Stage DAE 4 - IMA

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Département Aménagement et Environnement

The impact of weir removal on Daubenton's bats activity

Creation of a data baseline

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Mots clés

Bats, weir, dam, Thames Basin, United Kingdom, geomorphology, Structure from motion (SFM), Modular river survey (MoRPh).

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Résumé

Le présent rapport a été rédigé dans le cadre d'un stage réalisé de Mai 2017 à Juillet 2017 à l'université de Cranfield, au Royaume-Uni sous la supervision du Dr Robert GRABOWSKI. Ce fait stage fait suite à une demande de l'Environment Agency, en la personne du Dr Sarah Jane SCOTT. Depuis de nombreuses années, un suivi sur les populations de chauve-souris est mené par cette agence. Une espèce est particulièrement suivie, le Myotis de Daubenton, espèce commune au Royaume-Uni, en Europe et en Asie, dont les besoins en termes de zone d'habitat et de chasse sont très spécifiques. En effet, cette espèce chasse uniquement au-dessus de lacs, rivières et canaux où elle se nourris principalement d'invertébrés capturés au ras de l'eau. De nombreux travaux de restauration et d'arasement de seuils ou de barrages sont menés de façon à limiter les impacts anthropiques sur le milieu, et certains de ces travaux se sont déroulés sur des zones de suivi. Le résultat attendu de ces travaux était une amélioration notable des populations de chauve-souris. Ces dernières auraient en effet bénéficié de la restauration de leur habitat, en particulier à travers leur alimentation, bénéficiant des améliorations en termes de populations d'invertébrés. Cependant, l'exact inverse fut observé pour les populations du Myotis de Daubenton. De façon récurrente, des populations ont été affaiblies, ou on même totalement disparu suite à des travaux de restauration, et en particuliers après la destruction de seuils. L'Environment Agency mène donc une étude ayant pour objectif de déterminer quels paramètres influencent négativement les populations de chauve-souris après une restauration, en particulier à travers leur activité alimentaire.

Résumé traduit

The present report has been redacted during a placement in the Cranfield University, United Kingdom, from May 2017 to July 2017, with the supervision of the Dr Robert GRABOWSKI. This placement answer to a project of the Dr Sarah Jane SCOTT from the Environment Agency. From many years, bat's population are surveyed by this agency. One specie is especially studied here, the Daubenton's bat, which can be found across the United Kingdom, Europe and Asia. It has very specific habitat requirements, and is only found near rivers, lakes and canals. The reason for this is that the bat feeds on the insects that fly above the surface of waterbodies. Many restoration project, and especially dam or weir removal have been conducted to improve aquatic ecological community, and some project took place on bat survey areas. As insects are the natural prey of Daubenton's bats, river managers expected that bat populations would also benefit from river restoration. In fact, quite the opposite appears to be happening. On some rivers where weirs have been removed, bat populations have disappeared completely. The pilot study we are conducting is investigating the link between bat feeding activity and weir removal.

Mots clés

Bats, weir, dam, Thames Basin, United Kingdom, geomorphology, Structure from motion (SFM), Modular river survey (MoRPh).

Preambule

The Daubenton's bat is a species of bat found across the United Kingdom, Europe and Asia. It has very specific habitat requirements, and is only found near rivers, lakes and canals. Indeed, Daubenton's bats mostly feeds on the insects that fly above the surface of waterbodies, such as midges and mayflies. These bats use a special hunting method, called trawling, meaning that bats catch insects very close to water surface with their legs trawling into water. All bats are protected in the United Kingdom, therefore it is important to manage landscapes sensitively to conserve these populations.

The majority of rivers in the United Kingdom are impounded by small dams, known as weirs. These structures disrupt the flow of water and sediment, create long stretches of calm water, and block fish passage. To improve river habitats, weirs are increasingly being removed and rivers re-meandered. These restoration measures have been shown to improve the aquatic ecological community, particularly fish, amphibians, and insects. Bat populations are extensively monitored along the country especially by the Environment Agency. As insects are the natural prey of Daubenton's bats, river managers expected that bat populations would also benefit from river restoration.

In fact, quite the opposite appears to be happening. Some populations seem to be declining and recorded activity is decreasing after many restoration projects. On some rivers where weirs have been removed, bat populations have disappeared completely.

Surprised by this event, the Environment Agency launched a pilot study aiming to assess more relevant factors influencing bats feeding activity. This pilot study, through bibliographic analysis and fieldworks, will firstly allow to focus the final study on more relevant factors. Secondly, it creates a baseline of data useful for a long-term study.

The pilot study we are conducting is investigating the link between bat feeding activity and weir removal. The Environment Agency is monitoring bat activity and the Cranfield University is monitoring the rivers themselves.

Following previous study, Daubenton's bats population dynamics seem really dependant on many factors. Firstly, the land cover on a large scale, which needs to provide habitats, protection and few disturbances. On studied river's, only the land cover at the very closest scale will be modified. The vegetation near the channel can be a positive factor, when it acts as a protection. It can also be a disruptive factor when the vegetation is too much cluttered to allow the flight. In the channel itself, two elements seem dominant, the water surface and the river width. The river need to be width enough to allow the bat to fly easily. As the Daubenton's bats hunting method uses the water surface to improve targets echolocation, a smooth water surface increases their hunting efficacity.

To confirm the importance of these factors on bats activity, the pilot study will follow bats activity on three rivers, before and after a weir removal. Many factors are mostly visual and can't be directly recorded by percentages or indices. To record these elements, different methods are used in association with more computational methods as topography or flow measuring.

The Modular River Physical Survey, or MoRPh Survey launched by the Environment Agency is still under development. This method firstly aims to be part of citizen science and be used by anyone after a short training. The surveying method is based on visual information recording. The river is divided into three areas, the bank top, the bank face, and the channel bed. On each area, the surveyor record information of relative covering of different features as vegetation, human pressure of flow types. Survey are recorded on a website where many elements are converted into indices, allowing various calculations and multi-years comparison., which is the aim of the study.

The structure from motion (SFM) is a photography treatment allowing to construct various 3 dimensions (3D) or 2 dimensions (2D) models from a set of pictures. Pictures of the river are taken from many different positions (in fact, thousands of positions). Similarities and differences on couples

of pictures are used by a software to align them and reconstruct a unique model from these various pictures. In the context of this study, two kinds of models are very useful. The orthophoto which allow to keep every visual element in the area, like vegetation or flow surface characteristics, and the elevation model which provide morphological information. The repetition of surveys allows, by comparison of models produced at different dates, to identify short term variations, as vegetation development, and long-term variations, as bank erosion.

Bats activity was recorded by the Environment Agency, using ultrasonic recording. The number of echolocation buzzes recorded was used as an indicator of bats activity. As each bat specie emit different sounds the activity of each species can be studied separately. Bats activity will be monitored before and after weir removal.

If any variation is observed in bats activity, every environment parameters will be studied to find links with bats activity variation. Finding Daubenton’s bats disruptive parameters after a weir removal will increase knowledge of bat’s biology and will help rivers managers to conduct their restoration projects in a way less disruptive for bats.

Summary

Introduction

Myotis Daubentonii, also called Daubenton's bat is a common specie of bat, considered as medium or small sized (CORA Faune Sauvage - LPO, 2007). This bat is protected and has very slow population dynamics, which mean that any perturbation can affect the population on the very long term. The main specificity of this specie is that bats feeds on the insect that fly above the water surface. In the United Kingdom, lots of restoration project are now launched on rivers, these restorations include dams and weir removal. As Daubenton's bats are strongly related with aquatic system, it was expected that restoration will improve their habitat and prey availability. So, it was expected positive response of Daubenton's bats population after weir removal. In fact, on rivers where bat activity was monitored, it appeared that populations totally disappeared after weir removal. The Daubenton's bats biology needs to be studied to assess most relevant environmental parameters to explain variations in bats activity.

Foraging

The most of the time, bats leave their roosting sites thirty minutes after sunset to begin foraging (Arthur L. & Lemaire M., 2009). The foraging behaviour of this specie is very particular, bats capture preys, just above, or directly on the water surface, this is called trawling. The biggest part of the bat's diet is composed by Chironomidaes with local variability (Vaughan, 1997; Encarnação and Dietz, 2006; Nissen *et al.*, 2013). Daubenton's bats are able to catch small fish or crustaceans near to the surface (Siemers *et al.*, 2001; CORA Faune Sauvage - LPO, 2007) but for the moment, it doesn't appear to be an important part of the bat's diet (Nissen *et al.*, 2013). Preys are detected and discriminated by echolocation (Zsebok *et al.*, 2013). Theses mechanisms are enhanced by the low flying height of bats and the acoustic mirror provided by the water surface (Van De Sijpe, 2008; Zsebok *et al.*, 2013). Bat activity is strongly related to prey availability (Akasaka, Nakano and Nakamura, 2009).

Habitat and foraging sites

The specie needs the proximity of water to forage, with a preference for smooth surface, which allow an enhanced detection and discrimination of preys (Boonman *et al.*, 1998; Zsebok *et al.*, 2013). This needing for a smooth surface can explain the preference of Daubenton's bats for channelized rivers than restored areas (Akasaka, Nakano and Nakamura, 2009). Larger channel, with width superior to 5 metres seems to be more appreciated, probably because the flight is easier (Langton, Briggs and Haysom, 2010; Lopez-Baucells *et al.*, 2017). A good quality of water isn't always needed by this bat, eutrophic waters, because of the high number of insects that they contain can be very attractive for bats (Vaughan, Jones and Harris, 1996; Langton, Briggs and Haysom, 2010)

The riparian vegetation is another key element, an undisturbed vegetation, with a low cluttering (in terms of tree and shrub density, canopy cover) seems to be an important variable of bat activity (Scott *et al.*, 2010; Smith and Gehrt, 2010). Lines of trees on both sides of the river seems to be a help for bats when commuting (Lopez-Baucells *et al.*, 2017), but it also could be an important protection for insects against the wind.

Different types of roosting sites can be selected, like cavities in trees, caves, bridges or any structure with holes (CORA Faune Sauvage - LPO, 2007; Arthur L. & Lemaire M., 2009; Lučan and Hanák, 2011).

Moving

Daubenton's bats can fly on 10 kilometres to join their foraging site, but generally the foraging site is located 1 to 5 kilometres away from the roost (CORA Faune Sauvage - LPO, 2007; Encarnacao, Becker and Ekschmitt, 2010). The colony can choose a winter roost separated by 100 kilometres from the summer site, the more often, it doesn't exceed 50 kilometres (CORA Faune Sauvage - LPO, 2007; Arthur L. & Lemaire M., 2009).

Study

The present internship is a pilot study, aiming to reveal the most relevant factor which influence bats activity after weir removal. The environmental agency, especially the DR. Sarah Jane SCOTT, is conducting bat surveys and the Cranfield university surveys physical parameters of rivers. Three rivers just on the north of London have been chosen, the Ver, the Mimram and the Misbourne (Annexe 1), these three rivers are chalk streams and are part of the Thames basin.

The river Mimram flows from Whitwell, in the city of Hitchin, United Kingdom to the city of Hertford and runs on 20 kilometres (Km). The weir site is located close to the Tewin Water House in Welwyn and the control site is located 5 Km upstream on the property of the Sherrardwood-school (Annexe 2).

The river Misbourne flows from Great Missenden to Denham where it joins the river Colne after running on 25 kilometres. The weir site is located on the property of a confidential industry, in Denham. The Control site is located 5 Km downstream in the Denham Country Park (Annexe 3).

The river Ver flows on 20 kilometres from Markyate Cell, in St Albans to Bricket wood. The weir site is located at New Barnes Mill, in the city of St Albans, and the control site is located 1 Km downstream, at Sopwell Midow, on an agricultural property (Annexe 4).

According to bibliography, following hypothesis have been used to study the impact of environmental parameters on bats activity:

-Smooth water increase hunting efficacity and so bats activity.

-An important river width allows the bat to fly and hunt.

-Riparian vegetation (especially trees) is needed as commuting help and wind protection for insects.

-Cluttered vegetation, and especially shrubs, is an issue for the fly.

Cranfield University

The Cranfield University specialized in various fields, like Aerospace, Management or Environment is a post-graduated university, with an important concern in conducting research projects.

My placement took place in the Water Department of the university which is conducting various research projects liked with aquatic systems. This department works in cooperation with the Environment Agency which launched the present pilot study.

Announce plan

This report will firstly describe “Materials and methods” used to survey rivers. These methods produced various results which will be detailed in a second part called “Results”. In the “Discussion” results will be confronted to our hypothesis. The last part will be a “Conclusion” of the report.

Materials and methods

As the survey aim to reveal the impact of weir removal, and as bat's activity is linked with many factors, it was necessary to be sure that any variation observed is only linked with the weir removal. On each river, two sites are surveyed, one stretch with a weir (weir site) and the other is a control stretch without weir (control site), located on the same river at less than 5 kilometres from the weir site. Especially because of time restrictions and landowners' requests, it wasn't possible to survey both weir site and control sites with every method. The surveying will continue after my departure and weirs removal is not totally planned wet. It was aimed to produce a baseline data with reproducible method to compare with other years surveys.

Bats activity

Bats activity is estimated by the number of bat passes on a specific area and time. As bats use echolocation, their passes are recorded through these location sounds with an ultra-sonic microphone during complete nights. Recording need to be transferred into audible spectrum to allow counting. Each specie emits specific sounds, allowing surveyors to discriminate species.

Limits

Many sites were only surveyed twice times and not each month. Bats surveys weren't conducted at the same dates than rivers surveys. Some bats recorders were installed on the surrounding land and not always above water.

Flow velocity

Flows velocities were measured at every weir sites, using an acoustic flow meter when possible, and a simple weighted bottle when deep didn't allow to use flow meter. Flow meter was used following a cross section in an area free of any disturbances. The knowledge of flow velocity and river's dimensions allowed to calculate water discharge.

River width was measured using a simple measuring tape.

Limits

Flows velocities were measured in various conditions, some surveys were done during very low flow and others just after strong rains, resulting in strong variations. Moreover, as two different methods were used, results are not really comparable.

Modular River Physical Survey

The Modular River Physical Survey or MoRPh is a survey method developed, and still in devolpment under the direction of Angela Gurnell, Lucy Shuker, Geraldene Wharton and Judy England from the Environment Agency. The protocol is designed for citizen scientists, is based on low scale observations and is part of the Modular River Survey (ModRS) which works at catchment scale (Annexe 5). Surveys are conducted on modules, from 10 meters length (river width smaller than 5 meters) up to 40 meters length (for a river width up to 30m). A MoRPh survey aim to identify physical habitats and pressures of a short stretch of river. The combination of at least 10 modules allow to calculate Multi-MoRPh indices allowing to identify some morphological dynamics.

Survey are conducted following a form (Annexe 7) which are filled with the extent of each feature and with various codes (Annexe 6 MoRPh codes). These forms are especially designed to capture visual element (flow surface, riffle/pool, vegetation cover or choking). The use of a standardized form allow to give more reliability to data collected by many different surveyors, especially when all of them are not scientists (Hochachka *et al.*, 2012). To increase reliability of data, every surveyor need to be trained by an approved trainer and a surveyor can become trainer only after another special training.

Method

The mean river width is estimated and allow to determine the length of the module. The form divides the river in four separated areas, the bank top, the bank face and the river bed. Inside each area, the surveyor fill information like dominant vegetation, human pressure or bank profile. Pictures of the area and GPS location of the module are taken during the survey.

After filling forms on the field, all surveys are manually registered on the website (www.modularriversurvey.org), creating a cooperative map. Every survey is checked by an approved administrator, who especially check that description correspond to pictures and that not absurd values have been entered.

Tools

Simple pen, clipboard and form are needed to do the survey. A DGPS was used to take midpoint of each module and a digital camera used to take up to four pictures of the module.

Indices

Many information entered in the website are automatically converted into numeral data named MoRPh indices. These indices are calculated with the extent of each feature and a special coefficient (depending on the impact of each element). These indices are very useful to compare habitats and human pressures before and after weir removal.

The website produces 14 indices (Gurnell *et al.*, 2016):

-Channel physical habitat complexity

-Number of aquatic vegetation morphotypes

-Riparian physical habitat complexity

-Riparian vegetation complexity

-Degree of human pressure imposed by land cover on the bank top

-Reinforcement

-Extent of non-native invasive plants

-Number of bed material types

-Coarsest extensive bed material particle size

-Average bed material size

-Average bed material particle size class

-Extent of bed siltation

-Number of flow types

-Highest energy extensive flow type

Limits

The MoRPh survey is mostly based on visual records made by various surveyors, which means that a certain variability is unavoidable. Moreover, covering percentages are recorded under four adjectives "Absent, Trace, Present, Extensive" (A/T/P/E) respectively corresponding to: absent of the module, covering less than 5% of the module, covering from 5% to 33% and covering from 33% of area or length considered. Some percentage are not easy to estimate, the distinction between Trace (T) and Present (P) is really dependant on the surveyor.

In this survey, many sites needed to be surveyed, many different data needed to be collected and because of time restrictions from landowners, it was not possible to survey following the Multi-MoRPh method (e.g. 10 contiguous modules on each site).

Some elements are not converted into indices and keep the denomination (A/T/P/E), which complicates calculations. A three months survey is short and doesn't allow to produce continuous data.

Structure From Motion, presentation

The structure from motion (SFM) uses multiples pictures took from different positions to reconstruct topographic structure (Westoby *et al.*, 2012). The interest of SFM for river surveys is increasing because it provide a low-cost solution to survey various parameter, from bank structure to sediment deposition (Westoby *et al.*, 2012; Cook, 2017; Dietrich, 2017; Vázquez-tarrío *et al.*, 2017). Most SFM projects are realized by turning around the target or by using aerial pictures. As rivers are longitudinal structures and because it was not possible to take aerial pictures, the technique needed to be adapted to the project. In our study, SFM is used to detect changes in river's morphology, vegetation development and sediments composition. Many examples show the Mimram, because this river was the only one which allowed to use all types of survey.

Photography

This part of the SFM is probably the most important, pictures firstly needs to overlap each other, to be focused on the studied area, without background and glowering, and need to be taken in high resolution.

We used a single camera mounted on a pole. This pole allowed to take many pictures with the same angle (approximately 30° between the ground and the pod) and height. The in-build GPS of the camera was not used because of the low accuracy. In order to collect the maximum amount of information, different methods of photographing were combined on each river.

-The first method was to use the 1,55-meter pod and to take pictures from downstream to upstream. It allows to take good pictures of the river bed and avoid taking too much background (background perturbates processes). Walking from downstream to upstream is especially important when a strong siltation is present, walking in river put many silts in suspension and silts can very quickly cover entirely targets, furthermore, the turbidity doesn't allow to capture the river bed.

-The second method was to take pictures from the height of the arm in order to focus on the river bed and totally avoid the background. This method was totally abandoned in this study because it never gave good result, because of a lack of matching points. Theses bad results can be explained by the low overlapping associated with this method (narrow field of view) and the high vegetation on banks (higher than the camera).

-The third method used a second pod mounted on the first one. It allows to take pictures from a higher position (approximately 2-meter high). As it was impossible to control the camera at this high, an automatic mod was used (1 picture every 4 seconds, 10 pictures in total). This method, in good condition provide the best model. However, it was not always possible to use it and to provide good pictures, firstly because of the presence of many branches, secondly because of the wind, which doesn't allow the camera to focus correctly and last but not least, it was impossible to verify the focusing during the shooting.

-The first and the third method were also used from upstream to downstream, to capture some area which were hidden (by vegetation, weir, rocks).

-On the Ver, because the vegetation doesn't allow to have matching points between downstream and upstream, a different method was use (in combination with the others). Photos were taken from the embankment, with camera totally horizontal, like low-altitude aerial-pictures.

Ground Control Points

Especially because photos are taken with an angle (e.g. not horizontally), there is a risk of distortion and bowl effect ('Agisoft Photoscan Support', 2016). To materialize the ground position, we used Ground control points (or targets). These ground control points (GCPs) were disposed along studied

stretch. GCPs we used are encoded target, working with a pattern (sometimes) recognized by the software. The main aim of these GCPs is to provide accurate reconstruction of structure, with less deformation but as all GCP are georeferenced (Trimble DGPS), it allows to produce georeferenced models.

-GCPs were disposed along the studied stretch. Approximately 30 GCPs were used on 30 meters long stretches. The most of them were disposed on banks, on important features (embankment, weir) and some of them under water. Target cannot always be set under water, it depends on turbidity, flow characteristics or river bed for example. To be useful, each target must be seen on at least 3 pictures, but the most is the best and, in our study, many targets appears on at least 100 pictures. It was especially useful to set some target in order to be able to see them clearly on every shooting method (only flat target can be seen when shooting from upstream to downstream). The sun glowing on target is one of the main issue for the software.

Each target was located using a DGPS (Trimble) with an average number of points close to 60, to provide a good base for differential correction. When the vegetation cover was too important, more points were taken, but it didn’t really improve the accuracy (some point have an accuracy higher than one meter). Postprocessing used GPS Pathfinder and Rinex bases from the UK Ordnance Survey (https://www.ordnancesurvey.co.uk/gps/os-net-rinex-data/).

Processing structure from motion

Agisoft Photoscan Professional was used to create models. This software, needed very long calculation times because of the low altitude at which our pictures were took. Firstly, the software aligns pictures and estimates camera location by using matching points. This part needs pictures with a very important overlapping. This process creates a “sparse point cloud”, corresponding of the matching points (Figure 1, n1).

After alignment, targets are manually located on each picture (the software only recognize them on few pictures) and the optimizing process is launched to correct distortion.

The dense cloud can now be calculated (Figure 1, n2). It will be used as a base for different other process and need to be as accurate as possible.

A 3D model, the “mesh” is calculated with the previous dense cloud (Figure 1, n3). This model can be textured and tiled with the pictures (Figure 1, n4).

The digital elevation model (DEM), showing elevations, is calculated with different bases like the sparse cloud, the dense cloud or the mesh. It seems that in this study, the dense cloud was the more accurate source for the DEM.

The orthophoto can be calculated with the mesh or with the DEM. Depending of the river, it can give different results. Picture are orthorectified and georeferenced in an orthomosaic which can be projected in GIS software.

When it was possible, results from different shooting methods (chunks) were combined. It allows to fill holes created by masking structures (mostly the vegetation). This process need to have perfectly georeferenced models.

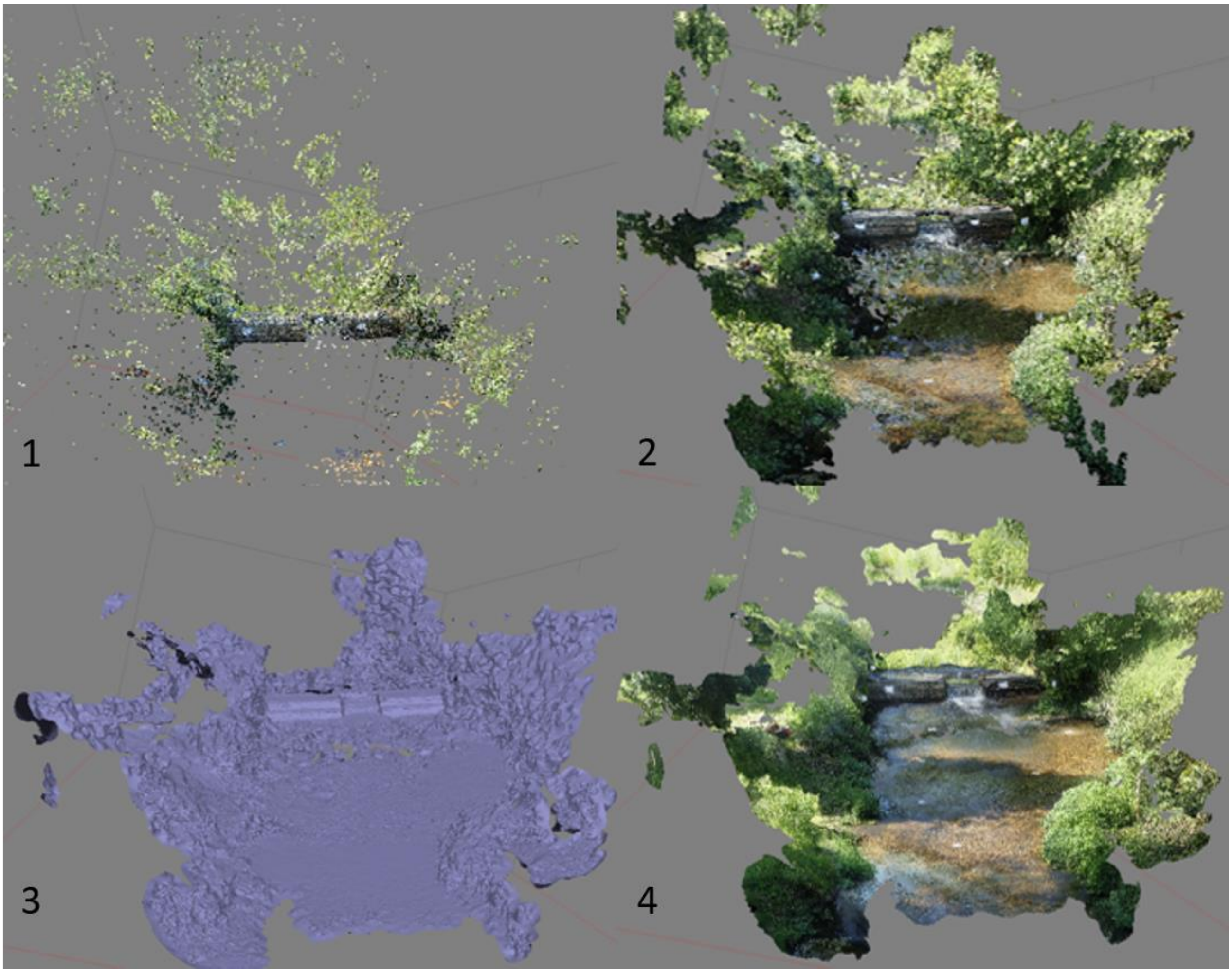

Figure 1 Agisoft steps (Mimram river), 1: sparse point cloud, 2: Dense point cloud, 3: 3D mesh, 4: textured 3D model

Limits

This method can provide Gis layer with lots of visual information. However, in this study, the vegetation was an important issue in two ways. Firstly, by masking the ground, it didn't allow to create an accurate digital elevation model of river's banks. Secondly, the tree cover perturbated the DGPS and didn't allowed a centimetric accuracy on many places when georeferencing Ground Control Points. One of the main issue when using SFM is that the accuracy of the model, linked with GPS location, but also the amount of deformations during processing, isn't known. Some punctual high dark element under water (as wood accumulation) can be considered by the software as a depression.

Topography

Topography was used to measure morphological changes after weir removal, especially slope and bank changes.

Cross section.

When possible, cross sections were done downstream and upstream of weirs. It consists in a transversal profile, with a measure every meter and at every important point (e.g. bank top, bank feet).

Length profile

When possible, length profiles were done in order to have weirs as central point. A point was measured every 10 meters longitudinally in the centre of the river bed or at the deepest point.

Tools

An optic level combined with a ranging pole were used to measure height differences. Distances were measured using a ranging tape. A Differential Global Positioning System (DGPS) was used to take accurate coordinates of every length profiles points and cross sections limits (e.g. left and right bank tops).

Limits:

Because of time limitations due to different factors (travel time, landowner request, security needs) we were not able to survey both weir sites and control sites, but no morphological changes are expected on control sites. Moreover, the vegetation cover, fences and the very thick layer of silts on some sites didn't allow to survey all the planned area.

The DGPS was not always able to take accurate location under the vegetation canopy.

The lack of accurate benchmark doesn't allow us to accurately represent the topography in Geographic Information System (GIS) like ARCMAP. Some DGPS points were used as benchmark, but with a low accuracy (0,4-meter accuracy on the Mimram, despite the differential correction was based on 485 logs).

Control topography

In order to estimate the accuracy of elevation model obtained with Structure From Motion, it was needed to have an elevation model with a known accuracy.

On the Mimram a DGPS was used to take elevation of many points all along the stretch. These points were taken by walking along banks tops and zigzagging inside the channel, including bank face (Figure 2). On the field, more than 700 points were taken to cover an area of 1050m² (16-meter width and 65-meter long).

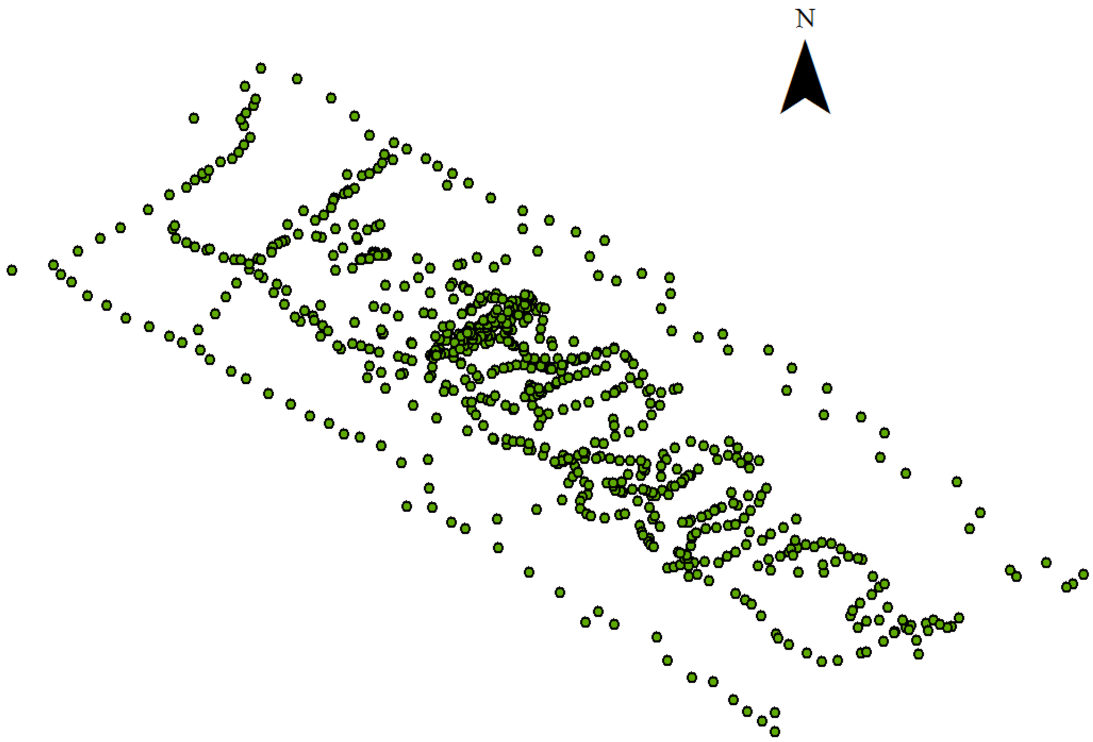

Figure 2 DGPS points on the Mimram

These points were used in ArcGis to create an elevation model by interpolation.

Tools

Accurate altitude was took using DGPS Trimble, with a 2-meter-high antenna and real-time correction from network. This allowed to take points with an accuracy close to two centimetres in good conditions. In order to have the best accuracy as possible locations have been post-processed with the software GPS Pathfinder processing a differential correction.

Limits

The vegetation cover was sometimes an important issue when it didn't allow to have centimetric accuracy. As this method requires to be physically on the area to survey, and because some areas were limited by fences, it was not possible to survey some parts of banks. Moreover, the river bed upstream of the weir is covered by a thick layer of silts which didn't allow to take enough points to have a good resolution.

Results

Flow

Because of the season and the weather, strong flow variations have been observed, visually and with measures. All flows velocities have been used to calculate discharge (Figure 3).

The first measure on the Mimram was took in May and corresponded at the lowest level of the river during this study, the discharge was 0,045 m3/s. The last measure, took just after thunderstorm gave a discharge of 0,057 m3/s.

The Misbourne also known strong variations, from 0,0768 m3/s in May in during low flow conditions to 0,124 m3/s during a heavy rain in July.

The Ver during the first survey, in May, had a discharge of 0,0588 m3/s, and a discharge of 0,0402 in July. During the last survey, the weir was totally above water and dry, the flow was concentrated in small holes in the weir.

Discharge m3/s			
	May	June	July
Mimram	0,045	0,057	0,077
Misbourne	0,077	0,123	0,124
Ver	0,059	0,047	0,040

Figure 3 Monthly discharge

Morph

MoRPh indices vary from 0 to 10 and allow to reveal variations in physical habitats. In the context of the bat study, some indices are more relevant than other ones. The channel choking by vegetation decrease the available feeding area for the Daubenton's bat which hunt by trawling above water. Module shading isn't converted automatically in a coefficient, and channel choking is only recorded in binary parameters, (YES/NO). Module shading was converted in numeral data by attributing to A/T/P/E parameters their minimal covering value (for example, A correspond to 0% and E correspond to 33%). The channel choking was calculated as the number of channel choking observed divided by the number of modules. The vegetation shading seems to be a limiting parameter for channel choking, no channel choking was observed when shading was higher than 9% (Figure 4). This fact could explain partially the affinity of bats for high tree cover.

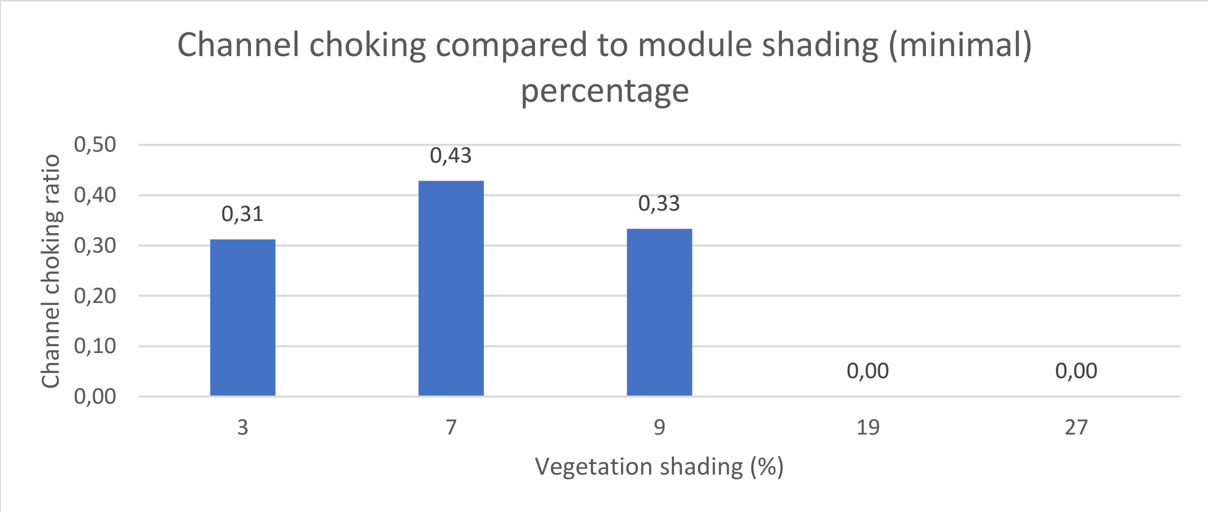

Figure 4 Channel choking compared to vegetation shading

The first survey was done early in terms of vegetation development and growth. The channel choking increased along the study (Figure 5).

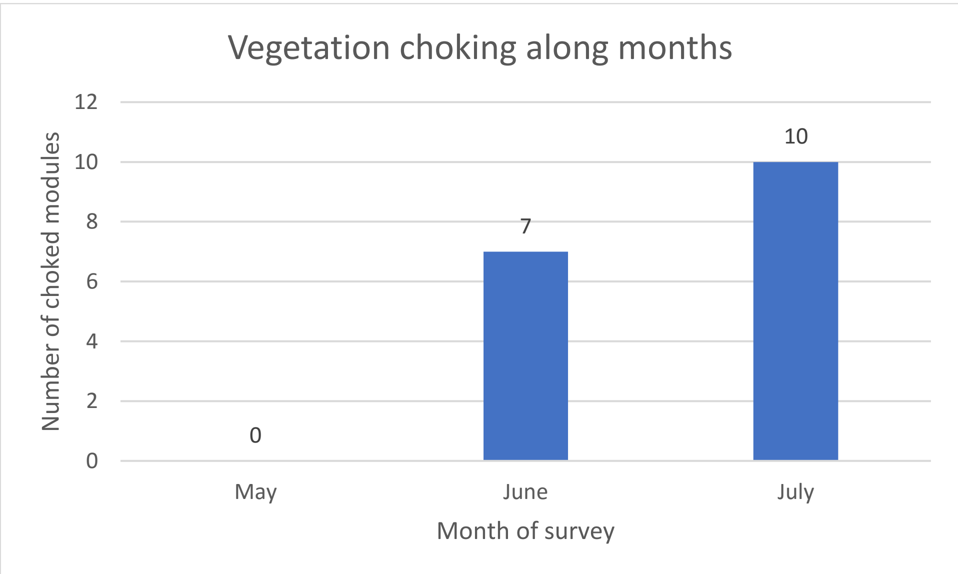

Figure 5 Vegetation choking along months

Bats have a better hunting efficiency above smooth water surface than above rippled surface (Zsebok *et al.*, 2013). Any variation in the water surface characteristic can strongly modify bat activity. The percentage of modules dominated by smooth flow surface shows that control sites are more likely to be dominated by smooth flow (91,7%) type than weir sites (89,5%) (Figure 6). The impact of the weir on the flow surface is also visible when comparing Upstream and Downstream of weir (Figure 6). Upstream modules are more likely to be dominated by smooth surface (46%) than downstream modules (43,5%).

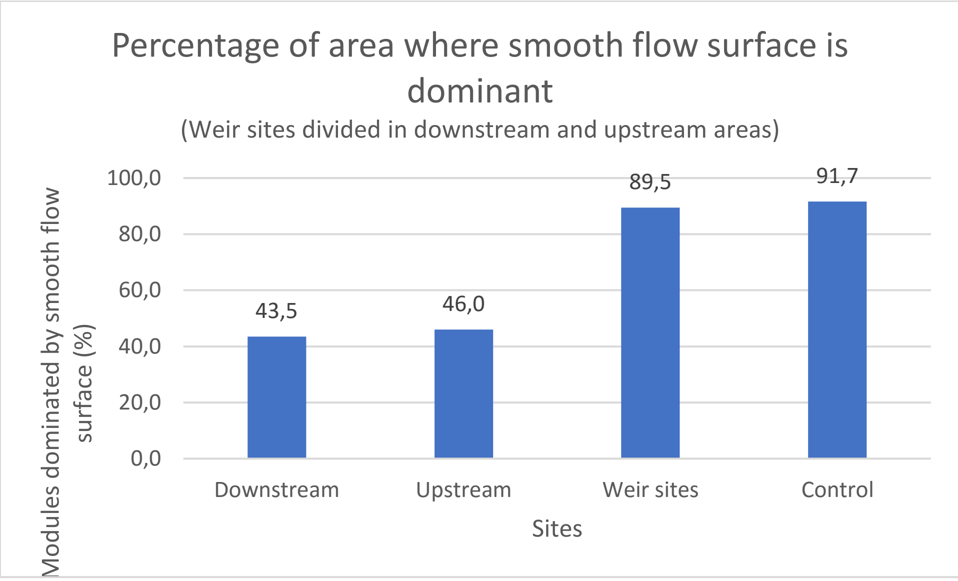

Figure 6 Modules dominated by smooth flow surface

SFM

The process of SFM produce two main GIS layers, an orthophoto (Figure 7, n1) and a digital elevation model (Figure 7, n2). The orthophoto is produce with a very high resolution, in vector format, allowing to focus on interesting features and to determine bed materials or vegetation types (Annexe 10).

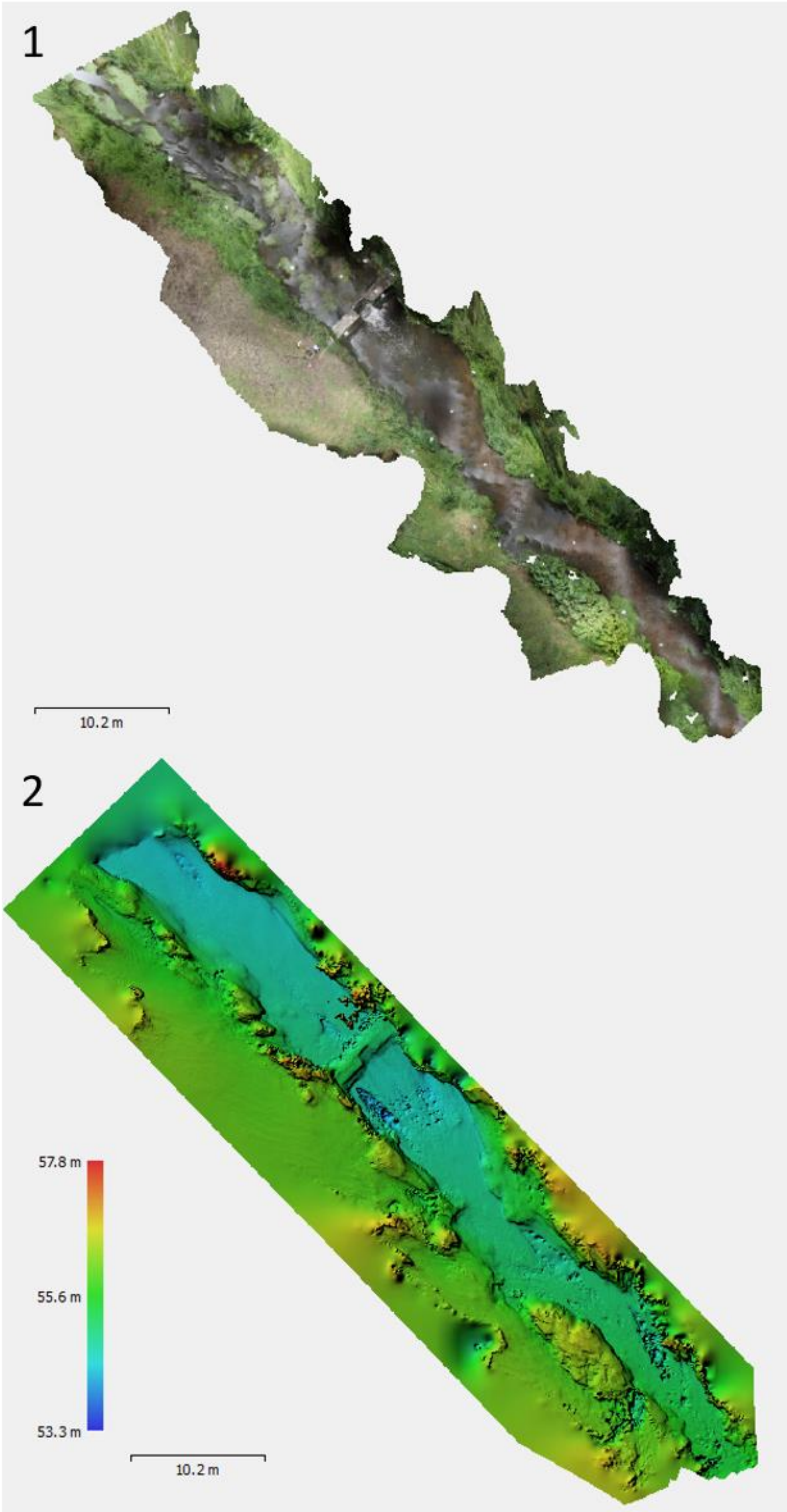

Figure 7 Pictures from Agisoft, Mimram river, 1: Orthophoto, 2: DEM

Topography

Cross-sections and length profiles have been georeferenced and represented in standardized forms. Only one topography was done on each river, it isn't possible for the moment to find topographic changes.

Control Topography

After inputting 700 points in ArcMap, triangular interpolation converted in Raster was used to create a digital elevation model (DEM) from DGPS elevation points (Figure 8).

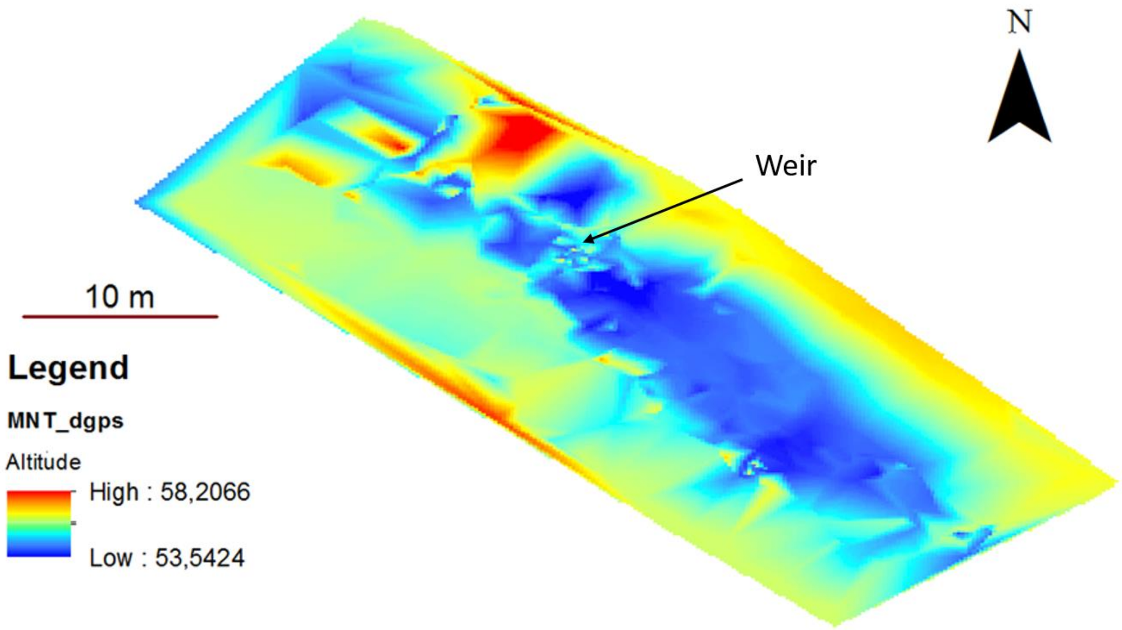

Figure 8 DEM produced with DGPS points, Mimram river

This DEM produced with DGPS was compared with the DEM produced with SFM (Figure 9) to create a raster of differences (Figure 10). This raster shows that the main differences between both DEM are located in the centre of the raster. This can be explained by fifty centimetres shift on the South-North axis resulting in a bad superposition of river's bank of both models.

If the comparison of entire model is not accurate due to geolocation issues, we can notice that altitudes ranges are coherent. Only 0,48 metres difference for maximum altitude and 0,19 metres for minimal altitude seems coherent, especially because one high bank was surveyable with DGPS and not with SFM.

The weir is the only flat and hard surface that can be found in the area, as its position is well known, it allow accurate punctual comparison. The difference of the altitude of the weir, given by DGPS and by SFM is only about 0,25 metres. This value is coherent with the variance of the 50 points took on the weir with the DGPS (0,23 metres).

As the SFM process is mostly based on visual data, it was necessary to verify if the SFM model is based on the altitude of the river bed or the water surface. The comparison of punctual points showed the SFM model is closer to the water surface (0,72 metres mean difference) than the river bed (0,82 metres mean difference).

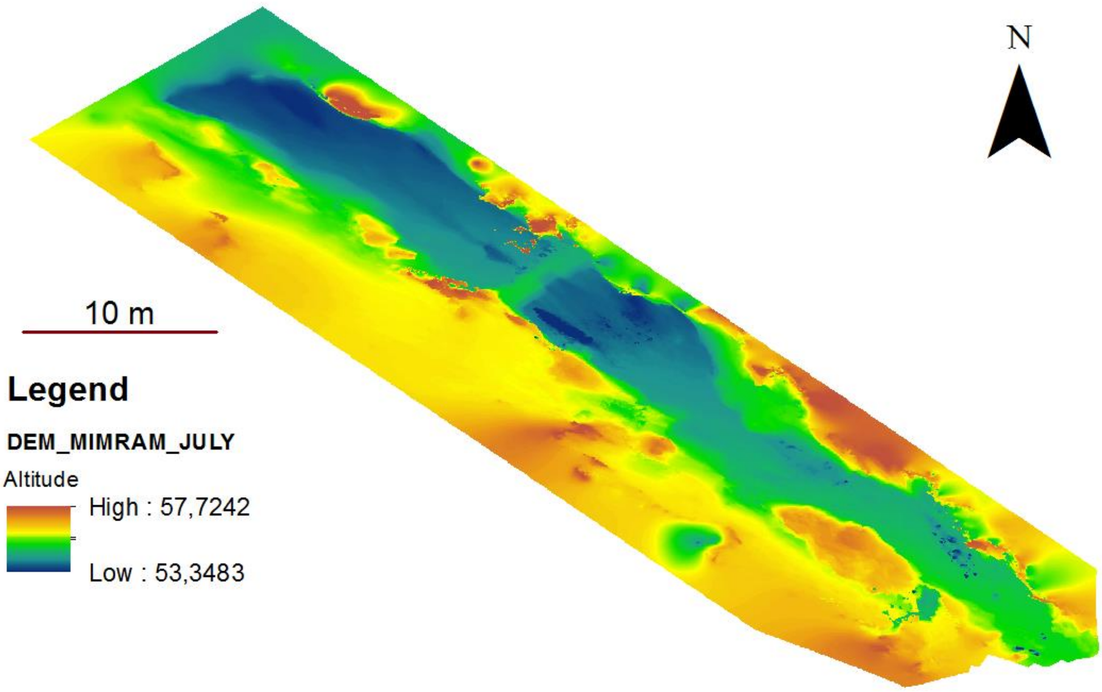

Figure 9 DEM produced with SFM, projected in ArcMap, Mimram river

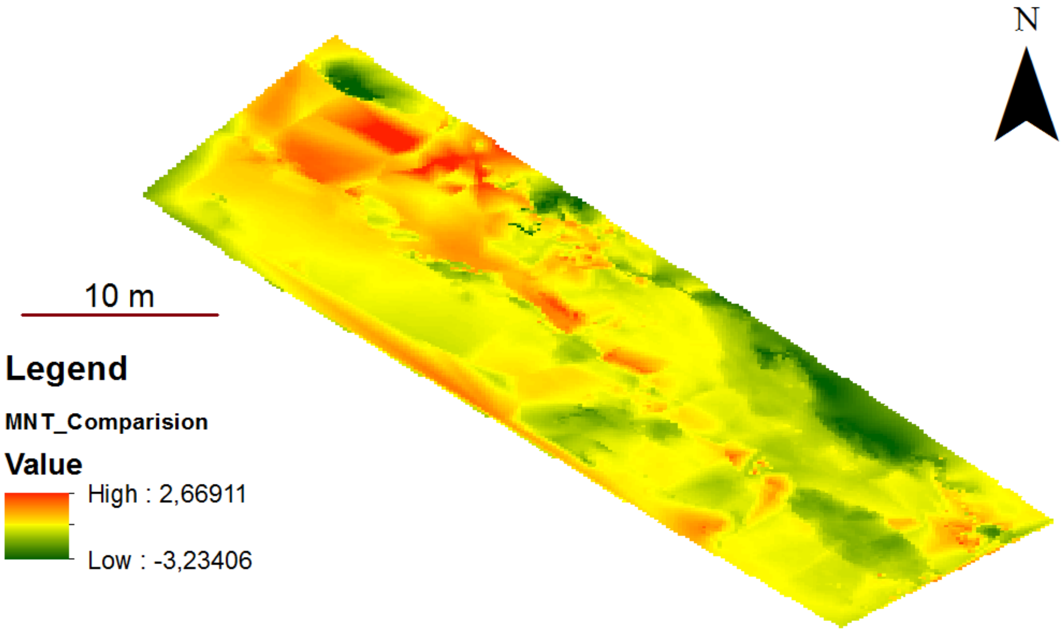

Figure 10 Differences raster, comparison between SFM DEM and DGPS DEM

Bats activity compared to habitat parameters

Results of bats surveys have been sent in Excel format (Annexe 11) by the Environment agency. Daubenton's bats passes were compared to the number of surveying nights (surveying effort). Results shows a strong decrease in activity during June (Figure 11). Some extra values needed to be excluded from graph for a better visual appearance.

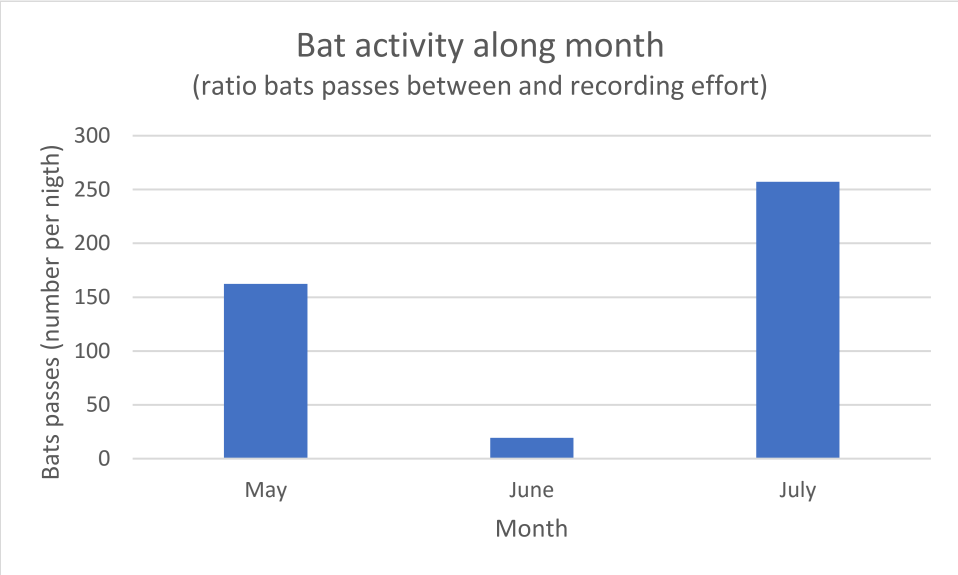

Figure 11 Monthly Daubenton's bat activity

It wasn't possible to link bats activity with river width (Figure 12) or water width (Figure 13) with a linear evolution.

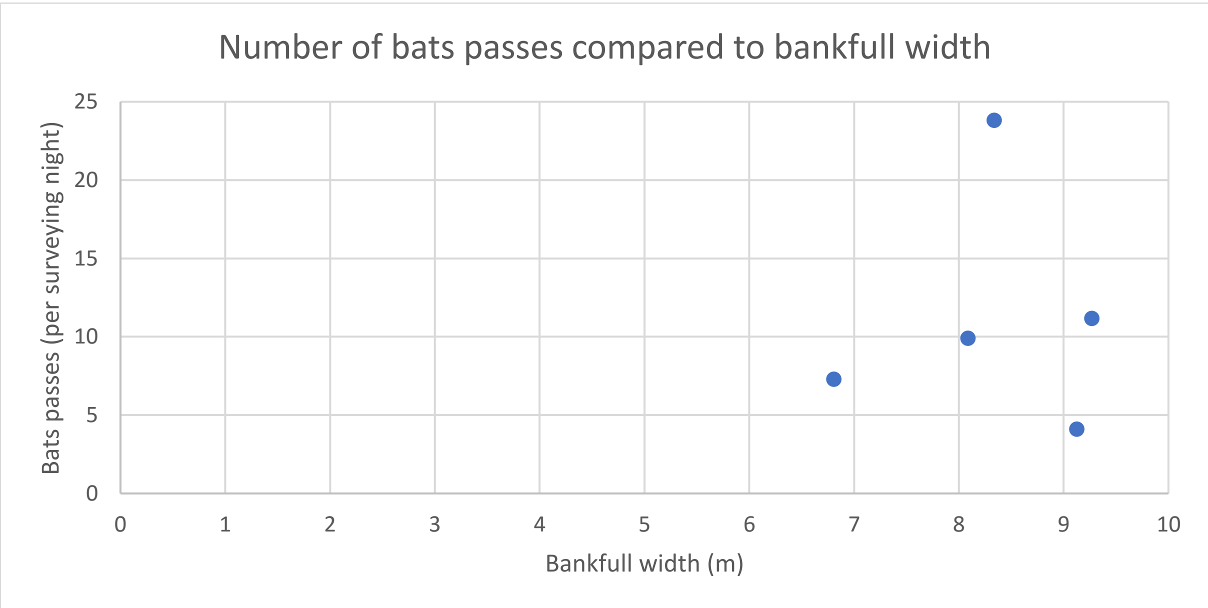

Figure 12 Influence o bankfull width on bats activity (excluding higher value)

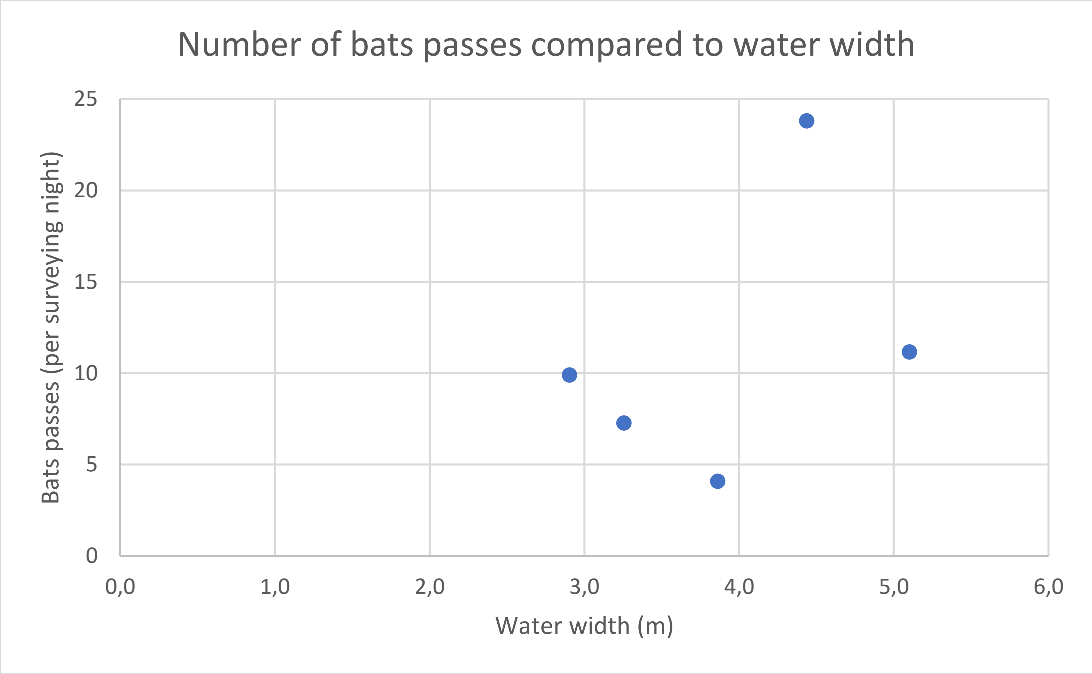

Figure 13 Influence of water width on bats activity (excluding higher value)

The increase of channel choking along month (Figure 14), was suspected to decrease flying and hunting ability of bats. However, the monthly evolution of bats passes (Figure 11) doesn't follow the same evolution at all.

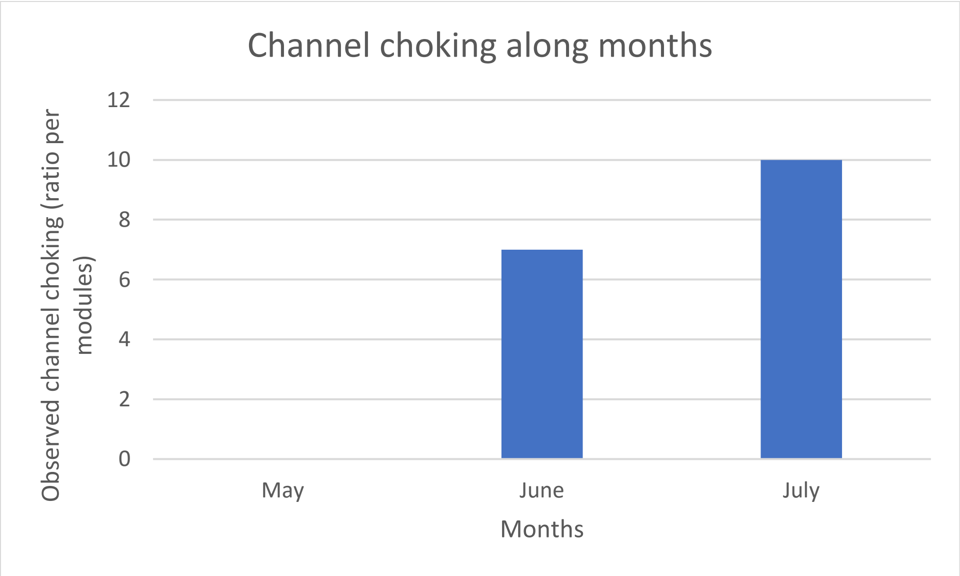

Figure 14 Evolution of the channel choking along months

Bats activity was supposed to be linked with an important tree cover on bank top, in so far as trees act as wind protection and flight guidance, but absolutely no linear correlation can be found between bats activity and tree cover on each site (Figure 15).

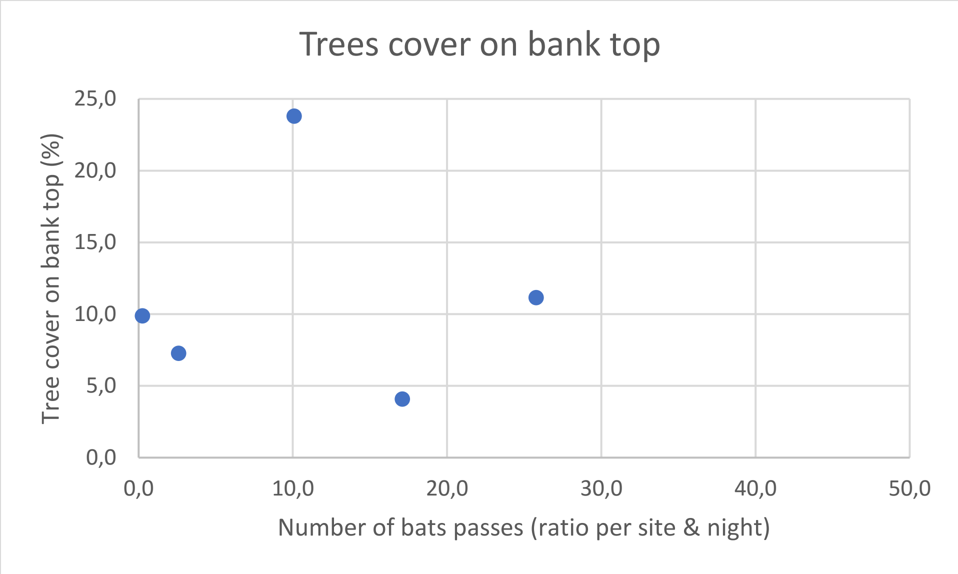

Figure 15 Comparison between tree cover and bats activity (excluding higher value)

An important covering of shrubs was suspected to disturb bat's flight and hunting. A negative linear correlation was expected between shrubs cover and bats activity. However, no linear evolution was found (Figure 16).

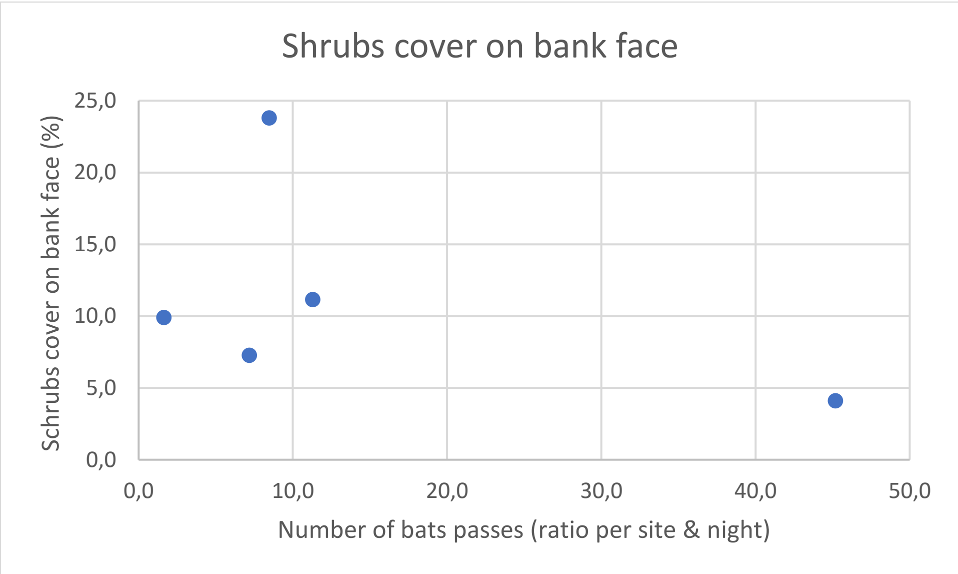

Figure 16 Comparison between shrubs cover and bats activity (excluding higher value)

The extent of smooth flow surface varied at lot along months (Figure 17). This can be explained by flow discharges variations, and vegetation development.

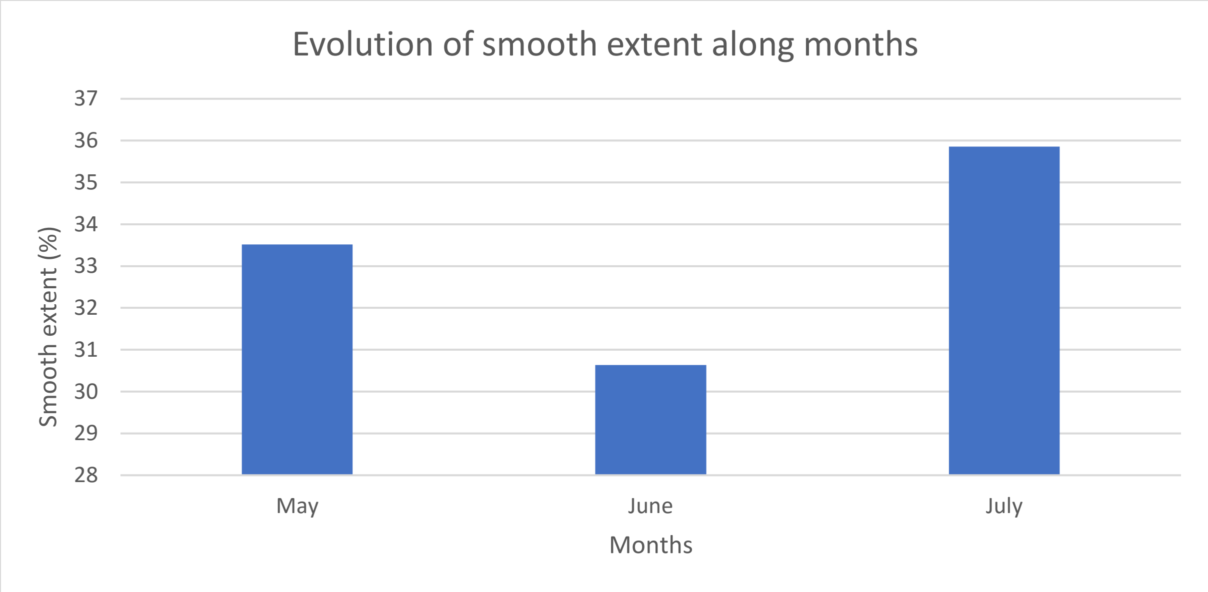

Figure 17 Extent of smooth surface along months

When comparing bats passes to monthly smooth surface extent, a linear evolution ca be observed (Figure 18).

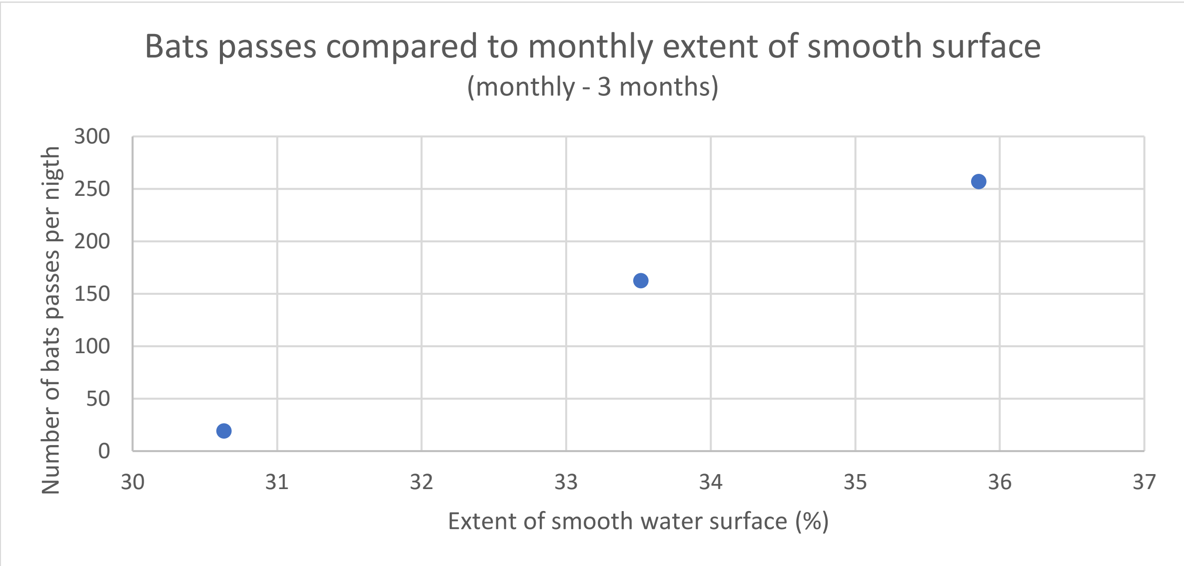

Figure 18 Monthly comparison between bats passes and smooth surface extent

However, when the comparison is made per site, no linear evolution appears (Figure 19).

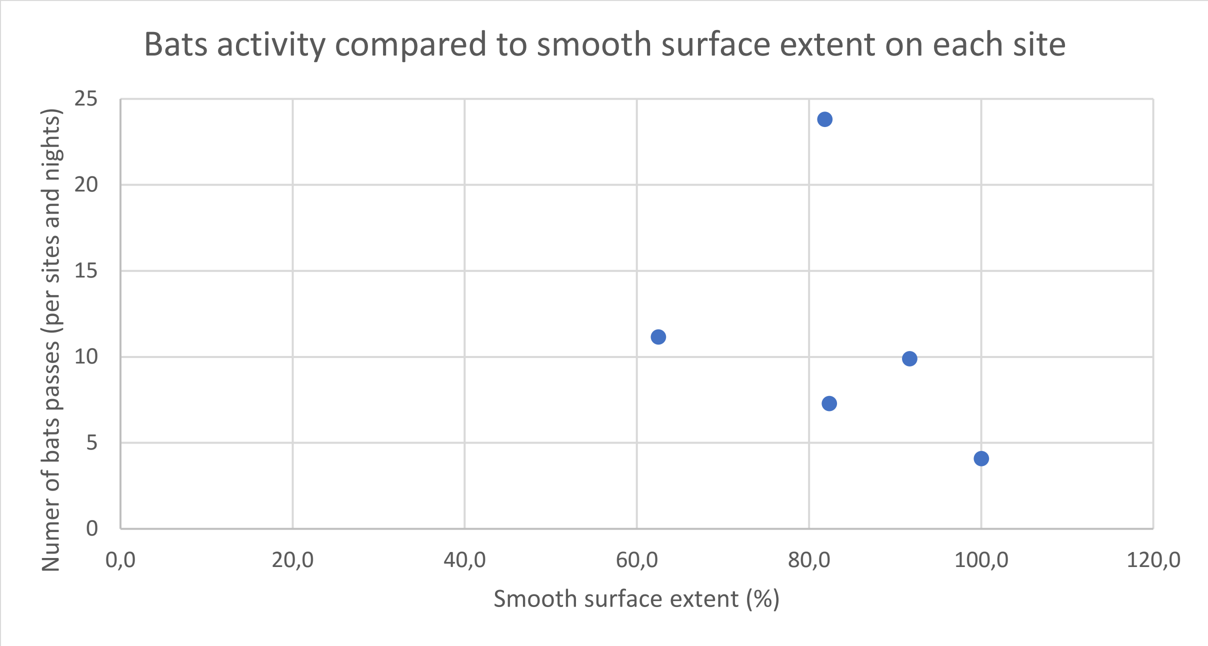

Figure 19 Comparison between number of bats passes and smooth surface extent (per site, excluding higher value)

No linear correlation was observed between bats activity and habitat indices, it is normal at this step of the study, the few amounts of data doesn't allow true statistical observations.

Moreover, a strong decline in bats activity can be observed in June, this event is probably not linked with any physical parameters but maybe only with the fact that females stayed in their roosts to give birth.

Discussion

The present study was a pilot study aiming to assess how weir removal impact Daubenton's bat activity. Many factors suspected to impact bats are mostly visual (trees alignment, flow surface characteristics). It complicates the use of calculations. Some methods have shown to be more relevant to convert visual elements in calculations, and other allow to keep traces of these visual information along years.

The measure of flow discharge allows to link flow characteristics variations to discharge variations or to physical parameters variations if the first parameter doesn't vary. A special attention need to be took when using these information as flow wasn't measured in stabilised conditions.

The MoRPh survey was conducted on each river on a weir site and a control site to ensure that any habitat's variation is only linked with weir removal. This survey method allows to convert visual information into numeral data. The ability to convert habitat parameters into various indices is especially useful in the context of the bat study. Among these indices, some of them are especially useful, as the ability to record surface flow characteristics, river's dimensions or shrub's covering. Indeed, numeral indices can be compared to numeral data from bat survey to link variations in bat's activity with physical parameters variations. The repetition of studies in the same area at a regular interval aim to register seasonal variability. Recording this seasonal variability, especially in terms of channel narrowing, can be useful to explain variations in bat's activity. Indeed, it is absolutely needed to differentiate any seasonal or annual variability from variation linked to weir removal.

However, the MoRPh survey shows some limits in terms of giving an accurate description of the site and detecting small variations. As the MoRPh survey is based on visual information which need to be converted in defined intervals by the surveyor, this result in an approximation. Moreover, as many different surveyors can be involved in the same study, the approximation is high. As intervals are quite big and aren't mapped, it will not be easy to detect small variations inside a module. As bats needs special vegetation organisations as tree alignment or low cluttering, the MoRPh doesn't provide enough information on bank top to be used as a standalone method.

The MoRPh survey allowed to create a baseline of numeral habitat's data which are especially useful to follow and detect seasonal variations and weir removal linked variations.

Structure from motion (SFM) was primary used to create high quality aerial orthophotos, as aerial imagery devices weren't usable on our sites. This method allows to capture various information, especially visual information. Orthophotos are needed to keep information on the location and extent of various features. These features include flow surface characteristics or channel narrowing (due to vegetation development or morphological changes), which are strongly linked with bat's activity. It is also possible to record and locate river bed materials, which can be linked with invertebrate's populations.

The SFM also allowed to create elevation models, with low-cost equipment. These elevation models shown a certain accuracy, especially on the horizontal extent, compared to DGPS models (e.g. the design of the weir is very accurate). These elevation models can be really useful to detect morphological changes as channel narrowing or widening. We can also expect to detect slope adaptation after weir removal.

The SFM showed some limits to represent banks tops and every area where it is impossible to walk. Using this method is sometimes really challenging and needs many adaptations because lots of factors can disturb the creation of the model. Moreover, models are created with various interpolations and the resulting accuracy isn't known.

The aim of the topography was to register accurately morphological changes. These changes can result from seasonal variability (very low on chalk-streams) or from weir removal.

Because of time limitations, it wasn't possible to repeat these surveys on our sites.

The primary aim of the control topography was to create elevation model with a well-known accuracy. This model was needed as a reference to estimate the relative accuracy of SFM elevation model. The control topography revealed a little issue in SFM georeferencing. The vertical accuracy of the SFM model on hard surfaces can be estimated to be close to 0,25 metres. On water surfaces, the vertical accuracy was a lot lower and close to 0,85 metres. This low accuracy comes from the transparency of the water, the model considered the structure of the river bed, but took approximately the altitude of the water surface.

Structure from motion orthophotos allowed to create a baseline of various features locations and extents (sediments, flow surface, vegetation). Elevation models are more useful as a baseline to detect lateral variations, banks profiles variations and many other morphological changes.

Cluttered vegetation, and especially shrubs, was suspected to be an issue for the flight, but it wasn't possible to observe less activity in cluttered sites. An important tree cover protects insects and bats against wind and help for commuting (Scott *et al.*, 2010; Lopez-Baucells *et al.*, 2017). Sites with an important tree cover weren't most likely to have an important bats activity. The river width needs to be sufficient to allow bats to flight easily (Langton, Briggs and Haysom, 2010). It was suspected that bats will preferentially flight above wider areas, but it wasn't possible to prove it. A smooth water increase the hunting ability of bats and is suspected to increase bats activity (Boonman *et al.*, 1998; Zsebok *et al.*, 2013). If the monthly evolution of bats activity follows the monthly evolution of the smooth water surface extent, it doesn't seem that bats only choose to flight above areas with smooth water surface.

No correlation can be found between habitat parameters and bats activity. This absence of correlation can be firstly explained by the lack of data. Bats activity is something really variable and three surveys is really a low amount to find any tendencies in a biological study. Furthermore, these three months are not comparable together, because in June many females give birth and probably don't flight. Likewise, the number of surveying sites is quite low to conduct statistical analysis. Finally, as it is the first year of surveying, no annual comparison is possible. Some habitats parameters have shown to be variable in short delays, and no bats recording was done exactly at the same time than morphological surveys, this shift in dates can also explain the lack of links.

The first aim of this pilot study was to detect most relevant factors to explain bat's activity changes after weir removal. To ensure that any variation in bat's activity is only linked with weir removal, two kinds of surveys are needed. Firstly, comparative surveys on weir site and control sites, to exclude variations linked with external factors as weather or insects emerging for example. Secondly annual surveys, before and after weir removal, to detect variations only linked with weir removal.

Conclusion

The first aim of this pilot study was to determine most relevant factors to explain the impact of weir removal on Daubenton's bats activity. Following bibliography, mains impacts can come from flow surface disturbance, vegetation organisation or river morphology. The final study needs a baseline of data, recorded before the weir removal. To this purpose, various survey methods were used as complementary methods. The MoRPh survey allowed to record information on habitat characteristics which can be compared years after years to detect any variation. The topography allowed to create a baseline of morphological data to detect river's response to weir removal. The structure from motion was used to create models recording morphological data, but also vegetation development or flow characteristics. The main issue was to adapt SFM, mostly used with aerial imagery to human-high imagery.

Because of the lack of data, it was impossible to calculate any statistical correlation between bats activity and habitats parameters but these bats data will be needed for the long-term study. Indeed, this pilot study was not only needed to reveal most relevant factors, it was also needed to adapt each method to each site, as they all have specific restrictions. Last but not least, it recorded various information on studied rivers, from geomorphology to vegetation organisation allowing long-term comparison for the final study.

The study need to be continued each year until weir removal, and many years after weir removal to evaluate long-term response of the Daubenton's bat population. In order to exactly survey same modules during every survey, with landowner's agreement, modules delimitations could be marked on the field. To increase accuracy of morphological analysis and georeferencing, stationary targets can be set on surveying sites. For the moment, the SFM elevation model is based on water surface. To increase accuracy of the model, two options need to be explored. Firstly, trying to make the software considering the river bed and not water surface. A different calibration of the camera and software can be needed, especially because of water diffraction. Secondly, if it is impossible for the software to consider river bed, it could be useful to use target set flat on the water. Orthophotos in association with MoRPh and field sketch-map can be used to create maps localising all the different features noticed. This would allow a more accurate control of the evolution of surveying sites.

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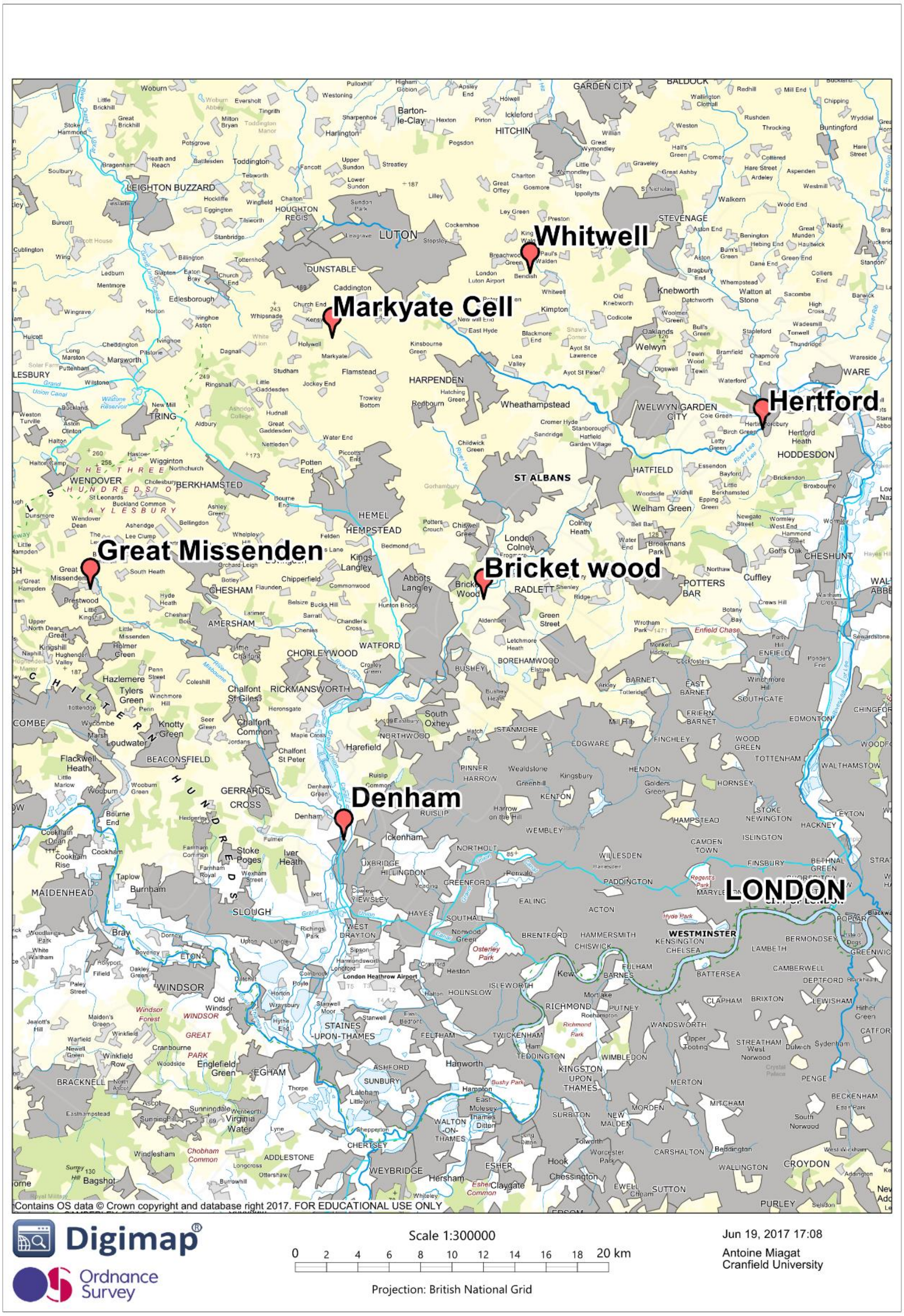
Illustrations table

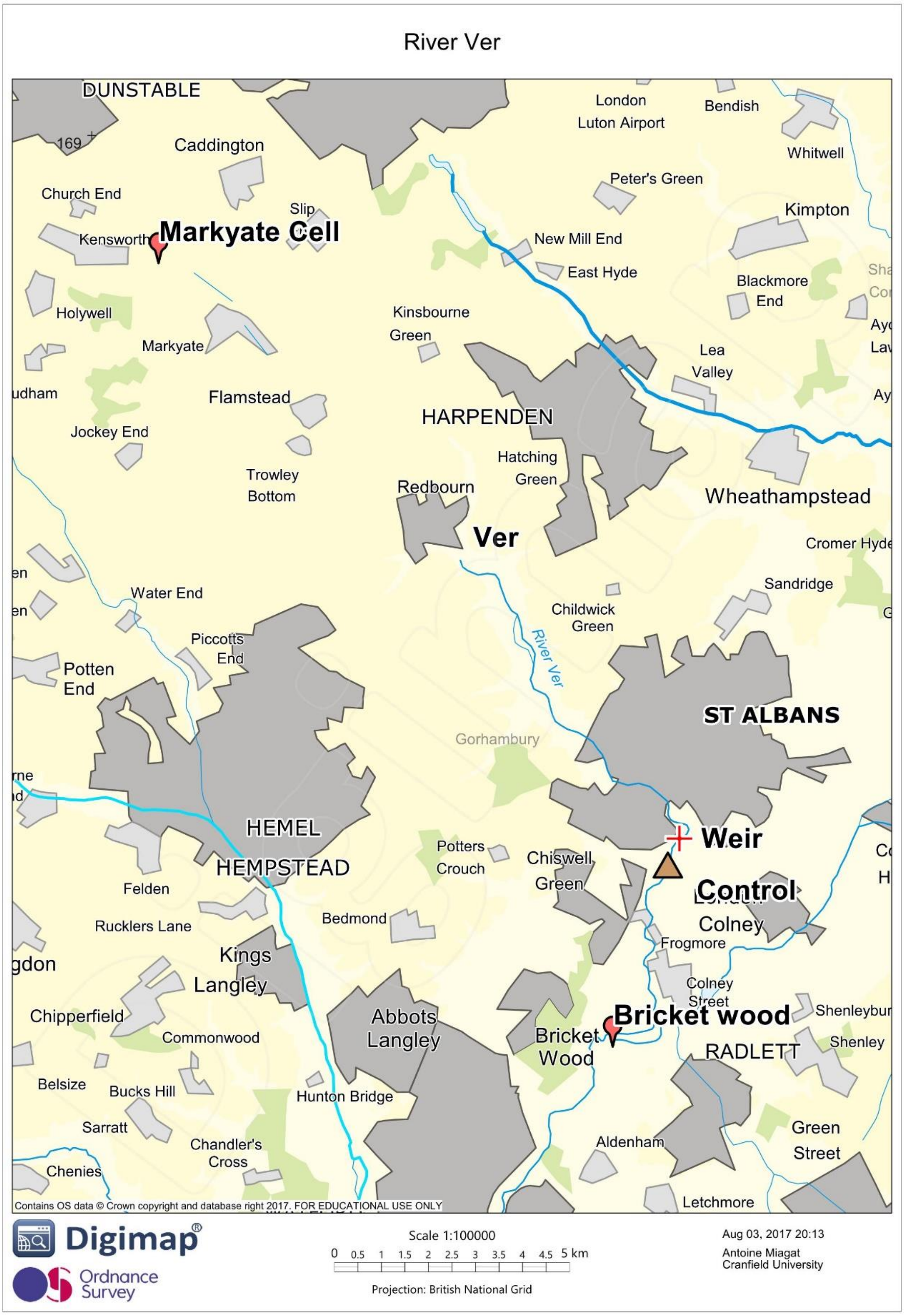
Appendix



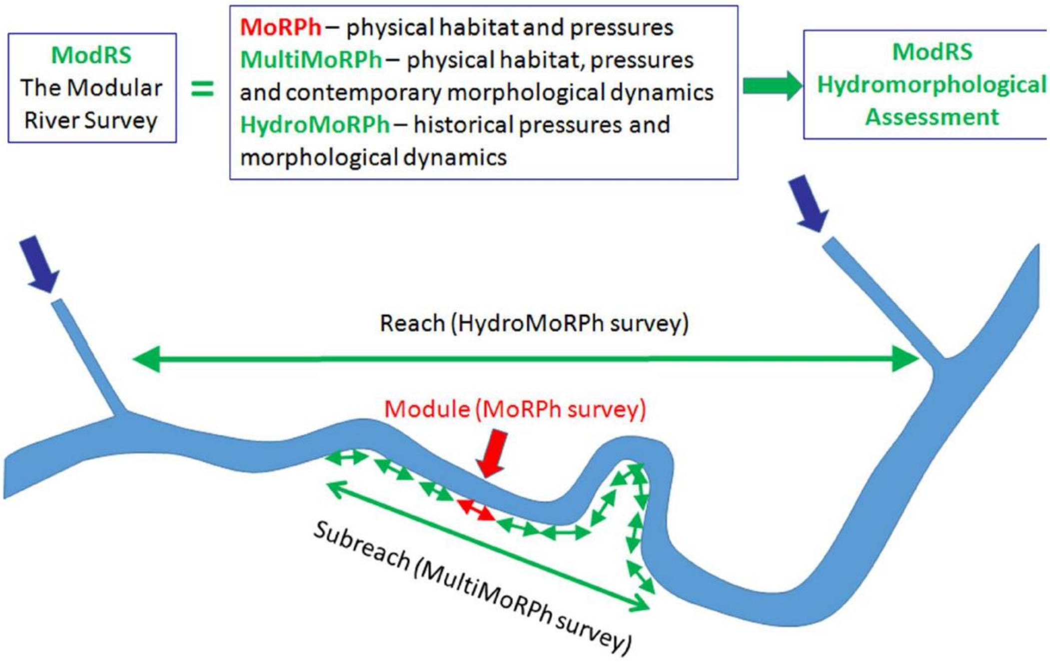
Annexe 1 Location of studied rivers

Annexe 2 Location of survey sites on the Mimram

Annexe 3 Location of survey sites on the Misbourne



Annexe 4 Location of survey sites on the Ver



Annexe 5 MoRPh scheme, extract from (Gurnell et al., 2016)

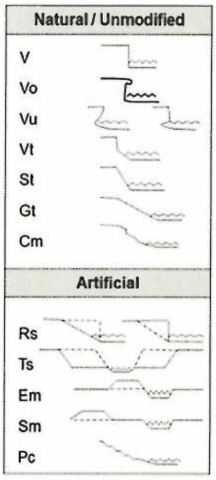
Modular River Physical (MoRPh) Field Survey (ver 7)

Sheet 5 - CODES

Section 2.1 Artificial / Managed ground cover types	
Fp	Pedestrianised, footpath
Tr	Transport infrastructure (road, railway, car park)
Ic	Buildings (commercial / industrial)
Re	Buildings (residential)
Sy	Storage area
Ld	Landfill area
Ar	Arable agriculture / allotments
Pv	Permanently vegetated agriculture (e.g. pasture, orchard)
Pr	Permanently vegetated recreation (e.g. playing fields, parks, gardens)
Pw	Plantation woodland
Ow	Open water (e.g. canal, reservoir)

Sections 3.2 / 3.3 / 4.1 / 4.3 Sediment sizes	
AR	Entirely artificial
BE	Bedrock
BO	Boulder
CO	Cobble
GP	Gravel-Pebble
SA	Sand
SI	Silt / Fine non-sticky sediments
CL	Clay
OR	Organic (leaves, twigs etc. not fully decomposed)
PE	Peat
EA	Earth (i.e. mixed, mainly sand and finer) **(for bank face material only)**
NV	Not visible

Section 3.1 Bank profile types	
	Natural / Unmodified
V	Vertical
Vo	Vertical with top overhang
Vu	Undercut or Vertical with undercut
Vt	Vertical with toe
St	Steep (> 45 degrees)
Gt	Gentle (< 45 degrees)
Cm	Composite
	Artificial (OBVIOUSLY MODIFIED)
Rs	Reshaped
Ts	Artificial two-stage
Em	Embanked
Sm	Set-back embankment
Pc	Poached bank



Section 4.2 Flow types	
FF	Free fall
CH	Chute
BW	Broken standing waves
UW	Unbroken standing waves
UP	Upwelling
CF	Chaotic flow (mixture of >2 of FF, CH, BW, UW)
RP	Rippled
SM	Smooth
NP	No perceptible flow
DR	Dry

Sections 3.2 / 4.1 Reinforcement types	
CC	Concrete
CB	Concrete & brick / laid stone (cemented)
BR	Brick / laid stone (cemented)
SP	Sheet piling
WP	Wood piling / panels
BW	Builders waste / hard core (tipped)
RR	Rip-rap (large laid stone, uncemented)
GA	Gabions / rock rolls
WS	Willow spiling
RE	Planted reeds
BC	Biotextiles / coir
WO	Washed out reinforcement

Annexe 6 MoRPh codes

Sheet 1 - GENERAL INFORMATION

RECORD WHAT YOU SEE NOT WHAT YOU KNOW

1.1 SURVEYOR AND SURVEY CONDITIONS	
Surveyor	
Survey date and time	
Module surveyed from?	left / right / both banks
Bed visible?	Yes / No
Adverse conditions?	Yes / No
If yes, describe e.g. elevated flow, turbid water, etc	

1.2 MODULE NAME AND LOCATION	
River name	
Location/Reach name	
SubReach name (used to reference a sub-reach of contiguous modules)	
Module number (1, 2, 3... number from upstream to downstream within SubReach)	
Riverfly site reference (optional)	
Module length (m) **(i)**	
NGR / GPS - Midpoint	

1.3 CHANNEL DIMENSIONS (m)	
Cross section GPS	
1. Left bank height	
2. Right bank height	
3. Bankfull width	
4. Water width	
5. Water depth	

(i) Determining your Module Length	
River width (m) (ii)	**Module length (m)**
< 5 m	10 m
5 to < 10 m	20 m
10 to < 20 m	30 m
20 to < 30 m	40 m
≥ 30 m	River channel too wide for this type of survey

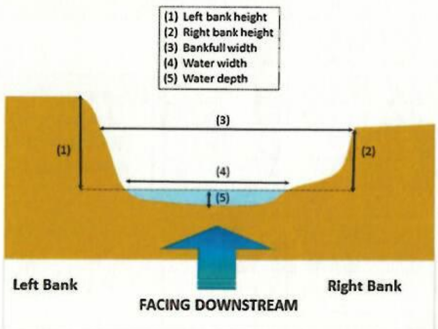
(ii) Predominant river width is used to determine module length. This is estimated as the **typical water width plus any area of bare sediment or emergent aquatic plants at the edge of the water.**

Multi-MoRPh Channel Dimensions

If surveying multiple adjoining modules: a minimum of ONE (REPRESENTATIVE) SET OF CHANNEL DIMENSIONS should be measured for each group - up to 10 modules. **TIP!:-** Bridges provide a good location for estimating dimensions of larger rivers.

Identifying the LEFT AND RIGHT BANK

The **LEFT** and **RIGHT BANK** of a river are on the left and right sides of the channel **when facing in a downstream direction with the water flowing away from you**



1.4 PHOTOGRAPHS (max 4)	
Fixed point photograph taken with NGR / GPS? (Y/N)	
Photo ref 1 (iv)	
Photo ref 2	
Photo ref 3	
Photo ref 4	

(iv) Photo 1: each survey requires a general view of the river module at a fixed point, with visual reference and/or NGR or GPS. Additional 3 photos are optional but a picture of the broader floodplain context is recommended as well as images of special features or to support queries in the NOTES box.

NOTES (up to 400 words)

Use this box to enter details where you are unsure of any measurements / records you have made.

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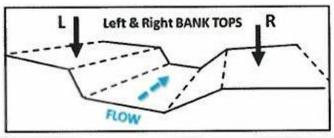
Annexe 7 MoRPh form (p40-41-42-43)

Modular River Physical (MoRPh) Field Survey (ver 7)

Sheet 2 - BANK TOP: FLOODPLAIN MEASUREMENTS



RECORD WHAT YOU SEE NOT WHAT YOU KNOW (within 10 m of bank edge)

MEASUREMENT CATEGORY	MEASUREMENT TYPE	CODE	ABUNDANCE	NOTES

2.1 BANK TOP - ARTIFICIAL / MANAGED GROUND COVER			LB	RB	LB	RB
Artificial ground cover	Artificial ground cover (Fp, Tr, Ic, Re, Sy, Ld, Ar, Pv, Pr, Pw, Ow)	DOMINANT TYPE			A / T / P / E	A / T / P / E
		SUB-DOMINANT TYPE (see (i))			A / P / E	A / P / E

(i) SUB-DOMINANT TYPE ONLY RECORD if it occupies > 20% of area within 10m of bank edge

2.2 BANK TOP - NATURAL / LIGHTLY MANAGED GROUND COVER			LB	RB
Terrestrial vegetation	Unvegetated (bare soil / rock)		A / T / P / E	A / T / P / E
	Mosses / lichens		A / T / P / E	A / T / P / E
	Short/creeping herbs/grasses		A / T / P / E	A / T / P / E
	Tall herbs/grasses		A / T / P / E	A / T / P / E
	Scrub or shrubs		A / T / P / E	A / T / P / E
	Saplings or trees		A / T / P / E	A / T / P / E
	Leaning trees		A / T / P / E	A / T / P / E
	Fallen trees (ONLY those predominantly on bank top)		A / T / P / E	A / T / P / E
	J-shaped trees		A / T / P / E	A / T / P / E
	Tree/shrub branches trailing into channel		A / T / P / E	A / T / P / E
	Large wood (wood pieces > 1m long, > 10 cm diameter)		A / T / P / E	A / T / P / E
Non-native invasive plant species	Himalayan balsam		A / T / P / E	A / T / P / E
	Japanese knotweed		A / T / P / E	A / T / P / E
	Giant hogweed		A / T / P / E	A / T / P / E
	Floating pennywort		A / T / P / E	A / T / P / E
	Other: NAME SPECIES		A / T / P / E	A / T / P / E
	Other: NAME SPECIES		A / T / P / E	A / T / P / E

ABUNDANCE CODES (proportion of area within 10 m of bank edge along the module length)
Circle one of:
A = absent,
T = trace (< 5% area),
P = present (5% - <33%),
E = extensive (> 33%)

PLANT IDENTIFICATION See MoRPh field guidance or MoRPh manual Appendix B

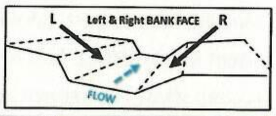
2.3 BANK TOP - WATER RELATED FEATURES			LB	RB
Water-related features	Pond	Disconnected from river at time of survey	A / T / P / E	A / T / P / E
		Connected to river by water-filled channel at time of survey	A / T / P / E	A / T / P / E
	Side channel - free flowing separate channel including tributaries and fish passes		A / T / P / E	A / T / P / E
	Wetland (recorded by dominant vegetation type)	Short non-woody vegetation (e.g. mosses, sedges)	A / T / P / E	A / T / P / E
		Tall, non-woody vegetation (e.g. reeds, rushes)	A / T / P / E	A / T / P / E
		Shrubs and trees (e.g. alder / willow carr)	A / T / P / E	A / T / P / E

NOTES (ctd.)

Modular River Physical (MoRPh) Field Survey (ver 7)

Sheet 3 - BANK FACE AND CHANNEL MARGIN MEASUREMENTS

RECORD WHAT YOU SEE NOT WHAT YOU KNOW

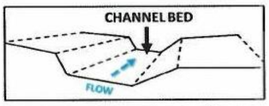


MEASUREMENT CATEGORY	MEASUREMENT TYPE		CODE			ABUNDANCE		NOTES
3.1 BANK FACE - PROFILE				LB	RB	LB	RB	
Bank face - Profile	Natural / artificial bank profile	DOMINANT TYPE *(V, Vo, Vu, Vt, St, Gt, Cm, Rs, Ts, Em, Sm, Pc)*	*Bank profile type*			A / T / P / E	A / T / P / E	(i) SUB-DOMINANT TYPE ONLY RECORD if it occupies > 20% of the bank length
		SUB-DOMINANT TYPE (see (i))	*Bank profile type*			A / P / E	A / P / E	
3.2 BANK FACE - MATERIALS				LB	RB			(ii) WHICH PART OF THE BANK IS REINFORCED? A = absent T = mainly the top B = mainly the bottom W = Whole bank face
Bank face - Natural materials	Bank face sediment *(AR, BE, BO, CO, GP, SA, SI, CL, OR, PE, EA, NV)*		*Sediment size (top 2/3)*					
			Sediment size (bottom 1/3)			LB	RB	
Bank face - Reinforcement	Which part of the bank is reinforced? (NOTE SPECIFIC CODES IN BOX (ii))					A / T / B / W	A / T / B / W	
	How extensive is the reinforcement horizontally along the module?					A / T / P / E	A / T / P / E	
	Bank reinforcement	DOMINANT TYPE *(CC, CB, BR, SP, WP, BW, RR, GA, WS, RE, BC, WO)*	*Reinforcement type*					(iii) SUB-DOMINANT TYPE ONLY RECORD if it occupies > 20% reinforced area
		SUB-DOMINANT TYPE (see (iii))	*Reinforcement type*					
3.3 BANK FACE / CHANNEL MARGIN - FEATURES				LB	RB	LB	RB	
Natural physical features	Bare / unvegetated side bar (< 50% vegetation cover)		*Sediment size*			A / T / P / E	A / T / P / E	A/T/P/E ABUNDANCE CODES (proportion of bank length occupied by feature) Circle one of: A = absent T = trace (< 5% area) P = present (5% - <33%) E = extensive (> 33%)
	Vegetated side bar (>50% vegetation cover)		*Sediment size*			A / T / P / E	A / T / P / E	
	Berm (if unsure whether berm/bench record as berm)					A / T / P / E	A / T / P / E	
	Bench (if unsure whether berm/bench record as berm)					A / T / P / E	A / T / P / E	
	Stable cliff (> 0.5 m)					A / T / P / E	A / T / P / E	
	Eroding cliff (> 0.5m)					A / T / P / E	A / T / P / E	
	Toe					A / T / P / E	A / T / P / E	
	Nest holes or animal burrows					A / T / P / E	A / T / P / E	
	Marginal backwater					A / T / P / E	A / T / P / E	
	Tributary junction / confluence: RECORD AS COUNT							
Artificial physical features	Pipes / outfalls (if appear potentially functional): RECORD AS COUNT							Maj (Major) = >20% channel width Int (Intermediate) = 10-20% width Min (Minor) = <10% width
	Jetty					*Maj / Int / Min*	*Maj / Int / Min*	
	Deflector					*Maj / Int / Min*	*Maj / Int / Min*	
	Other: INSERT FEATURE NAME					*Maj / Int / Min*	*Maj / Int / Min*	

MEASUREMENT CATEGORY	MEASUREMENT TYPE	ABUNDANCE		MEASUREMENT TYPE	ABUNDANCE	
3.4 BANK FACE / CHANNEL MARGIN - VEGETATION		LB	RB		LB	RB
Terrestrial vegetation on bank face	Unvegetated (bare earth or rock)	A / T / P / E	A / T / P / E	Fallen trees (ONLY those entirely / predominantly on the bank face)	A / T / P / E	A / T / P / E
	Mosses / lichens	A / T / P / E	A / T / P / E			
	Short/creeping herbs/grasses	A / T / P / E	A / T / P / E	Leaning trees	A / T / P / E	A / T / P / E
	Tall herbs/grasses	A / T / P / E	A / T / P / E	J-shaped trees	A / T / P / E	A / T / P / E
	Scrub or shrubs	A / T / P / E	A / T / P / E	Tree/shrub branches trailing into channel	A / T / P / E	A / T / P / E
	Saplings or trees	A / T / P / E	A / T / P / E			
	Large wood (pieces > 1m long, > 10 cm diameter)	A / T / P / E	A / T / P / E	Exposed tree roots	A / T / P / E	A / T / P / E
				Discrete organic accumulation (e.g. leaves, twigs)	A / T / P / E	A / T / P / E
Aquatic vegetation at bank-water margin	Liverworts, mosses, lichens	A / T / P / E	A / T / P / E	Amphibious	A / T / P / E	A / T / P / E
	Emergent broad-leaved	A / T / P / E	A / T / P / E	Filamentous algae	A / T / P / E	A / T / P / E
	Emergent linear-leaved (incl horsetails)	A / T / P / E	A / T / P / E			
Non-native invasive plant species	Himalayan balsam	A / T / P / E	A / T / P / E	Other: RECORD SPECIES NAME	A / T / P / E	A / T / P / E
	Japanese knotweed	A / T / P / E	A / T / P / E			
	Giant hogweed	A / T / P / E	A / T / P / E	Other: RECORD SPECIES NAME	A / T / P / E	A / T / P / E
	Floating pennywort	A / T / P / E	A / T / P / E			

Modular River Physical (MoRPh) Field Survey (ver 7)

Sheet 4 - CHANNEL BED MEASUREMENTS



RECORD WHAT YOU SEE NOT WHAT YOU KNOW

MEASUREMENT CATEGORY		MEASUREMENT TYPE	ABUNDANCE	MEASUREMENT TYPE	ABUNDANCE
4.1 CHANNEL BED - MATERIALS					
Channel bed - Natural materials	Bed sediment size	Bedrock (BE)	A / T / P / E	Silt (and finer non-sticky particles, SI)	A / T / P / E
		Boulder (BO)	A / T / P / E	Clay (CL)	A / T / P / E
		Cobble (CO)	A / T / P / E	Organic (leaves, twigs etc. not fully decomposed) (OR)	A / T / P / E
		Gravel-Pebble (GP)	A / T / P / E		
		Sand (SA)	A / T / P / E	Peat (PE)	A / T / P / E
	Silt overlying coarser sediments	Continuous silt layer (the form of underlying coarser sediments is visible)	A / T / P / E	Patchy thin layer (some coarser particles protrude through the silt layer)	A / T / P / E
Channel bed - Reinforcement		Bed reinforcement extent	A / T / P / E		
			CODE / DESCRIPTION	(i) SUB-DOMINANT REINFORCEMENT TYPE: ONLY RECORD if it occupies > 20% reinforced area	
	Bed reinforcement materials	DOMINANT TYPE *(CC, CB, BR, SP, WP, BW, RR, GA, WS, RE, BC, WO)*	*reinforcement type*		
		SUB-DOMINANT TYPE (see (i))	*reinforcement type*		
4.2 WATER SURFACE					
Water surface flow patterns	Flow types	Free fall (FF)	A / T / P / E	Rippled (RP)	A / T / P / E
		Chute (CH)	A / T / P / E	Smooth (SM)	A / T / P / E
		Broken standing waves (BW)	A / T / P / E	No perceptible flow (NP)	A / T / P / E
		Unbroken standing waves (UW)	A / T / P / E		
		Upwelling (UW)	A / T / P / E	Dry (DR)	A / T / P / E
		Chaotic flow (mixture of > 2of FF, CH, BW, UW	A / T / P / E		

MEASUREMENT CATEGORY	MEASUREMENT TYPE	CODE / DESCRIPTION		ABUNDANCE	NOTES
4.3 CHANNEL BED - FEATURES					**A/T/P/E ABUNDANCE CODES** (proportion of bank length occupied by feature) Circle one of: A = absent T = trace (< 5% area) P = present (5% - <33%) E = extensive (> 33%)
Channel bed - Natural physical features	Exposed bedrock			A / T / P / E	
	Exposed unvegetated boulders / rocks (< 50% vegetation cover)			A / T / P / E	
	Exposed vegetated boulders / rocks (> 50% vegetation cover)			A / T / P / E	
	Bare / unvegetated mid channel bar (< 50% vegetation cover)	*sediment size*		A / T / P / E	
	Vegetated mid channel bar (>50% vegetation cover)	*sediment size*		A / T / P / E	
	Island			A / T / P / E	
	Cascade			A / T / P / E	
	Riffle: RECORD AS COUNT				**(ii) WEIR TYPES / SIZES** **Major:** permanent, impermeable, impounding structure across entire channel width **Intermediate:** semi-permeable, loose stone / wood structure across entire channel width **Minor:** highly permeable, transient feature across entire channel width
	Pool: RECORD AS COUNT				
	Waterfall: RECORD AS COUNT				
Channel bed - Artificial features	Large trash (car parts, trolleys, traffic cones etc)			A / T / P / E	
	Major weir (see (ii)): RECORD AS COUNT				
	Intermediate weir (see (ii)): RECORD AS COUNT				
	Minor weir (see (ii)): RECORD AS COUNT				**(iii) BRIDGE SHADOW** **Wide** = > 25 m channel length, **Int** (Intermediate) = 10-25 m, **Narr** (Narrow) = < 10m
	Bridge piers in river bed: RECORD AS COUNT				
	Bridge shadow (see (iii))			*Wide / Int / Narr*	
	Culvert: RECORD AS COUNT				

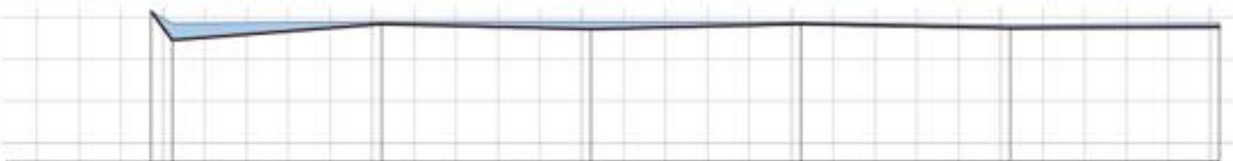
MEASUREMENT CATEGORY	MEASUREMENT TYPE	ABUNDANCE	MEASUREMENT TYPE	ABUNDANCE
4.4 CHANNEL BED - VEGETATION				
Vegetation within wetted channel	Unvegetated (bare river bed)	A / T / P / E	Amphibious	A / T / P / E
	Liverworts, mosses, lichens	A / T / P / E	Submerged broad-leaved	A / T / P / E
	Emergent broad-leaved	A / T / P / E	Submerged linear-leaved	A / T / P / E
	Emergent linear-leaved (incl horsetails)	A / T / P / E	Submerged fine-leaved	A / T / P / E
	Floating leaved (rooted)	A / T / P / E	Filamentous algae	A / T / P / E
	Free floating	A / T / P / E	Channel choked with plants?	*YES/NO*
Vegetation interacting with wetted channel	Vegetation shading channel	A / T / P / E	Large wood dam (in channel and crosses entire channel): RECORD AS COUNT	
	Submerged tree roots	A / T / P / E		
	Large wood in channel (pieces > 1m long, >10 cm wide	A / T / P / E	Fallen trees (ONLY those entirely / predominantly in channel): RECORD AS COUNT	
	Discrete accumulations of organic material in channel (e.g. twigs, leaves)	A / T / P / E		
Non-native invasive plant species	Himalayan balsam	A / T / P / E	Other: RECORD SPECIES NAME	A / T / P / E
	Japanese knotweed	A / T / P / E		
	Giant hogweed	A / T / P / E	Other: RECORD SPECIES NAME	A / T / P / E
	Floating pennywort	A / T / P / E		

Length profile: MIMRAM Tewin Water House

Location
GPS position National Grid
Upstream: TL 25875 14424
Downstream: TL 25901 14395
Position compared to weir: Downstream

Date : 26/05/2017
Description
Cliquez ou appuyez ici pour entrer du texte.

Length profil



Dist.	-1	10	10	10	10	10
Dist. cumul.	-1	10	20	30	40	50
Water dept (subreach's downstream)	0,8 00 0	0,1300	0,3700	0,1000	0,1500	0,2000
Cote	0,8	-0,5600	0,1500	-0,0950	0,1500	-0,0500
Heigh difference (Top of weir to 50 m downstream)						3,7600

Photography

Characteristics

Water width: 6
Bankfull width: 8
Water depth: 0,29
River bed: Silts predominant upstream and gravels downstream

Comments
Important amount of Ball-trap trashes.

Annexe 8 Example of Length-profile form

Cross section: MIMRAM Tewin Water House 5 m Downstream weir

Location

GPS position National Grid

Left bank: TL 25882 14422

Right bank: TL 25876 14417

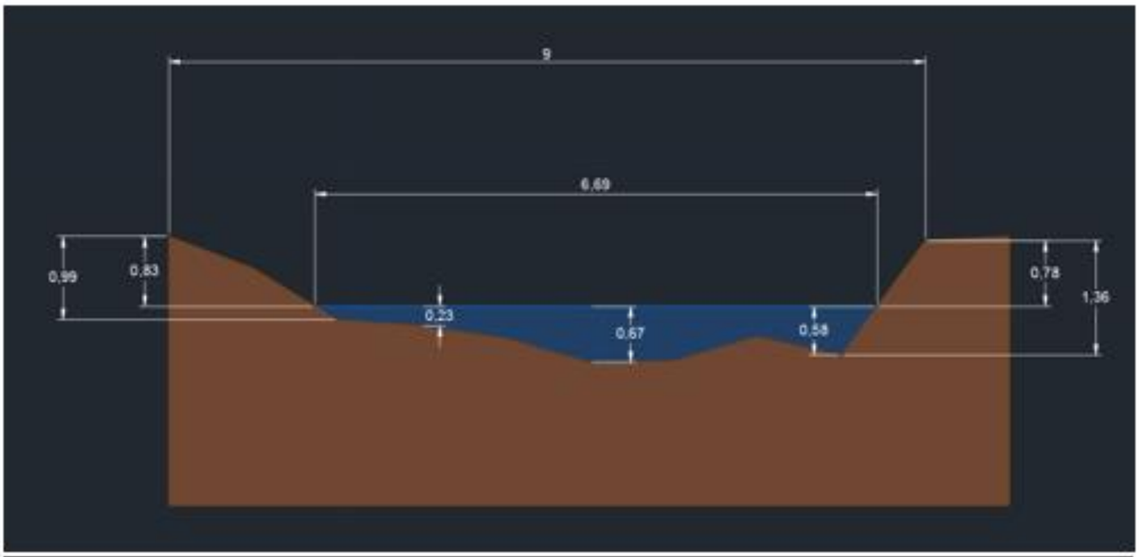
Position compared to weir: Downstream

Date: 26/05/2017

Description

Just downstream of weir, fence in river bed (left side).

Cross section



Photography

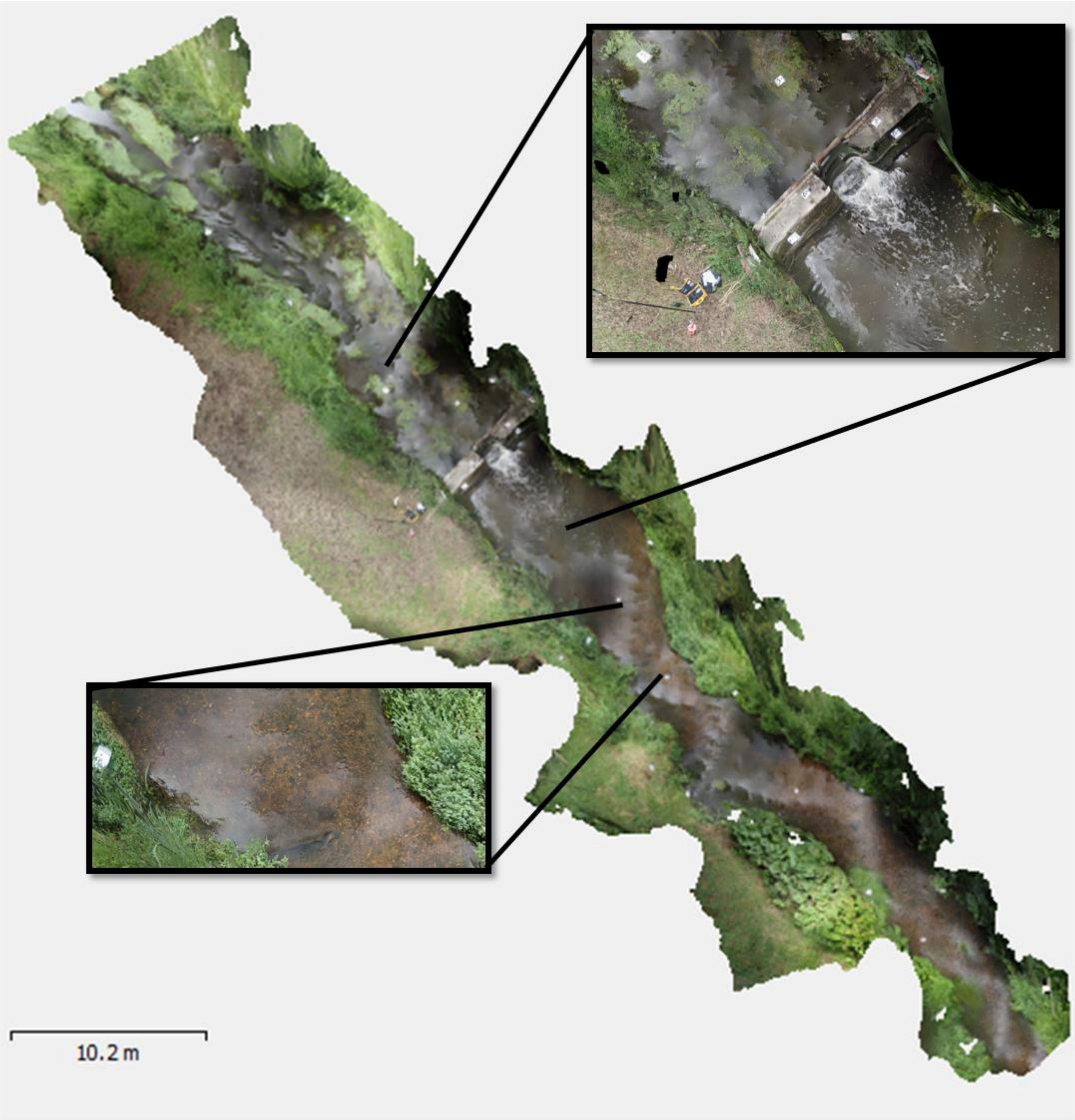
Characteristics

Water width: 6,70
Bankfull width: 9
Water depth: 0,5
River bed: Gravel, pebbles, sand organic matter

Comments

Pool just after the weir, discrete organic accumulation on 1 meter height and 1 meter diameter (twigs), few silt deposition.

Annexe 9 Example of cross-section form



Annexe 10 Orthophoto of the Mimram river with focus on the weir and on river bed

Pair	Site	Grid Reference	nights	Date	Bbar (1)	Malc	Mbec	MbraMmys	Mdau	Mnat	NSL	Paur	Ppip	Ppyg
Mimram	Tewin Water House	TL2593114322	6	5th - 11th May	3	0	1	0	7	3	31	3	1549	1089
			5	1st - 6th June	11	0	0	0	4	13	30	4	1502	970
	Sherrardswood School	TL2364315912	6	5th - 11th May	0	0	0	0	0	0	27	0	558	134
			5	1st - 6th June	0	0	0	0	3	0	27	4	732	162
Ver	New Barnes Mill	TL1560505501	7	11th - 18th May	0	0	0	0	0	13	15	0	2260	81
			7	16th -23rd June	0	0	0	0	6	1	22	0	1214	181
			6	13th - 19th July	0	0	0	0	0	9	12	0	170	17
	Sopwell Meadows	TL1528704788	7	11th - 18th May	1	0	0	0	0	3	122	0	2513	843
			7	16th -23rd June	0	0	0	0	0	3	33	0	812	73
			6	13th - 19th July	0	0	0	0	6	1	10	0	636	268
Misbourne	Martin Baker	TQ0194087628	6	25th May -31st May	0	0	0	0	66	4	790	1	950	585
			5	29th June - 4th July	0	0	0	0	152	0	1254	0	1921	1556
	Denham Country Park	TQ0501086292	6	25th May -31st May	0	0	0	0	81	3	9	0	1181	46
			5	29th June - 4th July	0	0	0	0	871	4	13	0	3462	498

Annexe 11 Bat's data transmitted by Environment Agency, NSL contain Daubenton's bats