# Calibrating Hydraulic Conductivity for Modeling Stream Discharge in Forest Catchments of Eastern Canada, on Varied Bedrock Formations

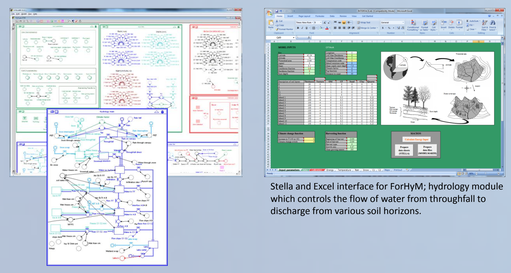
Marie-France Jutras, BScF MScF (Candidate)
Faculty of Forestry and Environmental Management, University of New Brunswick

## MODEL INTRODUCTION

This project describes the process of calibrating stream discharge based on the bedrock formations of forest catchments. Predicted stream discharge is derived using ForHyM (Forest Hydrology Model), a STELLA-based computer modeling program. The hydrology module within ForHyM uses known daily weather and watershed conditions to predict daily catchment stream discharge. By calibrating known stream discharge against the model derived discharge rate, valuable model outputs such as infiltration and percolation by soil horizon, frost depth, and water column height can be calculated with greater certainty. Furthermore, analysis of the stream discharge calibration parameters of different bedrock formations will enable improved future calibration for catchments with similar site specifications.

### What is STELLA?

STELLA is a computer modeling software that enables users to create dynamic interfaces which simulate realistic systems. ForHyM uses STELLA to predict thermal and hydrological flows in forests watersheds.



Stella and Excel interface for ForHyM; hydrology module which controls the flow of water from throughfall to discharge from various soil horizons.

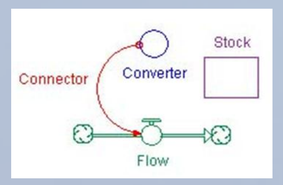
STELLA makes use of 4 basic building blocks: stocks, flows, connectors and converters. Each block has a specific function which enable the model to run automatically over various time periods.

**STOCK:** function used to represent things that accumulate (i.e. reservoirs, water in forest floor).

**CONVERTER:** function that creates an output value during each time interval (i.e. temperature, stream flow)

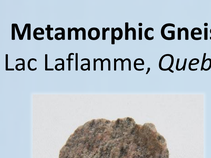
**FLOW:** functions representing activities that lead to inputs and outputs to stocks (i.e. thaw and freeze of forest floor)

**CONNECTOR:** transmits information to adjust flows.




## STUDY AREAS

**Metamorphic Gneiss**
Lac Laflamme, *Quebec*



**Sedimentary Shale/Sandstone**
Hayward Brook, *New Brunswick*

**Igneous Granodiorite**
Pockwock, *Nova Scotia*

**Igneous Metavolcanic Basalt**
Turkey Lakes, *Ontario*

**Metamorphic Slate**
Moosepit Brook, *Nova Scotia*

| *Site Parameters* | Moosepit Brook, NS | Pockwock, NS | Turkey Lakes, ONT |
|---|---|---|---|
| Abbreviation | KMB | PB | TL |
| Latitude (N) | 44°43' | 44°83' | 47°03' |
| Longitude (W) | 65°03' | 63°51' | 63°51' |
| Area (ha) | 1770 | 196 | 485 |
| Deciduous:coniferous | 75:25 | 75:25 | 100:0 |
| Rooting habit | Shallow | Shallow | Deep |
| Forest floor depth (cm) | 10 | 10 | 7 |
| Mineral soil: depth (cm); texture | 50; SL | 70; SL | 60; SiIL |
| Subsoil: depth (cm); texture | 100; LS | 100; SL | 200; SL |
| *Calibration Parameters* | | | |
| PET adjustor | 1 | 1 | 1.4 |
| Air temperature adjustor | 0.15 | 0.1 | 0.08 |
| Density of fresh snow | 0.15 | 0.15 | 0.15 |
| Surface runoff adjustor | 1 | 0 | 1 |
| Forest floor infiltration adjustor | 1 | 1 | 1 |
| Forest floor interflow adjustor | 0.2 | 0.2 | 0.2 |
| A&B horizon infiltration adjustor | 0.5 | 1 | 2 |
| A&B horizon interflow adjustor | 0.2 | 0.025 | 0.05 |
| C horizon infiltration adjustor | 0.5 | 1 | 5 |
| C horizon interflow adjustor | 2 | 2 | 1.5 |

SL: sandy loam LS: loamy sand SiIL: silty loam

Site and calibration parameters for Moosepit, Pockwock and Turkey Lakes. Other sites pending calibration.

There are five catchments across Eastern Canada on different bedrock types analyzed in this project. Moosepit Brook, Nova Scotia with metamorphic slate; Pockwock, Nova Scotia with igneous granodiorite (Peggy Brook catchment within Pockwock); Hayward Brook, New Brunswick with sedimentary sandstones/shale; Lac Laflamme, Quebec with metamorphic gneiss; and Turkey Lakes, Ontario with igneous mafic, metavolcanic basalt. These watershed were chosen because of long term studies that have been done on each site which provides ample data for the model. They were also chosen because each site have very different bedrock formations which will enable qualitative correlations with future research sites.

## GENERAL RESULTS

Discharge patterns were observed while calibrating the hydraulic conductivity of each site. Catchments with finer textured bedrock showed drastic decreases in interflow (up to 50 times smaller) when compared to the coarser textured soils. This was visible in the preliminary calibration results of stream discharge for Hayward Brook. The catchment at Hayward Brook is on sedimentary shale bedrock which produces loam to sandy loam textured soils. Water gets retained within the soil reducing movement across the catchment. Catchments with coarser textured bedrock had greater rates of infiltration. For example, the infiltration on the Turkey Lakes catchment (igneous basalt) increased 2-5 times, whereas Moosepit Brook (metamorphic slate) decreased. This shows a noticeable correlation between infiltration and soil texture derived from bedrock. Turkey Lakes has fast draining loamy sand which allowed for the water to move down through the soil quicker than the loam based soil at Moosepit Brook. Upon completion of further analysis the belief is that a continuing trend will be associated between hydraulic conductivity and bedrock formation.

## CALIBRATIONS

The focus of the calibrations is to generalize the hydraulic conductivity formulations based on local soil, landform and geological substrate conditions. This project analyzes the variation of calibration parameters within the ForHyM model for the five watersheds across Eastern Canada. One of the goals of this project is to create a lookup table that will generalize the calibration parameters by bedrock formation. The lookup table would act as a guide for new users that want to run ForHyM on their watersheds.

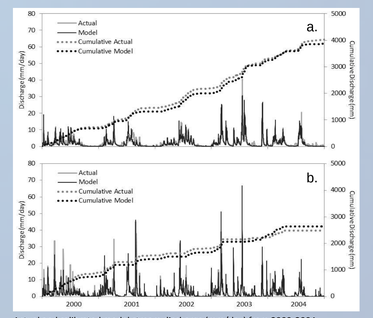
### Calibration Interfaces

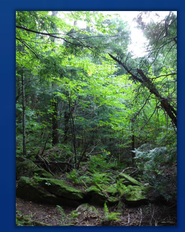
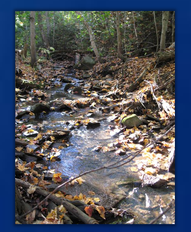
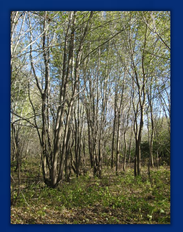
Calibration settings have been integrated into both the Excel User and Stella interfaces. The Excel interface provides 9 parameters for water flow snow density and snow melt which can be adjusted to calibrate the modeled data. Calibration graphs in Stella are used in conjunction with the parameter inputs in Excel to optimize data calibration.

**Model calibration**

| Water balance at watershed scale | |
|---|---|
| PET adjustor | 1 |
| **Snow density and snowmelt** | |
| Air temperature adjustor | 0.08 |
| Density of fresh snow | 0.15 |
| **Water flows** | |
| Surface runoff adjustor | 1 |
| Infiltration in FF adjustor | 1 |
| Interflow in FF adjustor | 0.2 |
| Infiltration in A & B adjustor | 2 |
| Interflow in A & B adjustor | 0.05 |
| Infiltration in C1& C2 adjustor | 5 |
| Interflow (base flow) in C1& C2 adjustor | 1.5 |

Excel interface calibration menu




Actual and calibrated model stream discharge (mm/day) from 2000-2004 for (a) Moosepit and (b) Pockwock