CANADIAN MOUNTAIN NETWORK

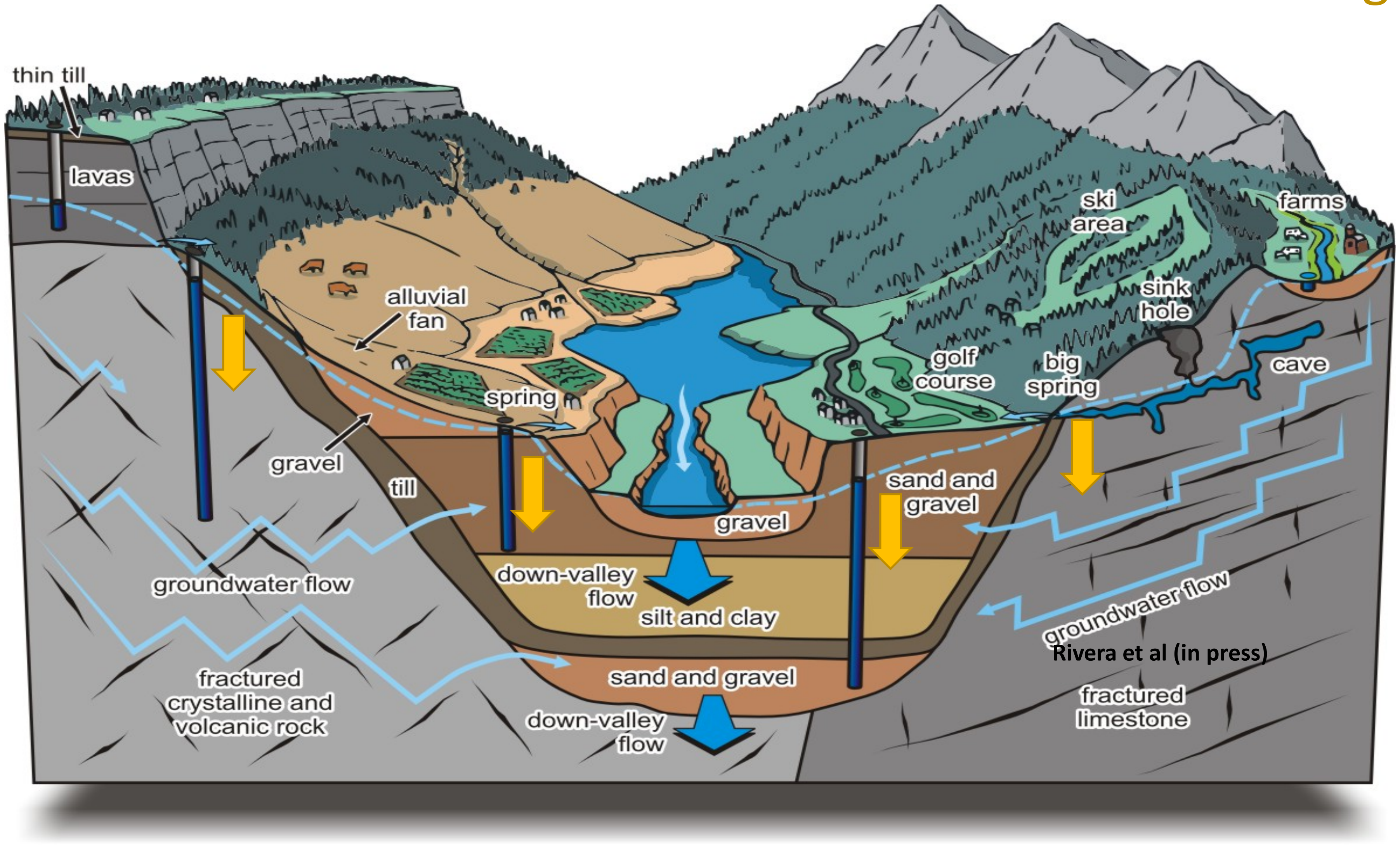
Managing Groundwater Resources in Mountainous Areas: Planning for and Adapting to Drought Conditions

Diana Allen and Adam Mitton

June 23, 2021
CMN knowledge summit

Groundwater in Mountain Regions

What happens during a drought?



Rivera et al (in press)

- Groundwater levels drop
- Wells may go dry
- Lower baseflow to streams
- Potential impacts to environmental flows

Goals of CMN Project

Goal 1: Develop a quantitative drought indicator for groundwater level

Goal 2: Evaluate the performance of the indicator and decision-support tools that are used during water scarcity

Goal 3: Identify drought sensitive aquifers in the Okanagan Basin

April Gullacher, MSc student

Adam Mitton, MSc student

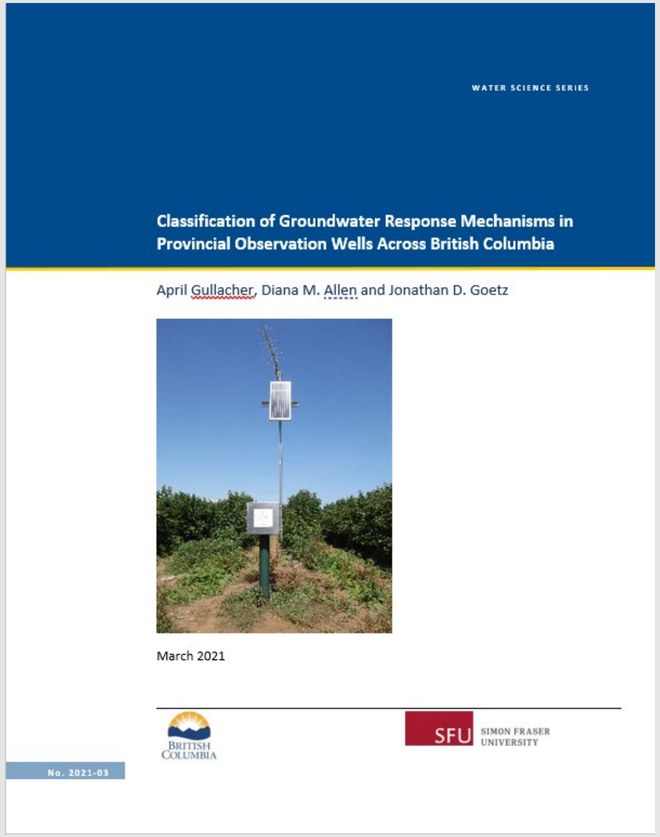
Diana Allen

The Team

- Jon Goetz, Julie-Ann Ishikawa, Robin Pike, Jillian Kelly (ECCS)
- Michele Lepitre, Jacqueline Shrimer, Tyler Anderson (FLNRORD)
- Carl Mendoza (U of A), Tom Gleeson (UVic)
- Anna Sears (OBWB), Tessa Terbasket and Chani Welch (ONA)

Alex Nott,
MSc student

Top 3 Successes


WATER SCIENCE SERIES

Classification of Groundwater Response Mechanisms in Provincial Observation Wells Across British Columbia

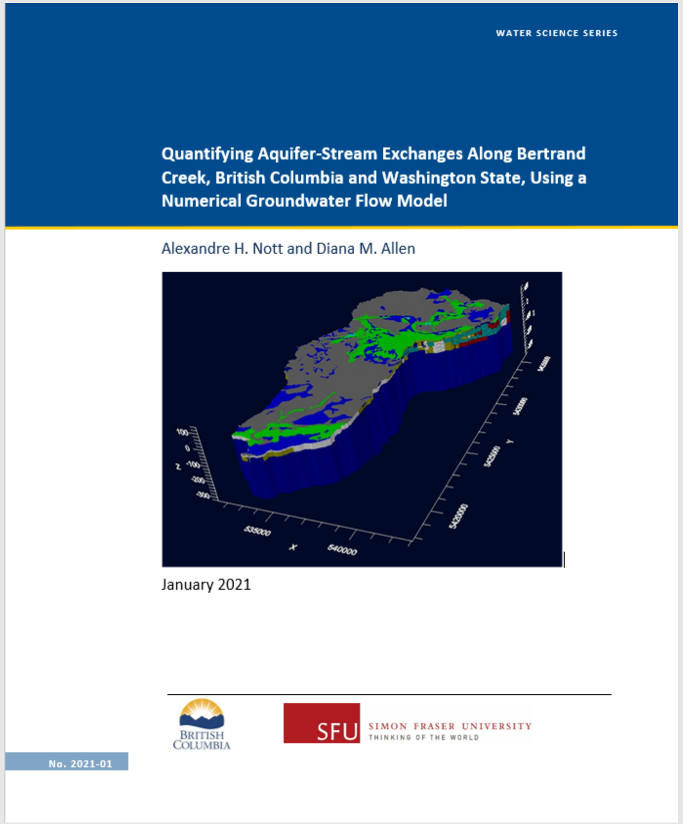
April Gullacher, Diana M. Allen and Jonathan D. Goetz

March 2021

BRITISH COLUMBIA

SFU SIMON FRASER UNIVERSITY

No. 2021-03


WATER SCIENCE SERIES

Quantifying Aquifer-Stream Exchanges Along Bertrand Creek, British Columbia and Washington State, Using a Numerical Groundwater Flow Model

Alexandre H. Nott and Diana M. Allen

January 2021

BRITISH COLUMBIA

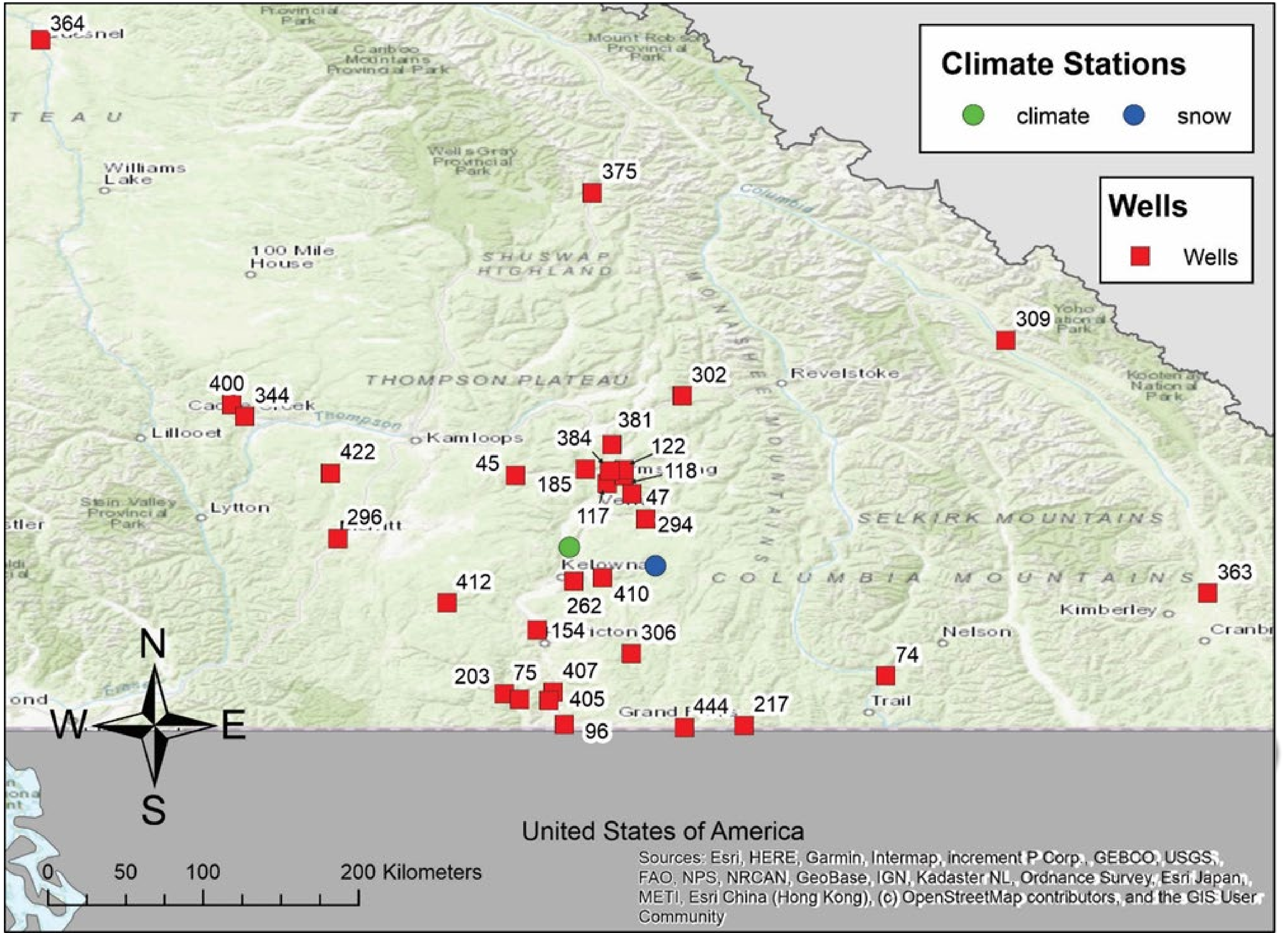
SFU SIMON FRASER UNIVERSITY THINKING OF THE WORLD

No. 2021-01

1. Province-wide classification of groundwater level response types
   - **BC Water Science Series Report** (Gullacher et al. 2021)
2. Modeling exchanges between groundwater and surface water in Bertrand Creek Watershed
   - **BC Water Science Series Report** (Nott and Allen 2020).
3. Highly successful field project to characterize associations between macroinvertebrates, stream conditions and groundwater exchanges.
   - Manuscript for Frontiers in Earth Sciences Journal (Mitton et al. in prep)
   - MSc thesis (Mitton) completion by end of summer.
   - Mitton to begin PhD in September.

Research Outcomes: Okanagan Basin

- April Gullacher is working towards a groundwater level drought indicator that can be used across BC to “predict” whether groundwater levels will be significantly lower than normal due to drought.
- We posed the question, “What climate-related factors have the strongest control on summer groundwater levels?”
- Started with Provincial Observation Wells in South Central BC (2005-2020) and selected wells that had the most complete records.

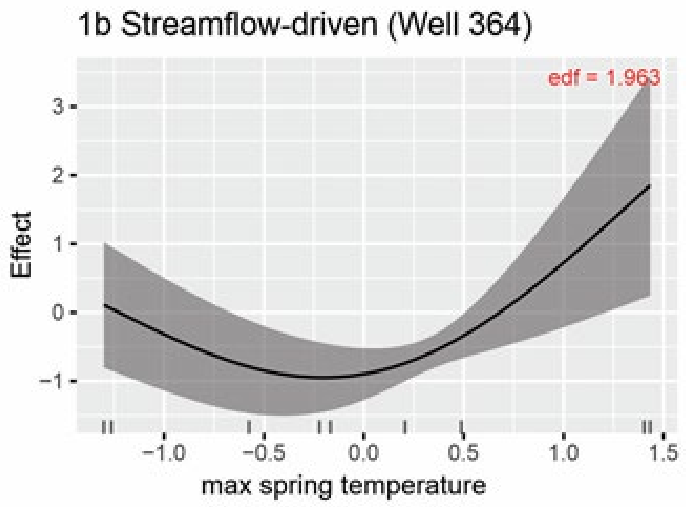


Generalized Additive Models (GAMs)

Which factors are most associated with summer groundwater levels?

GAM 1	GAM 2	GAM 3	GAM 4
max SWE	max SWE	max SWE	max SWE
max spring temp	max spring temp	min spring temp	min spring temp
max summer temp	max summer temp	min summer temp	min summer temp
	Niño 3.4 index		Niño 3.4 index

MAX Spring Temperature



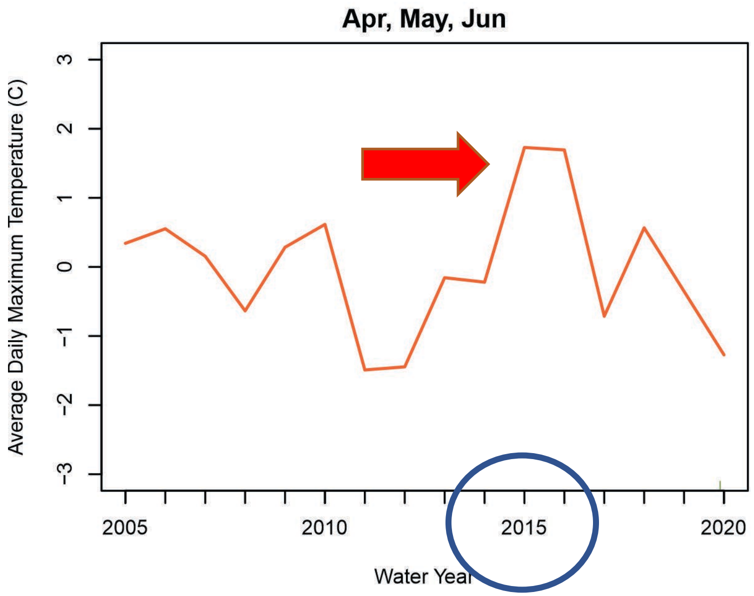
MAX SWE

Table of R^2 values

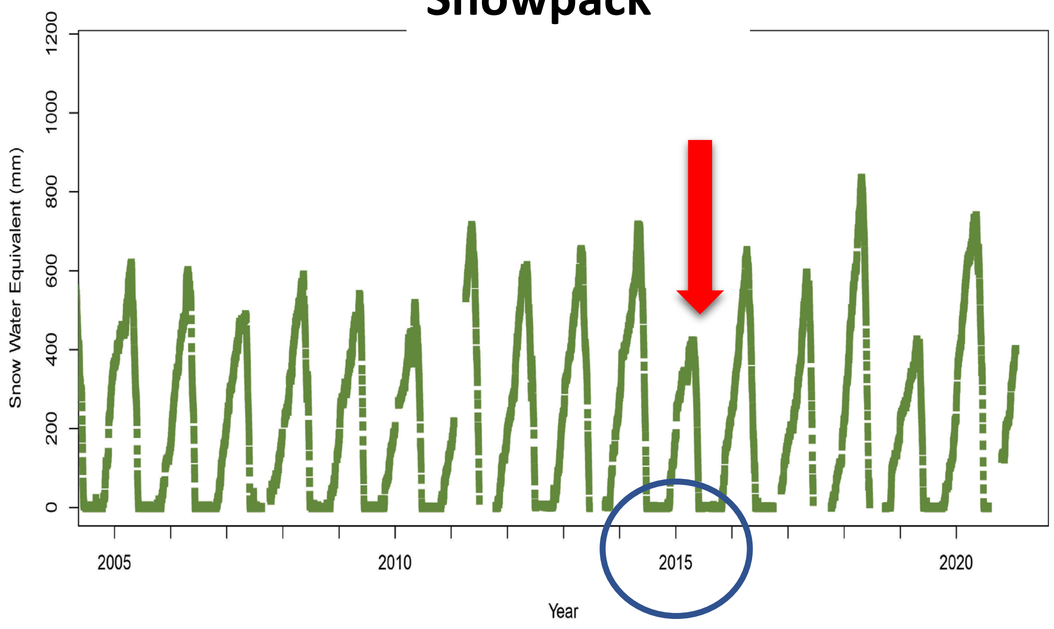
Aquifer type and response mechanism	Well number	GAM 1	GAM 2	GAM 3	GAM 4
1b Streamflow	Well 217	0.770	**0.885**	0.074	0.065
	Well 364	0.785	**0.942**	0.625	0.61
4a Streamflow	Well 381	0.651	**0.966**	0.578	0.616
4b Recharge	Well 262	**0.784**	0.772	**0.784**	0.702
	Well 344	**0.988**	0.984	-0.195	-0.100
	Well 384	0.182	0.828	0.774	**0.896**

Gullacher and Allen, GeoNiagara Conference Proceedings, Sept 2021)

Spring Average Daily Maximum Temperature



Snowpack



2015 : A major drought year in the Okanagan

P85 < P90	P90 < P95	> P95

	P85	P90	P95	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SPRING TEMP (°C)	**20.50**	**21.27**	**21.79**	20.19	20.43	19.97	19.04	20.12	20.51	18.04	18.09	19.60	19.53	**21.81**	21.77	18.95	20.45	N/A	18.29

< P05	P5 < P10	P10 < P15

	P15	P10	P05	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MAX SWE	**495.37**	**456.58**	**424.25**	619.00	600.00	488.16	588.79	539.79	517.00	715.00	613.00	653.00	716.00	**422.00**	651.00	594.00	834.00	425.00	739.00

Summer Groundwater Levels

Number of Wells (n = 41)

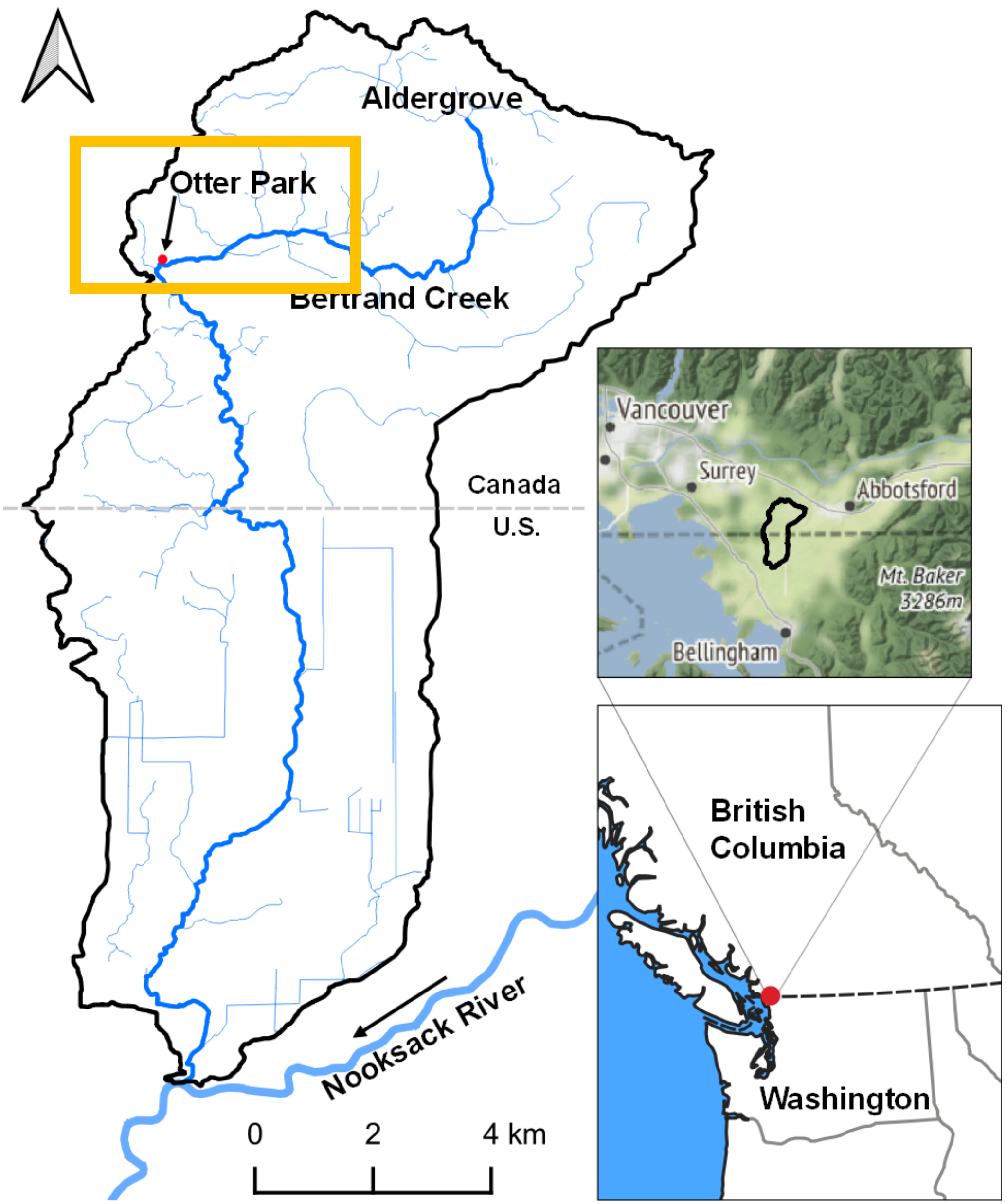
< P05	1		1	7	7	7		2		1	**9**	2	4	1	2	3
P5 < P10	1	3	1	6	6	4				1	**5**	1	4			
P10 < P15	1	2	2	2	2	1	3	1	4		**3**	4	3	1		

Research Outcomes: Bertrand Creek Watershed, Lower Fraser Valley

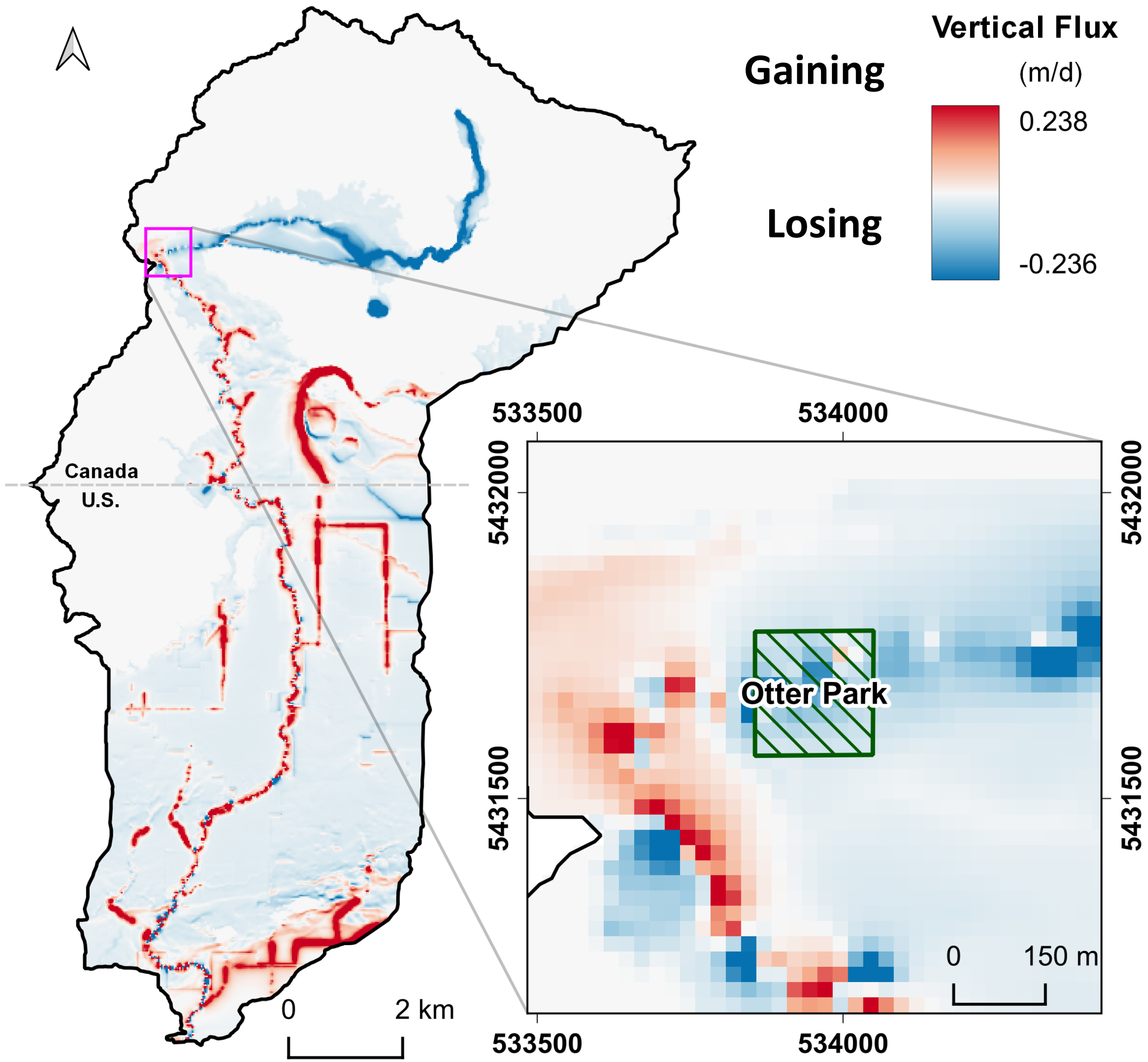
- Our second study area is Bertrand Creek Watershed
- Two components

1) Numerical modeling of groundwater flow in the watershed (Alex Nott)
2) A field study on aquatic habitat characterization in relation to environmental flow needs (Adam Mitton)

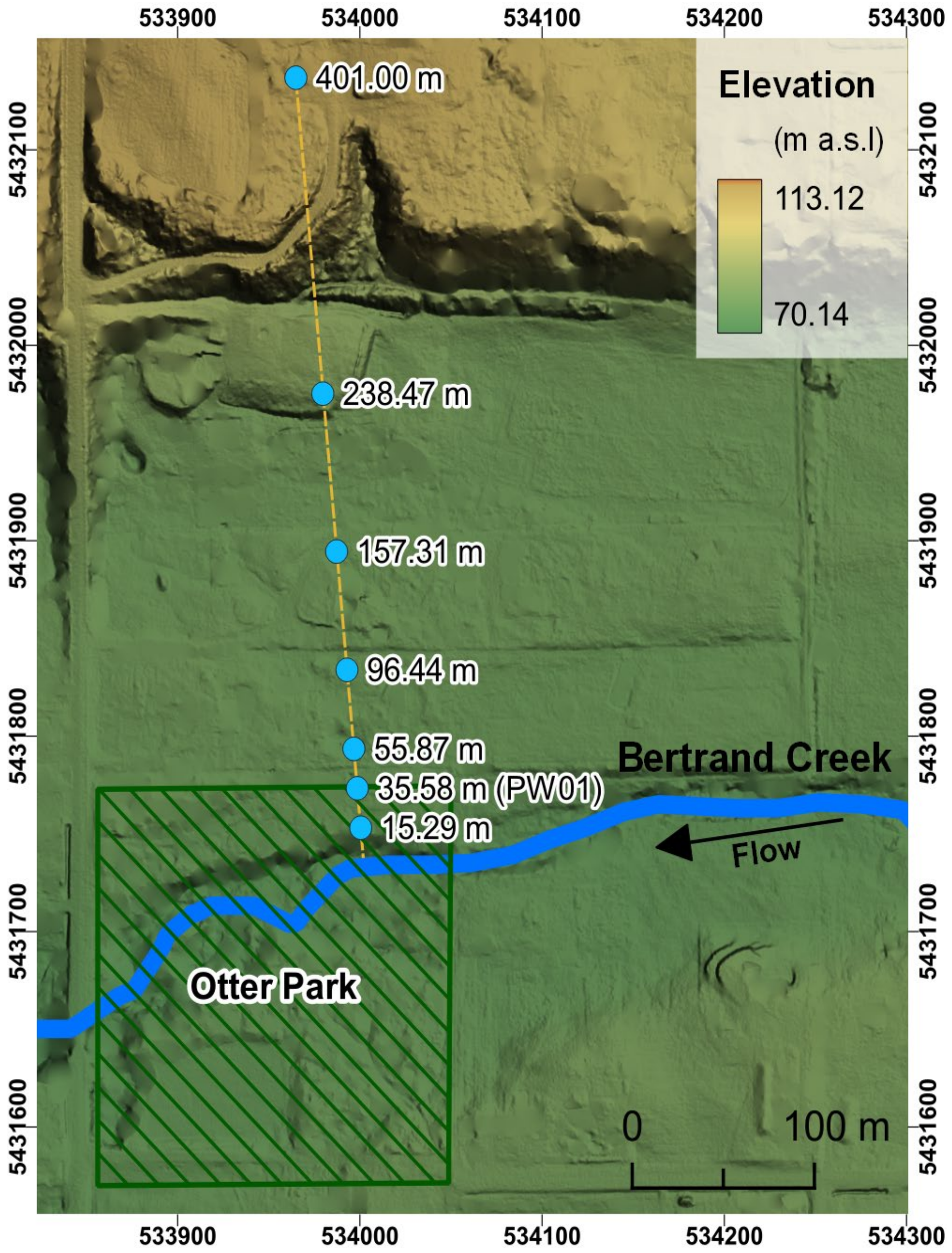
Bertrand Creek Watershed



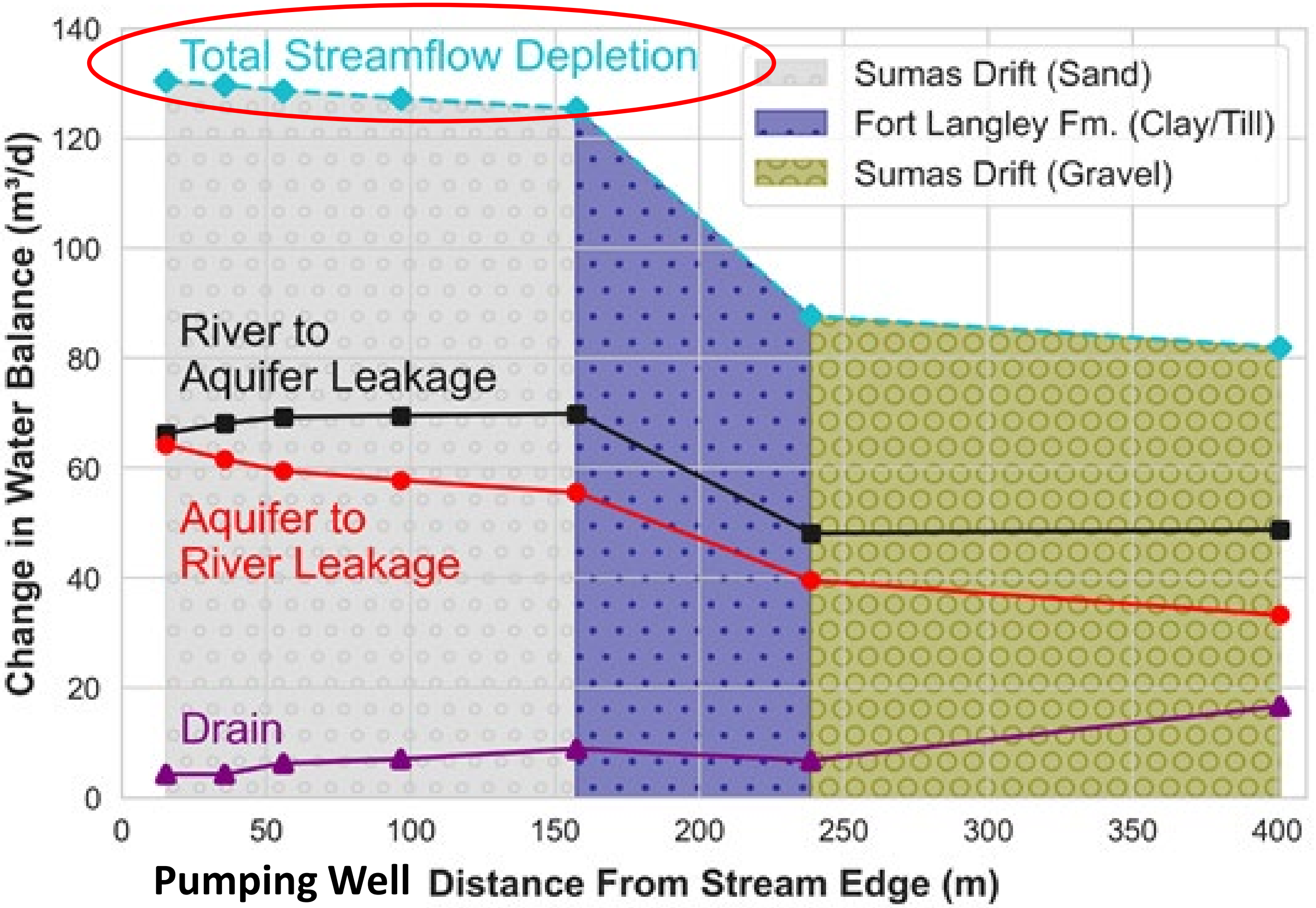
Pumping at 20,000 m^3/day across the watershed results in 4750 m^3/day less water in the stream



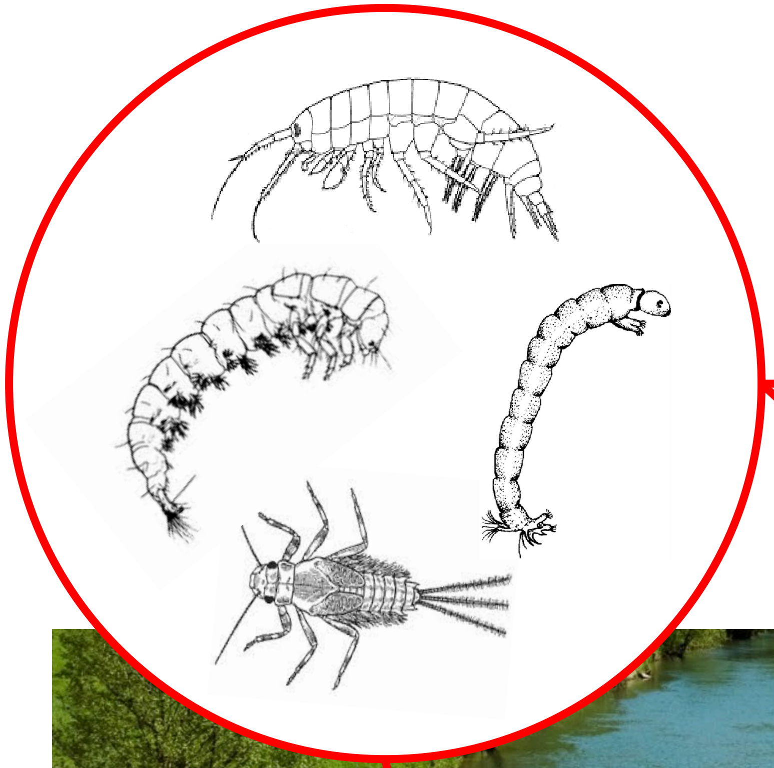
Nott and Allen (2020)



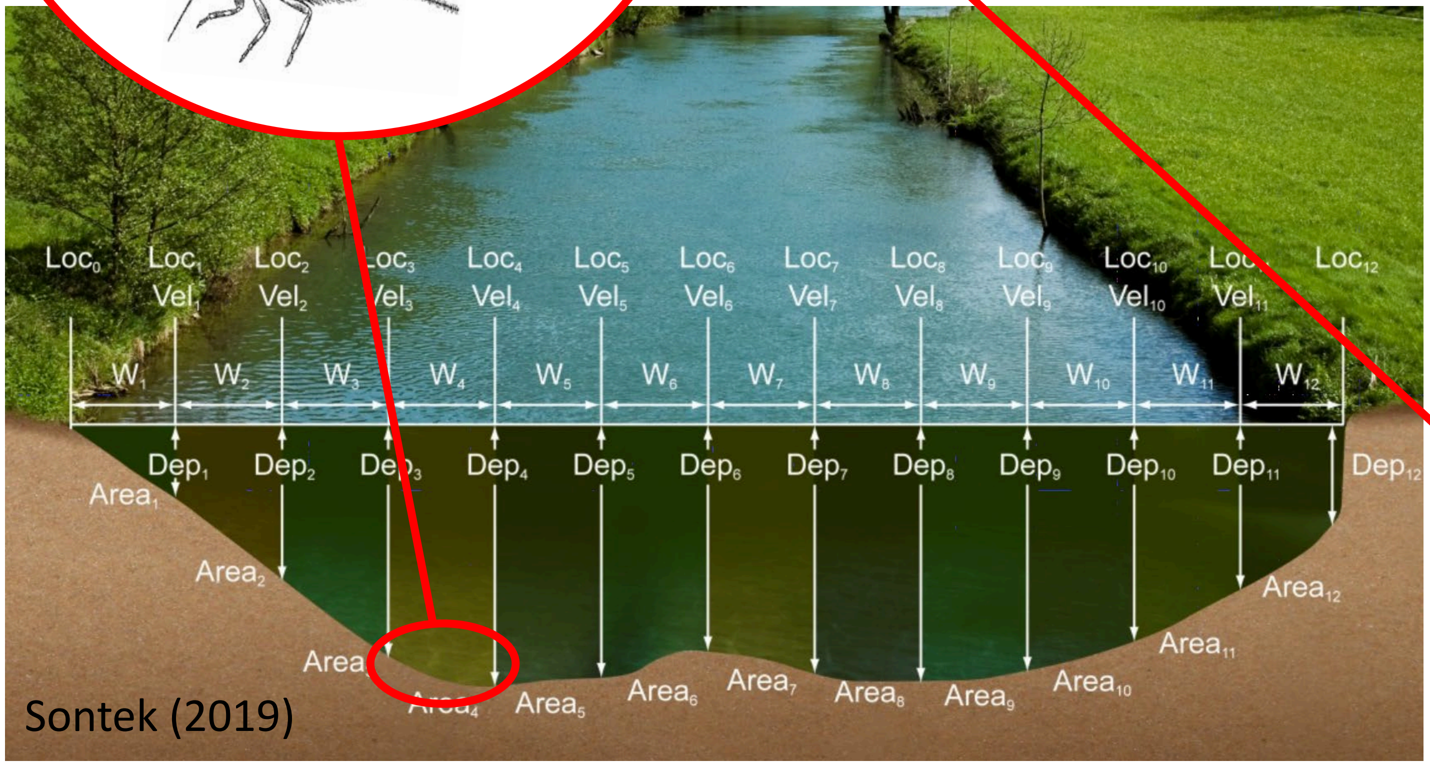
Streamflow Depletion due to Pumping

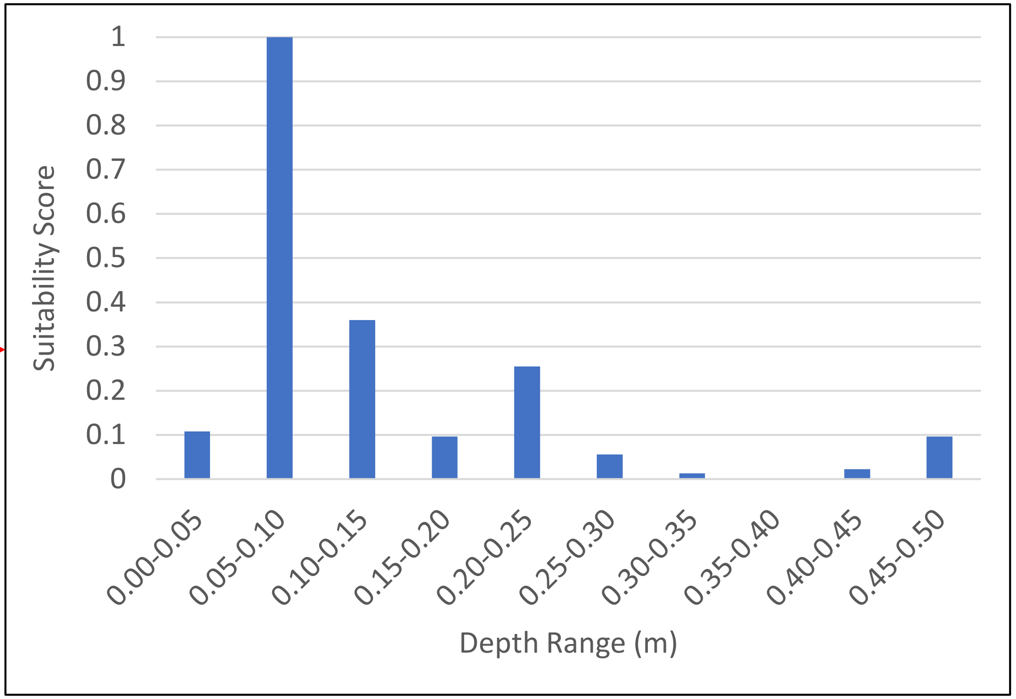


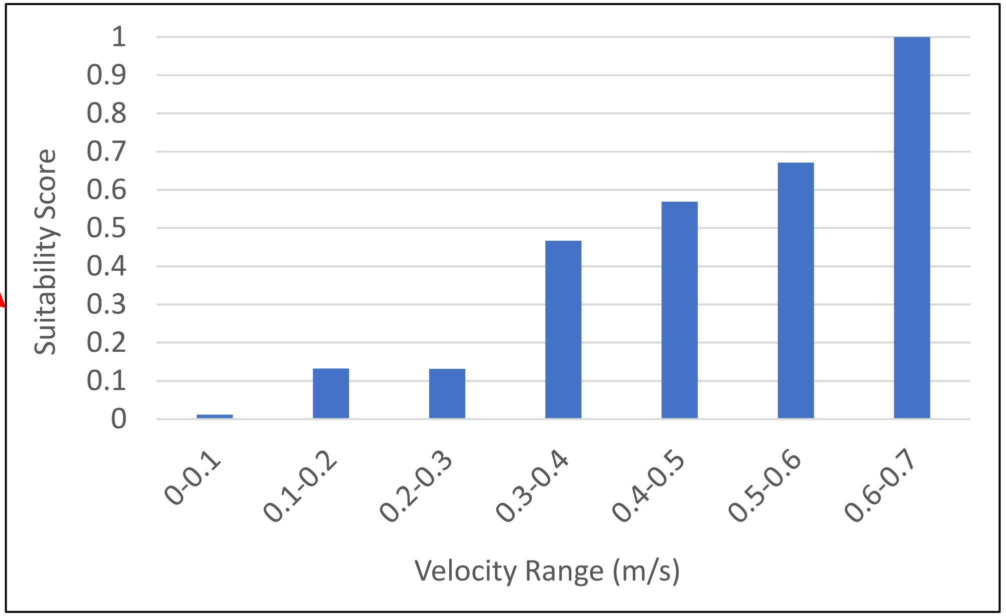
Nott and Allen (GeoNiagara Conference Proceedings, Sept 2021)



More insects = higher suitability score



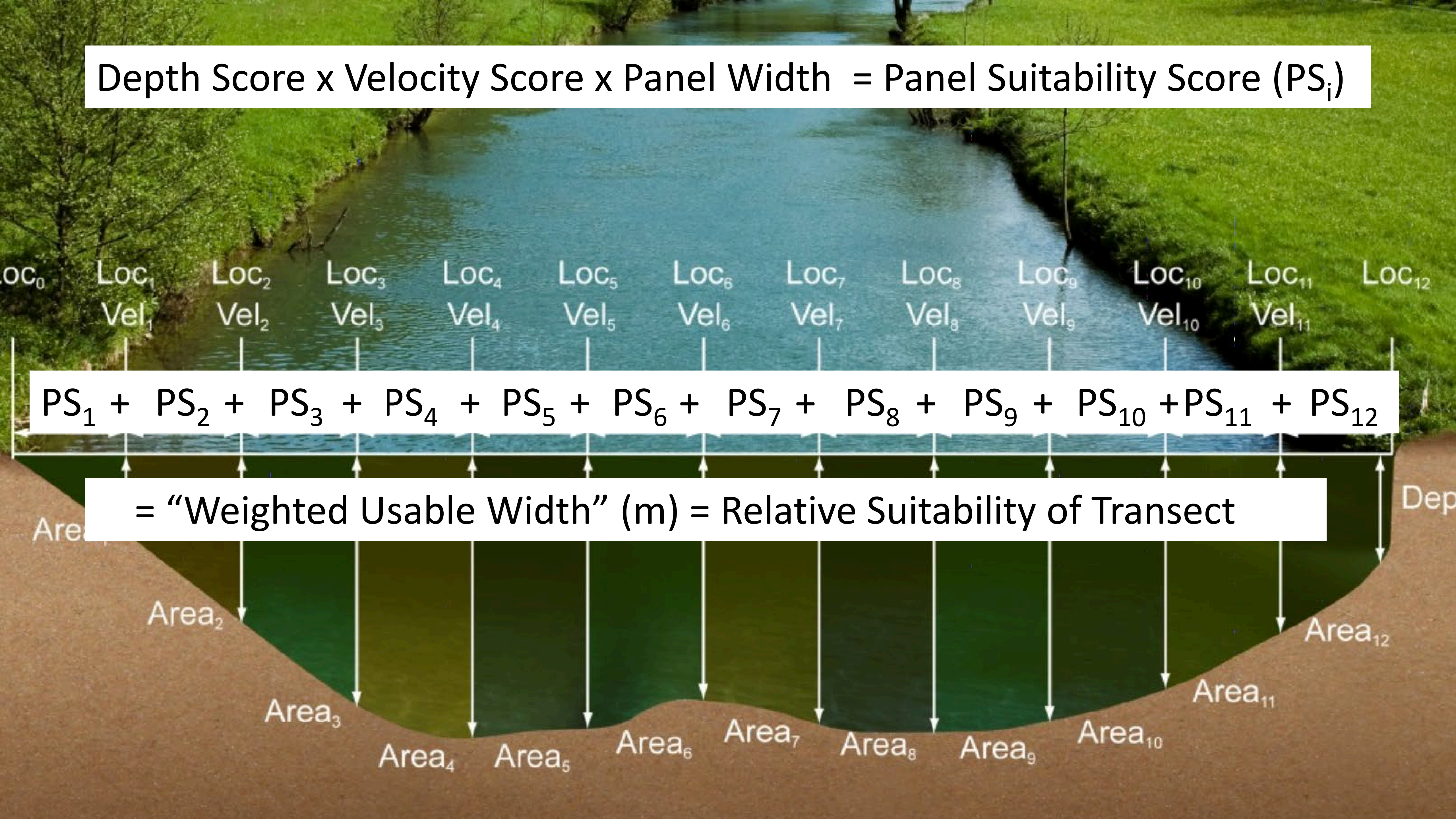


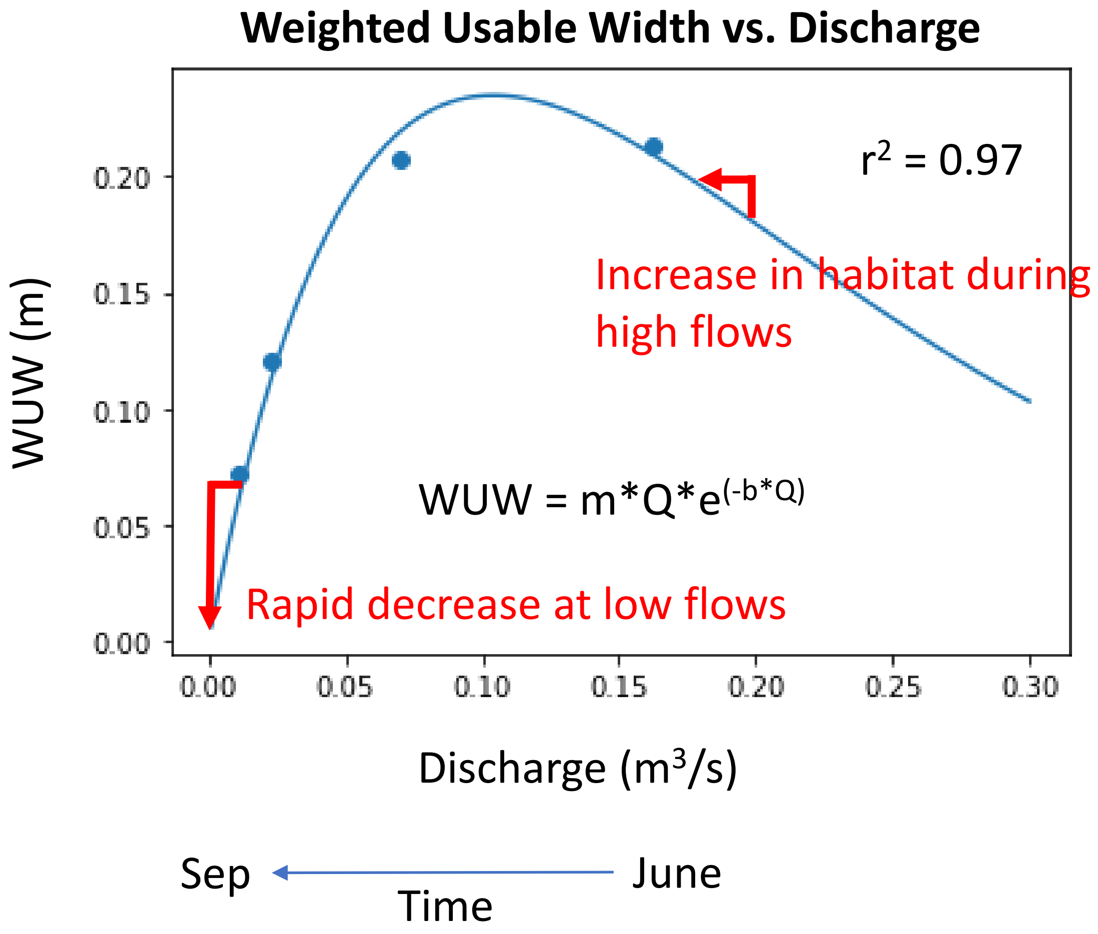


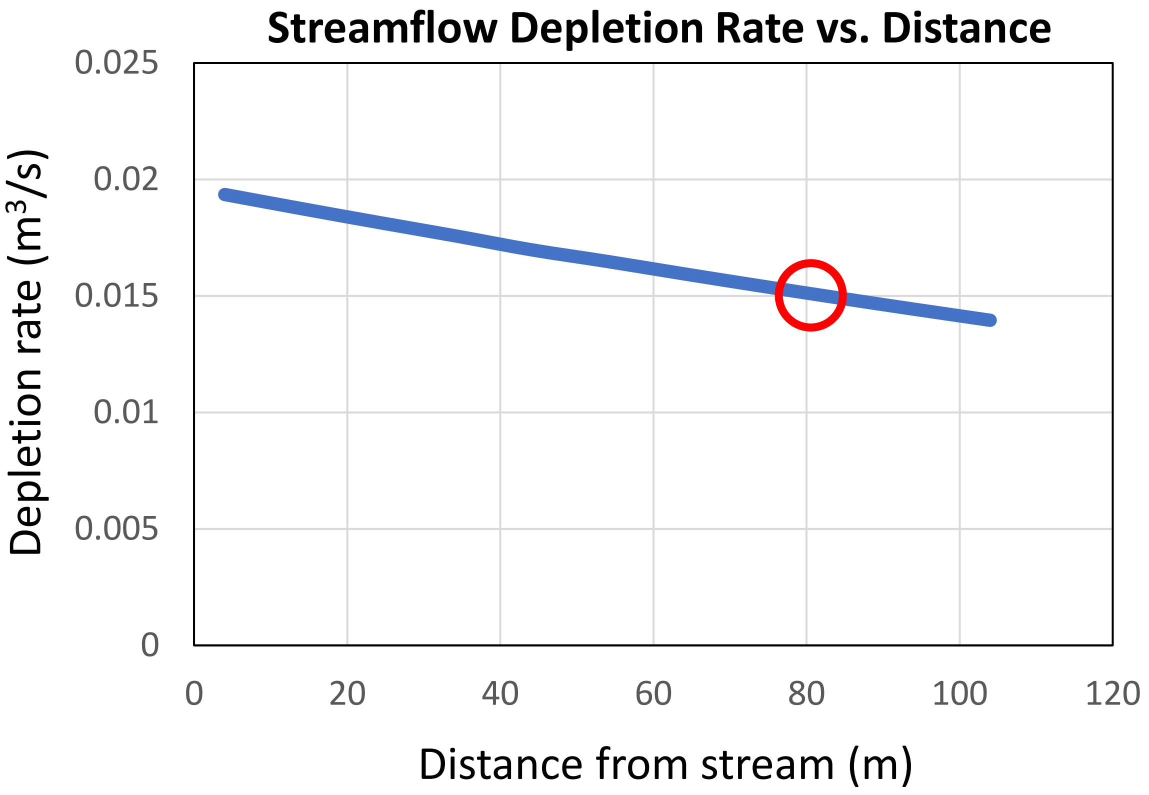
Depth Score x Velocity Score x Panel Width = Panel Suitability Score (PS_i)

$PS_1 + PS_2 + PS_3 + PS_4 + PS_5 + PS_6 + PS_7 + PS_8 + PS_9 + PS_{10} + PS_{11} + PS_{12}$

= "Weighted Usable Width" (m) = Relative Suitability of Transect




Weighted Usable Width vs. Discharge
WUW (m)
0.00
0.05
0.10
0.15
0.20
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Discharge (m³/s)
r² = 0.97
Increase in habitat during high flows
WUW = m*Q*e^(-b*Q)
Rapid decrease at low flows
Sep
June
Time


Streamflow Depletion Rate vs. Distance
Depletion rate (m³/s)
0
0.005
0.01
0.015
0.02
0.025
0
20
40
60
80
100
120
Distance from stream (m)

Top 2 Challenges

1. COVID travel restrictions meant we could not travel to the Okanagan to do field work, so we focused on the Fraser Valley field site.
2. Difficulty with analysis of BC observation well data.
   - Many wells have missing data, so the statistics were skewed. Have had to do extensive QA/QC to eliminate wells from the analysis and identify wells suitable for analysis – completed for Okanagan. Very time consuming.

CANADIAN MOUNTAIN NETWORK

SFU

syilx Okanagan Nation Alliance

Okanagan Basin Water Board

British Columbia

University of Alberta

University of Victoria