RAPIDE v.1:

RAPid GIS tool for Inundation Depth Estimation

USER'S GUIDE

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1. Overview of RAPIDE

RAPIDE toolbox calculates, in a GIS environment, the water depth distribution within an inundated area based on minimum data requirements, including a high resolution DTM and a flood footprint. The method relies on a spatial interpolation procedure assuming that the flood perimeter is the locus of points having null water depth. The procedure consists of the following steps (shown in Figure S1).

The shapefile of the flood perimeter is first discretized into a series of points where the water elevation is set as equal to that of the terrain based on the above assumption (Figure S1a). In order to improve the accuracy of the spatial interpolation, the latter proceeds in two sub-steps. First, the user must preselect several auxiliary lines based on an expected flood path (i.e. transverse to a possible flood path and not identifying storage areas). These lines should be perpendicular to the river axis and must intersect the flood perimeter at two symmetrical points of the external boundary, while not intersecting each other (Figure S1b). Along these lines, discrete additional points are considered, determining the water elevation at them by means of inverse distance weighted interpolation starting from the extreme points of each auxiliary line. In the second sub-step, a water surface elevation map is obtained by spatial interpolation over the entire area of interest, using a natural neighbor interpolation (Figure S1d). A water depth map can be easily obtained from the difference of the water surface and terrain elevations.

Remarkably, in an urban environment the assumption of null water depth over the boundary of the inundated area may not be always satisfied. For example, the flood perimeter may be determined by the presence of a bounding anthropic structure, like a wall or a road embankment. In this case, the model would underestimate the water depth because, according to the RAPIDE's hypothesis, a null value would be assigned in the proximity of the structure while the water depth could be higher, up to an elevation corresponding to the top of the bounding structure. In order to account for this, the model user can introduce a mask for filtering, thus excluding from the interpolation procedure, the boundary points located near urban areas or manmade structures, i.e. which do not fulfill the model's hypothesis (Figure S1c).

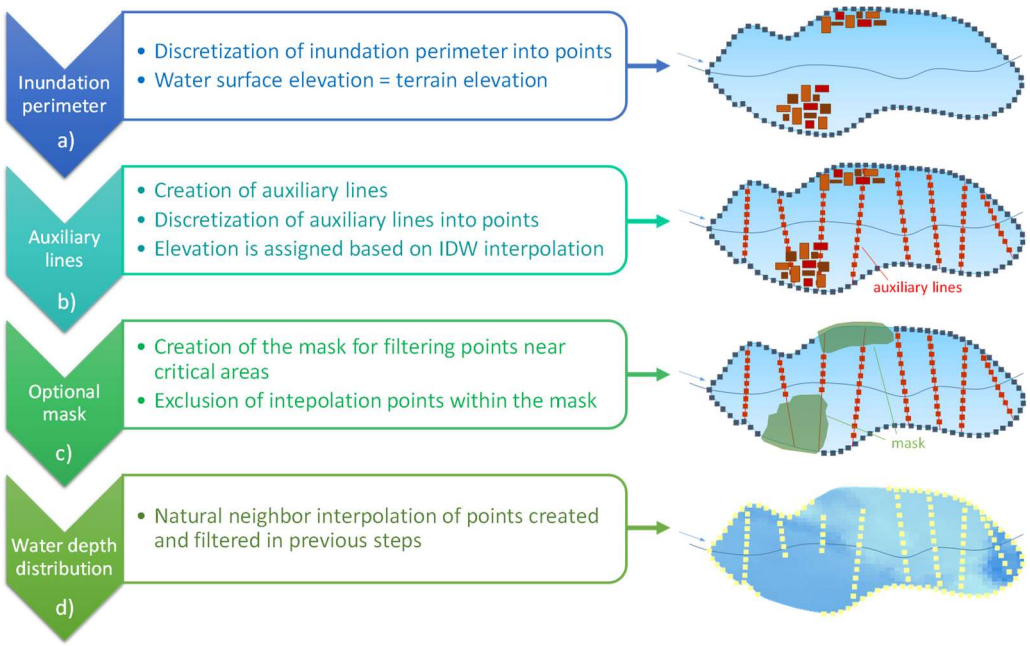

Figure S1. Schematization of the GIS processes in RAPIDE.

2. Guide for the use of RAPIDE toolbox

RAPIDE has been developed as an Esri ArcGIS toolbox (version 10.3.1 or later). Before applying the tool, enable Geoprocessing permissions, by opening up the Geoprocessing menu and selecting the options as shown in Figure S2.

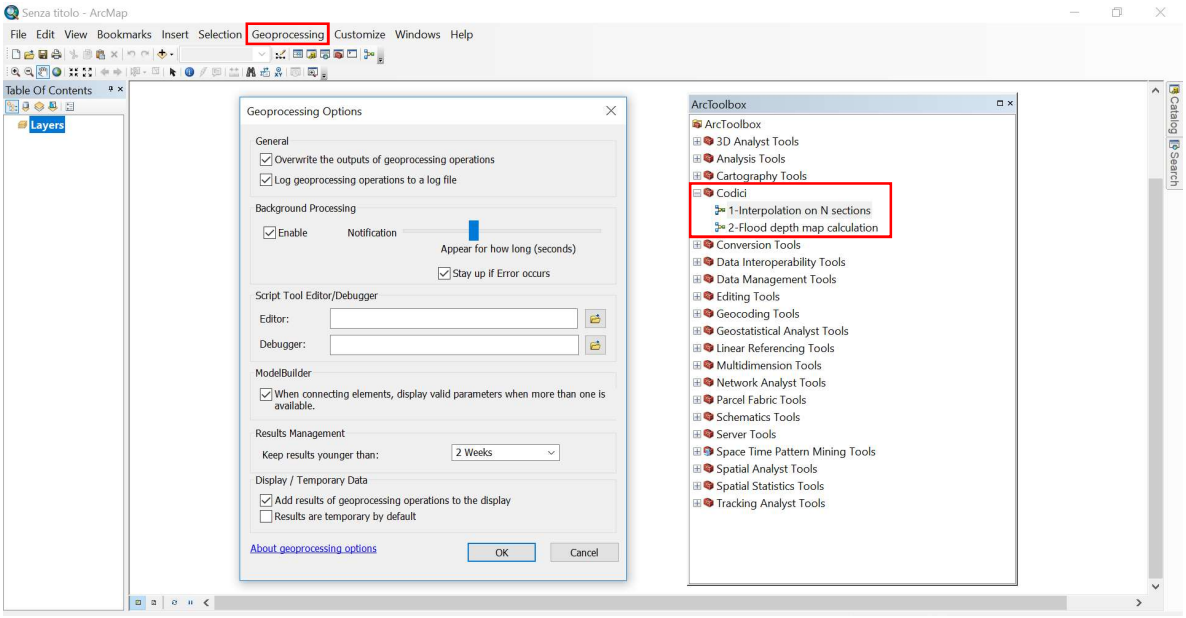

Figure S2. Enabling of geoprocessing options (left) and the two components of the RAPIDE toolbox (right).

RAPIDE consists of two tools (Figure S2) that must be executed in sequence:

1. **Intepolation on N sections** (Figure S3): this tool calculates water surface elevations by IDW interpolation on the N auxiliary lines given as input for the model.

   In detail, the following input data are required for the application of this part of RAPIDE:

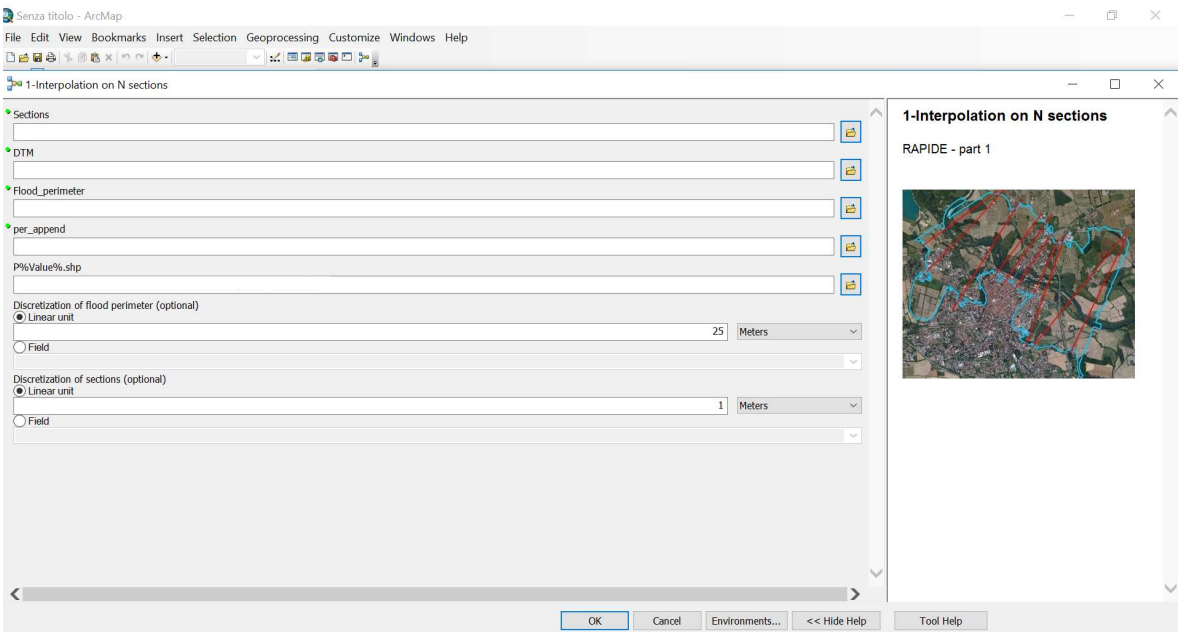

Figure S3. RAPIDE toolbox: interpolation on N sections tool.

- "*Sections*" (shapefile – line layer): the user has to introduce the auxiliary lines as defined in model's description, i.e. they should perpendicular to river axis and intersecting the flood perimeter over only two points of the external boundary and must not intersect each other. The attribute table of the shapefile should be set as shown in the figure on the right, where "numero_sez" defines the ID of each auxiliary line;

sezioni

FID	Shape *	Id	numero_sez
0	Polyline	0	106
1	Polyline	0	105
2	Polyline	0	103
3	Polyline	0	102.01
4	Polyline	0	102
5	Polyline	0	101.02
6	Polyline	0	101.01
7	Polyline	0	101

- "*DTM*" (raster layer): the user has to introduce the DTM of the investigated area (recommended resolution: 1 m);
- "*Flood_perimeter*" (shapefile – line layer): the user has to introduce the extent of the flooded area as a single, closed line;
- "*per_append*" (shapefile – point layer): upon execution of the tool, this file contains interpolated water surface elevation data. The attribute table of the shapefile must be set as shown in the following figure and it must be initially empty;

Table

per_append

FID	Shape *	OID_	CID	RASTERVALU	POINT_X	POINT_Y

- "*P%Value%.shp*" (shapefile – point layer): upon execution of the tool, a shapefile is created for each auxiliary line containing water surface elevation data. This is an intermediate output needed in the subsequent tool of RAPIDE (Flood depth map calculation). The user has to specify the name of the shapefile (which must be set as *FILENAME_%Value%.shp*) and the destination folder;
- "*Discretization of flood perimeter*": the user has to indicate the discretization to be used for the flood perimeter (suggested value: 25 m);
- "*Discretization of sections*": the user has to indicate the discretization to be used for the auxiliary lines (suggested value: 1 m);

2. **Flood depth map calculation** (Figure S4): this tool calculates water depth distribution within the flood perimeter based on natural neighbor interpolation of points created over auxiliary lines (in the previous tool) and inundation perimeter. In detail, the following data are required:
   - "*DTM*" (raster layer): the user has to introduce the DTM of the investigated area (recommended resolution: 1 m);
   - *"Mask"* (shapefile – polygon layer (optional)): the user can introduce a mask for filtering interpolation points near critical areas over the domain (for details, refer to model's description). The attribute table of the shapefile must be set as shown in the figure on the right;

mask

FID	Shape *	Id
0	Polygon	0
1	Polygon	0
2	Polygon	0
3	Polygon	0

   - "*per_append*" (shapefile – point layer): it is the output produced by "Interpolation on N sections" tool;
   - *"Flood perimeter"* (shapefile – line layer): the user has to introduce the extent of the flooded area as a single, closed line;
   - *"WSE_map"* (output raster): this is the output produced by the tool, as a raster representing the water surface elevation map within the inundated area. The user has to specify the destination folder;
   - "*WD_map"* (output raster): this is the output produced by the tool, as a raster representing the water depth map (i.e., water surface elevation – terrain elevation) within the inundated area. The user has to specify the destination folder;

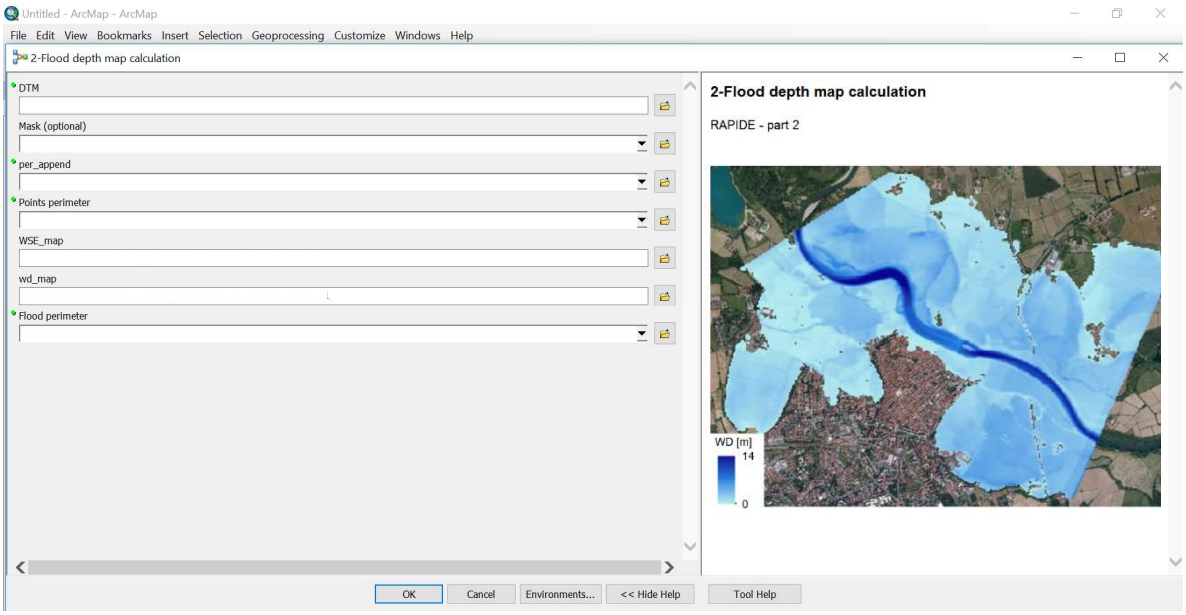

Figure S4. RAPIDE toolbox: flood depth map calculation tool.

WARNINGS:

- It is recommended to create a single working directory, including both the ArcGIS .mxd project and "input" and "output" folders.
- Folder and file names must not contain spaces or special characters.

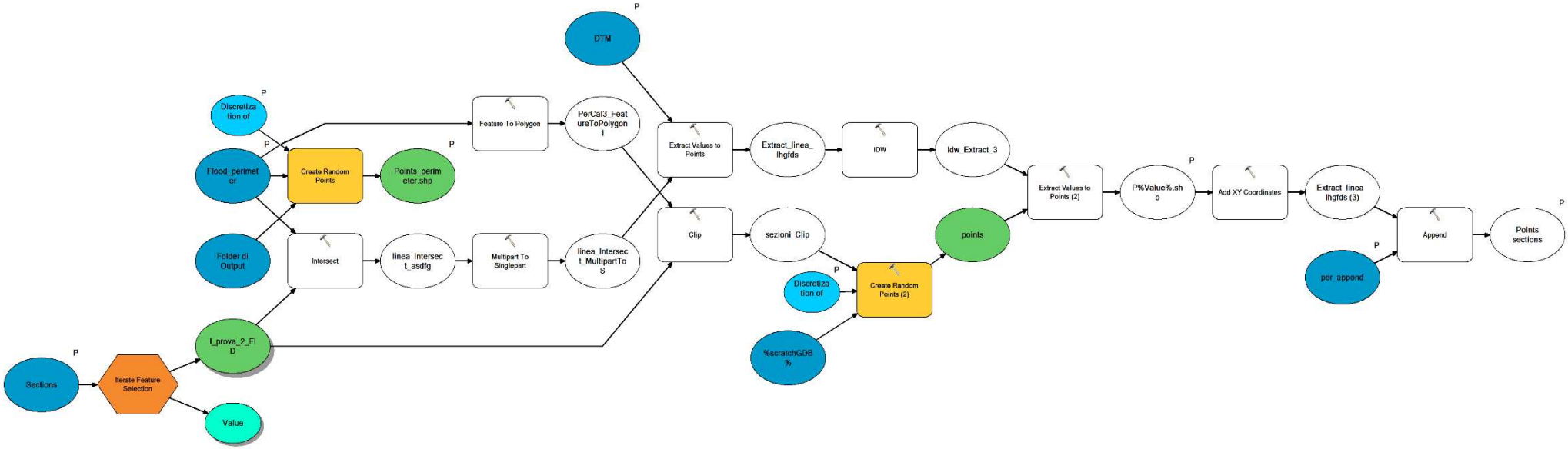

Figure S5. RAPIDE toolbox: workflow for the interpolation on N sections tool.

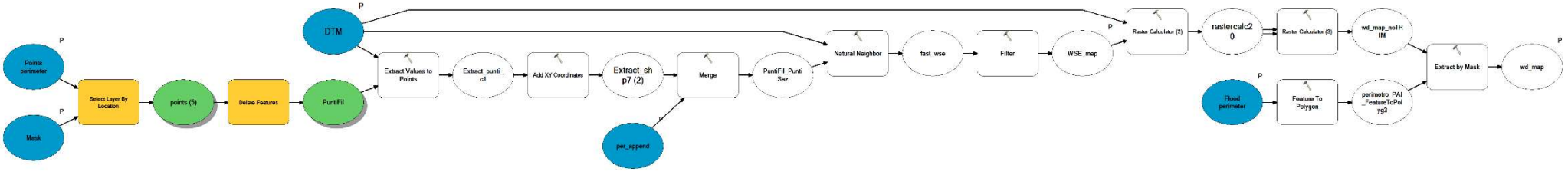

Figure S6. RAPIDE toolbox: workflow for the flood depth map calculation tool.