFA3 objective, but potentially with insufficient resources to complete the job in the time remaining – see also below). Successful integration must be led by the PI.

Sustainability:

While the panel commends iUTAH leadership for discussing and planning for sustainability beyond the current Track-1 award, it is self-evident that any viable path forward must be based on successful and visible (e.g., widely disseminated) completion of the science plan, especially integration across RFAs 1, 2, and 3. This includes publication and dissemination of the results of current and remaining work. Such demonstration of outputs leading to outcomes and impacts can be leveraged to secure future support. Communication of emerging iUTAH results and

outcomes to policy-makers will also serve to raise the profile of water resources as a central challenge for the state.

The panel recommends that iUTAH consider the costs and benefits associated with continuing research elements within two main potential funding scenarios, specifically:

- *Low- to mid-range funding scenario*– which elements can and should be preserved in a “triage” approach? Under such a piecemeal approach, the iUTAH team together with state-level stakeholders should identify which RFA1, 2 and 3 activities should be continued by whichever means possible (e.g., external grants). This would entail evaluation of possible future benefits of continuing activities, weighed against the resources required and efforts needed to secure these. For example, the AAAS panel understands that Red Butte watershed monitoring will be sustained. The triage approach also requires the identification of lower-value activities that should be terminated.
- *High-range funding scenario* – the AAAS panel understands that securing major funding to continue iUTAH as a consolidated initiative will be challenging. Under such a unified approach, the iUTAH team must work to secure top-down (university-level) funding as well as external (Legislature, federal, or private) sources to sustain the current integrated efforts. Even with bridge funds, the more unified approach would require keeping the administration of iUTAH intact. Thus, a large, EPSCoR-size grant, or combination of grants (e.g., EPA, NSF, etc.) must be pursued. Looking beyond water resources for funding (e.g., for air quality) may have its own merits but would do little to keep iUTAH intact.

The panel recommends that the iUTAH team identify the aspects of the project that have the most potential to be leveraged for future research grants. These likely include: the monitoring system (or some subset of it); the cyberinfrastructure with its database, policies, and accessibility; the GIRF; and the close collaboration with the PUIs. For each, a separate plan for continuity should be developed; for example, seeking funding from institutions, legislature, grants, municipalities, etc. Cost-sharing among multiple sources should be considered. It should not be expected that the same plan for sustainability would apply to each; rather, the most appropriate and potentially successful plan(s) should be developed for each. This effort should take precedence over efforts to find funding to sustain the entirety of iUTAH as an entity.

iUTAH needs to formally establish a clear sustainability plan including a strategy with institutional backing to advocate for this. Given multiple possible options and a diverse team drawn from numerous universities and stakeholder partners, iUTAH leadership may wish to consider a professional facilitator or moderator to interact with the group in order to most effectively consider the options and chart a path (or multiple simultaneous paths) going forward. In this respect, it is essential to re-engage with the State Committee because institutional and

political “capital” will be required for any of the options considered (other than the no-support, close-the-program option). A crucial opportunity that should not be missed is to enhance iUTAH interaction with Envision Utah (<http://www.envisionutah.org/>), launched in 1997 to “engage people to create and sustain communities that are beautiful, prosperous, healthy and neighborly for current and future residents.”), which indicates that population-based increases in water demand in the coming decades will be significant and are likely to stress ecosystem values of water. iUTAH should continue to inform and collaborate with Envision Utah.

II. Research Priorities

The AAAS panel met with investigators involved with each of iUTAH’s three Research Focus Areas (RFAs) - Biophysical Ecohydrologic System (RFA 1); Social and Engineered Systems (RFA 2); and Coupled Human-Natural Systems (RFA 3) – as well as investigators and graduate students involved in cross-cutting features of the program such as cyberinfrastructure development and external engagement. Team Co-Leads Zach Aanderud (RFA1), Doug Jackson-Smith (RFA2), and Court Strong (RFA3), and CI Co-Lead Jeff Horsburgh provided overviews of progress to-date and discussed plans for sustaining research beyond the EPSCoR award. Additionally, the panel had access to background material (listed in the Introduction of this report). Here we comment on the strengths and challenges of the research accomplished in each RFA as well as the cross-cutting areas, Cyberinfrastructure and Visualization, followed by recommendations for areas of focus in the final year of the project and for sustainability plans.

RFA 1: Biophysical Ecohydrologic System

Strengths:

Installation and data collection of eco-hydrologic monitoring along the mountain-to-urban gradient is well established in three watersheds, has expanded in the urban zone, and has and will continue to provide data for the main research questions in all of the iUTAH RFAs. This is a significant accomplishment of the project and an important asset for future research.

Ongoing research and publications of novel findings in the three sub-areas of water balance, water quality, and water demand for climate modeling demonstrate the value of the data to address research questions. Water balance studies have revealed origins and effects on water availability of dust on snow and effects of urban evapotranspiration on the water budget. Water quality studies include dynamics of stream organics and nutrients in the rural to urban gradient. Discoveries about local land-atmosphere effects have contributed to refinement of downscaled climate models. Many graduate students are engaged in this area leading to advanced degrees, and the publication rate is impressive.

Challenges:

It has been pointed out in previous reports (e.g., the 2015 Reverse Site Visit) that some key water quantity components are not included in the monitoring system, particularly groundwater and agricultural water, both of which are significant components of the water budget. If monitoring is not feasible at this time, these components could be accounted for through other sources of data and modeling to demonstrate ability to characterize the entire water budget.

The collection of data and discovery of the details of the dynamics of the biophysical and ecohydrologic system have inherent scientific value, but recognition of the value of the data and the understanding of the system will not be of interest to the larger community unless these can be demonstrated to inform management or policy decisions. The AAAS panel did not hear about efforts to make these connections, which also lead to integration with the other RFAs.

RFA2: Social and Engineered Systems***Strengths:***

Household and public surveys have built up a significant database of social science information about water consumption and perceptions. An urban neighborhood typology has been developed as a report. Research has been initiated to link water use and urban form, presumably using water use survey data and urban typology.

Innovative methodologies were developed for the social science database including metadata, data access and archiving. In addition to the innovation value and value to iUTAH research questions, the database can be leveraged for future projects/proposals.

The green infrastructure research facility has finally been completed and instrumented. Funding for its future support has been secured through an EPA Science to Achieve Results (STAR) grant. Data from the facility can inform green infrastructure research. The green roof project at the University of Utah provided data for research while the GIRF was under development. Instrumentation of stormwater drains and canals was established and linked to the GAMUT system to support development of urban water models.

This RFA also has resulted in many graduate student and post doc research projects and many papers submitted and published.

Challenges:

The green infrastructure research facility has been completed relatively late in the project, yet the goals of RFA2 are, in part, dependent on these data to be accomplished. Adequate resources and a detailed plan are needed to assure the contribution of this project investment to the outcomes.

Although infrastructure, monitoring, data, models, and methods have been built, collected, and developed, and these have resulted in some innovations and discoveries, the broader questions have not yet been addressed. The goals of RFA2 extend to policy and decision-making, i.e., to

better understand the interactions between urban form, environmental change, built water infrastructure, and decision-making on a range of issues. The AAAS panel did not hear that these complex relationships have emerged from the research, or that policy questions have been identified or articulated that may drive the investigation. The results of this level of discovery would be demonstrated or visualized in RFA3 modeling.

RFA3 Coupled Human-Natural System

Strengths:

A conceptual model that proposes the integration of water and humans through natural, social and built structures was developed by project investigators (led by a graduate student with stakeholder buy-in) in the first year of the project, and later refined and published. This conceptual systems model of the research domain of the overall iUTAH project has the potential to serve as a map or hypothesis for possible discoveries of complex relationships among the components, as was proposed.

A variety of models have been collected that describe the hydrologic, ecologic and human systems from atmospheric to surface water/land interaction to infrastructure/management.

Challenges:

The conceptual model does not seem to have been carried forward as the framework for the research agenda of iUTAH. Whereas much of the research likely does address the interconnections proposed in this model, the integration or unity of the pieces has not been highlighted. Use of the conceptual model for this purpose could drive the investigations that are needed to complete the project, as noted in next point, and make communication of iUTAH's scope, purpose, and contribution better understood by all.

Models have not yet been identified or developed that reflect discoveries about linkages between biophysical and social dynamics. The models describe the natural system and to some extent the human system, but so far do not provide information or insights about the nature of the interaction of the coupled system. Some of these interactions may have been identified, but not yet modeled; other interactions have not yet been identified.

There may not be adequate resources (i.e., scientific and technical personnel), to complete this task within the timeframe of the project.

Cyberinfrastructure

Strengths:

The data structure and access system developed by Cyberinfrastructure activities is one of the most successful aspects of the iUTAH project: it strongly supports the research efforts, and can be leveraged for other projects.

Researchers with skills in model integration have joined the team and some groundwork has been done in addressing technical issues of coupling models.

The Hydroinformatics class (developed initially through the CI-WATER EPSCoR Track 2 project, and expanded under the Track-1 award) has been offered three times, and has been very successful, with many students enrolled from all campuses.

Challenges:

The model linkage work that researches techniques and issues of linking models at different spatial/temporal scales does not seem to be driven by specific iUTAH modeling needs; that is, the need to model specific novel interactions of the coupled system. As such, this activity may detract (in terms of resources) from the RFA3 modeling efforts that address broader scientific questions.

Visualization

Strengths:

Several visualization efforts are under way: The iUTAH Visualization Lab (iVL) is a sensible and cost-effective alternative to the expensive Decision Theater originally proposed. The interactive kiosk at the Natural History Museum of Utah (NHMU) displays data collected from the GAMUT to familiarize the public with aspects of the natural watershed systems. The iUTAH web portal has a number of visualizations for data sets.

Challenges:

RFA3 provides a rich area for visualization but is just getting started. The RFA3 team has suggested they are homing-in on a good process for working with stakeholders, which usually involves sketching out visualization ideas with pen and paper. Eventually, visualization techniques should inform stakeholders and other scientists of significant and novel interactions of the coupled system, these reflecting scientific advances in RFAs 1 and 2.

The NHMU data display kiosk presents specific data in a skillful and imaginative interactive interface. There is a concern that the time required to interact with this tool may not be consistent with the typical museum visitor experience. A web-based version could also be provided.

Visual display of data would be more interesting and informative if it were to demonstrate the dynamic response of the system to various drivers: for example, what happens to various species under temperature and flow variations, how water management decisions might change under climate variability, population increases or land use changes. Visualization can inform both experts and the public about unexpected behavior of the coupled system: non-linear behavior, complex interactions, and tipping points due to certain values of driving forces such as climate, water supply and use, land use, urban development, etc.

Recommendations

Year 5 Research Priorities:

The primary incomplete aspect of the research appears to be in characterizing the complex interactions of the coupled system. To maximize the value of the iUTAH EPSCoR outcomes, the AAAS panel recommends that the lead investigators collaborate to identify one or a few key questions or novel findings about the complex interactions of the coupled natural and human system that can be answered/demonstrated based on the data, models and discoveries that have been accomplished in RFAs 1 and 2. Results should include aspects of system vulnerability and resilience and be of interest to stakeholders or policy makers. Efforts in all three RFAs, as well as in visualization and CI, can be coordinated to accomplish this and resources should be managed to assure success.

In addition to this coordinated effort, final progress in each of the areas should focus on:

RFA1: Complete water balance studies to account for all components at some scale, including agricultural water and groundwater. Identify and pursue specific modeling results that support the coordinated effort above; complete graduate WQ and other projects and publish results.

RFA2: Maximize collection and analysis of data from GIRF to advance knowledge of role of green infrastructure. Complete analysis of relationships between urban forms and water use and relate findings to management and policy decisions. Complete graduate projects and publish findings.

RFA3: Focus on coupled modeling to specifically support the coordinated effort above. Test the conceptual model based on project outcomes, modify it if needed based on discoveries made.

Visualization: Develop at least one visualization that demonstrates some aspect of the coupled human natural system and that can be of interest to stakeholders or decision makers. We recommend that RFA3 visualization be given high priority to flesh out data synthesis and communications on all aspects suggested by the conceptual model. A recommended process can be developed through evolving negotiation skills and heuristics from cognitive science.

Documenting the iterations of visualization provide opportunity for visualization specialists to advise as well as to document progress. We agree that finding a common ground is important for long-term success of visualization use.

Sustainability:

The iUTAH EPSCoR has grown several research assets that can be leveraged for future research grants and other activities that contribute to innovation and education. Regardless of whether or not iUTAH persists as an entity or organization, the research assets should be maintained for future benefits and will need resources to this end. In particular, the AAAS panel recommends that funding be sought to sustain:

- The GAMUT monitoring system: Perhaps not across the entire watershed or all gauges - the value/expenses should be evaluated. Federal and local agencies such as USGS, Utah DNR, and cities may help maintain individual components of GAMUT, especially if investigators can demonstrate the value of the data. The R1 universities may consider providing some level of funding if the systems can be demonstrated to have educational value. Future research grants could also help support this research infrastructure.
- Cyberinfrastructure: Expand the success in developing workflow standards and hardware/software standards to other peripheral domains at the R1 campuses. Integration with the library system sounds ripe with potential. Expand this core competency into the PUI institutions so as to make Utah a skilled workforce in supporting an information economy.
- GIRF: This green infrastructure research facility has been provided with ongoing support by an EPA STAR grant. Upkeep will be an ongoing endeavor.

III. Education, Outreach, and Diversity (EOD)

iUTAH's Diversity Enhancement (DE) goal is to "increase the individual, disciplinary, institutional, and geographic diversity of the STEM enterprise in Utah to address the water sustainability issues facing Utah and the Mountain West." By extension, the workforce development goal is to "enhance the STEM workforce in Utah by developing programs for a diverse range of learners that inspire students to choose STEM careers by promoting the retention of students in STEM degrees and enhancing the success of faculty in STEM disciplines."

The AAAS panel met with many members of the iUTAH team to review the wide range of EOD programs that have been designed and implemented with an on-going expectation for continuance. Via a lively interactive question and answer process with twenty-three iUTAH attendees representing a wide geography of Utah, personnel from the three research institutions (R1s) and various primarily undergraduate institutions (PUIs) debriefed meeting attendees on EOD design, implementation, and preliminary results. More formally, Daniel Bedford facilitated a discussion on the collaborations between those working at R1 institutions and those at PUI institutions who together provide the iFellows and Summer Institute programs and funding through Research Catalyst Grants. Mark Brunson facilitated a discussion on the unique demographics and education paths of Utah residents and the extended EOD work being done at PUI institutions (e.g., Weber State University, USU Eastern-Blanding, Salt Lake Community College) to map EOD services to demographics. Representatives of museums and online information repositories contributed relevant thoughts on how their facilities would continue to be used as places of service delivery.

Strengths:

The iUTAH team demonstrated the strength of demographics work done to identify targets for EOD services. The matching of appropriate work efforts, programs, and provided services to the demographic analysis demonstrates a firm awareness and context of demographic particulars. Impressive progress has been made regarding educational activities that were identified for implementation during the 2014 AAAS review. Since that time, iUTAH has implemented two strong years of iFellows and Summer Institute programs and has provided student research project funding through Research Catalyst Grants. The R1-PUI collaborations have been functioning well to provide students strong STEM-related experiences.

The iUTAH personnel have paid substantial attention to capturing quantitative and qualitative data appropriate for long-term evaluation purposes.

Challenges:

The strong EOD design and implementation work suggests potential for valuable results; however, the AAAS panel did not see evidence of the value of training programs to stakeholders. This is particularly concerning given the critical need to demonstrate the value of the iUTAH framework as the award nears completion. Long-term metrics become more valuable when stakeholders participate in the process of determining useful metrics. iUTAH personnel have an opportunity to engage in a full team effort to pursue obtaining short-term metrics that resonate best with stakeholders. Long-term metrics might seem more useful to stakeholders after any shared agreement that short-term metrics are difficult to acquire.

The ongoing collaboration between R1 and PUI institutions could entrench further through PUI involvement at every stage of R1 planning. Many, if not most, funding agencies are demanding a demonstration of broader impacts through EOD activities and the iUTAH PUI personnel have demonstrated competency in identifying and planning for broader impacts. Instead of R1 institutions pursuing EOD to check off boxes during grant proposal writing, PUI institutions can stay current in understanding funding pursuits and propose contributions as active participants in the proposal writing process. PUIs can also work together to pursue funding opportunities that allow for decoupling of the research results from STEM education and workforce development, as long as they remain aware of R1 research activities.

Recommendations***Year 5 EOD Priorities:***

iUTAH should continue existing EOD work with a goal of developing the long-term metrics associated with specific objectives being pursued. EOD leadership should work with R1 and PUI participants to develop a more comprehensive tracking approach that will demonstrate the value of the overall iUTAH framework, and be made available to the iUTAH community. In many cases, R1 and PUI personnel implementing EOD programs might have the best accessibility to

contribute to short-term metrics while confirming that broader impacts are being satisfied. Year 5 is a critical time for EOD teams to speak up as a consistent, bottom-up voice to attract buy-in from stakeholders and holistic R1 integration. The EOD voice should often address which metric is valuable to which stakeholder, especially where short-term metrics are identified as being necessary. Spending the requisite time to identify and confirm short-term metrics on a stakeholder-by-stakeholder basis is particularly relevant. The PUIs have a strong voice when speaking to an outside panel. That same voice, with conviction, should be pursued with R1s on a regular basis. The EOD leadership should make sure the requisite time has been put into communicating viable workforce development trajectories that amplify through iUTAH work.

Sustainability:

The value-added of the strong collaborations established by the iUTAH framework should enable development of a sustainable synergistic coupling of EOD and research across the state, such that new opportunities are identified and established.

To align best for sustainability, the PUIs should work hard to build cohesion amongst themselves as a support and advocacy group to approach R1 research processes and demand participation as a common goal of funded big science programs. The collective voice must focus on the need for institutional structure and commitment or to identify other viable, sustainable programming that would include buy-in. If commitments lack requisite funding, opportunities may be provided through training opportunities driven from research efforts. For example, revenue might come from providing training on cyberinfrastructure, data management, and monitoring techniques and equipment since such training is in high demand nationally.

Overall, incentives for sustainability should not be limited to existing disciplines and researchers involved in iUTAH. The vision for sustainable activities should be extended to include a broader range of disciplines relevant to the iUTAH subject matter that can be demonstrated to help stakeholders fill immediate diversity and skill gaps, as a sustainable discovery process identifies those opportunities.

On the whole, iUTAH can commit to being more active in workforce development by keeping in touch with iFellow, Summer Institute, and Research Catalyst grant participants and suggesting career paths that would demonstrate program success. Short-term metrics that identify changes in student attitudes toward key workforce careers could prove highly valuable. PUI-based personnel can continue to promote workforce goals with all students. Explicit communications of workforce career paths through iUTAH institutions could engage support from stakeholders.

Conclusion and Summary Recommendations

The 2016 AAAS panel reviewed progress made to-date (winter 2016) by iUTAH participants, plans for the implementation of the final year of the Track-1 award, and strategies for

sustainability. Specifically, the AAAS Panel also considered iUTAH's potential for competitiveness for future funding opportunities, opportunities to expand research, education, and workforce development collaborations, and evidence of substantive impacts of the iUTAH project. Here, we synthesize the principal findings of the panel review and briefly expand on each.

- The iUTAH leadership has successfully transitioned from the 2014 departure of the-then PI and State Director. The science program has made excellent strides. Completion and integration of the science program should be a high priority. The iUTAH leadership team and PI in particular should prioritize accomplishing this.
- The research program has succeeded in developing valuable infrastructure and utilizing it for scientific investigation. RFA1's monitoring system is a significant accomplishment that has provided data for studies ranging from large-scale water balance to dynamics of water quality constituents in the rural to urban gradient. RFA2, through highly successful public surveys, has developed a significant database of social science information about water consumption and perceptions and has developed an urban neighborhood typology. The GIRF is finally completed and will provide additional data. An innovative and robust cyberinfrastructure has been deployed to support the data from the other sources.
- A means of sustaining these research infrastructures should be identified to provide data for future research grants. The panel recommends that various sources of funding be considered and aggressively pursued for each.
- The primary incomplete aspect of the research appears to be in characterizing the complex interactions of the coupled system (RFA2) and modeling of the coupled system (RFA3) as hypothesized in the conceptual model. The highest priority should be placed on accomplishing this by the end of the project; it should have the attention and collaboration of all the PIs.
- Results should include aspects of system vulnerability and resilience and be of interest to stakeholders or policy makers. Efforts in all three RFAs, as well as in visualization and cyberinfrastructure, can be coordinated to accomplish this and resources should be managed to assure success.
- EOD efforts, notably the iFellows, Summer Institute, and Research Catalyst Grants programs, have produced great benefits across the demographic spectrum and age groups. Focused EOD efforts have cemented R1-PUI relations and resulted in the inclusion of under-represented minorities into Utah's higher education and applied-research system. Even so, they do not appear to have shown significant benefits to industry through workforce

development. Similarly, although the new R1-PUI collaborations have been viewed as highly valuable to the project, this success has not yet motivated administrators to see this collaboration maintained in the future. With continued hard work to build cohesion, the PUIs should aim to enable synergy between EOD and research efforts across the state, such that new opportunities are identified and established.

- Pursuit of long-term quantitative and qualitative EOD metrics should continue. However, establishing the value and relevance of EOD activities to specific stakeholders requires identification and confirmation of short-term metrics on a stakeholder-by-stakeholder basis.
- The State Committee appears to have been in hiatus since 2014, posing challenges for outreach and iUTAH sustainability. While this appears to be back on track, the State Committee also plays a key role in bringing iUTAH science and outreach activities and their impacts to decision-makers and in convincing them of the continued relevance of iUTAH to address the state's future water-resource challenges.
- iUTAH leadership must formally establish a clear sustainability plan, including a strategy with institutional backing to advocate for this. This AAAS panel report is intended to support this process. In the final debriefing session of the AAAS site visit, the State Director asked the panel to help identify which elements of iUTAH seem to hold the greatest appeal and potential for continued funding support, including from non-traditional sources such as family-based foundations, industry, etc. Because this report is intended to highlight strengths and challenges related to each RFA and cross-cutting program features, it provides summary information fundamental to sustainability planning. We encourage the program leadership, in concert with the State Committee and university administration, to set out a series of meetings (possibly with the support of an external, professional moderator) in order to prioritize iUTAH elements in special need of protection and enhancement, while simultaneously identifying others that are seen to have served their purpose and can be defunded and let go.
- A piecemeal vs. consolidated approach to sustainability planning should consider costs and benefits of continuing iUTAH's principal activities within two general funding scenarios:
 - a *low to mid-level funding scenario* – in which iUTAH components have to be triaged based on evaluation of the possible future benefits of continuing activities within the context of resources needed to sustain them, and
 - a *high-range funding scenario* – in which top-down (university-level) and external (Legislature, federal, or private) funding is secured that enables consolidated and continued pursuit of an integrated iUTAH program.

Aspects of the project that have the most potential to be leveraged for future research likely include: the monitoring system (or some subset of it); the cyberinfrastructure with its

database, policies, and accessibility; the GIRF; and the close collaboration with the PUIs. For each, a separate, appropriate plan for continuity should be developed and cost-sharing among multiple sources should be considered. This effort should take precedence over efforts to find funding to sustain the entirety of iUTAH as an entity.

Appendix A: 2016 AAAS Site Visit Agenda

iUTAH AAAS Site Visit Agenda 6-8 March 2016

Sunday, March 6

6:30pm *Introductory Dinner with iUTAH Leadership Team and Project Office Staff
(Alamexo Mexican Kitchen, 268 South State Street, Salt Lake City,
www.alamexo.com)*

Monday, March 7

Meeting Space

The University of Utah
University Guest House and Conference Center
Officer's Club, 150 South Fort Douglas Blvd., Salt Lake City
North Room (All Sessions)

Session A—Review Panel and iUTAH Leadership Team (closed)

8:00am Welcome and Opening Remarks—Dr. Michelle Baker, iUTAH Project Director

8:05am iUTAH's Integrated Socio-Environmental Observatory: Towards a New
Research Culture of Interdisciplinary and Cross-institutional Collaboration—
Dr. Michelle Baker, iUTAH Project Director

8:15am Overview of Review Panel Role, Charge, and Anticipated Outcomes

8:20am Discussion—Sustaining iUTAH's Infrastructure

Session B—Review Panel and iUTAH Management Team (closed)

9:00am Welcome and Introductions—Andreas Leidolf, iUTAH Assistant Director and
Project Administrator

9:05am iUTAH—Managing a Large, Interdisciplinary, Cross-Campus Research
Project: Lessons Learned and Implications for the Future—Andreas Leidolf,
iUTAH Assistant Director and Project Administrator

9:15am Discussion—Sustaining iUTAH's Collaborative Capacity

10:00am Break

Session C—Review Panel and PUI Faculty

- 10:15am Welcome and Introductions—Dr. Daniel Bedford, Professor of Geography, Weber State University
- 10:20am Connecting the Dots: PUIs, iUTAH, and the Culture of Collaboration—Dr. Daniel Bedford, Professor of Geography, Weber State University
- 10:30am Discussion—Sustaining PUI Engagement/R1 Collaboration

Session D—Review Panel and Executive Committee of the State EPSCoR Committee (closed)

- 11:15am Welcome and Introductions—Dr. Heather McInnis, AAAS Research Competitiveness Program
- 11:20am Discussion

12:00pm Lunch (by invitation only)

Review Panel: “The iUTAH STEM Pipeline”—Lunch with iUTAH undergraduates, graduate students, and postdoctoral associates (Natural History Museum of Utah, Swaner Forum)—Dr. Madlyn Runburg, Director of Education Initiatives, Natural History Museum of Utah

Executive Committee: Lunch with iUTAH Leadership and Management Teams (Officer’s Club, West Room)

Session E—Review Panel and iUTAH Hydroinformatics and Cyberinfrastructure Research Team

- 1:30 pm Hydroinformatics and Cyberinfrastructure: Innovative Management, Integration, and Visualization for iUTAH's Data Products and Resources—Dr. Jeff Horsburgh, iUTAH Hydroinformatics/CI Co-lead
- 1:35 pm Discussion—iUTAH Hydroinformatics and Cyberinfrastructure: Looking Forward

Session F—Review Panel and iUTAH Coupled Human-Natural System (RFA3) Research Team

- 2:15pm Coupled Human-Natural System Modeling: Leveraging Concept into Application—Dr. Courtenay Strong, iUTAH RFA3 Co-lead
- 2:20pm Discussion—iUTAH Coupled-Human Natural Systems: Looking Forward
- 3:15pm *Break*

Session G—Review Panel and iUTAH Social and Engineered System (RFA2) Research Team

- 3:30pm Human Drivers of Water Systems: Integrating People, Places, Plants, Pipes, and Policies—Dr. Douglas Jackson-Smith, iUTAH RFA2 Co-lead
- 3:35pm Discussion—iUTAH Social and Engineered System: Looking Forward

Session H—Review Panel and iUTAH Biophysical System (RFA1) Research Team

- 4:30pm Transcending System Boundaries through Integrative Ecohydrologic Research—Dr. Zachary Aanderud, iUTAH RFA1 Co-lead
- 4:35pm Discussion—iUTAH Biophysical System: Looking Forward
- 5:30pm *Meeting adjourns for the day*
- 6:30pm *AAAS Review Panel Dinner (Location TBA)*

Tuesday, March 8

Meeting Space

The University of Utah
University Guest House and Conference Center
Officer's Club, 150 South Fort Douglas Blvd., Salt Lake City
North Room (All Sessions)

Session A—Review Panel and iUTAH Leadership Team (closed)

8:00am Q&A and Discussion Follow-up to Day 1

Session B—Review Panel and iUTAH EOD Teams

9:00am The iUTAH Office for Engaged Scholarship—Dr. Mark Brunson, iUTAH EOD Director

9:15am Discussion—Sustaining iUTAH EOD Programs: Workforce Development, External Engagement, and Diversity Enhancement

10:30pm **Review Panel Executive Session with Working Lunch (closed)**

1:00pm **Debrief with iUTAH Leadership Team (closed)**

2:00pm *Meeting adjourns*

Appendix B: 2016 Charge to the AAAS Review Panel

Utah EPSCoR RII Track-1 Program

At the request of iUTAH, the AAAS Review Panel of scientific experts, led by AAAS Staff, will provide on-site assessment and guidance to the work supported by UT EPSCoR. The AAAS Panel will visit selected iUTAH participants in Salt Lake City on March 6-8, 2016. The 2016 visit (Year 4) will be the third panel visit by AAAS; a previous visit by two AAAS staff occurred during the fall, 2012 to facilitate the iUTAH strategic planning session, and a second visit by a AAAS panel comprised of 4 experts and 1 AAAS senior staff member occurred during the winter of 2014 to conduct an evaluation of progress to-date. The purpose of the 2016 visit is to understand and document the progress made to-date (winter 2016), advise on the implementation of the final year of the Track-1 award, and recommend potential strategies for sustainability.

In addition, the iUTAH leadership requests the AAAS Panel consider and address the following core questions:

1. iUTAH EPSCoR would appreciate the AAAS Review Panel's thoughts on where the iUTAH participants should place their research emphasis to position themselves to be competitive for future federal funding opportunities, such as CZO, LTER, etc.
2. Having successfully lowered barriers that used to exist between the three research institutions in the state of Utah, as well as between R1s and PUIs, iUTAH EPSCoR would appreciate the Panel's advice on what elements or programs (e.g., interdisciplinary degree or certificate programs, cross-campus courses, etc.) are most likely to continue and expand this new culture of collaboration in the realms of research, education, and workforce development.
3. iUTAH EPSCoR would be interested to learn what aspects of its research, education, and outreach program the AAAS Review Panel is most excited about. What does the panel judge the legacy of iUTAH to be? What are outcomes of the iUTAH project most likely to have substantive impacts beyond Utah's boundaries?