Model Scope			
Model	***Resolution of Model Calculations***	***Watershed size limitations***	***Related applications***
GSFLOW (PRMS w/MODFLOW)	Daily time step. Semi-distributed model calculates on hydrologic response units, a scale delineated by the user.	Can model both small and large watersheds; doubtful that it can model very small areas.	PRMS has recently been used for climate research in the Williamette basin. Use of GSFLOW would further that work.
HBV	Semi-distributed model which runs on sub-watershed scales delineated by the user.	Has been applied to plot scale up to very large river basins	The model has been applied in some 40 countries, in all parts of the world. Has been used in climate change impact on water discharge.
MIKE SHE	Daily or sub-daily time steps. MIKE SHE is a distributed model but the grid scale is delineated by user.	Can model both small and large watersheds. Can go down to plot scale if necessary.	MIKE SHE has been used in consultancy and research applications around the world. Promoted for use in climate change research.
DHSVM	Distributive model working at a DEM grid scale (common applications range from 10m to 150m) DHSVM is designed for sub-daily time steps. It does poorly at modeling daily or monthly time steps.	100 m to 100,000 km^2	DSHVM has been linked with climate models to determine climate change effects.
VIC	Calculates from a large grid of land surfaces (>1 km^2 per grid surface) at daily time steps or larger.	Large scale, river basin size (e.g. Columbia or Colorado Rivers). Probably too large scale a model for the watersheds in this project.	VIC has been used in climate change research on Colorado River. It is designed to be similar to other models that couple with GCM.

Model Data

Model	***Data Input Requirements***	***Sub-surface water algorithm***	***Soil/Geology consideration***	***Vegetation consideration***	***Snow Algorithm***
GSFLOW (PRMS w/MODFLOW)	Climate date of air temperature and precipitation, solar radiation is optional. Delineation of hydrologic response units. Information on other portions of hydrologic cycle can be used to improve model use.	PRMS soil water modeling is coupled with MODFLOW for an integrated routing of sub-surface and groundwater.	This can handled in the delineation of the hydrologic response units. Varying soil and geology conditions can be differentiated by the unit then adjust model parameters for that unit accordingly.	This can handled in the delineation of the hydrologic response units. The "average" potential evaporation across each unit is specified. Also interception of precipitation by vegetation considered across each unit by average plant cover density.	PRMS simulates the initiation, accumulation, and depletion of a snowpack on each hydrologic response unit.
HBV	Subbasin delination and altitude and land cover distribution needed. Time-series of precipitation and temperature (time-series of observed water discharge within watershed).	HBV works at the sub-basin scale. Uses a statistical distribution soil water response, user can alter this distribution.	This can handled in the delineation of the subbasins. Average soil and geology conditions that affect the hydrology can be adjusted for each sub-basin.	General land cover considered by sub-basin delineated.	Uses a degree day approach from air temperature and water holding capacity of snow for melt. Examples in the literature of modifications of snow melt algorithm in HBV for improved results.
MIKE SHE	MIKE SHE model can include any or all of the processes in the land-phase of the hydrologic cycle. Interacts with GIS files for simplicity in use.	Sub-surface calculation and routing done at user specified time steps and scales. MIKE SHE will do this well, maybe more than necessary	Soil and geology conditions that affect the hydrology can be adjusted for any use specified scale.	Will use GIS files for inputs on land cover. Models ET and interception .	MIKE SHE manages snow pack accumulation and melting using an advanced degree-day method

Model Data (continued)					
Model	***Data Input Requirements***	***Sub-surface water algorithm***	***Soil/Geology consideration***	***Vegetation consideration***	***Snow Algorithm***
DHSVM	Large input requirements: DEM of watershed Soils layer Vegetation layer Meteorlogical inputs of: solar radiation, wind, air temp, rel. humidity at the time scale of modeling	Sub-surface calculation and routing done at sub-daily time steps.	Required input to model.	Required input to model.	Models snow melt and accumulation very well. (Model is most accurate for this form of precipitation, much better than rain dominated runoff).
VIC	Inputs are time series of daily or sub-daily meteorological drivers (e.g. precipitation, air temperature, wind speed). Large scale land cover information is needed.	No consideration of sub-surface water, water is only routed based on surface water inputs, good for large scale applications i.e. entire U.S., but not for smaller watersheds.	Deals with soil effects based on changes made to the infiltration capacity algorithm of the model. Allows 3 separate layers of soil infiltration parameters.	Vegetation is considered by land cover type for modeled tiles or grid cells (>1 km2). Land cover is gross; forest, lake, grass, wetland, urban.	VIC considers snow in several forms: ground snow pack, snow in the vegetation canopy, and snow on top of lake ice. Main features: Ground snow pack is quasi 2-layer; the topmost portion of the pack is considered separately for solving energy balance at pack surface, can consider spatially-distributed (laterally) snow coverage, can consider blowing snow sublimation

Computing Needs			
Model	Operating Platform	Computing Needs	Model structure modifications
GSFLOW (PRMS w/MODFLOW)	Windows or Unix	Model can run on a powerful PC. However, speed is uncertain. If model runs really slow GLUE work would be a problem. However, the model will run on UNIX, which would enable use of a cluster of computers and likely handle the computing needs.	Parameters used in the various algorithms can be modified by user in the input files.
HBV	Windows	Model can be run on a powerful PC. GLUE has been used with HBV using simple MATLAB codes on a PC for a small watershed.	Parameters used in the various algorithms can be modified by user. In fact this is the intent of HBV. It provides a conceptual platform for modification as needed by the user.
Mike-She	Windows	Model can run on a powerful PC. Computing speed is likely slow. If really slow GLUE work would be a problem.	Lots of flexibility in use of parameters and methods depending on amount of input data or computing needs.
DHSVM	Unix	Data intensive model with lots of calculations. Would require model runs to be done on a cluster of Unix computers or large mainframe computer.	This is a research model you have full access to the code and control of the inputs.
VIC	Unix	Large scale model probably would require working on a cluster of Unix computers.	Model parameters are modifiable. The model calculations are not. The assumptions must be accepted.

Positives and Negatives

Model	Positive Attributes toward Project Objectives	Negative Attributes toward Project Objectives
GSFLOW (PRMS w/MODFLOW)	• Model has been used in Williamette basin, the PRMS structure is already defined. • Considers the necessary components of climate change in the western Cascades. • Lots of flexibility in the model's use.	• Computing speed may be a problem for GLUE analysis.
HBV	• Model is relatively easy to use. • Has been used in other climate/river change evaluations. • Does consider lakes • MATLAB code already available for assisting with GLUE analysis.	• Developed in Nordic climate. Although it has been applied in many situations, would need to be make modifications to fit PNW applications.
Mike-She	• Commercial model with easy to use GUI interface. • Can model in simple form or complex form depending on objectives. • Commercial software with customer support. • Can purchase sensitivity analysis software to do Monte Carlo analysis. Output probably can be incorporated into a GLUE analysis.	• MIKE SHE is a commercial model so it costs money, GSFLOW, HBV, VIC, and DHSVM are free. • Computing time may be a problem. • May not have a lot of flexibility for automated running of model for GLUE analysis.
DHSVM	• Accepted model for forested watershed assessment • Lots of control over inputs gives greater control of model. • Can provide simulations for whatever spatial scale desired, including the plot scale. • Chris Surfleet experienced with model, GLUE programs developed for its use.	• Computing intensive model requiring lots of inputs. • Most of the inputs for this model are not generated from a GCM, many assumptions to be made on other inputs. • Does not model lake or reservoir effects.
VIC	• Can be used on large river systems all over the world. • Is designed to be coupled with GCMs.	• Probably meant for larger scale modeling than this project. • Computing needs may be large for GLUE simulations. • Running the model will take quite a lot of time to learn.