Flow study on the Ambatolaona river (Madagascar) for tidal power generation

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PLAN

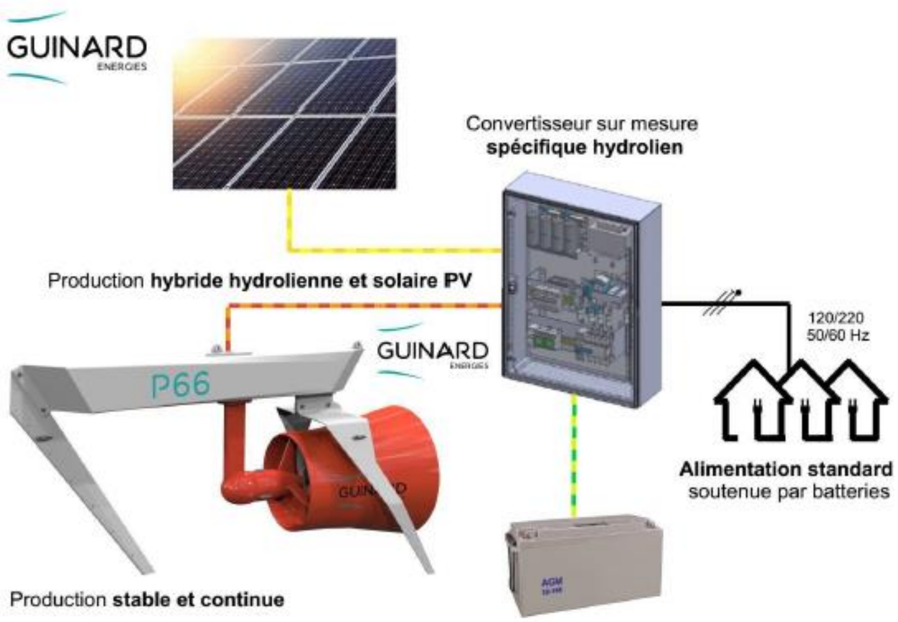
- **INTRODUCTION**
- **PROBLEMATIC**
- **STUDY BY BASEMENT**
- **SOLUTION PROPOSED**
- **CONCLUSION**

INTRODUCTION

Rural electrification project using a 100% renewable energy hybrid system

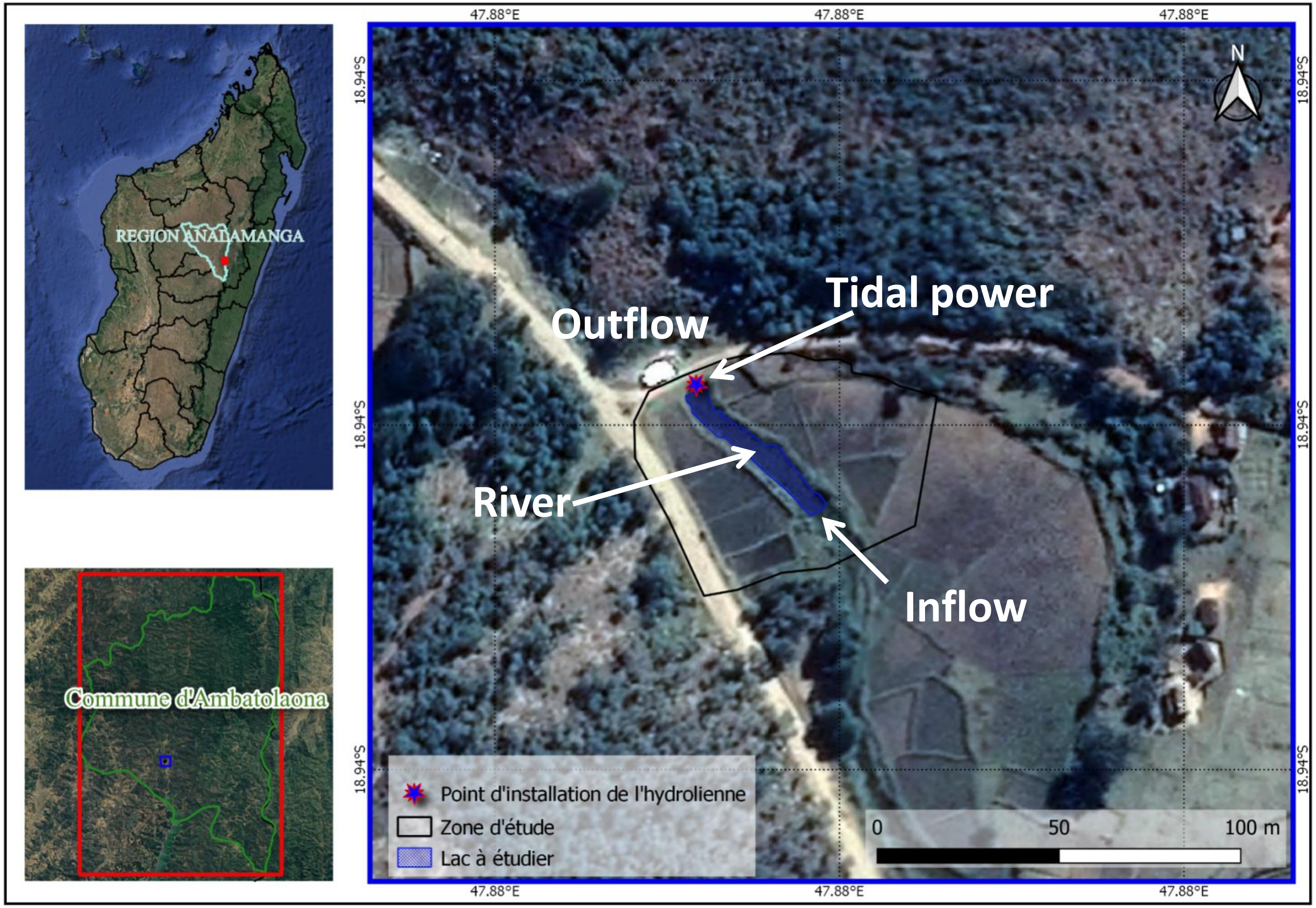
Demonstrator of a hybrid production system combining a P66 tidal turbine and a photovoltaic field, the Rural Electrification project by Hydrolienne Guinard Energies (ERHYGE):

- has benefited 50 households,
- 5 businesses
- and all public services including the school Municipality of the locality of Amboarakely in Ambatolaona



Delimitation of the study area

Ambatolaona, Manjakandriana, Analamanga (Antananarivo-Madagasacar)



PROBLEMATIC

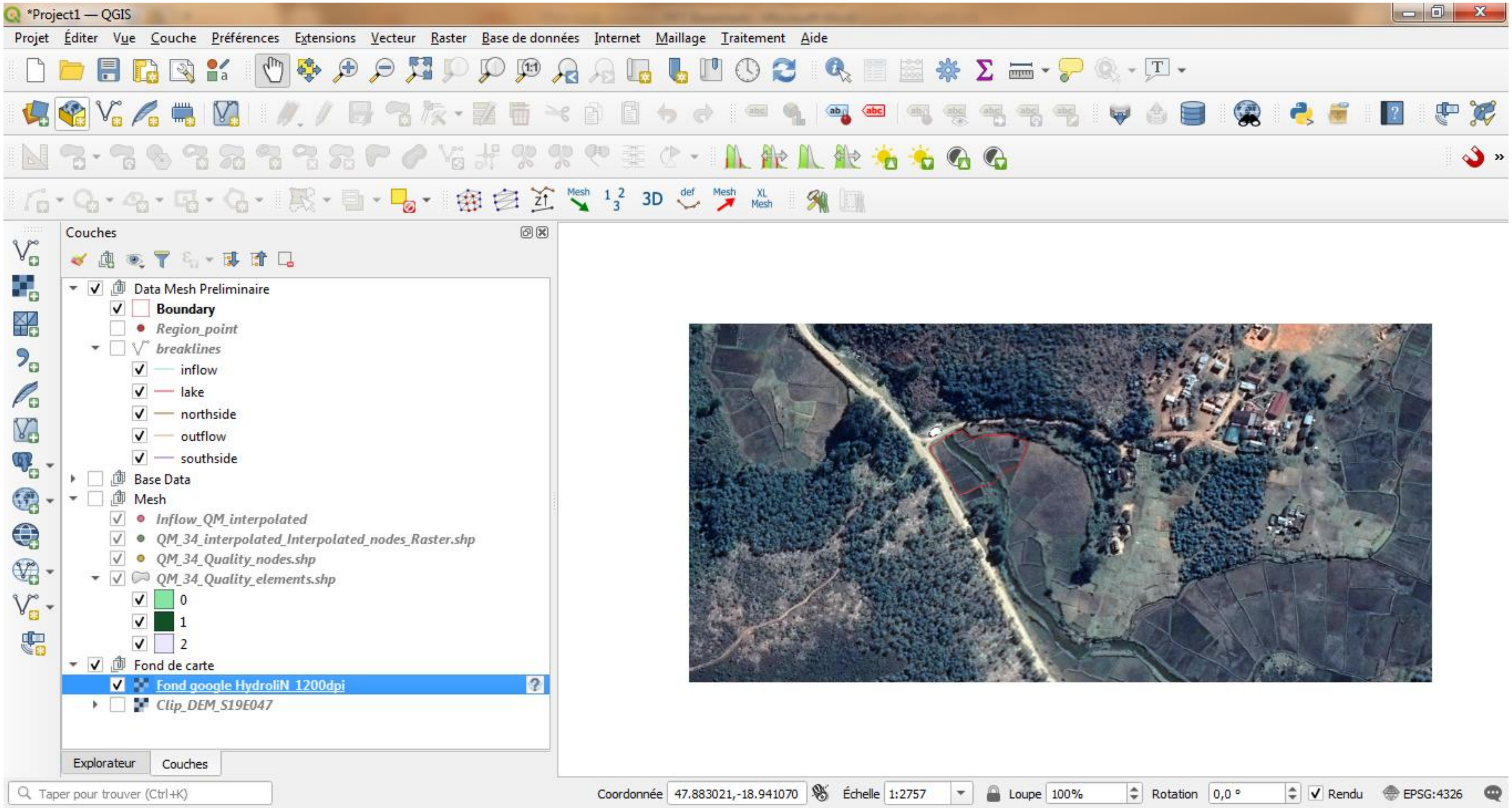
During the months April – October : the tidal turbine is operational

During the months November – March (the rainy season) :

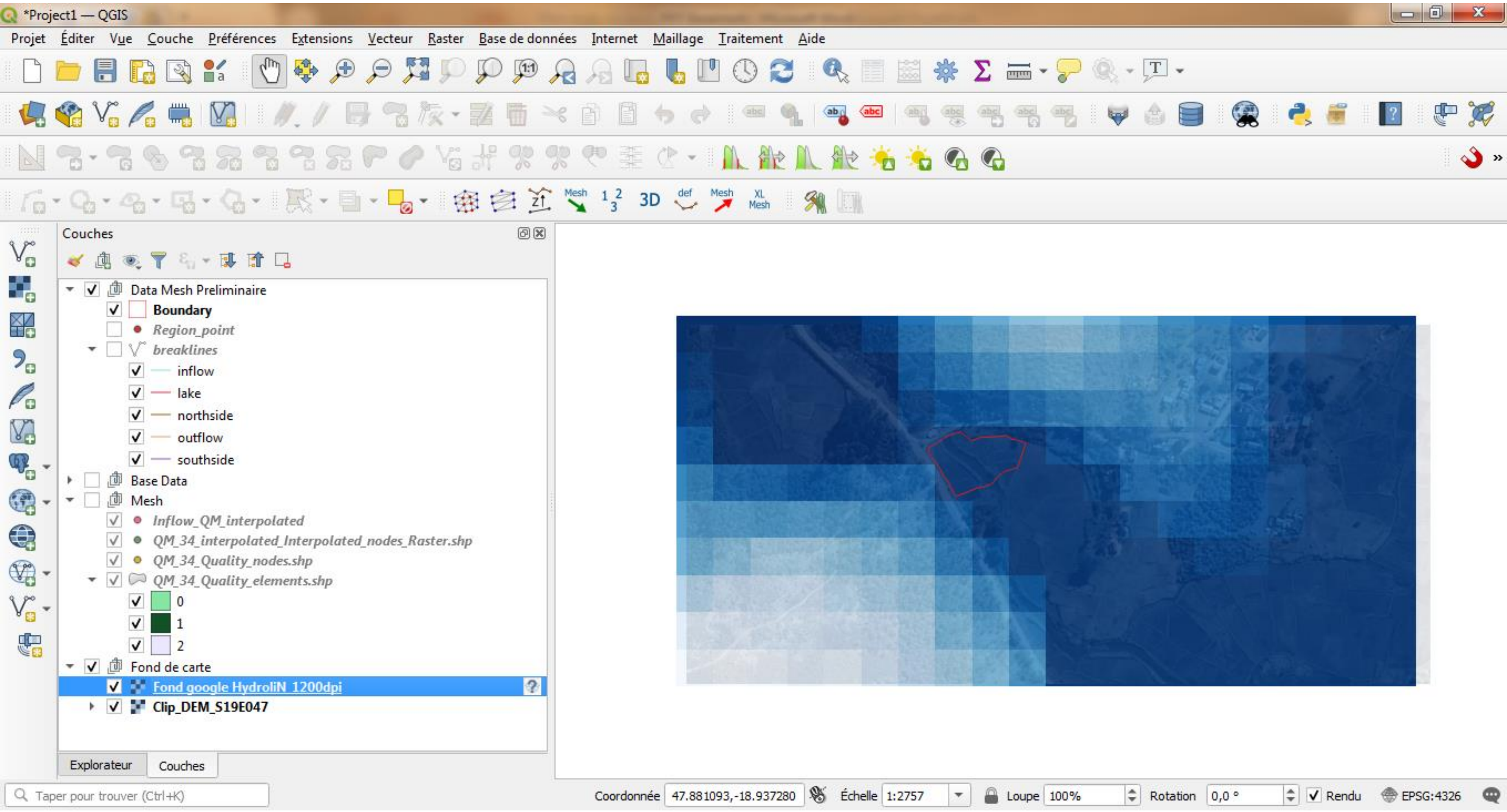
- **The flow of the stream flowing into the canal is reduced**
- **The tidal turbine: immobile and Not exploited**

STUDY BY BASEMENT

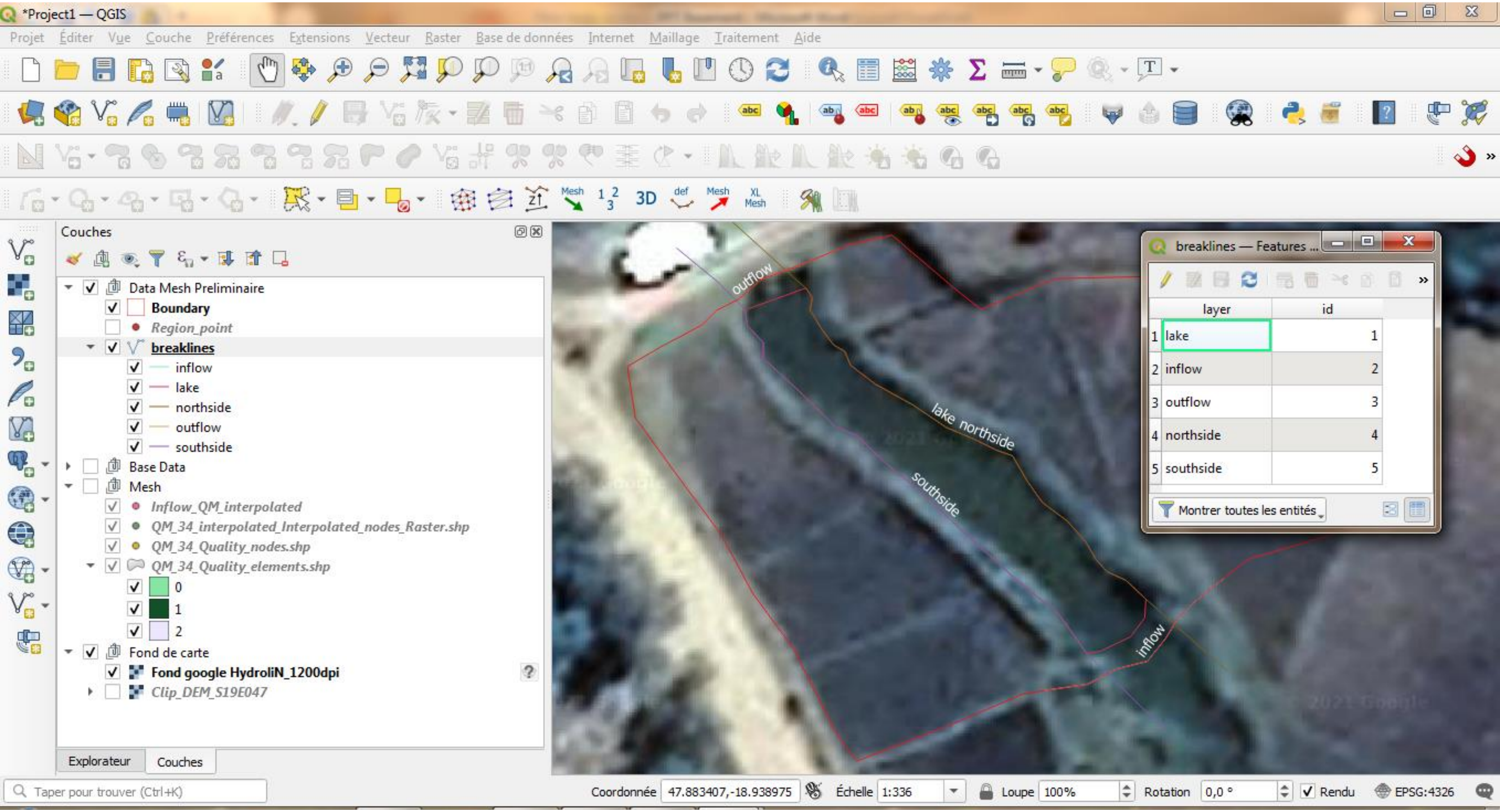
The bottom of the survey zone on a Google



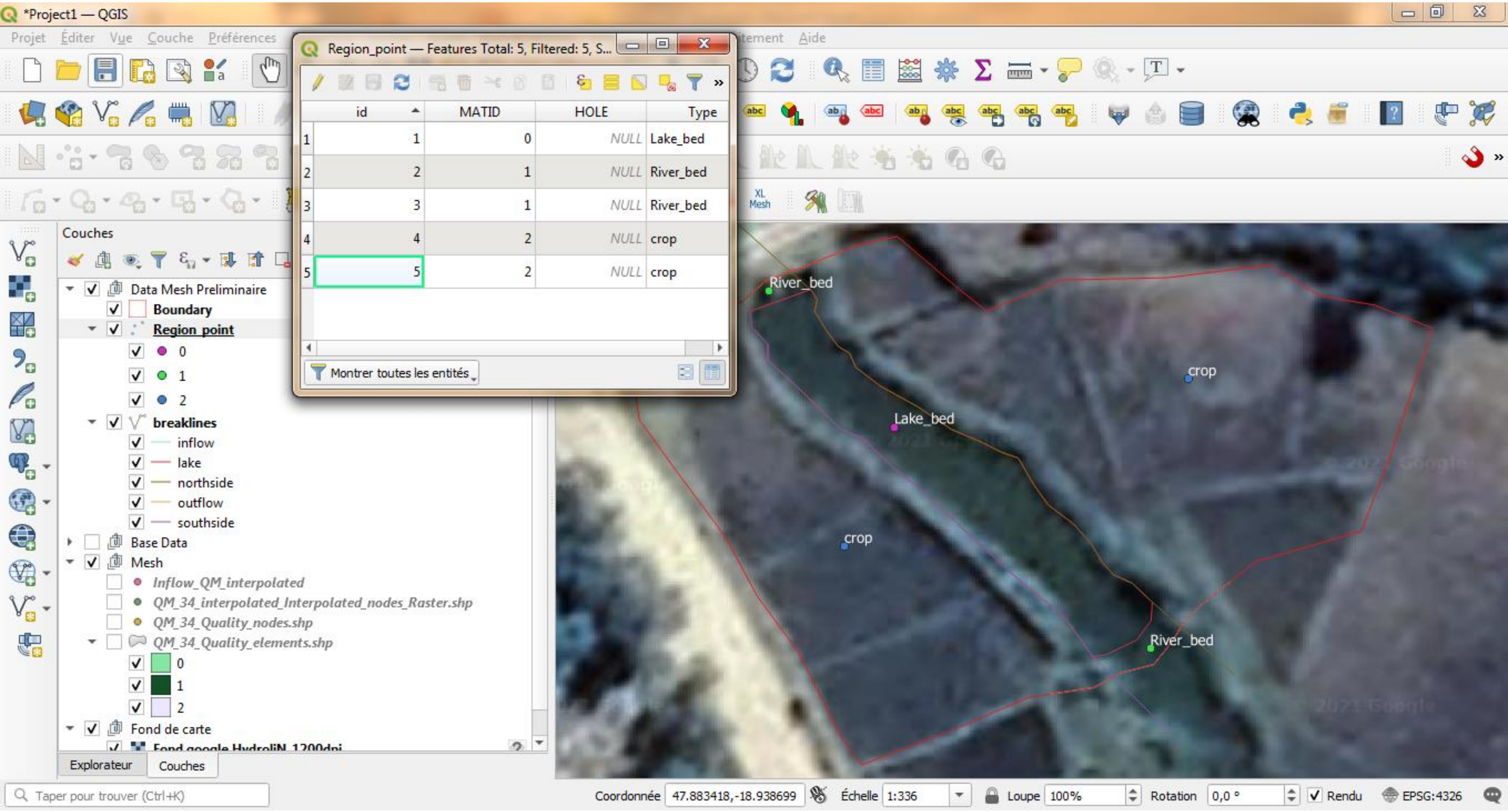
The imported DEM from the internet (srtm 30m of resolution)



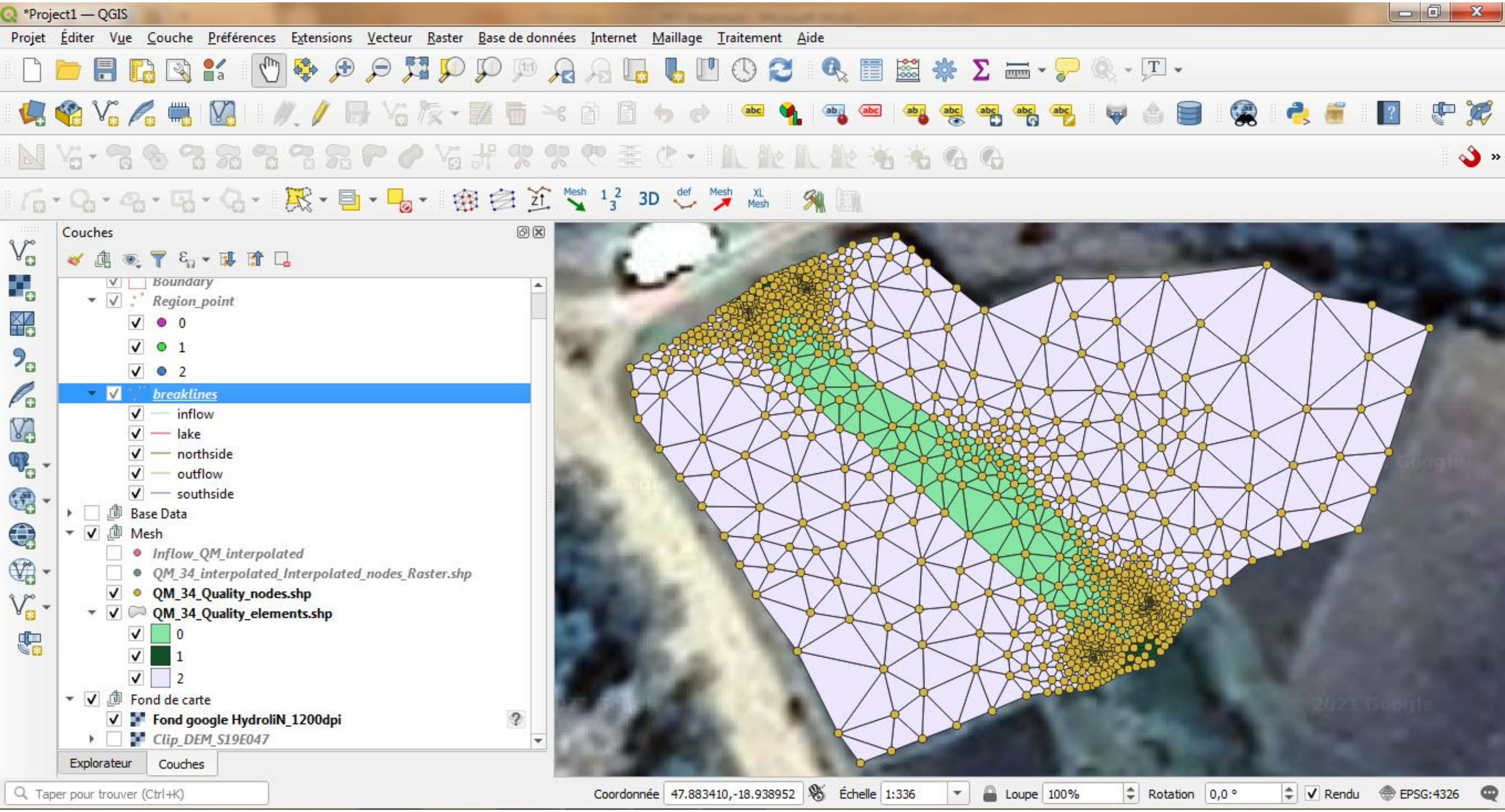
The breaklines



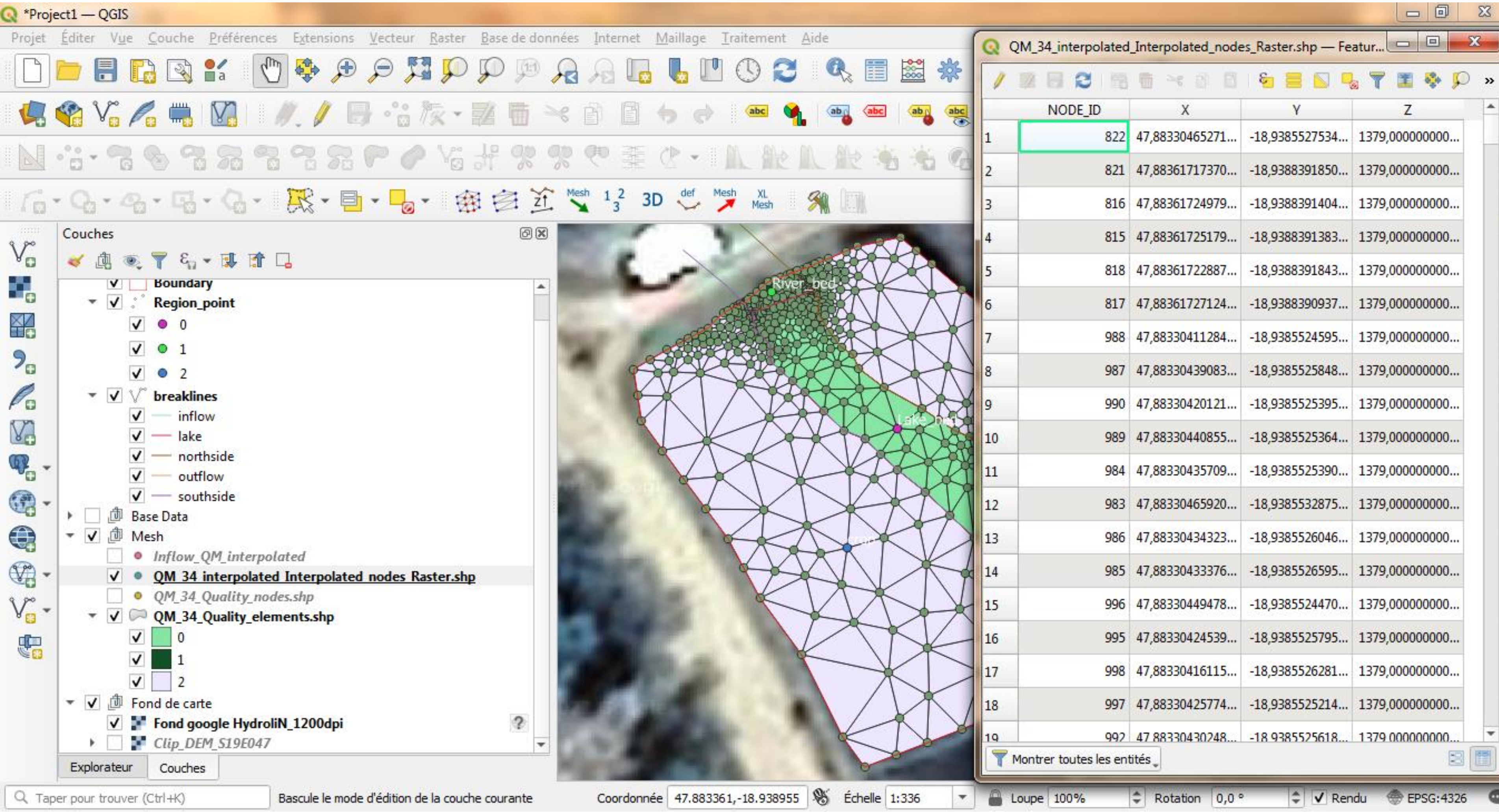
The region-points



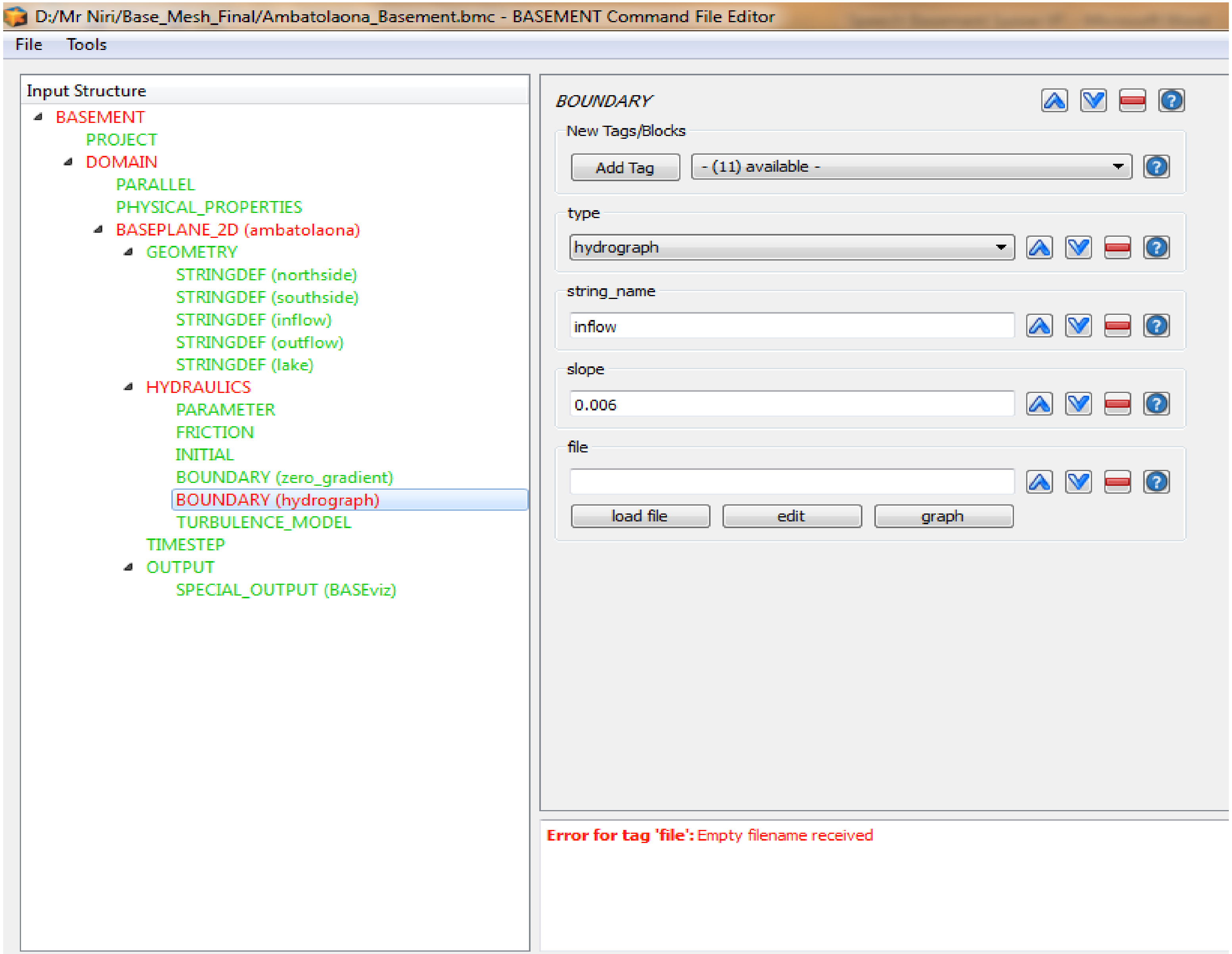
The quality mesh



The height-interpolated mesh



Basement



D:/Mr Niri/Base_Mesh_Final/Ambatolaona_Basement.bmc - BASEMENT Command File Editor
File
Tools
Input Structure
BASEMENT
PROJECT
DOMAIN
PARALLEL
PHYSICAL_PROPERTIES
BASEPLANE_2D (ambatolaona)
GEOMETRY
STRINGDEF (northside)
STRINGDEF (southside)
STRINGDEF (inflow)
STRINGDEF (outflow)
STRINGDEF (lake)
HYDRAULICS
PARAMETER
FRICTION
INITIAL
BOUNDARY (zero_gradient)
BOUNDARY (hydrograph)
TURBULENCE_MODEL
TIMESTEP
OUTPUT
SPECIAL_OUTPUT (BASEviz)
BOUNDARY
New Tags/Blocks
Add Tag
- (11) available -
type
hydrograph
string_name
inflow
slope
0.006
file
load file
edit
graph
Error for tag 'file': Empty filename received

Ambatolaona_Basement - Bloc-notes

Fichier Edition Format Affichage ?

```
// --------------------------------------------------
// BASEMENT log file:
// version:  2.6 R// bmc file: D:/Mr Niri/Base_Mesh_Final/Ambatolaona_Basement.bmc
// started:  Mon Jan 24 16:48:30 2022
// --------------------------------------------------
/*
-> InputParser: reading input from bmc file 'D:/Mr
   Niri/Base_Mesh_Final/Ambatolaona_Basement.bmc'
*/
PROJECT {
        title  = Hydro_Ambatolaona
        author = anonymous_author
}
DOMAIN {
        multiregion = unnamed_multiregion
        PARALLEL {
                number_threads = 1
        }
        PHYSICAL_PROPERTIES {
                gravity   = 9.81
                viscosity = 1e-006
                rho_fluid = 1000
        }
        BASEPLANE_2D {
                region_name = ambatolaona
                GEOMETRY {
                        type = 2dm
                        file = Ambatolaona_Mesh.2dm
                        STRINGDEF {
                                name                = northside
                                node_ids            = (80 439 436 445 441 443 451 425 447 454 442 455 453 465 462 476 478 474 422 497 509 505 513 508 421 555 523 564
568 563 576 581 588 603 648 417 650 639 667 649 691 673 670 666 416 675 674 713 668 669 655 671 689 660 631 598 656 629 833 714 672 748 838 415 834 914 979 967 1009
983 1136 935 1251 1105 1078 908 690 715 754 677 759 960 1362 1470 1252 414 1377 1318 1403 1390 1402 413 1547 1482 1492 1505 1579 1572 1533 1680 1608 1693 1829 1643 968
1389 1560 1646 412 1784 1841 1893 1873 410 1960 1758 1878 1965 1989 2003 1968 1988 1907 40 2264 2108 41 2365 2367 2358 2556 42 2587 43 44 45 46 47 2721 2725 48 2707 49
2701 50 51 2689 52 2673 53 2659 54 2639 55 2636 56 2538 57 2530 2508 2517 2527 58 2301 2327 848 2104 2136 1941 1834 1757 1549 1550 1433 1548 1484 869 1371 1294 1270
1282 1289 1172 1173 1170 875 1288 1171 1155 1039 1068 1028 955 957 877 945 879 898 884 886 889 946 947 948 954 953 919 956 876 1061 1095 975 951 950 925 949 899 905
952 1122 1113 1154 1300 1534 1293 1292 1370 1432 1575 1583 1483 1471 1641 861 1611 1582 1766 1911 1871 1915 1910 2103 1934 2152 2265 2320 2294 860 1922 1923 1296 1181
1272 1060 958 904 1207 1374 2196 2197 2443 2462 2326 81)
                                upstream_direction = right
                        }
                        STRINGDEF {
                                name                = southside
                                node_ids            = (87 63 1134 1132 1157 1200 1129 1219 1199 1305 1126 1303 1600 1117 1587 1852 2121 2074 2122 1073 1980 1102 1952
1951 2107 2138 2169 2163 2155 2203 2272 2288 2302 2315 2286 64 2452 65 2665 2657 66 2746 67 2766 68 69 70 71 72 2729 73 2681 74 75 2558 2561 2577 2560 2584 2559 2476
2600 2576 76 2084 2324 2298 2190 2090 2475 2458 77 1908 1913 1917 1899 1898 699 1909 1799 1801 1824 1817 1792 1795 1793 1772 1619 1607 1516 1517 1511 1514 1513 1508
1512 1500 1506 1486 1551 1435 1476 1373 1240 1175 1203 1141 932 930 766 928 768 842 772 771 770 867 939 972 1043 1210 1311 1312 1485 1472 1515 1529 1526 1507 1573 753
1378 758 1204 1222 763 931 933 856 1163 1076 1306 1704 1791 741 1796 78 88)
                                upstream_direction = right
                        }
                        STRINGDEF {
                                name                = inflow
                                node_ids            = (36 2660 16 2449 17 98 2407 2405 2408 2395 2345 2406 18 2492 101 2480 19 2591 2495 2502 20 99 2401 2412 2284 2335
```

Ambatolaona_Basement - Bloc-notes

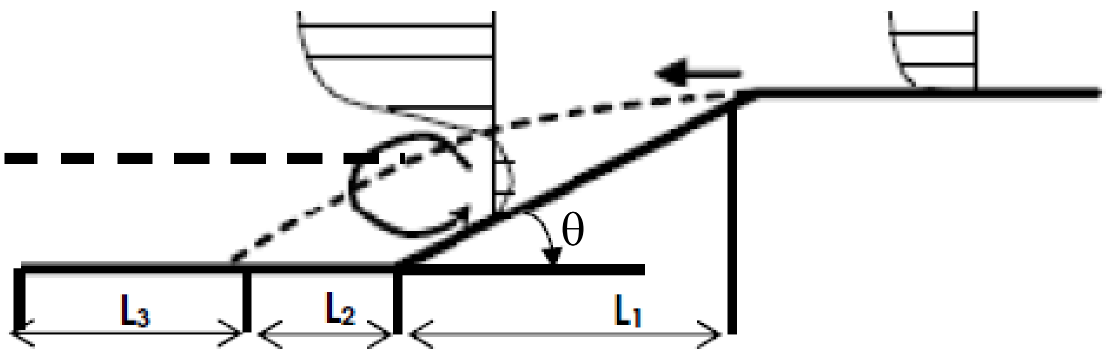
Fichier Edition Format Affichage ?

```
1299 1457 1448 1464 1577 1543 1711 1302 1158 1135 87 1131 1128 1421 1125 1456 1116 1761 63 1134 1132 1157 1200 1129 1219 1199 1305 1126 1303 1600 1117 1587 1852 212
2074 2122 1073 1980 1102 1952 1951 2107 2138 2169 2163 2155 2203 2272 2288 2302 2315 2286 64 2452 65 2665 2657 66 2746 67 2766 68 69 70 71 72 2729 73 2681 74 75 255
2561 2577 2560 2584 2559 2476 2600 2576 76 2084 2324 2298 2190 2090 2475 2458 77 1908 1913 1917 1899 1898 699 1909 1799 1801 1824 1817 1792 1795 1793 1772 1619 1607
1516 1517 1511 1514 1513 1508 1512 1500 1506 1486 1551 1435 1476 1373 1240 1175 1203 1141 932 930 766 928 768 842 772 771 770 867 939 972 1043 1210 1311 1312 1485 1
1515 1529 1526 1507 1573 753 1378 758 1204 1222 763 931 933 856 1163 1076 1306 1704 1791 741 1796 78 88 868 800 808 874 858 857 981 844 1074 1022 1103 1184 799 1185
1241 1343 1211 798 1393 1366 1189 1358 1360 1440 1596 1530 1624 1631 1615 1539 796 1557 1602 1626 1617 1681 1767 794 1905 1892 1872 2058 1953 1439 1453 1357 1712 17
1618 2114 38)
                        upstream_direction = right
                }
        }
        HYDRAULICS {
                PARAMETER {
                        minimum_water_depth          = 0.002
                        riemann_solver               = exact
                        riemann_tolerance            = 1.0e-6
                        simulation_scheme            = exp
                        velocity_update_partial      = volume_area
                        dynamic_depth_solver         = on
                        geo_min_area_ratio           = 0.05
                        geo_max_angle_quadrilateral  = 45
                        geo_min_aspect_ratio         = 0.06
                }
                FRICTION {
                        type                 = strickler
                        default_friction     = 30
                        wall_friction        = on
                        grain_size_friction  = no
                }
                INITIAL {
                        type   = index_table
                        index  = (0 1)
                        u      = (0 0)
                        v      = (0 0)
                        wse    = (0 5007)
                }
                BOUNDARY {
                        type         = zero_gradient
                        string_name  = outflow
                }
                BOUNDARY {
                        type         = hydrograph
                        string_name  = inflow
                        slope        = 0.006
                        file         = Inflow.txt
                }
                TURBULENCE_MODEL {
                        kinematic_viscosity  = 0.000001307
                        type                 = algebraic
                        const_eddy_viscosity = -1
                        turbulence_factor    = 1
                        boundary_gradient    = zerogradient
                }
```

Problem: Basement is blocked and closed????
Unfortunately, we cannot display the résultasts

SOLUTION PROPOSED

Proposition to solve the problem: we have observed an area that constitutes a basin fed by the movement of inclined fluids



- **On zone L_1**, Inclined plane: the direction, the slope and the roughness of the bed are invariable,
- **On the zone L_2**, when the fluid is close to the stoppage of the angle θ: the movement is rapidly varied, a hydraulic jump or a sudden fall,
- **On the zone L_3**, the movement is uniform: the parameters which characterize the flow remain invariable, therefore the flow is almost uniform.

Swirl curves in the basin: characteristic quantities (h_{n1}, h_c, h_{n2})

The hydraulic head at the sill is:

$$H = h_c + \frac{Q^2}{2B^2 {h_c}^2 g} + p = 1{,}60385 \text{ m}$$

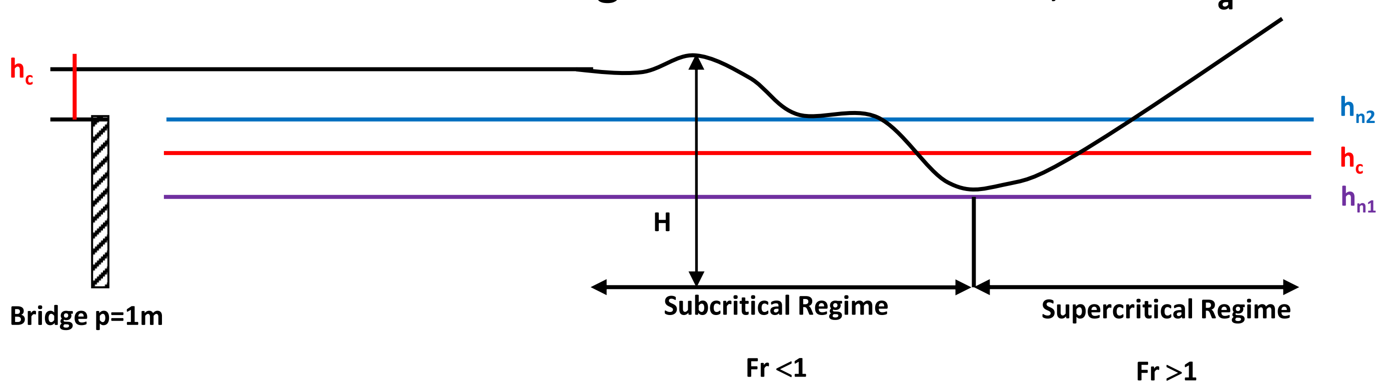
No losses in the channel, so the hydraulic head H is conserved

$$H = h_a + \frac{Q^2}{2B^2 {h_a}^2 g}$$

$$f(h_a) = h_a^3 - H h_a^2 + \frac{Q^2}{2B^2 g}$$

$$h_a^3 - H h_a^2 + \frac{Q^2}{2B^2 g} = 0$$

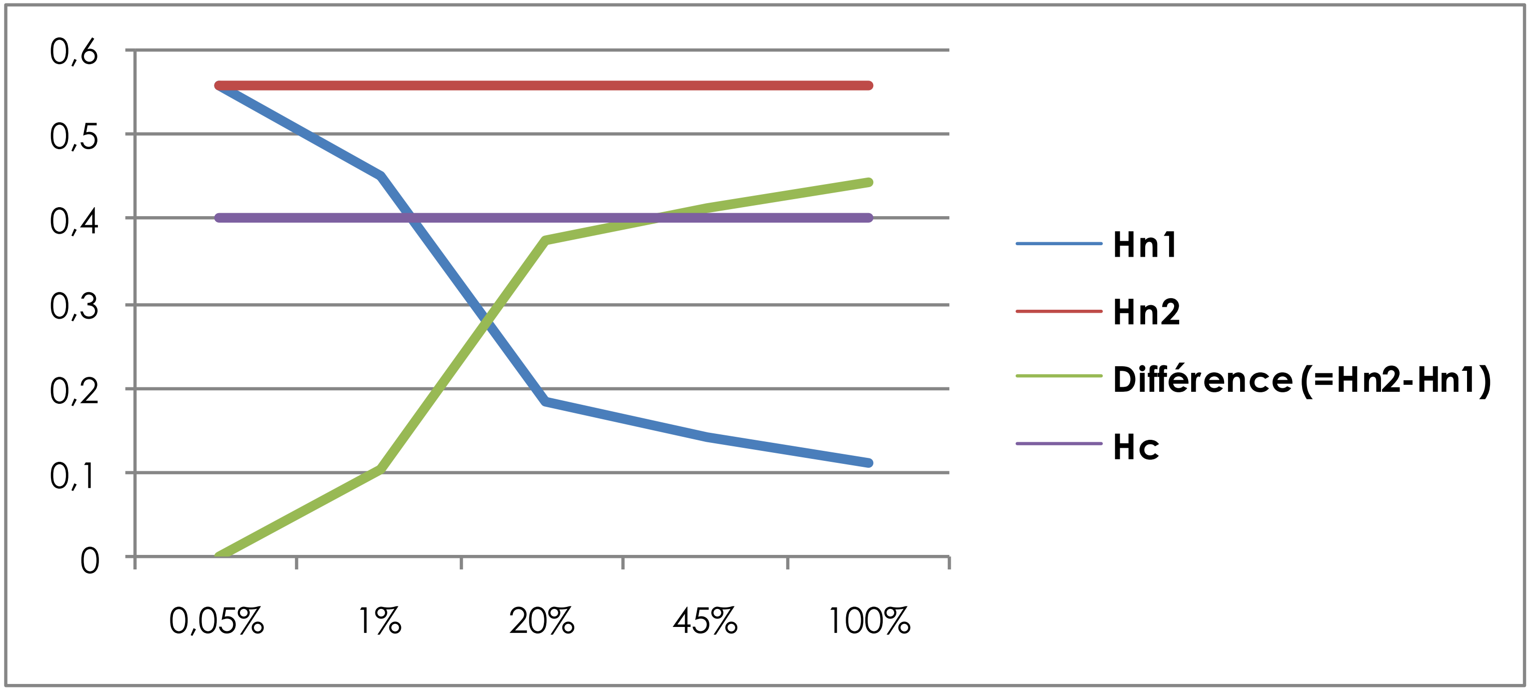
Polynomial equation of degree 3, after numerical resolution, one of the three converges to **ha=1.50001 m**, then $\mathbf{h_a \approx H}$



The loads **h_{n1}, h_{n2}, h_c** and the difference **(h_{n1}-h_{n2})** as a function of **I_{av}**,

Note: **the intersection h_c** of and the difference **(h_{n1}-h_{n2}): I_{av} =45%**

This is the optimum angle for smooth flow downstream and upstream in the basin



Study by BASEchain: the basin proposed considered by a survey 1D

The BASEchain module is based on the Saint Venant Equations (SVE) for unsteady one dimensional flow

- The continuity equation: $$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} - q_l = 0$$
- The momentum equation: $$\frac{\partial Q}{\partial t} + \frac{\partial (QV)}{\partial x} + gA\left(\frac{\partial z}{\partial x} + S_f\right) = 0$$

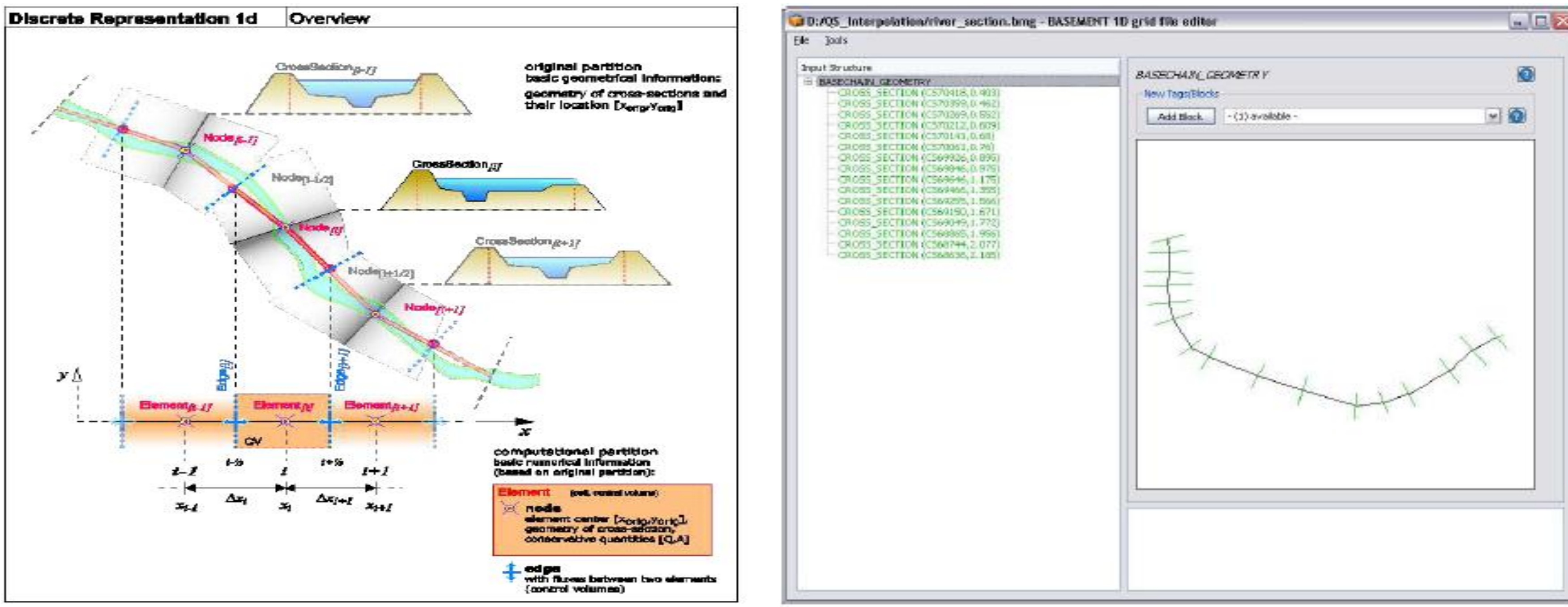
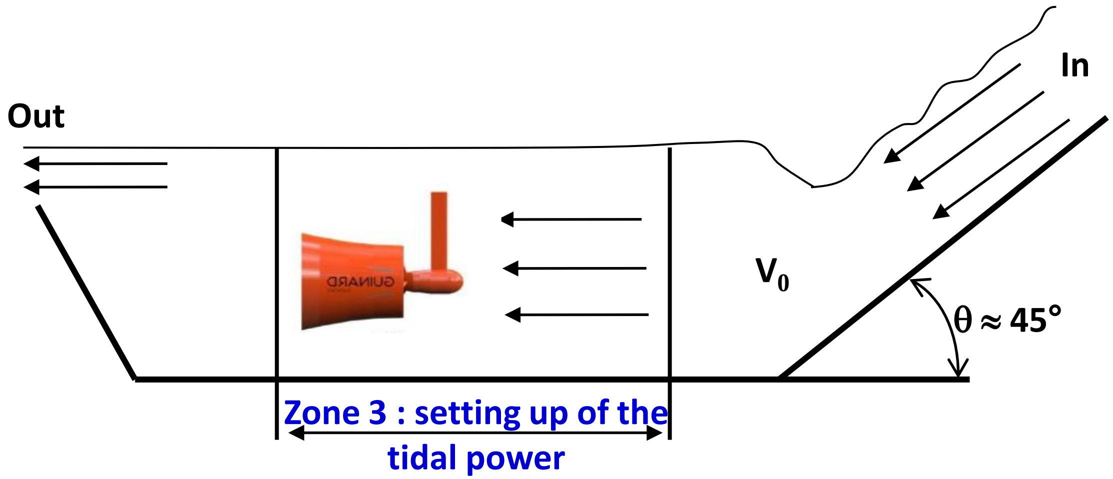


Figure : Discrete Representation of the Topography within BASEchain (BASEMENT System Manuals)

•The flow in **zone 2** presents **turbulence** and the closer the flow approaches **the edge of the basin**, the velocities are **reduced but the turbulence still exists**.
•The field lines in **zone 3** are **uniform**, **better performance** for the turbine.
•To optimize the tidal turbine installation, **zone 3 is chosen** for flow speeds of water at **least 2 m/s**.



CONCLUSION

•The studies that we did **are not complete**, **don't succeed to the final results** of the Basement. Therefore **we continue** them and **we need the collaborations**;
•It is therefore essential that the site of installation of tidal is chosen well to get a better output all along the year and very weak in maintenance, of natural basin (renewable Energy) or constructs in concrete with an angle of slant $i_{av} \approx 45\%$ upstream and that has an uniform out-flow downstream to immerse the tidal.

Acknowledgments

For the Promoter Financial, Technical partners of the realization of the project:

- **GUINARD-ENERGIES, GRET, SM3E**
- **ADEME**
- **ADER**

Thank you for your agreeable attention