Appendix 6: Worked Example for the Hierarchy Table Using the Freshwater Integration Project

The elements of AON Design briefly outlined in Table 4 provide an organizing framework for the process for developing actionable science questions (ASQs) into a plan for acquiring observations needed to answer those questions. These elements apply to the full range of issues related to physical and social sciences, as well as the interactions among them. Some issues may have already developed to the stage of tactics or even deployment, while others require careful thought to determine the core set of ASQs.

We illustrate the process with an example from the Freshwater Integration Project described in Section 6.2.1, in which changes in land-surface freshwater storage are shown to have uncertain consequences for human wellbeing. For example, changes in the amount, phase, and timing of precipitation are unknown, as is the response of terrestrial vegetation to those changes. Vegetation, in turn, has direct linkages with permafrost and active-layer depth, which affects freshwater storage on land. Additional freshwater benefits humans through an enhancement of drinking water resources, but may also impede transportation and complicate development of infrastructure.

Based on this evidence, the consequences to humans of changing precipitation is critical yet highly uncertain, and the strategy for resolution is immature. Beginning with the Problem Definition element in Table 4, a small set of ASQs could be: What has been and will be the nature of precipitation changes on high-latitude land in response to Arctic and global climate change? How is high-latitude terrestrial vegetation responding to changing precipitation? How will changes in terrestrial freshwater storage affect local economies, indigenous cultures, and commercial development?

The next step in addressing these questions is to form a strategy for identifying the key obstacles to solutions. Some of the methods described in Section 4.2 and Section 6.2 of this report --such as model-based sensitivity studies and heuristic feedback and uncertainty analyses – are possible approaches. These activities are studies unto themselves, and would require funding for dedicated efforts. Not only would these studies inform the tactics required to answer the ASQs (next step in Table 4), but they would also contribute fundamental understanding of the Arctic hydrologic system and the impacts of changes on human society.

Assuming that improved measurements of precipitation amount, type, and timing emerge as an essential requirement for answering the ASQs, tactics could then be developed to design an observing system that provides sufficient spatial and temporal information to assess the response of terrestrial vegetation, permafrost, and the active layer to varying precipitation. Other tactics would be targeted at assessing the human response to changes in those physical parameters. Then finally, the actual mechanics for instrument deployment is decided in the final stage of the process.