

Fishtrap Creek Hydrologic Model Update and Assessment

Final Report

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Table of Contents

Table of Contents	2
Contents of Digital Appendix	2
Abstract	3
Introduction	4
Watershed delineation	5
TOPNET model calibration	8
Model Analysis and Discussion	15
Impervious Surface Increase	27
Conclusions	32
References	33
Use of this memo	33

Contents of Digital Appendix

GIS files:

DEM (merged 30m and lidar data raster – 10m grid cell size, UTM Zone 10)

FTCnetwork112408.shp

FTCsubbasins112408.shp

FTCnodes112408.shp

Streamflow Calibration Deliverables: text file of streamflow at 36 sub-basin locations (cubic-meters/second): *FlowAtStreamNodes_cms112408.txt*. Node values in each column correspond to the sub-basin ID's used in the shapefile *FTCsubbasins112408.shp* available in the compressed file *FTCbasins112408*. Timesteps 1 to 21793 correspond to date values 10/01/1946 to 05/31/2006 available in *DateTime_yymmdd.txt*. A digital appendix of all related model inputs and outputs will be provided by November 7, 2008.

Flow Statistics: From the updated April (2009) calibration using only Abbotsford and Clearbrook stations, the flow volume statistics and hydrographs were delivered in spreadsheet *FVE_042809.xls*. Annual maximum flow values for each node in the U.S., Canada and the Border crossing, respectively, using the calibrated model simulation for the period 1946-2006, in *FlowStats_051309.xls*. The monthly exceedence flows for Front Street, the international border, and Pepin Creek are also available in this spreadsheet.

Abstract

This report describes the Fishtrap Creek update of the surface water quantity hydrologic model, TOPNET, which was originally developed as part of the WRIA1 Watershed Management Project. The model update has increased the spatial discretization of model elements, from one Fishtrap Creek sub-basin within the WRIA1 watershed to 50 sub-basins within the Fishtrap Creek watershed: 29 sub-basins in the US and 21 sub-basins in Canada. The increase in spatial discretization has resulted in an improved representation of the spatial variability of precipitation, as well as land use and soil based parameters in both the U.S. and Canadian portions of the watershed. After updating the hydrologic model, we conducted a new calibration to the observed streamflow measurements. Calibrated results show Nash-Sutcliffe efficiencies greater than 0.7 for model results for Fishtrap Creek at Front Road and close to 0.8 at the International Border for the calibration period between 10/01/1998 and 05/31/2006. These statistics, as well as visual analysis of the model hydrograph show that the updated model and calibration are a good representation of the hydrologic system. Using a historic climate record of 60 years, the simulated water balance illustrates the mean monthly relationships among precipitation, baseflow, soil storage, surface runoff, and irrigation demand. Comparing the water balance to the TOPNET model update of Bertrand Creek, model results show the relatively higher soil moisture recharge and baseflow in Fishtrap Creek compared to Bertrand Creek. The updated model developed in this work can be used to understand the potential effects of proposed management solutions developed to address the high flow flooding known to occur in the watershed.

Introduction

This work updates the Fishtrap Creek Hydrologic Model developed in the WRIA1 Watershed Management Project (Tarboton, 2007) by focusing on the following activities: sub-basin delineation with additional node locations, and calibration to observed streamflow at the international border and near the watershed outlet close to Front Street, Lynden. All spatial data inputs of the WRIA1 Watershed Management Project were re-processed for the extent of Fishtrap Creek. The data inputs that are the same as the WRIA1 project are the precipitation and temperature time series (end date 5/31/2006). The location of additional nodes for increased sub-basin delineation was determined based on each stream and tributary crossing of the international border and street crossings. The model parameterization based on soils was updated based on available SSURGO soils information (Soil Survey Staff, 2008) and preliminary groundwater model work provided by Diana Allen. The model parameterization based on land use and vegetation was updated only in the Canadian portion (Koole and Steensma, 2007).

Observed streamflow data was collected and analyzed for use in the calibration of the updated Fishtrap Creek model. The two calibration locations are Fishtrap Creek at Front Street, and Fishtrap Creek at the International border. The observed data for Pepin Creek was used for model validation, but these data are limited to only the irrigation season. The model calibration was conducted with an automatic calibration algorithm called MOSCEM (Vrugt et al., 2003), which is a multi-objective global optimization software tool. The model results at both calibration locations were very good, especially at the international border. Comparatively, the Bertrand Creek model update did not do as well at the international border, while the Fishtrap Creek model update was able to simulate at both the border, the watershed outlet, and capture the increase in soil storage and baseflow.

Watershed delineation

The extent of the digital elevation model grid includes the Canadian and U.S. portions of Fishtrap Creek, Bertrand Creek, and Kamm Creek. In the Canadian portion, the 30 m DEM from the WRIA1 portion was used. In the U.S portion, lidar data resampled to 10 m grid cell size was used. To force the Fishtrap Creek watershed delineation to match the current streamflow drainages, the sub-basins of the three creeks were delineated simultaneously (approximately 1000 sub-basins). The sub-basins known to drain to Fishtrap Creek were selected from the surrounding sub-basins using the Double Ditch-Bertrand Creek border to the west, the Kamm Creek border to the south-east, and including the Judson Lake drainage in the northeast of the watershed.

Next, the DEM was altered to create digital canyons where ditches and stream channels exist, and to create a wall around the sub-basins selected as within Fishtrap Creek. Because there is no GIS ditch information for Canada, the natural flow lines were connected to the ditch lines at the U.S. border using estimates based on the aerial imagery available on Google Earth. A field visit to the border was used to map the border ditch and stream crossings. There was a node, or model output location, created at each border crossing and most road crossings (Figure 1). The updated basin delineation for Fishtrap Creek, shown in Figure 2, can be considered an improvement on the WRIA1 Fishtrap Creek boundary due to the use of lidar data in the U.S. and improved attention to altered streamcourses and the resulting effect on the drainage of the system.

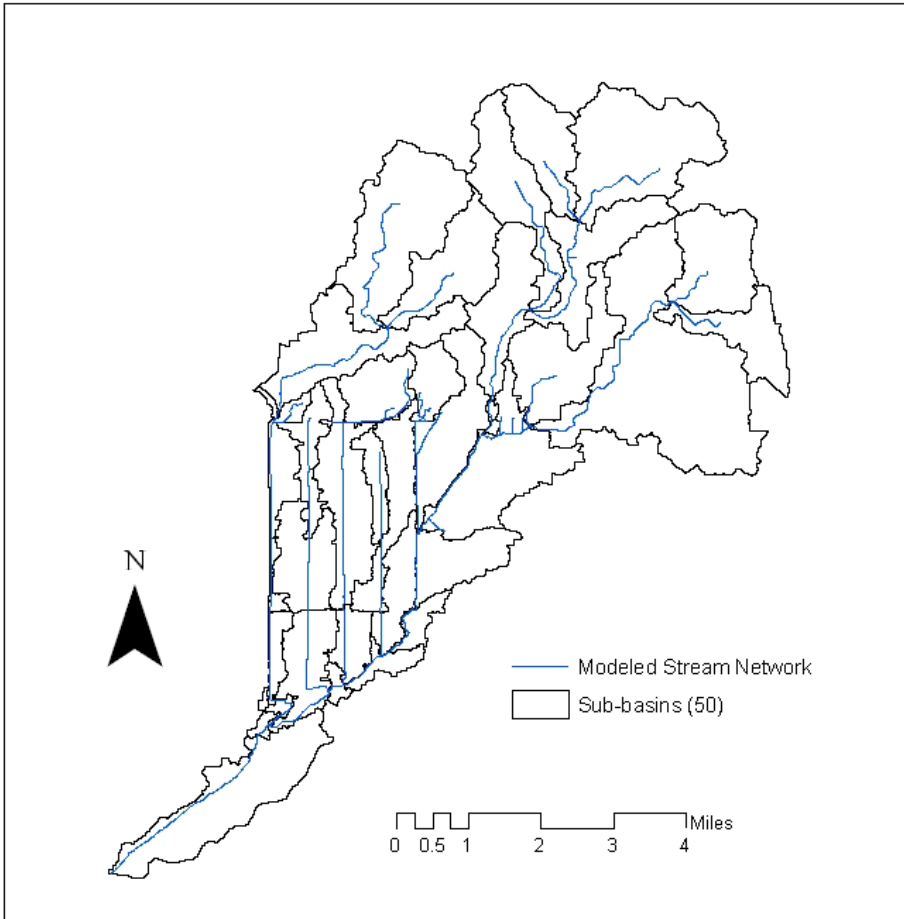


Figure 2. Updated TOPNET model delineated sub-basins.

TOPNET model calibration

The distributed rainfall-runoff model, TOPNET, has been successfully compiled and setup for Fishtrap Creek and linked to the automatic calibration algorithm, MOSCEM. The model calibration length was 2799 daily timesteps, from 10/01/1998 to 05/31/2006. The model calibration was repeated four times to test that the parameters were converging to a global minimum, or the minimum possible difference between the calibrated model and the observations. While a global minimum cannot be guaranteed, each of the four tests converged relatively quickly (within approximately 1000 model iterations) to approximately the same parameter values. Seven parameters were calibrated: saturated store sensitivity (f), surface saturated hydraulic conductivity (k0), drainable porosity (dth1), plant available porosity (dth2), depth of soil zone (soilc), transmissivity (trans), and impervious fraction (impf).

Calibrated results show Nash-Sutcliffe (Nash and Sutcliffe, 1970) efficiencies greater than 0.7 for model results for Fishtrap Creek at Front Road (Figure 3) and greater than 0.8 at the International Border (Figure 4) for the calibration period between 10/01/1998 and 05/31/2006. The Nash-Sutcliffe results at Pepin Creek, less than 0.2 (Figure 5), are not as good as the Fishtrap Creek results, but this is a seasonal gage, so it is not possible to compare how the high flows are matching or include this gage in the calibration. The model was first calibrated using multiple objectives of two locations and found a trade-off between underestimation of peak flows at the international border and overestimation of flows at Front Street. Using multiple locations, the model could not fit well simultaneously at Front Street and the border using the same set of parameter multipliers. Specifically, although the NSE statistic was close to or better than 0.7, the tradeoff which caused an underestimation of peaks, apparent when studying the simulated hydrograph, was unacceptable for using the simulation results in a flood forecasting application.

After optimization tests using a multiple objective calibration at Front Street and the international border, a two-step calibration was conducted. The best simulations resulted from first calibrating the model using Fishtrap Creek streamflow at the

International border as an objective. Next, the simulated streamflow of the model calibrated to the streamflow at the border were used as boundary conditions to a model calibrated to streamflow at the Front St. location. With this two-step calibration, the NSE statistics was improved to $NSE = 0.785$ at Front. Street and $NSE = 0.834$ at the international border (Figures 4 and 5). Figure 6 shows the calibrated model results at Front Street for the high flow events of the 2004 water year, Figure 7 gives the results for the same time period at the international border.

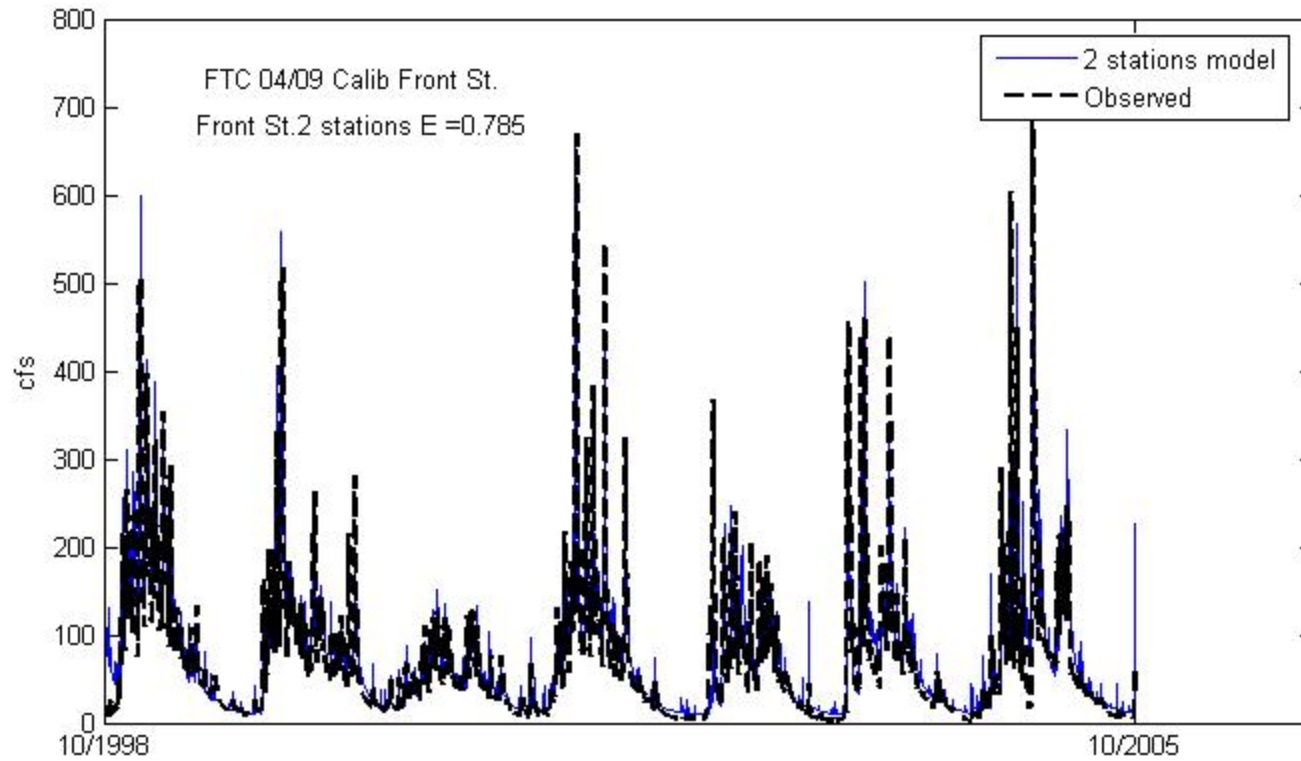


Figure 3. Fishtrap Creek at the Front Road - calibrated streamflow model.

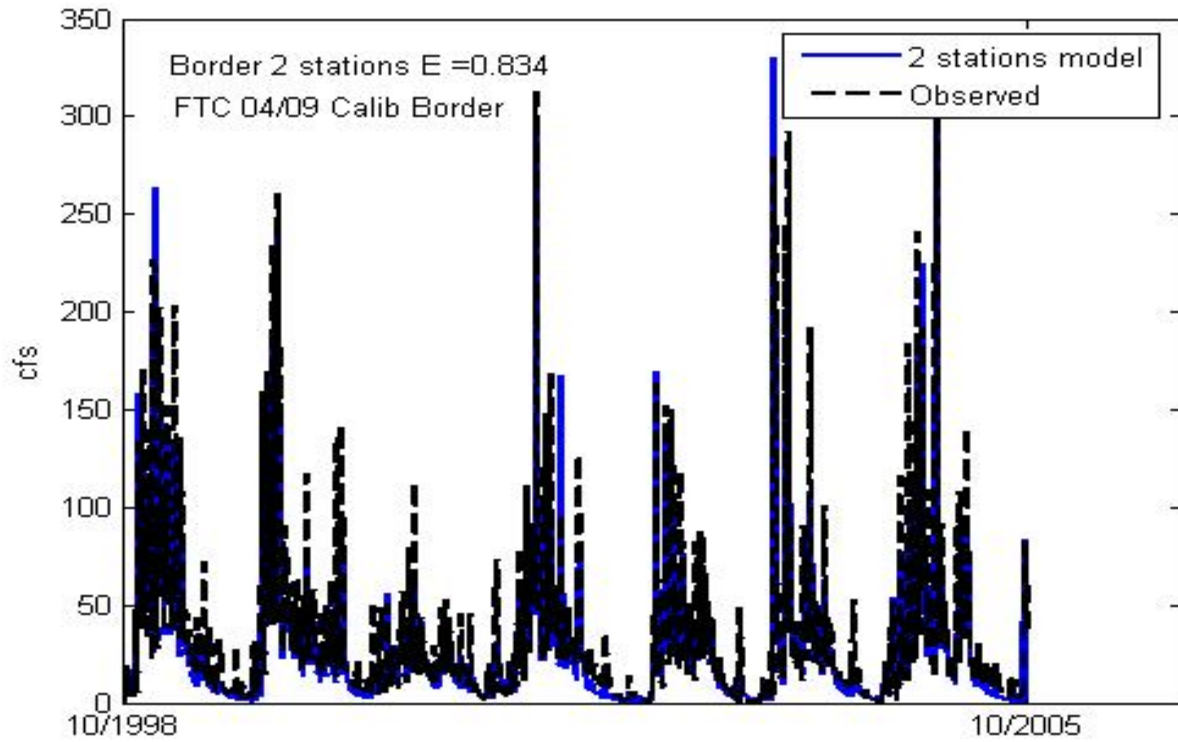


Figure 4. Fishtrap Creek at the International border - calibrated streamflow model.

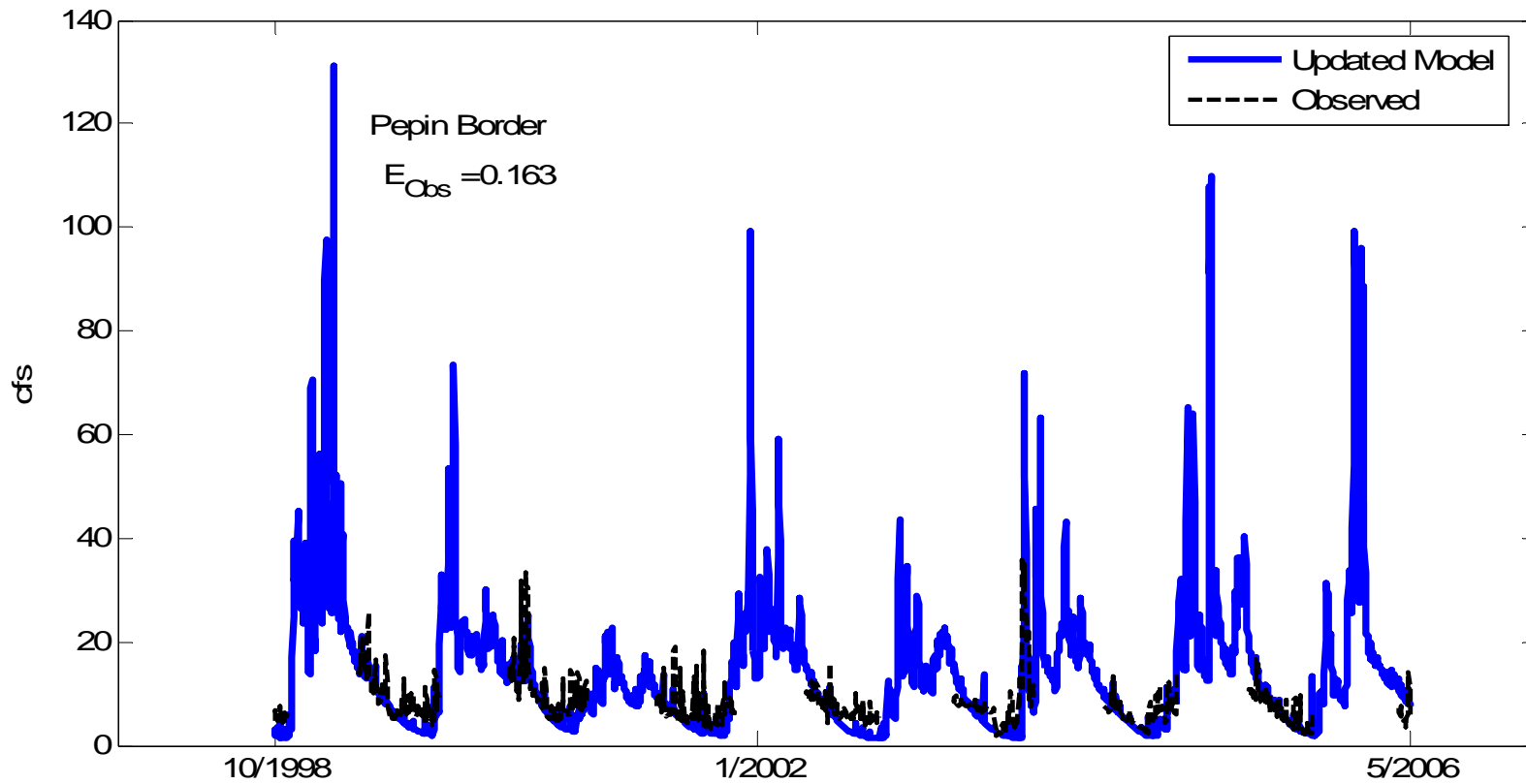


Figure 5. Pepin Creek at the International Border - calibrated streamflow model.

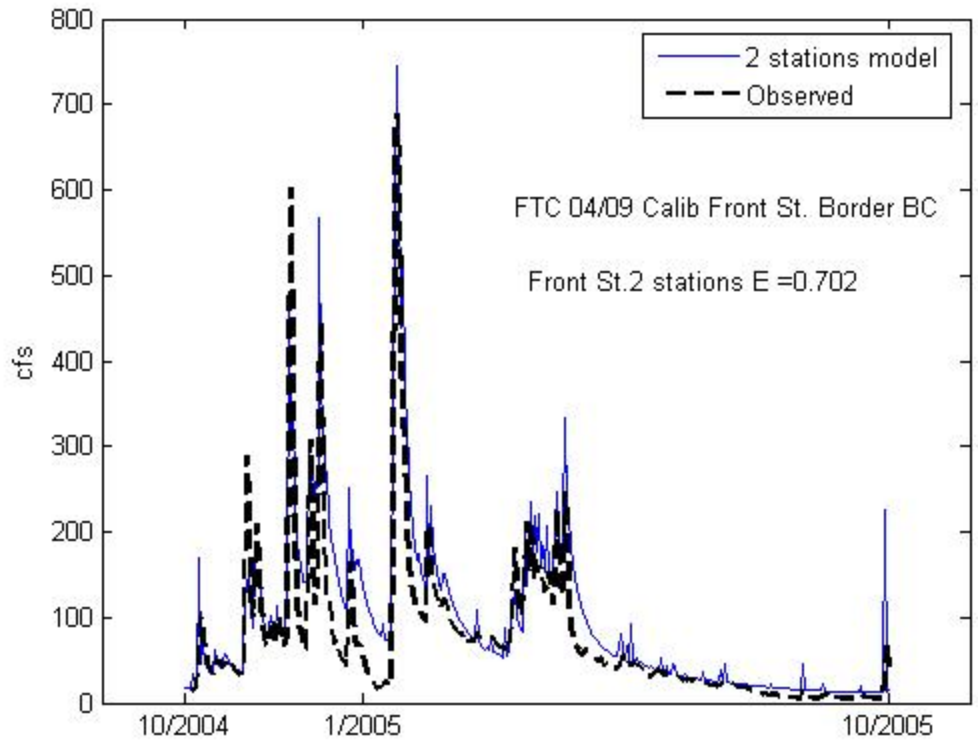


Figure 6. The calibrated model results at Front Street for the 2004 water year.

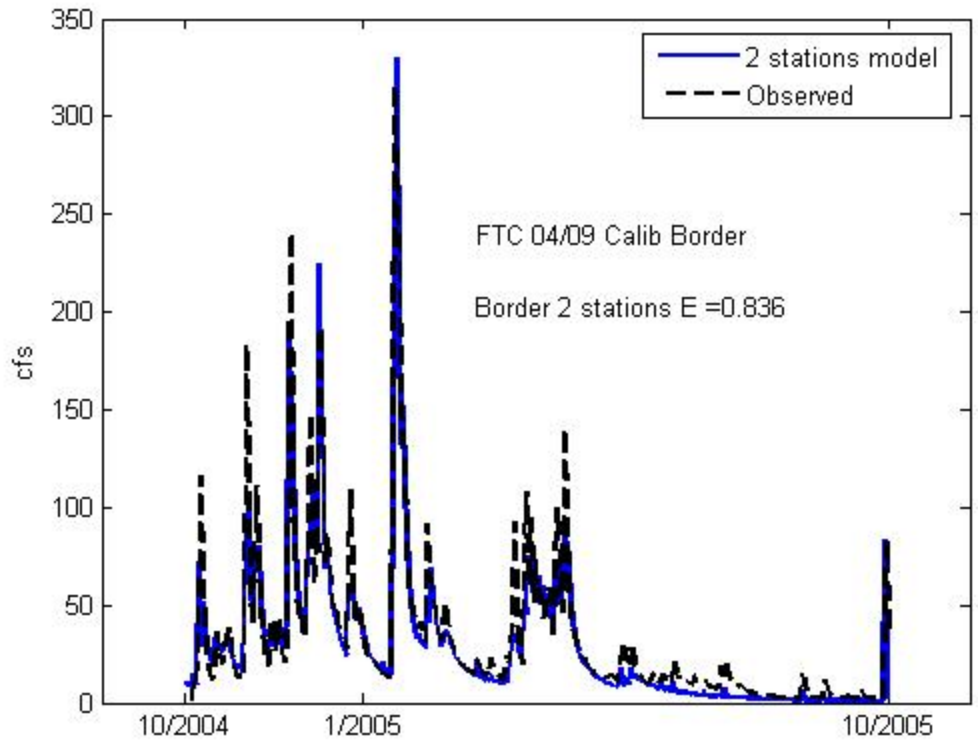


Figure 7. The calibrated model results at the international border for the 2004 water year.

Model Analysis and Discussion

Using historic climate data and calibrated model simulations from 1946-2006, Table 1 presents the exceedence probability flows for each month for Fishtrap Creek at Front Street; Table 2 for Fishtrap Creek at the international border; and Table 3 for Pepin Creek at the international border. Interestingly, the highest flows occur during February at Front Street and Pepin Creek, but during December at the international border. Table 4 gives the observed and best fit calibrated model mean monthly streamflows from the calibration time period 1998-2006. The observed January streamflows of Fishtrap Creek at Front Street during the calibration time period was close to the 40% exceedence probability flows given historical climate data inputs (1946-2006) for the best fit calibrated model. The observed January streamflows at the international border were between 25%-30% exceedence probability flows for the calibration period. Future work should compare these simulation differences compared to the flows used for culvert sizing based on factors of safety.

Flow volume error (FVE) was calculated as the monthly average observed flows minus the monthly average modeled flows, divided by the monthly average modeled flows (Equation 1) from 10/01/1998 to 05/31/2006. Figures 8 and 9 show the monthly FVE at Front Street and at the international border as a percent of observed flow and in acre-ft, respectively. These figures illustrate that, in general, the model simulation is higher than observations at Front Street. For the high flow months of December, January, and February, on average, the model simulations at Front Street are 28.5 cfs higher than the observations. In general, the model is lower than the observations at the international border. For the high flow months of December, January, and February, on average, the model is 4 cfs lower than the observations at the international border (Table 4).

$$MFVE_{month} = \left(\frac{\frac{1}{n} \sum_{i=1}^n Obs_t - \frac{1}{n} \sum_{i=1}^n Mod_t}{\frac{1}{n} \sum_{i=1}^n Obs_t} \right)_{month} \quad (1)$$

The average monthly water balance using model simulations of Fishtrap Creek at Front Street from the years 1946-2006 was calculated using simulated baseflow, surface flows, actual ET, potential ET, soil storage, and the precipitation time series used for forcing data (Figure 10). Table 6 presents some of the monthly values used to create Figure 10 where Total Streamflow is the Rainfall less the Actual Evapotranspiration (ET) less the storage. This is a water balance without irrigation (studies including irrigation were beyond the scope of work for this project). Positive values of storage indicate a net gain of soil water, and negative values indicate a net loss of soil water from storage. The soil storage and baseflow annual fluctuations are similar to those simulated in Bertrand Creek (Figure 11), except that, Fishtrap Creek has a higher amount of rainfall, relatively higher baseflows, higher soil moisture recharge in the winter and more soil water utilization through the summer months. The water management issues of Fishtrap Creek flooding in the winter compared to Bertrand Creek low flow water limits in the summer are trends captured by the model simulation and reflected in the differences in monthly water balance.

Only improved data inputs and knowledge of the hydrologic system can reduce model uncertainty. However, the use of observed streamflow data at the international border has decreased the uncertainty of model simulations at that location compared to using a calibration fit only to observed data at the watershed outlet (using Front Street data alone). Because of the spatial vicinity, we can assume that the model simulations at other ungauged border locations are also improved because of the use of the Fishtrap Creek border data, compared to using data at the outlet alone. With the multiple objective optimization results which underpredicted at the international border and overpredicted at Front Street, suggests that the apriori parameterization needs to be refined since one set of parameter multipliers did not give as good of simulations as using two sets.

Besides the apriori parameterization, the model results may be improved with improved rainfall data from a gridded data source, such as PRISM data. Our model

inputs used a distance algorithm to determine the weighting of Clearbrook and Abbotsford climate data for each sub-basin. If climate in the U.S. sub-basins is more similar to Abbotsford than Clearbrook due to weather patterns, the lower Clearbrook rainfall data inputs would affect the streamflow simulation outputs. In the final results, we used one parameter multiplier set for Fishtrap Creek drainages north of the border, and then optimized for a second set for drainages south of the border using a nested optimization approach. Future work using observed streamflow and climate data for dates after 05/31/2006 should be used to validate this model calibration and assessment of uncertainty.

Table 1. Fishtrap Creek at Front Street exceedence flows (cfs) using simulated streamflow from 1946-2006.

Exceedence	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.01	189.8	382.8	544.6	558.6	566.0	394.3	241.9	158.3	134.4	81.0	60.2	85.5
0.04	116.1	250.2	351.5	385.2	368.9	246.0	178.0	116.2	83.0	50.0	32.8	46.8
0.05	106.0	235.0	328.3	366.2	338.0	228.4	167.6	110.5	74.2	44.9	30.8	41.0
0.1	74.5	180.6	259.4	289.0	263.8	191.0	137.0	90.2	56.6	34.7	24.5	31.6
0.15	60.2	152.4	224.7	243.3	228.0	166.7	121.1	78.1	47.2	29.9	22.1	25.9
0.2	50.7	132.3	194.8	216.1	202.2	150.5	110.8	70.4	42.7	26.9	20.3	22.7
0.25	43.7	117.7	176.9	194.5	181.1	136.5	102.3	64.3	39.4	25.2	19.0	20.5
0.3	37.9	104.1	161.5	177.0	166.4	127.1	95.7	59.0	36.4	23.8	18.0	19.1
0.35	33.5	94.2	148.7	161.5	155.0	119.4	89.4	55.0	34.3	22.8	17.2	17.8
0.4	30.0	85.5	137.5	148.7	143.9	111.5	84.5	51.5	32.5	21.8	16.4	16.7
0.45	26.6	76.7	126.1	136.9	135.5	104.9	80.8	48.9	30.9	21.0	15.8	15.7
0.5	24.1	69.8	115.2	125.1	123.7	100.1	76.4	46.7	29.8	20.3	15.2	14.9
0.55	22.0	62.6	105.3	115.8	114.8	95.6	72.9	44.4	28.7	19.6	14.7	13.9
0.6	19.8	56.5	96.6	107.0	107.6	90.0	69.7	42.5	27.7	18.9	14.3	13.2
0.65	17.8	50.8	87.9	98.8	101.3	84.8	66.2	40.5	26.6	18.3	13.9	12.6
0.7	16.2	45.0	79.8	90.4	94.0	80.1	62.5	38.6	25.6	17.6	13.4	12.2
0.75	15.4	40.0	72.5	83.2	87.6	75.1	59.4	36.8	24.6	17.0	13.0	11.8
0.8	14.4	35.2	65.9	74.9	81.4	69.6	55.9	35.2	23.5	16.3	12.6	11.3
0.85	12.7	29.4	57.2	67.8	74.6	65.2	52.9	33.4	22.3	15.6	12.2	10.9
0.9	11.5	23.7	47.1	58.2	64.8	60.0	49.2	31.4	21.1	14.7	11.5	10.4
0.95	9.9	13.5	35.8	45.9	52.9	54.1	44.2	29.0	19.5	13.5	10.4	9.6

Table 2. Fishtrap Creek at the International Border exceedence flows (cfs) using simulated streamflow from 1946-2006.

Exceedence	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.01	120.1	173.3	219.6	201.0	190.8	123.3	77.9	48.1	46.0	25.2	16.9	39.3
0.04	72.4	109.2	132.5	135.3	115.0	72.6	51.2	32.2	21.9	11.7	9.5	22.5
0.05	67.6	102.0	120.9	123.8	106.4	68.0	48.9	30.7	19.8	10.5	8.5	19.8
0.1	46.8	81.5	92.8	97.5	82.8	55.1	39.4	24.7	14.6	7.7	5.7	13.2
0.15	35.1	69.4	78.5	79.6	68.9	46.9	34.0	21.1	12.0	6.4	4.3	10.1
0.2	28.7	59.1	67.6	69.3	59.3	40.9	30.2	18.8	10.4	5.4	3.7	8.3
0.25	24.5	52.7	60.3	61.4	52.3	36.2	27.1	16.4	9.3	4.8	3.1	7.0
0.3	20.7	47.4	53.8	55.0	47.2	33.1	24.7	14.4	8.2	4.4	2.8	6.0
0.35	17.4	43.4	49.5	49.1	42.8	30.3	22.7	13.2	7.5	4.0	2.6	5.3
0.4	15.0	39.7	45.5	43.9	39.4	28.2	21.3	12.1	6.9	3.7	2.4	4.6
0.45	13.0	36.5	41.5	39.6	36.2	26.3	20.0	11.2	6.3	3.4	2.2	3.6
0.5	10.9	32.8	38.0	36.1	32.7	24.7	18.8	10.4	5.9	3.2	2.1	2.8
0.55	9.2	29.7	34.0	32.6	30.0	23.2	17.7	9.5	5.4	2.9	1.9	2.4
0.6	7.9	26.7	30.9	29.4	27.9	21.6	16.6	8.9	5.0	2.7	1.8	2.1
0.65	6.7	23.9	28.4	26.4	25.4	20.2	15.5	8.3	4.6	2.5	1.7	1.8
0.7	5.8	21.4	26.4	23.8	23.4	18.6	14.4	7.7	4.3	2.3	1.6	1.6
0.75	5.0	18.8	24.3	21.7	21.4	17.3	13.3	7.1	3.9	2.2	1.5	1.5
0.8	4.0	16.6	22.2	19.7	19.8	16.0	12.3	6.5	3.5	2.0	1.4	1.3
0.85	3.2	14.3	19.9	17.8	17.6	14.7	11.3	5.9	3.2	1.9	1.3	1.2
0.9	1.8	11.7	17.8	15.5	15.7	13.3	10.1	5.3	2.8	1.7	1.2	1.1
0.95	1.0	5.1	13.9	12.6	12.7	11.7	8.8	4.5	2.5	1.5	1.1	0.9

Table 3. Pepin Creek exceedence flows (cfs) using simulated streamflow from 1946-2006.

Exceedence	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.01	21.4	30.7	48.2	54.1	83.9	60.0	29.6	21.5	17.1	14.0	12.1	12.9
0.04	12.6	23.1	38.4	41.0	46.8	36.3	23.0	17.2	13.8	11.1	9.0	9.1
0.05	11.5	21.1	37.2	39.9	42.9	33.6	22.0	16.7	13.2	10.6	8.7	8.7
0.1	8.7	17.0	32.4	34.9	35.8	26.1	19.4	14.5	11.4	9.0	7.8	7.2
0.15	7.7	14.9	28.9	31.7	31.4	23.5	17.9	13.3	10.3	8.3	7.3	6.7
0.2	6.9	13.3	26.7	29.1	28.0	22.0	16.8	12.5	9.6	8.0	6.9	6.4
0.25	6.4	11.9	24.8	26.9	25.7	20.9	16.0	11.8	9.2	7.7	6.7	6.1
0.3	6.1	10.7	23.1	25.1	24.3	19.8	15.4	11.2	8.9	7.5	6.5	5.9
0.35	5.8	10.1	21.4	23.5	23.2	18.7	14.8	10.7	8.6	7.3	6.4	5.7
0.4	5.6	9.3	19.6	22.2	21.9	17.9	14.2	10.4	8.4	7.1	6.2	5.6
0.45	5.3	8.4	18.0	20.9	20.7	17.3	13.7	10.1	8.1	6.9	6.1	5.4
0.5	5.2	7.8	16.7	19.6	19.7	16.6	13.2	9.8	8.0	6.8	5.9	5.3
0.55	5.0	7.3	15.2	18.4	18.7	15.9	12.8	9.5	7.8	6.6	5.7	5.2
0.6	4.9	6.8	14.0	17.4	17.7	15.1	12.3	9.2	7.6	6.4	5.6	5.0
0.65	4.7	6.3	12.4	16.6	16.9	14.5	11.9	9.0	7.4	6.3	5.4	4.9
0.7	4.6	5.8	10.9	15.4	16.0	14.0	11.6	8.8	7.2	6.1	5.3	4.8
0.75	4.4	5.4	10.1	14.4	15.1	13.2	11.2	8.5	7.0	5.9	5.1	4.6
0.8	4.3	4.9	9.2	13.3	14.3	12.7	10.7	8.3	6.7	5.7	4.9	4.4
0.85	4.1	4.6	7.9	12.1	13.3	12.0	10.2	7.9	6.4	5.5	4.7	4.3
0.9	3.7	4.2	6.7	10.3	12.0	11.3	9.7	7.6	6.1	5.2	4.5	4.0
0.95	3.3	3.6	4.7	8.2	10.5	10.5	9.2	7.0	5.7	4.7	4.0	3.5

Table 4. Observed and simulated average monthly flows for Fishtrap Creek at Front Street and the international border during the calibration period 10/01/1998-05/31/2006.

Front Street	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Observed	39.7	98.0	124.3	153.2	106.9	94.0	75.5	46.7	35.3	16.9	10.6	11.6
Modeled	41.7	99.5	155.0	181.5	133.4	105.4	89.6	54.1	41.3	24.6	19.3	20.1
International Border												
Observed	20.6	45.0	55.1	60.8	39.1	36.0	28.7	17.7	13.4	6.9	5.1	6.8
Modeled	21.5	45.2	52.9	55.2	34.9	26.7	22.8	12.0	9.1	3.8	3.5	5.9

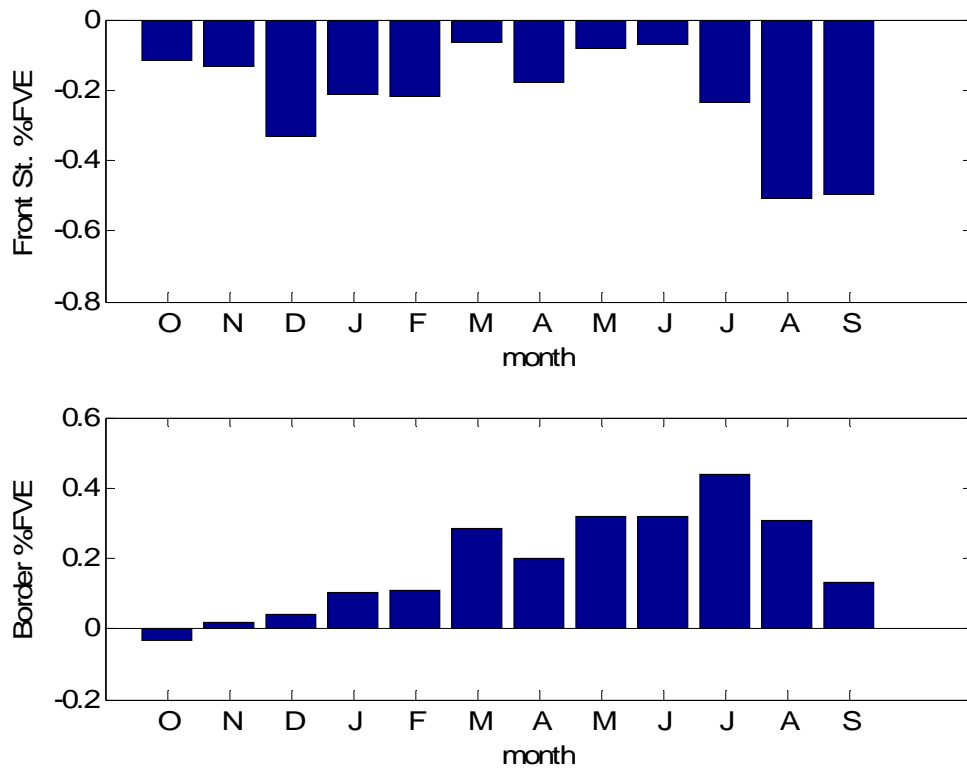


Figure 8. Flow volume error (percent) in each month using observed data from the calibration period 1998-2006.

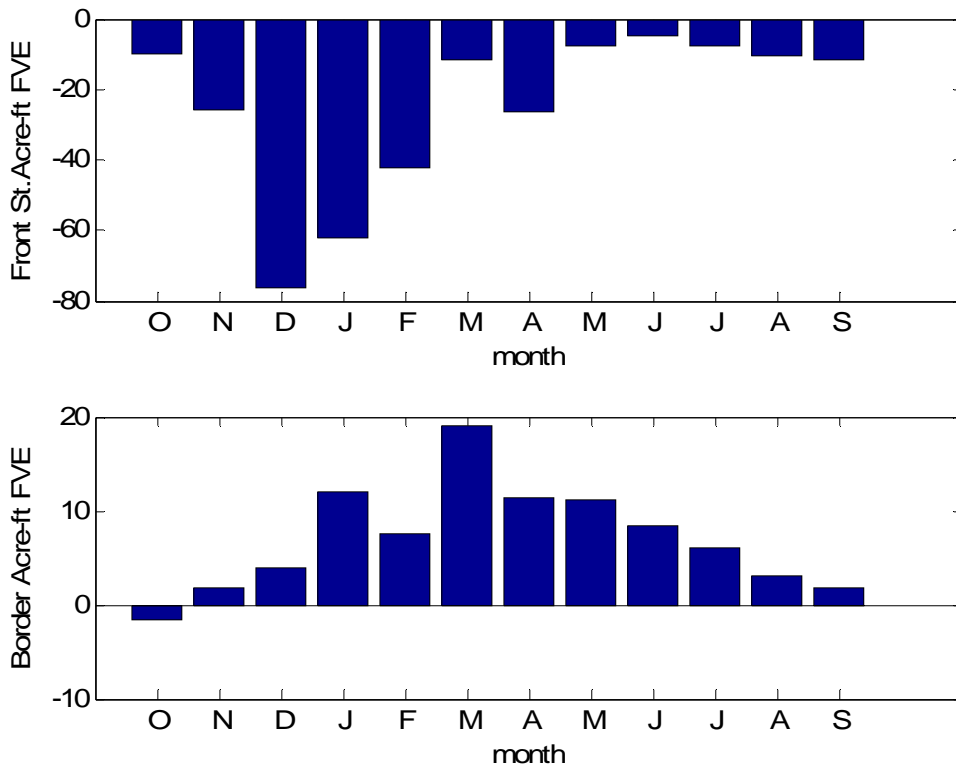


Figure 9. Flow volume error (acre-ft) in each month using observed data from the calibration period 1998-2006.

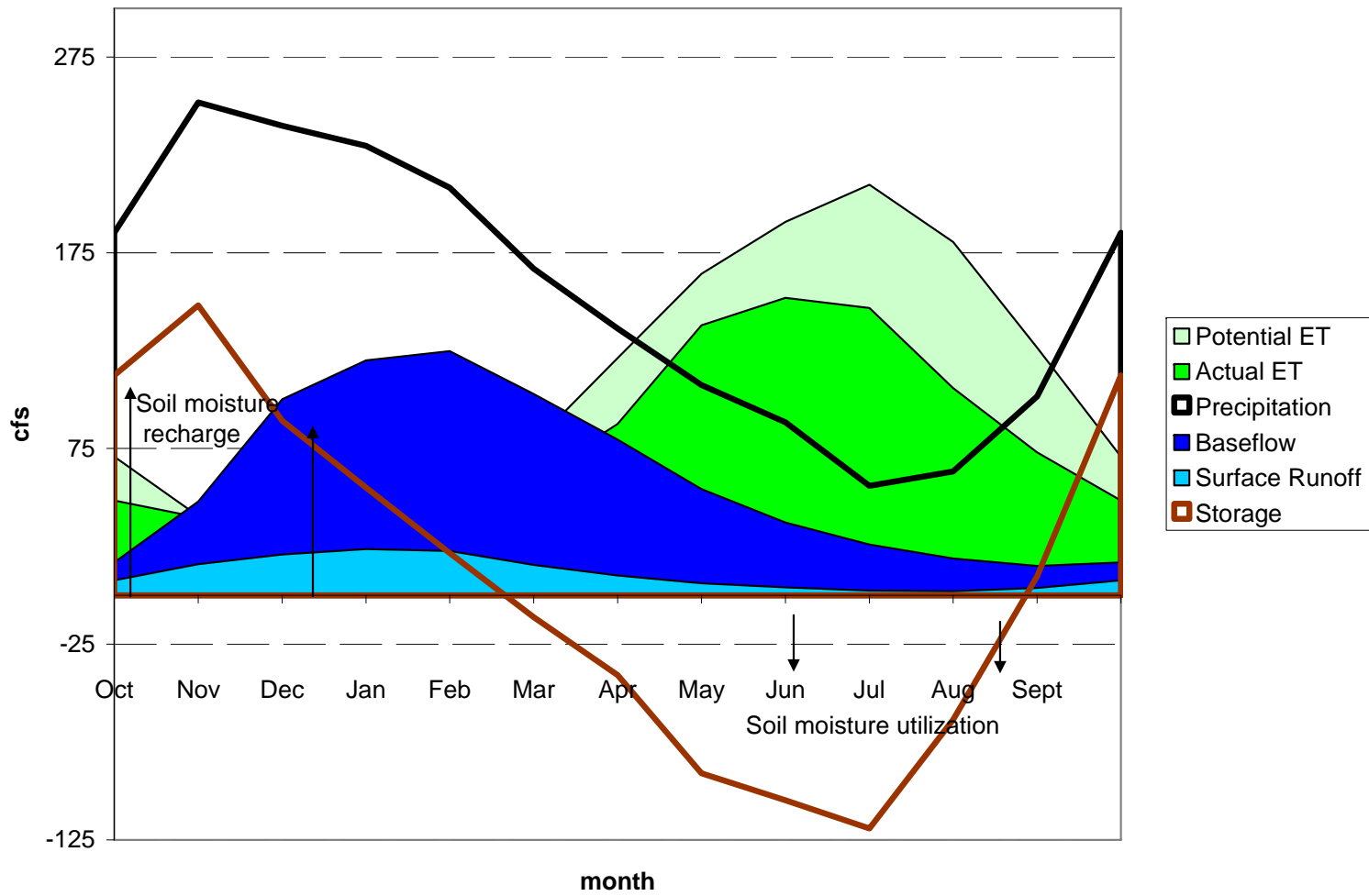


Figure 10. Fishtrap Creek at Front St. calibrated average monthly water balance (1946-2006).

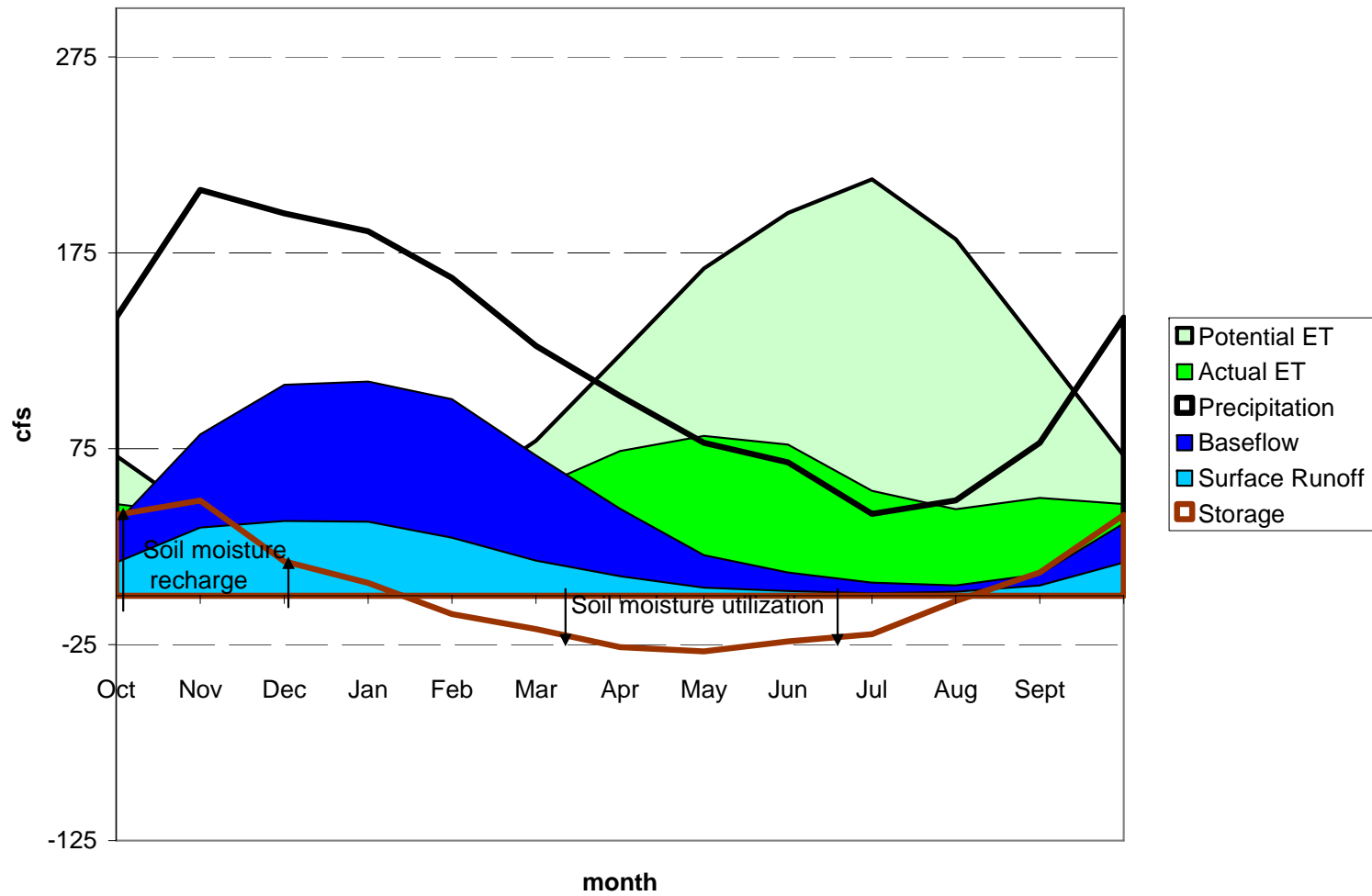


Figure 11. Bertrand Creek model update monthly water balance (1946-2006).

Table 5. Average monthly water balance (1946-2006) of Fishtrap Creek at Front Street. Positive values of storage indicate a net gain of soil water, negative values indicate a net loss of soil water from storage.

cfs	Rain	Total Flow	Actual ET	Storage
Oct	185.3	24.5	48.5	112.4
Nov	251.9	63.9	39.8	148.2
Dec	239.9	121.0	29.7	89.2
Jan	229.7	143.7	31.0	55.0
Feb	208.3	147.3	39.4	21.5
Mar	166.9	118.4	59.7	-11.2
Apr	136.3	89.6	87.6	-40.9
May	107.4	60.4	137.9	-91.0
Jun	88.4	41.2	152.0	-104.8
Jul	55.9	28.3	146.8	-119.2
Aug	63.3	20.9	106.0	-63.6
Sept	101.6	18.8	73.0	9.7

Impervious Surface Increase

To test the effect of potential future land use in the Canadian portion of the watershed, we used the updated and calibrated model with a varying increase in percent impervious surface. This is a calibrated parameter: the original parameter values for each sub-basin ranged from 0-35%, the calibrated parameters range from 0-12%. We doubled and tripled the calibrated impervious surfaces from the calibrated values. Increasing the impervious surface parameter increases the streamflow peaks, and consequentially decrease the low flow, as shown in Figure 14. Although, the impervious surface changes give different hydrograph timeseries, statistical analysis shows results not included here, there is no change the monthly average or predicted exceedence flows.

The percent impervious parameter is not one of the most sensitive TOPNET model parameters. More sensitive parameters include saturated hydraulic conductivity (derived from soils data shown in Figure 15) and porosity (derived from soils data shown in Figure 16). Additionally, the percent impervious parameter is based on the land use information shown in Figure 17. These data show the Canadian portion of the watershed dominated by ‘Cleared Land’, ‘Rural Residential’, and ‘Forest’ and may not be a realistic accounting for agriculture in the Canadian portion of the Fishtrap Creek watershed. The quality of the spatial representation of the percent impervious parameter depends on the quality of the land use distribution used to determine the area of impervious surfaces in each sub-basin.

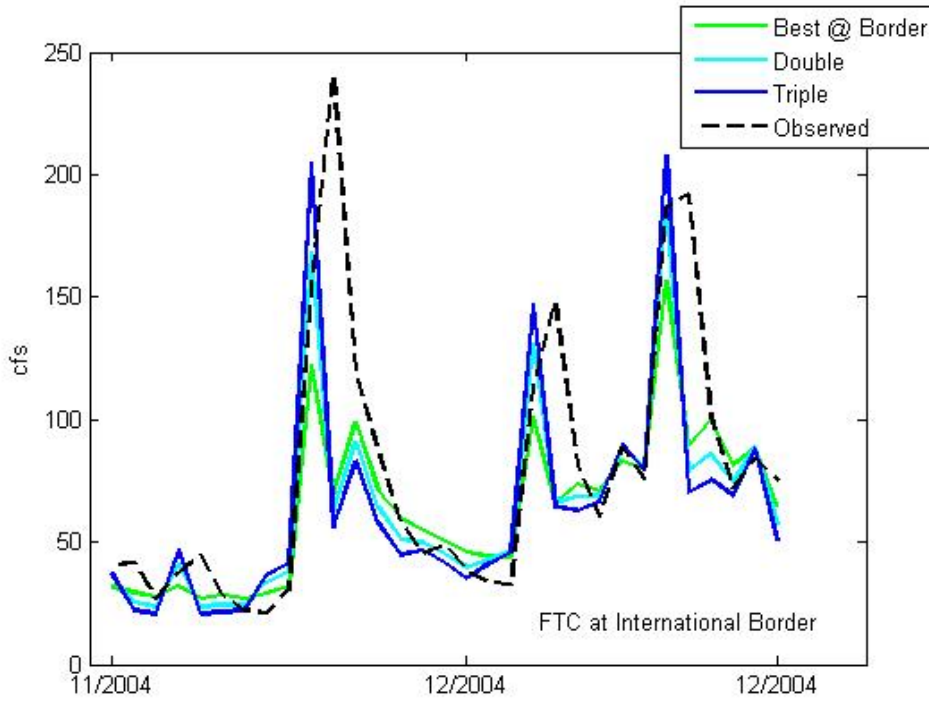


Figure 14. Results of increased impervious surfaces on Fishtrap Creek streamflow at the international border for a series of high peak flow events in the winter of 2004.

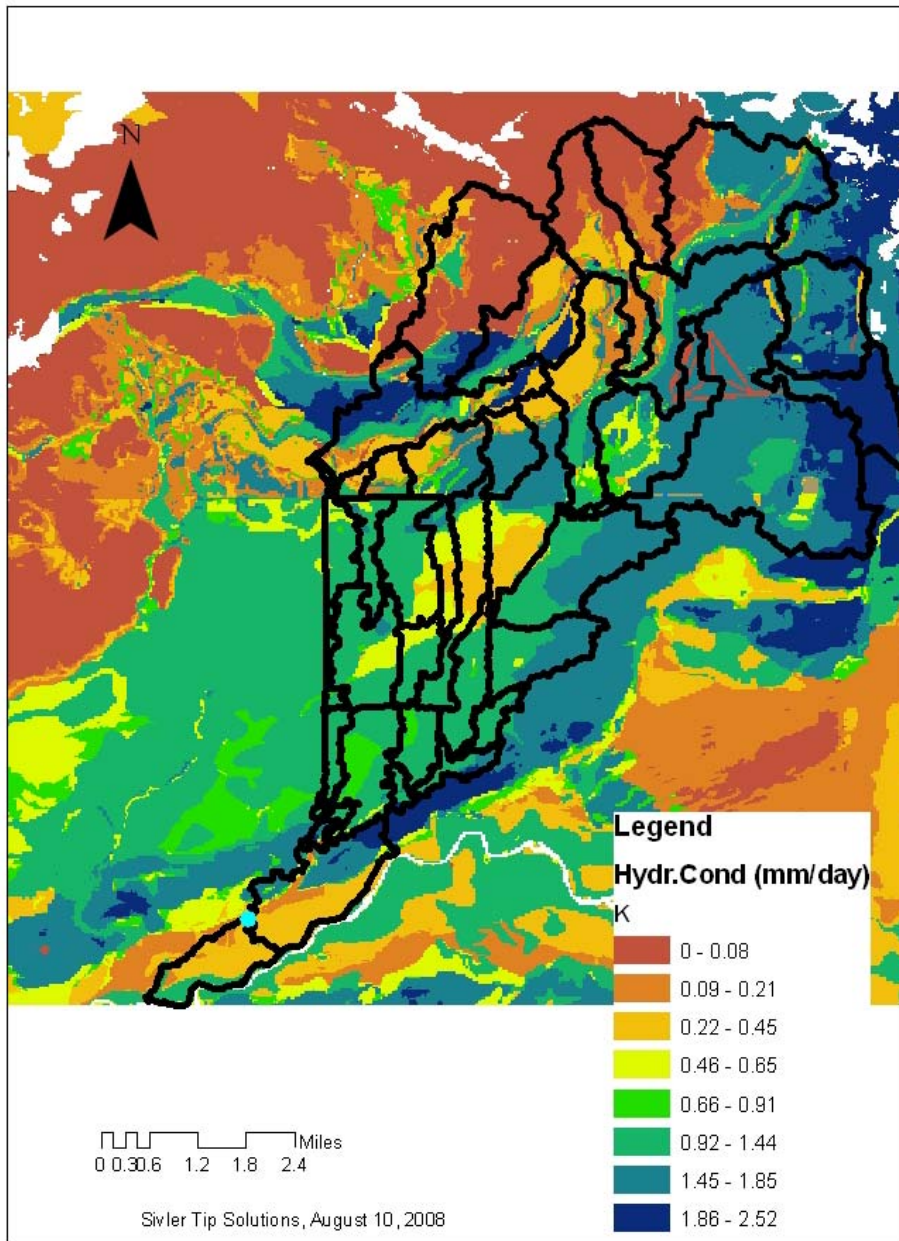


Figure 15. Hydraulic conductivity map for Fishtrap Creek.

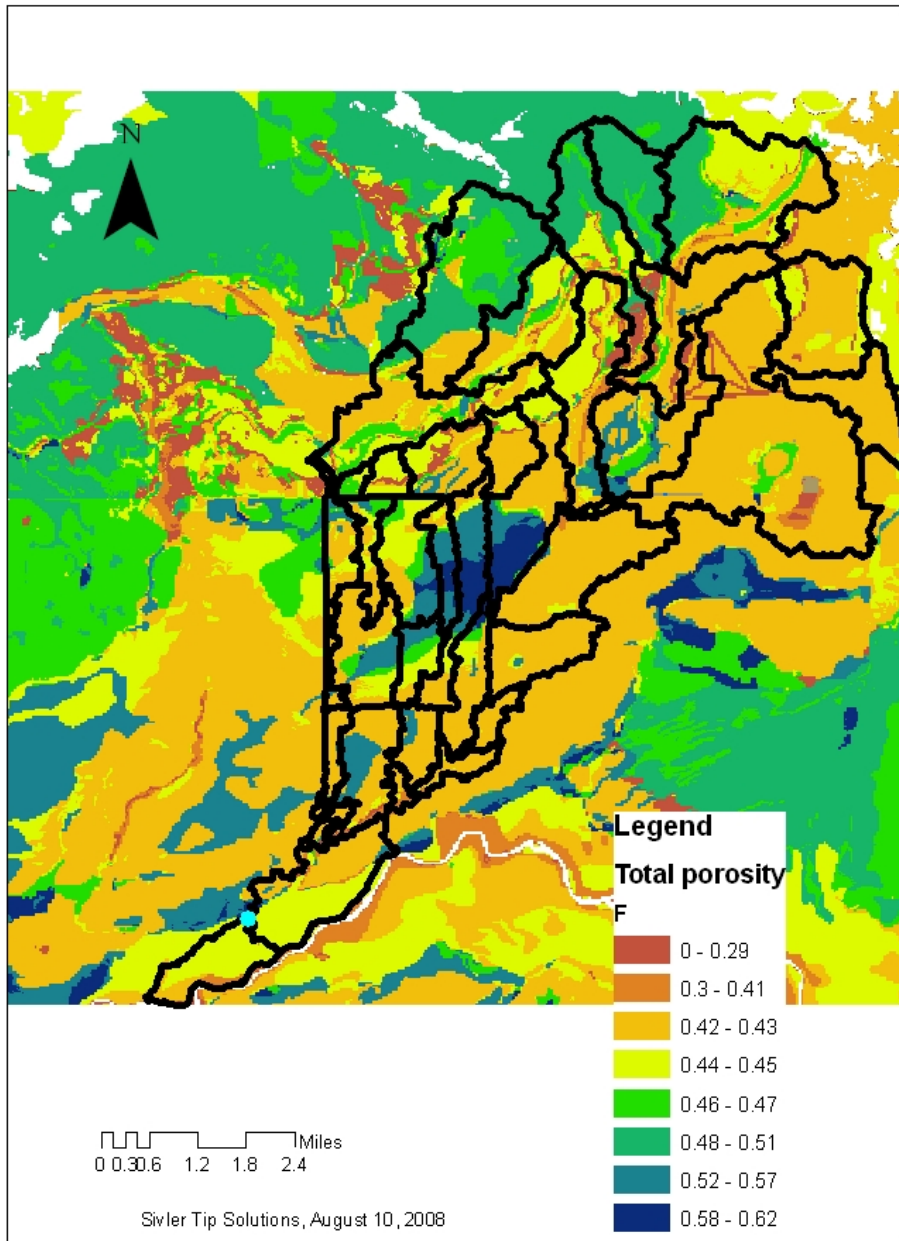


Figure 16. Total porosity map for Fishtrap Creek.

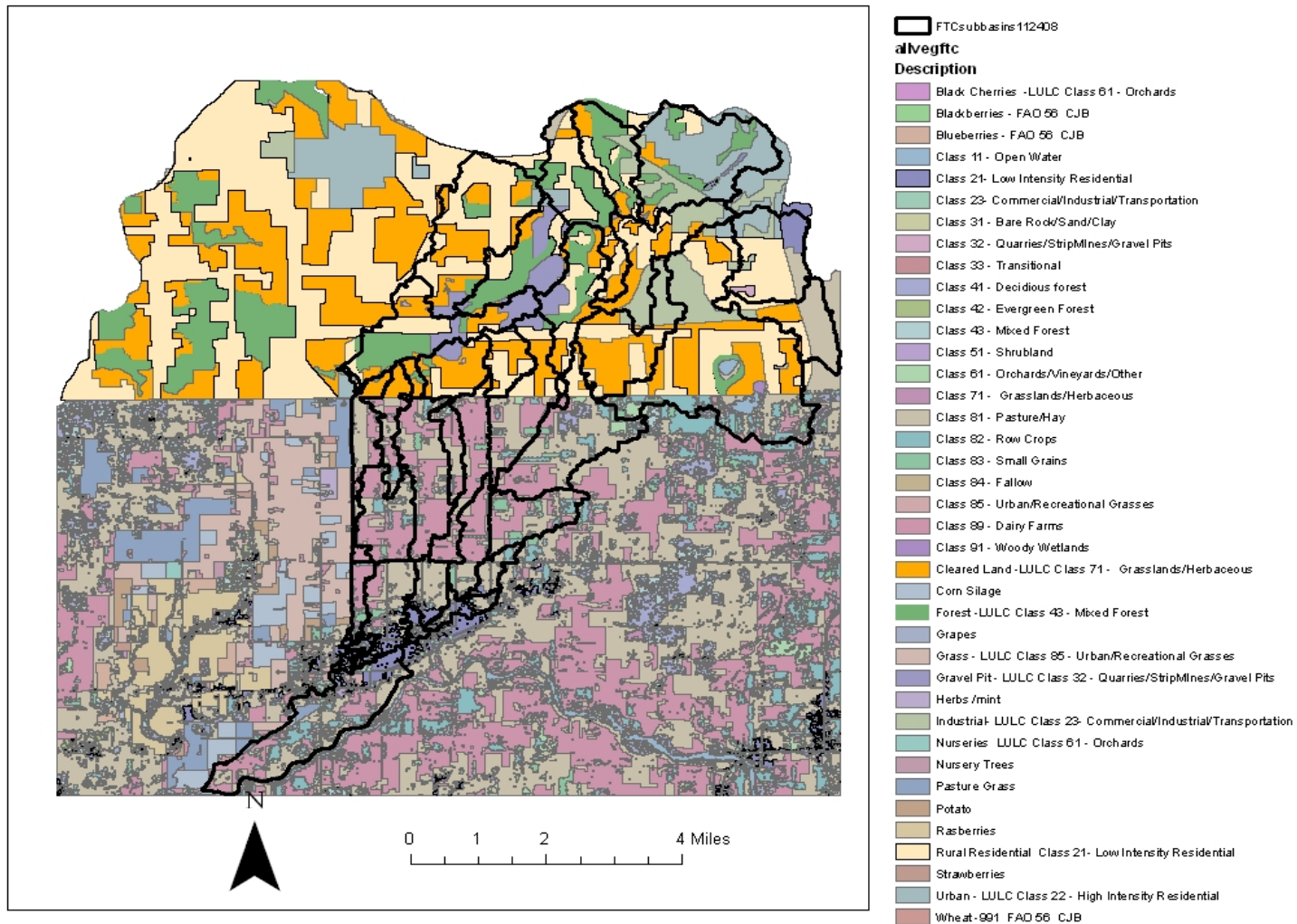


Figure 17. Land use map for Canadian and U.S. portions of Fishtrap Creek and Bertrand Creek.

Conclusions

This project updates the TOPNET hydrologic model for the Fishtrap Creek watershed originally developed in the WRIA1 Watershed Project. The main difference between the models is the increased spatial discretization of the model focused on Fishtrap Creek compared to the WRIA1 model developed for the entire Nooksack basin, and a new calibration focusing on fitting the model to both Fishtrap Creek at the international border and at Front Street in Lynden. The increase in nodes and sub-basins at key locations, including border and road crossings, will allow use of streamflow simulations and statistics as inputs to channel routing models.

Generally, the model simulations of peak flows are higher than observations at Front Street, and lower than observations at the international border – but overall, the model is a good representation of the watershed hydrology with Nash-Sutcliffe efficiencies close to 0.7 at both locations. Additionally, the average monthly water balance captures the higher soil water storage and baseflow that occurs in the winter months, which leads to flood control water management issues. Studies of the effect of land use change on percent area of impervious surface showed a relative insensitivity to changes. Although increased impervious surfaces was shown to increase peak flows, the available land use data for Canada may not be sufficiently detailed to fully capture the effects of land use change in a model parameterization.

Future work that could build on this study includes using observed streamflow and climate data for dates after 05/31/2006. This would help validate the model calibration and help with an assessment of uncertainty. Future work should also compare the differences in model simulations to the flows used for culvert sizing based on factors of safety. Additionally, more detailed land use information and future land development may improve the estimate of saturated hydraulic conductivity and/or porosity and consequently improve the model results.

References

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Use of this memo

Silver Tip Solutions, LLC. has prepared this memo for Reichart & E B Engineering Inc. and their agents for use in the understanding of the hydrologic conditions of Fishtrap Creek watershed. The scope of our work does not include services related to construction or design of water engineering systems. The results presented in this report relate to the probability of streamflow only in the Fishtrap Creek watershed and not any other watershed or system. There are possible variations in hydrologic conditions that may not be represented in this work. Our report, conclusions, and interpretations should not be construed as a warranty of hydrologic conditions. We recommend that Reichart & E B Engineering Inc. and their agents continue to support the collection of data and consultation services to evaluate whether future conditions differ from those anticipated. Incorporation of updated climate, streamflow, groundwater, and water use data into the hydrologic modeling system used in this work may result in different results, conclusions and interpretations than are presented in this report.

Appendix 1: TOPNET Water Management Component

During the WRIA1 Water Management Project (W1WMP), artificial drainage components were incorporated into TOPNET. However, preparing TOPNET water management inputs was beyond the scope of work of this project and the water management input files were removed or set to zero. Future work can be directed at exploring the functionality of the model and to develop reliable and accurate empirically determined drainage coefficients required as inputs. The following parameters would need to be determined for each sub-basin in the model followed by the W1WMP values for the single Fishtrap Creek sub-basin.

1. Tile Drained Fractional Area (W1WMP = 0.03)
2. Ditch Drained Fractional Area (W1WMP = 0.24)
3. Tile Coefficient (W1WMP = 0.00026)
4. Ditch Coefficient (W1WMP = 0.00008)
5. Irrigated Fractional Area (W1WMP = 0.34)
6. Sprinkler Fraction of Irrigated Area (W1WMP = 0.99)
7. Irrigation Efficiency (average) (W1WMP = 0.80)

Based on the information in the Task 4.1 Report (Tarboton, 2007), it is unclear how to best empirically determine the Tile and Ditch coefficients. However, given the results of the Bertrand Creek TOPNET model update and the reliance on groundwater for irrigation in Fishtrap Creek, we do not believe that surface water diversions during the irrigation season have a significant impact on the winter high flow peaks, which are the focus of Fishtrap Creek TOPNET model update.