Cartino Project:

A French automatized hazard flood map

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SIMHYDRO
Nice 12-1410/2012

SCOPE of the talk

Pages

- *Cartino project*
- *SHYREG*
- *Cartino process*
- *Pre-processing*
- *Hydraulic modeling*
- *Post-processing*
- *Prospects*

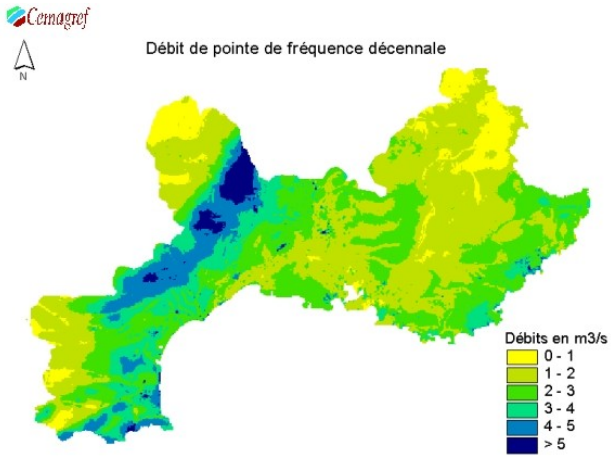
CARTINO Project *(CARTOgraphie des INOndations)*

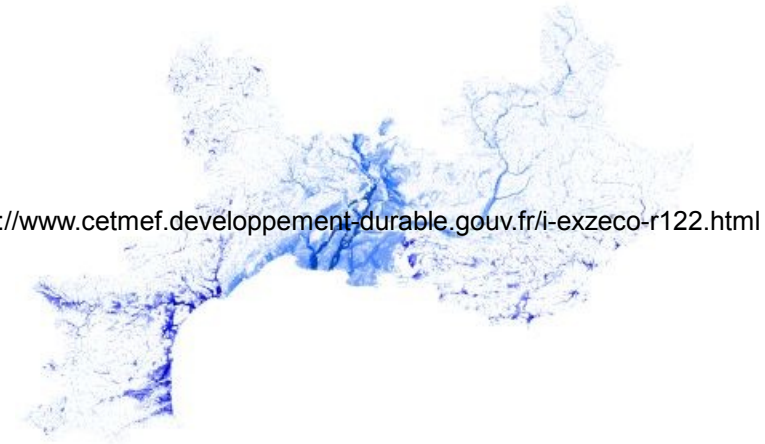
Context

- Conventions and programs with DGPR/IFSTTAR/IRSTEA/CETMEF/CETEs

Initial aims of DGPR:Cross Hydrology and Topography

- SHYREG & EXZECO





http://www.cetmef.developpement-durable.gouv.fr/i-exzeco-r122.html

- End using: Flood hazard map for european directive

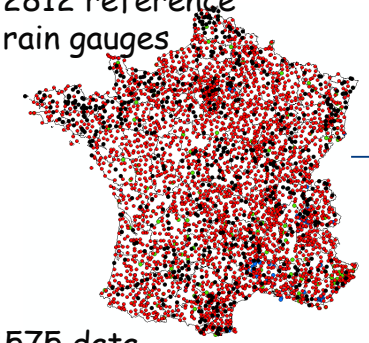
CARTINO => Try to create 1D hydraulic models automatically in steady flow injecting SHYREG flows

SHYREG database
for national cartography of flood risk

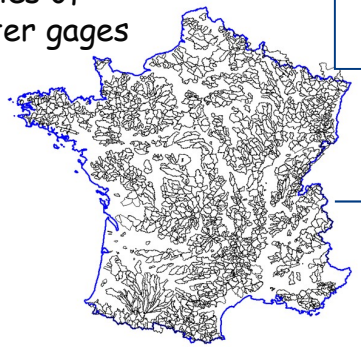
Approach by simulation : hourly rainfall model coupled with rainfall-runoff model
Regionalized approach : calibration on a exhaustive dataset and regionalization of model's parameters
Advantages : robustness , multi-duration information (floods design),

Dataset

2812 reference rain gauges

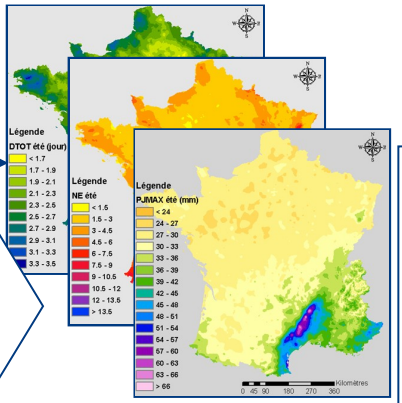


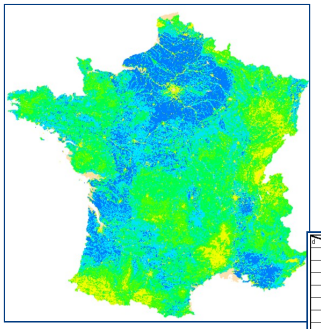
1575 data series of water gages



Calibration/Regionalization

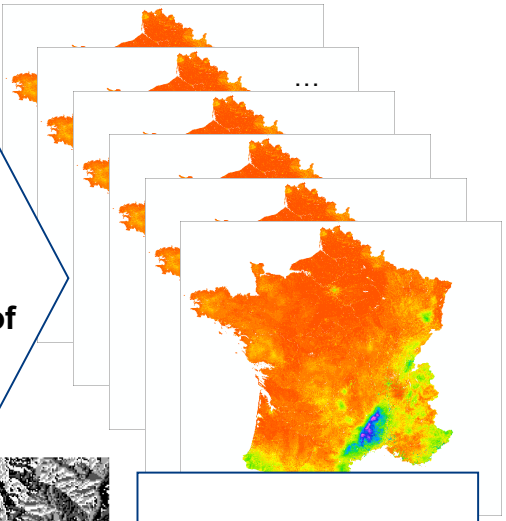
1. Models' calibration
2. Parameters' regionalization



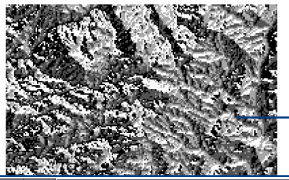


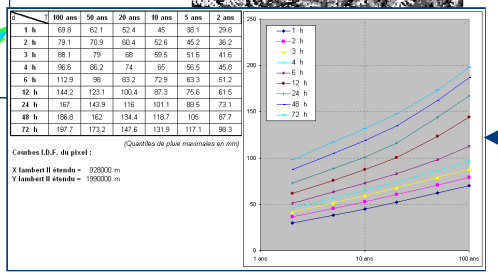
Rainfall and flood frequency distribution at 1km² scale

3. Flood scenarios simulation
4. Extraction of floods frequency



5. Accumulation



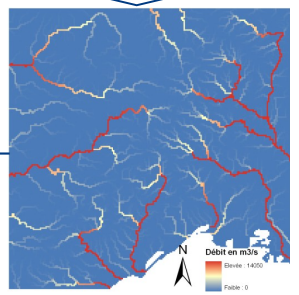


	100 ans	50 ans	20 ans	10 ans	5 ans	2 ans
1 h	69.8	62.1	52.4	45	38.1	29.8
2 h	79.1	70.9	60.4	52.6	45.2	36.2
3 h	88.1	79	66	59.5	51.6	41.6
4 h	96.6	86.2	74	65	56.5	45.8
6 h	112.9	98	83.2	72.9	63.3	51.2
12 h	144.2	123.1	100.4	87.3	75.6	61.5
24 h	167	143.9	116	101.1	88.6	73.1
48 h	186.8	162	134.4	118.7	105	87.7
72 h	197.7	173.2	147.6	131.9	117.1	98.3

(Quantiles de pluie maximales en mm)

Courbes I.D.F. du pixel :

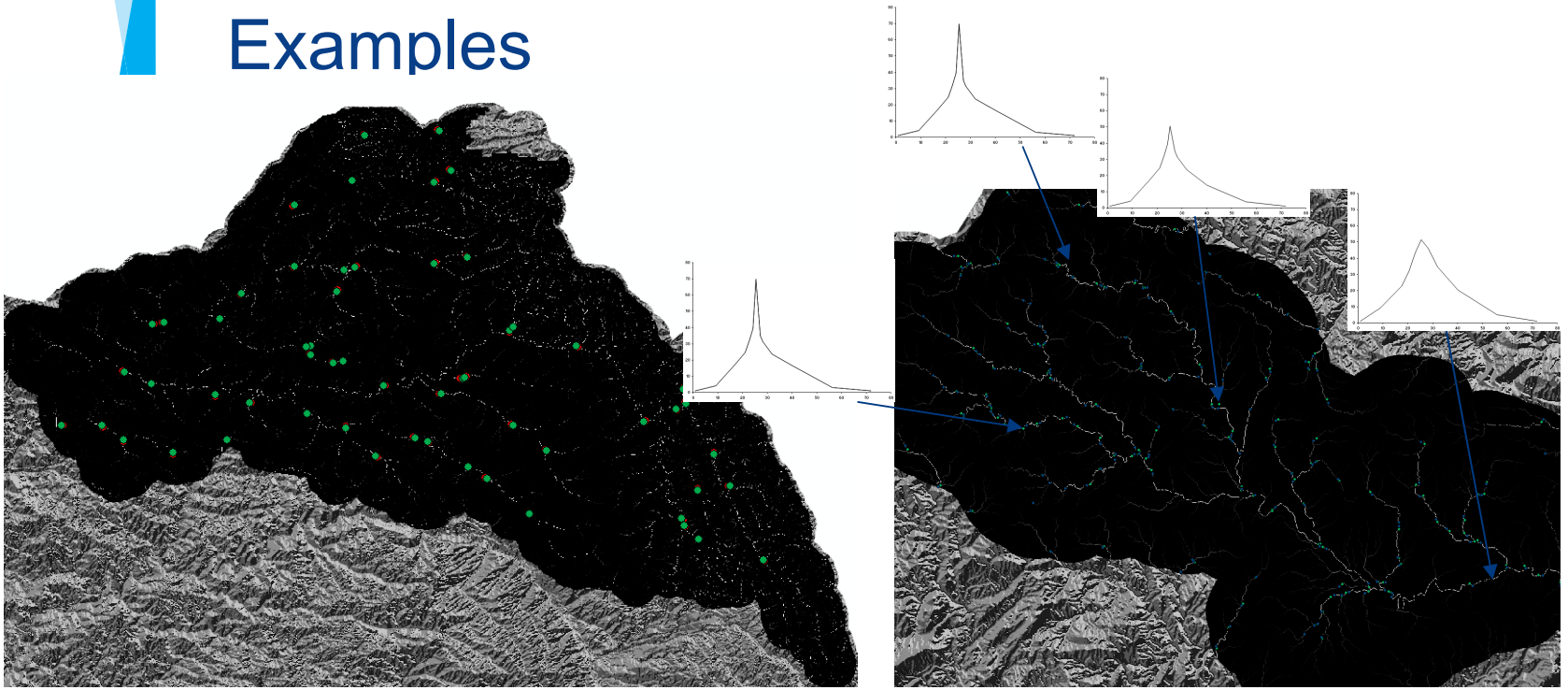
X lambert II étendu = 928000 m
Y lambert II étendu = 1990000 m



irstea

Irstea – Centre d'Aix-en-Provence

Examples



SHYREG Dadabase :

- Peak flood of 10, 100 and 1000-years return period along the drainage network for areas > 5km²
- Design floods on 200 000 outlets
- Quality code based on
  - localisation of dams
  - karstics areas
  - natural flood plain

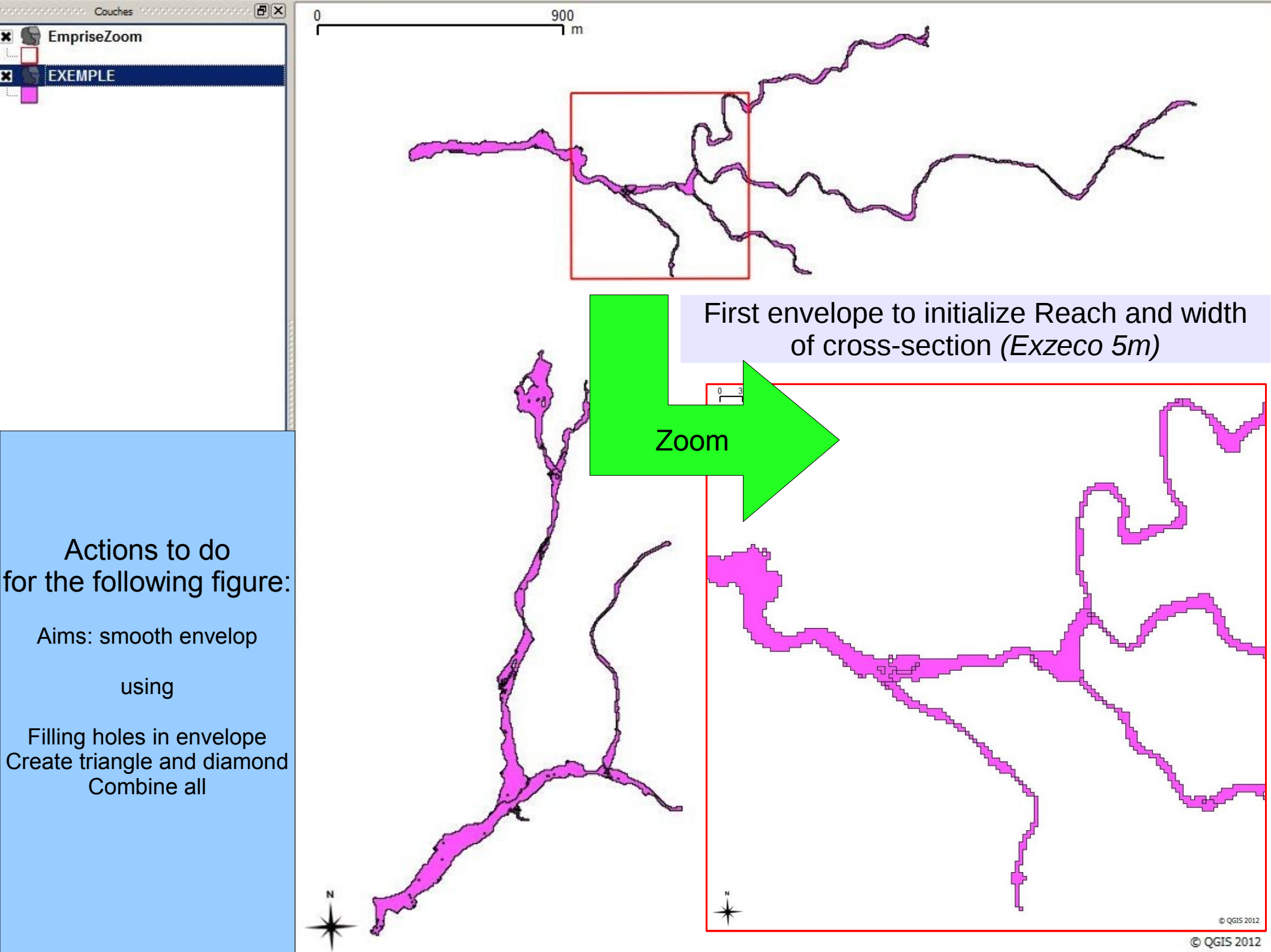
Cartino Process

Process

- Use a flood approached area (Exzeco) to initialize the process
- Create the middle of this envelop *(skeleton)*
- Create a network of river reach
- On each reach, create cross-section with non-equal distance (up/down) and without overlay
- Interpolate DEM and flow Raster on each cross-section
- Create file for 1D hydraulic models
- Calculate in steady flow
- Checking cross-section are enough wide
- Plot results on each reach and create a raster of results
- Combine all the results for each river reach

2 developments

- ***CETE Méditerranée: On PC with Qgis-Grass, Flutor et Mascaret launched with Matlab (to be available) – Website in French*** (http://www.wikhydro.org/index.php/Notice_de_Cartino)
- CETMEF: Application on cluster CETMEF with Manning, Flutor and Mascaret


Couches
EmpriseZoom
EXEMPLE
0
900
m
First envelope to initialize Reach and width of cross-section *(Exzeco 5m)*
Zoom
Actions to do
for the following figure:
Aims: smooth envelop
using
Filling holes in envelope
Create triangle and diamond
Combine all
N
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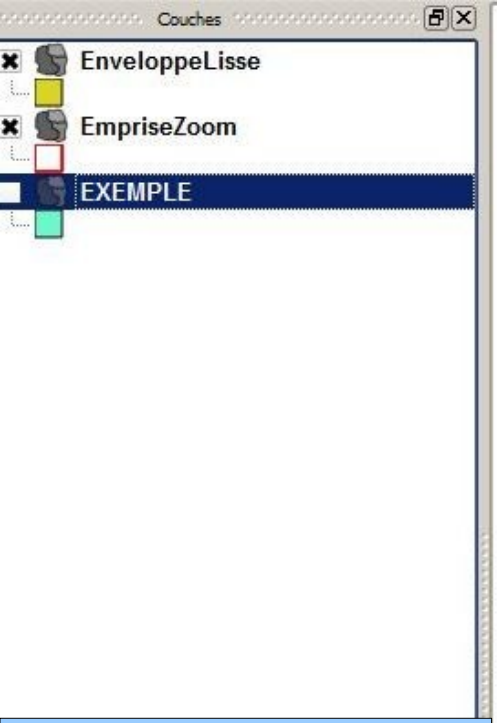
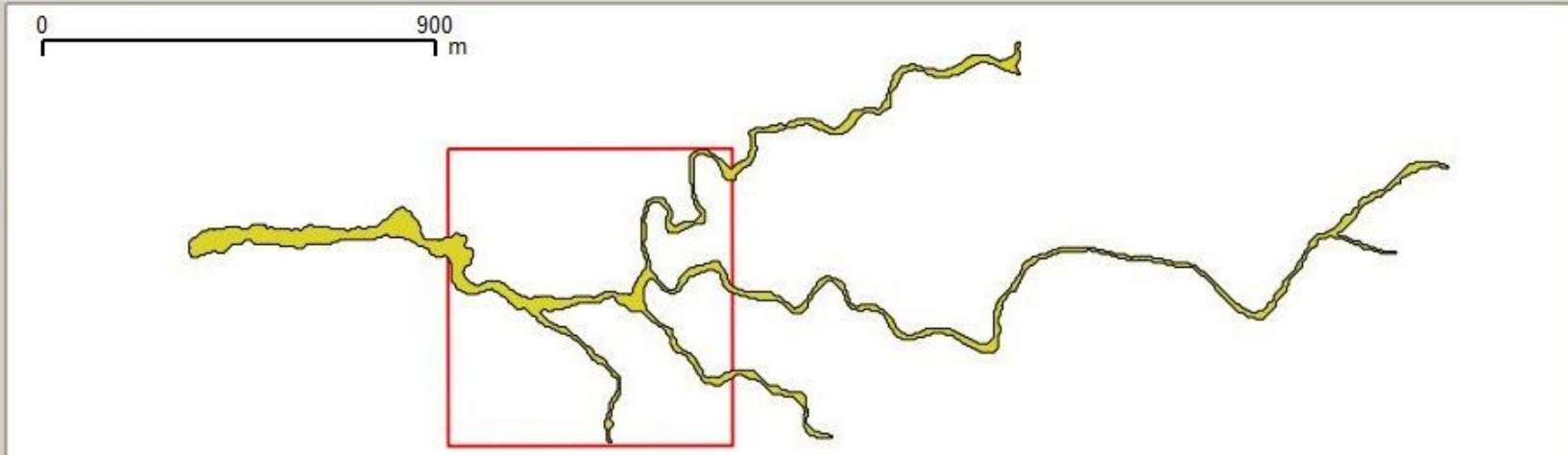




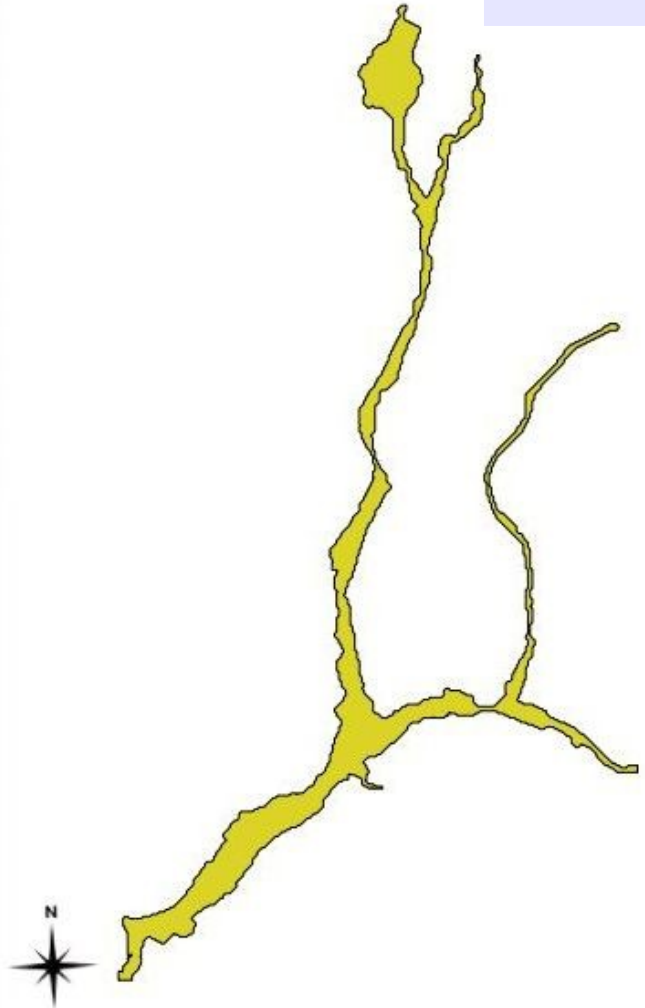
Smooth envelope

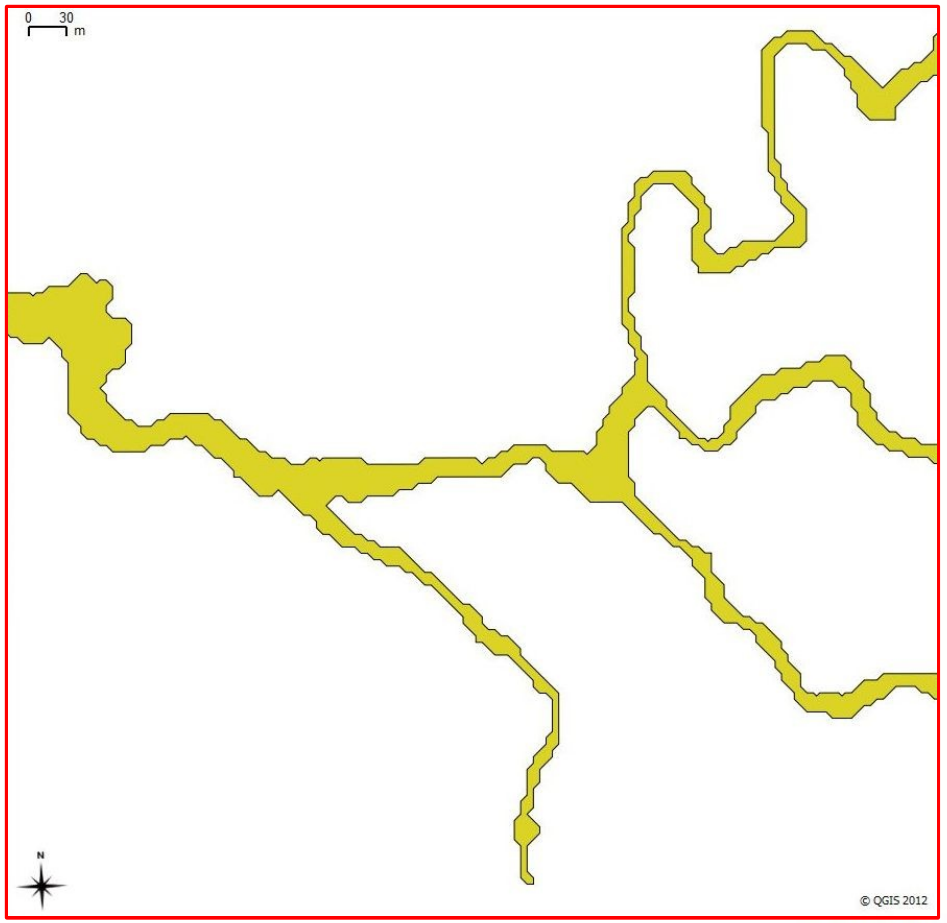
Actions to do
for the following figure:

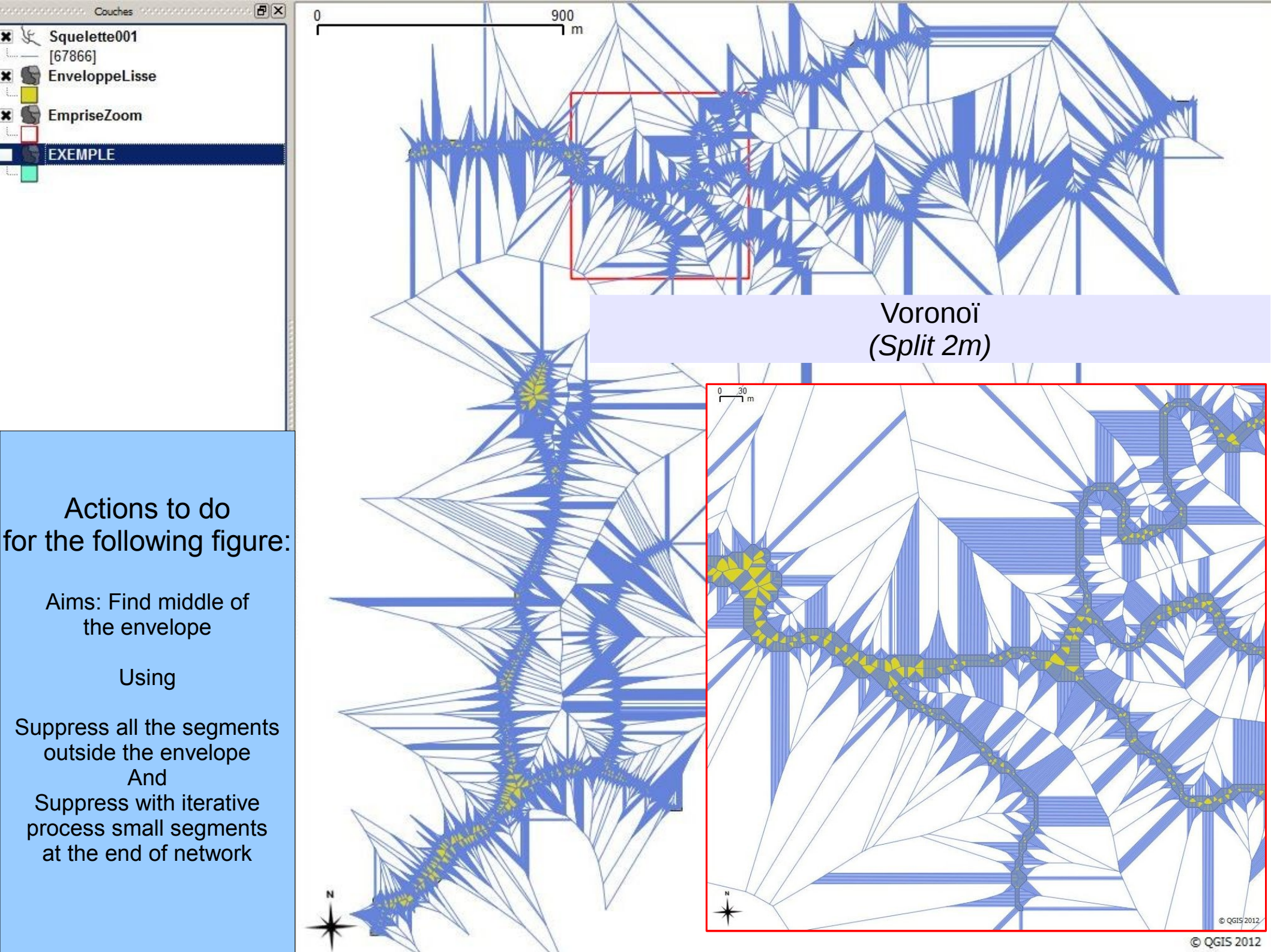
Aims: Find middle of
the envelope

Using

Split the contour of envelop
and launch Voronoï Diagram





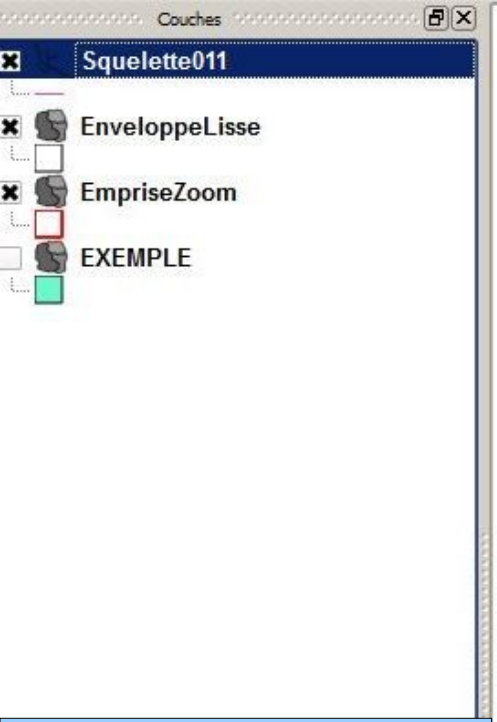


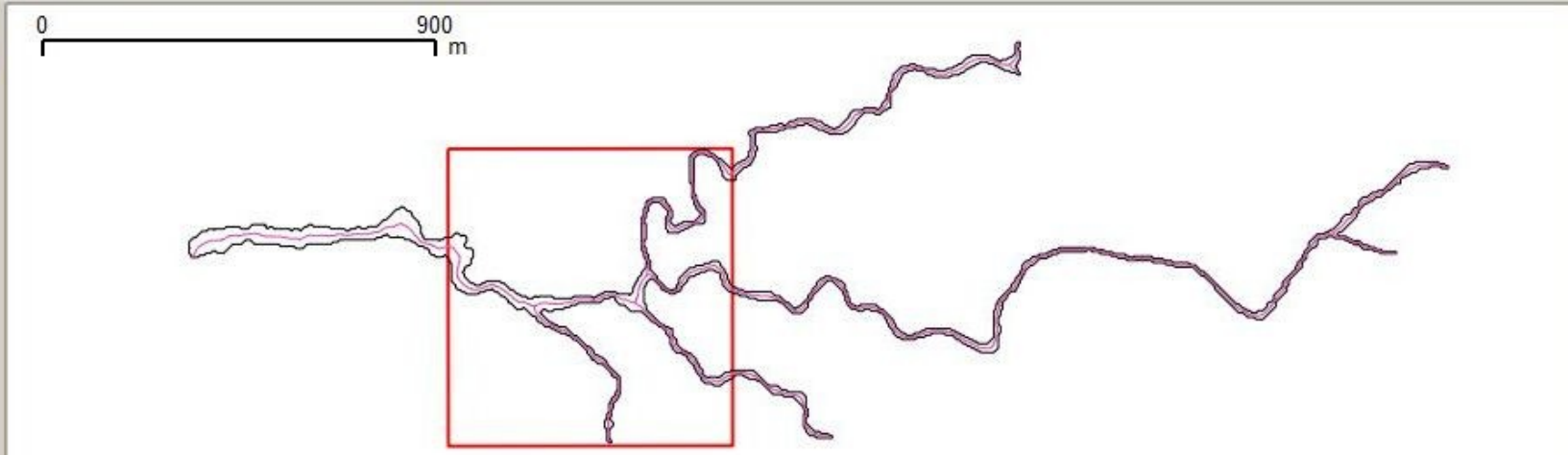
Actions to do for the following figure:

Aims: Find middle of the envelope

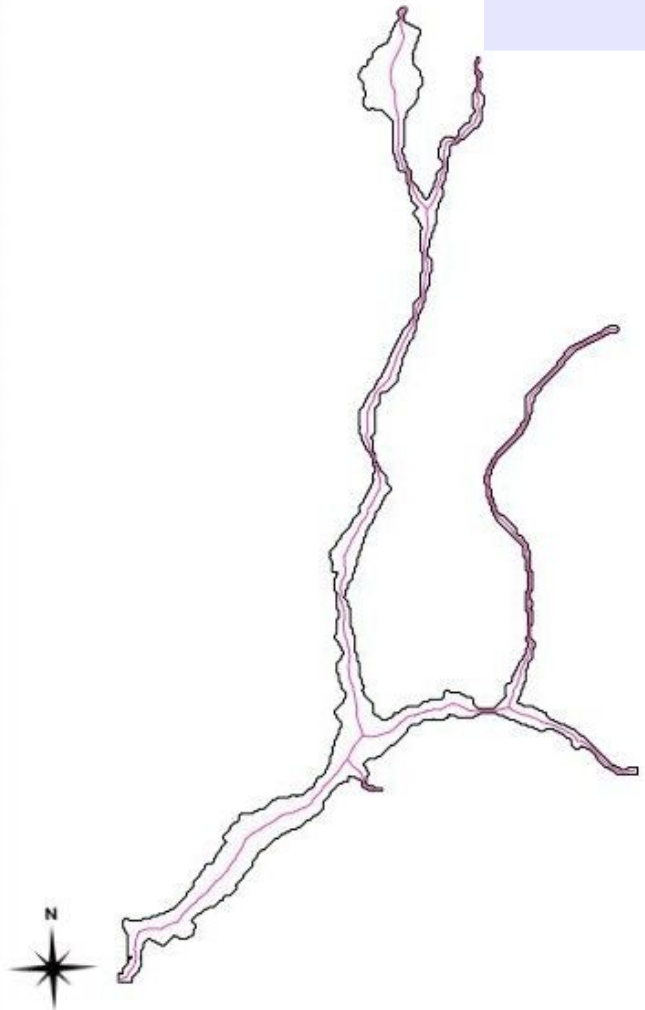
Using

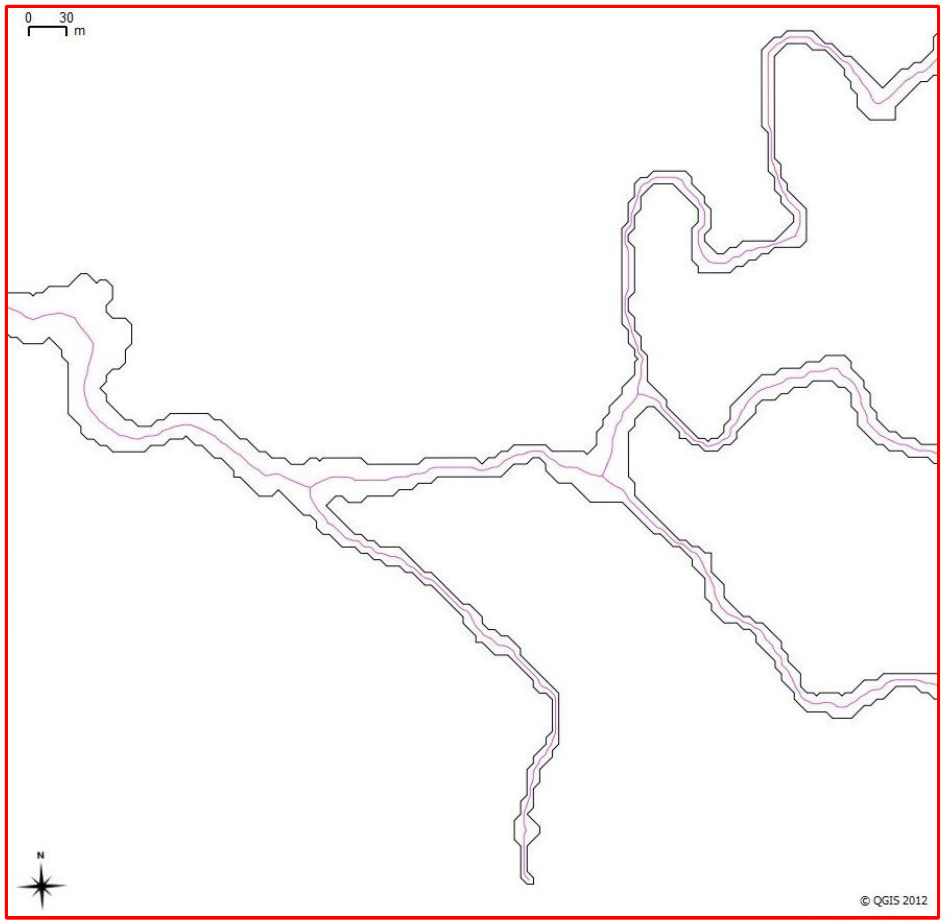
Suppress all the segments outside the envelope
And
Suppress with iterative process small segments at the end of network





Middle of envelop
(Iterative cleaning of skeleton)





Actions to do for the following figure:

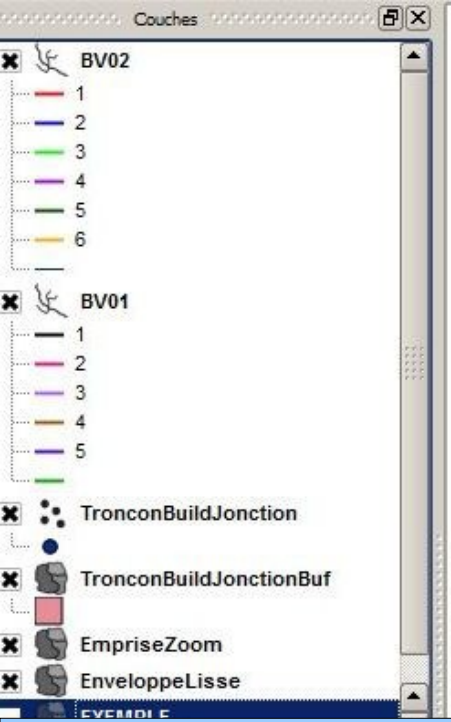
Aims: Create a network of reaches and prepare for flow interpolation

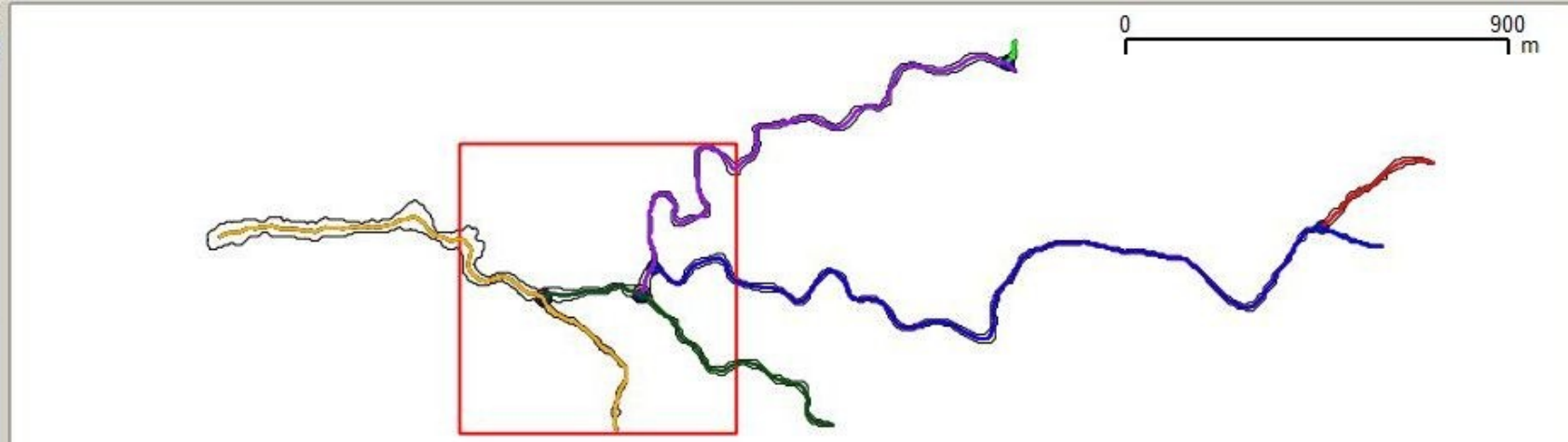
Using

Combine all section to have a reach for each upstream network to exit
(method to be improved)

And

Use a buffer on each junction with the distance to the nearest point of envelop



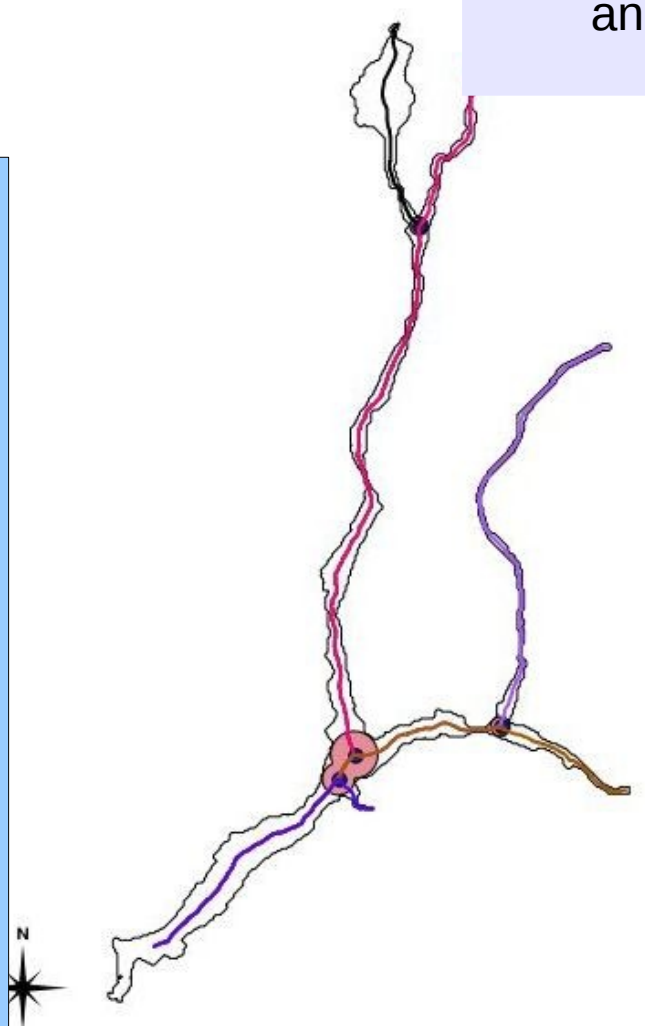


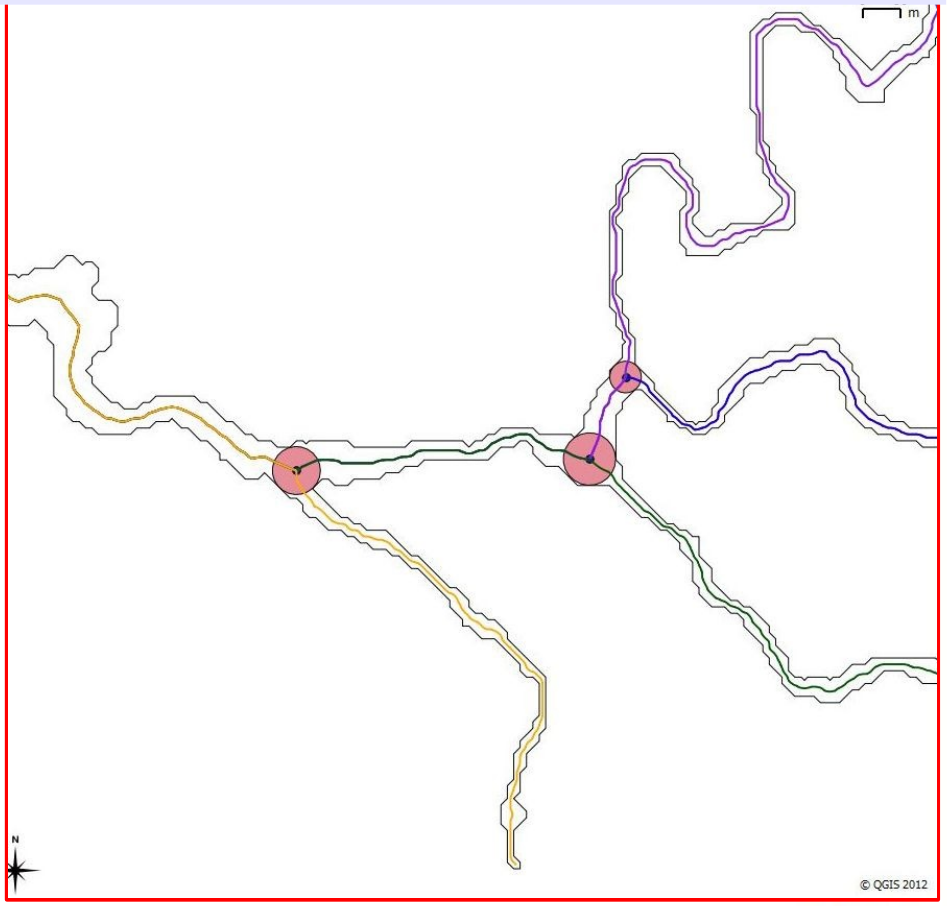
Create a network of reaches (upstream-> exit) and create banning zone to interpolate flow raster on future cross sections

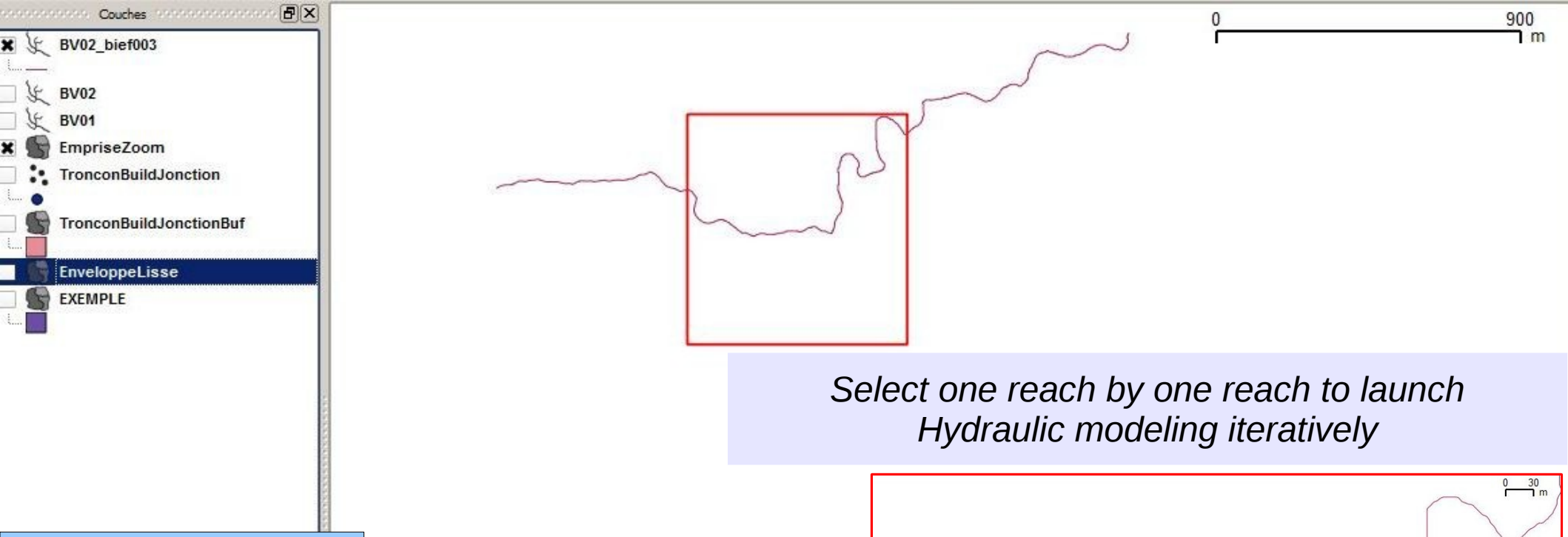
Actions to do for the following figure:

Aims: Select one reach by one reach to launch Hydraulic modeling iteratively

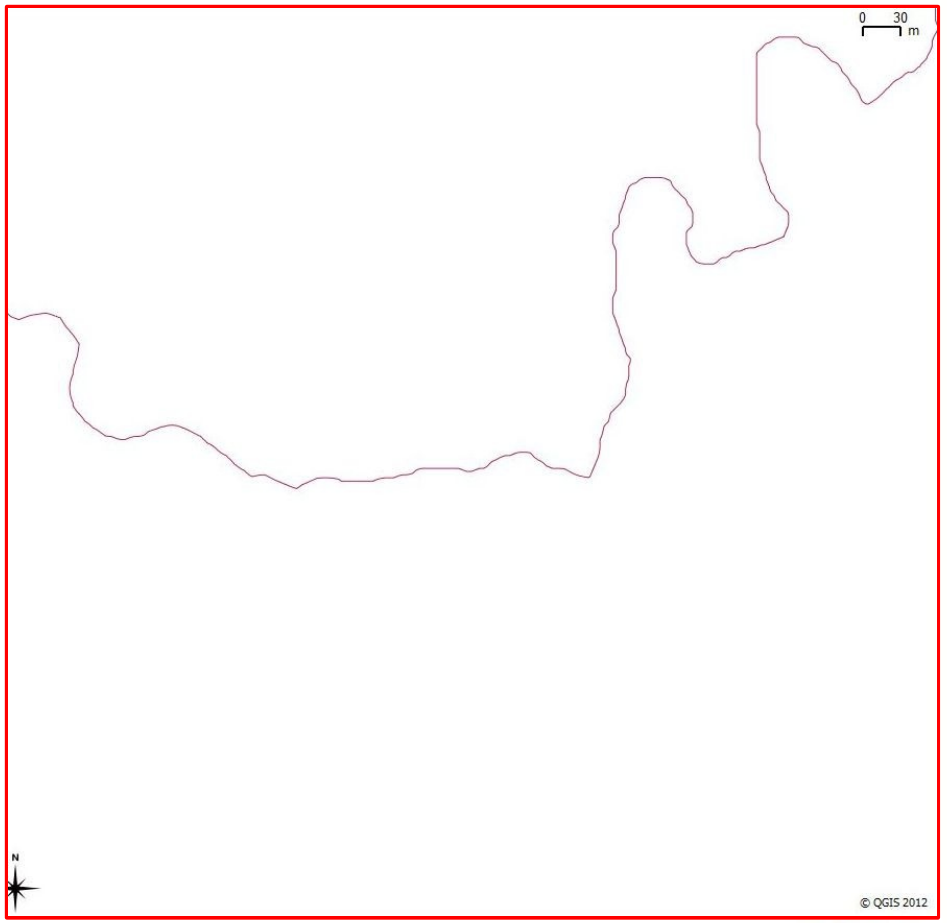
Select one number







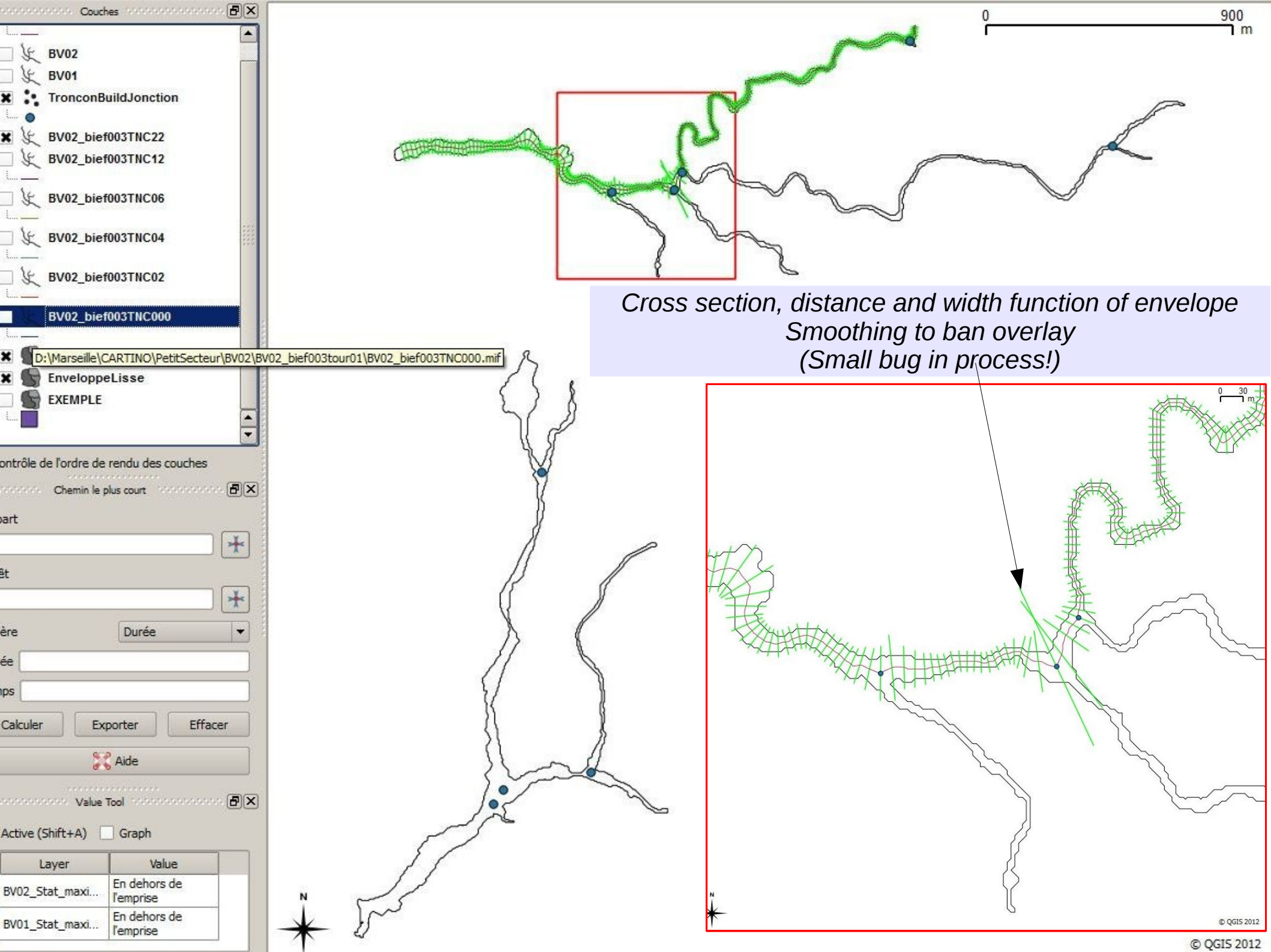
Select one reach by one reach to launch Hydraulic modeling iteratively



Actions to do
for the following figure:

Aims: Create cross section with distance between upstream and downstream cross section function of the width of envelope without overlay

First width of cross-section using width of envelope and smoothing angle of cross section to ban overlay


Couches
BV02
BV01
TronconBuildJonction
BV02_bief003TNC22
BV02_bief003TNC12
BV02_bief003TNC06
BV02_bief003TNC04
BV02_bief003TNC02
BV02_bief003TNC000
D:\Marseille\CARTINO\PetitSecteur\BV02\BV02_bief003tour01\BV02_bief003TNC000.mif
EnveloppeLisse
EXEMPLE
ontrôle de l'ordre de rendu des couches
Chemin le plus court
Durée
Calculer
Exporter
Effacer
Aide
Value Tool
Active (Shift+A)
Graph
Layer
Value
BV02_Stat_maxi...
En dehors de l'emprise
BV01_Stat_maxi...
En dehors de l'emprise
0
900
m
Cross section, distance and width function of envelope
Smoothing to ban overlay
(Small bug in process!)
0
30
m
N
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Hydraulic Modeling

- Interpolation on cross section of the DEM (split 1m)
- Interpolation on cross section of the Flow raster (split 1m)
- Calculate in steady flow
- Creation of geometry file (file *.geo) for Mascaret and Flutor

MASCARET

EDF/LNHE - CETMEF

- Manage flow contribution (some problems with number of laws in Mascaret)
- Create parameters file (file *.cas)
- Downstream boundary condition with normal depth out of the software
- Launch calculation out of fudaa interface
- Lot of bugs if running only on cross sections defined in the process

FLUTOR

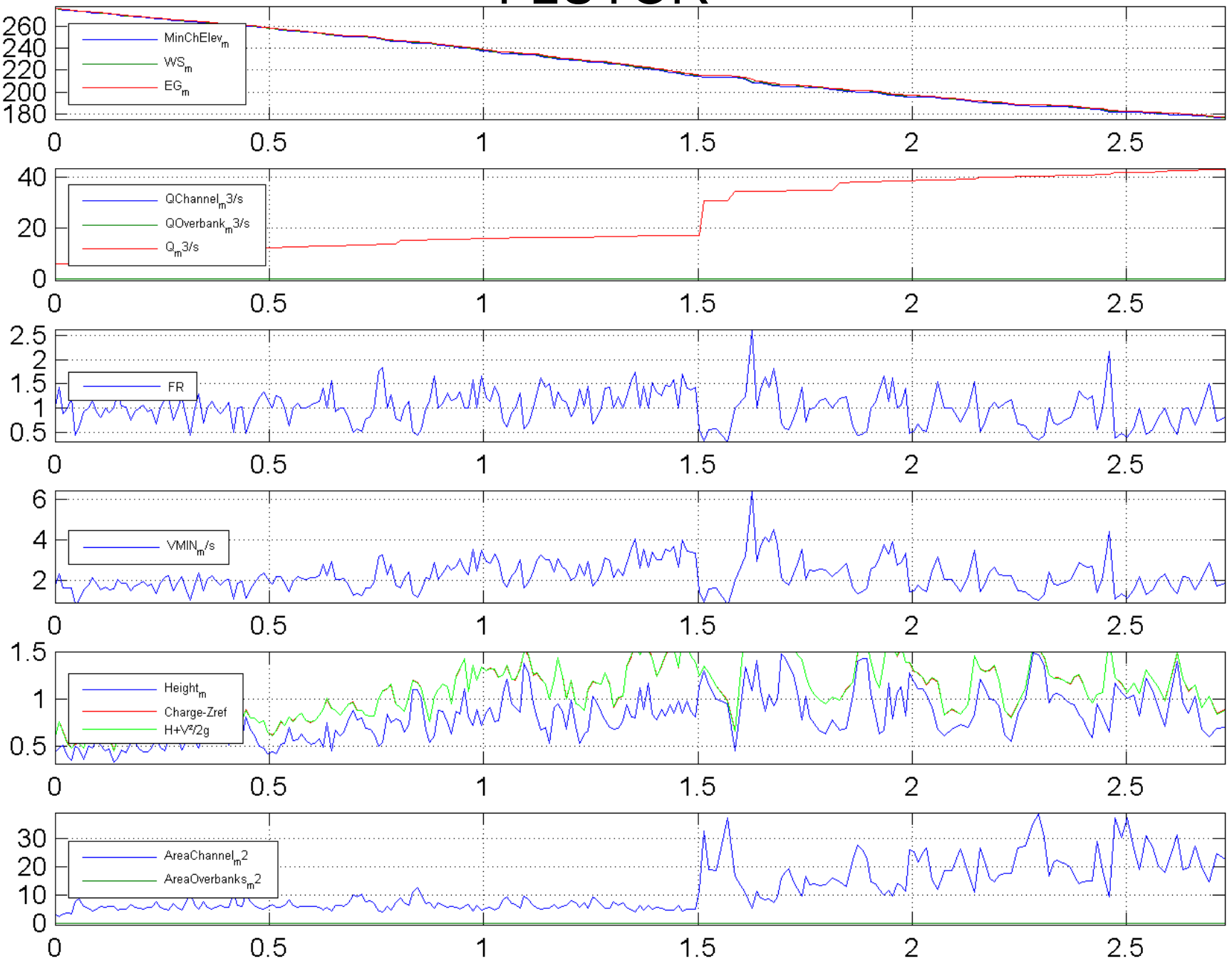
Patrick Chassé end of 80s

- No problem to manage flow contribution
- Create parameters file (file *.cas)
- Downstream boundary condition calculated automatically
- No bugs

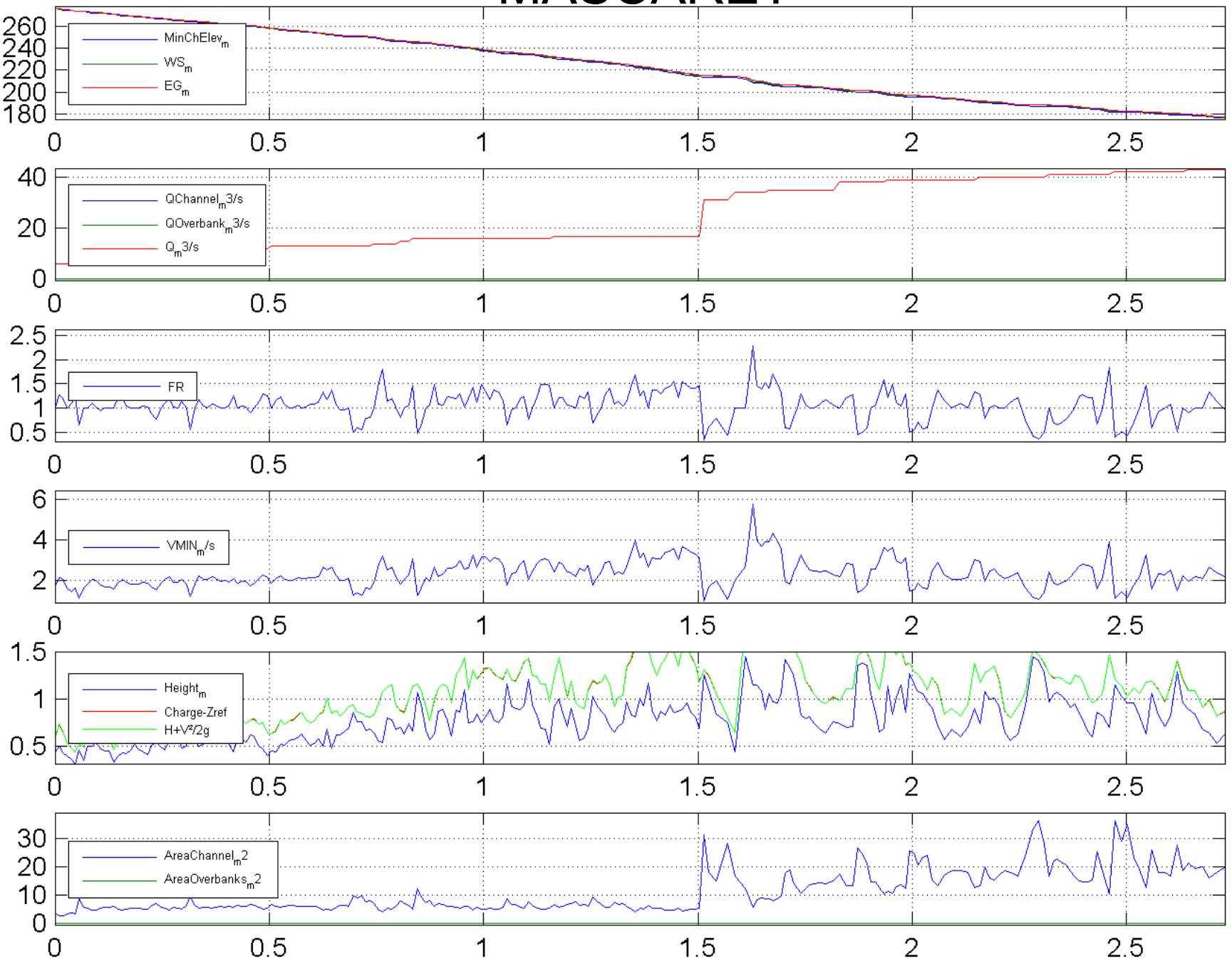
CHOICE TO KEEP THE FLUTOR RESULTS INSTEAD OF MASCARET

- Iterative decrease mesh for convergence (100 to 5 meters)
- Create a figure of results for each software and comparison
- Widening of cross-sections if necessary => Loop to restart the process

FLUTOR

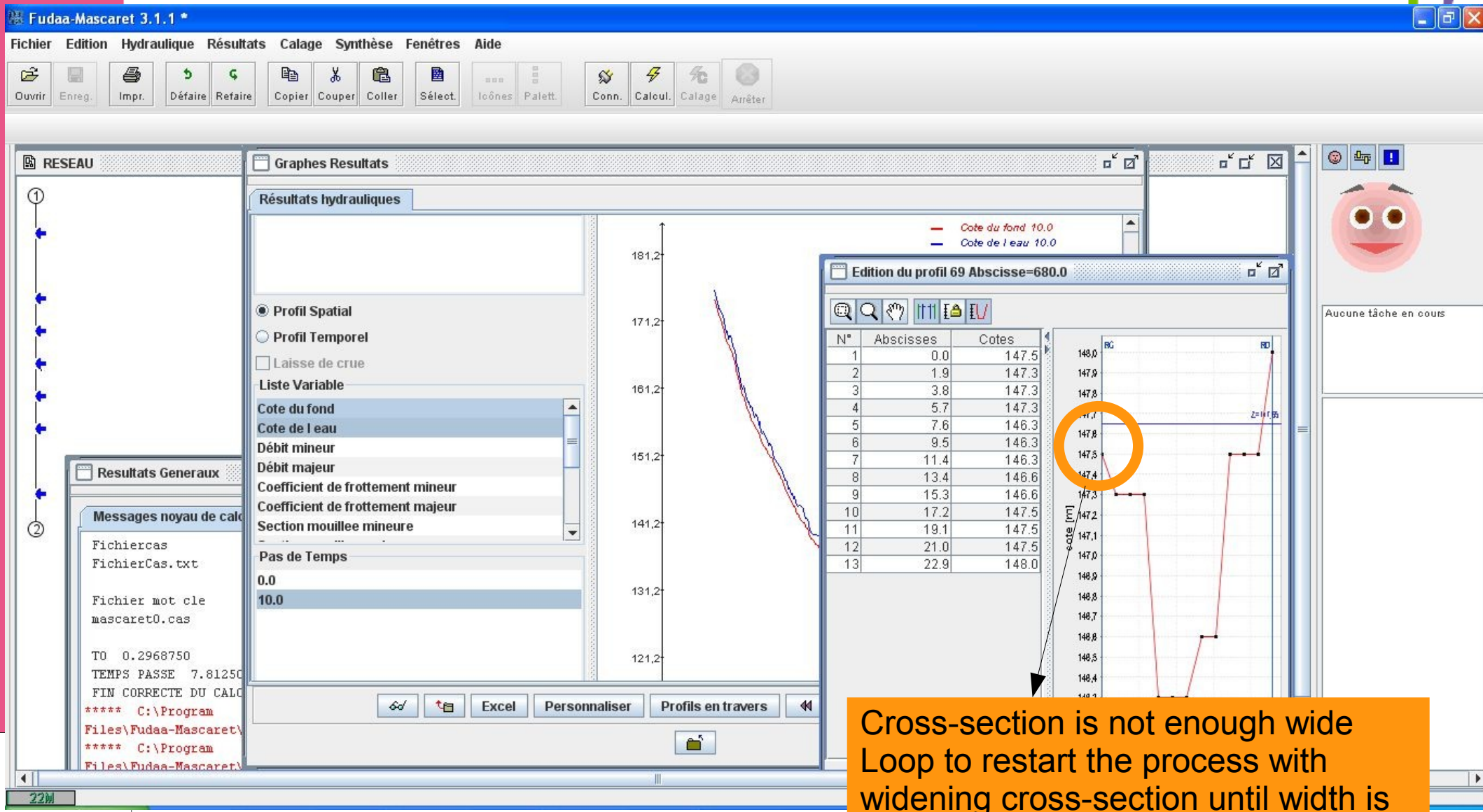

MinChElev_m
WS_m
EG_m
QChannel_m3/s
QOverbank_m3/s
Q_m3/s
FR
VMIN_m/s
Height_m
Charge-Zref
H+V²/2g
AreaChannel_m2
AreaOverbanks_m2

MASCARET

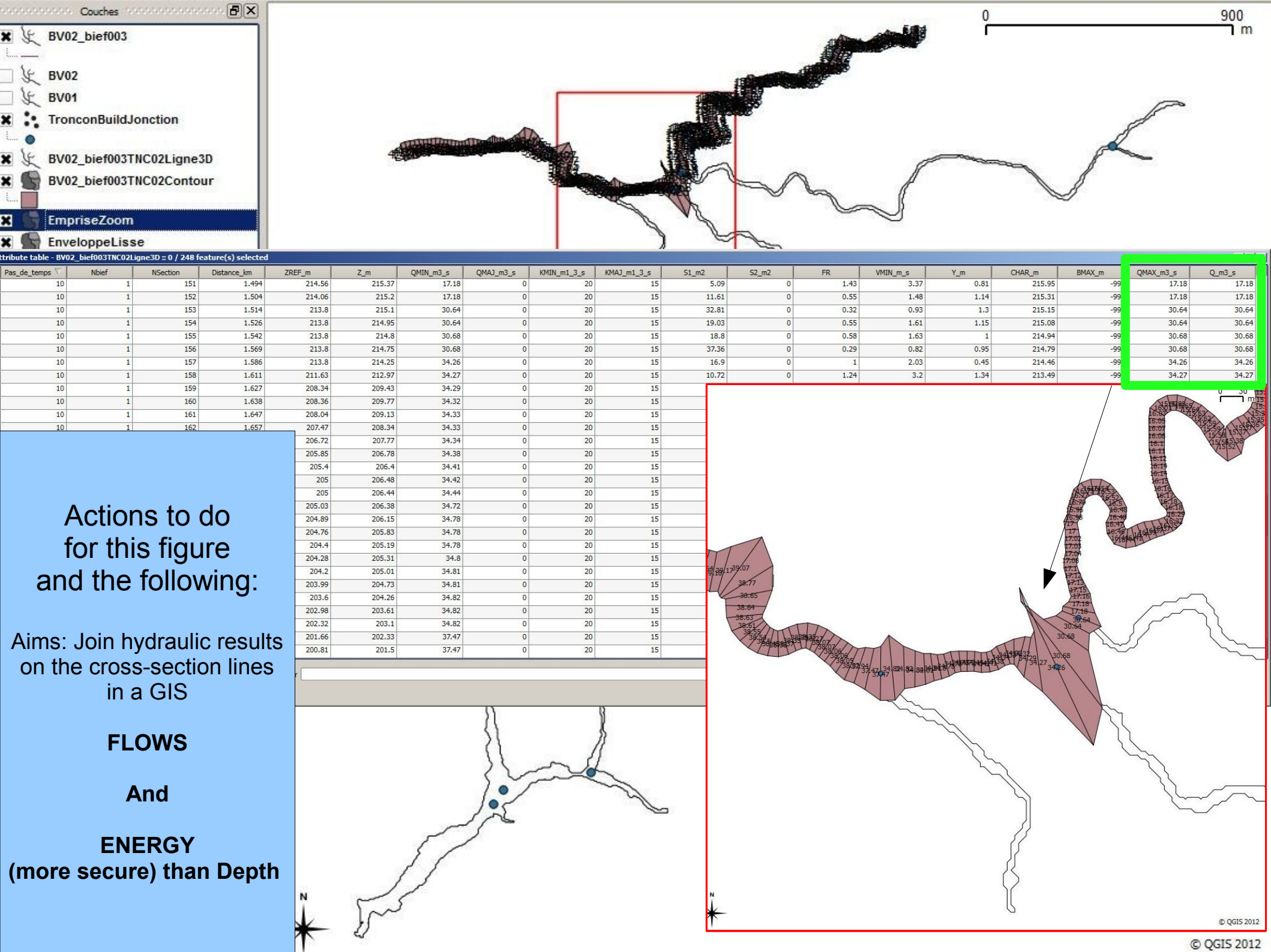

MinChElev_m
WS_m
EG_m
QChannel_m3/s
QOverbank_m3/s
Q_m3/s
FR
VMIN_m/s
Height_m
Charge-Zref
H+V²/2g
AreaChannel_m2
AreaOverbanks_m2

Gap: MASCARET - FLUTOR

Avalaible Checking in Fudaa-Mascaret



Cross-section is not enough wide
Loop to restart the process with widening cross-section until width is good


Couches
BV02_bief003
BV02
BV01
TronconBuildJonction
BV02_bief003TNC02Ligne3D
BV02_bief003TNC02Contour
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ttribute table - BV02_bief003TNC02Ligne3D :: 0 / 248 feature(s) selected
Pas_de_temps | Nbief | NSection | Distance_km | ZREF_m | Z_m | QMIN_m3_s | QMAJ_m3_s | KMIN_m1_3_s | KMAJ_m1_3_s | S1_m2 | S2_m2 | FR | VMIN_m_s | Y_m | CHAR_m | BMAX_m | QMAX_m3_s | Q_m3_s
10 | 1 | 151 | 1.494 | 214.56 | 215.37 | 17.18 | 0 | 20 | 15 | 5.09 | 0 | 1.43 | 3.37 | 0.81 | 215.95 | -99 | 17.18 | 17.18
10 | 1 | 152 | 1.504 | 214.06 | 215.2 | 17.18 | 0 | 20 | 15 | 11.61 | 0 | 0.55 | 1.48 | 1.14 | 215.31 | -99 | 17.18 | 17.18
10 | 1 | 153 | 1.514 | 213.8 | 215.1 | 30.64 | 0 | 20 | 15 | 32.81 | 0 | 0.32 | 0.93 | 1.3 | 215.15 | -99 | 30.64 | 30.64
10 | 1 | 154 | 1.526 | 213.8 | 214.95 | 30.64 | 0 | 20 | 15 | 19.03 | 0 | 0.55 | 1.61 | 1.15 | 215.08 | -99 | 30.64 | 30.64
10 | 1 | 155 | 1.542 | 213.8 | 214.8 | 30.68 | 0 | 20 | 15 | 18.8 | 0 | 0.58 | 1.63 | 1 | 214.94 | -99 | 30.68 | 30.68
10 | 1 | 156 | 1.569 | 213.8 | 214.75 | 30.68 | 0 | 20 | 15 | 37.36 | 0 | 0.29 | 0.82 | 0.95 | 214.79 | -99 | 30.68 | 30.68
10 | 1 | 157 | 1.586 | 213.8 | 214.25 | 34.26 | 0 | 20 | 15 | 16.9 | 0 | 1 | 2.03 | 0.45 | 214.46 | -99 | 34.26 | 34.26
10 | 1 | 158 | 1.611 | 211.63 | 212.97 | 34.27 | 0 | 20 | 15 | 10.72 | 0 | 1.24 | 3.2 | 1.34 | 213.49 | -99 | 34.27 | 34.27
10 | 1 | 159 | 1.627 | 208.34 | 209.43 | 34.29 | 0 | 20 | 15
10 | 1 | 160 | 1.638 | 208.36 | 209.77 | 34.32 | 0 | 20 | 15
10 | 1 | 161 | 1.647 | 208.04 | 209.13 | 34.33 | 0 | 20 | 15
10 | 1 | 162 | 1.657 | 207.47 | 208.34 | 34.33 | 0 | 20 | 15
206.72 | 207.77 | 34.34 | 0 | 20 | 15
205.85 | 206.78 | 34.38 | 0 | 20 | 15
205.4 | 206.4 | 34.41 | 0 | 20 | 15
205 | 206.48 | 34.42 | 0 | 20 | 15
205 | 206.44 | 34.44 | 0 | 20 | 15
205.03 | 206.38 | 34.72 | 0 | 20 | 15
204.89 | 206.15 | 34.78 | 0 | 20 | 15
204.76 | 205.83 | 34.78 | 0 | 20 | 15
204.4 | 205.19 | 34.78 | 0 | 20 | 15
204.28 | 205.31 | 34.8 | 0 | 20 | 15
204.2 | 205.01 | 34.81 | 0 | 20 | 15
203.99 | 204.73 | 34.81 | 0 | 20 | 15
203.6 | 204.26 | 34.82 | 0 | 20 | 15
202.98 | 203.61 | 34.82 | 0 | 20 | 15
202.32 | 203.1 | 34.82 | 0 | 20 | 15
201.66 | 202.33 | 37.47 | 0 | 20 | 15
200.81 | 201.5 | 37.47 | 0 | 20 | 15
Actions to do
for this figure
and the following:
Aims: Join hydraulic results
on the cross-section lines
in a GIS
FLOWS
And
ENERGY
(more secure) than Depth
N
0
30
m
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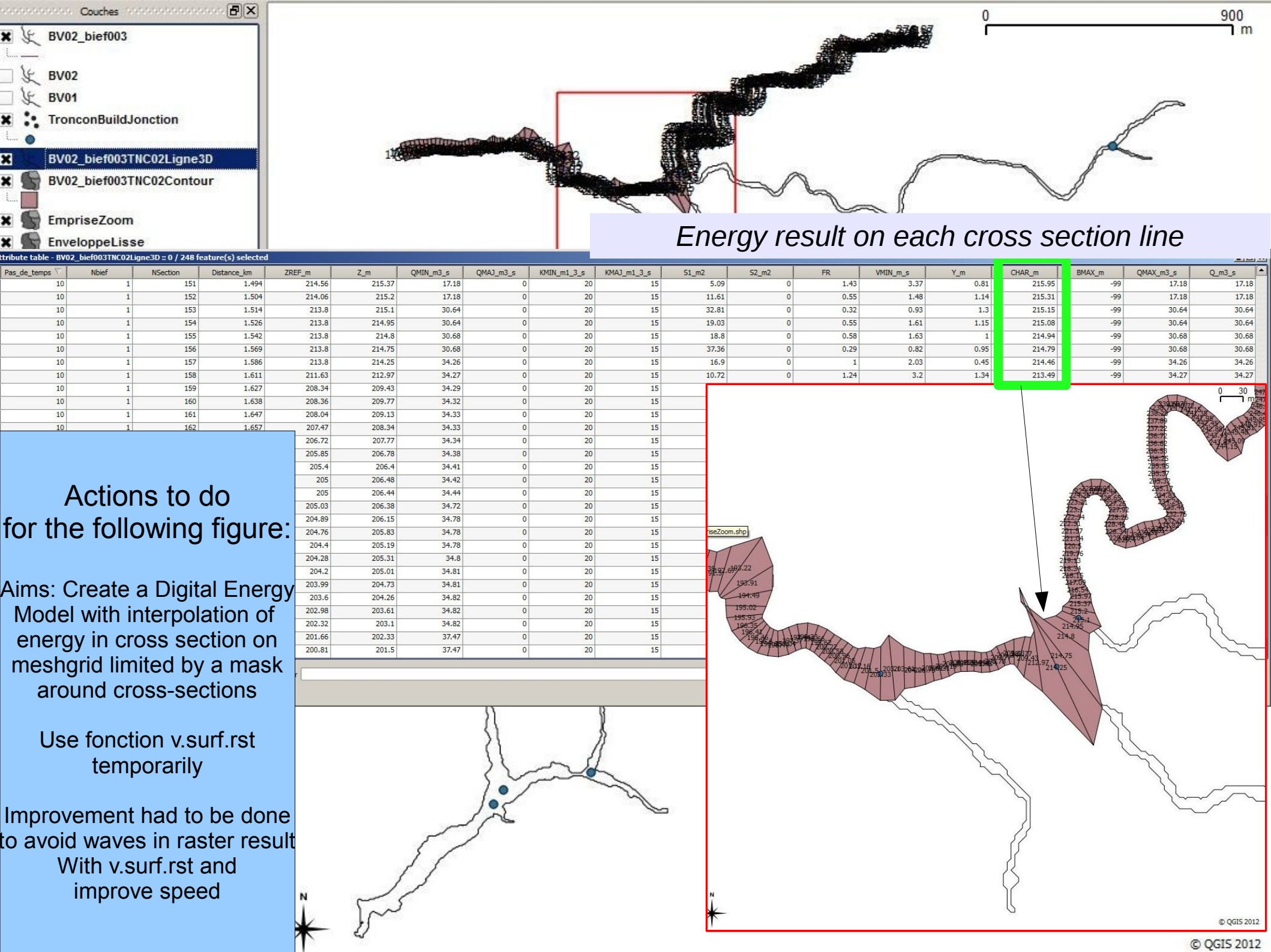
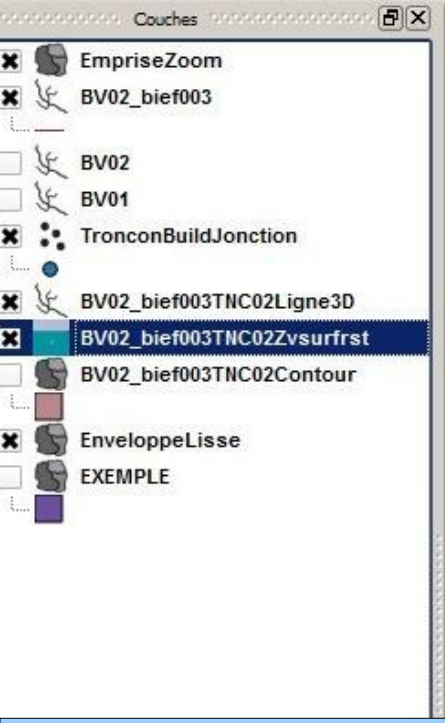
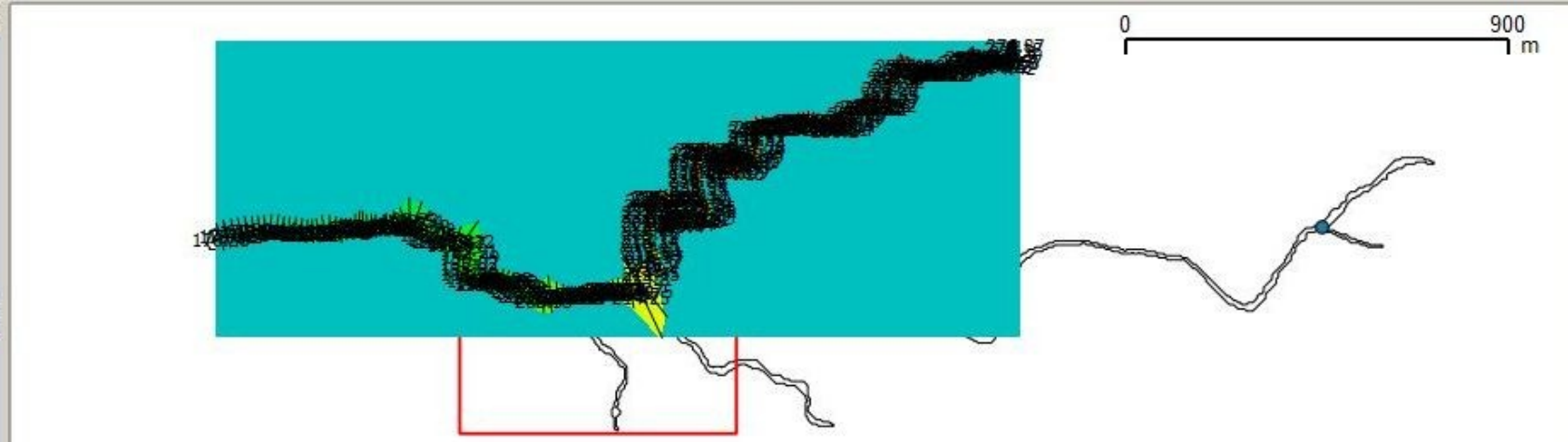

Couches
BV02_bief003
BV02
BV01
TronconBuildJonction
BV02_bief003TNC02Ligne3D
BV02_bief003TNC02Contour
EmpriseZoom
EnveloppeLisse
0
900
m
Energy result on each cross section line
ttribute table - BV02_bief003TNC02Ligne3D :: 0 / 248 feature(s) selected
Pas_de_temps | Nbief | NSection | Distance_km | ZREF_m | Z_m | QMIN_m3_s | QMAJ_m3_s | KMIN_m1_3_s | KMAJ_m1_3_s | S1_m2 | S2_m2 | FR | VMIN_m_s | Y_m | CHAR_m | BMAX_m | QMAX_m3_s | Q_m3_s
10 | 1 | 151 | 1.494 | 214.56 | 215.37 | 17.18 | 0 | 20 | 15 | 5.09 | 0 | 1.43 | 3.37 | 0.81 | 215.95 | -99 | 17.18 | 17.18
10 | 1 | 152 | 1.504 | 214.06 | 215.2 | 17.18 | 0 | 20 | 15 | 11.61 | 0 | 0.55 | 1.48 | 1.14 | 215.31 | -99 | 17.18 | 17.18
10 | 1 | 153 | 1.514 | 213.8 | 215.1 | 30.64 | 0 | 20 | 15 | 32.81 | 0 | 0.32 | 0.93 | 1.3 | 215.15 | -99 | 30.64 | 30.64
10 | 1 | 154 | 1.526 | 213.8 | 214.95 | 30.64 | 0 | 20 | 15 | 19.03 | 0 | 0.55 | 1.61 | 1.15 | 215.08 | -99 | 30.64 | 30.64
10 | 1 | 155 | 1.542 | 213.8 | 214.8 | 30.68 | 0 | 20 | 15 | 18.8 | 0 | 0.58 | 1.63 | 1 | 214.94 | -99 | 30.68 | 30.68
10 | 1 | 156 | 1.569 | 213.8 | 214.75 | 30.68 | 0 | 20 | 15 | 37.36 | 0 | 0.29 | 0.82 | 0.95 | 214.79 | -99 | 30.68 | 30.68
10 | 1 | 157 | 1.586 | 213.8 | 214.25 | 34.26 | 0 | 20 | 15 | 16.9 | 0 | 1 | 2.03 | 0.45 | 214.46 | -99 | 34.26 | 34.26
10 | 1 | 158 | 1.611 | 211.63 | 212.97 | 34.27 | 0 | 20 | 15 | 10.72 | 0 | 1.24 | 3.2 | 1.34 | 213.49 | -99 | 34.27 | 34.27
10 | 1 | 159 | 1.627 | 208.34 | 209.43 | 34.29 | 0 | 20 | 15
10 | 1 | 160 | 1.638 | 208.36 | 209.77 | 34.32 | 0 | 20 | 15
10 | 1 | 161 | 1.647 | 208.04 | 209.13 | 34.33 | 0 | 20 | 15
10 | 1 | 162 | 1.657 | 207.47 | 208.34 | 34.33 | 0 | 20 | 15
206.72 | 207.77 | 34.34 | 0 | 20 | 15
205.85 | 206.78 | 34.38 | 0 | 20 | 15
205.4 | 206.4 | 34.41 | 0 | 20 | 15
205 | 206.48 | 34.42 | 0 | 20 | 15
205 | 206.44 | 34.44 | 0 | 20 | 15
205.03 | 206.38 | 34.72 | 0 | 20 | 15
204.89 | 206.15 | 34.78 | 0 | 20 | 15
204.76 | 205.83 | 34.78 | 0 | 20 | 15
204.4 | 205.19 | 34.78 | 0 | 20 | 15
204.28 | 205.31 | 34.8 | 0 | 20 | 15
204.2 | 205.01 | 34.81 | 0 | 20 | 15
203.99 | 204.73 | 34.81 | 0 | 20 | 15
203.6 | 204.26 | 34.82 | 0 | 20 | 15
202.98 | 203.61 | 34.82 | 0 | 20 | 15
202.32 | 203.1 | 34.82 | 0 | 20 | 15
201.66 | 202.33 | 37.47 | 0 | 20 | 15
200.81 | 201.5 | 37.47 | 0 | 20 | 15
Actions to do
for the following figure:
Aims: Create a Digital Energy Model with interpolation of energy in cross section on meshgrid limited by a mask around cross-sections
Use fonction v.surf.rst temporarily
Improvement had to be done to avoid waves in raster result
With v.surf.rst and improve speed
N
0
30
m
© QGIS 2012
© QGIS 2012



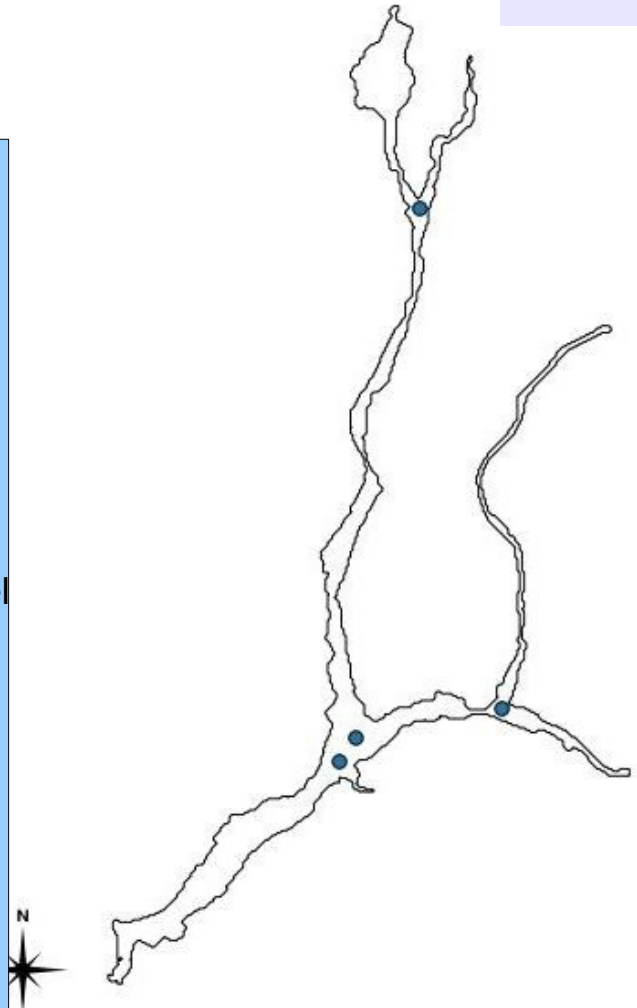


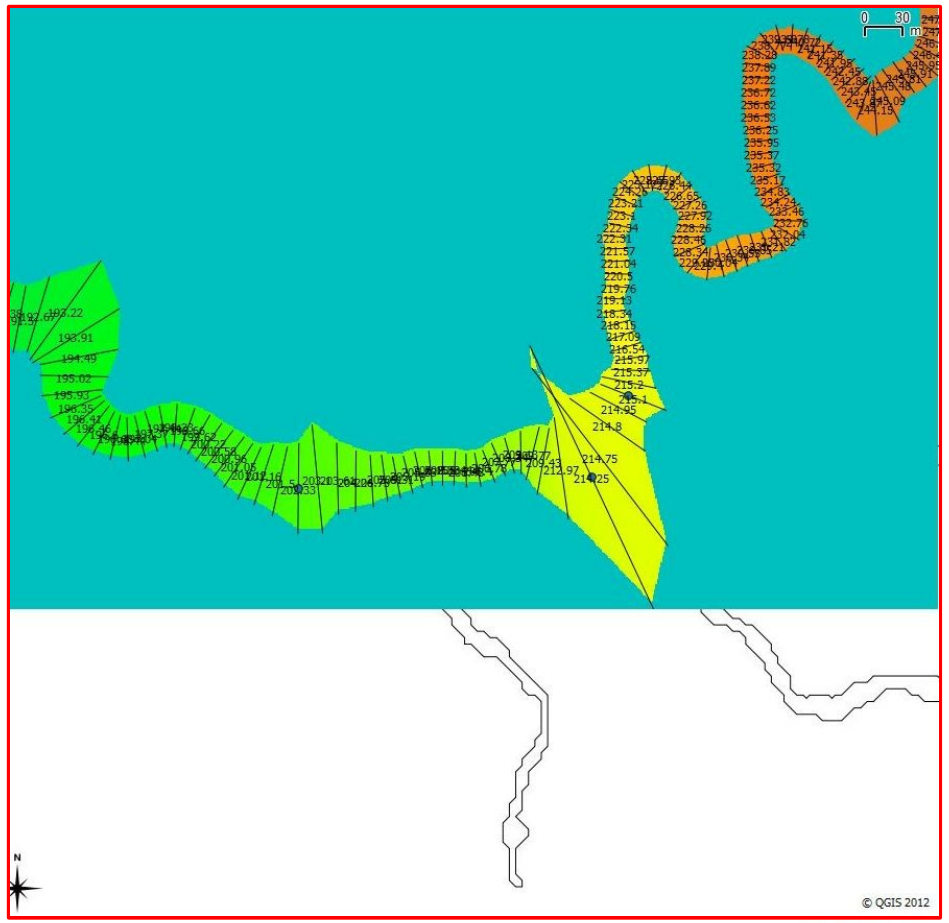
Digital Energy Model limited by cross-section

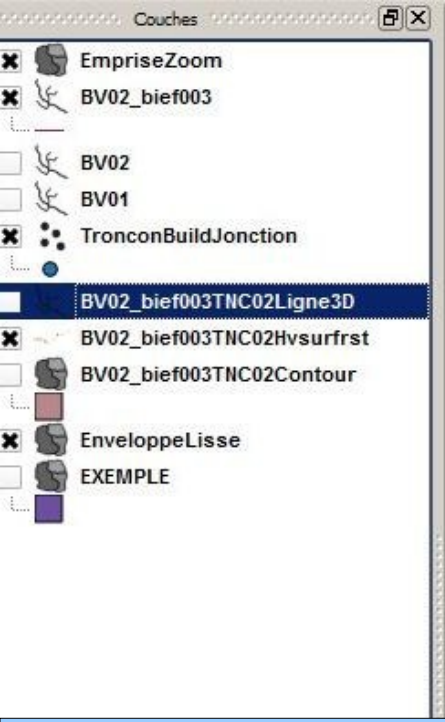
Actions to do
for the following figure:

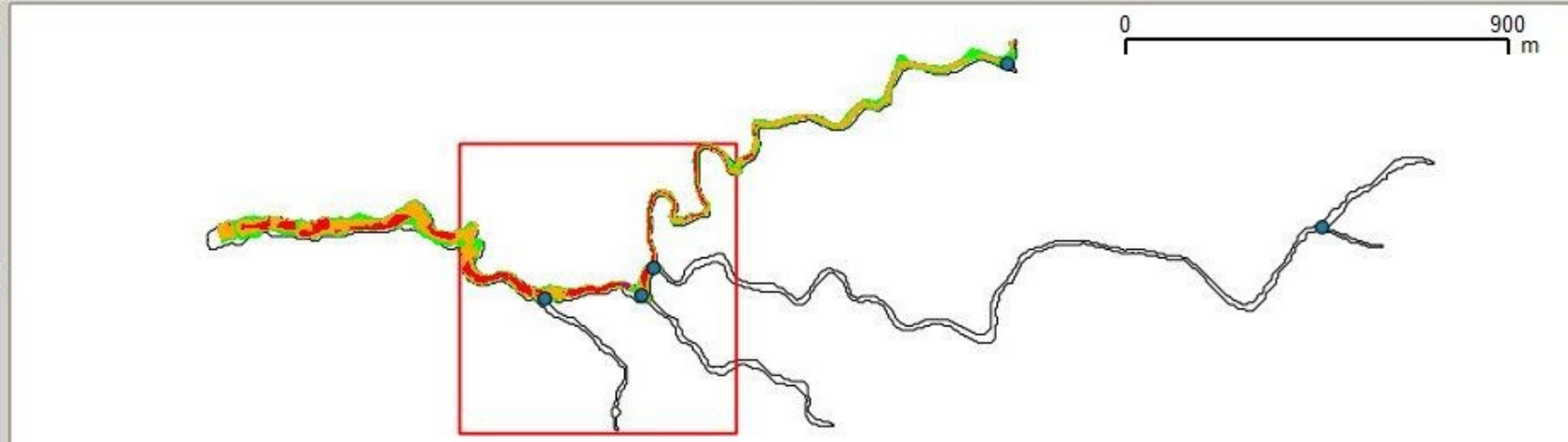
Aims: Have the difference between Digital Energy Model and Digital Elevation Model and keep only positive value

Use of Raster Calculator







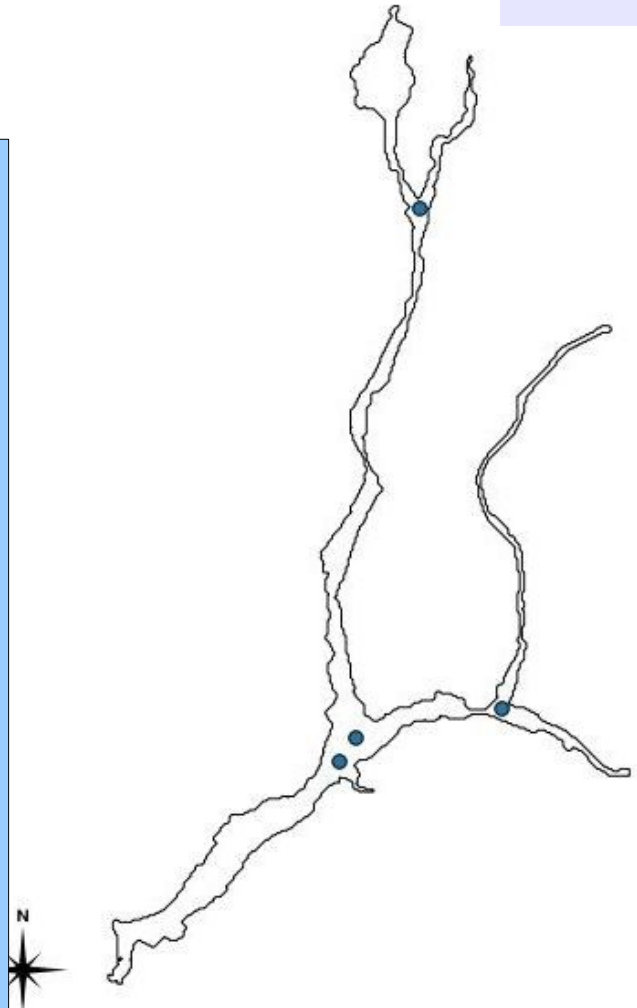


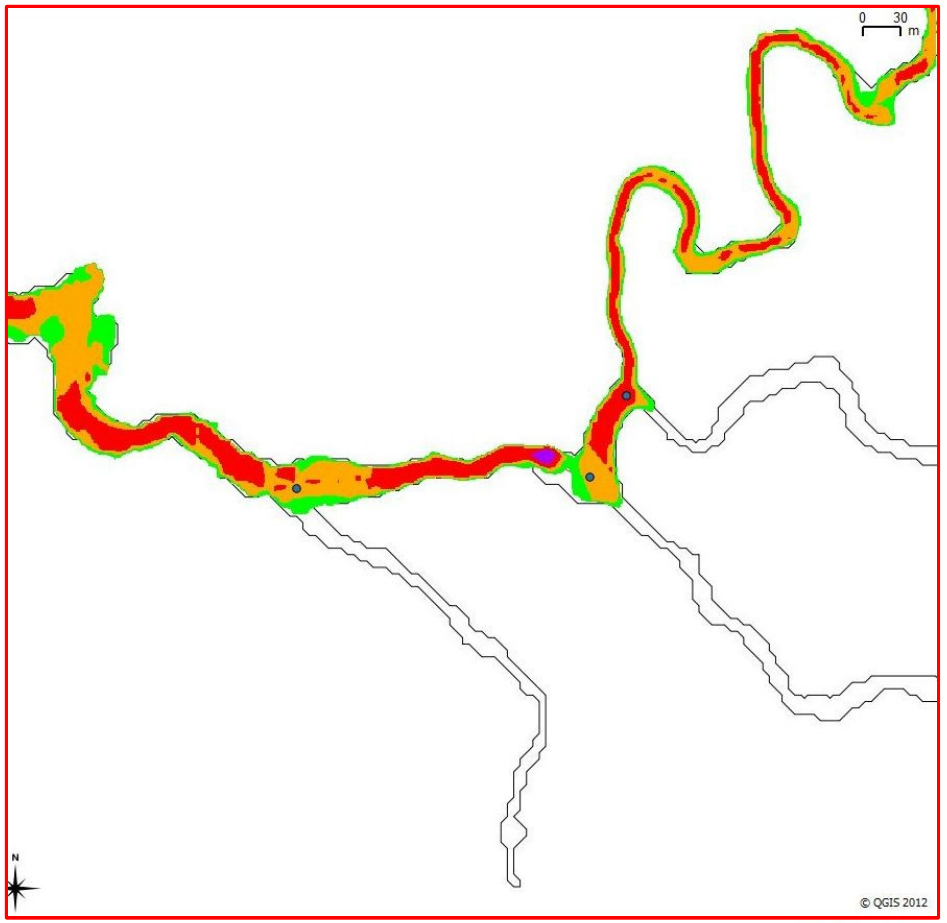
Difference between Digital Energy Model and Digital Elevation Model

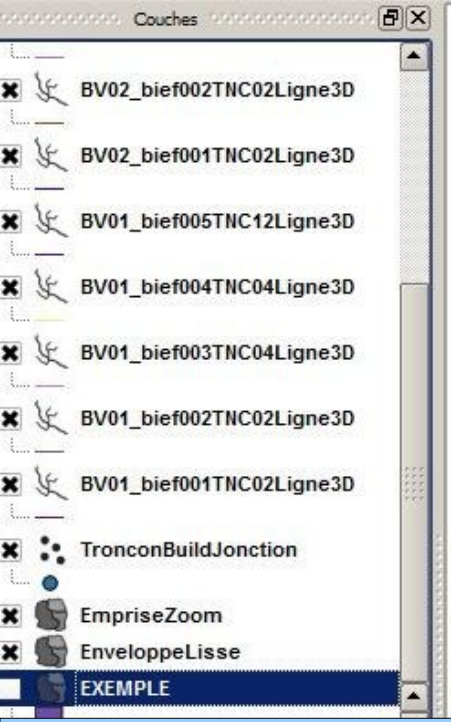
END OF A LOOP
FOR ONE REACH

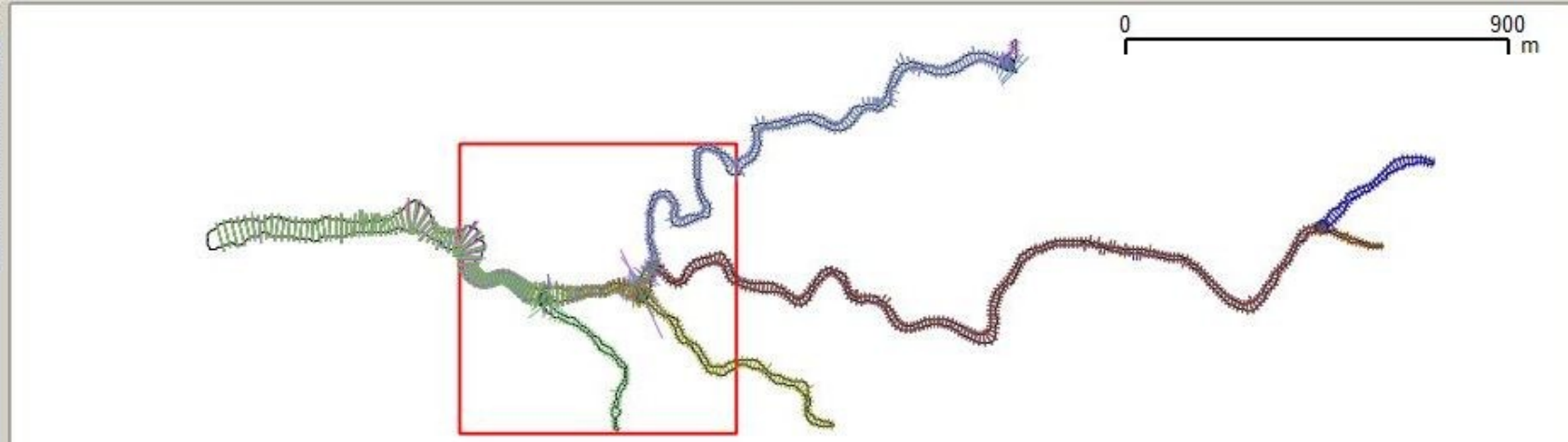
Actions to do
for the following figure:

Loop on each reach and
plot cross-section lines





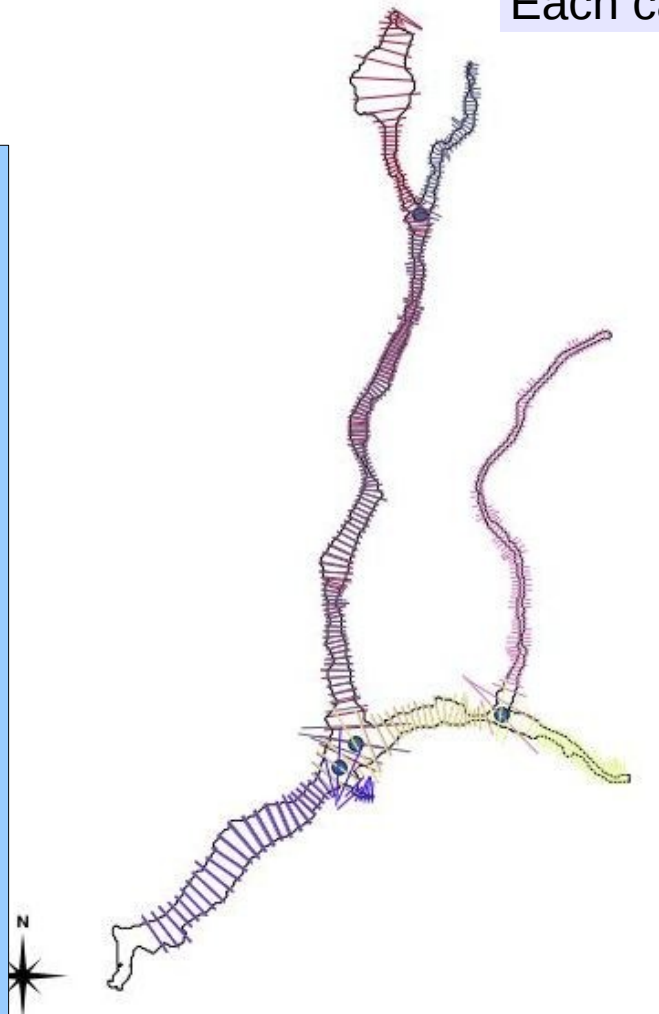


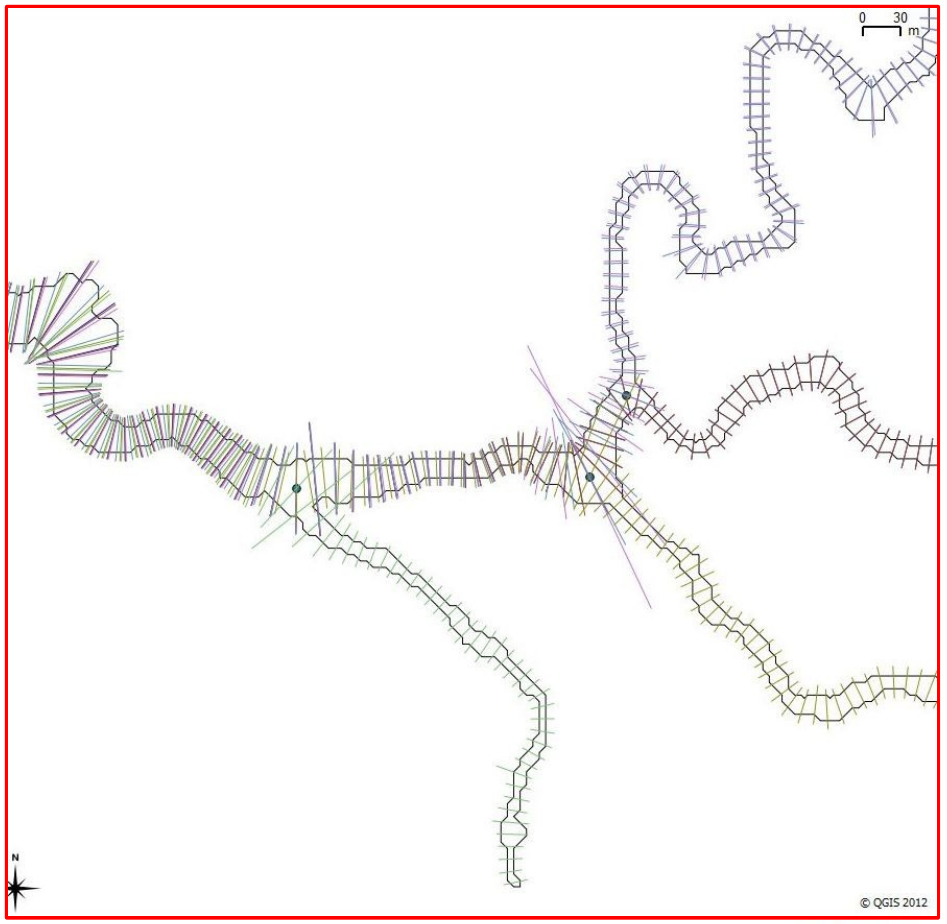


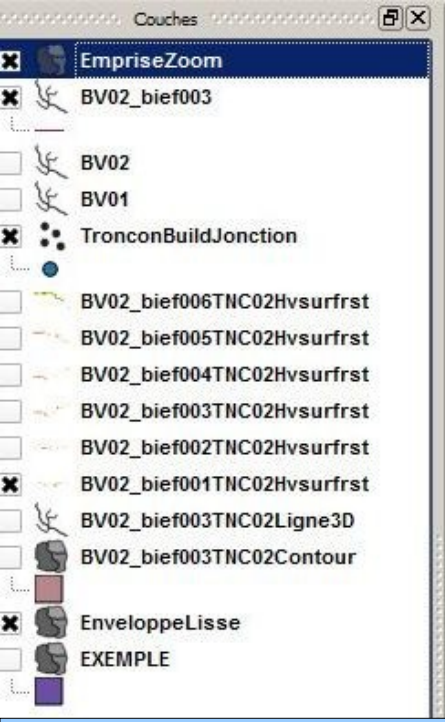
Plot cross-section lines on each reach
Each calculated reach overlay the other downstream

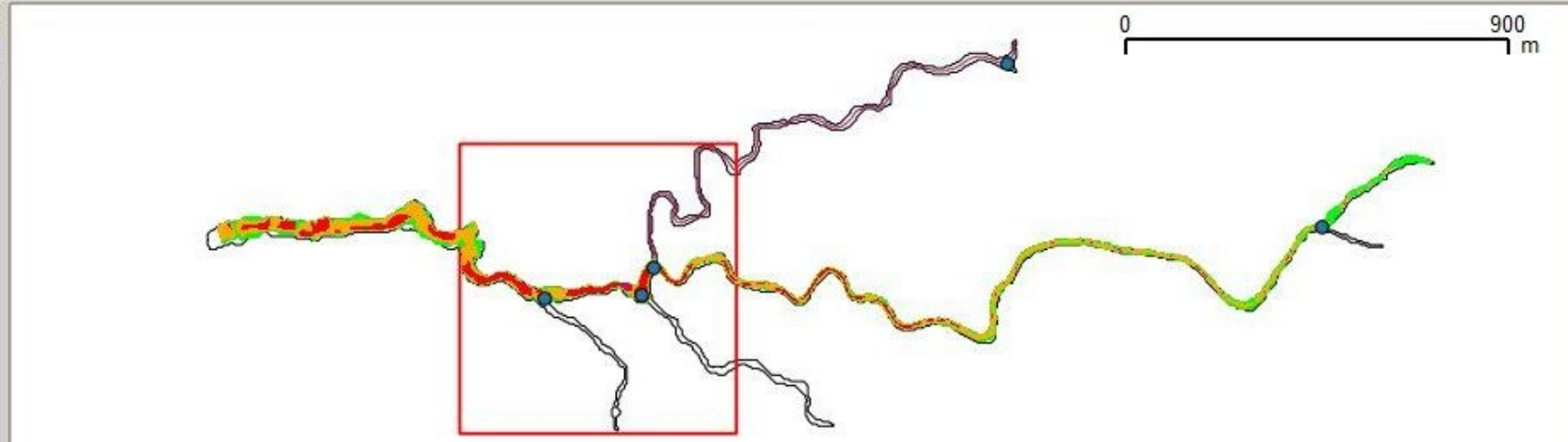
Actions to do
for the following figure:

Final result of first reach
(the longest)





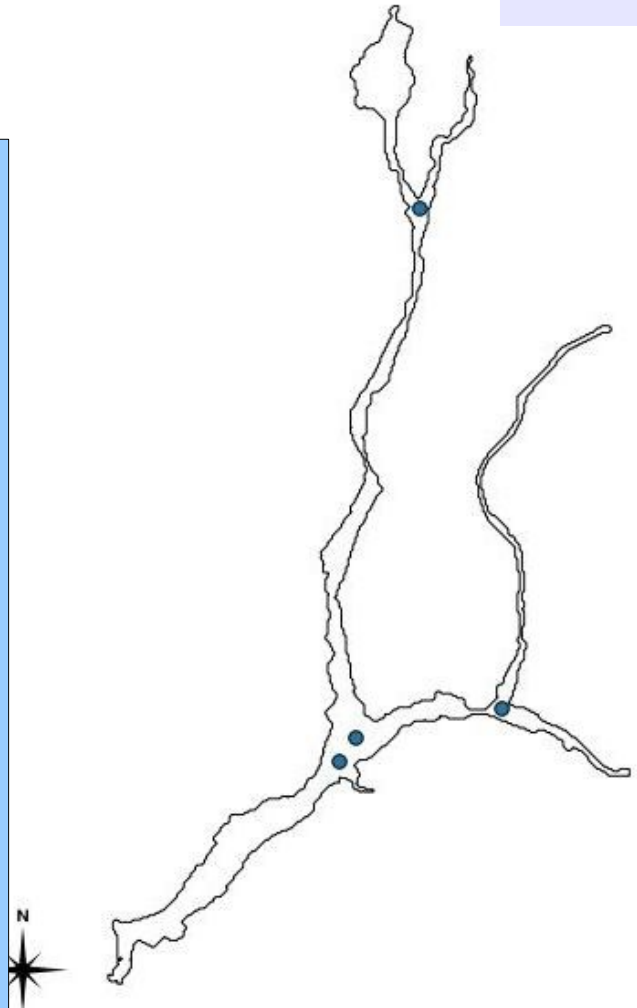


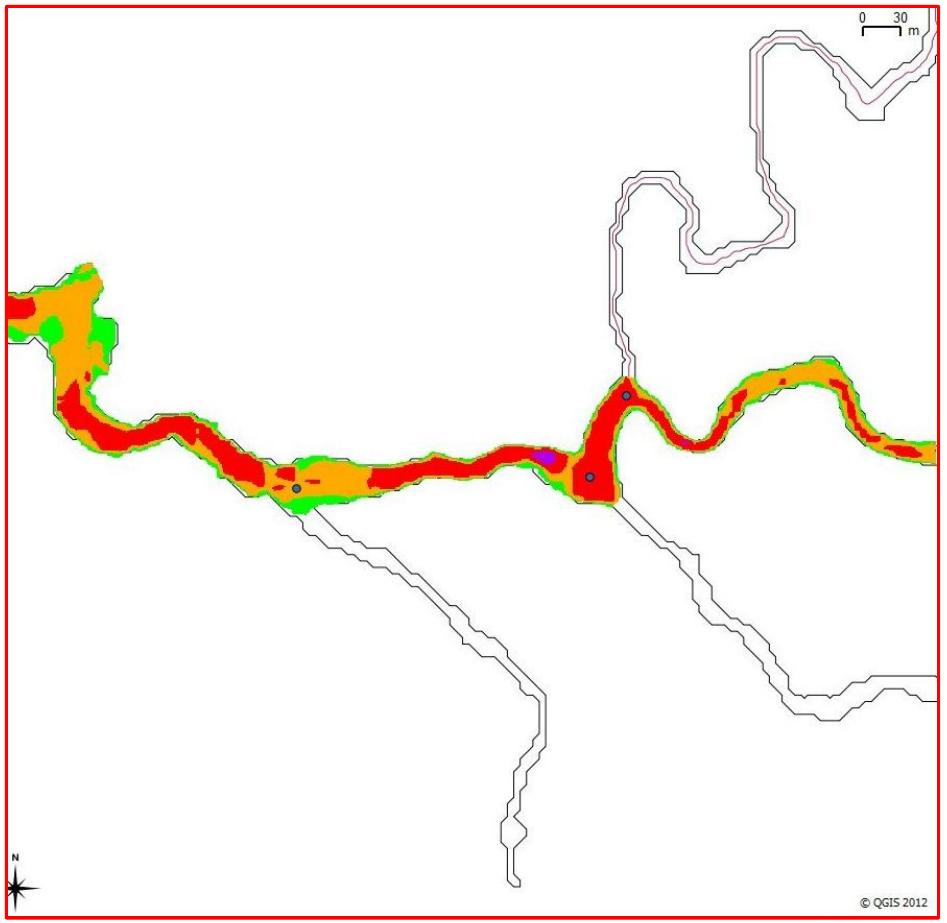


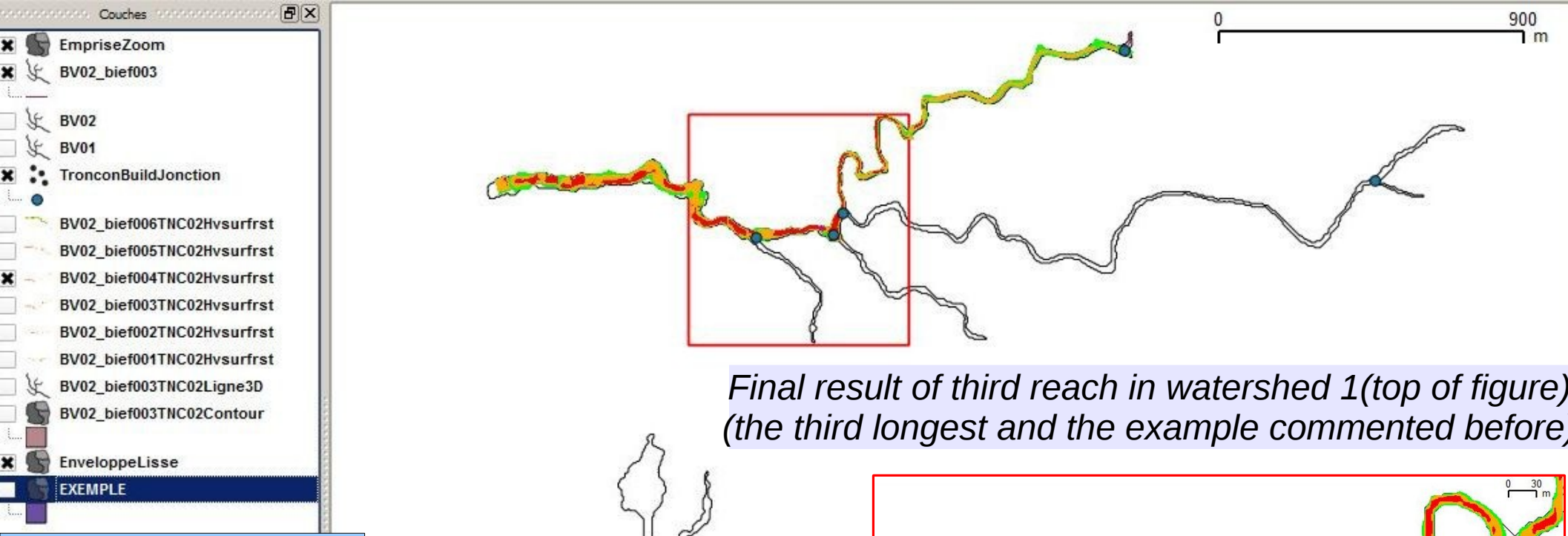
Final result of first reach in watershed 1(top of figure) (the longest)

Actions to do
for the following figure:

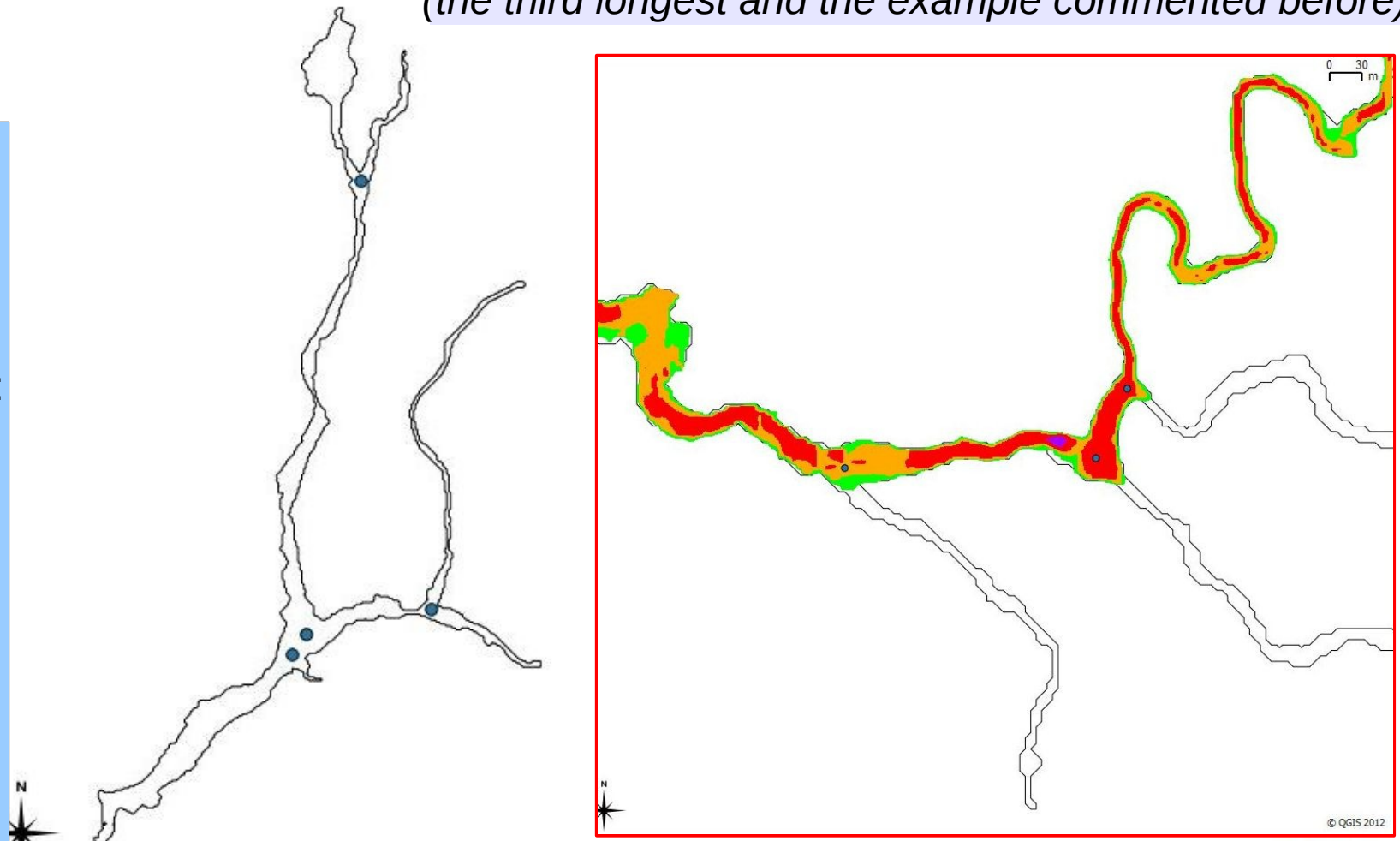
Final result of third reach
(the third longest)





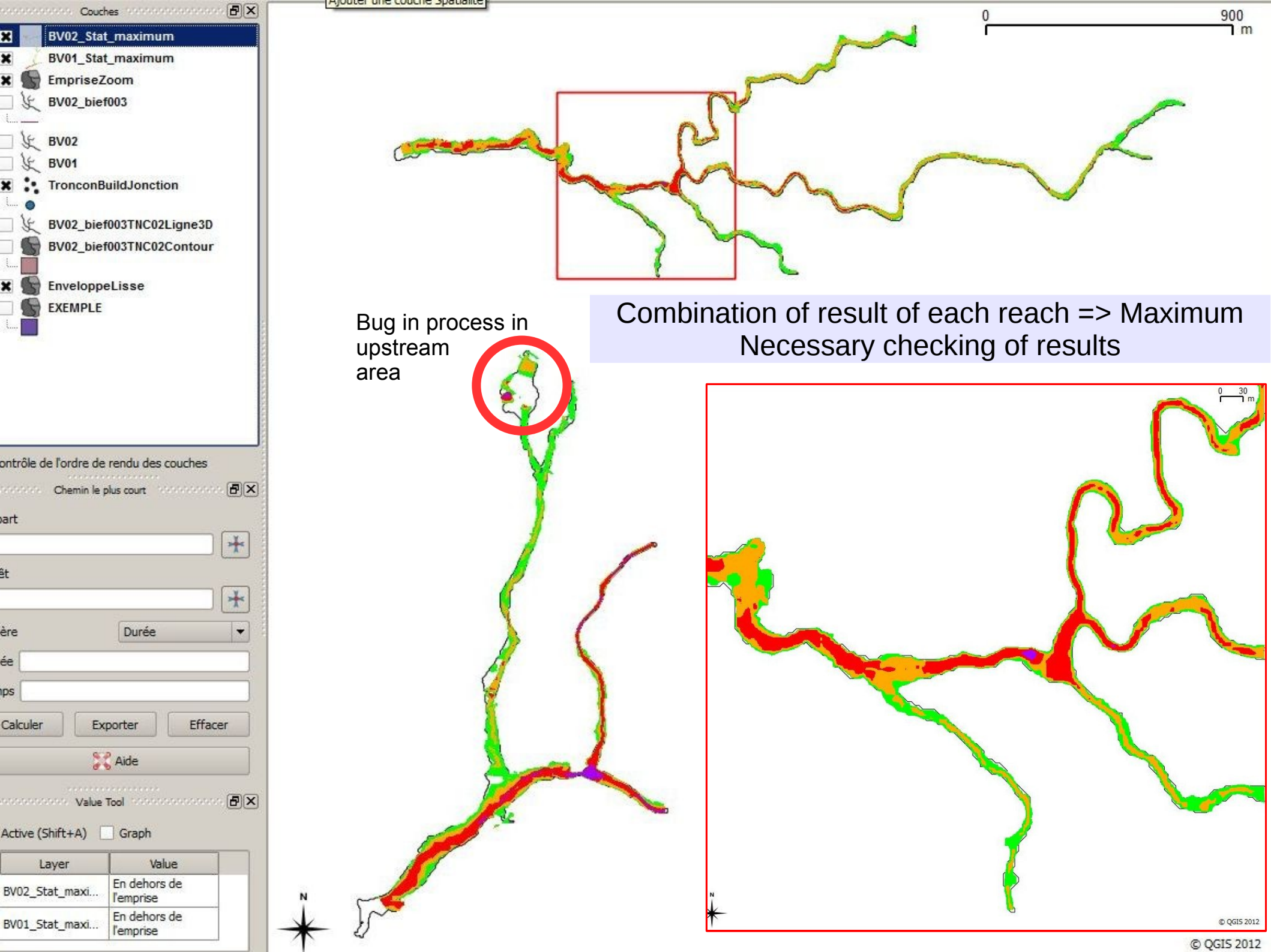


Final result of third reach in watershed 1(top of figure)
(the third longest and the example commented before)



Actions to do
for the following figure:

Aims: Combination of raster results of each reach
Maximum is presented
Minimum, average, range and standard deviation are also available.


Couches
BV02_Stat_maximum
BV01_Stat_maximum
EmpriseZoom
BV02_bief003
BV02
BV01
TronconBuildJonction
BV02_bief003TNC02Ligne3D
BV02_bief003TNC02Contour
EnveloppeLisse
EXEMPLE
Chemin le plus court
Durée
Calculer
Exporter
Effacer
Aide
Value Tool
Active (Shift+A)
Graph
Layer
Value
BV02_Stat_maxi...
En dehors de l'emprise
BV01_Stat_maxi...
En dehors de l'emprise
0
900
m
Bug in process in upstream area
Combination of result of each reach => Maximum
Necessary checking of results
0
30
m
N
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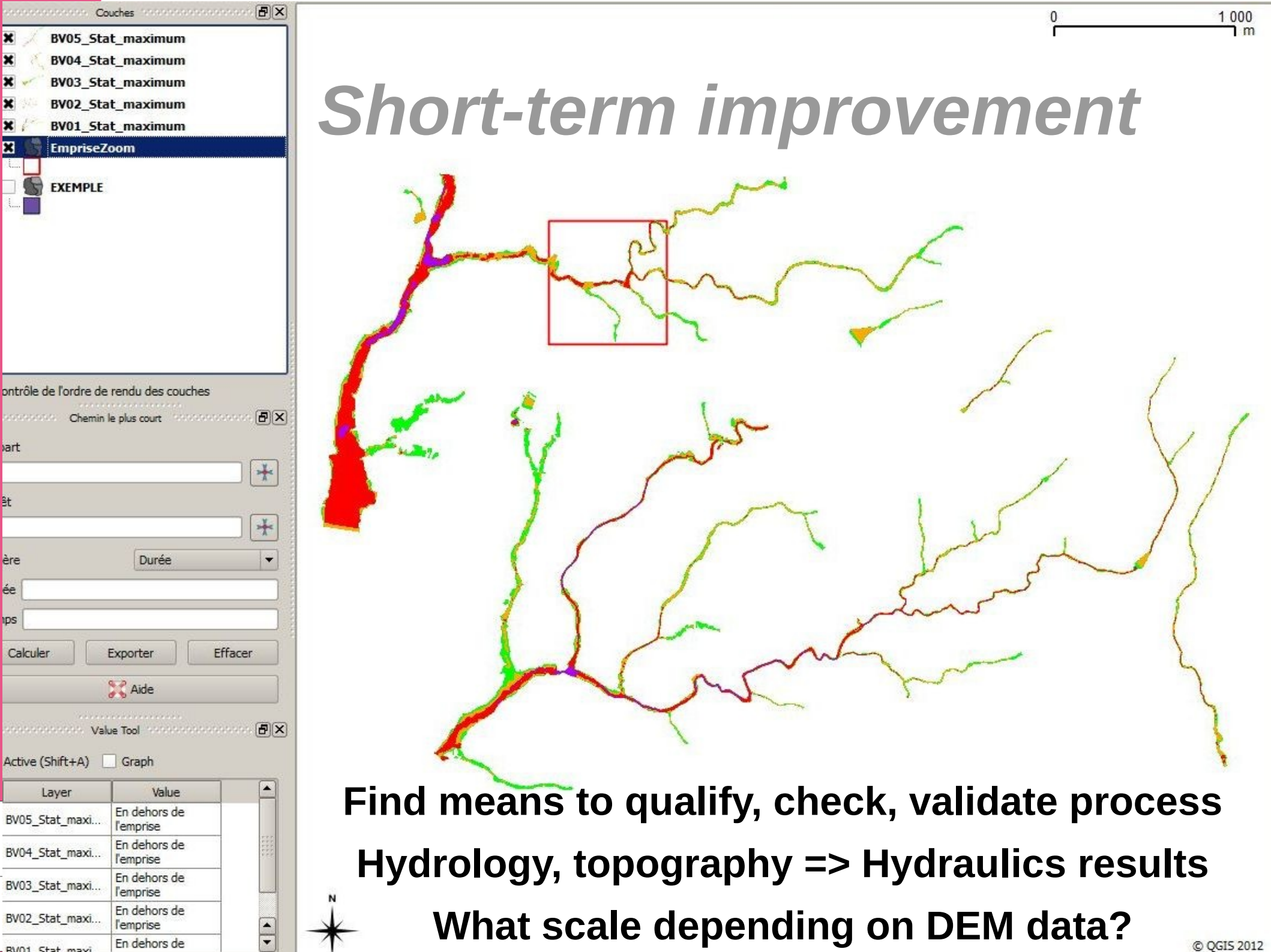
Short-term improvement



Find means to qualify, check, validate process

Hydrology, topography => Hydraulics results

What scale depending on DEM data?

Medium to long term improvements

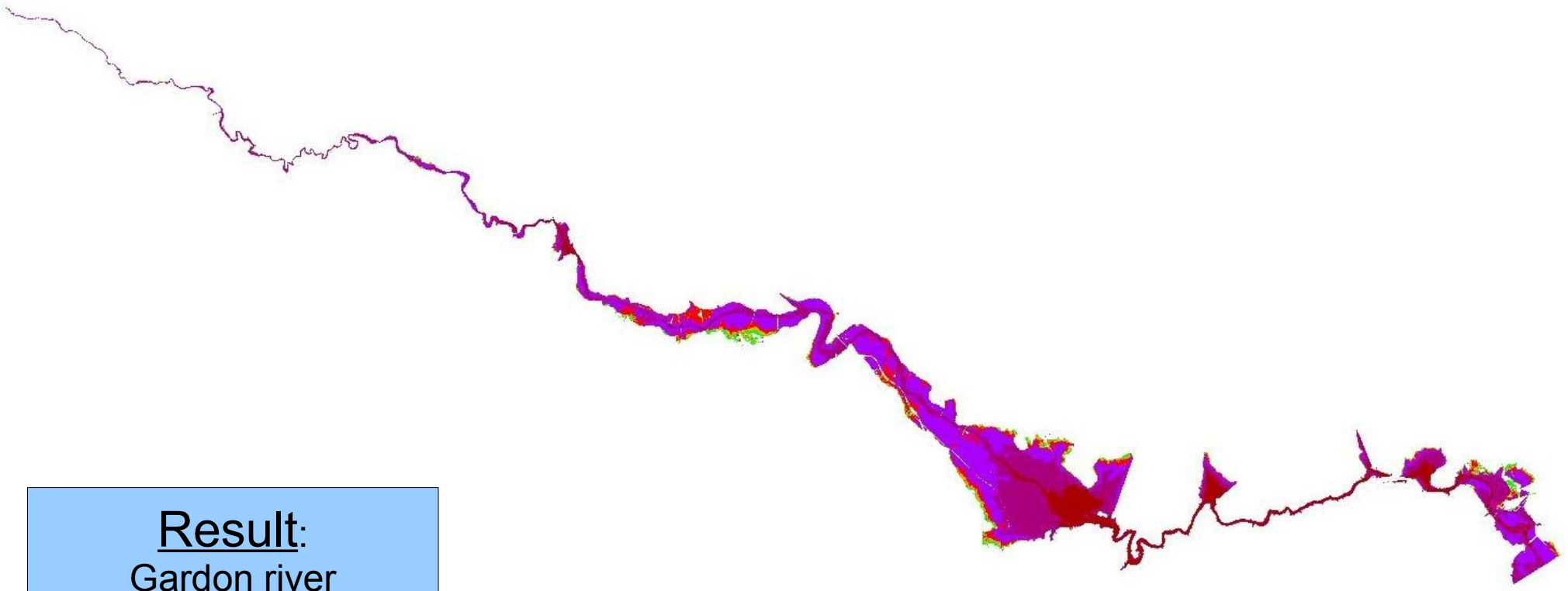
Thought of improvements in medium terms

- Manage reach network to improve speed
- Manage repetition of calculation
- Analyze and improve confluence
- Give a Quality code based on SHYREG and other hydraulic parameters
- Check influence parameters (topography, hydrology)
- **Cluster CETMEF**
    - Test a Manning approach before Hydraulic model
    - Interest of National topographic database for hydraulic?
    - Manage wide area improving speed

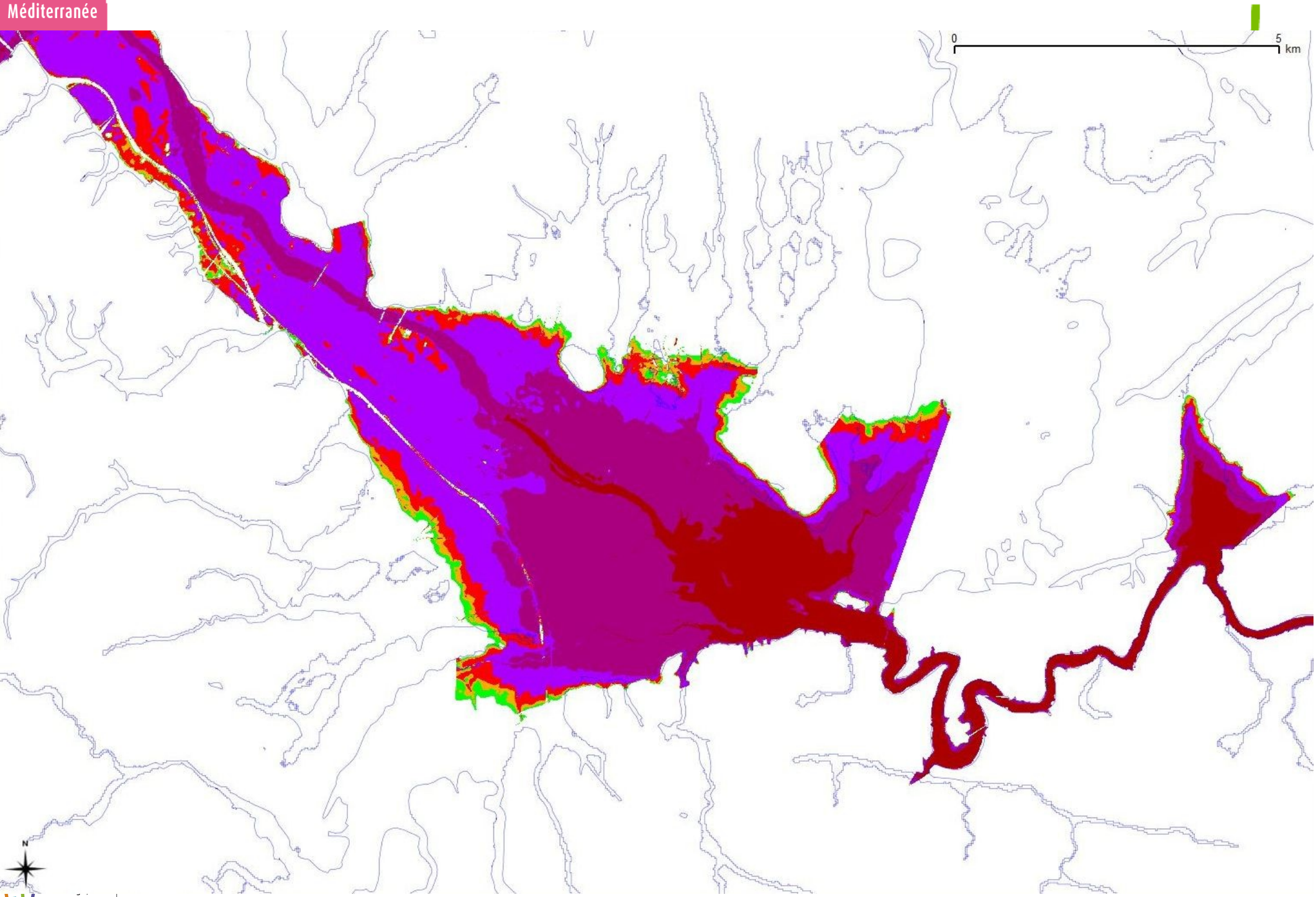
Perspectives...

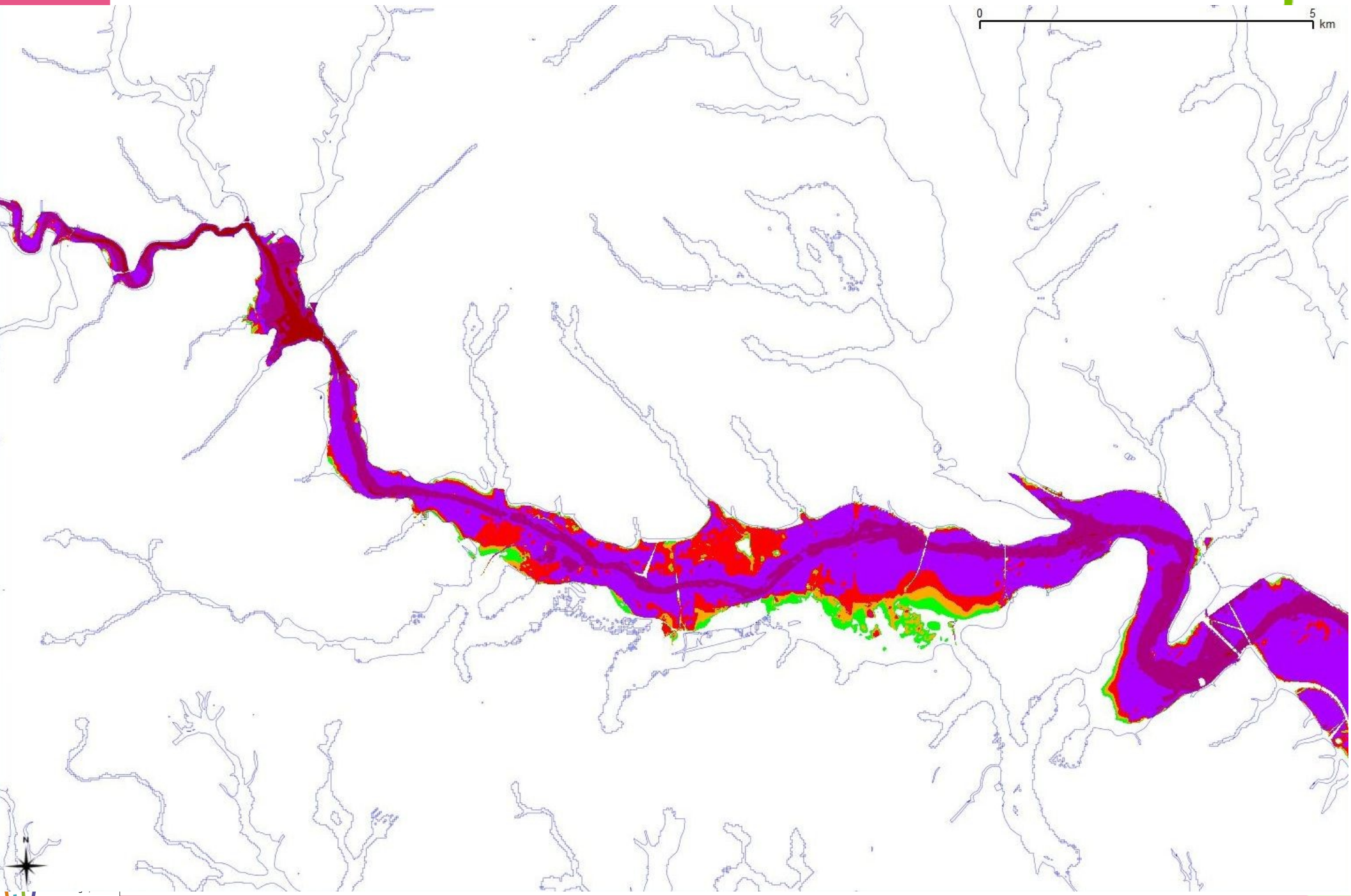
- Enable users to insert location and real cross-section like bridges
- Enable to input different Manning
- Why not analyze cross-section profiles to find banks
- Try to transfer this method for forecasting flood areas
- Carry out the same things in 2D models
- …

End



Result:
Gardon river
Reach ~120 km
~3000 cross sections
SHYREG 1000 ans
MNT 5m


0
5
km
N


0
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km
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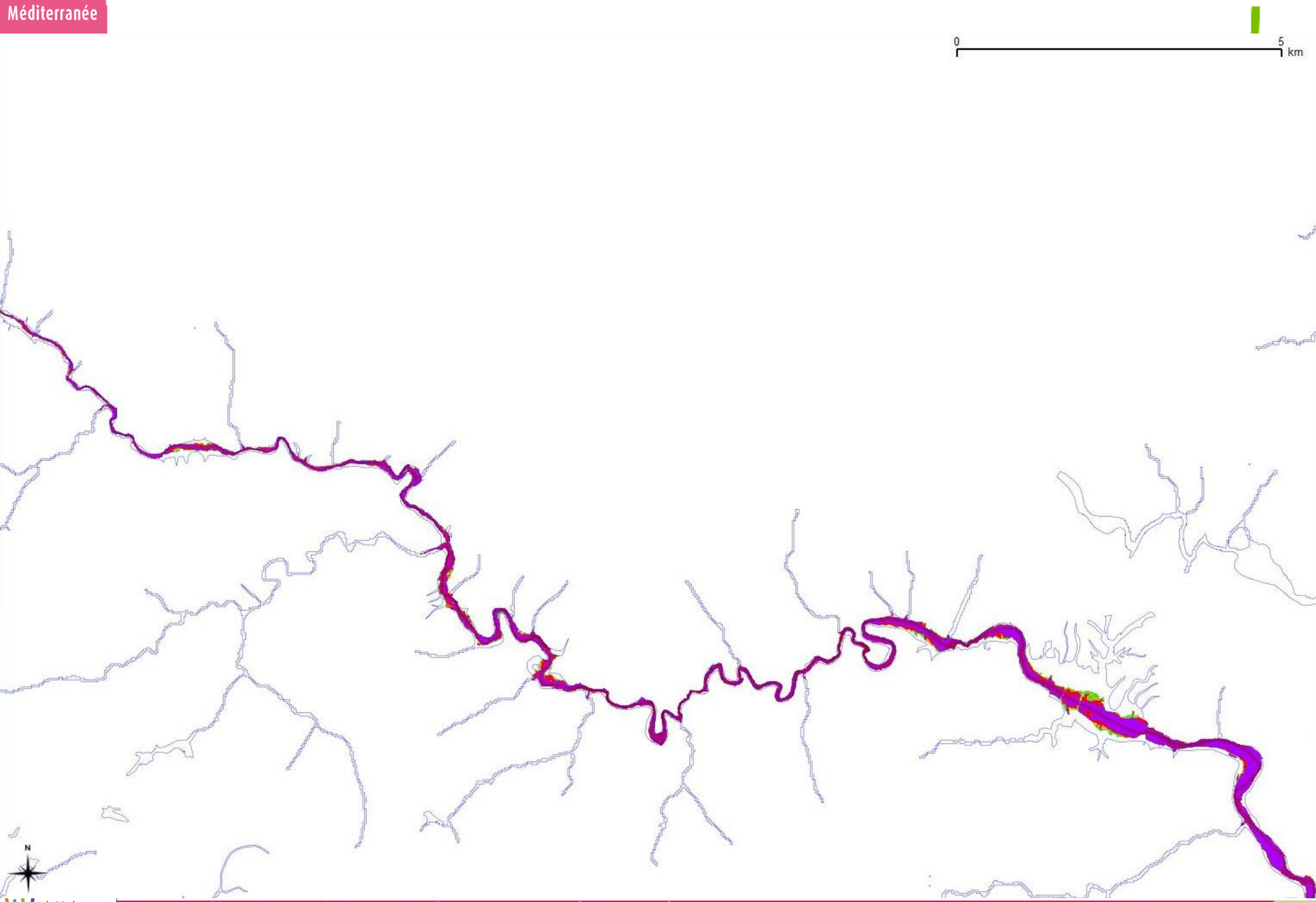
0
5
km
N