MORPHODYNAMIC MODELLING OF BEDROCK WIDTH DYNAMICS

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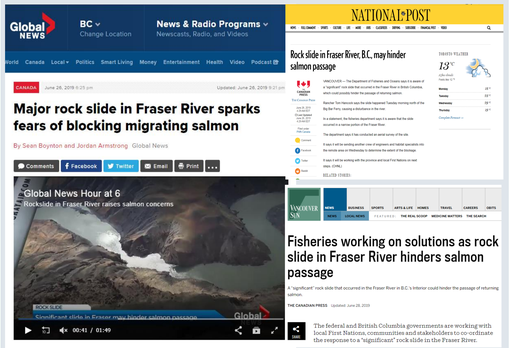
CRISIS on Salmon Migration at French Bar Canyon!



What Happened at French Bar Canyon?

A rock slide occurred at the exit to French Bar Canyon that referred to in the media as the "Big Bar Rockslide". The debris from the rock slide blocked fish passage during critical runs of salmon. The debris itself is not a barrier, but the fast moving water flowing over the debris is forming a velocity barrier to migration.

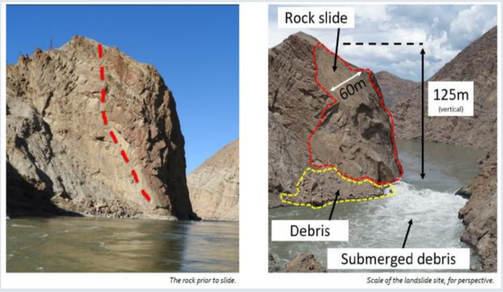


Figure 1. The rock mass before (left) and after (right) the slide (https://bc.ctvnews.ca/photos-show-big-bar-area-before-and-after-landslide-1.4510958)

The slide at French Bar Canyon is not uncommon!

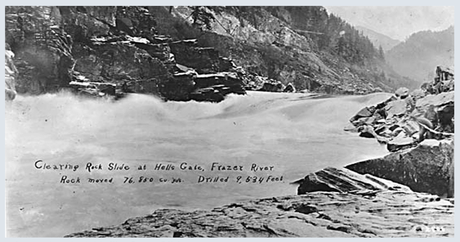


Figure 2. 1913 Hell's Gate Slide

What Caused the Failure?

The trigger that led to the failure is not certain, but the process is clear. The failure was caused by the undercut and the subsequent collapse of bedrock walls, which destabilized the slope above.

The process of undercutting walls is not well understood, but it is widely thought to occur when the bed is covered by alluvium, which deflects the downstream transport of bedload particles into rock channel walls.

Can we predict rock failures in bedrock canyons?

Model Development for Wall Undercutting

1) Hydraulic model with partitioned stress
2) Initial and deflected saltation trajectories

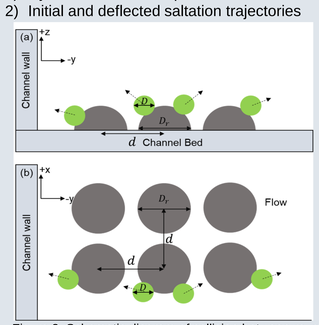


Figure 3. Schematic diagram of collision between roughness element (black) and bedload particles (green).

3) Deflection Rates

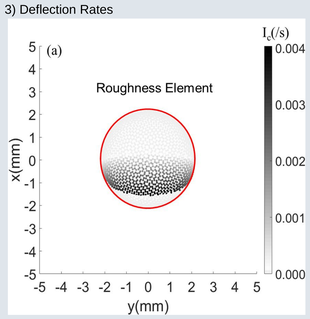


Figure 4. Distribution of impact rates on each grid cell of roughness elements

4) Movement after deflection

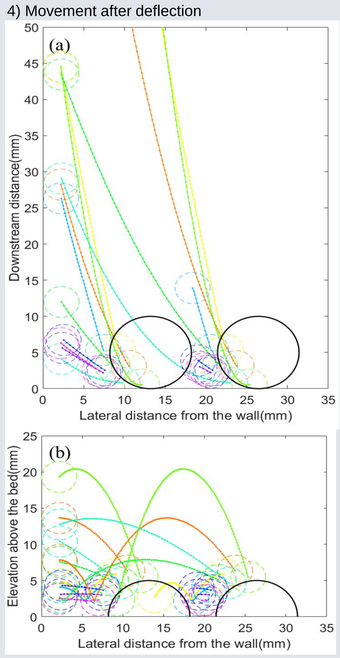


Figure 5. a) Plan view and b) downstream view of the deflection trajectories of bedload particles

5) Calculation of lateral erosion rate

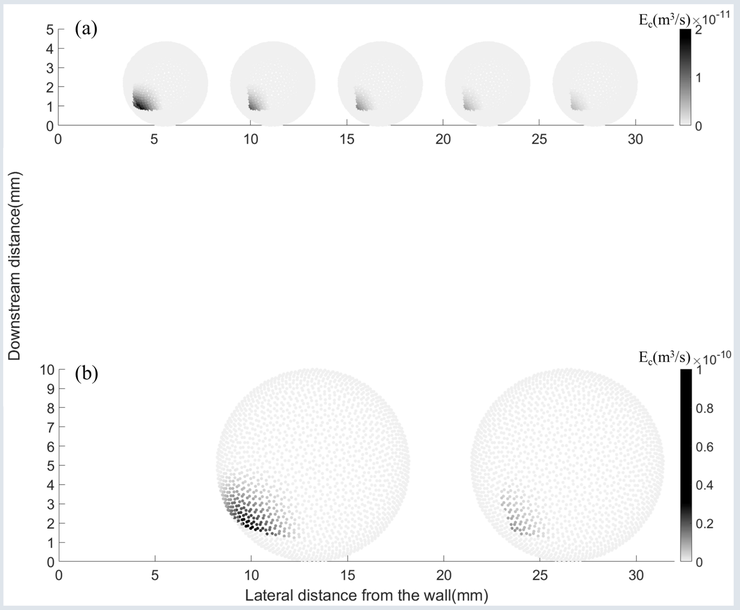


Figure 6. Variation of lateral erosion rate with each grid cell on the a) 4.3 mm roughness elements and b) 10.0 mm roughness elements using inputs from the Fuller et al. (2016) experiments.

Model Performance

Fuller et al. (2016) Experiments: Cement walls and bed with fixed roughness elements as deflectors

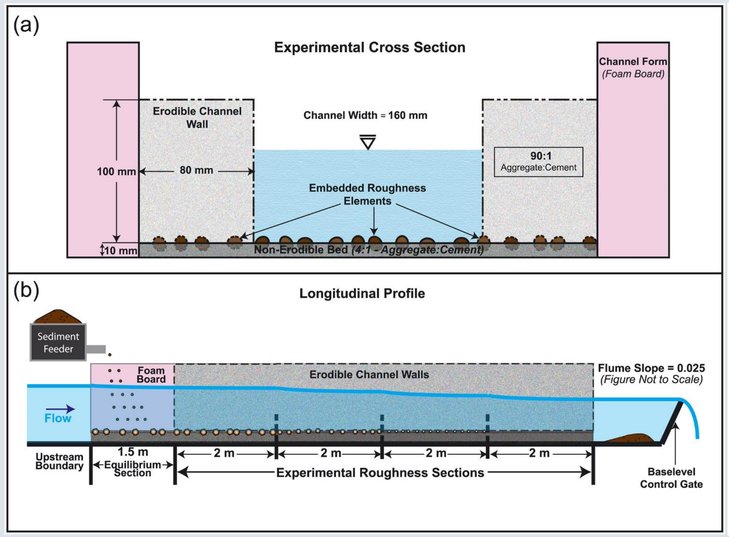


Figure 7. Experiment setup of the Fuller et al. (2016) Experiments

Model Comparison

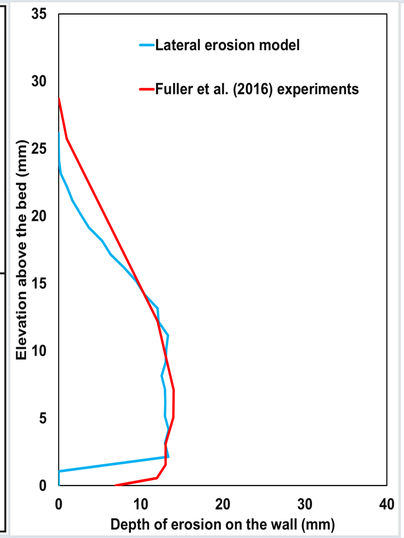


Figure 8. Comparison between the model and the experiments

Undercut Wall Evolution

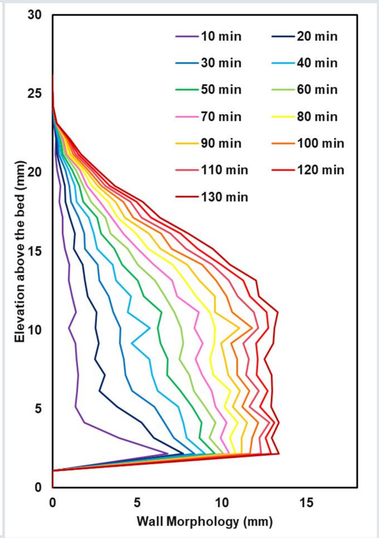


Figure 9. Undercut wall evolution over 2.15 hours

Competition between Vertical and Lateral Erosion

1) The ratio of lateral to vertical erosion rate monotonically increases with increasing relative sediment supply rate

2) Lateral erosion rate is lower than vertical erosion rate under nearly 75% of the transport and supply conditions

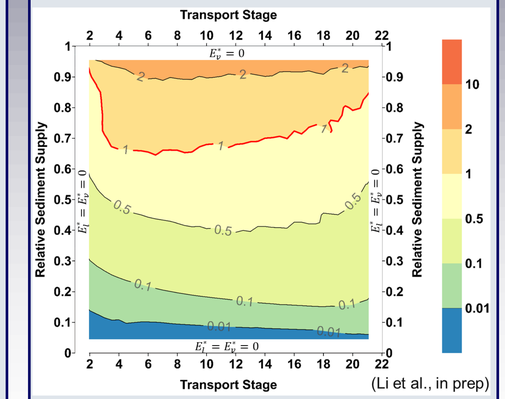


Figure 10. The ratio of lateral to vertical erosion rate as a function of transport stage and relative sediment supply.

What sets the limit of undercut walls?

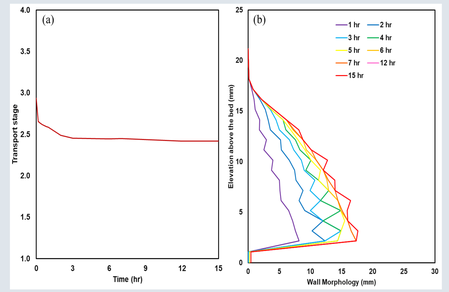


Figure 11 a) Shear stress evolution and b) wall morphology of 10.0 mm roughness section (C2) over 15 hr.

References

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