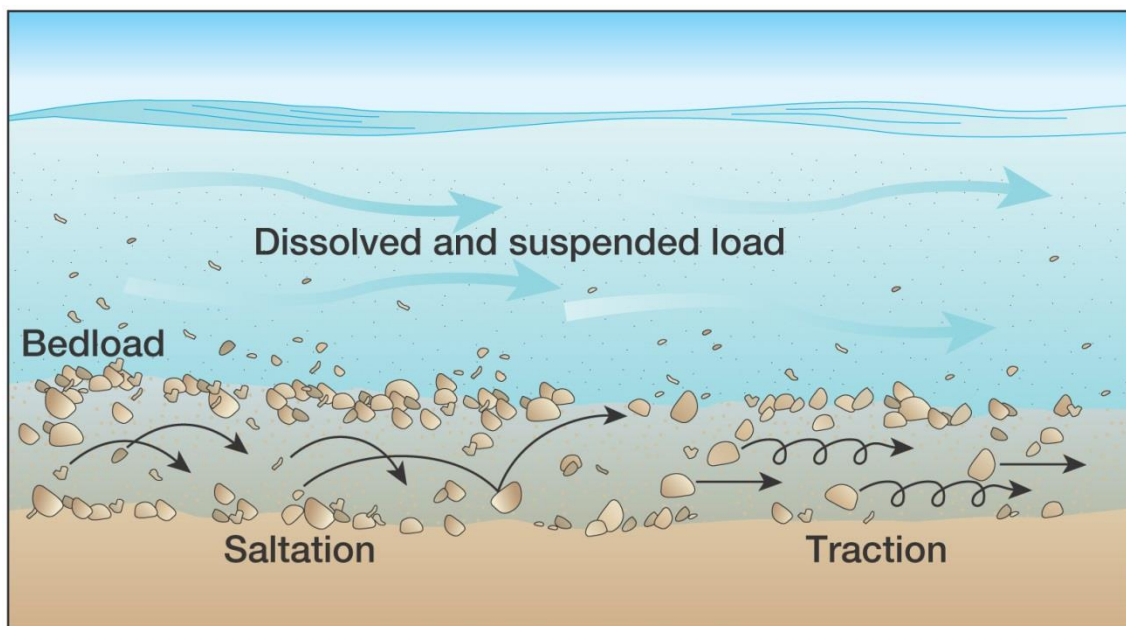


Bedload Calculator Program

Version 1.1



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1. Bedload calculator program

The program calculates the bedload capacity in a natural river cross section with different empirical formulae based on characteristic sediment sizes such as d_m and d_{90} . These sediment sizes are most of time known compared to the cumulative particle-size distribution curve. The input data are defined by the user through the prepared graphical interface. The data are saved in asci files, which are input files of the computational program. Through the interface the computational starts to compute the results. The main computational results are then displayed also on the interface.

Required computer specifications:

- 1) Windows 7 and higher
- 2) System type 64-bit
- 3) 500 MB on hard disc

1.1 Installation

It is suggested not to install the program on the drive C. There are sometimes problems with the access permissions. If there is no drive other than C you should start the program as administrator. This may solve the problem but not always. We are working on it to solve the problem for all cases.

The bedload capacity calculator in a cross section (Beta Version)

Input Data

Upload your cross section data:
Data separator must be comma (,) and it has a header as %Z

Upload the file

Distance of the left bank: Distance of the right bank:

Effective bed width for the bedload
 Distance of the left bed point: Distance of the right bed point:

Flow data:
 Discharge (m³/s):

Longitudinal slope (%):

Sediment denser / dm (mm): Sediment denser / d80 (mm):

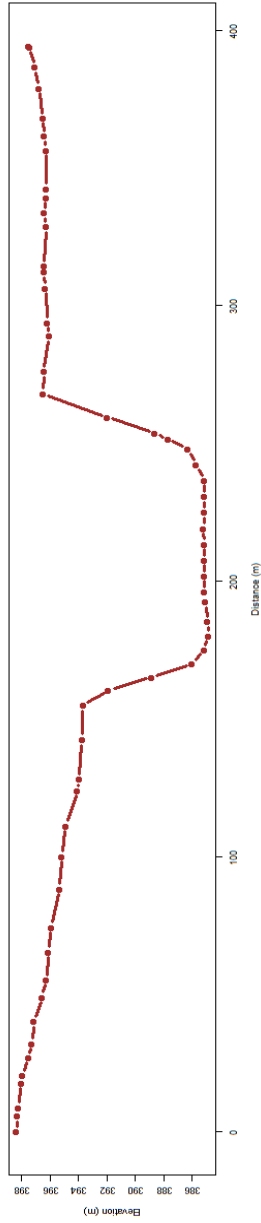
Strickler of the left bank: Strickler of the right bank:

Select the Method:

ENHYDRO
 EnHydro GmbH, Switzerland
 www.enhydro.ch

Your cross section data:

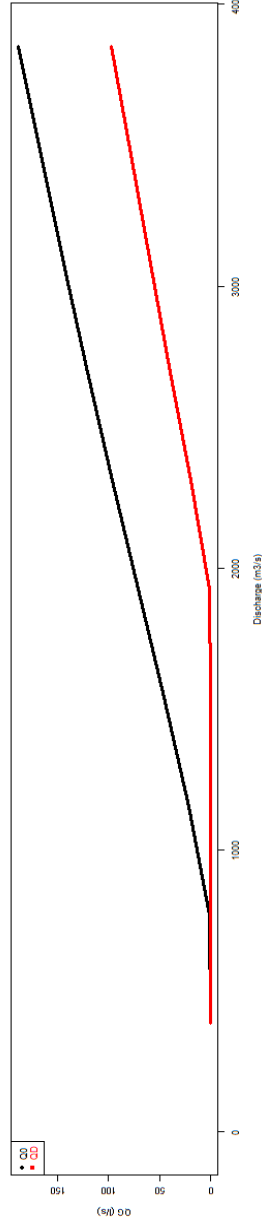
[About File](#) [Data](#) [Plot](#)



xx=155.0219060515918
 yy=393.7762684897777

Calculation results:

[Your Flow Data](#) [Bedload table](#) [Bedbed Diagram](#)



2. Mathematical Model

2.1 Rating curve of the cross section

The rating curve (H-Q relation) is calculated based on the equivalent friction value after Einstein (1934). The program uses Strickler ($1/n_{\text{Manning}}$) values for the friction value of the bed and the banks.

For the effective bed width of the bedload the friction factor is calculated based on the defined sediment diameter d_{90} with the formula $k_{bed} = 21.1/d_{90}^{1/6}$. The effective bed width is defined by the distance of the left and right points through the user (see chapter 3). Outside the effective bed width the friction factors are set based on the Strickler value for the left and right bank (see chapter 3).

2.2 Bedload Capacity

The bedload capacity will be computed for the defined discharge and nine other smaller discharges with a step of one tenth of the defined discharge.

After computing the rating curve of the cross section, the water surface elevation will be found or interpolated for each discharge. Using the calculated water surface elevation, the bedload capacity can be determined by using the strip method. The sediment density has been assumed equal to 2.65.

Following bedload formulae are available for calculation:

a) Meyer-Peter and Müller (MPM)

The MPM formula can be presented as follow:

$$q_b = \frac{8\sqrt{g}}{(s-1)} \left[\left(\frac{k_{sts}}{k_{str}} \right) R_s J - 0.047(s-1)d_m \right]^{1.5}$$

Where

q_b : Bedload capacity ($m^3/s.m$)

g : Gravity acceleration (m/s^2)

s : Sediment density (ρ_s/ρ_w)

ρ_s : Specific mass of sediment (kg/m^3)

R_s : Hydraulic radius (m)

J : Slope of Energy (channel bed)

$(k_{sts}/k_{str})^{1.5}$: Considering bed forms friction and is equal to 0.85 in natural rivers

d_m : Mean diameter of bed sediments

The value 0.047 represents the critical dimensionless bed stress (θ_{cr}). This value can be evaluated for armored bed by using Günter (1971) formula:

$$\theta_{crD} = \left(\frac{d_{90}}{d_m} \right)^{2/3} \theta_{cr}$$

Setting this value into the MPM formula gives the bedload capacity with considering armored bed condition (q_{bD})

The data for the MPM formula are valid in channels with slope of 0.4% to 2.3%. It is suggested to use this equation for rivers with gravel bed and slope under 0.5%.

b) VAW

The VAW formula can be represented as follow:

$$q_b = 2.5 \left(k_{st} R_s^{2/3} J^{1.1} \right) \left[R_s J - 0.04919 (s-1) d_m \right]^{1.5}$$

Where

k_{st} : Stickler value of the bed material.

The value 0.04919 in above formula represents the critical dimensionless bed stress (θ_{cr}). The bedload capacity with considering armored bed condition (q_{bD}) can be calculated by using Günter formula.

The VAW formula can be used for the gravel bed with slopes $0.2\% < J < 20\%$ and relative friction height of $h_m/d_m < 100$. These are the laboratory experiment values, which were used to derive the formula.

c) Smart and Jäggi (S&J)

Smart und Jäggi presented the following formula for steep rivers

$$q_b = \frac{4}{(s-1)} \left(\frac{d_{90}}{d_{30}} \right)^{0.2} J^{0.6} U_m (R_s J - \theta_{cr} (s-1) d_m)$$

Where:

U_m : Averaged velocity of the flow in the cross section

$$\theta_{cr} = 0.05 \left[\cos(\arctan J) \right] \left(1 - \frac{J}{\tan \psi} \right)$$

ψ : Angle of repose of bed material

This equation can be used for river slopes between 0.5% and 20%.

d) Rickenmann (Rickenmann)

Rickenmann derived a formula based on laboratory channel data with slopes between 7% and 20%. He studied specially the effect of density of fluid (ρ) on the sediment transport.

$$q_b = 3.1 \sqrt{g} d_m^{3/2} \left(\frac{d_{90}}{d_{30}} \right)^{0.2} \sqrt{\theta} (\theta - \theta_{cr}) Fr^{1.1}$$

Where:

θ_{cr} : critical dimensionless bed stress based on the Shield diagram

For the θ_{cr} equations of van Rijn have been used:

$$\begin{aligned} \theta_{cr} &= 0.24 D_*^{-1} & 1 < D_* \leq 4 \\ \theta_{cr} &= 0.14 D_*^{-0.64} & 4 < D_* \leq 10 \\ \theta_{cr} &= 0.04 D_*^{-0.10} & 10 < D_* \leq 20 \quad ; \quad D_* = d_{50} \left(\frac{(s-1)g}{\nu^2} \right)^{1/3} \\ \theta_{cr} &= 0.013 D_*^{0.29} & 20 < D_* \leq 150 \\ \theta_{cr} &= 0.055 & 150 < D_* \end{aligned}$$

and Fr : Froude number =
$$\frac{Q}{\sqrt{g \frac{A^3}{b_w}}}$$

3. User Interface

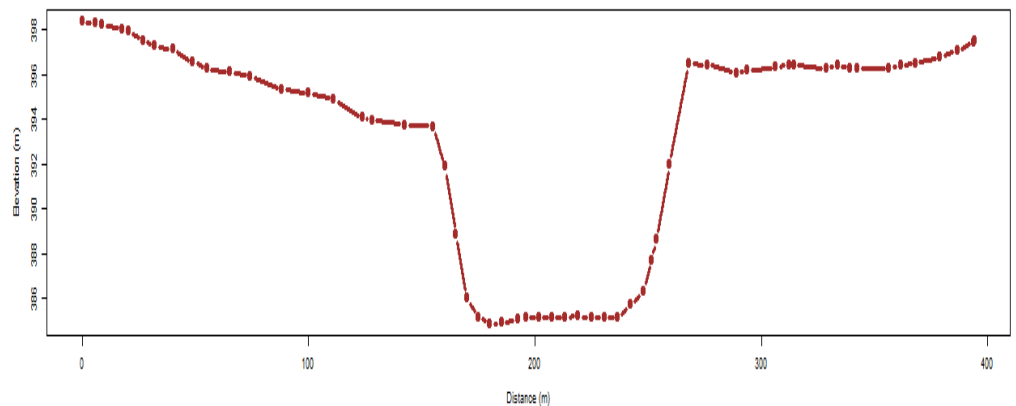
The user interface is developed by using Shiny R language to get the input data for calculation of the bedload capacity. The input data are divided into two parts:

- 1) Cross section data
- 2) Flow data

3.1 Cross section data

The cross section should be defined by importing an ASCII file, which includes the distance and elevation values of the cross section points in two columns. The columns have a header and the separator of the values is “,”:

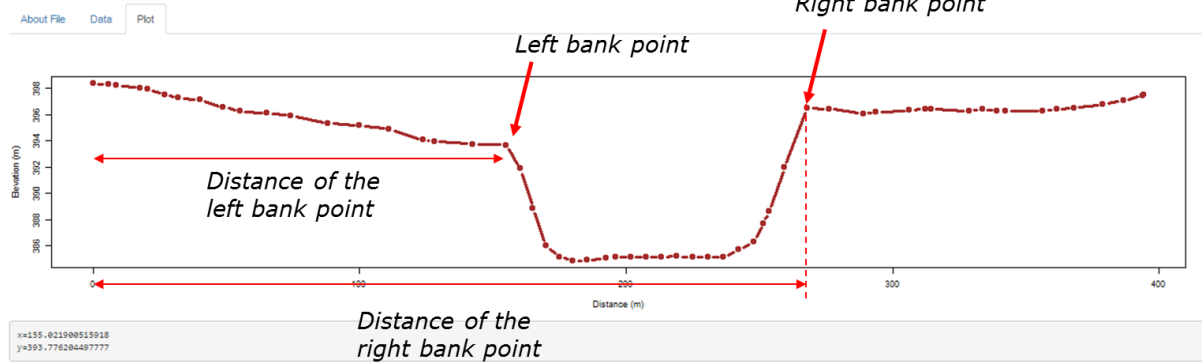
```
x,z
0,398.38
5.71,398.29
8.69,398.25
17.62,398.02
20.48,397.92
26.80,397.53
32.06,397.30
40.05,397.14
48.84,396.56
....
386.61,397.08
393.77,397.47
394.12,397.52
```



The cross section points have to be defined from left to right in flow direction. After uploading the file, the cross section will be illustrated under tab plot.

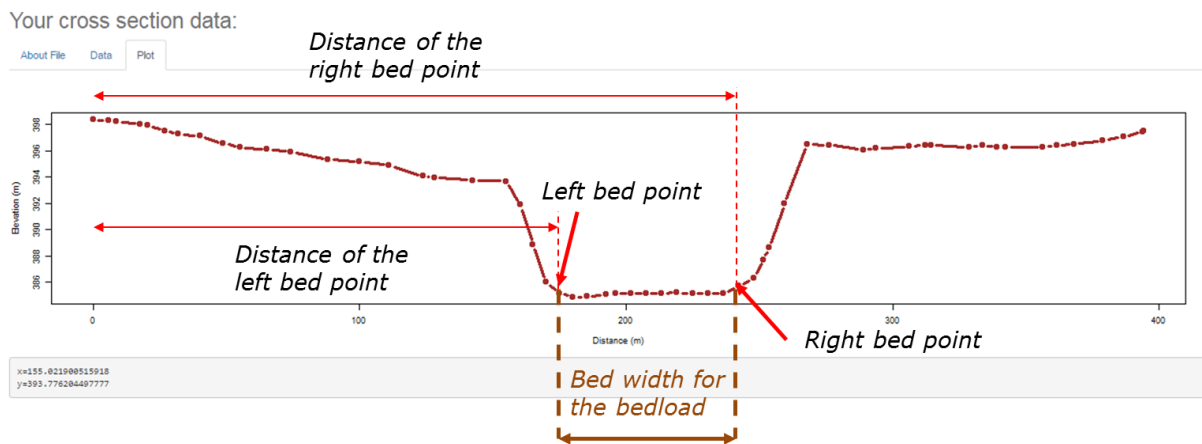
Additionally the user should define the distance of the left and right bank points:

Your cross section data:



The distance can be obtained in the graphical interface just by clicking on the point. After clicking the coordinates of the point will be depicted under the cross section in the gray field.

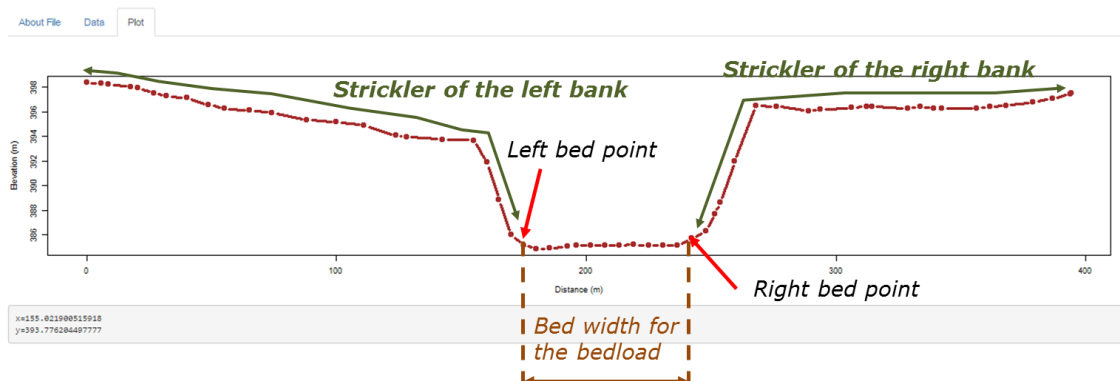
The effective bed for the bedload should be also defined. This is the width, in which the bedload can be transported:



3.2 Flow data

For the flow data, the discharge, the river slope (Energy slope) and sediment diameters can be defined. Additionally the friction values (Strickler) for the left side of the left bed point and also right side of the right bed point should be defined:

Your cross section data:



The Strickler value of the bed will be calculated based on d_{90} .