Project summary
The critical zone is the heterogeneous carapace of soil and weathered rock, and the ecosystems they support. Understanding the evolution of the critical zone, and its sensitivity to perturbations, requires an understanding of its architecture and the processes that produce this architecture. The Boulder Creek Critical Zone Observatory (BeCZO) is designed to understand how weathering (both physical and chemical) and transport processes control the structure of the critical zone, and to explore the impact of critical zone structure on hydrological, geochemical and biological functions of the landscape. The 1160 km² Boulder Creek watershed in Colorado’s Front Range encompasses strong contrasts in erosional regimes, and therefore contains critical zone architectures that range from dominantly bare rock to deeply weathered profiles. Through the late Cenozoic, a slowly eroding rocky upland comprising Precambrian crystalline rocks has been etched in its headwaters by glaciers, and bitten into by headward migrating stream knickzones. This has produced a landscape in which the critical zone is captured in three states. Each of these is represented in a focus subcatchment in the BeCZO where the critical zone will be characterized in detail. The BeCZO will explore these questions:

• What controls the spatial variation in critical zone development, and how does critical zone development vary across erosional and ecological regimes?
• How does the distribution of critical zone development control the hydrologic response of the catchment to both snow and rainfall?
• How does the stage of critical zone development influence weathering and nutrient fluxes?

Specific hypotheses inspired by these questions explore the roles of ecological and hydrological feedbacks, and the initial state of the rock upon encountering the critical zone as it is exhumed.

Tasks
Deep cores, soil pits, and available rock exposures will be used to document the mineralogy and chemistry of the weathered profile. Geophysical surveys at three levels will characterize each catchment, and will be calibrated using the deep cores. Shallow seismic, GPR, EM and electrical resistivity methods will be employed. Hydrologic and hydrochemical monitoring will provide data to guide hydrologic simulations and to measure chemical fluxes within and out of the catchments. Wells, piezometers, tensiometers, and TDR will be maintained, and water chemistry, including fractions within the dissolved organic matter (DOM), will be monitored. Biological activity will be characterized, including a survey of microorganisms and microbial activity in the subsurface environment.

Cyber infrastructure
Numerical modeling results will serve to guide the collection of relevant field data, and to integrate the diversity of those data to gain insight into the active processes. Hydrologic models are designed to ingest meteorological and hydrological data collected at each field site and will focus on concept development. New mathematical models of critical zone evolution will be developed at three scales: soil profile, hillslope, and catchment. Data management and distribution will be handled by a full-time data manager, who will work closely with related cyber-information networks and user communities.

Broader impacts
Education and outreach is built into the BeCZO at all levels. The project will expand a highly successful community-based watershed website (BASIN), offer undergraduate research experiences, develop a graduate-level critical zone course, award graduate field fellowships to non-CU students, lead a GSA field trip, and engage other scientists in project annual meetings. Partnership with CU’s 24 year old Science Discovery program will engage K-12 students and teachers through classroom and field programs involving urban 5th grade classes, summer field courses led by BeCZO graduate students, and inquiry-based curriculum workshops with middle school students. Communication with the wider public will come through participation in the Boulder Valley Water Festival, and creation of an educational video.