



GIS method for opportunity mapping for natural flood management: flow, diffuse pollution and landscape connectivity

Version 1

Document Title: GIS method for opportunity mapping for natural flood management: flow, diffuse pollution and landscape connectivity

iCASP Project: Don Hidden Heritage Secret Streams

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Non-Technical Summary

In 2018 the Don Catchment Rivers Trust (DCRT) were awarded a grant from the Heritage Lottery Fund for 'Hidden Heritage Secret Streams', a project based on the Upper Rother catchment. One of the aims of the project is to implement volunteer-led natural flood management interventions, with the aim to slow the flow, decrease diffuse pollution and increase landscape habitat connectivity. Prior to this iCASP project, the DCRT did not have access to a consolidated dataset to inform where the interventions should be placed.

This report highlights the methods used to produce opportunity maps in the Upper Rother Catchment for slowing the flow, decreasing diffuse pollution and increasing landscape habitat connectivity.

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1. Introduction

Natural flood management (NFM) is a technique that aims to work with natural catchment processes such as planting trees and the addition of large woody dams. Flood risk and environmental benefits include, but are not limited to: slowing flood peaks, reducing the depth and duration of flooding, reducing soil erosion and sediment risk, increasing carbon storage, improving water quality and increasing habitat connectivity. Natural flood management is increasingly being used for catchment management in the UK, as catchment-wide approaches have been championed, further, NFM offers sustainability benefits and can provide additional protection against climate change.

The purpose of this report is to showcase the step by step process used to create opportunity maps for the iCASP Don Hidden Heritage Secret Streams project.

Further outputs from the project can be found on the [Don Catchment project webpage](#).

2. Method

This chapter explains the datasets used and the processing steps within software used. Figure 2.1 shows the conceptualised steps taken during this project.

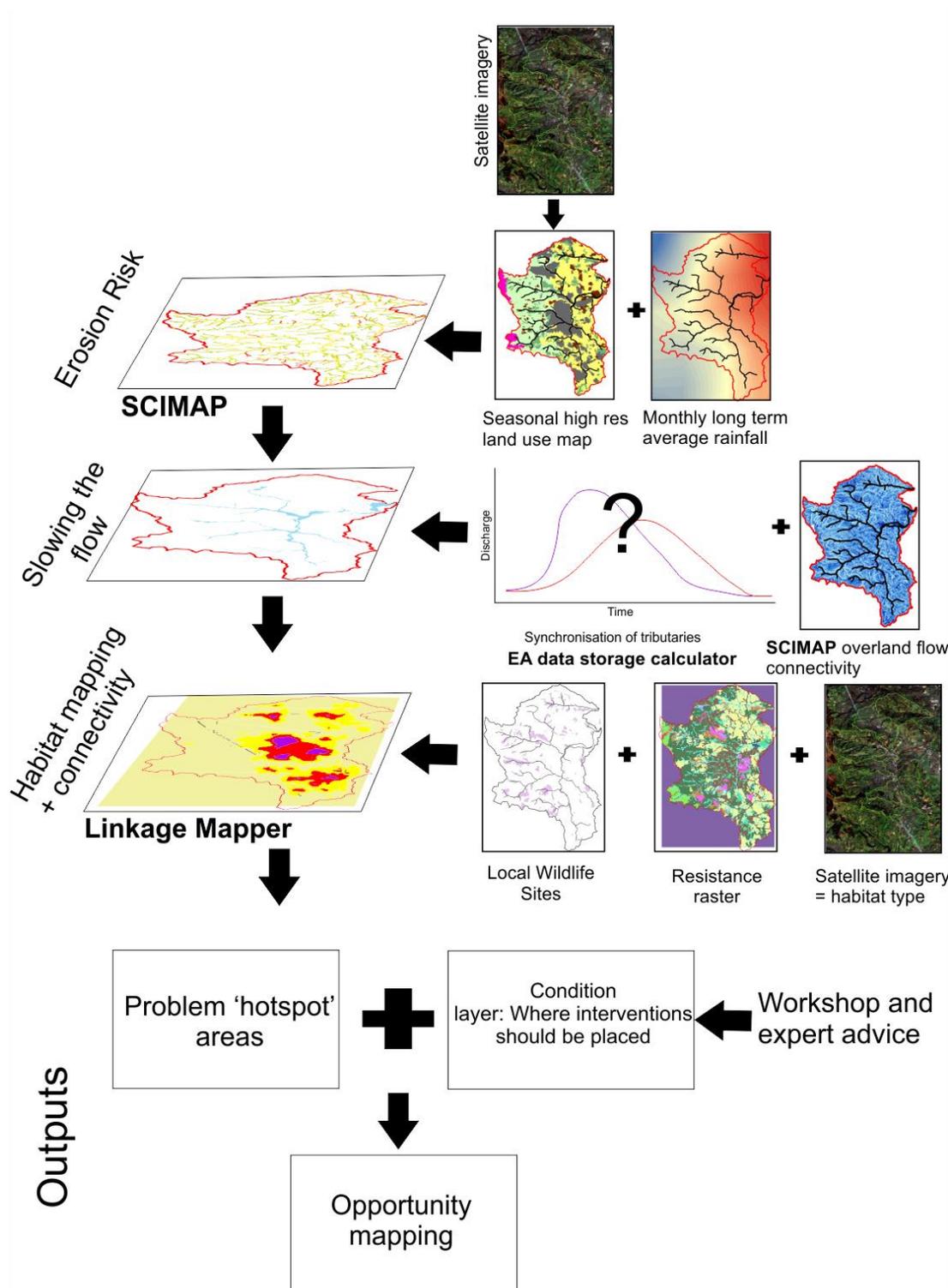


Figure 2.1 – Conceptual method followed in this report. Programs / plugins used are in bold.

2.1 Data used

Table 2.1 shows the data used within this report. Where possible, freely available data has been downloaded during the project to inform the hotspot and opportunity maps that will be used by the DCRT to inform where catchment interventions should be placed. However, to increase data resolution, academic licenses for data were also used (this data source is in

bold in Table 2.1, however alternative freely available datasets are also shown). Additionally, for flow modelling, Flood Estimation Handbook (FEH) catchment indicators were paid for and used under an academic license.

Key datasets are explained in more detail below.

2.1.1 Digital Elevation Models (DEMs)

DEMs, which show the topographic variation within a catchment was downloaded from the Ordnance Survey (OS) using an academic license. The DEM has a resolution of 5 m. DEMs are used in erosion risk modelling and overland flow modelling.

2.1.2 Land-use maps

Freely available 1 km land-use maps for the catchment are available from the Centre for Ecology and Hydrology (CEH)¹ and CORINE². Land-use maps are a crucial part of erosion risk mapping, as they show vegetation cover which influences the erosion risk and transport potential of sediment. Land-use maps can also be used to extend habitat maps (see Section 2.2.5).

2.1.2.1 Satellite imagery

Sentinel 2 data, freely available from the European Space Agency³, has a spatial resolution of 10 m. Thirteen spectral bands are measured via the satellite, however for the purpose of creating land-use maps the following bands are required:

- Band 2: Blue wavelength
- Band 3: Green wavelength
- Band 4: Red wavelength
- Band 8: Near infrared wavelength

Combined, these bands provide an image of land-use for the month chosen. For this project, data was downloaded for January and September 2018 as these dates represent the most recent and highest risk months for erosion due to agricultural practices and increased rainfall

The Sentinel 2 satellite has been active since 2015. Other sources of satellite imagery data, which have a longer dataset, include: Sentinel 1⁴; Landsat⁵; MODIS⁶.

2.1.3 Rainfall data

Met Office rainfall data was downloaded from the Centre for Environmental Data Analysis⁷. The data grids, used in the UK Climate Projections 2009 (UKCP09), have a resolution of 5 km. Monthly averages (mm) were downloaded and clipped to the HHSS study area.

¹ [Website link to CEH land cover map 2015](#)

² [Website link to CORINE land cover maps](#)

³ [Website link to sentinel 2 satellite imagery](#)

⁴ [Website link to sentinel 1 satellite imagery](#)

⁵ [Website link to Landsat data](#)

⁶ [Website link to MODIS data](#)

⁷ [Website link to CEDA](#)

Climate change projections were not used in this project. However, the modelling completed in this project could be used to stress test the opportunities by integrating in future changes in rainfall. UKCP18 data is freely available from the Met Office: [website link to UKCP18](#)

A UKCP18 iCASP project looked at the integration of these new projections into stakeholders needs: [Link to UKCP18 project on iCASP website](#)

2.1.4 Flood Estimation Handbook Catchment Descriptors

FEH catchment descriptors are used to model flow within a catchment⁸. The CEH web service⁹ was used to download descriptors at specific points within the catchment (Fig. 2.2) to explore tributary synchronisation (Section 2.2.4). The Drone, Hipper and Upper Rother sub-catchments were chosen as Chesterfield is a key area of interest to reduce flood risk, the Drone feeds into the wider Chesterfield constituency and therefore was also included.

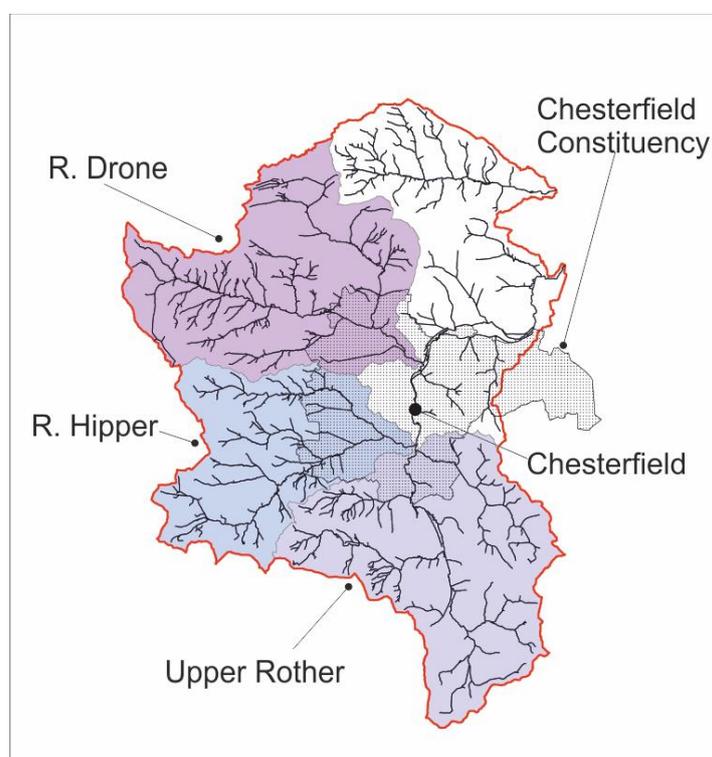


Figure 2.2 – Sub-catchments modelled for tributary synchronisation¹⁰. These sub-catchment scales were chosen as they represent the major rivers that join the Upper Rother, following the guidance from the EA Storage Calculator.

⁸ A full description of the FEH catchment descriptor dataset is available here: [Website link for FEH catchment descriptors](#) [accessed 20th June 2019].

⁹ [Website link to CEH web service](#)

¹⁰ Please note, this figure is not comparable to the WFD water boundaries in Figure 2.1 and represents the hydrological sub-catchments of the main rivers in the study area.

Table 2.1: Data used within this report

DCRT aims	No.	Dataset category	Dataset name (if applicable)	Importance	Source	License	Alternative sources of data
1. Catchment Setting	1.1	Digital Elevation Model (DEM)	DEM OS5m	Shows topographic variation in the catchment and can be used to extract additional catchment information on morphometry e.g., slope.	Ordnance Survey Website link to OS data (academic license)	Academic License	<ol style="list-style-type: none"> ASTER (30m): Website link to ASTER DEM Ordnance Survey (50m): Website link to OS DEM (free) LiDAR (0.25 – 2m): Website link to LiDAR data
	1.2	Land Use Map	CEH map	Land use maps are required for erosion risk mapping and habitat connectivity mapping.	Centre for Ecology and Hydrology Website link to CEH land cover map	Open Source	Satellite imagery (see row 2.1)
	1.3		CORINE		Copernicus Land Monitoring Service Website link to CORINE land cover map		
	1.4	Rainfall data	Met Office gridded land surface climate observations - monthly climate variables at	Rainfall data is needed for erosion risk mapping.	Met Office Website link to Met Office rainfall data	Open Source	

DCRT aims	No.	Dataset category	Dataset name (if applicable)	Importance	Source	License	Alternative sources of data
2. Diffuse pollution 3. Slow the flow	2.1	Satellite imagery	5km resolution <i>Sentinel 2</i>	Satellite imagery can be used to create seasonal land use maps, which can be used to assess seasonality in erosion risk. Satellite imagery can also be used to extend habitat maps, which may only focus on priority habitat areas.	European Space Agency Website link to sentinel data	Open Source	
	2.2	River Habitat Survey / Walkover surveys		These surveys may give more information on point source diffuse pollution within the catchment / information on where other erosion (e.g., bank) is causing problems.	Environment Agency Website link to EA data	Open Source	
	3.1	FEH catchment descriptors		Used in hydrological software to create design hydrographs	Centre for Ecology and Hydrology Website link to CEH	Paid for data. The FEH website has a graded scale of cost depending on the number of credits purchased. A single catchment retrieval (used here) costs 10 credits per	



DCRT aims	No.	Dataset category	Dataset name (if applicable)	Importance	Source	License	Alternative sources of data
4. Landscape connectivity	4.1	Habitat maps	Priority Habitat Inventory	Can be used instead of CORINE land use maps in creating resistance rasters.	Website link to priority habitat data	sub-catchment. The cost of this ranges between £5 to £25 per sub-catchment depending on how many credits have been purchased ¹¹ . Open Source	Habitat maps may need to be supplemented with satellite imagery.
	4.2	Designated sites	SAC / SPA / SSSI LWS	Can be used to assess the quality of habitats within the catchment. Used for landscape connectivity analysis.	Website link to data.gov	Open Source Local Authority	

¹¹ [Website link to FEH pricing](#)



2.1.1 Designated sites

Local wildlife sites have been used within this work; this information was supplied by the Derbyshire Wildlife Trust to the Don Catchment Rivers Trust.

Designated site data (SAC, SPA, SSSI etc.) can be downloaded from data.gov.uk.

2.2 Data processing and software used

This work has primarily used a mixture of ArcGIS and SAGA GIS. ArcGIS was chosen as the DCRT have a license. The methods below focus on ArcGIS, however it is not open source. The methods can be easily transferred to open source software e.g., QGIS.

2.2.1 Pre-processing of data

The data downloaded from the sources detailed in Section 2.1 is often not in the correct format to process, the steps below outline some of the pre-processing that was undertaken in this project.

2.2.1.1 Mosaic to new raster

The DEM was downloaded as tiles. In order to process the data effectively, the tiles need to be processed into one data output. In order to do this, the '*mosaic to new raster*' tool was used. An example of the key input is provided below:

Input rasters: DEM tiles

Output location: where you want the new merged raster to be saved.

Number of bands: 1 (this indicates one value is saved in each cell e.g., height)

2.2.1.2 Merging shapefiles

Again, shapefiles may be downloaded as tiles e.g., road network / detailed OS vector maps. In order to process the data effectively, the data needs to be merged. This is done by using the '*merge (data management)*' tool. For this tool, the individual tiles are dragged into the input dataset box and combined.

2.2.1.3 Clipping

The data extents are normally much greater than the study areas / catchment areas of interest. In order to reduce the data processed, it is clipped ('cut') to an area. Depending on the data types, there are two options:

1. '*Clip (data management)*': this tool clips raster datasets (e.g., .tif; .asc etc.). The input raster is the file that needs to be clipped, the output extent is the shape that you want the data to be clipped too (e.g., HHSS study area shapefile), it is important to click the 'use input feature for clipping geometry' box in order to get an exact clip.
2. '*Clip (analysis)*': this tool clips shapefiles (.shp) and follows a similar process to above.

2.2.1.4 Hydrological conditioning

DEMs can be used to extract the hydrological network, however, in order to do this, the cell pixels with missing data / no data need to be filled. This allows for the hydrological network to be connected properly. In order to do this, the '*fill sinks*' tool can be used in GIS.

This step was not undertaken, as the SCIMAP plugin (Section 2.2.3.2) has an option to fill the sinks within the processing for diffuse pollution risk.

2.2.2 Processing satellite imagery

GIS software has a suite of image processing tools, in order to produce land-use maps in GIS the following tools are required: object based image segmentation and supervised classification for shapes. For this step, SAGA GIS¹² was used, as it is open source and efficient at processing rasters. Object based image segmentation creates shapefile segments depending on the colours of the underlying image. Supervised classification for shapes is based on the information provided in training cells (cells that have been defined to represent a specific land use) combined with the colour combination of the underlying image.

Figure 2.3 shows a step by step guide of creating a land-use map using sentinel 2 data; from data download to using the object based image segmentation and supervised classification for shape tools.

For this project, the following land-use classes were used¹³:

1. Woodland¹⁴
2. Arable and Horticulture
3. Improved grassland
4. Bogs, moors and heathlands
5. Mineral extraction site
6. Urban
7. Bare land

¹² SAGA GIS is open source software that is very effective at processing rasters. The programme is available here: [Website link to SAGA GIS](#)

¹³ This can be adapted for each land-use map created.

¹⁴ As the erosion risk value (in SCIMAP) does not vary between different types of woodland, it was not necessary to differentiate between broadleaved and conifer forests.

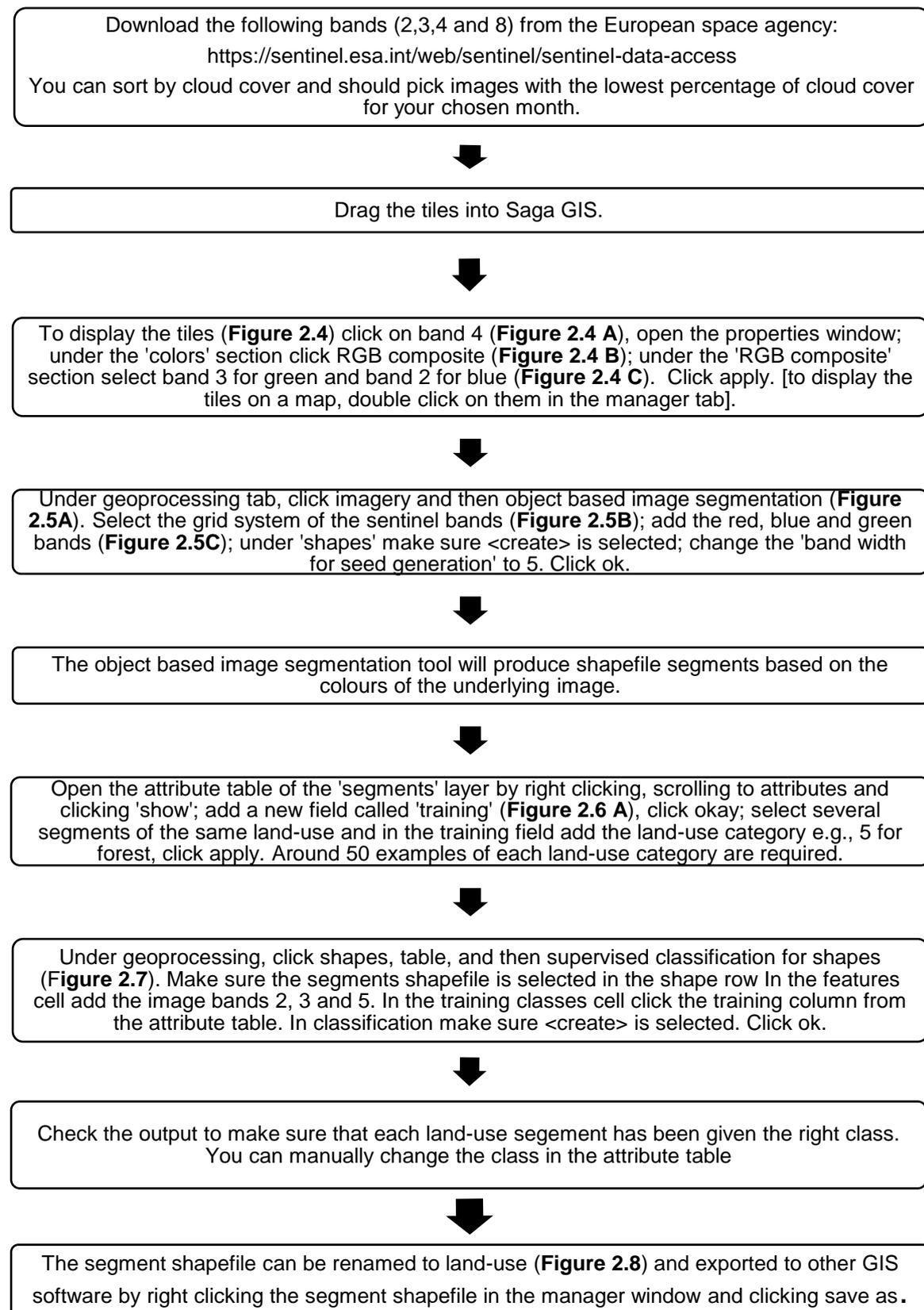


Figure 2.3– Flow chart of how to create land-use maps from satellite imagery (sentinel 2 data).

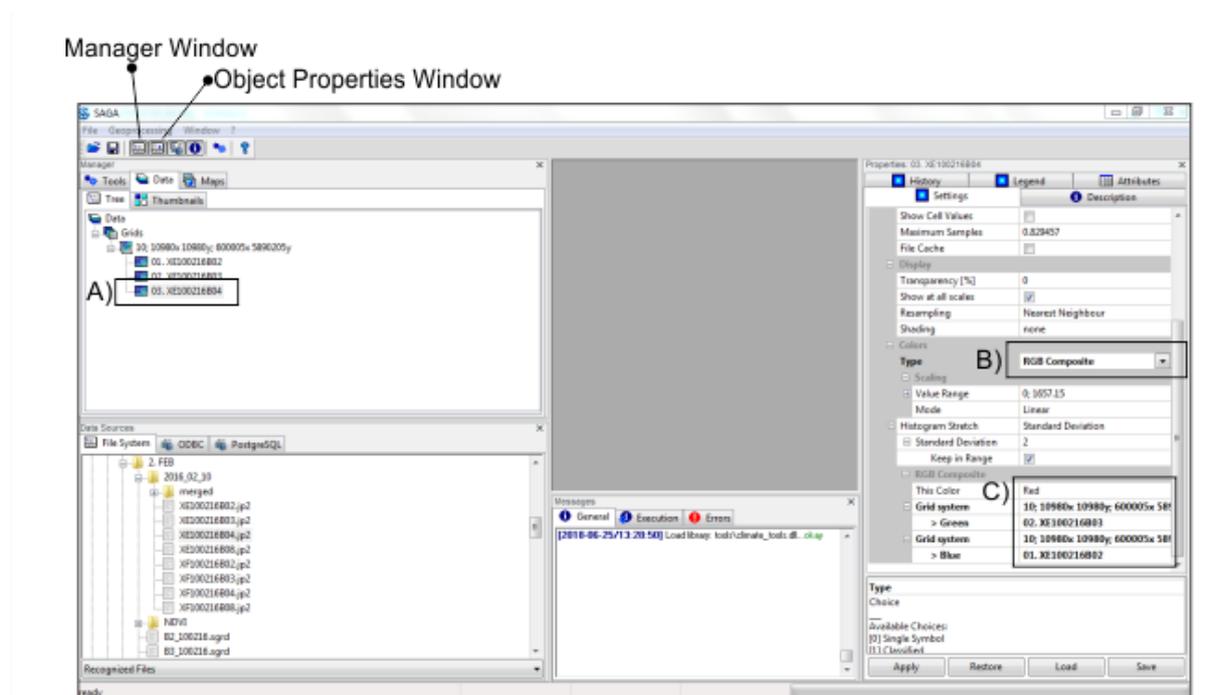


Figure 2.4 – How to load sentinel bands into SAGA GIS.

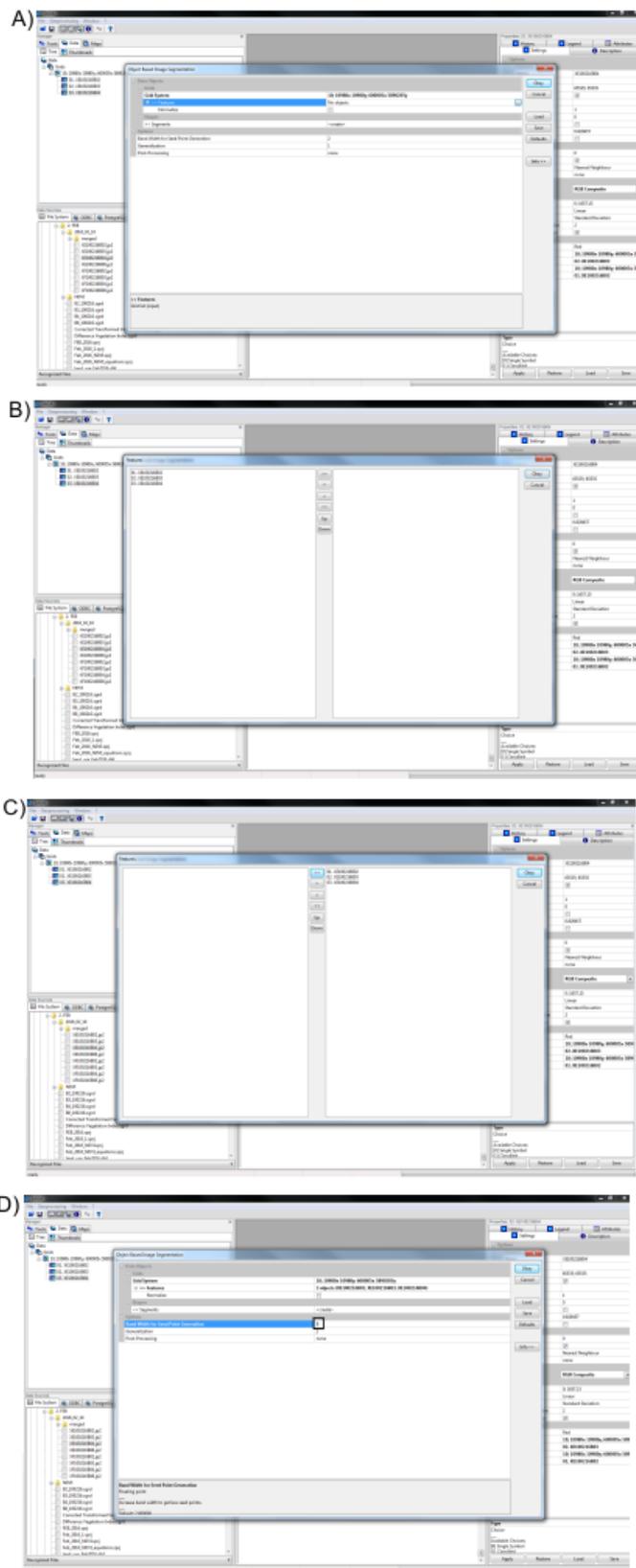
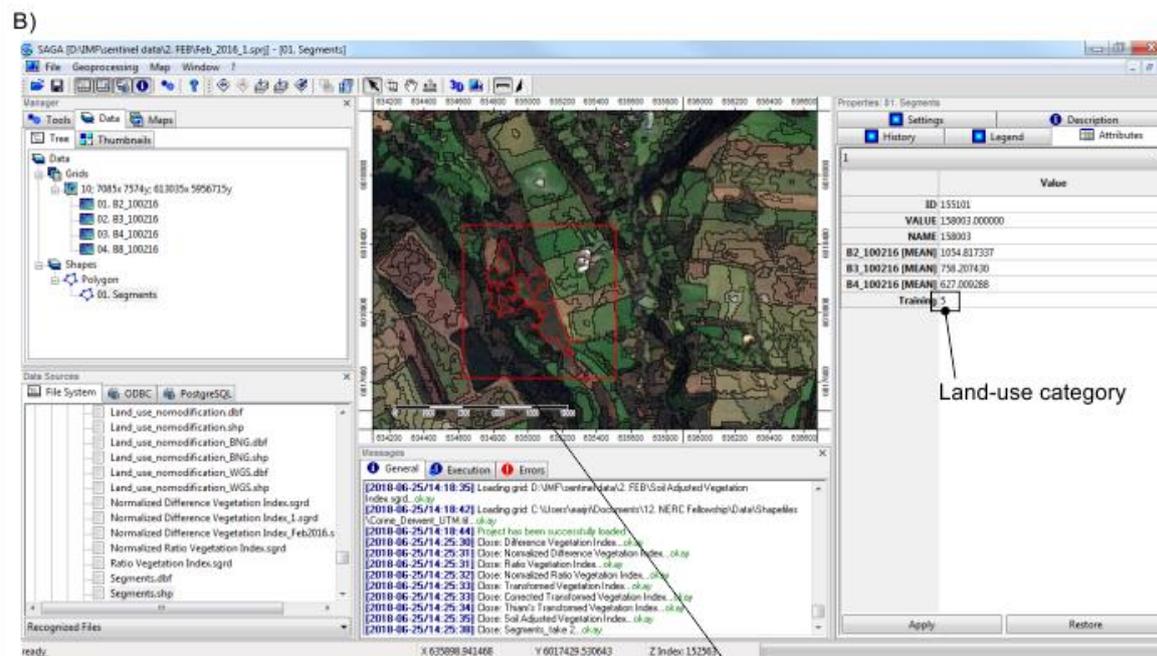
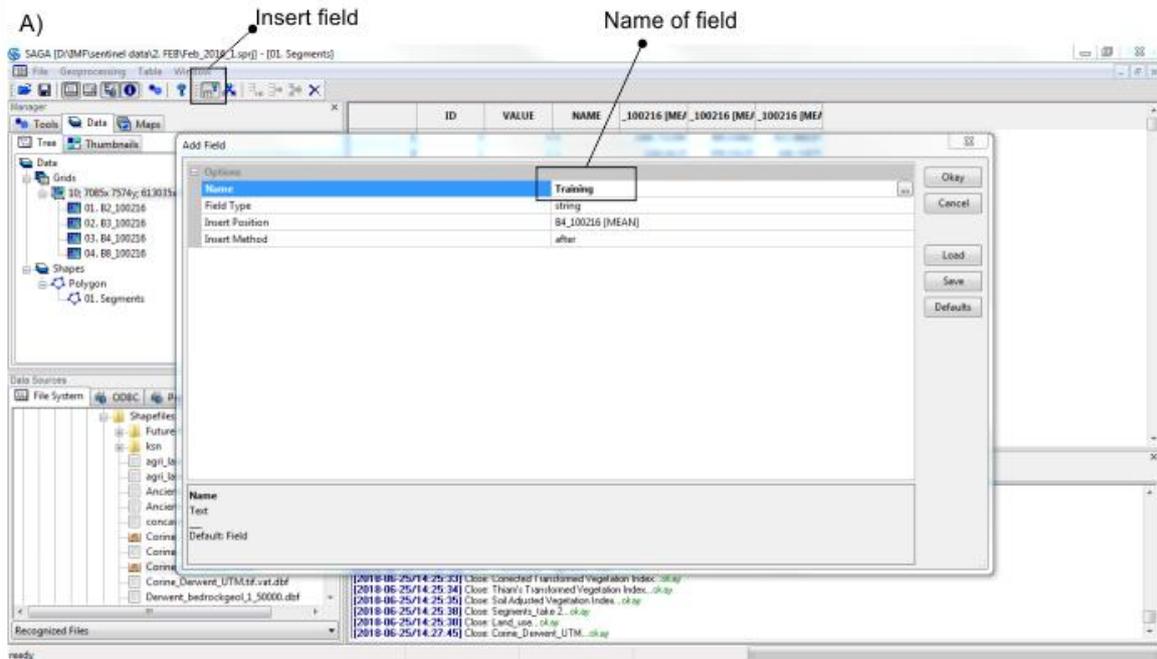


Figure 2.5 – Object based image segmentation.

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Drag and select some segments of the same land-use

Figure 2.6 – Training.

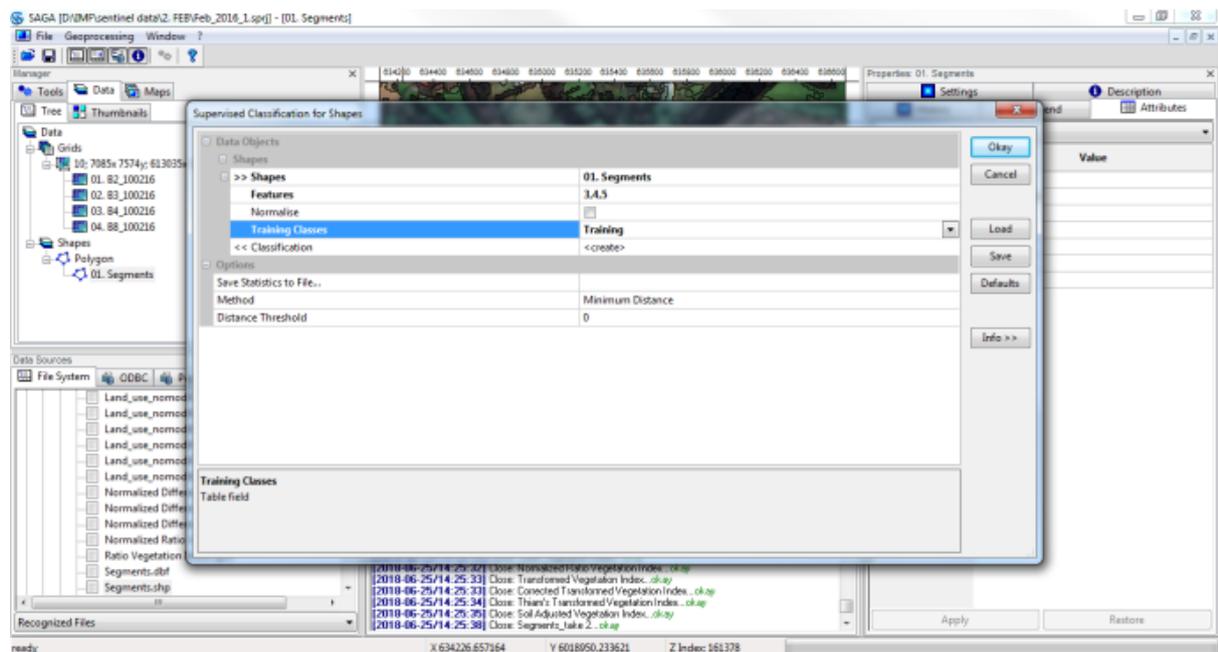


Figure 2.7 – Supervised classification.

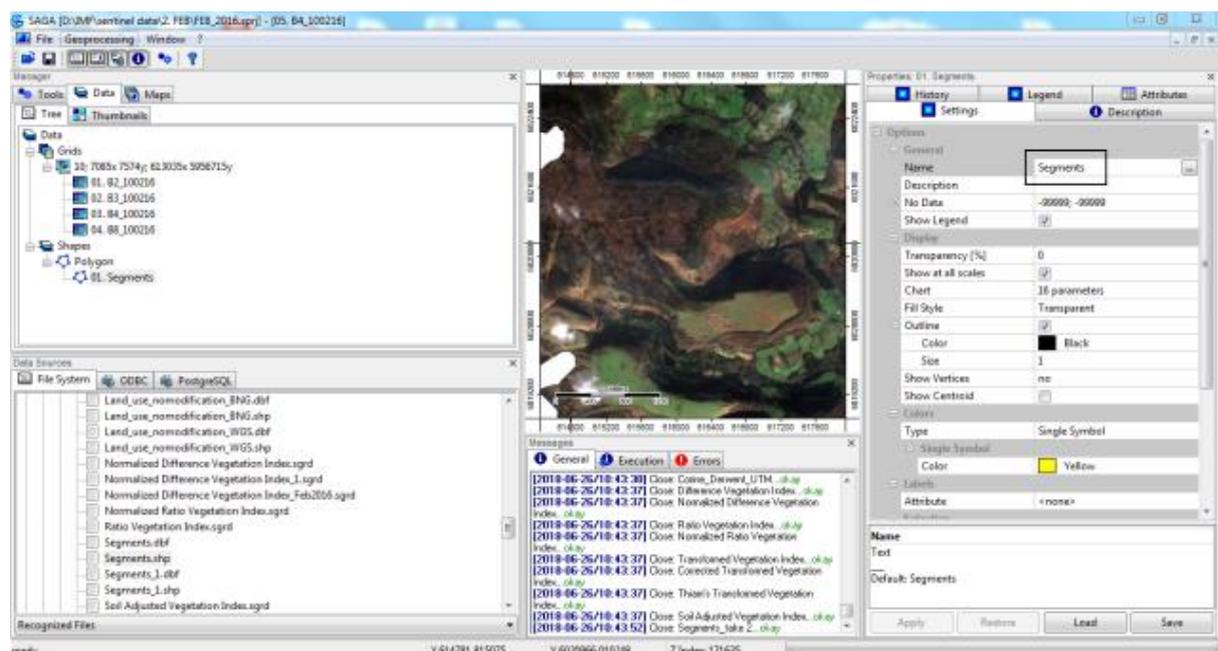


Figure 2.8 – How to rename the shapefile.

2.2.3 Erosion Risk mapping of Diffuse Pollution: SCIMAP

Erosion risk, as defined in SCIMAP, is the sum of the availability of soil to be eroded, together with the potential to be mobilised (source); however, the sediment must also be connected to the drainage network (pathway) for there to be an impact. The availability of soil to be eroded is related to underlying geology, soil and land-use (including vegetation), whilst the

connectivity is dependent on gradient (e.g., DEM) and moisture availability (e.g., level of rainfall, soil moisture content). The factors that influence erosion risk such as land-use and vegetation cover, vary seasonally, however erosion risk maps normally uses a static land-use map (the average of the year). Erosion risk maps produce hotspot maps of where there are areas of higher risk; these maps can be used to inform catchment management.

SCIMAP (Sensitive Catchment Integrated Modelling and Analysis Platform), is an open source SAGA GIS plugin developed by Reaney *et al.*¹⁵, it can be downloaded from: [download link for SCIMAP](#). The output of Scimap is a relative assessment of erosion risk in the catchment for one location, compared to all other locations within the catchment. SCIMAP does not give an indication of the amount of sediment produced, but shows the source areas of sediment within the catchment.

SCIMAP requires the following inputs: DEM, land-use (which have been reclassified, see Section 2.2.3.1) and rainfall, together these layers estimate the amount of sediment availability and the pathways to the main channel. The SCIMAP interface (Fig. 2.9) indicates the rasters needed (DEM, land-use, rainfall) and the outputs produced: slope, catchment area, channels, erosion risk, network index, accumulated erosion risk, erosion risk in channels and erosion risk in channels concentration. Two boxes (fill DEM and use stream power) need to be ticked for the model run.

Further information on SCIMAP training can be found here: [website link for SCIMAP training](#)

For this project, the downloadable version of SCIMAP was used, however the online web tool¹⁶ allows the user to change the input files (DEM / land use / rainfall) e.g., to higher resolution and could be used during this step¹⁷.

¹⁵ SCIMAP is maintained and developed by Dr. Sim M Reaney, Durham University

The original SCIMAP team from the NERC and EA funded projects were:

Prof. Stuart N. Lane, now at Université de Lausanne
Prof. Louise Heathwaite, LEC, Lancaster University
Dr. David G. Milledge, Durham University
Dr. Sim M Reaney, Durham University

¹⁶ [Website link to SCIMAP online version](#) - online version of SCIMAP. Login details are needed to access the tool and users can register for free.

¹⁷ The downloaded SCIMAP, which is a plugin for SAGA GIS was use as processing speeds are quicker using the desktop version rather than the online version.

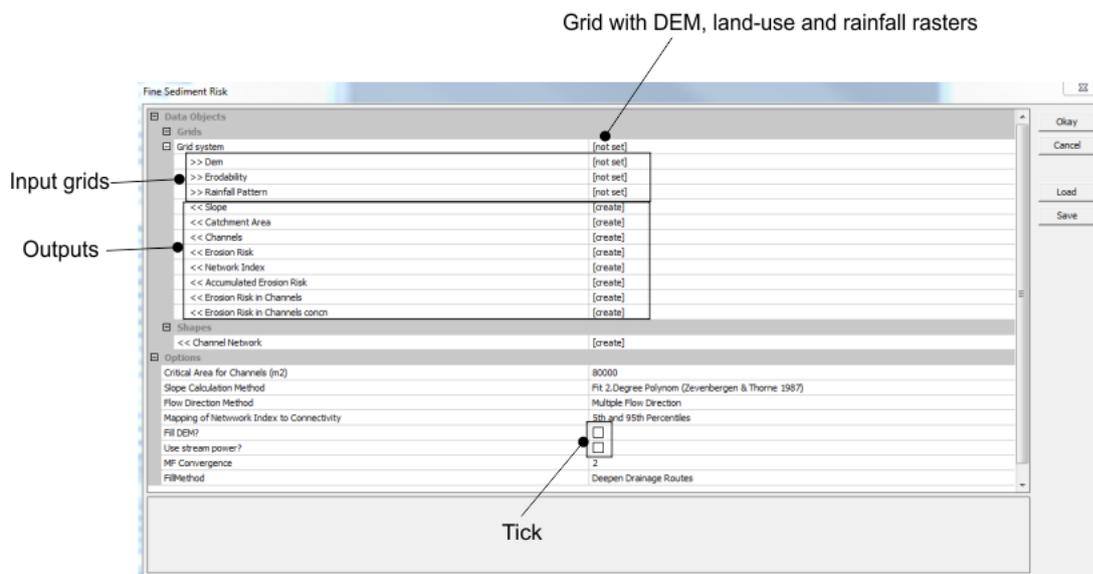


Figure 2.9 – SCIMAP interface. The first tick box allow the DEM to be filled (Section 2.2.1.4).

2.2.3.1 Seasonal satellite maps

When the model is run, each land-use category¹⁸ is assigned an erosion risk value (Fig. 2.10), which needs to be updated when using satellite derived seasonal maps (Fig. 2.10). In the case of the satellite maps for the Don, seven land-use categories were chosen, the corresponding risk of erosion values were copied from the ‘LCM2007’ text file saved within the SCIMAP files.

¹⁸ The numbering system relates to the CEH LCM2007² land-use categories as follows (Countryside Survey: Land Cover Map 2007 Dataset Documentation, CEH: [website link to CEH documentation](#))

Aggregate class	Aggregate class number ¹	Broad Habitat	LCM2007 class	LCM2007 class number ²
Broadleaf woodland	1	Broadleaved, Mixed and Yew Woodland	Broadleaved woodland	1
Coniferous woodland	2	Coniferous Woodland	Coniferous Woodland	2
Arable	3	Arable and Horticulture	Arable and Horticulture	3
Improved grassland	4	Improved Grassland	Improved Grassland	4
		Rough Grassland	Rough grassland	5
Semi-natural grassland	5	Neutral Grassland	Neutral Grassland	6
		Calcareous Grassland	Calcareous Grassland	7
		Acid Grassland	Acid grassland	8
		Fen, Marsh and Swamp	Fen, Marsh and Swamp	9
		Dwarf Shrub Heath	Heather	10
Mountain, heath, bog	6	Heather grassland	Heather grassland	11
		Bog	Bog	12
		Montane Habitats	Montane Habitats	13
		Inland Rock	Inland Rock	14
Saltwater	7	Saltwater	Saltwater	15
Freshwater	8	Freshwater	Freshwater	16
Coastal	9	Supra-littoral Rock	Supra-littoral Rock	17
		Supra-littoral Sediment	Supra-littoral Sediment	18
		Littoral Rock	Littoral Rock	19
		Littoral Sediment	Littoral sediment	20
Built-up areas and gardens	10	Saltmarsh	Saltmarsh	21
		Urban	Urban	22
		Suburban	Suburban	23

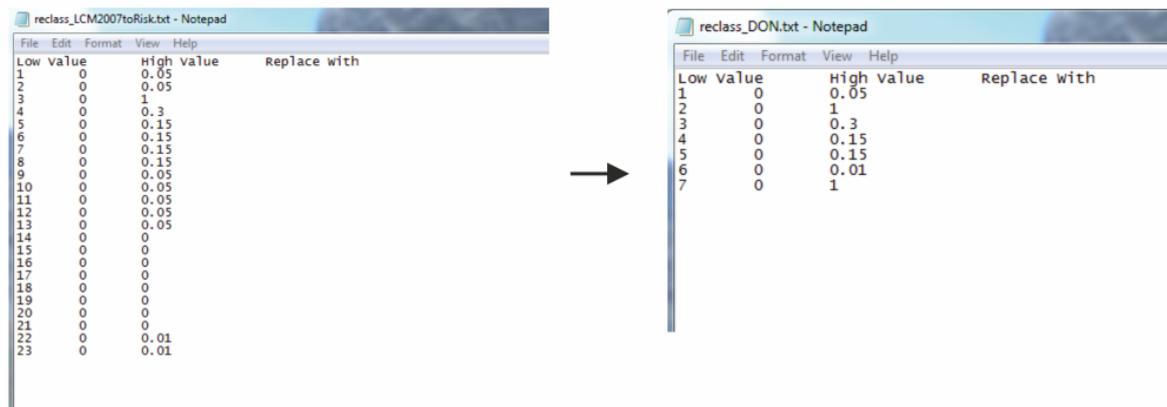


Figure 2.10 – Reclassifying the land-use maps.

2.2.3.2 SCIMAP output

SCIMAP assesses relative erosion risk within a catchment, and therefore does not produce absolute volumes of sediment produced. SCIMAP produces three output datasets of relevance to this work. Each dataset is described below:

1. Erosion Risk: This grid shows erosion risk across the catchment and ranges from 0 (low risk) to 1 (high risk).
2. Erosion Risk in Channels Concentration: This shapefile shows the concentration risk of the sediment in channel. In order to display the shapefile, it is recommended to use 1/3 standard deviation.
3. Network Index: This grid shows the hydrological connectivity of the catchment, the data ranges from 0 (low connectivity) to 1 (high connectivity). This grid can be used to look at overland flow connection within the catchment (Section 2.2.4.2).

2.2.4 Hydrological data

2.2.4.1 Synchronisation of tributaries

Understanding how different sub-catchments will act under different NFM interventions is vital in order to not synchronise the flood peaks and exacerbate flooding downstream. The process depicted below is a first step approach and indicates what sub-catchment may have the greatest impact by slowing the flow. **However, further quantification is required as the steps below only form a preliminary hydrological analysis.**

This process requires the use of two steps:

1. Creating design hydrographs in Flood Modeller¹⁹
2. The use of the Environment Agency’s NFM storage calculator

The outcome of the hydrological data will help prioritise which sub-catchment would have the greatest impact for flood reduction by slowing the flow.

Flood modeller:

FEH catchment indicators for four sub-catchments (Section 2.1.4) were imported into flood modeller in order to create design hydrographs using the revitalised flood hydrograph (ReFH)

¹⁹ [website link to flood modeller](#)

method. A 1 in 2, 1 in 5 and 1 in 10 year flood was modelled with a critical storm duration of 18.75 hours²⁰.

Figure 2.11 shows the processes undertaken to create design hydrographs, these steps will need to be undertaken for each sub-catchment. ReFH uses a theoretical approach to assess time to peak, which may not represent local conditions e.g., runoff related to differences in soil or geology, but offers a good first step in assessing flow conditions within the catchment. Design hydrographs are created in lieu of gauging records in the individual sub-catchments.

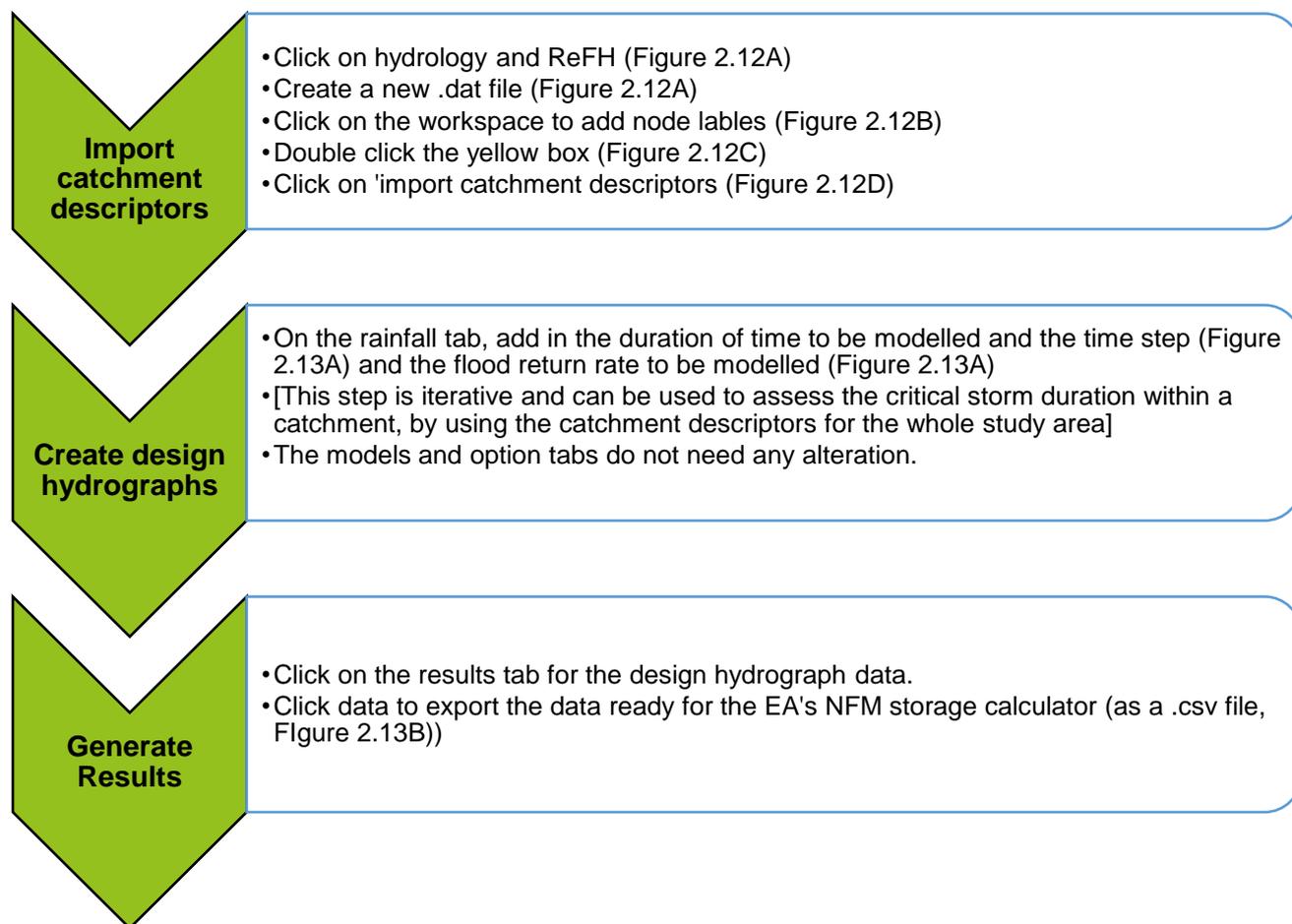


Figure 2.11 – Process of creating design hydrographs in Flood Modeller.

iCASP's work on NFM in Calderdale is using SD-TOPMODEL to model NFM intervention, this model allows for a more in depth look at the hydrological impact of implementing NFM by integrating catchment specific properties. More information is available here:

[Link to Calderdale NFM project on iCASP website](#)

²⁰ The critical storm duration was determined based on a whole catchment response of the entire HHSS study area.

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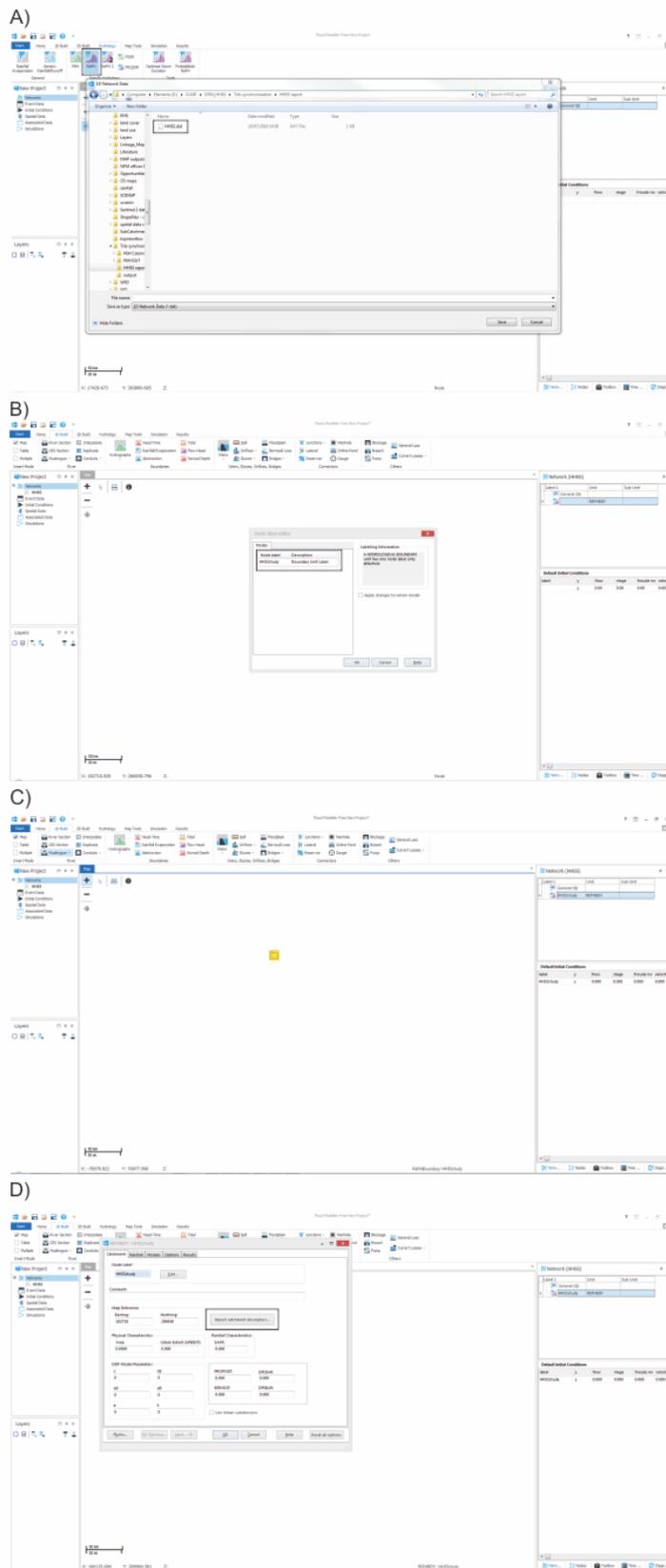


Figure 2.12 – The process of importing catchment descriptors to create design hydrographs.

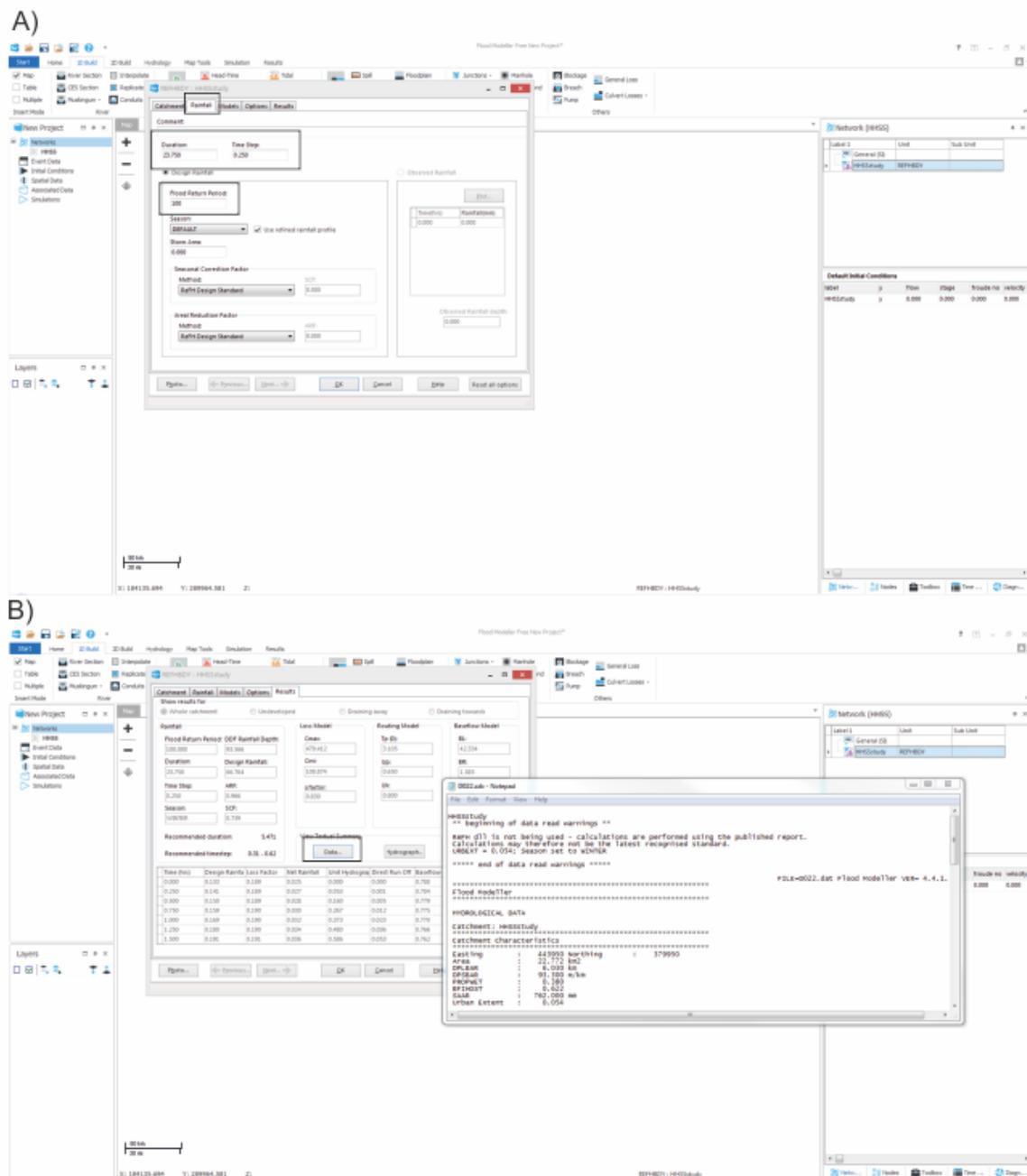


Figure 2.13 – A) Data input for rainfall information and flood return rates and; B) export of design hydrographs.

Environment Agency’s NFM Storage Calculator²¹:

The storage calculator allows for the mitigation provided by NFM to be modelled (by varying the time to peak and storage potential of a sub-catchment). The calculator includes a methodology, which is summarised in Figure 2.14.

²¹ Nicholson, Owen, Quinn and O'Donnell (2015). Natural Flood Management Tool for assessing impact of storage within sub-catchments. Arup, Newcastle University and Environment Agency.

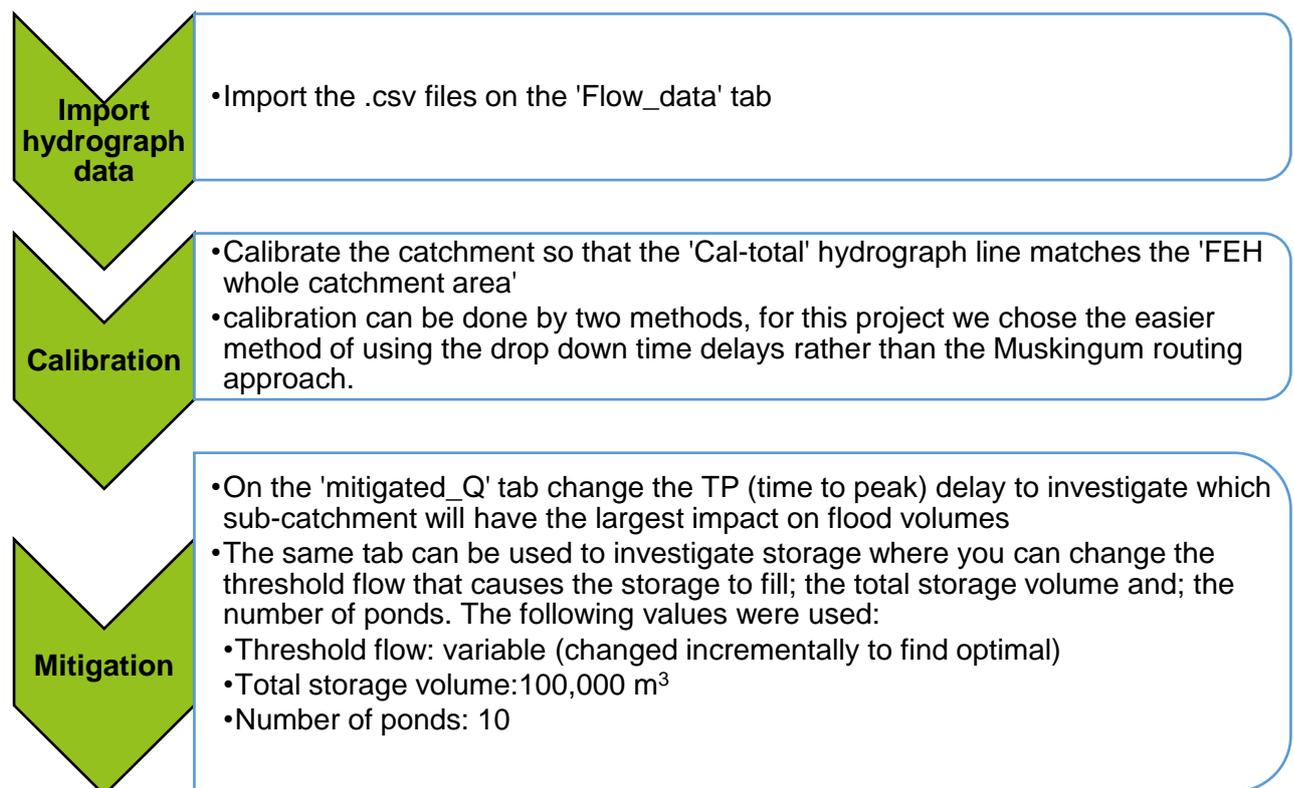


Figure 2.14 – EA’s NFM storage calculator method.

2.2.4.2 Overland flow

One of SCIMAP’s raster outputs is the Network Index, which assesses overland flow potential within a catchment. For each point in the landscape, the probability of continuous flow to the river channel network is assessed. This is achieved through the prediction of the spatial pattern of soil moisture and the susceptibility of each point in the landscape to generate saturated overland flow. For a point in the landscape to export risk in surface flow, every other point along the flow path to the channel must be capable of transporting the risk. If a down slope point is not also saturated, the upslope risk will be captured at this point and not reach the river channel, the cell is disconnected. The total risk that a point represents is a function of the point scale risk and the risk of connectivity to the river channel.

2.2.5 Landscape Connectivity

Landscape connectivity was assessed using ‘Linkage mapper’, an open source plugin for GIS available: [website link to linkage mapper](#). Linkage mapper assesses corridor routes and the connectivity between different target habitats.

In order to use linkage mapper the following datasets are required:

1. Core polygon areas of the habitat (shapefile)
2. Resistance raster

Core Areas of habitat: Local wildlife sites (LWS) were used as they have a greater spread across the catchment than SACs/ SPAs and SSSIs. Using the LWS assumes that all of these habitats are ‘good’. However, there is limited information on the reasons for designation to assess the quality level of each LWS.

The LWS shapefile was split depending on habitat type, for this work the following was assessed:

1. Woodlands (broadleaved and conifer)
2. Meadows
3. Grasslands

These three habitat types were chosen as they are the most frequent LWS within the study area.

The 'select by attribute' tool was used to select all features containing the word 'wood'; 'meadow' and 'grassland' respectively.

Landscape connectivity modelling is an iterative process, the inputs can be modified to model the impacts of creating new target habitats, for example by creating a new shapefile. This will update the resistance raster that is produced. The [case study on habitat connectivity](#) highlights this point.

Resistance maps: The CORINE²² land use maps of the catchment were 'reclassified' to show resistance levels following Theobald *et al.* (2012)²³ (Table 2.2). The road network (shapefiles) was then converted into a raster ('feature to raster') and integrated into the resistance raster, by using the method in Figure 2.15.

²² [website link to CORINE land cover maps](#)

²³ Theobald, D.M., Reed, S.E., Fields, K. and Soule, M., 2012. Connecting natural landscapes using a landscape permeability model to prioritize conservation activities in the United States. *Conservation Letters*, 5(2), pp.123-133.

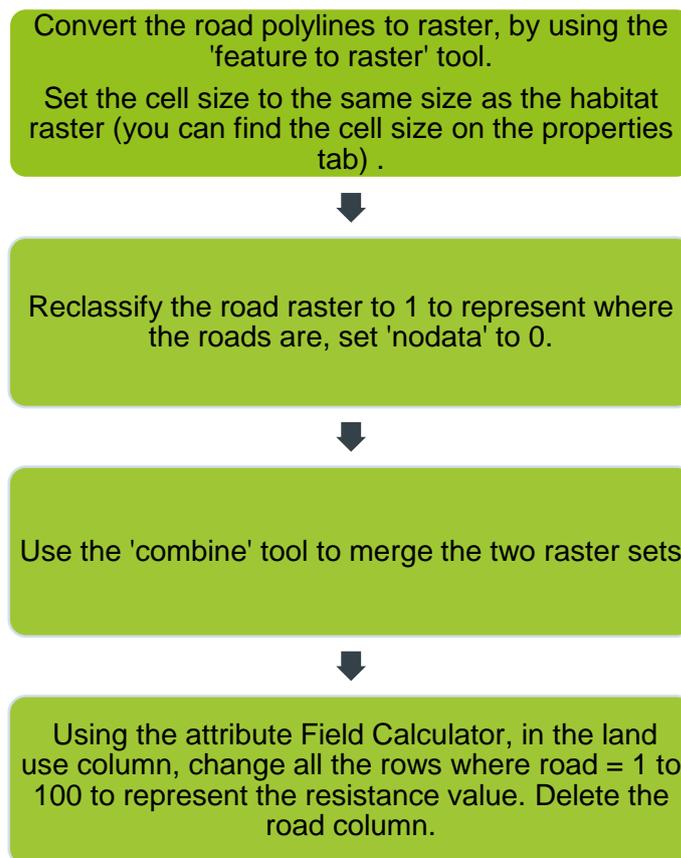


Figure 2.15 – The process of creating a resistance map with roads.

Table 2.2 – Resistance values used²⁴.

Land use	Resistance
Continuous urban fabric	85
Discontinuous urban fabric	85
Industrial or commercial units	85
Mineral extraction sites	24
Dump sites	85
Green urban areas	64
Sport and leisure facilities	64
Non-irrigated arable land	68
Pastures	17
Complex cultivation patterns	68
Land principally occupied by agriculture, with significant areas of natural vegetation	68
Broad-leaved forest	7
Coniferous forest	7
Mixed forest	7
Natural grasslands	17
Moors and heathland	5
Peat bogs	11
Rivers	10
A roads	100

²⁴ Resistance values are unit-less. The values used are from Theobald et al. 2012 and are global values, which stay the same regardless of the target habitat type.

B Road	100
Minor roads	100

2.2.5.2 *Habitat connectivity output*

Linkage mapper produces the following rasters used in the project:

1. Corridor raster– This map shows the resistance between different target habitats which can be used to assess which target habitats are easiest to connect. Low values of resistivity indicate easier target habitat to connect e.g., connecting these pockets will have a greater success of becoming established. The map is created using the resistance map of underlying land-use and the potential pathways between the habitat pockets.
2. Target habitat lines – these connect target habitats, which are used to create the corridor map. The target lines represent the shortest route to connect target habitats. Not all the target habitats are connected directly, this is because in some cases, the corridor is through multiple target habitats.

2.2.5.3 *Hardware limitations*

Due to the size of the study area, the linkage mapper plugin could not be run successfully for the woodland habitat modelling the full study area. Therefore, sub-catchments were modelled. In the results produced in the report, the sub-catchments have been mapped for woodland connectivity and therefore, resistance near the watershed does not represent the 'real world' situation (e.g., nearby woodland in a neighbouring sub-catchment if included in the modelling would change the resistance output). The [case study on habitat connectivity](#) addresses this issue by producing a 1 km buffer²⁵ around each sub-catchment to incorporate woodlands near to the watershed of a neighbouring sub-catchment.

2.3 Turning hotspot maps into opportunity maps

The hotspot maps indicate challenge / problem areas within a catchment. This information is used to make an informed decision of what interventions would be helpful and where. The maps shown in Chapter 5 were completed during an expert advice workshop and focus on the most effective areas for interventions. Nonetheless, hotspot maps can be used with a willing land-owner to implement further measures not identified on the opportunity maps presented in this report. Areas for interventions are prioritised on the problems e.g., highest risk areas for overland flow or erosion risk and areas that are easiest to connect from a habitat point of view. Depending on the problem in question, a range of interventions can be chosen.

2.4 Limitations of data and approach

Modelling and mapping are limited by the resolution of data that is used, the processes used in this report are not the only way to look at erosion risk, hydrological connectivity or landscape connectivity. The tools used in this report, represent a quick and effective way to assess catchment opportunities, which could lead to further, more detailed investigation.

Erosion risk – SCIMAP was used in this project as it is used by a range of stakeholders, and is a quick and effective way to analyse source areas within a catchment. More detailed mapping processes such as the 'revised universal soil loss equation' (RUSLE), which can integrate information on soil and geological variation could be used to increase the detail of the erosion risk maps.

²⁵ A tool in GIS – with the buffer set to 1km.

Hydrological connectivity – SCIMAP was used to look at overland flow in this work as it is quick. However, more detailed modelling can be undertaken. For example, the iCASP project on Calderdale NFM is using SD-TOPMODEL to understand intervention placement in the catchments. SD-TOPMODEL assesses hillslope hydrology (overland flow, throughflow) and incorporates soil data information, which can then be used to model the effects of placing NFM in a catchment at higher resolution.

For further information on the Calderdale NFM project visit: [link to Calderdale NFM project on iCASP website](#)

Landscape connectivity – Linkage mapper was used in this work due to its usability. However, a range of GIS plugins / models exist that can be used to model connectivity e.g., Fragstats; GRAPHAB etc. We have used local wildlife sites in this work, however, more detailed habitat quality mapping will indicate what habitat pockets should be connected to not only increase connectivity but also habitat quality.

Note of caution

Interventions tend to be site specific, and the maps produced in this report only signpost where interventions could be placed based on the data available and hotspot maps created. It is strongly recommended that the maps are ground truthed before any interventions are put in place to ensure they are placed in the correct location.

2.5 Summary

Table 2.3 provides a summary of the software and data used for each aim.

Table 2.3 – Summary of data and software used in the report.

Aim	Software used	Data input
Diffuse pollution	SCIMAP	DEM, seasonal land use maps, seasonal rainfall
Slow the flow	SCIMAP	DEM, land use map
	Flood Modeller	yearly rainfall data
	EA NFM storage calculator	FEH catchment indicators
Landscape connectivity	Linkage Mapper	Design hydrographs from flood modeller
		Habitat Resistance map, local wildlife sites



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