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Exploring the Relationships Between Groundwater Processes and Properties of Surficial Deposits in the Canadian Rockies

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Summary

Many downstream communities and ecosystems rely on river flows from mountain watersheds (Viviroli et al., 2007). Within these watersheds, surficial deposits such as moraine and talus are important conduits and reservoirs of groundwater, capable of contributing a majority of stream runoff (Langston et al., 2011; Liu et al., 2004; McClymont et al., 2010; Muir et al., 2011). Groundwater flow and storage in these deposits are affected by spatially varying properties such as porosity and permeability. Study of these properties and their influence on groundwater is therefore a necessary step towards understanding the discharge behavior of mountain regions.

Due to harsh field conditions, there exist few dedicated studies which investigate groundwater in mountain regions. Consequently, our picture of mountain hydrogeology is limited to only a handful of research catchments. In the face of future uncertainty, there is need to improve our ability to characterize mountain regions at larger, more meaningful scales. This necessitates further research in new and unique study sites. This study investigates relationships between groundwater processes and the physical properties of surficial deposits within a new research site located at the Fortress Ski Area of Kananaskis.

Theory / Method / Workflow

Research in the Fortress Ski Area study site consists of two major phases: 1) field data collection and analysis and 2) groundwater modeling.

The field data set collected in the first phase spans several years and includes: precipitation and snowmelt; streamflow within and from the site; groundwater levels; and direct measurements of aquifer properties. The field data set was analyzed and used to build conceptual understanding on how different surficial deposits capture, store and release groundwater.

In the second phase, numerical models were developed using field observations and conceptual understanding. Several models of varying complexity were tested ranging from a single 'bucket' model up to a fully-distributed, heterogeneous groundwater flow model. The benefit of added model complexity is explored via comparison of model performance. Analysis of models also sheds light on the relative importance of different surficial deposits and the specific properties which exert the greatest influence on discharge.

Results / Observations / Conclusions

A conceptual model describing the hydrogeological role of various surficial deposits within the study site was developed. Emphasis is placed on the significance of a moraine deposit near an outlet (Figure 1), which acts as a 'gatekeeper' to most flow leaving the catchment. The importance of vertical variations in hydraulic conductivity as a control on discharge is also indicated.

Results from numerical simulation show the inability of simple 'bucket' models in reproducing discharge observed in the field data. Such models are based on single valued storage-discharge curves, which are intuitive and easy to parameterize, but have serious deficiencies where behavior of the watershed is hysteretic. More complex distributed models perform better in this regard, but are potentially marred by uncertainty in forcing and initial conditions. Model performance improves with increased complexity and greater number of parameters, however, certain parameters such as those relating to properties of the moraine are less sensitive than others. This may mean that certain elements of model complexity can be left out without large detriment to model performance.

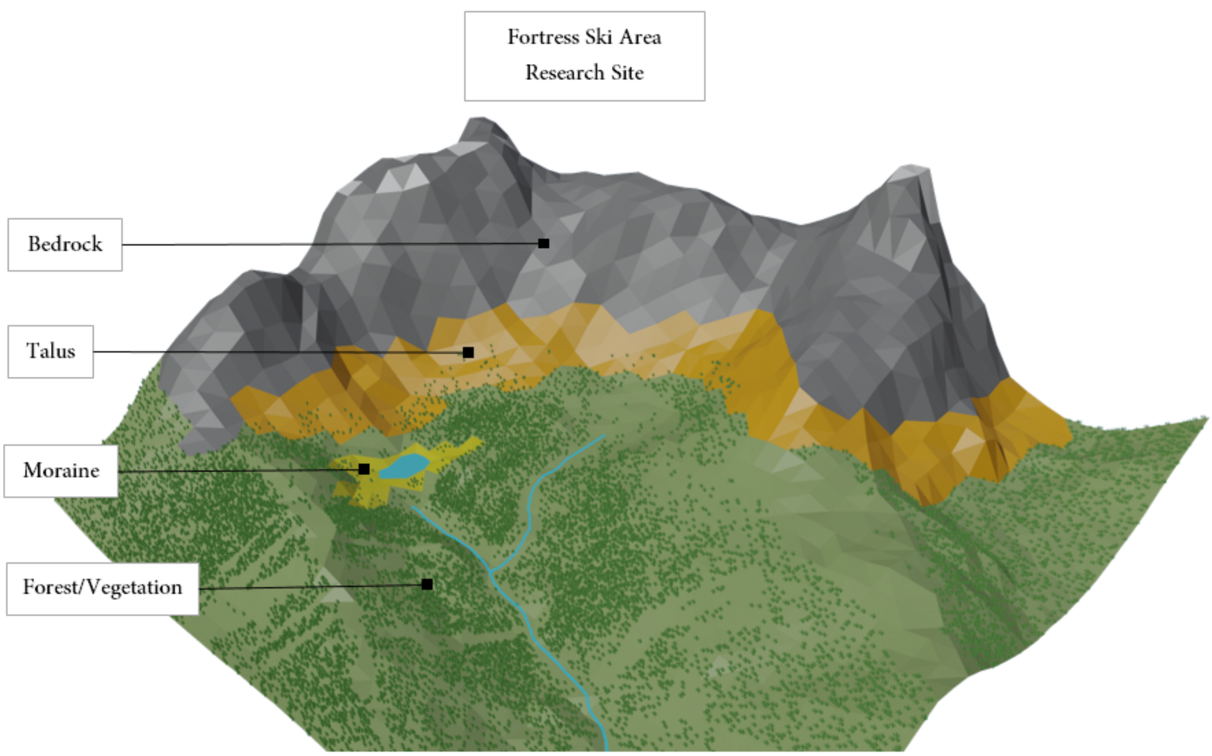

Figure 1. Graphic of the Fortress Ski Area site in Kananaskis.

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