Changing mentalities on flooding in the Upper Rhine valley landscape

An interdisciplinary landscape study on the role of changing flood perception on the emergence of its management in the Upper Rhine valley

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Changing mentalities on flooding in the Upper Rhine valley landscape

An interdisciplinary landscape study on the role of changing flood perception on the emergence of its management in the Upper Rhine valley

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English Summary

This interdisciplinary project '*Land Unter?*' aims to develop a history of flooding for the Upper Rhine valley from Strasbourg to Mannheim. A multidisciplinary variety of methods, sources, and data is used and combined into an interdisciplinary landscape study. By arranging a chronological cultural biography of the perception of flooding, mentality templates were defined. The great variety of data has been fit within these templates. The results show how the human perception changed over time, affecting the landscape of the Upper Rhine valley.

The mentality templates shift from settlement on healthy and save terrace rims, to self-sufficiency for greater wealth. When flooding is seen as a sign for new disasters, the church offers protection of the property. Although, ongoing flooding and harsh climate conditions during the 10th century demanded a new approach and the necessity of actions on flood management had to be taken by the church. Draining and dike construction provided the possibility to extend lands and use former natural wilderness as a resource. While an increasing number of farmers got their own land, they were also obliged for the protection of their property. These were the results in a period when villages in the Upper Rhine valley had a hard time to survive natural vagaries. However, when techniques improved humans gradually gained total control of the river, resulting in the Tulla-rectification in the early 19th century. Only recently, a more harmonious interaction with nature seems to gain support.

In order to see whether this theoretical timeline of mentalities holds up in practice, two case studies have been conducted. The first case study in Speyer did not result in prove of flood protection measures by Bishop Benno in the 11th century. However, bringing together geophysical data and historical sources provided some new prove on the course of the Rhine around Speyer during the early medieval period. Another case study in Ottersdorf near Rastatt included an archaeological excavation of a medieval dike. This dike has been dated back to the 11th century by humins and humin acids of the former surface layer. This is significantly earlier than other dikes in Western Europe and on top of it, it can be linked to the expansion of arable fields, which also seems quite early for offensive dike construction.

Altogether, including the perception into a landscape study, this work provides a good link between geophysical data and cultural narratives. The case studies additionally confirmed and challenged several outcomes. Furthermore, this research has overcome the lack of knowledge on flooding in the Upper Rhine valley and additionally added to the academic debate on interdisciplinary research and inclusion of subjective landscape perception.

Deutsche Zusammenfassung

Das interdisziplinäre Projekt „Land unter?“ hat das Ziel die Geschichte der Hochwasserereignisse im Oberrheingraben von Straßburg bis Mannheim zu rekonstruieren. Diese Studie soll mit einer Vielfalt an Methoden, Quellen und Daten verschiedene Disziplinen verbinden. Die generelle menschliche Wahrnehmung von Hochflutereignissen soll ebenfalls miteingebunden werden. Darauf aufbauend, konnten diverse Mentalitätskonzepte durch eine chronologische Ordnung der Kulturgeschichte entworfen werden. Eine große Menge an verschiedensten Daten wurde hierbei berücksichtigt. Die Ergebnisse offenbaren, dass sich die Wahrnehmung des Menschen über die Zeit veränderte und, dass dadurch ebenfalls die Landschaft des Oberrheingrabens einem Wandel unterworfen war.

Diese Veränderung äußert sich darin, dass sich die Siedlungen von sicheren und gesunden Terrassenkanten hin zu Ortschaften wegverlagern, welche autark einen größeren Wohlstand ermöglichen. Sobald Überschwemmungen als Zeichen einer Katastrophe interpretiert werden, versuchte die Kirche Schutz für den Privatbesitz zu ermöglichen. Dennoch veranlassten wiederkehrende Fluten und schwierige klimatische Bedingungen im 10. Jahrhundert den Entwurf von neuen Gegen- und Hochwasserschutzmaßnahmen von Seiten des Klerus. Mithilfe von Trockenlegungen und Deichkonstruktionen wurde die Möglichkeit eröffnet, neues Land zu gewinnen und ehemals unberührte Landschaften als Ressource zu nutzen. Der Besitz von eigenem Land verpflichtete die Bauern ab einem gewissen Zeitpunkt dazu, sich selbst um die Sicherung ihres Besitzes zu kümmern. Dies war die Ausgangslage zu einer Zeit, in der es für Dörfer und Siedlungen im Oberrheingraben schwierig war, die Launen der Natur zu überleben. Allerdings veränderte sich dies, als sich die Technologien weiterentwickelten und der Mensch infolgedessen die Kontrolle über den Fluss erlangte. Ein passendes Beispiel hierfür ist die großräumige Flussbegradigung durch Tulla im frühen 19. Jahrhundert. Heutzutage wird jedoch ersichtlich, dass man neuerdings versucht, wieder einen etwas harmonischeren Umgang mit der Natur zu pflegen.

Um zu beobachten, ob diese theoretische Entwicklung von Mentalitäten der Praxis standhalten kann, wurde diese Annahme mithilfe von zwei Fallstudien überprüft. Die erste Studie konnte keinen endgültigen Beweis für Hochwasserschutzmaßnahmen von Bischof Benno im 11. Jhd. in Speyer beweisen. Dennoch offenbarten die geophysikalischen Messungen und die historischen Quellen einige neue Rheinverläufe während des Mittelalters um Speyer. Am nächsten Untersuchungsstandort in Ottersdorf (nahe Rastatt) konnte sogar eine mittelalterliche Deichanlage archäologisch ergraben werden. Mithilfe von naturwissenschaftlichen Analysen im Labor wurde dieser Deich anhand der Humine/Huminsäuren in der ehemaligen Paläooberfläche in das 11. Jhd. zurückdatiert. Im direkten Vergleich zu anderen Deichen im westeuropäischen Raum, liefert dieser Deich in Ottersdorf ein signifikant älteres Datum. Zusätzlich kann diese Struktur mit landwirtschaftlichen Äckern dieser Zeit in Verbindung gebracht werden. Dies ist ein Beweis für eine äußerst frühe Form der offensiven Landgewinnung durch den Deichbau.

Zusammenfassend kann festgehalten werden, dass diese Arbeit eine gute Verbindung von geophysikalischen Daten und kulturellen Narrativen darstellt – miteingeschlossen die subjektive Wahrnehmung in Form einer Landschaftsanalyse. Zusätzlich bestätigten die Fallstudien diverse Resultate, stellten diese aber auch zugleich wieder in Frage. Weiterhin hat diese Untersuchung das fehlende Wissen über Hochwasserereignisse im Oberrheingraben verringert und zusätzlich eine wissenschaftliche Debatte über die interdisziplinäre Forschung und die Einbindung von subjektiven Landschaftswahrnehmungen eröffnet.

Résumé français

Ce projet interdisciplinaire nommé « Land Unter » a pour but de présenter l'historique des inondations de la vallée du Rhin Supérieur qui s'étend de Strasbourg à Mannheim. Pour ce, diverses méthodes, sources et données multidisciplinaires ont été utilisées et combinées pour en faire une étude interdisciplinaire du paysage, comprenant la perception des inondations. En arrangeant la biographie culturelle dans l'ordre chronologique, un modèle concernant la mentalité des peuples a pu être défini. Ensuite, la grande variété de données a pu être intégrée dans ce modèle. Les résultats ont pu montrer le changement de la perception humaine avec le temps, affectant donc le paysage de la vallée du Rhin Supérieur.

La mentalité des peuples s'est transformée au cours du temps. L'emplacement de leur habitat, jadis situé sur les rebords sûrs et stables des terrasses, a été remplacé par une gestion d'autosuffisance, dans le but d'atteindre un niveau de richesse plus élevé. Les inondations étant considérées comme de nouvelles catastrophes naturelles par l'Eglise, celle-ci va garantir la protection de la propriété personnelle. Vu les inondations permanentes et les conditions climatiques très rudes du 10ème siècle après J.-C., une nouvelle approche quant à la gestion des conséquences est nécessaire. L'établissement d'un système de drainage et la construction de digues offrirent la possibilité d'étendre les terres et d'utiliser d'anciennes zones sauvages comme ressources. De plus en plus d'agriculteurs acquirent leur propre terre et furent donc obligés de garantir la protection de leur propriété. Ceci furent les actions nécessaires durant une période pendant laquelle les villages autour de la vallée du Rhin Supérieur avaient du mal à survivre face aux caprices de la nature. Cependant, l'amélioration des technologies permit aux humains de gagner le contrôle total sur la rivière, entraînant la rectification du Rhin par Tulla. Une interaction plus harmonieuse, en accord avec la nature, semble pourtant gagner du terrain depuis peu.

Deux études ont été conduites pour déceler si la ligne du temps des mentalités, émise théoriquement, tient la route en pratique. La première étude, dirigée à Speyer, n'a démontré aucune preuve de mesures de protection menées contre les inondations par l'évêque Benno au 11ème siècle après J.-C. Néanmoins, des Indices sur le cours du Rhin autour de Speyer durant le Haut Moyen-Âge ont pu être découverts en combinant les données géophysiques et les sources historiques. La seconde étude dirigée à Ottersdorf, près de Raststadt, comprenait les fouilles archéologiques d'une digue datant du Moyen-Âge. Celle-ci a pu être datée au 11ème siècle grâce à la datation par acides humiques se trouvant sur la couche ancienne. La datation de cette digue est donc considérablement plus ancienne que d'autres digues de l'Europe de l'Ouest. De plus, elle peut être connectée à l'expansion de terres arables, ce qui semble assez précoce pour ces constructions de digues offensives.

En somme, en incluant la perception des inondations dans l'étude du paysage, ce travail permet de faire le lien entre des données géophysiques et le narratif culturel. De plus, les études ont à la fois confirmé et défié plusieurs résultats. Enfin, cette recherche a surmonté le manque de savoir à l'égard des inondations dans la vallée du Rhin Supérieur et a enchéri les débats académiques pour ce qui en est de la recherche interdisciplinaire et de l'inclusion de la perception du paysage.

List of abbreviations

^{14}C = Carbon-14
ADAB = Allgemeine DenkmAldatenBank
AD = Anno Domini
BC = Before Christ
BP = Before present
BUND = Bund für Umwelt und Naturschutz Deutschland
DGM = Digitales Gelände Model
ERT = Electrical Resistivity Tomographies
GIS = Geographic Information Systems
GLA-K = Generallandesarchiv Karlsruhe
IPCC = International Panel for Climate Change
IRP = Integriertes Rhein Programm
J.-C.= *Jésus Christ*
Jhd. = *Jahrhundert* (century)
LiDAR = Light Detection and Ranging
OSL = Optically Stimulated Luminescence
RPK = Regierungspräsidium Karlsruhe
UTM = Universal Transverse Mercator

Acknowledgements

When I started this PhD project, my passion for investigating landscape won from my ambition to actually contribute to applied landscape development. However, from the very first moment I have kept in mind that my research should have value for real world application. Fortunately for me, the theme of flood management is very relevant for debates on contemporary spatial developments all over the world. It might however be questioned whether science is ultimately the best way contribute to such discussions. Where creative landscape designers innovate with new out-of-the-box ideas, I have always believed that scientists innovate by developing knowledge through facts and state-of-the-art methods. But during the past three years I have got the insight that science, at least social sciences and humanities, is built upon a sequence of interpretations and trust. The body of relevant literature has grown extensively over the decades, especially when conducting a broad interdisciplinary research. For this reason, it is impossible to read everything and therefore only the most recent and relevant sources were taken into account. Since it is no longer possible to read all related publications and my critical attitude refuses to blindly and unconditionally trust all former researchers. I expect that the following research will invite and challenge researchers into debate, encouraging every reader to critically reflect on my methods, interpretations and results, as well as to take my study as a source of inspiration for further research or future spatial developments.

Precisely as I have been inspired by the many researchers I have come to know during my decade at various universities. I would specially acknowledge Prof. Jelle Vervloet for showing me how big the human expressions in our landscape is. This inspired me to continue my education in landscape development with Prof. Theo Spek, who teached me the essence of an interdisciplinary approach and including the knowledge of other experts in research. Following, a small thanks goes to Prof. Jan Kolen and Prof. Hans Renes who made me understand the field of science better and provided me with a theoretical fundament to execute this PhD studies. Additionally, Prof. Petra Van Dam kept me critical to science, and especially to my own work and methods. She was one of the many attendants who reflected on the project during the workshop in Heidelberg in November 2016 and gave me the inspiration at the workshop at the VU in Amsterdam in July 2017. Also, the cooperation with our colleagues at the Universities of Strasbourg, Freiburg, Jena and Darmstadt is appreciated deeply. Furthermore, the contributions of the *Generallandesarchiv* in Karlsruhe and the *Landesdenkmalpflege* in Esslingen are also taken thankfully into account. This is also notable for collaborating parties that made the fieldwork in Speyer and Ottersdorf possible. For the case study in Ottersdorf, I am especially thankful to Franz Ruf for sharing his extensive knowledge on the area.

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1 - Introduction

1.1 Flooding: an eternal and ongoing problem

Flooding of rivers has always been a risk to humans, and therefore a matter of great interest for society. Not just locally, but everywhere in the world floods occur, along every river. River floods damage not only, for example, infrastructure and houses, but also the economy, and even causalities occur frequently. (IPCC, 2012, pp.242-243, p. 249) Flooding is not only a problem of recent years, but has been one for at least the past two millennia. Recently, the topic of flooding has been in the news and on scientific agenda's even more heavily, since the effects of climate change stand to increase the number of floods. (Alfieri *et al.*, 2018, p. 1; IPCC, 2012, p. 175) For this reason, it remains relevant to keep developing new measures to cope with such eventualities, on multiple scales. The increasing intensity with which land around rivers is used, including the dynamic interplay between human actors and natural processes, increases potential damage and therefore demands continuous research.

Even though contemporary rivers are bounded by kilometres-long dikes, flooding is still regarded as a considerable risk to human settlement. Various flood prevention measures are still being developed and improved by engineers, debated in local forums, and implemented along rivers. (IRP, 2007, p. 11; Jacobs & Kuijer, 2007, pp.1-2) Recent practice in flood management has seen dikes being reverted backwards so that a river is given more land to flood reducing danger to humans and their property. This includes the so-called *Ruimte voor de River* or 'room for the river' projects in the Netherlands and the *Renaturierung* or 'rewilding' projects in Germany. (FLOODsite, 2009, p. 51) One of the main reasons for and driving forces behind these projects is the perception that controlling or taming rivers might lead to new problems. (Haas, 2015, p. 25) Europe has acquired about 2000 years' worth of knowledge on water management. (Van de Ven, 2004, p. 325; Schmidt, 2000, p. 221; Blackbourn, 2007, p. 3) Even before having tamed most of Europe's big rivers and streams, which was done especially during the 19th century in Western Europe. Europeans had been interacting with flooding already for centuries, and many measurements (like constructing dikes, embankments and bypasses) for flood management have been proposed and executed over this time. (Van de Ven, 2004, p. 325) Humans and rivers have gone hand in hand but humans also fought numerous battles with the natural river's vagaries. On the one hand, inhabitants of river areas have been fed by fertile river soils and economically flourished through exploiting its possibilities for trade routes. On the other hand, the natural dynamics of a river cause shifting water levels and redirection of channels. (Blackbourn, 2007, pp.73-76)

The contemporary river landscape in Western Europe is thus formed and transformed by natural dynamics and cultural expressions over many centuries. Therefore, contemporary flood management engineers should take an interest in the history of river landscapes. They should question themselves why a dike has been built in the first place before removing it. It was probably constructed during a period in which people experienced the disastrous power of a more natural river, which is something we can hardly imagine nowadays, since we have been living behind dikes our whole lives. Such differences in perception definitely influence society's solutions. (Haas, 2015, p. 17) Especially when perception of multiple people are taken together, in mentalities. In addition to research on the history and nature of the river itself, a river landscape's cultural history should also be included as a matter of course. This serves not only the purpose of finding inspiration in former measurements of flood management, but also of seeing how a different perception of flooding and changing interactions between human and nature might lead to different measurements and to a better understanding of cultural landscapes in which humans have interacted with the dynamics of a river. Developments in flood management should also be inspired by the intensive and ongoing interaction between humans and flooding.

1.2 Geographical and chronological framework for the medieval Upper Rhine valley

Although much research has been carried out on the history of flood management, hardly anything is known about historical flooding in the Upper Rhine valley. The Upper Rhine is a section of the Rhine between Basel and Mainz, which follows through the Upper Rhine valley partly along the border of France and Germany. The lack of research is surprising, since the Upper Rhine valley has been inhabited at least since the Roman period, probably even before that. Moreover, it is populated quite densely in comparison to surrounding areas. (Filtzinger, 2001, p. 138) Settlements on the Upper Rhine valley flood plain are attested for at least the 8th century. Due to the plain's relatively flat elevation, flooding has definitely had a strong impact on this landscape. Its rich cultural history and the lack of preliminary research have made the Upper Rhine valley an interesting and challenging area for investigation. Within the present project, the Upper Rhine section from Strasbourg to Mannheim is studied, including both the eastern and the western bank. (Figure 1.1) The research focussed on the floodplain, but its relationship to the higher terraces has been taken into account as well. The research has been conducted at three scales: (1) the international scale of Western Europe; (2) the regional scale of the Upper Rhine valley; and (3) the local scale of individual case studies in Speyer and Ottersdorf. The international scale is taken into account in order to place the Upper Rhine valley in its wider context with respect to other Western European river landscapes (Loire, Lower Rhine, Meuse) that have experienced comparable cultural and climatic transitions. At the regional scale, the Upper Rhine valley was chosen for its early inhabitation and relatively flat elevation, increasing potential damage when flooded. The local case studies are included in order to illustrate the practical elaboration of the developments described more theoretically at the regional scale.

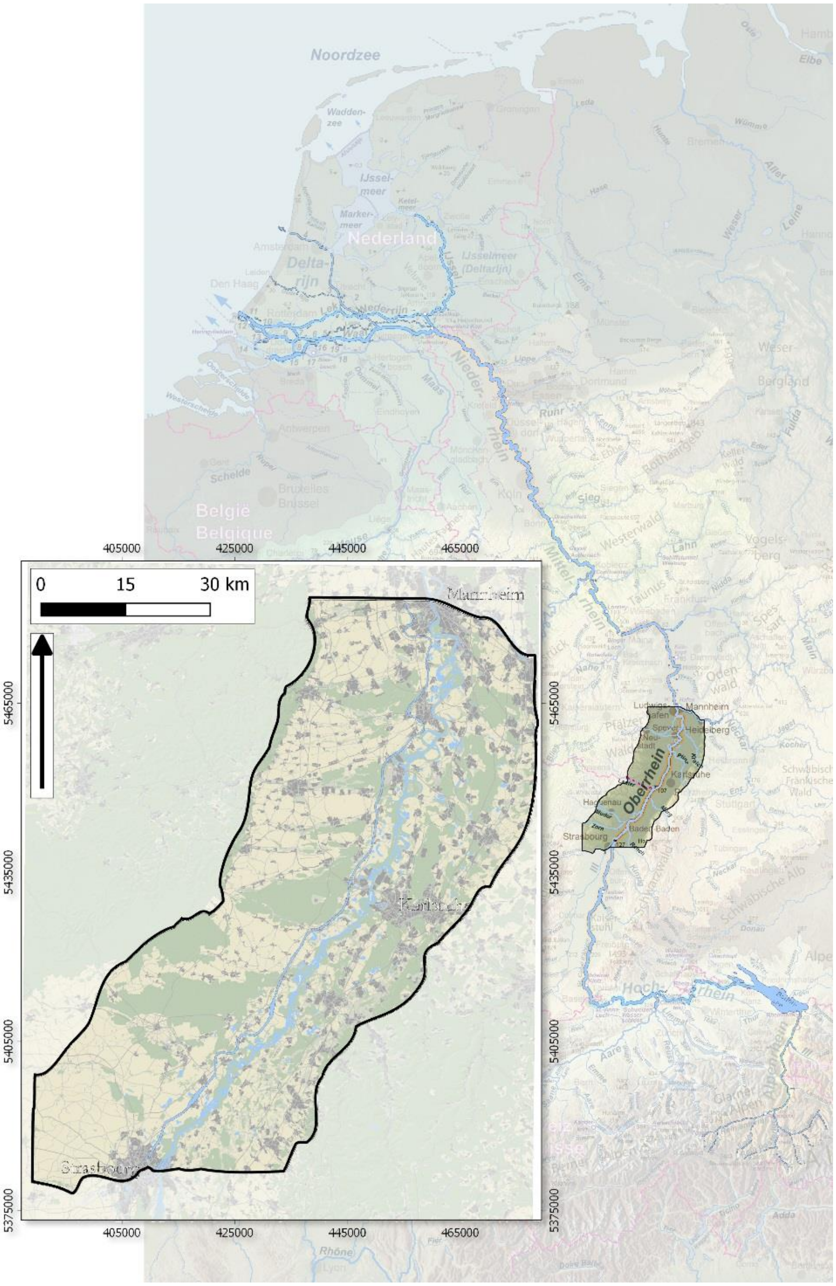


Figure 1.1: Map of the Upper Rhine valley research area, including cities of Mannheim, Karlsruhe and Strasbourg

Since a historical overview of flood management in the Upper Rhine valley is lacking, this dissertation's timeframe for early dike construction is established by reference to that of other river landscapes in Western Europe's history, which is discussed in more detail in chapter §2.3. This definition is legitimately made because these other Western European rivers have participated alongside the Upper Rhine valley in a shared cultural history and been affected by comparable climatic factors considered to influence flooding. Significant part of this common history are dikes, irrefutably related to flood management. Dikes go far back in written records, and on historical maps and, due continuous maintance, are often still present in the landscape, offering a suitable location for and archaeological excavation. Along the Loire in France, early dike construction is recorded for the 12th century, the same period counts for the Netherlands. (Dion, 1961, p. 109; Charlot *et al.,* 1996, p. 6; Van de Ven, 2004, p. 73) The earliest mention of dikes in the Upper Rhine valley dates back to 1206. (*Reineri Annales* in Pertz, 1864, p. 660) Based on these records, the time-period for early flood management in the Upper Rhine valley could be set to the 11th and 12th century. (§2.3) However, many settlements in the flood plain of the Upper Rhine valley are mentioned in historical documents for as early as the 8th century. (§4.5; Glöckner, 1936) Since these settlements were located on the flood plain at risk of potential flooding, some kind of interaction must have occurred there between humans and the river. However, no clear notion of flood management is known to have existed in these early centuries. The timeframe of this research has been extended from the 8th to the 13th century, in order to understand how the people of these Early Medieval settlements interacted with the Upper Rhine, without any known dike construction. On top of that, written sources for this early period are scarce. Therefore, new and creative approaches for studying how flooding was perceived during this period are of particular significance.

1.3 Defining the problem

Corresponding to the above, it will not suffice to review simply contemporary developments in flood management for the river system in question. Extended knowledge of its natural and cultural history is required. Since such a historical narrative is lacking for the river landscape of the Upper Rhine valley, this dissertation aims to fill that gap in knowledge. Many and varied actors have lived in the Upper Rhine valley landscape, and their interaction with the natural dynamics of the river landscape are studied. Not only human cultural expressions are important, but since perception plays an important role in such expressions, also the perception, or impressions, of the river landscape and other humans actors are relevant. Thus, the human perception of flooding and the river landscape is an important object of study. It is assumed that the contemporary perception of the interaction between humans and nature played a significant role in the further development of the Upper Rhine valley river landscape. For this reason, this dissertation aims to tackle the following problem:

> *What is the role of changing human perception of flooding in the Upper Rhine river landscape influence the interplay between human actors and natural dynamics that lead to the emergence of flood management – more specifically dike construction – in the medieval (8th to 12th century) Upper Rhine valley?*

1.4 Research topics and research questions

This research covers two main topics. The first relates to the methodology of interdisciplinary landscape studies with an aim to include the study of human perception. The other topic pertains to the emergence and development of flood management in the Upper Rhine valley. The concluding interpretations (§9) therefore aim to answer the following two questions.

> Research topic A: *How can changes in human perception of a landscape be included in interdisciplinary landscape research?*
> Research topic B: *How did flood management – more specifically dike construction – emerge and develop in the medieval Upper Rhine valley?*

Both research topics are properly introduced in §2 through an overview of the current state of the research. The status of contemporary landscape studies is described and briefly discussed first, followed by flooding history. Flooding history starts with a general description and definitions, then it specifies to the Western European rivers of the Loire, the Lower Rhine and the Meuse. Finally, the state of current research on flooding history in the Upper Rhine valley is described. Chapter 2 thus aims to answer the following two questions:

> A1: *What is the state of research on interdisciplinary landscape studies, and how has human perception been included?*
> B1: *What is the state of research on flooding history for rivers in Western Europe and more specifically the Upper Rhine valley?*

Chapter §3 elaborates on the state of current research in landscape studies. It gives an overview of the multidisciplinary sources and methods used in the present study. In the end, suggestions are offered how to integrate the multidisciplinary sources and methods into an interdisciplinary approach answering the following question:

A2: *How can the various sources and methods of a multidisciplinary landscape inventory contribute to an interdisciplinary study on landscapes?*

Chapter §4, which is the most elaborative chapter, starts by explaining how the interdisciplinary methodology follows from chapter §3, and is set up in this research project. The subsequent paragraphs are an elaboration of the collected data on the Upper Rhine valley by putting the developed method into practice for the research area. It is chronologically ordered concerning the changing human perception of flooding and its effects on the river landscape of the Upper Rhine valley. This section starts with the Roman period, because its richness in sources provides a profound background and starting point for research on flood perception in the early medieval period. After elaborating on various stages of changing human perception, paragraph §4.9 briefly discusses more recent landscape developments in order to relate the results to the contemporary Upper Rhine landscape. A timeline of mentalities given in the concluding paragraph, §4.10, answers the following question:

B2: *What is the role of changing human perception of flooding in the Upper Rhine valley river landscape influence the emergence of flood management – more specifically dike construction?*

Chapter 4 supplies several theoretical conclusions. To verify the posed conclusions in practice, in §5 two case studies were introduced, in which the reasons behind the selection of Speyer (§6) and Ottersdorf (§7) as case studies are discussed. The results from preliminary research are supplemented with those attained through fieldwork conducted for this project. Because historical sources for these local case studies are limited, those available are discussed against the backdrop of the timeline established for the broader region and given in the concluding §8. This elaborates on whether the specific findings of the case studies confirm or challenge our hypothesized understanding of the changing human perception of flooding in the broader research area, as captured by the following question:

B3: *How do the case studies in Speyer and Ottersdorf confirm or challenge the hypothesized historical shifts in the human perception of flooding in the Upper Rhine valley river landscape?*

In §9, about both research topics– the methodology of interdisciplinary landscape studies and the changing human perception of flooding in the Upper Rhine valley – concluding interpretations are provided. The conclusions of the various chapters are put together to comprehensively address the role of the human perception of flooding in shaping the medieval river landscape of the Upper Rhine valley. The final chapter, §10, then provides a critical discussion on the newly developed method by critically elaborating on the results.

2 - State of the research

Since this research has two main research themes, a state of the research is included for both. §2.1 describes the historiography of landscape studies in order to develop an interdisciplinary landscape study including perception for this research. In §2.2 to §2.4 the second research theme is discussed: flooding in a river landscape At first, some general terms in flooding history are defined. Then three research cases on river landscapes in Western Europe are discussed: the Loire, the Lower Rhine and the Meuse. Finally in §2.4 the state of the research on the flooding history of the Upper Rhine valley is discussed.

2.1 Including mentalities in landscape studies

Flood management, being the crossing point and borderline between nature and culture, asks for an integral and interdisciplinary geographical approach. Geophysical measurements require a more specific study area and provide only technical data. Historical and archaeological data can add a narrative to the case studies and provide a broader understanding on the history of dike construction in the context of the Upper Rhine valley. At the same time, geophysical data could support the ideas derived from archival sources and toponyms. Such interdisciplinary approaches have been used in research before. The next paragraph introduces four approaches for landscape studies: layers approach; cultural biography of landscape; landscape biography; and *histoire de mentalités* (history of mentalities).

2.1.1 Various schools on the study of landscapes

On the crossing of natural and social sciences, landscape studies emerged in the late 19th century. Kolen explained how Darwin's theory of evolution contributed to raising awareness of the human influence on nature. The same could be said for Perkins Marsh's publication '*Man and Nature*': the combination of these publications provided a starting point for cultural geography. This directly led to diverging schools of cultural geography. (Kolen, 2005, p. 26) The German Ratzel initiated antropo-geography, which was further developed by Schülter towards *Landschaftskunde* (landscape science) and the attempts to define *Urlandschaften* (primal landscapes). In a reaction to this all-inclusive movement, a more regionally focused approach was argued at the French *Annales*-school of Bloch and Febvré, followed by Vidal de la Blanche. Their *genre de vie* (regionally specific way of life) included all regional influences that constructed the landscape. Carl Sauer and his Berkeley School formed a combination of these two schools. (Kolen, 2005, p. 26) The Berkeley School paid attention to the relation between the physical landscape on one side and the natural and cultural landscapes on the other. However, the self-constructing role of culture as a superorganism and the lack of recognition of human labour has been criticized among geographers. (Mathewson, 2008, p. 21) Hoskins, who used a good pair of boots to understand a landscape from the field, initiated a return to regional history during the 1950's. (Johnson, 2007, p. 34) He pointed out the human impact on the landscape, but naturalistic landscape studies remained very important. Landscape morphologists like Darby, Jäger and Nitz held on to the importance of the *Landschaftgenese* (landscape genesis), which focused on the long-term development of landscape ecosystems. These analyses and descriptions lead to the definition of typologies and models for Europe's landscapes. (Kolen, 2005, p. 33)

After some years of quantitative and holistic geography, a paradigm shift appeared on the horizon. *The Interpretation of Ordinary Landscapes* by Meinig was one of the key notes of the upcoming humanistic and social geography in the 70's. (Meinig, 1979) This collection of essays included *The Biography of Landscapes* by Samuels, mentioning biography in relation to landscape for the first time. In this essay, Samuels empathizes the contribution of 'nobody in particular' to the development of a landscape. These 'nobodies', or individuals, conceive the landscape from their former generation, process it and edit it by living their life. (Kolen & Renes, 2015, p. 31) However, according to Ingold (2000) and Jacobs (2006), landscape perception is not the individual perception of the physical landscape (or matterscape in Jacobs), it is influenced by culture and its various human actor groups. (Ingold, 2000, p. 47, p. 171; Jacobs, 2006, p. 47) According to Koren, Samuels *"identifies a 'landscape of impressions', a layer of ideologies and cultural representation of space, which in turn forms the context of the actual creation of landscapes, the 'landscapes of expression' "*. (Koren, 2015, p. 255)

Inspired by studies on material culture, this sequence of reshaping landscape over generations resulted in a revival of the biography idea in the 90's. However, the structuralist perspective on landscape as being shaped by man, changed as a result of fast upcoming ecological movements after the 1992 Earth Summit. Environment gained more attention and the focus of geography shifted from physical and humanistic geography to a third bridging discipline, the environmental geography. (Gebhardt *et al.*, 2011, p. 79) This can be seen in the European Landscape convention of 2000 in which Landscape is defined as: *"an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors."* (Council of Europe, 2000) Both natural and humanistic sciences are taken into consideration in this definition. In addition, the perception people have of a landscape has a dominant position in this definition. Growing awareness of differences in perception and an increasing importance of participation in landscape planning can be identified ever since. This creates momentum for a revival of the landscape biography ideas by Samuels.

2.1.2 Layers approach

Dutch spatial analysists and planners De Hoog, Sijmons and Verschuuren were asked by the Dutch government to develop a concept for future strategic choices in Dutch planning, which resulted in their layers approach, published in *Het Metropolitane Debat* in 1998. (Van Schaick & Klaasen, 2011) The Dutch layers approach, clearly inspired by Hettner's seven-layer political model, is a visualized presentation of three layers: the substratum (underground); the network layer; and, the occupation layer. These three layers are chosen for their time to develop, as inspired by Braudel. (Van Schaick & Klaasen, 2011, p. 6; Neuburger, 2006, p. 197; Gebhardt *et al.,* 2011) The underground layer takes several centuries to develop, networks change every few decades, and the occupation layer changes all the time. By defining these various layers, the experts break through the sectoral division in planning. The layers approach was developed as a policy tool for spatial planning, but it proved to be a very structured approach for landscape analyses on various scales. The layers approach distinguishes itself from other models by using the relation between time and space as starting point, which provides clear visualization opportunities. Although the approach overarches sectoral division, the layers might be considered too complex and superficial. By putting their focus on temporal transition, the authors oversee the complexity of adding various sectors in every layer and the relations between the layers. Off course, the layers approach must be seen in its context as a policy tool simplifying the environment for spatial planners and not a detailed description of reality. (Van Schaick & Klaasen, 2011, p. 10) This layers approach provides a suitable foundation for future landscape research. Especially the visible relation between time and space is valuable for historical geographers.

2.1.3 Cultural biographies of landscapes

Although the layers approach provides a wide range of topics overcoming sectoral division, it leaves hardly any attention to values and meaning and the role of individuals in the landscape. Attention to these individual actors is one of the main principles of Kolen's definition of a landscape biography. As confusing as it is, the concept of landscape biographies has been developing in several directions; alike Renes argues that landscape biographies have become an umbrella for a number of ideas. (Renes, 2015, p. 403) However, it was Kolen who recently (re-)introduced the idea of a biography of landscapes in the Netherlands. Inspired by Americans Meinig and Samuels, he elaborated on the historians who wrote biographies of objects. (Kolen & Renes, 2015, p. 26) In the papers Kolen collected for his book *Landscape Biographies,* two perspectives can be distinguished. Biographies can be written by describing the development of a landscape, derived from its representations and key-moments of human interaction with the landscape. Another method to define biographies of landscapes is to accumulate the biographies of the key-actors that have changed the landscape throughout the years. Either of them is better, both methods are relevant and a combination might provide even more information. (Huijbens & Benediktsson, 2015, p. 101) This flexibility is also the most notable weakness of the landscape biography: it is not well defined, nor a comprehensive method exists yet. It has to be said that Kolen solely aimed to open up the discussion on new perspectives, in which he clearly sufficed. The landscape biographies as gathered by Kolen provide an extended body of qualitative data on a landscape that can hardly be provided by any other analytical method. On the other side, it hardly provides any quantitative data, which could support outcomes of the studies. The landscape biographies as described by Kolen could profit from adding structure and a clear methodology. (Kennislab IJsselID, 2015) This should not necessarily harm the qualitative identity of the method.

On the contrary, the narratives following from Kolen's landscape biography, presented in a structured layer approach might get landscape studies to a new and more complete level. Inspired by the same approaches, Elerie and Spek developed a cultural biography of landscapes. This interdisciplinary approach aims to combine ecological and cultural perspectives. (Elerie & Spek, 2010 p.83) Meijles and Spek distinguish an abiotic, biotic and Anthropocene layer. (Meijles & Spek, 2015, p. 5) In their extended and comprehensive methodology-brochure, the researchers define twenty steps. Summarizing after a quick analysis of a topographic map their abiotic layer includes relief, geomorphology, soil and hydrology. Supported by field data, the biotic layer contains vegetation information (including paleo-ecology), aerial photography and some toponymy. The Anthropocene layer is the most extended layer. It is built up from culture historical elements, toponyms, landscape experience studies, historical maps and archival research. In the end, this research is merged in a GIS-map and a timeline in order to bring the various disciplines together. (Meijles & Spek, 2015) This interdisciplinary cultural biography of a landscape is put into practice in the Drentse Aa region. Together with local stakeholders in several local case studies, both ecological and cultural information is gathered and put into a policy plan for this region. (Elerie & Spek, 2010 p.83; Spek *et al.,* 2015) As the above already implies, this comprehensive method can be executed in many ways depending on the research focus. This flexibility makes that outcomes of the landscape biographies differ not only regionally, but also depending on the assignment. The wide range of data sources make this interdisciplinary approach applicable in science, but also in policy and design. One of the assets of this approach is the visible interaction between the abiotic, biotic and Anthropocene layers, and specifically focuses on how the abiotic and biotic landscape influences human behaviour. The applicability of this approach in both contemporary and historical landscape studies is an important strength as well.

On top of that, Spek argues that religion, economy and the perception of landscape contribute to the development of a landscape. (Spek *et al.*, 2015, p. 14) However, the methodology to include these cultural aspects falls short in comparison to the more geophysically oriented methods. Although I deem this cultural biography of landscapes to be balanced slightly towards landscape-geneses instead of landscape biography. Nevertheless, this approach provides sufficient leads to reconstruct the development of a landscape and its settlements throughout history.

2.1.4 Histoire de mentalités

Fairclough argues that perception is one of the most important characteristics of a landscape. (Fairclough, 2006, p. 205) In spite of the fact that both Spek and Kolen aim to include people's values and meanings, a thorough method to include *'histoire de mentalités'*, as the *Annales*-school called the study on how groups of people think, is still lacking. According to Hutton the history of mentalities focuses on the attitudes of people in relation to their daily lives, the interplay between habits and innovation, and thought versus emotion. (Hutton, 1999, pp.800-801) History of mentalities was seen as a historiographical movement that gave attention to private traditional attitudes in a world of increasing globalization and unification of culture in a public environment. Hutton describes history of mentalities as history of the common man (Hutton, 1981, p. 238), the individual. At least aiming to fill the gap between high culture and common culture. The *Annales*-school did not see political history with its political turning points as backbone of history. On the contrary, everyday life at a slower pace was regarded as showing longer lines of continuation, using the past as an unending continuum. (Hutton, 1981, p. 240) Strongly worded, a change in attitude is an essential condition for innovation. Duby describes the role ideology plays in structuring society, whereas objective studies can create a *"simple, ideal and abstract image of social organization"*. (Duby, 1980, p. 8) Ideologies add a more specific picture of a developing structure and connects the material and mentalities of an evaluating society. (Duby, 1980, p. 8) One could also state that the study of mentalities adds a subjective layer to the objective image of history so far (Gurevich, 1992, p. 150). According to Kühne it is this subjective construction of landscape, which nowadays gains more importance for people and therefore provides incentives for more research by qualitative methods on individual actors. (Kühne, 2018, p. 75)

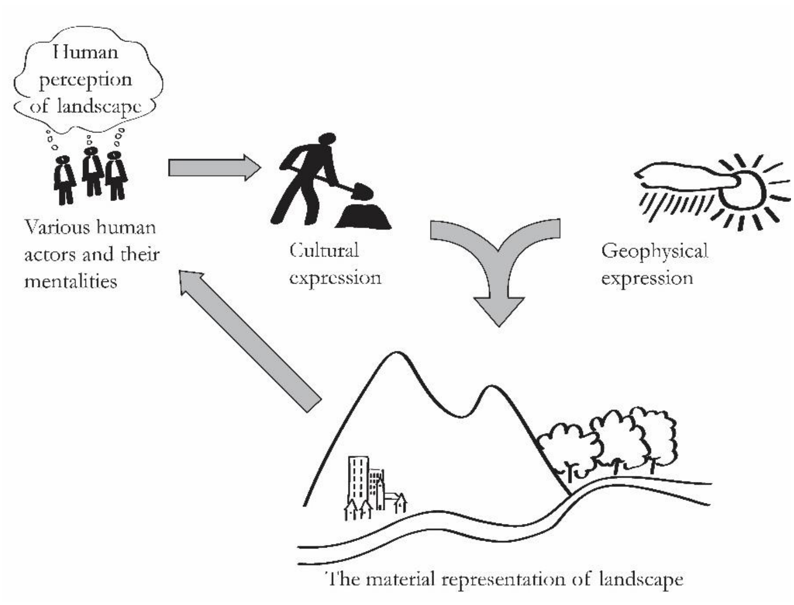


Figure 2.1: Visualization of landscape as it is defined and used in this research. "The material representation and human perception of the ongoing interplay between geophysical and cultural expression, driven by various human actors and their mentalities."

When combining all of the above, a landscape is both a material representation and a subjective cultural perception. (Jacobs, 2006; Ingold, 2004) It is formed by the interplay between geophysical processes and cultural expressions. (Koren, 2015) The cultural expressions are the result of individual actors and actor groups inspired by various mentalities. (Koren, 2015; Samuels, 1979) This research thus defines landscape as *the material representation and human perception of the ongoing interplay between geophysical and cultural expression, driven by various human actors and their mentalities*. (Figure 2.1) The interplay between humans and nature, between natural and cultural expressions have been part of the landscape definition for a long time. In addition to that, the human impression and expression, which is taken into account more and more by participation in spatial development, has to be specified for its (individual) actors and their mentalities.

The perception of flooding has changed over the centuries. Such shifts in perception might even have caused several of the problems we have to deal with nowadays. At this moment, only few minor studies consider why historical dikes have been built. In his study on the Cistercian monks in Frisia, Mol (1992) argues that these monks did not cultivate marginal lands in order to finish God's work on earth. Their clearances during the 12th and 13th century are argued to have an economic incentive. Dutch researcher De Kraker (2017) does not directly go into reasons for dike building, but acknowledges the different effects a flood had on poor populations and landlords, due to different perceptions of these groups towards flooding. Van Dam (2012) also pays attention to the perception of flooding. In her inaugural speech she points out that the number of flood victims were lower than expected, as a result of an alleged amphibian culture. Although, in recent years, more attention has been given to the various stakeholders in relation to flooding, most of these studies are executed in the coastal area of the Netherlands. (Bartels *et al.*, 2016) Studies that have been conducted in river areas hardly take into account various actors and their perception towards flooding, with exception of Dion (1961) in the Loire valley. (De Koning *et al.*, 2009; Mulder *et al.*, 2001; 2002; 2003; 2004; Mulder, 2002; Van de Ven, 2004; Dion, 1961; Schmidt, 2000) A river has been influenced by geophysical and climatic factors, and by expressions of various human actors and their mentalities over the last centuries. In order to study such a complex landscape a combination of the discussed approaches is necessary. Especially in order to develop a method in which human mentalities can represent the values and meaning people give to landscape, and how this leads to cultural expressions in the landscape. How this is applied in this research is described in the next chapter. §3 describes how multidisciplinary sources and methods are combined into an interdisciplinary approach, to study the landscape including the perception of its various actors.

2.2 Flooding in the river landscape

The IPCC defines a flood as *"the overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged"*. (IPCC, 2012, p. 175) Since this research focusses on the Upper Rhine valley, only river floods are taken into consideration. In contrast with tidal floods, rivers do not flood depending on the tide. River floods, depending on the rivers' regime (§4.6), are caused by melting waters and/or heavy rainfall. Because of this, water levels in rivers fluctuate continuously, resulting in low water levels, average water levels and high water levels. Flooding in rivers normally occurs when high water levels are abnormally high, depending on the season and variation throughout the years. We speak of a flood when high water levels leave their natural riverbed and the retention areas in its flood bed, and move into the floodplain. Nowadays, this would mean a dike breakthrough or overflowing of the dike is necessary for a flood. However, before dike construction the difference between high water levels and flooding was less clear. Therefore, contrasting the IPCC's definition, several authors argue that flooding is a cultural concept, which first occurred after the construction of dikes. This change in perception is extensively elaborated on in chapter 4. (Meier, 2005a, p. 265; Rohr, 2016; Groh *et al.*, 2003, pp.16-19) In addition, other causes like barriers (trees, or ice dams) or deforestation might increase chances on river flooding.

Everything humans have performed over the centuries with the intention to protect their lives, their houses, lands and other properties against flooding is considered flood management. This might vary from praying to moving away to higher ground, and from digging drainage ditches to construction of dikes. The actual actions involving construction to redirect water, might as well be considered water management. However, this also includes irrigation or drainage of fields. Water management definitely influences the hydrology of an area, and thus affects flooding. For this reason, it is important to investigate to what extend flood management was considered an effect of water management. Aside of that, embankments along the river are also taken into account as flood management. Embankments are usually meant to diminish erosion, which is often caused by a river with high energy and/or high water levels. The construction of a dike defines the whole scope from the accumulation of soil to building wooden or stone constructions to redirect the water. When we define dikes, it is important to make a distinction between offensive dikes, which aim to gain more (arable) land and defensive dikes, which aim to protect land from being eroded or flooded. In German language, a dike is often referred to as a dam, which might cause confusion. In this research a dike is defined as an earth structure parallel to the river, while a dam is defined as a structure transverse crossing (a channel of) the stream. The '*turcies'* as discussed beneath (§2.3.1) are also an example of dams. In this research, the main focus will be on such dams and dikes, since these are clearly visible in the landscape. Nowadays many dams have evolved into a dike, next to a myriad of contemporary dikes. For that reason, such elevations in the landscape constructed for reasons of flood management are referred to as dikes.

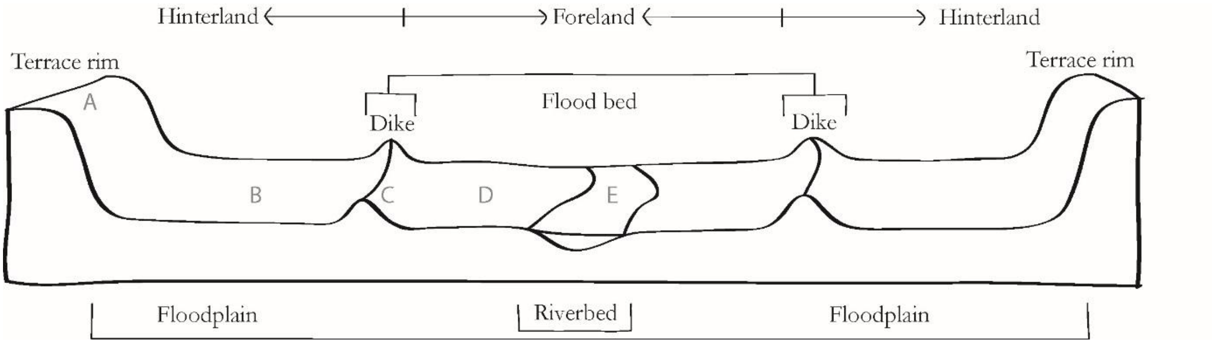


Figure 2.2: Model of the Upper Rhine river landscape including the terraces (A), the floodplain (B) in the hinterlands behind the dike (C), the flood bed (D) in the foreland of the dike and the river bed (E).

A river flows through a river valley, and it flows over a floodplain. The flood plain is the area in which the influence of the river floods is still significantly visible in its soils and geomorphology. This also includes the contemporary flood bed. However, the contemporary flood bed is much smaller than the whole flood plain because width in which the river meandered has been diminished by diking activity. This diking activity has divided the floodplain in hinterlands, which are located behind the dikes and protected against flooding; and, forelands on the riverside on the dike, the contemporary flood bed. (Pleijster *et al.*, 2014, p. 176) The riverbed is the main channel of the river in which it flows with average water levels. Nowadays if the river water levels rise and the river floods, the water rises in between the dikes. It is this flooded area, which is called the flood bed. (Figure 2.2)

2.3 Flooding history in the river landscapes of Western Europe

Rivers have been iconic elements in the landscape and occur already in Roman and Early Medieval writing. How knowledge on flooding in river landscapes has developed over the centuries is discussed in chapter §4. Also in recent decades flooding has increasingly been studied as already addressed in the introduction. Western European rivers have been subject to intensive research over the years. In this paragraph, other big rivers in Europe, the Loire, the Lower Rhine, and the Meuse are studied. (Figure 2.3) These rivers have comparable natural, climatically and cultural circumstances. Thus, some basic understanding on research to historical river flooding and the cultural response to it is provided. The next paragraph then elaborates on this for the Upper Rhine valley.

Figure 2.3: An overview map showing few of the biggest rivers of Western Europe.

2.3.1 Loire

The Loire has an extended watershed, with a flood plain in which nature reigns. (Figure 2.4) Precipitation of various origins can cause stormy and unpredictable hydrological circumstances along the Loire. (Dachary, 1996, p. 53) Despite disastrous floods, the Loire's low water level keeps the public focus on drought as well. Alike the Rhine, continuous dikes constrain the river in a small contemporary flood bed. Dachary (1996) describes this as the cumulated outcome of 100 years of flood prevention by local inhabitants. (Dachary, 1996, p. 47) Fear for devastating floods lays at the base of most of the spatial planning in the area.

Figure 2.4: The Loire valley in France between Gien upstream (right) and Angers downstream (left).

Charlot *et al.* (1996) argues that there is a direct relation between the Loire and the hills of Val d'Orléans, St. Benoît and la Vallée d'Anjou. When high water was expected, the local residents would collect their livestock and leave for these 'unsinkable' hills. By tradition, these people knew that the water could not reach those locations. (Charlot *et al.,* 1996, p. 5) For these farmers the limited safety on nutrient rich lands was better than living in absolute safety on poorer lands. As long as they had natural elevations in the direct surroundings to find refuge during high water periods. Multiple elevated mounds with known history of settlements are located in and around the Loire valley. (Dachary, 1996, p. 47) Sustainable living was hardly possible in the flood plain before the construction of levees and dikes and was restricted to natural elevations. Besides these natural elevations, also some man-made elevations were constructed. These elevations were the first measures of dealing with flooding in the area. However, these are hard to recognize due their ordinary occurrence. (Charlot *et al.,* 1996, p. 5) According to Charlot, the early residents of the Loire valley mainly dealt with erosion and sediment deposition around the river, not specifically flooding. They started to build small dams, so-called *turcies,* in overflow currents. (Figure 2.5) In addition, paths along the river seemed to have preceded dikes. Over time these paths, which became the main routes through the flood plain, got more and more fixated, strengthened and elevated, gradually transforming them into dikes. A flood did not threat the elevated places where people lived, but might have damaged these roads or dikes. As a result, the inhabited mounds in the landscape got cut off. (Charlot *et al.,* 1996, p. 5) This *turcies* only protected empty lands, the peasants on the elevated mounds were not threatened by flooding at all. However, the landowners who own the nutrient rich lands had a lot more to lose. In case of the breakthrough or overflow of *turcies* their income would have definitely been affected negatively. Their landlords had more interest in proper maintenance of the *turcies* than local peasants or servants had. For this reason Henri II Plantagenêt gave home to *hôtes* (non-locals), who maintained the *turcies* in exchange for exemption on serving the army or other feudal duties. (Charlot *et al.,* 1996, p. 6) With help of implementation of foreigners constructing *turcies* and dams, Henri II gained the trust of locals in the flood plain. This process contributed significantly to the power and wealth of the landowners and the royal power in la Basse-Touraine and around Orléans.

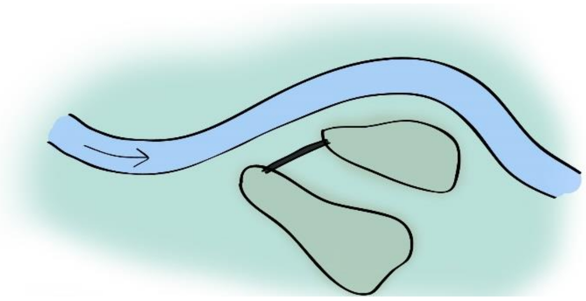


Figure 2.5: 'Turcies' connect elevated mounds in the flood plain. Since turcies are more and more used as roads they are strengtened to dikes.

The constructions of the *turcies* contributed to a shifting perception of the local farmers towards the river, and fear for flooding reduced. This trust was supported by a lack of flooding during the 13th and 14th century. According to Charlot, this was the result of a climatic stable period. Flooding still happened, but mainly in less densely inhabited areas upstream. This feeling of overconfidence lead to neglecting the risks of flooding and settling in more risky places. A similar 'fake' feeling of safety can be recognized during the 19th century and again during the second half of the 20th century before recent flood management measures. (Charlot *et al.,* 1996, p. 6) Every time a *turci* is overflown; people believed that elevating the dam only a few centimetres would be enough to be protected against flooding indefinitely, as also Louis XI argued in 1482. Louis XI expanded the dike-building concept to a larger, but less densely populated area. The *turcies* where not necessary for transportation, and the few attracted people seemed more interested in living along a main road instead of protection against flooding of the river. New dikes mainly resulted in new main transport routes; only around Amboise some new low lands became available due to diking and drainage. (Charlot *et al.,* 1996, p. 6) Dikes did not provide new lands, since they were often constructed after cultivation of the lands. Landowners where hardly involved in dike construction anymore. Mainly royal intervention resulted in dike construction, to improve transportation and trade between cities. The money of traders and the rich bourgeoisie from the cities were essential to safeguard power. (Charlot *et al.,* 1996, p. 7) However, the reduced flood bed needed more space, and dikes were elevated more. Problems got bigger, and the number of floods increased up to the development of modern diking in the 15th and 16th century. *Turcies* were replaced by uniform dikes, and were mainly constructed in order to control the riverbed instead of protecting nutrient rich lands. More and more, dikes had the function to control the riverbed in order to maintain trade in the cities. (Charlot *et al.,* 1996, p. 7) Locals did not feel responsible for dikes as imposed by the cities bourgeoisie, however big floods in the early 16th century increased the feeling that high elevations would contribute to their safety. In the area of Saumar and Angers, dikes were perceived as common constructions. While farmers in the valley between Gien and Tours lack this responsibility due the fact that the bourgeoisie imposed the dikes. This changed when in the 17th century the government of Louis XIII recognized flooding and dike maintenance as a problem. Slowly, the insight both, cities and arable lands, should be protected against flooding. It was even discussed whether several dikes should be removed in order to redirect the rivers course in case of floods. (Charlot *et al.,* 1996, p. 9)

2.3.2 Lower Rhine

One of the most well-known studies on water management is the book by the Dutch Van de Ven (2004): *Man-made lowlands*. In his publication, he gives extensive attention to the central Dutch river landscape, including the Lower Rhine. (Figure 2.6) The Lower Rhine is characterized by its stream ridges and backlands system. The elevated ridges are located along the river, while the lower backlands are slightly further away from the river. Height differences between this levees and backlands can diverse between 0,5 and 1,5 meters. Due to dynamic meandering, this system has become very complex in the central Dutch river area. (Jongmans, *et al.*, 2013, p. 460) The backlands were badly drained and peat could develop there. Development of drainage techniques and a drier climate made it possible to cultivate these lands as well during the 11th and 12th century. From the 12th century onwards, the regime of the river became more and more irregular. (Van de Ven, 2004, p. 73)

Figure 2.6: The Lower Rhine valley and the IJssel in the Netherlands. The historical Lekdijk is located south of Utrecht.

Habitation in the central Dutch river area around the Lower Rhine dates back into the Neolithic period. Due to the dynamic river and changing climatological circumstances many settlements appeared and disappeared in various places. Settlements were mainly found on higher elevated levees, but during period of lower water levels also on the flanks of these levees. The backlands contained more vegetation than nowadays, leading to a more stable drainage of water and a lower amount of flooding. Since the Roman period, settlements have also been proven to be at the levees, actually a relative dense population is suggested. (Jongmans *et al.,* 2013, p. 461) It is said that the small settlements on these ridges actively elevated these levees, using local materials and organic matter. These elevated places are called *'woerden'*, related to the German *'wörth'*. (Jongmans *et al.,* 2013, p. 461) Around 800 AD the Dutch river area was densely populated on the sandy ridges. (Van de Ven, 2004, p. 98) The badly drained backlands were only used during dryer summers for cattle grazing. The main transport roads were located on and between the levees, and therefore are quite tortuous. The parcels are oriented towards these roads and are set up in long land strips from the levee into the backlands, which became better drained over the years. (Jongmans *et al.,* 2013, p. 463)

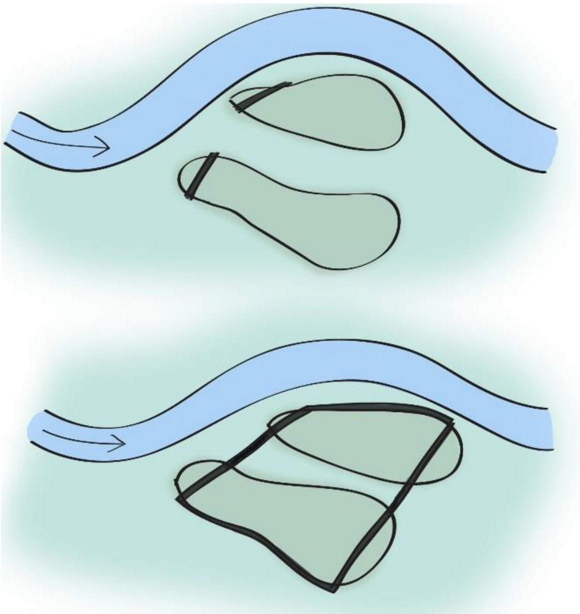


Figure 2.7: In the central Dutch river area, dikes were first built to protect the villages. Later these dikes were connected into circular and linear dike lines. This gave opportunities to drain hinterlands and cultivate them.

From the 11th century onward human activity in the river area increased mainly driven by the construction of dikes, so-called *kades* (embankment) and *dijken* (dikes). (Van de Ven, 2004, p. 72; Lascaris, 2016; De Koning *et al*., 2009) The first dikes where built transverse on the river upstream of the village. In this way, the water should flow around the agricultural fields on the levees and discharged over the lower backlands. Because these dikes redirected water, surrounding villages got into trouble. The barriers pushed the water up, causing higher water levels upstream. For this reason, cooperation in diking was initiated and villages started connecting their levees with dikes parallel to the river. (Van de Ven, 2004, p. 65, p. 91) In the central Dutch river area such dikes were either connected into circles, so-called *ringdijken* (circular dikes), or, around the 13th century, this resulted in *bandijken* (linear dikes) and a new landscape element *uiterwaarden*, what has been called flood bed in this research. (Figure 2.7) During the following centuries people started to drain the backlands. Many measures like drainage channels, embankments and bypasses have been used to manage the water in the central Dutch river area. (Jongmans *et al.,* 2013, p. 464) The reclamations of these backlands started at least as early as 1075, and already in 1300 most of the land in the river area was reclaimed. (Van de Ven, 2004, p. 71) Van de Ven argues that these reclamations where caused by population growth and an increasing demand for grazing ground for cattle, primarily for manure production to improve arable farming. The first mentioned record of a river dike in the Lower Rhine area dates from 1122. The landlords around the Kromme Rijn decided on the dam (the *Lekdijk*) on behalf of reclamations. In the years thereafter, the Lekdijk was constructed and finished in 1150. This did not end the battle against water, the dikes had to be maintained and repaired. (Van de Ven, 2004, p. 74) Van de Ven claims that the first record of a river flood is the breaking of the Noorder Lekdijk in 1233. He argues that high water was not considered flooding before the construction of dikes. (Van de Ven, 2004, p. 41)

The bishop of Utrecht was the overlord of the waterboard during the construction of the aforementioned 12th century dikes and dams. However, he had representatives doing the work for him. (Van de Ven, 2004, p. 79) The emergence of a board deciding on water management issues is unknown, but around 1250 such institutes were documented. (Van de Ven, 2004, p. 78)

Part of the Rhine water is drained by a Dutch river called IJssel, which has a length of about 125 kilometres and is draining into the IJsselmeer. This river can be compared to the Upper Rhine valley, because instead of braiding out on the Dutch delta plain, it cut its way through a sandy plateau. For the IJssel it is said that dike building started around the 11th century. (Bosch Slabbers, 2017, p. 25) In this early dike construction process the landscape's topography was smartly used by connecting the various elevated mounds with sand levees. Short dikes filled the low laying area in between, which in Dutch is called a *gatendijk*. During the 13th century, this diking method expanded to a regional level in which many different actors of the whole region contributed, concluding in a famous historical document, *de dijkbrief van Salland*. This is a charter on dike maintenance indicating that the area had a water board as early as 1308. (Bosch Slabbers, 2017, p. 25)

2.3.3 Meuse

Renes (1995) studied the dikes along the Limburgse Maas (Meuse) in the southern Netherlands. (Figure 2.8) He recognized a lack of research in comparison with the central Dutch river area. The Meuse is only partly diked in a continuous and linear way as is done along other Dutch rivers. Renes states that the variations in occurrence of dikes mostly depends on geological and geomorphological factors. (Renes, 1995, p. 4) The Meuse in Limburg exists of various sections. In the southern section some hilly extensions of the Ardennes can be found, and the Meuse had to cut its way through the valley. Because of the elevated terrace rims, hardly any dikes were necessary. Practically the same can be seen north of Neer, where the Meuse cuts into the Peelhorst plateau. In between these sections with higher banks, a reduction area is located in which the Meuse had space to meander widely and relocate its course repeatedly. This caused very thick gravel layers, making this area suitable for gravel mining. This section of the Meuse was already inhabited during the medieval period, at least the higher parts. In this section, few dikes are built as measure of flood management. Further, downstream the Meuse gradually flattens and becomes wider. As the river starts to meander again, some historical dikes can be found. After passing Mook the Meuse flows into the central Dutch river area of sandy levees and lower backlands. (Renes, 1995, p. 4) Especially the cutting in the terraces and the gravel subsoil make the Meuse valley comparable to the Upper Rhine valley.

Figure 2.8: The Meuse valley in the Netherlands were cutting section alternate with meandering sections.

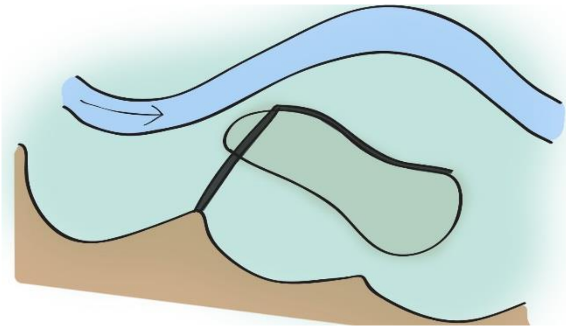


Figure 2.9: Where the river cuts through the terraces 'haakdijken' can be made. Especially since the Meuse's gradient makes the hinterlands easily drained.

Renes shows that at first *'haakdijken'* were built along the Meuse. This had also been the case in the central Dutch river area. A transverse dike upstream of the village was connected with a dike between the village and the river. This protected the village against the river, and lead overflow waters into the lower backlands. Once a village started to dike, other villages had to follow, because the water was redirected or pushed upwards. (Renes, 1995, p. 6; Van de Ven, 2004, p. 73) In the Meuse valley *haakdijken* (L-shaped dikes*)* were still present in the 19th century. (Figure 2.9)The reason was that these dikes where connected to the higher terrace rims instead of circling around the lower backlands. This 'cut' in the flood plain made a parallel dike at the hinterland side of the village unnecessary. Around the islands of Stephensweert and Ohé en Laak U-shaped dikes are present instead of *haakdijken*. This was because the river flowed on both sides of the villages. The western side arm around these villages was dammed with a so-called *inlaatdijk* (overflow dike), so that only in case of flooding the water could pass. This does not explain why the downstream side of the villages have not been diked. Renes argues that this has to do with the gravel soils of the area. This gravel would allow so much seepage water to drain through the soil, underneath the dikes into the area protected by dikes. Especially during flooding. When the dikes were circular, the water could impossibly flow out of the village area. This would cause flooding within the diked village area, causing lots of damage and deaths. Inflow from the downstream side was not such a big risk, because of the gradient of the Meuse. Because the gradient of the Meuse was steeper than for example the Rhine, the water would stay in the lowest and most northern and downstream parts of the village area, hardly reaching the villages. Renes concludes that the dikes were mainly meant to prevent the main course of the Meuse to damage the villages. Nevertheless, numerous breakthroughs show that the interaction between man and the river was not easy along the Meuse. (Renes, 1995, p. 8) Villages located along the Meuse occur in the early medieval period. However, these villages are usually located in slightly elevated places along the Meuse. For example on terrace rims. Dikes are first mentioned during the 14th and 15th century. (Renes, 1995, p. 8)

Altogether, in all the river areas discussed, people lived on elevated mounds. Regularly such mounds had been connected by *turcies*. In the Netherlands, such dams have been constructed as well, for example *inlaatdijken* and *gatendijken*. Continuous strengthening of these dams reduced overflowing and made that the lands behind the dams could be taken into agricultural use. This led to a change in perception on overflowing of these dams. High water used to be considered a natural event. When a dam overflowed, or later a dike broke through, it was considered a disaster. Whether this has to do with ownership of damaged land and other properties like in along the Loire remains unclear. The gradient of the Upper Rhine can best be compared with the Loire. Settlement on elevations can therefore be expected. Since the Upper Rhine has cut its way through terraces alike the Meuse, there should be opportunities for *haakdijken*. The less steep gradient however might demand for circular dikes like along the Lower Rhine. However, the Upper Rhine's soil contains more gravel than the Lower Rhine. According to Renes this makes the Upper Rhine valley unsuitable for such circular *ringdijken*. Altogether, it could be stated that these other rivers mainly provide an indication on what to expect. The numerous differences however make it impossible to sketch a hypotheses what to find.

2.4 Flooding history of the Upper Rhine valley

The Upper Rhine valley, as it is an important region in Germany and the France Alsace, has been studied repeatedly from many different points of view. The regionally structured history by Febvre (2006, originally from 1931), provides a insight on the Rhine and how live along the Rhine was generally structured. Together with Tümmers (1994), they provide a severe starting point on the Upper Rhine's prehistory to the current day. Additionally, one could used the more recent written Abt (2005). Both authors focus on the cultural history, but especially Tümmers provides insight on the geophysical landscape of the Upper Rhine as well. In addition, Blackbourn (2006) and Cioc (2002) provide a broad and historical study on the Rhine. Blackbourn even mentioned the relation between man and nature in the river landscape as a main theme. However, he focusses on the more recent rectifications of the 19th century. Cioc also focusses on contemporary history and especially the negative effects mankind has on the river. In order to understand the geophysical landscape of the Upper Rhine, Galluser and Schenker (1992) have provided an understandable and visualized study of the Upper Rhine valley. Additionally a recent study by Holzhauer (2013) provides more depth, although his focus lays mainly on the sandy terraces and less on the flood plains. For the whole Upper Rhine valley, also Schmitt *et al.* (2016) should be taken into account. His geophysical studies focus on Upper Rhine valley south of Strasbourg. Also for climate research by Glaser (2008), Glaser and Stangl (2004), Himmelsbach (2012) and Behringer (2007) the southern part of the Upper Rhine valley has the main focus. Nevertheless, these researchers provide significant attention to flooding. On flooding in Germany, Meier (2005b) and Reinhardt (1983) might be additionally useful. Most of the research focussed on cultural history is pretty dispersed in several riverine regions as well. Damminger (2002) provides some insights on the Kraichgau and the northern part of the Upper Rhine valley during the Merowinger period. Geiger *et al.* (1991; 2010) provides an overview for the history of the Upper Rhine valley of Rheinland-Pfalz. For the Alsace, Bonneaud (2015) has written an overview history with special attention to the landscape. One of the few studies concerning at least both banks of the Upper Rhine valley following on Febvre is Musall (1969) although his study is limited to the settlement history between Karlsruhe and Speyer. An understanding of the various important actors in the Upper Rhine has also been a process of gathering information from many sources. Another important publication is Stenzel (1975) who wrote and overview on deserted villages. Rösener (1985; 1992) provided in depth insights on the interrelations between actors. Zotz (2003) additionally provided some more specific knowledge for both worldly actors and actors related to Christianity, especially for the more southern part of the Upper Rhine valley. Nevertheless, Both Rösener and Zotz have written the main scope of their repertoire during the 20th century. Several theories on settlement history and actor interrelations are debated repeatedly by Schreg (2006; 2008), Schröder (2016) and Rösch & Tserendorj (2011). In should be taken into account that most of these authors mainly debate theories on settlement development in the hilly areas surrounding the upper Rhine valley. Despite the extensive publications on local history by Ruf (1994) and Müller (1994), more specific literature for the case studies in Speyer and Ottersdorf are elaborated on in chapter §7 and §8.

For the Upper Rhine valley, a specific flooding history, like Visscher (2003) published on the High and Alpine Rhine in Suisse, is non-existent. Schmidt (2000) wrote a chapter on the Rhine in his book: *Hochwasser in Deutschland vor 1850*. Although he notes many of the water management measures along the Rhine over the centuries, it is beyond the scope of his book to include the perception of flooding and the various involved actors. In addition, Rückert (2005) notes some flooding history of the Upper Rhine, even including some archival sources. Besides these two works, flooding history has at most been a secondary subject in Upper Rhine studies. Studying the relevant actors as Schreiner (1995) did for Lower Rhine in Germany, has not been done at all for the Rhine valley. In order to fill this gap in knowledge, one of the main goals of this study is to reconstruct a flooding history of the Upper Rhine valley. With this historical overview, it becomes possible to get further investigate the arguments on flood management, and how the perception of various actors might have been one of the dominant factors in decision-making. Thus, this research aims to overcome the lack of knowledge on the flooding history of the Upper Rhine valley, and, taking this historical basis as a starting point, to conduct a research on the perception of flooding by various actors over the centuries.

3 - Sources and methods: a multidisciplinary inventory

3.1 An introduction to multiple disciplines as resource for interdisciplinary research

The study of dikes, and flood prevention in general, is positioned at the crossing between natural sciences and humanities. Although, it would be possible to study dikes from one singular discipline, this research aims to place flood management in its environmental context of landscapes. (Meier, 2012, p. 504) One of the main difficulties of an interdisciplinary approach is the combining of sources from multiple disciplines. Meier explains interdisciplinarity as social behaviour of academics, although additionally the cooperation between various disciplines can strengthen each other as well.

Data within a single discipline should be evaluated whether it meets the standards of its field. Reliability and validity are to be checked. Additionally interdisciplinary research provides ways to check the generalisability of a study. The interpretations of data must be validated in accordance with data of other fields. (Meier, 2012, p. 511) If data of various fields fit together, they form a cluster of arguments. Such clusters not only strengthen argumentation, they also provide new connections. Reasons for change can be discovered that are impossible to see from the single field of science. Especially sources from the fields of humanities and natural sciences can provide additional value to research. As chapter 2 already discussed such studies are accommodated in environmental geography and landscape studies. (Gebhardt *et al.,* 2011, p. 76)

This research developed an interdisciplinary landscape study that includes geophysical data on the landscape, but also cultural developments and a history of mentalities. Many various sources and methods have been used to gather data. Since this includes sources from both humanities and natural sciences both the author and the reader are expected to have a basic grasp on several scientific fields. For that reason, this chapter introduces the multiple disciplines and explains how they have been used and combined in this research. In addition, this chapter provides a brief critique on the source and data and how this is processed within this research.

3.2 Geological and soil maps

Dikes are usually made of local materials. It is important to gain insight in the variety of soils in the Upper Rhine Valley. The available soil maps usually tell something about hydrological circumstances and ground water levels of the area. Additionally, they contain information on how various soil layers overlap and are deposited on top of each other.

German soil data is publically accessible at geoviewer.bgr.de (visited at 22.10.2018). Furthermore, local soil maps from 1986 are used: BK25 6616 Speyer and BK25 7114 Iffezheim. The soil data of the Alsatian side in France is extensively reported in guides in accordance with the soil maps of the Alsace. A division is made for the regions: *Ried-Nord, Collines de Brumath du Kochersberg et du l'arriere Kochersberg* and *Outre Foret* (2005). (Party & Muller, 2005a; Party & Muller 2005b; Lebreton-Thaler, 2001; Skrzypek *et al*., 2007) The relation between soil and land use in the Alsace has additionally been derived from Bonneaud (2015).

Soil maps provide information on the main materials (gravel, sand, loam, clay or loess) present in the soil and its vertical order. In addition, more detailed knowledge, like grain size, provides for example information on the way the soil has been deposited or its water permeability. Furthermore, soil types provides an indication of possible land uses. For instance, loess soils have often been cultivated earlier than more loamy soils due to technological possibilities. The shape of specific soil areas might contain information on its history. For example, linear and curved areas might indicate former river arms, especially when they are hore humid than their surroundings, or when they contain materials with a bigger grain size in comparison to its closer environment. Such former river channels cannot easily be derived from other data. Thus, soil data might provide the crucial data necessary to reconstruct the historical landscape. The grain size of the sediments in river landscapes contain information on the rivers energy when depositing these sediments. Bigger grain sizes are deposited during phases in which the river had more energy, probably during a flood or a period of high water. It is also relevant to look at the sediments higher up in the surrounding mountain areas. Finally, the soil information also provides information on nutrient richness of soils, which gives clues for land use and the best places to settle or to develop agriculture.

The use of a soil map might be criticized because modern maps often do not contain soil data underneath villages. Villages and cities have been expanding enormously over the last decades, making a lot of soil information hard to access. Another point of critique is the process of erosion, which has severe influence on distribution of soil, especially in a river area. Erosion dislocates material from one place and overlies sediment at other places. This implies that over the last decades and centuries a lot of soil material has been taken away by rivers and relocated it to places far from their former place. Erosion has definitely caused a loss of valuable information by displacing materials. Therefore, soil data must be interpreted carefully and during examination of soil, it should be considered that the top layer might not have originated there or that the top layer may have been eroded. When such erosion processes are recognized, the quality of the information must be analysed and the loss of knowledge considered. For example, it is important to realise the difference between a sandy and a gravel island, the difference being caused due to variations in the rivers flow speed at the moment of sediment deposition. Thus soil data has to be interpreted carefully.

3.3 LiDAR-data

In flooded areas, an elevation of just a few decimetres can make the difference between arable or not arable land, or the difference between land high enough to build a house on, or not. Therefore, it is of importance to look at the Upper Rhine Valley through the perspective of elevation. The digital elevation model in France and Germany is based on LiDAR-data. LiDAR stands for Light Detection and Ranging (LiDAR) and uses a laser to measure the distance between the target surface and the sensor. By gathering this information for a larger surface, normally done via airborne remote sensing, a high-resolution depth map can be created. Nowadays, LiDAR can be accurate up to less than one meter. (Sittler *et al.,* 2007, p. 540) For this research several datasets are used, which are illustrated in figure 3.1. The Landesdenkmalpflege of Baden-Württemberg provided access to their dataset containing LiDAR-data for the area east of the Rhine between Kehl and Mannheim. (I in figure 3.1) This data is projected in DHDN Gauss Kruger Zone 3 (EPSG:31467). On the western side of the Rhine, the Alsatian datasets are provided for by open access. (3d.strasbourg.eu; Direction Départementale des Territoires (DDT) Bas-Rhin Service Sécurité Transport et Ingénierie de Crise (SSTIC), Unité Système d'Information Géographique (SIG); lvermgeo.rlp.de/de/geodaten/opendata) The set around the Eurometropol Strasbourg (MNTCUS_i EMS 2015/2016) has an accuracy of 50 centimetres horizontally and 20 centimetres vertically and is projected in RGF93 – Lambert 93 CC48 (EPSG:3948). (II in figure 3.1) The dataset north of the Moder (Mode_Bande_Rhénane_Nord) has an accuracy of 30 centimetres horizontally and 8 centimetres vertically and is projected in NTF (Paris)RGF93 / Lambert Nord France-93 (EPSG : 27561). (III in figure 3.1) No detailed data was available for the region of Rhineland-Palatinate. Therefore, this research only used the open access *Digitales Gelände Model* (DGM1), which has an accuracy of 20 meters horizontally and 10 centimetres vertically and is projected in ETRS89 UTM zone 32N (EPSG:25832). (IV in figure 3.1) However, a dataset with the same geographical projection and an accuracy of 30 centimetres horizontally and 16 centimetres vertically has been provided for the case study area around Speyer. (V in figure 3.1) In order to be able to connect these datasets, they all have been re-projected to WGS 84 UTM Zone 32N (EPSG 32632) projection.

In this research, the LiDAR-data has at first been used in an overall scan in order to find linear dike structures. Later in the project, the LiDAR-data is used in order to reconstruct former Rhine channels within the case studies. Moreover, during the whole project, the data has been used as a valuable source in order to interpret the elevation villages, fields, and dikes have in relation to their surrounding lands and the river Rhine.

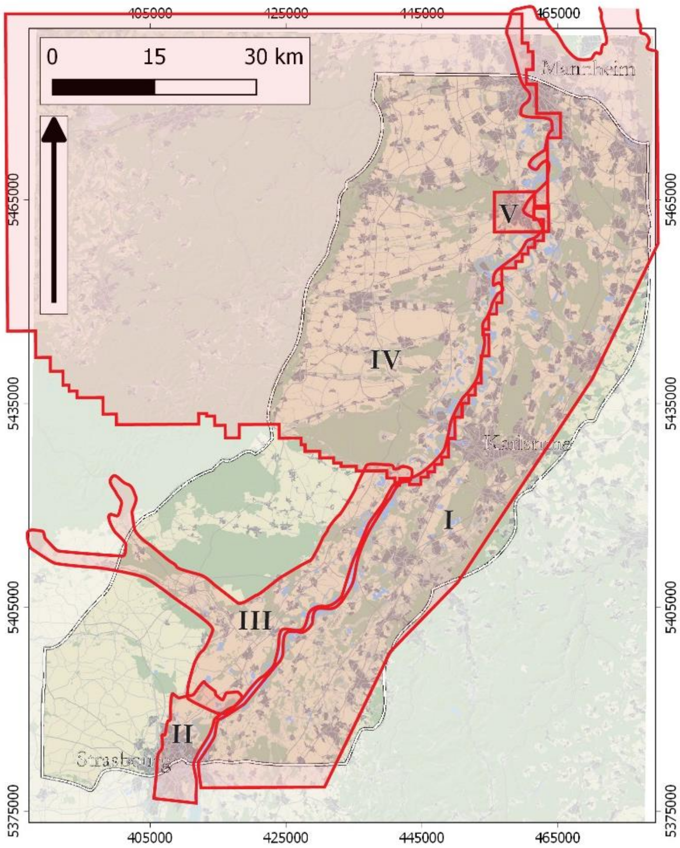


Figure 3.1: Map with borders of various LiDAR datasets (I:Rheintal_DGM ;II: Eurometropol Strasbourg; III: Moder_Bande_Rhénane_Nord; IV: DGM1_rlp; V: DGM1_2km_Speyer

The biggest difficulty of working with LiDAR-data in a river landscape is the descending landscape that characterizes a river landscape. The river section studied in this research descends about 46 meter over the studied 130 km section, as follows from the LiDAR-data. Therefore, at least 46 colours are necessary to make elevations of 1 meter visible in a depth-map of the area. Unfortunately, this 1-meter accuracy is not accurate enough, and 46 colours make a map too complex to interpret. Therefore, a solution is created by modelling a relative elevation map, in which the elevation relative to the nearest river level is shown. This model makes it possible to see how many decimetres the land was elevated above to water level. At one glance, it becomes clear which part of the land is in danger of flooding when the water level raises one meter. However, these simplifying recalculations bring inevitably new inaccuracies. For example, the nearest river height is modelled into a straight line from the river at Strasbourg to the river at Mannheim. Meanders thus are not taken into account in this model. (Figure 1) It should also be taken into account that the LiDAR-data is gathered during recent years and does not indefinitely show the elevation levels of former times. Both natural and human factors can cause changes in the surface and its elevation levels over time, especially in a dynamic river landscape. (Mlekuž 2013, p. 100) Another, more common critique on LiDAR-data is the influence of buildings and trees causing deviations in the depth-map. Often these deviations are erased. Nevertheless, this erasing process has some weaknesses like missing buildings

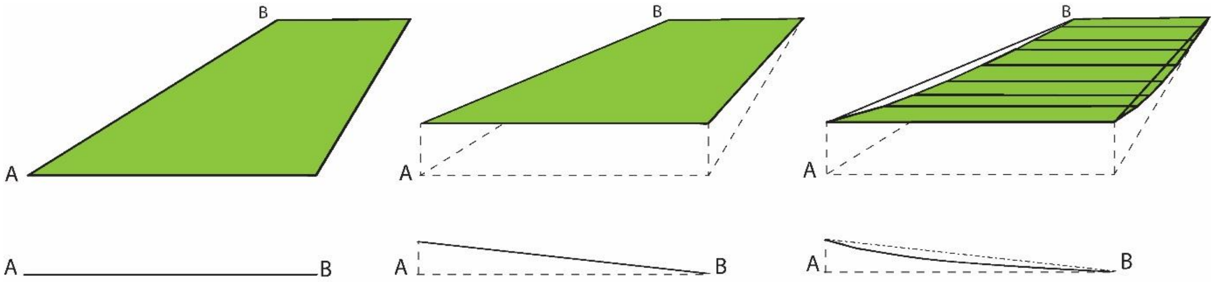


Figure 3.2: Elevation data, always needs a reference height, in this case the green field. The leftermost picture shows the horizontal flat surface, as model for LiDAR-data which provide height in relation to one certain point per area (country) resulting in the same referencce point for the whole area. The picture in the middle shows how including a slope would tilt this surface modelling the slop of a river landscape. The picture on the right is the result of putting in more detialed information on the varying gradient of this slope. This resulted in a more accurate model of the slope in a river landscape. This made it possible to develop a height map relative to the river slope.

or thick grass fields. (Hesse, 2010, p. 369; Sittler *et al.,* 2007, p. 540) In the case study of Ottersdorf (§7) a 'gap' in the LiDAR-data is caused by the modern Mercedes factory and therefore is refilled by using existing coring data to reconstruct the elevation in this area from the period before the factory was build. (Boreholemap.bgr.de) Finally, it should be noted that LiDAR-data as it has been provided to us in raster data, which means that it is only an approximate model of the real elevations in the area.

3.4 Electrical Resistivity Tomography and Corings

After preliminary research and field explorations, the most probable places for historical dikes and former river channels were identified. Once a spot was selected, geo-electric resistivity measurements have been conducted. Electrical Resistivity Tomographies (ERT) are a low invasive geophysical method used to determine apparent electrical resistivity (unit Ωm) by feeding direct current into the subsurface. A Geotom 200/100 RES/IP multi-electrode system from GEOLOG2000 has been used. This system automatically switches 100 electrodes in a four-point arrangement with preselected configurations in series and produces a vertical 2D pseudo-section of the subsurface. Whenever the geo-electric resistivity measurements provided promising results, and in order to calibrate the geophysical data by comparing them to the sedimentology, supplementary drill cores were taken. (Conijn *et al.*, in press)

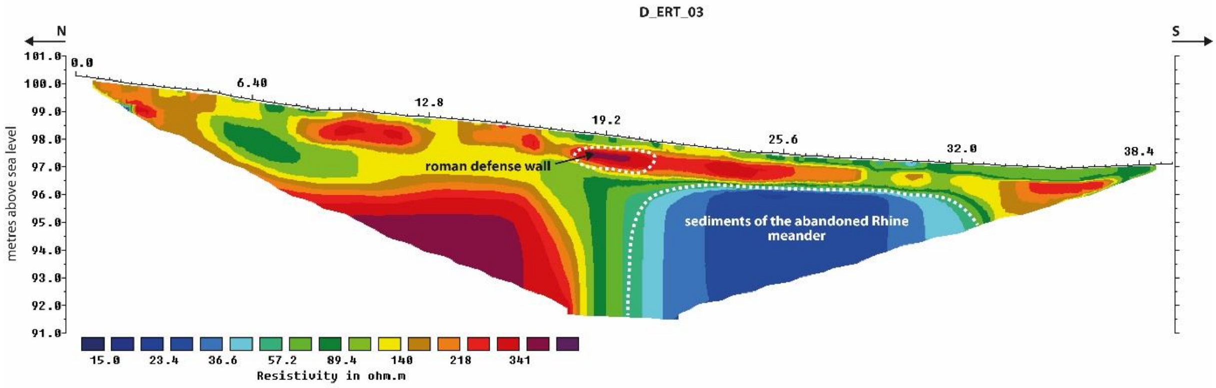


Figure 3.3: An example of ERT result. Darker red areas indicate high resitivity, and more blue areas indicatie low resistivity, possibly caused by or smaller and tighter packed up sediments.

Sampling via percussion drilling - or coring - into the ground provide undisturbed soil samples within a liner tube of 5 cm diameter. Such corings are done in vertical sections of one meter, but can go as deep as six or more meters, depending on the soil features. In the most promising locations of the conducted geo-electric lines, three corings were performed. One on each side of the potential dike and one on top of the dike, vertical through its core. In the laboratory, the pipes were completely opened for a more detailed research.

Besides a detailed sketch of each coring, organic materials are collected for ^{14}C-dating to infer on the age of the sediments and – probably – of the dike. The corings on both sides of the dike should show several variations in soil material, since, on the riverside, fluvial sediments like gravel and sand continued to be accumulated, while, on the diked hinterland, an anthropogenic or humus layer, depending on the land use, could be expected on the surface. By lining up the soil profiles along the ERTs (corrected in topographic height), they provide a detailed stratigraphy without heavily disturbing the soil. Additionally, grain-size, colour and mineral studies can be carried out to collect more information about the origin of the sediments. (Conijn *et al.*, in press)

The combination of ERT measurements and corings are hardly invasive on the research area, which is especially in nature protection areas a valuable asset. While the ERT produces extensive sections through the determined area, the corings supplement these sections with information about the actual soil substance. Nevertheless it is important to keep in mind, that a dike is a large scale object and these methods generate comparatively only a very small amount of data. For this reason, these methods are only being used in the explorative phase. The ERT and corings in Ottersdorf have provided a good indication where to put up the archaeological excavations (§7.4.2). In Speyer, time and money for an excavation lacked, but organic matter in the corings provided some dates for the sediment layers deposited in a fluvial way (§6.4.2). A *Schlumberger* configuration was used, because it has a low amount of distortions and is well suited for recognition of horizontal layers. (Holzhauer, 2013, p. 105) With the additional corings a realistic vertical sequence of the layers was possible. The combination of these two methods provide the best preliminary work without bigger disturbance in the soil. These findings will be elaborated on in the laboratory by means of a magnetic susceptibility, a grain size analysis and ^{14}C-datings.

3.5 Archival sources

Societies have been keeping written records since many centuries, especially for administrative purposes. Much of these administrative and juridical documents are nowadays preserved as archival sources, which provides valuable base of knowledge on historical times. Early records from around the 8th century are known from high medieval collections. Starting from the 12th and 13th century onward, more and more sources have survived over time. As for the 14th and 15th century, there are enough sources to connect them in narratives. From the 16th century, the number of sources increases explosively that a selection of relevant sources has to be made in order to do research with archival sources.

For the Upper Rhine area various monasteries have left records of land donations: the monasteries of Weißenburg, Lorsch and Fulda. (Glöckner & Doll, 1979; Glöckner, 1936; Minst, 1972) These sources regularly contain the first records of villages and therefore form a valuable source in the development of settlement. Often the number of farms or lands, workers, or goods that are donated from some local landlord to the monastery is written down as well. During the high medieval period, many fake charters emerge. It goes beyond the scope of this research to check every charter concerning its originality, but the issue of more recent charters falsified to be 'ancient' should be taken into account. Starting from around the year 1000, more and more charters are saved, not only containing donations of land, but also juridical correspondence or conflicts. This information is oftentimes quite specific and related to the regulation of tax goods or land transfers, providing a valuable insight on land ownership and land use, and thus on spatial components of society. Most of the settlements existing in these centuries have a few records. How important a village or city was also influences the numbers of records available, as, for example, could be seen from the difference in the amount of records for Selz and Ottersdorf. From the 15th and 16th century several tax books, the so-called '*Lagenbucher*' or '*Berainen*' have been preserved. These books contain an enumeration of fields and lands for which villages had to pay taxes. For the purpose of this dissertation these sources are very valuable since it describes the village's land possessions very precise. Since these tax books contain names of roads and fields, it can be reflected on later maps. A 15th century map of the village can be reconstructed as is done by Trachet. (zwinproject.ugent.be) Multiple villages in the Upper Rhine

Valley have such tax books. In this research only the oldest available and most readable books of the *'Rieddörfer'* are used in the case study of Ottersdorf (§7). (GLA-K/66-8383, 1472; and, GLA-K/66-8384, 1511) The archive in Karlsruhe also has an extended collection of historical maps, on late medieval juridical cases, on villages, and on Rhine constructions of dams and bypasses. These maps have all been collected, digitalized and georeferenced in order to be combined with other sources. In some of the older maps, it is important to search for the archival description in order to clarify the purpose of the map. For example, the planned dike construction from 1590 between Au and Neuburg. (GLA-K/229-3032, 1590) The further use of historical maps from the archive is described in the next paragraph (§3.6), in which the use of historical maps as a source is discussed.

Flooding and other climatological observations are quite commonly mentioned in archival sources and this topic has been studied extensively. Therefore this research can resort to a wealth of secondary literature on climatological observations (i.e. Alexandre (1987), Weikinn (1958), Gotschalk (1971), Buisman (1995) and the online project of tambora.org (2019)).

In many historical studies, available and qualitatively sufficient sources are taken as starting point. In this study however, the locations are taken as starting point, considering the presence of dikes (§5.1). In this research the two villages of Speyer and Ottersdorf are focussed on. In the case of Ottersdorf, local historian Franz Ruf has done an extensive amount of work in researching and understanding the available archival sources. These are described in a narrative form in his publication. (Ruf, 1994) Because Ruf already collected most archival sources, the time investment and low chances on new information diverted the focus to the combination of other sources and methods. It is also important to understand that the archival sources are hardly ever made for the purpose of reconstructing the past. Most of the documents are created for administrative purposes and should therefore be carefully read. Another point of critique on archival sources is the readability of the sources. Knowledge on palaeography and former handwriting is often necessary to interpret a source correctly. Even then, some words are open for interpretation. Within this study the transcribed version of the *Lagenbucher* are corrected with known field names and person names from the book by Franz Ruf in order to gain better understanding of the source. Although this gave the understanding of the *Lagenbucher* as an important impulse, it must be taken into account that Ruf used the same kind of sources for his publication, and thus failures might have been repeated. Therefore, the information from archival sources should be studied very carefully and critically and should always be aimed to cluster their arguments with arguments from other sources.

3.6 Historical Maps

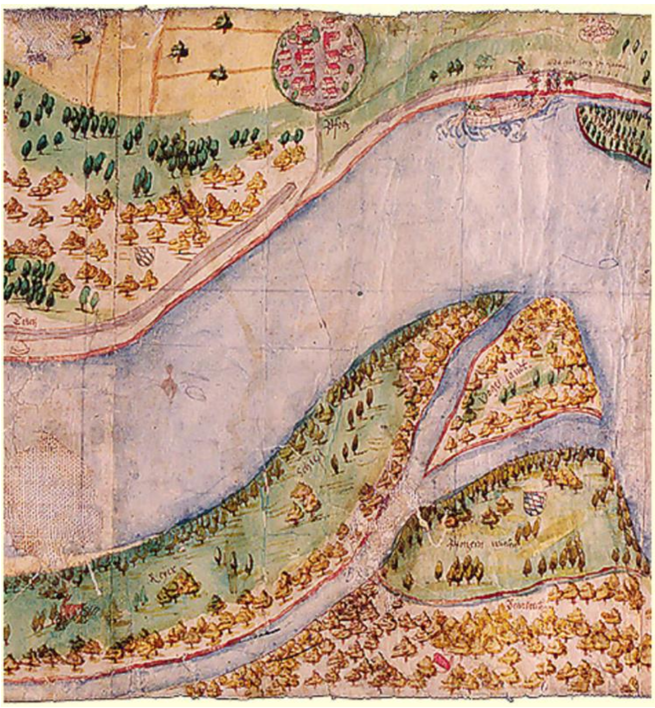


Figure 3.4: Wilhelm Besserers Rheinstromkarte from 1595, section Pfotz.

The spatial variant of archival sources are historical maps. Maps are a visualization of a space and are therefore one of the most valuable source in historical geography. However, they often have descriptions coming along, which can be interpreted as an archival text.

Although few incidental maps like drawings are known from earlier periods, it could be said that mapping first starts in the 15th century, as it does in the Rhine Valley as well. (Musall, 1981; Musall *et al.,* 1986; Sabala, 1997) This stretches the historical time-span as provided by scientific measurements and topographic mapping with several centuries, since this originates in the 18th century (Zlinszky & Timár, 2013, p. 4598) In the 15th century mapping started with big overview maps containing mostly the bigger towns and iconic landscape elements like mountain ranges or big rivers like the Rhine. From this period onwards, bird's-eye perspective drawings of cities also add some spatial knowledge. Famous cartographers like Martin Waldseemüller (1513), Sebastian Münster (1550), Daniel Specklin (1576) and Mathias Merian (1644) made early maps, picturing the Rhine and its surrounding villages. These maps only show town names, few also show whether the Rhine is braiding or meandering. In 1595, Wilhelm Besserer produced a very detailed bird's-eye perspective of the Upper Rhine, following on his journey by boat on the Rhine (Figure 3.4.2), picturing the section from Beinheim to Mannheim. (Große kurpfälzische Rheinstromkarte von Beinheim bis Phillipsburg, 1595; GLA-K H Rheinstrom Nr. 19; Musall *et al.,* 1986, p. 118; Schäfer, 1974, Beiwort Karte I,3) This drawing by Besserer was aimed to produce a juridical base map in order to follow up *Rheinprotokolle*. In this period also other juridical eye-witness maps provide some detailed maps of the region, some of them including the Rhine (Illingen, 1628 (GLA-K H Illingen 8); Figure 3.5) or even early dikes (Au and Neuburg am Rhein, 1590 (GLA-K H Baden-Kurpfalz 1). (Schwarzmaier, 1986, p. 21) These maps usually contain several field names, borders, and landownership information. From the 18th century onward maps contain more detailed information on the landscape oftentimes in the wake of military campaigns. These maps contain information on villages, land use, important infrastructure like river crossings, but also moors, tributary streams, and mountains. Mapmakers, as for example Broutin (1733), Cassani (1744) and von Schmitt (1797), made extensive surveys in order to produce their maps, often by the triangulation method, which made maps more precise than before.

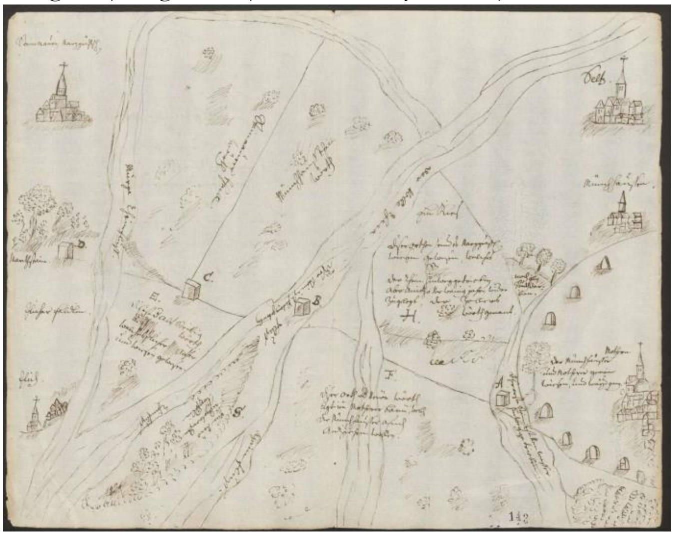


Figure 3.5: The juridical map from 1628 depicting the border dispute between Münchhausen, Mothern and Illingen

With Napoleon's army conquering Europe during the early 19th century, more detailed maps were produced in order to structure tax payments. These so-called cadastral maps are still the base for contemporary land ownership data in Germany at the *Landesvermessungsamt*. Maps since this period are therefore more accurate, mostly due to new measuring technologies like triangulation. (Neumann, *et al.,* 1986, p. 15) These maps show on a detailed local scale every parcel and corresponding records which contains information about the size, the use, and the owner. Additionally, these maps also contain information on fieldnames and infrastructure. Around the same period, detailed maps of the river Rhine were produced, commanded by the famous military engineer Johann Gottfried Tulla. These maps functioned as a starting point for the 19th century Rhine rectifications. This extensive engineering project demanded as much detail as possible on the river and therefore, the most exact pre-rectification maps are produced in the early 19th century. These maps, however, were only published many years after fabrication. (Rösch, 2009, p. 248) These early 19th century maps often contain an enormous number of field names and provide an insight in the land use of those days. In addition to these maps, the hydrological Rhine survey of 1867 is used in this research because of its data on flood plain, river depths, and flood levels before the construction of the dams at Iffezheim and Gambsheim (Der Rheinstrom und seine wichtigsten Nebenflüsse, 1889). For this research, later maps are mainly used in order to locate earlier pictured objects in the contemporary landscape.

Since the 19th century Rhine-rectification has changed the course of the Rhine, historical maps are essential in order to reconstruct its course before the rectification. Additionally, former land use becomes visible, which might give some indication on the hydrology of the fields. For example, too wet lands would not be used as fields but might have been used as grasslands or forests. The third aspect taken from historical maps are the field names, which are discussed in more detail in the paragraph on toponymy (§3.9). (Reinhard, 1986, p. 4)

Historical maps provide a lot of information but should be interpreted very carefully. Historically, maps where not as precise as they are now and quite often, some distortions, displacements and scale irregularities might have occurred. (Mapanalyst.org, 2018) It should also be taken into account that traveling in former times was not as easy as it is nowadays, and cartographers might not even have been to every location they have mapped. Copying happened more regularly in those days. For this reason, arguments derived from historical maps should be clustered with other sources in order provide a scientific reliability. (Zlinszky & Timár, 2013, p. 4598)

Another important aspect is political perspective of historical maps. The questions: "Who is the cartographer?", "Who is the client?" "What is the purpose of the map?",the questions of context, are important for an intrinsic grasp of the map. It provides valuable insights on the meaning of land, landownership and actor interaction in the area. In order to make sure that the maps used in this dissertation are of reliable quality, maps of local cartographers are used when available. Local cartographers are more likely to have visited the mapped area, or at least might have had contacts in the area. In addition, the dating of a map should be taken carefully since surveys often took time (up to several years) and therefore mapped information might have been outdated already before publication of the map. (Zlinszky & Timár, 2013, p. 4599) The inaccuracy of historical maps should always been taken into account, but in order to reduce the number of misinterpretations the historical maps are geo-referenced in GIS as accurate as possible. This gives a general idea on where the flaws in a map are located and how accurate a historical map is compared to current standards. In addition, geo-referenced historical maps must be interpreted carefully since they do not provide exact geographical coordinates, only approximate locations. (Mapanalyst.org, 2018; Zlinszky & Timár, 2013, p. 4599) Most of the maps used in this research are publicly accessible online, for example by the website of the regional archive in Karlsruhe (landesarchiv-bw.de, *Findbuch H*). However, a visit to the archive of *Kartensammlung* at the Institute of Geography at the University of Heidelberg and the *Generallandesarchiv* Karlsruhe provided even more original historical maps.

3.7 Archaeological methods

One of the possible reasons that diking is first known from is the extensively increasing number of written sources from the 12th century onward. To get to know whether diking emerged before, it is necessary to study dikes in the field. However, many historical dikes are not suitable or accessible for fieldwork. This is discussed in more detail in §5.3. When a dike is still visible but not in use anymore, for example along a former channel, an archaeological survey can be executed. Usually in prehistoric settlement archaeology, an excavation can provide information on four topics: topography, form, function, and construction. (Eggert, 2001, p. 74) Dikes are part of the topography of a village and therefore provide information about the form and function of the village and its lands. The function of the dike seems clear: to protect the land from high water levels. However, the dike's function in local water management should be studied in more detail, as should the aforementioned (§2.2) nuance of offensive and defensive diking, to understand the settlements land use. The construction of the dike might clarify its function or might provide information on the used materials and possible knowledge networks.

Since not all of the selected case studies were suitable for an excavation (§5.3), within this research only the dike near Ottersdorf was excavated. This excavation (§7.4.3) had two main goals: 1) making a soil profile of the dike construction and its relation to the fluvial sediments, and 2) search for materials to date the dike (findings or organic matter), in order to put the dike in its contemporary and local context.

1. Making a soil profile was necessary in order to study the historical sediment deposition of the area. Variations between the soil layers can occur in colour, consistence (including grain size) and enclosed elements like roots or corrosion marks. Unfortunately, in this case such soil transitions had become a bit vague over the years. Finding a defining border between various layers was in several cases impossible to do by eye. Scratching the soil with a trowel was necessary to define the border in such cases. On top of that, the weather made it even harder to define these borders by shifting from sunny to severe rains in less than a few minutes, changing both the colour and the structure of the sediments. Aside of these inaccuracies, the human perception might also have influenced the drawing part, since both measuring and drawing have been executed with precision of the human eye. The measuring accuracy should be around 1 cm, while the drawing accuracy lays around 0,5 cm. In addition to the drawings, Justin Schmidt has made photographs of the profiles. It was also impossible to picture the excavated section at once, because it was around 10 meters in length. Therefore, the pictures had to be merged together in a collage, leaving possibilities for small inaccuracies. Due the limitations of excavation in a nature protection area, the ditches were no broader than 1 m and because they were over 1 m deep, it was impossible to picture the profile from a right angle. For this reason, the photographic collages only function as support to the drawings (figure 5). In addition, the archaeologists have described all the defined soil layers. Everything on form, colour, consistence and enclosures were described. In addition to these subjective perceptions, the Munsell soil colour charts were used as a reference. (Renfrew & Bahn, 1991, p. 203)

2. The second goal of the excavation was to get an idea how old the dike actually is. It should however be taken into account that due the dynamics of a river landscape, artefacts might not be located at the place where they originated. They might have been eroded from one place and deposited at another place. For this reason among others, reconstructing a rivers course could be valuable, because of their perpetual change of course. Settlements tend to be built nearby rivers for transport or water purposes. (Renfrew & Bahn, 1991, p. 202) For the excavation in Ottersdorf, also a chronological stratigraphy of the area's fluvial morphology was made (§7.2.1), in order to be able to construct a relative chronology of the river over the centuries, in which our dating should fit. (Eggert, 2001, p. 154) Bartels described seven methods for dating a dike: a) written sources; b) historical maps; c) tree-ring dating; d) ^{14}C-dating; e) auto-dating; f) coins; g)

other objects like ceramics, glass, metal etc. (Bartels *et al.*, 2016, pp.511-512). The archaeological excavation has been conducted as an addition to the written sources and historical maps. These methods were included in the preliminary research. Since no datable artefacts have been excavated, the possibility of 'auto- dating' by coins and other objects is ruled out. Also the dating of organic matter and wood (tree rings) remained impossible through the lack of finding any objects or constructions within the dike. Therefore, some other methods like OSL dating and dating of humin acids had to be explored, not knowing whether the outcome is accurate.

3.8 Archaeometry - dating of soil samples

The dating of the soil samples were crucial for this research, because a dating puts the dike and possibly its construction into its chronological and spatial context. Nowadays one of the most common ways to date organic materials is radiocarbon dating. Based on ^{14}C's half-life time, a date before present is calculated in the laboratory. Although ^{14}C-dating is regularly used, the data should be interpreted carefully. Besides inaccuracies in the laboratory, Renfrew and Bahn (2008) describe four general errors that are easily made: 1) Organic materials could have been contaminated before sampling, as a result of groundwater and animals moving organic materials through the soil. This causes the probability that the samples are contaminated with more recent organic materials, thus affecting the outcome. 2) Secondly, contamination could occur during sampling. The samples within this research have been taken carefully by professional archaeologist and have been packed in plastic bags immediately in order to reduce the risk on contamination during sampling. 3) The context of deposition should be clear before dating the samples. In this research this was not too hard, because of the drawn soil stratigraphy (§7.2.1). Only the ^{14}C samples from the ditch must be interpreted carefully, because they have been deposited, and probably been in streaming water for a while. It is therefore not clear where the organic materials originate from, and how long it has been in the water. Also underneath the dike, we had to be careful with organic materials, since in this forest environment roots could have grown deep in the ground until very recently. 4) It is also important to know what you are exactly dating. For example, a trees trunk might be way older than a twig. For that reason, in this research, we interpret the organic material ^{14}C as *'terminus post quem'* since the charcoal is taken from under the dike. (Renfrew and Bahn, 1991, pp.126-127) The ^{14}C-datings from the corings in Speyer and Ottersdorf have been done by the Curt-Engelhorn-Zentrum-Laboratory in Mannheim. The macro-organic ^{14}C-dating has been conducted Leibniz-Labor für Altertumsbestimmung und Isotopenforschung in Kiel. The same laboratory in Kiel conducted the humin acid dating.

One of the sources of ^{14}C materials are pollen. However, the sediments in this research hardly showed any organic materials in it. Therefore, the focus of the conducted pollen analyses was to get an idea of the vegetation in the surrounding landscape during the period the sediment was the surface layer. For this research, mostly the distinction between pollen of wet wilderness species like willows (*Salix*) or alders (*Alnus*) and pollen that are linked to agricultural use of the land, like for example grains. On one hand, in case the dike is built on top in wild nature, offensive dike construction is expected. While, on the other hand, if agricultural pollen are found, the dike is constructed on top of former agricultural lands. Reducing agricultural land is logically only done in case of the protection of the hinterland. Therefore, defensive dike construction can be expected. Since pollen analyses function best at peat layers because of the amount of pollen, the found humus and former surface layer within this research are no easy study objects. On top of that, there are some points of critique, which should always be taken into account with pollen analyses. Intrusion or soil life might move pollen throughout the various sediment layers. Therefore, the pollen could be found out of place. It also must be taken in consideration that insects or wind might transport pollen from other areas towards the case study area. The results of the pollen analyses should therefore be seen within a cluster of comparable conclusions. (Renfrew & Bahn, 1991, p. 208) The pollen analyses in this research have been conducted at the Groninger Institute of Archaeology (GIA) and the Institute for Biodiversity and Ecosystem Dynamics at the Vrije Universiteit in Amsterdam.

Within the Upper Rhine valley, various studies have dated minerals by means of Optically Stimulated Luminescence (OSL). (Quik & Wallinga, 2018; Candel *et al.*, 2018; Esbach *et al.*, 2018) Schmitt and Salomon (not published) of the university of Strasbourg and Quik and Wallinga (2018) at the University of Wageningen have been using sequences of OSL dating in order to define the development of river courses. The aim is to discover the age of the dike by dating the moment the former surface layer, directly underneath the dike, was last exposed to sunlight. Therefore, at least two OSL samples should be taken. In practice OSL dating is often sampled in vertical sequences, in order to correct deviant datings. In this research the adjustment of the OSL data is made by the comparison with the Humin dating. In this research, the OSL datings are conducted 'single grain' with the Feldspar mineral instead of the more common Quarts, because the Quarts minerals in Rhine sediments have a low luminescence sensibility. (personal correspondence Wallinga; Geach *et al.*, 2018) Another point of critique for our case is that the border between the dike body and the former surface was vague. This made that it hard to define the upper few millimetres that have been exposed to light right before the dike was build (personal correspondence Wallinga). For this reason, two more OSL samples are taken from the ditch in front of the dike. Since it is assumed that the ditch has been dug in order to elevate and construct the dike, it could be stated that sediments have been deposited within a few years afterwards, when water ran through the ditch after a high water occasion. The period of time that remains between the final exposure of the former surface and the sedimentation of the ditch should provide a short time frame in which the dike has been constructed. In the case of OSL samples it should be noted, that every exposure to light, resets the luminescence 'clock' to zero, and therefore the samples should have been taken during the night in complete darkness. (personal correspondence Wallinga) Since this was not a legal opportunity, dark circumstances were reconstructed. It should be clear in the results when the samples have been exposed during the sampling, since in that case the retrieved date goes back to approximately the moment of sampling.

Besides macro organic dating and OSL dating, humin acid dating was used. Notable for sampling the humin acids samples is that they should not be contaminated with organic matter. Therefore, it should be taken very carefully with a trowel and directly put into aluminum foil before it is saved at a temperature of about 8 degrees. The humin and humin acid datings in this research are conducted by the Leibniz-Labor für Alterbestimmung und Isotopenforschung in Kiel. Humus can be divided into humins, humin acids, and fulvo acids. The fulvo acids are left out of consideration in this research because their presence was too small for a dating. (Brock *et al.*, 2011, p. 551) Humin acid is formed during humification, while humins date closer to the plants origin. (Brock *et al.*, 2011, p. 551) In addition, it is suggested that humin acid is partly formed by the degradation of *in situ* plant materials. (Brock *et al.,* 2011, p. 554) For the degradation of humus, oxygen (O) is needed. This oxygen is usually relying on the humidity of the soil, which in this case is assumed to decrease as a result of dike construction and related drainage. (Jongmans *et al.*, 2013, p. 544) (Figure 3.6) In order to take a sample of humins from the soil sample is extracted with hydrogen chloride, lye and again with hydrogen chloride providing the leach residue for dating. The extracted material is again precipitated with hydrogen

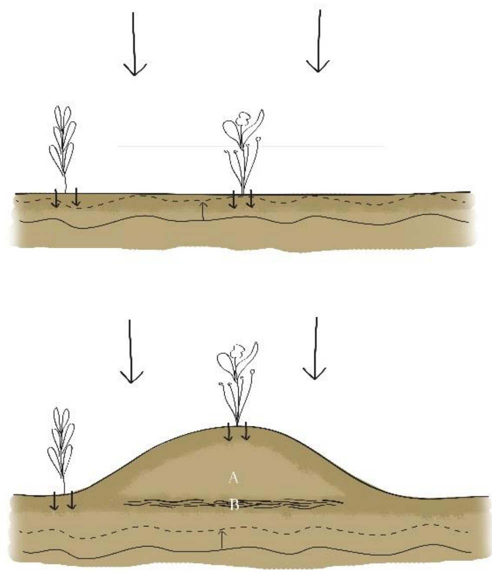


Figure 3.6: Humin acid dating in a dike aims to date humin aicds of the former surface (B), on which relative sudden a dike is constructed. It can be expected that such a thick body of dirt, which is meant to be impermeable, would cut off the water supply, and withhold humin acids from becoming mobile.

Chloride, from which the humin acids dating is taken. Further explanation on the method used by the laboratory is attached in appendix A. Further critical remarks and elaboration on the humin dating in this research is reported in §7.5.1.

In addition to these dating methods, a landscape scale stratigraphy of former Rhine channels has been made for the case studies. This stratigraphy is based on three stratigraphical and hydrological premises 1) the law of superposition and continuity: If one channel cuts of another channel, one is older than the other. Usually, the youngest one remains as an unbroken line, since it has been flowing for several years, after cutting the older channel. (Eggert, 2001, p. 172) 2) Water always flows to the lowest point with the lowest resistance 3): A meander always moves outward. (Bridge, 2003, p. 205) Taking these three premises into account, a sequence of active courses can be made, indicating the chronology of the various river arms. (Eggert, 2001, p. 172)

In archaeological studies, much preliminary research has already be done. A huge amount of excavations and studies have already been executed, also within the Upper Rhine valley. The Ministry of heritage conservation (*Landesdenkmalpflege)* files the excavations for the Upper Rhine valley and supervises a database (ADAB) with all the data. This data is accessible through GIS applications (ArkeoGIS) in which the data is visualized in a map. The database includes short summaries on the excavations and the most important findings. These maps are a valuable asset to scan the Upper Rhine Valley both on a regional and on a local scale for a historic-chronological framework. This way, archaeological excavations from the last century are easily accessible in overview.

3.9 Toponymy: water names, place names and field names

Toponyms are names of landscape elements (villages, streams, and fields) given by people who lived in the area or were somehow related to these places. Such names can tell a lot about the landscape, because they provide a subjective description of the place in a way that other people can understand its meaning. Such descriptions can be observations of nature, or possibilities for land use. Spek (2009) also recognizes religious references in names, but in this research, these are considered land use as well. Because toponyms provide a cultural perception of natural elements, toponyms are an adequate link between the historical narrative and the spatial environment. Often passed on orally, by archival records, or historical maps, they provided an idea on how people perceived their surrounding environment, and thus a great source to link natural science with cultural perception of the landscape. (Spek, 2009, pp.106-109)

In toponymy water names, place names, and field names are included. All of these can be used for different purposes. Water names tell something about the rivers, streams and other water surfaces. Water names regularly relate to its location (related to place names), its wildness, or its colour. (Greule, 2014, p. 3) Water names are among the oldest names, since they are an important instrument for environmental orientation before maps and GPS, especially during a period when knowledge was mainly passed on orally. Place names are well known for an indication of the settlement history. For example, settlement names in German can provide an indication on the period the settlement has been founded; many studies claim that town names ending on *–heim* or *–ingen* have been founded during the early medieval period. (Kommission für geschichtliche Landeskunde in Baden-Württemberg, 1974, Karte IV.1; Hoeper, 2001) Of course, these names provide a *terminus post quem* since the towns might have been named or renamed with these suffixes afterwards as well. Because towns are also often quite important landscape elements, it is generally accepted that town names do not change too much over time, as is suggested for water names. This might be different for field names and local water bodies. These are probably only used by a small group of people and therefore can easily be changed, forgotten or renamed, in contrast to bigger and more important landmark or landscape elements. On top of that, the land use might change, which might lead to changing a fieldname as well. Sometimes change of land use is included within the field name. In this case often a composed name occurs. These names actually contain information on the land use change.

In this research place names, water names and fieldnames were studied. Depending on the research scale, regionally the place and fieldnames are useful, while locally field names are most useful containing detailed information on the landscape. The use of fieldnames on a regional scale produces much data, which takes time to process. Due to new GIS technologies, this research explores possibilities for a 'big-data' use of field names in the Upper Rhine valley (§4.6). (Gildemacher, 2009, p. 96; Spek, 2009, p. 123) Water names and place names are derived from contemporary maps. Both have been checked with pre-rectification maps and known disappeared villages. The field names are best visible on 19th century maps, which show the pre-rectification topography as well. (GLA-K H Rheinstrom Nr.79 12-18, 1838; GLA-K H Rheinstrom Nr. 72, 1822; Karte über den Lauf des Rheins, 1861) These 'older' maps, covering the whole Upper Rhine section from Strasbourg to Mannheim, are used because the maps depict a time-depth before the extensive landscape changes of the last two hundred years. As a precaution recent changes in land use or changing field names have been considered as well.

Several researchers doubt the use of fieldnames for research because of their subjective origin and their sensitivity to change. (Elerie, 2009, p. 151) Although field names are no longer essential for administrational purposes, the names seemed to survive such changes in local daily use and when used for orientation. (Elerie, 2009, p. 29) In this study, field names occurring in 15th century '*Lagenbucher'* were also found on 19th century maps and contemporary maps as well. Another point of critique is the etymological of names changes over time. Words might at least partly change over time, resulting in a changed meaning and misunderstanding. Fortunately, etymologists executed an enormous amount of research on field names, thus this critique is mostly taken into account by selecting the right overview books. A third point of critique is the variation in local dialects. Especially on a bigger scale, various dialects might create many differences in field names, which actually are not so different in their origin. The research area of this study includes the language border between French and German. However, it is impressive to see that this language border is more like a gradual zone of change according to the toponyms. Nevertheless, this toponymy study must be read very critical in order to overcome wrong interpretations caused by differences in language and dialect. Wrong interpretations have probably lead to several doubtful links between names and places. However, finding these missing links is excluded from this research's frame and left open for further etymological research. Another difficulty of using toponymy is that it is usually based on a first record instead of its emergence. This makes it difficult to find the origin of a toponym, making it risky to use toponyms in a temporal way. When such temporal interpretations of toponymy are used in this research, it is interpreted as a *terminus post quem*.

One of the solutions to overcome critique on field names is by combining them statistically with a big-data approach. The field names are studied within the database instead of using every field name literally. On a local scale, the classical perceptive use of field names is used naturally, but therefore multiple explanations and definitions of the field names need to be investigated. The most logic compilation of these explanations are used in the final definition. The publications used to get to such compounded definitions of field names are Dittmaier (1963), Schneider (1980), Zernecke (1991), *Directie Bos en Landschapsbouw* (1991) and Herget *et al.* (2005). Altogether, field names are regularly checked on multiple occurrences over time and where possible aligned with other archival sources and historical maps.

3.10 GIS

In contemporary geographical research, Geographic Information System (GIS) applications are almost indispensable. The spatial database provides possibilities to combine the enormous variety of collected maps overlay them and even do calculations on the data. In this research mainly the program QGIS (Version 2.18.0) has been used.

Almost every method described above has, at some point, profited from the GIS application. Historical maps became georeferenced in order to overlay them with contemporary maps. These maps have been combined to the LiDAR-data and soil maps in order to gain an understanding of the relation between the soil and the land use.

Within this research, also a database of toponyms has been added to the GIS, which made it possible to geographically locate them. Thus could these names be related to the LiDAR-data and historical- and soil maps. Much of the toponymy research has been executed in the 20th century, before GIS has been used on a regular bases. This research has digitalized over 1500 fieldnames in the flood plain of the Upper Rhine Valley, being able to see spatial patterns within the diversion of fieldnames (figure 3.7). Hereby adding a geographical component to the regularly etymological toponymy research. Besides these spatial patterns, which provide very interesting insights, for the first time ever calculations could be performed with these fieldnames. This was beyond the scope of this research, but a few explorations indicate many possibilities for future research. For example, by overlaying this point data over the LiDAR-data, it is possible to calculate the elevation of every field with only one click. Polygon data would have provided more accurate results but would have demanded significant more working hours and is therefore just recommended as possibility for further research. In addition, the distance to the closed village or to the river was calculated. After studying the attributes table of this data laying behind this GIS application, it provided us with new statistical knowledge on this fieldnames. Before GIS, it was hardly possible to calculate whether fieldnames with the suffix *–bruch* were located further from the river Rhine than for example fieldnames with the suffix *–grund*. When combining and overlaying such findings with other maps, again, new conclusions can be drawn relating to the cultural perception of field names and the included geographical circumstances in the landscape. For example, the hinge point in the gradient of the river seems to be an important border when looking at the field names geographically, appendix H. Therefore, GIS is used in this research as a connection between the data sets of the natural sciences and the cultural narratives of the humanities.

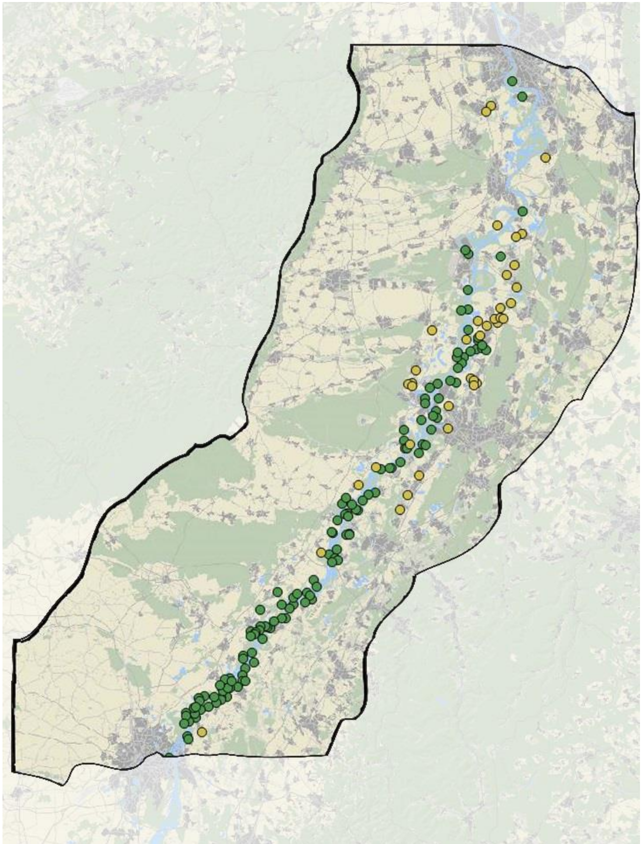


Figure 3.7: The diversion of -Bruch and -Grund fieldnames in the Upper Rhine valley:

3.11 Field excursions

For studying the spatial environment, it is essential to visit the field. (Johnson, 2007, p. 34) A real life visit of the study area is the most realistic overlap of various sources. In the field, the tiniest variations in hydrology or vegetation can be seen, while this is not visible on maps. Even wet or dry spots within a field can be spotted. This is also possible with different ecological species which can indicate, for example, several groundwater levels or specific nutrient availability. (Meijles & Spek, 2015, p. 7)

In this study, a bicycle tour has been conducted from Heidelberg to Strasbourg and back within the beginning of this research (June 2016). The focus was to see and understand the bigger landscape elements and varieties throughout the Upper Rhine Valley. Furthermore, this tour functioned as a possibility to check on the contemporary situation of already identified dikes and their suitability for fieldwork. Fieldwork campaigns to case study sites during later phases of the research mainly focused on the dikes, their location and the surrounding land use. More local studies around the case study areas would have provided better understanding of the relationship between the villages and the river. However, such field explorations are quite time and money consuming in relation to the use of other source like maps or GIS based analysis.

3.12 Interdisciplinary approach

When taking the above paragraphs all together, it becomes clear that in order to study historical flood management, a broad scope of sources from both natural sciences and humanities are necessary. Since natural data comes in a different form than clues from historical narratives, it is important to find clusters in the argumentation. This means that it is important to assess how the geophysical landscape is perceived, to be able to connect it with cultural perception of the landscape. Ingold sketches how such a perception of physical landscape is though to define, since humans are part of the environment. (Ingold, 2004) When its is known at what moment various aspects of geophysical knowledge emerged, it can be chronologically ordered. Another possibility is to define several mentalities and fit in the scientific data in the mentality where it fits best. The other way around, cultural narratives have to be aligned with the geophysical data. Geographically this can be done by including historical maps and toponyms in the GIS-overlay. Toponyms also provide some perception of the natural landscape. Since these toponyms are also linked to archival sources, these archival source can often be located as well.

Arguments within this research are mainly supported by data from both natural sciences and humanities. In order to create such clusters, an overarching and common denominator is necessary. A commonly used denominator is time, since all processes happen over time. However, the problem with this method is briefly addressed in §2.1 at the layers approach. Several geomorphological processes take significantly longer to affect the landscape than cultural expressions. Since the timeframe for this research only includes a few centuries, the geophysical representation of the landscape is hard to fit in clusters of the historical changes that occur in short term. Nevertheless, chronologically order the data would provide structure in the research. To overcome the difficulty that processes in the landscape occur on different time scales, an additional denominator is defined in human perception. Humans perceive the material representation of landscape, including both geophysical and cultural expressions. The moment a human perceives the landscape is not depending on the landscape forming processes, but mainly on the moment this human exists. However, human perception is subjective. For this reason, human perceptions should be clustered, possibly by actor group, and generalized into mentalities. The mentality templates, derived from a thematic biographical study, are placed on a timeline that fits in this research's timeframe. This way the mentality templates form the backbone of this research. All arguments derived from various sources from multiple disciplines can be placed within the template that fits best. In this research the shifting of mentalities over time are important. For that reason it might be benicial to work with the most dominant mentalities and investigate how that follows from his predesessor and leads to its successor.

4 - Changing mentalities on flooding in the Upper Rhine river landscape

4.1 Overarching disciplines by perception

4.1.1 Mentality templates, filled with multidisciplinary data

This research aims to gain an understanding of the changing perception of the Upper Rhine flood landscape. As mentioned in the current state of the research chapter, a clear methodology to include mentalities in landscape studies is lacking. (§2.1) For that reason, in this research a novel method has been developed. Since this method is new, it can be a starting point for other researchers to build upon it.

Human perception is the process of gaining information from filtering and connecting elements of the material representation of the surrounding landscape. A landscape is defined as a continuous interplay between geophysical and cultural expressions in §2.1. By selective grouping of such perceptions as suggested in §2.1, a corresponding mentality can be defined. Mentalities can thus be defined as a frame of thinking, sensing and imagining, and thus represent the human perception. Mentality templates formulated in this research are the dominant way of converting perception into action. It is thus important to realize that multiple ways of converting perception into action exist next to each other among various groups of actors, but also within one and the same person. (Ariès, 1988, pp.137-138) For example, one man could go and pray to have his family spared from upcoming natural disaster. While on the same day, the same man could contribute in dike construction in order to protect his family against flooding. These two different actions, as a reaction on perceiving an upcoming flood, indicate two different mentalities within one person. Additionally, it is assumed that mentalities shift. Thus, a new and more dominant way of converting perception into action replaces the most dominant one. This does not mean that the latter completely disappears, since multiple mentalities can exist next to each other. (Meier, 2005a, p. 281)

These mentalities in this research are first defined according to the perception of flooding. These perceptions are mainly based on historical influential writers and their ideas on flooding, disasters and the river landscape. Mainly writers, which are related to the Upper Rhine valley have been selected. In addition, a few important influential writers are selected as well, because of their influence and impact on many areas in Western Europe. This actually comes close to the landscape biography as explained in §2.1. In this case, the landscape biography is not written by describing one person or actor, but it describes the theme of perception of flooding in the Upper Rhine valley landscape. (Huijbens & Benediktson, 2015, p. 101; Kolen *et al.*, 2015) In accordance, this biography is linked to a time line. Combining these two overarching themes, a backbone for the study on flooding in the Upper Rhine valley is created. The results are called mentality templates because these form the templates in which the gathered information must be placed in. In this case the inventory of geophysical and cultural developments in the Upper Rhine valley gathered by the multitude of sources that is listed in §3.2 to §3.11 has to be included. Moreover, by relating geophysical knowledge to the mentality template, and adding cultural developments to a dominant mentality. The mentality template frames the presented facts within this template and forces a certain perspective on the presented information. These mentality templates sketch how the perception of flooding mainly affected the landscape and vice versa, during a certain period. This transits the multidisciplinary landscape study into an interdisciplinary one.

To clarify the conceptual model used in this chapter, it is visualized in figure 4.1. At first, a multidisciplinary inventory is conducted. Afterwards, a biography of perception of flooding in the Upper Rhine valley landscape has been used as a backbone for the study. This study of the changing perception take the work of many influential writers into account, however, it is mainly based on secondary literature as far as human–nature relations are concerned. Schouten (2005), Hoffmann (2014), Aberth (2013), Epstein (2012) and

Schama (1995) all debate the shifting interaction between man and nature in their publications. To grasp more detail, Fear (2016) and Barney et al. (2006) are studied on the topic of Isidore de Seville, and Arnold (2017) is studied on Gregory of Tours. Additionally, several individual articles are used for specific authors. Since not all secondary literature takes the perception of flooding into account, several of the historical publications by these influential writers are consulted to better our understanding. The mentality templates resulting from this biography are connected to a timeline, as suggested in the cultural biography of landscapes. This adds a chronological order to the study, to which the mentality templates relate. Every piece of information/data/map gathered in the inventory has then been related to this backbone. A chronological development of the relation between the human perception of flooding and developments in the material landscape is the result.

The results are elaborately presented in §4.2 to §4.9 of this research. Every mentality template is described in a new paragraph and every paragraph starts with a brief introduction, which is the result of the preliminary cultural biography. In this research the theme of the conducted biographie was flood perception in the river landscape. This gives the reader the opportunity to interpret the information neutrally. The mentality templates, as explained by the author, are summarized in a concluding timeline of shifting mentalities in §4.10. This is the paragraph were the reasons fro mentality shifts should become clear.

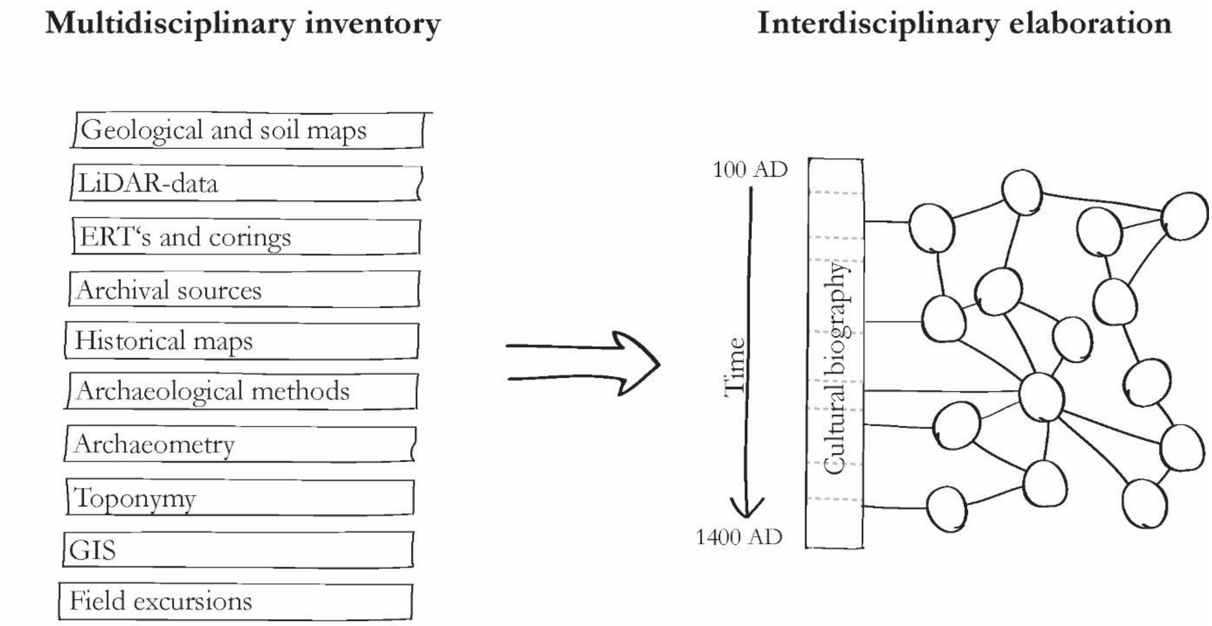


Figure 4.1: The multiple disciplines fit into a cultural biography of perception of flooding. The gather data by these disciplines is symbolized by the circles, interconnecting and together they form the scientific base for a mentality template.

Additionally, in order to see how this theoretical approach holds up with practice, two case studies have been conducted. These case studies are in Speyer and Ottersdorf and a wide range of sources were used to collect information. However, on a local scale hardly any additional sources on landscape perception can be found in order to produce a biography on the perception of flooding. For that reason, the case studies are presented in their multidisciplinary inventory form, however slightly thematically grouped in geophysical landscape, climate, cultural settlement history, actors and perception through field names. Only in the concluding §8 the findings of the case studies are related to a timeline and formulated into mentality templates. In §9 the concluding interpretation it is discussed how these results confirm or challenge the research results on the Upper Rhine valley scale.

4.1.2 Contemporary definitions of disasters and concepts of flooding solutions

In order to understand this chapter properly it is necessary to be aware of the contemporary debates on the definition of disasters and thus the definition of flooding. At first it is essential to understand what is considered a disaster, and whether flooding could be considered as one. According to Jankrift, flooding is not a stand-alone disaster but a flood is often followed by hunger and plagues. (Jankrift, 2003, p. 54) These consequences should be taken into account while perceiving a flood. Groh *et al.* (2003) describes a natural disaster as an extreme event and a natural danger. (Groh *et al.*, 2003, p. 15) A catastrophe is a misfortune, an often unexpected turning of events that causes human drama and damage, which in the case of a natural disaster is caused by nature. (Groh *et al.*, 2003, pp.16-19) Although in this definition Groh *et al.* argues that natural catastrophes have been designated in five different ways over the centuries. 1.) Natural disasters are a challenge for rulers and their legitimacy. (Groh *et al.*, 2003, p. 25) 2.) A more moral discourse is that disasters are a punishment by the gods, which can only be avoided by good behaviour. (Groh *et al.*, 2003, p. 27) 3.) A natural catastrophe provides an image of vibration of fear correlating with the sublime during the popular English Romantic in the 18th and 19th centuries. (Groh *et al.*, 2003, p. 29) 4.) The fourth discourse stands for man battling nature, which supports building identity alike the Dutch battling floods for centuries. (Groh *et al.*, 2003, p. 31) 5.) The final fifth discourse contains the struggle between chaos and order, or differently formulated nature versus man and civilization. (Groh *et al.*, 2003, p. 32) All of these discourses include that a disaster is only a disaster if so perceived as such humans. This is agreed many researchers arguing that a catastrophe is per definition a cultural event, since it is called a catastrophe by humans in retrospect. (Meier, 2005a, p. 265; Pfister, 2009, p. 17) Also Rohr acknowledges the human aftermath of a disaster in his definition: *"(a) the helplessness of the people trying to cope with the damage, with the available means; (b) the inability of individuals to explain and understand the event; (c) the material and personal suffering; (d) the unexpectedness of the event, which depends on how prepared a society is for one-time or recurrent threats; (e) whether there is a series of natural hazards within a short period of time, which can raise the vulnerability of the afflicted people; (f) the symbolic connotations and patterns of interpretation, such as connections to natural disasters described in the Bible; and (g) the general predicament, such as the simultaneous economic, religious and climatic crises during the sixteenth century in Europe."* (Rohr, 2016) Meier even goes a bit further by stating that a catastrophe not only affects people, but it is often also (partly) caused by people. Meier then mentions the distortion of Antiochia because the city was built in an earthquake risky area and people remained rebuilding the city there after every earthquake. (Meier, 2005a, p. 266) Although nature might be the original cause of a disaster, men's lack of learning ability should not be taken out of consideration. (Meier, 2005a, p. 268) It could even be questioned whether it can be called a natural catastrophe even if man caused it himself, even unintendedly. (Meier, 2005a, p. 267) Meier argues that medieval people believed in their religions, and considered praying an equal prevention measure against flooding among others, while nowadays we almost solely believe in our ratio and logic for preventive measures. In the end, Meier argues that we should look for solutions to natural catastrophes outside the limited perspective of contemporary science and society, like in archaeology. (Meier, 2005a, p. 283)

In 2015, Haas conducted a study in order to look at solutions on flooding from a philosophical and historical perspective. In this study, he defined five concepts for solving flood issues over the centuries. These concepts have occurred in various periods by various actors. Haas mentions five conceptual relations between (the) God(s), humans and nature. Central in this study is the question whom to blame for flooding and where to look for possible solutions. 1.) Survive at the river, the Gods are responsible for flooding, the river, considered a God, can decide for itself when to flood. People try to satisfy the Gods in order to prevent flooding. (Haas & Stork, 2016, p. 19) 2.) Living under the eye of god. Nature cannot create and act for itself, nature must be coordinated by God. To prevent flooding a fear of God is necessary and people who do not respect that should be removed. (Haas & Stork, 2016, p. 21) God punishes man for disrespecting his creation and sinning. In modern times, this variant occurs as God protecting the good people, praying or processions are considered a measure to prevent flooding. (Haas & Stork, 2016, p. 22) 3.) Taming the river. Man follows God's order to finish his creation; humankind was obliged to cultivate nature. (Haas & Stork, 2016, p. 23) People believe in human skill and technical solutions. (Haas & Stork, 2016, p. 24) 4.) Technical crisis, the natural river will not be tamed. Many secondary effects follow on technical solutions and human actions are seen as cause for these problems. (Haas & Stork, 2016, p. 25) Humans decide to give more space to nature and acknowledge and respect natural systems. Nature becomes an equal priority in developing solutions. (Haas & Stork, 2016, p. 26) 5.) Living along and with the river, the river should get more space conflicting with the complex situation of which many people somehow have an interest in the river and its surrounding space. (Haas & Stork, 2016, p. 28) These five concepts show various relations between God, humans, and the nature of the river.

Although Haas mentions that, his concepts are not meant to identify their dominance during specific periods. Therefore, in this thesis it is used as a valuable guide in order to identify how ideas have led to the building of flood defences. Therefore, it is essential to relate these concepts to the various discourses occurring over the centuries, and search for the most dominant of these concepts. The following paragraphs will discuss specific periods of time defined by how people perceived rivers and flooding. The boundaries of these periods should be considered more gradual and interwoven than can possibly be written down in clear form. This chapter starts providing a background in the perception of the Upper Rhine valley from the Roman period onward, since from this moment onwards, written sources occur in addition on archaeological sources and geographical data. The influence of the Roman Empire has been significant enough to set a base from Roman perception, into early medieval perception of flooding and the landscape in order to explore from which moment the idea of flood management and dike construction appears.

4.2 Unhealthy swampy forest and save settlements on terrace rims

Several Roman settlements, such as Noviamagus Nemetum, are located on the rim of a terrace in the Upper Rhine valley. This provided a location close to the river which was used as an important trade route in the first centuries AD, but it was also located higher up, and therefore easier to defend against flooding than the lower flood plain. The swampy forest in the flood plain was regularly flooded and standing waters were considered a main cause for various diseases. One could argue that the Romans picked this higher location for their settlements because of the beneficial geophysical circumstances. Did the Romans actually consider these geophysical circumstances or did they see the river Rhine as one of their mighty Gods, Pater Rhenus, which they should not disturb?

4.2.1 Terraces and a dynamic flood plain

The Upper Rhine valley is a rift valley formed during the tectonic collision between the European and the African plate during the Alpine orogeny, also forming of the Alps. This collision in the Alps generated a huge sideward power on the northern side of the Alps forming the rift valley that we now call the Upper Rhine valley. In this research only the section between Strasbourg and Mannheim is taken into consideration. The Alsatian Vosges and the Pfälzer Wald on the western side, and the Schwarzwald, Kraichgau and the Odenwald at the eastern side are slowly moving away from each other. This resulted in the area in between subsiding, creating a difference in height which can still be seen today. (Tümmers, 1994)

Since the moment that the Rhine found its contemporary course through the Upper Rhine valley during the early Pleistocene about two million years ago, its fluvial sediment has been deposited in various layers. The sediments point out a shift from a slow and constant sedimentation towards a more discontinue and more rapid sediment deposition. The soils in the Upper Rhine valley have been heavily influenced by the most recent Ice Age, the Würm-Ice Age (115000 to 12000 years ago), when the Alpine glaciers had their last period of significant expansion. Sediment deposition and erosion have been alternating, forming fluvial terrace levels. During this Ice Age two ways of sediment deposition dominated. Firstly, the melting waters from Alpine glaciers brought sand and gravel into the Upper Rhine valley in the range of the river Rhine and its flood bed. Secondly, aeolian sediments were blown of the sparsely vegetated glacier tongues by the winds and taken into the Upper Rhine valley. Stone dust, taken from the fluvial gravel was blown mostly by western winds to spread out a thick loess-layer on the terraces. (Gallusser & Schenker, 1992, p. 6; Geiger, 1991, p. 14, p. 25)

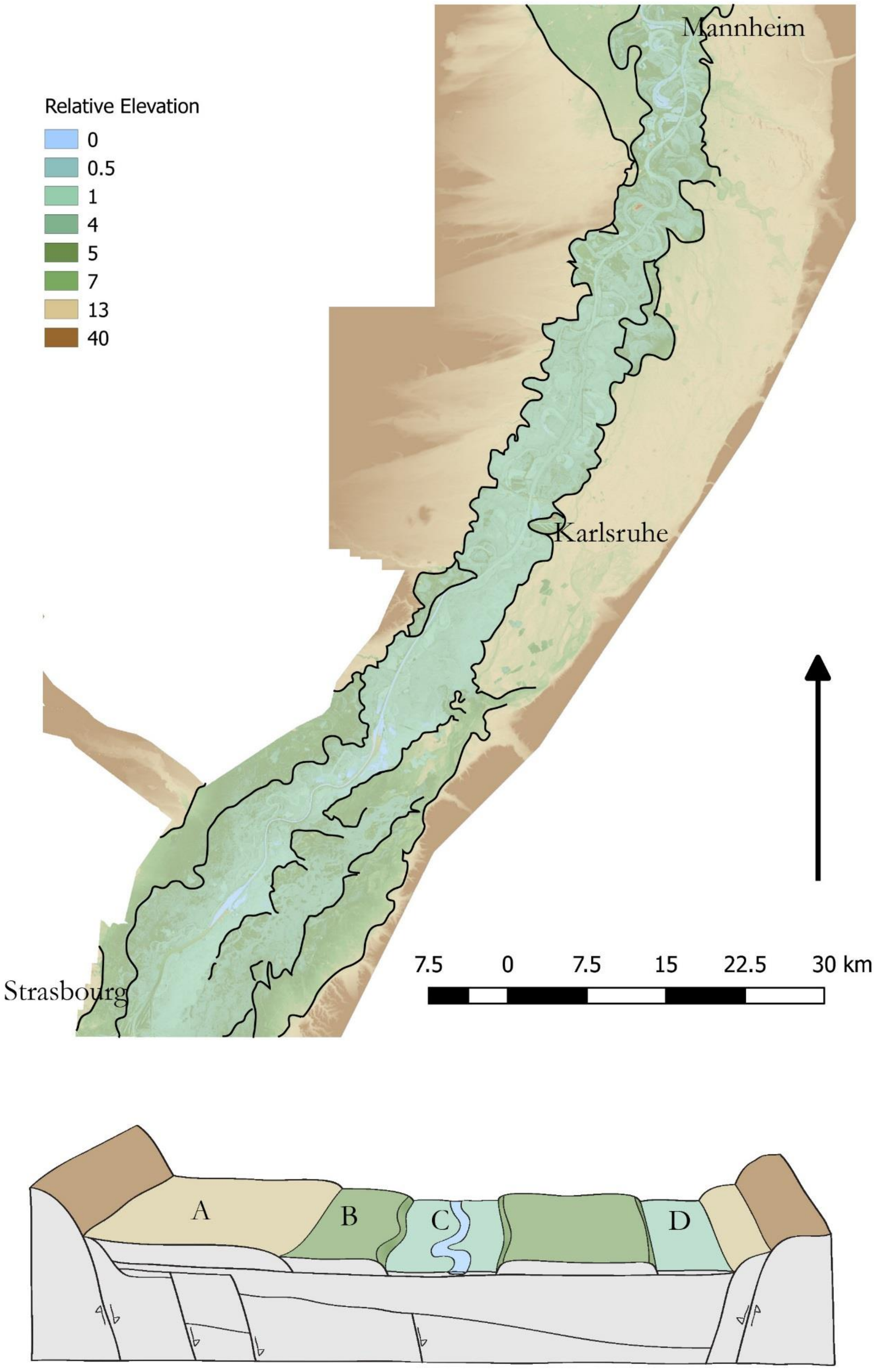


Figure 4.2: The height differences in the Upper Rhine valley pictures by relative LiDAR data and a profile sketch. (after Steinrötter, 2005, p. 267) A) Higher terrace, B) Lower terrace C) Upper Rhine flood plain D) Kinzig-Murg-Rinne

As can be seen in figure 4.2, the meandering of the Rhine left a 10 to 15 kilometres broad reduction in between the terraces and this flood plain is nowadays called *Rheinniederung*. Generally, the flood plain is about ten meters lower than the terraces and therefore the area is in risk of flooding. The soil in this flood plain is completely coated by fluvial sediments of the Holocene. (Hagedorn, 2004, p. 4) This includes gravel and sand, as well as clay. Additionally the smaller tributaries discharging into the Rhine from the surrounding hilly areas have such variety of fluvial sediments as well. Nevertheless, such tributaries have brought older sediments from the hills, thereby leaving an enormous triangular shaped fan of sand sediments as they enter into the lower terraces. The Kinzig-Murg Rinne is a parallel riverbed east of the Rhine at the base of the Schwarzwald and Kraichgau. The Kinzig-Murg river slowly moved westward, leading into breakthroughs through the terrace. Especially the Murg breakthrough during the Atlanticum (6000-10000 years BP) costed the Kinzig-Murg river a lot of water input, which in the end lead to the landing of this river. (Holzhauer, 2013, p. 50) Although the former channel is mainly dry, it collects the eastern tributaries from the hills before they cross the terrace at a low point and discharges into the Rhine. It is debated whether the Kinzig-Murg-Rinne starts at the Dreisam river near the Kaiserstuhl, or at the point where the Kinzig river flows into the upper Rhine valley. The Kinzig-Murg-Rinne ends around Heidelberg. Whether it used to discharge into the Rhine at Hockenheim or the Bergbahnneckar around Ladenburg is debated. (Holzhauer, 2013, p. 48) During the middle Holocene the alluvial fans of Schwarzwald streams could no longer be eroded and became a barrier for this Kinzig-Murg-Rinne, sometimes also called *Ostrhein*. At the western side the Ill flood bed can also be considered a former Rhine bed, however, this is mainly south of Strasbourg. (Schmitt *et al.*, 2016, p. 16) While the smaller tributaries and the Kinzig-Murg Rinne have risks of flooding as well, the focus of this research is on the flooding risks in the Rhine flood plain.

4.2.2 Settlements on the terrace rim

During the first century AD, when Romans settled in the Upper Rhine, Tacitus (ca. 56-117 AD) provided an early written description of the Roman border with Germany. This border, we consider the Rhine and its surroundings, exists of *"bristling forests and foul bogs"*. (Schama, 1995, p. 76) Note that Tacitus is suggested to have exaggerated the contrast between the cultivated Roman lands and the Germanic uncivilized wilderness of swamps and forests. (Schama, 1995, p. 76) Also the Roman Vitruvius (ca. 85-20 B.C.)pointed out the danger of vapours and standing waters, a theme which remained to be extensively described far into the Middle Ages. (Aberth, 2013, p. 44)

Actually, the Rhine valley was already cultivated to a significant degree during Roman times. According to Bork *et al.* (1998) deforestation had already started in Central Europe during the Roman period. (Bork *et al.,* 1998, p. 222; Aberth, 2013, p. 90) This is affirmed by the various cities founded or adopted by the Roman Empire in the Upper Rhine valley, most of which are located on the terrace rims. Aside of the bigger cities like Argentorate (Strasbourg), Brocomagus (Brumath), Aquae (Baden-Baden), Noviomagus Nemetum (Speyer), and Lopodunum (Ladenburg), several smaller settlements like Saletio (Selz) and Tabernae (Rheinzabern) are known. According to the digital map of the Roman Empire from Lund University, which can be found in figure 4.3 the number of identified villas in the Upper Rhine valley is below average. When compared to, for example, the Kraichgau or the area northwest of Worms. Only the Neckar mouth into the Upper Rhine valley is intensively settled with villas. Of course the high number of studies conducted in this area might be a reason for this, another reason is the general assumption that the Rhine has eroded or covered all possible findings in its flood bed. On top of that the number of archaeological findings also depends on contemporary building activities. If there is no contemporary occasion to open up the soil, there are no findings to be recorded. Moreover it should be notified that in the Schwarzwald there are no records of Roman settlement at all, which is even less than in the other minimally settled mountain ranges. When comparing these objects to figure 4.1 containing the height difference between the terraces and the flood plain, it becomes clear that many of the Roman settlements are located at the terraces, close to their roads, and close to the mountain streams.

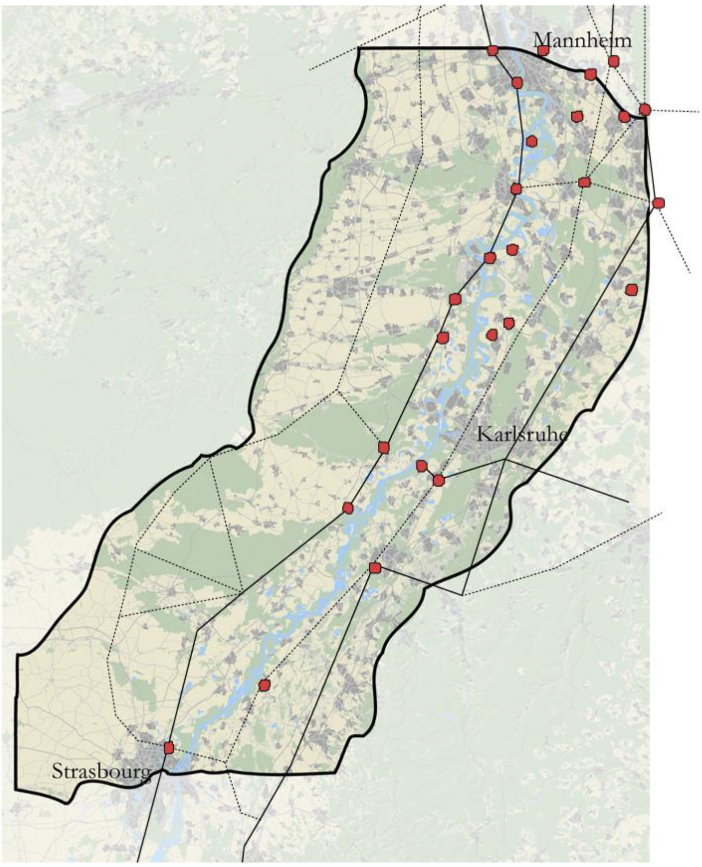


Figure 4.3: A mapped selection of Roman Settlements and routes in the Upper Rhine valley (after Lund University).

The main routes in the Upper Rhine valley were already known during the Roman period. (Figure 4.3) The north-south connections move past the base of the mountain ranges, or along the edge of the terrace. The main route for north-south connections was the so-called *Rheintalstrasse*, from Basel via Strasbourg, Speyer and Wörms to Mainz. (Doll, 1999, p. 387; Mone, 1845, pp.135-187) An important west-east connection from the Pfalz crossing the Rhine near Speyer passing through the Kraichgau, which, because of its reduction, formed less of a barrier than the other mountain ranges surrounding the Kraichgau. Other options were the valley of Rhine tributaries alike the Neckar or the Murg valleys, of which the latter was not very accessible. (Bittmann & Bittmann, 2009, p. 13) An important obstacle in passing from west to east or vice versa was crossing the Rhine. In Roman times ferries were already used in addition to fords at crossable places. Ferries are logically located on the easiest and safest crossing points in a river. Since meander curves have a deeper outside curve, the safest place is at the turning point between two meanders, where the river bottom is as good as equalized. Storbl & Zunic call this place a *furt*, which not coincidentally is the best location for crossing the river, both to wade and to cross by ferry. (Strobl & Zunic, 2009, p. 87; Kröger, 2016) Besides ferries, it is also known that Romans were able to build bridges, for example in Koblenz, Mainz and Köln. In contrast none are known for the Upper Rhine. However, there might have been a bridge near Strasbourg during the 4th century. (Hough, 2010, p. 50) Bridges could be a possibility for crossing in case of smaller parallel channels. It is also known from the Moselle region that bridges or elevated roads were built. (Arnold, 2017, p. 130) Elevated roads to ferries are documented more often; making it possible to reach islands or ferries also during periods of high water levels. Since elevated roads also stop the water, these can be considered an (unintended) predecessor of dikes. Strengthened elevated roads get less damage from flooding, and therefore have the benefit of being useable during periods of high water levels. Since these elevated roads are hardly damaged by the river, the investment of strengthening these roads suggests a hint of understanding the effects of flooding.

4.2.3 Antique knowledge and the function of the river

It is generally accepted that Romans were already able to control water. (Franconi, 2017, p. 12) However, not as extreme as 19th century historian Mone argues. His theory on cutting the Murg through the terrace at Rastatt in order to drain water from the Kinzig-Murg Rinne for military defence purposes is disproved by contemporary dating of the breakthrough. (Mone, 1845, pp.233-243; Holzhauer, 2013, p. 51) Especially canal building was the kind of water management seen in Roman times. Two examples are projects of linking the Saône and the Moselle, and the diversion of the Chiana into the Arno. While the planning of these projects shows a deep understanding of water engineering; the Romans did not finish these projects. (Franconi, 2017, p. 12) Nevertheless, projects like the Fossa Cordulo in the Dutch Rhine delta and the Fossa Augusta in the Po valley showed the Roman capability of water management. However it does not become clear if this understanding has been practised in the Upper Rhine valley. The aforementioned Tacitus, who described the Rhine area as wilderness, who also acknowledges antique knowledge on rivers and flooding for other Roman areas. This suits well in the general assumption that Tacitus exaggerated the differences between the cultivated Roman lands and the uncivilized beasts in Germania. Nevertheless, several inscriptions along the Rhine of Roman soldiers worshipping *'Pater Rhenus'*, the river god have been found. (Franconi, 2017, p. 85) This shows that Haas's concepts of living along the river, in which the river is its own entity already coexists with his concept of taming the river during the Roman period.

Lucretius (99-55 B.C.), a Roman poet who sees nature as unfriendly to human, argues that nature is using humans like humans use nature. (Schouten, 2005, p. 104) He acknowledges the demolishing power of floods, dashing wood and destructing bridges. (Lucretius, Book I, p. 15-16) By damaging cities and their inhabitants disasters or floods show mortality of man. (Lucretius, Book V, p. 206) Additionally, Lucretius also states that continual rains cause flooding. (Lucretius, Book V, p. 423; Book VI, p. 255) However, in the case of the Nile floods, Lucretius recognizes the role of the northern winds, the snow melting and possible obstructions by sand blown into the riverbed, thus multiple causes for flooding. (Lucretius, Book VI, p. 710-723-738) In contrast, also the nourishing role of water is described by Lucretius, who indicates that water gives life to plants, animals and man. (Lucretius, Book II, p. 86; Book V, p. 227) Pliny the Elder (Ca. 23-79 AD), who wrote the *Historia naturalis*, which remained influential until the Middle ages, makes notion of inundations. (Schouten, 2005, p. 114) Along the Nile in Egypt these inundations bring fertility and are caused by heavy summer rains in Ethiopia. He then recognizes the evaporation of the inundated water by the sun, disproving Timaeus' argument that the sun sucks the water from the soil. (Pliny the Elder, Book V.10) Pliny the Elder claims that water and earth are mutually depending from each other. The earth needs water to grow, and water needs the earth in order not to fall, or evaporate. (Pliny the Elder, Book II.66). These explanations of the water cycles show a thorough understanding of how hydrology works. It might even be assumed that during antiquity the human role in flooding disaster was recognized since Plato (Ca. 427-347 B.C.), who argues that a loss of fertile soil is caused by disasters, or by human actions like deforestation. (Schouten, 2005, p. 99)

In an attempt to deal with disasters like flooding during the antique period, people already found solutions, or at least methods to deal with flooding. Pliny the Elder describes the Chauci, a tribe in Northern Germania living on elevated parts of the land since the sea is covering the land two times a day. The man-made elevated mounds, *terpen* or *wierden* in Dutch, can be seen as an early form of adaptation to live on flooded areas. An early form of the concept of living along and with flooding is described by Pliny the Elder. (Pliny the Elder, Book XVI.1) Epstein (2012) cites an example from Tacitus works in Roman times dealing with a Tiber flood. The contemporaries came with three suggestions, 1) diversion of the floodwater; 2) spread the water over flood plains; 3) or dam the water. He mentions that Tacitus does not mention any supernatural cause and lays focus on the engineering solutions, which in the end are not conducted, since the people argue that nature should be handled with respect and left alone by humans. (Epstein, 2012, p. 150) In addition, Campbell states that Roman land surveyors had been very aware of flooding, especially in the Po flood plain, alike the Rhine caused by Alpine snow melting. Using the familiar methods of measurements, they set perimeters around the rivers to the widest known extension of the river during a flood. Allocation of Roman settlements happened outside of this perimeter; however, individuals were allowed to settle within these perimeters at their own risk. Romans reacted proactively on river changes and damage. They caused by the river, and even set out land surveyors in order to give advice and take decisions in these cases of the river disturbing its boundaries. (Campbell, 2017, p. 30) This attitude seems to suit with Haas' live along and with the river concept. The role of rivers in transport, culture and agriculture was quite important in the Roman mission to manage nature for the benefit of the people. However, when the Roman Empire declined, the rivers, like the Rhine and the Danube where used as shields for protection instead of a symbol of power. (Campbell, 2017, p. 30) Despite of the disappearance of sources, there is no indication of Roman river management disappearing, neither is there any evidence of it continuing.

Altogether, Roman settlment along the river seems to be related to the defence line along the Rhine and the trade routes running north–south through the Upper Rhine valley. Citizens in these settlements were thus part of a bigger network. The reasons for why the Roman settlements made perfect use of the differences in elevation between the terraces and the flood plain might differ. The unhealthy vapours in the swampy forest can be considered a risk, but also not disturbing the river God Pater Rhenus might be the reason. Repeatedly it becomes clear that the Romans had sufficient knowledge to understand flooding and the capacity to build flood management. However, the hostile side of nature was pretty clear to them as well, resulting in their living in safely elevated places, thus the terrace rims.

4.3 Nature as a resource for wealth at the semi-fixed settlement relocation

After the Roman decline during the 4th and 5th century, the inhabitants and new settlers in the Upper Rhine valley searched for the best locations to continue habitation. The easily arable and nutrient-rich loess soils proved popular. Moreover, former Roman settlement provided benefits. The former grazing lands of the cavalry, nearby the settlements, had been fertilized by manure for decades. Could this use of natural resources just be common sense, or does it reflect the contemporary conception of nature as a resource to support humans as suggested by the influential Christian Augustine of Hippo?

4.3.1 Land fixation for Frankish and Aleman settlers

After the Roman Empire declined, more and more Frankish and Alemannic influences characterized the Upper Rhine valley. It should however be noted that nowadays it is more and more accepted to consider these influences as smaller tribes profiting from the decline of the Roman involvement in the area. (Schreg, 2006, p. 28) The Roman cities of Noviomagus Nemetum (Speyer) and Lopodunum (Ladenburg) among others have been taken over by new rulers during the 3rd century. (Damminger *et al.,* 2017) The degree in which Roman culture was persisted and Frankish and Alemannic influences where included is extensively debated and goes beyond the scope of this research. Nevertheless, the areas around Roman settlements were continuously used during the 4th to 6th century, and settlements remain known at the same location, since these locations where often suitable for agriculture and easy to defend.

Within these villages, the Roman agricultural structure remained influential. The social, economic and juridical conditions that developed in these Northern Roman provinces led to a fixed relation between farmers and their land, which would play an important role in the landscape development of this period, and thus the Upper Rhine valley. Along a class of nobility and imperial domains, small landowners and even free farmers have existed. However, the slavery that occurred under Roman rule slowly lost its importance and disappeared. In contrast the dependence of servants of landowners increased, especially since the German differentiation between a ruling class and depending servants increased in influence. According to Rösener (1992), Tacitus described that in the German structure lords did not depend on the land, but on food and other products they demanded from their servants. The exchange between these two systems probably supported the increase of semi-fixed settlements and naming of settlements (*-heim*) instead of families (*-ingen*). (Directie Bos- en Landschapsbouw, 1991, p. 17) Lords ruled specific fixed lands on which their servants where supposed to produce. (Rösener, 1992, pp.8-9) While Gallian areas west of the Rhine had suffered severe Roman influences, large areas east of the Rhine first learned about Roman influences during the Frankish expansion. (Rösener, 1992, p. 10)

Settlements with a name ending on the suffix *–ingen* are usually considered the oldest post-Roman settlements, have often been related to Alemannic culture of the 4th and 5th century. (Eigler, 1999, p. 182) The suffix *-heim* indicates a slightly later (5th, 6th and 7th century) settlement which in earlier research is often attributed to Frankish settlers. This corresponds to the villages with *Reihengräberfelder* in the Breisgau region, the southern part of the Upper Rhine valley and the Schwarzwald. (Hoeper, 1994, p. 31; 2001, p. 75) A quick scan of the Reihengräber and the place names in the Upper Rhine section from Strasbourg to Mannheim indicates that a similar trend can be expected here. (Schreg, 2006, p. 29) However, a more torough study is essential in order to state if the older *Reihengräber* indeed correspond with the place names with -ingen and -heim suffixes in this section as wel. Nowadays *–heim* names are considered to have been used by multiple Germanic tribes. (Bauer, 1999, p. 151) Place name studies should be considered carefully, because the name can also be given during a later or even a modern period. Figure 4.4 shows *–ingen* and *–heim* names in the Upper Rhine area. For the Breisgau, Hoeper (2001) has supported these place names with findings, which can be found plenty on the terrace's rims in the 4th and 5th century, along the Rhine. Hoeper assumes continuation of the Roman settlements and the use of the similar fields. Hotspots for settlements can be found around Roman *Castella*, and Rhine crossings. (Hoeper, 2001, p. 116) These settlements are closely related to the Roman system of productive areas and locations along transport networks. Such settlements first disappear when the Roman military moves out in the 5th century. (Hoeper, 2001, p. 116) Earlier around Roman Castella, extensive grazing lands were especially necessary for the cavalry. (Mitterauer, 2010, p. 33) The grazing fields of the cavalry have been fertilized with manure for many decades, and thus might provide nutrient rich soils. This might be one of the reasons people resettled directly outside Roman settlements as is known for Lopodunum (Ladenburg) and Noviomagus Nemetum (Speyer), which is also indicated by Hoeper's theory that after the decline of the military in the of the 5th century people were settling around the former Roman city, possibly at villa rusticate that were providing the Roman

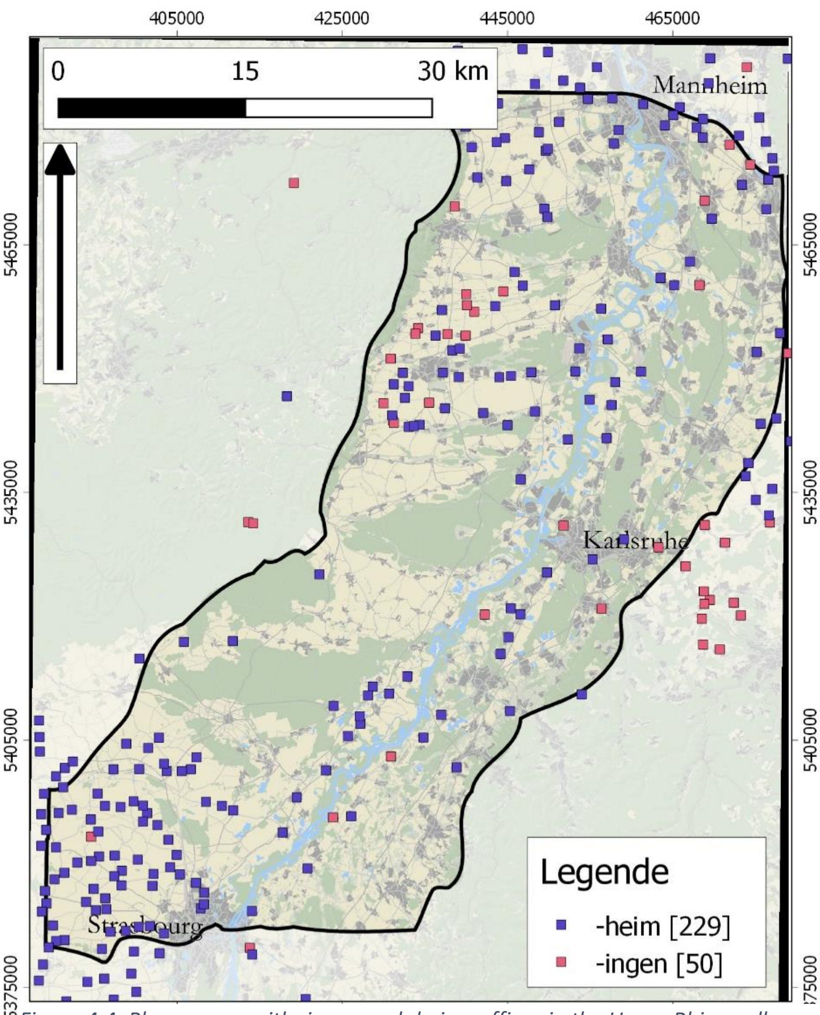


Figure 4.4: Placenames with -ingen and -heim suffixes in the Upper Rhine valley

settlements. (Hoeper, 2001, p. 116; Schreg, 2006, p. 27)

Villages with the suffixes *-dorf* and *-hausen* are also considered to have occurred early, around the 5th and 6th century, while villages with suffixes like *-hofen, -stetten, -weiler, -au, -bach, -berg, -wald* and *-kirch* are considered to emerge from the 7th century onward. (Hoeper, 1994, p. 32; Rösener, 1985, p. 43 ;Jänichen, 1974, IV.1,2, p. 3) The manifold of suffixes from this period show how many new settlements were founded (or just named) during that period. According to archaeological findings the populated area was not so densely populated that there was no place left for new settlers to settle. (Schreg, 2006, p. 29) However, the remaining lands might have been less suitable for agriculture. In this period livestock and cattle farming provided the main livelihood for the rural population, which was also more suitable in these marginal newly reclaimed lands. However, new agricultural lands were taken exploited as well. (Rösener, 1985, p. 42) In his Breisgau study, Hoeper (1994) connected these aforementioned place names with soil quality and deserted villages, so-called *Wüstungen*. This provided the interesting result that *–ingen* place names are located on the best soils and therefore hardly occur in lists of deserted villages. He concludes that settlements founded slightly later on worse soils tend to become deserted more often. (Hoeper, 1994, p. 33) This indicates that during the period of settlement after the Roman decline, settlers or founders of new villages were aware of the best suitable soils.

4.3.2 The best soils for early agriculture

The richest soils of the Upper Rhine valley by means of nutrients are deposited river sediments. In addition, loess soils were popular soils to settle on early on, because they were easy to cultivate with the limited tools available during this period. (Schreg, 2006, p. 22) As the soil map (figure 4.5) points out, the Upper Rhine valley and especially the flood plain is characterised by its river sediments deposited by the Rhine river, mostly gravel, sand and loam. Nevertheless, there are some differences in the surrounding terraces and hills to be aware of.

The western terrace, which is about 25 kilometres broad, mostly contains loess, formed during the Würm-Ice Age. The way narrower eastern terrace or ridge, about 10 kilometres, consists also of the Würm-Ice Age sediments. However, no loess is formed there, because this was part of the active flood plain. This ridge also locates some sandy dunes, consisting of these former flood plain silt and sand created by winds in the aftermath of the latest Ice Age. (Holzhauer, 2013, p. 205) The flood plain sediments on this ridge are expected to have been less nutrient rich, since during the Ice Age it was probably too cold to provide sufficient plant remains in the sediment. This difference in surface soil therefore leaves richer and easier

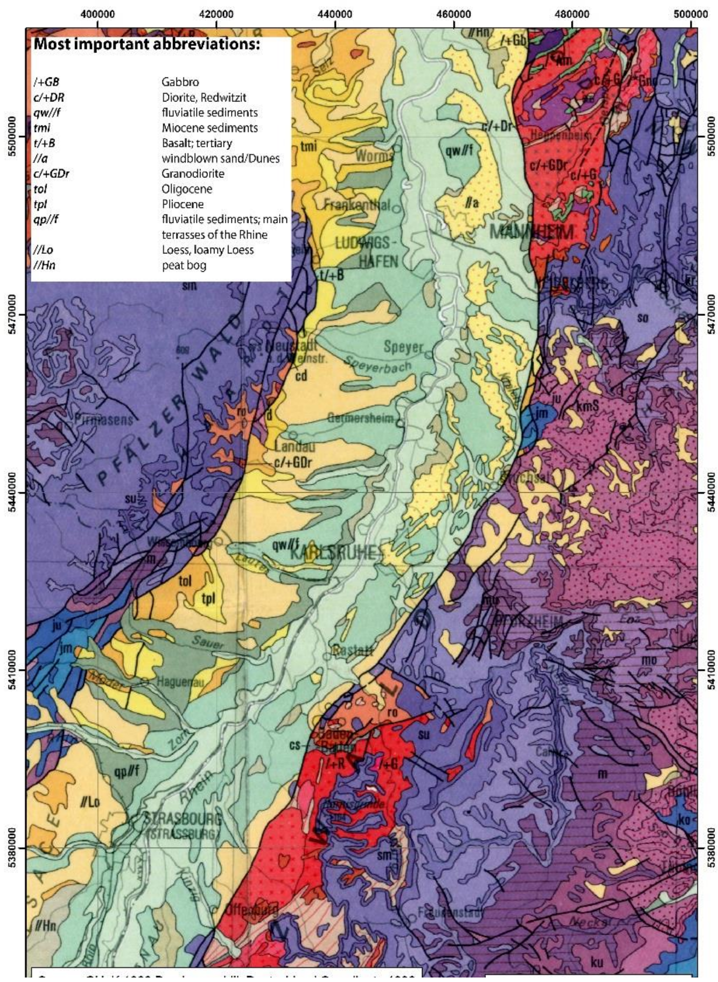


Figure 4.5: The soil map of the Upper Rhine valley clearly show division between the hilly areas, the terraces and the flood plain.

to cultivate soils on the western terraces, while the eastern rim quickly dried out when the Rhine cut out its flood plain and thus sunk the ground water level. This eastern terrace did hardly get any water from tributaries, because of the Kinzig-Murg-Rinne. The western terrace however, can be considered suitable soil for early settlement, especially around the stream. Most of the western tributary streams originate in the Pfälzer Wald and the Vosges mountain range, both mainly consisting of poor and dry sandstone. The sandy triangles, caused as a result of mountain streams depositing sand from the sandstone while cutting in the lower terraces, often consist of extended woodlands. In more wet, sandy areas and along the streams predominantly grasslands can be found. On the fertile loess-plains (called '*Riedel*') many villages have situated their fields. The loess-layer can be one to two meters thick. (Geiger, 1991, p. 28) However, it is easily eroded by wind and especially quick by water. It could therefore be expected that the western terrace has been eroded to a large extent over the years, and these loess terraces would have been reduced in nutrient richness because of severe loss of the top soil layer. It could be that the significant input of loess sediment from the western side has caused the Rhine moving slowly eastward at the point where tributary streams mouth into the Rhine. This has been indicated by Schmitt for the southern Upper Rhine valley, but further research, supported by datings from field work, is necessary to elaborate on this argument for the north of Strasbourg. (Schmitt *et al.*, 2016, p. 26; geoviewer.bgr.de, 2019)

On the eastern bank of the Rhine in the North, the Neckar flows through a sandstone area, while south of the Neckar the erosion sensitive Kraichgau consists mostly of loess sediments. South the Pfinz river, the Schwarzwald granite soils can be found. The Kraichgau has lower and flatter hills, it was the easiest route from west to east and vice versa, right in between the Odenwald and the Schwarzwald. Thus, the Kraichgau valley gave place to important trade routes. On top of that its loess soils were rich in minerals, well drained and very suitable for early simple farming. Therefore, the Kraichgau got settled significantly earlier than the surrounding hill ranges. It is expected that the Kraichgau acted ahead to its surrounding regions. Not only in first settlement, also in expansion of settlement, milling and settlement clustering. (DGM, 2016, p. 15; Rösener, 1985, p. 59) The Kraichgau area between the Pfinz and the Leimbach still provided more sediment to than the surrounding hills, due loess erosion into the Upper Rhine riverbed. This is also in the watername of the Leimbach, derived from Lehmbach, which means clay stream. (Greule, 2014, p. 306) Especially since the nutrient rich loess area was deforested and cultivated earlier than its surroundings hills. Because of that a surplus in sediments in this area can be expected. This could cause an impoundment in the water upstream of this area and therefore increases the flood risks south of the tributaries from the Kraichgau.

According to Damminger the south Kraichgau has been influenced by Frankish tribes later than the near Upper Rhine. Damminger, for example, states that Liedolsheim and Rußheim are continuously settled, understated by both their *–heim* suffix and *Reihengräber*. Both of the settlements are also mentioned in the Lorscher Codex, meaning the nowadays flood risky floodplain was settled during the Merowinger period. (Damminger, 2002, p. 152) Although these villages where located on slight elevations. The slightly more southern villages of Linkenheim and Eggenstein, were located on the pointy protrusions of the terrace rim, which was seen more often. (Doll, 1999) Eggenstein however is linked to a late Merowinger cemetery within the flood plain, which is big enough to be the cemetery of the main village. For Linkenheim the same can be expected due to findings of a *Zwiebelknopffibel* (early medieval dress pin) in the flood plain near Linkenheim. (Damminger, 2002, p. 153) Knielingen is located on a protrusion as well, and in accordance to Rußheim and Eggenstein a 4th century settlement can be expected. (Damminger, 2002, p. 154) Damminger then concludes that the majority of the village on the eastern bank of this northern Upper Rhine section are located on protrusions, possibly with a cemetery in the flood plain. Although such cemeteries within the flood plain could tell a lot on the perception, this provides an opportunity for further research. The sandy terraces are covered by forests (with the exception of the settlement of Hagsfeld. While the Kinzig-Murg Rinne is hardly populated as well. Further settlements are located at the feet of the hilly areas near the tributaries. The emergence of these settlements seem to be related to the transverse roads over the terrace.

(Damminger, 2002, p. 156) In the Upper Rhine valley not too many *Reihengräber* are found from the Merovingian period, at least much less than in the Neckar valley and in the Breisgau. Hotspots in the Upper Rhine valley are the whole Neckar valley around Heidelberg, and the urban centres of Speyer and Strasbourg, remarkably similar to areas of Roman settlement. In the surrounding area, as aforementioned the Kraichgau has more than a few *Reihengräber*, mainly situated around the Rhine tributaries of the Pfinz, the Saalbach and the Kraichbach, while the other mountain ranges have hardly any *Reihengräber.* (Damminger, 2002, p. 14; Dauber, 1974; Kommission für geschichtliche Landeskunde in Baden-Württemberg, 1974, Karte III.7)

All of these hilly ranges, including the Kraichgau reduction, are intersected multiple times by small streams draining towards the lower laying Rhine. This can result in valleys of several hundred meters within the plain. (Geiger, 1991, p. 26) From the Western Vosges the biggest tributary is the Ill around Strasbourg, but the Moder can also be considered significant. At Lauterbourg the Lauter flows into the Rhine which is the biggest tributary from the Palatine forest together with the Queich. From the southwest the significant Kinzig joins the Rhine at Kehl. Moreover, the Rench and Murg form significant water dischargers from the Schwarzwald. The Alb and Pfinz discharge the water of the northern Schwarzwald. From the Kraichgau only smaller tributaries join the Rhine, the Kraichbach being the biggest. However still not significant compared to the Schwarzwald tributaries and the Neckar. The Neckar is one of the biggest tributaries the Rhine has on his whole course. But since it joins the Rhine at Mannheim, the Neckar inflow hardly affects the research area. The small tributary streams that drain into the Rhine provide a big diversity in sediments in the river. Transported sand from the sandstone mountain ranges, loess from the terraces, and in addition sand and gravel transported originating from the Alps.

The alluvial flood plain is flooded regularly and there are new sediments arriving regularly when melting water thrives up the water levels. Besides sediment deposition, this also causes erosion. Soils of the flood plain are thus often refreshed and provided with new nutrients. For this reason, it is argued that hardly any archaeological remains can be found in the flood plain, because they have been washed away be the flood dynamics. These soils often have high ground water levels since the river is close. Therefore, these soils consist of heavy loam within reach of ground water. (Geiger, 1991, p. 31) The hardwood forests that are now located on these soils are located slightly elevated and are therefore seldom flooded. This results in extensive ground planting, a healthy layer of shrubberies and a variable tree assortment. (Gallusser & Schenker, 1992, p. 22) Flood plain soils with less elevation that are subject to flooding regularly consist of weak wood communities. Such vegetation slows down water speed is case of flooding, resulting in an increase of sediment deposition, thereby heightening its own elevation. This results in elevated parts and lower parts shifting constantly over decades or even centuries. Moreover this causes constant dynamic changes in vegetation. Often these swamp forests are underneath the ground water level for larger parts of the year. These *auen*-soils (swampy forest soils) are therefore heavy loamy and clayey gley soils. (Geiger, 1991, p. 31) The river brings in new nutrients regularly providing a very fertile area combined with a plenitude of water. (Gallusser & Schenker, 1992, p. 22) The species in weak wood areas and on the frequently flooded grasslands have to be adapted to get their oxygen in other ways, which is called aerenchym. The Rhine stills brings new rocks and sand every day. These are deposited at slower flow paces and for example in case of flooding. When the water withdraws, the gravel and small rocks remain, providing sand- and gravel banks, creating a perfect location for pioneer species. (Gallusser & Schenker, 1992, p. 22) Species in these frequently flooded places have adapted to a dynamic environment. (Gallusser & Schenker, 1992, p. 29) Many islands in the Rhine start out as gravel banks. In toponymy these hardly overgrown banks are called *wörth.* (Herget *et al.,* 2005, p. 301) Since the Tulla-regulations, the influence of high water on ground water levels only last to about three to four kilometres from the Rhine's main stream. Further than four kilometres of the Rhine the ground water level is only determined by rain water. (Dambeck, 2005, p. 67) In addition, many of the former Rhine channels still encounter groundwater. Most of these channels have gotten in disuse since Tulla's Rhine rectification during the 19th century. Yet, also before Tulla's correction meanders have been cut off. Both, as a result of the interference of humans by creating bypasses, and by natural river displacement like avulsions, the process of a river channel suddenly shifting its location on behalf of an easier gradient. In these old channels of the river the water does not flow anymore and as a consequence these lagoons become overgrown, unless they are kept open by human effort. Without human interference it might take at least up to a hundred years for a former channel to become land again. Besides the fact that these overgrown channels have nutrient rich and normally thick humus layers, the sandy soils underneath are consisting of sand and loam deposited by regular flooding. However, these former channels are often too wet to suit for agriculture. (Geiger, 1991, p. 31)

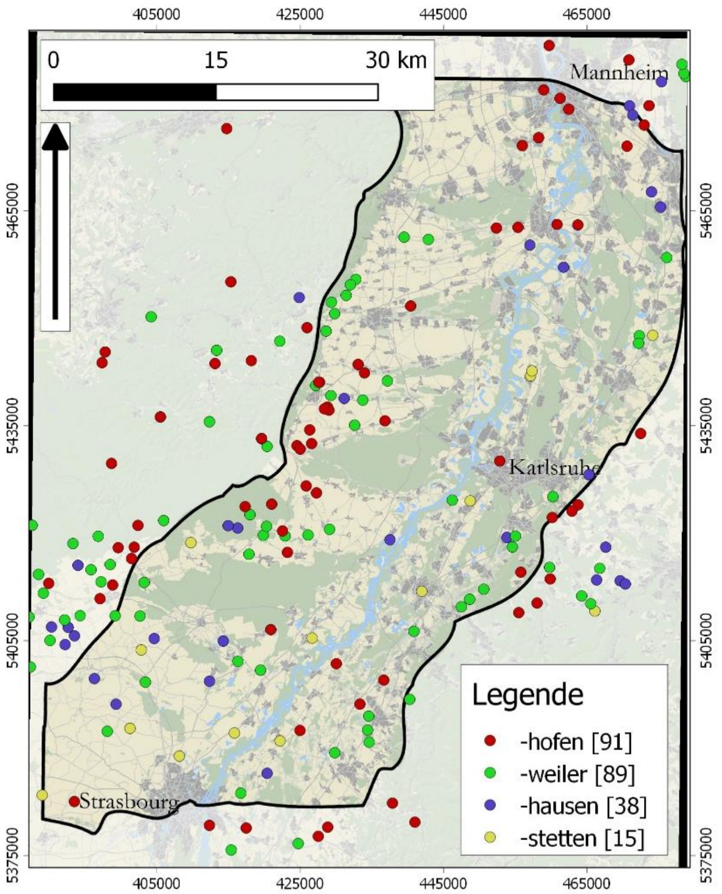


Figure 4.6: Placenames with -hausen, -hofen, -weiler and -stetten suffixes in the Upper Rhine valley.

Similar settlement patterns can be discovered when looking at the aforementioned place names. However, many of the Upper Rhine valley place names have the *–heim* suffix. (Kommission für geschichtliche Landeskunde in Baden-Württemberg, 1974, Karte IV.1) Additionally, around Speyer a few *–hausen* and *–stetten* place names can be seen, while around Strasbourg and Baden-Baden *–hofen* place names occur. Over the whole valley many *–weiler* place names are found, however most of them are on the western bank and all of them are on higher ground like the loess terraces. (Kommission für geschichtliche Landeskunde in Baden-Württemberg, 1974, Karte IV.2)

During the early Middle Ages settlements varied more than in the high Middle Ages. Solitary farmsteads, groups of farmsteads, and small villages still moved occasionally because of natural or military influences. On top of that, nutrition of the soil was not as easy as it is nowadays with fertilizers. Therefore, every one or two years a land had to lay fallow and relatively large surfaces of lands where necessary. However, livestock was also used to fertilize such fields, livestock was a substantial contribution in the people diet as well. (Rösener, 1985, p. 22)

4.3.3 Nature challenging and helping mankind in order to survive on earth

Another aspect has to be added to this diversion of developing societal structures. After the Roman decline, Christianity made its way into European society and to the Upper Rhine valley. Already in the 4th century, Bishop Jesse is documented in Speyer. Moreover the diocese of Strasbourg is known in the 4th century. (Ammerich, 2011, p. 25; Müller, 1994, p. 93; Geiger, 1991, p. 106) Both these Upper Rhine dioceses were parts of the Archbishop of Mainz. Christianity in this period provided diversion of a set of ideas over extensive areas. This ecclesiastical infrastructure was first partly implemented into other 'pagan' believes, but slowly gained power into conversion of an increasing number of people. Influential North-African

Christian Augustine of Hippo (354-430) described nature as material darkness, which can only be escaped by ascetic behaviour. However, later on in his life he more and more indicated the good of nature, which was provided by God in order to help mankind surviving life on earth. (Schouten, 2005, p. 108) However, claiming that this idea inspired people to search for nature's possibilities would not be supported by any evidence at all. Therefore it seems that knowledge on sufficient soils and natural risk was quite common among the contemporary population. In the 5th and 6th century, it became common to interpret disasters as a sign of God being unhappy. (Schouten, 2005, p. 108) Although it should not be underestimated that rulers were still held responsible for natural disasters as can be understood from Meier's study on the case of Antiochenis in which it appears that the king is held responsible for disasters like earthquakes and flooding, since it is his responsibility to secure his citizens. (Meier, 2003, p. 58) This is in accordance with Groh *et al.*'s first definition of a disaster. (Groh *et al.,* 2003, p. 25) In the same time, this increased power to clerisy since they are able to communicate with the Gods. (Meier, 2003, p. 55) These arguments suggest that people lived under the eye of God during the late Roman and early medieval period, referring to Haas' concepts. Even Origenes (Ca. 185-253) claims this influence of God on human life. Although he does not specifically refer to disasters, he argues that God causes floods and conflagrations on earth in order to sweep his creation clean. (Origenes, Book, IV, c.69; Book VI, c.58) Where Lucretius interpreted the cruelties of nature as challenging for mankind, Origenes calls this a challenge for the human intellect in his reaction to Celsus. (Origenes, Book IV, c.76; Schouten, 2005, p. 107) Putting these arguments together, man could argue that floods are perceived as intended by God to challenge human intellect.

According to Arnold the natural resources rivers provided were an important part of everyday life around the year 500. *"Early medieval people built canals, constructed mills and millraces, dammed smaller rivers to create millponds and fishponds".* (Arnold, 2017, p. 126) Using nature's resources is not something new, since hunters and gatherers practically did the same, as can be said for fishery. Fishery along the Upper Rhine goes back a long time as Kuhn points out by explaining the Celtic place name Jockgrim as Salmon-corner. (Kuhn, 1976, p. 20) Also during Roman times, fishes like perch and salmon are noted in the Rhine. When population along the Rhine increased during the medieval period, fish became an important source of nutrients for humans during the Lent term. Sources of this period are scarce, but it is no debate whether fishery on the Rhine continued. The amount of *Salmengrund* field names around the Upper Rhine are prove of this, also pointing out that especially the salmon was one of the Rhine's important resources and great ware to trade. Sources of fishery and fisher guilds however first occur during the 14th century, with exception of the Wormser guild of the early 12th century. (Kuhn, 1976, p. 24, p. 43) In Mainz two different kinds of fisherman are defined: *Weydeloude*, and *Stadelude*. (Mainzer Fischmarktordnung, 1333) It could be questioned if this describes for example, fishermen from the flood plain, fishing in river channels and pounds, and fisherman from the terraces who fished by damming streams. However, more research is necessary on this topic to elaborate on it. In addition, the fishery rights around Selz are documented in 1338, by then owned by the king or Emperor. (Ruf, 1994, p. 359; Kuhn, 1976, p. 46) At the fishermen quarter in Speyer an eye witness described how fishermen sailed off to the Rhine, passing the cities impressive Dom in the 14th century. Furthermore, it is known that many cities along the Rhine had a fisherman quarter several centuries before that. (Müller, 1994, p. 170)

All in all, it seems that, after the Roman decline during the 4th and 5th century, its influence remained significant in the Upper Rhine valley. Inhabitants and new settlers settled at fixed locations (-heim) close to former Roman settlements. Probably because, the Romans had already settled on the best arable soils, or maybe because the soil around Roman settlements had been fertilized with manure. Local settlements had to be more self-sufficient, and shift to a more local focus. This urge to take care of themselves might have contributed to seeing nature as a resource for expansion of wealth.

4.4 Search for save elevations

From the Loire and the Lower Rhine, it is known that early habitation of the nutrient-rich flood plain started at slight elevations. Whether this also occurred in the Upper Rhine valley can be questioned, however, an increasing number of settlements

Figure 4.7 : 'Blick vom Isteiner Klotz' by Birmann

in the flood plain has become known, especially in the southern part, where the river has more islands, due to its anabranching character. Could it be that settlment in the areas at risk of flooding unintentionally initiated a search for protection, which was gladly offered by emerging Christianity?

4.4.1 River gradient as a signifier for meandering or anabranching river

In the case of a natural river, anabranching. At the source of a stream or river, high up in the mountains, alluvial channels flow through a steep and narrow floodplain. As the main channel emerges from the mountain range, it usually forms an alluvial fan. (Bridge 2003, p. 1) This can be seen at the Upper Rhine tributaries from the hilly areas, but also used to be visible at the Rhine as visualized on Peter Birmann's *'Blick vom Isteiner Klotz Rheinaufwärts gegen Basel'*. (Figure 4.7) (Blick vom Isteiner Klotz Rheinaufwärts gegen Basel, 1819) Since the river's gradient decreases, the river becomes more anabranching, as the Rhine does in the southern part of the Upper Rhine valley. When the gradient decreases below 1.0‰ the anabranching slowly shifts towards a main channel and then transits into a meandering river. When the gradient comes below 0.3‰ the river will continue as a meandering river. (Jongmans *et al.,* 2013, p. 379; Strobl & Zunic, 2006, p. 91; Gallusser & Schenker, 1992, p. 5) In the contemporary Upper Rhine valley, the Rhine starts anabranching and starts shifting towards a meandering river upstream of Strasbourg. From Strasbourg onwards a transition section from an anabranching to a meandering river with only one main channel emerges. Around Karlsruhe, the Rhine continues downstream purely meandering. (Gallusser & Schenker, 1992, p. 5; Schmitt *et al.,* 2016, p. 17; Rinaldi *et al.,* 2016, p. 23)

It is important to note that this is the current situation cannot be compared to the situation before the Tulla-rectification. Mainly since the pre-Tulla Rhine was over 50 kilometres longer, which directly influences the gradient. The famous Rhine engineer Johann Gottfried Tulla recognized the hinge point in the Upper Rhine as early as 1822. He located it at the Murg mouth and related it to the sedimentation of gravel in the southern part, and more sandy sediments in the northern part. (Tulla, 1822, p. 33) Based on Honsell's report (1885) on the rectification and the hydrological Rheinstromkarte of 1889, a reconstruction of the pre-rectification Upper Rhine gradient is modelled, as can be seen in Figure 4.8. (Der Rheinstrom und seine wichtigsten Nebenflüsse, 1889; Uelinger *et al.*, 2009, p. 10) The most visible difference is, that by definition the meandering part of the river used to start at Maxau, while nowadays it shifted downstream and starts at Leopoldshafen, according to the gradient. Additionally, it should be taken into account that the Rhine is completely rectified nowadays, and has lost most of its natural dynamics. In addition, it should be noted that the assumed hinge point of when the Rhine purely starts meandering, might possibly shift because of shifting water levels. This is one of the reasons Strasbourg to Karlsruhe can be called transition zone.

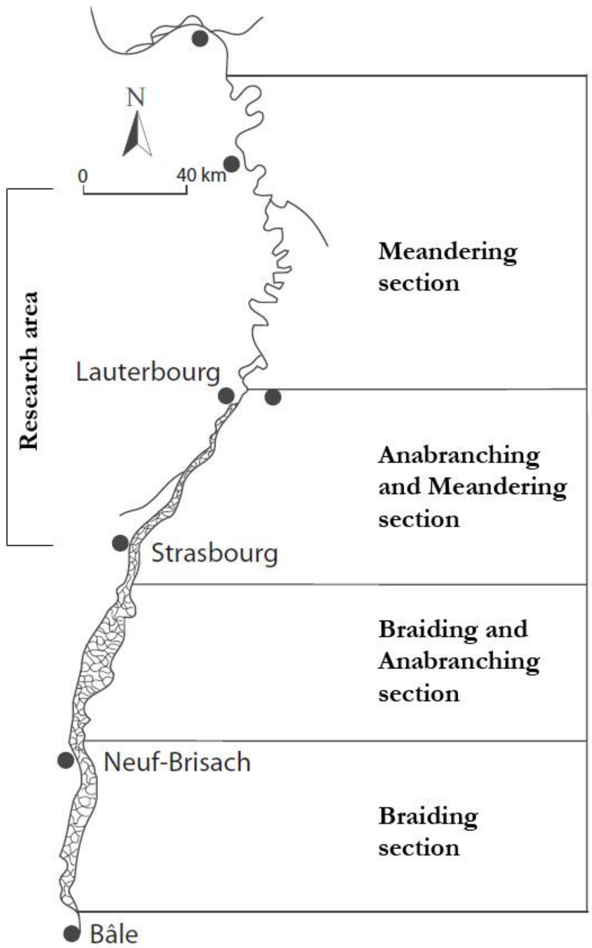


Figure 4.8: Anabranching or meandering depends on the gradient of a river. In the Upper Rhine anabranching fades out around Karlsruhe. (after Schmitt et al., 2016)

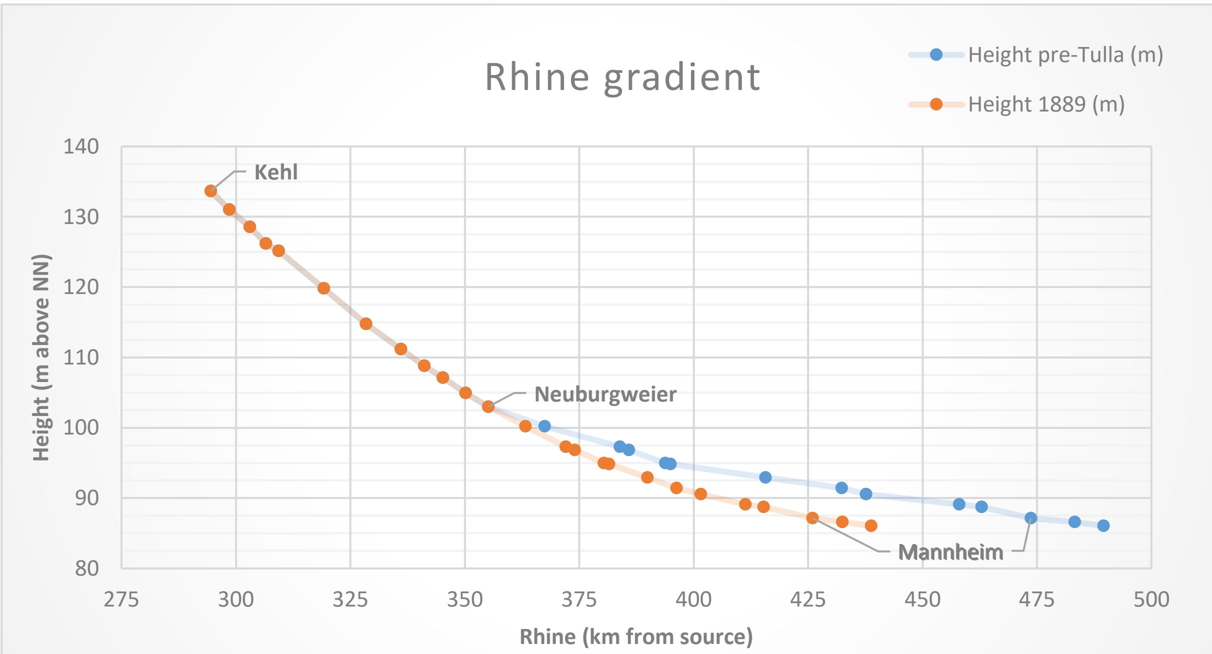


Figure 4.9: A graph on the gradient of the Upper Rhine before Tulla's bypasses and in 1889, before the dam constructions. (pre-Tulla after Honsell, 1885; Der Rheinstrom, 1889).

Concerning that, at least in the south, where the Rhine was anabranching, there might have been more smaller channels to cross. The water divided over multiple channels might have lowered the water level, thus making fords a realistic option. Moreover it is important to remark the effects these various typologies have on the landscape in case of flooding. Staying and slow water deposits sediments, of which grain size decreases further away from the channel. (Bridge, 2003, p. 270) Along the braiding and anabranching sections, multiple channels will provide a mosaic of slightly elevated mounds, or islands during high water levels. While at the more meandering section of the river, a strechted levee deposit can be expected along the main channel. This also must had effect on the form of flooding, because in the southern more anabranching part, increasing water levels would search their way through the elevated islands, nibbling off the banks of these mounds. In the northernmore meandering part, it can be expected that the water level raises up untill the levee is overflown or a breakthrough occurs. Both causes significant flooding in the backlands, since this is located lower then the levees. Such differences would in later periods probably also effect on which measures of flood management would function best.

4.4.2 Settlements on elevations in the flood plain

During dryer periods however, the sandy terrace soils would not have been very fertile. Especially during the early medieval period, when farming mainly focussed on livestock farming, wetter soils were less of a limitation then compared to the later medieval period, when much grain and other crops were cultivated. For this reason, it could have been attractive for inhabitants of the Upper Rhine valley to settle on the nutrient rich soils of the flood plain, especially since higher ground for eventual evacuations was near. In the search for the best places to settle on the floodplain, the difference between a levee and a mound is significant. It would of course be preferable if the farmstead and other facilities where not washed away yearly, so more elevated spots would have been chosen, as is also known for the Loire and the Lower Rhine valley (§2.3).

Figure 4.10 illustrates how villages (mainly in the flood plain and the eastern terrace, due the used data) settled on elevated parts of the Upper Rhine valley. Especially the rims of the terraces are a location of many villages, as it was during the Roman period. Three detail studies are highlighted. Figure 4.10A shows villages on the terrace rims, both higher and lower terraces. However, a few villages can be identified within the flood plain. These villages are all located on an elevation. In the case of the villages of Dettenheim and Rußheim, and more in the north Rheinsheim and Udenheim (contemporary Phillipsburg), these elevations are along older Rhine arms and relatively save for high water levels. (Damminger, 2002, p. 152) Figure 4.10B shows (north to south) the villages of Beinheim, Roppenheim, Röschwoog, Routzenheim, Auenheim, Sessenheim and the younger Stattmatten on a lower terrace on the western bank, and additionally Hügelsheim and Iffezheim on the eastern terrace. The only exceptions in this detail study are Fort-Louis, the 17th century defense work on the French German border and Wintersdorf and Ottersdorf. The place names indicate that the slightly elevated spots were settled first, and during early expansions of the 6th and 7th century more risky places in the flood plain were settled as well. However not visible on this map, it could be argued that Wintersdorf and Ottersdorf are located on a sand levee, placing these villages a few decimeters higher than their surrounding lands. (§7.2.1) Figure 4.10C shows how the villages of Rheinmünster, Lichtenau, Muckenschopf and Memprechtshofen are located on the lower elevation in the flood plain. To the south east the villages Gamshurst and Waghurst are located on slightly elevated mounds, which is indicated by their place name as well: *–hurst*. This means an overgrown or forested elevation. (Directie Bos- en Landschapsbouw, 1991) These three examples show, that when looking to the elevations in the Upper Rhine valley in more detail, it becomes clear that settlements are usually located slightly higher than their surrounding lands.

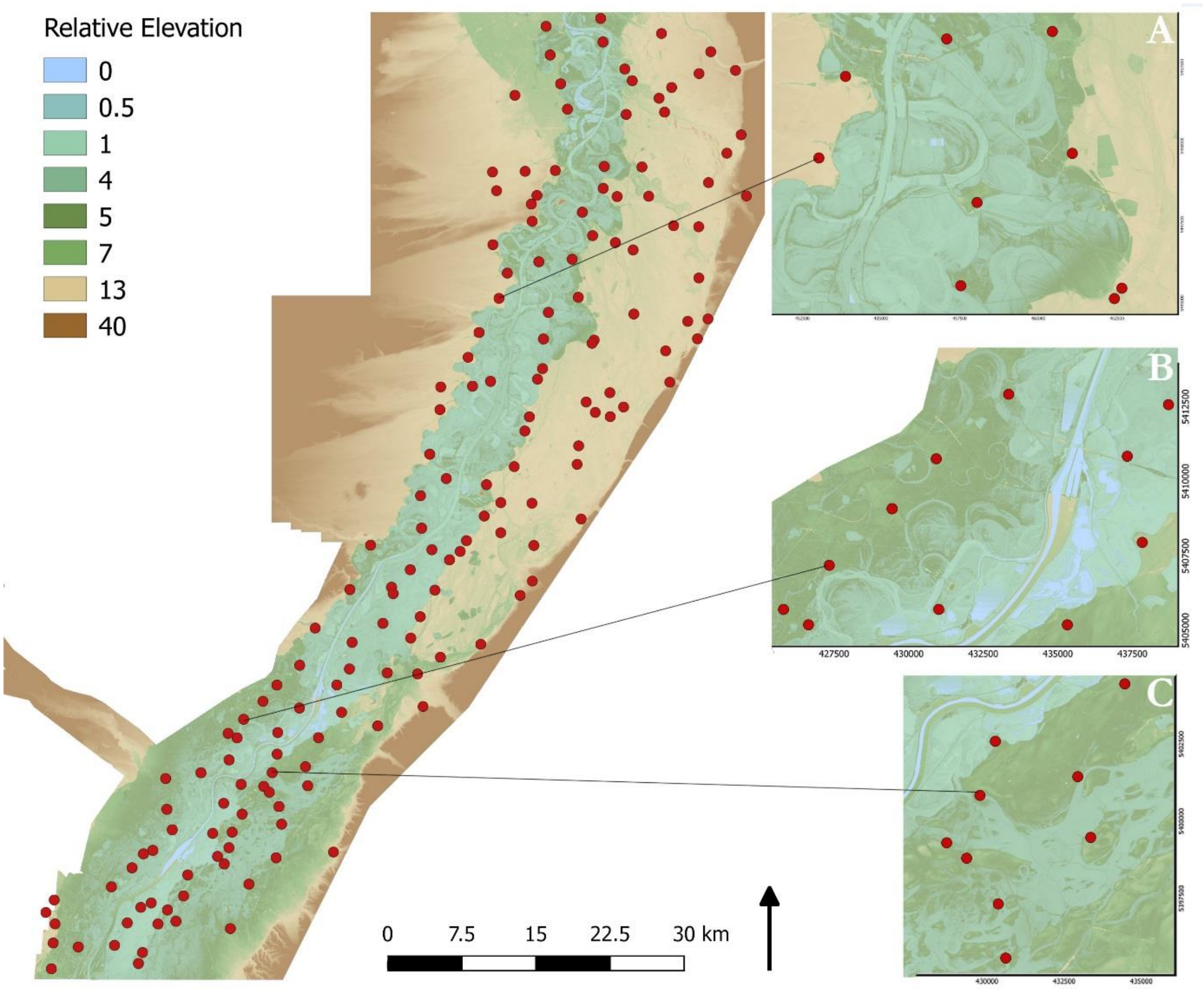


Figure 4.10: An elevation map of the Upper Rhine valley, relative to the Rhine. A. Villages on terraces rims and lower terrace elevation. B. -heim villages on the lower terrace and -dorf villages in the flood plain. C. Villages on the elevated islands in the anabranching section of the river. (Elevation is indicated in metres)

4.4.3 Flooding disasters framed as a signal for future events

After the Roman decline, Christianity increased in Western Europe and religious leaders gained public power. The church thereby became the hotspot for science and development. One of the early influencers up to the High Medieval period was Christian Isidore of Seville (560-636), and his works were copied far into the medieval period. In his encyclopaedic works Isidore pays much attention to water, which he considers one of the most powerful elements for human life. He argues that water *"tempers the sky, makes the earth fertile"*, and *"It brings forth fruits and trees, produces shrubs and grasses, cleans away filth, washes away sins, and provides drink for all living creatures."* (Barney *et al.,* 2006, p. 276 – XIII.xii) Thereby the quality of water is definitely recognized as an important resource for soil nutrition in the works of Isidore, whose influence reached as far as the Upper Rhine valley, to for example Boniface (675-754). Isidore describes various kinds of water bodies, like rivers and lakes that have a great diversity of qualities. These qualities can affect not only health both positively and negatively, but also behaviour, or in the case of the Thessaly sheep the colour of their fur. These variations have been caused by differences in temperature, but also in saltiness, and the presence of sulfur and alum. (Barney *et al.,* 2006, p. 276 – XIII.xiii) Isidore of Seville describes two variations of rivers in the 7th century. The naturally flowing rivers and the sort of rivers being called torrents, that swell by rain and dry up in drought periods during the summer. He also recognizes *amnis* in being another name for a river surrounded by forests along the river's boughs. (Barney *et al.,* 2006, p. 280 – XIII.xxi) Altogether, a very descriptive and scientific vision on rivers is given by Isidore. Isidore describes the Rhine as being one of the three mightiest rivers of Europe, directing its waters from the Alpine mountain towards the deep ocean. (Barney *et al.,* 2006, p. 282 – XIII.xxi) In the case of the Nile River, Isidore recognizes its quality to fertilize Egypt with new muds, which he connects to other rivers like the Euphrates and the Ganges. (Barney *et al.,* 2006, p. 280, XIII.xxi) Isidore de Seville mentions three divine floods, which covered big parts of the world and demanded humankind to recreate. Like in the former period Augustine of Hippo had highlighted the hostile side of nature. In his last sentences, Isidore mentions that floods can occur if rivers are swollen by rain, thus, a natural contribution to the water level. It can however still be debated why it rained, whether a God made it rain, to make it flood. Nevertheless, Isidore also mentions that floods do not only bring destruction, but also signify a future event. (Barney *et al.,* 2006, p. 283 – XIII.xxii) Altogether, it could be stated that the antique knowledge on rivers and flooding had not disappeared, mainly because of these extensive works of Isidore this knowledge was reciprocated in the middle ages. Remarkable is however, that Isidore was selective and mentioned only one reason for the flooding of the Nile, the Northern Winds. Andrew Fear interprets this, as a reaction on Lucretius in order to show that Christianity knows the one and only explanation, while the Epicurist Lucretius provides various possible reasons. (Fear, 2016, p. 58)

As stated, river floods have regularly be interpreted as signal for future events. Rohr formuletas it as connections to natural disasters in the Bible. (Rohr, 2016) This message from God was more important than the actual damage to the settlement or lands. Meier suggests that approaching the 6th century, natural disasters have been seen more and more as a signal for the approaching apocalypse. (Meier, 2003, pp.46-47, p. 54) In his latter Book X, influential Christian Gregory of Tours (Ca. 538-594) announces that disasters have increased as a predictive gift of the upcoming end of the world, which was generally feared during the 6th century. (Rohr, 2003, pp.75-77) Pliny the Elder, for example, believed that a stretched cloud and the water from wells signal earthquakes. (Pliny the Elder, Book II.81) According to Epstein, Pliny the Elder also believed earthquakes were a sign of Godly imperfection. (Epstein, 2012, p. 151) A comparable example of a flooding disaster as a signal for future events is noted when Gregory of Tours ascribes a Tiber flood to predict the papal appointment of Gregor the Great in 590. (Rohr, 2003, p. 75) However, Gregory of Tours does not mention floods and other natural disasters as being the thorn of God. He hardly makes any mentioning of the divine, but describes natural disasters as a signal, a warning to future events regarding kings or popes. It should however be noted that the dualism of a good church and the bad royal houses are present in Gregory's 6th century works. (Rohr, 2003)

Natural disasters, during and after the Roman period, were interpreted as a punishment of God. According to Meier it could even be said that the message of the Gods were more important than the actual damage a disaster did. (Meier, 2003, pp.46-47) This can be interpreted twofold, on the one hand, this could reflect the people's moral, whether they have been acting wrongly or sinning according to God. On the other hand, a disaster was interpreted as a signal for future events.

Arnold aimed to discover how Gregory of Tours communicated the risks of rivers in Gaul and how local communities, the bishops and saints could help to mitigate or avert disasters like flooding. (Arnold, 2017, p. 118) Gregory of Tours does not only describe the Loire, but also pays attention to the Rhône, the Rhine and various smaller rivers. Actually, Gregory of Tours almost drowned in the Rhine during a river crossing accident near Koblenz. (Arnold, 2017, p. 121, p. 125) Gregory of Tours describes the Moselle as a risky river instead of the healthy lifeline described by forbearers like Ausonius (Ca. 310-393). Arnold writes that Gregory believes that *"immersion in rivers as symbolizing sin and spiritual risk".* (Arnold, 2017, p. 129, p. 131) Gregory more than once mentions a flood as being more of a personal threat than a collective risk. Could it however be that by discouraging river traveling and spreading fear, Gregory of Tours was building an incentive for people to support the church, because the church took the risk of fishing? All in all Gregory of Tours mainly focuses on the individual risk, since the Bible mainly writes on salvation of the individual soul. As Rohr explains it, the inability to understand such natural events for individual. (Rohr, 2016) Therefore, natural disasters should be seen separate of the dangers that a river has for individuals. In contrast

Gregory describes a storm on the Loire, when a miracle occurs: a man with Saint Martin's relicts aboard luckily found the shore during this storm. He recognizes that miracles lights came from the lighthouse, which actually might be a common routine for locals in case of storms (Arnold, 2017, p. 133) Besides the risk and danger, Gregory also describes water, especially in springs, as clearing and healing, pointing out the complexity of early medieval allegoric understanding of water. (Arnold, 2017, p. 142) However, rivers were clearly used creating a fear for God, as Haas points out in his concept living under the eye of God. All together Arnold describes the important role clergy had in this era. *"Gregory and the other abbots and bishops of Gaul whom he describes for us were participants in their ecosystems, not merely observers of them. Their local decisions about bridges, river crossings, urban defence, watermills, springs, aqueducts and river access shaped the flow dynamics of rivers and also affected other downstream and upstream communities."* (Arnold, 2017, p. 143)

Processions, praying and passim in order to please God became more common in the 6th century. These were important activities in order to reduce the amount of disasters. (Meier, 2005a, p. 282) The people aimed to improve the relationships with God, both through clergy as through the king who was ruling under God. (Meier, 2003, p. 46-47, 54) After a disaster, the credibility of the clerics reduced, although they referred to the king as being the culprit. (Meier, 2003, p. 62) Groh *et al.* also pointed out that natural disaster were usually seen as a challenge for the ruling elite. (Groh *et al.,* 2003, p. 25) However, praying is not seen as the only possible solution. Arnold quotes the story of Abbot Senoch who built bridges over the riverbed in order to diminish the risk of people drowning by boats when a flood comes. *"Senoch thus enacted a public and practical response to routine risk. Throughout the early Middle Ages, other abbots and church leaders, leading communities dealing with disaster, enacted both similar practical measures as well as public religious rituals."* (Arnold, 2017, p. 130) Thus, arguing that aside of Haas' living under the eye of God, which is clearly dominant during this period, also more practical and technical solutions for diminishing flood risk are chosen, more close to living along the river or taming the river of Haas' concepts.

The slope of the Upper Rhine divides the river section into an anabranching part south of Karlsruhe and a meandering part north of Karlsruhe. This has an effect on the deposition of sediment and resulting elevations in the flood plain, being more island-like in the southern part and having more levees or linear cut rims in the north. People started to settle on the flood plain, on these slight elevations. This was during a period in which natural disasters like flooding were often interpreted as a sign of future events, reflecting a response to the moral behaviour of the individual. The church gained in importance, and its early educated elite distinguished itself from pagan researchers from the antique by providing clear answers. People who believed themselves to have the proper morals could safely settle in the flood plain, since they were assured to be protected against flooding, both by God and otherwise by their respective local ruler.

4.5 Church protects against the danger of flooding

It seems that the predictability of flooding and the promised protection due to an improving relationship with God made for a safe and flourishing life on the Upper Rhine flood plain. However, as population grows, trade and travel increase such that grain production becomes more important. Settlements then have to expand. The pressure this puts on the land becomes a problem in the floodplain only during wet periods. The less stable climate of the 7th, 8th and 9th century therefore demanded greater measures of protection. Might this be an important but hardly acknowledged reason for the increasing donations of flood plain lands to monasteries? Or was the church using this threat in order to retain their power?

4.5.1 Development of *Villikation* and land ownership

During the 5th and 6th century, Frankish tribes gained more and more influence in northern Gallia and later in the area between the Loire and the Rhine. Recent studies assume that the Franks overtook the Roman manorial system of the *villa rustica.* (Hoeper, 1994, p. 116) A big distinction from the *villa rustica* in the Roman period is the absence of slaves. Eigler recognizes this as the first of three phases of settlement development during the medieval period in the somewhat northeastern Main region. Only a few decades after Romans disappeared out the region, Frankish and Alemannic settlers took over the villages, still working from one main farmstead now called *Fronhof*. (Eigler, 1999) Eiglers second phase starts when the Germanic, or Frankish, social structure led to the emergence of the *Villikation* system. (Rösener, 1992, p. 25; Eigler, 1999, p. 219) The dual *Villikation* system called *domaine biparte* in French assumes that a landlord or his steward, the *Meier* (landholder), is seated at the main farmstead. This main farmstead comes with a significant areal of land, the *Salland*. In order to cultivate these extensive lands servants provide labour. These servants are allowed to own houses, the so-called *mansi*. (Rösener, 1992, p. 7-10; Mitterauer, 2010, p. 29) Apart from the main farmstead, and some essential lands and buildings, a few additional farmsteads were built. Servants that owned a house also had some private land to grow some crops, however, these *servi* still had to work at the manor. The social bond on such a manor was quite important and the people living and working on the manor were called *familia*. (Rösener, 1992, p. 14) Nevertheless, the *Villikation* system existed of both unfree farmers owning houses, called *servi casati*, and personally free *coloni* which had to provide services. (Mitterauer, 2010, p. 30)

From the 7th and 8th century onwards more and more houses, or smaller farmsteads, appeared. In addition, the field structure changed, the big block parcels were divided in long strips. Strips were a logic form since ploughing happened in straight lines that are as long as possible. With multiple landowners, the former blocks divided in strips are the result. Eigler calls this process the Franconian land reform. (Eigler, 1999, p. 220) This corresponds with Mitterauer's suggestion of a 7th century agricultural revolution, initiated by the royal court in the Austrasia, the area west of the Upper Rhine valley. (Mitterauer, 2010, p. 38)

During this period the church was a very important actor west of the Rhine in the Alsace and the Pfalz. Already in the 6th century, the monasteries of Marmoutier and Surbourg were founded, and several monasteries followed during the 7th and 8th century (Wissembourg, Honau, and Neuwiller). The establishment of abbeys or monasteries is mostly accompanied by creating or strengthening villages. (Bonneaud, 2015, p. 57; Prinz, 1988, p. 674, p. 676) The influence of the church seems to have grown over the 8th and 9th century, as well in Alemannia as in other regions. (Zeller, 2016, p. 38) In the 8th century, Benedictine monasteries emerged in and around the Upper Rhine valley. The most famous ones were Lorsch (764) and Wissembourg (641). In addition, Honau (722), Schwarzach (749) Fulda (744) and Reichenau (724) had properties and therefore influence in the Upper Rhine valley. (Kommission für geschichtliche Landeskunde in Baden-Württemberg, VIII.2, VIII.3) Monasteries were often set up as support to the royal court, because in exchange for prayers, they were provided with funding and donations by the king. This resulted in many monasteries set up in the same way as a royal manor; their focus laid more on praying and self-sufficiency. (Mitterauer, 2010, p. 39) Monastic courts were often seen as centres for technological innovation in agriculture, but also as centres for science and writing, although this is contested nowadays.

Kohl writes on the peak period of donations for Bavarian monasteries and churches. He agrees that the peak of donations between 750 and 850 in Bavaria also seems to have been the peak of donations for the monasteries of Lorsch, Fulda, Wissembourg, and St. Gallen. All of these were heavily involved in the Upper Rhine valley, and also got many donations (in form of land) from the research area. (Kohl, 2010, p. 97) However, Kohl cannot explain why the number of donations decreased; he suggests that it corresponds with a period in which the Carolingian expansion stagnated. Another argument for this increase in donations presented by Mitterauer: the growing importance of memorial of the death during the 8th century. In exchange for prayers for the dead, agricultural land was gifted to monasteries. (Mitterauer, 2003, p. 53) Kohl also argues that the churches and monasteries were among the biggest land owners and gained much power in that period. Therefore, support by means of donations might not have been considered necessary any more. It also seems that monasteries lost their momentum. Hardly any new monasteries were founded until the 10th century reform period in which the number of donations increased again. (Kohl, 2010, p. 98) When

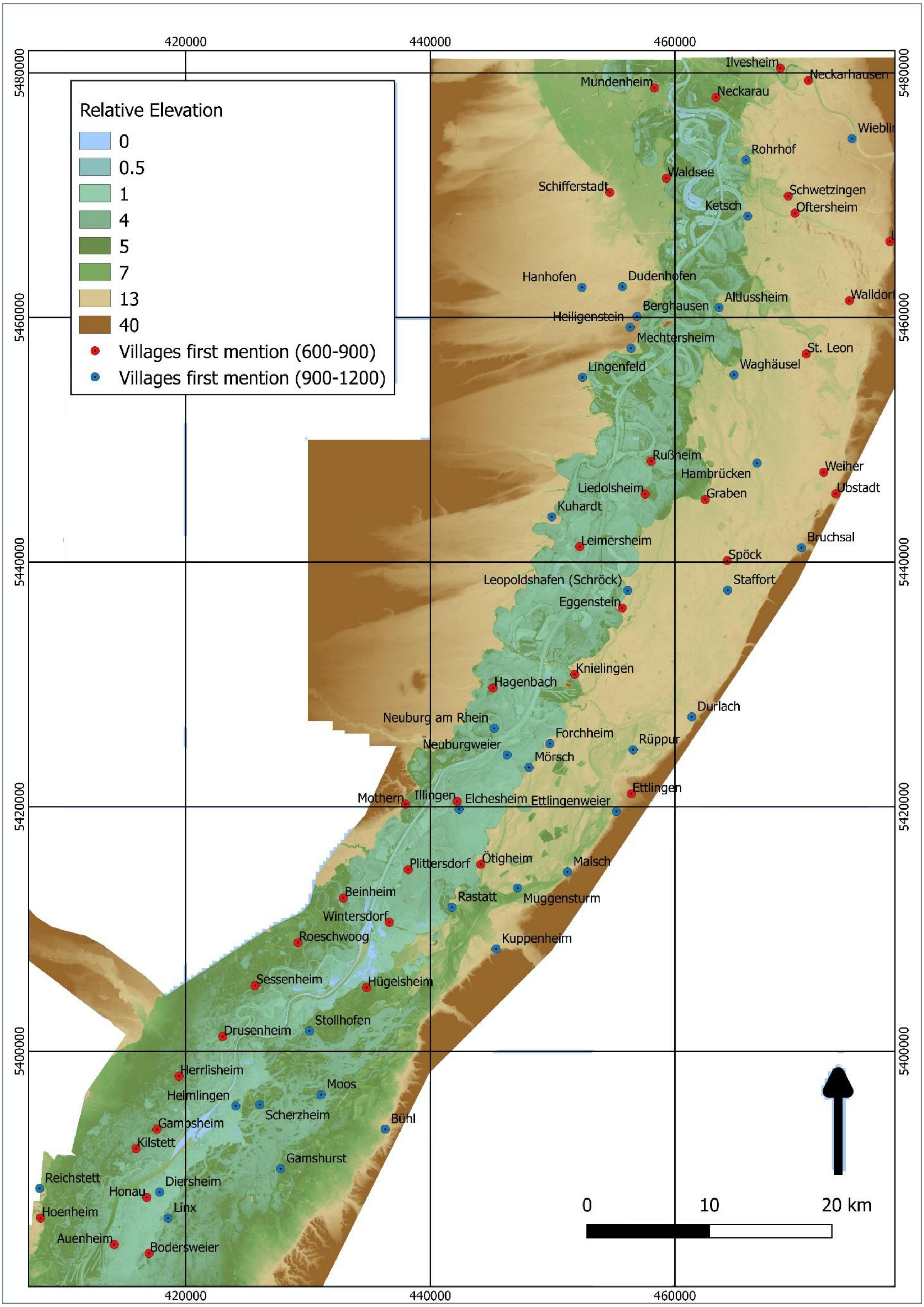


Figure 4.11: First records of villages, between 600-900 many villages within the southern floodplain give away land, while, between 900 and 1200 higher located villages are mentioned in donations or juridical correspondence. (Elevation is indicated by metres)

locating such donations on a map, as can be found in figure 4.11, it becomes visible that donations during the first peak are mainly located in the Rhine flood plain. While on the other hand, donations of the second peak are mainly located on the terraces. Locations at the edge of the terrace had the benefits of living close to the Rhine for transport, water, and nutrient rich soils within the flood plain. While, at the same time they lived dry and save on the terraces, as was done during the Roman period. According to Tulla early settlements where already built on the points sticking out of the terraces. (Doll, 1999, p. 303; Tulla, 1822, p. 30) Assuming that settlements both in the flood plain and on the terraces have existed continuously and somehow on a fixed location since the 7th and 8th, figure 4.11 suggests that there could be a geographical reason for giving farmsteads and land away to the church. Lands in the floodplain are gifted to monasteries during this 8th century, while lands on the terraces are not. Although solid prove is lacking, the instable climate could cause the need for more divine protection of villages in the flood plain in exchange for their gift of land. Another possibility is that circumstances within the flood plain were too hard to deal with for local landlords and inclusion in the church cooperative would be the most sensible possibility to survive. Both scenarios assume that it was a choice of the landowner to give away his land, and eventually his farmsteads and servants.

In small medieval villages, various actors run into each other constantly. In church, in the fields when sharing a plough, transferring the livestock to the common grazing lands or simply since many families are intertwined through marriage. An extensive and thorough study as Le Roy Ladurie did on Montaillou is not available for the Upper Rhine valley, but it is imaginable that such complex relations or double roles occurred in contemporary villages of comparable size. However, when focussing on construction projects, not only the relations between villagers are important, but also the role of landowners, their representatives and their relation towards the local residents becomes important.

From the 6th century onwards, local priests are known and from Charlemagne's reign in the 8th century these local priest are known to have the function of middle men between the literate court and the peasants in the rural settlements. Because of their literacy, they gained some tasks, or privileges, as for example to intermediate in local disputes and at the buying and selling of properties. (Van Rhijn & Patzold, 2016, p. 1-2) The example of a Wissembourgian local priest given by Czock (2016), sketches an image in which the priest is the local real estate manager, but at the same time the local mediator in the salvation economy. (Czock, 2016, p. 31) The practical role of the priests, as derived from charters, shows how ecclesiastical ideas hardly influence practice, because wealth and family are more important. The function of a priest was regularly followed up by a successor from his own family. (Zeller, 2016, p. 45) Additionally to charters, priest handbooks illustrate how priests should be good Christians and support the local community in being good Christians as well. (Van Rhijn & Patzold, 2016, pp.7-8) One of these handbooks comes from the monastery of Lorsch, which also had influence within the Upper Rhine valley. (Patzold, 2015, pp.227-254) According to Zeller it could be said that many of these local priests did not only act locally, but few of them were related to families and conducted activities of an 'official' and more administrative character as well. This implies a more regional network of those priests, often regionally correlating with royal fiscal districts. (Zeller, 2016, p. 40) How the role of a priest has changed over the centuries, especially during the reform periods, is at this moment still unclear and further research is necessary in order to distinguish whether a priest had a passive or an active role in the property market and development of agricultural lands. (Van Rhijn & Patzold, 2016, p. 10)

From the 7th century onwards nobility graves return in the landscape, often related to the increasing importance of the church. During the 7th and 8th century monasteries took an increasing important role in the landscape. The Reforms of Boniface could be considered one of the reasons for this; however, his influence seemed minimal in the Alemannic areas south of the Upper Rhine valley. The Weisemburg monastery at the periphery of the Alemannic area is however founded in the 7th century. (Schreg, 2006, p. 30)

4.5.2 Farmsteads cluster on behalf of landlord's centralization

It is generally accepted that every generation builds a new farmstead during the early medieval period. For that reason these farmsteads might move around the settlement area. However, this also kept farmsteads quite dynamic and flexible to changing circumstances. According to Schreg, farmsteads do cluster together from a single farmstead to a cluster of farmsteads. (Schreg, 2006, p. 30) Cemeteries are centralized as well, often on significant higher places. Several Roman settlements are deserted due to organisational changes in society as a result of the decreasing Roman influences and Merowingian expansions. In addition, the assumed improvement of climatological circumstances from the 5th to the 7th century provide new opportunities for settlement on places that are suitable for mixed farming, being crop cultivation and livestock farming. (Hoeper, 2001, pp.118-110)

The area of a medieval farmstead cluster can be described in three rings. (Schreg, 2006, p. 15) The centre of a village has common buildings and is surrounded by farmsteads. Most of the farmsteads have a small garden for private crop growing. This part is often walled, or at least marked. The second ring consists of agricultural fields. These fields are divided in blocks, in which every farmer would have one or more strips of land. The third ring consists of grasslands (often along a stream or in the lower parts of the settlements area) and forest for fire- and construction wood, but also for grazing and fattening of pigs. (Rösener, 1985, p. 56) During this period an estimated 2.4 people lived per square kilometre. Every farmstead had about 2.5 to 4 hectares of land. (Rösener, 1992, pp.4-6) From the 7th century the expansion of settlements start and from the 8th and 9th century onwards reclamations and clearances are conducted. Moreover early Three-field-system is argued. (Bork *et al.,* 1998, p. 163)

During early medieval times forests were mainly used extensively for grazing of livestock. Especially pigs were fattened with acorns, the so-called acorning. (Aberth, 2013, p. 89) Forests surrounding the settlements were additionally used for resources as firewood or construction wood. Aside from that, it probably was used to supplement the diet with berries and mushrooms, and probably for some game hunting by the elite. As stated before, the forest is located in the third ring around the settlement, thus when villages started to expand, this third ring of common forest was nibbled off. (Bonneaud, 2015, p. 41) However, Aberth illustrates that forest-products and services were valued during the early medieval period. King Gundobad had to compensate for clearing common forests during the 6th century and Charlemagne ordered not to cut down wood where ought to be forests in his Capitulare de Villis. However, two years later, in 802-803, Charlemange ordered to clear the woods if possible, which Aberth assumes is in order to create more agricultural production. (Aberth, 2013, p. 90) It is assumed that clearances start during the 7th and 8th century, as it does in Bavaria. (Kohl, 2010, p. 359; Rösch & Tserendorj, 2011, p. 71)

In 807 Charlemagne ordered that all farmers that owned three (later four) or more farms or loan workers had come to join the millitary. Because this was impossible for smaller farmers, they had to join up together, so that one of them could support Charlemagne in his conquests. Altogether, this led to a layer of landowning knights in societal hierarchy. (Rösener, 1985, p. 29) Colonists and military settlers often gained the benefits of being a free farmer. (Rösener, 1985, p. 28) Besides that, servants played an important role in clearances as aforementioned. Offering their labour on clearances and reclaiming land in exchange for owning part of the land and/or their own farmstead. However this was considered an improvement over working for a landlord, people probably still had to pay taxes.

The relation between a landowner and his servants is hierarchal. When an order was given by the landowner, it had to be conducted by his servants. However, it also matters what a lord hopes to achieve. There is a difference between the landlords demand for higher grain production or for higher income, no matter what is produced. (Hoffmann, 2014, p. 126) On the other hand, peasants need a motivation to conduct the demanded work. Hoffmann lists three of the possible motivations for peasants: 1) needs for family substance; 2) greater freedom; 3) greater income. A fixed annual rent, for example, would motivate peasants to increase their efficiency and stimulate technical improvement in order to raise their own income as well as that of their lords. (Hoffmann, 2014, p. 141) In the end, Hoffmann argues that the main motivation goes back to the amount of pressure their landlords executes.

Besides the villages that survived until contemporary times, many villages have been deserted over the centuries. The Historical Atlas Baden-Württemberg contains a map with *Wüstungen*. In the adverb, Schaab roughly defines five relevant periods of desertation. A first period of desertation of settlements is quite commonly suggested after the antique period, some discontinuity is assumed for the whole of Germany, which stabilizes in the early 6th century. During the Merovingian period, Schaab points out Christianisation and intensification of agriculture as a cause for concentration of settlements. Especially in more advanced areas like the Neckar mouth and the Kraichgau. Secondly, Schaab recognizes the significant number of deserted villages during the Carolingian period as well, which might be the result of the concentration of settlements. (Schreg, 2006, p. 352) However, foreign invasions and military unrest could also be a cause of deserted or demolished villages. (Schaab, 1974, p. 8) The *Weisemburger Güterlisten* mentions many deserted farmsteads during the 10th century. However, these are not all in completely deserted villages; several villages even recovered. (Schaab, 1974; Kommission für geschichtliche Landeskunde in Baden-Württemberg, Karte IV.23; Schreg, 2006, pp.349-352)

4.5.3 Early medieval farmsteads with a focus on livestock farming

The dynamics of population growth is a main factor for the growth or decline of a village. After the reduction of a population following on the antique period, population came to grow from the 8th century onwards at an increasing speed, as is commonly accepted. However, significant variations among regions should be taken into account. (McEvedy & Jones, 1978, p. 57, p. 69; Meier & Graham-Campbell, 2007, p. 425; Hoffmann, 2014, p. 52, p. 117) The causes of this population growth are heavily debated, as are the effects population growth had on the landscape. However, it is more and more agreed upon that population growth demanded agriculture to innovate. (Rösener, 1992, p. 100)

The expansion of settled areas becomes more and more visible. In addition to settlements with *–ingen* and *-heim* names (figure 4.4), several other suffixes occur. By analysing these suffixes, at least two sequences of expansions can be recognized, as are visualized in figure 4.12. The first one can be seen north of Strasbourg, around the river Zorn. Strasbourg is surrounded by places names with the suffix *–heim*. When also taken the suffixes *–dorf, -weiler (-willer, -weier),* and *–hofen (-hof)* into account, it becomes visible that these suffixes do not occur within the *–heim* centre. It might even be suggested that an outward sequence can be recognized. The *–dorf* names are found directly next to the *–heim* names, the *–weiler* names are mixed or outside of the *–dorf* names, and *–hofen* names occur in the unsettled areas even more outward from the *–heim* centre at Strasbourg. Thus, it can be concluded, that assuming an outward expansion of the area, *-dorf* names older than *–weiler* names and *–hofen* names have emerged even more recent. A second sequence is visible in the hilly area between the Pfinz and the Alb, west of Pforzheim. This small centre of *–ingen* names is mapped together with *–hausen* (*-house*), *-weiler*, and, *-rode (-rot)* names. Assuming that an expansion follows the stream valley in a stream upward direction, the *–ingen* placen ames and a few *–hausen* names are found near the start of the valley, followed by several *–weiler* names. (Jänichen, 1974, IV.1,2, p. 2; Hoeper, 2001, p. 164) These *–weiler* names also occur at the feet of the hilly areas surrounding the Upper Rhine valley. Deeper into the valley the *–rode* names occur, of which it is known that they first occur relatively late, during the 11th century. They are accompanied by the *–wald* and *–berg* names, which are not in the picture. However, these *–wald* and *–berg* names fit perfectly in a phase of land descriptive names, prior to the *–rode* name. (Schreg, 2008, p. 297) *–Heim* and *–ingen* names are the oldest in the region, and it is assumed that expansion and reclamation of new agricultural grounds directs deeper into the valleys. Therefore, *-hausen* names seem older then *–weiler* names, following from the figure. (Figure 4.12 Both are older than *–wald* and *–berg* names, and *–rode* names are the most recent names from the reclamation period. According to Hoeper (2001, p. 164) the *–heim* and

–ingen suffix are followed by *–stetten, -hausen, -hofen* and *–weiler* in the Breisgau region. However, the expansion sequences in the Upper Rhine valley between Strasbourg and Mannheim add *–dorf* suffixes to this list. It should also be stated that Schreg (2008, p. 309) claims, *"chronological differences in place names are rather the result of the changing recognition of landscape by people than of a planned colonization of cleared areas"*. However, the first sequence clearly shows rings of expansion in an area with similar soil and elevation circumstances, both south and north of the Zorn. (LiDAR-data Alsace; Lebreton-Thaler, 2001) While the second sequence in the Pfinz valley perfectly holds up with Schreg's theory of an infield-outfield ecosystem in this region. It should be noted that Schreg's theory is based on examples from elevated areas as will be discussed in the next paragraph.

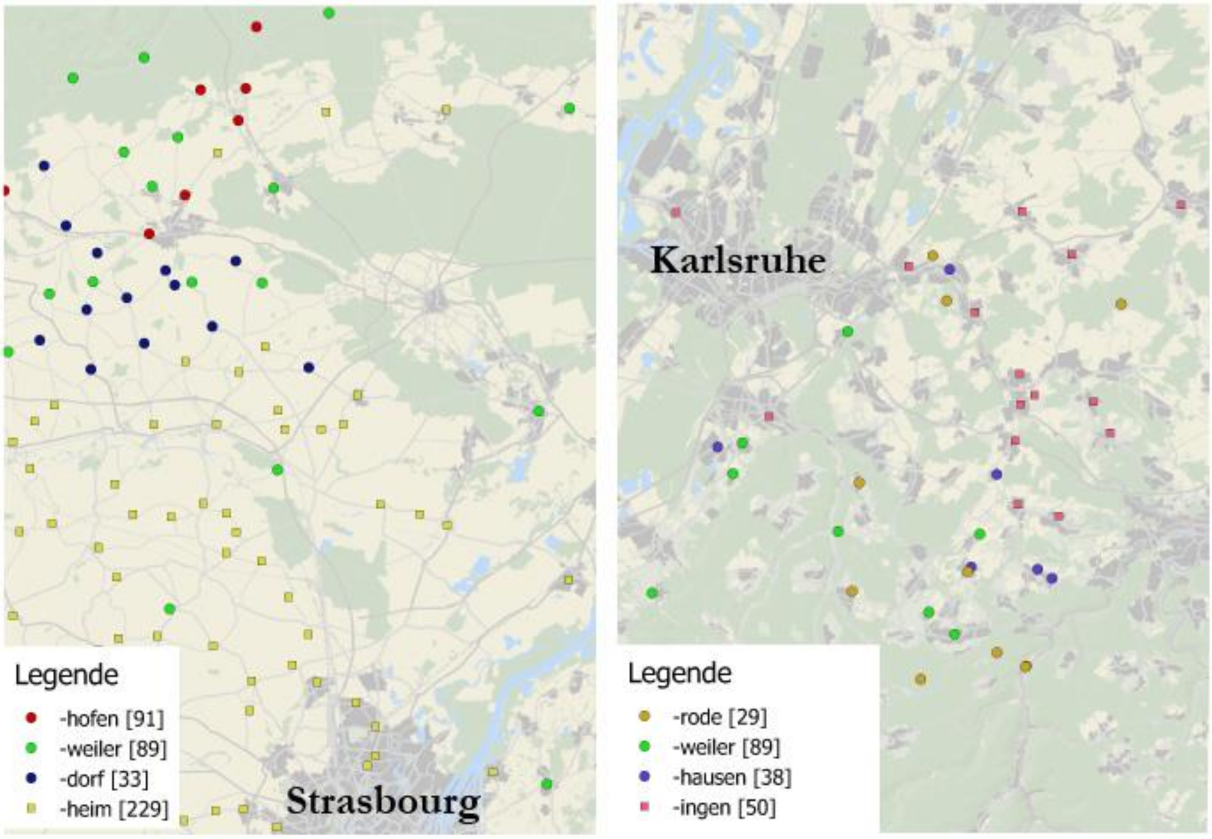


Figure 4.12: Two sequences of fieldnames indicating expansion. North of Strasbourg expansion north of the Zorn river and east of Karlsruhe expansion into the Pfinz valley.

The hilly zone between the Pfinz and the Alb, south of the Kraichgau was settled following on the Kraichgau, but before settlers moved on into the Schwarzwald. In the northern Schwarzwald, the Murg valley hardly has any record of settlement during the early medieval period. So settlement in the lower Murg valley is expected to have occurred from around the 11th century onwards. In accordance, the monastery of Reichenbach was first founded in the 11th century in the upper Murg valley. The donations charter, which is the proof of this monastery's settlement, includes records of the downstream farmsteads of Schwarzenberg, Röt and Heselbach downstream, and Tonbach upstream. This points out that the Murg valley had been taken into use at least during the 11th century. Important to note is that the toponyms *–berg, -rode (-röt),* and *–bach* are already in use during the 11th century. (Bittmann & Bittmann, 2009, p. 20) In the Upper Rhine valley, the biggest extension was taking the hilly ranges into use. It used to be accepted that the hill range like the Schwarzwald were hardly settled before the 11th century. Although Rösch argues that few settlements in the hill ranges existed, in the 11th century these settlements started to become independent from their mother village and built their own church and named the village. For that reason they have hardly been recognized before, though archaeological findings did indicate earlier use of the hill ranges. (Rösch &

Tserendorj, 2011, pp.66-73) Nevertheless, over the centuries, people started to settle deeper and deeper into the valley of the Rhine's tributary streams. Intensive use of the hilly areas became an important boost for the aforementioned deforestation. More south in the Kinzig valley, the Alemanni settled near the Kinzig, and over the centuries more and more marginal lands were claimed. Further south in the Schwarzwald reclamation increases around the 11th century, mainly initiated by monasteries like St. Peter, Hirsau and St. Blasien, but landlords and free farmers also contributed to the reclamation of the Odenwald and Schwarzwald. (Rösener, 1992, p. 27, p. 76) It should be added that Schöder recently argued that the Odenwald has already been settled many centuries before the 8th century. This was considered by Nitz. Schröder, who states that the Odenwald has been used extensively for many centuries, before the reclamations started in the 8th century. (Schröder, 2016, p. 382) Schreg argues similar theses for the Schwarzwald. (Schreg, 2008, pp.293-313; Rösch & Tserendorj, 2011, pp.66-73) This diversion away from the *Alt- und Jungsiedelland*-theory, towards an ecosystem of infield-outfield slowly seems to win support. (Schreg, 2008, p. 308) Elaborating on the extent to which these surrounding hills like the Schwarzwald, the Pfälzerwald, but also the Vosges have been cultivated at which point in history goes beyond the scope of the research. This should however be taken into consideration for further research.

4.5.4 Flooding: a predictable disaster

Besides examples of expansions over the terraces and into the hilly regions, toponymy also provides examples of continuous habitation on the flood plain, such as several *–hausen, -hofen* and *–dorf* place names. This is especially true for the southern section of the study area. An increase of settlements in the floodplain should not have been a problem if it was not for fluctuating water levels. Several decades or even generations of lower water levels might convince people to settle on the elevated parts of a flood plain. Especially as long as the agricultural focus was on livestock. In case of sudden high water level, the livestock could be driven out of the Upper Rhine flood plain on to the surrounding terraces.

The Rhine is a river with a mixed regime depending on both rainwater and melting water. The rivers hydrography shows three maxima, of which two present themselves during winter and one during the summer season. Rainfall causes a maximum in November/December, snow melting in the middle high mountain ranges causes a peak in February/March, and the melting of Alpine snow causes a peak in July/August. Noted must be that the rain peak in November/December does not stand statistically (Dambeck, 2005, p. 66). The relative amount of melting water is significant in the Alps and directly downstream of the Alps, as can be seen in figure 4.13. Further downstream, more tributaries are joining the Rhine, discharging hinterlands, which reduces the relative importance of melting waters. In this downstream section, rainwater becomes more important, as are the melting waters of surrounding hill ranges. The Upper Rhine region is the final section where Alpine melting waters cause bigger peaks than rain. Thus, in the Upper Rhine, flooding is mostly expected during the summer period in June and July. However, the other peak periods around February and November should not been overseen.

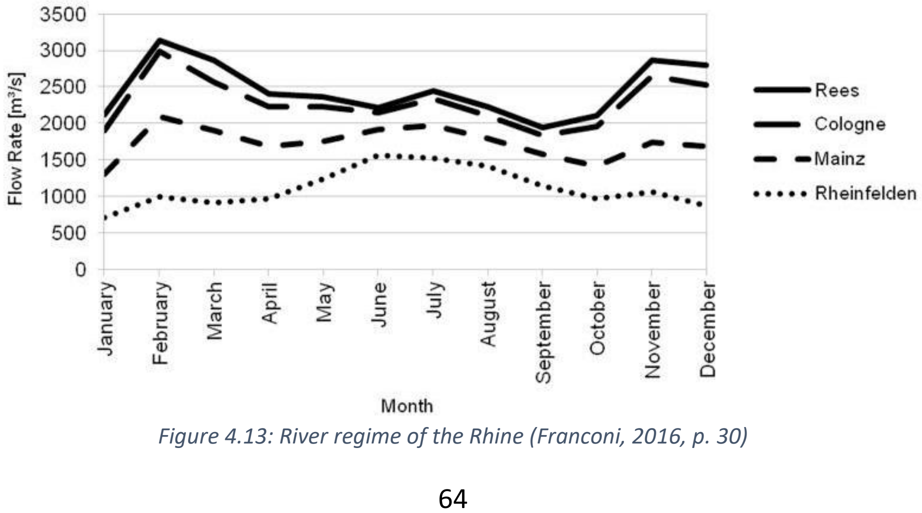


Figure 4.13: River regime of the Rhine (Franconi, 2016, p. 30)

River flooding is depending on the river regime, since the Rhine is a mixed regime, flooding can have four different causes: 1) melting waters; 2) local rain; 3) discharge of rain in hinterlands; 4) breakthrough of a barrier. A flood on a river does not have to be as deathly as other disasters, like earthquakes or a plague, since a flood can be predicted and usually develops slowly. (Van Dam, 2012, p. 5; Schenk, 2012, p. 52) Van Dam recognizes that disasters are heavily dependent on the commemoration of the event. Mostly amounts of deaths and financial damage count for strengthening such a memory. (Van Dam, 2012, p. 5) For flooding in the Netherlands Van Dam recognizes that its death rate is relatively low and often exorbitant documented in relation to the size of a disaster. From these observations, she concludes that accepting the flood risk by a coping mechanism: an amphibious culture, which must have reduced the deaths. According to Van Dam an amphibious culture includes compartmentation, living on elevated places, having a transport system over water and possibilities to evacuate the livestock easily. (Van Dam, 2012, p. 6) In Table 4.1, the predictability, the regularity, the speed of development and the potential danger is listed for those four kinds of flood.

Table 4.1: Types of floods relevant for the Upper Rhine.

Type of Flood	Predictability	Regularity	Speed of develop.	Potential danger
Melting waters	Good (long term)	Yearly	Weeks	Low
Local rain	Good (short term)	Occasionally	Days	Medium
Discharge of hinterlands (rain)	Bad (short term)	Occasionally	Few days	Medium
Breakthrough of a barrier	Not	Incidentally	Minutes	High

As stated, floods are to some extent predictable. By paying attention to weather conditions, one could expect severe levels of melt water when the weather warms up quickly after a cold winter. This melt water also causes a yearly repeating peak in water level, and probably has been well known for centuries. Rain does not happen regularly, but occasionally. It is easy to understand that the water level rises when it rains locally, where you can see it happening. This makes it easy to predict upcoming floods. When a heavy thunderstorm comes down in, for example, the Schwarzwald, the people in the Upper Rhine might not be aware of this. Tributaries drain this rain water to the Upper Rhine and water levels might unexpectedly rise within a few days. However, as opposed to the possibility of quickly rising water levels in small mountain streams, the Rhine has a much greater buffer, which could only cause a static flood. (Strobl & Zunic, 2006, p. 392) This is completely different in the case of a barrier bursting, which causes immediate flooding since it happens all of the sudden and is barely if at all predictable. This might even result in a flood wave, which the river valley is definitely not used to. Such barriers can be be formed by accumulating ice or wood in the river course. The greatest risk of flooding occurs when multiple of these aforementioned causes occur at the same time. For example, snow melting after a long winter combined with sudden heavy rains could lead to extreme local water levels.

4.5.5 The river as trade route for long distances

In Roman times, the Rhine has been used as trade route. (Franconi, 2017, p. 15) This was also the case afterwards in the Frankish Empire, and up to the Carolingian and medieval centuries. This statement is supported by an extensive collection of archaeological finds, like the *Mayener Waren*. (Grunwald, 2011, p. 143; Verhulst, 2002, p. 112) Arnold argues that the extensive descriptions Gregory of Tours gives of his travels pictures common river travel back then. There are many examples of ferry crossings during daytime, but even at night. Additionally transport and travel can be derived from his stories dating back to the 6th century. These descriptions do not only deal with the Loire, but Gregory of Tours also extensively mentions the Moselle and the Rhine. (Arnold, 2017, p. 126; Weidemann, 1982, p. 353)

Rivers used to be wild and unregulated during early medieval times, not easy navigable. First during the 8th century on the Danish Island of Samsø a canal is mentioned again. Vikings built a canal for navel defensive purposes and in order to cut the shipping route around the island. (Nørgård Jørgensen, 1998) In contemporary Germany a canal was built as early as 792. Not only to shorten a shipping route, but also in order to cross the European main watershed between the Danube (flowing to the Black Sea) and the Main (watering into the North sea via the Rhine). This so-called Karlsgraben shows a developed understanding of nature and the technical ability to deal with water management issues during the Carolingian period. (Ettel et al., 2014) Since the Christian period, aristocrats, kings and other lords had to provide their people with water. However von Reden and Wieland reflect on clean drinking water, their final statement that rulers had to be engineers in order to keep their people safe, might as well count for flood safety. (Von Reden & Wieland, 2015, p. 25) More often, Dutch colonists are linked with building canals and draining lands. On German soil this is documented at least since 1106, when Dutch colonists signed contracts to gain a piece of marshland along the Weser. In return, they had to drain these lands and pay taxes. (Rösener, 1985, p. 46)

Especially the Frisians are known to be living on hills elevated by themselves along the coast of contemporary Netherlands. (Hoffmann, 2014, p. 72; Verhulst, 2002, p. 113) Although it is not known whether Frisians migrated through the Rhine valley, they are known to have been important traders, especially in the early medieval period. The settlement names of Friesenheim north of Wörms, Friesenheim at Ludwigshafen, and Friesenheim south of Offenburg, might be the result of this. On the other hand most of these names date back to the eight century, and could therefore also be the result of a *–heim* name with a personal name as a prefix. A remarkable addition is that, the name *Friesen* for water ditch diggers and street builders from the Lower to the Upper Rhine is used around Strasbourg, indicating their knowledge of water management. (Berlinger, 1873, p. 147-150; Volquartz, 2017)

The river was not only used for trade or transport. It also took an important role in local villages. Another important industry along streams and rivers was milling. Milling techniques were already used during Roman times, when water was harnessed as a source of energy for a multitude of tasks. Damminger argues against a hiatus between Roman and Frankish agricultural techniques. For a mill, not only technological knowledge is needed; also social and economic structures must be in place. According to Damminger, this was the case in 7th century Baden, since the Merowingian Rang society (*Ranggesellschaft*) shifted into the Carolingian class society (*Ständegesellschaft*), in which grain production gradually became more important than livestock farming. Debating the reasons for this goes beyond the scope of this research. (Damminger, 2000, pp.226-227) However, like 8th century Bavarian mills, the mills in the Upper Rhine valley were usually not built along major rivers, but rather on smaller tributaries, creeks, or mountain streams. (Hammer, 2008, p. 324) If a mill was built in the Upper Rhine valley, from an energy perspective, it made more sense to build it at the mouth of a tributary stream. Mills were built near sources of raw materials, and close to the places of final consumption. One of the major consumers was the church. An ecclesiastical structure only developed in the 8th century in Bavaria, and probably only slightly earlier in Baden. (Hammer, 2008, p. 329) Nevertheless, the early medieval churches and monasteries provided possible locations for early milling. Gregory of Tours allowed a mill to be built at a monastery as early as the 6th century. In addition, embankments near the *Bruchsaler Königshof* indicate a mill dating from the 7th or 8th century at Bruchsa.l (Damminger, 2000, p. 224) The oldest remaining mills in Baden-Wurttemberg are the 8th century water mill in Zuzenhausen and the grain mill with a waterwheel in Singen, both located in the early settlement at Kraichgau. (DGM, 2016, p. 15)

Some sources make note of fish being harvested in flooded fields. In the Upper Rhine valley, the example of Knielingen and Daxlanden is illustrative, but seems to be fictional. During a dike construction in the 16th century, the Knielingen population did not trust the inhabitants of Daxlanden. They expected the Daxlanders to break the dike they were building, in order to harvest the fish from the fields of Daxlanden. This, of course, would cause fewer fish to reach Knielingen. No proof of a dike breakthrough can be derived from the source, and it seems to have been only an argument during the construction process. (Morrison-Cleator, 2007, p. 47) Dikes closely along the river were often used as elevated roads as well, the so-called

Leinpfaden. (Engelhardt, 1910, p. 35) The river was used intensively for transport. Mostly in downstream direction, since that would hardly any effort. However, quite often ships also had to move upstream in order to trade in Strasbourg or Basel. Usually the ships were then pulled by man or draught animals like horses. Wilhelm Besserer beautifully illustrates this at the Kurpfälzische Rheinstromkarte in 1595. (Kurpfälzische Rheinstromkarte, 1595) Besserers map is discussed to have been drawn to solve many borderdisputes between the margraves and the Palatinate. Such disputes happened relatively often, because the river as a border changed its course continuously. Also land was washed away and especially new emerging island as a result of sediment deposition were often cause for dispute along rivers.

4.5.6 The effects of sediment deposition and erosion

Main influences on erosion and sedimentation are the grain size of the sediment; the water discharge related to the basin; the gradient of a river; and the form of the river and the location in the river. When a river is flooding, additional deposition and erosion aspects become important in extreme situations, possibly leading to avulsions of the river.

Simply seen, erosion takes place in a river section with high energy and higher flow speed. Sedimentation takes place on sections where the speed of the water is low, so at low energy sections of the river. Most important to know on deposition of sediments is that the speed of the water discharge plays a big role in sedimentation. Variations in deposited grain sizes are also depending on the speed of water. Figure 4.14 shows how gravel gets deposited when the river discharge comes below 100 cm/s. When the discharge goes below 25 cm/s sand gets deposited as well. Clay almost always stays moving as long as the water does not stand still. (Jongmans *et al.,* 2013, p. 376)

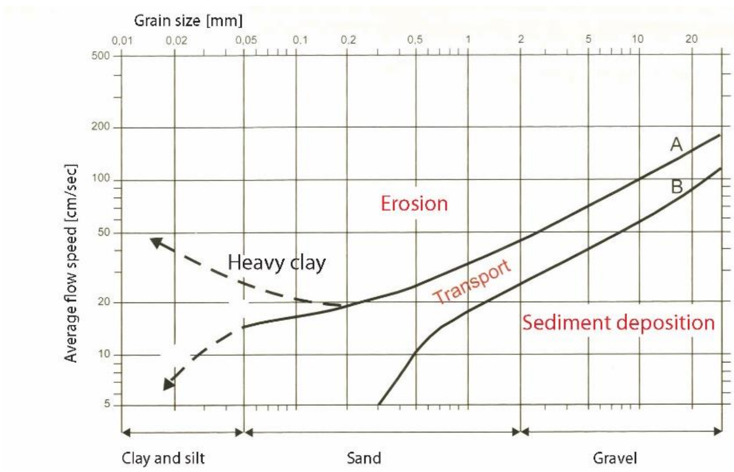


Figure 4.14: Erosion and deposition of sediment versus flow speed (Jongmans, 2013, p. 376)

Other important aspects of erosion and sediment deposition are variations in river gradient. When a slope increases, erosion would increase as well, and vice versa. When an uplift of the river bottum occurs after a slope's decrease, and the slope increases again, a new erosion section would emerge, possibly causing the river meander more than it did before. (Bridge, 2003, p. 298; Jongmans *et al.,* 2013, p. 377) Looking at the gradient graph of the Upper Rhine (Figure 4.9), something like this might have happened during the early 19th century, before the rectification between Gambsheim and Drusenheim, between Leopoldshafen and Leimersheim, and between Altlußheim and Speyer. An uplift in the river can be caused when a tributary river, with a lot of sediment, enters the riverbed of the main channel. This tributary comes from an erosive channel into a plain, therefore slowing down and depositing sediments, leaving an alluvial fan. (Figure 4.15)(free after Bridge, 2003, p. 298; Tulla, 1822, p. 12) Since this creates a bump in

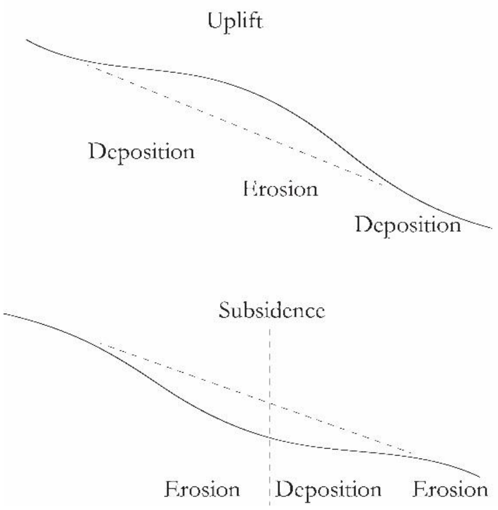


Figure 4.15: After an uplift erosion occurs and sediment deposits after a subsidence. (After Bridge, 2003, p. 298)

the slope of the main channel, the section upstream of the tributary mouth decreases in slope and becomes a deposition area. Downstream, the slope increases and erosion occurs. Increased sediment deposition could cause a blockage, or at least a hindrance in a river, like vegetation or ice dams could cause. Such blockages could redirect the rivers main course and could thus cause an avulsion. Such avulsions normally occur during a flood. They can occur abruptly, but it could also be a process of various years, decades or even centuries. (Bridge, 2003, pp.310-313) High deposition rates indicate avulsions. (Bridge, 2003, p. 326) One specific avulsion is explained in more detail in the case study of Ottersdorf, chapter §7. The opposite occurs when a depression in the rivers slope, which is caused by, for example, bypasses, and sometimes during dike breakthroughs, would cause an increase of erosion in the bypass. This would lead to increasing deposition when the bypass returns into the original river course.

An anabranching river system usually has higher energy and moves faster, which increases erosion. From this point of view more sediment deposition can be expected in a meandering river. However, it should be noted that erosion is not only indicated by the flow of a river, but also the sediment load in a river. According to Bridge *"a downstream increase in water and sediment discharge in a tributive river system might be expected to give rise to a downstream change from single channel to braided-channel pattern. Actually, it is quite common to see the opposite, because, although discharge increases, channel slope and mean grain size may decrease."* (Bridge, 2003, p. 297) This example shows that the erosion of a river or sedimentation is very complex and should be reviewed very carefully. Clearer is that erosion takes place in the outer curve of a meander, while sedimentation occurs in the inner curve. (Jongmans *et al.,* 2013, p. 375, p. 382; Strobl & Zunic, 2006, p. 87) It seems to me that this counts on multiple scales, meaning that if the main axis of the Upper Rhine moves eastward, more erosion could be assumed to be found in the eastern cut banks and more sedimentation in the inner curves (slip-off slope) of the western bank. This works cumulative with the aforementioned local scale inner curve sedimentation and outer curve erosion. In the Upper Rhine, this would mean that from Strasbourg up to Drusenheim erosion might be stronger at the western side, while sedimentation might occur more often at the eastern bank. Downstream from Drusenheim up to the end of the study area at Mannheim, this would be the other way around. However it should be added that increasing sediments from tributary fans, or a slight slope in neo-tectonics might cause a more significant shift here. The effects of this assumed shift is relatively negligible compared to erosion and deposition effects on local scale. A comparable statement can be made for islands. The upstream point of the island where water hits first is a place for erosion, while sedimentation usually occurs at the downstream end of an island; Leonardo da Vinci already notes these statements on hydrology in 16th century in Italy. (Pedretti, 2000, p. 130)

During a flood, the highest discharge is in the main channel, and thus most of the water flows through the main channel, which therefore becomes more erosive. Because the water level in this main channel is higher than its surroundings, flooding occurs in the form of an overflow at lower banks into tributaries and crevasses on the floodplain. These overflowing waters contain a lot of sediment, which is deposited in the slow flowing waters on the floodplain. Usually the deposition rate decreases when the distance from the main channel increases, which also causes the grain size to decrease. Mud tongues tend to spread more equally and continuously over the floodplain, while deposits on the floodplain equalize the floodplain relief (Bridge, 2003, p. 265-268). When the flow speed increases, erosion increases, creating deeper channels. In addition, in topographically narrow areas, or floodplain sections with less vegetation, erosion will increase. (Bridge, 2003, p. 268)

Since sediments are necessary for sedimentation, this always occurs downstream of an erosion section. Moreover, the sediment in a river always originates from the hills around the river and its tributary streams. This means that the grain size of surrounding lands are important, but other soil aspects like absorption of water, rootedness and gradient of the land also plays a role. Therefore, land use is important. Hills with lots of vegetation slow down and diminish the water discharge in comparison to agriculturally used hillsides.

Nowadays it is generally accepted that deforestation causes an increase in erosion. When there is no vegetation absorbing the water, more water will run off the hill. The lack of vegetation creates a run-off without barriers, and therefore causes that water run-off more quickly. On top of that, lack of vegetation means lack of roots within the dirt holding the soil together. The water that runs off therefore will take more sediment down with it. These are the main reasons in the increasing erosion. This also means that streams from deforested hillsides, draining into the bigger rivers like the Rhine, will carry more sediment with them. This sediment has to be deposited at some point. (Bridge, 2003, p. 13; Bork *et al.*, 1998, p. 221) More erosion also resulted in lower evaporation and higher surface water drainage, while the water levels in rivers rose. Bork et al. especially notes an erosion peak during the 1310's and in 1342. (Bork *et al.*, 1998, p. 230) Around 1300 a monk from the Dominican order in Colmar recognized the relation between deforestation and water levels in the rivers. (Schenk, 2012, p. 53) It can be argued that a period of erosion of hillside sediment and increased sedimentation in streams would follow, knowing when forest clearances were conducted and at which location they were conducted. Therefore it can be concluded, that the early clearances of the Kraichgau would have led to a period of sedimentation in the Kraichgau streams. This effect probably continued into the Upper Rhine valley, causing an increase of sedimentation in the Upper Rhine downstream of the Pfinz mouth around the 6th and 7th century. The other Upper Rhine hinterlands where cleared increasingly, with a peak from the 11th century onwards, which logically caused the second period of sedimentation in the whole Upper Rhine section from the 11th century onwards, as illustrated by Kern. (Kern, 1995, p. 107)

4.5.7 Ruling of the church and God's thorn

The Anglosaxion monk Bede (672-735) wrote 'On the Nature of Things', which was clearly inspired by work of Isidore de Seville. Notable detail in this publication is that Bede again makes notion of two reasons for flooding the Nile. Besides the northern winds that push up the water, the winds also displace sands blocking the river, as we recognize from Lucretius. (Bede, On the Nature of Things, p. 224) While it is claimed that Isidore wanted to provide one single truth, this does not hold up anymore. (Fear, 2016, p. 58) A student of Bede was Alcuin of York (735-804) who continued the encyclopedia works into the Carolingian Renaissance, as peronal advisor of Charlemagne. Alcuin who worked at the court in Tours saw the Flood as God's way to wash away the sins of mankind. Alcuin of York proposed several river crossing issues in his education, which might indicate that rivers were considered a barrier during that period, in accordance to the earlier Gregory of Tours. One of Alcuin's best-known students was Rabanus Maurus (ca. 780-856), archbishop of Mainz and educated at the Fulda monastery, and therefore familiar with the Rhine. Rabanus wrote *De Universo* and later *De Rerum Naturis*, which was heavily inspired by Isidore's *Natura Rerum*. (Fear, 2016, p. 75) It should be mentioned that Rabanus Maurus added many allegoric interpretations in *h*is work, which contrast with Isisdore's writing. Therefore, it might be stated that Isidore was more likely to gain a bigger understanding of the world through words. (Berg, 2015, p. 96) While on the other hand, Rabanus focused more on his readers' morals. As Epstein (2012) also explained, sinning caused the wrath of God, Who then initiated disasters like flooding in return.

In Book XI, which deals with water, rivers and floods, Rabanus Maurus makes notice of two kinds of rivers: torrents and rivers. Of these torrents swell because of rain, like Isidore explained. (Rabanus, De Rerum Naturis, XI.10) Rabanus pays much attention to the connections between the four rivers (Geon, Ganges, Tigris and Euphrates) and the four Gospels by Matthew, Mark, Luke and John. (Rabanus, De Rerum Naturis, XI.10) Remarkably, Rabanus does not make notice of the Rhine in the chapter on rivers, while he, alike his student Otfrid of Weissenburg (ca. 800-870), lives close to it. However, Rabanus Maurus mentions the Rhine in his description of Germany in in Book XII.4. (Rabanus, De Rerum Naturis, XII.4) In *De Rerum Naturis*, Rabanus Maurus renewed argues that the cause of Nile flooding are only the northern winds pushing up the water, therefore not mentioning Lucretius and Bede's other reasons. Thereby he returned to Isidore's single explanation strategy. (Rabanus, De Rerum Naturis, XI.10) Rabanus also acknowledges that floods do not only damage in the same moment, but also meant bad news for the future. (Rabanus, De Rerum Naturis, XI.21) In the final sentences of *De Rerum Naturis* Rabanus reassures his readers that future floods will not come, by repeating Jesus Christ's prediction. (Rabanus, De Rerum Naturis, XI.21) Altogether, Rabanus allegoric approach to flooding fits in an ideational world. However, his acknowledgment of the nature of rivers and natural causes of flooding, could be an early indication of the world becoming less ideational and more open to empiricism and material manipulations.

In the 7th, 8th and 9th century, the Villikation develops to its full extent. However, with new monasteries, more landowners were present, which influenced actor interrelations within the settlement. Donations to monasteries seem to concentrate in the flood plain, especially in the anabranching part of the river. Next to the network of local priests, also (river) trade increased. Erosion and sediment deposition would affect this river trade in causing avulsions or flooding. The allegoric ideas on flooding provided by the educated elite keep on applying to their followers' moral. It might even be argued that the church held on to this fear of flooding in order to retain power.

4.6 Continuing expansions and observing natural processes

Water levels raised into the 10th century, flooding became more and more a threat because many villages had now expanded to more risky lands in the flood plains. Could it be that an increase in devastating floods had damaged faith in God and the church, which had increasingly become interwoven with worldly power? Influential writers from a Christian background increasingly integrated observation of natural processes. What were the influences of the planets lining up on flooding, and did these nature observers recognize the human influence on erosion and run-off?

4.6.1 Changing climate in the Upper Rhine Valley

The Upper Rhine river valley in Germany is characterized by its moderate oceanic climate, with adequate precipitation during all seasons. Since the Upper Rhine valley is quite far from the coast, it is also characterized by elements of a continental climate, including relatively warm summers and – to some extent - extreme winters. (Geiger & Kurz, 2010, p. 128) The Upper Rhine valley is protected from western winds by the Palatine Forest range and the Vosges Mountains, which contributes to the relatively high temperatures. Precipitation in the Vosges and the Pfalzer Wald is higher than its surroundings areas like the Upper Rhine valley, because of the prominent hills. This is directly related to lower precipitation in the Upper Rhine valley. Precipitation increases again at the Odenwald and Schwarzwald ranges, which drain into the Upper Rhine. Little of the precipitation that falls on the western slope of the Vosges or the Palatinate Forest ends up in the Upper Rhine. Significantly more water drains into the Upper Rhine from the eastern side than from the western side. During rainy periods, this affects the inflow of sediment from the western side.

In order to consider the irregularities and variations of climate, two major parameters/indicators are included in studies on climate, namely temperature and precipitation. These parameters appear repeatedly even in historical sources. By combining these two parameters, four standard climate scenarios can be sketched. These are sufficient for this research, since the climatic history of the Upper Rhine valley is not the main focus. Since low precipitation does not contribute to higher water discharge and the risk of flooding, only increasing precipitation is considered, along with warmer and colder temperatures. The most common scenarios are increasing temperatures combined with decreasing precipitation, and the opposite scenario of decreasing temperatures along with increasing precipitation.

Warmer years: In this scenario, rising temperatures result in drier summers. Increasing temperatures over the entire year result in increased evaporation and therefore a decrease in water drainage into rivers and smaller water flows. According to Franconi (2016, p. 34), this reduction results in 5-15% less water discharge into the Rhine. Higher winter temperatures lead to less snowfall. Precipitation falls as rain, increasing the winter discharge into a river, rather than contributing to the growth of the snow layer and glaciers in Alpine areas such as Schwarzwald and Vosges. When glaciers and snow layers are smaller, the volume of melting waters draining into the river during the summer is reduced. (Franconi, 2016, p. 34) Nevertheless, since temperatures have risen, the shrinkage and melting of the glaciers increases. In the long term, this rising temperatures result in a lower overall volume of water from snow and glacier melt, but a higher volume of water discharge from melting Alpine glaciers in the spring and summer.

Colder years: In years of decreasing temperatures, drainage into the river increases as a result of less evaporation and increased rainfall. Winter precipitation in the Upper Rhine region comes in the form of snow rather than rain, reducing winter discharge, but contributing to glacier growth and an increase in melting water discharge during spring and summer. Reduced temperatures may cause the peak water discharge from melting glaciers and snow water peak to occur relatively later in the summer.

Precipitation: An increase in precipitation always leads to a larger volume of run off and higher water discharge in the Upper Rhine area. Rain peaks in specific areas rapidly increase the discharge from mountain streams during a short timeframe. The drainage basin of the Rhine includes the cumulative contribution of all its tributaries. This means that discharge from every tributary contributes to the overall drainage of the Rhine into the North Sea, but only the few tributaries upstream of the Upper Rhine contribute to its water. In the Upper Rhine the infiltration areas of the Main and Moselle, for example, have not yet joined the Rhine watershed. Rainfall in these areas influences water discharge from their mouth onwards. Rising water levels do influence the river upstream as well, but to a lesser extent. Because the Rhine is such a large river, it offers a substantial buffer. Heavy rains that cause local flooding might only minimally raise the water level in the Rhine. Therefore, regionally heavy rains lasting multiple days should be considered a cause for flooding.

Increased runoff caused by rain increases erosion and the amount of sediments flowing into the Rhine from its tributaries. This increase of sediments might contribute to an anabranching river form rather than a meandering one. (Franconi, 2016, p. 34) Factors influencing the speed at which rainwater arrives at the river include distance, steepness, soil percolation, and the mass of the water body as calculated by Darcy's Law. (Bridge 2003, p. 35) This is relevant in predicting how soon after a rain peak water levels will reach their maximum. Additionally, the influence of precipitation might vary depending on temperature. For example, precipitation along with higher temperatures result in higher evaporation, and therefore less water ends up in the river. High precipitation during colder periods, especially winter, causes snowfall and glacier growth, which contribute to meltwater discharge rather than direct rainwater discharge. Precipitation preserved in the glacier does contribute to the peak in the long-term. Higher water discharge, predictably, leads to an increased risk of floods. Highly concentrated precipitation results in local high-water and flood risk. This risk also occurs downstream, but the risk is reduced, as the relative influence of a catchment is limited.

The effect of variations in circumstances on discharge and erosion are summarized in table 4.2. Additionally combination of these are deviations in temperature or precipitation

Table 4.2: Climatic effects on river discharge and sedimentation (after Franconi, 2016, pp.34-36)

		Discharge				**Sedimentation**
		Winter	Spring	Summer	Autumn	
Warmer period	more melting water					
	more rain than snow in winter	+	+	-		-
	less runoff, less sediment					
	less glacier growth					

Colder period	more snowfall glacier growth more melting water	-	+	+		
Precipitation	more runoff more sedimentation	+	+	+	+	+

	Discharge				**Sedimentation**
	Winter	Spring	Summer	Autumn	
Warm temperatures and high precipitation	++	++	(+)	+	
Cold temperatures and high precipitation		+	+	+	+
Warm temperatures and low precipitation	+	+	-		-
Cold temperatures and low precipitation	-	+	+		

These climatic variations occur on a yearly basis. A cold wet winter, combined with a warm wet spring results in peak discharge during spring due to increased melting waters. In contrast, a wet summer/autumn combined with a warm wet winter results in a peak discharge during winter, due to high water discharge levels from rain. The same effects can occur over periods of years. High water levels due to multiple warm, wet summers will cause discharge peaks in autumn. Alternatively, growing glaciers resulting from cold, wet winters cause increased discharge from melting waters as soon as one or more warm summers occur. One effect apparent after several years of climate change includes decreased sedimentation during periods of less precipitation due to lower water runoff. As a result, the river meanders rather than braiding. In periods with an increase in precipitation, more runoff will occur, increasing hillside erosion and forcing rivers into an anabranching pattern, creating new channels and islands. (Franconi, 2016, p. 35)

One of the primary contributors to Upper Rhine flooding is melting glaciers. Brázdil et al. studied the size of glaciers in the Alps. Their graph, (Figure 4.16) shows how the *Grosser Aletsch* glacier has grown and shrunk over the last centuries. When the glacier grows, this indicates a colder period, with less glacier melting, and the water remaining frozen in the glacier. When the glacier shrinks, this indicates it is melting, probably providing higher water discharge in the Alpine discharge rivers, such as the case of the *Grosser Aletsch* via the Aare into the Rhine. (Brázdil *et al.,* 2005, p. 390) However, there is a grey area, in which a glacier shrinks and grows, in length, volume, and thickness. Since a detailed focus on glacier melting goes beyond the scope of this research, it is not addressed here. However, for this reason these data should be considered cautiously, and they only provide rough indications of increased drainage.

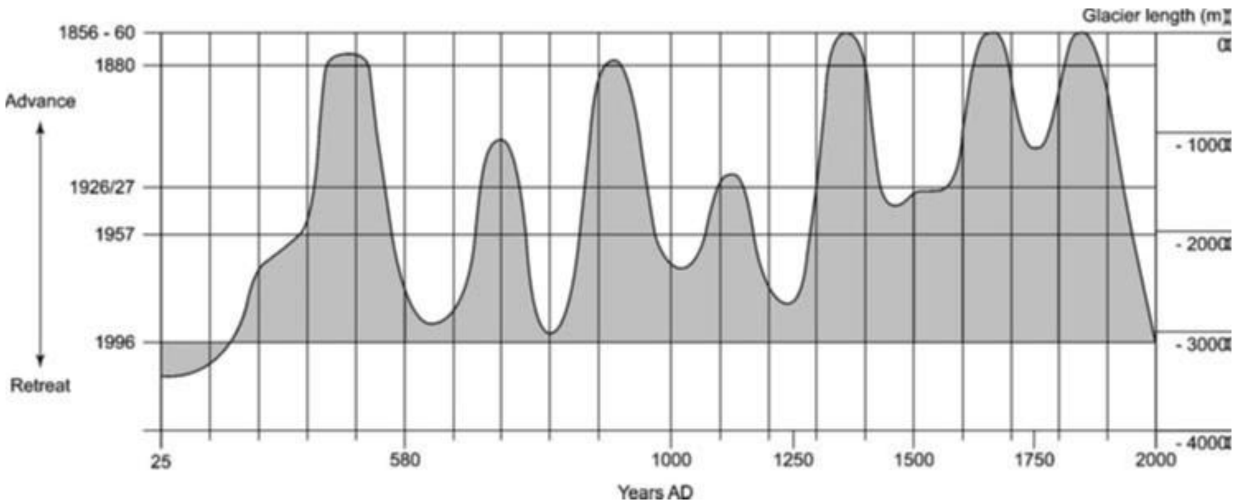


Figure 4.16: Glacier melting in the Alps by example of the Grosser Aletsch in the Suisse Alps. (Brádzil et al., 2005, p. 390)

Additional risk of flooding is caused by ice dams or other barriers, such as accumulations of floating vegetation. Occasionally, the winter is so cold that the Rhine or its tributaries freezes. This is indicated in several archival sources. (Alexandre, 1987; Buisman, 1995; Weikinn, 1958) When the frozen river begins to melt and ice floes float around, there is a risk of accumulation at a hindrance such as a bridge. This directly increases water levels upstream of the ice, causing a risk of flooding. Ongoing melting and the pressure of water increase the risk for the natural ice dam to break, resulting in a flood wave. This is extremely uncommon in river areas, and human infrastructure definitely is not designed calculating on such occurrences. Ice dams have resulted in some of the largest flood disasters recorded, such as the floods during the winters of 1286 and 1784. (Weikinn, 1958, p. 145).

Historical climate studies often base their research on natural archives developed over years and centuries. Büntgen *et al.* (2011) use tree ring dating. Schuh, Kluge and Meyer (2016) use the geological archives of stalactites. Brázdil *et al.* (2005) use glaciers or lake levels. Due to these varying approaches, the field of climate studies is one of extensive debates, such as Rahmstorf and the IPCC criticizing Mangini's approach using solar activity. Due to these manifold approaches, the scope of the studies was particularly difficult to accord with the current research regarding the early and high medieval times. Vollweiler and Mangini *et al.* (2006) study several thousands of years, while Wetter and Luterbacher (Wetter *et al.,* 2011), Brázdil *et al.* (1999; 2010), Pfister (2009) and Glaser and Stangl (2004) focus on the most recent 500 years. Thus, despite the rough cultural interpretations in Büntgen *et al.* (2011), their dendrology data provide the most detailed information on climatic dynamics in areas surrounding the Upper Rhine valley, and are thus extrapolated to cover the research area. Therefore, Büntgen *et al.*'s climate curve is used as an indication of the changing climate in the Upper Rhine over the centuries. This climatic exploration is lacking in detail and the data are extrapolated, therefore it should be seen as a superficial introduction to climate variations in and around the Upper Rhine valley over time, and cannot be used as a source for further research. (Büntgen *et al.,* 2011)

Several climatologists identify a colder and wetter period following the Roman climatic optimum (250 B.C. – 400 A.D.), starting from the 3rd century. (Franconi, 2017, p. 88) Büntgen *et al.* suggests a drier period first, based on their wood samples from floodplains. (Büntgen *et al.,* 2011, p. 580) After this drier period, their graph shows increasing precipitation from the 4th to 6th centuries. Some scientists argue this climate change shaped the context for the fall of the Roman Empire. (Hoffmann, 2014, p. 52) Hoffmann (2014, p. 62, p. 68) recognizes a possible 80% reduction of former Roman settlements during this period of continental climate, characterized by cold winters and warm summers. In accordance with Büntgen *et al.*'s graph (Figure 4.17), Hoffmann also argues that precipitation increased. He derives this from Berger and Brochier's (2006) study documenting significant sediment deposits in the Rhône Valley, indicating increased runoff. According to Büntgen *et al.*, this period was characterized by decreased tree harvesting and therefore reduced construction works. (Büntgen *et al.,* 2011, p. 579) From the 6th to 8th centuries, Hoffmann recognizes growing glaciers as a result of wet winters and cold summers. (Hoffmann, 2014, p. 69) From the 9th century onward, temperatures and precipitation seem to have stabilized at a level comparable with the Roman optimum. After significant precipitation during the 10th century, during the 13th and 14th century summers tended to be wetter again, the first characterizations of the upcoming Little Ice Age (LIA). (Büntgen *et al.,* 2005, p. 580)

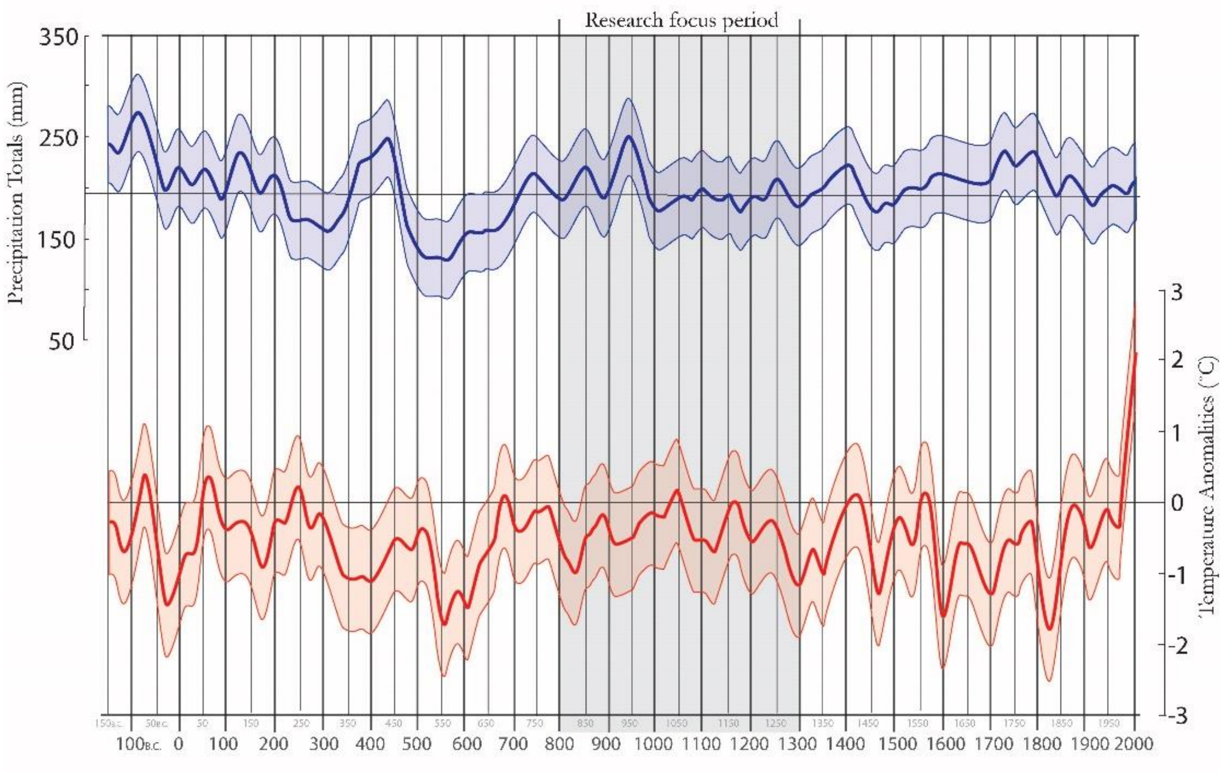


Figure.3.17: Climatic variations over the centuries in regions around the Upper Rhine valley. (Büntgen et al., 2011, p. 581)

4.6.2 Indications of medieval water levels

Since the Rhine is a river with a mixed regime, it has, as mentioned, three possible water peak periods. Peaks may be caused by rainfall (Nov./Dec.), local snowmelt (Feb./Mar.) or Alpine snowmelt of glaciers (July/Aug). Although weather differs each year, in centuries with above-average rainfall, the average water level on the Rhine is likely to be higher. Most years, rainwater discharge peak occurs during November and December. In centuries with above-average glacier melting, water levels might be higher than average. This study focuses on a section of the Upper Rhine that is slightly more influenced by glacier melting waters than by rain peaks. Brázdil's graph shows that the centuries during which glacier melt increased and the glacier shrunk were the 6th, 8th 10th, early 15th, and 20th centuries. (Figure 4.16, Brázdil *et al.,* 2005, p. 390) Deriving from Büntgen *et al.*'s graph on precipitation, the 3rd, 10th, 18th, and 19th centuries were characterized by above-average rainfall. (Figure 4.17, Büntgen *et al.,* 2011, p. 581) In addition, Devroey and Nissen argue that the 6th century was among the wettest since the Roman period. (Devroey & Nissen, 2015, p. 21) Considering these two graphs together, in the 10th century average water levels seem to have been higher. The 15th and 20th centuries can be recognized as having above-average water discharge as well. By this means, the 7th, 9th and 14th centuries are identified as having lower water levels. It must be noted that the author did not access the original data on which these graphs are based, but since they are only used for rough estimates, this should not pose a problem. Devroey and Nissen acknowledge the difficulties of interpreting such data for historical purposes, although they come to comparable conclusions of an instable phase in historical climate between the years 600 and 900. (Devroey & Nissen, 2015, p. 22) Further and more thorough research might provide interesting insights. The aforementioned centuries can only be seen as having average high or low water levels. The water level is, as explained before, dependent on rainfall and yearly weather conditions. It can therefore easily occur that average water levels during a purportedly drier century might be higher than most of the decades in wet centuries. Warmer temperatures increase the chances of thunderstorms with high precipitation, and therefore increased runoff, since soils absorb less water. This makes the additional value of this data doubtful. However, when discussion increased chances of high or low water, it gives some indication about the role water plays in the landscape of the floodplain.

4.6.3 Extension from grouped farmsteads to villages with intensive grain cultivation

Despite the unstable circumstances during the 6th to 9th centuries, settlements continued to expand. Based on field measurements and names, Eigler argues that only a few decades after the Romans disappeared from the Frankisch Alb region, Alemannic tribes took over the settlements. (Eigler, 1999, p. 215-220) Unfortunately, there is no proof that this can be extrapolated to the Upper Rhine area, as no comparable study of the Upper Rhine valley has been found. Therefore, Eigler's study functions only as a source of inspiration. Eigler describes three phases of change in settlement structure. During the first phase, servants worked for one main farm and its manor. In the second phase, during the Merovingian period, the social structure changed. In addition to the main farmstead and some essential parts, the settlement was divided into four or five farmsteads. From the 8th century, smaller farmsteads appear, the concentration of farmsteads increased, and agricultural field blocks were divided into long strips. During the third phase, in the early 12th century, servants where allowed to build their own houses, but they still worked at the larger farmsteads. Schreg argues that such concentrated settlements might not have been oriented towards the main manor or the church, and private churches might have been founded. (Schreg, 2006, p. 294) Over the centuries, servants gained more property of their own and the nobility emerged. Single farmsteads developed into clustered farmsteads, which later increased in concentration and developed into clustered settlements or villages. (Eigler, 1999, p. 215-220; Schreg, 2006, p. 354) Rösener points out that these early settlements did not have clear divisions of collective fields and grasslands, as we know them from the high medieval period, since a lord owned everything. Other historians suggest that the division and privatization of fields shifted, similar to the process of single farmsteads becoming clustered villages. Rösener argues that collective use of fields and grasslands (commons) occurred later, during the period of population growth. According to Kohl, commons first appear in Allemania around the 9th century and in Bayern during the 10th century. (Kohl, 2014, p. 257) In this period, the main single farmstead was divided into multiple farmsteads, and these clusters of farmsteads eventually were concentrated into settlements during the high medieval period. The high medieval clustered settlements formerly had been single farmsteads or hamlets, with a focus on livestock farming. (Rösener, 1985, p. 58) The first areas where these shift towards clustered settlements became visible are areas that were important for trade and had accessible and nutrient-rich soils. This includes the Kraichgau region as well as the Upper Rhine valley. (Rösener, 1985, p. 61)

The transition to the three-field-system (*Dreifelderwirtschaft*) from the two-field-system (*Zweifelderwirtschaft*) during the 12th and 13th centuries made increased differentiation in food production possible. (Rösener, 1985, p. 33) The Alsatian area north of the Zorn continued to use two-field-system until the 19th century. (Bonneaud, 2015, p. 41) Remarkably, this concerns the area outside the concentration of *-heim* place names, and it is thus assumed they were also cultivated later. No clear data was found on variations in soil or elevation. The three-field-system varied locally due to specialisations, nutrient availability, climate, and local traditions. The shift to increased grain production, often called cerealization, resulted in a decrease of grasslands and forests for grazing. During the high medieval period (11th to 13th centuries), land reclamation and clearance became essential to access enough lands to produce grain for the growing population. First, the intervening spaces between villages and settlements were cleared. Soon after, marginal mountains and moorlands had to be cleared as well. (Aberth, 2013, p. 93) As Schröder notes, deserted settlements were sometimes brought back into use, and were not necessarily newly founded settlements. (Schröder, 2016, p. 365) Extension and reclamation of new agricultural fields often happened cooperatively. Therefore, a structure of planned settlements emerged. The extension of villages during the high medieval period first consisted of converting collective grazing lands between the village and forest into fields for grain production. Livestock farming became less important. This corresponded with a decrease of livestock products in the diet and the increased use of cereals. (Bonneaud, 2015, p. 41; Rösener, 1985, p. 43) Various methods were used, including cutting, stocking, and burning. Burning seems to have been uncommon in the Upper Rhine valley, as derived from field names that often refer to the used method to clear the field. At the same time, the reduction of livestock caused a decrease in manure to be used as fertilizer for the fields. (Rösener, 1985, p. 52) Reduction of forested areas caused an increase in water permeability, which eventually would cause reduction in available nutrients and lowering of the ground water level. The pressure on common forests and grazing lands also led to stricter rules on using these lands. (Rösener, 1985, p. 53)

It is questionable whether intensive use of agricultural lands demanded the development of new techniques, or whether development of new techniques shaped the possibilities for more intensive agriculture. Along with the three-field-system, Hoffmann mentions the mouldboard plough as one of the most significant technical developments in medieval agriculture. (Hoffmann, 2014, p. 122-124) The mouldboard plough was first known locally, but spread to a wider area during the later centuries of the early Middle Ages. The mouldboard plough picks up the soil and turns it over, which makes it better suited for draining wet soils. It also elevates leached-down nutrients into the upper layers of the soil, making them accessible to the shallow roots of grains. It has long been debated how and when plough techniques developed. Areas in northern Europe with heavy wet soils, such as river floodplains, would definitely have benefited from the development of these techniques and the resultant possibilities to cultivate the soil. (Henning, 2004, p. 405; Hoffmann, 2014, pp.122-124) The introduction of this technique contributed to a reduction in woodland and an increase of agricultural land use. A tracing of a destroyed 12th century drawing of this mouldboard plough relates such a plough to the Alsace. (Hoffmann, 2014, p. 122-124) The mouldboard plough demanded more pulling power, requiring stronger and more draught animals such as oxen. Later, horses were used, but a special collar and harness were necessary to make this possible. Horses were (generally) not eaten, whereas oxen also provided food at the end of their lives. Therefore, a farmer's need for pulling power had great enough to justify the switch from oxen to horses. (Hoffmann, 2014, p. 122-124) This also forced a farmer to dedicate land to feeding the animals, at the cost of lands for growing crops. Another possibility for the farmer was to cooperate with other farmers in the settlement, and share the animals and the plough. When a settlement shared the draught animals for a plough, grazing lands could be further reduced. Tom Williamson suggests there was sharing of ploughing teams and other resources in the south-eastern English *Champion* landscapes. It may be asked what would prevent a local community from sharing expensive tools such as a plough. (Williamson, 2003; Hoffmann, 2014, p. 128; Devroey & Nissen, 2015, p. 36)

4.6.4 A renewed momentum for monasterial expansion

In the 10th century, many monasteries were managed by lay abbots, who were mostly interested in wealth. The influential Cluny monastery ordered a reform during the early 11th century. Involvement of the Cluny abbey quickly restored rest in the final decades of the 11th century during the *Investiturstreit*. This mainly involved the elite level of the Emperor and the Pope debating the entanglement of worldly leaders and the church. The Upper Rhine valley was not a hotspot of this debate, and the Cluny abbey managed to restore quiet relatively easily. (Lamke, 2009, pp.19-35) During the 11th and 12th centuries, the monastery of Hirsau elaborated on the Cluny reform and gained significant property in the Upper Rhine valley and the Kraichgau. In accordance, also the Maulbronn monastery had many links to villages and towns in the Upper Rhine valley. (Rückert, 2005; Engelhardt, 1910, p. 16; Doll, 1999, p. 392)

This is period during which Kohl argues that landlords began to centralize their property, in order to be able to facilitate managing their lands with only one manorial mill or church. This might be for reasons of controlling the peasants and providing a monopoly in the village. (Kohl, 2014, p. 257; Rösener, 1985, p. 27) Kohl places this in a period of internal growth and societal building within clustered settlements or villages. Residents of such villages were called *cives*. They were provided with rights on the common, and thus indicates a bond between villagers as early as the 9th and 10th centuries. (Kohl, 2014, p. 257) Kohl however, recognizes that these changes probably happened in accordance with the Hungarian raids and climatic changes.

Increasing cooperation between villagers demanded more rules, partly due to the planning necessary for three-field-system. Various common agreements and projects had to be initiated or at least supported by the landlords, worldly ones as well as those associated with the church. Most farmsteads were protected by landlords and clergy. This facilitated expansion, since landlords were better organized than individual farmers. (Rösener, 1985, p. 27, p. 61) Population growth around the 10th century demanded expansion and prompted changes in societal relations. According to Mitterauer, one of the most important changes was the increase of tax or labour immunities among ordinary landlords. While this primarily affected the manorial estates of the nobility, it might have occurred in ecclesiastical estates as well. The local nobility, who often had juridical powers, could assert their authority over all peasants living in their area, unfree farmers, and free farmers. They could sometimes even execute their authority on ecclesiastical estates, which led to conflicts. Peasants working under a church *Vogt* (bailiff) had manorial lords with juridical authority. Additionally, an increasing number of lay brothers acted in reclamations and clearances, therefore acquiring land and income for themselves. (Mitterauer, 2010, p. 41)

Due to a minimum number of sources about the Upper Rhine valley, it is necessary to look at the surrounding regions. Kohl argues that in Bayern, kings did not regularly order land clearances during the 7th and 8th centuries. Kohl assumes that private landlords would have been the most important actors in clearances, supported by their servants. (Kohl, 2010, p. 361) Forest reclamations in Bayern had a *Reutmeister* who had the same role as the Locator in eastern Germany and the Netherlands. Gathering colonists were willing to reclaim the wilderness, in exchange for benefits such as ownership rights, low taxes, or personal freedom. Church or worldly landlords used to instruct such assignments. (Rösener, 1985, p. 47) Locators became nobility in the eastern regions. These village entrepreneurs organised the colonists, planned new field structures, and coordinated large exploitation projects such as drainage ditches. In return, they gained a special position in the village, and often acquired a larger farmstead and tax benefits. The colonists also gained benefits, or at least could revoke their labour duties to the landlords. (Rösener, 1985, p. 49) Many of these new settlements had free farmer rights, and generally included a shift from extensive agriculture to the three-field-system. (Rösener, 1985, p. 49)

The disappearance of the *Villikation* system during the 11th and 12th centuries contributed to a shift from the economic and social centre away from the main farmstead to the village as a whole. This provided the farmers with a social structure and social cohesion. (Rösener, 1985, p. 38) Taking over tasks of the main farmstead, such as specializations and juridical rights, shifted their relation to the landlords. This collective cooperation resulted from mutually caring for each other, working cooperatively in the fields, and sharing common grazing grounds. (Rösener, 1992, p. 28) Agricultural labour became more intensified and specialized. At the same time, the nobility class increasingly withdrew from the agricultural labourers. This caused an expanding gap between the two classes. In addition, the village administration took care of the rights for all its inhabitants. For that reason, the differences between the farmers decreased. (Rösener, 1985, p. 20) During the 13th century, the differences between free and unfree peasants had almost disappeared. The differences then were based on ownership and size of farmsteads, among others. (Rösener, 1992, p. 30) The few farmer rebellions of this period mostly occurred locally.

Ministerials can be described as unfree lords. They ranked high in the social class, but functioned under a lord, who owned the land. The ministerial class, comprised of promoted serfs, emerged around the 11th century under Emperor Konrad II. They came from the *servi propria*, who carried out household tasks such as administration, finances, and farm management. This is in contrast to *servi casati*, who worked the land.

During the 10th century, ministerials rented their land from a lord in exchange for an oath of fealty. During the 12th century, they usually were allowed to buy or sell their own property. Ministerials worked both with worldly landlords and with landlords from church institutions. (Rotonda-McCord, 1991, p. 185) Rückert argues that only the richest landlords had enough money and resources to execute major projects like flood prevention. (Rückert, 2005, p. 125)

Emo van Huizinge/Wittewierum (1175-1237) reacted to the works of William of Conches, but most of his work was a reaction to flooding in the northern Netherlands. Floods in the years 1170, 1196, 1214, and 1219 caused the development of the Dutch inner seas, which Emo witnessed during these years. For that reason, he warned people to build better houses. (Wegmann, 2005, p. 130) For the 14th century, Jankrift gives examples of the floods caused by snowmelt and heavy rains, indicating that natural, scientific reasons became more widely known and agreed upon. (Jankrift, 2003, p. 55) Additionally, Jankrift recognizes the relatively quick rebuilding of cities and facilities such as bridges after a flooding disaster. (Jankrift, 2003, p. 60) This indicates the importance of such facilities, and people's ability to build such facilities in a relatively short time. One could argue that the disaster was ignored, or at least not seen as an unsurpassable threat. Whereas in earlier periods the meaning attributed to a flood was most important, during the high medieval period, damage and property loss became more important.

4.6.5 Observation of natural processes

During the 10th and 11th centuries, a renewed understanding of nature by science seems to occur. Anselm of Canterbury (1033-1109) was one of the most influential scholars of the 11th century, and the teacher of Honorius Augustodunensis (1080-1154). His works contain knowledge of Boethius, Aristotle, and Augustine. In Honorius Augustodunensis' most important work, *Imago Mundi*, this popular writer from Autun describes the cosmography and geography of the earth. He points out that the Nile's delta has the shape of the Greek letter *Delta*. The delta area is not irrigated by rain, but is fertilized by flooding of the Nile (Honorius Augustodunensis, 17) Honorius writes that the Nile River was formed by Atlasian winds, and through secret underground ways taken by the earth. Before it comes to the Red Sea, it makes a turn in Ethiopia and descends through Egypt, leading into seven 'doors' to the sea. (Honorius Augustodunensis, 9) In his description of Europe, he makes notice of the Rhine flowing north of the Alps towards the ocean. Regensburg is also mentioned. (Honorius Augustodunensis, 23) He points out the dual nature of water, and its deathly dangers. (Honorius Augustodunensis, 52-54) According to Honorius, earthquakes are caused by winds. (Honorius Augustodunensis, 42) In chapter 43, Honorius argues that the difference between an earthquake and lighting is that earthquakes, as movements of earth, can cause flooding. Overall, Honorius derives from purely allegoric descriptions such as Rabanus Mauras offered, and antique knowledge about several natural processes return, but observations of natural process are not yet found.

In contrast, the Arab and Islamic writer Avicenna (980-1037) was the first person to explain the formation of mountains. These are not attributed to winds and volcanic eruptions, as in the antique period, but rather emphasize the role of sedimentation and erosion. He writes that valleys are excavated by the actions of currents of water, in addition to earthquakes. Avicenna got this elaborate vision of the role of water currents, erosion, and sedimentation from his own explorations, and is therefore it is new in science. Avicenna joined Aristotle in his theory that nature has both a being and an essence, leading to a debate as to whether the earth was formed by essence or by accident. Translator Gerard of Cremona (1114-1187) translated Avicenna's work into Latin during 12th century in Toledo. It has been studied ever since. Slightly more than 100 years after Avicenna's death, his theory was thus well known in Europe as well. (Afnan, 1958, p. 260) With the works of Avicenna and other Islamic academics, the theories of Aristotle were revitalized. New translations of his theories in Latin entered Western European schools. It could therefore be expected that knowledge of natural geologic processes entered the library of enlightened minds in Western Europe, which of course influenced their perceptions of phenomena such as flooding.

William of Conches (1090-1154) explains that planets rising in the sky cause flooding, possibly as a result of his interest for antique science. He posits that when multiple planets are visible in the sky, they use less moisture or water, and therefore the water level on earth rises. This is compared to the moon's affect on the tide. (William of Conches, Philosophia 3 §39; Wegmann, 2005, p. 101) He also says that the end of the world will not be a flood (Philosopia 4 §39). William argues, according to Augustine, that the earth is God, and therefore the earth contains traces of God. With this statement, he supports what later became scientific reasoning. Other examples of a perception of flooding without divine intervention are found in several 10th century annals, probably based on the same works. These works mention that a riverbed is formed by nature. Hazardous violence caused the river to change its natural riverbed. This changed riverbed can therefore be seen as a contrast to the natural riverbed. (Wegmann, 2005, p. 148-149) Also, in the 12th century, the term nature is used. (Wegmann, 2005, p. 150)

Another author from the same period as William of Conches was Bernardus Silvestris (ca. 1085-1178), who lived in Tours. He discussed macro- and microcosms and thereby personifies nature. (Böhme & Böhme, 1996, p. 193) Although this is not directly related to flooding, it corresponds to Haas' earlier concepts of living along the river and under the eye of God. Hildegard von Bingen (1098-1179), who is considered one of the founders of scientific natural history in Germany, attributes 15 characteristics to water. Additionally, she compares the role water in enabling the earth to live with the way blood enables humans to live. (Böhme & Böhme, 1996, p. 198) All three of these 12th century authors struggled with questions of how to harmonize ancient science with the strongly Christianized view of everyday life and explanations for natural events. Wegmann (2005, p. 130, 145) argues that growing interest in knowledge of nature stems from an increase in natural threats like flooding and plagues. Various authors and chroniclers aim to connect historical natural sciences within the Christian worldview. This led to a new principle that *"In der Sinneswahrnehmung liegt die Quelle der Erkenntnis"* (In the sensory perception or observation lies the source of knowledge). (Wegmann, 2005, p. 132) Wegmann also writes that descriptions of natural events in annals and chronicles can lead to the possibility of predicting natural events (Wegmann, 2005, p. 146). Wegmann states that a common understanding of nature gradually unfolded as result of the observations of 12th and 13th century chroniclers and analysts. (Wegmann, 2005, p. 161)

From this period onward, observers of nature begin making notes of climatic conditions, providing us today with valuable insights into medieval circumstances. Many climate scientists attempt to rediscover climate data from the past through the natural sciences, but these have to be calibrated with historical archival sources. Various authors have studied records of flooding in written sources over the centuries. Among others, Weikinn, Alexandre, Gottschalk and, more recently, the Tambora.org project at the university of Freiburg, have gathered and organized the records from historical and archival sources that mention floods during the medieval period. (Tambora.org, 2019; Alexandre, 1987; Buisman, 1995; Gotschalk, 1971; Weikinn, 1958) Over 60 of these records include floods in the Upper Rhine valley. The Rhine floods mentioned in these sources through the year 1400 (this time frame of the current study) are listed in Table 4.3. During the medieval period, the intensity of record-keeping increased, as did the details of the records, but often the reason a particular flood was documented is not clear. Since the selection criteria are not clear, the list of floods is probably not complete, and the extent of a flood might be exaggerated. Such documentations of floods do provide insight into the perceptions of floods and indicate that flooding occurred regularly. Quite often, the damage to buildings and bridges were noted, along with loss of livestock. It seems that floods threatening property was considered important, at least according to examples from the 12th, 13th and 14th centuries. Additionally, based on the extensive number of written records of medieval flooding in the Upper Rhine valley, it could be deduced that the Rhine did not experience a period without flooding during the medieval period, in contrast to the Rhône. (Berger and Brochier, 2006, p. 471) The hypothesis that dike construction first occurred during the 12th century due to a lack of floods during the previous centuries is thereby refuted.

Table 4.3: Known floods from archival records in the 8th to 14th centuries, Month: S = summer, W = Winter (after Tambora.org project; Buisman, 1995; Alexandre, 1987; Gotschalk, 1971; Weikinn, 1958)

Year	Month	Country	Location	Source
711		Germany	Rhine	Weikinn
815	*(s)*	Germany	Rhine	Gottschalk / Buisman
850	*w*	West-Germany	Rhine	Gottschalk / Buisman
857		South-Germany		Weikinn
868	*w*	West-Germany	Rhine	Gottschalk / Buisman
886	*s*	Germany	Rhine	Gottschalk / Buisman
987	*w*	Germany	Rhine	Weikinn / Gottschalk / Buisman
1012	*s*	Germany	Rhine	Weikinn / Beckmann / Tambora / Buisman
1086	*January*	Germany	all rivers	Weikinn / Gottschalk / Buisman
1097	*w*	West-Germany	S-, W- and N-Germany	Gottschalk / Buisman
1124		Germany	Rhine	Weikinn / Tambora
1150	*June*	West-Germany	Strasbourg	Gottschalk / Weikinn
1152	*January*	West-Germany	Strasbourg	Gottschalk / Tambora / Buisman
1170	*September*	Germany	Southern Germany	Weikinn / Gottschalk
1174	*s*	Germany	Rhine	Weikinn / Gottschalk / Buisman
1184	*November*	France	Strasbourg	Alexandre / Tambora / Gottschalk
1198	*January*	France	Strasbourg	Tambora
1206	*December*	Germany and France	Rhine	Weikinn / Tambora / Alexandre / Buisman
1246	*(s)*	Germany	Rhine	Weikinn / Buisman
1258	*March*	Germany	Wörms	Tambora / Buisman
1260	*(s)*	Germany	Rhine	Weikinn / Buisman
1269	*January*	Germany	Schwarzwald	Tambora / Buisman
1270		France	Alsace and Basel	Gottschalk / Tambora / Weikinn / Buisman
1280	*January*	France	Alsace	Weikinn / Tambora / Buisman
1281	*February*	France	Alsace	Tambora / Buisman
1286	*(w)*	Germany and France	Rhine	Weikinn / Alexandre / Buisman
1290	*December*	France	Rhine	Weikinn / Alexandre / Buisman
1295	*w*	Germany	Upper Rhine	Weikinn / Alexandre / Buisman
1302	*August*	Germany and France	Upper Rhine	Tambora / Weikinn / Alexandre / Buisman
1303		Germany	Rhine	Weikinn
1305	*March*	Germany	Rhine	Weikinn
1314	*s*	Germany	Rhine	Weikinn / Buisman
1321	*s*	Germany	Rhine	Weikinn / Buisman
1322		Germany	Rhine	Weikinn / Buisman
1342	*July*	Germany	Main and Rhine	Weikinn / Alexandre / Buisman
1343	*July*	Germany and France	Rhine	Alexandre / Weikinn / Buisman
1353	*s*	Germany	Rhine	Weikinn / Buisman
1354	*(w)*	Germany	Rhine	Weikinn / Buisman
1355	*(w)*	Germany	Rhine	Weikinn / Buisman
1356		Germany	South-West	Weikinn
1357		Germany	Rhine	Weikinn / Buisman
1359		Germany	Rhine	Weikinn / Buisman
1362	*(s)*	Germany	Rhine at Mainz	Weikinn / Buisman
1366		Germany	Main and Rhine	Weikinn / Buisman
1372	*w*	Germany	Rhine	Weikinn / Buisman
1373	*w*	Germany	Rhine	Weikinn / Buisman
1374	*January*	Germany and France	Rhine	Weikinn / Buisman
1378		France	Ill	Weikinn / Buisman
1379		Germany	Rhine	Weikinn / Buisman
1381	*w*	Germany	Rhine	Weikinn / Buisman

1382	*(w)*	Germany	Rhine	Weikinn / Buisman
1383	*(w)*	Germany	Rhine	Weikinn / Buisman
1385	*January*	Germany	Rhine	Weikinn / Buisman
1388	*(w)*	Germany	Rhine	Weikinn / Buisman
1389	*October*	Germany	Main and Rhine	Weikinn
1393		Germany	Rhine	Weikinn / Buisman
1395	*August*	Germany	Rhine at Mainz	Weikinn
1395	*May*	Germany	Main and Rhine	Weikinn
1396	*w*	Germany	Rhine	Weikinn / Buisman
1399		Germany	Rhine	Weikinn / Buisman

4.6.6 Field names indicating a shift from land observation to land use

Not only in climate studies has the perception of nature changed. A similar trend can be identified in field names, as seen in a database of over 1500 field names in the Upper Rhine flood plain from Strasbourg to Mannheim. Field names provide a narrated insight into the perceptions of the environment. Adjectives in field names can tell something about their location, vegetation, ownership, soil, elevation, nutrient availability, or water circumstances. Suffixes contain information on the parcels' characteristics. In order to be able to draw a representative conclusion, only field names that occur regularly are taken into consideration. The field names in Table 4.4 all occur at least 16 times in the studied section of the Upper Rhine valley. In order to understand what a field name tells about the perception of a landscape, several sources on toponymy are used, with preference given to those dealing with data in the south German Upper Rhine area. Because field names are easily influenced by interpretation, a combined definition of various sources is used in the table. (Directie Bos- en Landschapsbouw, 1991; Dittmaier, 1963; Herget *et al.*, 2005; Schneider, 1980; Zernecke, 1991) Close examination reveals a division in these field names. The terms *–au, -grund, -kopf, -wörth* and *-wald* are essentially observations of a natural landscape. On the other hand, *-acker, -feld, -wiesen* and *-waide* describe the land use of the appointed field. This division of land observations, or land descriptions on one hand and land use on the other hand can be derived from antropological studies, according to Spek. (Spek, 2009, p.109)

Table 4.4: Commonly occurring field names in the Upper Rhine valley

Name	Occurance	% of total	Firest record	Description	Souce
Feld	141	9,2	12th	Field division of the three-field-system	Schneider, 1980, p. 46
Grund	131	8,5	13th	Wet islands or depressions	Herget et al, 2005, p. 30
Wiesen	124	8,1	12th	Open area covered with grass, used for grazing or growing hay	Zernecke, 1991, p. 571
Kopf	120	7,8	11th	Dry island, minimally covered with vegetation, gravel island	Herget et al, 2005, p. 30
Wörth	104	6,8	8th	Island covered with coppice or high forest	Herget et al, 2005, p. 30
Wald	80	5,2	9th	Wooded areas	Zernecke, 1991, p. 548
Acker	73	4,7	11th	Single field of ploughable land	Zernecke, 1991, p. 36
Au	55	3,6	10th	Wetlands surrounded by water, islands	Herget et al, 2005, p. 30
Bruch	38	2,5	10th	Swampy grazing land (forest)	Schneider, 1980, p. 16
Lach	34	2,2	14th	Reduction, with or without water	Schneider, 1980, p. 16

Waide	32	2,1	11th	Pasture, used for grazing animals	Zernecke, 1991, p. 558
Matt	32	2,1	15th	*Made*, feeding grasland	Dittmaier, 1963, p. 199
Stücke	28	1,8	14th	Part of the fields	Zernecke, 1991, p. 519
Rot	21	1,4	12th	Cleared land	Directie Bos- en Landschapsbouw, 1991
Gewann	16	1,0	13th	Field from a certain size, bordered field	Schneider, 1980, p. 46
Horst	16	1,0	9th	Overgrown (forested) elevation, used for grazing	Directie Bos- en Landschapsbouw, 1991
Garten	16	1,0	14th	Private vegetable, herbs and fruit garden close to the house	Zernecke, 1991, p. 178

Since field names provide a perception of the landscape, one can expect that various field names would be related to various periods of perception over time. A study of this could produce a dissertation on its own, because field names are not easy to date, and changes in field names over the centuries are unclear in the data. Nevertheless, by putting the field names on a timeline of their earliest appearance (based on the above-mentioned sources) an intriguing conclusion can be drawn. (Figure 4.18) (Directie Bos- en Landschapsbouw, 1991; Dittmaier, 1963; Herget *et al.*, 2005; Schneider, 1980; Zernecke, 1991) To strengthen this conclusion, another eight field names are included, all of which occur at least ten times in the Upper Rhine valley section. Although a significant increase is known for the use of field names since the 11th and 12th centuries, it seems that field names revealing observations about the land were first recorded before the 11th century. This perfectly fits this time period, since nature was increasingly cultivated and mankind saw more possibilities to use land. In addition, the exceptions of *–grund* and *–lach* become clear. While an explanation for this would be pure speculation, both terms relate to wet conditions, and the landscape might have been too wet to have been considered as fields previously. A similar conclusion can be drawn by looking at composited field names such as *Alte Kopfgrund* or *Wörthwiesen*, in which the land observation name comes before the land use name. The only exceptions to this are *–au* and *–grund.* As mentioned, *-grund* is a more recent name for a field, while *-au* indicates that it had been used for centuries. There is plenty of opportunity for further research on this theme. In summarizing this field name data, a transition from land observation names to land use names can be identified around the 11th century.

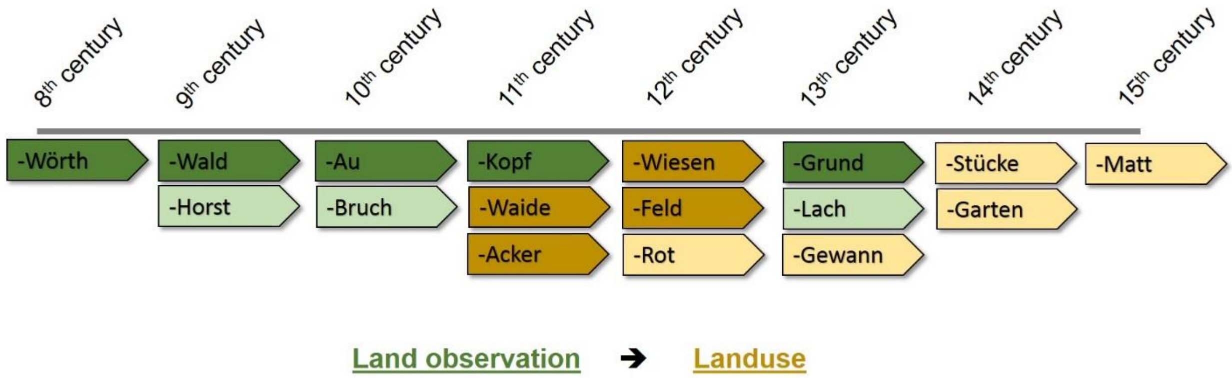


Figure 4.18: Timeline of the most commonly occurring field names in the Upper Rhine valley

During the 10th century, water levels were probably higher than usual, and flooding might have happened more regularly than before. Thus, it seems that more protection against flooding was necessary, which can be seen in the renewed momentum for monasteries and donations to them. However, it can also be considered a reason to doubt the protection offered by Christianity. The educated elite, for example, started to observe climatological circumstances more instesively in order to be able to predict them. This happened at the same time that grain cultivation became more important, which would not have been easy on the flood plain considering the high ground water level. Since also field names show more and more indications of human land use, it can be argued that people gradually came to perceive their surrounding landscape as a resource, and become more aware of material and property.

4.7 Taking control: cultivating wild nature

The Cistercian monasteries aimed to cultivate the Earth. However, it was repeatedly questioned as to whether their important influence on clearance and drainage projects was exerted out of a religious motivation, or an economic one. Was it they who initiated the cultivation of wilderness or did they merely continue to extend the arable fields of former generations? To what extent did the Cistercian order initiate or inspire clearances, and what was their role? Or was it simply necessary during a period of increasing population, cerealization and expansion of agricultural land? Could it be that the Cistercians managed to successfully put people's struggles into words?

4.7.1 Further expansion and commercialization of resources

Excluding a minor stagnation during the 10th century, deforestation exponentially increased until the period of population decline during the 14th century (see Figure 4.19). In southern and central Germany, the expansion of agriculture reached its peak between the 12th and early 14th centuries (Bork *et al.,* 1998, p. 222). Poor harvests, livestock diseases and epidemics caused crises. Especially in the early 14th century, poor harvests were known to have caused the catastrophic famine of 1315 to 1317. The burden of tax duties to landlords made this period even harder (Rösener, 1985, p. 53)

In addition to the newly acquired arable land, deforestation was stimulated by wood becoming an important resource in the medieval period. It was used for firewood, construction material, charcoal, and products with resin. In the Murg valley, wood production became an important commerce. After the Murg valley was inhabited during the high medieval period, the importance of wood as a market product became apparent to landlords. Around the 13th century, commercial wood production emerged. (Küster, 2013a, p. 143; Bittmann & Bittmann, 2009, p. 55) Large tree trunks could be transported downstream with little effort along the streams through the valleys. During later centuries, the streams and tributaries were dammed, enabling collection of more wood at once. By occasionally breaking the dam, a large amount of water with high velocity carried the wood downstream efficiently. This so-called *Flößerei* mainly occurred on streams in the mountain area, but also affected the Rhine, since much of the wood was transported as far as the Dutch delta. In addition, several villages along the Rhine flourished by this practice, for example Steinmauern at the mouth of the Murg. (Werner, 2011)

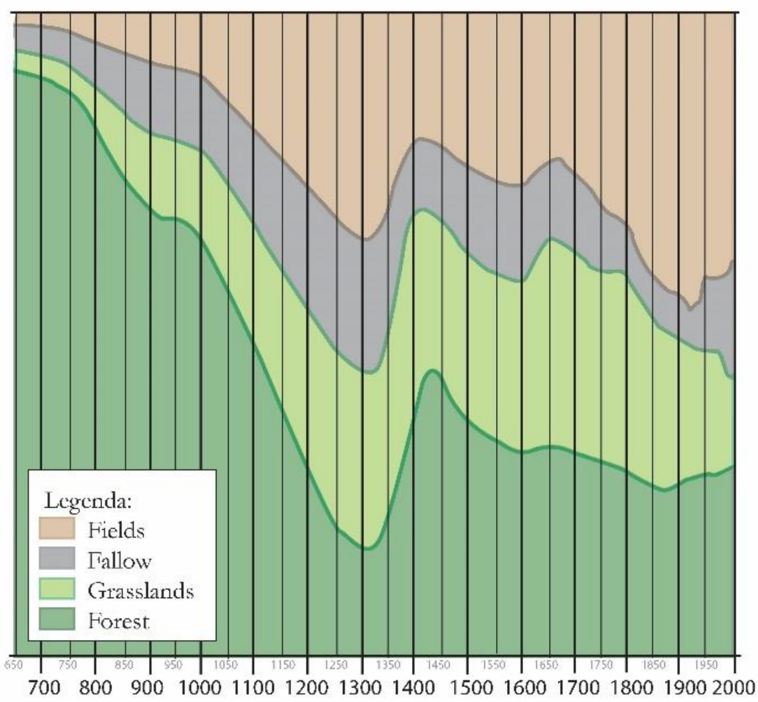


Figure 4.19: Land use over the centuries (Bork et al., 1998, p. 221)

4.7.2 The Cistercian order: higher aim or smart entrepreneurship

In the same period that natural causes were being rediscovered, the monastic order of Cistercians emerged. The Cistercian order is often linked to reclamation works such as draining swamps or dike constructions. (Duby 1989, p. 15; Schouten 2005, p. 112) Robert of Molesme (1018-1110) was the founder of the Cistercian

Order in the swampy lands of Cîteaux. (Butler, 1866, St. Robbert) He became a monk in Montier-de-Celle and later became abbot of Saint-Michel de Tonnerre. Since the monks would not follow his lead, he decided to leave. He helped several hermits of Colan to leave the desert and settle in Molesme around 1075, where they lived in self-made cells. After leaving them and living in the desert of Hauz, he returned. Together with six of the Molesme monks, he wanted to reform St. Benedict's Rule. Supported by the Duke of Burgundy, they settled in the swampy forest of Cîteaux with 21 monks in 1098, and founded the Cistercian Order. Robert of Molesme left one year later, but within 50 years the Cistercian Order was widespread spread. Bruno of Cologne asked Robert for advice and lived with his community for a while in 1082. If this did not spread Cistercian knowledge towards the Rhine area, then the founding of monasteries of Maulbronn in the 12th century did. The real expansion of the Cistercian order came with Bernard of Clairvaux (1090-1153), who was a theologian rather than a natural scientist. He helped profile and spread the Cistercian ideas. In his book *Cantica Canticorum,* he describes how water follows a circuit, returning to the sea. In addition, he states that the subterranean water course becomes an ecclesiastic metaphor for spiritual operation. However, Bernard of Clairvaux believed that answers cannot be discovered by an individual's brilliance, but in studying the classic scientists. (Rheggen, 2015, p. 45) At this point, the tension between scientific knowledge and spiritual explanations seemed to have become more balanced. (Schouten, 2005, p. 109)

The emergence and rapid rise in importance of the Cistercian order was thus a reaction to the Benedictine monasteries (like Cluny) gaining more wealth and power. The Cistercian order aimed to only live from its own labour and gifts, instead of collecting taxes. The Cistercians aimed to restate the Benedictine Rule, and had focused on self-sufficiency and a return to the *eigenwirtschaft* (self-reliant economy), as was done by landlords in the peak centuries of the *Villikation* system. (Mitterauer, 2003, p. 54) During the early 12th century, this order flourished, led by Bernhard of Clairvaux. It is argued that Cistercians were the first and most important monastic order that aimed to complete God's work on earth, cultivate the wilderness, and transform it into paradise. (Duby, 1989, p. 15; Schouten, 2005, p. 112) The removal of thorn bushes and drainage of swamps was seen as contributing to fight diseases and evil on earth. Thorn bushes had to be replaced with fruit-bearing plants in order to serve mankind, God's creation. Wild animals had to be replaced with domesticated animals in order to return to the paradise under the rule of the first human, Adam. (Duby, 1989, p. 105) These higher aims of the Cistercian Order corresponded with the ideas of Bernardis Sylvestris. His allegoric personifications of nature encourage humans to master their terrestrial environment. (Kauntze, 2014, p. 172) However, Bernardis Silverstris was also often interpreted as exponant of pagan humanism. (Knautze, 2014, p. 92) Nevertheless, the Cistercian Order played a major role in the reclamation of wilderness from the early 12th century onward. Although these reclamations are not very visible in the records, in south-western Germany the Cistercian monks and their granges contributed to forest- and wasteland reclamations, and draining moorlands in order to make them arable. (Rösener, 1992, p. 77) Building the Maulbronn dam and trusting it not to break shows the capability of mid-12th century Cistercian monks. (Grewe, 1991, p. 45)

Around monasteries such as the one in Maulbronn, an extensive pattern of fishponds can be found. Monks in the high medieval period and their lay-brothers built enormous dams or weirs to raise the water level and collect fish in these ponds. This praxis has been done at least since the 9th century, and in Maulbronn since the 12th century, and shows an impressive capability of controlling nature. (Küster, 2013b, p. 234; Keller, 2015, p. 296) It may be noted that Gregory of Tours mentions a fish reservoir as early as the 6th century in Trier. Clergy were eager to remain in charge of allocating the fishing rights. This was probably partially due to the allegoric value of Petrus as a fisherman fishing for lost souls, but mainly because it singles out the clergy as having the divine power to provide people with food. (Arnold, 2017, p. 130) A 10-meter high dam was built directly upstream of the Maulbronn monastery. If it broke, it would have completely demolished the monastery. Thus, it shows an enormous trust in their own construction skills.

The increasing knowledge of nature made it increasingly difficult for the church to proclaim God's good intentions for mankind and his creation. For example, Albertus Magnus (1200-1280) describes natural causes for floods and makes a distinction between a universal flood, such as the biblical flood brought in reaction to mankind's sin in the time of Noah, and a local flood, caused by a natural event. (Aberth, 2013, p. 46) Thus, he sees a division between divine will and natural causes. The following quote indicates that Albertus did not see God's hand in every flood, but that God does allow floods to occur.
"There are, however, some who attribute all these things to a divine disposition alone and who say that we should seek no cause for things of this sort other than the will of God. We agree with them in part, because we say that these things occur by the will of God, who governs the world, as a punishment for the evildoing of men. But we still say God does these things on account of a natural cause, of which he who confers motion on all things is himself the first mover. However, we are not seeking causes of his will, but we are seeking the natural causes that are like certain instruments through which his will in such matters is brought into effect." (Albertus Magnus, *On the Causes of the Properties of the Elements*, p. 72)
Albertus searched for this natural cause in astrology, as did William of Conches. (Albertus Magnus, *On Causes of the Properties of the Elements*, pp.75-76) According to Epstein, Albertus was familiar with both Pliny the Elder and Avicenna, and he elaborated on Avicenna's theory on petrifying fluids. (Epstein, 2012, p. 20) The most famous student of Albertus Magnus in Paris was Dominican monk Thomas Aquinas (1225-1274). Thomas Aquinas was sent to Paris at the age of 20, where he met the professor Albertus Magnus, with whom he travelled to Cologne to study. Like Albertus Magnus, Thomas Aquinas tried to show that nature and wilderness are parts of God's creation and plan. Thomas Aquinas came to be one of the most influential writers of his time, being primarily remembered for explaining how worshipping God could be practiced alongside observing natural sciences. (Schouten, 2005, p. 109)

While Duby and Schouten emphasize the higher aim of the Cistercians, other researchers argue the monks had a primarily economic interest. The lands gifted to Cistercian monasteries often were located in less arable areas than those given to earlier orders. These lands required draining and/or deforestation in order to generate any income. (Bond, 2003) Mol illustrates how Cistercians in Frisia only contributed to diking if they could gain economic profit from the labour. (Mol, 1992, p. 32) In contrast to their original statements, Cistercians managed their own granges, and during the 12th and 13th century they also used to have access to tithes paid by dependant farmers. (Rösener, 1992, p. 86) Additionally, Aberth argues that the Cistercian reclamations are a myth, and that they often settled in already cultivated areas. Aberth even states that Cistercians *"were more inclined to preserve the forest than to cut them down"* in order to retain the diversified landscapes, including the wild and isolated places in which the Cistercians claimed to settle. (Aberth, 2013, p. 94) In the Upper Rhine valley, the Cistercians monasteries of Eußerthal, Schönau, Herrenalb, and Maulbronn owned land and other properties. As derived from the Cistercian property map in the Historical Atlas of Baden-Württemberg and incidental mentions in local historical overviews, most of these properties were located on the terraces of the Upper Rhine valley. (Historische Atlas Baden-Württemberg, VIII.4)

The development of new markets and cities around castles (*burgen*) increased in importance as economic centres, and the development of cities correlated with the expansion of landownership. This gaining of land started during the 11th century and reached a peak in the 13th and 14th centuries. The new reform monasteries like the Cistercians emphasized the self-sufficiency of individual farmsteads, acquiring farms and their lands into the farmstead of the monastery. (Schreg, 2006, pp.31-32) At the end of the high medieval period, according to Schaab, the Cistercians brought deserted farmsteads back into use, and concentrated their agricultural work from a central base. Known for this period are Frencanstetten and Atenherd in the Upper Rhine valley.

Earlier processes like cerealization and the development of the three-field-system, population growth and the expansion of fields through clearances continued during the 11th and 12th century. The newly-founded Cistercian order seems to have been at the right place on the right time. The orders' vision of self-sufficiency demanded enough agricultural land. Using nature as a resource and a directive to cultivate wilderness aligned very well with the clearances. However, since many of these processes have already been documented in earlier phases as well, it could be doubted whether the Cistercian 'higher aim' of cultivating wilderness truly inspired people to do so. It would make more sense to say that the Cistercians very efficiently adapted to what was going on in the world and thereby managed to play an important role in clearances, and other technical developments.

4.8 Taking control of nature and shifting responsibility

Expansion of agricultural land increased the pressure on the landscape. Even marginal areas were brought into use, demanding measures of flood protection in the wet flood plain. Bypasses, embankments, and dike construction supplemented or even replaced processions and prayers. They became a financial burden for landlords. Could it be the final push that lead to the total disappearance of the Villikation system? Did landlords provide rights and land to servants in order to evade responsibility for disasters and the costs of maintenance?

4.8.1 Taking responsibility for disasters and trying various solutions

In medieval times, disasters were regularly explained as being punishment for sinning. The sins were attributed to people in general or to individuals who died. Epstein gives an example from a landslide in Savoy. (Epstein, 2012, p. 165) Disasters were seen as symbols of divine justice. A primary reason to record accounts of disasters such as an earthquake or flood could be as a warning to people. (Epstein, 2012, p. 166) In his analyses on a Genoese disaster, Epstein finds that 13th and 14th century processions with the bones of St. John the Baptist were held as a solution to disasters such as a series of storms or earthquakes. In these cases, sinning was not mentioned as a cause for the disasters. (Epstein, 2012, p. 174) This contradicts Epstein's model, shown in Figure 3.16 in which human sinning is portrayed as main cause for divine wrath and thereby natural disasters. (Epstein, 2012, p. 161) God was seen as a doctor healing mankind from their sins. (Epstein, 2012, p. 176) In his Genoese example, Epstein illustrates that an earthquake in early 1348 was assumed to have released poisonous vapours out of the earth, which later caused a plague in 1348. The two most likely reactions to a plague or a disaster were to flee or to pray. (Epstein, 2012, p. 180) Epstein's main argument is that medieval people took responsibility for natural disasters and for their response to them. Some form of stewardship of nature might be derived from this attitude. On the other hand, taming a river or draining a swamp did not convince people they were in control. *"These practical activities did not lead to a secular viewpoint seeing natural disasters as emergencies to manage."* (Epstein, 2012, pp.183-184) Human acceptance of their role in causing a natural disaster is an aspect of Haas' concept of the technical crisis. Thus, Haas' concept of living under the eye of God perfectly corresponds with Epstein (2012).

During the late medieval period, another peak in deserted villages can be seen, which Schaab attributes to the growing importance of cities. Examples from this period are Hundsfeld and Gugelingen. For people in the Upper Rhine valley, the never ending battle against the river was a significant reason for deserting villages. The threat of the Rhine made villages resettle in new places. To name only a few, people settled in Neuenburg am Rhein, Rheinau, and, Potz (Neupotz) (in 1535); in Wörth/Forlach (in 1629), or Daxlanden (1651). Others resettled in existing villages, such as Knaudenheim (1758), Dettenheim (1831, as a result of a by-pass), or Muffenheim (1481), Dunhausen (1583). (Schmidt, 2000, p. 150; Stenzel, 1975, pp.87-162) The map shows that deserted villages in the southern part of the research area around Strasbourg date mainly from the 13th to 18th centuries, and most of them consisted of only a few farmsteads. In contrast with the smaller number of deserted villages located in the northern part of the research area, these are suspected to have been deserted during the early and high medieval periods. These settlements seem to have consisted of multiple farmsteads. (Kommission für geschichtliche Landeskunde in Baden-Württemberg, Karte IV.23)

From this period, the early records of dikes and other flood prevention measures are available. This corresponds with Haas' concept of taming the river. There was discussion about how the river should be tamed. For example, Schmidt cites a discussion in 1458 on the costly maintenance of the winter-dikes, and a proposal to only maintain the summer-dikes. (Schmidt, 2003, p. 30) Whether dikes should be removed entirely was debated in Xanten after the flood of 1458. Kanonikus Pau from Xathen argued that without dikes the harvest could have been demolished, but with dikes this risk was not removed, and water could flow away more rapidly. (Schmidt, 2003, p. 187) This is closely related to Haas' technical crisis or living along the river concept.

4.8.2 Taming the natural river

The earliest recorded building of a canal or digging of a ditch as a bypass along the Upper Rhine was at Germesheim in 1391. In order to protect the village of Germersheim, a meander at Liedolsheim was cut off. Similar early bypasses were constructed in Tulla's 19yh century. A canal was dug to direct water in the necessary direction, then high water further widened the bypass canal. (Schmidt, 2000, p. 160) Bypasses increase the river gradient, increasing the water velocity and subsequent erosion. (Schmidt, 2000, p. 62) Since the late medieval period, an increasing number of bypasses have been documented. In the Upper Rhine valley, for example, there are documented bypasses at Daxlanden, built in 1560, Wörth in 1613, Neupotz in 1617, Linkenheim around 1628, Drusenheim before 1650, Dettenheim in 1756/63 and Pforz in 1780. (Schmidt, 2000, p. 160)

The erosive force of the Rhine has always been obvious, it might therefore be assumed that embankments were made for many years. The earliest mention of an embankment is Rückert's (13th century) dam at Eggenstein. In this case, farmers contributed to clearing the embankments. (Rückert, 2000, p. 69) During the 15th century, around Strasbourg, building embankments was also quite common, as can be deduced from the commission of experts hired to give advice on the Rhine embankments in the 15th century. (Schenk, 2012, p. 69) Even if rural villages did not have the money for a dike master, they might have hired some kind of experts, either cooperatively or as advisors to the landlords. Further research on this topic could provide interesting insights.

Transverse embankments or dams, also known as groynes (in German, *Buhne*) constructions were used through the 1820s as an alternative to the above-mentioned parallel bank protections. In transverse embankments, a strong, long object was used to redirect the river away from the damaged riverbank towards the overlying bank, sometimes in order to gain new lands. (Schmidt, 2000, p. 158, p. 189) An example from the Inn shows how villages on both sides of the river constructed dams and groynes. Each would redirect the river to the opposing bank, providing them with more land, but damaging the village on the opposite bank. Juridical processes in such cases were documented since the 16th century. (Leidel & Franz, 1998, p. 232) Damming side channels was often done to reclaim islands, a common practise from the 16th to the 18th centuries. Such practices regularly lead to court cases, documented in archives. (Schmidt, 2000, p. 157) Constructed avulsions added land to local authorities, increasing their profits. (Schmidt, 2000, p. 64, p. 158, p. 176, p. 180) Schmidt suggests that the famous Kurpfälzische Rheinstromkarte was created to acquire new land. Laws addressing this issue were made in the 1575 Deichordnung am Niederrhein. (Schmidt, 2000, p. 183) Also in the 18th century *Schmidt'sche Karte* many examples of embankment building and damming can be seen. *(Schmitt'sche Karte, 1797)* The line between protecting existing lands and acquiring new lands, between defensive and offensive diking, is thin. An example of presumably defensive diking can be seen near Iffezheim in the Plittersdorf 1712 drawing. Fascines were located on land tongues pointing into the Rhine floodplain in order to prevent erosion. (Schmidt, 2000, p. 158)

Not taking into account the early Roman dikes, dike construction in the medieval period is assumed to have started in the Netherlands along the lower Rhine. A dike presumed to have been built in the 8th century between Schmithausen and Brienen, along the contemporary Dutch and German border, supports this statement. A few kilometres upstream, the village of Wissel is presumed to have built a ring dike during the 9th century. This was further developed upstream during the 10th and 11th centuries. (Schmidt, 2000, p. 177)

Because a dike pushes the water upstream, causing problems at the next settlement upstream, motivating them to build a dike, and so on. (Van de Ven, 2004, p. 73) This cannot be extrapolated as far as the Upper Rhine, since the completely separate Middle Rhine lies in between. Nevertheless, upstream from Mainz a similar sequence would be possible. The first documented dike in the lower Rhine area is at Warbeyen, built in 1318. The first known linear dike along the Rhine is the *Düffelsche Deich* from Kleve to Nijmegen, built in the 14th century. Parallel drainage is necessary for this type of linear dike. (Schmidt, 2000, p. 177) As mentioned, Dutch colonists settled along the North German coast and south along the Weser during the 12th century, thanks to their knowledge of diking and drainage. (Rösener, 1992, p. 77) Unfortunately, no proof of Dutch dike construction is documented. An early parallel dike in the Netherlands is documented as early as 1122. (Van de Ven, 2004, p. 79)

The first known record of a barrier breakthrough by flooding along the Rhine dates to 1206, when major floods occurred at the Main and the Rhine. The term *claustra* is used, which could be translated as a cloister, prison, enclosure, or a dam; the latter makes the most sense in relation to flooding. (Pertz, 1864, p. 660; Schmidt, 2000, p. 148) Along the Upper Rhine, the first recorded dam is found in a record by the Abbot of Wissembourg, who declares the Markgrave Rudolf VI lost his vassalage to a number of settlements in 1362. Among these settlements was the village of Elchensheim (Elchesheim) including the dam and the associated *Auwe* lands. (GLA-K/46/108) Another early record indicates dike construction at the Upper Rhine in 1419, near the town of Speyer. (Schmidt, 2000, p. 155; Mone, 1850, p. 306) This is one of the oldest known dikes on the Upper Rhine. Speyer's case study goes into some detail in order to locate it in the contemporary landscape (§6), along with other dikes and dams in the Upper Rhine valley (§5).

4.8.3 Responsibility for dike maintenance according to the *Sachsenspiegel*

Eike von Repgow's *Sachsenspiegel*, a 13th century compilation of early law texts, describes policies for dike building and maintenance, implying they were common praxis in those years. Although this book deals with the Sachsisch Thüringse region, some aspects of dike construction and maintenance can be extrapolated to the Upper Rhine area, especially since the Oldenburger *Sachsenspiegel*, which relates to the downstream Weser region, includes many similarities in terms of dike laws. According to Koschoreck, the pictures in the *Sachsenspiegel* are not simply decorations, but graphic illustrations of the law. The Oldenburger version is a bit more symbolic, and the Dresdener (only known by the author from literary sources) and the Heidelberger *Sachsenspiegel* are more realistic. (Pieken, 1996, p. 6) The pictures directly relate to the text, and for such a juridical text, this can only be done by using standardized symbols. (Pieken, 1996, p. 7) Pieken interprets the dikes illustrated in the *Sachsenspiegel* as dike-walls, based on archaeological findings he elaborates on in his studies. (Pieken, 1996, pp.43-46)

Figure 4.20: The Heidelberg Sachsenspiegel, considered one of the oldest. (Pieken, 1996, p.9)

The Heidelberger *Sachsenspiegel* shows a tall wall being constructed by two people. On the right side of the wall, a high water level is pictured, with a house on the left side (Figure 4.21). The wall is built of green and brownish yellow quadrats, seemingly the same size. On the water side of the dike is a vertical line, which corresponds to Pieken's idea of the reinforcement of a dike-wall. It is notable is that this dike-wall is called a *"damm"* in the text. The two people are standing with their hands holding the dike, which is interpreted as a sign of labour. (Pieken, 1996, p. 10) According to Pieken, the colours the people are wearing represent various actor groups. The person on the left, with a striped robe and green shoes, is interpreted as peasant dependant on the landlord. Besides cultivating the lands they rent from the landlord, peasants were also obligated to contribute to dike construction labour. The person in the brownish-yellow robe represents the free landowners, who also had to contribute to dike construction activities. (Pieken, 1996, p. 10) Since the green and yellow can also be seen in the building material of the dike, it might be interpreted that the landlord and free landowners had to pay the cost of the construction and maintenance together. The building in the back could be considered a house or a representation of a village, but Pieken settles for an illustration of the worldly and clergy powers in the region. According to Pieken, they did not have the easy access to personnel who could contribute to diking, as local farmers did. For this reason, landlords tried to avoid their dike maintenance tasks. (Pieken, 1996, p. 11)

Figure 4.21: The Wolfenbütteler Sachsenspiegel. (Pieken, 1996, p.12)

The house in the Wolfenbütteler Sachsenspiegel differs from the Heidelberger one. (Figure 4.21) It has more perspective, a clearer window, and an O on the roof. A braided fence can be seen in the Wolfenbütteler, which usually represents a village. Since this is not included in the Heidelberger *Sachsenspiegel*, it seems that a village was not indicated. (Pieken, 1996, p. 13) The house in the Dresdener *Sachsenspiegel* apparently represents the village, surrounded by a fence a court arbour, and a heavenly canopy representing the (church or worldly) landlords. The court in the Wolfenbütteler book should be a simpler representation of all the juridical relations within the villages, like in the Dresdener and Oldenburger *Sachsenspiegel*. The blue arbour of the Wolfenbüttel *Sachsenspiegel* can be recognized in another illustration in the book, slightly below the diking picture. This picture illustrates how people paid taxes to the landowner. The landowner is pictured in a green robe and holding a crop, as sign that he holds the land. On the left side of the picture, three men are drawn. The further right is the *Meier*. Pieken assumes it is the same *Meier* as pictured in the right half of the picture, giving the landlord money. The *Meier* is supported by the second man, as indicated by his white feet. The third, with a blue rope, is independent from the *Meier*, with land acquired directly from the landowner, as indicated by his red feet. The peasants in the Heidelberger and Oldenburger books are working the land with a sickle. (Pieken, 1996, p. 14) Pieken argues that the farm holder has military duties to the landlord, while the other peasants living and working on the farm have obligations only to the landlord. The people in the first dike construction picture in the Wolfbütteler *Sachsenspiegel* look similar to each other and to the farm-holder in the third picture. Pieken argues that the artist misrepresented the purpose of the drawing by leaving out the dike, and did not understand the role of the multiple people. Therefore, the hand gestures seem meaningless. Pieken concludes that in the original picture, multiple persons were necessary to represent multiple actor groups. (Pieken, 1996, p. 14) Another possibility is that the farm-holders are pictured, because they were responsible for dike construction and maintenance. The multiplicity of represented persons could, in that case, be explained by the need to picture various activities. The text related to this picture mentions the Hufenschlag, a calculation whereby the costs of the dike were equally divided among the people who benefit from it, a term which is commonly used in the Netherlands. (Pieken, 1996, p. 15) Elaborating on these arguments, Pieken concludes that the Wolfbütteler and Dresdener *Sachsenspiegel* were elaborations of the Heidelberger and Oldenburger *Sachsenspiegel*, mainly because the landlords managed to avoid their dike obligations, and farm holders became the final responsible parties. More realistically, the landlords rented out their remaining lands to farm-holders, so they would take care of dike building. This idea corresponds with this period in which the land became increasingly divided among farm-holders, and landlords only received a tax instead of managing their own land and farm, because the tax-paying picture in the Heidelberger *Sachsenspiegel* shows only one peasant working the land and handing over the taxes. Pieken concludes from this that the Heidelberg text is older, probably from the early 1300s, while the Dresdener and the Wolfbütteler versions were written around 1350. He derives this from the lack of division in land and the variety of peasants. (Pieken, 1996, p. 17)

The Oldenbugrer *Sachsenspiegel*, which is not coloured, seems to show a further developed dike-wall. (Figure 4.22) The dike is built from quadrats placed on top of each other in a triangle against a vertical front enforcement on the waterside. The pointed top of the dike is interpreted as the obligation to maintain and make the dike higher in eternity, indicating the ever ongoing maintenance. (Pieken, 1996, p. 18) The Oldernburger picture also shows three people, but since they are not coloured they cannot be differentiated by class. The tallest person makes a working gesture with his hand. The smallest could be a black-and-white visualization of the lowest class. Pieken proposes that the smallest person represents the weakest person, and that putting his spade across into the dike indicates that he is unable to continue working, and stronger actors have to take over his job, which will cost the weakest person his right to his lands. Although this weakest person theory is plausible, it is a free interpretation in relation to other aforementioned symbols. (Pieken, 1996, p. 19)

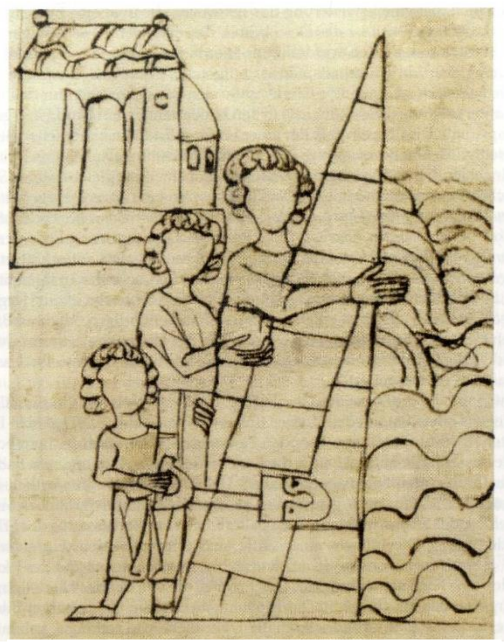


Figure 4.22: The Oldenburger Sachsenspiegel (Pieken, 1996, p.16)

One of Pieken's most remarkable conclusions is that landlords seem to have withdrawn from their duties in dike construction during the 14th century. The reduced role of landlords directly on the land and the farm was a trend visible in other areas, such as milling. Milling increased during the high medieval centuries due to cerealization. During the high medieval period, milling was often done independently from the main farm, and was possibly managed by colonists, as in the example of Kleinbasel, given by Schweizer. Schweizer concludes that the 13th century mills in Kleinbasel were not built at the founding of the city by the landlords, but later, by colonists such as Brotmeister Heinrich, who only paid taxes for the land and not for the mills and waterworks they constructed. (Schweizer, 1927, p. 9) Further research on milling along the Upper Rhine valley includes Sascha Bütow's extensive study on milling along the Brandenburger Spree. Bütow distinguishes a triad of mills, bypass channels, and weirs, and thus gives a clear understanding of water management among certain colonists. (Bütow, 2015, p. 128) The colonist and his personnel constructed the milling canal in Kleinbasel. Large-scale projects like dike construction, which benefit the whole community, demand cooperation, especially when multiple landowners were involved, and their approval was necessary. During the high medieval period, grazing lands were increasingly located in wetter lands along a river or stream, exactly where a dike would be planned. In case of a dike on common ground, all villagers would be involved, and contribution arrangements like the *Hufenschlag* could be made. Van de Ven also notes such a bottom-up approach for various areas in the Netherlands. (Van de Ven, 2004, pp.78-79) In the Netherlands, the bishop of Utrecht in the Netherlands was the head of the first water management board, supported by representatives of the actual work. (Van de Ven, 2004, p. 79) This indicates the involvement of an overarching actor, at least since 12th century, and cooperation between local communities and the government authority.

Several archival sources detail the process of dike construction and maintenance. For example, after a flood in 1458, the people of Kleve along the lower Rhine debated whether maintenance of winter-dikes should be stopped, in order to save money. Summer-dikes, which cost less effort, allowed the winter flooding to bring nutrients to the fields. (Schmidt, 2000, p. 177) Eventually, all the dikes were built higher and checks on summer-dikes were implemented. (Schmidt, 2000, p. 179) Schenk goes into the process of dike construction and maintenance, including several charters at the Ill, from 1404 and 1459 and after 1531, with explicit orders to prevent ruinous damage. In the following century "Further measures, taken by the *Illsassen* against floods included processions, appointments of foreign experts to construct dams, bridges, and canals, organization of *corvées* for building activities, removal of barriers that could lead to backwater, cultivation of willows to protect the banks from erosion, and the maintenance of trenches."

In the Alsace, cooperative action on diking and repairs was common. In contrast, a top-down practice was found in Tuscany. (Schenk, 2017, p. 150) Schenk illustrates examples in which the Bishop of Strasbourg and the Markgraves of Baden initiated dike construction projects in response to complaints of flooding in 1458, 1480, and 1529. (Schenk, 2012, p. 56) In 1465, an advisory commission of experts on the Rhine was initiated by the Strasbourg city council after a damaging flood. This commission of local experts included a weirmaster, the Rhine-bridgemaster, a Rhine-toll expert, a fisherman, and highly placed figures from Ober- and Nieder-Neuenburg. The commission members took a boat tour on the Rhine to observe and give advice about it. According to Schenk's study of the report of this commission, it illustrates perfectly how erosion was the largest threat along the Rhine, and how money and available resources played an important role in deciding which embankments to strengthen. At one point, the experts decided it was better to let the Rhine follow its course, and if damage or a breakthrough occurred, repair might be less expensive. (Schenk, 2012, p. 69) In contrast, Schmidt argues that there were no dike experts until the 18th century. He assumes local builders and workers had to develop their own dike-building strategy. (Schmidt, 2000, p. 61) It is logical that such a commission of experts was convened for major projects on the Rhine. On smaller tributaries, Schenk cites an example from the early 15th century of five stakeholders signing a contract to keep the Ill navigable, with violations punishable by a fine. (Schenk, 2012, p. 58) Schenk clarifies that the best interests of the Strasbourger merchants were included, indicating their influence on the contract. Such contracts led to the *Illordnung*, a set of rules regarding the river Ill. In contemporary terms, this would have been an early water management board. During the 16th century, the focus moved from damage control to prevention. (Schenk, 2012, p. 59)

Gradually people took more responsibility for disasters like flooding, earthquakes or plagues. Joining in processions was one of the popular measures of flood management during this period. Over time, also other methods of flood management are documented. Bypasses, embankments and dikes were built, taking control over natural threats to human property. In the early 14th century, the number of land owners increased. This happened in the same period that Villikation was completely dissolved. The high cost of dike construction, and especially its continuing maintance, might have even stimulated private land ownership, since landlords wished to free themselves from this responsibility.

4.9 The contemporary flood landscape of the Upper Rhine valley

Humans took increasing action to reduce the risk of property damage or loss of life. Increasing responsibility was taken by the overarching states and the role of local actors was reduced to that of executors. Was this because of the supposed 'flood disaster gap'? Did confidence in human construction capability reach a peak? Did mankind finally gain complete control over nature? Or was nature on the brink, reclaiming land and taking back its mastery over man?

The Rhine rectification ordered by Johann Gottfried Tulla during the 19th century is beyond the scope of this research, but this area cannot be studied without a basic understanding of his arguments and the impacts his interventions had on the regional landscape. The Upper Rhine valley as we know it today can hardly be compared with the historic landscape discussed in this chapter and the case studies. Thorough studies on Tulla's work can be found in Bernhardt's *Im Spiegel des Wassers* and Blackbourn's *The Conquest of Nature*. (Bernhardt, 2016; Blackbourn, 2006) Bernhardt discusses the political process of the rectification, while Blackbourn focuses on the changing balance between man and nature. Many books and articles have been written on this landscape-changing intervention. This section considers reviews of the project written by Tulla and his successor Honsell. These writings can be seen as somewhat presumptuous, and did not admit any flaws in the project.

4.9.1 The Tulla rectification

The Upper Rhine landscape before its 19th century rectification was completely different than it is today. This has beautifully been portrayed in the earlier mentioned painting by Peter Birmann. (Birmann, 1819) Several flood management measures had been undertaken, but a significant part of the Rhine was still dynamic, redirecting its channels, taking and making islands, and flooding regularly. This romantic image of a wild and natural river has a negative side. As many as 26 dike breakthroughs occurred at the eastern Upper Rhine bank between Kehl and Phillipsburg in 1801and 1802. In 1824, as many as 37 breakthroughs occurred on the eastern side, between Mannheim and Hochstetten and an additional 21 at the western bank. (Schmidt, 2000, p. 156) This flooding contributed to Johann Gottfried Tulla's motivation to develop a major engineering project for the Upper Rhine valley. As Rösch points out, Tulla's main argument was to generate more land for agriculture. Reducing potentially flooded areas and the riverbed would contribute to this goal. Peak water discharge would happen more quickly, eroding sediment and lowering the riverbed, thus lowering the water level. (Rösch, 2009, p. 4) Since such an extensive engineering project had hardly ever been done, there was much opposition to Tulla's plan. In 1822, Tulla wrote the project plan, including refutations to his opponents' arguments. (Tulla, 1822, pp.50-88.)

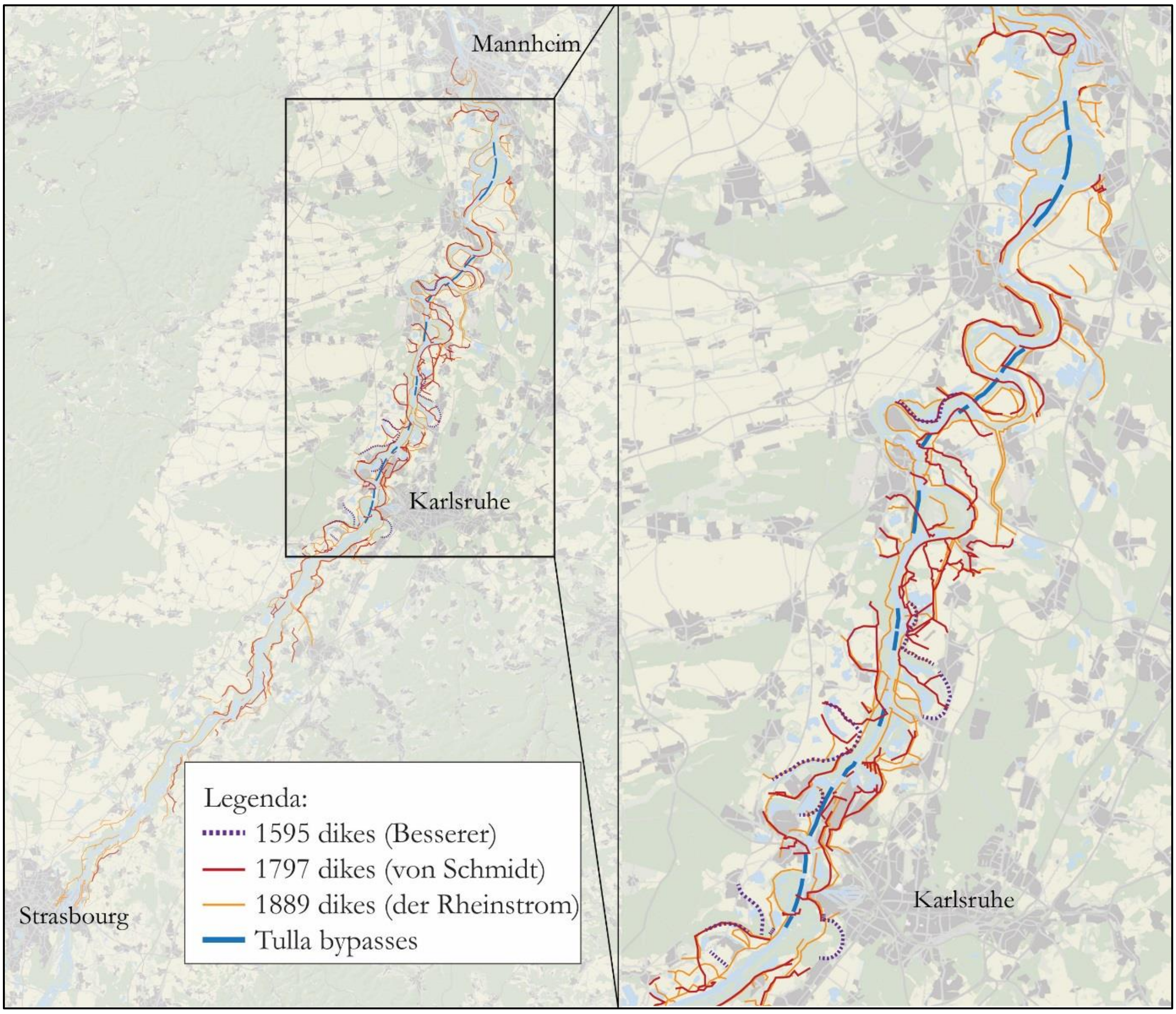


Figure 4.23: Dikes and Bypasses in the Upper Rhine valley. (After Besserer, 1595; von Schmitt, 1797; Rheinstrom, 1889)

Tulla recognized that the local approach undertaken until then was no longer sufficient. It repeatedly failed, at the cost of significant effort and land. Tulla acknowledged that the quell water behind the dikes increased due to the elevation of the riverbed. (Schmidt, 2000, p. 161; Tulla, 1822, p. 38) Tulla's extensive and thorough project contained an extensive land measurement, focused on the river and its flood bed, to be done during the early 19th century. The main aspect of Tulla's rectification is his proposal for 18 bypasses, shortening and straightening the Upper Rhine by 50 kilometres. Figure 4.23 shows the locations of these by passes. All of these bypasses significantly changed the course of the Rhine and thereby the local landscape. All of these bypasses were conducted in the formerly meandering part of the river, north of the hinge point around Neuburg am Rhein. This corresponds perfectly with earlier known dikes from 1595 and 1797 that were mainly located in this northern part as well (Figure 4.23). Each bypass was dug to between 24 and 30 meters, after which the flowing water could continue to widen the new course. Former arms were closed off by dams, leading the water into the desired direction. Most of the sediment of these projects was used in dike building or was eroded into the former arms or downstream. The people living along the river could be more secure of their lives and properties as a result of the continuous dike along the Rhine. However, it made the flood bed much smaller, causing high water levels that did not drop as expected. The river eroded and therefore got lower. The lower water level drained the surrounding agricultural lands properly, which increased the surface area available for agriculture. Precisely as Tulla intended, there were fewer flooding disasters and an increase of agricultural lands. This made him an honoured engineer. (Schmidt, 2000, pp.161-171)

4.9.2 Contemporary situation

Whether flooding always happened is strongly questioned for the so-called 'flood disaster gap' between 1877 and 1999. (Wetter *et al.,* 2011, p. 746) Nowadays, it is clear that the 19th century rectification had some unanticipated side effects. The rectification made more lands for available for agricultural use and contributed extensively to the flourishing of the Upper Rhine valley's economy, because quicker and safer navigation allowed increased transport. However, the rectification caused significant ecological damage, affected fishing, and impacted drinking water and industrial water supply; these issues have been widely debated. (Van de Ven, 2004, p. 365) Additionally, the Upper Rhine valley now suffers from increasing erosion, while in the lower Rhine increasing sedimentation has become a problem. Both of these affect the groundwater level. The 19th century rectification seemed to be a long-term solution, but new solutions must to be continuously researched. (Van de Ven, 2004, p. 412)

Contemporary extensively studied solutions include Ruimte voor de River projects and Renaturierung. (FLOODsite, 2009, p. 51) In addition, Building with Nature is popular nowadays, aiming to use natural processes to improve flood safety without harming nature. Nature organizations in Germany and the French Alsace identify possibilities for the Rhine floodbed to be developed naturally and how this would contribute to the biodiversity in the area. This would perfectly fit into Germany's goal of developing biodiversity. On top of that, it would contribute in the function of high water level reduction basins, when the river has the possibility of widening itself in natural areas. (BUND and Alsace Nature, 2012, p. 3) BUND and Alsace nature recognize the benefit of a nature-filled floodbed, because trees and other natural obstacles will slow down flood waves. (BUND and Alsace Nature, 2012, p. 4) Revitalizing Auen also provides a long continuous corridor with many varying biotopes because of its kilometers long length. (BUND and Alsace Nature, 2012, p. 6) Especially the return of high and low water dynamics would regenerate natural life in the Auen. Presently, the water levels are mainly regulated. (BUND and Alsace Nature, 2012, p. 5) A dynamic floodbed demands much space. Nowadays a lot of space is taken by forest, agriculture, recreational activities and is used for nature purposes. This is one of the most regularly appearing conflicts with respect to the floodbed. How to use the available land? Conflicts concerning flooding nowadays do not demand total prevention of flooding, but rather more controlled flooding. In the Upper Rhine valley, citizens are regularly informed about flood management projects and are encouraged to provide input and participate in the planning as well. Relevant stakeholder groups alike, fishermen, hunters, forestry and farmers are involved in meetings as well. (IRP, 2016, p. 36) During the construction phase, again informing is the most important interaction between the responsible parties and the citizens. (IRP, 2016, p. 37)

4.10 Conclusions

A definite change in the perceptions of the Upper Rhine valley flood landscape has become apparent. (Figure 4.24) The above chapter repeatedly shows various mentalities shifts occur next to each other and therefore gradually take turns in dominance. How these mentalities merge into each other, gets attention in this concluding paragraph.

Significant knowledge about rivers and flooding was already known during the antique period. Economic reasons, expansion, and later defence mechanism of the Roman Empire played an important role in selecting places along the river to settle. On top of that, also the wilderness in the flood plain and bad vapours appear in its swamps, steered the settlements to locations on the surrounding terrace rims. Approximately, around the decline of the Roman Empire, densely settled areas were left behind. These became the centres where new settlers started to build their farmstead, which created such a continuity that their names remained until modern times. These early settlements are often located on areas with better soil conditions to enable a profitable harvest.

During a climatically stable period in the 5th and 6th centuries, in which flooding was quite predictable, it was still seen as a treath according to written sources. Nevertheless, slight elevations in the flood plain provided attractive settlement locations for a society focused mainly on livestock. In particular, the southern anabranching part of the river provided elevated islands in the flood plain. In contrast, the climatically less stable 6th to 9th centuries influenced the expanding churches and monasteries in protecting the residents of the flood plain. The local priests had a similar role as the *Meier*, which was to officiate as a middleman between the landowners and the servants. When the community increased in importance, the landlords still held a coordinating role, for example in centralized milling. This transition from solitary farmsteads to clustered farmsteads and villages was stimulated by a shift to an intensified grain production and an increasing necessity for arable lands rather than grazing lands.

Landlords organized/funded clearing projects in exchange for servant benefits, such as a transfer of self-owned property. Nevertheless, the settlement pressure on the land increased especially in the flood plain. This increased the risk of flooding. When the climate got worse during the 10th century, monasteries and accompanying donations gained a new momentum. Additionally, several influential circles started to observe these natural processes. Supplemented with knowledge from the Arabian society and inspired by an Aristotelian materialistic worldview, they recognized flooding as a natural process. The church, by means of the Cistercian Order among others, wanted to control such natural disasters. Beginning in the 11th century, they promoted cultivation of the wilderness. The growing population and cerealization increased the demand for arable lands. Forests that used to be used for grazing were cleared and wetlands were drained. Over the years, people shifted from accepting the wild nature into taking responsibility and action in order to protect the land they used as their livelihood. Thereafter, an increase in landowners is visible which provided more possibilities to undertake large-scale projects like dike constructions or the construction of embankments and bypasses.

This control over nature reached its peak during the 19th and 20th century, in which a compelling number of rivers along the Upper Rhine were rectified. This often happened in order to increase flood safety combined with an increasing agricultural potential. This was also the case with the Tulla-Rectification in the Upper Rhine during the 19th century. Nowadays, this total control over nature seems obsolete. Engineers and society try to include more and more natural processes and their forming qualities into design projects.

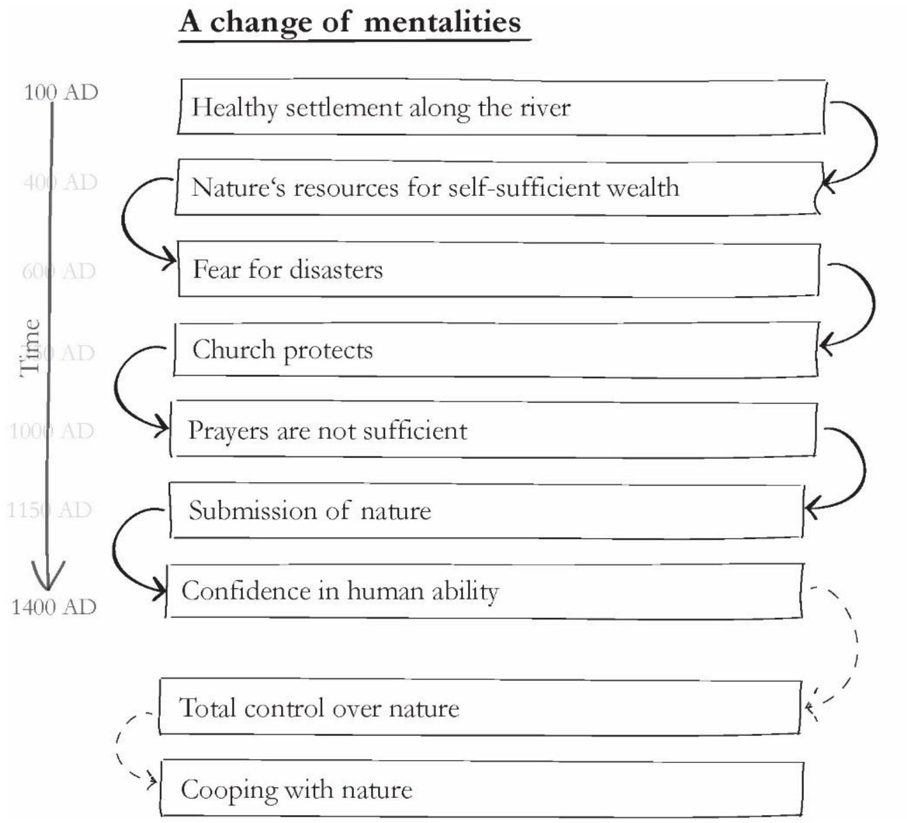


Figure 4.24: The changing mentalities in the Upper Rhine valley

5 - Selecting the case studies

5.1 Sources to explore historical dikes

Chapter 4 combines various disciplines and perspectives on the history of flooding in the Upper Rhine valley. To test these theories in practices, two detailed local case studies were conducted. In order to gain a thorough understanding of these case studies, the aim of this study is finding and dating medieval dikes. Dikes are chosen as a research object because they are known as clear measures of flood management and possibly date back to medieval times. The fact that dikes are regularly strengthened, makes that they are still visible in the landscape. Besides that, dikes are regularly depicted at historical maps, shown in field names and are very suitable for a minor archaeological excavation. An archaeological excavation could provide information of the construction of the dike and place the dike in its contemporary context. Due to the lack of research on the flooding history of the Upper Rhine valley, no medieval dikes to conduct this research on were known at the start of this research. For that reason, the whole Upper Rhine valley has been scanned in order a historical dike in various sources (archives, historical maps, LiDAR-data, Fieldnames).

LiDAR-data was expected to be the main source for discovering dikes. However, gathering the LiDAR data took more time than expected. On top of that, the difficulty of reading LiDAR-data on a regional scale, as result of the slope, which is discussed in chapter §3.3. Potential linear elevation had to be verified on contemporary aerial photography. Many roads are slightly elevated in the landscape and have a linear form. Despite these struggles, multiple possible dike lines have been identified through LiDAR-data, like the case study area of Ottersdorf (§7). Also geomorphological and soil maps might indicate some height difference, or linear structures in the soil formation. (geoviewer.bgr.de; BK25 6616_Speyer; BK25 7114_Iffezheim) This gave an indication for the case study in Speyer, in addition to the known archival text by bishop Benno of Osnabrück. (Bresslau, 1902) Archival sources have been a contribution in the search for historical dikes. Due to a lack of time it was impossible to search through all extensive archives for dike lines, but a focused selection of search terms (*Deichbau, Wasserbau,* and *Flussschifffahrt*) gave some relevant hits. In addition, records in secondary literature provided links to archival sources, which have been verified. A more worthy asset were historical maps. The historical maps, mainly 16th, 17th and 18th century, gave valuable insights in the locations of dikes before the Tulla rectification and its impact on the landscape. This provided several *tempus ante quem*, and dated few - seemingly old - dikes to modern times. Especially the 18th century maps where suitable for this. (Carte Cassani, 1744; Schmittsche Karte, 1797). But also on the older maps like Wilhelm Besserers Kurpfalzische Rheinstromkarte clearly showed several dikes. (Kurpfalzische Rheinstromkarte, 1595) In addition, several local maps provided insight on historical dikes alike the 1590 drawing of Au am Rhein and Neuburg. (Neuwenburger neuw angefangen Deuch, Auwer Deuch, 1590) The difficulty with historical maps was locating the dike on contemporary maps. Since historical maps are often hard to geo-reference. By identifying a 16th century dike on a 17th century drawing first, subsequently on a 18th century map and afterwards on a 19th century topographic map it became possible to locate several of these dikes in a reliable way. Place names gave another indication for historical dikes as well. Steinmauern is said to be called after the stonewall protecting the village to water. (Krämer, 1926) The place name of Daxlanden is also said to be derived from Deichslanden, which means something as dikelands. (Koch, 2007) These two villages have gained more attention in the exploration of other sources for this reason. In addition, field names regularly mention dikes, or in this part of the Rhine even more often dams. For example, *Dammfeld*s are mentioned near Mörsch, Kielingen and Forchheim. (Flurplan Ettlinger Gemarkung, second half 18th century) In addition to these various desk research sources, a multiple day field excursion by bike along the Rhine was conducted, mainly in order to experience the contemporary landscape and see the current state of the discovered dike lines. This also resulted in several potential dikes that have not grasped attention before.

5.2 34 possible research objects of flood management

Whilst exploring these various sources, a broad range of measures of flood management (mainly dikes) that are part of the flooding history of the Upper Rhine valley where identified. Most of them could be located, a few were only known from written sources. Several measures of flood management from older sources alike the Besserer map had not exactly been located.

Possible locations varied from elevated roads along former Rhine arms, to dikes on historical maps, and from archival notifications of former villages to linear elevations on the LiDAR-data. For the case studies the decision was made to focus on dike lines, since these elements are visible in the landscape and can properly be research by (geo-) archaeological methods.

Dikes found in the various sources are listed in table 5.1 and mapped in Figure 5.1. Disappeared villages and villages that crossed the river through avulsions, are identified and located during this process as well. These have already been discussed in chapter §4.8.1. Other elements regarding flood management that have been considered of interest are dams, alike the damming of the Hagenbach Rhine arm around 1595 (Kurpfalzische Rheinstromkarte, 1595). Additionally, several bypasses have been taken in consideration in this search, and have been discussed in more detail in chapter §3.81.

Table 5.1: A table with the 34 possible objects indicating historical flood management along the Upper Rhine valley between Strasbourg and Mannheim.

ID	Name	Source	*Terminus ante quem*	Contemporary
NW-01	*Hoherweg* at Rheingonheim	Schmittsche map	1797	Water power plant
NW-02	Several dikes			Line of trees
NW-03	Dike at Otterstadt	TK 20th century		Abandoned meander dike
NW-04	Roman wall and former Rhine channel in Speyer			Park
NW-05	Behind the *Fischergasse*	1419 document	1419	City
NW-06	Four dikes			Nature remainder
NW-07	Dike at Mechtersheim	Besserer	1595	Island
NW-08	Dike at Neupotz	Besserer	1595	Acre
NW-09	Neuburg I and II	Besserer	1595	
SW-01	Dike at Munchhausen	Gallusser & Schenker (1992)		Play- and camping ground
SW-02	Dike at *Kopp* Beinheim	Besserer	1595	Village
SW-03	Inundation dike	Vauban	1720	Highway
NO-01	*Damgewann* at Brühl	Schmittsche map	1797	Acres and tree lines
NO-02	Contemporary dike at Brühl			Dike
NO-03	*Herrenteich Angelhof*			Dike
NO-04	Bridge head Germersheim	Military archive	1876	Nature
NO-05	Dike at Linkenheim	Besserer	1595	Dike
NO-06	Dike breakthrough at Linkenheim	Besserer	1595	Nature and dike
NO-07	Roman road at Linkenheim	Schmittsche map	1797	Forest
NO-08	Dike in the field near Leopoldshafen/Eggenstein	Google		Old Dike
NO-09	Dike structure in LIDAR-Data at Knielingen			Acres
NO-10	*Im Dammfeld* Knielingen			Industrial area
NO-11	Dike between Alb and Rhine	Archive and Schmittsche map	1739	Industrial area
NO-12	Dike on the other side of Knielingen	Besserer	1595	Island
NO-13	New Daxlanden dike	Archive	1683	Village
NO-14	Old dike	Schmittsche map	1797	Village
NO-15	*Dammfeld* Forchheim	Archive	1867	Ackers

SO-01	Steinmauern	Schmittsche map	1797	Village
SO-02	Dike at Plittersdorf	Archive and Schmittsche map	1788	Dike
SO-03	*St.ber Teich* at the Murg	1797 Archive	1797	Forest and industrial area
SO-04	Dike at Ottersdorf former Rhine channel	LiDAR-Data		Forest
SO-05	Wooden embankment at Iffezheim	1712 Archive	1712	Nature
SO-06	Dike intersection at Grauelsbaum			Dike intersection
SO-07	Dike at Auenheim	Schmittsche map	1797	Dike

Figure 5.1: An overview map of possible objects of historical flood management. Highlighted the selected case studies of Speyer and Ottersdorf.

5.3 Criteria for case study selection

In order to select suitable case studies with proper chance for results the following criteria are used: accessibility, visibility, *terminus ante quem*. From site visits in the field, it became clear that although these criteria seem unambiguously, the accessibility can vary from bad to good. In addition, the visibility and the certainty that a dikes dates back several centuries are more gradual criteria. It is therefore that even the selected cases are not the perfect sites in terms of accessibility and visibility.

Accessibility and visibility were indicated with a verification on Google Earth and additional site visits in order to see whether the suspected dike's location was accessible. For example site SW-02 had turned into a residential area and was therefore not accessible. In several cases, the historical dike was expected to be located on exactly the same location as the current dike. This is known more often from other dike excavations. (Bartels, 2016; Mulder *et al.*, 2001; 2002, 2003; 2004; Mulder, 2002) Excavation of a functioning dike is very difficult and expensive, such dikes are therefore excluded. A dike line at Knielingen (NO-12) and Mechtersheim (NW-07 I) have been excluded because they were only accessible by boat.

The second criteria was whether the dike was still visible in the landscape. Since a dike is an elevation in the landscape, it is expected that the dike is still visible. If not, it might have been removed as for example a dike at Forchheim (NO-15). If the dike is still visible it is suitable for fieldwork even if it is asphalted or used as a road over centuries (NW-07 IV; SW-01; north-section of SO-04). The third criteria for the selection of the case studies was that the dike had to be known from historical sources. This presumption has to be proven for example by historical maps and archival sources dating these structures over many centuries. For this reason, the dike lines must be located on the *Schmitt'sche Karte* in order to at least date them back to the 18th century. However, the selected case studies could all be dated back to the 15th or 16th century on forehand by means of archival sources or the Kurpfalzische Rheinstromkarte. In the end, permits have been obtained from the local and regional governmental institutions, which made sure that the fieldwork in the selected case studies could legally be executed.

5.4 Introduction to the case studies

In order to find the origin of flood management constructions in the Upper Rhine valley, also Speyer has been taken as a case study. The reason is a hint in archival sources that Bishop Benno constructed some kind of flood protection for the cathedral as early as the 11th century (Bresslau, 1902). Fortunately, the mentioned area where the flood protection is expected, is nowadays used as a recreational park. The downside is that there are no dikes visible and the area has been used intensively over the last centuries. However, the site is easily accessible today. Additionally, fieldwork could almost start right away since the network for permits in Speyer has already been established due to earlier researches on the *Eselsdamm* (Lange, 2016). The *Domgarten* case study also functioned as a basis for the latter dike search south of Speyer, derived from a 1419 archival source. (Mone, 1850, p. 306) This research is combined with the exploration of four elevated linear elements taken from the geomorphological map, which are also located in the area around the *Goldgrube* south from Speyer. Not all of these dikes were visible in the landscape and the poor accessibility made it even harder to study the most suitable of these four dikes. This results in the conduction of the second field work campaign directly next to the *Goldgrube*. This was done in addition to the preliminary work on historical maps, toponymy, and other sources. The complete results for the Speyer case study in the *Domgarten* and the *Goldgrube* are elaborated in §6.4.

One of the main aims of this research was to get an accessible case study which ensured the possibility to conduct geo-archaeological measurements and, if possible, an archaeological excavation in order to get exact dating material of the dike. The elevated linear element around Ottersdorf visible through LiDAR-data provided such a dike. However, located in a nature protection area, it had been saved for many centuries and therefore the chances are high that it has not yet been damaged by human activities. Within this forest the dike was clearly visible in height and length which made it a very suitable object for a case study. The assumption is that the dike structure has only been disturbed by trees and their roots at some point over time. According to preliminary research, the dike was located along a former Rhine arm and was dammed during the 15th century. This left a good chance that this dike would date back into the medieval period. This dike (SO-04) in the *Ottersdorfer Oberwald*, also called *Gemeindewald*, near Rastatt is discussed in §7.

The chosen case studies represent a variety of used sources. This represents itself in its selection and execution of the interdisciplinary research. Case studies have been chosen east and west of the Rhine and in the northern and the southern parts of the Upper Rhine valley due to known differences in the geophysical circumstances. (§4.4.1; Figure 5.1). Dikes around the city of Speyer and around the rural villages, both on the terrace rim and in the flood plain, were selected. Therefore, these case studies provide a various representation of the villages in the Upper Rhine valley and illustrate the flooding history of the Upper Rhine valley. This can be read about in detail in chapter §4.

5.5 Case study structure

The case study research in this project is structured in four phases:

1. Identifying potential dike lines via multiple overlying GIS layers of historical maps, LiDAR-data and other geological and topographical maps (§5).
2. Conducting preliminary analyses of the local landscape and environmental development. (§6.2 and §7.2).
3. After the preliminary research a hypothesis for field work is formulated, in order to know what to expect (§6.3 and §7.3)
4. Executing fieldwork through electrical resistivity tomographies (ERT) and several corings. More extensive ERT research and soil sampling are supplemented by archaeological excavations. Analyses and dating of the findings provided by external laboratories (§6.4 and §7.4-7.5).
5. Comparing findings of the Upper Rhine valley in a wider context (§8).

The research is embedded in an interdisciplinary cooperation between the Institute of Geography and the Department of Prehistory and Protohistory of the University of Heidelberg. Thereby the ERTs, the soil studies, and the evaluation of the samples in the laboratory were conducted by the Institute of Geography. On the other hand the Department of Prehistory and Protohistory was focused on the excavation, its findings and the contextual desk research. Beside the university, this project was supported by the heritage department (*Landesdenkmalpflege* Baden-Württemberg; *Regierungspräsidium* Karlsruhe) and the regional archives (*Generallandesarchiv* Karlsruhe; *Stadtsarchiv* Rastatt). The permits for the excavated areas were made possible by the local municipality (*Stadt* Rastatt) and its forestry department (*Forstamt* Rastatt).

6 - Case study Speyer

6.1 Introduction: Protection against the Rhine

Speyer is one of the case studies in this research in which fieldwork has been conducted in order to elaborate on the written sources. The preliminary study on archival data, (historical) maps are supplemented with data from fieldwork campaigns, which provide a detailed and illustrative case study within the overarching flooding history of the Upper Rhine valley.

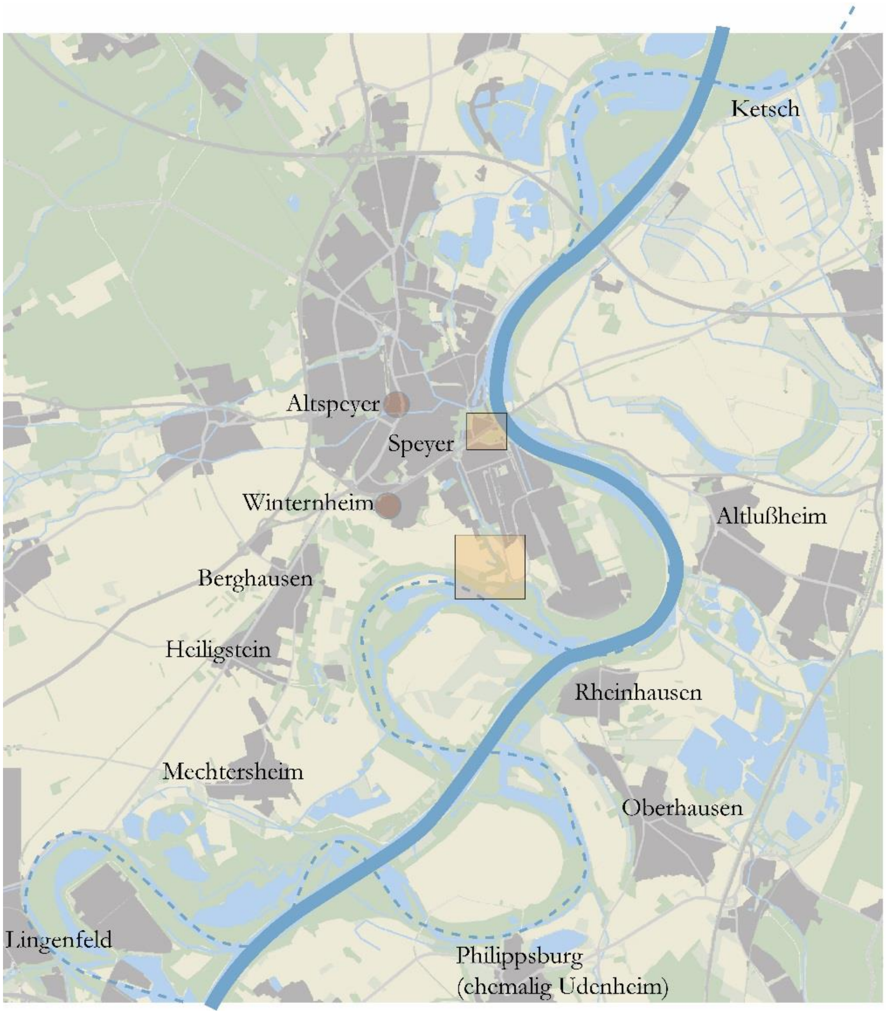


Figure 6.1: An overview map of the location of Speyer

Speyer is located about 18 km south of Mannheim at the western side of the Rhine in the state of Rhineland-Palatine. (Figure 6.1) Speyer is a city descending from a known Roman settlement; therefore, it has an extensive history. Its location along the Rhine provided a perfect transport location, the history of Speyer cannot be studied without its relation to the river. Already in 1080, Norbert of Iburg acknowledged the risks of living near the Rhine. In 1080 emperor Heinrich IV ordered Benno II, bishop of Osnabrück, to refurbish the cathedral of Speyer, which was only a few decades old. A few years after Benno's death his successor Norbert, abbot of Iburg, wrote his biography to promote the canonisation of Benno. Norbert briefly tackles on Benno's building activities in Speyer mentioning that the cathedral, due to its size, was not carefully placed on the bank of the Rhine. For that reason, Benno placed an immense mass of stone boulders in order to prevent the rush of the river of subverting the cathedral. (Bresslau, 1902; Vita Bennonis II, cap. 21)

> *"Unde regis imperio in Spirensem urbem adductus [Benno] ecclesiam illam amplissime sublimatam et prae magnitudine operis minus caute in Rheni fluminis littus extentam maximo ingenio difficilique paratu egregii operis novitate perfecit, et immensas saxorum moles, ne fluminis illisione subverteretur, obstruxit"* (Vita Bennonsis II)

So far, these sentences are interpreted that Benno built a dike or some other kind of flood protection at the feet of the cathedral of Speyer. Since no evidence of this building has ever been found, our research has started from nothing to locate this assumed medieval flood protection. (Conijn *et al.*, in press)

The case study of Speyer is developed on the oldest known record of human action on behalf of prevention against flooding. The biography of Bishop Benno writes on 11th century flood protection, predating every other known medieval river dike in Europe. Additionally, another mention of dikes is known south of Speyer in 1419 when Bishop Raban impeaches the city of Speyer that the ships from Rheinhausen could not return because of the dikes they had crossed during high water.

> *"Item sprich ich, das sie dyche und keche gebuwen und gemacht habent in der weyde giensijt dem vyscherdore hinder der vyschergassen, davon myne schiffe an dem fare zu Husen, so der Rin etwas groß wirt, (nit) in die goltgrube kommen mogent, der Rin were dann als unmeselich groß, das man uber die dyche und keche gefaren mohte; und man doch von alter her darin gefaren ist. und so sie etwann dar komment in großem Rin und der Rin wieder etwas fellet, so mag man die Schieffe nit herwieder uß bringen vor deselben dichen und kechen."* (Mone, 1850, p. 306)

The text of Bishop Raban from 1419 describes that dikes and *keches* (probably ditches) are constructed on the other side of the *Fischerstor* behind the *Fischersgasse.* Additionally, it is stated that the ships coming from Rheinhausen navigated into the *Goldgrube* on their way to Speyer. There they had the problem that they could not return because of the dikes. This would indicate that the dikes are built somewhere in between the *Fischerstor* and the *Goldgrube*, which leaves an area of about 2,5 km in length open for research.

The main question in both these locations of the case study therefore is: where could this historical flood protection be located? If found, it will be among the oldest flood protection measures in Europe. Therefore it is also interesting to know how it was constructed and which stakeholders played a role in its construction. In addition to preliminary research on literature, (historical and thematic) maps and field explorations, some archival work has been conducted. This includes a thorough LiDAR study and field work by means of ERT and corings. (Priß, 2018; Zube, 2016) The case study in Speyer came forth from preliminary research in Speyer at the *Eselsdamm*. (Lange, 2016) Therefore, the necessary contact network for fieldwork was already established and fieldwork could be started quite early in the process.

A lot has been written on the history of Speyer and although most of it is supported by valid arguments and data, but much relies on the interpretation of its various authors. In order to conduct this case study in Speyer, literature had to be studied critically. However, not all of the former studies have been clearly annotated, which leaves their reliability questionable. The most elaborate and recent work on the spatial development of Speyer is written by Müller (1994), who wrote an extensive book on the defence walls of Speyer, thereby including the direct surroundings like water streams as well. In addition, a work of Doll (1999) has been studied, which goes into various aspects of Speyer's history, like the topography and parishes. Both works rely on the 17th century chronicles of Lehmann (1662), which was only studied briefly to find the exact paragraphs that are referred to, in order to gather more details. Additionally, Engelhardt's (1910) work on field names around Speyer is used for a deeper understanding of the relationship between various field names and the landscape around Speyer. Despite the extensively studied history of Speyer, hardly anything is known on its flood management.

6.2 Preliminary research: Use of lands in the flood plain

In Speyer, two locations have been studied in more detail. The *Domgarten*, right at the feet of the land tongue on which the cathedral is situated, was chosen because a passage in Benno's biography suggests that he put up boulders at the feet of the cathedral in order to protect it. The second location is located south from Speyer near a former Rhine arm, around a small pound, which is called *Goldgrube*. The geomorphological map showed several elevations in the landscape, which could be interpreted as dike lines. The two locations have been studied within the same context assuming that Benno had severe understanding of a river's dynamics. In this case it could make sense that he understood that protecting the Cathedral could happen more efficiently southwards of Speyer. This study however does not provide any proof for this assumption.

The *Domgarten* is located about 500 meters away from the contemporary Rhine, and it might be hard to imagine that the Rhine has flown through the *Domgarten*. However, on historical maps at least one side channel of the Rhine can be recognized. In addition, when going into the history, a washed away Roman city wall is mentioned and the biography of Benno tells us that the Rhine threatened the cathedral, which indicates that a river with severe energy should have passed through the *Domgarten*.

Not every single one of the suspected dike lines around the *Goldgrube* are very well visible. Roads, hedgerows and trees hide these relicts of the formerly dynamic river landscape. Nowadays various grassland and fields can be recognized and the *Goldgrube* itself is a nature protection area. Slightly more south, along the pre-Tulla (19th century) river arm, hidden within a wet brook forest, a linear dike can be identified with a height of about 1 to 1.5 meters. This dike has been modernized over the years. This indicates that even after this arm was cut off during the Tulla's rectification in the early 19th century, this dike was updated in order to keep the fields behind it dry in case of rising water levels. The small airfield has influenced the landscape as well. Not only did its expansion in 2011 relocated a road, also a noise wall was placed in order to protect the natural protected *Goldgrube* from noise pollution. This noise wall is already one of the identified possible dike lines on the geomorphological map. Unfortunately, the other dike lines could not be located anymore or were not accessible for fieldwork. For that reason, several of the measurements have been conducted on the noise wall, in order to understand the landscape underneath.

6.2.1 Physical landscape

The pre-Roman town of Speyer is located on the western bank of the Upper Rhine. Most parts of the town are located on a lower terrace. On the tip of the lower terrace, the cathedral of Speyer stands as an iconic landmark, visible from all surrounding directions including the river Rhine. It is known that Speyer had a harbour and therefore it is assumed the town had been located directly at the banks of the Rhine, or at least closer than it is today. Nowadays the cathedral is situated about 500 meters in distance to the Rhine, because the river has changed its course over the years and was straightened and diked during the 19th century by Tulla. (Müller, 1994, p. 90) The land tongue, on which the cathedral is located, is elevated about seven meters above the *Domgarten* park, which is located within the flood plain and partially on the former riverbed.

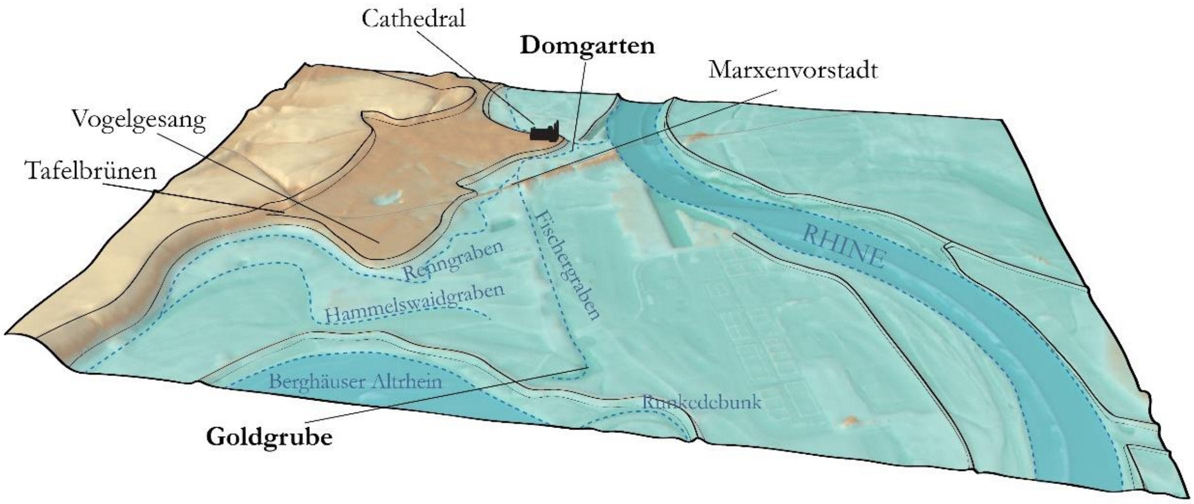


Figure 6.2: An elevation illustration of the Speyer Upper and Lower terraces above the Flood plain, based on LiDAR-data.

From Berghausen south of Speyer the steep upper terrace rim (ca. 110 meters above NN) directs north until *Tafelbrunnen*, at which point the lower terrace diverts. (Figure 6.2) This lower terrace lays closer to the Rhine, passing along *Vogelgesang* and the *Marxenvorstadt*. At its land tongue the Cathedral is located. The higher terrace passes the train station, before it directs west into the forests. The lower terrace (ca. 100 meter above NN, still seven metres above average water level, and about five metres above the floodplain), which started at *Tafelbrunnen*, continues east along the resident area of *Vogelgesang*, afterwards bends north around the *Marxenvorstadt* towards the *Domgarten*. The famous cathedral of Speyer is located at the most eastern point of the lower terrace providing it with a landmark location over the almost flat Rhine flood plain. North of the cathedral, the lower terrace follows the Speyerbach and Woogbach out of the city in the north. (Doll, 1999, p. 302; Priß, 2018, p. 7)

A little south of the city of Speyer, within the flood plain, the most noticeable on the geomorphologic map is the contemporary dike line parallel to a former Rhine arm, which is still connected to the Rhine southeast of Speyer. Also noticeable are four short elevation lines around the *Goldgrube*. A Rhine channel located closer to the city centre is expected according to the notifications of the harbour. The Goldgrube, which is one of the lowest parts of this area, is a possible location for this former Rhine arm. For that reason, these surrounding linear elevations, are considered potential historical dikes and are therefore a study object.

The soil of the upper terrace on the western side of the Rhine, in Rhineland Palatinate mainly exists of nutrient rich and easy farmable loess. The water draining from the palatine hills has cut into this loess terrace over the centuries. These tributaries of the Rhine brought much sediment into the alluvial fans coming from the mountains. (Figure 6.3) (Bodenkarte Deutschland, BÜK200 – CC7110 Mannheim, 2015) These lands were also attractive for early farming because of the nutrient richness and the availability of water, despite the risk of flooding. Closer to the Rhine the loess layer has completely eroded away, down to the windborne sand. These sandy lower terraces form a solid foundation for many settlements close to the Rhine and among these settlements is Speyer. Down at the flood plain around Speyer, soils mainly consist of fluvial gravel and sand, indicating former river arms with a high energy. Depending on the groundwater level these soils are suitable for crop cultivation or grazing lands. (Bodemkarte Deutschland, BÜK200 – CC7110 Mannheim, 2015)

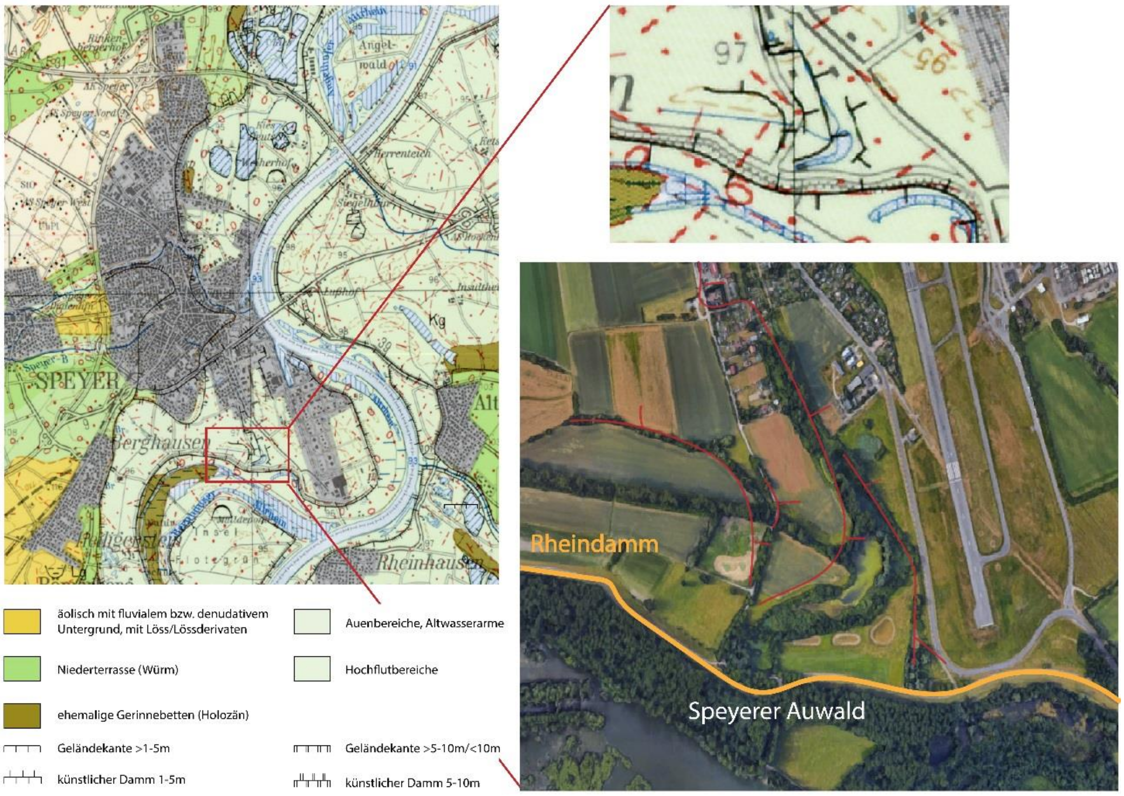


Figure 6.3: The geomorphological map op Mannheim shows four linear elevation south of Speyer, around a pond called the Goldgrube. (Priß, 2018, p.3)

Figure 6.4: A 1788 geometric map of the Berghäuser Altrhein, including former channel outside in the Rhine floodbed in the field of Hegenich

Because of the anthropogenic changes over many centuries, the former course of the Rhine is unclear. The course of the recent Rhine has probably distanced from its medieval riverbed and might not even be close to its riverbed during the Roman period. It is repeatedly suggested that the Rhine has flown closer at the foot of the terrace (Müller, 1994; Doll, 1999). However, close might be considered relatively since nowadays Speyer would still be considered a city close to the Rhine. Early authors might have had the same perception. What we know at least is, that the contemporary Rhine has been straightened during the 19th century. Before that, the Rhine flowed south of Speyer around what is nowadays called the island *Flotzgrün*. It can be expected that this Rhine arm had an outward curve, which is confirmed in the LiDAR data. It additionally explains the multiple former channels on the parcel maps of this area on the other bank south of Speyer. (Figure 6.4). On historical maps, a small stream can be identified at the feet of the terraces. This is the so-called Rinna, or later called Renngraben, which is often considered a former Rhine channel. However, nowadays it is probably filled by seepage water from the terraces. This Rinna is already mentioned in a 1211 charter, it notes a dispute on street and bank rights between the Rinna at the feet of the cathedral until the road to the German-diocese. (Hilgard, 1885, Nr. 534) This is an indication that this water was not called Rhine in 1211. It can also be noted that no link to a former Rhine channel has been made by naming it Altrhein, which is quite common in the Upper Rhine valley. Without any sources, Müller states that the Rinna is a prehistoric Rhine arm, and the Spich would have been the main Rhine during Roman times. The Spich should have cut off the Renn channel of the Rhine and by depositing sediments the Renn was dammed completely. This led to the emergence of a pound, which has been named later on *Froschau*. It also must be noted that water would have flown through the *Altlußheimer Thalweg* (Not visible on the map, but located between Altlußheim and Speyer in a East to slightly West North West direction) during the period in between. (Müller, 1994, p. 91)

Notable is the theory that the Rhine has demolished a part of the Roman city wall and eroded sediments from the lower terrace. (Müller, 1994, p. 93) This theory aligns with the findings of the ERT measurements conducted at this place, which will be discussed in the fieldwork part of this chapter (§6.4). This odd corner can still be seen in the contemporary *Domgarten* with a visible stone relic of the Roman wall, making this a plausible story. (Müller, 1994, pp.94-98) Therefore, it can be assumed that after the Roman period the Rhine would still pass along at the feet of the terrace, and at some point the Rhine had enough power, maybe during a flood, to tear down this part of the Roman wall. This has happened at least before the construction of the Ottonian wall around 950, considering the fact that the Ottonian wall followed the Roman wall but had to redirect its route at the corner of the eroded terrace. (Müller, 1994, p. 99)

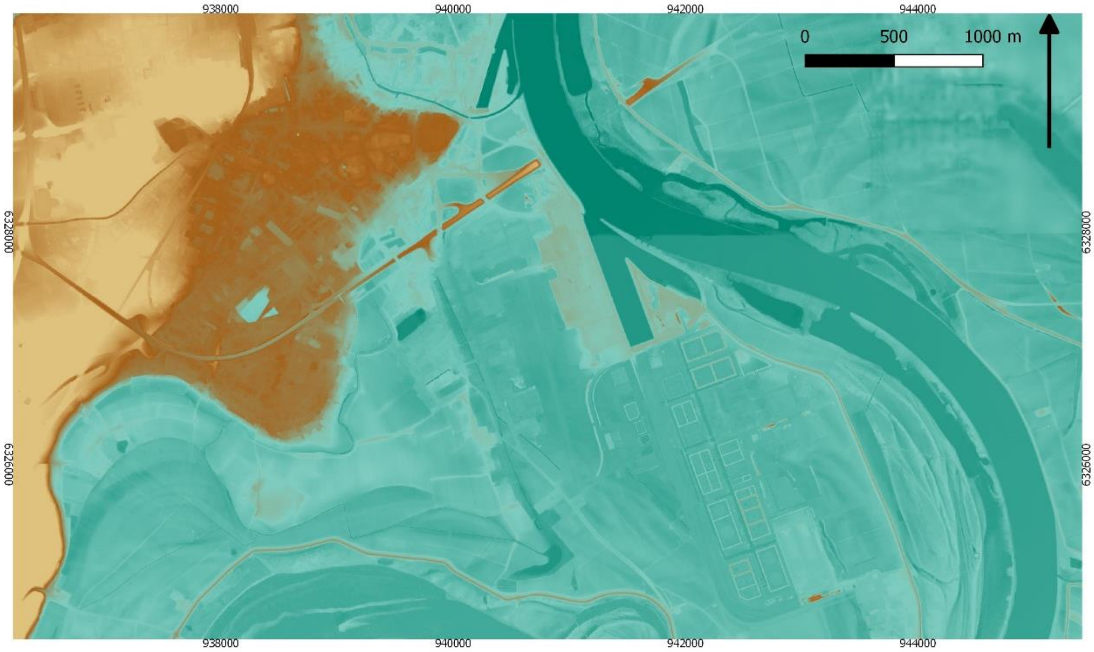


Figure 6.5: LiDAR-data indicating elevation south of Speyer

The LiDAR data of the surroundings of Speyer show perfectly the river channels. (Figure 6.5). The contemporary and the pre-19th century Rhine courses are broad and therefore pretty clear. The Spich, which nowadays is called Fischergraben is also visible. In addition, the Rinna along the feet of the lower terrace can clearly be recognized. Actually, the Rinna becomes visible in two phases. One directly at the feet of the terrace (the contemporary Renngraben) and one about 300 meter closer to the former Rhine channel (the contemporary Hammelwaidgraben). The Renngraben, which cut into the terrace, created a curve in the terrace rim. This Hammelswaidgraben moves with another curve around some fields and a farm at *In der Haingereut 34* before making another serpentine line towards the *Goldgrube*. However, it does not seem to connect to the *Goldgrube* reduction. From the LiDAR-data it remains unclear where this reduction emerges from. The only notable indication is on a cadastral map from 1838 where a dam at the *Goldgrube* is visible. (Figure 6.6) This dam can also be seen on the LiDAR-data and suggests that the *Goldgrube* is somehow fed from a more southward direction.

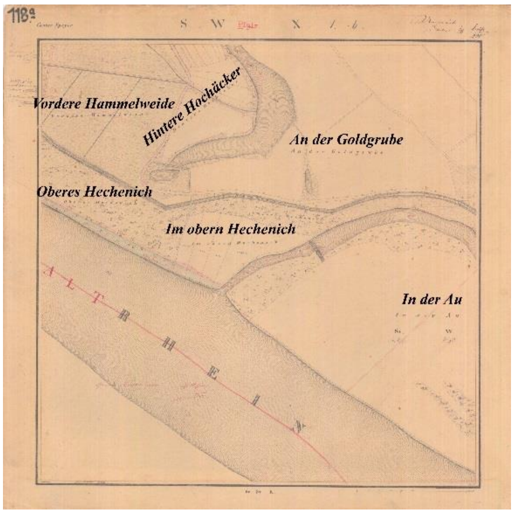


Figure 6.6: A geometric map of the Goldgrube in 1838 shows a damm in the Goldgrube. (Vermessungs- und Katasterverwaltung Rheinland-Pfalz, Kataster-Uraufnahmeblätter der Pfalz (1820 - 1848), Blatt SW X 1b (1838, unpubliziert))

A 1574 court drawing by Wilhelm Besserer is, together with Sebastian Münster's drawing (1550) and Braun and Hogenberg's drawing (1572), among the oldest views on the city of Speyer with a focus from the side of the Rhine. Since Besserer was a resident of Speyer, his drawing is supposed to be most detailed and complete. It was however a juridical drawing and might therefore be biased by the ordering party. On this Klüpfelsau plan, a few aspects are interesting. (Figure 6.7) The road to the Lußheimer ferry can be seen, while on Münster and Braun Hogenberg's drawings, the ferry itself is portrayed. In the foreground this braided fence seems to include a ditch, indicated by a small bridge over it. This fence indicates the use of the *Klüpfelsau* as grazing ground, as the juridical process mentions as well. Also, clearly the Kleebach can be seen and in contrast with the other two maps it is named as well. The Kleebach clearly diverts into many various water bodies in front of the city of Speyer, showing that this area is still very wet. It splits also into two channels up to the *Fischerstor*, located on the thereby created island between the Spich and a harbour. From this harbour the water continues underneath a bridge and past a weir. However, in this area embankments can be spotted everywhere. According to Müller, this was necessary because of the big amount of gravel in the soil. (Müller, 1994, p. 225)

Figure 6.7: The 1574 Klüpfelsau plan by Wilhelm Besserer picturing one of the oldest and most detailed views of Speyer from the Rhine.

Another former channel can be seen in *Runkedebunk* round *Insel Horn*. It is not clear which part of the arm emerged at which moment in time, however the widening of the curve in the centre seems the most recent, which aligns with Musall's reconstruction of the development of the Rhine in drawings from 1968. (Alter, 1968, map 2 and 3) The mouth into the Berghauser Altrhein could be a former connection between Speyer, along the Goldgrube to Rheinhausen where already in the 13th century a ferry arrived from Speyer. However, this is speculative and it seems pretty clear that the Rhine used to flow directly west of Rheinhausen. This becomes clear in a map from 1688 (Figure 6.6), among others. If this potential Rhine would continue northward, it could easily connect with the *Runkedebunk* in direction of the contemporary *Fischergraben*. The *Altlußheimer Thalweg* channel is not visible on the LiDAR-data anymore, because of the construction of the industrial harbour and the airfield. Another aspect to highlight the map from 1688 are the two visible dike lines along the Hammelswaidgraben. This is also visible on the Favrot Rheinstromkarte from 1696 and the S*chlacht am Speyerbach*-map from 1703. (Musall, 1969; Rheinstromkarte 1696; die Schlacht am Speyerbach, 1703)

Figure 6.8: A 1688 drawing of the Rhine south of Speyer indicating the swampy Flotzgrün as an island, and more islands in the Berghäuser Althrein. The Goldgrube seems linked to the Hammelswaid graben, and two lines of dikes can be seen along this Hammelswaidgraben.

The water name *Runkedebunk*, or in earlier days *Unckenbunck*, indicates a calm piece of land (or water in this case) where many toads live, first mentioned in 1599. This could indicate that *Runkedebunk* was already silted up and had not been a flowing water for a significant amount of years. In 1643 people from Speyer wanted to mark the area with willow trunks, so when it would completely silt up, the Rheinhäuser could not take possession of all of it. Therefore it could be stated that *Runkedebunk* was completely cut off the Rhine, and the silted up process was in an advanced state. (Engelhardt, 1910, p. 43) In relation to the Rhine meanders of the Berghauser Althrein and the road to the Rheinhauser ferry, this is an important argument in the reconstruction of the river's course.

Furthermore, many other former meanders can be seen around Speyer. A thorough study with many datings is necessary to reconstruct the Rhine and its course changes over the years. However, one more thing should be pointed out for this research: the meander around the Insultheimer Hof seems to have developed eastward over the years. It seems clear that this channel origins from the direction of Speyer. It can be imagined that this channel continues to Speyer, passing closely along the cathedral. Although this again is speculative, but it would fit to the Insultheimer Hof being documented in the Speyergau in 782 in the Lorscher Codex, which will be discussed further in this chapter.

In addition to the climate of the Upper Rhine valley, discussed in chapter §4.6.1, there are hardly any specific climatic remarks for Speyer. However, Pierre Alexandre got the years 1258 and 1259 from the *Annales Spirenses*. The year 1258 was a rainy year, explained by a bad harvest for grapes as well as for cereals and grains. However, the year 1259 came out to have a good harvest. (Alexandre, 1987, p. 395; p. 396).) Such small detail on very few years do not provide any more information on the influence of climate on Speyer. However, there are no records of flooding in and around Speyer. The core of the city is located on top of the terrace, but at least since the Middle Ages buildings within the flood plain are known. Searches on historical flooding dates, however, come no further than the 1880's and 1955. (LUBW, 2006).) Even for the big ice dam floods in 1784, Speyer did not get damaged. Citizens of Speyer only seemed to have organised a small party on the ice in order to gather money for the poor during the tough winter. (Poliwoda, 2007, p. 64)

6.2.2 Settlement history

Around the first century, Romans took the lower terrace of Speyer from the Nemeter, which were already Roman *foederates*. During this period the antique city of Speyer was founded and called the city Noviomagus Nemetum, which means "new market". In the 3rd and 4th century Alemannic invaders ruined the city. In the early 5th century, the Romans completely disappeared from the region. After the decline of the Roman influence, it seemed that the lands outside of the Roman centre got settled. Altspeier in the North, and Winternheim in the South west. (Figure 6.8.) (Fesser, 2005, pp.132-138)

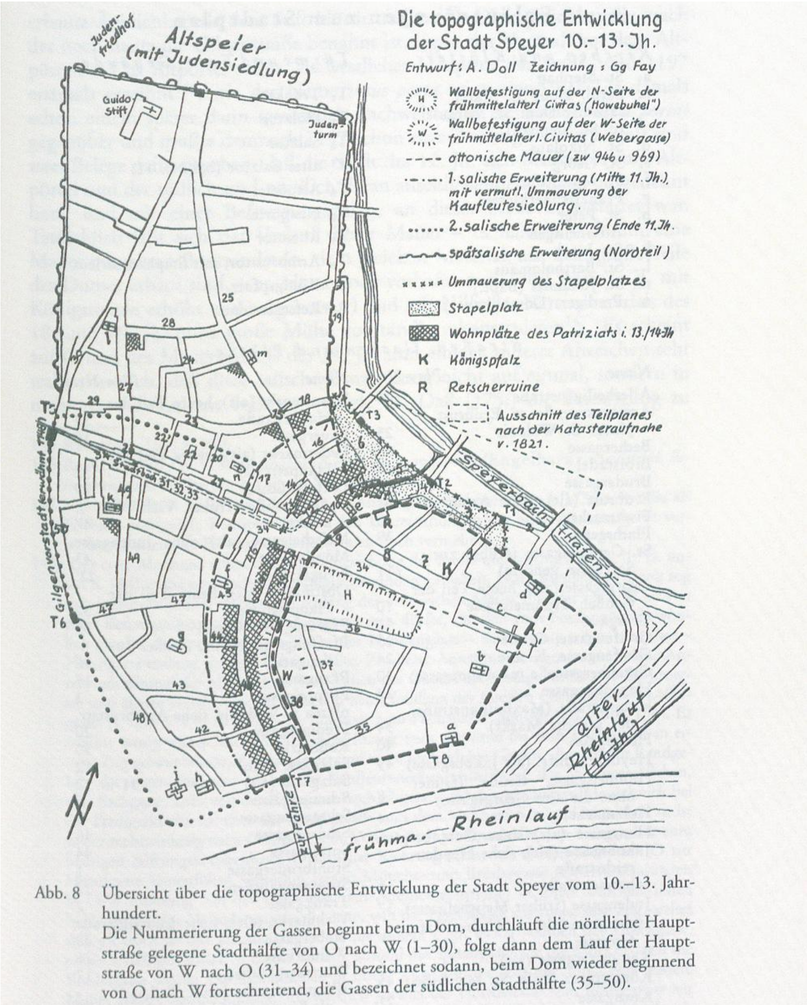


Figure 6.9: A map of Speyer with relevant medival location. The settlements of Altspeyer and Winternheim outside the Roman city walls. (Doll, 1999, p.333)

From the 5th century onward two villages are known in this area. Winternheim in the south and the former Roman settlement Altspeyer beginning from the 6th century. (Fesser, 2005, p. 132) There are also clues for a Merovingian monastery under the reign of king Dagobert at the site of St. German. This monastery should have been located close to the Rhine according to its extensive trade rights on the river. (Doll, 1999, p. 312) Thus, the church was a main actor in and around Speyer as early as the Merowinger period. Speyer was the capital city of the region Speyergau and among others they had the right to vote the king. The Bishop of Speyer gain rights for toll and coin making, which were used for the construction of the cathedral. In the 11th century they started building the cathedral on its recent location. Winternheim, which was located on the contemporary area of *Vogelgesang* disappeared in the 12th century.

The Insultheimer Hof about 4 kilometers east from Speyer is noted in the Lorscher Codex in 770 as being located in Lobdengau, together with several other (disappeared) villages east of the Rhine. A second documentation in 782 in the Speyergau, is proven misinterpreted by Dolch. He argues, based on field names, that Ansilheim is not the Insultheimer Hof near Speyer. He suggests, that it is located near Dannstat, North of Speyer. (Dolch, 1990, p. 154) It remains, however, notable that the Insultheimer Hof is located in the flood plain. This is documented, while other villages around Speyer first appear in documents around the 12th century. Dudenhofen in 1156, Berghausen in 1192 and Heiligenstein at 1190. Ketsch (1226) and Rheinhausen (1256) on the other side of the Rhine even later. Only Altlußheim at the eastern Rhine bank is mentioned already in 964 and was gifted in 1148 to the monastery of Maulbronn.

Near Winterenheim and St. German a *clausae* was located. This is at least known for the 13th and 14th century (1273, 1354). Engelhardt argues that this *clausae* was located at *im Kloßhorst* near the *Mörschbückel* right past *Tafelsbrünnen* along the *Kloßweg*. (Engelhardt, 1910, p. 24) A field (*im Closweg*) and a pasture (*im Closdeych*) are documented around the c*lausae* in the 16th century. It should be located at a *horst* which, according to Engelhardt, means small forest. However, other sources also indicate that a *horst* is a forested elevation in wet areas, which fits very well to the region. (Directie Bos- en Landschapsbouw, 1991; Schneider, 1980, p. 20; Hall, 2011, p. 88) Such a *clausae* might indicate that it was initially located in solitude, before the flood plain was used for agricultural purposes. A clear date of origin for this *clausae* however lacks, thus it can not be taken into account in this study.

Fishermen could not live inside the city walls, because they either could not manage to be inside the city gates in time, or wanted to leave early in the morning. Therefore, fishermen lived south of Speyer. Around the 12th century when the St. Markus church was erected outside the city walls, probably some fishermen were already living there, however, none are mentioned. An access road to the Rheinhauser ferry was built between 1293 and 1318 in this area. (Müller, 1994, p. 169; Doll, 1999 p.396) At first in 1339 it is known that people were living on the elevation along the stream called the Spich. Spich or Speich means an embankment strengthened with wood and poles. (Müller, 1994, p. 65, p. 170) Although during the first half of the 14th century the St. Markus portal and the Rheinportal were build, in a part of the city which was not walled. This probably happened between 1360 and 1420. Notable is that the water on which the fishermen navigate at this time was called Spich and not Altrhein. This would suggest that the Spich was already cut off the main Rhine arm in this time. Unfortunately, this conflicts with the assumption that the dikes and ditches built shortly before 1419, closed off the shorter route from Rheinhausen to Speyer, as is stated by Bishop Raban. (Mone, 1845)

Like many other cities in the 15th century, also Speyer started to construct a defence wall (*landwehr)* in 1410. This should serve as a first defence line on hearing distance of the city walls. (Müller, 1994, p. 250) This wall marked the lands of the city of Speyer, as defined in 1314. Although the wall mainly consisted from closed hedges, within the flood plain a ditch was dug as extension. (Müller, 1994, p. 262) The ditch in *Hegenich*, located south from Speyer along the Rhine, was constructed up to the *Harthauser Warth* in 1411. (Lehmann, 1662, p. 871) The Speyer lands on the eastern side of the Rhine were not walled and belonged to the flooding areas of the Rhine and the Kraichbach.

During the 17th century, St. Ulrich's church was still located at contemporary *Vogelgesang*. (Engelhardt, 1910, p. 24) Furthermore, a St. Catharina chapel was located on the St. Germansberg outside the city walls but inside the defence wall. (Engelhardt, 1910, p. 26)

6.2.3 Agricultural fields

It is often suggested that Speyer's agricultural fields have been located on the terraces. While nowadays the built-up area goes up to the Speyer Forest, the 1767 map (figure 6.10) shows that in earlier days many agricultural fields were located around Speyer. The city part in front of the *Altpörtel* is actually called *Ackervorstadt* (agricultural fields suburb). (Engelhardt, 1910, p. 18) Among others, the *Burgfeld* is located there along the Woogbach, which means the old fields of the city. A medieval city with walls, towers and a canal was often called a burg. This *Burgfeld* can therefore be considered Speyer's oldest fields in the medieval period when contemporary fields were still heath and moor. (Engelhardt, 1910, p. 34) Indeed these agricultural fields are located on the terrace while mainly wet grasslands can be seen in the flood plain. The only fields within the flood bed, are the ones behind the *Alte Feldteich*, which is interpreted as a dike. The *Rheinhauserstrasse* seemed also to function as a division of the fields and grassland on the southeastern side of Speyer. This indicates that the *Rhinehauserstrasse* was slightly elevated compared to the surrounding landscape.

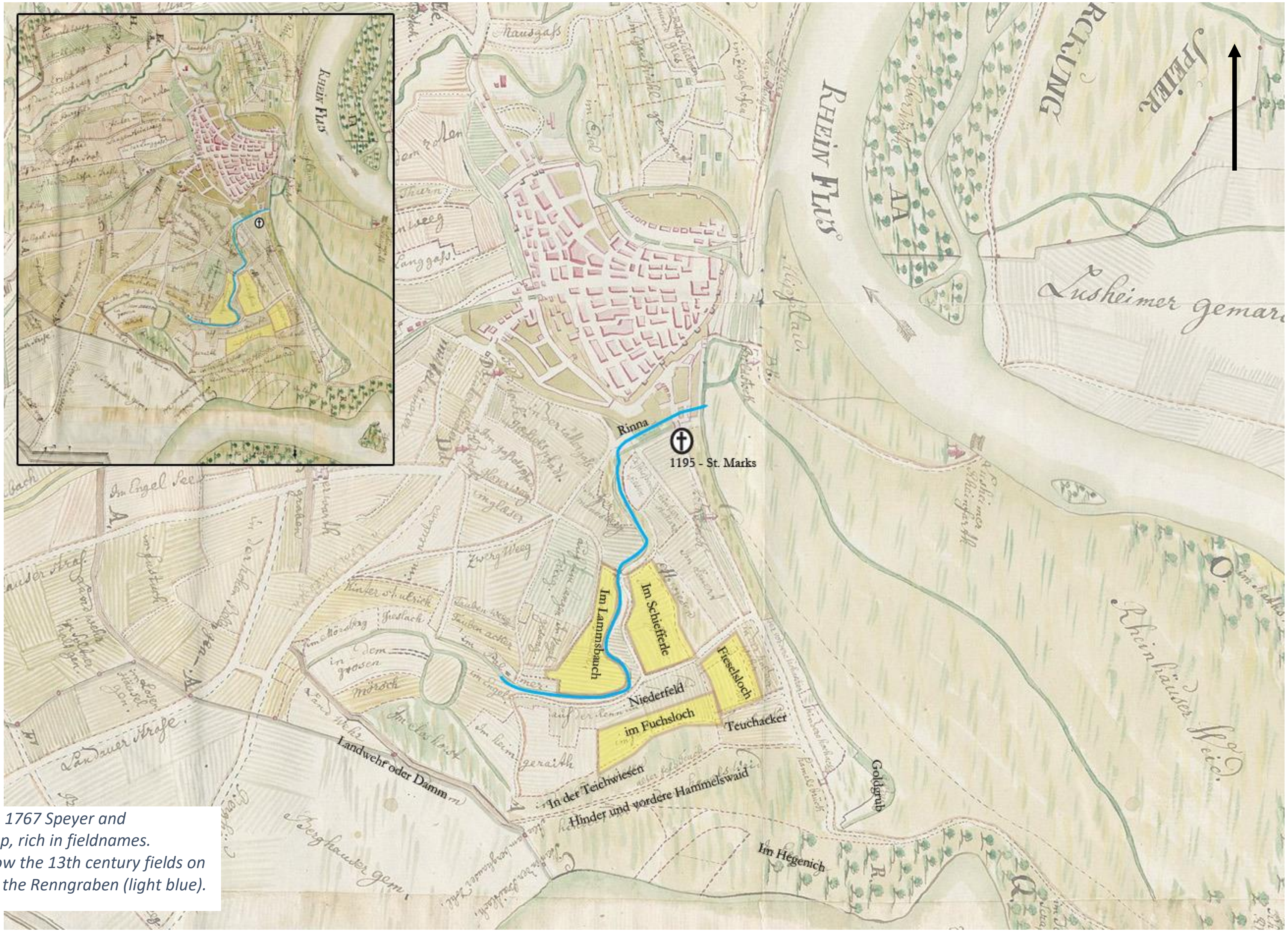


Figure 6.10: The 1767 Speyer and Rheinhausen map, rich in fieldnames. Indicated in yellow the 13th century fields on the other side of the Renngraben (light blue).

In 1538 a field outside of St. Marx is mentioned with the phrase *im fuchs lochern*. In 1584, there can be located another area called *fuchsloch* along the Rinnen. This land was owned by the Fuchs family. Although *loch* indicates a reduction or wet fields on the flood plain. Engelhardt on the contrary suggests that *loch* means bushy forest. (Engelhardt, 1910, p. 46) The nearby *Fieselsäcker* is considered by Engelhardt to be a field of the same family, which can be related back to the early 14th century. (Engelhardt, 1910, p. 46) Also *Im Schiefferle* can be related back to Schiverlin a resident of the city in 1330. *Im Lammsbauch* goes even longer back to Marquardi Lambesbuch, who was living along the Renngraben. The banks of the Renngraben were inhabited on both sides in 1211. (Engelhardt, 1910, p. 46) In between the aforementioned fields on the flood plain, the *Niederfeld* (lower fields) is located. If its surrounding fields were already in use during the 14th century, it would not be suprising if *Niederfeld* also dates back to this period. Indicating that the expansion of fields into the flood plain was not extraordinary during the 14th century, and probably even earlier. Between the Berghäuserstrasse and Gieshübelbach the fields of Kämmerer are located on the flood plain, which were gifted to the Dom-diocese by Bishop Konrad who died in 1224. (Engelhardt, 1910, p. 61) In addition, the German-diocese provided an arable field for a resident of Speyer on the other side of the Rinna as early as 1214, named *ultra Rinnen*. (Engelhardt, 1910, p. 36) Altogether, it can be expected that since the 13th century the people from Speyer cultivated several fields on the flood plain. However, the field *im Neuland* is located in the flood plain close to *Vogelgesang*. It is documented in the 16th century (1537 *"de novis agris hinder St. German"* and in 1555). The name suggests new lands, which might be interpreted as newly cleared or recently taken into use. (Engelhardt, 1910, p. 25) However, it lacks any date of when these fields are taken into use. According to Engelhardt this was related to the *Katzenloch*, which in 1613 is documented as *Ackerland im Katzeloch oder Vogelgesang*. This also points out that these fields used to be forested area. (Engelhardt, 1910, p. 37) The *Hochacker*, north of Speyer, is assumed to be the same as the in 1253 documented *Hohengrient*. (Engelhardt, 1910, p. 65) However, another *Hochacker* is known near the *Goldgrube*.

In the flood plain north of Speyer lays a grazing district. In a former river channel, the livestock could drink (*Schwemme*, *Drenck*) which is again visible near the *Drenkthor* (14th and 16th century) and the *trinckgasse* (14th century). The *Kühtor* (1433) and the *Kühgasse* (16th century) marks the way the cattle were taken to the *Bürgerweide*. (Engelhardt, 1910, p. 32) In 1727, this *Speyerer Lache* was under water for a few years, as the result of higher water levels. When such an emergency high water happened, the livestock was normally allowed to graze up to the district borders with Schifferstadt or Hanhofen. (Engelhardt, 1910, p. 65) In the grazing area near *Hasenpfuhl* north of Speyer there is also a *Nachtweide* on which the animals were herded during the night. *Esel* is mentioned in 1330 and the *saltus hinnulinus* is the Latin predecessor of *eselwiesen*, where the mules where grazing. (Engelhardt, 1910, p. 66) A second grazing district is the *Rheinhäuser Weide*. Most of it was common land for horses, cattle and pigs. However, the sheep where only allowed at the *Hammelswaide*, because of their smell. (Engelhardt, 1910, p. 66)

6.2.4 Forests

In the northwest of Speyer sandy soils can be found, containing the most important forest areas of Speyer. (Engelhardt, 1910, p. 38) In the wetter area around the Woogbach the field *Erhlich* is located, meaning closed alder brook forest. (Engelhardt, 1910, p. 37) In 1596 this was still an alder forest. The wet *Hechenich* in the south of Speyer has also the meaning of closed or tight forest. (Engelhardt, 1910, p. 36) *Vogelgesang* is related to forest area because the presence of birds. *Gesang* is derived from the verb *sengen*, which is explained as clearance of forest by means of fire according to Engelhardt. (Engelhardt, 1910, p. 37) *Horst* and *hain* are also expressions for forested area. *Im heingereide* (1537) therefore means cleared forest. This succeeded into the *Niederfeld*. New agricultural land was placed on areas where forests used to exist. (Engelhardt, 1910, p. 35)

Engelhardt (1910) suspects heathlands between the land tongue with the cathedral and the Rhine, because of the *Heidenturmchen*. *Heide* means disused lands, which were left to nature. This city gate was built in the 11th century (Engelhardt, 1910, p. 30) Another wasteland was the *Hasepfuhl*, which used to be a swampy land directly north of Speyer in the flood plain. This *Hasepfuhl* was already known in 1276. *Mörsch* (1369) also means swamp, a fieldname with *mörsch* is identified south of Speyer in the flood bed near *Tafelsbrunnen*. (Engelhardt, 1910, p. 39)

6.2.5 Infrastructure

Along the *Rheinhauserstrasse,* Bronze Ages findings were unearthed, indicating the long history of this area and its road network. (Müller, 1994, p. 168) Roads along the Rhine, so called *Leinpfade,* when elevated were often additionally functioned as dikes, (Engelhardt, 1910, p. 35) Important to know is that the *Rheinhauserstrasse* was constructed or probably improved between 1293 and 1318. (Müller, 1994, p. 169) The direction of this road might therefore indicate the direction of the ferry, since it was the cheapest and most common way to build straight roads. However, the *Rheinhauserstrasse* nowadays shows a bend in a southward direction. It makes sense that the Berghauser Altrhein curve moved outward to the west and the ferry landing place moved with it. For example, this could be related to the channel that created *Runkedebunk*, which landed during the 17th century. So probably this bend in the road was made before the 17th century. The road crosses the *Fischergraben* close to the city and reaches the Rhine east of the *Goldgrube*. This indicates that the ferry landing place has been replaced again. The redirections of this road and the assumed relocation of the ferry landing places contribute to the reconstruction of the Rhine course in this area.

In its trade network Speyer was not only located on the north-south axis along the Rhine, but also on a west-east axis from Paris through the Palatinate forest through the Kraichgau towards Nürnberg. Therefore, the Rhine had to be crossed, in which Speyer was the key node. Four ferry crossings were important for Speyer: Rheinsheim, Ketsch, Altlußheim and Rheinhausen. (Figure 6.11) (Doll, 1999, p. 390) Doll also provides an extensive description of these ferries, which goes beyond the purpose of this paragraph. In the Salian period (10th to 12th century) the Lußheimer route was the most important. In the late medieval times, the route via Rheinhausen towards Bruchsal and Maulbronn (15th century) became more important. In the late 12th century the Rheinsheimer ferry was already in use, when the Eußerthal monastery bought 1/6th rights for a farmstead in Mechtersheim. Later this monastery would agree on free ferry crossing for goods produced at this farmstead, by providing the rights of this ferry to the St.German-diocese of Speyer, until they rented it out to the Bishop of Speyer in 1574. (Doll, 1999, p. 392) In the north, the Ketscher ferry is first mentioned in 1226. It seemed that this ferry was not legitimate, therefore everybody was demanded to take the Lußheimer ferry in the early 15th century. However, only a few years afterwards, everybody was summed to take the Ketscher ferry again. As a result, of continuously increasing tolls demanded by the bishop, people diverted to the Lußheimer and the Altripper ferry. In the end of the 13th century the territorial expansion of the count of Zweibrücken demanded another ferry between Mechtersheim and Udenheim (nowadays Phillipsburg), but only after a few years this was closed down again on behalf on the Dom-diocese and the German-diocese, which were the owners of the ferries at Rheinhausen and Rheinsheim. Like the Lußheimer ferry, the Rheinhauser ferry is first mentioned during the 13th century in tolling books, owned by the Dom-diocese and the German-diocese. In the early 14th century new access roads were built to these ferries. The Rheinhauser ferry was so

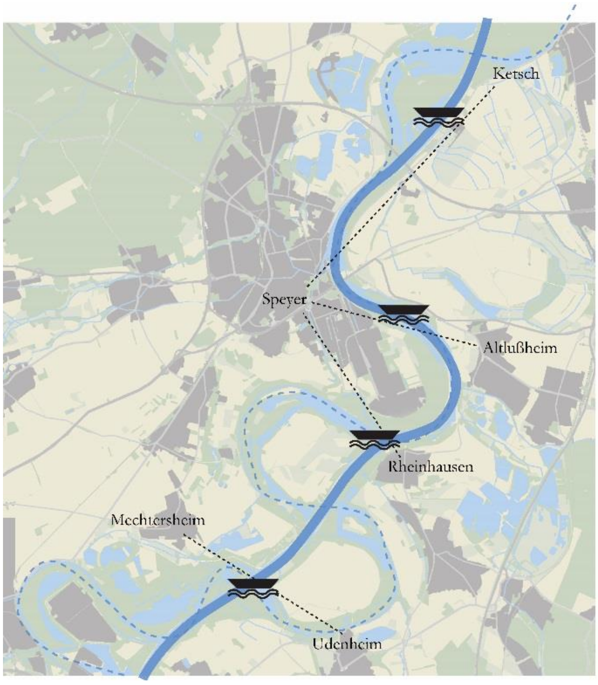


Figure 6.11: The ferries around all at a 'furt', the turning point off meanders, and mainly first mentioned during the 13th century.

important that the new bishop would cross the Rhine with this ferry when arriving in Speyer. (Doll, 1999, p. 396) The Rheinhauser ferry became a very important place on the route from Mechelen (Belgium) to Innsbrück (Austria) during the 15th century. In 1535, it was possible to reach the ferry from Speyer over land, but also over water. However, because the city of Speyer constructed a dam in the former Rhine channel, the journey by boat took twice as long as before. (Doll, 1999, p. 397) This is probably based on a charge on the city of Speyer by Bishop Raban in 1419, which also mentions dikes and ditches.

The Woogbach and the Woog around the *Dietbrücke* where very suitable for the rich numbers of fish in this area, especially salmon. The city of Speyer used to get its salmon from the *salmengrund* located on the *Rheinhauser Weide*. (Engelhardt, 1910, p. 41) In the Rheinhäuser wiesen several fish waters are mentioned over the years: *Dornegrub, Breitweyher, Weydenweyher, Hüttenweyher, Vogelweyher, Kleinbachweyher, Nagelweyher*. *'Weiher'* is a pound, often dammed by a weir, which let the water in, but made it possible to control the size and moment of discharge. In this case, the fish that remain in these pounds can be harvested. Such weirs are called *Kirschwerr* and *Hollerwerr*. These names are still visible in road names nowadays, at least in the case of the *Kirschweg*. (Engelhardt, 1910, p. 43) The *Heringssee* (1779) in the flood bed north of Speyer could certainly be related to the fish (Herring), but as well be related to the owner Friedrich Häring who lived in Speyer in 1773. (Engelhardt, 1910, p. 43)

Another use of the river was the *Goldgrube*. The *Goldgrube* was already known in 1419 (in the aforementioned charge by Bishop Raban). However, in 1688 multiple *Goldgrube*s are rented out around Speyer according to Engelhardt. (Engelhardt, 1910, p. 42) South of the *Goldgrube* the *Lausgrube* is located. Engelhardt connects this with a 1575 sue of a servant who navigated into the forbidden *Leißwehr*. (Engelhardt, 1910, p. 42) Engelhardt then mentions a *kehlwiesen*, which could not be linked to a location by historical maps. This should mean the reduction of a former river arm, in this case located next to the Rathswörth along the contemporary Rhine.

During the high medieval period (11th century) Speyer was known for its bad air conditions and the resulting bad health of its inhabitants. It was sad that it was hard to breath in Speyer, concluded by Doll . (Doll, 1999, p. 281) He argues that this might be the result of the high waters leaving swampy lands around the city with rotting vegetation remains. Doll continues in his argumentation that the canalization of the Speyerbach in 1305 can be seen as an investment in order to deal with the terrible smell in Speyer. However, within the frame of this research it shows that the early 14th century had the technical ability to plan and construct a stone drainage canal underground. (Doll, 1999, p. 281)

There is hardly anything known on dikes around Speyer. *Deichwiesen* (1613) and *Deichacker* indicate some protection against the eroding Rhine by constructed embankments and dikes. As can be seen on the map of 1767 these two field names relate to a dike along the *Hammelswaidgraben*. This is also one of the possible dike lines on the geomorphological map. However, it seems to be related to the defence wall which was constructed in the early 15th century. Historical sources like maps and fieldnames provide very little information about the age of the various dike lines. The contemporary Rhine dike can partly be seen on a map in 1688. The dike along the *Hammelsweidgraben* can be seen on the same map and is located parallel of the Rhine dike in the hinterland of the dike. The *Goldgrub*e can still be seen and is assumed to be a remainder of the former Rhine channel that passed here in direction of the cathedral. The dike around the *Hammelswaidgraben* is also drawn on maps of Speyer from 1696 and 1703. Notable is that on these maps two parallel dikes are visible, the second one closer to the Rhine. This could indicate that more lands could be won, and an offensive dike is built about 300 meter south of the first dike at the *Hammelswaidgraben*. This does not directly mean that the dike at *Hammelswaidgraben* was left deserted, but leaves open questions for discussion. If it becomes possible to access this dike, it is recommended to date it in order to confirm this assumption.

6.2.6 Actors

According to Fesser (2005), for the area around Speyer various landowners had extensive properties. Church institutions were among them, which gained their property by private donations. Furthermore, they were supported by the royal estates. (Fesser, 2005, p. 321) This meant that land in villages could be split between mutiple landowners from the state, the church, and private citizens.

The diocese of Speyer is considered to have been refounded in the time of Dagobert I (ca. 603-639). At least in 614 a bishop in Speyer is mentioned, and therefore it is expected that at the latest the former Roman town on the land tongue of the lower terrace is taken into use again. From this point onward, the church became an important actor in the development of Speyer. For example, the coining rights were provided to the Bishop of Speyer in 946 by Konrad the Red. This did not mean that the diocese was separated from the kingdom. It would make more sense that both the king and the bishop, had the same influence and power at least until the late 11th century. Actually, Doll (1999) argues that Konrad handed over the merchant quarter to the Bishop, so that merchants could trade like insiders instead of outsiders. Instead of giving away parts of the city, the city merged into one. Which contributed to the construction of the city wall (Doll, 1999, pp.323-330). This cooperative rule in the city can be seen in the fact that Bishop Benno was sent to Speyer by the king in order to build the cathedral (Vita Bennonsis II), and even if the king was not involved personally, it would have been someone from his administration. However, this changed over the years and in a charter from 1111 several civilians rights and privileges were provided which were, until then, only legal for the bishop. After 1294, Speyer became a free city and the rule of the Bishop diminished. (Doll, 1999) This would indicate that the power of the Bishop was slowly shifting towards more bottom-up approach.

The Merovingian cathedral shifted its Patronym between 782 and 858 to the St. Markuskirche *"am Ufer des Rheins gelegen"*. This is documented for the first time in 1195 as a part of an acknowledgment of the St. German-diocese by the pope. It was located outside the city walls. (Engelhardt, 1910, p. 15) The influences of St. German have been visible especially in the *Fischervorstadt* of Speyer.

An archival map from 1788 depicts the *Hospital Hechenig* within the *Hechenig* south of the *Goldgrube*. Remarkable is that many of these lands are located in the flood plain. Especially this last one is located right in front of an *Alter Damm* (old dike). This can be an indication that the *Spital* mainly gathered lands in the period and that the flood plain was already in use.

6.2.7 Perception of landscape

Fear of the cathedral destruction by the Rhine was big enough for the king to let Benno come for refurbishments in 1080 from Osnabrück. Only circa 100 years later, in 1195, the church of St. Markus was built on the flood plain. Therefore, the fear of flooding had most likely gone away. Alternatively, it can also be postulated that the church was built there in belief that it functions as protection against flooding. However, there is no proof for this statement. A more interesting question is the way how this possible perception did change over time. This might just have been locally since the Rhine had redirected its course, because of the boulders of Benno. Alternatively, it could correspond with a broader trend in which people started to see the landscape more and more for its resources.

Although, many fieldnames have already been discussed, this paragraph briefly shows how the field names based on land observations, differ from those that indicate land use. As a starting point the map of Speyer and Rheinhausen from 1767 (figure 6.10) is used for this paragraph, supported by Engelhardts analyses of the fields names around Speyer. The field names based on land observations are very scarce. The wet areas have forests like *Hegenich, Erlich* and the *Wühl* or *Wile*. In 1314 *"super prato sito citra Rhenum in loco bey dem Wile"* already indicates such a relict of a dike breakthrough. (Engelhardt, 1910, p. 29) The names indicate a gully or deep pond emerged due a dike breakthrough (Engelhardt, 1910, p. 29) Other observed names around Speyer are the *Bieberwörth*, the *Rathswörth* and the *Klüpfelsau*, all located along the contemporary Rhine. In addition, the land observing suffix, *Rath-* and *Klüpfel-* prefixes indicate are giving hints about ownership.

Another interesting aspects is the *Heidentürmchen,* which was built in the 12th century. It indicates the wasteland in front of the portal. This land is nowadays named the *Rheinhauser Weide*. (Engelhardt, 1910, p. 30) This clearly shows how the perception of this land has changed since the 12th century. Only the fields in the contemporary flood bed seem to have land observative fieldnames. A final example is the *Insel Horn* named after its pointy form. (Engelhardt, 1910, p. 47)

On the contrary, many fields around Speyer indicate land use. This counts for almost all the fields on the terrace, including the *Niederfeld* on the flood plain in the south of Speyer. Even the wet flood plain contains many names that indicate land use: the *Rheinhauserweide*, the S*almengrund, Nachtwaid*, and the *Hasenpfuhler Waid*. It should however be noted that most of these fields are located on newly developed lands. Subsequently, this is only possible if the Rhine indeed used to flow directly at the foot of the cathedral. Most of these lands have been taken into use during a period (12th and 13th century) in which all the surrounding land was taken into production for the increasing city.

6.3 Hypothesis for the field work

6.3.1 Where was the Rhine and where could dikes be expected

According to this preliminary research, two main sources for historical flood protection should be distinguished. At first Bishop Benno who placed big boulders to protect the cathedral of Speyer. Since this building is located on a severe elevation, flooding of the cathedral itself does not make any logical sense. However, erosion of the land tongue makes a lot of sense. This is the area where the cathedral is located. Especially when taking in consideration that the land tongue already partly eroded sometime after the Roman settlement of Speyer and before the construction of the Ottonian wall in the 10th century. If this happened during the 11th century, or being commemorated in stories at that time, it would make sense that Bishop Benno was asked to protect the newly constructed cathedral. The most logical location to search for Benno's boulders is at the feet of the cathedral where the Rhine potentially already eroded the land tongue. This is located in the recent *Domgarten*. However, on every location where the channel eroded parts of the land tongue flows, the redirected boulders can be expected. This means at least upstream and therefore south of the *Domgarten*, presumingly somewhere along the *Fischergraben*.

A second source for early dike construction around Speyer is the charge of Bishop Raban, dating back to the early 15th century. Locations for field work were selected based on the two main written historical sources introduced earlier, those of Benno and Raban. Hardly any sources mention dikes or other forms of flood management taking place between the 11th and 15th century. However, in the contemporary landscape much of this area is overbuilt with a highway exit, an industrial area, and an airport. Practically this means that only the area around the *Goldgrube* is suitable for further field research. Fortunately, exactly in this area four potential dikes have been identified on the geomorphological map and are taken into consideration for field work. However, it seems that these four elevations will not be the described dike of 1411. It seems clear that the dike from 1411 is constructed as part of the defence wall in *Hegenich*. (Doll, 1999, p. 281) Assuming that the outward moving meander of the *Berghauser Altrhein* has continued moving outwards up to the place where it was cut off in the 19th century, it can be expected, that the 1411 dike has been washed away by the *Berghauser Altrhein*. However, the dike along the *Hammelswaidgraben* can be part of the 1411 construction. This statement cannot be proven because the area was not accessible during this research. For that reason the *Fischergraben* at the *Goldgrube* was studied in more detail in order to gain more knowledge on the former course of the Rhine. It has become a quite complex puzzle to locate the medieval Rhine and its dynamics. Dating of former water courses would contribute to the understanding of Speyer's medieval landscape and the perception of the river and its threat of flooding.

6.4 Field Work: An early medieval water course

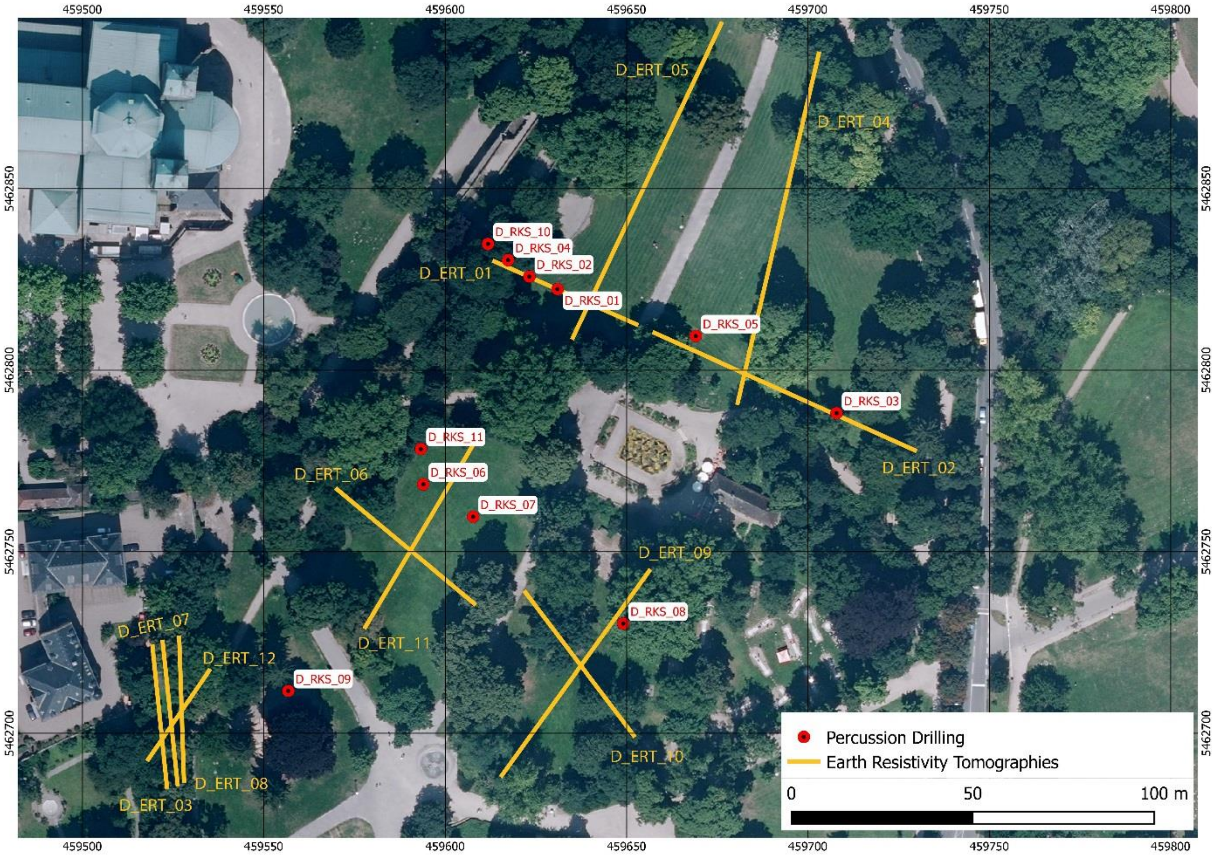


Figure 6.12: Exact location of the field work in Domgarten Speyer.

6.4.1 Domgarten: Water, but no boulders

Fieldwork in the *Domgarten* of Speyer consisted of several Electrical Resistivity Tomography (ERT) arrays and soil core samples. The activities were conducted by Janine Lange and Carsten Zube from February 2016 to April 2017. The former Rhine channel most probably crossed the *Domgarten* from the southwest to the north. The ERT arrays were therefore laid out from east to west in order to make height differences and possible dikes or ditches visible (Figure 6.12. The attendant corings are located on these lines in order to provide information that is more detailed.

The northernmost section of corings show a variety of anthropocene sediments on top, dating back to the 8th until the 17th century. These sediment layers vary in thickness from 50 centimeters to 5 meters (Figure 6.14). Mixed sediments indicate either fluvial activity or human disruption. Since not the whole research area contains these mixed sediments it is assumed that the thicker layers of mixed parts (corings RKS2 & RKS4) are former canals of Speyer's harbour infrastructure. This postulation is derived from corresponding 18th century maps. The organic materials from underneath these thick layers date back to the 16th century by ^{14}C-dating of charcoal, which supports this assumption. Thus, these corings indicate former canals during the 16th century that have been filled with anthropogenic materials. (Conijn *et al.,* in press)

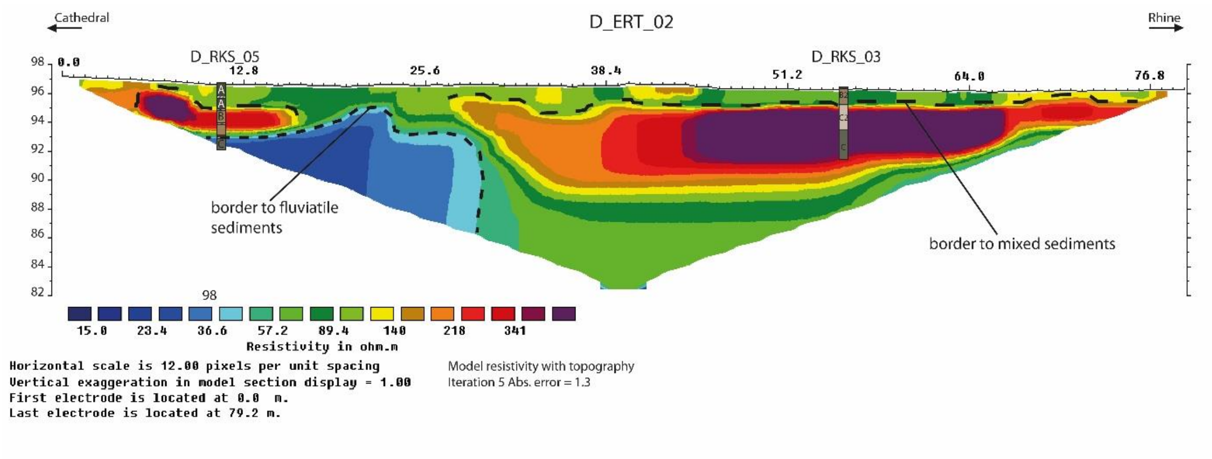


Figure 6.13: D_ERT_02 in the Domgarten shows a fluvial sediment, right underneath D_RKS_05.

Corresponding with the D_ERT_02, coring D_RKS_03 contains a fluvial sand layer, indicating a former river channel. (Figure 6.13) At coring D_RKS_05 no fluvial sediment was found under the 1 meter thick anthropogenic deposit. Instead a 2 meter loess layer can be recognized. The loess, which has been deposited there by wind and fluvial erosion from the palatinate terraces (west of Speyer), can be found widespread in the region. However, it makes no sense to use loess in a dike because this material can easily be eroded away by the river. The ^{14}C-dating of organic materials, derived of these corings and ERT's indicate an active water channel through the *Domgarten* around D_RKS_05, as early as the 7th century. (Table 6.1)

Altogether, no dikes or other flood protection measures could be traced by the ERTs and corings. Only an early medieval river channel has been found. The tight grid of our fieldwork with earth resistivity measurements hardly leaves room for Benno's boulders. Either the river channel has already eroded them away or the flood protection was not located directly at the foot on the land tongue on which the cathedral is build. (Conijn *et al.,* in press)

Table 6.1: ^{14}C Datings Speyer Carsten Zube

Core	***Depth [cm]***	***calibrated age 1-σ***	***calibrated age 2-σ***	***^{14}C-Age BP***	***sample type***
D_RKS_01	249-250	cal AD 1040-1153	cal AD 1029-1160	934	wood
D_RKS_01	284-285	cal AD 1529-1659	cal AD 1522-1795	272	charcoal
D_RKS_01	383-384	cal AD 782-878	cal AD 773-993	1191	charcoal
D_RKS_02	334-343	cal AD 1481-1625	cal AD 1458-1633	352	macroremains
D_RKS_02	393-396	cal AD 1466-1618	cal AD 1453-1630	365	macroremains

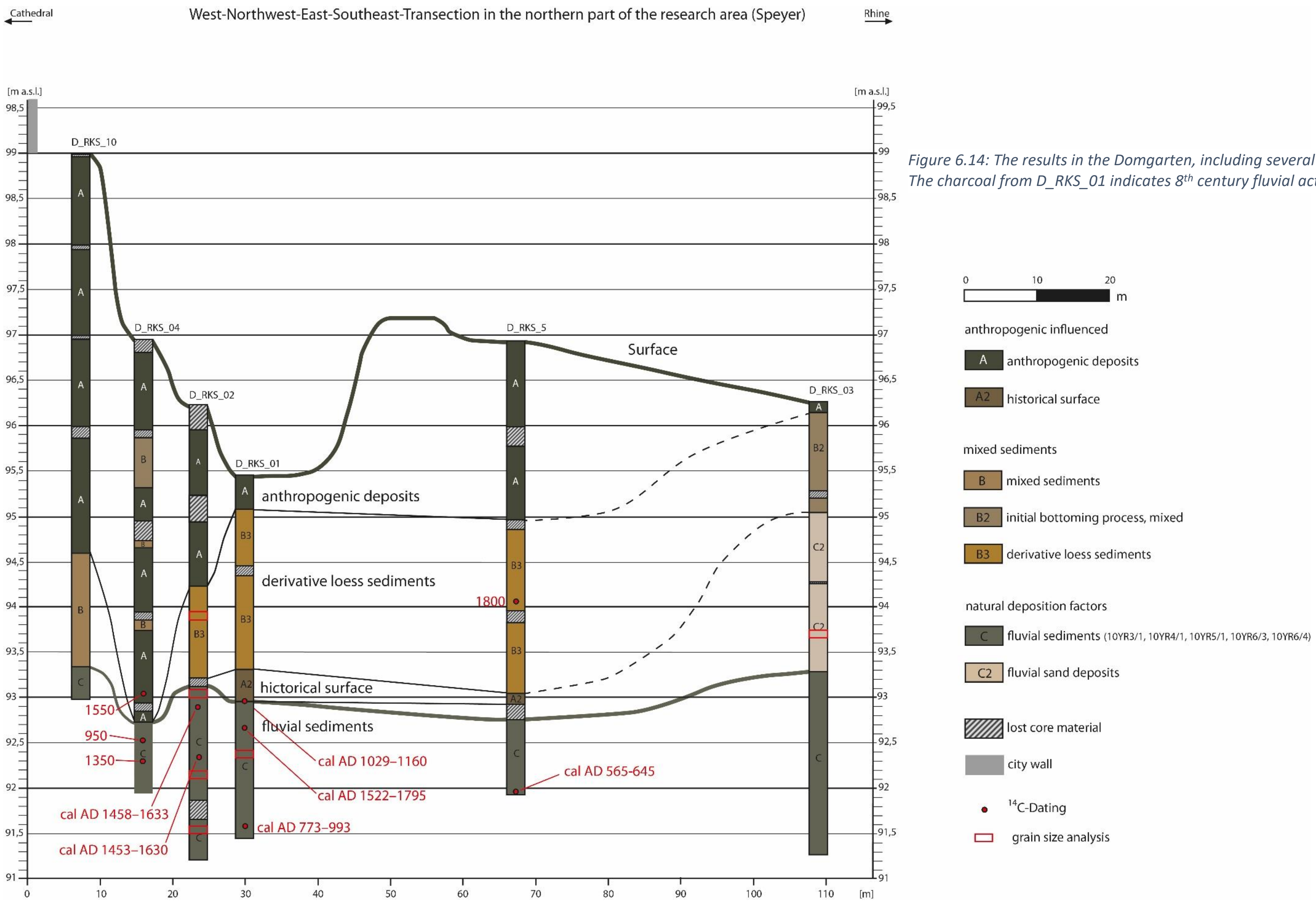


Figure 6.14: The results in the Domgarten, including several datings from table 7.1. The charcoal from D_RKS_01 indicates 8th century fluvial activity.

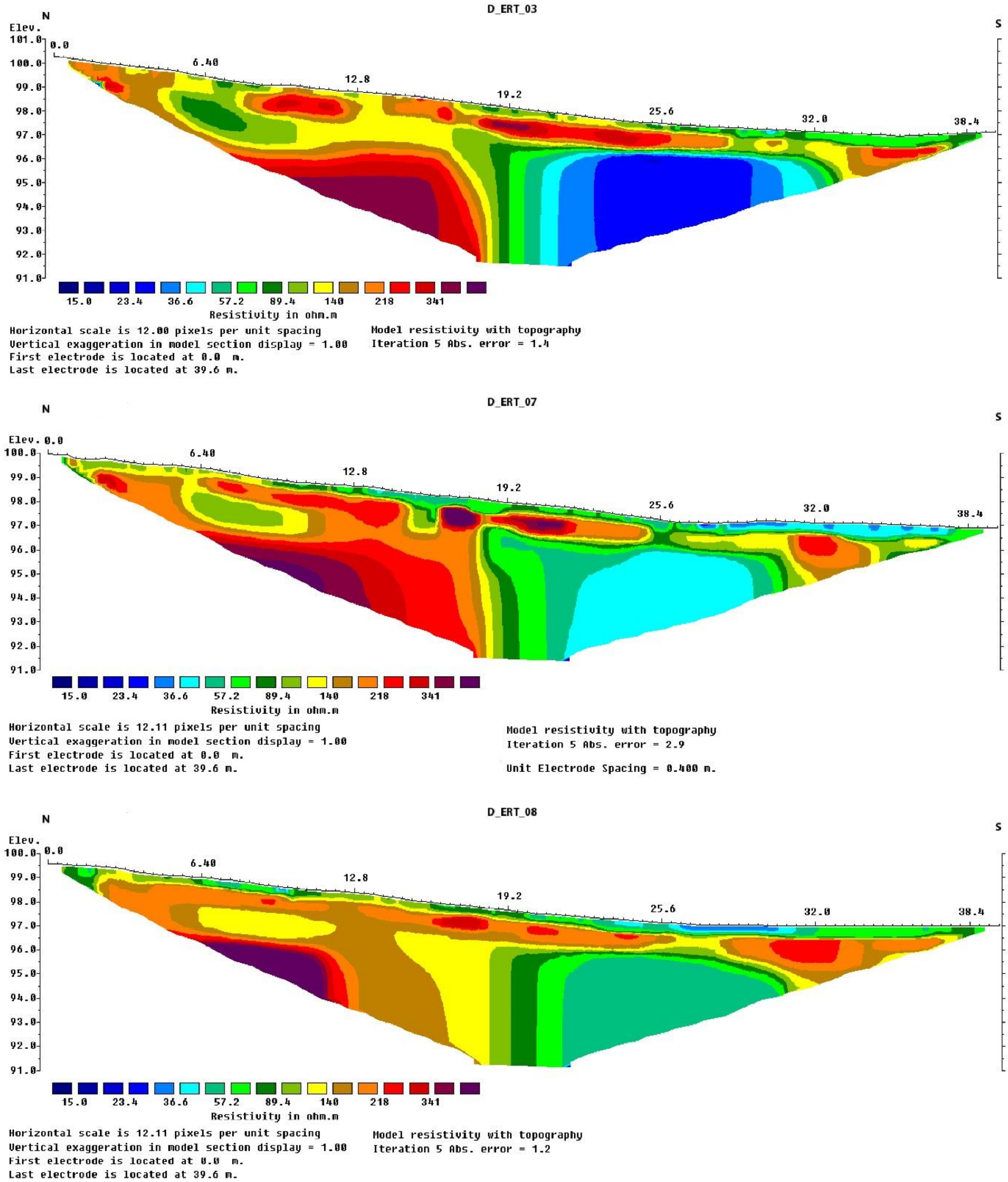


Figure 6.15: ERT's at the former Roman city wall, which has been washed away by the Rhine. In the middle, right under the surface, the Roman wall is located. At right the electric resistivity is way lower than on the left, indicating that possibly these soils on the right are more humid, or excist of more claylу material that gives a lower resistivity.

Additionally, several ERTs (Figure 6.14) were taken around the place where the Roman city wall is partly washed away. At the starting point of the wall, a stone can be identified as Roman. (Müller, 1994, p. 94) In line with this stone, several measurements were taken. The resistivity of the 1 meter thick surface layer indicates anthropocene influence. Underneath, a clear distinction can be seen between high resistivity behind the former Roman wall and a significant lower resistivity in front of the wall which indicates fluvial sediments. This would confirm the hypothesis that the Roman wall was built directly near a water course. However, also in this part of the research area, no high resistivity boulders were found pointing towards Benno's involvement on this location. Only additional corings or an excavation will clarify the situation at the *Domgarten*. (Zube, 2015, p. 39) All in all, no proof for flood management, but for fluvial activity instead. (Figure 6.15)

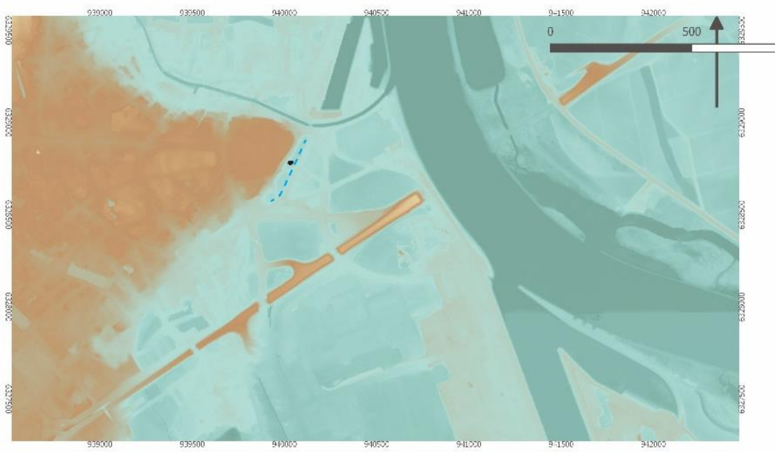


Figure 6.16: A 7th century dating indicates am active water in the Domgarten

6.4.2 Goldgrube: a former Rhine channel?

The fieldwork at the *Goldgrube* south of Speyer was conducted in July and August 2017. (Figure, 6.16) Deborah Prië and Janine Lange located the four dike lines that were visible on the geomorphological map with a tomographic measurement. (Figure 6.3) The elevation west of the *Goldgrube* seems to have totally disappeared, however the line corresponds with the embankment of the *Fischergraben*. The next elevation in the west seems to overlap with the contemporary *Rheinhauserstrasse*. Because the road was located in the flooding area, it would make sense to elevate the road in order to be able to use it during flood periods.

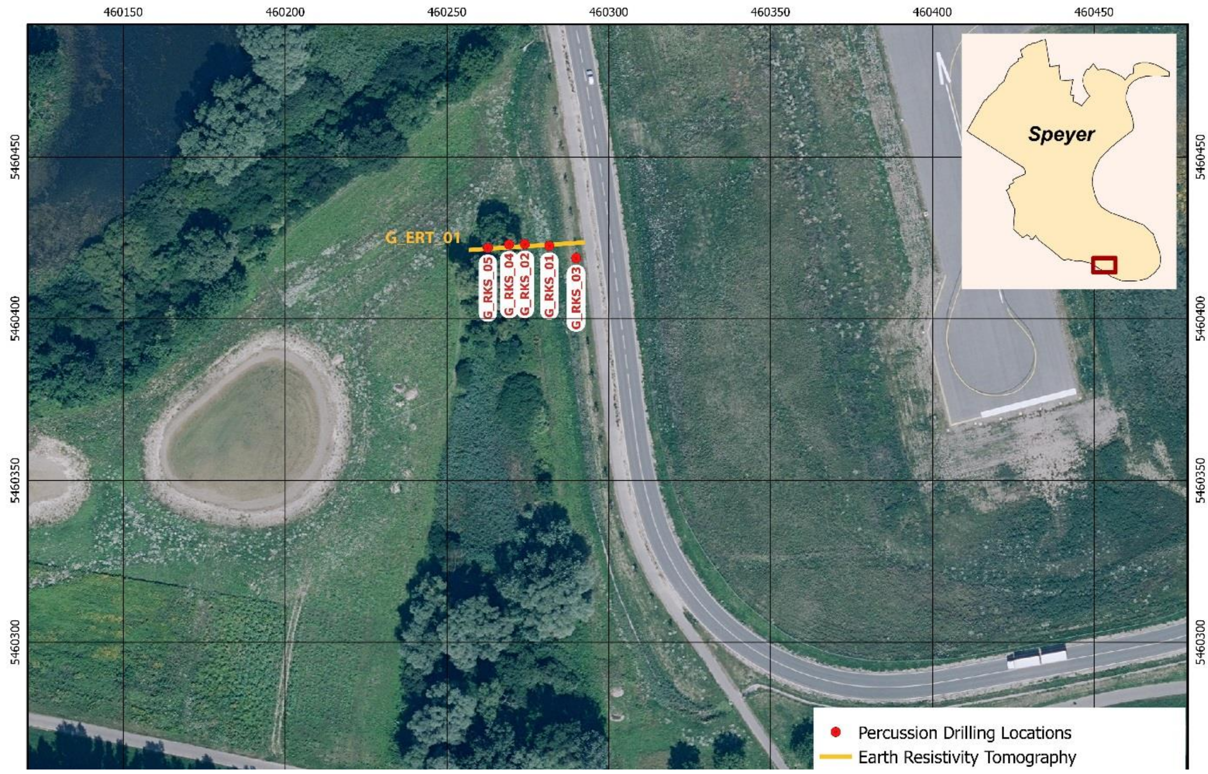


Figure 6.17: The exact locations of the corings on the geo-electric resistivity line near the Goldgrube. The fixpoint are made for exact measurements.

Construction work on this road is known in the late 13th century. This can be connected to the *Hammelwaidbrücke* at the 1767 map. However, it does not seem so logical to draw a road on the geomorphological map that is hardly elevated. The potential dike along the *Hammelsweidgraben* is not visible as a dike nowadays, however, an elevated field border could be recognized. It is currently overgrown with vegetation. The elevations can also be seen on the LiDAR-data as pointed out in figure 6.5. Unfortunately, three of the four possible dike lines were not accessible in the field. This left only an elevation east of the *Goldgrube* to be research. However, it is clear that the dike along the *Goldgrube* does not make sense as a dike because it would protect the *Rheinhauser Weide* from flooding, instead of any fields. (Priß, 2018, p. 64) In addition, this earth wall has been elevated as recently as 2011, therefore this fieldwork mainly focuses on the possibility of a former Rhine channel in this area. (OVG Koblenz, 2009, p. 893)

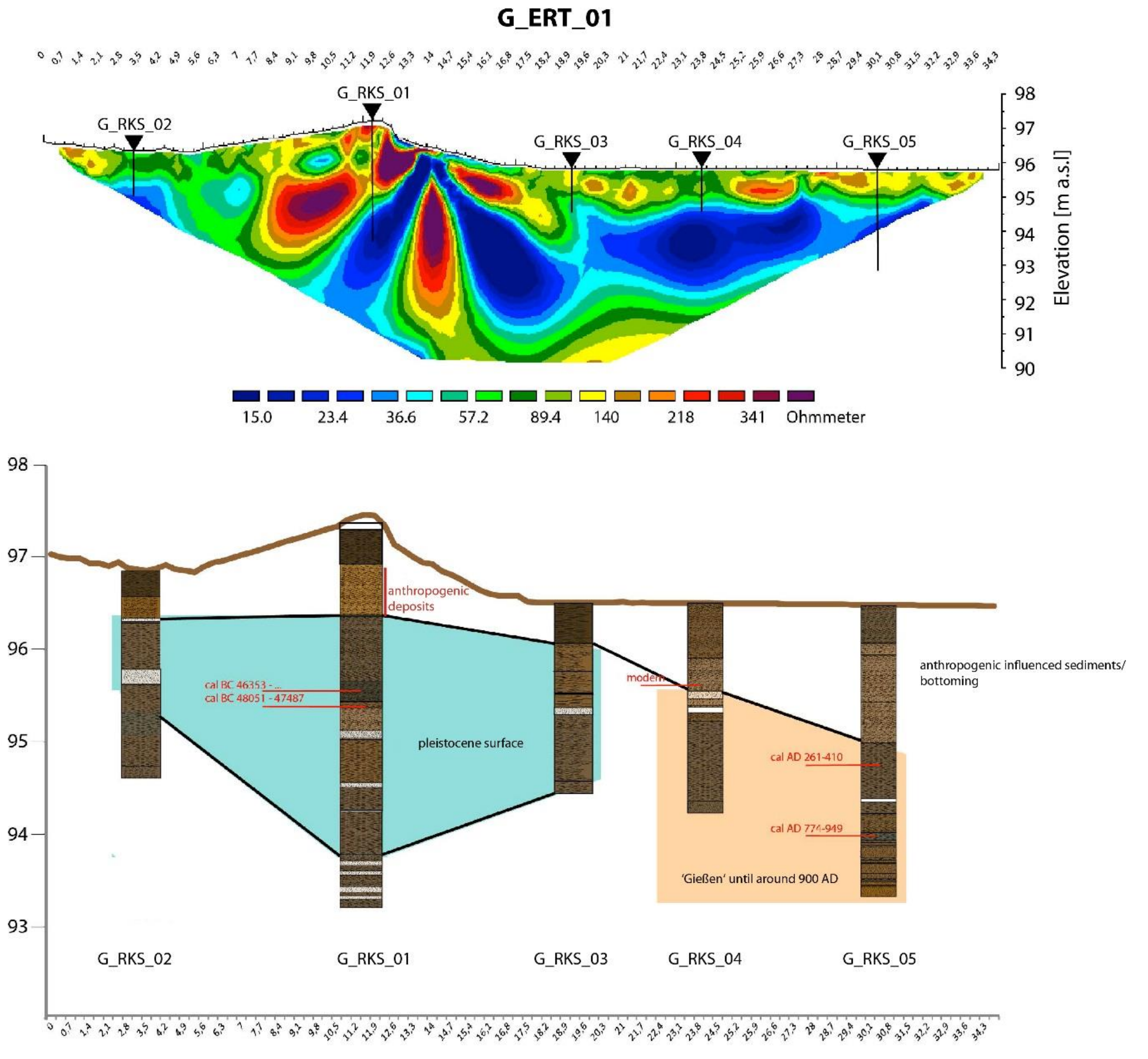


Figure 6.18: Visualization of the fieldwork at the Goldgrube. The ERT shows a very messy result right of the elevation; this is due a baffle plate (screen) to guide amphibians awy from the road left of the elevation. The corings together indicate a paleo surface underneath the elevation, and a fluvial area on the right. This water course is dated back by a piece of coal to the 8th century.

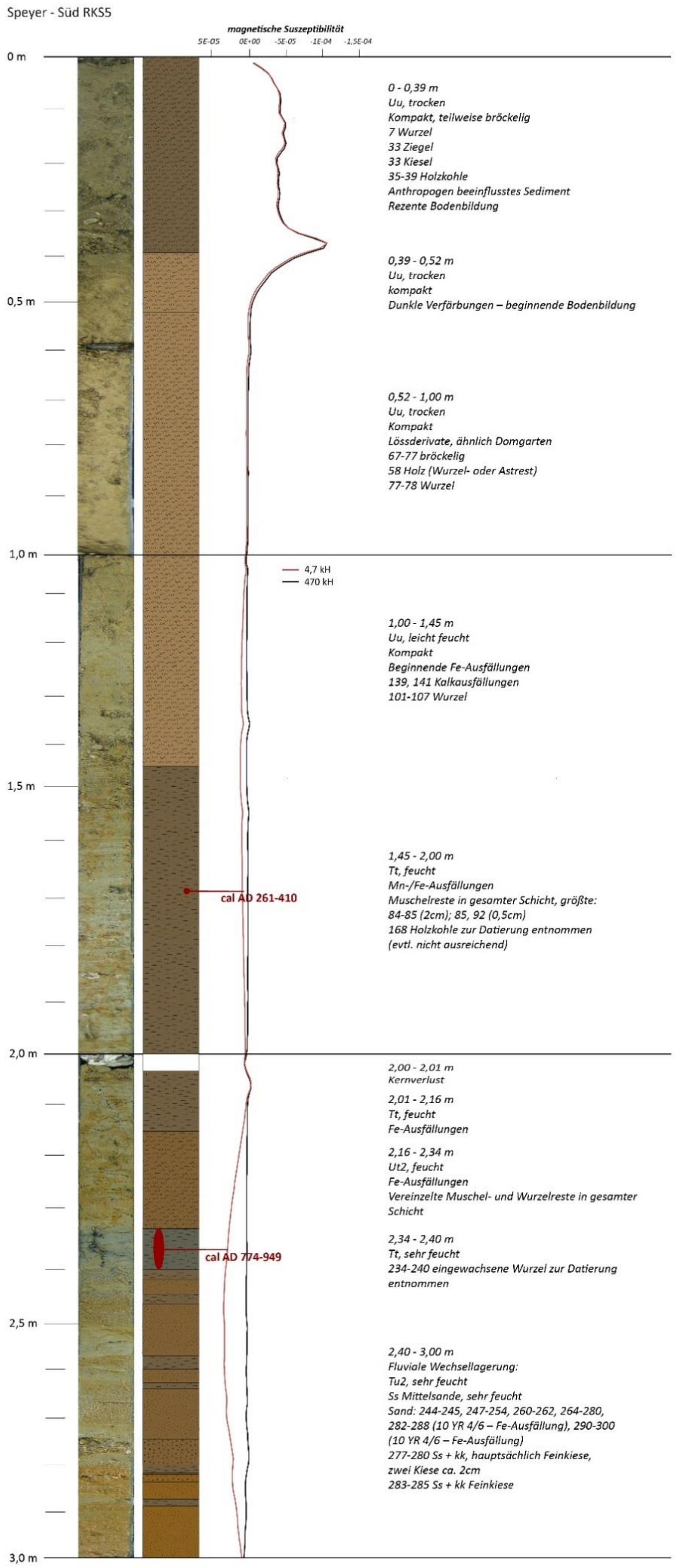


Figure 6.19: A visualization of RKS5 showing fluvial deposited sediment on top of 8th century sediment, indicating an active water course around the 8th century, slightly south east of the Goldgrube.

The easternmost located dike along the *Goldgrube* has been subject to a geo-electric resistivity measurements. However, this measurement was disturbed by an amphibian baffle plate, which reduced the resistivity of the soil. The corings are essential in order to understand this profile. (Figure 6.17) Coring G_RKS_01, which has been conducted on top of the earth wall (97,81 meters above NN), consisted of almost 2 meters of local materials and the top 40 centimetres contains soil building. At a depth of 192 centimetres underneath the top another former surface layer was identified, indicated by several coals and bricks. At a depth of 230 centimetres the influence of shifting water levels is visible. This is caused by its close location near the Rhine. Nowadays it is caused by groundwater. In earlier days flooding and staying waters have also played a role in the gley formation of this area. G_RKS_02 (95,87 meters above NN) was taken west of the earth wall about two meters down from the top of the dike. The coring showed again, that soil development layers are visible. However, a clear cut showed some unnatural influence at 25 centimetres under the surface. Although clay and silt indicate fluvial influences, some brick remains show Anthropocene influences in the research area. G_RKS_03 (96,42 meters above NN) is taken east of the dike and has a similar composition but the deeper it gets, more and more silt and clay are found. Hardly any sand can be identified. However, from 116-122 centimeters few eolic sands were found. G_RKS_04 (95,83 meters above NN.) was taken west of the dike, near to the Goldgrube. After a top layer of soil building, again brick and glass relics indicate Anthropocene influences. Deeper down the soil gets more moist and loamy. Down at 189 cm the fluvial layers start. G_RKS_05 (95,805 meters above NN) is taken even further (11,60 meters) into Goldgrube and thereby represents the most eastward coring (Figure 6.18). The top soil building layer shows remains of anthropocene influence. Shell fragments first occur at a depth of 145 centimetres. Down at 277 centimetres the fluvial sediments start again. (Prіß, 2018, pp.69-79)

From these corings several roots and coal samples were taken for ^{14}C dating. (Table 6.2) Underneath the earth wall (G_RKS_01) at a depth of 2 meters a piece of charcoal dated almost 50.000 years before present. This date, gained by ^{14}C-dating does not fit the scope of this research. It could be assumed that these parts have arrived in older fluvial sediments and somehow ended up in the top soil layer before the dike was built. A root from G_RKS_04, which was taken only 76 centimetres under the surface has been dated modern, thereby confirming the anthropocene influence in the *Goldgrube*. However, in the most eastward coring (G_RKS_05) a piece of coal was dated from 168 centimetres under the surface. It is 1688 years BP (deviation 22 years) and therefore dates back to the 4th century. However, this also seems to washed up by fluvial processes and is probably relocated there. This is in line with a root at 234-250 cm under the surface. This one dates back 1165 years, with a deviation of 21 years. Because the older coal arrived here fluvially, this must have happened after the root had been located or grown there. That means this happened at least after 774 AD, therefore the earliest calibrated date. (Prіß, 2018, p. 82) According to these datings it could therefore be expected that after 774 a severe stream passed the *Goldgrube.* This fits perfectly with the datings from the Domgarten and the demolished Roman city wall. The exact location of this stream in this area remains unclear, however archival sources like the canonization of Benno, the complaints of Bishop Raban and the building of the Ottonian city wall provide some arguments. These sources will be tackled in the concluding paragraph of this chapter.

Core	Depth [cm]	calibrated age 1-σ	calibrated age 2-σ	^{14}C-Age BP	sample type
G_RKS_01	185	cal BC 47006-…	cal BC 46353-…	49660	charcoal
G_RKS_01	200	cal BC 48050-47801	cal BC 48051-47487	48500	charcoal
G_RKS_04	76	modern		-792	root
G_RKS_05	168	cal AD 342-391	cal AD 261-410	1688	charcoal
G_RKS_05	234-150	cal AD 778-938	cal AD 774-949	1165	root

Table 6.2: ^{14}C Datings Speyer-Süd Deborah Priß

In the end, the most useful outcome of the field work south of Speyer is the assumed presence of a 8th century active river arm, which corresponds with the one in the *Domgarten* and the myths on the cathedral being threatened by the erosive powers of the Rhine. (Figure 6.19)

Figure 6.20: A significant Rhine channel originating from Rheinhausen in the southeast is suggested, as a result of charcoal dating in coring G_RKS_05.

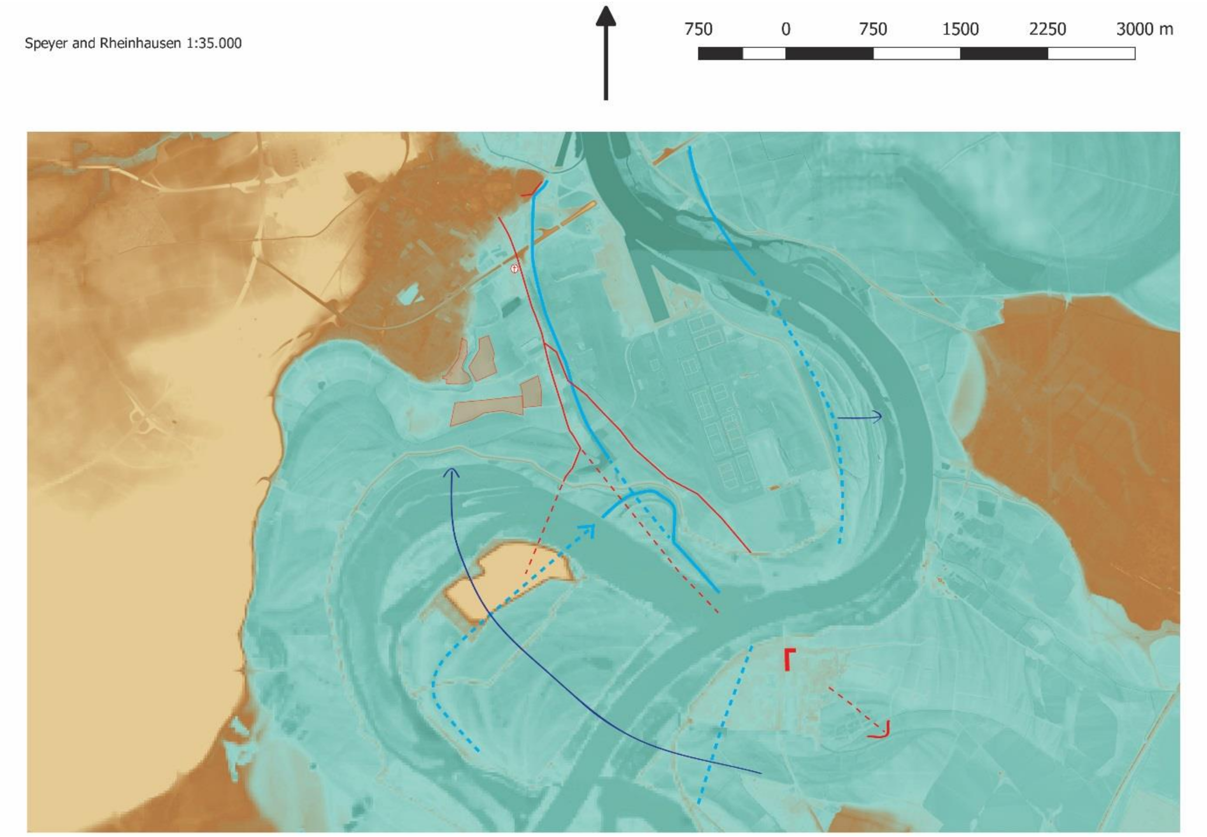
6.5 Conclusions: No boulders, no dikes

6.5.1 Where did the Rhine go?

Early sources mention Speyer's location close to the Rhine. This is a valid assumption, though it still depends on the scale used by the interpreting persons. Proximity to the Rhine argues in favour of an early harbour at Speyer, in turn suggesting at least some activity on the floodplain. Also, after Romans left Speyer the Rhine flowed near to the land tongue on which the settlement was located. The eroded Roman city wall and washed away part of the land tongue are a proof of this theory. This statement is supported by the fieldwork in the *Domgarten* which indicated fluvial activity during the 8th century. Due to another dating of D_RKS_01 in the *Domgarten*, fluvial activity is proven in the *Domgarten* around the 8th and 9th century. However, the presence of water is expected until the 16th century and even visible on later maps with harbours or fishery pounds. The additional fieldwork at the *Domgarten* provided prove of fluvial activity in the 8th century slightly south of this *Domgarten*. However, in order to prove that these two points have been connected at that time, further geophysical research is necessary. For now, it can only be stated that in the *Domgarten* fluvial activity in the late 8th century is shown by fluvial sediments. This activity seems to follow the contemporary Fischersgraben into the *Goldgrube*. This is emphasized by the proven fluvial traces during the 8th century southeast of the *Goldgrube*.

The damage to the Roman city wall must have occurred before the residents of Speyer started to the Ottonian city wall in the 10th century around the year 950. At this the new Ottonian city wall followed the route of the Roman city wall, except at the eroded point. If this part of the wall is indeed eroded by the Rhine, this means that the river flowed through the contemporary *Domgarten* at least before 950. However, it is not proven that the Rhine did flow there afterwards. The effort of Benno's protection boulder in the 11th century indicates that a significant Rhine channel still passed through the contemporary *Domgarten* while the second building phase of the cathedral took place. The Rinna (nowadays Renngraben) flows along the feet of the terrace, but is not assumed to have been the main Rhine channel. The earliest mentioning of this is in sources from 1211. However, whether it is a side channel or a former side arm is not clear. Another 1214 note on the Rinna makes note of arable fields on the other side. This suggests that there had been fields on the floodplain, which apparently were arable during this 13th century. This inhabitation of the flood plain is also indicated by the foundation of St. Markus church on the bank of the Rhine in 1195. Another clue is the various field names dating back to families from the 13th century. Altogether this suggests that the risk of flooding events had not been experienced as a danger prohibiting inhabitants from living and gaining income from the flood plain. Therefore, it does not seem logical that the main Rhine channel would still flow near these fields. Additionally, contemporary elevation data show hardly any height difference between the supposed former Rhine arm around the recent *Fischersgraben*. This structure, formerly called the Spich, however it is mentioned as early as 1339. This is when people where living along the Spich. Translated it means (strengthened) embankment. Notable is that the Spich is not called Altrhein, which is often used for isolated main arms. Altogether, it seems that the main arm of the Rhine had already shifted its main course significant time before.

It is not clear when the Rhine developed its bend around the contemporary island *Flotzgrün*. It seems clear that this meander was formed over many years since the outward development of the meander is clearly visible on the LiDAR-data. An indication could be derived from the *Rheinhauserstrasse*. This road used to pass the *Goldgrube* on the left on its way to the Rheinhauser ferry. This road was constructed between 1293 and 1318. Strengthening this road would only make sense in two scenarios. First, when the Rhine passes from south to north along this *Rheinhauserstrasse*. Secondly, when the Rhine passes through the Berghäuser Altrhein from west to east, and the road lead to the ferry quay. The *Rheinauserstrasse* however changes its direction at the *Goldgrube* more southwards. This might be an indication that the former ferry landing place vanished. The outward moving meander of the Berghäuser Altrhein might be a reason for this event. This would shift the ferry landing place more eastward, exactly towards the place where the *Rheinhauserstrasse* bend is directing to. The same argumentation can be made again for the *Rheinhauserstrasse*, which crosses the *Goldgrube* to the *Rheinhauser Weide* east of the *Goldgrube* in 1767. The Rheinhauser ferry now crosses the Rhine channel and approaches Rheinhausen from the north. This means that the Rhine meander flows west to east around *Flotzgrün*. This ferry quay in 1767 does not make any sense when the *Goldgrube* was still a significant arm of the Rhine, which is also not indicated by historical maps of that period. Also important in this imaginative reconstruction is the fact that the extension of the *Fischersgraben* through the *Goldgrube*. This makes sense because the charcoal dated back to the 8th century. Further southeast the reconstruction perfectly lines out with the most eastern part of the water *Runkedebunk* around *Insel Horn*. It can be expected that this is another extension of the former Rhine channel in direction of Rheinhausen. However, if this is the case, it is to be expected that at this point the Rhine enters from a more south direction, west of Rheinhausen, visible by a side channel on the Besserer map from 1595. This makes sense because the *Rheinhauser Weide* on the east side of this channel, means grazing area. Such names refer to neighbouring villages, more often at the other side of the river. Due avulsions these fields have got cut off of the village centre, for example at Linkenheim, Leimersheim and Neupotz. At *Runkedebunk*, it is remarkable that the water channel around *Insel Horn* drains in an east direction into the Rhine. According to basic fluvial understanding this means that the water came from the southwest meander around *Flotzgrün* in eastern direction towards Lußheim. This indicates that the former Rhine channel that once eroded the land tongue has been cut off by the Berghauser Altrhein. This happened at the moment when *Runkedebunk* started to land in 1634 This probably continued even when the water flew through *Runkedebunk* in 1599. It can be assumed that these short side arm around *Insel Horn* was formed during the same period as the development of *Flotzgrün* (only visible on LiDAR-data; must be proven with geophysics). This perfectly fits to the argumentation line of the ferry landing place at the end of the *Rheinhauserstrasse*, when the Berghäuser Althein was already developed hallway during the 16th century.



6.21a: Geophysische LiDAR-data, a road and field names mentioned in archives and datings of charcoal, provide new insights on the course of the Rhine in Medieval Times.

6.5.2 Where did Benno put his boulders?

In Benno's canonization it is noted that the cathedral of Speyer was build at the bank of the Rhine and a significant number of boulders was used to make sure that there will be no risk that the cathedral gets damaged or eroded by the Rhine. This should be read in perspective of such a canonization, which is usually written to convince people of the good intentions the person had. This quite often describes the main subjects deeds exorbitantly. Since the cathedral is located several hundreds of meters from the riverbed on a 7 meter high terrace, the erosion risk is not immense. It would take a significant number of floods and water force to wash away this geomorphological feature. However, if an enormous flood recently washed away one or two meters of sediment, the fright of the possible damage is imaginable. If stories of such witnesses got to Benno, he had to deal with the fear of the people, be it on behalf of Konrad II. Especially if the Rhine would still pass through the same main arm along the land tongue on which the cathedral is located. For that reason it would make sense that he took the erosion risk into account and, as is stated in his canonization, he took away the fear of the people. In order to prove if this story is true it would be helpful to locate and identify these pretended immense boulders.

In the conducted fieldwork in the Domgarten no indication for such builders have been found. These findings leave us no trace that Benno's protective boulders are located at the feet of the land tongue has been found. When assuming that the boulders exist, one could wonder where they are located, if not at the feet of the cathedral. Benno could be considered as a bright mind considering his architectural achievements in the cathedral of Speyer. If he had some understanding of river hydrography, he could have placed his boulders everywhere, redirecting the main course of the Rhine away from the land tongue. Since the recent Rhine is located a distant location, this should be considered as a possibility. Such an approach could even result in an increase of possible arable lands in the flood plain. This paragraph would briefly explore possible locations for Benno's boulders concerning this hypothesis. If the Renngraben was the main Rhine arm, a location for boulders is hard to appoint. This derives from the fact that this Renngraben flowed directly along the feet of the terrace and was still carrying water as late as the 18th century. Its tight curves make it hard to believe a main Rhine arm has run through this ditch. If the Spich or the contemporary Fischersgraben is considered the main Rhine arm, the most logical place to put the boulders would again be at the feet of the already eroded spot of the land tongue. This is logical because the Fischersgraben flows in one straight line towards this spot. The only way the Rhine has been redirected from this straight course is a cut off. The result would mean that boulders would have been placed more south at the spot where the straight-line ends. This can be seen around the Goldgrube, however the reconstruction of the Flotzgrün meander indicates that the straight water course through the Goldgrube might have come from a more close direction to Rheinhausen. The area around the Goldgrube will be discussed in the ongoing results considering the complaint on dike construction by Bishop Raban in 1411. This potential location near Rheinhausen is relatively hard to study since the contemporary Rhine exactly flows through there. However, at this point the Rhine nowadays flows from south to northeast, which is the opposite of the former northwest direction towards the cathedral. Thus, a redirection of the Rhine would make sense at this point. However, since no solid proof supports this statement for now, it should also be considered that the story of Benno's boulders is unclear or has not even taken place.

6.5.3 Which "*Deiche und Keche*" are meant by Bishop Raban?

As stated, Bishop Raban complains to the city of Speyer in 1419 because they built *"deiche und keche"* (dikes and ditches), which made his ships from Rheinhausen redirect their navigation a long way over the Rhine. These dikes are located somewhere between the *Fischerstor* and the *Goldgrube*. The geomorphological map indicated four elevations around the *Goldgrube* nowadays, which could be these aforementioned dikes. The most east of these dikes is a recent noise prevention wall built in at the same time as the extension of the airport (2011). This was an action in order to protect the natural area of the *Goldgrube*. Since this was the only accessible dike, ERTs were conducted. The analysis also revealed with these measurements a dating which indicates that there was fluvial activity southeast of the *Goldgrube* during the late 8th century.

The second two elevations on the geomorphologic map on the other side of the *Goldgrube* indicate on both sides small elevations on which the *Rheinhauserstrasse* is located. Old roads through on the flood plain like the *Rheinhauserstrasse* iare often built elevated. Therefore during high water levels the ferry could still be reached. On the map from 1767, directly east of the *Rheinhauserstrasse*, two fields are located which may still be on the slight elevation. In addition, the LiDAR data indicates that the *Rheinhauserstrasse* is not a linear dike and more like an elevated plateau. The record of the fields on this plateau suggest that the Rhine was no danger for the fields. This elevation is not part of the complaint about dike by Bishop Raban around 1419. The exact structure, building phases and dating of this plateau is left for further researches with geophysical methods.

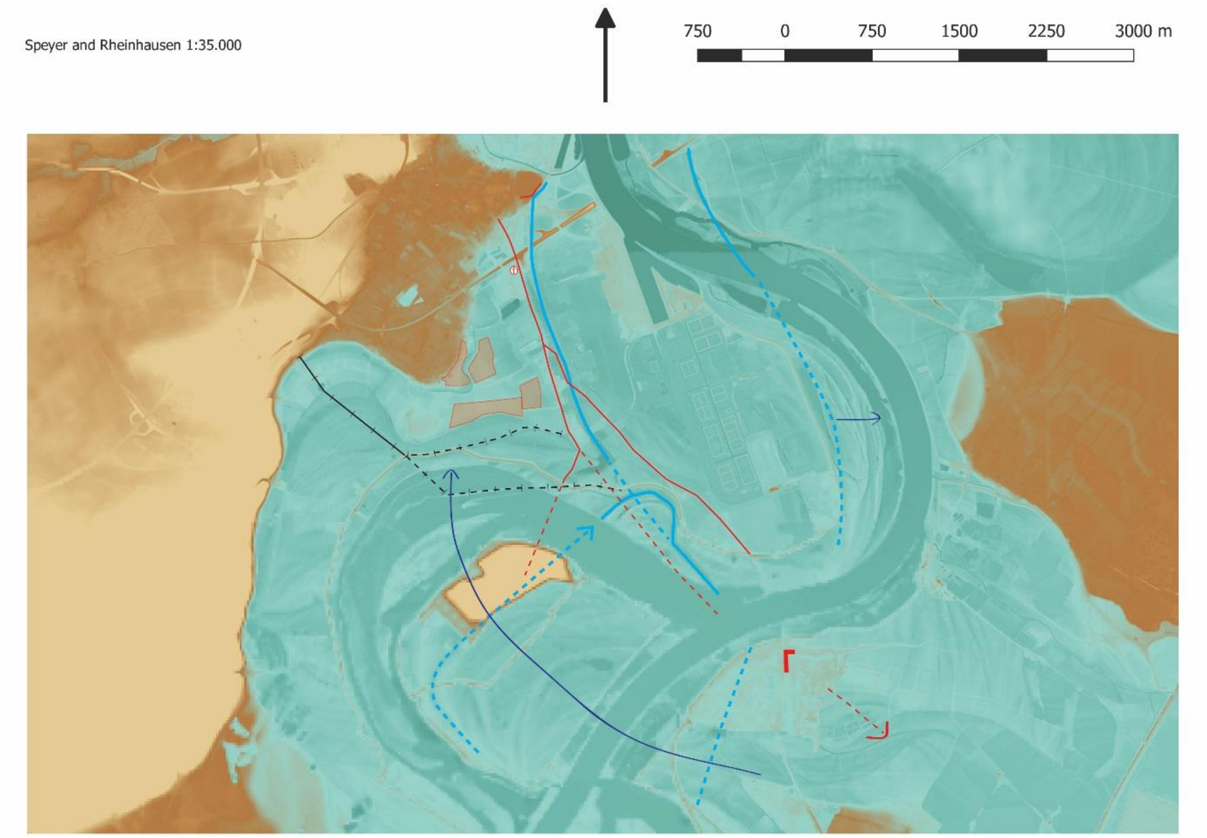


Figure 6.21b: Additionally to the other conclusions, the Landwehr has been considered a dike, at least the parts constructed in the floodplain. Since several maps show multiple lines, multiple construction phases can be expected.

The final elevated line on the geomorphological map seems to follow the former *Hammelswaidgraben*, which is visible on the LiDAR data as well. This *Hammelswaid* is shown on a map from 1767. It is called *'alter feld Teich'*. Other features are called *'Teuchacker'* and *'hinter Teuch Wiesen'*. These fieldnames clearly indicated that there used to be a dike at that location. However, nowadays it is overgrown with trees and shrubs. In the direction of Berghausen this dike connects to the '*Landwehr oder Damm'*. This suggests that the defence wall had also the function of a dike when located in the flood plain. A ditch is constructed for this southern part of the defence wall, between the *Harthauser Warth* and *Hegenich,* in 1411. However, only a ditch is mentioned, which might be a logical result. It is supposed that you first dig a ditch and the elevated wall from the excavated material forms an elevated wall. It is mentioned by Müller (1994, p. 265) that the defence wall consisted of a ditch and an earth wall, interpreted as a dike. The construction in 1411 fits perfect to bishop Rabans complaint. This charge makes completely sense if there is an consideration that high water or floods did not occur every year. Nevertheless, a dating of the dike along the *Hammelswaidgraben* would be necessary in order to prove this assumption. Therefore, some further percussion drillings or an archaeological excavation are indispensable. Moreover, because several maps from the end of the 17th century show a dike parallel to the *Hammelswaid*'s one, probably also located in *Hegenich* and therefore another possible suspect to be the dike Raban was complaining about.

On the 1838 cadastral map (figure 6.6) of the *Goldgrube* a dam is quite visible. This dam clearly cuts off the *Goldgrube* from inflow of the Rhine. In this period its course went around *Flotzgrün*. However, this observation came too late in the timeframe of the research and has not yet been studied. Furthermore, since this dam is not visible, for example on the Schmittsche Karte from 1797 or the very detailed one from 1767, the age and significance of the dam might be questioned.

Another possible location for the dikes mentioned by Raben came to mind during the analysis of this research. The dams in the *Rheinhauser Weide* on behalf of fisheries. These have been located in Speyer at least since the 13th century, but probably date back way before. One known way of fishing was to dam water courses and control the water flowing. This enabled also a control to catch every fish that wanted to leave. This made the catch of all the fish easier. The ones that missed getting away were dying on the drying surface that remains when the water is let out. The *Holderweg* and the *Kirschweg* are stated to be related to such dams. The LiDAR-data also shows that at least the contemporary *Kirschweg* is an elevation in the landscape. Further research in the archives and in the field will provide valuable information about these fisheries and Speyer's relation with water and the perception of flooding.

7 - Case Study Ottersdorf

7.1 Introduction: A village in the 'Ried'

Ottersdorf is one of this project's case studies and a fieldwork location. The case is studied in order to overcome the lack of written sources dating from the medieval period that deal with medieval flood management in the Upper Rhine valley. The archaeological data derived from an archaeological excavation conducted in this research. contribute to the reconstruction of the Upper Rhine's flooding history while being a detail study and an illustrative example.

The dike structure near Ottersdorf was revealed by scrutinizing LiDAR-data of the federal county of Baden-Württemberg for linear structures. Dikes can be distinguished through elevation data as they generally are narrow, extensively long and have higher elevation than their surroundings. When the Ottersdorf dike was identified, quite far from the Rhine, other sources like the soil map, aerial photography and available historical maps where checked. These sources immediately pointed out that this linear structure was located at a former arm of the Rhine. Since this dikes is located near this former Rhine channel it is carefully assumed to be dating back to the period this channel was still the main Rhine channel. Making this dike even more interesting for this project, because of its older date.

Ottersdorf is one of the five so-called *Rieddörfer* – villages in Ried (Dunhausen, Plittersdorf, Muffenheim, Ottersdorf and Wintersdorf), near Rastatt (figure 7.1). The history of these *Rieddörfer* was most recently summarized in the chronicle of the municipality of Rastatt. (Ruf, 2002; Landesarchiv Baden-Württemberg, 2002) These villages have been described more extensively in their own respective chronicles. The villages

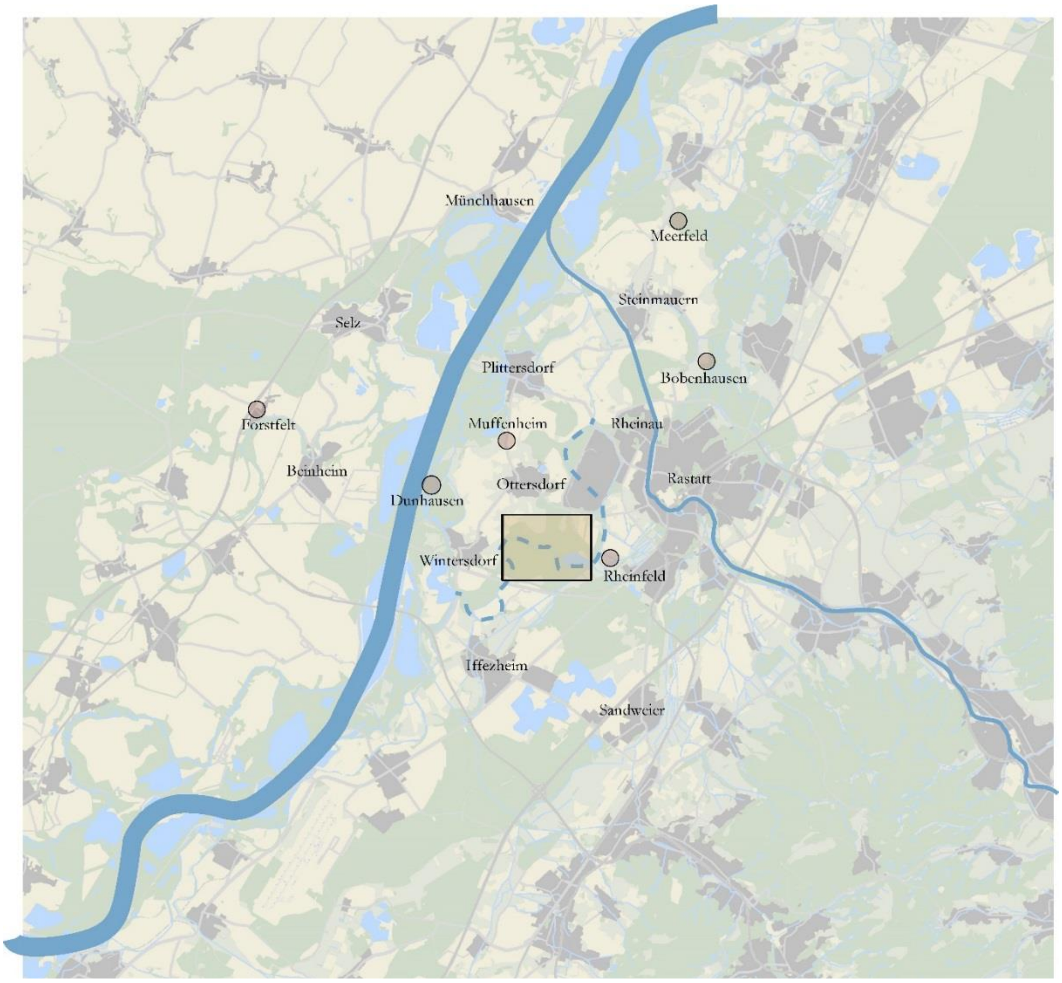


Figure 7.1: The village of Ottersdorf located in the Ried near Rastatt.

of Ottersdorf and Plittersdorf are elaborated upon in extended chronicles honoring the anniversaries of the villages. (Ruf, 1994; Ruf *et al.*, 1980) The currently disappeared village of Dunhausen and Muffenheim have been described in shorter articles. (Ruf, 1977; Ruf, 1983; Gross, 1994, pp.27-63; Ruf, 1994, pp.41-63) Wintersdorf does not have any local history published so far. Because of the extensive reasearch and publications archive data has mostly been exhausted. It is therefore unlikely that new data will be uncovered from literary sources. Due to this fact, the archival research in this case study has been limited to the sources contained within the *Landesamt für Denkmalpflege* Baden-Württemberg of and the *Generallandesarchiv* in Karlsruhe. Most of these early records are solitary donation-records. On the other hand, studies concerning archaeological findings in these villages might provide new information as a result of recent discoveries which have not yet been taken into account in the overview books. (Hoffmann, 2004; Planck, 1994) Additionally, fieldwork, both archaeologically and geo-archaeologically, might provide new insights into the local history such as why settlers decided to settle in swampy and flood risky areas like the Ried.

7.2 Preliminary research: Dikes along former water courses

The dike, located in the *Ottersdorfer Gemeindewald Oberwald* is positioned south of the small village of Ottersdorf. Together with the neighbouring villages of Wintersdorf and Plittersdorf, Ottersdorf form a part of the city of Rastatt that is separated from Rastatt by a former Rhine channel, and, since the final decade of the 20th century, a Mercedes-Benz factory as well. The city of Rastatt is located on the slightly higher terrace, while the villages are located in the flood plain of the river Rhine. The contemporary Rhine flows west of the villages, between river dikes, which have been connected to form a closed continuous dike during the 19th century Tulla rectification. Around the villages of Wintersdorf, Plittersdorf and Ottersdorf the agricultural lands, in which the historical plot structure is still visible, show a diversity of mainly croplands and orchards, but also several grasslands can be found (figure 7.2). The area around the former Rhine arm consists mainly of production forests, owned by the municipality and managed by the forestry office Rastatt. Besides wood production, the forest is also used for hunting boar. Within the forest former river channels, clearly visible on the LiDAR data, can be recognized in the field. (Figure 7.3) The former Rhine arm lays more than one and half meter lower than the surface level, and is characterized by reed vegetation. Although it hardly carries any water streaming into the *Oberwald* from Wintersdorf, after passing the gravel quarry the former Rhine arm carries water again and quickly broadens to a few meters. Also during a high water period in Januar 2018, the water level rose, and the stream was several meters broad when flowing into the forest. The opposite side of the former Rhine arm, called Geggenau, is a production forest as well.

Figure 7.2: Ottersdorf's agricultural lands, forest, fields, orchards and grazing lands (Real figure in the making).

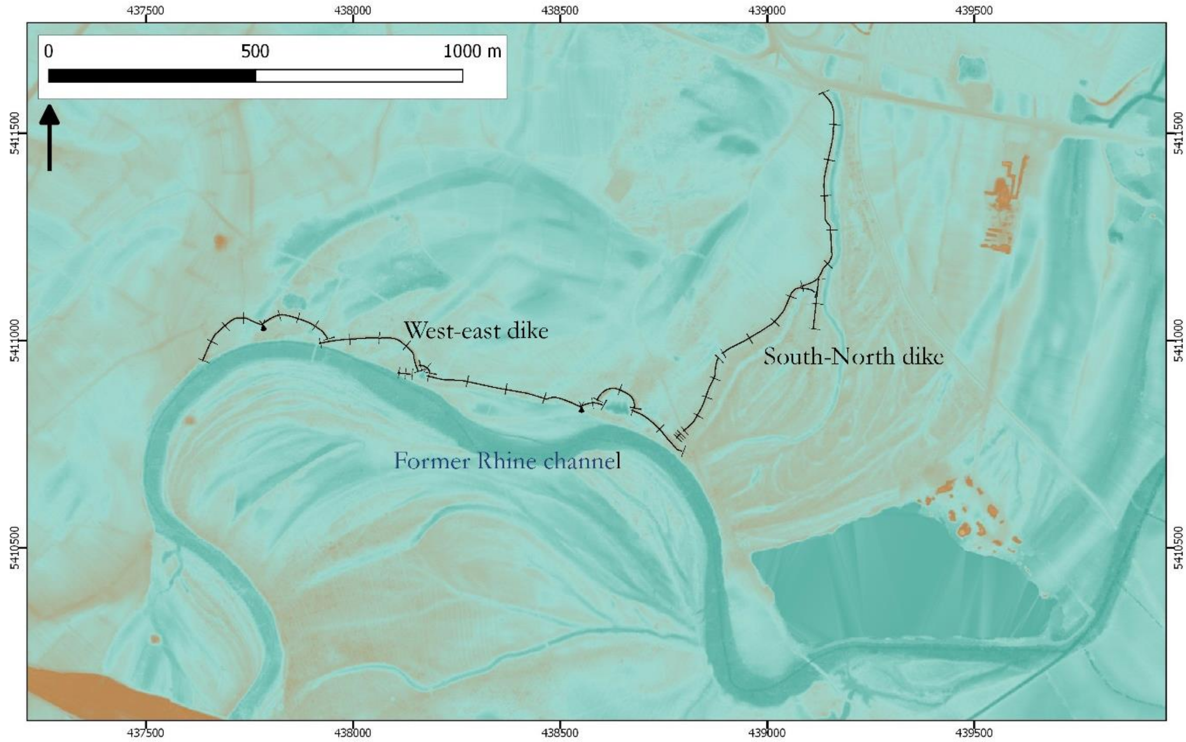


Figure 7.3: LiDAR map of the Rieddörfer, showing the complexity of many former Rhine channels. The studied dikes are represented in black.

Along this former Rhine arm the identified medieval dike can be seen in the field as a 1 – 2 meter elevated line through the forest. Normally a dike would be a straight linear element in the landscape; however, the LiDAR-data in figure 7.3 shows several irregularities along the dike element. This is a clue to the construction of the dike in several phases, much in the same way as it is done nowadays. These phases can be dated relatively when looking at the dike's connections. A younger dike most probably connects to an earlier one in order to reduce the possibilities of flooding, as is seen in figure 7.4. It is expected that the eastern (and quite straight) part of the Ottersdorf dike is the oldest, followed by the middle part and the western part, which would be the youngest. These suspicions are confirmed by the regularity that a river meander always moves to its outside curve. It therefore makes sense that the most recent breakthroughs or dike improvements have been built in this outer corner, as it was done at the Ottersdorf dike. Another remarkable aspect is a huge repair in the oldest part of the dike. When a dike breakthrough occurs, the water will start to swirl directly behind the dike, because of the pressure with which water is pushed through the small hole in the dike. Since it is hardly possible to repair the dike in the same place again, a repair dike is created, usually around the pit that was formed by the swirl. (Jongmans *et al.*, 2013, p. 466)

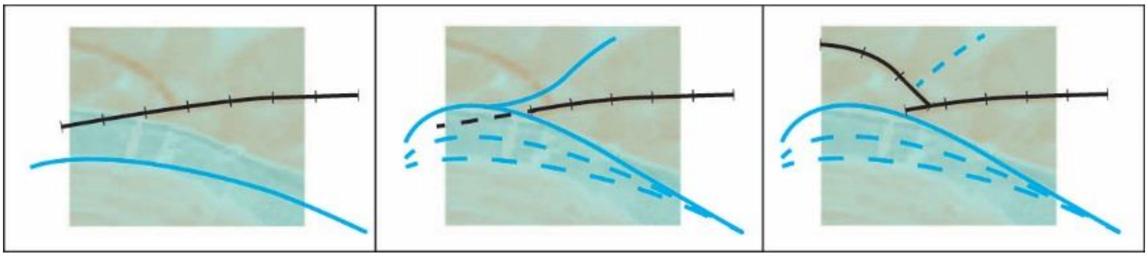


Figure *7.4*: Concept drawing of a second dike building phase after *its predecessor was demolished* by a flood.

A second dike section can be found several hundreds of meters northeast of the first one, and is located along the agricultural field called '*Hofröder*'. It used to connect to the aforementioned dike, but nowadays a road runs through and the connection so cannot be seen any more in the field. Again, linear elevated elements were identified within the forest and on the LiDAR-data. Because of the 90-degree turn in the dike near this location. It could therefore be expected that the former Rhine arm used to make a turn towards the north-eastern direction. However, such a sudden turn is unusual for a river, especially for a river the size of the Rhine. A more likely theory therefore is that the Rhine used to have its course in a south to north direction, which at one point changed towards a more east to west direction (as it is today). It is remarkable to see that the riverside of the dam is higher than the field behind the dike on the LiDAR-data. (Figure 7.4) Although this is likely because of flooding events in which the river left a thick layer of sediments in its riverbed and elevated its streambed. Another point of interest on this dike line is the land use behind the dike. *Hofröder* is known to have been used as an agricultural field since at least the 15th century, while its surrounding parcels have been used for forestry ever since. It could be interesting to see whether this difference in land use affected the dike, or whether the presence of the dike has affected various forms of land use in different ways. But therefore it is necessary to first study this dike and put it in its temporal context.

7.2.1 Physical landscape

As explained in chapter 4 the Rhine gained more erosive power in the course of history and the (current) floodplain of several kilometres width was cut out, lying 5 to 10 meters lower than the terraces. The floodplain contains wet, nutrient rich soils, which are very suitable for agriculture, especially for grazing. The village of Ottersdorf is located on such a flood plain. Within this flood plain, the Rhine meanders from the left to the right rim of the terraces deposing fluvial sediments, and leaving a complex system of stream ridges within the flood plain. Often the river chooses a new course, an avulsion, because of a flood or by human actions which try to control the river. (Bridge, 2003, p. 314)

Figure 7.5: The development of the Rhine around the Rieddörfer. Before 1306, the villages were located on the Alsatian side, and after a period on an island, the eastern Rhine channel was dammed in 1472, which made the villages end up in contemporary Baden-Württemberg.

An illustrative example of such an avulsion is the former Rhine channel at Ottersdorf. (Figure 7.5) When Ottersdorf and its fellow villages in the Reed were first documented during the 8th century, they were located in Alsace, (which is discussed in more detail further down in this paragraph). Ruf argues that the villages have been located in Alsace at least until 1288. (Ruf, 1994, p. 69) Around 1307 the monastery of Selz was demolished by a disastrous flood, which indicates that the Rhine at that time flowed along the monastery of Selz. In 1310 and 1318 the villages in Reed are called "*die fünf Dörfer im inneren Ried"* which when roughly translated means *"the five villages within the inner Ried"*. (Ruf, 1994, p. 73) Ruf interprets this as the villages being located on an island between the Rhine arms at Selz and the Rhine arm between Ottersdorf and Rastatt. (Ruf, 1994, p. 21) These villages are located on an Island until 1472 at the latest, because in 1472 the *Altrhein* (former Rhine arm), is dammed. A document from 1494 describes that the arm was closed due to a discord on tolls between the Margraves and the Selz in the Palatinate. (Ruf, 1994, p. 73) However, water still ran through the arm, it seems a bit overdone to invest in extensive diking projects on a former river arm. This idea became the starting point for elaborative research on this case, since there existed a plausible chance that the dike was constructed before 1494, and would therefore be older than most of the other dikes in the area.

Studying the LiDAR-data, the first thing that springs into sight is that the flood bed on the riverside of the contemporary dikes lays slightly lower than the floodplain behind the dikes. This suggests that since the dikes have been constructed, more erosion than sedimentation has occurred. Probably caused by the Tulla-rectification, but cleaning the Rhine and keeping shipping routes open, also deepens the river basin, and therefore reduces sedimentation on the riverbanks.

The LiDAR data also reveals several ditches, probably former river channels. (Figure 7.6) In the area of Ottersdorf the complex system of stream ridges can be seen clearly, however hardly be understood. The former channels studied in this paragraph are clearly recognizable, as is the river curve near Wintersdorf. In addition, less visible ridges can be identified in the LiDAR data. For example north of Ottersdorf along the *Niederwald* the curves of the river arm seem quite broad (A), but surprisingly do not connect the former Rhine course. This might suggest that this river was active in another, maybe earlier period. The ridges continue in the direction of the Murg and Plittersdorf, but their origin can hardly be seen, since

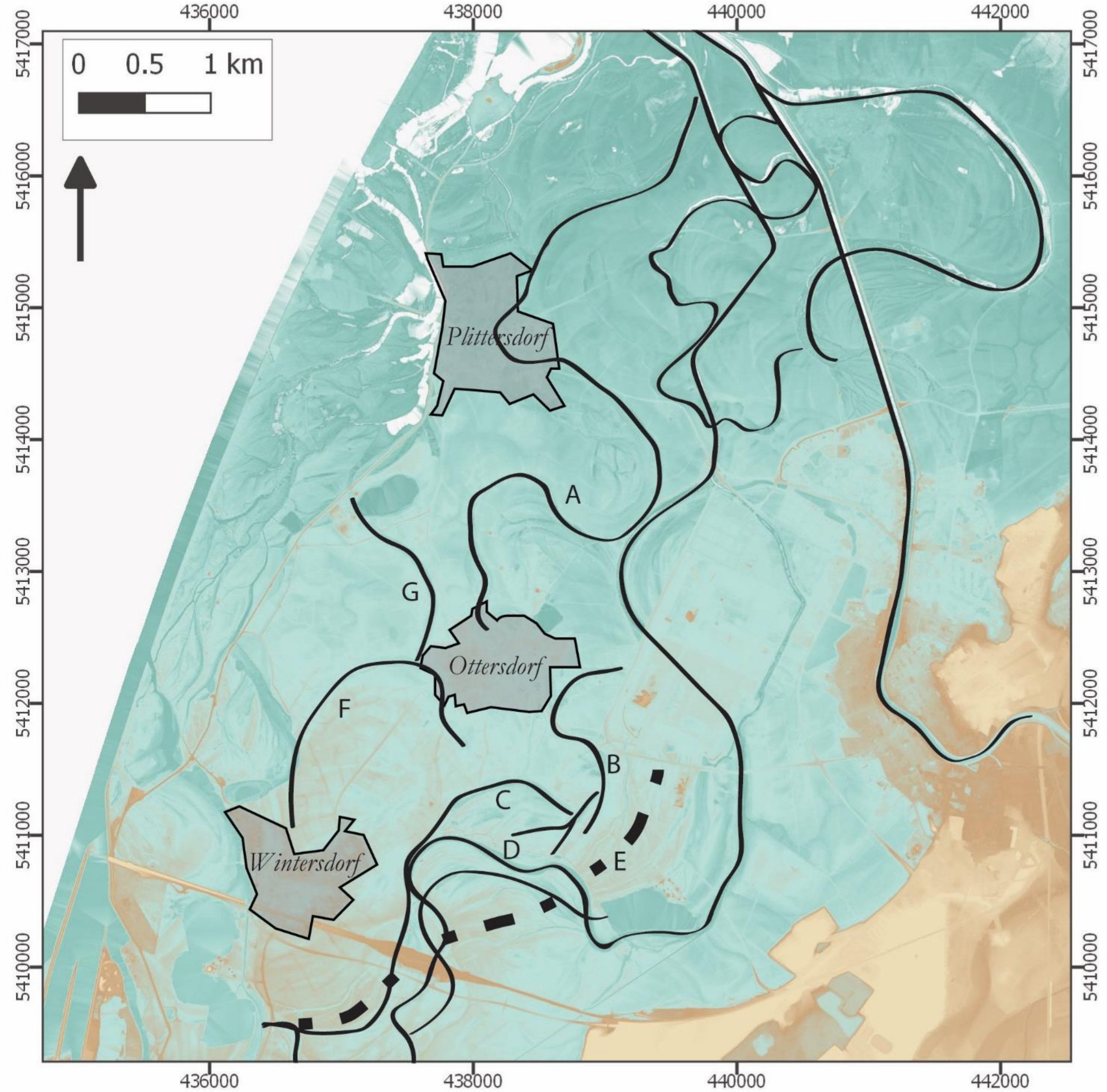


Figure 7.6: LiDAR map of the Rieddörfer, showing the complexity of many former Rhine channels.

contemporary Ottersdorf is built on top of it. With imagination, several ridges south of Ottersdorf (B) might indicate these origins; however, additional physical geographic research is necessary to make statements on this. Notable is that one of these possible origins for the northern ridges fits perfectly with the enormous dike breakthrough in one of the dike sections. It seems plausible that this ridge emerged after the dike, however it cannot be said with certainty, because it might have flooded into an older ditch. Transversally to this breakthrough ridge another ridge becomes visible (C). This transverse position indicates that it predates the continuing breakthrough ridge. The transverse ridge follows a field, which is called *Lange See* (long lake) indicating its wetness. This ridge originates in the most recent part of the dike. In this case it seems that the ridge was there at the moment of dike construction. A curve in the dike was made to cross the ridge transverse, which is the shortest possible way. The conducted fieldwork indicated a gravel subsurface, which makes it plausible that a former river arm flowed in that position, as a deposition of gravel indicates that depositions have been near to the stream channel. In addition, other breakthrough ridges (D) along the dike are visible. These breakthrough ridges seem relatively small but as long as these ridges are not dated properly, they are not considered in this research. Aside from these breakthroughs, the outward meandering of the former Rhine arm becomes strikingly visible. When projecting these meanders backwards by imagining where these meanders originated, the former Rhine arm seems to have been straighter. Remarkably this leads exactly to significantly elevated ridges (E). This elevated ridge can be spotted south of Wintersdorf, in the *Geggenau* and east of *Hofröder*, exactly parallel to our (south-north) dike line. While one would think a river would eroded its course and leave a trace cut out of the surface, in this case so much sediment has been deposited that the river left a elevated trace on top of the surface. Corings within this elevated ridge would provide valuable information in reconstruction the river course in this area. Unfortunately, this goes beyond the scope of this research. These three sections of the elevated ridges seem to belong together, because their height and broadness seem quite similar. When the elevation caused by sediment deposition becomes too high it disturbs the rivers flow, the river would seek an easier way around. This probably has happened in this case as well, originating the contemporary *Altrhein.*

Figure 7.7: Im Deist at the 1715 Map 'Carte de Basse Alsace' .

Between Wintersdorf and Ottersdorf various meanders can be seen as well. It becomes clear that the river has flown through in multiple phase, however no clue for dating can be given here without geophysical research. The broadest ridge (F) directly southwest of Ottersdorf strikes the eye, partly because it is located along the *Fliesweg*, meaning road along the river, especially because this ridge crosses transversely over another ditch which on recent historical maps is called *Deist* (G). This *Deist* might also be visible as a draining channel on the Carte de Basse-Alsace, a historical map from 1715. (Figure 7.7). Unfortunately, other maps have not indicated this stream ever since. In addition, the broad former meander along the *Fliesweg* is not visible on historical maps, for which reason it is unlikely that the meander cut off the Deist after its 1715 documentation. Such an event would have changed the landscape so dramatically that it would have occurred in maps. Archival records of these lands are available starting from the 15th century, and although *Deist* is mentioned several times, the other ridge is not.

The area east of Ottersdorf (currently the site of the Mercedes-Benz factory) is completely lacking in the LiDAR-data since this the factory disturbs the LiDAR measurements. This is unfortunate since the factory is located exactly on top of the former Rhine arm. Detailed information about the elevation could have shown valuable information on the former course of the Rhine. However, before building the factory numerous drillings have been conducted at the site, preliminary to the construction works in 1986. Fortunately, the coordinates, including the height of the drilling-points, have been documented and are publicly available online. (Bohrholemap.bgr.de, visited on 01.11.2018) The raster of points resulting from this is interpolated in GIS and provides an insight in the elevation of the area before the Mercedes factory was built. Figure 7.8 shows the, not very detailed, results. Due to the lack of detail, it can only be stated that the former Rhine used to continue in this area as expected, and there are a few more height differences, which unfortunately do not provide a clear direction.

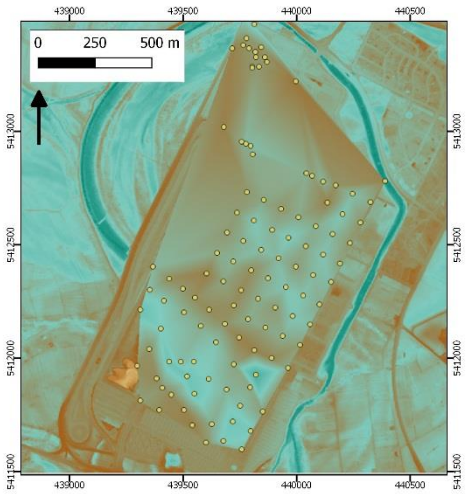


Figure 7.8: The constructed LiDAR-data underneath the Mercedes factory near Rastatt.

The soil map of the Ried area shows that the whole Ried lies in the flood plain and therefore mostly consists of Auengley soils as a result of fluvial depositions and recent fluvial influences. The soil map (BK25 7114 Iffezheim, 1998; BK50 maps.lgrb-bw.de, 2017, visited on 13.02.2018) differentiates three main Auengley soils: 1) Brown Auensoil with gleying near the surface; 2) Auengley-Brown Auensoil; 3) Auengley. The Auengley soils are most recently influenced by the river or water, caused by seepage. It is probable that this seepage occurred in the zones near the terraces, where relatively big height differences cause seepage water to emerge to the surface at the feet of the terraces. Auengley soil can also been seen in the areas that are regularly influenced by the river

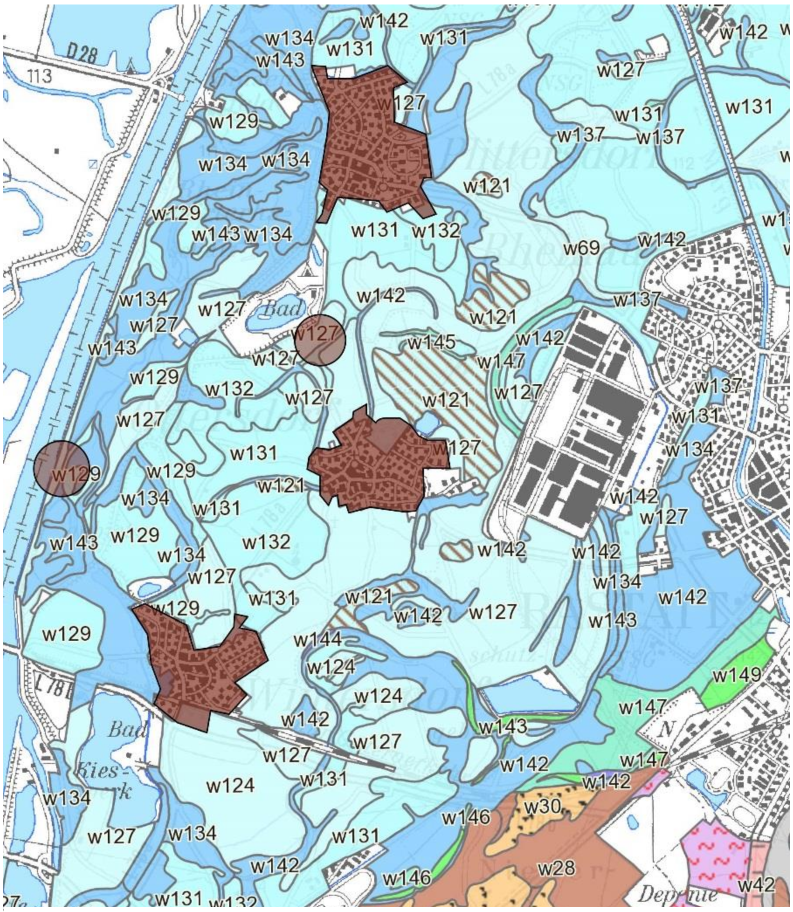


Figure 7.9: Soil map of the area around the Rieddörfer

and its high water levels, in the contemporary flood bed. Illustrated on figure 7.9, starting at the river, a general differentiation can be made: the Auengley outside of the diked areas, Auengley-Brown Auensoils directly inside the dike's areas and slightly further away from the dike the Brown Auensoils appear.

It should also be noted that a multitude of linear Auengley soils show up everywhere in the diked area. These are supposed to be former river arms, often positioned slightly lower than their surroundings and therefore receiving seepage water and rain run-off water regularly. The former Rhine arm south of Ottersdorf still carries so much water that vegetation growing in and around the channel slowly develops a peat layer. Finally, the w121/Red-striped areas contain older river sediments, mainly gravel. These areas also seem to occur in a linear shape, and therefore can be interpreted as former river arms, or, as can be seen north of Ottersdorf, an accumulation of former river arms.

The BK25 from Iffezheim in 1998 additionally shows calcareous sediments south of Wintersdorf. This map also gives an indication of the sediment grain sizes in the area, which shows that the calcareous area south of Wintersdorf is actually more sandy than loamy. This sand band continues in a northward direction up to the village of Plittersdorf, probably also including the location of the disappeared village of Dunhausen and maybe even Muffenheim. However, due to extensive village expansions over the centuries, the soil underneath the villages has not been mapped and it can only be assumed that these villages were located on the more sandy parts of the Ried. The exception of this is Ottersdorf, where no sandy sediments are recognized in its direct surroundings.

Climate is mainly defined on a more regional scale and therefore chapter §4.6.1 should be studied as an introduction to this paragraph. However, in his book on local history of Ottersdorf, Ruf adds that the area is characterized by the big amount of foggy days over the year, more than 50. In comparison with the Schwarzwald, the Rhine valley could be considered a precipitation low area. Its 800 mm precipitation a year is almost half of the amount of precipitation in the Schwarzwald. Therefore, droughts are a well-known phenomenon at the Rieddörfer. The spring, indicated by apple blossom, usually starts around the last week of April, slightly later than in the hilly north of the Schwarzwald, and as in the more southern parts of the Upper Rhine valley (Ruf, 1994, p. 19). Because of its location at the mouth of the Murg, North of the Schwarzwald, the water levels around Ottersdorf are heavily influenced by precipitation in the Schwarzwald, but mainly the melting waters of both the Alps and the Schwarzwald define the water level. However, the differences to other places in the Upper Rhine valley are hardly worth mentioning.

7.2.2 Settlement history

Since when exactly the Upper Rhine valley and especially the flood plain has been inhabited is debated, because the dynamic river landscape might have removed many traces. The oldest archaeological record of human dwellings in the surrounding area of Ottersdorf are five Roman grave monuments discovered in 1521 near the former village of Dunhausen. The Romans founded the nearby settlement of Selz in 12 BC, and at least one Roman road passed the Rieddörfer at Dunhausen. (Hoffmann, 2007, p. 164; Ruf, 1977, p. 98) In 1968, an Alemannic-Frankish double grave was found, including bones, beads and a clay pot. The location of this find, which was discovered during a road construction on the road from Ottersdorf to Plittersdorf, was exactly on the spot where the village of Muffenheim used to be. Combining these finds with the Frankish name, and the early record of Muffenheim (790) in the Lorscher codex, makes it plausible that the village of Muffenheim had already been founded around the 6^{th} or 7^{th} century. This again is confirmed by findings of clay shards from this same period onward found in the area around the deserted village since, as described by Gross. (Gross, 1994, pp.27-40)

The five villages in the Ried, the *Rieddörfer* Wintersdorf, Dunhausen, Ottersdorf, Muffenheim and Plittersdorf, are all located on the floodplain of the Rhine. They have been under continuous treat of flooding, however, the aforementioned soil map does indicate the possibility that the villages were located on slightly higher sand levees. Wintersdorf is the southernmost of the *Rieddörfer*. When the Rhine streams around the terrace tongue on which Iffezheim is located, the Rhine arrives at Wintersdorf, where it used to flow around on the eastern side, but since the 14th century flows west from Wintersdorf. It could be expected that this 'Wende', this turn of directions at Wintersdorf, is the reason for the name of the village, suggesting that the Rhine had been turning there ever since the emergence of this village in around the 8th century. The name, therefore, would have nothing to do with the season of winter but derives from phonetic changes. Another explanation for the name Wintersdorf could be the naming of the village after a common personal name: Ruf found a source about Winiharius and Ortharius and their families who had a farmstead close to the nearby located Beinheim around 774. This fits perfectly with the contemporary villages of Wintersdorf and Ottersdorf. (Ruf, 1994, p. 25) The suffix *–dorf* is normally seen as another Germanic word for village. In the Dutch province of Fryslân it is unclear whether their *–dorf* or *–dorp* is related to *–terp* (village on a human made elevation). Nevertheless, there are no clues from the region that the Rieddörfer could have derived their names from an elevated *–terp.* A more interesting element is the *–harius,* nowadays, via *-thars*, still visible in all three Rieddörfer by the form of *–ter*. The Latin *–harius* could have transferred into the more Germanic *–hari* or *–haar,* which in early medieval times meant an elongated elevation, usually with tree vegetation. In Swedisch however *–har* suggests gravel, while Jellinghaus also mentions it as dry (Jellinghaus, 1923, p. 75). This final definition of *–haar* matches very well with the Rieddörfer and sounds plausible. Especially when corresponding to Bischof relating to the suffix *–hard*, meaning forest, usually on sandy soils. (Bischof, 1959, p. 135) The same derivations on *–hardt* or *–hari* can be made for Ottersdorf and Plittersdorf. However, the personal names might be a regular reason for the prefixes *pli-, win-* and *ot-*, Bischof suggested that *pli-* might even have to do with poles *(pali), ot-* might be related to property, but lack of corresponding arguments make it hard to believe this. Moreover, it should be noted that Ruf (1994) suggests that the names Muffenheim, Plittersdorf and Wintersdorf are simply a renaming of the home village the Frankish settlers came from. (Ruf, 1994, p. 26)

Ottersdorf is located northeast of Wintersdorf and located closest to Rastatt and the Murg. It seems that Rastatt first emerged in the 11th century, but from that moment onward, Ottersdorf was the location of the ferry to Rastatt. (Andermann, 2002, p. 374) However, as discussed above, the course of the Rhine might have shifted over the years. Plittersdorf is the northernmost of the Rieddörfer, located between the mouth of the Murg and the contemporary Rhine. Ever since the Rhine began flowing west of Plittersdorf, it has been under risk of flooding. In the 18th century, this nearly lead to the end of the village, but a renewed dike construction and the later Tulla rectification saved the village of Plittersdorf. Around Plittersdorf, the landscape shows several former river or stream ridges and wet strips in the landscape pointing out the swampy surroundings in which Plittersdorf was located.

Between Plittersdorf and Ottersdorf, the village of Muffenheim was located. Some of its field names are still there, however, the village disappeared between 1494 and 1511, probably because most of the village's agricultural land was lost due to flooding. (Ruf, 1977, p. 102) Bischof explains the name Muffenheim as *am Uffen heim*, which would roughly translate to 'house at the bank'. The fifth village of the Rieddörfer is Dunhausen, which can be explained as houses on the (sand) dunes. (Bischof, 1959, p. 136) Although the village was supposed to be located on sand, its disappearance as a result of flooding, does not seem very logical for dunes, since these are usually elevated. However, Ruf (1977) identified several elevated points in the contemporary Rhine flood bed near the location of the lost Dunhausen. Therefore, Ruf argues that the name might relate to remains of a terrace rim, which might explain why several roman burial stones have been found near Dunhausen. The people of Dunhausen were relocated to Wintersdorf in 1583; the reason for this was once again the unstoppable threat of the Rhine flooding their lands and the houses. The heavy losses of this late 16th century included 90 acres of land which had been washed away. (Ruf, 1977, p. 103)

Besides these villages, there was also a clinic between Wintersdorf and Ottersdorf. This Lepra clinic had to be outside of the village because of assumed infection risks. The St. Gilgen 'Gutleutehaus' is mentioned in the sources between 1415 and 1652. (Ruf, 1994, p. 74) A 15th century source also makes notion of a brick kiln near St. Gilgen. Another noteworthy settlement is the disappeared settlement of Rheinfeld. However, not much is known of this settlement east of the Rhine. According to Ruf, several tools have been archeologically found around Rheinfeld. However, it is unclear whether this indicates a settlement or maybe a ferry quay. (Ruf, 1994, p. 209)

The village of Ottersdorf has been expanding for many years now. In 2007 almost 2500 inhabitants were counted. This is a significant growth in comparison with the 1100 inhabitants of 1900 and the 396 of 1800. (Ruf, 1994, p. 345) Around the 16th century, it is expected to have had 200 inhabitants. (Ruf, 2002, p. 372) The drawings of Ottersdorf in figure 7.10 show the development of the village on historical maps and drawings.

Figure 7.10.1: The development of Ottersdorf in drawings, 1712, 1785, 1797 and in the last 75 years.

The most important farmstead of the village during the 15th century was the Detlinger Hof and the Vogt-Brunnings Hof. The Detlinger Hof is located at Wilhelmstrasse 11, and the Vogt-Brünings Hof next to the church at Rheinstrasse 19. Since the church, which was built around 1371, is also located at the Rheinstrasse, it can be assumed that the contemporary Wilhelmstrasse and the Rheinstrasse formed the early centre of the village, which can still be seen at the Schmitt'sche Karte from the late 18th century. (Schmitt'sche Karte, 1797)

7.2.3 Agriculture

In the tax books of the Margraves dating to the 15th century, the agricultural lands of the *Rieddörfer* were mainly located around Ottersdorf. (GLA-K/66-8383, 1472; GLA-K/66-8384, 1511) It is not stated that this has always been, since the Rhine has probably moved around the *Rieddörfer*, taking and creating land over the centuries. From these books it becomes clear that the Margraves only possessed two farmsteads at Ottersdorf, the *Dettlinger Hof* (only partly (Ruf, 1994, p. 349)) and the so-called *Vogt-Brunningshof* which replaced the *Adelheidshof* during the 14th century. Additionally there was the *Hof Widemgut* in Muffenheim, owned by the parish of Selz, the *Rommelshof* and the *Stockhof* in Plittersdorf owned by the monastery of Lichtenthal, of which its administration has been lost over the years. Also the *Merckel's Hof* in near Muffenheim and the *Henckhofe* at Dunhausen are documented. (Ruf, 1994, p. 42, p. 47) However, of these farmsteads hardly anything is known.

The *Adelheidshof*, which has been the main farmstead during the 10th century, has rights to fields which are mainly located around Ottersdorf, suggesting these are the best lands, most suitable for agriculture with maximum profits. At least the known fields of the 15th century (owned by the *Adelheidshof*'s successor, the *Vogt-Brüningshof*) reflect the best lands in an earlier period, since there is no indication to assume that the fields around Ottersdorf have been exchanged or adopted into *Vogt-Brünings* possession, other than the 1310 division of lands by the monastery of Selz. According to figure 7.11 the fields are centred around Ottersdorf, excluding the north-eastern side of the village. The 15th century fields west of Ottersdorf are located centrally between the five *Rieddörfer* and are within walking distance of these villages. Other reasons for the early adaption of these fields, like for example soil preferences or elevations in the landscape, do not immediately become clear from the soil map data (GK25 7114 Iffezheim, 1998) and the LiDAR-data. The fields southeast of the village of Ottersdorf are not in this centralized position. Field names even show relations

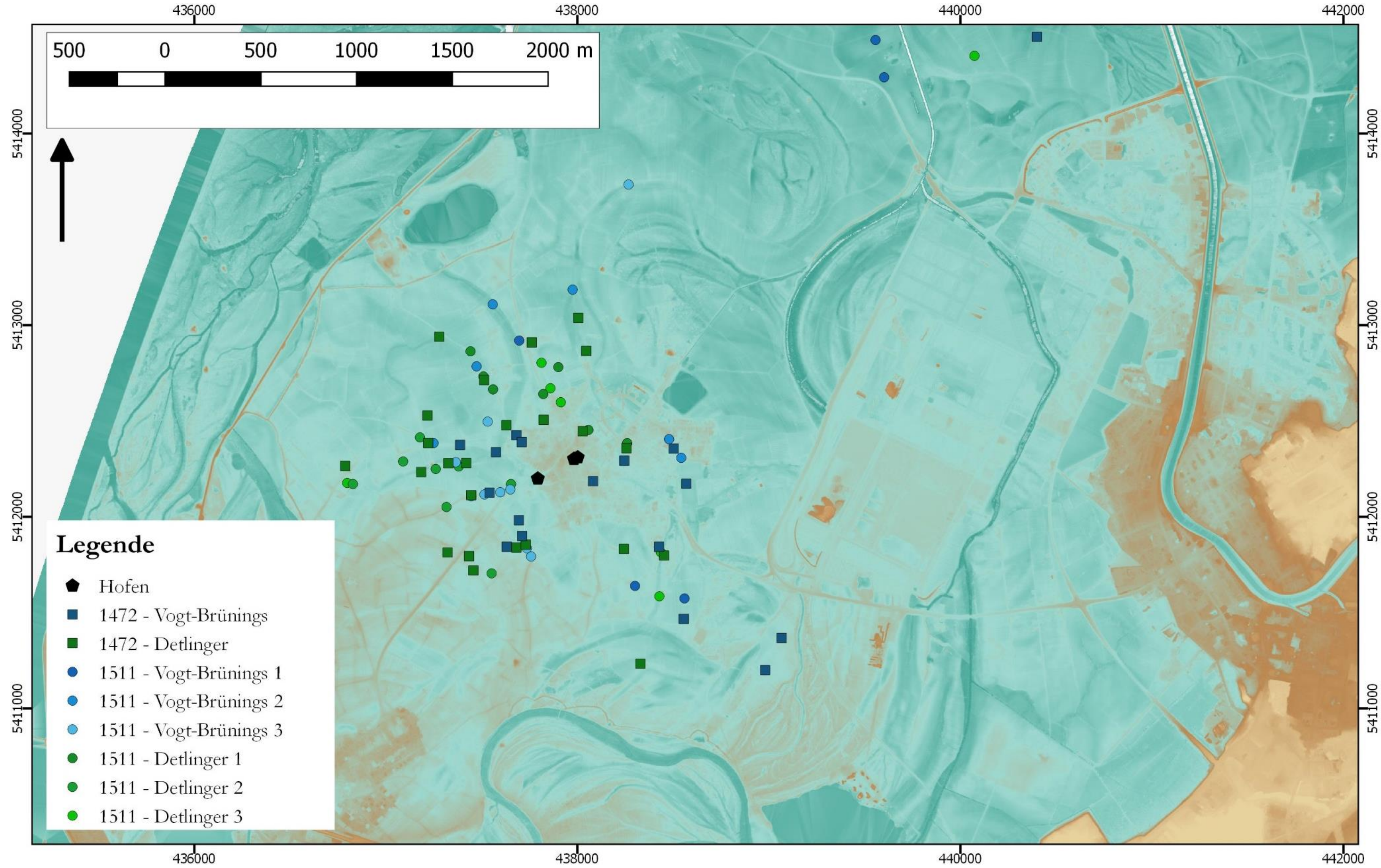


Figure 7.11: Fields around Ottersdorf, managed by the Vogt-Brüningshof and the Detlinger Hof in 1472 and 1511 according to Lagenbucher. The division 1, 2, 3 is derived from the three-field-system as it function in Ottersdorf.

with the former water bodies, for example, *grün* means gravel, *grübig* means ditch, and *Langen See* means a long stretched water body. The influence of the river is better visible in the LiDAR data in this part of the fields than it is in the centred area of the *Rieddörfer*. The fieldname of *Hofröder* points out that these fields where at some point newly cleared, a field name which regularly occurs around the 12th century. Notable is that these whole area is located in an inner curve of the former Rhine arm which is still carrying water. This means that the risks of erosion in this area were negligible. Even newly deposited lands could be expected in an inner curve. The area around *Hofröder* can therefore be defined as a safe place to clear new fields.

In this area, the three-field-system was common, at least up to the 17th century. During the 18th century, the three fields around Ottersdorf where called: *Großfeldzelgen* in the northern part of the village, *Beyzelgen* in the southwestern part and *Grimmesauzelgen* in the eastern part of the village. This correlates perfectly with the location of the fields derived from the 1472 and 1511 tax books. (Ruf, 1994, p. 345) An indication that the fieldnames and land use did not drastically change over the centuries.

When using the tax books (*Berainen/Lagerbucher*) of the *Rieddörfer*, a more detailed picture of the 15th and early 16th century can be sketched. This archival sources show that many field names are still used. It becomes clear that the main agricultural land of the *Rieddörfer* is located around Ottersdorf. Most of these fieldnames can be recognized in tax books of 1472 and 1511. The record from 1472 divides the lands into the two farmsteads in the village of Ottersdorf. The 1511 taxbook also makes a distinction between the various fields of the three-field system. The *Vogt-Brünings Hof* has it lands far from the village. Only the further away *Tolmans Wörth* is located in the former Plittersdorfer district. Notable are the two pieces of land documented on *Hofröder*, quite near to the former Rhine arm, which was already referred to in 1472. Closer to the Rhine hardly any field names are known. In the 1511 tax books, the three fields of the *Vogt-Brünings Hof* can also be distinguished. All three fields provide a few field names and thereby indicate their location. The first field is less clear since, the recognized fieldnames are widely diverted, at *Tolmans Wörth, im Kessel* and at the *Deist*. The second field is located north of Ottersdorf, from *Loschfeld* until Streibelsgrund, also including the *Muffenheimer Feld*, of which the village had disappeared in the period between the two tax books. The third field is located southwest of the village roughly between the *Dunhauserweg* and the *Mühlweg*.

However, this first field of the *Vogt-Brünings Hof* suits the third field of the *Detlinger Hof* very well. This field also includes the diverted fields of *Im Kessel* and *Abstwald* in the east, the *Tolmans Wörth* in the Plittersdorfer district, several fields along the *Kirchweg* to Plitterdorf, which follows the *Deist*, and on point at *Rheinwinkel*. The second field of the *Vogt-Brünings Hof* corresponds perfectly with the second field of *Dettlinger Hof*, containing fields from *Loschfeld* up to *Fahrmatten*. Interesting is that the size of the fields remain more or less the same, however the *Vogt-Brünings Hof* has more land, 60 acres, over about 45 acres of the *Dettlinger Hof*. The second field of the *Vogt-Brünings Hof* corresponds perfectly with the third field of the *Dettlineger Hof* with fields in the southwest. However, it seems that the fields of the *Detlinger Hof* are located slightly further from the village and more towards Dunhausen and mostly Wintersdorf.

The past few years, the forests around Rastatt have become publicly known for research on ridge and furrow complexes, *Wölbäcker* in German. (Sittler et al., 2015, p. 194) This was a very regular field system in the Upper Rhine valley, both in the Alsace and on the eastern bank of the Rhine. A Wölbacker is an elongated field, which due an unsymmetrical plough gains a higher centre and lower edges. This wavy form, that provided the name as well, helps the drainage of the fields. For this reason, it became possible to farm on land which would otherwise be too wet. (Sittler et al., 2015, p. 184) Such *Wölbäcker* can also be identified in the forest south of Ottersdorf, as they are visible on the LiDAR data. At *Hofröder*, which is still in contemporary use as agricultural fields, these *Wölbäcker* are visible in a north-west to south-east direction. Parallel to this direction, but slightly more westward, more of these *Wölbäcker* become visible, and when creating an elevation section in GIS, the wavy fields show height differences of about 30 to 50 centimetres

(Sittler et al., 2007, p. 541). According to the direction of the fields it could be assumed that they were developed in the same period as *Hofröder*. In accordance with this, these *Wölbäcker* are cut off by the contemporary road which runs parallel to the slightly younger dike. This weird cut off cannot be explained by any landscape structure logics and therefore it might be assumed that the *Wölbäcker* emerged before the younger dike was constructed. However, as at *Hofröder* these *Wölbäcker* seem to relate to the older south to north dike. Dating the *Wölbäcker* might therefore contribute to understanding when the dike was constructed, but also explains why. If the *Wölbäcker* date back to the same period as the dike construction, it seems logically that the dike was built in order to protect agricultural fields. Whether it was offensive or defensive diking will not become clear. However, the direction of the *Wölbäcker* seems odd. One of the grounds why the ridge and furrow systems developed is because it was not easy to turn the plough, especially in the heavy river soils. In accordance with that it can be expected that the strips of land where as long as possible. In the *Ottersdorfer Gemeindewald* this is not the case since the *Wölbäcker* seem to be cut off by the dike. The fields are still draining towards the river, so it could be expected, that the *Wölbäcker* were located on that location before the dike. Since the dike is built on top of the *Wölbäcker*, which definitely costs land and thus income, defensive diking can be expected. People might have built the dike in order to protect the remainder of the lands against the river, which was coming closer.

Additionally, on suggestion of Fransesco Silva and Ferréol Salomon of the University of Strasbourg another *Wölbacker* was revealed on the LiDAR-data in the forest south of the former Rhine arm, the so-called *Geggenau*. A local story tells how the *Geggenau* used to be part of Ottersdorf, but during a famine the area was exchanged for food with the villages of Sandweier and Iffezheim on the terraces. In this *Geggenau*, on top of the aforementioned sedimentation band, another *Wölbäcker* can be distinguished. However, this field could only have developed after the Rhine had left the sedimentation band. Otherwise, the structure of the soil would have been levelled by the flowing water. Thus, another *Wölbäcker* in the *Geggenau* is suggested to have been developed after the early 14th century's sedimentation period. At least it is quite clear that this *Wölbäcker* dates to another period than the aforementioned one, because of its location on the other side of the older dike (when the dike is virtually elongate). Unfortunately, *Wölbäcker* are almost impossible to date since they have been in use for many centuries, up to the 20th century. (Sittler et al. 2015, p. 184; Sittler et al, 2007, p. 545) However, a ridge and furrow system 15 kilometres south of Ottersdorf at *Stollhofener Platte* is dated, and is said to have developed following the clearances during the 12th and the 14th century, and an abandonment of the fields is dated around the late 17th century after the 30 years' war. (Sittler et al. 2015, p. 193)

In the charter of 731 in which Plittersdorf and Unnenhaim are mentioned, the handover of meadows, pastures and waters are noted as well. This indicates culture mainly focussed on animal husbandry during the 8th century. Agricultural fields are not mentioned at all. (Glöckner & Doll, 1979, p. 194) This matches with the knowledge from the broader region of the Upper Rhine valley.

Until 1338, the sheep of the *Rieddörfer* (only Plittersdorf, Ottersdorf and Muffenheim) where allowed to graze in the *Munchhäusener Wald*. Sheep were the main livestock in the area, which can also be derived from the field name Arnau, which according to Ruf indicates sheep grazing. (Ruf, 1994, p. 353) It is assumed that it was quite easy to travel from the *Rieddörfer* to the *Munchhäsuener Wald,* and therefore it is assumed that the Rhine had not yet interrupted this path for good. From the 1st January 1338 on, this right was split. The sheep that belonged to the community of Münchhausen should graze in the forest, while the *Rieddörfer* sheep could graze at the *Schafsried*. The breakthrough of the Rhine in the early 14th century had disrupted the existing cooperation on grazing between the villages. In addition, the cooperative grasslands and gold searching rights were divided at a later moment. (Ruf, 1994, p. 69, p. 353) In cases of emergency, the Rieddörfer were allowed to move their livestock to the western Rhine bank onto the lands of the Selzer diocese. This regulation functioned mutually, during a war in 1445 the cattle, sheep and pigs of Selz were moved into the Ried area. (Ruf, 1994, p. 353) During the 15th century, when the pressure for space was high in the *Rieddörfer*, inhabitants of the *Rieddörfer* got the opportunity to rent 310 acres (locally called *Joch*) land around Baden-Oos, 10 km south of Ottersdorf. This former brook area of the Kinzig-Murg-Rinne had been drained, and the reclaimed lands became the property of the Margraves. The farmers from Iffezheim and Sandweier also owned 180 acres of land in this area. (Ruf, 1994, p. 355)

According to Ruf, the *Rieddörfer* already had their own sub-districts before the 15th century. Unfortunately, it is not clear how long they have had them. The district border between Ottersdorf and Wintersdorf shows a very interesting curve between the fields called *Bey* and *Birkfeld* and dividing *Arnau*. On the side, this makes the field name of *Arnau* even older than the district border. Borders are usually drawn by rational logics or by forms derived from the landscape. Since a curve is not logic, a landscape motivation could be expected. In this river landscape, a former river meander could provide such a curved form. However, the soil map does not indicate any former river arm in this place, and the LiDAR-data shows more of an elevation than a ditch. This elevation however cuts off a ditch, another indication that an elevated riverbed is a real possibility. It should therefore not be excluded that the district border followed a former river channel, a river arm during a period of sedimentation. Additionally, in the archival source of 1472, the *Birkfeld* is called *Birklach*. (GLA-K 66-8383) The fieldname *-lach* is an indication for a wet strip of land unsuitable for agriculture, and is probably an extra indication for a former river channel or at least a swampy strip of land in that place. (Schneider, 1980, p. 16) Nevertheless, it would be very valuable to know when then district border was drawn, since at that time, the landscape clearly provided a reason to divide the fields with a curve.

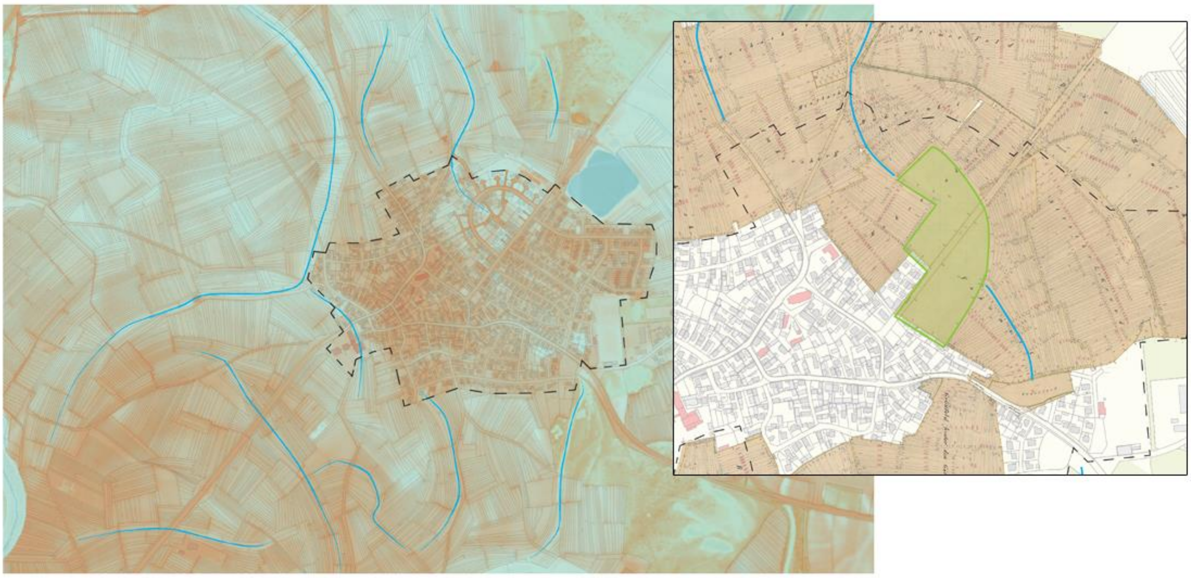


Figure 7.12: Cadastral map of Ottersdorf in overlay with the contemporary map.

Field structures often provide some indication of the reclamation history. Barriers in the landscape like hills or roads, but mostly watercourses are usually the reason to start or end the plot structure. During the 8th century, the blocked plot structure started to emerge since more and more various inhabitants acquired land in the various fields of a village. Especially with the three fields system, it was normal to have fields in all three of the fields, in order to keep the working process and the income of farmers in harmony with the whole village, and to spread the risks for the individual farmers. Thereby they also reduced the risk of bad harvests and damaged fields as a result of droughts or flooding in one of the three fields. If land parcels were not enlarged or relocated during recent allotments, the plot structure could tell a great deal on the landscape history of a village. In the village of Ottersdorf and Wintersdorf, the contemporary plot structure has hardly changed since the development of cadastral maps in 1859. In Plittersdorf, multiple enlargements of the plots are visible. Older information on plot structure does not exist on a regional scale and only incidentally on the local scale, but unfortunately not for Ottersdorf. However, the seemingly random mosaic of field-strips suggest a longer history than the 19th century. By overlaying the contemporary cadastral map and the 19th century map of the village of Ottersdorf, as is done in figure 7.12, the similarity is remarkable. Most remarkable thing is the extension of the built area of the village, which is a common practice of the 20th century. This has influenced some of the plots around the village, mainly in the eastern side. Some industry developed on the site of the field called *Wasum*, while the *Grimmesau* is now crossed by several roads and is over-built with (a part of) the Mercedes factory. Also the fields called *Grünfeld hinter den Gürten, Krautland, Fahrmatt, Steibelgrund, Im Ruthen* (partly), *Muhrwinkel* and *am Kirchweg* have been over-built with houses nowadays. Since contemporary buildings have deleted the historical plot structure and thereby the landscape history of these fields it is a unique possibility to gain this knowledge through 19th century cadastral maps. The most remarkable thing that can be derived of the cadastral maps from Ottersdorf is a notable curve in the eastern side of the village, over *Fahrmatt* and *Muhrwinkel*, that connect to a former watercourse at *Winkelweg*. Along this curve, which indicates an extension of the watercourse, no plots are shown. This could suggest that these fields were in common use. Although it is marked as crop farming, it would not be surprising if this piece of land was actually used as a pasture or grass productive land, which the name *Fahrmatt* also suggests. A 'matt' is usually too wet to grow crops on and is therefore used to produce grass, for extra feeding of the cattle. If this curve is indeed wet, this is an extra argument for a former watercourse in these lands.

Figure 7.13: The old roads (1472) between Ottersdorf in the North and Wintersdorf in the Southeast, on an overlay of the soil map and the LiDAR-data. The map shows how the Mühlweg is located along a border on the soil map.

Reconstructing former water courses contributes to understanding the historical landscape, since too wet lands were probably not in use and deeper or broader water courses were often seen as borders. Unfortunately, through the LiDAR-data it does not become clear where the watercourse through *Fahrmatt* originates. One reason for this may be, that it had not recently been a running watercourse, but that it might only have functioned as a drainage. Other possibilities for a possible connection can be found when overlaying the cadastral map with the soil map. This provides two more possibilities: the Auengley strip running from south (*Grübig*) to north *(Im Wasum*), and the Auengley curve north of the *Fliesweg*. It can also be noted that the *Mühlweg* is located exactly on the border between Auengley (w132) and the calcium-rich, brown Auensoils (w127). (Figure 7.13) This feeds the thought that either the road influenced the soil building, or that the road was built on the border between these two different soils for a reason, excluding coincidence as a possibility. Various curves are visible in the plot structure, called *Bey unterhalb the Mühlweg* (bend underneath the road to the mill). The LiDAR-data shows a slight reduction for these fields and it would connect perfectly with the aforementioned arm in *Fahrmatt*.

7.2.4 Forests

The fact that the Rhine flood bed has been inhabited since at least the 8th century, probably already during Roman times, suggests that the landscape did not solely consist of forest. However, the area that regularly flooded would probably have consisted of wetland forests, since other land use was hardly possible, allowing nature to develop to a forest stadium.

Around the Rieddörfer, it is not clear when deforestation started. Of course it makes sense that the 8th century settlements required open space for housing and fields. The first record of forest being cleared is in the 991 document which mentions the 40 acres of land at Ottersdorf, which was gifted to the monastery of Selz by the emperor's wife Adelheid. This text says *'In silvestri novali*'. (Sickel, 1893, Nr.80 p.488; Ruf, 1994, p. 67) This can be translated freely into *in wooded clearances*, or more logically interpreted by Ruf *in cleared woodlands*, new fields in the wooded area. However, the incorrect spelling of the term leaves room for discussion. A quick search in Du Cahnge's *Glossarium mediae infimae latinitatis* gives the additional explanations of fallow land, or fields that were taken back into use. This is however based on searches of *silvestres, sylva, novalis* and *novalis ager*, since *silvestri* and *novali* are no proper conjugations in Latin. (Du Change *et al.*, 1886) This document is however stated to be a forgery, because the handwriting is similar to other facsimiles, and the monogram is similar. The persons and content however fit very well in the period. (Sickel, 1893, Nr.80 p.488) This source should thus be considered and interpreted very cautiously, but its content should not directly be disqualified. At least it suggests that fields were cleared in the forested area around Ottersdorf during the 10th century.

The aforementioned document of 1338 describes the end of the grazing cooperation between Munchhausen, Plittersdorf, Muffenheim and Ottersdorf. This indicates that at the time, the *Münchhausener Wald* was used for grazing. The same is known for the forest at the deserted village of Bodenhusen (the fieldname Bollmanshausen refers to this place) near Steinmauern. A source states that the monastery of Selz shared its acorning rights for this forest. (Krämer, 1926, p. 44; Stenzel, 1975, p. 104)

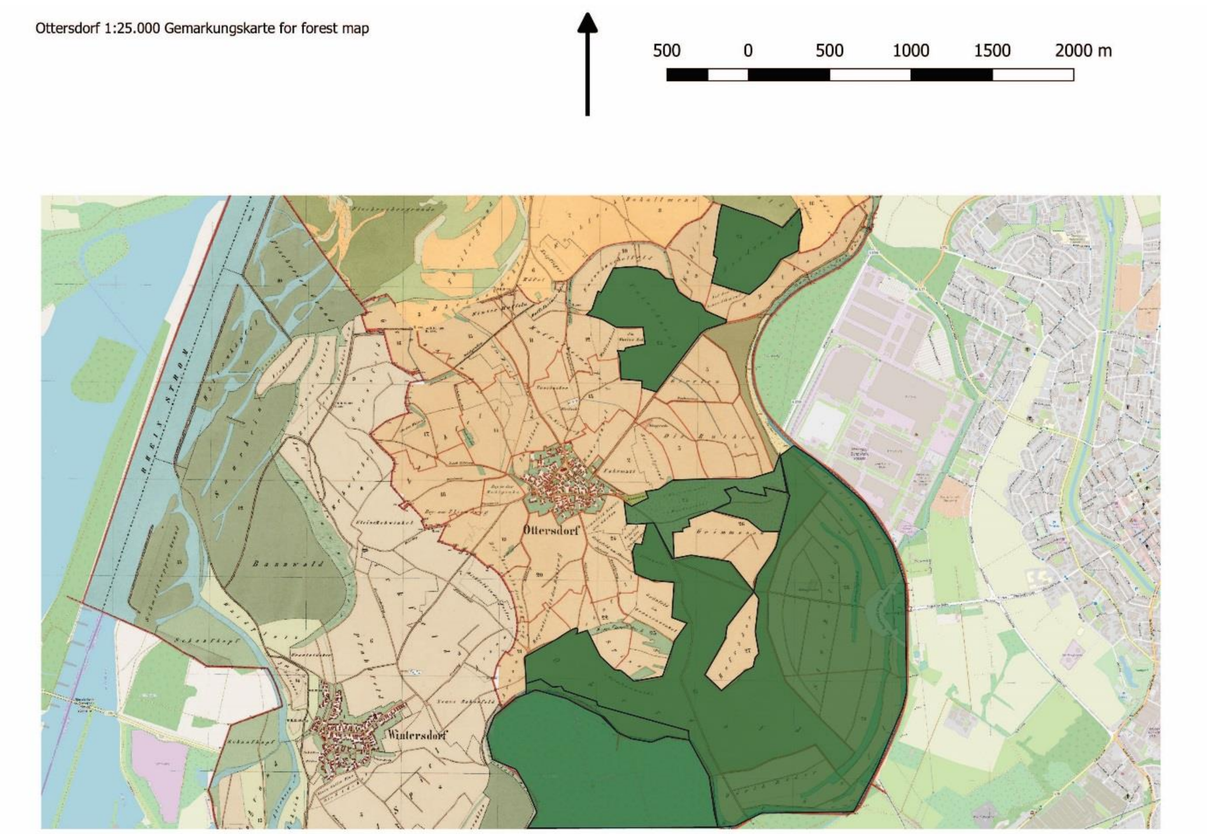


Figure 7.14: Forests around Ottersdorf in 1597, based on forest and field names of 1859, thus the measurements are not exact.

A clear overview of the forests around Ottersdorf is given in 1597. Derived from the city archive in Rastatt, Ruf describes a forest at *Muelwerdtlin*, near *Geggenau*, the *Ottersdorfer Oberwald* along the former Rhine arm (*Mühlwerl* and Altrhein), a forest at Rheinfeld in *Grimesau*, *in Wassum* and *Underböschlein* and finally the *Niederwald* and *Riedtwerdt* (now called *Riedwörr*) near the Rastatter district border. (Figure 7.14) (Ruf, 1994, p.

216) The exact size of this forested area does not become clear. What should be mentioned is that the forest at *Geggenau*, which nowadays lies at the other side of the former Rhine arm, might have belonged to the areal of Ottersdorf before, and was probably not even cut off by the river. However, this is based on oral history and there is no other proof.

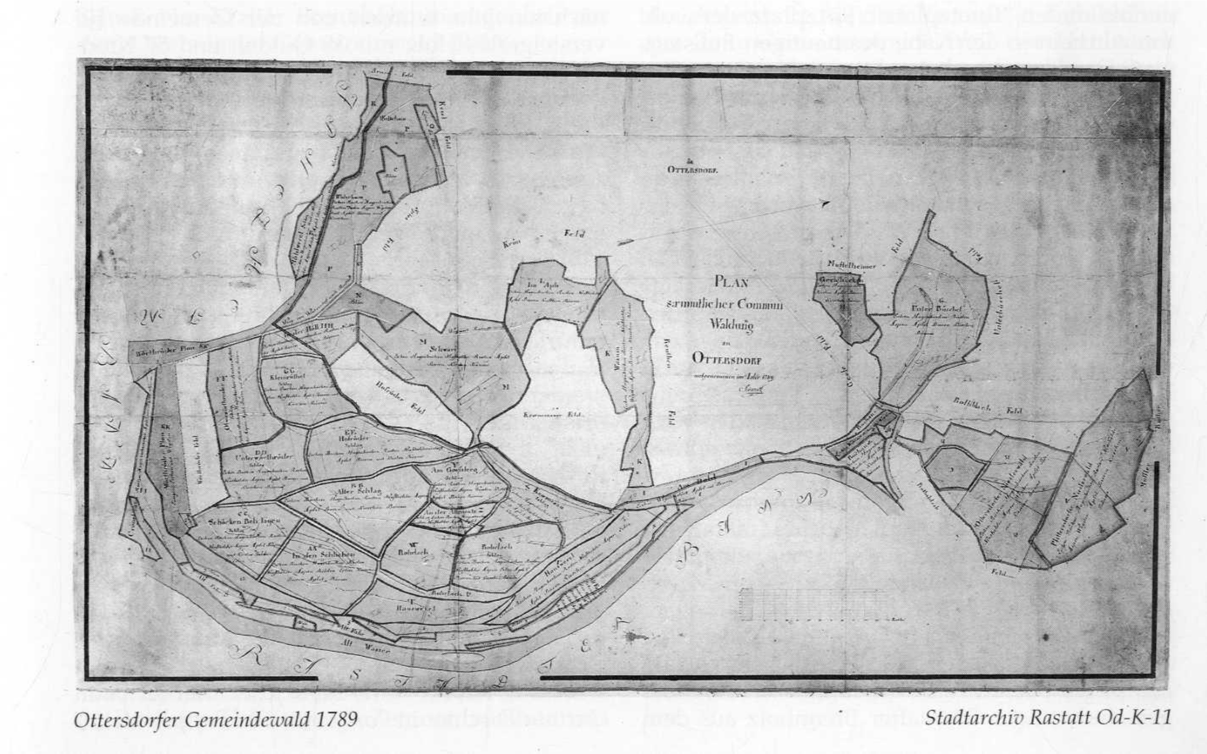


Figure 7.15: Ottersdorfer Gemeindewald Karte proves that the Oberwald has been a forest at least since 1789. (Stadtsarchiv RastattOd-K-11)

The forest surrounding Ottersdorf was mainly common ground. Gathering wood, or letting the animals graze was free, however, acorning the pigs came at the cost of a tax to the landlords. In addition, hunting was a privilege for the lords. (Ruf, 1994, p. 216) In 1602, the *Ottersdorfer Wald* was called *Heßelnschlag*, it started at the district border with Wintersdorf and continued up to the pedestrian bridge to Rastatt. The Unterbüschwald and Niederwald at the Muffenheimer district were also to be used by the Ottersdorfer residents. However, for many years significant taxes had to be paid to the lords by means of wood, firewood and fascines for the Murg canalization and constructions at the Rhine. During the early 19th century, many new poplars and willows were planted for this project. (Ruf, 1994, p. 216) The *Ottersdorfer Oberwald* forest of Ottersdorf is very well mapped in 1789, figure 7.15. It does not only show the presented dike lines, also fieldnames and even present tree species are noted. The figure also shows which species occurred at which field. After mapping these mentions, it became clear that species with better resistance to water were present outside of the dike lines. The water adaptive trees are the willow, the alder, the aspen and the beech. It is important to mention the construction of the Rastatter defence works around the 1850's. In this period over 160 acres (60 ha) of forest were cut down in order to have a free shooting range to see the enemy. This area is now called *Stockstucker*. For the construction of the Mercedes factory another 13,5 ha of forest was chopped down in 1990. In 1994 only 201 ha of the 330 ha of forest in 1831 have been preserved. (Ruf, 1994, p. 217) A point of note in the forest is the *Salzleck*. This slightly elevated piece of land was a good place to find refuge for wildlife and livestock during flooding. A mineral lick stone was placed there in order to compensate for the poor vegetation because of the gravel soils, especially during high water periods. (Ruf, 1994, p. 212)

7.2.5 Infrastructure, River use and Water Management

Infrastructure might not be a clear argument for landscape reconstruction since early roads were not paved and were thus no permanent structures in the landscape. However, roads often keep their location, and in an early landscape with less barriers, they often led directly and straight to their goal. Therefore, the *Dunhauserweg* probably tells something on the location of the former village of Dunhausen, which is suspected to have been on the crossing of the *Dunhauserweg* from Ottersdorf (nowadays *Loschfeldweg*) and the *Dunhauserweg* from Wintersdorf. In addition, the *Muffenheimerweg* seems to have connected Muffenheim to Dunhausen. (Figure 7.16) Thus, roads can help us reconstruct the historical landscape. One of the most notable clues the infrastructure of the Rieddörfer provides is the lack of a *Wintersdorfeweg*, starting in Ottersdorf, in the 1472 and 1511 archival sources. (GLA-K/66-8383, 1472; GLA-K/66-8384, 1511; see appendix B and C) When looking at the contemporary road between Wintersdorf and Ottersdorf (L78a) it does not follow landscape lines or parcel lines as well, indicating that it was planned at a later moment. This also applies to the *Lindenallee* and the *Wintersdorferweg* and *Plittersdorfeweg*, which seem younger than the plot structure. In this case it is known that this road was constructed around 1780, and the former connection between Iffezheim and Ottersdorf went past the *Mühlwerlsteg* (-bridge) at *Wertrödern*. (Ruf, 1994, p. 19; GLA-K 182/159) This *Wintersdorferweg* can be identified on 18th century maps, but it is absent in the 15th century maps and written sources. This might indicate that a direct connection between Wintersdorf and Ottersdorf was less obvious then moving through Dunhausen or the *Geggenau*. It therefore could be that some kind of barrier existed between the two villages. Such a barrier is in accordance with the presence of the former watercourse in the LiDAR data, which was well visible in the plot structure of the 19th century cadastral maps. This water course agiain perfectly holds up with the aforementioned argument of the curved district border and the document of 1338 which distinguishes Ottersdorf, Plittersdorf and Muffenheim from the other two *Rieddörfer*. Ruf points out even more examples of the strong connection between Dunhausen and Wintersdorf in contrast to the other Rieddörfer. He even suggests that the villages might have shared an island in the Rhine for a period of time. (Ruf, 1977, p. 92)

Figure 7.16: Infrastructure around Ottersdorf, roads directing to the disappeared villages of Dunhausen and Muffenheim

Various actors use the water around Ottersdorf for many different purposes. Fishing waters usually belonged to the landlords instead of the local community, and therefore it was the landlords who could decide who to rent out fishing rights to. Also in the *Rieddörfer* there was a fishing guild, however, in Ottersdorf it was not a very important way of income. In the 1338 document, the knights of *Hohenburg* were in charge of the fishing rights in the waters between Munchhausen and the *Rieddörfer*. In the 1472 tax book, the Margraves are also mentioned providing the rights for two bodies of water. The first was the i, which started at the river, and ended at *Elmans Rhein*. The second stretch of water started at the former Rhine and entered into the *rechten rhin*, which can be translated as straight or right Rhine. (Ruf, 1994, p. 359) A reconstruction of these river arms is sketched in Figure 7.17, but leaves room for discussion, since nowadays the *Mühlrhein* and the former Rhine arm are considered the same water body. The rent of rights in a specific fishing water was valid for 10 years, although it could be ended after five years. The caught fish had to be offered to the Margraves first before selling them to other parties. (Ruf, 1994, p. 359) The *Mühlrhein* is named several times in combination with the *Augießen im Ried*. However, this *Augießen* is not located on contemporary maps. The Altrhein, a former Rhine arm, which is considered the *Mühlwerl* by Ruf, flowed through Iffezheim, Wintersdorf and Ottersdorfer lands. The contemporary *Mühlkanal* was constructed during the early 19th century. When the former *Muhlbach* (*Mühlwerl*) was dammed, the number of fish was reduced and the former arm started to silt up. (Ruf, 1994, p. 360) The aforementioned second stretch concerning the *Altryn* to the *rechten* Rhine is mentioned in 1481 as *Altryn*, which is today called *Engelhartswinckel*. (Ruf, 1994, p. 361) Since this stretch of water is located on Iffezheimer (nowadays Sandweierer) and Rastatter lands, most probably the source is referring to the contemporary Riedkanal. In the 16th century, local fishermen complained that Rastatter fishermen took fish from the Murg. At this time, the former Rhine arm entered into the Murg between Plittersdorf and Rheinau and therefore, inhabitants of the *Rieddörfer* claimed to also have fishing rights in the Murg. Unfortunately for the fishermen from the *Rieddörfer*, an old fisherman from Rastatt testified that he had already been fishing in the Murg around 1500. With this testimony, the fishermen from the *Rieddörfer* were prohibited to fish in the Murg, which has been reserved for Rastatter fishermen ever since. (Ruf, 1994, p. 360) The Rhine would have had different rules. For example, it is known that the people from Dunhausen were allowed to fish in the emperor's waters (the Rhine), without paying any taxes. (GLA-K 67/589)

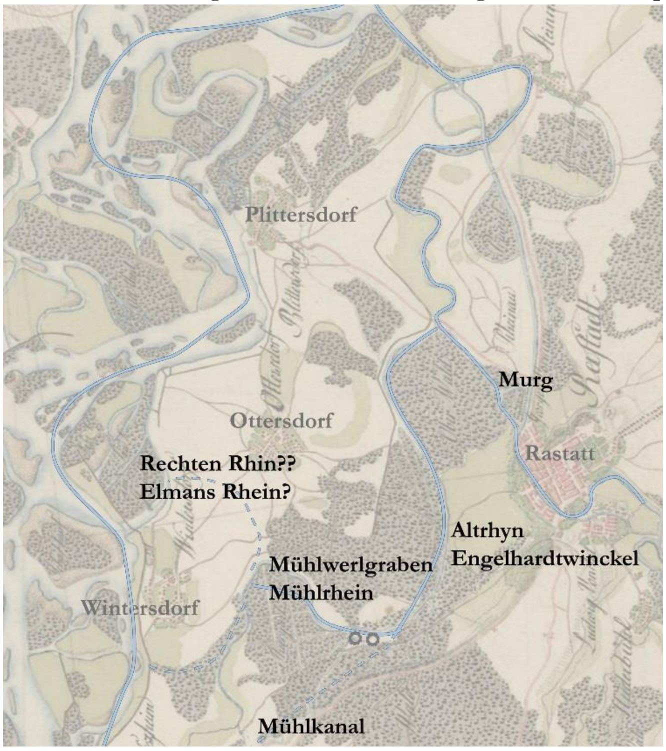


Figure 7.17: The water bodies around Ottersdorf as derived from 15th and 16th century sources.

The *Goldgrube* north of Plittersdorf has been used for gold washing for many centuries. The use of this gold searching place was shared between Munchhausen, Plittersdorf, Otterdorf and Muffenheim up until the 17th century. (Ruf, 1994, p. 69; GLA-K 37/187) At the *Vogelwerth* a catchment for ducks is known (Ruf, 1977, p98)

Multiple ferries have been mentioned at the *Rieddörfer* since at least the 14th century. Among these is the ferry to Beinheim. This ferry from Iffezheim to Beinheim is visualized in the *Kurpfälzische Rheinstromkarte*, in a 1653 map by Rheinwald and in the 1712 Plittersdorf drawing. (Ruf, 1994, p. 196; Kurpfälzische Rheinstromkarte, 1797; GLA-K 229/81914; GLA-K H Plittersdorf 1b) In 1472 it is mentioned that Abrechts Heintze was the ferryman on the ferry (*Rutzelmanns Fahr*) from Ottersdorf to Rastatt for 40 years, dating this ferry back to at least 1432. However, a ferry connection between the *Rieddörfer* and Rastatt is mentioned in the 1310 document as well. (Ruf, 1994, p. 72) Whether this ferry was located at the field with the name *Fahrmatten* or at *Altfahr* is unclear. With a shifting river a ferry location could also have changed. This would also influence the access roads. (Ruf, 1994, p. 19; p.209) In 1288, a ferry over the Rhine at Meerfeld (or Mervelt), northwest of Steinmauern, is noted. It can be questioned whether this means that the Rhine had been flowing west of the *Rieddörfer* earlier than expected. (Walter, 2002, p. 520) The village of

Meerfeld is already mentioned in 1102, and was deserted in the early 15th century. Most of the time the ferry and tolling place at Meerfeld is named. Stenzel suggests that the separation of the *Rieddörfer* from the Selzer parish might have led to the disappearance of Meerfeld as a tolling place. However, the Rhine's movement probably played a role as well. (Stenzel, 1975, p. 105)

In 1466, Karl I of Baden approved that Jakob Müller rented two mills at Sandweier and Iffezheim. The people from those two villages where obligated to mill their cereals at these mills, even if the mill of Rastatt might have been closer for the people from Plittersdorf. (Ruf, 1994, p. 74) Although it is stated that all the milling of the Rieddörfer had to happen in Iffezheim, it seems that in a 1795 map two mills are drawn in the place right before the *Mühlwerl* flows into the channel at the foot of the terrace, which continues as the aforementioned *Engelhartwinckel*. (Rheinwald, 1795, Ruf, 1994, p. 190) This location laies on the border of the Iffezheimer, Sandweier and Ottersdorfer districts, located very centrally. (Ruf, 1994, p. 190) The *Schmitt'sche Karte* (1797) only shows one mill-like symbol in this place. (Schmittsche Karte, 1797)

It seems evident that the inhabitants of the Ried have battled the Rhine and its flooding ever since their settlement. However, as already mentioned for the whole Upper Rhine, any documentation of flood protection in the early and high medieval period is missing. It is exactly this gap between first records of villages like Ottersdorf in the early medieval period, and the known measurements of flood management, which is the study period of this research. Around Ottersdorf, already in 1472 the *Deistwerb* and *Uf die Werbe* are mentioned. A *werb* is an elevation in the landscape, which is regularly used along rivers during that period; in addition, it is used for dikes as well. (GLA-K 66/8383) Again, in 1486 a *werbe* is mentioned, this time more specific along the studied former Rhine arm southeast of Ottersdorf. (GLA-K 67/58b; Ruf, 1994 p.360) From 1586 on, several documents provide insight into the renewal of multiple dikes in the *Rieddörfer*. (Ruf, 1977, p102) Since the role various stakeholders had in this process, these documents are discussed in more detail in the next paragraph. One thing which can be found multiple times in this paper by Ruf, is the fact that people took down their houses and rebuilt them further away from the river on a regular basis. Apparently, this was seen as a proper measure of flood prevention. Such rebuilding and relocating of villages is also known in the Netherlands. (Ruf, 1977, p. 104; GLA-K 61/310; Stulp, 2008, p. 78) Practices of continuous dike building and replacement of villages continued over the years. At the change from the 18th to the 19th century the village of Plittersdorf had nearly disappeared. Fortunately, dike building techniques were applied and the village could be saved. Shortly afterwards the straightening of the Rhine by Johann Gottfried Tulla started.

During the more modern centuries, multiple water management measurements were undertaken around the Rieddörfer which go beyond the scope of this research. However, in order to gain a complete context, these measures are briefly summed up. In 1602 the mouth of the Murg was located at the contemporary Riedkanal bridge. (Ruf, 1994, p. 23) A flood in 1660 near Iffezheim forced people out of their houses. During this flood, it was feared that the Rhine would take its former bed again, flooding into the direction of Rastatt. The bridge over the Riedkanal was converted to a fixed bridge in 1765. Unfortunately, the bridge was washed away during the extreme ice floods in 1784, only shortly after the construction of the Murgkanal had started in 1778. In 1802, the Iffezheimer stream into the *Mühlwerlgraben* was dammed, after the construction of the new Mühlkanal from Iffezheim to the mouth of the contemporary *Mühlwerl* into the Altrhein. Although the idea of canalizing the Altrhein had existed since 1812, it took until 1827 before it was canalized. From now on, this water was as well called Riedkanal; however, Altrhein is still used in local language. Finally, in 1989 a part of the Riedkanal was moved eastward to make the construction of the Mercedes factory possible. (Ruf, 1994, p. 23)

In the early 19th century, a cooperation between the French and Baden governments emerged in order to develop flood safety along the Rhine. Plans for bypasses at Greffern and Plittersdorf where developed.

(Reinhard, 1974, p. 4) Historical maps provide evidence for many more dams or dikes in order to manage the water around the Rieddörfer. However, most of them have been built quite recently and many are poorly documented. (Schmitt'sche Karte, 1797; GLA-K H Plittersdorf 5, 1788) Nowadays the biggest flooding danger in the Ried area is pressured groundwater from underneath, flooding basements and the lower fields. (Ruf, 1994, p. 23)

The historical dike that is the main study object of this case study can hardly be found in documentations. The *werbe* noted in 1486 appears to be the one, providing us with a *terminus ante quem* for the dike construction. Also the dike is visible on the *Ottersdorfer Oberwald* map of 1789 and parts of it can already be seen on the *Carte de la Basse-Alsace* (1715) and the *Carte particuliére d'Alsace* (1733). However, the aforementioned archival source claims that it is many years older. Nowadays the dike is located in a forest in the formal district of Ottersdorf. However, from the field formerly known as *Wasum* northward the dike is nowpaved and used as a road. Almost everywhere the dike sections in the forest contain a ditch right in front of the dike on the riverside. The dike used to continue as well on the former Wintersdorfer district, but this was taken away as a job creation during the German-French war at the end of the 18th century. (Ruf, 1994, p. 19)

7.2.6 Actors

The earliest written record of the Rieddörfer is the 731 gift report of the Weissemburg monastery. In 731, Graulfo donates the Weissemburg monastery everything he inherited at Plitharesdorphe and Unnenhaim – assumed to be the disappeared village of Dunhausen, which was called Duonnenhusen in 1310 and Dunnenheim in the 1318 records - from his father Madalhari, including two serfs. (Glöckner & Doll 1979, nr. 16; Ruf, 1994) A 799 record mentiones Winidharesdorf which also fits very well into this line of spelling, although it seems that the family's farmstead expended into a village. (Glöckner & Doll, 1979, nr.27, p. 207) In 790, the village of Muffenheim is mentioned in a donation-record of the monastery of Lorsch. The monastery of Lorsch was founded in 764 more than 100 kilometres north of the villages in Ried. But, in this period the monastery gathered more lands even further south, for example some lands in Wintersdorf. The donation of Muffenheim included a forest and a farm. (Glöckner, 1936, nr. 3610) This shows that the influences of the church go relatively wide

It is important to note that the villages were located in the Alsace at the time. This suggests that the Rhine passed the villages on their eastern side. In the Lorscher Codex more properties in the Alsace area are mentioned in 799. Besides the villages of Marcolfesheim and Elsenheim the former village of Holzheim in the Rhine riverbed by Strasbourg is mentioned. Also Frankenheim near Selz, which disappeared after 1208, and Wintersdorf are mentioned. A farm (*mansus*) and church (*ecclise*) are recorded for Wintersdorf, together with a lordland and lands owned by serfs. Although the other mentioned villages have more *Huben* (privately owned farmstead), Wintersdorf is the only one with a *Hofreite* (building at a farmstead linked to clearances) and a church. (Glöckner, 1936, 3158). During the same year (799) the serf Otgis donated his property to the free man Theodo in Wintersdorf (Glöckner, 1979, nr. 27).

From 915 on, Selz and its surroundings belonged to the Holy Roman Empire and thus the Herzog of Schwaben, also during the Hungarian raids in 917 and 926. In 962 King Otto I gave Selz and 13 surrounding villages to his second wife Adelheid, who was born in the region. Adelheid retreated to the region multiple times and founded the monastery of Selz in 991. In 1058, the Abbey followed the order of Cluny. (Bannasch, 1969, p. 121) In 1310 the *Rieddörfer* were still called *"Sankt Adelheids Eigen"*. (Ruf, 1994, p. 183) This means that Adelheid, later her monastery was still the owner. The monastery of Selz took over the management of these villages. Unfortunately, a flooding of the archives of the monastery of Selz and a fire at the landlords of Eberstein's destroyed most of the medieval history of the *Rieddörfer*.

The few archival sources that survived these disasters confirm that the *Rieddörfer* were located in the Alsace. The payment of a debt of the Margraves of Baden to Strasbourg in 1288 suggests that the *Rieddörfer* where still part of the Alsace. (Ruf, 1994, p. 69) As mentioned before, the monastery of Selz was destroyed by an enormous flood around 1307. (Ruf, 1994, p. 66) In 1310, the *Rieddörfer* were mentioned for the first time all together in a record stating that Selzer cattle was allowed to graze on both sides of the Rhine during bad times. This suggests that Selz now lay on the other side of the Rhine than the *Rieddörfer*. The ferries mentioned in 1310 from Selz to the *Rieddörfer*, and another one from the *Rieddörfer* to Rastatt, indicate the *Rieddörfer*'s location being surrounded by two Rhine arms. In 1318 the five *Rieddörfer* are all mentioned together again when Albert Röder von Schauenburg and Albert Röder von Staufenberg sell their tenths to a priest from Strasbourg. (Ruf, 1994, p. 70) It has already been noted that in 1338 the former collective use of forest, meadows and gold searching area between Münchhausen on one side and Plittersdorf, Ottersdorf and Muffenheim on the other side is renegotiated, and the rights of forest use are even split up.

The *Rieddörfer* are often considered a Markgenossenschaft, or a mark community, in which Dunhausen and Wintersdorf took a special position. (Ruf 1977, p92; GLA-K 37/187) Possibly, Dunhausen was founded by residents of Wintersdorf who wanted to expand. Another theory states that they shared an island in the Rhine for many years. (Ruf 1977, p. 92) In 1338, the two villages are not mentioned separately in use of the common forest around Münchhauen. This special position feeds the speculation that there would have been some kind of distance between Wintersdorf and Ottersdorf. (GLA-K 37/187, GLA-K 37/276) Going to church in Selz had become hardly possible after the Rhine avulsion that split off the *Rieddörfer* from the Alsace and onto an island. For this reason from 1371 onward a church and parish are founded in Ottersdorf, this process ended in 1415 when Ottersdorf received parish rights in the new church for the *Rieddörfer*. However, in 1424 Wintersdorf had its own St. Nazarius-altar in a chapel together with Dunhausen, but the Ottersdorfer priest was summoned to contribute. (Ruf, 1994, p. 72) This again shows the special position Wintersdorf and Dunhausen had even during the early 15th century.

The location of the donated 40 acres in 991 of land remains unclear. However, this document does reveal that during the final decades of the 10th century significant clearance activity is conducted in the Ottersdorf area. Ruf suspects this 40 Morgen directly north of Ottersdorf. In the 15th century two *Höfe* can be identified in Ottersdorf. The *Dettlinger Hof*, which used to be the property of the Weisemburg monastery, was located at the contemporary *Wilhelmstrasse* 11, near the *Luisenstrasse*. (Ruf, 1994, p. 348) Along the *Luisenstrasse* several pieces of pottery have been found, dating back to the Carolingian period (751-911). (Ruf, 1994, p. 68) The *Vogt-Brünings Hof* is located between the church of Ottersdorf and the *St. Adelheidshof*, which should have been located on *Rheinstrasse* 19. The *Vogt-Brünings Hof* is probably named after Konrad Brüning who was a margravely bailiff (in German: *Vogt*) in 1385. During the medieval period, the *Adelheidshof,* which clearly is the *Regengers Hof* that is mentioned in the 991 document, took care of St. Adelheids lands, and later on the *Adelheidshof* became the property of the margraves. (Ruf, 1994, p. 67) This probably occurred during the early 14th century, when the Selzer monastery was divided between the Palatine Emperors, the lords Fleckenstein and the margraves. (Bannasch, 1969, p. 142) The margraves had been involved with the *Rieddörfer* since 1139. However, a bailiff often aimed for independency of the lords. (Ruf, 1994, p. 183) When in 1371 (until 1415) the church and parish house of Ottersdorf were built, their plots were donated by the margraves, probably land of the *Vogt-Brünings Hof,* or, at that point, still *Adelheidshof.* Without mentioning any sources, Ruf argues that the *Herrenäcke*r surrounded the church and the parish house was located at the northeast village edge. Also, the *Farmatten* might have belonged to these *Herrenacker*, which Ruf identifies as the 40 acres of the *St. Adelheidshof. Farmatten* is named after its role as a ferry port, crossing the former Rhine arm in the direction of contemporary Rastatt. This was usually done by monasteries, and therefore the *Adelheidshof* probably owned this land. (Ruf, 1994, p. 68) The *St. Adelheidshof* is still mentioned until the 30 years' war, and it paid hardly any taxes to the margraves. After the war, the *St. Adelheidshof* is not documented anymore. (Ruf, 1994, p. 352)

During 1587, the residents of the Rieddörfer started complaining that the Rhine damaged houses and fields time after time. Also, the next year, the loss of 90 acres of the best fields was mentioned in another complaint. (Ruf, 1977, p. 102) In 1596 about 150 inhabitants of the remaining *Rieddörfer* started building a new Rhine dike. However, they did not manage to finish within seven weeks, because they had to strengthen other places as well. The margraves supported them by granting them fruits and grains. The monastery of Lichtenthal and the diocese of Selz. (Ruf, 1977, p. 103) However, the margrave Ernst Friedrich wanted a more thorough estimation on how long the construction works would take, how long and how high the dike would be built and whether it would cost more time and effort than the last dike six years before. (Ruf, 1977, p103) The representative from Amt Stolhofen reported back that the dike of 1700 steps long and 9 shoes high which had been built six years ago, had already disappeared into the Rhine. A comparable dike which was built two years before had already eroded away. At that time, the local inhabitants had not asked for help because of the changes in the government. The newly planned dike would be shorter than last one, about 1231 steps, and roughly the same height. However, it would be slightly higher in several sections. The 154 people living in the *Rieddörfer* had been working for ten days already and needed at least another six weeks to finish this dike. After that, they would still have to dig a ditch in *Lichtenwörth* in order to redirect the river more into the direction of Selz. In addition, maintenance was necessary in the next years. In the end, the margrave decided to provide six *Malter* (a southern German unit of measurement) of the 72 *Malter* grain. (Ruf, 1977, p. 103) The above illustrates that in the 16th century, the locals were familiar with dike construction and they built defensive dikes from a bottom-up approach, protecting their fields. However, support of the landlords was necessary, mainly by means of food, but later also by menas of materials and personal. (Ruf, 1977, p. 103)

7.2.7 Perception of landscape

The perception of the river landscape around Ottersdorf in past times is very hard to grasp. The contextual perception of a river landscape was discussed in chapter §4. However, the perspectives of the church elite do not directly correspond to the perception of local servants and peasants, or the local priests and landlords. In order to find the perception of these groups, field names are studied. These names provide an insight into the perception of a field, the perception of the people who gave, and intentionally used that name. A field name is a way for human actors to distinguish their land from each other. Unfortunately, in order to relate a field name to a certain period of time more research is necessary. However, §4.6 discusses a shift from names dealing describing land observations and names indicating land use. It should be taken into account that many of the field names have their first occurrence during the 12th, 13th or 14th century, which can probably be related to the fact that from this period on, more documents and charters had to stand the test of time. As a data source for such names around Ottersdorf, Wintersdorf and Plittersdorf, the Germarkungskarte from 1861 is very useful. Many names are indicated that still occur on contemporary maps, but also appear in archival sources of the 15th century. Additionally, the *Ottersdorfer Gemeindewald* map of the forested area display several names of the forest area around Ottersdorf. (*Ottersdorfer Gemeindewald,* 1789; Figure 5.8)

Land observations

At first field names related to water shall be scrutinized. In the district of Ottersdorf, the *Knorrgiessen* in the north obviously indicates an elongate body of water. Also the *Lange See* and its alternative name (nowadays wet pasture) is *Grübig* which is related to *graben* meaning digging or canal or dich. Even recently, people have known this field as a wet area and it is visible on the soil maps as well. The *Grünfeld* located directly north of this *Grübig* means gravel field. Gravel usually indicates a former river, since water must have the energy to transport gravel. However, in the river landscapes, underneath the top soil layers, there will be gravel layers, since the river has been flowing there for so many years that its course passed every square centimetre of the floodplain over the years. Another example of this is the name *Girrlen* north of Ottersdorf and *Grünel* along the Altrhein. It is remarkable that several field names containing gravel can be found east of Ottersdorf, while none are known directly west of Ottersdorf. Also the suffixes *–au*, *–grund* and *–wörth*, occur more often to the east than the west of Ottersdorf, and more closely to the Altrhein river arm. Only around the area of the former village of Dunhausen do such names appear again, but these are located within the contemporary flood bed.

The *Bey* field south of Ottersdorf could be related to a former river arm, since Ruf connects *Bey* with *Bug* or *Bünde* which could be interpreted as bow or bending, both indicating some kind of curve in the landscape, as the earlier mentioned district border did. (Ruf, 1994, p. 200) Another notable name is the road name *Fließweg*, which means flowing road or path, however, *Fließ* is certainly related to the German *Fluss* (river) or *fließen* (flowing). This road might therefore have followed the river, or maybe, more logically, might have led towards the river in the time that the name first emerged. The names ending on *–lach* (*Kotzlach, Krumlach* and *Mistlach*) all describe a wet swampy area, however it is often related to as bordermark as well. (Schneider, 1980, p. 16)

Around the village of Wintersdorf most of the descriptive land names are located outside the dikes, hence in the contemporary flood bed of the Rhine. It should be stated that this landscape has been very dynamic, even after the rectification of the Rhine. Therefore, field names in this area might not be so old. The suffixes *–kopf, -grund* and *–see* are examples of this. Most of these suffixes have a prefix related to the land use of the field. Remarkable is the *Lichtenwörth* field, which is the only one that transformed into an agriculutral field on the 1861 map. Two other *-wörth* names (*Vogelwörth* and *Pfarrenwörth*) are the only of these suffixes located east of Wintersdorf, however they are directly located to the Altrhein, and thus still related to the river. Two names that stand out, considering landscape perception are *Böse See* and *Saurhein*. Both propagate a negative image of the river Rhine. This may be due to their location right at the spot where the drowned village of Dunhausen is said to have been. It therefore makes sense that these names are related to the period when the village of Dunhausen was threatened by the river.

The village of Plittersdorf is slightly further away from the research area, but since the Rieddörfer are so much related in archival sources and even nowadays, it is safe to presume that there would have been much interaction between the villages, not least at church services in Selz. Much the same, at Wintersdorf the *–kopf, -grund* and *–wörth* endings mainly occur in the contemporary, still dynamic, flood bed. Exceptions are *Thomaswörth* and *Silberau*, which are located along the former course of the Murg. Another quite descriptive name is *–wald* which in the Plittersdorf area are mainly located along former river arms as well.

Land use

The fields in the *Rieddörfer* usually end with the suffix *-feld*. Around Ottersdorf this includes *Grossfeld, Loschfeld* (might be related to Wintersdorf's early bond with the monastery of Lorsch (Ruf, 1994, p. 204), the *Grünfeld* and the *Mufflheimer Feld*. Near Wintersdorf the *Birkfeld* and *Pfuhlfeld* can be identified. Slightly west of *Grossfeld*, close to the Rhine and around the former location of Dunhausen, *Rheinfeld* is located. Close to Plittersdorf, *Wörthfeld* and *Binsenfeld* can be found. *Wörthfeld* already indicates its location near the water, and the *Binsenfeld* is most probably named after the reed vegetation on the field, which normally grows in wet areas. *Krummfeld* and *Seefeld* also suggest wet fields or at least a location close to water, with matches their location near former Murg arms. Only one *Acker* is documented, the *Wiesenacker* in the north of Plittersdorf. It at least becomes clear that even the fields, which are expected to be suited the best for agriculture often relate to the wet circumstances around the *Rieddörfer*.

Other fieldnames that indicate the use of the land are the *Waideplatz* (also called *Im Wasum*) and the *Fahrmatt* directly east of Ottersdorf. Also, *Schröckmatten* and *Wittmatten* on both sides of the *Schröckmatter Wald* north of Plittersdorf are located relatively close to the village. These *-matt* lands are usually lands with a high groundwater level, or hard to drain due to heavy soils. For that reason, the remaining possibility to use the land is grass production for feeding of the livestock. (Dittmaier, 1963, p. 199)

The fields called *-röder* (or other words derived from *Rodung* (clearance) are related to clearances. Therefore, these fieldnames still reflect the situation in which the land was opened up for use. Indications on former land uses are lost, but the clearances go back to at least the 12th and 13th century, maybe even earlier, because for example in the Murg valley clearances start around the 11th century. Usually clearances occurred earlier around existing villages and thus in the valleys and floodplains. The *-röder* names around Ottersdorf are *Hofröder* and *Wörthröder* (which only dates back to the 18th century), located near the former Rhine arm, which would still have been the main arm in the period of clearances. However, they are located in the inner curve of the Rhine arm and are therefore not at risk of erosion. In the Plittersdorfer district the *Grosse Röder* and *Kleine Röder* are located, both on the other side of the former Murg arm. This is also true for the slightly more southerly *Muffelheimer Röder*. It seems remarkable that all of these *-röder* fields are located east of the villages near the former water arms. However, west of the villages, the Rhine has developed a dynamic landscape; it has been developing at least since the 13th century, and the Rhine might have washed clearances in this area away. The only exception on this is *Schäfers Röder* south of Wintersdorf.

Altogether, the fieldnames provide the image of a very wet landscape, which also influenced the land use. However, the fieldnames indicating land use are regularly located closer to the villages than the names that describe land observation, give the impression that they are mainly too wet to use for agricultural purposes.

7.3 Hypotheses for the field work

Concluding from the preliminary research several hypotheses can be made, that need to be to examined during the fieldwork. Firstly, the LiDAR-data clearly indicates linear elevations, which are interpreted as dikes. A distinction is made between the west-east dike and the south-north dike, because, if elongated, they connect in a 90 degrees angle, which is irregular for a dike and a parallel river. The east-west dike exists in several sections, probably building phases. The south-north dike seems to be one section. Both dikes show a ditch on the riverside of the dike.

The Altrhein, which is mentioned in the 15th and 16th century sources, can be assumed to be the contemporary *Mühlwerlgraben* and *Riedkanal*. This contemporary arm cuts transversely through the dike and the sedimentation band. This suggests that the sediment band parallel to the south-north dike was there earlier than the contemporary Altrhein. The south-north dike seems to have been constructed before the sediment deposition period in 13th and 14th century, because, according to the LiDAR-data, the village side of the dike is lies at a lower elevation than riverside,. It also makes sense that after a period of sedimentation, a river will eventually search for a new and easier course through avulsions. This might have caused the contemporary Altrhein to move to the side of the sediment band. This Altrhein has later meandered along the west-east dike.

The fieldname *Hofröder* is regarded to be related to *Rodung*, the German word for clearance. These fieldnames seem to occur mainly during the 11th to 13th centuries, when a period of intensive clearances occurred, especially in the mountainous areas around the Upper Rhine valley. Whether this occurred earlier in the flood plain is unclear, it seems possible though. This expansion was caused by the need for more agricultural land due population growth. In order to make more fields arable in a flood plain, proper flood management and drainage is essential. The *Hof* in *Hofröder* refers to a farmstead. It does not become clear which farmstead. No sources are known that there has ever been a farmstead on or near the *Hofröder*-field itself. Therefore, it could be possible that a farmstead in the nearby village of Ottersdorf is referred to. The field can most logically be related to the *Vogt-Brünings Hof,* the former *St. Adelheidshof*. St. Adelheid was the land owner of the village in early years. If this was the only farmstead until the disintegration of the Villikationssystem (8th to 13th century, §4.6.3), this could be an explanation as to why the farmstead in *Hofröder* is not specified. Whether the 40 acres land as mentioned in the 991 source also include *Hofröder,* does not become clear.

The south-north dike that became visible on the LiDAR-data east of the field *Hofröder* is therefore expected to date back before the 13th or early 14th century, maybe even as far back as the 11th or 12th century. The west-east dike is supposed to have been built later, at least after the start of the sedimentation period, since the aligning Altrhein indicates more erosion. This would have been a major Rhine arm at least far into the 15th century. From that moment onward, the channel was dammed and probably started to silt up. However, this does not exclude high water levels. Therefore, the dike building phases that are assumed at the west-east dike can be dated up until 1789, when they are mapped.

As mentioned above, it seems clear that the south-north dike is older than the west-east dike due to the fact that the contemporary Altrhein, which is aligned to the west-east dike, cuts through the south-north dike. Besides that, since a meander usually moves outward, it can be expected that the furthest section of the dike is the youngest. When an outward moving meander erodes outward and takes parts of the dike with it, it makes sense to build a new dike section. However, this dike had to be connected to the older section in order to make sure that no water came through. Most logically, the new dike was connected to the older one, instead of the other way around, since the construction of the new dike had to be done anyway (Figure 5.6). In the LiDAR-data, this can be seen very clearly at the most western part. It would have been visible at the central part of the west-east dike, but it seems that another breakthrough hit this weak spot of the connection. Also within the repair point at the most eastern section of the west-east dike, the connection to the remaining parts can be seen. There can be two explanations for the youngest part of this dike has two of these points where it connects. Firstly, like the other, a breakthrough has occurred and it has resulted in a not so clear example. Or, secondly the ditch visible in the LiDAR data was already there, and it would have cost less effort and materials to build past the ditch in a 90° angle. The relative dating of the dike sections already provides much insight in the landscape development of this area.

Since the preliminary research hardly provided any evidence on the dike construction in this area, and none before the 16th century, nothing can be stated on the techniques or the materials used during the construction of the dike for now. However, it seems that a drainage ditch can be found in combination with the dike almost along the whole stretch. It can be questioned whether this ditch worked as a drainage, or if it also provided the necessary earth material for the dike. In order to gain more knowledge on the construction of the dike and to get an absolute dating, fieldwork is necessary, which will be discussed in the next paragraph.

7.4 Field Work: Excavation of an medieval dike

7.4.1 Current situation

The *Ottersdorfer Oberwald* nowadays is a production forest. However, it is also a protected nature area, part of the *Rastatter Ried*. This *Rastatter Ried* is being developed close to natural, removing canal banks and redeveloping the natural erosion and deposition of sediments. This is done in order to stimulate a better living environment for species like the Kingfisher and the Wolffish. (RPK, 2015) The wet former river arms provide perfect locations for meadow- or riverbank ecosystems, providing perfect shelter for animals in the agriculturally used environment. (RPK, 1993, p. 3) The *Oberwald* is, together with the *Geggenau* and *Jagen*, a

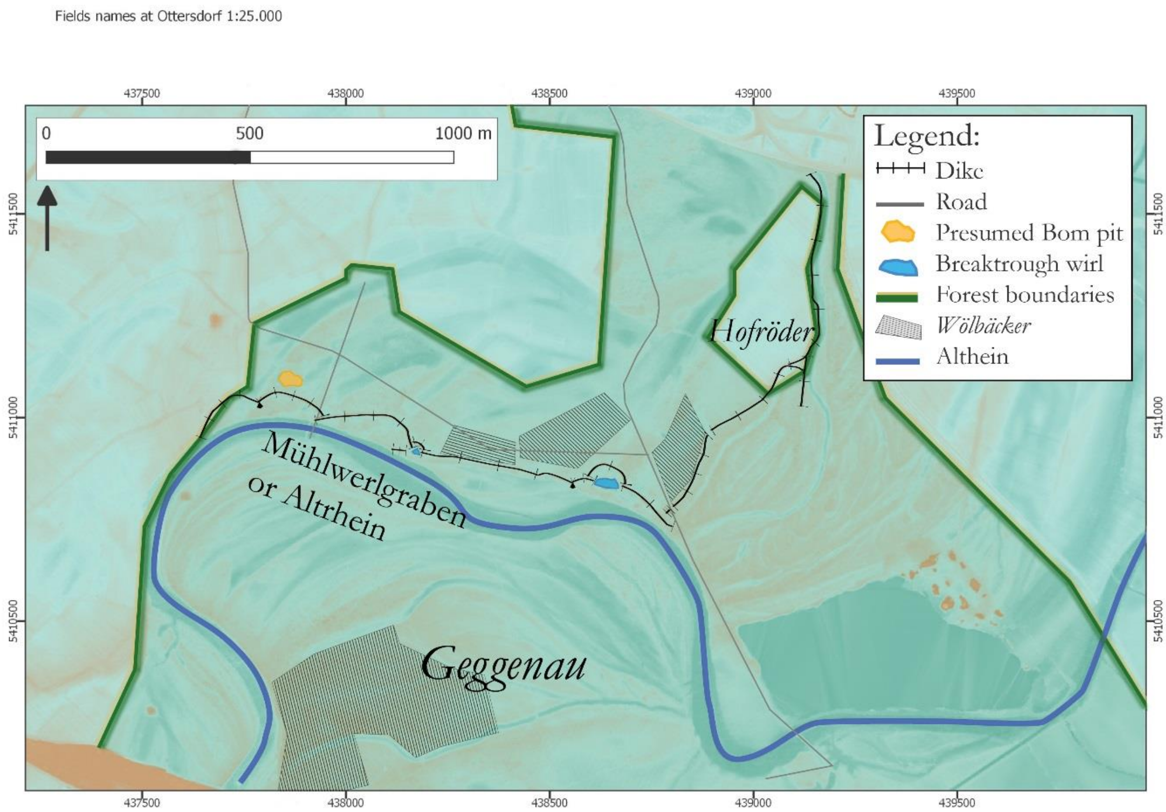


Figure 7.18: A map of the research area containing the dikes, and the Wölbäcker presented in the LiDAR-data

wet Oak-Hornbeamforest, developed from a former hardwood floodplain forest. The slightly vaulted surface provides various water circumstances, resulting in various compositions of trees. Common species in the higher situations in this forest are the European beech, the field maple, the mountain maple, and the oak, complemented with a varied herb layer. The lower and wetter areas consist mainly of alders and ashes.

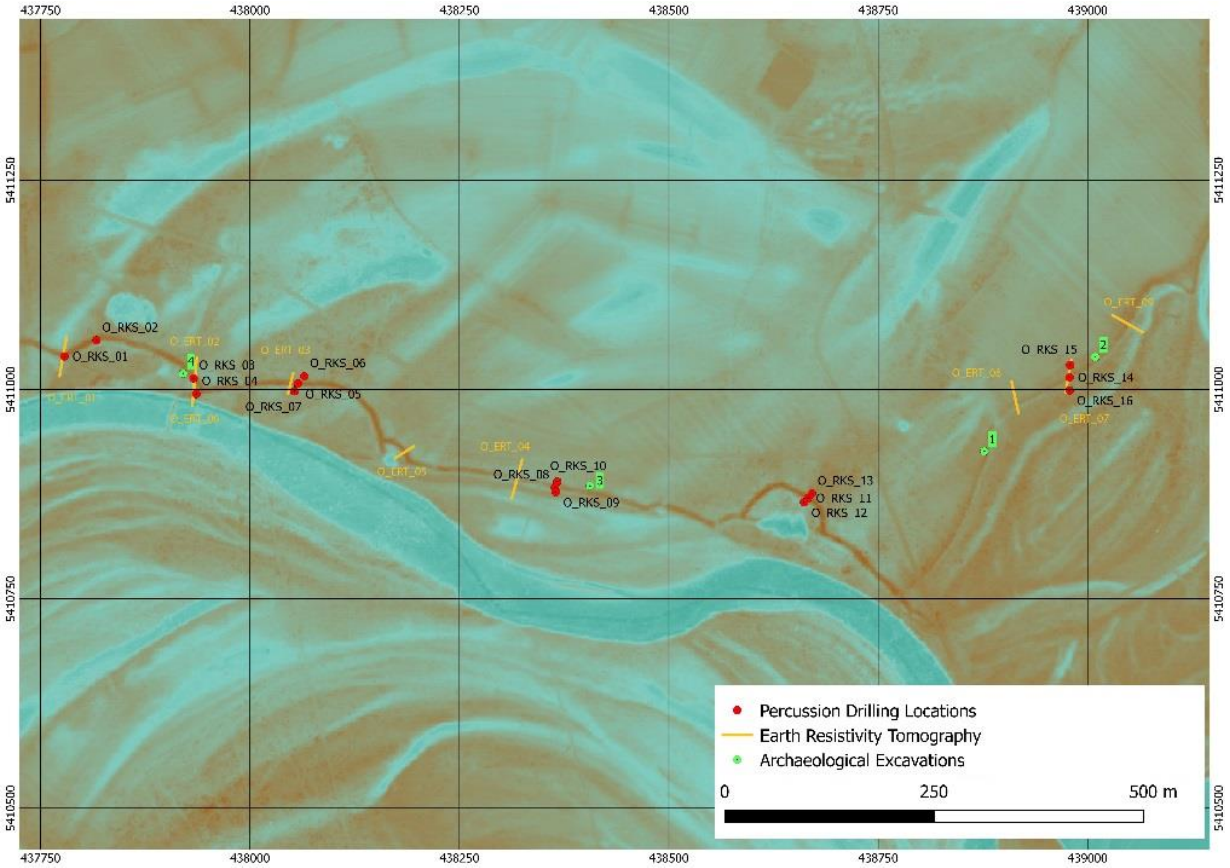


Figure 7.19: Overview of the conducted fieldwork in the Ottersdorfer Oberwald

(RPK, 1993, p. 6) Also important in this forest area are the forest edges, in which the gradual transition towards the grazing lands that are rich in species takes place. The most important disturbances in this area are the railroad on the southern border, and the Kaltenbach gravel-mining pound on the former field *Wörthröder* in the south-eastern part of the forest at the point where the *Mühlwerlgraben* enters the Riedkanal. (RPK, 1993, p. 7) Because of the is nature and landscape protection, the forest area was not accessible for our research team during the period of March to October.

The former dike line is well known and well visible within the forest during the winter period. Covered by a layer of organic material and many trees and shrubs, the west-east dike is elevated 50 centimetres to over 1 meter above the average surface level. The south-north dike is a bit lower, but usually around 50 centimetres above the surface level. A road runs parallel to the west-east dike with varying distances from this dike, figure 7.19. Where the west-east dike should meet the south-north dike, a road runs south in the direction of the gravel pit. Another road goes north and after several turns, out of the forest again. In both dikes, several hollows were cut into the dike, all transversing in a 90° angle in order to get to the other side, on behalf of the wood production. Another hollow was cut at the small bridge, the *Mühlwerlsteg* in the western part of the forest area. This bridge crosses the *Mühlwerlgraben* to the *Geggenau* forest on the other side. The *Mühlwerlgraben* contains hardly any water (during drier periods), but gains more and more water and could definitely be considered a stream beginning from the bend in the river around the point where the two dikes should have connected. Up to the point where the *Mühlwerlgraben* can be considered a stream, it is embedded in a flood bed with a depth of about 2 meters. However, during the high water period that we have experienced in January 2018, the water level did by no means come close to this height. During the low water season, there is no water under the *Mühlwerlsteg*-bridge at all.

The forest is a popular place for local recreational purposes like running or walking the dog. Other returning users of the forest are people with foresting rights gathering their yearly wood during the winter period.

7.4.2 Geo-electrics resistivity and corings fieldwork

During fieldwork in 2017, conducted by Janine Lange and Jan Schmitt (2018), six geo-electric resistivity measurements and thirteen corings have been conducted, figure 7.20 Most of this research was focused on the west-east dike, although it is expected to be slightly younger than the south-north dike. Since various building phases could be clearly recognized and this dike is well accessible, this area would be an easy and efficient subject for the excavation in 2018. The majority of this fieldwork's findings have been confirmed by the later excavations and will therefore be discussed in the next paragraph. However, three findings have to be singled out here.

Firstly, the geo-electric resistivity O_ERT_02, located close to the later discussed dike section IV, shows a low resistivity area right in front of the dike on the riverside. Since the resistivity within the dike is high, caused by a surprisingly thick layer of gravel in the body of the dike. Since the gravel layer in front of the dike is lacking, it could be that the gravel in front of the dike has been removed, and has been used in order to elevate the dike. This is a clear indication that materials to elevate the dike are exploited near the dike, as will be elaborated on when discussing dike section IV.

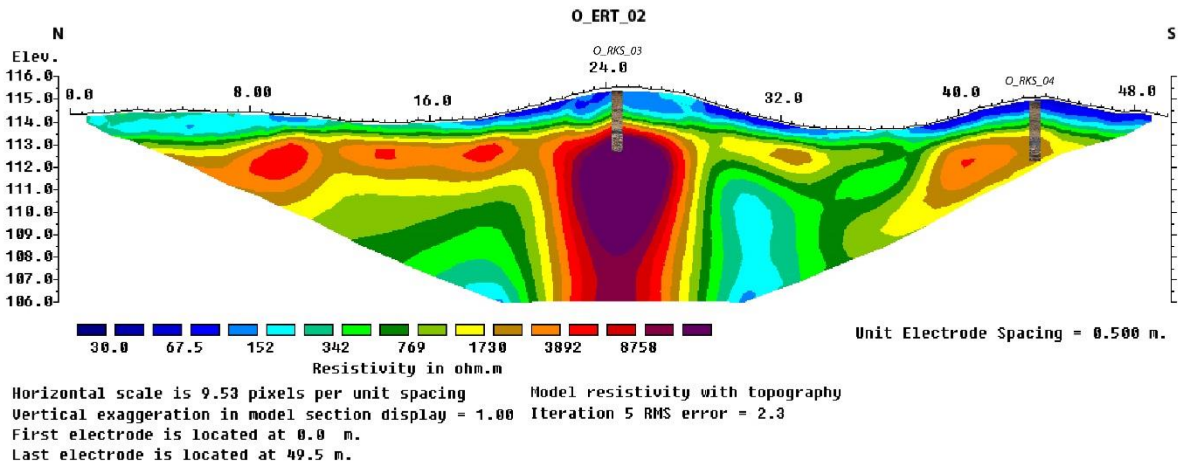


Figure 7.20: O_ERT_02 shows a small area without high resistancy right of the dike, on the riverside. It is assumed that this could be the former location of the gravel identified within dike section IV. Important evidence in order to argue that building materials are gained locally.

In the same surrounding area of dike section IV, several corings have been conducted. These corings illustrate the actual composition of the soil, in order to compare and extrapolate it with the geo-electric data. But additionally charcoal was found in the corings O_RKS_04, and O_RKS_08 and a shell in O_RKS_03, which were all taken from the underneath the dike. For that reason, the charcoal and the shell are dated. The charcoals from coring O_RKS_04 and the shell were taken about 100 centimetres underneath the surface, which would mean they were probably located within the dike body. Therefore thesecharcoal and shell have probably been in the sediment when the dike was constructed. Unfortunately, the shell dates back more than 3000 years ago. (Table 7.1) The charcoal of O_RKS_04 dates back 1132 years with a deviation of 20 years, which means that the charcoal was created in the 8th century. Coring O_RKS_04 is suspected to be one of the youngest parts of the dike. The coring RKS 8 was taken in the assumed oldest part of the west-east dike. The charcoal there was found between 178 and 188 centimetres underneath the top of the dike, and would thus be located in the fluvial sediments underneath the dike. Again, a *terminus post quem* can be expected, which was confirmed by the dating of 28000 year BP. The best possible conclusion from this datings is thus that the middle part of the west-east dike at coring O_RKS_04 is at least younger than the 8th century, which easily fits into the hypotheses.

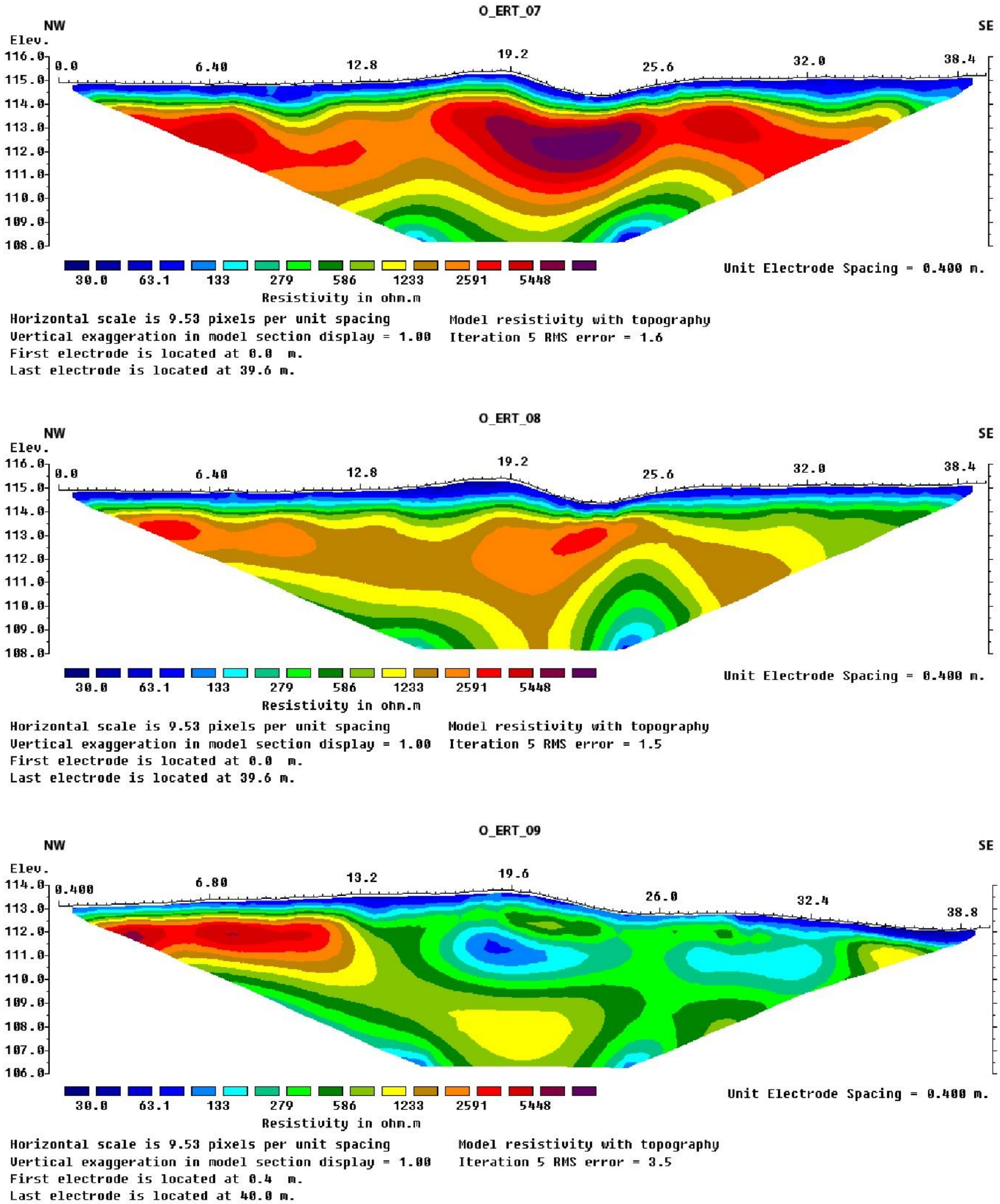


Figure 7.21: Three ERT's on the south-north dike show hardly any difference between the hinterland and the riverside of the dike. Only O_ERT_09 shows such, but it might bethere has been a river channel at all.

One final remark comes from a geo-electric resistivity measurement over the south-north dike (Figure 7.21). O_ERT_07, O_ERT_08 and O_ERT_09 were taken from northwest to southeast covering the south-north dike, which is considered the oldest. Remarkable about these geo-electrics is that only in O_ERT_09, a clear decrease in resistivity can be seen on the riverside of the dike. This is also the case for the geo-electrics at the east-west dike and several geo-electrics at the Speyer case study. Because such is lacking in O_ERT_07 and O_ERT_08, it might be wondered whether there was a river channel close to the dike or maybe slightly further away. Before jumping to conclusions, it has to be stated that in this area the river channel has significantly deposited sediment and thus lays higher than the hinterland, while in the other examples, the river channel has cut itself lower than the hinterland.

Table 7.1: ^{14}C Datings Ottersdorf Jan Schmitt.

Core	Depth [cm]	calibrated age 1-σ	calibrated age 2-σ	^{14}C-Age BP	sample type
O_RKS_03	100	cal BC 3330-3101	cal BC 3340-3092	4487 ± 26	shell
O_RKS_04	100	cal AD 890-963	cal AD 780-982	1132 ± 20	charcoal
O_RKS_08	178-188	cal BC 28890-28638	cal BC 29010-28474	26380 ± 120	charcoal

7.4.3 Archaeological cross-sections (soil profiles)

The Ottersdorf dike excavations was one of the field case studies of this project in order to overcome the lack of written sources mentioning dike construction in the medieval period (8th to 13th century). The case of Ottersdorf was chosen because it would be among the oldest identified dikes in the Upper Rhine valley, if the hypotheses on its construction before the 15th century holds up. If the dikes date back before the 13th century, they would become the oldest known dikes in the Upper Rhine and thereby contribute significantly to the flooding history of the Upper Rhine. The locations of the four trenches were chosen in order to clarify different building phases of the dike section. Two trenches were made in the south-north dike, and two in the west-east dike in order to compare them within the dike as well. In the south-north dike various construction phases are not explicitly known. Nevertheless, the two trenches provide the possibility to double check the results. The locations in the *Ottersdorfer Oberwald*, which has been a forest on maps since the 18th century. This indicates hardly any modern interference in the dike relicts. The forestry office Rastatt confirmed in personal correspondence that over the last 180 years only forest roads have been improved, and no other disturbance of soil has taken place within the forest. Also, some trees around and on the dikes indicate an age of an estimated 200 years. Most of the water bodies indicated on the Gemeindewald map of 1789 (figure 7.15) are nowadays not carrying water anymore, however, these are of course the places where pressure water comes up first and thus they are areas of swampy soils. The elevations that are considered (the dikes) are somewhat topped of, especially the south-north dike. However, such erosion can be expected over long extents of years. Within the trench's profile, this will be confirmed by a thinner humus layer on top of the dike, and a thicker pack of humus sediments at the feet of the dikes. For this reason, exact measurements on the dike body are not indicative for the measurements of the dikes during the time they were built.

Although the project has a wide range of research topics to which this case study will contribute, there are also some questions specifically for this case study.
The research questions for this excavation were:

1. Can these elevations in the landscape be considered anthropocene, which we interpreted as dikes in the conclusion of the preliminary research?
2. How old is every dike section?
3. How was the dike constructed and were did the materials come from?
4. Can various building phases be recognized in the body of the dike?

As made clear in the hypotheses (7.3), the archaeological excavations can provide us with answers to the question whether an elevated body of earth in the landscape is anthropocene. This can be recognized by wooden or stone constructions within the dike body, or the clear piling of sods. However, both are not expected in this case. Therefore, differences between sediment layers should be paid attention to, especially differences in material, grain size or colour. However, if the floodplain was vegetated, as has to be expected, a humus layer can be expected right underneath the dike. However, Bartels argues that the top surface might have been removed in order to keep the dike from slipping. (Bartels, 2016, p. 179)

The excavations also have to provide conclusive arguments in dating the dike. Although its construction is expected between the 11th and 13th century, it is known that a clearance in the flood plain already happened in the 10th century, and the *Hofröder* field indicates a clearance. This goes for the south-north dike, because the west-east dike is expected to be younger. It is unclear how much younger, even an early modern age cannot be excluded.

Because the dikes are expected to be medieval, no visible construction is to be expected. Although a few late medieval Dutch dikes show sods, this only makes sense in case of heavy clay soils. (Bartels, 2016, p. 523) Since more sandy soils are expected in the research area, the presence of a sod construction seems unnecessary. Wooden or stone constructions are usually more modern (15th, 16th or 17th century) On top of that, the excavation trenches are mainly located in the inner curve of the Rhine, and thus no extra erosive measures had to be taken.

Recent studies by Bartels and Mulder show that dikes are quite often strengthened and thus elevated or broadened over the years. (Bartels, 2016; Mulder *et al.*, 2001; 2002, 2003; 2004; Mulder, 2002) Whether multiple building phases are to be expected is hard to say, since it depends on how long the dike was actively used and how often it was damaged. However, the west-east dike indicates various building phases from its spatial stratigraphy as discussed in §7.3. Various dike construction phases can be recognized by sudden changes in sediment. On top of that, every construction phase had to be built on top of a former surface layer, a humus-rich layer, which should be recognisable by a slightly darker colour. However, depending on the period, the former surface layer might not have developed a humus layer, and a short period of exposure might hardly be visible.

The archaeological excavations in the Ottersdorfer Gemeindewald were only allowed during the months November to February since it is a protected nature area. The excavation therefore took place beginning from the 8th January to the 14th February of 2018. The lack of foliage provided the benefit of an easier access to the more remote dikes like the presumed oldest south-north dike, (Dike section I and II) which were excavated by hand with two to four people. (Figure 7.24) In consequence, these trenches that had to be dug completely by hand provided the possibility of easily observing differences in corn size and colour-changes of the soil while excavating. The two easy accessible cross sections in the presumed younger west-east dike (dike section III and IV) were chosen close to an existing cut through the dike by a forest path and therefore better accessible for an excavator. During the whole campaign, special caution was given to archaeological findings like pottery, charcoal or bones. By chance, various materials could be retrieved and were labelled and archived. However, the most important outcome of the archaeological excavation were the cross-sections showing the profiles of the layers (Stratigraphy) in the subsoil. The trenches through the dike were made across the dike. The profile resulting from this shows the differences between the soil layers on the hinterland side of the dike, the dike body itself and the soil layers on the riverside. (figure 7.23) After those were photographed, drawn and sampled in various ways the trenches were closed again by the excavators in order to leave as little traces as possible in nature. Unfortunately, trenches were only allowed to be 1 meter wide and therefore photographing the profile was hardly possible. For that reason, drawings are the

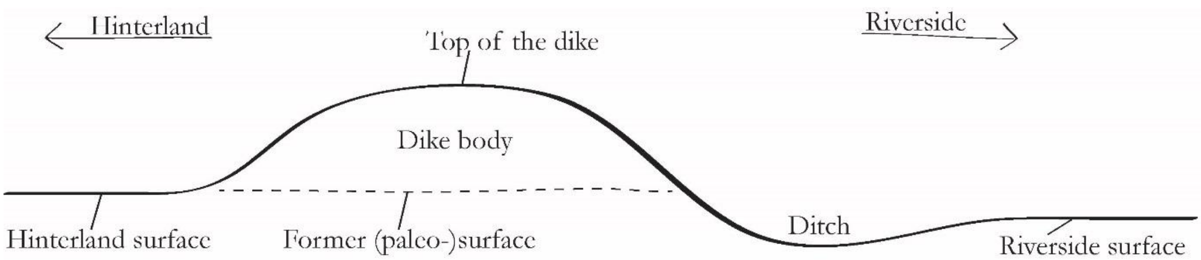
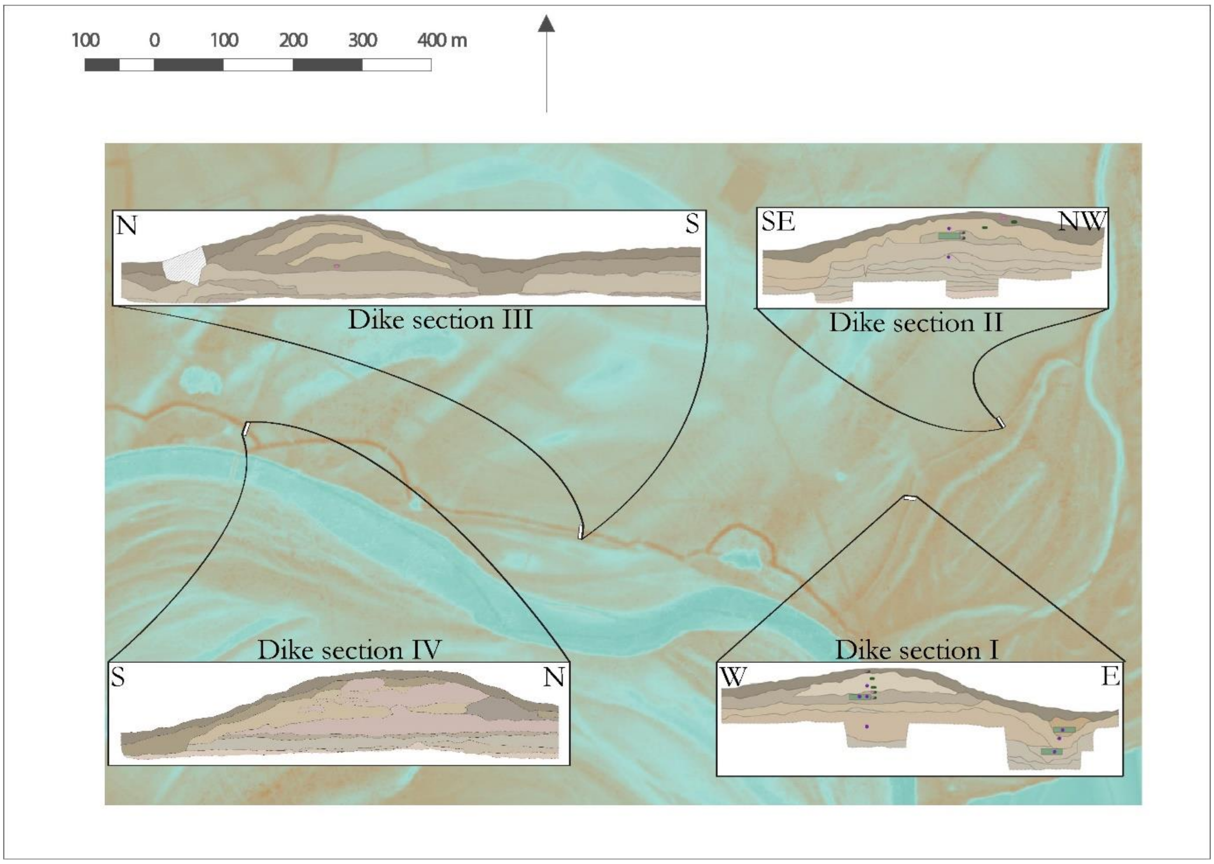


Figure 7.22: Dike body, in study always has a ditch at the river side of the dike.

best representation of the profile. Additionally to the drawings and panoramic photographs to give an impression of the situation in the field, a table was created with further information on the various sediment layers and their colours, consistency and inclusions.

Figure 7.23: The four dike section on the LiDAR-data, as they are located in th Otterdorfer Oberwald.



The profiles of the scrutinized cross-sections can be split into two periods: the pre-dike profile, which is expected to contain various layers of flood sediments and a certain degree of homogeneity, while the layers of the actual dike should contain traces of human activity and may vary in consistency or material. In the former period, the phases of fluvial sediment deposition can vary a lot in their thickness, depending on the available sediment in the river. During a flood, the thickness and grain size of the sediment might differ from one another, because a river normally has more energy during a flood. In addition, the duration of a flood influences the thickness of a deposition layer. The sediment colours and corn size might vary, caused by the origins of the sediments. The second phase visible in the profiles are the dike bodies themselves, containing homogenous material and a humus layer on top of it. As mentioned before, eventually multiple construction phases can be recognized, and construction materials can be found.

Dike section I: south-north near forested hinterlands (Top of the dike 115,27 m NN)

The first dike cross-section (Dike-section I) is located in the supposedly older south-north dike. This section is 940 centimetres long, including the westernmost elevation in this part of the forest, a reduced ditch right at the feet of this elevation and the actual main dike body, figure 7.25. The height of the top of the dike compared to the surface behind the dike at the village on the (western) side was 50 centimetres. However, the total height difference from the top of the dike to the deepest part of the cross-section on the paleo-gravel soil was 240 centimetres. The surface on the riverside of the dike was 105 centimetres lower than the top of the dike. The cross section was slightly over 100 centimetres wide, because of the restrictions in the nature protection area.

Starting from the top (Figure 7.26), the layers are structured as follows: The surface layer (Bef. 001) of the section was on average about 20 centimetres thick and consisted mainly of dark brown humus. Underneath this humus layer, the dike body became visible. The somehow brownish but mostly yellow sandy (Bef. 002) elevation was almost 50 centimetres thick at its highest in the centre and gradually evened out at both sides of the dike. Underneath the hinterland and underneath the dike a brownish paleo-soil (Bef. 003) of about

Figure 7.24: Panoramic view of dike section I

30 centimetres was visible. Since it was levelled with the contemporary hinterland soil, this seems to be the former surface. The brownish colour was probably caused by continuous humus forming, and degradation causing the slow decolouring. The layer did not continue on the riverside of the dike, which might indicate that it had never been there, or, more plausible, that it has been washed away by the river‘s current. Beneath the paleo-soil another greyish yellow sand layer (Bef. 004) of 20 centimetres thickness was visible, which continued underneath the ditch on the riverside. It is interesting to mention a bright grey sandy ellipse (Bef. 005) of only 90 centimetres in length and 10 centimetres thickness in the centre under the dike. Underneath this sandy ellipse lay a very thick grey yellow loam layer with rusty spots (Bef. 018). This layer was up to 80 centimetres thick and covered the whole length of the profile up towards the ditch on the riverside of the dike. In the central trench, layer 018 was followed by a bright greyish sand layer (Bef. 019), which was also recognized at the same height underneath the ditch in layer 024.

The ditch shows a more complex sequence of layering: Underneath the humus it was filled with a reddish brown clay material (Bef. 020) which is at the widest 100 centimetres wide. Underneath the ditch, layer 018 seems to duck into something that seems to be an older ditch (Bef. 021). This older ditch seems a bit unnatural due to its steep vertical border. The colour of the aforementioned layer shifts into a slightly greyer colour here. A possible cause for this could be poor drainage or the accumulation of humus and iron particles. This possibly older ditch was cut out of a dark grey sand layer (Bef. 022) with rusty spots. Underneath this, a thin grey sand layer (Bef. 023) can be recognized. A sandy and bright grey layer (Bef. 024) follows, which seems to be comparable to 019. Underneath this a gravel layer follows, which is not visible in the drawing, but is seemed to be covering the whole area. It indicated a phase of high energy drainage of the river, assumed to have occurred after the last Ice Age.

Dike section I has become the focus of the research since the profile showed dike construction so clearly and most samples were taken from there. Most were taken from underneath the dike, in order to get a date which predates the dike’s construction

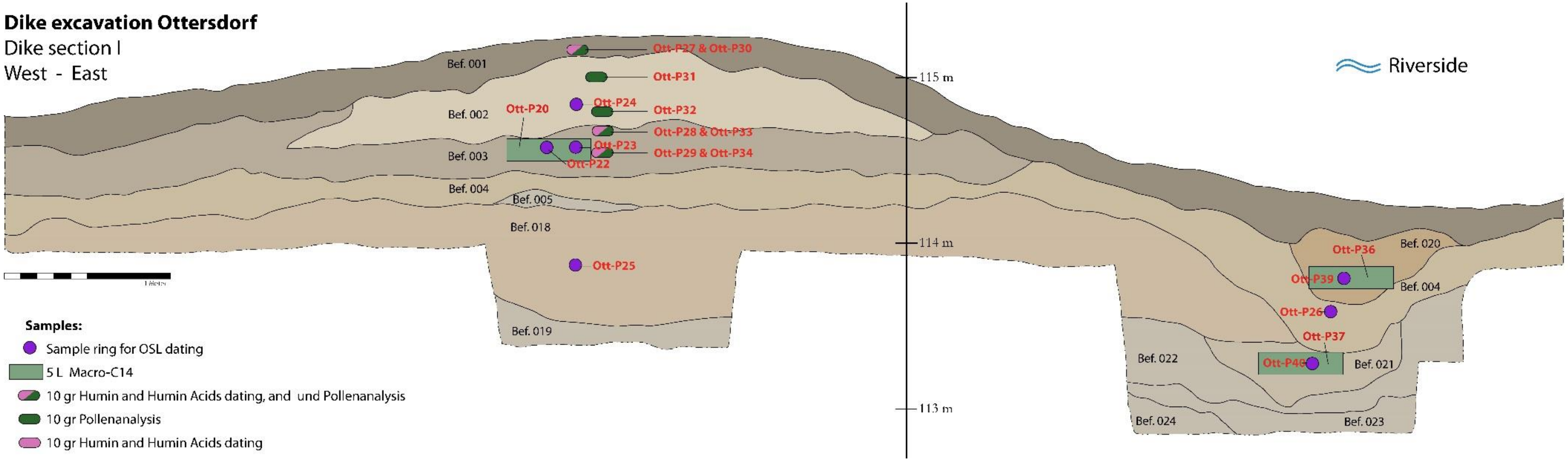


Figure 7.25: Schematic drawing of dike section I

Table 7.2: Details on the soil layers of dike section I.

Bef. Nr.	Section	Description	Colour	Rust	Consistency	Roots?	Snails	Pebbles	Classification
Bef. 001	I	Humus	Dark brown		Humose	Many roots			H
Bef. 002	I	Raised dike body	Yellow, brownish		Sandy, slightly clayley	Many roots			Ah a
Bef. 003	I	Humus gradient and former surface (humunized)	Brown		Clayley and Sandy	Some roots			H b
Bef. 004	I	Sandy band	Greyish yellow		Sandy with silty share	Few roots	Some snails		ABC b
Bef. 005	I	Grey sandy containment	Light grey	Rust	Sandy				Fluvial
Bef. 018	I	Tihck loamy layer	Greyish yellow	Rust	Clayley with a small silty share	Few roots	Few snails		Fluvial
Bef. 019	I	Light Sandy	Light grey		Sandy				Fluvial
Bef. 020	I	Redish brown clay in the ditch	Redish brown		Clayley and a little sandy	Roots			a
Bef. 021	I	Former ditch fill	Grey	Rust	Loamy and Sandy	Some roots			b
Bef. 022	I	Sandy band	Dark greyish	Rust	Sandy with minimal clay				Fluvial
Bef. 023	I	Thin sandy band	Grey	Rust	Sandy				Fluvial
Bef. 024	I	Sandy, light greyish yellow	Light grey		Sandy				Fluvial

7.4.5 Dike section II: south-north near cropland hinterlands (Top of the dike 113,05 m NN)

The second cross-section (Dike-section II) on the south-north dike is located about 200 meters north of dike-section I, near the *Hofröder* field. Dike section II is 810 centimetres long and again about 100 centimetres wide, figure 4.26. The forest around this dike section was denser than the first section, and especially on the riverside many recently planted trees disturbed the excavation. Although the location with the least disturbances was chosen, some roots still caused minor disruptions in the profile. For this reason, the profile

Figure 7.26: A hand-made roof tile, without its charateristic elements. make it hard to date.

drawn was the south profile of the section, as becomes clear from figure 7.29. The hinterland of the dike was 40 centimetres lower than the top of the dike and 50 centimetres higher than the ditch on the riverside. The maximum depth of the trench was 210 centimetres.

The humus layer (Bef. 006) covering the soil with a pack of leaves and organic materials was about 15 centimetres thick, and slightly thicker on the slopes. The layer underneath the humus still contained many roots and other organic materials, especially in the ditch. (Figure 7.26) The latter also contained some finds,

Figure7.27: Panoramic view of dike section II

includin6g some bird bones and a roof tile. (Figure 7.27) This roof tile is hand-made and, thus assumed pre-industrial. However critical characteristic to date the roof tile are lacking. This layer (Bef. 007) had a brown yellowish colour and coverd the whole cross-section with a thickness of 30-40 centimetres. Because it covered the whole section it seems hard to believe that this would be an artificial dike elevation. In comparison to dike section I no distinct mound of dike material can be recognized. However, a slightly darker ellipse of soil seemed to lie at the bottom of layer 007, right underneath the dike. This darker (dark brownish-yellow) area was 240 centimetres in length and 20 centimetres in height (Bef. 008). This could indicate a former surface level, being darker because of the presence of humus, which was on the surface before the dike was built on top of it. As was seen in dike section I, the height of this darker layer suits the height of the hinterlands behind the dike very well. Layer 008 did also not continue underneath the hinterland, which makes sense if it is only the dike body. It is however quite thin for a dike. On top of that the layers above, 006 and 007 continue underneath the ditch and the hinterland, but are quite thick. Depending on the age of the dike this is quite a large quantity of sediment deposited on top of the dike, but also in its hinterlands. This could indicate that the dike overflowed here. However, in this case, the layer did not clearly continue into the contemporary surface soil. The dike body was followed by a sequence of fluvial sediments that can be summed up as following: a sandy brown yellow layer (Bef. 009) underneath 008 was about 40 centimetres thick. This layer ended at the ditch on the riverside. The following layer (Bef. 010), which was a greyish yellow and about 20 centimetres thick stretched from the hinterland to a point exactly at the centre under the top of the dike. From here on down, traces of rust could be identified in the layers underneath, caused by dynamic groundwater levels. The bright grey sand layer (Bef. 011) underneath was located only under the dike and was hardly 20 centimetres thick. Only in the centre under the top of the dike, a thickness of about 30 centimetres was measured. The sandy reddish grey layer (Bef. 012) with rusty spots covered the whole length of the profile, only disturbed by a root, which came down from layer 009 at the foot of the dike on the riverside. A greyish yellow sandy layer (Bef. 013) of 20 centimetres thickness ended at the ditch as well. The three following layers underneath however appeared to continue in both pits, underneath the dike as well as underneath the ditch. The darkish grey layer (Bef. 014) was about 10 centimetres thick and consisted of compact sand. The grey layer (Bef. 015) beneath was also 10 centimetres thick, but consisted of compact fine sand. Like in dike section I, this was again followed by a gravel layer (Bef. 016) which consisted of gravel and coarse sand of a reddish colour, which again is presumed to be the covering gravel layer after the last Ice Age.

The only layer that was clearly a filling of the ditch, located between 007 and above 014, consisted of yellow grey sand (Bef. 017) of 20 centimetres thickness. The aforementioned layers 009, 012, and 013 ended at the exact beginning of the ditch, this was probably caused by construction of the ditch, and/or it washed away during the periods the ditch was still a running water course.

Two OSL samples have been taken from dike-section two. They were taken from layer 008, which is the suspected former surface before the dike construction. When comparing these samples with samples from dike section I's layer 003 (also former surface), they should correlate to the same time period, since dike-section II lays in line with dike section I.

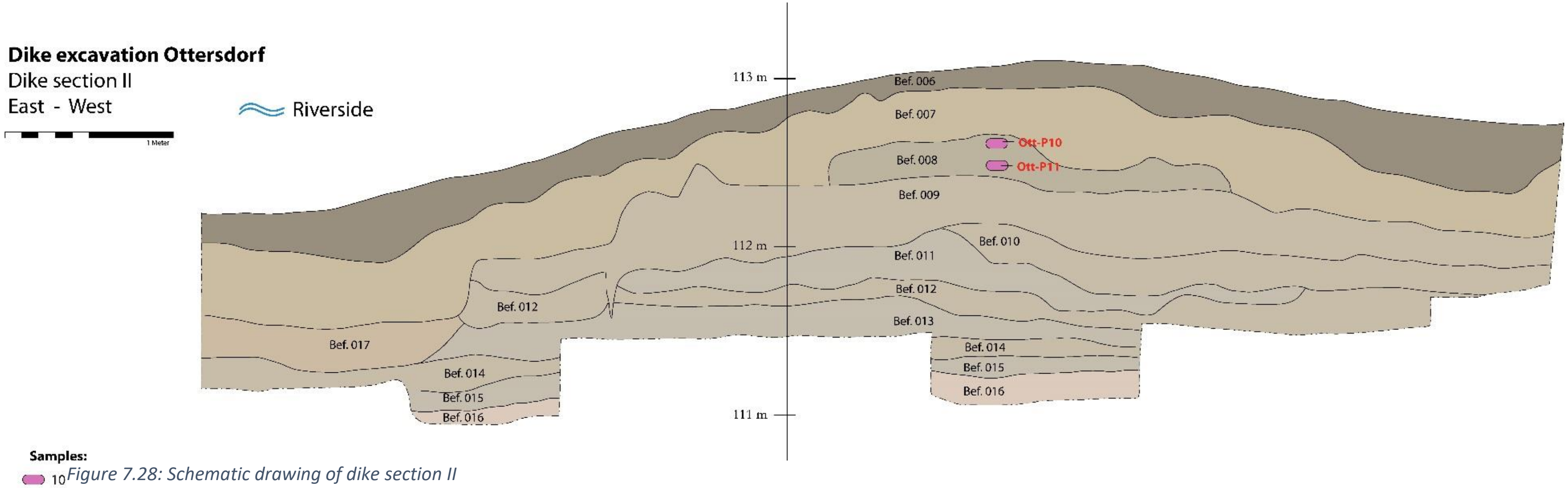


Figure 7.28: Schematic drawing of dike section II

Table 7.3: Detail on the soil laters of dike section II

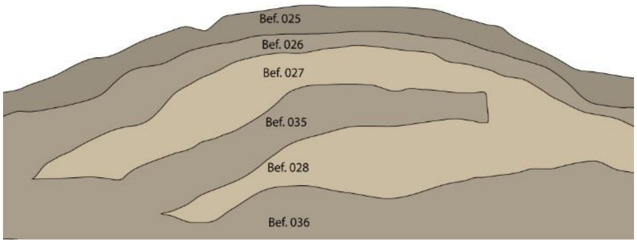
Bef. Nr.	Section	Description	Colour	Rust	Consistency	Roots?	Snails	Pebbles	Classification
Bef. 006	II	Humus	Dark brown		Humose	Many roots	Snails		H
Bef. 007	II	Humus gradient (raised dike body)	Brown yellowish		Loamy sand	Many roots	Snails		ABC a
Bef. 008	II	Former surface (humunized)	Dark yellowish brown		Silty sand	Roots	Snails		H b
Bef. 009	II	Brown yellow loam with rust	Brown yellowish		Silt loam	Few roots	Few snails		ABC b
Bef. 010	II	Grey yellowish sand with rust	Grey yellowish	Rust	Sandy silt	Few roots			Fluvial
Bef. 011	II	Grey fine sand with rust	Bright grey	Rust	Sand				Fluvial
Bef. 012	II	Rusty sandy layer	Reddish grey	Rust	Sand				Fluvial
Bef. 013	II	Bright grey fine sand with rust	Greyish yellow	Rust	Sand				Fluvial
Bef. 014	II	Enlonged grey band with rust	Somehow darker grey	Rust	Compact sand with clay				Fluvial
Bef. 015	II	Compact grey fine sand layer	Grey	Rust	Compact fine sand				Fluvial
Bef. 016	II	Gravel layer	Reddish grey		Gravel and coarse-grained sand				Fluvial gravel
Bef. 017	II	Yellow Grey silt sand with rust	Yellowish grey	Rust	Schlufig Sandig	Few roots			Fluvial gravel

7.4.6 Dike section III: west-east (presumably oldest part of the dike) (Top of the dike 115,44 m NN)

The third dike section was chosen in the oldest part of the west-east dike. The section through the dike was dug by an excavator, and therefore located about 1 meter from a pathway (Figure 7.30). The section is 100 centimetres wide, and the profile on the eastern side of the section is drawn (figure 7.31). This section has a length of 1430 centimetres, and is longer than the former two because it was presumed that there might be another dike lying parallel to the south, located right in front of the riverside of the dike. However, the excavations provide no indication of any human involvement in the construction of this slight elevation of 30 centimetres above the contemporary surface. The top of the actual dike is 150 centimetres above the hinterland surface. The surface in the ditch was in this case 10 centimetres higher than the hinterland surface. This is not unusual since apparently, this ditch did not erode deeper because of the dike, but sediments that were deposited elevated the riverbed. This makes sense because the section is located in the inner curve of the river channel and therefore sediment is deposited there. The total height difference between the top of the dike and the lowest point in the section is 220 centimetres. It has to be noted that a tree trunk disturbed this profile at the foot of the dike in the hinterland.

The topmost humus layer (Bef. 025) of this third dike section is 20-30 centimetres thick, however, at the ditch - in this case between the dike and the natural elevation - it gets up to 40 centimetres thick. The humus here is a bit more greyish in colour than the humus layers from dike sections I and II, which are browner. On the hinterland side of the dike, on its slope, a removed tree trunk disrupted the profile, which is marked in the drawing. Directly underneath the humus layer a brownish grey transition layer (Bef. 026) can be seen. This layer is regularly 30 centimetres thick, however, on top of the dike it is only 10 centimetres thick. This layer also seems to be a former surface layer, since it continues horizontally underneath the dike (Bef. 036), with a thickness of 40 centimetres, but without showing a clear border. It could even be said that another feature is formed within the dike body. This seems to indicate a second surface phase, which suggests a second construction phase. (Figure 7.29) This feature (Bef. 035) is the original humus layer of the (first) dike at about 60 centimetres height above the former surface level and it is about 30 centimetres thick. Borders between the layers in this feature are unfortunately very unclear. Between these unclear forks dike sediment is visible. It consists of yellow-brownish sand, which also does not have a clear border, almost as if some sediment has been washed away or has been cleared. The top and youngest yellow-brownish sand is slightly brighter (Bef. 027) than the older dike sediments (Bef. 028).

Tabelle 7.29:A zoom on the second construction phase of dike section III, which variuous soil layers were hard to distinguish.



Underneath the complex layer 026 and 036, which are the former surface layers, rusty spots appear within another layer of greyish yellow loam (Bef. 029). This layer is about 60 centimetres thick, except underneath the hinterland side slope of the dike, where it is only about 30 centimetres. This layer is only interrupted at the ditch. Underneath layer 029, a bright grey (somewhat yellowish) sandy layer (Bef. 030) is located in the area under the dike. In between this layer 030 and the aforementioned 029 on the hinterland side of the dike, three other layers are visible. Firstly, a bright grey sand layer (Bef. 032) on top of 030; secondly, on top of that, a yellowish-grey loam layer (Bef. 033) containing rusty spots. Thirdly, on top of 033 a tiny grey-yellow sand ellipse of only 40 centimetres is present (Bef. 034).

Another sandy ellipse can be identified underneath the natural elevation on the riverside. On top of layer 029, a small bright grey ellipse of coarse sand is visible, which is about 110 centimetres in length (Bef. 031).

Underneath the ditch this 026 layer became wet and continued into the bottom of the section, which is the gravel layer (Bef. 048). The gravel layer on the bottom of the section was not visible everywhere, but is assumed to be present continuously underneath the whole section. This gravel layer consists of reddish gravel and coarse sand.

Figure 7.31: Panoramic view of dike section III

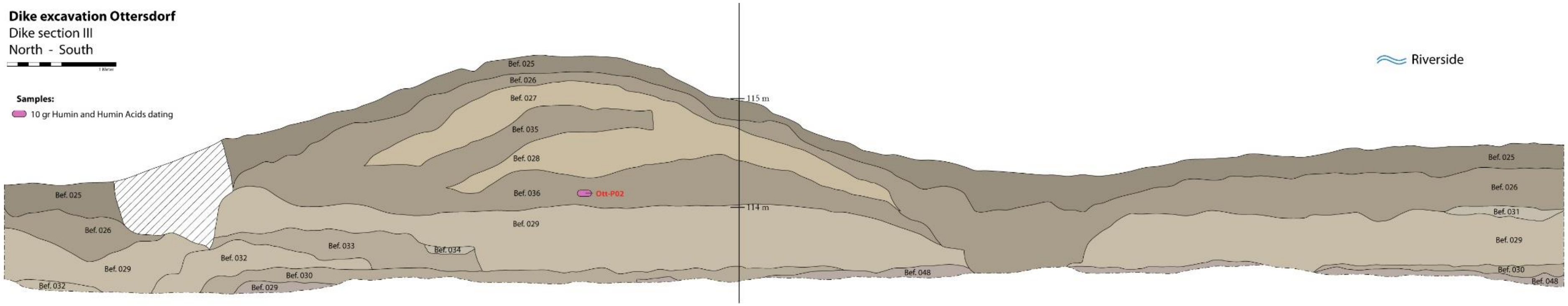


Figure 7.31: Schematic drawing of dike section III

Table 7.4: Detail on the soil laters of dike section III.

Bef. Nr.	Section	Description	Colour	Rust	Consistency	Roots?	Snails	Pebbles	Classification
Bef. 025	III	Humus	Dark greyish		Humose	Many roots			H
Bef. 026	III	Humus gradient and former surface (humunized)	Brownish grey		Loamy and sandy	Roots		Gravel	AB a
Bef. 027	III	Bright sandy raised dike body	Brightest yellow brown		Sandy loam	Sever roots			BC a
Bef. 028	III	Yellow brownish loam and sand layer	Yellow brown		Loamy sand	Some roots			ABC a
Bef. 029	III	Grey yellow loam layer with rusty spots	Grey ish yellow	Rust	Sandy loam	Some roots			ABC b
Bef. 030	III	Bright grey sand layer	Birght grey (slightly yellowish)	Rust	Sand				Fluvial
Bef. 031	III	Coarse-grained sand elipse	Bright grey	Rust	Coarse-grained sand	Few roots			Fluvial
Bef. 032	III	Grey-yellow sand	Birght grey (slightly yellowish)	Rust	Silty sand				Fluvial
Bef. 033	III	Grey yellowish with rusty spots	Grey yellowish	Rust	Sandy loam			Gravel	Fluvial
Bef. 034	III	Grey yellow sand elipse	Grey yellowish	Rust	Sand				Fluvial
Bef. 035	III	Middle fork of [026]	Brown yellowish		Sandy clay	Some roots	Few snails		H b 1
Bef. 036	III	Bottom fork of [026]	Yellowish brown	Rust	Sandy clay	Some roots	Few snails		H b 2
Bef. 048	III	Gravel layer	Somehow reddish		Gravel and coarse-grained sand				Fluvial gravel

7.4.7 Dike section IV: west-east presumably youngest part of the dike (Top of the dike 115,58 m NN)

Dike section IV was cut into the youngest part of the west-east dike, along the path over the Mühlwerl bridge, with its profile on the western side of the section. The excavator dug out about 100 centimetres deep, again making sure that the profile was about 1 meter away from the path in order to diminish disturbances (figure 7.33 and 7.34). The trench had a length of 1100 centimetres. The surface in the hinterland is elevated 90 centimetres lower than the top of the dike, on the riverside this is 160 centimetres, which is remarkably different than at dike section III. The lowest point of the section is 130 centimetres lower than the surface on the landside of the dike. A remarkable thing that was noted during the excavation was that slightly under the street level a gravel layer was found. It was therefore questioned whether the gravel was part of the layer or the layer was part of a path. However, after studying the soil map and earlier corings, it became clear that this gravel layer was present in a bigger area, and probably for that reason, gravel was used as a material for the path.

The brownish grey humus layer (Bef. 037) in the fourth section is about 20 centimetres thick. The soil is again covered with leaves and trees. Underneath the humus layer, a yellowish-, brownish-grey sandy loam layer (Bef. 038) is found, still consisting of some humus, and several roots were present. In the ditch, this layer runs all to the way to the gravel layer at the bottom of the pit. On top of the dike, a gravel compartment disturbs this layer, part of layer 039, which is explained in more detail below. Over the top of the dike, where the slope on the landside starts, the 038 layer is ended again by the gravel of layer 039. This layer (Bef. 039) is a mixture of a brownish-dark grey loam and compartments of gravel. Most notable is that on the riverside the layer mainly consists of loam, while on the landside more gravel is found. It seems that this gravel and loam have been put there alternately in layers. The hypothesis is that the dike had to be elevated in this position and the only locally available material was gravel. Since a gravel dike would not serve its purpose to keep water out, the riverside is covered with several loam layers in order to make the dike waterproof. Underneath this mixed layer 039, there is a yellowish sand layer (Bef. 040) of around 25 centimetres thickness, which almost completely separates the mixed layer 039 and the underlying gravel layer 042. But first, in the landslide slope of the dike, a gravel compartment consisting of dark yellow gravel (Bef. 041) is positioned. This compartment is at least 180 centimetres in length and at most 60 centimetres in height. The aforementioned grey and pink gravel layer (Bef. 042) is on the street level, and has a thickness of 50 centimetres. It continues underneath the dike and its hinterland, but disappears gradually when closer to the ditch, into layer 040. Underneath the gravel layer, a compact grey (yellowish) loam layer (Bef. 043) of about 10-20 centimetres thickness is situated. This might suggest that this used to be a surface layer, before the gravel was deposited by fluvial means. Underneath the compact loam layer, another yellow sand layer (Bef. 044) is visible, which is about 20 centimetres thick. Another bright yellow and sandy layer (Bef. 045) of hardly 10 centimetres thick extends underneath the dike and its hinterlands. Finally, the reddish gravel layer (Bef. 046) underneath to whole profile consists of gravel and coarse sand.

Figure 7.32: Panoramic view on dike section IV

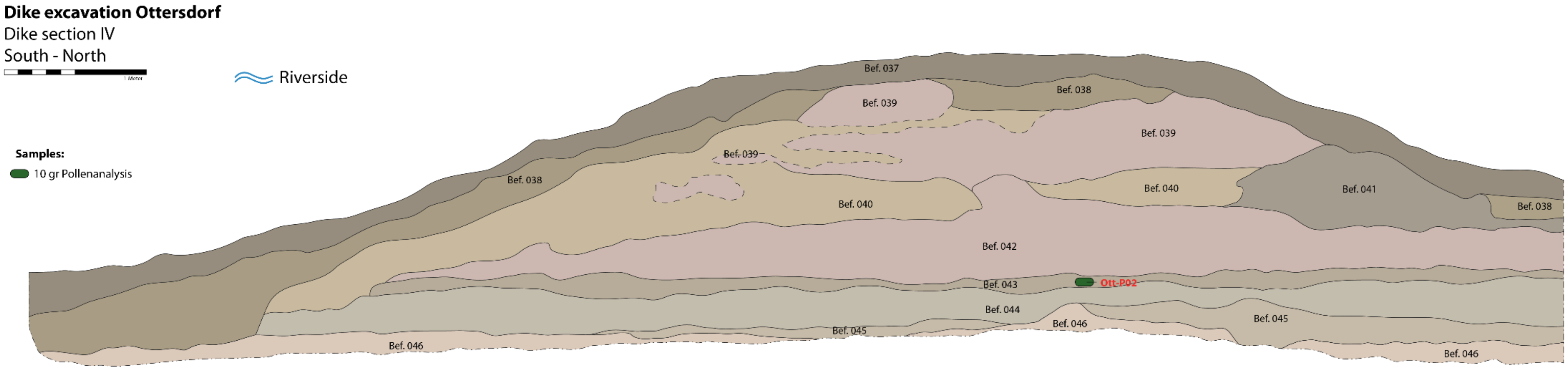


Figure 7.33: Schematic drawing of dike section IV

Table 7.5: Detailed desciption of soil layers dike section IV.

Bef. Nr.	Section	Description	Colour	Rust	Consistency	Roots?	Snails	Pebbles	Classification
Bef. 037	IV	Humus	Dark grey somewhat brownish		Humose with loam	Many roots		Many gravel	H
Bef. 038	IV	Humus gradient	Dark yellowish grey, somehow brownish		Humose sandy loam	Many roots		Many gravel	ABC a
Bef. 039	IV	Sand with gravel belts	Dark grey somewhat brownish		Loam and gravel	Roots		Many gravel	ABC a
Bef. 040	IV	Sand between gravel layers	Not so bright yellow		Loamy sand			Some gravel	ABC a
Bef. 041	IV	Dark graveldeposit	Dark yellow		Gravel and sandy loam	Few roots		Gravel	a
Bef. 042	IV	Gravel layer on road level	Grey and pinkish		Gravel and coarse-grained sand				Fluvial gravel
Bef. 043	IV	Thin loam layer (with possibly some humus)	Grey (yellowish)		Clay loam	Few roots			Paleo-H
Bef. 044	IV	Sandy laom	Yellow (greyish)	Rust	Compact sandy loam	Few roots			Paleo-ABC
Bef. 045	IV	Bright grey yellow sand	Bright grey yellow		Sand				Paleo-ABC
Bef. 046	IV	Continuous gravel layer	Somewhat reddish		Gravel and coarse-grained sand				Fluvial gravel

7.5 Datings of soil samples and field work conclusions:

The first conclusion derived from the excavation at Ottersdorf is that every dike section had a ditch immediately in front of it. Logically, these were made for drainage. Another reason could be to force seepage water from the dike and the hinterlands to come up on the river side of the dike. They could have also been used as pits to collect materials for the dike. The materials used within the dike body were commonly found in the area, indicating they were gathered locally. In dike section IV, for example, local gravel was used to construct the dike.

In most of the trenches, a former surface layer, slightly darker and indicating humus, becomes clear. In some sections (such as I and III) it is clearer than in others (II) and in some it can hardly be seen, as in dike section IV.

Another conclusion drawn from these excavations is the lack of clear construction techniques. One could detect a layered technique of loam and gravel alternating in dike section IV. In section III, two construction phases can be identified, but there is no clear indication that sod or building blocks were used, and no wooden or stone constructions were used to strengthen the dike. Such strengthening constructions make more sense in erosive places. It seems that the excavated dikes were mostly located in the inner curve of a meander, with exception of section IV.

7.5.1 Humin and humic acid datings

As mentioned, the soil profile of dike sections can roughly be divided in two parts. The paleo-soil contains layers of fluvial deposit. This soil once had temporary high groundwater levels. The dark former surface layer indicates a rich layer of vegetation and humus, as expected in a nutrient-rich and dynamic location such as a flood plain. During high water levels, water could hardly be transported and a gley-forming process occurred. Additionally, groundwater levels recently reduced the iron and manganese, which leached out of the top layers, causing a greyish colour in the lower layers. (Jongmans *et al.*, 2013, p. 59) The second part, the dike body, created by humans several centuries ago, was probably covered with grass. Possibly the dike was used as a path, but after falling into disuse, the forest took over. Again, a humus layer caused a darkish colour in the top of the dike body. Within the dike body, dependency on groundwater diminished, because it was located higher above the groundwater level, and rainwater became the main water source. The dike's function of not letting water through might have caused increased runoff of surface rainwater.

Following this, a contemporary and a former humus layer occur in the profiles of dike sections I, II, and III. In the latter, a third former humus layer is present, due to a second dike construction phase. The dating of the contemporary humus layer is sure to yield a very recent date, which is why sample Ott-P27 was taken to create a control sample. The focus of this section is on the oldest humus layer visible in dike sections I, II, and III. Within these humus layers, it can be expected that organic remains are present, which enables dating these layers. In particular, the humic acids of the humus layer underneath the dike are expected to provide a date before construction of the dike. A lack of oxygen is expected in this layer because there is less influence from rainwater (due the impermeable dike) and less influence from groundwater (because of improved drainage, linked to dike construction). This lack of oxygen reduced the degradation of humic acids from the moment the dike was constructed. Since humic acids emerge during degradation, the date which can be derived from carbon (C) within the humic acids would be close to the moment that degradation started, since it did not have enough time to be washed out, because the surface humus layer was covered by the water-impermeable dike. This is verified by sample Ott-P27, in which the humic acids dated to 2006. Older humic acids have been washed out, while the recent ones have hardly emerged. The datings derived from the humans, on the other hand, are a mixture of all the organic material derived by plants growing in the area, from the moment they started growing. Since the humins have been mobile within the soil, an average date follows, including one-year-old plants and trees that are hundreds of year-old. This date cannot be used to get an indication of when the former surface layer was covered by a dike. The only useful indication is that it should date back longer than the humic acids. Another aspect that should be pointed out is that, according to McGeehin, the presence of clay could contaminate the sample because carbon would bind to the clay corns, disturbing the date. (McGeehin *et al.,* 2001, p. 255) The samples of Ott-P28 and Ott-P29 from dike section I and Ott-P02 from dike section III come from a layer in which clay was present.

As mentioned, Ott-P27 was used as a control sample. We know that this humus layer was still developing in 2018. Therefore, the humic acids dating to around 2006 show that the humic acids accumulated within a short period. The dating of the humins going back to the 17th and 18th centuries shows that some of the plants that are degrading at this time started growing in the 16th and 17th centuries. This fits with the available map materials, which show that these areas have been forest since the area is mapped.

Table 7.6: ^{14}C Datings Ottersdorf (humin acids)

Sample ID	***Transection***	***pMC****	**$\delta^{13}C$ *1**	***^{14}C-Age BP***	***sample type***
Ott-P02	3	82.24 ± 0.30	-25,88 ± 0.46 ‰	1571 ± 29	sediment/ humin acid
Ott-P02	3	73.74 ± 0.25	-26,63 ± 0.42 ‰	2447 ± 27	sediment/ leach residue
Ott-P10	2	86.97 ± 0.30	-25,6 ± 0.23 ‰	1121 ± 28	sediment/ humin acid
Ott-P10	2	80.91 ± 0.29	-27,33 ± 0.16 ‰	1701 ± 29	sediment/ leach residue
Ott-P11	2	87.35 ± 0.31	-28,08 ± 0.28 ‰	1086 ± 29	sediment / humin acid
Ott-P11	2	81.84 ± 0.30	-27,45 ± 0.34 ‰	1610 ± 29	sediment/ leach residue
Ott-P27	1	105.14 ± 0.32	-26,95 ± 0.23 ‰	-	sediment/ humin acid
Ott-P27	1	97.75 ± 0.33	-27,44 ± 0.19 ‰	-	sediment/ leach residue
Ott-P28	1	87.64 ± 0.26	-26,63 ± 0.21 ‰	1060 ± 24	sediment/ humin acid
Ott-P28	1	85.41 ± 0.24	-27,68 ± 0.39 ‰	1267 ± 22	sediment/ leach residue
Ott-P29	1	87.33 ± 0.26	-26,24 ± 0.14 ‰	1088 ± 24	sediment/ humin acid
Ott-P29	1	85.01 ± 0.27	-27,5 ± 0.52 ‰	1305 ± 25	sediment/ leach residue

*pMC describes the procentual part of modern carbon referring to the hypothetical amount in the atmosphere around 1950, corrected to δ13C = -25 ‰ calculated via the AMS value of δ13C

*1 $\delta^{13}C$ describes an isotopic signature. It measures the ratio between the stable isotopes ^{13}C to ^{12}C

From the former humus layers of dike section I and II, two samples were taken. One was taken from the upper 5-10 centimetres of the layer and one from the middle 5-10 centimetres of the layer. This was done in order to ascertain whether it made a difference if the humus was on top when it was covered by the dike, or if it was already covered by other humus. However, since the layer was relatively thin, the results show no clear variation between the samples. Therefore, all the samples are considered to be a sample of the whole former humus layer. Ott-P28 and Ott-P29 are samples of the former surface layer of dike section I. The humic acids of the samples date back to 1060 and 1088 before present date, both with a possible deviation of 24 years. These datings suggest that the degradation of the measured humic acids took place roughly between the years 958 through 940. The humins date back to the 8th century. Ott-P10 and Ott-P11 are samples of the former surface layer of dike section II. The humic acids of the samples date back to 1121 and 1086 before present date, with a possible deviation of 28 and 29 years. These datings suggest that the degradation of the measured humic acids took place roughly around the years 897 through 938. The humins in these samples date back to the 4th and 5th centuries. Altogether, these four dates indicate that the former surface humus layer in dike section I and dike section II were still the top soil layer during the first half of the 10th century. In addition, it is expected that shortly afterwards these top layers were covered with a body of sand by the dike construction. The humin datings suggest that the vegetation around the area of dike section II was slightly older than the vegetation around dike section I.

For dike section III, A humic acid dating was conducted for the former surface layer before both construction phases. The humin acid of sample Ott-P02 dated back to 1571 before present, with a deviation of 29 years, dating it to the 4th century. The humins date to six centuries BC. The datings of this sample are so different than the others that they cannot be seen in correlation with them. One of the causes could be its location further from dike sections I and II. Another possible cause, at least for the deviant humin dating, is the larger presence of clay in the layer. As stated before, this might have added organic matter to the sample. Without corresponding samples, it is impossible to elaborate on these results. Further research on the soil of section III is necessary. An overview of the results of humic acid and humins dating can be found in Table 4.5 and Appendix A.

7.5.2 OSL dating

Another method to date the paleo surface layer used in this research is Optically Stimulated Luminescence dating. The method is discussed in detail in §3.8. Briefly, it dates Feldspar to its most recent exposure to light. For this reason, the samples are taken when it is as dark as possible, and are kept completely in the dark in a sample ring until they are taken to the laboratory. Both the dike and the ditch from dike section I were sampled.

The paleo surface underneath the dike was exposed to light for the last time right before it was covered with the earth of the dike. Samples Ott-22 and Ott-P23 were taken from the paleo surface (Bef. 003). Sample Ott-P24 was taken from the dike body (Bef. 002), and thus contains earth which probably was exposed to light before and during the construction of the dike. Since the sample was taken from the bottom part of the dike body, it can be expected that its last exposure to light was in the same year that the paleo surface was covered, perhaps even the same day.

It is hypothesized that materials from the ditch were used to build the dike and a similar dating from the ditch can be expected. Thus OSL-dating is a way to prove the relation between the ditch and the dike. From dike section I, three samples were taken from the ditch. Ott-P39 was taken from the contemporary ditch filling (Bef. 020). It was expected to yield a recent date, since it was probably covered due erosion of the dike and building of the humus layer in the contemporary forest. Ott-P26 was taken from underneath the contemporary ditch filling (Bef. 004) and was therefore expected to be covered during a period that water still flowed through the ditch and sediment was deposited on top of it. This would provide a *terminus ante quem* for the emergence of the ditch. Third, Ott-P40 was taken from Bef. 021 underneath the layer underneath the ditch. This was done because the soil profile left some uncertainties. As the profile was drawn, it seemed that an older ditch was located underneath the contemporary ditch. This is logical due to the steep banks of the ditch. In this case, Ott-P40 was a sample from an historic fluvial sediment that was deposited in this ditch. It can be considered coincidental when a new ditch develops at exactly the same place in the landscape. In this case, it can be expected that Bef. 021 correlates temporarily with Bef. 018, which is clearly located underneath the paleo surface. This means that this historical ditch should be expected to be significantly older than the paleo surface, and thus the dike. For now, we must wait for the results of the OSL datings conducted in the Dutch Luminescence Laboratory in Wageningen.

7.5.3 Dredging macro-organic remains for ^{14}C datings

Since a single method to date historical dikes was lacking, several various methods were used to date historical dikes. In addition to humin and humic acid dating and OSL dating, dating of macro-organic materials was tried. Several litres of soil were sifted to separate the present organic material, which was hardly visible by eye. Due to the amount of macro-remains, a mixed date could be provided for these remains. The samples were mixed with hydrochloric acid to separate even the smallest clay particles from organic matter. This results in micro- and macro-remains, which where individually separated under the microscope. These micro-remains have not been dated, but the macro-remains were separated again. A blackish, perhaps charred colour was visible on a significant part of the macro-remains and these have been separated from the others. This resulted in five samples: Ott-P36 I and II, Ott-P20 I, and Ott-P37 I and II. All of these samples come from dike section I, Ott-P36 from the filling of the ditch (Bef. 020), Ott-P37 from underneath the ditch (Bef. 021) and Ott-P20 from the former surface layer underneath the dike (Bef. 003). These samples were dated by ^{14}C methods by the Leibniz Laboratory in Kiel.

Unfortunately, all of the macro-organic remains gathered this way date to the 1960s. Since it is impossible that these dikes were so recent, the remains in the sample must be recent organic remains or the sample was contaminated. This is possible due to tree roots going deep into the ground or insects and other soil creatures taking organic material with them into the ground. Contamination of the samples could have occurred somewhere in the process, although there are no clues as to when this might have happened. The results of the macro-organic ^{14}C datings are not taken into further consideration for this research. More detailed information can be found in Appendix D

7.5.4 Palynological Analytics

To learn more about the flora during the period the dike was constructed, an archaeobotanical research was conducted by the Groninger Institute of Archaeology (GIA) and the Institute for Biodiversity and Ecosystem Dynamics at the Vrije Universiteit in Amsterdam. The aim of this study was to determine whether wet or dry plant species could be recognized, or perhaps cereals, indicating agricultural use of the lands. In particular, finding crop or grain pollen would reveal much, indicating a defensive dike. Dry natural species would indicate natural wilderness or extensive grazing. For this research, five samples were taken: Ott-P30 from the contemporary humus layer (Bef. 001), Ott-P31 and Ott-P32 from the dike body (Bef. 002), and Ott-P33 and Ott-P34 from the former surface layer (Bef. 003), all from dike section I.

Unfortunately, only palynological and macro-botanical remains were found in the contemporary humus layer of sample Ott-P30. The fact that remains of sedges (*Cyperaceae* and *Carex*) and alder (*Alnus*) were found is a strong indicator of locally wet conditions. The presence of an elderberry (*Sambucus nigra*) seed indicates a nitrogen-rich environment. No date was derived for these samples. It is likely that the samples are contemporary, since they are part of the contemporary humus layer. For this reason, the palyobotanical research did not provide valuable information on the historical landscape around the dike. In Appendix E, further explanation on the conducted archaeobotanical research can be found.

7.6 Conclusions for the case study Ottersdorf

7.6.1 A geomorphological puzzle

The dynamics of the Rhine on its flood plain are not easy to trace. Changes in discharge as a result of variations in climate and sediment availability cause the already dynamic river to constantly redirect its course. On the local scale of Ottersdorf, it becomes clear that the Rhine, its side arms, and the Murg have constantly influenced the *Rieddörfer* through rigorous avulsions. The complexity of these dynamics and the lack of sources make it nearly impossible to reconstruct where and when the *Rieddörfer* was threatened by water. By a combination of LiDAR-data, soil maps, historical maps, archival documents, and field names, an approximation of the course developments can be reconstructed.

The contemporary Rhine and Murg are products of straightening of the rivers in the late 18th and early 19th centuries. High and continuous dikes reduced the flood bed to the contemporary size. Before that, the Rhine flowed closer to Plittersdorf, Selz, and Munchhausen, creating swampy islands north of Plittersdorf. During the 18th century, Plittersdorf was in constant danger of flooding and erosion of its lands. East of the *Rieddörfer*, the Mühlkanal was connected to the Riedkanal mouth where it flowed into the Murg. The Mühlkanal replaced the Altrhein or the *Mühlwerlgraben*, which is still visible as a continuous streaming channel on the 1715 map of the Basse Alsace, although it is known to have been dammed around 1472. On the same map, north of Ottersdorf, a former arm is still visible streaming towards Plittersdorf and continuing north from there. This arm probably had more water and a higher erosive power during the 15th century, and is probably one of the streams taking lands from Muffenheim. Dunhausen battled the Rhine longer than Muffenheim, and it disappeared from the maps during the late 16th century. This suggests that the intense activity west of Wintersdorf occurred around the 16th century.

West of Ottersdorf, a stream drains into the Rhine. This stream can be identified by the field name *Im Deist*, which can be recognized in the LiDAR data and soil map as a former river arm. *Im Deist* is supposed to have been dry, or at least easy to cross, since several of the main fields of Ottersdorf were located on the other side of *Im Deist* since the 15th and 16th centuries. It seems from the LiDAR-data that *Im Deist* was cut off by a younger meander, but when looking more closely at the overlaid LiDAR-data and the cadastral map, it becomes apparent that two smaller streams fed *Im Deist.* The western one is especially clear, and comes from Wintersdorf. It is even visible on the soil map. The curve it creates should, according to fluvial morphology, come from the inside, moving in an outward direction. When moving inside a comparable curve remains visible from the LiDAR data, it seems however that the inner curve becomes more elevated. Since this is exactly how a meander would move, leaving sediment deposits in the inner curve, Especially during a period of increased sediment deposition, this might provide a possible explanation. This meander curve may date back to the moment the district border between Wintersdorf and Ottersdorf was drawn, which can still be seen as a clear curve. This district border might date to the early 14th century, since Wintersdorf and Dunhausen are suggested to have been cut off from the other *Rieddörfer*, based on a 1338 document. In addition, any evidence of a Wintersdorfer road is lacking. It seems that in the period of archival sources (late 15th century) the most logical road to Wintersdorf was passing by the *Loschfeldweg* in the direction of Dunhausen, or along the *Mühlweg.* Additionally, the field name Birgfeld first occurs in 1506, while in 1472 *Birgenlache* was mentioned. A *-lach* name usually indicates a wet strip of land or a former river arm. It seems that a flowing watercourse was present between Wintersdorf and Ottersdorf during the sedimentation period of the early 14th century, perhaps even earlier. Where this arm avulsed from the Rhine's main arm, or where it returned, is not clear. However, the land between Wintersdorf and Ottersdorf seems to have been first cleared during the late 15th century. Earlier expansion of Ottersdorf might have taken place closer to the village in a north-western direction, or in an eastern direction.

A similar situation might have occurred around the contemporary Altrhein. The now-meandering former river arm whose mouth leads into the Riedkanal is suggested to once have had a straighter course passing over the *Geggenau* along *Hofröder* and its dike. Assuming that the high sediment band was deposited during a sedimentation period, it could be expected that it developed in the 5th to 7th centuries or after the 11th century. Since the Murg valley began to be reclaimed during the 11th century, it is logical that other more easily accessible areas were reclaimed before that, causing more runoff water and more sediments to be deposited (§4.5.6). This would be the case if the dike along *Hofröder* was built prior to that period, around the 11th or 12th centuries. The field name, *Hofröder,* probably dates back to this period. However, the humic acid datings of the dike go even further back, to the 10th century. This would not influence this line of argumentation, since the dike might have functioned for many years before sediment deposits increased. Probably around the 14th century, the risk for flooding increased and perhaps an avulsion caused a change of course for this former Rhine arm.

7.6.2 The oldest dike in the Upper Rhine Valley

The hypothesis of a 12th century dike seemed logical when considering archaeological finds. However, the results of the humic acid dating indicate the south-north dike had already been constructed in the 10th century. Villages were already expanding at that time, reclaiming nearby accessible lands. The major clearance period of the 11th and 12th centuries refers to the clearance of marginal mountain areas, while the flood plain was a nutrient-rich and accessible area, and was probably cleared earlier. Villages emerging during the 8th century support this statement. In addition, the forged document of 991 that mentions 40 acres of newly cleared woodland in Ottersdorf also indicates that in the area around Ottersdorf there was demand for new agricultural fields. St. Adelheid bought this land for the monastery of Selz, and the monastery was seen as the main actor in the village at that time, and the main farmstead was *St. Adelheidshof.* It could be argued that the *Hofröder* field, which refers to an undefined farmstead, suggests either a farmstead on that field or the main farmstead of the village, namely the *St. Adelheidshof.* It makes sense that the *Hofröder* field was cleared during the 10th century, that is said to have been a wet century with high water levels (§4.6). A dike could have been constructed to protect these fields from flooding, or ditches dug to contribute to proper drainage of this field. Altogether, the 10th century datings derived from the humic acid dating can be considered plausible. Nevertheless, more supportive research is necessary to extrapolate the 10th century dike construction to a bigger area in the Upper Rhine valley.

7.6.3 A sequence of dikes

It is logical that the straighter and lower energy Rhine arm shifted over time to the Altrhein. Especially in the area east of *Hofröder*, it is highly apparent that there has been a moving river course, because a river seeks the easiest and quickest route to drain, and the elevated sediment band would have become slower and lower as alternatives became more easily accessible. Something similar seems to have happened on the southwest of *Hofröder* as well. There It becomes apparent in the LiDAR data that the meander splits into a double meander. It could be assumed that the first meander (northwest) was limited by the dike, causing another meander (northeast) to emerge. This suggests that the development of these dike sections were developed from the oldest in the east to the youngest further west. This corresponds to the outward meander movement and the connections of the various dike segments.

In order to date all the dike sections and their repairs, more coring samples or cross sections will be necessary. Dating of the former river arms is necessary as well. For now, it seems clear that there were four construction phases for the dikes in the *Ottersdorfer Oberwald.* The first construction phase occurred along *Hofröder,* dated to the 10th or early 11th century. This would make it the oldest dike identified in the Upper Rhine valley, probably even the oldest river dike in Western Europe. The second construction phase connected at a roughly 90° angle to the first phase, despite the recent road. A proper date for this dike has not been clarified, but this part is already visible on 18th century maps. This second construction phase contains a straight linear dike, with exception of a more recent repair. At the eastern point of this straight line, another repair becomes visible. It seems that this repair was built after connecting the second section to the new third phase. Otherwise, it would be more logical to immediately include the repair into the new dike section. A curve was necessary in this dike, indicating that the ditch visible in the middle of the curve was already there. It is shorter and costs less material to cross a ditch at a 90° angle. At the end of this curve, after a short straight section, another connection point is visible. This is where the fourth building phase began. A curve and perhaps a second curve were necessary to cross the former ditch, which would easily flood. Even the fourth building phase seems outdated, since the meander again cuts off the dike at the western-most point. However, this amount of water is not currently a threat. In this fourth building phase, local materials were clearly used for the dike construction. This is the only area where gravel was close to the surface, and much gravel can be found in the dike. More research should be done to confirm that local materials were also used in the other dike sections. This research clarifies that flood management is not a onetime intervention. Continuous maintenance has to be conducted and weak spots have to be repaired.

8 - Mentalities in the case studies

8.1 Findings of the case studies in mentality templates

A perception perspective by mentality templates, as conducted in chapter 4, can hardly be performed on the local scale of a case study, because of the dependency of a continuous availability of sources. It is therefore necessary to place the local findings in a regional context. First the available sources that give an indication of perception are discussed in §8.2 and §8.3 and afterwards these findings are compared with the conclusions of §4.10. This will provide an insight into whether the perception at a local scale is in accordance with the regional perception or not. Again, this mentalities-based aspect of the study relies on subjective connections and only indicate a minor aspect of the complex mentalities of humans in various groups of actors.

8.2 Speyer: Action on flooding

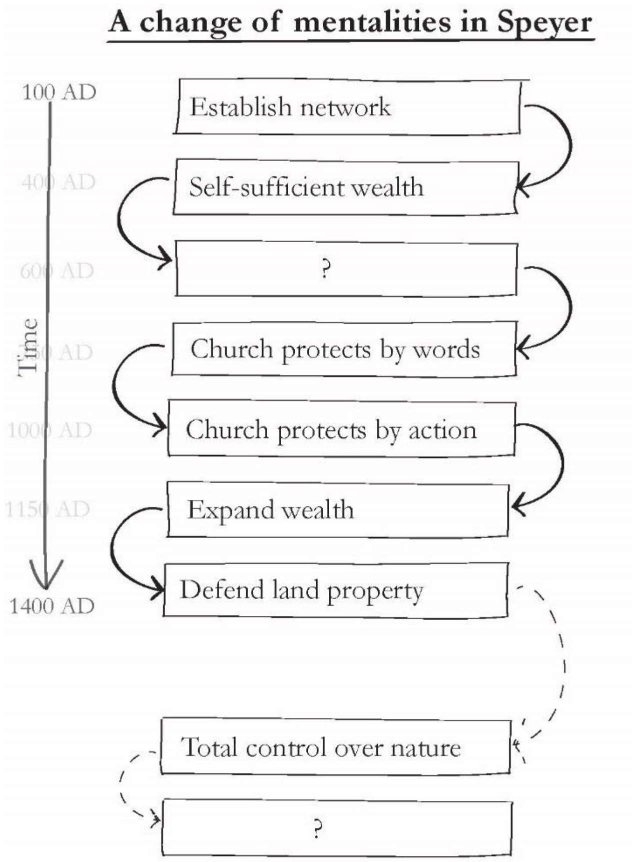


Figure 8.1: How data form field work in Speyer fits in the mentality templates.

For the city of Speyer (*Noviomagus Nemetum*), it is known that, already during the Roman period, it played a role in defence and trade and was therefore part of the extensive Roman network in existence along the Rhine and throughout Western Europe. (Figure 8.1) After the Roman Empire declined, people started to settle outside the Speyer city walls in the villages of Altspeyer and Winternheim. Rather than being able to depend on the Roman network, people now had to be self-sufficient and thus sought the best available soils, thereby improving their own wealth. In the period thereafter, the church came to settle in Speyer, and a monastery was founded near St. German. For the people of Speyer, the church was understood to provide protection and salvation. This continued for centuries. However, in the 11th century, it is recorded that Bishop Benno sought to protect the cathedral of Speyer against flooding from the Rhine by putting boulders up to stave off high waters. This is a clear indication that the promised protection to be had though prayer and devotion to the church did not suffice and real action was necessary in order to protect the people of Speyer. Apparently, this contributed significantly to the people's belief in their security against flooding, since the people of Speyer began to settle in the flood plain during the early 13th century, following on St. Marks church, which was built there during the final decade of the 12th century. Thus, people began to expand the lands of Speyer, which indicates an effort to improve local wealth. This, however, quickly brought with it the concerns of ownership of this new land such as feeling the need to defend it, such that, by the early 15th century, a defence wall (*Landwehr*) was built, which additionally functioned as a dike in the flood plain. Thus, the land was protected against both human invasions and natural events.

In the following period, beyond the scope of this research, this urge to protect the people's property evolved into total control over nature, as is visible in Speyer by means of the continuous dikes, already present in the 18th century. The bypass cutting off the Berghäuser Altrhein also exhibits this control over nature. However, nowadays the island of *Flotzgrün* serves as an overflow area. (Struktur- und Genehmigungsdirektion Süd, 2001) This indicates that nowadays space for the river and natural developments are essential aspects of the primary mentality-template.

8.3 Ottersdorf: Early clearances

Since the small village of Ottersdorf has hardly played an important role in regional history, its availability of sources is quite scarce. The first record of Ottersdorf and most of the other *Rieddörfer* dates back to the 7th century in records of donations to the monasteries of Weisenburg and Lorsch. It is known that such donations to a monastery came in exchange for prayers and promises of salvation, although this is not specifically stated in the documents concerning the *Rieddörfer*. Nevertheless, this information can be interpreted as the church offering protection to the people. Another important document is the later copy of the 991 ownership document in which clearances around Ottersdorf are pointed out. This likely indicates a need or desire to expand production lands, or to expand the wealth of the local society. Whoever it was that initiated this clearance is subordinate in historical importance to the fact that it happened.

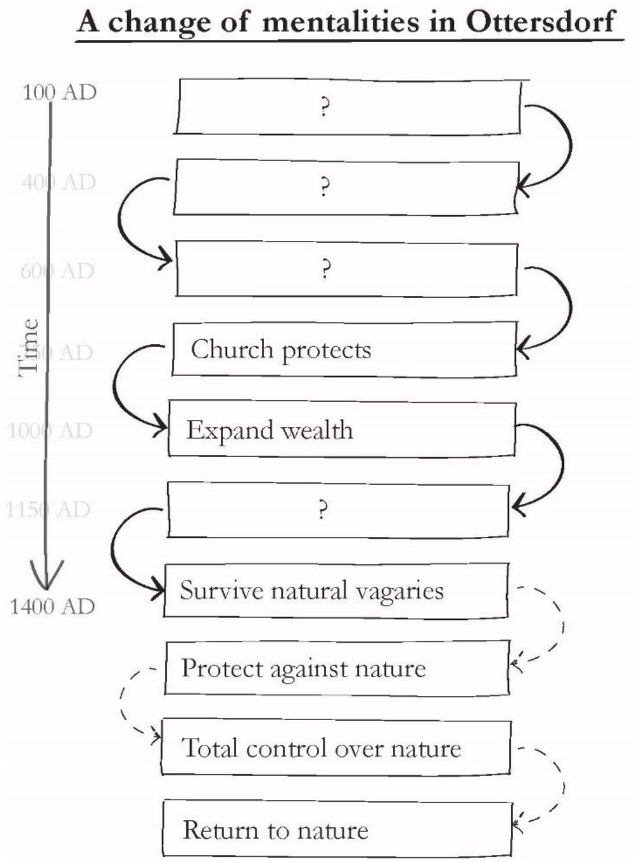


Figure 8.2: How the fieldwork of Ottersdorf fits in the mentality templates.

As a result of the archaeological dike excavation carried out in Ottersdorf and the subsequent archaeometric datings, these dikes have been dated back to the 11th century. Since it appears that this south-north dike cut off the agricultural fields, it is likely that this dike was built in order to protect the people's lands from natural flooding. This is a relatively early indication of defensive diking and does not fit perfectly into the established timeline. It could be regarded as fully compliant with the timeline only if it is an example of the church providing protection through concrete action. Although this dike construction project seems to have been initiated by a monastery, there is no indication what the reasons for this were. Another explanation could be that the agricultural fields were not cut off on the river side, but rather behind the dike due a breakthrough, which is clearly visible on the LiDAR data in figure 7.3. In that case, the dike might be older than the agricultural fields, and might have been constructed in order to win land, that is as offensive diking. This fits better with its location in the inner curve of the river channel and the sediment deposited on the river-facing side of the dike. Such an expansion of fields and, thus, local wealth can still be considered early with respect to comparable developments in neighbouring regions. However, this is in accordance with the ongoing expansions in the Upper Rhine valley.

After some years in which hardly any written records reported on the *Rieddörfer,* it becomes clear that, around the 14th century, the river Rhine played an important role, since the villages became isolated, being located on an island, and even the rights on the common land had to be changed for that reason. It could therefore be stated that the villages were victims of the river and were left trying to survive the consequences of such vagaries of nature. It is younger sources that first show how the local society started to build dikes and moved houses and whole settlements, resulting in a perception of having established protection for themselves against these natural events. This evolved into the modern dike constructions that are the main feature of total control over nature with respect to waterways. However, more recently, in connection with Rastatt Life+ and Nature2000, projects are underway that aim to renaturalize the floodbed, the so-called *Rheinauen*. (RPK, 2015)

9 - Concluding interpretations

This dissertation is the primary result of the interdisciplinary project *Land Unter?*, funded by the *Fritz Thyssen Stiftung* and executed by the Geographical Institute and the Institute for Prehistorical Archaeology at the University of Heidelberg. The project's aim is to develop a history of flooding on the Upper Rhine valley landscape, with a focus on the flood plain of the Upper Rhine valley between Strasbourg and Mannheim. This flooding history contributes to our understanding of the interaction between humans and the river Rhine and to contemporary flood management. Contemporary developments in flood management pay significant attention to a river's nature. However, cultural interaction with rivers is underrepresented, especially where underexplored, despite the fact that a future without human influence seems out of the question. While studying the history of landscapes, it becomes clear that the human perception of a landscape bears out a significant impact upon cultural expressions in that context. A clear methodology for including human perception in landscape studies is still lacking. Developing such a methodology and producing a history of flooding for the Upper Rhine valley are the two main topics examined in this research project. This has resulted in the following main research question:

> *What is the role of changing human perception of flooding in the Upper Rhine river landscape influence the interplay between human actors and natural dynamics that lead to the emergence of flood management – more specifically dike construction – in the medieval (8th to 12th century) Upper Rhine valley?*

As a first step in answering this question, a brief exploration of other Western European rivers was undertaken, in order to get to know the material. It seems that, along the Loire, the Lower Rhine and the Meuse, settlements were located mainly on elevated mounds. In the Loire valley, *turcies* were built to connect such mounds and, through being strengthened over time, these eventually developed into dikes. Comparable dams can also be found in the Netherlands. Dike construction is to be expected in the Upper Rhine as well. However, it is dependent on the gradient and surrounding terraces whether circular or hook-formed dikes will be found. Preliminary research on the topic of flooding in the Upper Rhine valley has been relatively absent in the scientific literature. Because such research has scarcely been conducted, especially for the period in which flood management first emerged, this research project on flooding in the Rhine Valley stands to contribute much to this area. This is of particular interest, since dike construction along the other mentioned rivers occurred from the 12th century onward but, in the Upper Rhine valley, written records provide evidence for settlements located in the flood plain since the 8th century. Presumably the people living in those settlements had to deal with flooding, or at least had to interact with the Rhine, already several hundred years before beginning to construct dikes. This gap in our knowledge demands a broad and interdisciplinary study with respect to the landscape of flooding in the Upper Rhine valley. In accordance with other landscape studies, the human perception of flooding is to be considered as well, because it is an important factor in the cultural expression of humans living in the landscape.

Landscape studies take into account human perception, including both natural dynamics and cultural expressions. The combination of physical and social geography is not a new concept or approach; such environmental geography has roots in, for example, a well-structured layers approach. Nevertheless, landscape studies have, so far, only made sparse reference to human perception. More recently, among others, Elerie & Spek (2010) and Kolen (2015) have aimed to add a cultural biography of the landscape and a landscape biography to the more scientific *Landschaftgenese*. These biographies result in more-narrative descriptions of a landscape's history. However, these various approaches still lack a thorough methodology for integrating human values and meaning into our understanding of a given landscape and the discipline of landscape studies in general.

From this starting point, the present research has elaborated on the available multidisciplinary sources and methods. Based on the works of influential writers over history, mentality templates related to flooding have been derived. Such templates are highly generalized frames of mind characterizing the most dominant mode of human perception during a certain period. Several of these mentality templates are historically and chronologically defined, forming in themselves a cultural biography of the shifting perception of flooding. The information gathered and made available by the multiple disciplines have been fit into the various mentality templates. Arguments from climate studies, geomorphological maps or changing actor relations, among others, have been consolidated and fit to a certain timeframe. This method has been carried out for the Upper Rhine valley at the regional scale, in order that it be populated with enough source materials. However, this provides mainly a hypothetical representation of the developments in the Upper Rhine valley. Therefore, two case studies on the local scale have been conducted: one in Speyer and one in Ottersdorf. The results of these case studies have been mapped to their own timeline of mentality templates. In conclusion, the timelines of the regional scale and the local case studies have been used to formulate a final timeline of mentality templates regarding the flooding history of the Upper Rhine valley.

Although outside the scope of this research, the first mentality template was defined for the Roman period, as a starting point for further developments. At the regional scale, reconstructions of Roman settlement clearly show a preference for establishing communities on the terrace rims. The operative mentality may be formulated as: **"safe and healthy terrace rims"**. This conclusion is mainly derived from secondary literature on the period and overviews of archaeological findings in the area. A motivation for settlement on the rims is argued to be the unhealthy vapours in the swampy flood plain, caused by standing waters. Additionally, arguments linking settlement locations to trade routes or defence lines are given in the regional study of the Upper Rhine. These arguments also follow from the case study in Speyer. Thus, during the Roman period, for the most part settlements were located near the river for reasons of trade and defence. The location on the terrace rim might additionally speak for a perspective which sets the "dry and healthy" land in contrast to the "damp and unhealthy" river site.

After the decline of Roman society around the 4th century, communities gained a more local orientation. Inspired by Roman landownership, tribal settlements followed a trend to become more permanent, according to place name studies. However, farmsteads did still move around within the settlement area. In order to ensure for themselves enough food and other resources, tribes settled on the best available soils. These conclusions are inferred from place names, deserted villages and datings of *'Reihengräbenfelder'* from the secondary literature. The case study of Speyer supports the thesis of people settling in this period on the most suitable soils. The settlements of Altspeyer and Winternheim were located near the Roman city centre, which were probably located on the former grazing lands of the cavalry. Such grazing lands were left particularly fertile as a result of manure, providing nutrient rich fields for local communities. Also, on a regional scale, settlements in the 4th and 5th century were located mainly near the Roman towns of Argentoratum (Strasbourg), Noviomagus Nemetum (Speyer) and around Lopodunum (Ladenburg). The dominant mentality for this period could thus be described as: **"self-sufficiency for greater wealth"**.

During the 6th century, disasters were regularly interpreted as a sign of important and catastrophic events, thus: **"flooding as a sign of new disasters".** Especially in regard to the widely spread belief of an upcoming apocalypse, flooding could be seen as an omen. In an effort to accommodate a growing population, new settlements were established. Combining LiDAR-data with place names has shown that slight elevations in the flood plain were chosen for this purpose. This seems not to correlate with a growing fear of disasters like flooding. But it may be the case that the arrival of Christianity mitigate this fear to some extent. Several sources in Speyer confirm the emergence of the church during the 6th century.

The fear of rivers and flooding as an overarching aspect continued in the 7th, 8th and 9th century. This correlates with a period of further flourishing of Christianity and the founding of monasteries. These monasteries became powerful landowners, mainly by acquired donations, especially during the 8th century. These donations have been mapped in GIS and then compared to the LiDAR data. It can consequently be stated that most such donations came from villages on the floodplain, mainly in the anabranching part of the Upper Rhine valley. Considering a more unstable climate, it can be reasoned that landowners on the flood plain were more willing to part with their fields, perhaps in order to get to a more protected environment in this way. The corresponding mentality, in effect for the 7th, 8th, and 9th century, may be formulated as: **"the church protects the good against flooding"**. While both local case studies, in Ottersdorf and in the surroundings of Speyer, have proven that such donations occurred, no direct relation to flood management has been established so far.

The 10th century shows a growing risk of high water levels due to increasing rainfall and glaciers shrinking in the Alps. This might be considered as one of the causes for a renewed momentum with respect to monasteries. The appearance of new monasteries and a revival of donations indicate an increasing demand for prayers or salvation. Nevertheless, increasing flooding and harsh living conditions call for reviewing the churches' attitude to natural events. Influential writers of the time increasingly payed attention to natural processes. Additionally, greater knowledge of natural processes became available via translations of ancient Greek and Arab scholars. A river exceeding its natural bed was, however, still assumed to be an act of God. The dominant mentality derivable from the available evidence describes a form of reaction to natural challenges and may be stated as: **"the church initiates action on flood management"**. For example, Bishop Benno reportedly had boulders placed in order to protect the Speyer cathedral, which can be interpreted as defensive flood management. During field work, no boulders were found at the foot of the cathedral, but if future research manages to locate these boulders southeast of the *Goldgrube* and show that they redirected the Rhine's main channel, a plea for offensive flood management could be made as well. Furthermore, the redirection caused by this act, could have enabled the possibility of cultivating fields in the flood plain at Speyer, which were put into use in the centuries afterwards. Notably, also around Ottersdorf clearances are known for the 10th century. These clearances provided new lands that had to be protected against flooding and, thus, can be linked to dike construction in the early 11th century, as follows from archaeological excavation conducted in Ottersdorf. It therefore seems that the human perception of flooding changed around the 10th century.

The clearances of forest around Ottersdorf seem relatively early in comparison to developments at Speyer. In Speyer, a comparable expansion can be seen during the 12th and 13th century, following archival sources combined with historical maps and the LiDAR-data, which indicate cultivation of fields in the flood plain. There are no indications that the expansions in Speyer and Ottersdorf were carried out expressly for the purpose of taming nature. The mentality of bringing wilderness under human control was derived from extensive Cistercian influence on the regional scale. In the local case studies, Cistercian influence can be recognized in land ownership and self-sufficiency. However, no forest clearances are known to have been initiated by Cistercian monks. The impact on the landscape during the 12th and 13th century is clear: the expansion of arable fields to included more and more marginal lands. But the reason for this expansion can still be debated. Whether clearances were initiated because of an increase in demand or an imperative to cultivate wilderness, the dominant mentality is captured in: **"nature as a resource for humans"**.

During the 14th and 15th century, the *Villikation* system disappeared completely from the Upper Rhine valley. The three-field system was generally adopted to meet the demand for cereals. More and more peasants became private land owners, in exchange for their contribution to clearances. This indicates that responsibility was shifting from landlords to local farmers. Correspondingly, the *Sachsenspiegel* illustrates how landlords left dike construction and maintenance to locals and only supported them when deemed necessary. This mentality may be defined as: **"local landowners are responsible for protection of their own property"**. Since early dike construction and, therefore, flood management occurred, at the latest, during this period, the scope of the present research ends here.

The flooding history of the Upper Rhine did not, however, end in the 15th century. Although only studied briefly, some general remarks can be made for this period. Especially in the case of Ottersdorf, many archival sources are known for the 15th and 16th century. It becomes clear that the nearby *Rieddörfer* had a hard time

"surviving nature's whims" in the dynamic flood plain of the Upper Rhine. The villages of Muffenheim and Dunhausen disappeared, and a need for continuous dike maintenance placed a heavy burden on the remaining residents. This represents an enormous shift in comparison to cultivating the wilderness, which was an influential mentality during the 12th and 13th century. Flood protection was also considered a burden in 15th century Strasbourg, where a flood management commission debated over the resources necessary in order to provide complete safety from flooding. Whether similar trends occurred in the whole Upper Rhine valley should be addressed in further research.

During the 17th, 18th and especially the 19th century, measures taken for flood management evidently increased. More sources are known for this period on embankments, bypasses and dike construction. Archival sources, publications and historical maps show many dikes in the Upper Rhine valley, especially in the meandering northern part. **"Total control over nature"** eventually developed into a dominant mentality. For an outstanding achievement of this mentality, one can look to the Tulla rectification of the Upper Rhine during the 19th century.

Only during the last century has the downside to this degree of control over nature become visible. Reduced natural dynamics have produced unexpected effects in the Upper Rhine valley. Increasing erosion and lowering ground water levels demand new perspectives on flood management. This can be regarded as the main reason that, nowadays, such mentalities as "returning to nature", "coping with nature" and "room for the river" have become more dominant. In a similar vein, **"human interaction with nature"** lies at the base of contemporary developments in flood management, aiming to achieve an optimal balance between safety and intensive land use.

Thus, including mentalities in a landscape study provides many new insights. For this reason, it may be recommended that the mentality-based approach be yet further optimized. Besides natural dynamics, also the cultural history of a river landscape should be studied in order to gain a better understanding of the possibilities for interaction – at best harmonious – between humans and rivers. This can especially be related to current day mentalities, in which this interaction becomes more and more important. All in all, this study has shown that shifting mentalities have very much influenced the landscape of the Upper Rhine valley over time. This research should help to deepen our knowledge and to develop new sustainable methods for flood management, since an inhabited river landscape demands a harmonious balance between natural dynamics and cultural expression.

10 - Discussion

The project *'Land Unter?'*, in which this dissertation is embedded, was originally intended to be an interdisciplinary initiative jointly carried out by physical geography and archaeology. As discussed (§2), this type of cooperation is essential in landscape research. Especially for topics in which human–nature relations are investigated, cooperation between the humanities and natural sciences is mutually beneficial. Unfortunately, owing to external circumstances, the original vision for the project had to be revised halfway through, such that the project was ultimately conducted from mainly archaeological perspective. Nevertheless, the available geographical results, from the earlier period in which some geophysical work has been conducted, have been taken into account and have resulted in a varied and interdisciplinary study, of which was presented in this dissertation

Because there was no methodology described for including perception in a landscape study, the methodology employed in the present work was developed during this project.. For this reason, it is important to address the insecurities in the methodology used, and the effects this had on the results. The primary reason to conduct a landscape study in the first place, was to include as many relevant factors as possible in the Upper Rhine valley that affect flooding and pertain to the human (re)action in response to it. Since a landscape study aims to account for most aspects of a given landscape and its context. The geophysical and cultural expressions, including changing perceptions on the part of various actors are all included, but to validate and balance the importance of these aspects has hardly been studied.

The choice to use mentality templates as a methodology, provided a possibility to use the perception of humans as a bridge between natural scientific data and cultural narratives. Additionally, it should be emphasized that the concept of mentality templates allowed the variety of sources in a understandable structure. The concept of mentalities represents values, meaning people give to a landscape, and the perception of individual experience, by sensing and imagining among others, which is quite hard to consider in historical research. Therefore, mentalities allowed to highlight relevant shifts in thinking of bigger actor groups, assuming that change hardly ever can be realized by one man, as is also addressed in the used landscape definition in this research.

Although mentality templates were beneficial in this interdisciplinary research, biases could have been occurred in defining them. Unfortunately, defining mentalities can never be fully objective as the perception of the person defining them is coloring the definitions. The aim of the big amount of scientific data brought into these mentalities is to reduce the subjectivity. At the same moment, here lays an opportunity for other researchers to elaborate and expand the work presented in this thesis.

The discussion of this study's content is intended to remain short, thus the following discussion will consist of a few general remarks taking the bird's eye over the performed research. The Roman period has only been studied briefly here by means of overview-type sources, since it was only the prelude to the period comprising the scope of this research. Finding that multiple concerns like health, trade and defense lay at the base of decision-making with respect to settlement location might seem a superficial and unsurprising conclusion. Many experts have already demonstrated that interaction between Romans and German tribes existed to great extent. Archeological excavations of Roman settlements showed particularly fertile lands around Roman settlements. The hypothesis that such fertile grounds were the reason for settlement continuation are supported by secondary literature on settlement patrons, soil quality of those regions, evidence of deserted settlements and grazing grounds. Archaeological findings and a soil map, brought together within the perspective of the human tendency to seek advantage in using nature's resources, this provided a benefit of the interdisciplinary approach.

Understanding the period in which flooding was seen as a sign of future events (6th century) was not straight forward. The upcoming church from the 6th century dominate in the written sources of this period when studying human perception. Eventhough, there is hardly any physical evidence of flood protection preserved from that time. The inclusion of the perception in the methodology does allow us to establish a dominant attitude towards flooding for this period. Flooding as a punishment for bad moral behavior is dominant, but hardly affects the landscape. This provides new questions on the role local clergy had in dealing with this phenomenon, in relation to their duties to the village. If future research expands the scope of the research up to the 6th century, for example through further studies on cemeteries located on the flood plain, might reveal a yet greater relationship between this perception of flooding and cultural expression in the landscape.

For the 7th to 9th century, an unstable climate is shown in (§4.6.2). Regarding the results of geographically mapping donations to monasteries, it can hardly be considered a coincidence that landowners in the flood plain gave more donations, than done elsewhere. (§4.4.2). These settles in the flood plain probably needed more protection from the church, as a result of unstable water levels. Villages on the terrace rims – where Romans had also settled – often had a later first record as documentation increased. Thus, mapping such archival sources and combining the results with climate data provided new first insights into these donations that are worthy of being extended in follow-up research.

The 10th century's doubts about the church's protection against flooding should be viewed with realizing that how important the church was in everyday live. Nevertheless, responses to harsh conditions do indicate that, next to prayer, also other methods for dealing with natural disasters were taken into consideration. New monasteries were founded and donations acquired a renewed momentum. In the same period Benno's boulders were mentioned and the observation of natural processes gained ground in the written discourse. This indicates that a shift in belief or in the perception of flooding was occurring. Moreover, the perception of human capability to deal with flooding changed. This change of perception was demonstrated by the dike excavated at Ottersdorf, which provides the earliest material proof of flood management in the region.

The 11th and 12th century show an enormous expansion of settlements and clearances, creating new arable land. This process of expansion dominated the landscape, but its causes include new agricultural techniques, population growth, improving climatologic conditions and changing actor relations. Taking marginal lands into use, because of cerealization is therefore a heavily debated subject. The literature on perception often relates this to the Cistercians' imperative toward the taming of wilderness. However, many studies lack convincing evidence for this perception of Cistercians being the main driver behind the expansion of arable ground. Cistercians were definitely involved, but their intentions and role in the process are unsure. An archival study of these clearances and especially on the initiators and executers could provide valuable insights.

The period after 1400 is only briefly taken into account in this research in the interest of linking its relevance to contemporary mentalities. A further, more comprehensive study on changing mentalities on flooding for this period is recommended. Since many more sources for that period are available, than for the Medieval period. Such a study would have the potential to provide a valuable elaboration on the present research, extending beyond the early emergence of flood management in the Upper Rhine valley. As a contribution to contemporary spatial development useful methods in landscape reconstruction have been discussed, in particular a case is made for including cultural history in contemporary planning projects. And, most significantly, perception and societal mentalities are shown to have had a significant role in historical landscape development. Thus, placing contemporary developments in a more extended time frame can hopefully contribute to their sustainability.

Many of the in this thesis mentioned changes in mentalities may have been influenced by a myriad of reasons. For example, socio-economical factors and the importance of war and interregional politics, among others, are not taken into account in this research. Additionally, geographical factors could have had more importance than has been accounted for here. For example, improvement of local climate reconstructions. Or aspects such as location on the western versus the eastern bank of the Rhine as well as on the terrace versus on the flood plain might have played an important role. The difference between the regional scale and the local case studies has already been discussed in the chapter on concluding interpretations.

All things considered, the interdisciplinary landscape study conducted in this research project provides many new insights that should certainly be taken into account by future landscape studies. The results awaken curiosity and ask for further elaboration by experts from specific disciplines. In the end, the results obtained here ought to inspire future research and spatial developments, in addition to having advanced knowledge by combining the findings of various disciplines.

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