

## **EPSCoR Western Tri-State Consortium Innovation Working Group Summary Report**

**Title:** How will Springflow Processes Respond to the Effects of Climate Change?

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### **IWG Summary**

The study of springflow processes and how they will respond to the effects of climate change has scientific, economic, and cultural significance. Springs are important hydrologic features in watersheds. For example, springs serve as proxies for groundwater in watersheds where groundwater wells are sparse; streamflow originates in many cases from springs especially in headwater reaches of streams; springs are important sources of water and solutes for higher order streams; and the geochemistry and residence times of spring waters are used to provide estimates of bedrock weathering fluxes and mineral dissolution rates at watershed scales. Springs are often used in ranching communities as perennial sources of water for irrigation ditches and for livestock and wildlife waterers while hot springs are recreational destinations. Yet, despite the importance of springs, our understanding of the processes that control springflow generation and the geochemical fluxes from springs remains poor. Recent research indicates that the processes that control the generation of springflow are very dynamic. In fact, springs may be integrating water from a variety of sources ranging from recent meteoric water flowing along preferential flowpaths in the soil to very old groundwater flowing along deep, perhaps regional flowpaths. Furthermore, individual springs may be sourcing distinct portions of the groundwater flowpath distribution present within their contributing area; thus, in some cases, the geochemical composition of individual springs may be different than wells located geographically near the spring. Other variables often used to characterize springflow processes, such as magnitude of discharge, residence time of spring water, and estimated contributing areas of springs may be largely uncorrelated with each other and with the elevation of spring emergence. If this is true, then these observations suggest that we may know less about springflow generation processes than we currently know about streamflow generation processes. This problem is further exacerbated by the “hidden” nature of springflow processes (i.e., these processes cannot be easily quantified using surficial observations). By improving our fundamental knowledge of springflow processes, we will be better equipped to quantify how springs will respond to the effects of climate change.

## **IWG Goals**

The goal of this Innovation Working Group was to discuss existing and develop new hypotheses of springflow processes in order to better understand how springflow processes will respond to the effects of climate change. Participants were invited from all three states in the EPSCoR Western Tri-State Consortium. External participants that provided a greater breadth in the study and understanding of springflow processes were also invited. The expectations of this Innovation Working Group were to use the discussions to draft a synthesis article on springflow processes in different climatological, geological, and geographical settings and facilitate proposal development. The deliverables from the IWG include science news-type articles drafted for *EOS Transactions* and *Limnology and Oceanography Bulletin* and collaboration on future proposals under the NSF Integrated Earth Systems program. The Working Group discussed three main science questions (these questions were amended during the IWG):

1. How do we define springflow resilience or resistance? Can residence times be used as descriptors of springflow resilience/resistance?
2. How do we define springflow resilience or resistance? In extension, can other data be used as descriptors of springflow resilience/resistance?
3. How do we provide better estimates of spring contributing areas and sources of water for springflow generation? Are modeling approaches more effective since they can provide better estimates of the three-dimensional extent of these contributing areas? Which field observations and approaches are the most useful predictors of spring contributing area?

## **IWG Structure and Approach**

This IWG was designed to bring together scientists with multidisciplinary expertise in the research of springflow processes to encourage collaboration and discussion of science questions regarding the response of springs to the effects of climate change. The lead investigators ensured that scientists from each state participating in the EPSCoR Western Tri-State Consortium were invited and were in attendance. There were 8 in attendance from NM (Marty Frisbee, John Wilson, Fred Phillips, Jesus Gomez, Lani Tsinnajinnie, and Gus Tolley from New Mexico Tech; Laura Crossey from the University of New Mexico; and Shari Kelley from the New Mexico Bureau of Geology and Mineral Resources). There were 2 in attendance from NV (Don Sada from the Desert Research Institute, Reno, and Brian Hedlund from the University of Nevada, Las Vegas) and there were 2 in attendance from ID (Sarah Godsey from Idaho State University and Jerry Fairley from the University of Idaho). There were two scientists in attendance from states not participating in the Western Tri-State Consortium (Abe Springer from Northern Arizona University and Laura Rademacher from the University of the Pacific). The requirement for multidisciplinary representation and interdisciplinary collaboration was ensured. The breadth of expertise included hydrology, geochemistry, groundwater age-dating, geomorphology, ecology, and microbiology.

The goals of the IWG were achieved through a combination of individual presentations, break-out sessions, open discussions, evening social events, and field trips. Individual presentations were requested from each participant beforehand in order to learn more about the individual's research as it relates to the science questions and to determine how their research addresses the science questions of the IWG. Individual presentations took place during the evening of Day 1 and were completed by noon of Day 2.

Break-out sessions were held to take advantage of the diverse set of skills present within the group in order to encourage the development, testing, and exchange of interdisciplinary ideas. Each group was assigned one of the science questions. Group 1 discussed Question 1 and this group consisted of Fred Phillips, Laura Rademacher, Jesus Gomez, and Lani Tsinnajinnie. Group 2 discussed Question 2 and this group consisted of Don Sada, Brian Hedlund, Sarah Godsey, Abe Springer, and John Wilson. Group 3 discussed Question 3 and this group consisted of Jerry Fairley, Gus Tolley, and Marty Frisbee. Break-out sessions were conducted during the afternoon of Day 2 and a representative from each group provided a detailed list of their findings during the evening of Day 2.

Open group discussions were held during the evening on Day 2 and throughout the morning of Day 3. The open discussion format was chosen on Day 3 due to the great progress the group was making toward future deliverables. Evening social events and field trips were held to encourage communication and collaboration across disciplines. On Day 1, Shari Kelley led a short field trip to the visit the geothermal springs in Jemez Springs where she discussed the geothermal activity and geologic history of the Valles Caldera. On Day 2, Laura Crossey led a short field trip to Soda Dam where she discussed the hydrological, geochemical, and geothermal characteristics of site. Brian Hedlund gave a short discussion during the first field trip about sampling methodologies for microbiology and he sampled the waters at both sites.

The IWG group broke up after lunch on Day 3. Don Sada, Brian Hedlund, Jesus Gomez, and Lani Tsinnajinnie departed for Albuquerque. The remaining participants continued working on a schedule for planned outcomes until 3:00 pm. A copy of the final agenda is attached at the end of this report.

## **IWG Outcomes**

The goals of the IWG were achieved successfully.

Many of the participants have expertise in the geosciences. Thus, a geo-holistic appreciation of springs and springflow processes was easily achieved. However, the inclusion of participants with expertise in ecology and microbiology greatly improved the scope of the IWG. The social science perspective was the only perspective that was missing and members of the group provided personal contacts that they thought could cover this perspective moving forward. There are several deliverables in progress:

1. The break-out sessions and open discussions were very fruitful. The group is collaborating on the creation of two "science news" type articles. One article will be drafted for the geoscience community and the other article will be drafted for the aquatic

ecology community. Both articles will be inclusive and interdisciplinary. Marty Frisbee will take the lead on drafting an *EOS* article tentatively entitled, "Climate change and the fate of desert springs". Brian Hedlund and Don Sada will take the lead on a similar article targeting ASLO (Association for the Sciences of Limnology and Oceanography) Bulletin. In these articles, we will briefly discuss the motivation, results, and proposed science questions of the IWG. We propose that these articles be drafted, reviewed, and submitted by December 2012/January 2013 so the group doesn't lose momentum. Funding from NSF EPSCoR will be acknowledged in any and all resulting publications.

2. The group was extremely interested in pursuing NSF funding to support future collaborative research. In fact, the group developed a hypothesis based on the conceptual models presented during individual presentations and open group discussions. The working hypothesis is: Climatologically-driven loss of large-scale spring systems and associated ecosystems is organized from most local to most regional. The hypothesis test will include an array of hydrological and hydrometric data, geochemical and isotopic age-dating data, and ecological and microbiological indicators. Funding will be sought from the NSF Integrated Earth Systems (IES) Program. The proposal is due in November 2013 and individual tasks have been assigned.
3. Two smaller proposals are also being considered. The hypotheses for these two proposals are still being discussed and developed. One of the proposals will use geomorphologic indicators to understand past resistance to climate change. This data can be used to better understand why some springs have been resistant to the effects of climate change while other springs have not. The second proposal will use UAV or drone technology to investigate how springs are related to landscape position and whether or not we can use this information to better locate, monitor, and archive new springs. Marty Frisbee will take the lead on one of these proposals.
4. It was agreed that in order to maintain momentum and cohesiveness within the group that we should collaborate on a proposal for a Special or Topical Session at AGU, GSA, or other annual meetings next year. The call for proposals for GSA and AGU usually go out in March or April. Thus, it is advantageous for the group to submit the news-type articles by January 2013 as acceptance and publication of these articles will provide leverage for the group's Topical Session.

## **Final Agenda:**

### **October 1, 2012 (Day 1):**

10:00 am: Marty Frisbee, Jesus Gomez, and John Wilson arrived at Valles Caldera Science and Education Center and began making preparations.

10:00 am - 12:00 pm: Lani Tsinnajinnie (NMT) began shuttling early arrivals from the ABQ Sunport to the Valles Caldera Science and Education Center (VCSEC). Snacks/lunch were provided for participants arriving before 12:00 pm.

1. Brian Hedlund arrived at ABQ at 10:05 am (Flight # SW 0560 from Las Vegas).
2. Don Sada was picked up in Albuquerque since he arrived at ABQ on Sept. 30.

12:00 – 2:00 pm: Three participants arrived at ABQ between 11:30 and noon. Gus Tolley (NMT) shuttled those participants to the VCSEC and he picked up boxed lunches at Jason's Deli in Albuquerque for the late arrivals.

1. Sarah Godsey arrived at ABQ at 11:37 am (Flight # DL 4499 from Salt Lake City).
2. Jerry Fairley arrived at ABQ at 11:37 am (Flight # DL 4499 from Salt Lake City).
3. Laura Rademacher arrived at ABQ at 12:00 pm (Flight # SW 0842 from Phoenix).
4. Shari Kelley arrived between 12:00 and 2:00 pm.

2:15 – 2:30 pm: Welcome/Schedule/Logistics were provided by Marty Frisbee and John Wilson.

2:30 – 2:45 pm: Departed for field trip to Jemez Springs. Field trip was led by Shari Kelley (NM Bureau of Geology and Mineral Resources) with assistance from Fred Phillips (NMT).

5:30 – 6:00 pm: Returned to VCSEC for dinner.

6:30 – 7:30 pm: Dinner followed by short break.

8:00 – 9:30 pm: Evening social and we began the Individual Presentations. The purpose of individual presentations was for participants to introduce themselves to the group within the context of the proposal. Participants were told to limit their individual presentation to 12 minutes (15 minutes with questions).

1. Marty provided a presentation that described ongoing EPSCoR research in NM (also including data from Saguache Creek Watershed in CO) and provided direction for the IWG on springflow processes including evolution of science questions, motivation for IWG, and expected outcomes.
2. Individual presentations began after his presentation.

### **October 2, 2012 (Day 2):**

7:00 – 8:15 am: Breakfast provided by Center.

8:30 – 10:00 am: Finished remaining individual presentations from Day 1.

10:00 am: Mid-morning break with snacks provided.

10:15 am – 12:00 pm: Introduced science questions. Begin break-out sessions were developed based on science questions (one group per science questions). The science questions are:

1. How do we define “springflow resilience”? Can residence times be used as descriptors of springflow resilience?
2. How do we define “springflow resilience”? Can other data be used as descriptors of springflow resilience?
3. How do we provide better estimates of spring contributing areas? Are modeling approaches more effective since they can provide better estimates of the three-dimensional extent of these contributing areas? Which field observations and approaches are the most useful predictors of spring contributing area?

Expectations from each group were:

1. Provide synthesis of individual presentations and datasets,
2. Discuss implications of presentations with respect to the science questions,
3. Provide feedback on IWG deliverables: is there a sufficient synthesis for publications such as *EOS* or in a higher impact article, is there sufficient interest in pursuing interdisciplinary NSF proposals, what gaps and/or contradictions do the synthesized datasets present with respect to the science questions and/or new science questions.

12:00 – 1:00 pm: Lunch provided at the Center.

1:30 – 3:15 pm: Resumed break-out sessions. Each group completed summary of findings and provided suggestions for future deliverables. These findings were delivered on the evening of Day 2.

3:15 – 6:00 pm: Departed for field trip to Soda Dam. Laura Crossey (UNM) led this field trip.

6:00 – 6:30 pm: Returned to the VCSEC for dinner.

6:30 – 7:30 pm: Dinner at VCSEC followed by short break.

8:00 pm: Evening social.

### **October 3, 2012 (Day 3):**

7:00 – 8:15 am: Breakfast provided by Center.

8:30 – 10:00 am: Briefly re-stated the science questions. Each break-out group presented their findings and recommendations for future deliverables.

10:00 am: Mid-morning break with snacks were provided.

10:15 am – 12:00 pm: Provided feedback on IWG deliverables:

1. Is there a sufficient synthesis for publications such as *EOS* or in a higher impact article,
2. Is there sufficient interest in pursuing interdisciplinary NSF proposals,

3. What gaps and/or contradictions do the synthesized datasets present with respect to the science questions,
4. What new science questions can be addressed?
5. Seek volunteers and/or assign duties for completion of proposed deliverables.

12:00 pm: Lunch was served at VCSEC.

1:00 pm: Shuttled early departures back to ABQ Sunport:

1. Brian Hedlund had a 3:45 pm departure (Flight # SW 0747),
2. Don Sada had a 3:40 pm departure (Flight # US 2715).

1:00 – 3:00 pm: Continued working on scheduling of future deliverables.

3:00 pm: Shuttled late departures back to ABQ Sunport:

1. Sarah Godsey had a 5:40 pm departure (Flight # DL 4462),
2. Jerry Fairley had a 5:40 pm departure (Flight # DL 4462),
3. Laura Rademacher remained to assist colleagues with field work in the Valles Caldera.