

A change of course

Assessment of old- and new coring data, field observations and archaeological contents of fluvial deposits to gain new insights in a temporally and spatially changing geomorphology in an embanked floodplain of the Meuse, the Netherlands



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1. Introduction

1.1 Research Aim

The aim of this bachelor thesis research is to assess the shifting of rivers and build-up of a channel belt near the village of Moordhuizen, in the Rhine Meuse delta, of the Netherlands. These developments are studied for the period from roughly the Late Iron age until the late middle ages, since many archaeological finds have been found during dredging activities near Moordhuizen. Palaeogeographic maps of former Meuse channel belts in the central Rhine-Meuse delta have been constructed at delta scale, but when zooming in these reconstructions are not very specific for the study area (*i.e.* the time steps are too crude and the accuracy is too low, see ch. 2.4). Therefore a reconstruction of the channel belt courses in the study area specifically is presented. More detailed knowledge about the shifting course of the Meuse, leads to a more profound understanding of the human activity, of which many archaeological remains have been recovered. Additionally, this will provide better insights into the taphonomy of the archaeological remains (*i.e.* the way archaeological remains are preserved in the different sediments). Since relatively little academic overview studies have been conducted on the character of the deposits in the embanked floodplains of the deltaic branches of the Meuse compared to the Rhine (the larger river in the shared delta), this study could prove useful for future physical geographical and (geo)archaeological studies on the Meuse on a larger scale.

1.2 Setting of the study area

The study area '*Over de Maas*', at present part of the embanked floodplain of the Meuse, is located near the little village of Moordhuizen (municipality of West Maas en Waal, province of Gelderland) adjacent to the modern day channel of the Meuse, some kilometers from the river Waal, the main distributary branch of the Rhine in the Netherlands (see [figure 1](#)). The area is located near the Peel Boundary Fault, dividing the Roer Valley Graben from the Peel Horst (Cohen *et al.*, 2002; Cohen, 2003). Since 2011 sand and gravel have been extracted from large parts of the *Over de Maas* area for exploitation. Eventually, after all the valuable sediments have been extracted, the area will be redesigned to be a recreational nature area. Comparable activities have taken place during recent years upstream of the study area in the province of Limburg (Rensink *et al.*, 2015a; Rensink *et al.*, 2017) as well as along deltaic branches of the Rhine (*e.g.* Willemse, 2016). Since 1997 different areas mostly on the Eastern side of the Meuse between Mook and Eijsden (province of Limburg, the Netherlands) have been dredged as part of flood safety measurements in the context of the project *Maaswerken* ('Meuse works'). As with the *Over de Maas* area, after all sand and gravel is extracted and sold, these areas are redesigned as nature areas (Rensink *et al.*, 2017).

Prior to the execution of the safety measurements and the commercial dredging activities, archaeological investigation has taken place in the concerned areas, under the authority of the Cultural Heritage Agency of the Netherlands with a focus on coupling the archaeological contents with the reconstructed landscape features. Recently, Rensink *et al.* (2015a) published a series of Geomorphogenetic maps as well as a series of Archaeological Expectation maps of the Limburg Meuse valley based on the results of these various archaeological investigations (*e.g.* coring campaigns and test excavations) and numerous other (multi-disciplinary) reports by specialists from other fields. Unfortunately, the local authorities decided that large scale archaeological investigations

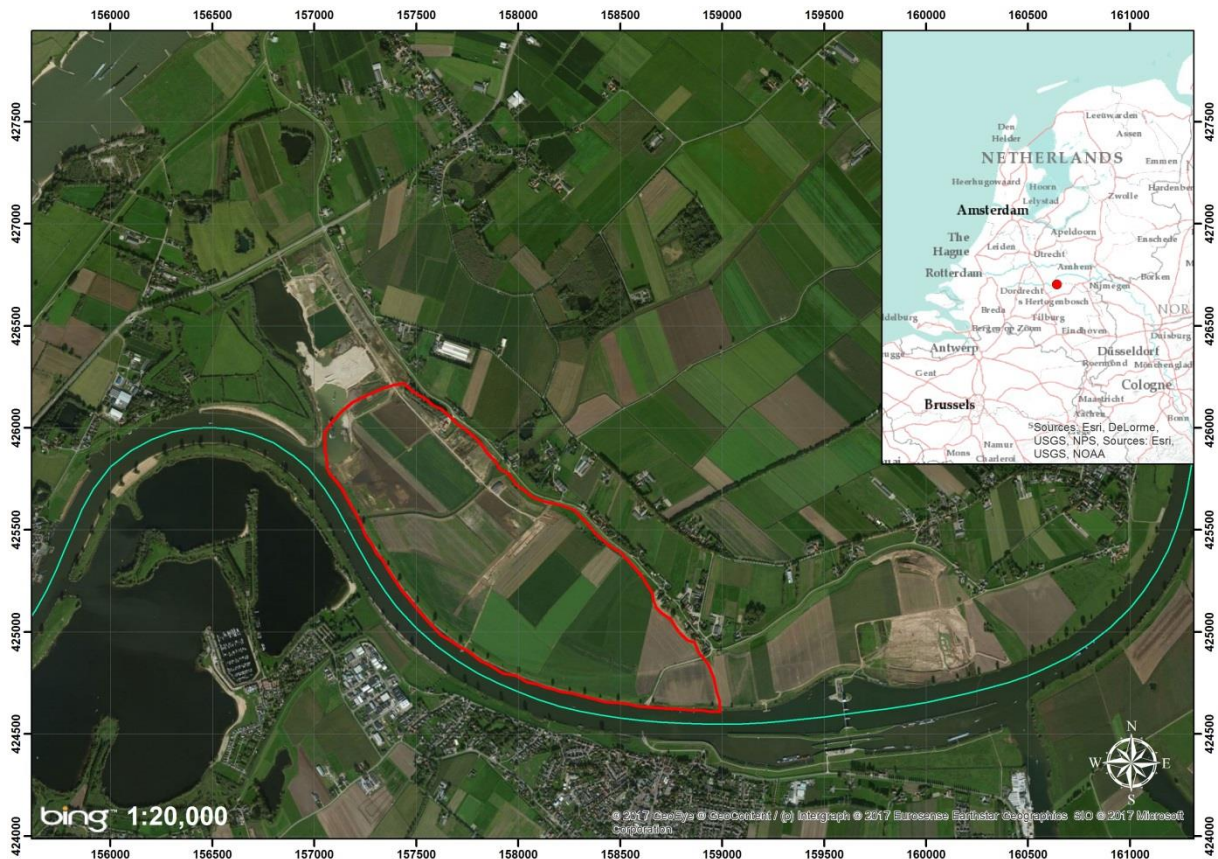


FIGURE 1: LOCATION OF THE STUDY AREA *OVER DE MAAS*. THE RED DOT IN THE INSET MAP SHOWS THE LOCATION OF THE STUDY AREA IN THE RHINE-MEUSE DELTA, THE RED LINE IN THE AERIAL IMAGE ROUGHLY OUTLINES THE STUDY AREA. THE RIVER IN THE TOP LEFT CORNER OF THE IMAGE IS THE WAAL, THE RIVER ADJACENT TO THE STUDY AREA IS THE MEUSE.

were not needed in the *Over de Maas* area, whereas this area later - when dredging activities had already started – in fact turned out to be excessively rich in archaeological remains from different periods (see ch. 2.3). A group of enthusiastic volunteers guided by archaeologist Nils Kerkhoven attempts to save as many archaeological finds/remains that come up along with the extracted sediment on the dredging ships, and keeps them in a former barn that serves as storage facility. Furthermore, they have found and excavated several ships of various ages, some of which were *in situ* and (nearly) complete (see ch. 2.5). These ships have been dendrochronologically dated by prof. dr. Esther Jansma at the Cultural Heritage Agency of the Netherlands in Amersfoort.

This archaeological data is very useful for the geomorphogenetic reconstruction of the study area through time. *Vice versa*, the geomorphogenetic reconstruction is equally important to understand the lateral and vertical distribution of various find categories. A detailed literature review on the local and regional physical geography, geology and archaeology/history follows in Chapter 2.

1.3 Approach

In order to achieve the research aim described in ch. 1.1, different types of data and literature have been collected, studied and analysed. The research was accomplished in three phases: **i) preparatory work in the office**: studying background literature on the regional setting of the study area, the Meuse, river morphodynamics, and fluvial geomorphology; deriving borehole data from the UU-LLG database (Berendsen & Stouthamer, 2001; Berendsen *et al.*, 2007) and DINOLoket (<http://www.dinoloket.nl>, data provided by the Geological Survey of the Netherlands, TNO) as well as from earlier project reports (*e.g.* Cohen, 2003; Hebinck & Heunks, 2011); making a field map of the study area, plotting Dutch LiDAR altimetry data for height reference (AHN1 from 2001 and AHN3 from 2015; <http://ahn.nl>) and derived borehole data; planning of the location of a

new borehole transect for cross-section reconstruction and determining the desired minimal coring depth; determination of more specific research questions. **ii) Fieldwork in the study area:** coring several hand-augered boreholes along a transect perpendicular to the current Meuse channel; logging field observations in the mining part of the study area; discussing preliminary results with assistants in the field, drs. Nils Kerkhoven and dr. Kim Cohen. **iii) Analysis of data and writing the thesis:** constructing cross-sections based on borehole data obtained in the field and/or during preparatory work; producing a map series of morphological change of the study area through time; reporting results and providing products described above by writing this thesis; interaction with archaeological workers and their reporting.

2. Background of the study area

2.1 Fluvial geomorphology and morphogenetic units in the Rhine-Meuse Delta

Over the last ca. 2 ka, the Meuse has been a meandering river with a maximum depth of ca. 5 m and width of ca. 200 – 300 m (in the natural, pre-embankment situation). To analyze the morphological change of the environment around Moordhuizen for the last 2 kyr, insights and theories from recent literature have been applied in this study (*cf.* Gouw and Erkens, 2007; Cohen *et al.*, 2009; Nichols, 2009; Kleinhans, 2010; Jongmans *et al.*, 2015; Stouthamer *et al.*, 2015). The specific parameters determining river channel pattern will not be discussed here (for a solid overview see *e.g.* Kleinhans, 2010; Kleinhans and van den Berg 2011). Instead, the different sediments deposited by an actively meandering river will be reviewed to provide a solid theoretical background to interpret and discuss the results presented later in this thesis. Some important figures about the Meuse have to be mentioned however to illustrate the general setting of the Meuse. The maximum depth of the channel is ca. 5 m, its width generally ca. 200-300. Channel Belt sand units deposited by the Meuse are about a couple of 100s m (at maximum ca. 500 m). The average discharge is ca. 230 m³/s.

A meandering river transports and deposits sediments from a mixed load; that is, sediments of different grain sizes are carried as bedload (*i.e.* rolling and saltating grains) or as suspended load (*i.e.* grains are in suspension in the water column). The coarsest sediments – coarse sand and gravel - are transported as bedload in the deepest part of the channel where water is flowing fastest: the *thalweg*. On the other hand, finer grained sediments are transported and deposited in the inner bend of a meander bend as bedload where flow velocity is reduced due to friction and the bed shear stress is higher (Kleinhans, 2005; Nichols, 2009). Thus an inner meander bend typically shows a characteristic sedimentary structure of fining upwards sediments: coarse material at the base followed by gradually becoming finer material on top of it. This accretional morphological feature is known as a point bar (Nichols, 2009). The outer meander bend, on the contrary, is being eroded by fast flowing water of the *thalweg*. Hence a pattern of meandering river bends develops: expanding inner bends and outer bends being eroded. As a result the river channel undergoes lateral migration and the outer bend becomes steeper over time (Cohen *et al.*, 2009). The different morphological units and their associated lithofacies relevant for this study denoted in [figure 2 and 3](#) are described in detail separately below.

Note: other geomorphological features, which also occur in the Land van Maas en Waal, such as inland aeolian river dunes (*e.g.* the Dreumelse Berg), formed during the Late Glacial, Younger Dryas stadial, *cf.* Cohen, 2003) are left out of this review as they do not occur in the study area properly.

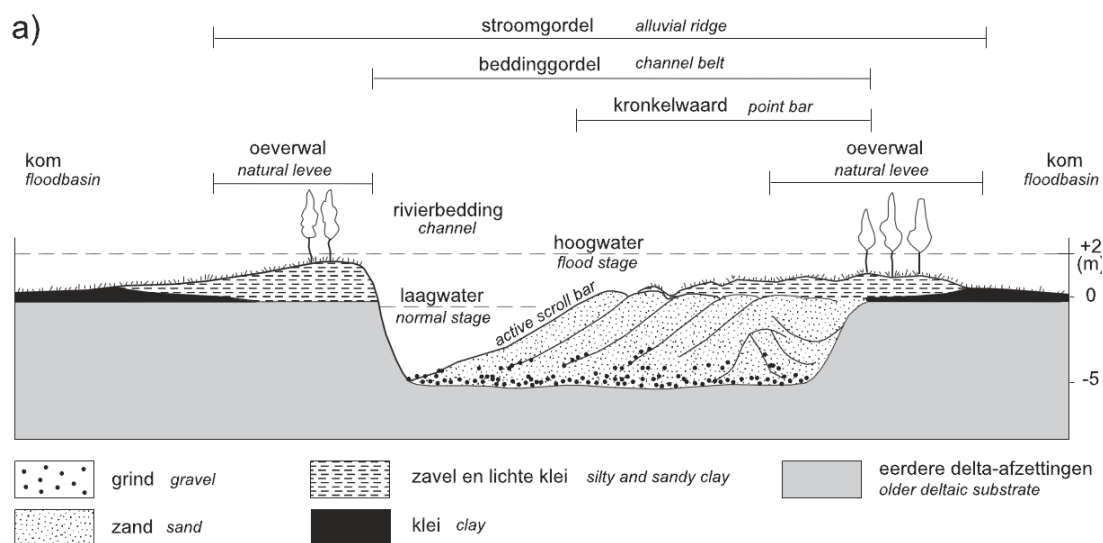


FIGURE 2: SCHEMATIC CROSS-SECTION OF MEANDERING RIVER DEPOSITS IN THE RHINE-MEUSE DELTA. ADAPTED FROM COHEN ET AL. (2009, FIGURE 13A).

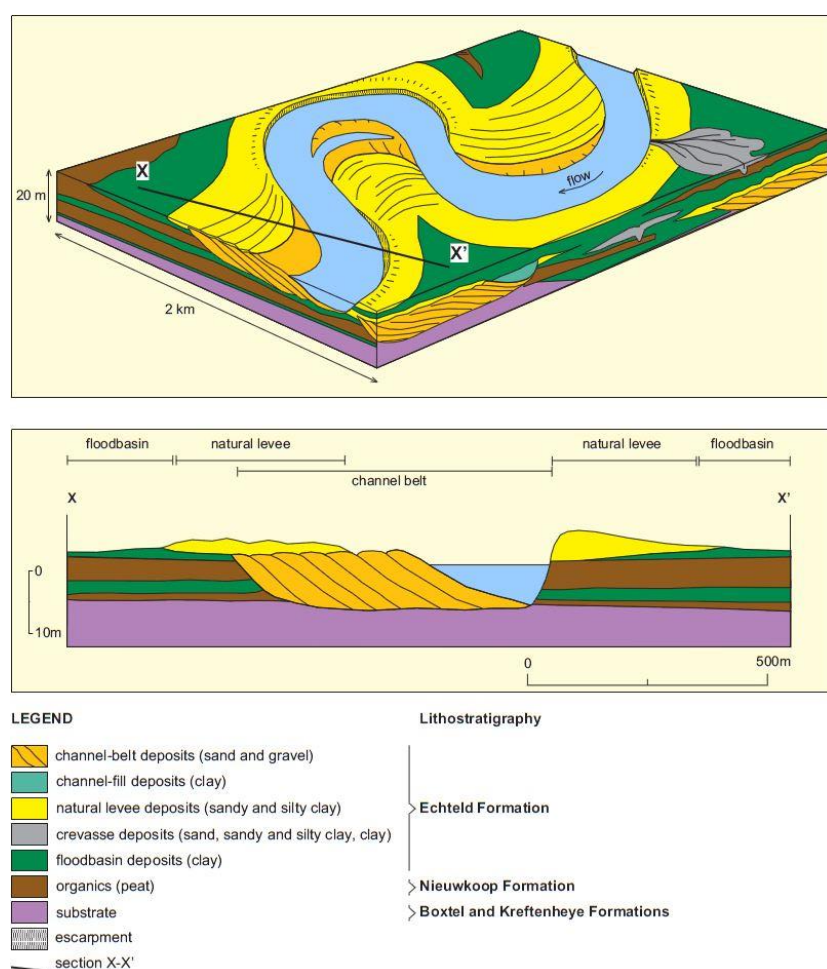


FIGURE 3: SCHEMATIC CROSS-SECTION AND BLOCK DIAGRAM OF MEANDERING RIVER FACIES. ADAPTED FROM GOUW AND ERKENS (2007, FIGURE 3).

2.2 Channel deposits & morphology

The channel belt (see figure 2) is the zone within the riverine environment in which the river channel shifted and left different sorts of channel deposits, namely: *channel lag* on the channel bed, *bars and dunes* in the river channel and *point bars, chutes bars, tail bars* and *scroll bars*.

Channel and channel lag deposits

Most sediment in the channel is transported during when the channel is fully filled with water, or when it extrudes its river banks; moreover, larger grain size sediment are transported further downstream when the discharge is higher. The outer meander bend of a channel is eroded by water flow, whereas in the inner bend sedimentation takes places, and as a result the meandering channel is characterized by an asymmetrical profile: the outer bend has a steep sloping bank, whilst the point bar of the inner bend has a much more gently sloping bank (see figure 2) (Jongmans *et al*, 2015). The channel bed consists of different types of deposits (see figure 2).

In the deepest parts where erosion takes place, channel lag deposits are found, consisting of coarse sand sometimes with an admixture of gravel near the substrate. In the shallower parts, where sedimentation is dominant bar deposits are deposited, comprising medium to coarse sands. They are in general well permeable (Cohen *et al.*, 2009). The channel belt deposits near the (former) inner bend are covered by a sequence of fining upwards point bar deposits and subsequently overbank deposits, especially in the case of a laterally migrating meandering river (see figure 2 and 3). When a channel is gradually being abandoned because of an avulsion upstream (*i.e.* another channel of the same river has become the primary discharge carrying channel), it fills with different kinds of smaller grained sediments, depending on the type of abandonment and the type of channel. These types of filling in sequences are described below.

Point, chute and tail bars

The point bar is the accretional part of the inner meander bend, where sediments (predominantly sand, sometimes with an admixture of gravel) eroded in the outer bend of a meander bend upstream is deposited (Leopold and Wolman, 1957). Point bar deposits generally show a fining up sequence for a given location of a laterally migrating meander bend becomes progressively more distant from the active channel.

Three different kinds of bars can be found that make up a point bar complex, each with a different morphodynamic origin, associated with different types of meandering rivers, namely: tail bars, scroll bars and chute bars (Kleinhans and van den Berg, 2011) (see figure 4). Tail bars are formed behind obstacles on the bars (*e.g.* organic debris such as tree branches) irregardless of the specific river type. Scroll bars are ridges between swales on top of point bar deposits, which can only be formed in meandering rivers on top by various processes, some of which are only remotely understood nowadays. Nanson and Croke (1992) describe three possible processes by which scroll bars can be formed. They can be formed by landward migration of submerged transverse sand bars on to previously accumulated parts of the point bar in a laterally migrating meandering river (Sundborg, 1956; Nilsson and Martvall, 1972; Jackson, 1976; Nanson and Croke, 1992, 26).

Alternatively, they can be formed behind a tail bar near the meander bend apex or by sedimentation of suspended sediment in a flow-separation envelope over the point bar (Nanson

1980; Nanson, 1981; Nanson and Croke, 1992, 26). Moreover, scroll bars can result from the sequential formation of chute channels on a point bar leading to a surface pattern of ridges (scroll bars) and swales (McGowan and Gardner, 1970; Nanson and Croke, 1992, 27). In meandering rivers, for chute bars to be formed the river should have a relatively high specific stream power during peak discharge events (McGowan and Gardner, 1970; Kleinhans and Van den Berg, 2011). They are formed at the end of chute channel, crossing the (point) bar at peak discharges; flow is converged into the chute channel until it reaches the chute bar at the end where it is diverged and slowed down, resulting in aggradation of the chute bar (Ferguson *et al.*, 1992; Kleinhans and Van den Berg, 2011: 724). Chute channels completely crossing a point bar can cause the point bar to be cut-off, thus forming a new braid bar or leading to meander bend cut-off. In wide river bends chute bars migrate downstream until ca. halfway the point bar, whereas in bends with a tighter curve chute channels are more likely to cross-cut most of the point bar and thus chute bars are formed farther downstream on the point bar. The frequency of chute bar (and channel) development and reactivation depends on the frequency of (extreme) flood events (Van den Berg and Middelkoop, 2007).

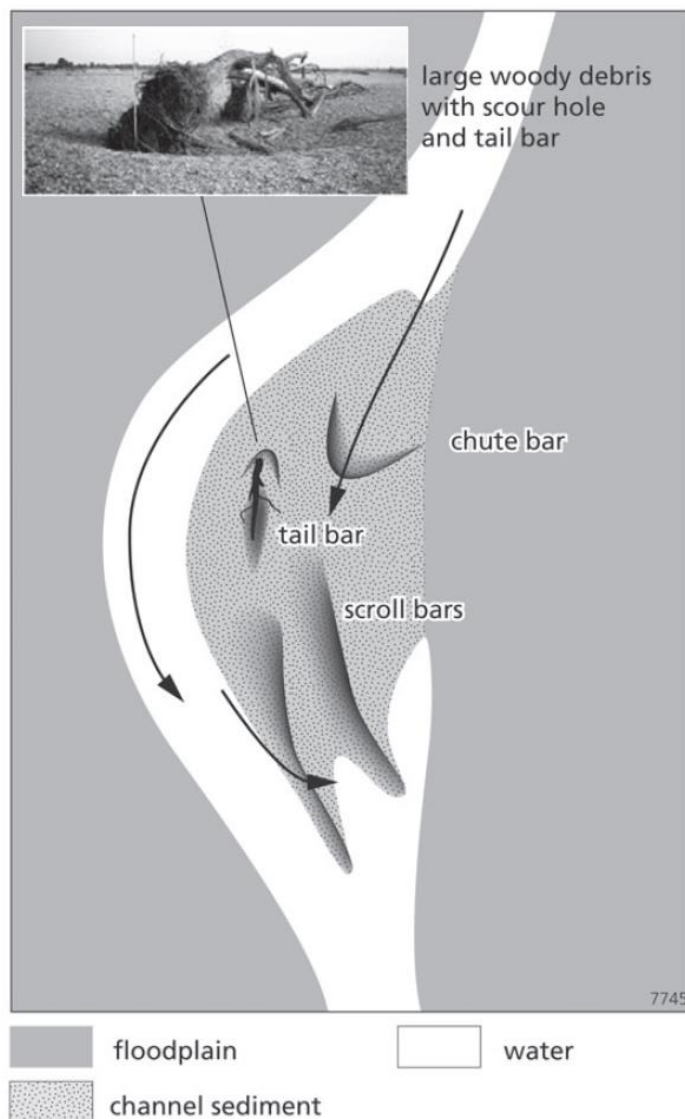


FIGURE 4: SCHEMATIC TOP VIEW OF CHUTE-, TAIL- AND SCROLL BARS IN A MEANDERING RIVER. ADAPTED FROM KLEINHANS AND VAN DEN BERG (2011, FIGURE 2).

2.3 Overbank deposits & morphology and soil formation

The overbank deposits include *natural levees* and *flood basin* deposits. The former ones are part of the alluvial ridge (of which the channel belt is also part of), whereas the latter ones are not. Former alluvial ridges in a delta can be recognized in the landscape due to the fact that the former channel belts and former natural levees are less prone to subsidence than the flood basin deposits alongside them, since their sandy and silty sediments show less compaction over time than the clayey and peaty floodbasin sediments (Cohen *et al.*, 2009; Jongmans *et al.*, 2015). Of course, it depends on the time it takes for them to be covered and eventually completely buried by other sediments, how long they can actually be recognized in the delta landscape.

Natural levees

At times of peak discharge and flood (*i.e.* (much) higher than bankfull discharges) - when water overflows the river banks - levees form directly on top of the river banks, existing of fine sand and silt (*the coarsest fractions of the suspended load*) as well as clay, deposited in the proximity of the channel where the flow velocity is still relatively high. Fine sand laminations can be found in the lithofacies. In the Rhine-Meuse delta natural levee deposits tend to reach of maximum thickness of ca. 1 – 2 m, and vary in width depending on the size and age of the river (Cohen *et al.*, 2009, Jongmans *et al.*, 2015, Stouthamer *et al.*, 2015).

Since natural levees are the higher parts of the riverine landscape, they formed attractive places to live on for people through the ages as they did only flood during extremely high floods and had/have a fairly good drainage while still located close to the river. This river then acted a source for food and as a possible trade route (Pierik and Van Lanen, *in press*).

Flood basin

During a flood, after the coarsest material has been deposited on top of the natural levees, farther away from the river channel the remaining suspended material in the water column is deposited when water flow comes to a halt and also clay particles tend to settle down (Middelkoop and Asselman, 1998; Nicholas and Walling, 1998; Cohen *et al.*, 2009, Kleinhans, 2010, Stouthamer *et al.*, 2015). Thus, sediment grain sizes progressively decrease with increasing distance to the active river channel (Pizzuto, 1995; Kleinhans, 2010). These clayey sediments comprise the floodbasins adjacent to the river.

Crevasse splays

Crevasse splays are formed when a river breaks through a natural levee (or dyke) under peak discharge circumstances or when an ice dam is formed (Stouthamer *et al.*, 2015). This protrusion produces a narrow, shallow (at most a couple of meters deep) new channel flowing through and eroding the flood basin sediments, sometimes with several (secondary) branches. As a result, relatively coarse grained material is deposited in the flood basin from these crevasse channels. The resulting proximal splays are characterized by a coarsening up sequence (apart from the upper 1 m, which is fining upwards). Most crevasse channels are only active for a short time after they are formed, although some might eventually, under certain circumstances, grow out to become new channels (as a so-called avulsion belt complex) (Stouthamer *et al.*, 2015). Therefore, the filling in of the crevasse channel mainly consists of sand with only near the top silty clayey deposits.

Archaeological research by Arnoldussen (2008), Arnoldussen and Fokkens (2008) and Van Dinter and Van Zijverden (2010) has indicated that man since the beginning of the Bronze age (4000 BP for the Netherlands) found crevasse splay complexes likeable places to live on. Occupation of crevasse splay complexes was widespread from ca. the beginning of the Middle Bronze Age B (3400 BP) onwards (Van Dinter and Van Zijverden, 2010). Crevasse splay deposits were fertile, thus appropriate for agriculture and, moreover, elevated areas close to a (residual) river channel suitable for transport purposes. In the course of time however, these complexes became less attractive to occupy than natural levee complexes, as floodbasin sedimentation and subsidence of the complexes themselves decreased the relative height of the crevasse splay complexes in the landscape (Van Dinter and Van Zijverden, 2010). Natural levee complexes, part of the alluvial ridge, show significantly less subsidence.

Abandoned channel fills

Channels or parts of channels can become abandoned by either meander bend cut-off (for a review see Toonen *et al.*, 2012) resulting in oxbow lakes; or via avulsion of the channel, abrupt or gradual over the course of decades, centuries or even millennia in the case of the Dutch Rhine delta (*cf.* Jones and Schumm, 1999; Stouthamer and Berendsen, 2000; Stouthamer 2001; Stouthamer, 2005; Stouthamer and Berendsen 2007; Jones and Hajek, 2007; Makaske *et al.*, 2007; Toonen *et al.*, 2012; Kleinhans *et al.*, 2013; Cohen *et al.*, 2016; Van Dinter *et al.*, 2016); or by human interferences (*e.g.* as is the case with the Rhine branche the *Linge*). The sedimentary structure of the channel fill is determined by several factors, the most important being the distance from an active channel and the frequency of extremely high discharge events (*i.e.* floods that do not occur yearly or per decade but more infrequently). Additionally, the architecture of the channel fill of a cut-off meander (an oxbow-fill) differs significantly from that of an avulsion-abandoned channel (a residual channel). The latter one acts as a flood-active channel for a much longer time than the former one, usually disconnecting within the course of decades, is not discussed here (Stouthamer and Berendsen, 2000; Kleinhans *et al.*, 2011; Toonen *et al.*, 2012; Stouthamer *et al.*, 2015). As such, channels (gradually) losing most of their discharge to a new channel resulting from an avulsion upstream (*e.g.* caused by a crevasse splay complex developing into a permanent water carrying channel), undergo an 'abandoning' or 'transitional' phase during which they progressively become narrower and shallower; eventually they will become completely disconnected after which residual channel fill sediments are deposited (Toonen *et al.*, 2012).

The sedimentary structure of the residual channel in filling is characterized by alternating laminations of thicker and thinner, coarser and finer material. Finer material is deposited in the abandoned residual channels during normal flooding events, whereas the coarser sandy laminations are deposited during extreme flooding events. This is due to several factors. Firstly, extreme floods – with even higher discharges than during a normal flood – lead to larger volumes of water in the floodplain, which, in addition, also flows faster than during a normal flood of the floodplain. Thus, coarser grains can be carried farther into the hinterlands of the floodplain and reach more distal abandoned channels. Secondly, extra sand is brought into suspension during the higher energetic extreme events; therefore a greater amount of sand can be deposited during extreme events. Finally, the coarser sandy laminations are only deposited during the period of the extreme flood with the highest flow velocities when the extreme flood is at its maximum/peak discharge, because the coarser grains precipitate faster from suspension than finer grains and the latter ones are supplied for a longer duration of the flood even after its peak (Cohen *et al.*, 2016).

Abandoned channels that are located more distal from the active river channel are more favourable locations for investigating flooding sedimentary archives, since they receive less sediment per flood because of their large distance from the active channel; thinner laminations are produced and more information about flooding frequency over a longer time span is preserved (Cohen *et al.*, 2016).

Soil types in the study area

Where floods occur sporadically instead of frequently and when the time of inundation (*i.e.* the time a part of the land is flooded), large areas of the flood basin can become covered by dense vegetation, of which the decaying organic material can form peat, when water drainage is poor and the water table is relatively close to the surface (Cohen *et al.*, 2009, Jongmans *et al.*, 2015, Stouthamer *et al.*, 2015). On the other hand, where floods occur infrequently but drainage of the organic clayey surface layer is better (*i.e.* no enduring stagnation of water), soil formation takes place. These palaeosoils can be recognized as brownish layers in the sedimentary lithofacies.

Physical geographers and archaeologists alike benefit from the presence of multiple individually distinguishable peat layers and/or palaeosoil, for they can be ¹⁴C dated using their organic material. Inspection and dating of these kind of layers is more important in natural levee complexes or former alluvial ridges than in floodplain units, since humans were more likely to inhabit the former ones than the latter ones in the Rhine-Meuse delta landscape (as described above). By doing so different clay layers in the flood basin can be linked to different riverine systems in the area, active at different times. Thus, archaeological finds and features found in a certain flood basin layer can be dated more tightly (and vice versa), thereby improving archaeologists' understanding of the (local) history of the site.

Most soils in the physical geographical region '*Rivierengebied*' are too young for much soil formation to have taken place. This is, naturally also the case for the *Land van Maas en Waal* wherein the study area is located. Therefore, most soils belong to the class of '*vaaggronden*' (*i.e.* vaagsoils); *poldervaagsoils* in the floodplains, *ooivaagsoils* on the alluvial ridges (Jongmans *et al.*, 2015). Pons (1966) states that the floodplain clayey soils underneath a palaeosoil (at the surface in Roman times) have abundant concentrations of oxidized iron stains and concretions and signs of reduction at shallow depths, because the height of the watertable in the floodplains was heavily fluctuating throughout the year (*i.e.* they were drained until late spring). Furthermore, the alluvial ridge deposits in the *Land van Maas en Waal* show similar oxidized iron stains and concretions, and can thus be linked to the floodplain deposits in a geological profile (Pons, 1966). The flood basin deposits above the palaeosoil are approximately younger than 1500 years according to Pons (1966). Nevertheless it should be kept in mind that the phenomena described by Pons in the 1960s might not be visible anymore in the present study area due to *e.g.* water level reductions or other (human) activities.

For a more detailed description of specific soil types present in the region see *e.g.* Berendsen (2007, 104-105), Jongmans *et al.* (2015, part IV, chapters concerning the Dutch river landscape) and Pons (1966).

2.4 Lithostratigraphy and chronological palaeogeographic development

Lithostratigraphic units present in the area

According to Berendsen and Stouthamer (2008) the study area along the Meuse is located in the physical geographical region '*Rivierengebied*' (i.e. Dutch for River area/region), more specifically in the western part of the '*Land van Maas en Waal*' (i.e. The land of Meuse and Waal, the latter being the main distributary branch of the river Rhine in the Netherlands); in Jongmans *et al.* (2015) it is considered to be part of the Central River area (*Centrale Rivierengebied* in Dutch). The Land van Maas en Waal belongs to the Rhine-Meuse delta archaeological region according to the 'Archaeological Landscapes map' of Rensink *et al.* (2015b). This region is characterized by the presence of riverine deposits (of the different types described above) at shallow depths below the surface. These riverine deposits are either part of the *Echteld Formation* (when they originated from the Rhine-Meuse deltaic river system) or of the *Beegden* formation (when it concerns deposits originating from the Meuse river system) (Stouthamer *et al.*, 2015; Berendsen and Stouthamer, 2008; de Mulder *et al.*, 2003). Pleistocene (Weichselian) fluvial and local aeolian formations are not reviewed here.

An important difference between fluvial deposits of either Rhine (Waal) or Meuse is the fact that Rhine deposits have relatively high detrital calcium carbonate content whereas the sediments deposited by the Meuse only have very low calcium carbonate content or do not contain any calcium carbonate at all (*cf.* Pons, 1966; Berendsen and Stouthamer, 2008). This has to do with a difference in calcium carbonate concentration of the sediment load of the two rivers: the Rhine sediments (especially the 20–150 µm silt fraction) have a higher calcium carbonate concentration than the Meuse (Van Helvoort, *et al.*, 2005). This calcium carbonate is partly derived from pedogene calcium carbonate from Central Germany. Percolation of rainwater can cause the upper layers of clayey deposits to have relatively low concentrations in calcium carbonate for rainwater can dissolve the calcium carbonate and transport it to deeper layers. This is however not the case with the clayey Waal deposits because these are relatively young and their calcium carbonate content has therefore barely decreased. When conducting fieldwork, this difference can be used to determine what the origin of *e.g.* clayey flood basin sediments retrieved by hand-coring a borehole is, or to distinguish between different sediments in the same coring. Furthermore, Pons (1966, 36) mentions that there is a slight colour difference between floodplain clays deposited by the two river systems in the western part of the *Land van Maas en Waal*: clays deposited by the Waal generally have a dark grey to dark-greyish brown colour, whereas the ones deposited by the Meuse commonly have a lighter grey to greyish-brown colour.

Holocene peats present in the floodplain (subsurface) are part of the *Nieuwkoop* formation. The older deposits underneath consist of aeolian sand deposits (*Boxtel* formation) or fluvial deposits from the Late-Pleistocene/Weichselian and early Holocene (*Kreftenheye* formation). The *Wijchen* member is a specific layer distinguished at the top of the *Kreftenheye* formation and in the *Beegden* formation, generally consisting of little to very sandy silty loams or clays, without calcium carbonate content as a result of soil formation, with a red-brownish colour (for the Beegden formation; Westerhoff and Weerts, 2003: <https://www.dinoloket.nl/formatie-van-beegden>) or silty or sandy clays, lacking a concentration of calcium, with a light grey to dark grey colour (for the Kreftenheye formation: Busschers and Weerts, 2000; Busschers and Weerts, 2003: <https://www.dinoloket.nl/formatie-van-kreftenheye>; Törnqvist *et al.*, 1994).

The Wijchen member comprises silt or silty clays with a light-grey to blue-grey colour, with a thickness of 0.5 – 1 m and generally a downwards increasing medium to coarse sand admixture; moreover has it a low calcium concentration because of percolating groundwater (Stouthamer *et al.*, 2015). The Wijchen member can be found (locally) in the subsurface of the Rhine-Meuse delta all the way to Rotterdam at the mouth of the delta at increasing depth. It can be humic to peaty at the very top, more peaty downstream than upstream. The Wijchen member is ca. 20 – 40 cm thick in the subsurface of the Land van Maas en Waal (Cohen, 2003; Cohen *et al.*, 2009).

For more detailed information about the different lithostratigraphic units described above and how the classification of the different units came to be, see *e.g.* Berendsen and Stouthamer (2008), Stouthamer *et al.* (2015), de Mulder *et al.* (2003), or DINoloket (dinoloket.nl) and references therein.

Development of the Central Rhine-Meuse delta since 8.0 ka

A chronologic overview of the palaeogeographic developments in the (central) Rhine Meuse delta can be found in Stouthamer and Berendsen (2000), Berendsen and Stouthamer (2001), Cohen (2003), Gouw and Erkens (2007), Stouthamer *et al.* (2011), Pierik *et al.* (2016) and Van Asselen *et al.* (2017). A concise review of the palaeogeographic developments in the central Rhine-Meuse delta for the last 8 ka (*i.e.* the beginning of the Middle Holocene) is included here. This specific period is reviewed because during the Middle Holocene the character of the Rhine and Meuse in the study area changed from incising to aggrading (as it was until the construction of dykes in the 13th century, see 2.5). In order to fully understand the changing landscape of the study area in Late Iron Age, Roman and medieval times as described in chapter 4, it is important to have a general understanding of the preceding landscape change in the broader region, the Central Rhine-Meuse delta, of which the study area is part of.

During the Holocene sea level rise due to the warming of the climate and subsequent melting of the terrestrial ice caps in the Northern Hemisphere, the Dutch coastline gradually moved landwards. As a consequence the delta onlap (*i.e.* the line beyond which net delta aggradation occurs) also moved progressively upstream. During the Middle Holocene the position of the delta onlap moved eastward through the Land van Maas en Waal, thus the character of the Rhine and Meuse changed from incising to aggrading (Cohen, 2003; 110). Upstream, incision continued during the Middle Holocene. Near Wijk bij Duurstede, northwest of the Land van Maas en Waal net aggradation started ca. 7 ka (Cohen *et al.*, 2003 in Cohen, 2003, 110). Aggradation in the lowest parts of the central Rhine-Meuse delta floodplain mainly comprised the formation of peat and humic clays, as there was too little input of clastic sediments compared to the provided accumulation space by the main palaeochannel belts in the area/base level rise. Locally, abundant peat formation occurred in the case of an absence of a nearby channel belt depositing clastic sediments. Elevation differences in the Central Rhine-Meuse delta caused different parts of the area to be covered in peat at different times.

Importantly, during the Late-Holocene the Rhine's main channel (Mars-Nederrijn, Houten and Lienden channel belts) gradually switched to a southern course via an avulsion that initiated the Distelkamp-Afferden channel belt (just northwest of the area in [figure 4](#)). From the latter channel belt the Leeuwen and – important for the study area – Waal (175 and 174, see [figure 4](#) abandonment age map for channel belt numbers mentioned) channel belts gradually came into existence (Cohen,

2003, 128). Until the end of the Early Holocene, the Meuse' main channel belt was located more or less in the middle of the Land van Maas en Waal (ca. 3 km north of the modern-day village Alphen, south of the earlier mentioned Dreumelse Berg Younger Dryass aeolian dune). At the turn of the Middle Holocene (ca. 8 ka, Cohen, 2003, 134) this channel belt was abandoned for a more southerly Meuse channel belt (257), which was active until ca. 6.5 ka. The Molenblok channel belt (112), was also an active channel belt at that time. After the abandonment of these two channel belts, since ca. 6 ka, the main channels of the Meuse were located at the present-day Meuse (101), the Haren (59) and Macharen (102) channel belts; the Dreumel (38) and Nieuweschans (121) channels were secondary channels of the Meuse flowing partly through (older) floodplains. As in the rest of the Rhine-Meuse delta, the floodplains parallel to the channel belts in the last 6 kyr accumulated peat and humic clayey deposits in the absence of a substantial supply of clastic sediments (Cohen, 2003, 128).

Since ca. 3 ka BP the sediment load and discharge of both the Rhine and Meuse in the Netherlands increased due to external factors upstream (*i.e.* more intensified land use by humans and climate change) (Gouw & Erkens, 2007). Figures 5-7 (overall, 50 BC and 100 AD) and Appendix 1 show which channel belts were active in the study area and its surrounding area of the Land van Maas en Waal were active at different moments in the past from ca. 1250 BC to 1200 AD (approximately after which for most parts along the river Meuse dykes were constructed, see ch. 2.5), based on reconstruction data from Cohen *et al.*, (2012). Note the static position of the main Meuse channel belt in the study area in the last 3 kyr.

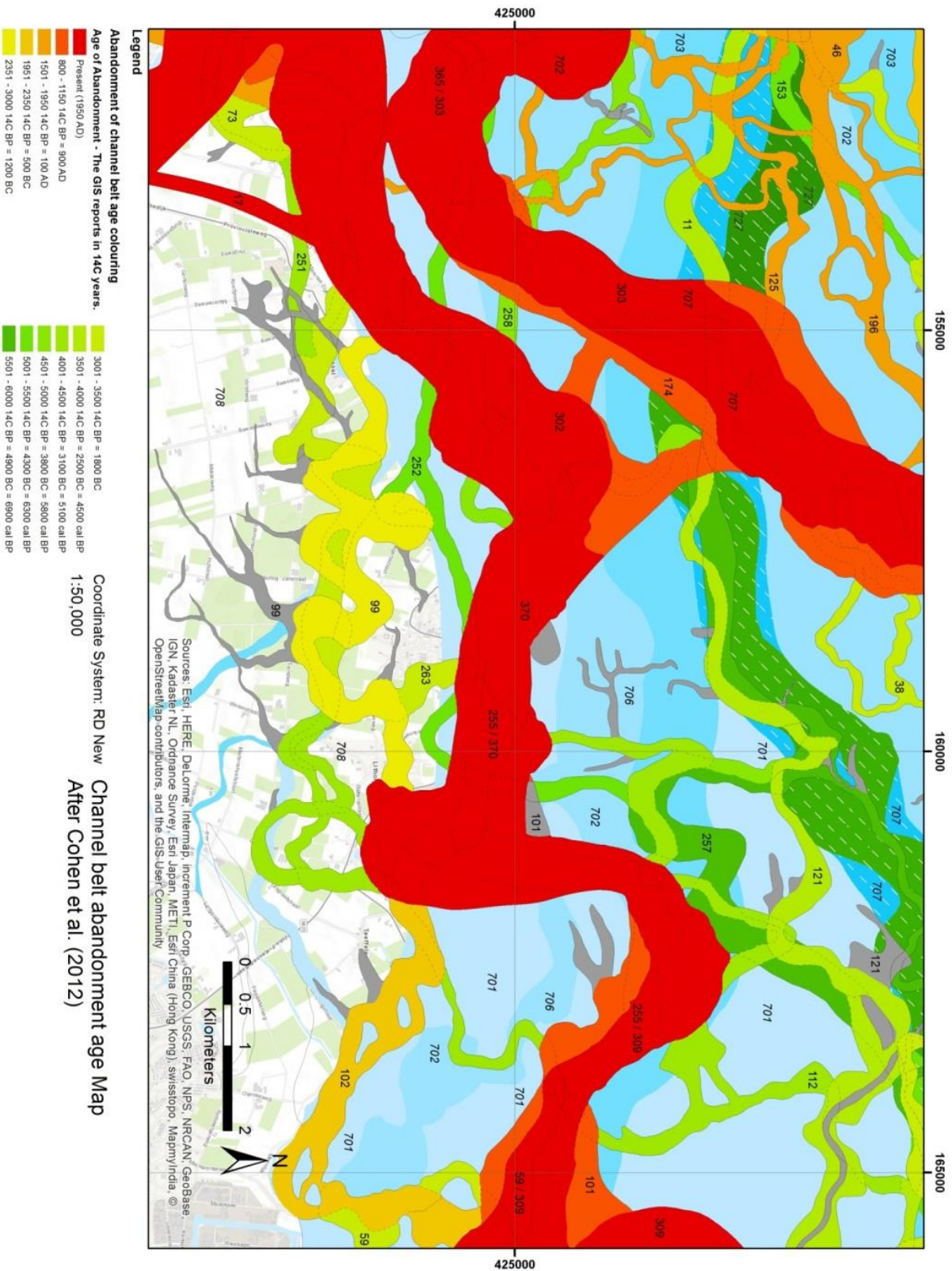


FIGURE 5: ABANDONMENT AGE MAP (SEE CAPTION IN FIGURE).

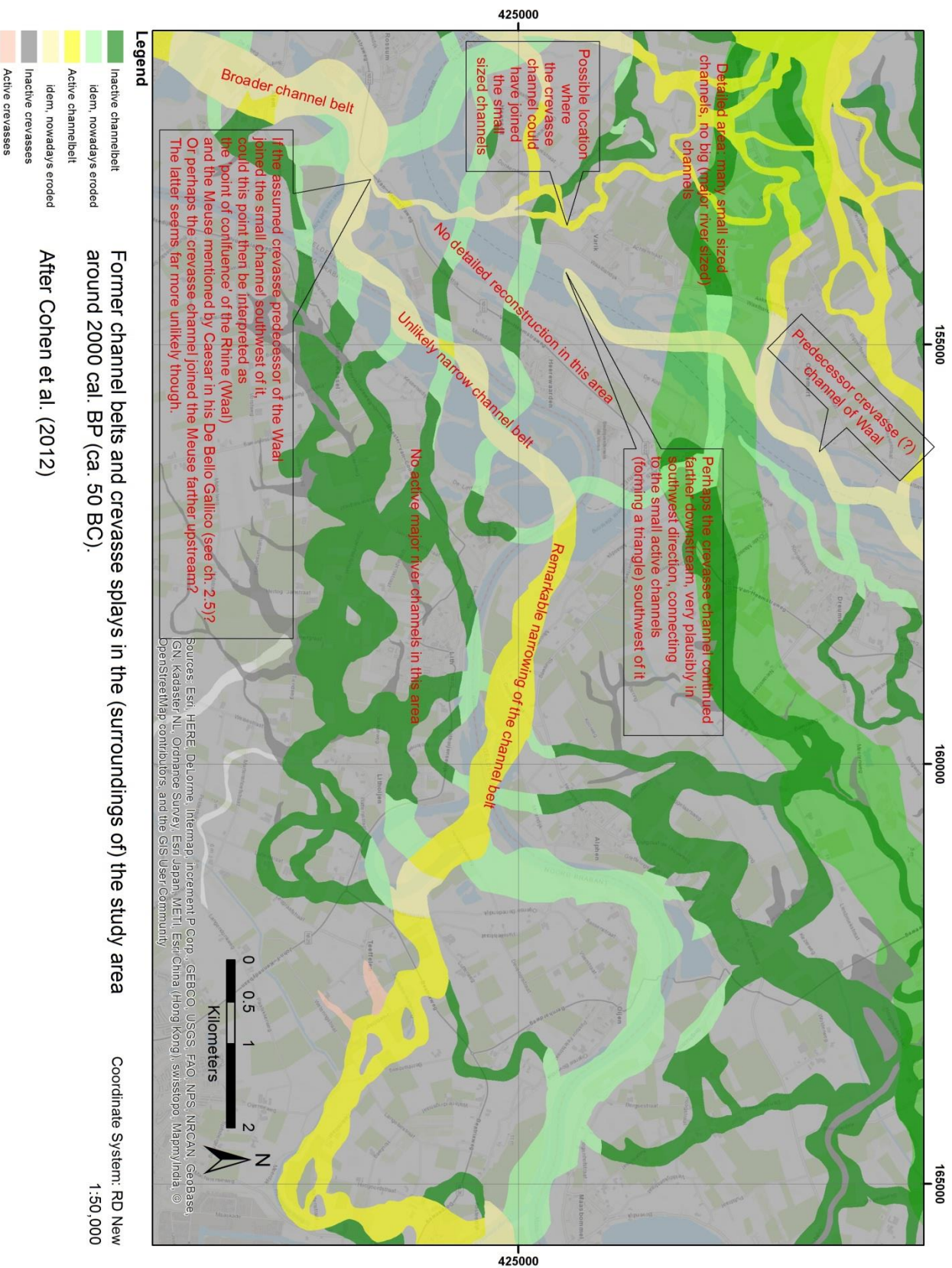


FIGURE 6: CHANNEL NETWORK MAP CA. 50 BC (SEE CAPTION IN FIGURE).

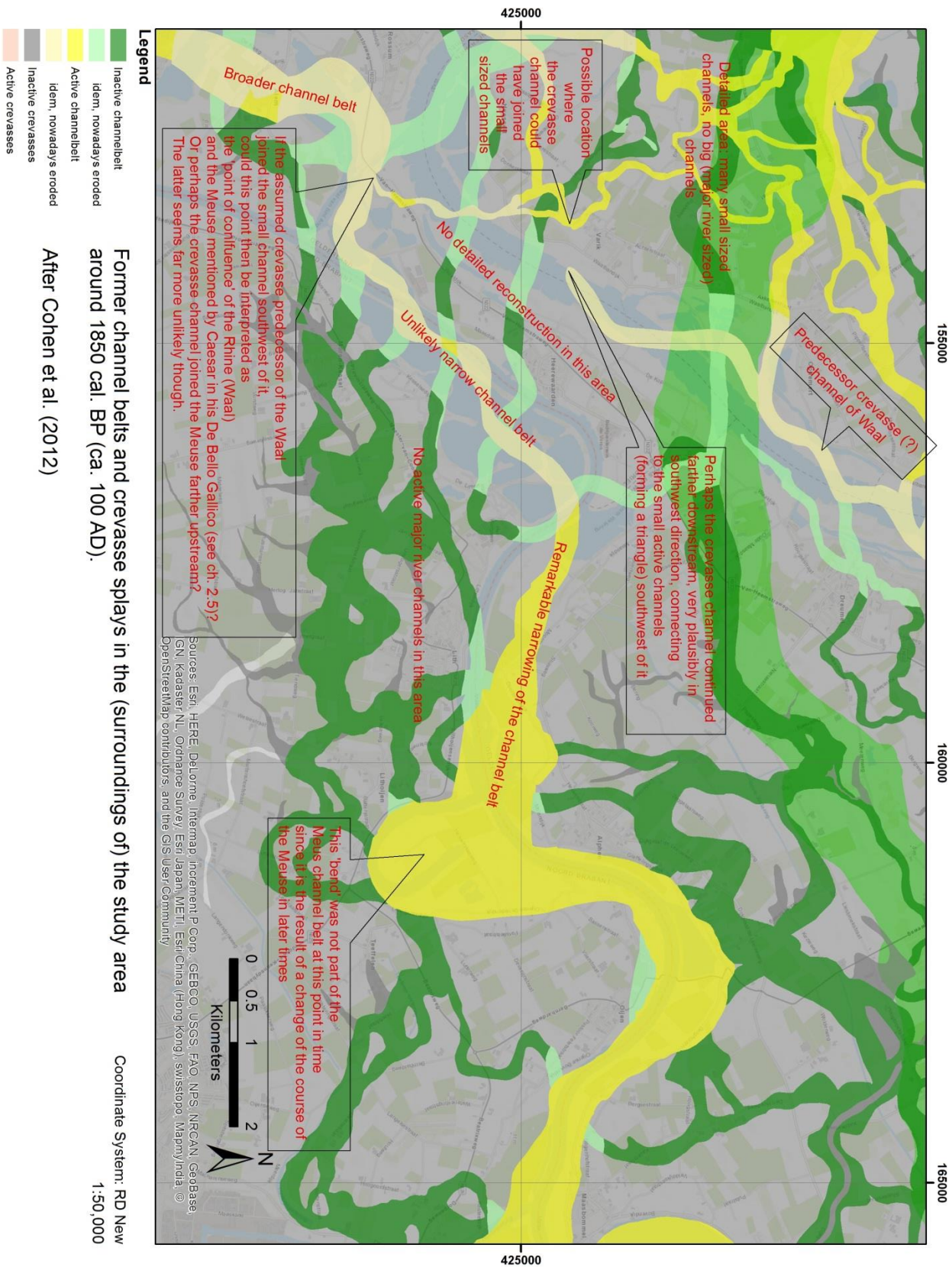


FIGURE 7: CHANNEL NETWORK MAP CA. 100 AD (SEE CAPTION IN FIGURE).

2.5 Archaeology and History

Occupation history of the study area and the broader region

Berendsen (2008) mentions that some finds of Mesolithic hunter-gatherers have been found in the ‘*Rivierengebied*’ and states that the oldest finds of people in this region living sedentary lives are from the Neolithic period (6400 – 3650 BP for the Netherlands). In the central river area settlement sites from different archaeological periods are found in a variety of different fluvial landscape units: half-buried inland dunes (Dutch: *donken*), crevasse splays (active or fossil systems) or on natural levees (active or fossil systems) (Arnoldussen, 2008).

Arnoldussen (2008), states that during the Late Neolithic, people living in the river area utilised a variety of different fluvial landscapes. Particularly crevasse splay deposits were intensively used and are possible locations of settlement sites. The identification of individual settlement site elements however is difficult (as is the case for the following Early Bronze Age period). Moreover, the settlement dynamics and the character of occupation are largely unknown for the Late Neolithic and the two following periods, the Early Bronze Age and the Middle Bronze Age A. Other types of sites which he calls “special activity sites” (Arnoldussen, 2008, 418), would have also existed in the central river area. ‘Special activities’ might for example comprise logistics or extraction of resources. More research into the nature and exact locations of these kinds of sites (within and outside of the central river area) is needed. Farming became the most important way to obtain enough food after the Middle Neolithic.

The Early Bronze age did not differ significantly from the Late Neolithic in terms of the locations in the fluvial landscape where different activities took place. Based on two case studies, Arnoldussen states that settlement sites from this period are certainly expected to be found on crevasse splay- and fossil levee deposits. Different landscape units in the fluvial landscape have not been investigated widely enough in terms of the (character of) their Early Bronze Age remains.

Little is known about the possible settlement site locations and their nature in the Middle Bronze Age A. Arnoldussen suggests, based on the relative low percentage of diagnostic pottery finds in the central river area compared to coastal areas, that the central river area was a periphery to the more important coastal area. Meanwhile, for the Middle Bronze Age B, many more settlement sites in the central river have been found in a larger variety of fluvial landscape units, compared to the preceding Middle Bronze Age A. This is probably due to the fact that these settlement sites are better preserved (and are thus more easily detectable), that their elements are easier to recognize and that they have been the subject of more intensive (and targeted) research (Arnoldussen, 2008). Based on this variety of settlement site locations, it is suggested by Arnoldussen that the Middle Bronze Age B people were very adaptive in their strategy of land use.

During the Late Bronze Age avulsions occurred more frequently (Stouthamer, 2001; Stouthamer and Berendsen, 2001; Stouthamer *et al.*, 2011) and new fluvial systems, crevasse splays and reactivated residual waterways deposited their sediments at the locations of Middle Bronze Age B habitation. As a consequence some parts of the central river area were completely or partly abandoned, others were differently utilised (Arnoldussen, 2008).

In the Iron Age, the habitation of the central river area differed markedly from the habitation in the preceding archaeological periods. Sedimentation covering the Bronze Age occupation

elements such as settlements site elements and parcelling structures obscured these elements for Iron Age people. Additionally, Iron Age people chose to build a notably different type of house than Bronze Age people. Some older, larger fossil fluvial landscape units were still used as settlement site locations however.

Abundant finds from the Roman period have been found in the study area and the surrounding region. At Kessel-Lith, the inner bend of the present Meuse channel belt, opposite to the study area (see [figure 1](#)), a large collection of late iron age, Roman and early medieval finds has been found during dredging activities (Roymans, 2004). These dredging activities were carried out in the 1930s (large-scale river regulation) and from the 1950s until the 1990s (sand and gravel extraction in the embanked floodplains) and are very similar to the dredging activities now employed in the Over de Maas study area. All the Late Iron Age finds are mainly dated based on their typology. Metalwork find categories discussed in Roymans's book (Roymans, 2004, 108-129) are: Late La Tène swords and scabbards, spearheads, (parts of) helmets, shield fittings, belt hooks, fibulae, cauldrons, socketed axes, and Late Iron age and early Roman coins. Tuff stone blocks and ornamental architectural limestone columns point to the presence of several structures in the area, possibly at different times in the Roman period. Some of the tuff stone blocks were possibly building blocks of a bridge crossing the Meuse in the Roman period, connecting the Roman city of Nijmegen with the coastal regions via a southern road following the course of the Waal and Meuse shown on the Peutinger Map (Roymans, 2004; 132, 145).

Another interesting category described is human bone material. More than 650 bones of at least 65 individuals (90 % of whom are adults, predominantly male) were found during dredging. In his work from 2004, Roymans assumed that these bodies were placed in the river as a ritual sacrifice at a cult place (Ter Schegget, 1999, 240 in Roymans, 2004, 129). The fact that a portion of the swords was still in scabbards and that some swords are deliberately bended before deposition could also be interpreted as evidence pointing to the place of deposition being a cult place. The ornamental limestone segments are believed to have been part of a monumental (early) Roman temple located at Kessel-Lith, placed there because of ritual/spiritual importance of the site (Roymans, 2004, 134-144). Moreover, Roymans argues that the settlement at Kessel-Lith could have been the Roman settlement of *Vada*, mentioned by the classical author Tacitus when he describes the events of the Batavian revolt in 69 and 70 AD (Tacitus, Hist. 5.20-21. in Roymans, 2004, 144). *Vada* was attacked near the end of the revolt in 70 AD by the leader of the revolt Julius Civilis himself, and was defended by Roman auxiliary units. It is stated that *Grinnes*, another settlement that was attacked in 70 AD, close to *Vada* on the southern bank of a major river (Roymans, 2004) is located near the modern villages of Alem and Rossum, just west of Kessel-Lith. Based on the location of *Vada* described by Tacitus and on the rich archaeological record from the early Roman period on this location, Roymans believes that the settlement at Kessel-Lith was *Vada* because of its proximity to (within 5 km) Alem/Rossum.

In recent years however, Roymans revised his interpretation of the find complex at Kessel-Lith. He now states that Kessel-Lith and the surrounding area was the location where Caesar slaughtered 160,000 individuals of the Usipetes and Tencteri, two Germanic tribes, in 2055 BP (55 BC). This theory gained a significant amount of media attention, and Roymans was interviewed in some major Dutch newspapers and on national television (*cf.* NRC of 10th of December 2015; NRC of 30th of January 2016; de Volkskrant of the 26th of May 2017). He has, however, not yet published

peer-reviewed literature to substantiate his theory. The main source Roymans bases his new theory on are passages about this massacre in the classical source Caesar's *De Bello Gallico*. Caesar mentions that his troops slaughtered 430,000 persons at the confluence of the Meuse and Rhine (Waal) ca. 120 km out of the coast. The above-mentioned metalware finds and the bone material - some of which bears evidence of injuries caused by violent actions - are believed to be important conclusive evidence that indeed substantial slaughter actually took place at this specific location.

Moreover, Roymans believes that it is the prime reason why the broader area became dramatically depopulated in the decades following the presumed massacre. In a recent article in a newspaper (Volkskrant of 26th of May, <https://www.volkskrant.nl/wetenschap/caesar-roeide-voor-groot-deel-onze-voorouders-uit~a4497196/>) Roymans bases this presumed depopulation on dozens of excavations of (small) settlements in the province of Limburg and the (central) river area that became abandoned around 50 BC and on the analysis of pollen near Köln which show a strong increase in forest vegetation, a possible indication of a significant decrease in the presence of man in the area. He states that in this period 'the Netherlands', present-day Belgium and a part of present-day Germany were largely depopulated.

Roymans' theory, nevertheless, is quite debated among archaeologist and scholars from other disciplines (e.g. historians) alike (cf. NRC 30th of January 2016; Van Ginkel, 2015). Critics point out that the number of bones showing evidence of violence is too small to draw big conclusions from, that he relies too much on the description of the location in *De Bello Gallico*, and that he bases his new insights too much on just a small selected part of all the (dredged) finds from Kessel-Lith (he leaves out the pottery and animal bones finds). Two historians, however, think that Roymans' theory is (at least) plausible explanation of what happened at Kessel-Lith (newspaper article in NRC of the 30th of January, <https://www.nrc.nl/nieuws/2016/01/30/de-slag-om-caesars-slachtpartij-1582707-a377333>). They point out that a recent excavation of a fortification near Thuin in the south of present-day Belgium pointed out that it was captured by Caesar, thus proving that Caesar has visited the Low Countries, which earlier was thought to be impossible to prove with archaeological finds. Moreover do they stress that therefore Caesar's description in *De Bello Gallico* should be taken seriously. It will be interesting to see what arguments Roymans will postulate in future scientific literature.

The early-Medieval (Merovingian) period following the Roman period shows a significant decline in the population inhabiting the river areas. This has probably to do with an increased flooding frequency of the Rhine and Meuse in this period (Toonen, 2013; Cohen *et al.*, 2016; Van Dinter *et al.*, 2017), besides social factors of the collapse of the Roman empire and the migration period afterwards.

Construction of dykes and further human influence on the Meuse

To prevent the main Dutch rivers from flooding adjacent settlements along the river channels, dykes were erected since ca. the beginning of the 11th century AD, starting in the western parts of the Rhine-Meuse delta (Pons, 1957). Mid-fourteenth century AD dykes had been constructed along most parts of the Dutch main rivers (Stouthamer *et al.*, 2015). The Land van Maas en Waal was completely protected by dykes around the start of the fourteenth century AD (Pons, 1957). As a result large parts of the (former) floodplains were now protected from river floods, making them

more attractive for cultivation and habitation, allowing for further growth. Since they were not inundated regularly anymore, sedimentation of these parts of the (former) floodplain decreased dramatically, in contrast to the areas outside of the dykes, where sedimentation continued. Thus the parts of the (former) floodplain within the dykes now subsided relative to the parts that were not (Stouthamer *et al.*, 2015). These latter parts, ‘*uiterwaarden*’ in Dutch and translated to ‘embanked floodplains’ in the further text, formed a novel - anthropologically constructed and influenced - distinctive morphological unit within the fluvial landscape (Hesselink *et al.*, 2003). They can still be seen in the Dutch riverine landscape.

Dredged archaeological finds from the study area

Of relevance for the study area are some preliminary results of the archaeological ‘rescue’ excavations and surveys conducted since dredging activity began by the (earlier mentioned) ‘*Over de Maas*’ group of volunteers led by archaeologist Nils van Kerkhoven. It is important to note that the finds described below are but a small selection of the total number of finds. Besides, it should be taken into account that the vast majority of the dredged finds has not been analysed extensively yet, thus limiting the interpretation in the follow sections of this thesis. The brief overview of finds below is based on personal communication between the author and archaeologist Nils Kerkhoven. Any errors are solely accountable to the author.

The majority of the dredged archaeological finds is either from the Roman period or from early-medieval times (Merovingian). Earthenware fragments from an undisturbed setting (*i.e. in situ*), ceramic building material (*ex situ*) and tuff stone building blocks (*ex situ*) are examples of finds frequently found in the dredged sediments. Some Merovingian finds are possibly re-used Roman material used as ballast to sink fishing nets and earthenware among others.

Moreover, 10 ships of different ages have been found in the study area, some almost completely intact (and *in situ*) when encountered, others more degraded and/or damaged. After excavation, wooden parts of the vessels are or will be dendrochronologically dated by prof dr. Esther Jansma at the RING foundation lab at the Dutch Cultural Heritage Agency (RCE) in Amersfoort. Parts of riverine vessels of possibly Roman, early and late medieval age have been found (see [figure 8 - 10](#) and [table 1](#)).

Prehistoric and Late Iron Age finds are generally scarce in the study area. [Figure 11](#) shows a rough distribution map of different finds as communicated by Nils Kerkhoven. [Figure 12](#) shows the expectancy of archaeological finds in the study area.

Vessel/ 14-C	Age	RD X-coordinate	RD Y-coordinate
<i>Nils Kerkhoven et. al. (pers. comm.) – surveying/salvage during sand extraction activities</i>			
ODM1	ca. 1350-1500 AD	157145.1	425884.5
ODM2	ca. 1000-1200 AD? Presumably Late Middle ages	157414	425935
ODM3	ca. 1350-1500 AD? Presumably Late Middle ages		
ODM4	Presumably Late Iron Ages-Early Roman	158430	425362
ODM5	ca. 1350-1500 AD? Presumably Late Middle ages	157627	425699
ODM6	10 th century AD	No data available yet	No data available yet
ODM7	Presumably a Roman age canoe (still uncertain).	No coordinates available yet. Just West of the 2017 transect, in the middle of the embanked floodplain.	
ODM8	<i>No (estimated) age available yet.</i>	No data available yet	No data available yet
ODM9	<i>No (estimated) age available yet.</i>	No data available yet	No data available yet
ODM10	<i>No (estimated) age available yet.</i>	No data available yet	No data available yet
<i>Hebinck & Heunks (2011) – Pre-sand extraction prospective survey; ARC report.</i>			
ARC #2	800 AD (wood sample in clay layer)	158089.911	425540.591
ARC #11	150 AD (top of channel fill, organic matter)	157936.452	425383.164
ARC #24	1400 AD (wood sample in top sand fill)	157716.186	425135.778
ARC #28	610 AD (plant material in basis of sand fill channel)	157836.903	425282.291

Table 1: Locations *Over de Maas* ship finds (ODMx) and 14C-dates (borehole column #) from the study area



FIGURE 8: PICTURE OF THE SETTING IN WHICH THE ODM4 LATE IRON AGE/EARLY ROMAN VESSEL WAS FOUND: THE INFILLING OF THE PRESUMED EARLY ROMAN SECONDARY CHANNEL. PHOTO BY NILS KERKHOVEN.



FIGURE 9: CLOSE-UP OF THE ODM4 LATE IRON AGE/EARLY ROMAN VESSEL PHOTO BY NILS KERKHOVEN.



FIGURE 10: CLOSE-UP OF ODM5 LATE MEDIEVAL BOAT. PHOTO BY NILS KERKHOVEN.

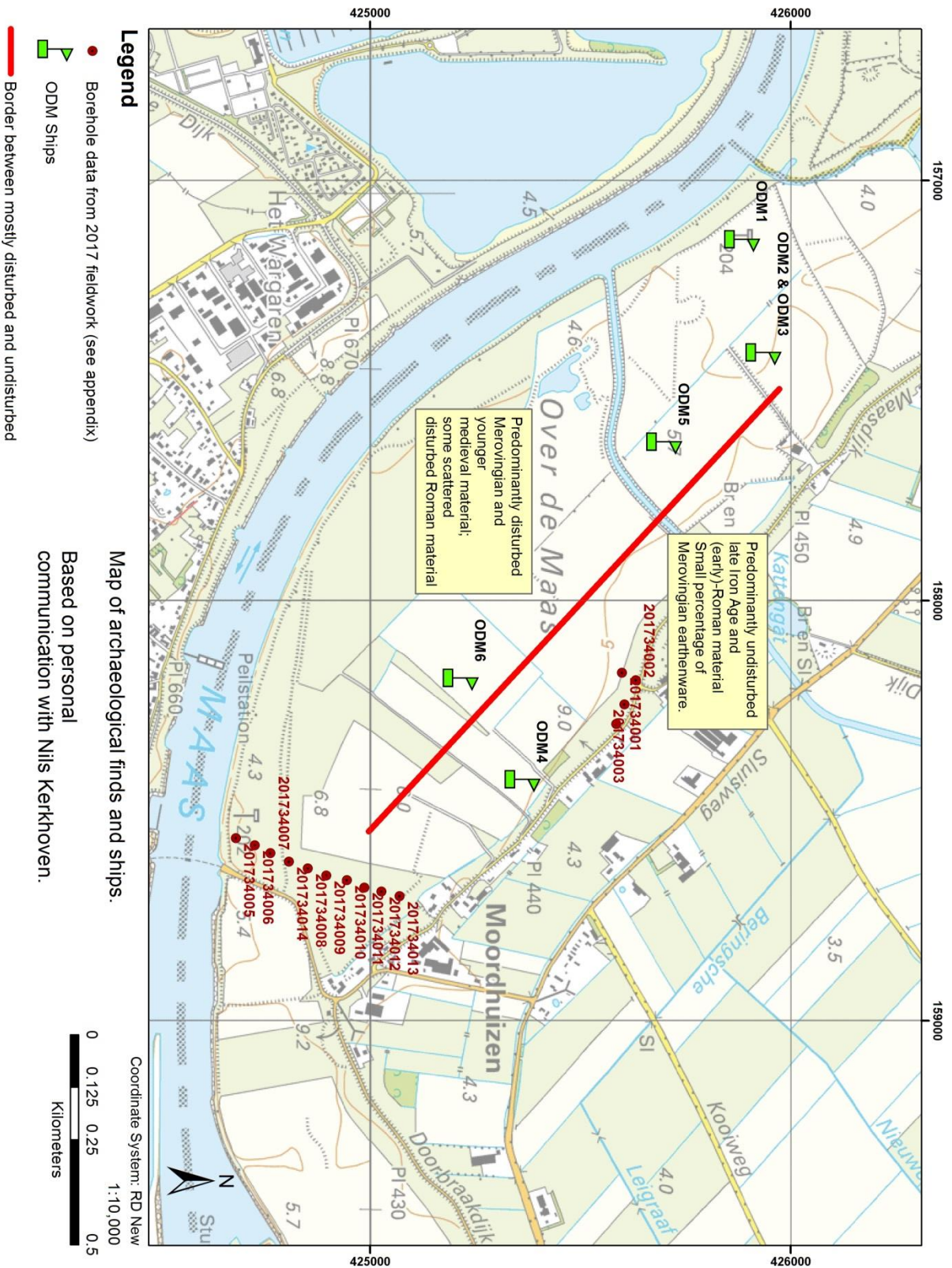


FIGURE 11: SCHEMATIC ARCHAEOLOGICAL FINDS DISTRIBUTION MAP

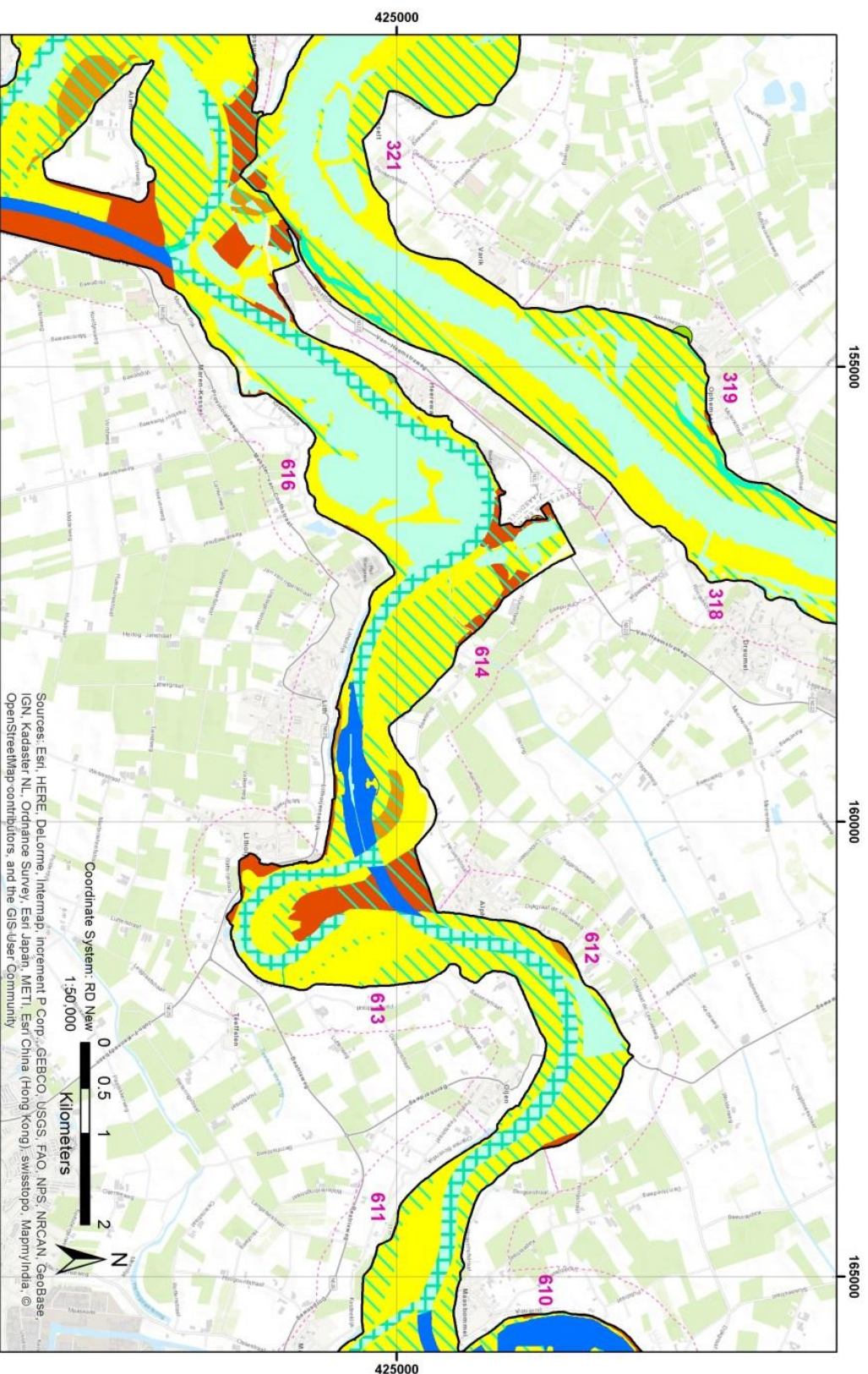


FIGURE 12: EXPECTANCY OF ARCHAEOLOGICAL FINDS IN THE EMBANKED FLOODPLAINS: ALL PERIODS (SEE CAPTION IN MAP).

3 Materials and Methods

3.1 Materials

In order to achieve the research aim described in ch. 1.1, different types of data and literature have been collected, studied and analysed. Various types of geological data from the study area were used:

- Borehole data and core description data of fourteen boreholes hand-cored along two transects in 2017, specifically for this study. One transect runs perpendicular to present flow direction of the Meuse, the other runs along the dike near Moordhuizen. See [figure 13](#): 'FG 2017 Corings' and the Addenda for individual borehole data.
- Three field observations from 2017 of small exposed parts of the sediments in the part of the area that was subject of mining activities. See [figure 13](#): 'Observations 2017'.
- A lithogenetic and chronostratigraphic profile constructed by ARC archaeological research and consultancy company (Hebinck & Heunks, 2011). See [figure 13](#): 'ARC Profiles' and [figure 16](#) and [17](#).
- Borehole and core description data from students in 1995 from the Utrecht University-LLG database of the Faculty of Geosciences (Berendsen *et al.*, 2007). See [figure 13](#): 'FG 1995 Corings'.
- Various Coring data retrieved from [dinoloket.nl](http://www.dinoloket.nl), a national web resource for subsurface geological and hydrological data, provided by the Geological Survey of the Netherlands (<http://www.dinoloket.nl>). See [figure 13](#): 'DINOloket Corings'.
- Historical topographic maps of the study area. See Appendix 4.
- A sand depth map of the enlarged study area, after Cohen *et al.* (2009). See Appendix 3.
- Archaeological expectancy maps. See Appendix 2.

3.2 Methods

The reconstruction of the palaeogeography of the study area is predominantly based on the 14 new hand-cored boreholes, 4 of them located along the Maasdijk/Moordhuizen dyke, 10 of them located in the Southwest part of the study area along a transect that runs perpendicular to the present Meuse channel (corings 2017005 -2017014, hereafter called *005-013 transect*). The fieldwork was carried out by the author and a fellow student from February until mid-April during multiple field visits under varying weather conditions.

Borehole data was collected with the so-called '*Edelman*' auger with a length of 15 cm and a diameter of 7 cm and gauge with a diameter of 3 cm (Oele *et al.*, 1983). To make sure that the collection of enough borehole data was manageable within the fieldwork period whilst also ensuring a sufficient spatial resolution to construct a lithogenetic cross-section, boreholes were cored every 50 m. A Garmin GPS device was used to obtain *Rijks Driehoekstelsel* coordinates of the boreholes, generally with an accuracy of ca. 5 m. Local topography was either measured/determined in the field or inferred from LiDAR altimetry data (AHN1 and AHN3; <http://ahn.nl> , see [figure 13](#)) using GIS software (ArcGis 10.3.1).

The data was logged in the field mainly by the author, to assure a consistent manner in which different aspects of the borehole data were interpreted and noted. Sediment texture, colour, carbonate content, plant remains, organic matter content, macroscopic details and other observations such as lamination were described per 10 cm applying the 'De Bakker and Schelling' texture classification scheme (De Bakker & Schelling, 1966; De Bakker & Schelling, 1989). Note that the description of sediment texture is converted into the USDA soil description using a standard UU-LLG conversion scheme (see Appendix 5) in order to improve international accessibility. Borehole data was interpreted and discussed during fieldwork and compared to observations of corresponding facies in the dredging area directly adjacent to the *005-013 transect*. Photographs of representative borehole sample sequences and facies were taken with a mobile phone in the field under varying light exposures.

The resulting borehole data logs were digitalised later and added to the UU-LLG borehole database. Borehole data descriptions of individual boreholes analysed in this study can be found in the Addenda. Using software developed by Utrecht University (*i.e.* LLG201), the corings were plotted as transects with correct coordinates and height. A cross-section was constructed for the 005-013 transect, drawn following methods for facies and lithogenetic units discrimination as described and applied by Gouw and Erkens (2007), Toonen *et al.* (2012) and Kleinhans *et al.* (2011). To keep in mind the correlation between a given lithological unit or layer and how this given unit is deposited and post-depositionally deformed in a fluvial setting is key (see ch. 2.1-2.3).

The cross section, in combination with the additional above-mentioned data, was used to construct a series of reconstructed palaeogeographical maps of the study area at different periods in its history. Furthermore, archaeological data was used to refine the palaeogeographic analysis of the area.

Exact locations of the ships, the context in which they were found and their dating, most of them only dated based on the characteristics of their remains - provided a sound method to validate the presumed location of the Meuse channel belt in a given period based on the geological data. Likewise the distribution of smaller individual finds from different periods (and even more important the lack of finds from a certain period at a given location), roughly outlined by Nils Kerkhoven (*personal communication*) added extra means to attest the predicted shift of the channel location (see ch. 2.3). All maps were schematically constructed using GIS software (ESRI ArcMap 10.3.1).

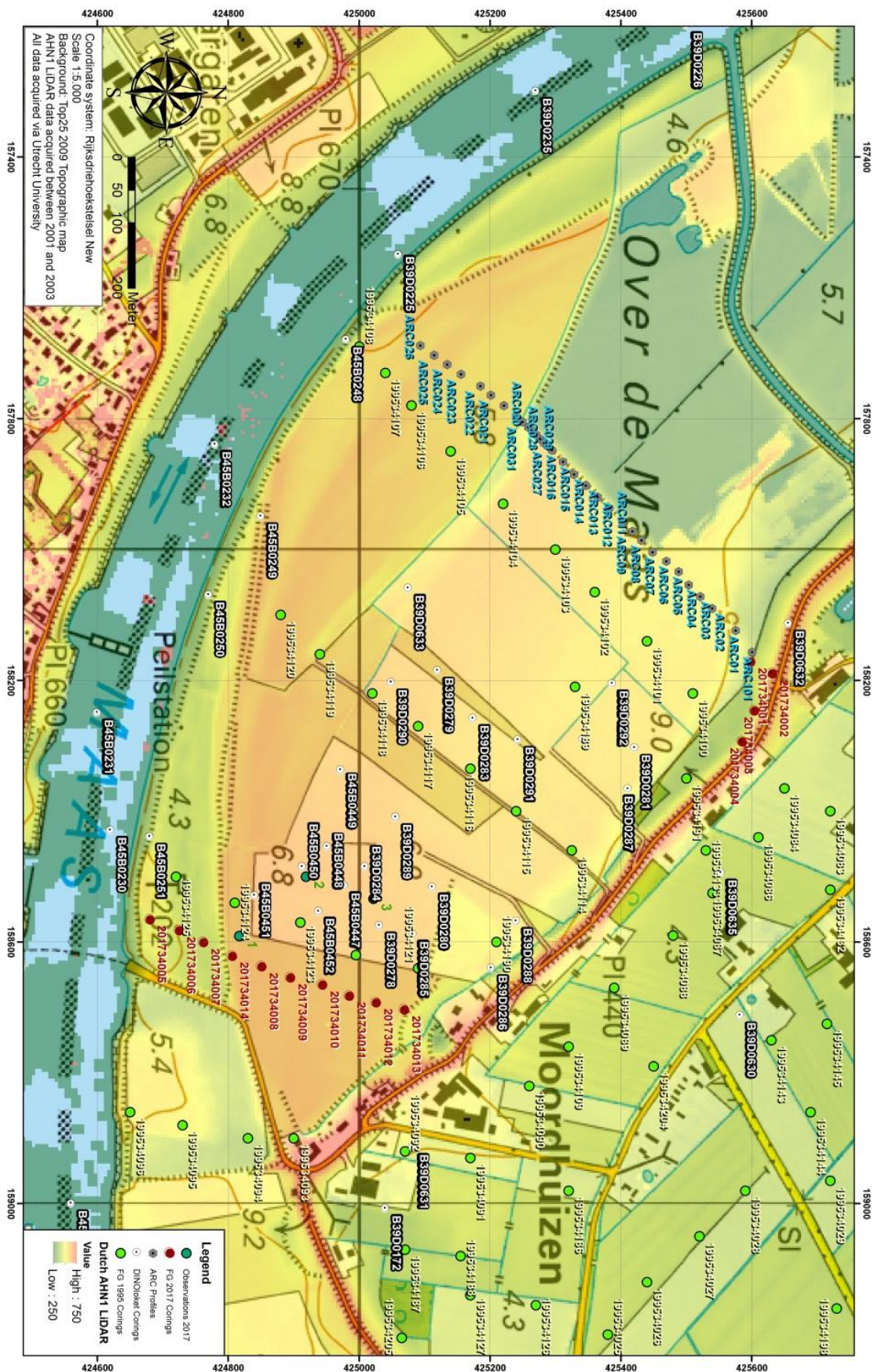


FIGURE 13: LOCATION OF THE DIFFERENT TYPES OF BOREHOLE DATA AND OBSERVATIONS WITHIN THE STUDY AREA.

4. Results

4.1 Description and analysis of the lithogenetic profiles

Corings 005-013 lithogenetic profile

The borehole data of corings 005-014 acquired during the 2017 fieldwork in the southeast of the study area along transect 005 – 013 (see [figure 13](#)), are put together into a lithogenetic cross section of the embanked floodplain in the southeast of the study area.

The 005-013 lithogenetic profile (see [figure 14 and 15](#)) can be divided into two segments: **1) the southwestern part of the transect** (see [figure 14](#)), a part of the embanked floodplain still in use as grassland and not incorporated in the dredging activities: corings 005-007; **2) the remainder of the transect** (see [figure 14](#)), from southwest to northeast, at greater distance from the present-day Meuse and until recently in use as agricultural land but now being dredged: corings 014, 008-013.

The surface of segment 2 is ca. 2.5 – 3 m higher than that of segment 1, with a relative steep rampart dividing the two. This suggests that the part of the embanked flood plain of which segment 2 is part of, was levelled up at some point in (recent) history. By whom and when, however, could not be traced back from historical maps or sources (see appendix 4).

All corings (except for 005, which is located on top of the summer dyke directly next to the present-day Meuse channel) begin in slightly silty to silty clays and end in medium to coarse sand with an gravel admixture (except for coring 010 which ends in uniform medium sand lacking said gravelly admixture). The top of the coarse sand (420 -1000 µm median grain size) deposits in segment 1 (**unit 3**, see [figure 15](#)) is found at shallower depths below the surface than in segment 2 (**unit 1 & 2**, see [figure 15](#)): on average at ca. 3.2 m NAP in segment 1, on average at ca. 1.5 m NAP for segment 2. These deposits clearly show a fining-up sequence as well as a downwards increase in gravel concentration in the corings of segment 1. Additionally, fining upwards of grain sizes can be recognized in the coarse sand deposits of corings 008, 012 and 013 too, but it is less pronounced and more diffuse than in segment 1 corings. Occasionally small chunks of silty clayey sediments were present in the coarse sand deposits (*e.g.* coring 009 is notable in this respect).

The coarse sands at the bottom of the corings in segment 1 (**unit 3**, see [figure 15](#)) are clearly bar features deposited in the inner bend of a meandering river (see ch. 2.1 and 2.2), based on the fining upwards character of these deposits - with an abrupt transition to the clay deposits at the top - and the relatively large admixture of gravel in an otherwise coarse, but not extremely coarse matrix. Moreover it can be stated that this point bar was built out in a south/southeast direction and thus that the meandering Meuse was laterally migrating in the same direction. Based on the proximity of these deposits to the modern-day Meuse channel and the inferred estimated dating of the channel deposits encountered in segment 2 it is concluded that the oldest channel point bar deposits in the northeast of segment 1 are presumably of Late Roman or Merovingian age, becoming progressively younger in the southwestern direction.

The coarse sandy deposits are generally directly overlain by clayey and silty clayey deposits, sometimes interrupted by medium sand (210 – 420 µm median grain size) deposits

of a few dm. Corings 008, 009, and 013 differ markedly from this general trend for they are overlain by thicker layers of medium sand deposits, formed by different processes than the thinner medium sand layers or the thick clayey deposits. The thick medium sand layers in corings 008 and 009 (**unit 5**, see [figure 15](#)) contain small clayey chunks or laminations of either clayey or coarser sandy sediments, whereas the medium sands on top of the coarse sands in coring 013 are remarkably uniform in composition and lack any lamination or other admixture.

The clayey and silty clayey deposits mentioned at the beginning of this paragraph are ca. 1-1.5 m thick and generally contain spots of oxidized iron and manganese and sometimes even iron concretions in the form of tiny rusty orange chunks of iron (see ch. 2.1). A remarkable difference between the clayey sediments on top of the segment 1 corings (**unit 4a**, see [figure 15](#)) and the clayey sediments located at the same NAP height in segment 2 (**unit 4b**, see [figure 15](#)) is their respective calcium concentration: the former ones do have a relatively high concentration of calcium, whereas the latter ones do not contain any calcium at all. The relatively high calcium concentration of the segment 1 clays might be due to the fact that the part of the embanked floodplain directly adjacent to the present-day Meuse of which segment 1 is part of was rearranged around the 1890s (note the difference between the historical topographic map of 1874 and 1930, see appendix 4). New sediment might have been deposited increasing the overall calcium concentration of the clay deposits in segment 1. The absence of calcium in the remaining clayey deposits in segment 1 seems to point to a Meuse origin of these sediments (see ch. 2.4).

Unit 6 (see [figure 15](#)). Overlying the clayey deposits in segment 2 in upwards direction are: silty clay loams (*lichte klei* and *zware zavel* in Dutch), clayey to sandy loams (*lichte tot matig zware zavel* in Dutch), medium sand, again clayey to sandy loams and on top the (silty) clays mentioned at the previous page. It is unclear whether any of these sediments are deposited by natural (fluvial) processes or embanked floodplain fluvial processes. An anthropogenic origin seems more likely (see above), coring 013, ca. 1.5 m lower, lacking these typical deposits on the top. Therefore these layers are not considered here or in subsequent paragraphs in detail, since they are not of interest for the palaeogeographic reconstruction of the study area in archaeologically relevant periods.

Corings 001 - 004

Corings 001 and 002 in the northwest of the study area (see [figure 13](#) and Addenda) are very similar in their lithology. Comparing AHN1 data (acquired in 2001 before the dredging activities started) with AHN3 data (acquired when dredging activities were taking place in 2015) revealed that the surface was raised by ca. 1.5 m at the location of coring 001 and 002, after the acquisition of the AHN1 data in 2001. These sediments are probably dredged sediments from another location in the study area. Underneath this disturbed layer from top to bottom clayey deposits overlying silty clay loam deposits on top of medium to coarse sands with a thin clay layer in between are found. The medium and coarse sands in coring 002 contain a gravel admixture. In coring 001 some humic clayey sediments are found near the bottom of the coring. The medium sand at the bottom of coring 001 lack a gravel admixture.

Corings 003 and 004 also in the northwest of the study area (see [figure 13](#) and Addenda), without recently dumped sediments on top heightening the surface, differ from

coring 002. Medium sand in coring 003 is found at approximately the same NAP depth as in coring 001 (ca. 1.4 m NAP, whereas in coring 002 medium sand is encountered at ca. 2.8 m NAP) and lack a gravel admixture. In coring 004 medium sand is found even lower, around 0 m NAP. On top of the medium sands in both corings silty clays, sometimes humic, are found.

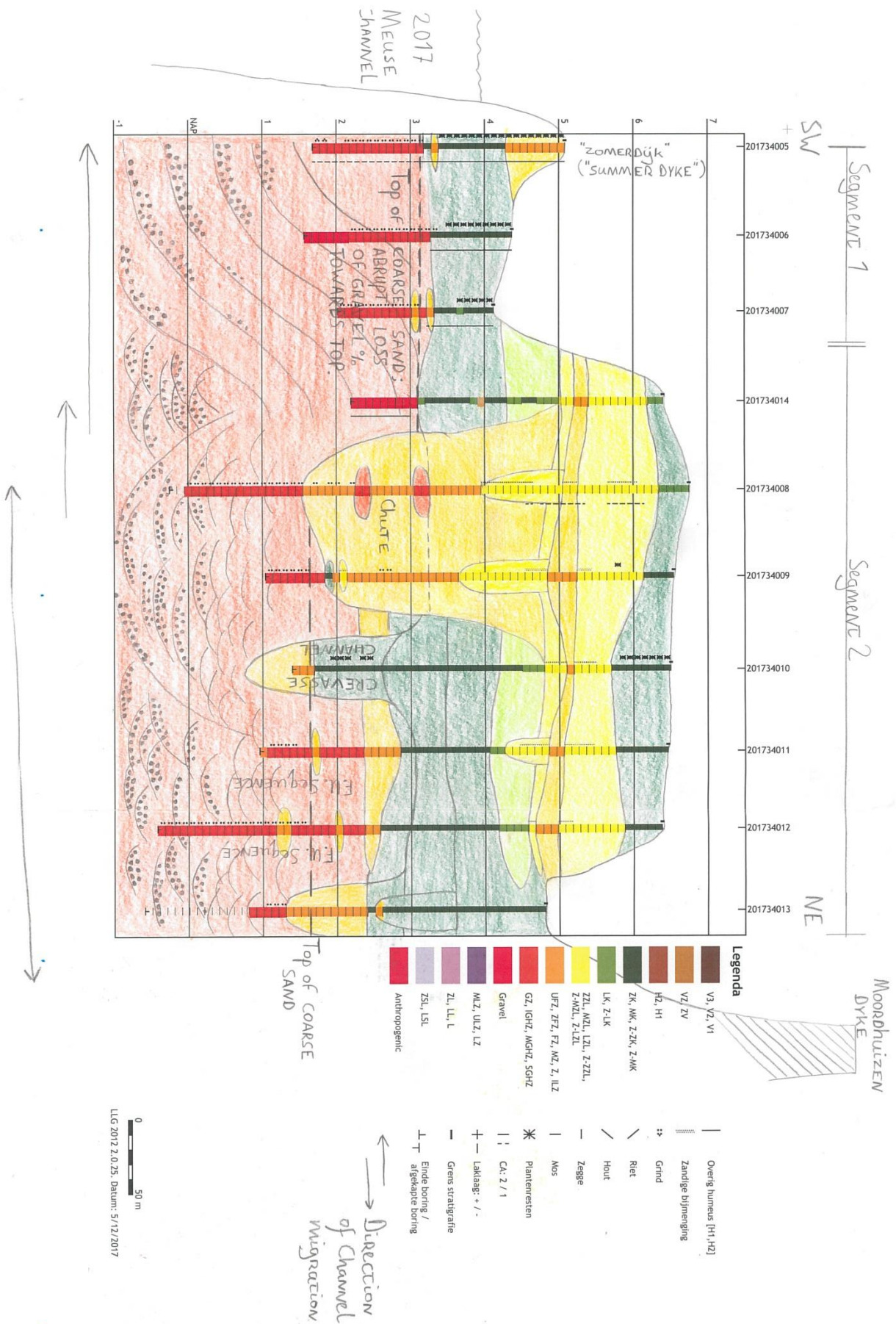
ARC Profile

The lithogenetic profile constructed by Hebinck and Heunks (2011, see [figure 16](#)) is located in the northwest corner of the study area (see [figure 13](#) 'ARC Profiles'), has a length of ca. 700 m and is constructed based on the descriptions of 31 column profiles and 1 hand-augered coring ([figure 13](#): 101). In general the profile is made up of a characteristic succession of facies. Just beneath the surface silty clayey- to very silty fine sandy overbank deposits are encountered, ca. 100 – 200 cm thick. These are floodplain facies. Underneath these lie medium sandy overbank deposits, some contain (humic) clay laminations (sometimes showing cross lamination). They are interpreted as levee-like facies. In the northeast of the profile (columns 1 - 4) a reduced dark blue gray silty clay layer (very silty sand for column 4) is embedded in the sandy overbank deposits. Nearly all profile columns end in coarse sand channel deposits, comprising bar facies in the northeast of the profile and point bar facies in the southwest of the profile. The bar facies in the northeast of the profile were deposited by the Meuse in prehistoric (pre-Roman) times, when the channel of the Meuse was continually diverting its course in either southwest or northeast direction.

Five columns differ significantly from the general succession of facies, namely column 11, and 16, 17, 27 and 28. Column 11 contains silty clayey overbank (floodplain) deposits under the top of the column, followed by a thin layer of silty sandy overbank deposits (levee-like), underneath which lies a thick layer of blue gray very silty clay deposits containing wood and shell remains and a downwards increasing amount of sand layers, interpreted as fill facies of a (residual) Meuse channel still existing in (Middle) Roman times (based on the ^{14}C dating, 1850 ^{14}C BP = 100 AD, of the organic material in the top of the fill facies, see [Table 1](#) and [figure 16](#)). It ends in fine sand deposits. The point bar facies on the bottom of the columns southwest of column 11 are deposited by a continuously in southwestern direction migrating Meuse channel from ca. the Late Iron Age onwards. Columns 16, 17, 27 and 28 also contain channel fill facies underneath a ca. 100 cm disturbed layer of sandy clays and silty sands consisting of a thick sequence of alternating sand and clay layers with a downwards thickening of the sand layers. It is interpreted as being a filled in chute channel from the early middle ages (1390 BP = 610 AD, see [Table 1](#) and [figure 16](#)).

All FG 1995 corings were analysed in this study, but since almost all of them were only ca. 3 m deep below the surface ending mostly in fine sandy overbank deposits, they were deemed not very useful for the palaeogeographic reconstruction in ch. 4.2. Thus no lithogenetic profiles of the 1995 transects are adopted in this study.

FIGURE 14: LITHOGENETIC PROFILE OF THE 005-013 TRANSECT.



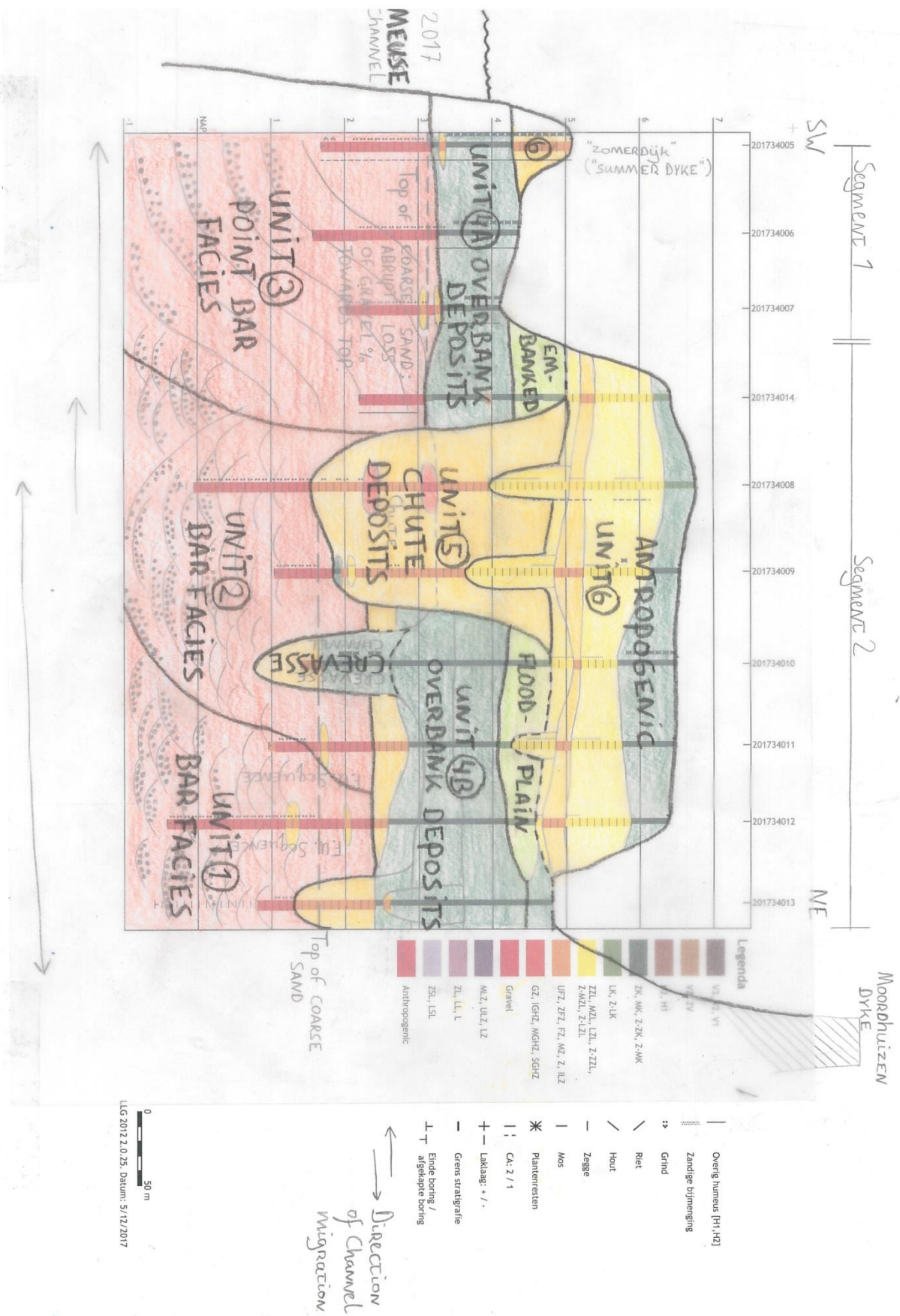


FIGURE 15: LITHOGENETIC PROFILE OF THE 005-013 TRANSECT.

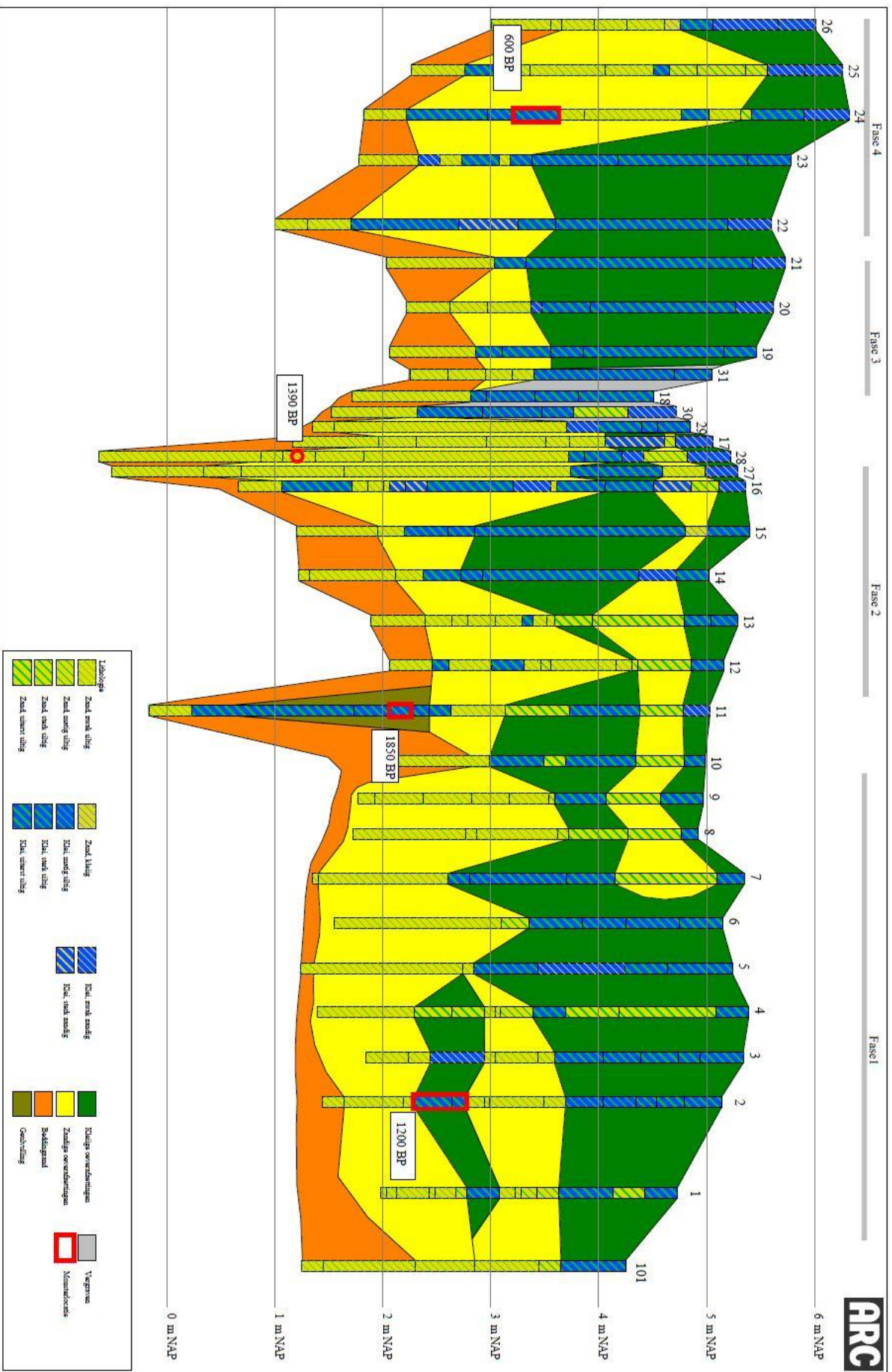


FIGURE 16: LITHOGENETIC PROFILE OF THE ARC TRANSECT. ADAPTED FROM HEBINCK AND HEUNKS (2011, BILAGE 2)

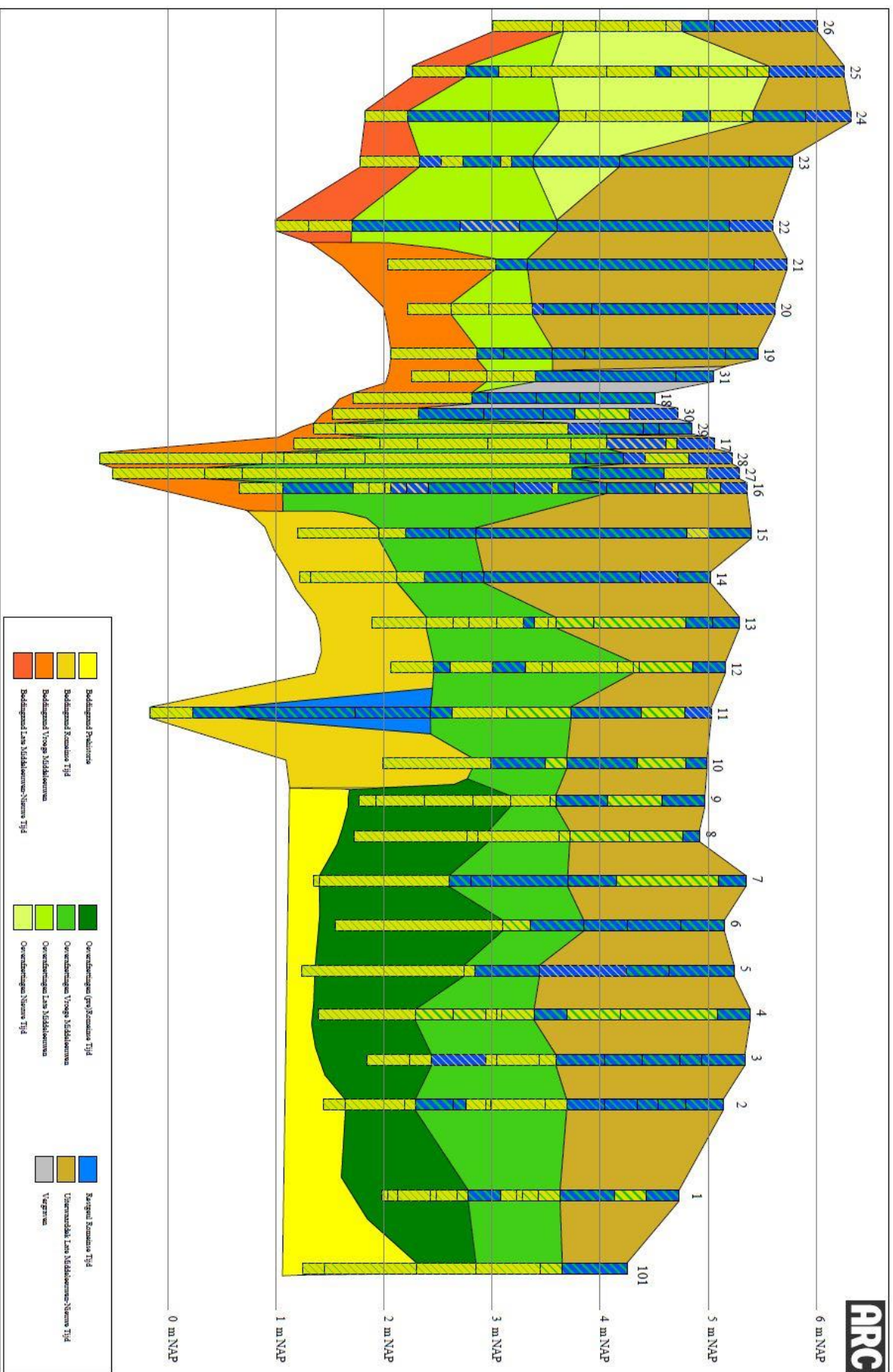


FIGURE 17: CHRONOSTRATIGRAPHIC PROFILE OF THE ARC TRANSECT. ADAPTED FROM
HEBINCK AND HEUNKS (2011, BIJLAGE 3)

4.2 The lithogenesis and palaeogeographic development of the study area

A main question is the age and genesis of the segment 2 coarse sandy substrate. They are also channel deposits but differ significantly from the ones in segment 1. Point bar aggradation is not recognized in the borehole data of the individual coring. Instead it is proposed that these features comprise submerged bar deposits of an older course of the Meuse channel belt, constantly diverting its course in either the southwest or northeast direction. Moreover, it could well be that at some moment there were two Meuse co-existing active channels, possibly a primary and secondary channel. The data of Hebinck and Heunks (2011) also allow for this interpretation (see [figure 16](#)).

The coarse sand deposits in corings 008 and 009 then probably comprise the youngest submerged bar deposits of the former Meuse channel before active lateral migration of the Meuse channel at this location, as recognized in segment 1, commenced. Thalweg deposits are expected to be found about 2 meters below these submerged bar deposits. This former channel would have been active around early Roman times, around the time Caesar would have visited *Germania Inferior* during his Gaulic campaigns (see ch. 2.5) and could be identified as the '100 AD Roman channel' in Hebinck and Heunks (2011) (see above and [figure 16](#)). This 100 AD date is based on ¹⁴C-dating of organic channel fill sediment relatively high up in the channel fill sediments, suggesting that the channel existed at this location earlier than 100 AD, at least in the first century BC.

A proposed secondary channel would then have been located more or less along the north-eastern boundary of the study area and could have resulted from a crevasse or chute channel originating upstream from the study area. Maybe this crevasse or chute channel followed a former little residual channel. It would have carried a smaller portion of the Meuse discharge, (active at peak discharges only). Fluvial activity north-east from the main channel at that time seems to be confirmed by the fact that the ODM4 canoe has been found close to the north-eastern boundary of the study area and is presumably of Late Iron age or Early Roman age. This presumed age has yet to be confirmed by dendrochronological dating though. The secondary channel would have been short-lived and eventually filled in by channel fill sediments. The sediments in corings 003 and 004 might be interpreted as residual channel fill sediments, but this is still uncertain. The deposits found in corings 001 and 002 correlate well to the ARC profile (see [figure 16](#)). A small ditch (a *sloot* in Dutch) might be recognized in the bottom deposits of coring 001 (3.3 m below the surface at + 2.2 m NAP) consisting of the humic clayey and medium sand lacking gravel admixture. Possibly, this ditch (*sloot*) existed in Roman times.

Coring 010 deviates from the other corings in segment 2 as it ends in medium sand deposits on top of which lie about 1 m of clays containing 2-5 mm fine sand laminations as well as 2 cm thick medium sand laminations, cutting through the relatively thin layer (50 cm thick) of medium sand containing clay laminations found in coring 011 on top of the channel deposits. The medium sand deposits combined with the laminated clayey sediments on top of them (coring 010, **unit 4b**, see [figure 15](#)) together probably comprise overbank deposits: initially crevasse splay or channel fill deposits possibly deposited by a (short lived) crevasse channel (see 2.1) existing in the pre-aggradation phase of the former Meuse channel belt; later on low levee like deposits. The medium sand was deposited under relatively high energetic circumstances during the creation of the crevasse splay, when the natural levee of the river was breached in the course of *e.g.* a flooding event.

It is estimated that this crevasse channel was formed in late Roman or early medieval times. The channel cut through presumably natural levee deposits encountered in coring 011 (it is supposed that they are natural levee deposits based on the occurrence of clay laminations); this natural levee, very plausibly, continues in southwestern direction. The 110 cm thick medium sand layer on top of the coarse sand deposits in coring 013 might also be formed during the creation of a crevasse splay. This is, nonetheless far less likely because of the absence of a laminated filling sequence and further the uniformity of the sandy sediments, lacking for example a coarsening upwards sequence, which both are generally encountered in crevasse channel deposits (see 2.1). Instead it might be seen as deposits of a shallower channel, carrying sediments of a smaller grain size; this theory is not further elaborated on though.

The laminated medium sandy facies found in corings 008 and 009 from ca. 3.20 m NAP to a maximum depth of 1.65 m NAP are proposed to be formed by one (mega)chute channel or multiple chute channels (see [figure 14](#): facies marked as 'chute' and [figure 15](#): unit 5). These chutes, would have been existing, although not continuously active, for a relatively long period of time, probably during the early middle ages, the second half of the first millennium AD. The flooding frequency of the Rhine is significantly higher during the period from 600 until 850 AD than the preceding and succeeding period (Cohen *et al.*, 2016, 45). A similar increase in flooding frequency of the Meuse in the early middle ages (mentioned by Pons, 1966, 113) would explain the presence of a large chute channel or multiple chute channels on the point bar of the meandering Meuse, since the flooding frequency of a meandering river determines the recurrence of chute channel development and reactivation (see ch. 2.2 on chute bars). Moreover the abundance of sandy laminae in these chute facies can be seen as evidence for a high frequency of flood events.

The clayey deposits found in all the corings of the 005-013 transect between ca. 4.40 m NAP and 2.50 m NAP are most likely floodplain deposits of the laterally migrating Meuse channel; the overall trend then should be that they become progressively younger of age near the top of this layer. The three loamy units in the silty clay loam layer of probably anthropogenic origin in segment 2 are here interpreted as filled in ditches, which were maybe used for drainage when this part of the embanked floodplain was used for agriculture or for livestock farming.

Thus a map series of the palaeogeographical change of the location of the Meuse channel belt can be constructed (see [figures 18 - 21](#)). It is based on newly acquired fieldwork data from 2017, re-interpreted LLG 1995 borehole data and DINOloket borehole data, as well as the preliminary results of the distribution of archaeological finds in the study area and reviewed literature (see 2.2 and 2.3).

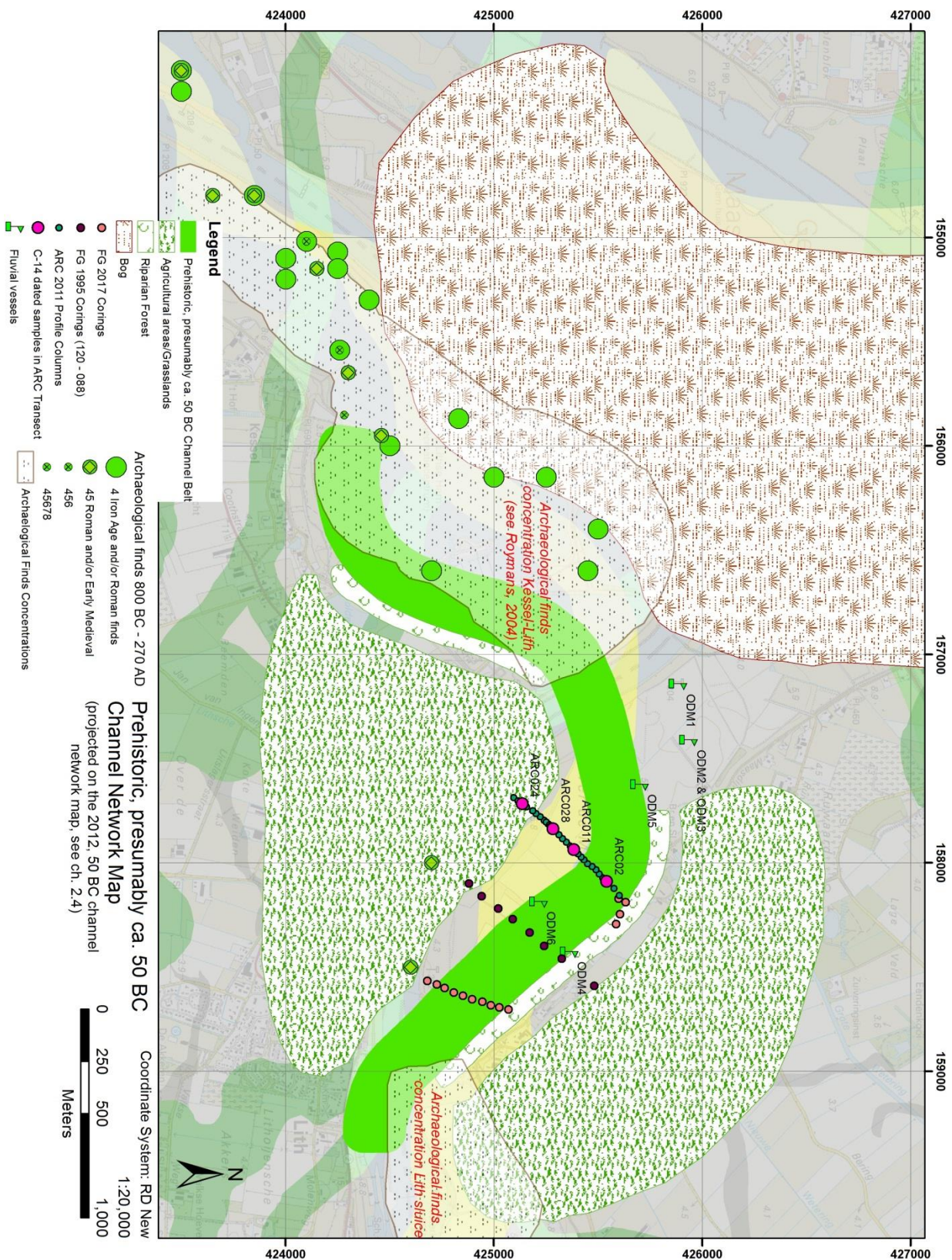


FIGURE 18: PREHISTORIC (CA. 50 BC) CHANNEL BELT MAP. ARCHAEOLOGICAL FINDS LOCATIONS DERIVED FROM ARCHIS.

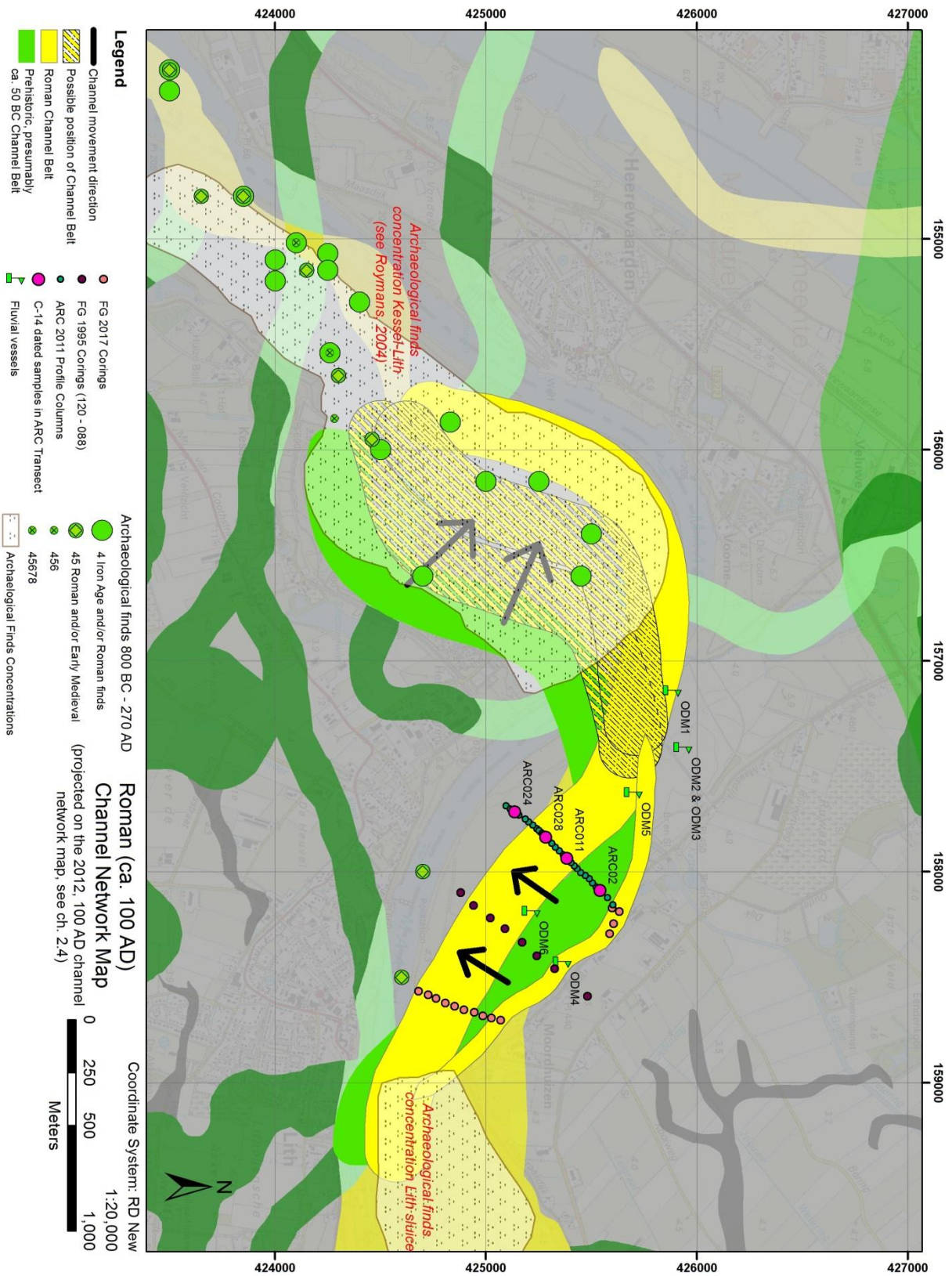


FIGURE 19: ROMAN (CA. 100 AD) CHANNEL BELT MAP. ARCHAEOLOGICAL FINDS LOCATIONS DERIVED FROM ARCHIS.

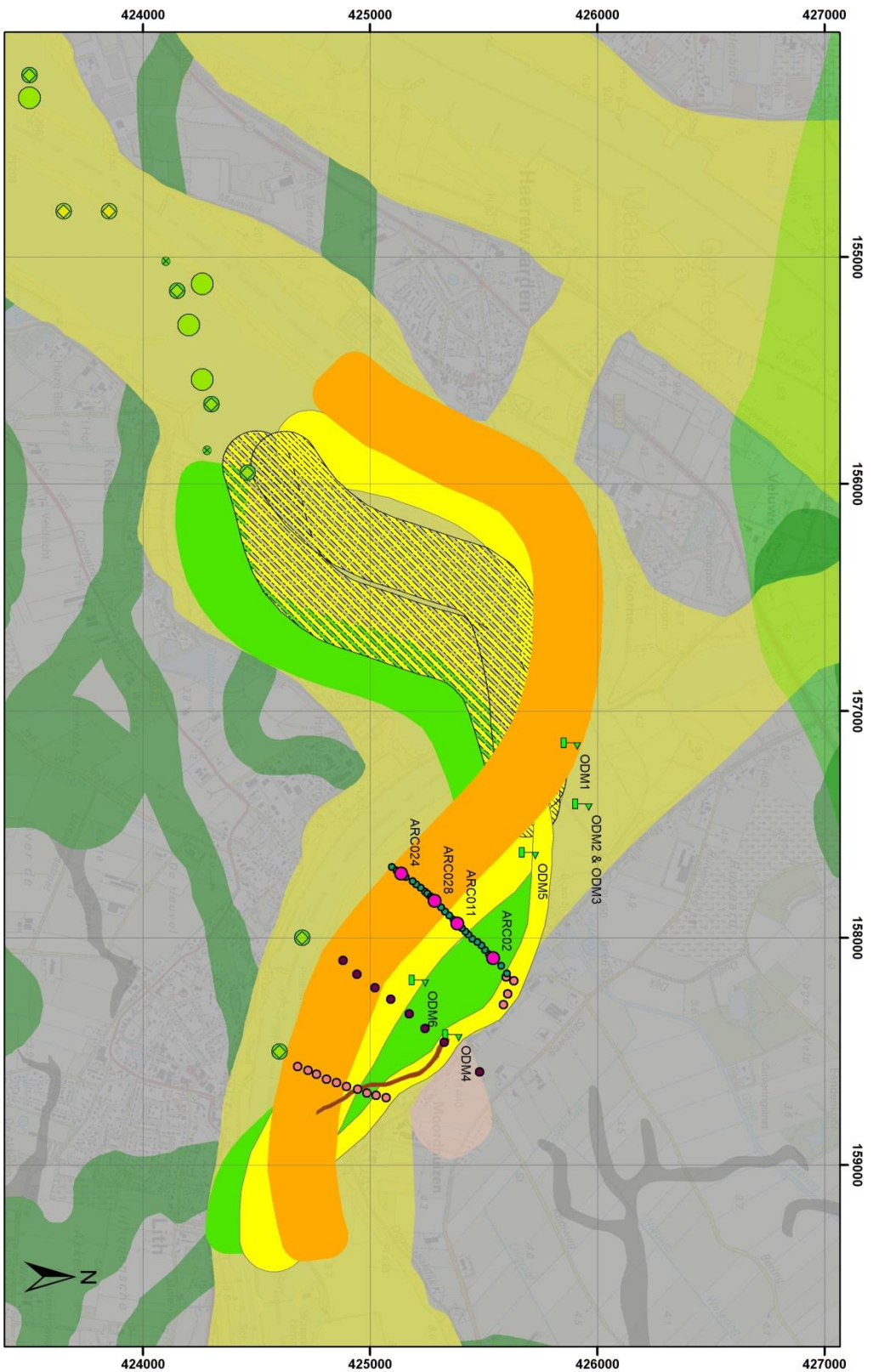


FIGURE 20: EARLY MEDIEVAL (CA. 500 AD) CHANNEL BELT MAP. ARCHAEOLOGICAL FINDS LOCATIONS DERIVED FROM ARCHIS.

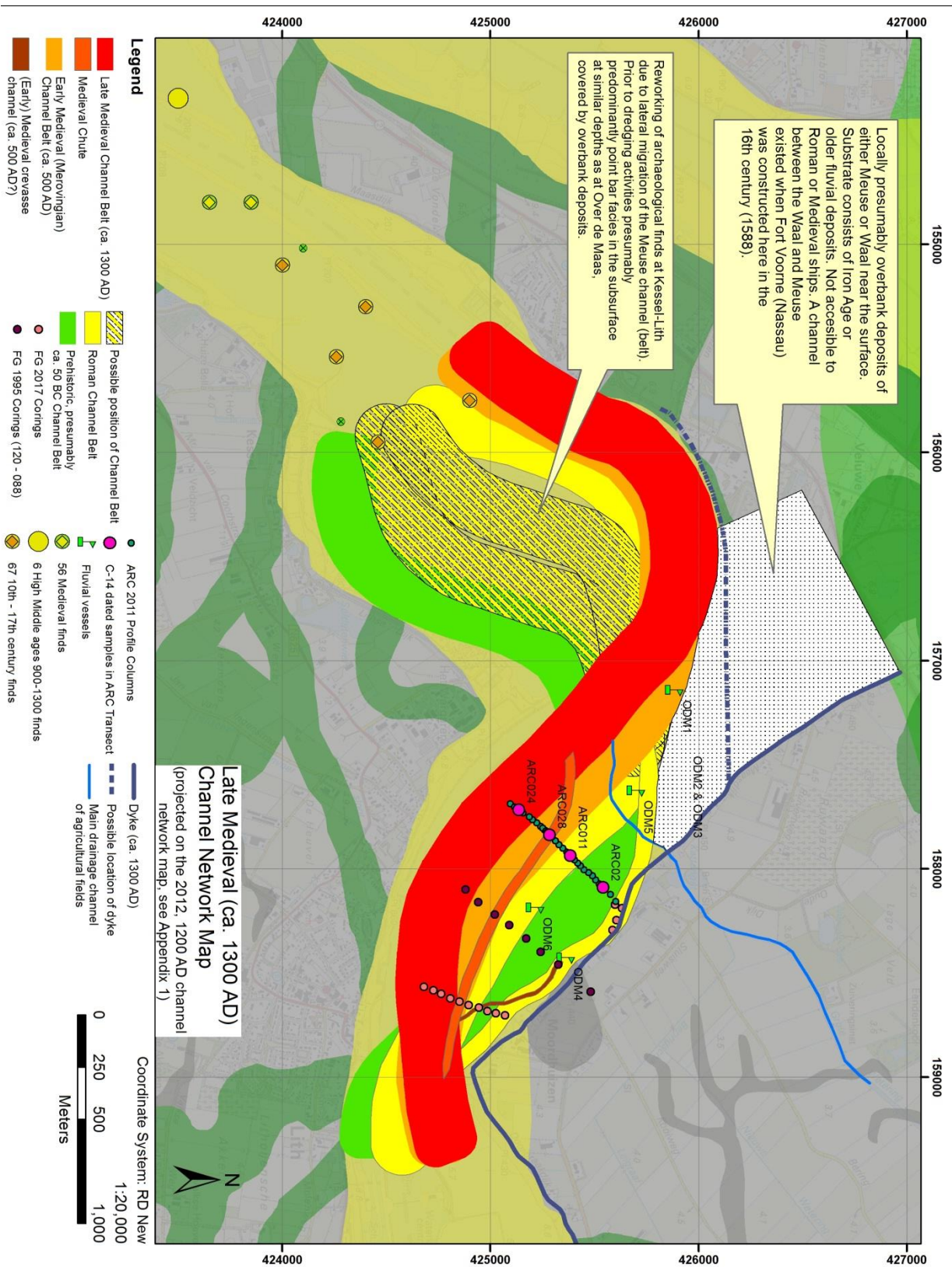


FIGURE 21: LATE MEDIEVAL (CA. 1300 AD) CHANNEL BELT MAP. ARCHAEOLOGICAL FINDS LOCATIONS DERIVED FROM ARCHIS.

5. Discussion

5.1 New reconstructed maps series versus older maps

The new reconstructed map series of channel belt migration of the Meuse in the study area is clearly more detailed than the earlier reconstructions (figures 4-11, cf. Berendsen and Stouthamer, 2001; Cohen 2003; Cohen et al., 2012). This is due to the fact that the earlier reconstructions are made for a larger area (i.e. the central Rhine-Meuse delta or even the complete Rhine-Meuse delta, regional or national scale), whereas the new reconstruction is specifically produced for only a small part of the whole Rhine-Meuse delta (local scale). Moreover, the new reconstructions resulted from examination of a far larger and more varying data set than the earlier reconstructions for the study area, which only used relatively little borehole data (most of the time of only limited depth).

The most important limitation of the new reconstruction, however, is the lack of reliable absolute or even relative dates of different layers in the lithogenetic profile and map (so far). No ^{14}C -dating or other absolute dating methods were applied to sediments (which in the case of ^{14}C is quite reasonable seen the absence of organic material encountered). The reconstruction would greatly benefit from the results of the archaeological investigation, particularly the distribution of finds and the context or even sediment type in which they have been found.

Incorporating this information in the analysis would enable to validate the age and presumed course of the different channel belts in the new reconstruction through the study area. The preliminary results as communicated by archaeologist Nils Kerkhoven give some insight in the general pattern and age of different deposits but they are far from conclusive. Nevertheless, the new reconstruction provides a well thought through document which can be used in later research.

5.2 Implications of new reconstruction for archaeological finds

The reconstruction of the channel belt location at different times in the history of the study area has a couple of implications for the taphonomy (i.e. how well archaeological material is preserved) of archaeological finds in the study area. The Meuse channel constantly diverting its course in either north(-eastern) or south(-western) direction in pre-Roman times will have eroded much of the prehistoric remains. This could explain the general lack of older than Late Iron Age material and the relative low concentration of Late Iron age finds in the study area. The fact that most of the finds of Roman age are undisturbed in the northern part of the study area (see [figure 11](#)) correlates well to the reconstructed primary and secondary channel locations.

Since there would be two co-existing channels active, the Meuse discharge would have been divided by them, resulting in two relatively calm channels. Floods were more infrequent compared to the later early medieval period, and would have had less of an impact on habitation in these parts than upstream or downstream. Moreover, the secondary channel would have served as an additional waterway for transport (possibly a shortcut?), which seems to be confirmed by the presence of the Late Iron age/early Roman ODM4 canoe/ship in the zone of the presumed secondary channel. The presence of two shallower, overbank-flow channels in the study area would have made it a suitable

location to build a bridge across the Meuse using the tuff stone blocks, that were found during dredging activities in this part of the study area. A kind of island between the two channels was, of course, also beneficial. Further archaeological research has to determine what these tuff stone blocks were definitely used for.

The increased frequency of large flooding events in the early middle ages might explain the disturbed character of the Merovingian finds in the study area. Since floods occurred more frequent, Merovingian material that was just deposited did not get the chance to firmly settle in a certain layer, but instead was eroded by an extreme flood, or otherwise, material deposited in a flood event layer was not covered by sufficient overbank deposits of lesser, 'normal' floods to be not disturbed or eroded by an extreme flood.

There is an important difference between archaeological research conducted in embanked floodplains and in terrestrial environments, and even more so for the expectation maps constructed for both environments. Not many reconstructions of the palaeogeographic developments in embanked floodplains in the Netherlands have been published yet. The same is the case for large open water bodies and the (former) coastal zones. These three types of landscape units have been subject of morphological change until quite recently, altering the physical landscape relatively fast and influencing the way in which archaeological remains are buried and preserved (or not preserved). This morphological change however has not been studied extensively, especially when it concerns the embanked floodplains of the Meuse. This should be taken into account when trying to determine the expectation of finding archaeological remains in the embanked floodplains.

Expectation maps have to be constructed per (archaeological) period for a constantly changing landscape (*e.g.* Cohen *et al.*, 2014), and should incorporate both terrestrial and aquatic (*i.e.* both subaqueous finds and the ones preserved in (former) riverbanks) archaeological remains. Earlier expectation maps, national or local, are mostly limited for they lack detailed physical geographical reconstructions and extensive data sets of both *in situ* and dredged archaeological finds and do not take the dynamically changing landscape into account. Moreover, they focus too much on terrestrial find categories. The palaeogeographic reconstruction in this study combined with knowledge about the taphonomy of the abundant archaeological remains in this specific embanked floodplain of the Meuse as described above, could therefore be used as a 'case study' to improve the expectation maps of the embanked floodplains in central Rhine-Meuse delta of the Netherlands (*e.g.* the expectation maps constructed by Cohen *et al.*, 2014, see Appendix 2).

5.3 Limitations of the research materials and methods

The limited depth of the 1995 corings limits the extent to which the palaeogeography of the study area can be reconstructed. The vast majority of the 1995 corings investigated in this study end in a few dm of medium sand but do not reach the coarse sand channel deposits, presumed to be present in the area at roughly the same NAP height as the respective channel deposits found in the 005-013 cross section. This causes the reconstruction of the channel belt location change between the 005-013 cross section and the ARC cross section to be uncertain, and more of an estimation based on recognized patterns in the upper layers of the 1995 corings. Moreover, the sediment determination of the 1995 students might differ, if only slightly, from the determination of the

author and a fellow student in 2017. A given layer with a specific percentage of *e.g.* silt admixture in a clayey matrix might be interpreted differently by different persons, resulting in a variety of different classifications of the layer. This difference undeniably influences later interpretations of older borehole data. Besides, large-scale cross-section drawings of one or more profiles perpendicular to the present-day Meuse channel would not only enhance the current understanding of the palaeogeography of the study area, but would also enhance its resolution significantly. Unfortunately, this was not possible to do this during the fieldwork period of this study.

6. Conclusions

As of today, not many (academic) studies into the nature of the fluvial deposits of the embanked floodplains of the Meuse in the Central River area of the Netherlands have been conducted and/or published yet. Combining geological, archaeological and historical data it was possible to produce a map series of the palaeogeographical development of the embanked floodplain 'Over de Maas' for ca. the last 2000 years. These maps provide more detailed reconstructions of the location of the Meuse channel belt in the now embanked floodplain than early (delta-scale) reconstructions.

Before the Late Iron Age/early Roman period, the Meuse channel belts was continuously shifting its course, either in the southwest or northeast direction. Thereafter, it began its lateral migration in the southwest direction (at the location of the now embanked floodplain), building out a point bar. From that stage, a filled-in secondary channel remains present near the present-day location of the Moordhuizen dyke, making this area a favourable location to cross the river. From a yet younger stage, a large medieval chute channel is recognized in the embanked floodplain as is an early medieval crevasse channel.

The presence of multiple (intact) ships from different periods in the above palaeochannels indicates this area must have been a significant economic and cultural area throughout different times. Analysis of the full set of archaeological finds from the area would further enhance the understanding about the significance of this area, and could validate and further refine the reconstruction in this study.

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<https://erfgoedstem.nl/caesar-was-in-kessel/>

All above webpage articles were inspected on 19-06-2017.

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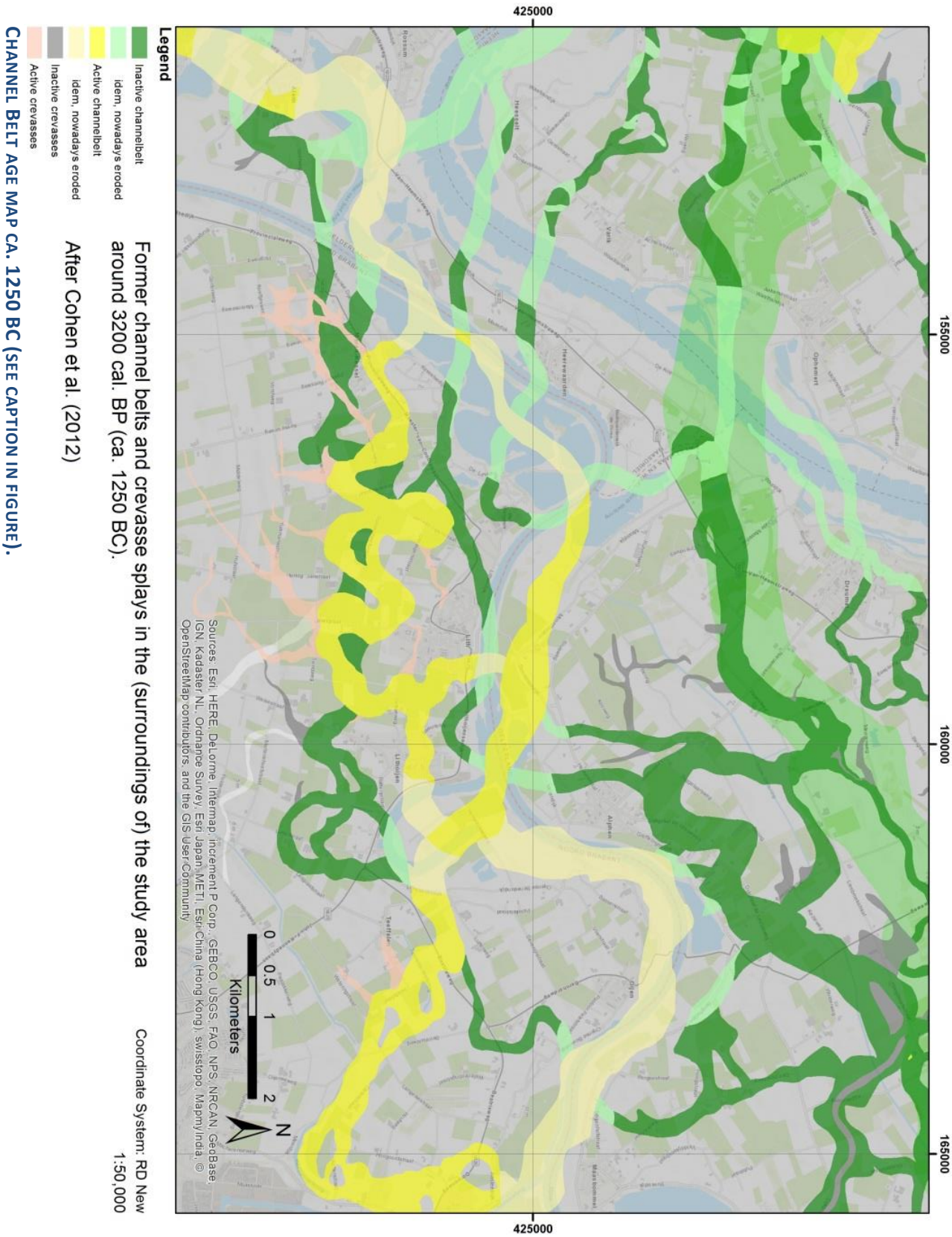
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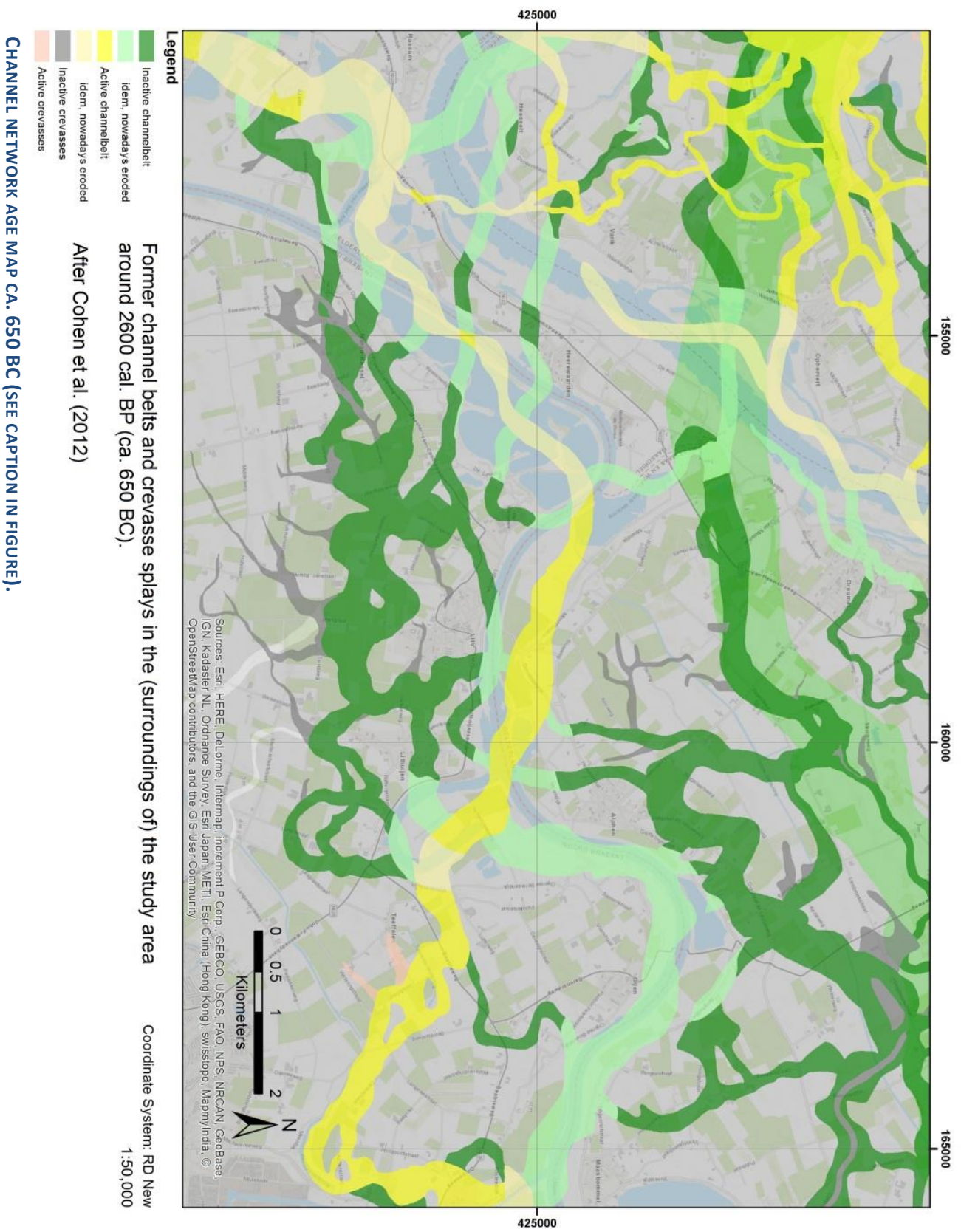
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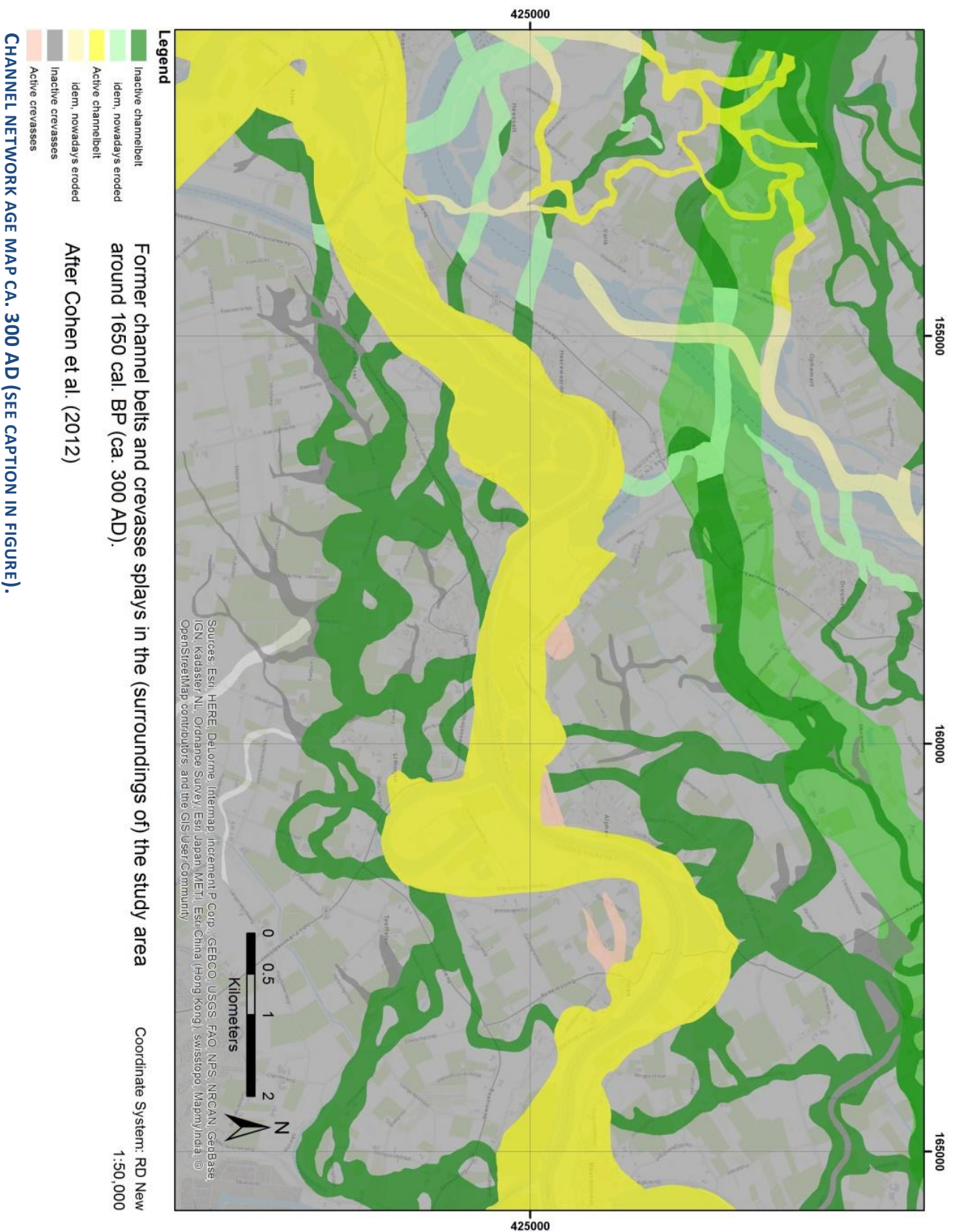
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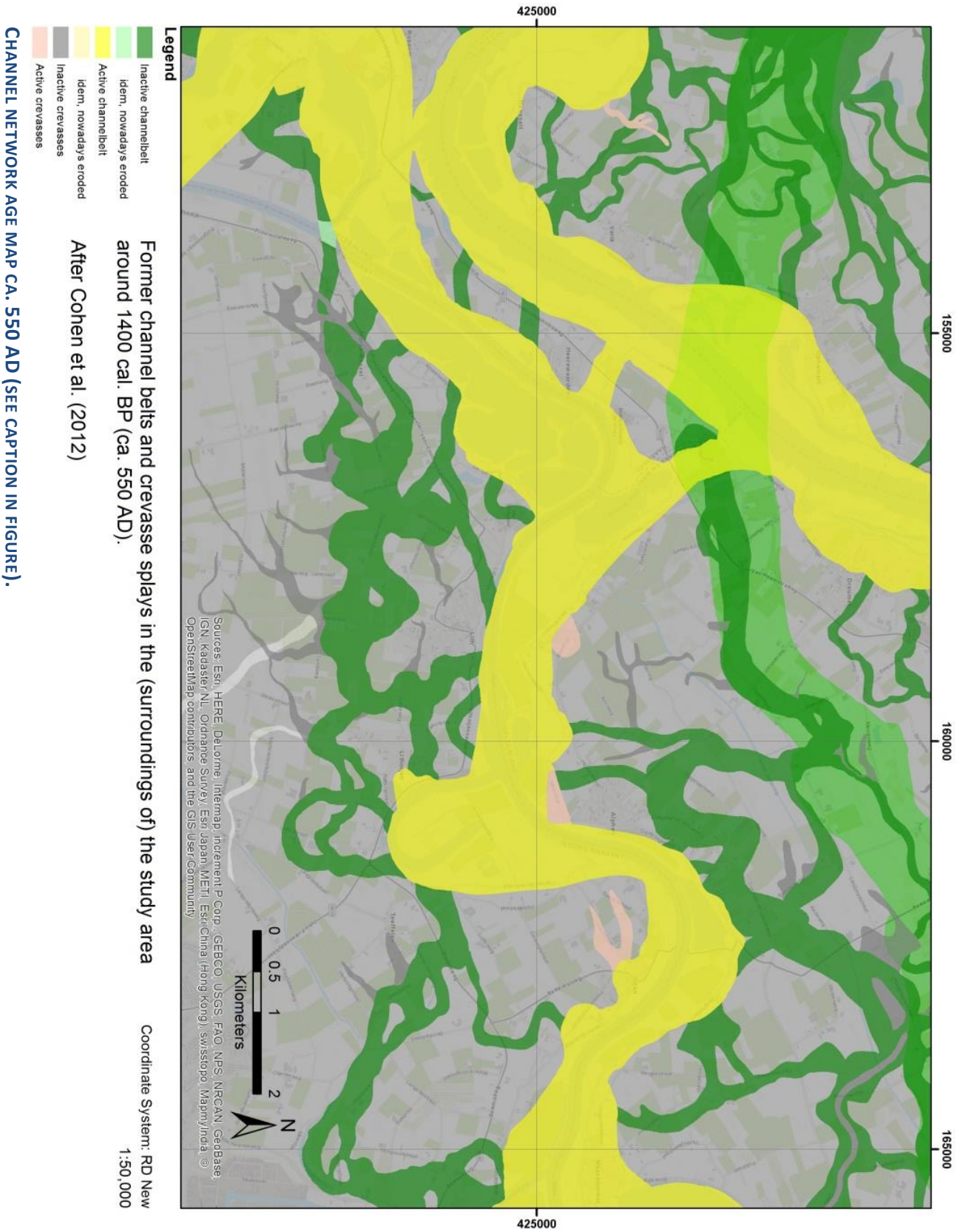
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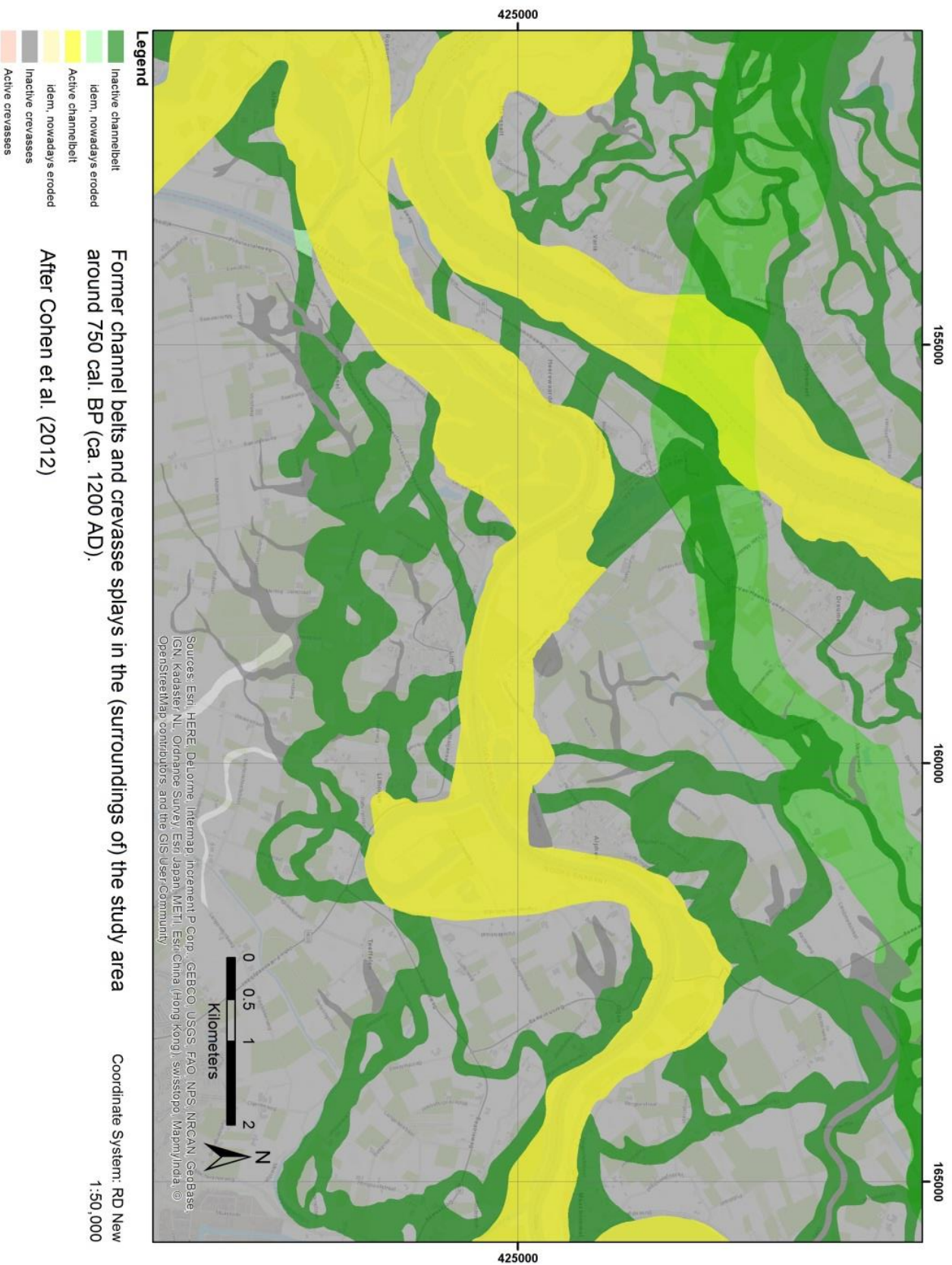
Appendix 1: Palaeochannel network maps





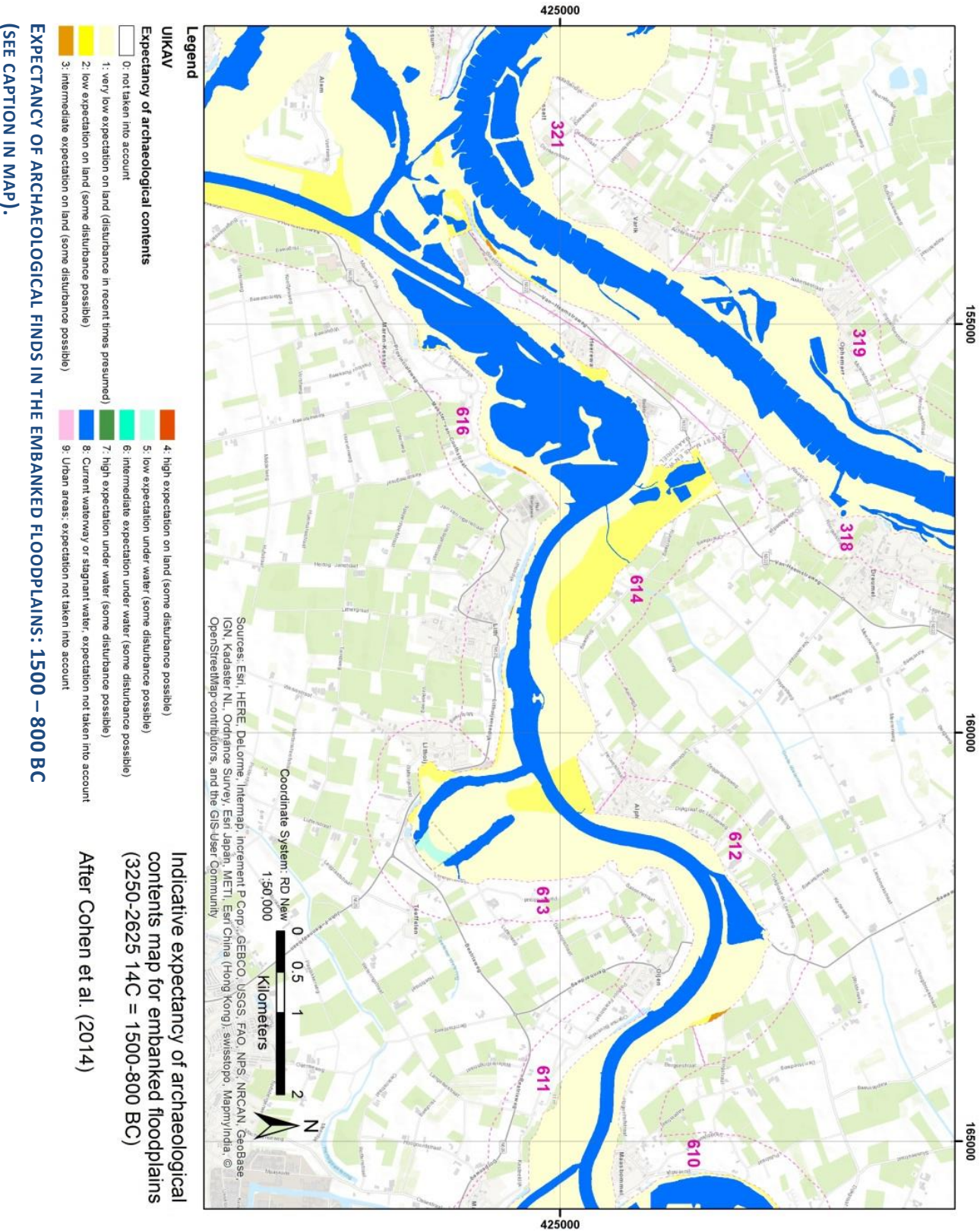


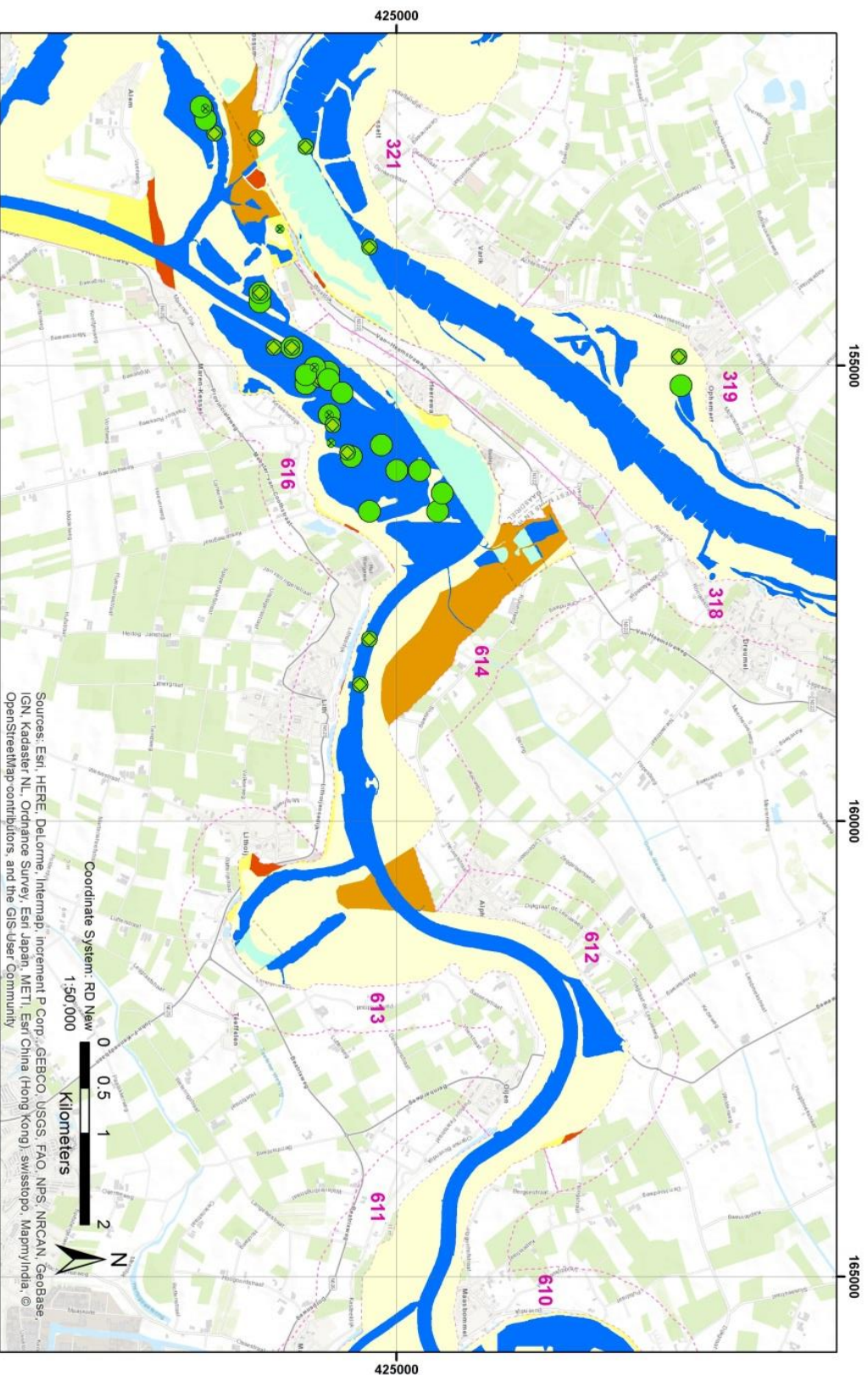


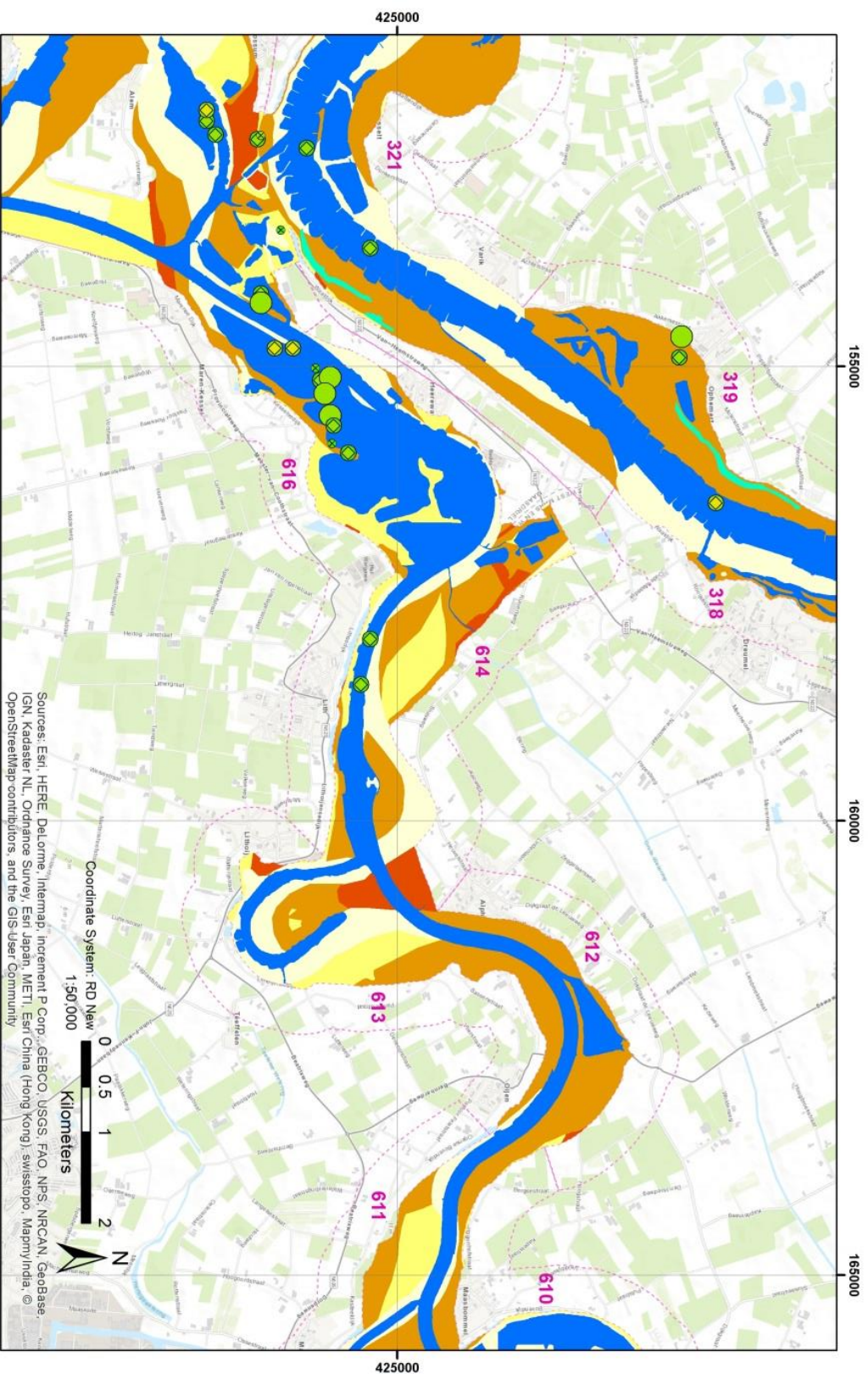


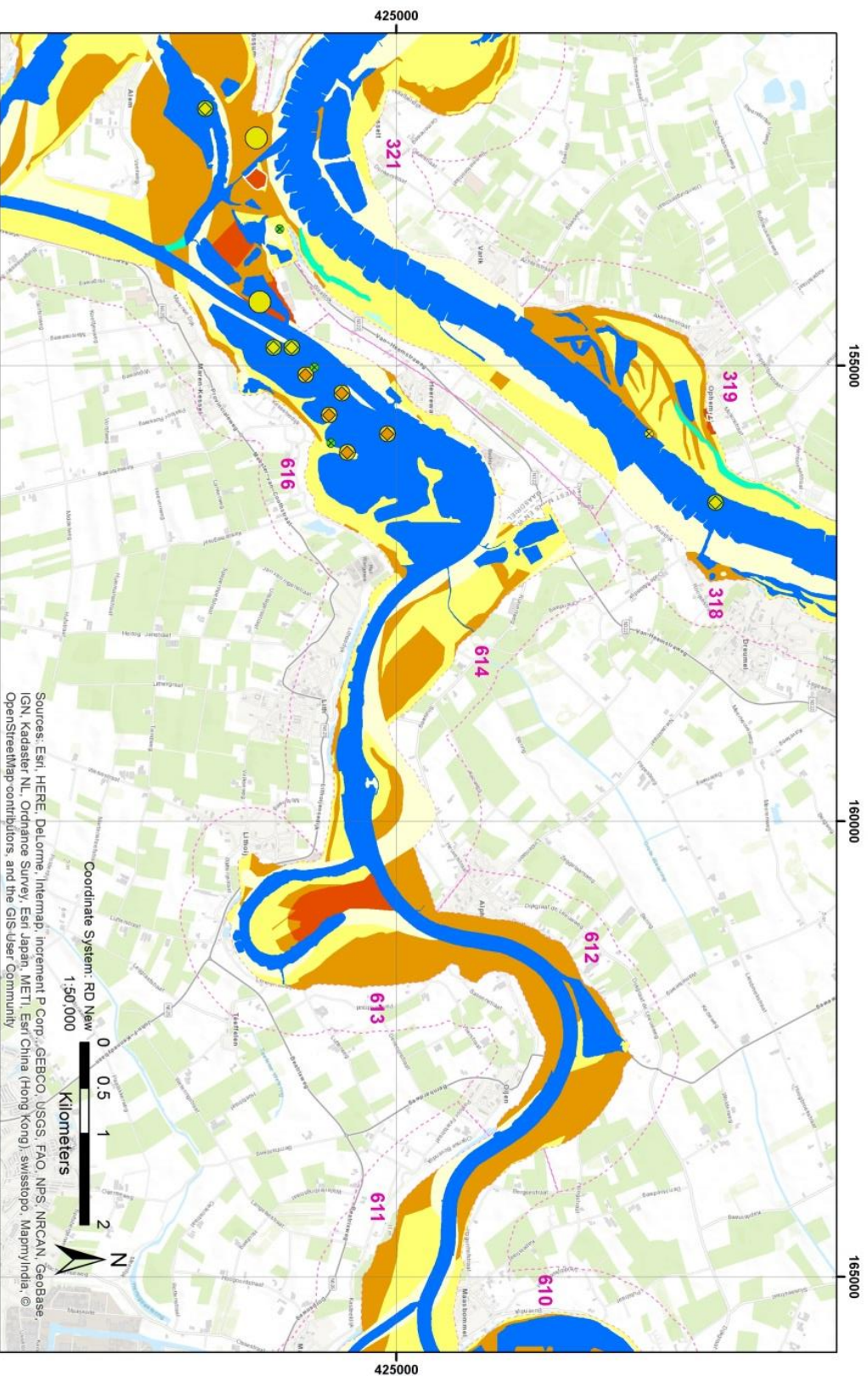
CHANNEL NETWORK AGE MAP CA. 1200 AD (SEE CAPTION IN FIGURE).

Appendix 2: Archaeological expectancy maps

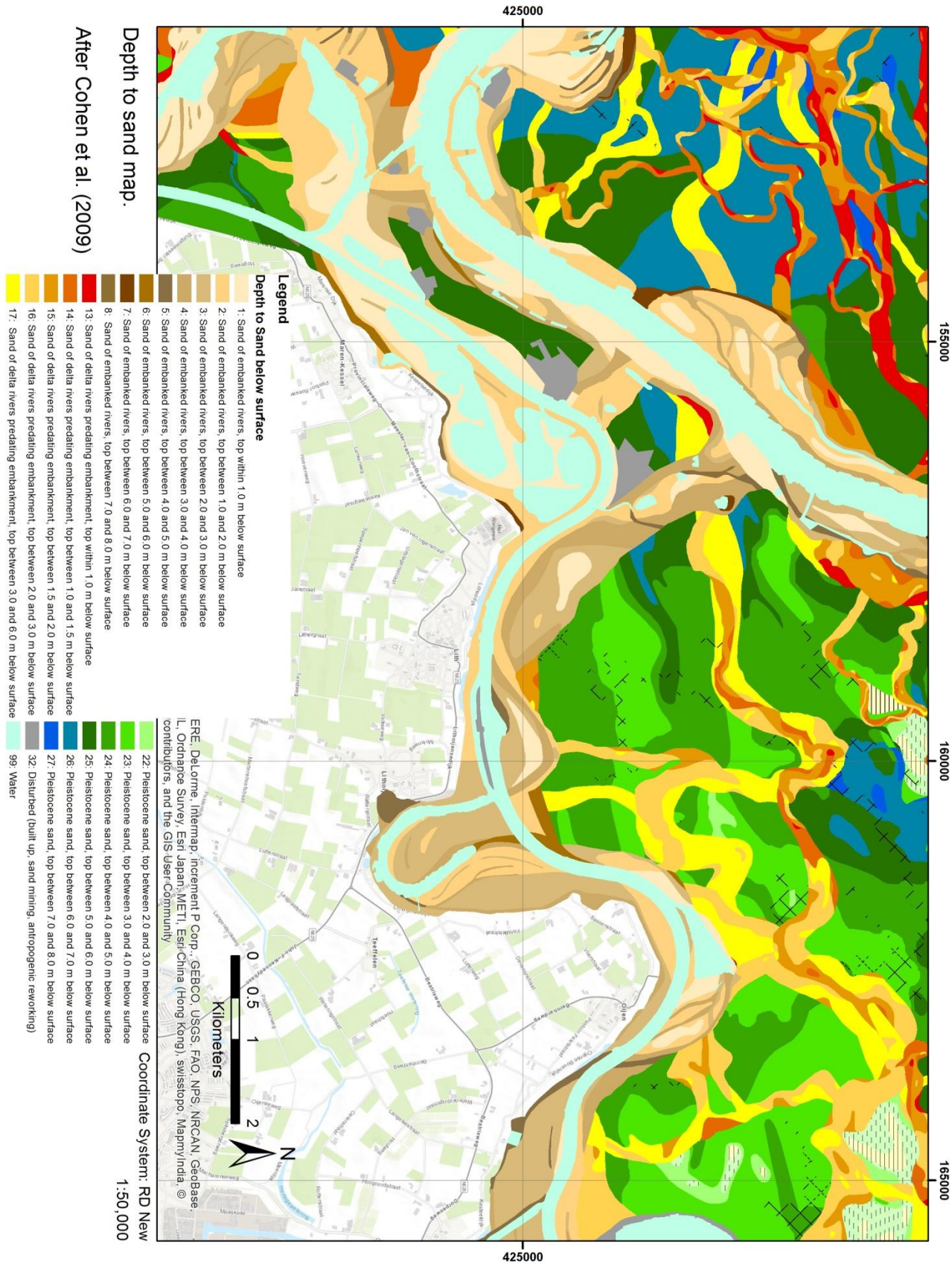




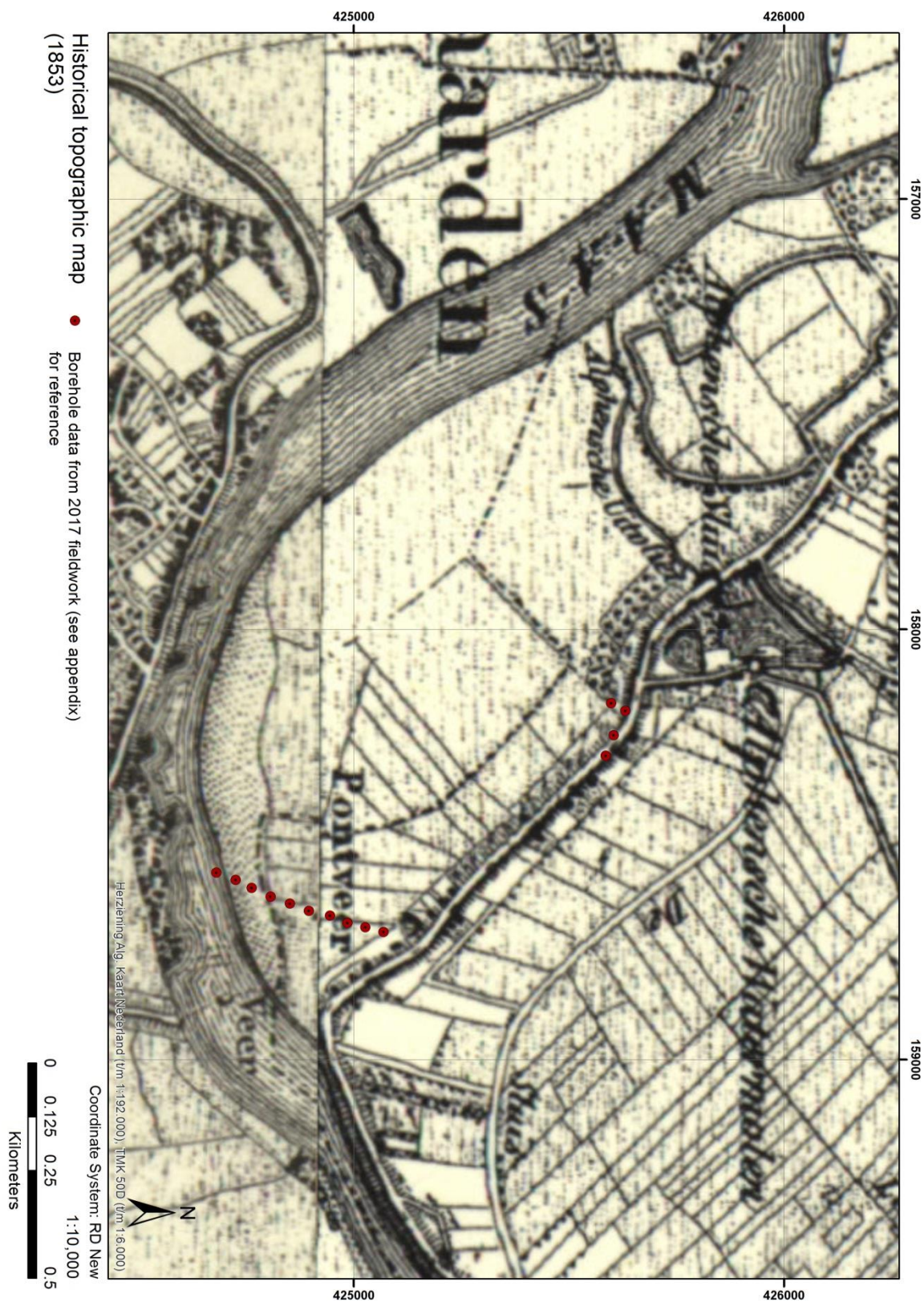


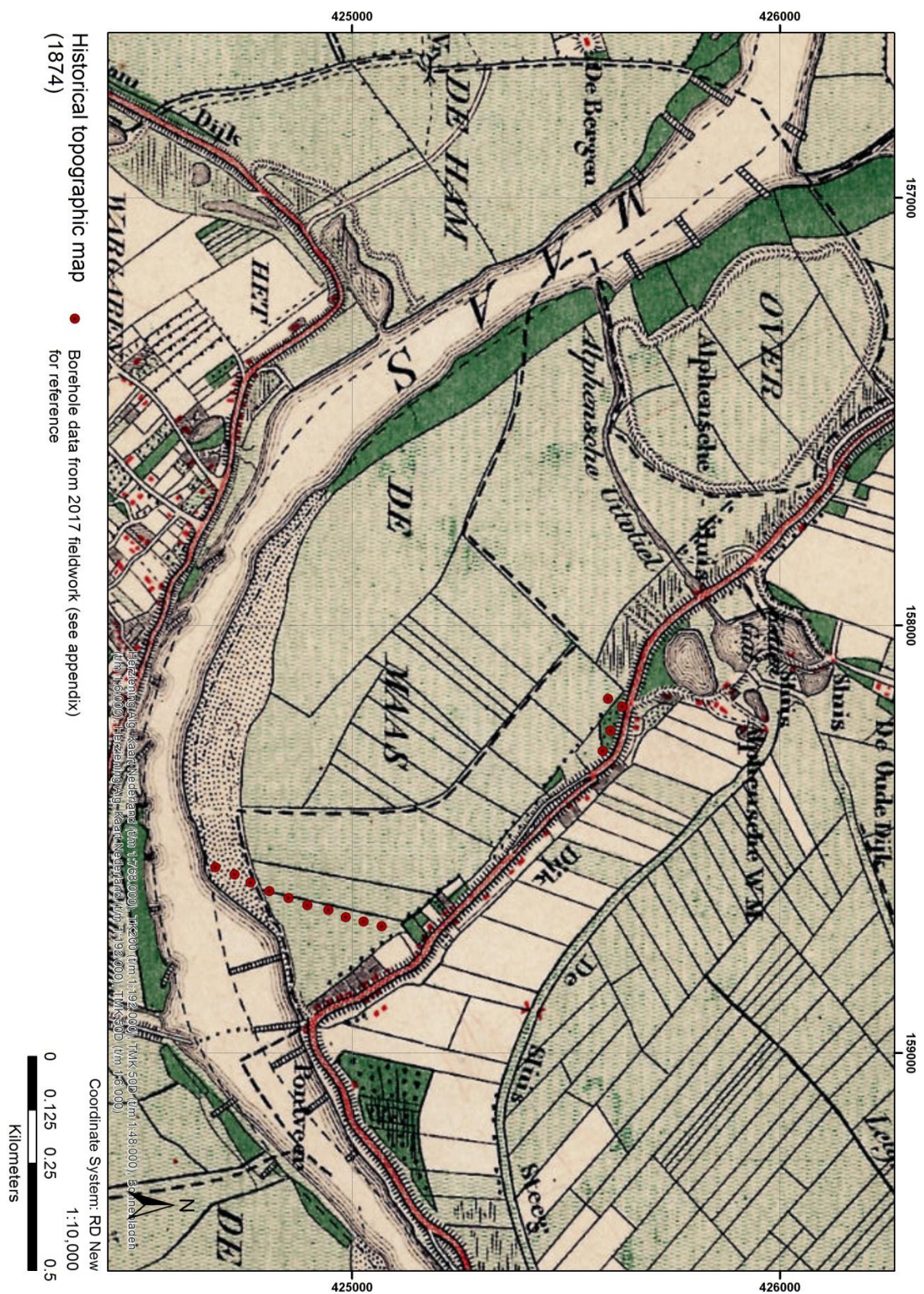


Appendix 3: Sand Depth map



Appendix 4: Historical topographical maps







Appendix 5: UU-LLG – USDA Conversion scheme

CONVERSIETABEL UU-LLG CODERINGEN				LLG-NL codes vs. LLG-USDA codes		
UU-LLG (B&S 2001)				LLG USDA		
TEXTUUR	ORG	Omschrijving	M50 / %GR	TEXTURE	ORG	Description
None	V3	Veen		None	P	Peat
None	V2	Kleig Veen		None	PM	Peat Muck
None	V1	Venige Klei		None	M	Muck
...	H2	Sterk Humeus		...	M2	Very Mucky / Very Humic
...	H1	Humeus		...	M1	Mucky / Humic
...	H0	Iets Humeus		...	M0	Little Mucky / Little Humic
None	ZV	Zandig Veen		SP		Sandy Peat
None	VZ	Venig Zand		PS		Peaty Sand
ZK	...	Zeer Zware Klei		C	...	Clay
MK	...	Matig Zware klei		SiC	...	Silty Clay
LK	...	Lichte klei		SiCL	...	Silty Clay Loam
ZZL	...	Zware zavel		SiL	...	Clay Loam
MZL	...	Matig lichte Zavel		SiL	...	Loam
LZL	...	zeer Lichte Zavel		SL	...	Sandy Loam
ZSL	...	Zware siltige leem		SiL	...	Silt Loam
SL	...	Siltige leem		SiL	...	Silt Loam
LSL	...	Lichte siltige leem		Si	...	Silt
ZL	...	Zware zandige Leem L		SiL	...	Silt Loam
L	...	Zandige leem		SiL	...	Silt Loam
LL	...	Lichte zandige leem		SiL	...	Silt Loam
Z-ZK	...	Zandige Zeer Zware Klei		C	...	Clay
Z-MK	...	Zandige Matig Zware Klei		SC	...	Sandy Clay
Z-LK	...	Zandige Lichte Klei		SCL	...	Sandy Clay Loam
Z-ZZL	...	Zandige Zware Zavel		SL	...	Sandy Loam
Z-MZL	...	Zandige Matig lichte Zavel		SL	...	Sandy Loam
Z-LZL	...	Zandige zeer Lichte Zavel		LS	...	Loamy Sand
Z-L	...	Zandige Leem		SiL	...	Silt Loam
ULZ	...	Zeer sterk lemig zand		SL	...	Sandy Loam
MLZ	...	Sterk lemig zand		SL	...	Sandy Loam
LZ	...	Lemig zand		LS	...	Loamy sand
ILZ	...	Zwak lemig zand		LS	...	Loamy sand
Z	...	Zand		S	...	Sand
UFZ	...	Uiterst fijn zand	50-105 μ m	vfs	...	Extremely fine sand
ZFZ	...	Zeer fijn zand	105-150	vfs	...	Very fine sand
FZ	...	Matig Fijn Zand	150-210	fs	...	Fine sand
MZ	...	Matig Grof Zand	210-420	ms	...	Medium sand
GZ	...	Grof tot Zeer Grof Zand	420-2000	cs	...	Coarse/ very coarse sand
ZFG	...	Zeer fijn grind	2-5 mm	fg	...	Very fine gravel
FG	...	Fijn Grind	5-16	G	...	Fine gravel
GG	...	Grof Grind	16-64	cG	...	Coarse gravel
ST	...	Steen	64-100	ST	...	Stone
KEI	...	Kei	100-500		...	Rock / Cobble
BLOK	...	Blok	> 500		...	Block / Boulder
IGHZ	...	Iets Grindhoudend Zand	3-10 %GR	S	...	Slightly gravelly sand
MGHZ	...	Matig Grindhoudend Zand	10-25	S	...	Gravelly sand
SGHZ	...	Sterk Grindhoudend Zand	25-50	S	...	Strongly gravelly sand
SZHG	...	Sterk Zandhoudend Grind	50-75	G	...	Strongly sandy gravel
MZHG	...	Matig Zandhoudend Grind	75-90	G	...	Sandy gravel
IZHG	...	Iets Zandhoudend Grind	90-97	G	...	Slightly sandy gravel

Versie 1.5 – K.M. Cohen, M.P. Hijma, T.E. Törnqvist

Addenda

201734001	Moree & Sonnemans	28-02-2017
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Coördinaten		Hoogte		Diepte		KAARTEENHEID		Geomorfofenetische kaart:						
Xco	Yco	Z [m]		[cm]		Geologische kaart:		Grondwatertrap:						
158172	425598	5.5		460		Begroeiingskaart:		Bodemkaart:						
31 UTM (?) Circa 25-30 m vanaf dijk 6,1 m accuracy, piketpaaltje circa 8 cm boven mv. Eerste 1,4-1.5 m opgehoogd vlak, waarschijnlijk circa 6 jaar geleden (schapenwei ten ZO ongeveer 1,5 tot 2 m lager).N.B. hoogte door AHN3.														
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden
10	MK		plr	brgr	o			0	1					Mn1 plr1 Zand ca. 10%
20	MK		plr	brgr	o			0	1					Mn1 plr1
30	MK		plr	brgr	o			0	1					Mn1 plr1
40	MK		plr	brgr	o			0	1					Mn1 plr1
50	MK		plr	brgr	o			0	1					Mn1 plr1
60	MK		plr	brgr	o			0	1					Mn1 plr1
70	MK		plr	brgr	o			0	1					Mn1 plr1
80	MK		plr	brgr	o			0	1					Mn1 plr1
90	MK		plr	brgr	o			0	1					Mn1 plr1
100	MK		plr	brgr	o			0	1					Mn1 plr1, brokje vuursteen
110	MK		plr	brgr	o			0	1					Mn1 plr1
120	MK		plr	brgr	o			0	1					Mn1 plr1
130	MK		plr	brgr	o			0	1					Mn1 plr1
140	MK		plr	brgr	o			0	1					Mn1 plr1
150	MK		plr	brgr	o			0	1					Mn1 plr1
160	MK		plr	brgr	or			0	1					Mn1 plr1, kwarts kiezel ca.1cm
170	MK		plr	brgr	or			0	0					Mn1 plr1 stukje ver. riet
180	MK		plr	dbgrgr	r			1	0					plr1 Mn0
190	MK		plr	dbgrgr	r			1	0					plr1 Mn0
200	MK		plr	dbgrgr	r			1	0					plr1 Mn0
210	MK		plr	dbgrgr	r			1	0	GW				plr1 Mn0, riet
220	ZK		plr	dbgrgr	r			1	0					plr1 Mn0, /2 MK-ZK
230	Z-ZK		plr	dbgrgr	r			1	1					plr2 wss oud opp. Mn0
240	Z-ZK		plr	dbgrgr	r			1	1					plr2 Mn0, mos+riet+wr.
250	Z-ZK		plr	dbgrgr	r			1	1					plr2 Mn0, zfijn Z bijmeng.
260	Z-ZK		plr	brgr	r			1	1					Mn1 plr1
270	Z-ZK		plr	brgr	r			1	1					# Mn1 plr1
280	Z-ZK		plr	brgr	r			1	1					Mn1 plr1
290	Z-ZK		plr	brgr	r			1	1					Mn1 plr1
300	Z-ZK	H0	plr	brgr	r			1	1					Mn1 plr1, korrel AW
310	Z-ZK	H0	plr	brgr	r			1	1					# Mn1 plr1
320	MK	H0		brgr	r			1	1					# Mn1 geen waarneming
330	MK	H0		blgr	r			1	1					Mn1
340	MK	H0		blgr	r			1	1					Mn1
350	MK	H0		blgr	r			1	1					Mn1
360	ZK	H1		brgr	r			0	1					Mn0, zandbrokjes ca. 0,5 cm
370	ZK	H1		brgr	r			0	1					Mn0, zandbrokjes ca. 0,5 cm
380	ZK	H1		brgr	r			0	1					# Mn0, zandbrokjes ca. 0,5 cm
390	ZK	H1		brgr	r			0	1					# Mn0, zandbrokjes ca. 0,5 cm
400	ZK	H1		brgr	r			0	1					Mn0, zandbrokjes ca. 0,5 cm
410	ZK	H0		lgr	r			0	1					fijnzandlaagje, Mn0
420	ILZ			gr	r		300-420	0	2					# scherpe // 415 ZK-Z Mn0
430	ILZ			gr	r		420	0	0					Mn0
440	Z			gr	r		420	0	0					Mn0
450	Z			gr	r		420	0	0					Mn0
460	Z			gr	r		150-210	0	0					Mn0, einde boring

201734002	Moree & Sonnemans	28-02-2017
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Coördinaten				Hoogte		Diepte		KAARTEENHEID							Geomorfogenetische kaart:		
Xco	Yco	Z [m]		[cm]		Geologische kaart:							Grondwatertrap:				
158190	425631	6.07		440		Begroeiingskaart:							Bodemkaart:				
Ca. 20 cm van begin dijk af, verlengde van 001 acc 2.3 m 1e 2 m gedaan op 28-02 afgebroken, slecht weer. Nieuw boorgat ca, 20 cm verder langs zelfde lijn langs dijk 13-03. Bijm. = Bijmenging. Grind bij benad. NB niet opgehoogd																	
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden			
10	ZK		plr	grbr	o			0	1					Mn1 Fijn Zand bijm.			
20	ZK		plr	grbr	o			0	1					Mn1 Fijn Zand bijm.			
30	ZK		plr	br	o			0	1					Mn1 Fijn Zand bijm.			
40	ZK		plr	br	o			0	1					Mn1 Fijn Zand bijm.			
50	ZK		plr	br	o	5		0	1					Mn1 Fijn Zand bijm., wat grind			
60	ZK		plr	br	o	5		0	1					Mn1 Fijn Zand bijm., wat grind			
70	ZK		plr	br	o	5		0	1					Mn1 FZ bijm. Gruis wi bouwpuin			
80	ZK		plr	br	o			0	1					Mn1 FZ bijm. Gruis wi bouwpuin			
90	ZK		plr	br	o			0	1					Mn1 FZ bijm. Gruis wi bouwpuin			
100	ZK		plr	br	o			0	1					Mn1 FZ bijm. Gruis wi bouwpuin			
110	ZK		plr	br	o	5		0	1					Mn1 FZ bijm. Gruis wi bouwpuin			
120	ZK		plr	br	o	5		0	1					Mn1 Gruis wi bouwpuin			
130	ZK		plr	br	o	5		0	1					Mn1			
140	ZK		plr	br	o			0	1					Mn1			
150	ZK		plr	br	o			0	2					Mn2			
160	ZK		plr	br	o			0	2					Mn2			
170	ZK		plr	br	o			0	2					Mn2, Bouwgruis?			
180	ZK		plr	br	o			0	2					Mn2, Bouwgruis?			
190	ZK		plr	br	o			0	2					Mn2			
200	ZK		plr	br	o			0	2					Mn2			
210	ZK		plr	br	or			0	2					Mn2			
220	ZK		plr	br	or			0	2					Mn2			
230	ZK		plr	br	or			0	2					Mn2			
240	ZK		plr	br	or			0	2					Mn2			
250	ZK		plr	br	or			0	2					Mn2			
260	ZK		plr	brgr	or			0	2					Mn2			
270	ZK		plr	brgr	or			0	2					Mn2			
280	ZK		plr	brgr	or			0	2					Mn2			
290	ZK		plr	brgr	or			0	2					Mn2			
300	ZK		plr	brgr	or			0	2					Mn2			
310	ZK			gr	or			0	1					Mn0			
320	ZK			gr	or			0	1					Mn0			
330	Z-ZK			gr	or			0	1					Mn0 2 cm grind			
340	FZ			gr	or	10	150-210	0	0					Mn0 /2, 5 mm grind			
350	MZ			gr	or	5	210-300	0	0					Mn0			
360	MZ			gr	or	5	300-420	0	0					Mn0, (2cm)Fe-laagje op MK-laag			
370	MZ			wige	or	5	210-300	0	0					Mn0, 2 cm grind, 365 / kleur			
380	MZ			gebr	or		210-300	0	0					Mn0,			
390	MZ			gebr	or		210-300	0	0					Mn0, 385 Fe-Laag / 1MK(Z bijm?)			
400	MK			dblgr	r			0	0	GW				Mn0			
410	MGHZ			dblgr	r	10	150-210	0	0					Mn0			
420	MGHZ			dblgr	r	10	150-210	0	0					Mn0			
430	SGHZ			dblgr	r	10	300-420	0	0					Mn0			
440	GZ			dblgr	r		420-600	0	0					Mn0			

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Coördinaten		Hoogte		Diepte		KAARTEENHEID									Geomorfofenetische kaart:	
Xco	Yco	Z [m]		[cm]		Geologische kaart:									Grondwatertrap:	
158247	425604	4.36		360		Begroeiingskaart:									Bodemkaart:	
Ca 65 m ZO van 003 ca. 1,2 m lager dan 003 (=opgebracht) 1,5 m van hek schapenwei. Acc 4,6 m																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	MK		plr	brgr	o			2	1		1			AWpuin		
20	MK		plr	brgr	o	15		1	1		1			Kiezels >1 cm		
30	MK		plr	brgr	o	15		1	1		1			Kiezels >1 cm		
40	MK		plr	brgr	o	15		1	1		1			Kiezels >1 cm		
50	MK		plr	brgr	o	15		1	1		1			Kiezels >1 cm		
60	ZK			brgr	o	15		1	2		2			Kiezels >1 cm		
70	ZK			brgr	o	15		1	2		2			Kiezels >1 cm		
80	ZK			brgr	o	15		1	2		2			Kiezels >1 cm		
90	ZK			brgr	o	15		0	2		2			Kiezels >1 cm		
100	ZK			brgr	o			0	2		2					
110	ZK			brgr	o			0	2		2					
120	ZK			brgr	o			0	2		2					
130	ZK			brgr	o			0	2		2					
140	Z-ZK			brgr	o			1	2		2			FZ (5-10%)		
150	Z-ZK		plr	brgr	o			1	2		2			FZ (5-10%)		
160	ZK		plr	brgr	o			1	2		2					
170	ZK		plr	brgr	o			0	2		2					
180	ZK		plr	brgr	o			0	2		2					
190	ZK		plr	brgr	o			0	2		2					
200	ZK		plr	brgr	o			0	2	GW	2					
210	ZK		plr	gr	or			0	2		2					
220	ZK		plr	gr	or			0	1		0					
230	ZK	H0	plr	dgr	or			0	1		0					
240	ZK	H1	plr	dblgr	r			0	0		0					
250	MK	H1	plr	dgr	r	3		2	0		0			Ca. 1 cm grind		
260	MK	H2		dgr	r			2	0		0			MONSTER 001		
270	LK	H1	plr	dgr	r			2	0		0			# Schgr		
280	LK	H0		dgr	r			2	0		0			Schgr		
290	LK	H0		dgr	r			2	0		0			Schgr		
300	LK	H0		dgr	r			2	0		0			Schgr		
310	LK	H0		dgr	r			2	0		0			Schgr		
320	MZ			dgr	r		210-300	2	0		0			Schgr 3cm Z/0 4cm MK/0 3 cm Z		
330	MZ			dgr	r		210-420	1	0		0			# Schgr		
340	MZ			dgr	r		210-420	0	0		0			# Schgr, brokje K		
350	MZ			dgr	r		210-420	0	0		0			Brokje K en ILZ		
360	FZ			dgr	r		150-210	0	0		0			# 370->380 bandje MZ 300-420		

201734004	Moree & Sonnemans	13-03-2017
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Coördinaten		Hoogte		Diepte		KAARTEENHEID									Geomorfofenetische kaart:	
Xco	Yco	Z [m]		[cm]		Geologische kaart:									Grondwatertrap:	
158294	425585	4.66		500		Begroeiingskaart:									Bodemkaart:	
ZO van 003 & 002 (op 't oog in een rechte lijn) Ca. 2,5 m van hek, tegen dijk. Acc. 2,1 m. Monster = Mangaan. Op boorformulier per ongeluk Fe en Ca omgewisseld, hier correct ingevuld. Bijm.=Bijmenging. Hoogte door AHN3																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	ZK		plr	br	o			0	1		1					
20	ZK		plr	br	o			0	1		1					
30	ZK		plr	br	o			0	1		1					
40	ZK		plr	br	o			2	1		1			ijzerdraadfragment hek		
50	ZK		plr	br	o			2	1		1			Grote brokken baksteen		
60	ZK			br	o			2	1		1					
70	ZK			br	o			0	1		1					
80	ZK			br	o			0	1		1			Brokje beton		
90	ZK			br	o			0	1		1					
100	ZK			br	o			0	1		1					
110	ZK			br	o			0	1		1					
120	ZK			br	o			0	1		1					
130	ZK			br	o			0	2		2					
140	ZK			br	o			0	2		2					
150	ZK			br	or			0	2		2					
160	ZK			lgr	or			0	1		1					
170	MK			lgr	or			0	1	GW	1			Ca. 10 % ZFZ bijm. (105-150)		
180	MK			lgr	or			0	1		1			Ca. 10 % ZFZ bijm. (105-150)		
190	MK			lgr	or			0	1		1			Ca. 10 % ZFZ bijm. (105-150)		
200	MK			lgr	or			0	1		1			Ca. 10 % ZFZ bijm. (105-150)		
210	MK			lgr	or			0	1		1			# bandjes van 5 mmZFZ(105-150)		
220	MK			lgr	or			0	1		1					
230	MK			lgr	or			0	1		1					
240	MK			lgr	or			0	1		1					
250	MK			lgr	or			0	1		1					
260	MK			lgr	or			0	1		1			#		
270	MK			gr	r			0	0		0			#		
280	MK		r	gr	r			0	0		0					
290	MK		plr	gr	r			0	0		0					
300	MK	H1		dgr	r			0	0		0					
310	MK	H1		dgr	r			0	0		0			Schgr		
320	MK			lblgr	r			0	0		0			Schgr, 3 mm bandjes ZFZ		
330	MK			lblgr	r			0	0		0			Schgr 10 bandje ZFZ		
340	MK		plr	lblgr	r			0	0		0			# Schgr 3 bandjes ZFZ		
350	MK			lblgr	r			0	0		0			# Schgr		
360	MK			lblgr	r			0	0		0			Schgr		
370	MK			lblgr	r			0	0		0			Schgr+ (bandjes?)		
380	MK		plr	lblgr	r			0	0		0			Schgr RietII		
390	MK		plr	lblgr	r			0	0		0			Schgr RietII		
400	MK		plr	lblgr	r			0	0		0					
410	MK	H0	plr	lblgr	r			0	0		0			brokje veen		
420	MK		plr	lblgr	r			0	0		0			#		
430	LK		plr	lblgr	r			0	0		0			# Schgr		
440	LK		plr	lblgr	r			0	0		0			Schgr		
450	LK		plr	lblgr	r			0	0		0			Schgr		
460	MK			lblgr	r			0	0		0			Schgr, Humeuze vlekken		
470	MZ		plr	gr	r		210-300	0	0		0			/1 MK-MZ		
480	MZ			gr	r		300-420	0	0		0			10 mm laagje K		
490	MZ			gr	r		300-420	0	0		0					
500	MK		plr	gr	r			0	0		0			# 3 mm laagje H2		

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Coördinaten		Hoogte		Diepte		KAARTEENHEID				Geomorfogenetische kaart:						
Xco	Yco	Z [m]		[cm]		Geologische kaart:				Grondwatertrap:						
158566	424680	5.08		340		Begroeiingskaart:				Bodemkaart:						
Op zomerdijk langs Maas tussen 2e en 3e boom ca. 60-70 m vanaf veerpontaanmeringspunt, ca. 15 m vanaf Maas haaks daarop. acc. Monster = Mangaan. einde broing omdat broogat steeds instortte door natte omstandigheden.																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	ILZ		plr	dgrbr	o		105-150	2	0		0					
20	ILZ		plr	dgrbr	o		105-150	2	0		0					
30	ILZ		plr	dgrbr	o		105-150	2	0		0					
40	ILZ		plr	dgrbr	o		105-150	2	0		0					
50	ILZ		plr	dgrbr	o		105-150	2	0		0					
60	ILZ		plr	dgrbr	o		105-150	2	0		0					
70	ILZ		plr	dgrbr	o		105-150	2	0		0					
80	ILZ		plr	dgrbr	o			2	1		1					
90	MK		plr	dgrbr	o			2	1		1					Bandjes 10 mm ZFZ (105-150)
100	MK		plr	dgrbr	o			2	1		1					Bandjes 10 mm ZFZ (105-150)
110	MK		plr	dgrbr	o			2	1		1			Bandjes 10 mm ZFZ (105-150)		
120	MK		plr	dgrbr	o			2	1		1			Bandjes 10 mm ZFZ (105-150) Bandjes 10 mm ZFZ (105-150) Bandjes 10 mm ZFZ (105-150)		
130	MK		plr	dgrbr	o			2	1		1					
140	MK		plr	dgrbr	o			2	1		1					
150	MK		plr	dgrbr	o			2	1		1					
160	MK		plr	dbrgr	o			2	1		1					
170	MK		plr	dbrgr	or			2	0		0					
180	MZ			wige	or		300-420	2	0		0					
190	MK			wige	or			2	0		0					
200	GZ			orge	or	5	420-600	2	0		0				Ca. 5 mm grind	
210	GZ			grwi	or	15	600-850	1	0		0				Ca. 3-15 mm grind	
220	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
230	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
240	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
250	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
260	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
270	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
280	GZ			grwi	or	15	600-850	1	0		0			Ca. 3-15 mm grind		
290	GZ			gebr	or	15	600-850	1	1		1			Ca. 3-15 mm grind, FeMn1obvklr		
300	GZ			gebr	or	15	600-850	1	1		1			Ca. 3-15 mm grind		
310	GZ			gebr	or		600-850	1	1		1			Nu ook 30-40 mm grind aanwezig Nu ook 30-40 mm grind aanwezig		
320	GZ			brgr	r		850-1000	1	0	GW	0					
330	GZ			brgr	r	50	850-1000	1	0		0					
340	GZ			brgr	r	50	850-1000	1	0		0					

201734006	Moree & Sonnemans	14-03-2017
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Coördinaten		Hoogte		Diepte		KAARTEENHEID									Geomorfogenetische kaart:		
Xco	Yco	Z [m]		[cm]		Geologische kaart:									Grondwatertrap:		
158583	424725	4.37		280		Begroeiingskaart:									Bodemkaart:		
ca. 50 m vanaf 005 midden in weiland. acc 4,8 m. Monster = Mangaan. Einde broing vanwege instorten boorgat wegens natte omstandigheden.																	
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden			
10	ZK		plr	dbr	o			2	0		0						
20	ZK		plr	dbr	o			2	0		0						
30	ZK		plr	dbr	o			2	0		0						
40	ZK		plr	dbr	o			2	0		0						
50	ZK		plr	dbr	o			2	0		0						
60	ZK		plr	grbr	o			2	1		1						
70	ZK		plr	grbr	o			2	1		1						
80	ZK		plr	grbr	o			2	1		1						
90	ZK		plr	grbr	o			2	1		1						
100	MK			grbr	o			2	1		1						
110	MK			grbr	o	5		2	1		1				Tegen 110 / 1 MK-GZ 5mm grind		
120	GZ			wige	or	5	420-600	0	0		0				5 mm grind		
130	GZ			wige	or	5	420-600	0	0		0				5 mm grind		
140	GZ			wige	or	5	420-600	0	0		0				5 mm grind		
150	GZ			brge	or	5	600-850	0	0		0				10 mm grind		
160	GZ			brge	or	5	600-850	0	0		0				10 mm grind		
170	GZ			brge	or	5	420-600	0	0		0				10 mm grind		
180	GZ			wige	or	5	420-600	0	0		0				10 mm grind		
190	GZ			wige	or	5	420-600	0	0		0				10 mm grind		
200	GZ			wige	or	5	420-600	0	0		0				10 mm grind		
210	GZ			wige	or	5	600-850	0	0		0				10 mm grind		
220	GZ			wige	or	5	600-850	0	0		0				10 mm grind		
230	ZFG		br	or			2-5mm	0	0		0				30 mm grind		
240	ZFG		br	or			2-5mm	0	0		0				overwegend rond 10 mm grind		
250	FG		br	or			5-16mm	0	0		0				overwegend rond 10 mm grind		
260	FG		grbr	or			5-16mm	0	0		0				overwegend rond 10 mm grind		
270	ZFG		grbr	r			2-5mm	0	0	GW	0						
280	ZFG		grbr	r			2-5mm	0	0		0						

201734007	Moree & Winkels	28-03-2017
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Coördinaten		Hoogte		Diepte		KAARTEENHEID					Geomorfogenetische kaart:				
Xco	Yco	Z [m]		[cm]		Geologische kaart:					Grondwatertrap:				
158601	424762	4.12		210		Begroeiingskaart:					Bodemkaart:				
50 m in verlengde van ODM005 en 006 M=Mn. vanaf 1 m tot 1,8 m afwisseling fijnere en grovere zandlaagjes en af en toe organisch materiaal laagjes(?) --> Cross-bedding (verg. met foto). Acc.: 5.4 m. bijm.=bijmenging. gr.=grind															
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden	
10	MK		plr	dbrgr	o			2	0		0			ca. 10 % silt	
20	MK		plr	dbrgr	o			2	0		0			ca. 10 % silt	
30	MK		plr	dbrgr	o			2	0		0			ca. 10 % silt	
40	MK		plr	dbrgr	o			2	1		1			ca. 10 % silt	
50	LK		plr	dbrgr	o			2	1		1			ca. 10 % silt, stuk zandiger	
60	MK			brgr	or			2	1		1			ca. 10 % silt	
70	MK			brgr	or			2	2		2				
80	MK			brgr	or			2	2		2			bandje Z rond -75 -cmv MZ	
90	MZ			br	or		300-420	1	2		2			Bandjes siltige K ca. 2 cm	
100	GZ			br	or		420-600	0	2		2			Bandjes siltige K ca. 2 cm	
110	MZ			br	or	3	300-420	0	2		2			Bandjes siltK ca.2cm gr5mm	
120	GZ			br	or	10	420-600	0	2		2			BandsKca.2cm/1-wige5-10mm	
130	GZ			wige	r	10	600-850	0	0		0			gr. 5-10 mm	
140	GZ			wige	r	10	600-850	0	0		0			gr. 5-10 mm	
150	GZ			wige	r	15	600-850	0	0		0			gr.2-3 mm	
160	GZ			wige	r	15	850-1000	0	0		0			gr.2-3 mm	
170	GZ			wi	r	15	850-1000	0	0		0			gr.2-3 mm	
180	GZ			wi	r	15	850-1000	0	0		0			gr.2-3 mm	
190	GZ			wi	r	15	850-1000	0	0		0			gr.2-3 mm	
200	GZ			wi	r	20	850-1000	0	0		0			gr. 5 mm	
210	GZ			wi	r	30	850-1000	0	0		0			gr. 5-30 mm K bandje,EindeBor	

201734008	Moree & Winkels	28-03-2017
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Coördinaten		Hoogte		Diepte		KAARTENHEID								Geomorfogenetische kaart:		
Xco	Yco	Z [m]		[cm]		Geologische kaart:								Grondwatertrap:		
158638	424851	6.75		700		Begroeiingskaart:								Bodemkaart:		
In (opgehoogde?) veld tussen dijk en weiland circa 15 m van rand afgraving. acc. 6,9 m Bijm.= bijmenging. M=Mn. gr.=grind mediaan. In dit geval geldt voor Fe2= IJzerconcreties (op fysiek boorformulier aangegeven met 9).																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	LK			grbr	o			0	0		0			Geen Fe/Mnvlekken		
20	LK			grbr	o			0	0		0			Geen Fe/Mnvlekken		
30	LK			grbr	o			0	0		0			Geen Fe/Mnvlekken		
40	LK			grbr	o			0	0		0			Geen Fe/Mnvlekken		
50	ZZL			grbr	o			0	0		0			Geen Fe/Mnvlekken		
60	ZZL			grbr	o			0	0		0			Geen Fe/Mnvlekken		
70	ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
80	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
90	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
100	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
110	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
120	ZZL			grbr	o			0	0		0			Geen Fe/Mnvlekken		
130	ZZL			grbr	o			0	0		0			Geen Fe/Mnvlekken		
140	ZZL			grbr	o			0	0		0			Geen Fe/Mnvlekken		
150	ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
160	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
170	Z-ZZL			grbr	o			1	0		0			Geen Fe/Mnvlekken		
180	ZZL			grbr	o			1	0		0			Humusvlekken		
190	ZZL			grbr	o			1	1		0			Humusvlekken		
200	ZZL			grbr	o			1	1		0			Humusvlekken		
210	ZZL			grbr	o			0	1		0			Humusvlekken		
220	Z-ZZL			grbr	o			1	1		0			Humusvlekken		
230	Z-ZZL			grbr	o			0	1		0			Humusvlekken		
240	Z-ZZL			grbr	or			0	0		0			Humusvlekken, Steeds meer Z		
250	Z-ZZL			grbr	or			0	1		0			Humusvlekken, Steeds meer Z		
260	Z-ZZL			grbr	or			0	1		0			Humusvlekken, Steeds meer Z		
270	Z-ZZL			grbr	or			0	1		0			Humusvlekken, Steeds meer Z		
280	Z-ZZL			grbr	or			0	1		0			Humusvlekken, Steeds meer Z / 1		
290	MZ			grbr	r		210-300	0	0		0			Laagjes K ca. 1cm		
300	MZ			grbr	r		210-300	0	0		0			Laagjes K ca. 1cm		
310	MZ			wi	r		300-420	0	0		0			Laagjes K ca. 1cm		
320	MZ			wi	r		300-420	0	0		0			Laagjes K ca. 1cm		
330	MZ			grwi	r		300-420	0	0		0			Uniform Z		
340	MZ			grwi	r		300-420	0	0		0			Uniform Z		
350	MZ			grwi	r		300-420	0	0		0			Uniform Z		
360	GZ			grwi	r		420-600	0	0		0			Uniform Z		
370	GZ			grwi	r		420-600	0	0		0			K Brokjes		
380	MZ			grwi	r		210-300	0	0		0			K Brokjes		
390	MZ			grwi	r		210-300	0	0		0			K Brokjes		
400	MZ			gewi	r		210-300	0	0		0			K Brokjes		
410	MZ			gewi	r		300-420	0	0		0			K Brokjes		
420	MZ			gewi	r		300-420	0	0		0			K Brokjes		
430	MZ			orwi	r		300-420	0	2		0			K Brokjes		
440	GZ			orwi	r		420-600	0	2		0			K Brokjes, afw. MZ-GZ		
450	GZ			orwi	r		420-600	0	2		0			K Brokjes, afw. MZ-GZ		
460	MZ			orwi	r	1	300-420	0	2		0			afw. MZ-GZ gr. 2mm		
470	MZ			orwi	r		300-420	0	0		0					
480	MZ			orwi	r	1	300-420	0	0		0			gr. 2 mm Humus/Kbrok		
490	MZ			orwi	r	3	300-420	0	2		0			gr. 2 mm		
500	MZ			orwi	r		300-420	0	2		0					
510	MZ			orwi	r	2	300-420	0	0		0			gr. 4 mm		
520	MZ			orwi	r		210-300	0	0		0					

530	GZ			wi	r	8	420-600	0	0		0			gr. 2-5mm
540	GZ			wi	r	8	420-600	0	0		0			gr. 3 mm
550	GZ			br	r	8	420-600	0	0		0			#
560	GZ			br	r	10	420-600	0	0		0			
570	GZ			br	r	10	420-600	0	0	GW	0			
580	GZ			br	r	10	420-600	0	0		0			
590	GZ			br	r	10	420-600	0	0		0			
600	GZ			br	r	10	420-600	0	0		0			# gm
610	GZ			br	r	10	420-600	0	0		0			#
620	GZ			br	r	10	600-850	0	0		0			
630	GZ			grbr	r	20	600-850	0	0		0			
640	GZ			grbr	r	20	600-850	0	0		0			
650	GZ			grbr	r	20	600-850	0	0		0			
660	GZ			grbr	r	20	600-850	0	0		0			
670	GZ			grbr	r	20	600-850	0	0		0			
680	GZ			grbr	r	20	600-850	0	0		0			gm
690														# gm Einde Boring
700														

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Coördinaten	Hoogte	Diepte	KAARTEENHEID	Geomorfogenetische kaart:
Xco Yco	Z [m]	[cm]	Geologische kaart:	Grondwatertrap:
158655 424895	6.54	550	Begroeiingskaart:	Bodemkaart:

Ca. 50 m vanaf ODM008 in verlengde raai. Acc. 6.9 m Wanneer hier Fe = 2 betreft het in dit geval IJzerconcreties (vermeld als Fe9 op het fysieke boorformulier). Bijm. = bijmenging. Monster = Mn.

Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden
10	MK			dbgr	o			0	0		0			
20	MK			dbgr	o			0	0		0			
30	MK			dbgr	o			0	0		0			
40	MK			dbgr	o			0	0		0			
50	ZZL			brgr	or			0	0		0			
60	ZZL			brgr	or			0	0		0			
70	ZZL			brgr	or			0	0		0			Zandiger
80	ZZL		plr	brgr	or			0	0		0			Zandiger
90	ZZL			brgr	or			0	0		0			Zandiger
100	ZZL			brgr	or			0	0		0			Zandiger
110	ZZL			brgr	or			0	0		0			Zandiger
120	Z-ZZL			brgr	or			0	0		0			
130	Z-ZZL			brgr	or			0	0		0			
140	MZ			brgr	or		210-300	0	0		0			K brokjes
150	MZ			brgr	or		210-300	0	0		0			K brokjes
160	MZ			brgr	or		300-420	0	0		0			K brokjes
170	MZ			brgr	or		300-420	0	0		0			K brokjes
180	Z-ZZL			brgr	or			0	0		0			
190	Z-ZZL			brgr	or			0	0		0			
200	Z-ZZL			brgr	or			0	0		0			
210	ZZL			brgr	or			0	1		1			
220	ZZL			brgr	or			0	1		1			
230	ZZL			brgr	or			0	1		1			
240	ZZL			brgr	or			0	1		1			
250	ZZL			brgr	or			0	1		1			
260	ZZL			brgr	or			0	1		1			
270	ZZL			brgr	or			0	1		1			
280	ZZL			brgr	or			0	1		1			
290	ZZL			brgr	or			0	1		1			
300	MZ			gewi	or		300-420	0	0		0			
310	MZ			gewi	or		300-420	0	0		0			Grovere Bijmenging
320	MZ			gewi	or		300-420	0	0		0			Grovere Bijmenging
330	MZ			orwi	or		300-420	0	0		0			Grovere Bijmenging K Brokjes
340	MZ			orwi	or		300-420	0	0		0			Grovere Bijmenging K Brokjes
350	MZ			orwi	or		300-420	0	0		0			Grovere Bijmenging K Brokjes
360	MZ			gewi	or		300-420	0	0		0			Grovere Bijmenging K Brokjes
370	MZ			orwi	or		300-420	0	0		0			Grovere Bijmenging
380	MZ			orwi	or		300-420	0	0		0			Grovere Bijmenging
390	MZ			gewi	or	1	300-420	0	0		0			Grovere Bijmenging

400	MZ			gewi	or	1	300-420	0	0		0		Grovere Bijm. Humus Brokje
410	MZ			orwi	or		300-420	0	2		0		K Brokjes Fe Concretie laagje
420	MZ			orwi	or		300-420	0	2		0		K Brokjes Fe Concretie laagje
430	MZ			wi	or		300-420	0	2		0		Fe Concretie brokje
440	MZ			wi	or		300-420	0	0		0		
450	Z-ZZL			gr	or			0	0		0		
460	MZ			gr	or		300-420	0	0		0		
470	MK			gr	or			0	0		0		Humus brokje/laagje
480	GZ			brwi	or		600-850	0	2		0		K Brokjes
490	GZ			brwi	or		600-850	0	2		0		K Brokjes
500	GZ			brwi	or	1	600-850	0	2		0		K Brokjes
510	GZ			gewi	or	1	600-850	0	0		0		K Brokjes
520	GZ			gewi	or	1	600-850	0	0		0		K Brokjes
530	GZ			gewi	or	1	600-850	0	0		0		K Brokjes
540	GZ			gewi	or	1	600-850	0	0		0		K Brokjes
550	GZ			gewi	or	3	600-850	0	0		0		K Brokjes, einde gat stort in

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Coördinaten	Hoogte	Diepte	KAARTEENHEID	Geomorfogenetische kaart:
Xco Yco	Z [m]	[cm]	Geologische kaart:	Grondwatertrap:
158666 424944	6.5	510	Begroeiingskaart:	Bodemkaart:

bandjes 430-480 Regelmatige afstand Kleur Bandje 490-510. Ba = Bandjes. Monster = Mn

Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden
10	MK		plr	dbgr				0	0					
20	MK		plr	dbgr				0	0					
30	MK		plr	dbgr				0	0					
40	MK		plr	brgr				0	0					
50	MK		plr	brgr				0	0					
60	MK		plr	brgr				0	0					
70	MK		plr	brgr				0	0					
80	MK		plr	brgr				0	0					
90	ZZL			brgr				0	0					
100	ZZL			brgr				0	0					
110	Z-ZZL			brgr				0	0					
120	Z-ZZL			brgr				0	0					
130	Z-ZZL			brgr				0	0					
140	MZ			brgr			210-300	0	0					
150	Z-ZZL			brgr				0	0					Zandiger dan 110-130
160	Z-ZZL			brgr				0	0					Zandiger dan 110-130
170	Z-ZZL			brgr				0	0					Zandiger dan 110-130
180	LK			brgr				0	0					
190	LK			brgr				0	0					
200	LK			brgr				0	0					grindje 15 mm
210	MK			brgr				0	1		1			
220	MK			brgr				0	1		1			
230	MK			brgr				0	1		1			
240	MK			brgr				0	1		1			
250	ZK			brgr				0	1		1			
260	ZK			brgr				0	1		1			
270	ZK			gr				0	2		1			
280	ZK			gr				0	2		1			
290	ZK			gr				0	2		1			
300	ZK			gr				0	2		1			
310	ZK			gr				0	2		1			
320	ZK			gr				0	2		1			
330	ZK			gr				0	2		1			
340	ZK			gr				0	2		1			
350	ZK			gr				0	2					
360	ZK			gr				0	2					
370	ZK			gr				0	2					
380	ZK			gr				0	1					
390	ZK			gr				0	2					ca. 4 cm bandje Fe concretie
400	ZK			gr				0	2					
410	ZK		plr	gr				0	1					# Ba Z 5 mm 150-210
420	ZK		plr	gr				0	1					Ba FZ 5 mm 150-210 / kleur
430	ZK			dgr				0	0					Ba FZ 2-5mm 150-210 Ba H2 10mm
440	ZK		plr	dgr				0	0					Ba FZ 2-5mm Ba Z 20mm 300-420
450	ZK		plr	dgr				0	0					Ba FZ 2-5mm Ba Z 20mm 300-420
460	ZK		plr	dgr				0	0					Ba FZ 2-5mm Ba Z 20mm 300-420
470	ZK			dgr				0	0					Ba FZ 2-5mm Ba Z 20mm 300-420
480	ZK			dgr				0	0					#Ba FZ 2-5mm BaMZ20mm Fe Concr
490	MZ			gewi			300-420	0	0					# Fe Concretie
500	MZ			gewi			300-420	0	0					Grindje 5 mm
510	MZ			gewi			300-420	0	0					#

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Coördinaten		Hoogte		Diepte		KAARTEENHEID								Geomorfogenetische kaart:		
Xco	Yco	Z [m]		[cm]		Geologische kaart:								Grondwatertrap:		
158683	424985	6.46		550		Begroeiingskaart:								Bodemkaart:		
59 m in verlengde van ODM010. Wanneer Fe = 2 dan betreft het hier IJzer concreties (vermeld als Fe9 op betreffende fysieke boorformulier). acc. = 3.8 m. van 510-540 Rooiig en grind van 2 mm. Monster = Mn.																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	MK			dbgr	o			0	0		0					
20	MK			dbgr	o			0	0		0					
30	MK			dbgr	o			0	0		0					
40	MK			dbgr	o			0	0		0					
50	MK			brgr	o			0	0		0					
60	MK			brgr	o			0	0		0					
70	MK			brgr	o			0	0		0					
80	ZZL			brgr	o			0	0		0					
90	ZZL			brgr	o			0	0		0					
100	ZZL			brgr	o			0	0		0					
110	Z-ZZL			brgr	o			0	0		0					
120	Z-ZZL			brgr	o			0	0		0					
130	Z-ZZL			brgr	o			0	0		0					
140	Z-ZZL			brgr	o			0	0		0					
150	ILZ			brgr	o		150-210	0	0		0					
160	ILZ			brgr	o		150-210	0	0		0					
170	Z-ZZL			brgr	o			0	0		0					
180	Z-ZZL			brgr	o			0	0		1					
190	Z-ZZL			brgr	o			0	1		1					
200	Z-ZZL			brgr	o			0	1		1					
210	ZZL			brgr	o			0	1		1					
220	ZZL			brgr	o			0	1		1					
230	LK			brgr	o			0	1		1					
240	LK			brgr	o			0	1		1					
250	MK			brgr	o			0	1		1					
260	ZK			lgr	r			0	0		0					
270	ZK			lgr	r			0	0		0					
280	ZK			lgr	r			0	0		0					
290	ZK			lgr	r			0	0		0					
300	ZK			lgr	r			0	0		0					
310	ZK			lgr	r			0	0		0					
320	MK			brgr	r			0	2		0			Fe Concreties		
330	MK			brgr	r			0	2		0			Fe Concreties		
340	MK			brgr	r			0	2		0			Fe Concreties		
350	MK			brgr	r			0	2		0			Fe Concreties		
360	MK			gr	r			0	2		0			Fe Concreties		
370	MZ			gr	r		300-420	0	0		0			K Laagjes		
380	MZ			gr	r		300-420	0	0		0			K Laagjes		
390	ILZ			lgr	r		300-420	0	0		0			K Laagjes		

400	MZ		gewi	r		300-420	0	0		0		K Laagjes
410	MZ		gewi	r		300-420	0	0		0		K Laagjes
420	GZ		wi	r		420-600	0	0		0		
430	GZ		wi	r		420-600	0	0		0		
440	GZ		wi	r		420-600	0	0		0		
450	GZ		wi	r		420-600	0	2		0		K brokjes
460	GZ		wi	r		420-600	0	2		0		K brokjes
470	GZ		orbr	r		420-600	0	0		0		
480	MZ		orbr	r		300-420	0	0		0		K Brokjes/laagjes
490	GZ		orbr	r		420-600	0	0		0		
500	GZ		orbr	r		420-600	0	0		0		
510	GZ		orbr	r	5	420-600	0	0		0		K brokjes zie orwi eindeODM008
520	GZ		orbr	r	5	420-600	0	0		0		K brokjes
530	GZ		orbr	r	5	420-600	0	0		0		K brokjes
540	GZ		orbr	r	5	420-600	0	0		0		K brokjes humus brokje
550	MZ		grwi	r		300-420	0	0		0		einde boring

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Coördinaten		Hoogte		Diepte		KAARTEENHEID								Geomorfofenetische kaart:		
Xco	Yco	Z [m]		[cm]		Geologische kaart:								Grondwatertrap:		
158693	425026	6.38		680		Begroeiingskaart:								Bodemkaart:		
50 m in verlengde van ODM011 Helaas batterijen van gps op, daarom geen UTM31 coördinaten, wel piketpaaltje geslagen. Monster = Mn. Gr. = grind. Bijm.= Bijmenging. gm = geen meting. waar.= waarschijnlijk. Mons 2 diepte op zak.																
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden		
10	MK			dbrgr				0	0		0					
20	MK			dbrgr				0	0		0					
30	MK			dbrgr				0	0		0					
40	MK			dbrgr				0	0		0					
50	MK			dbrgr				0	0		0					
60	ZZL			brgr				0	0		0					
70	ZZL			brgr				0	0		0					
80	ZZL			brgr				0	0		1					
90	ZZL			brgr				0	0		1					
100	ZZL			brgr				0	0		1					
110	ZZL			brgr				0	0		1					
120	ZZL			brgr				0	0		1					
130	Z-ZZL			brgr				0	0		1					
140	Z-ZZL			brgr				0	0		1					
150	MZ			gebr			210-300	0	0		1					
160	MZ			gebr			210-300	0	0		1					
170	MZ			brgr			210-300	0	0		1					
180	Z-ZZL			brgr				0	0		1					
190	LK			brgr				0	0		1					
200	LK			brgr				0	0		1					
210	LK			brgr				0	0		1					
220	LK			brgr				0	1		1					
230	MK			brgr				0	1		1					
240	MK			brgr				0	1		1					
250	MK			brgr				0	1		1					
260	MK			brgr				0	1		1					
270	ZK			dgr				0	1		1					
280	ZK			dgr				0	2		1			Fe Concreties		
290	ZK			dgr				0	2		1			Fe Concreties		
300	ZK			dgr				0	2		1			Fe Concreties		
310	ZK			dgr				0	2		1					
320	ZK			dgr				0	1		1					
330	ZK			dgr				0	1		1					
340	ZK			dgr				0	1		1					
350	ZK			dgr				0	2		1			Fe concreties		
360	ZK			dgr				0	2		1			Fe concreties		
370	ZK			dgr				0	2		1			Fe concreties		
380	ZK			dgr				0	0		0					
390	MZ			wi			300-420	0	0		0			K brokjes		
400	MZ			wi			300-420	0	0		0			K brokjes		

410	GZ		orwi		420-600	0	2		0		
420	GZ		wi		420-600	0	0		0		
430	GZ		wi		420-600	0	0		0		
440	MZ		wi		300-420	0	0		0		
450	GZ		wi		420-600	0	0		0		
460	GZ		or		420-600	0	2		0		
470	GZ		or		420-600	0	2		0		
480	GZ		or		420-600	0	2		0		
490	GZ		br	3	420-600	0	0		0		
500	GZ		br	3	420-600	0	0		0		
510	MZ		br	3	300-420	0	0		0		
520	MZ		br	3	300-420	0	0		0		
530	GZ		or	3	420-600	0	0		0		
540	GZ		or	3	420-600	0	0		0		
550	GZ		or	3	420-600	0	0	GW	0		
560	GZ		or	5	420-600	0	0		0		
570	GZ		br	5	600-850	0	0		0		
580	GZ		br	3	600-850	0	0		0		
590	GZ		br	3	600-850	0	0		0		
600	GZ		br	3	600-850	0	0		0		
610	GZ		br	3	600-850	0	0		0		
620	GZ		br	3	600-850	0	0		0		
630	GZ		br	5	600-850	0	0		0		
640	GZ		br	5	600-850	0	0		0		
650	GZ		br	3	600-850	0	0		0		
660	GZ		br	3	600-850	0	0		0		
670	GZ		br	3	600-850	0	0		0		
680	GZ		br	3	600-850	0	0		0		

rooiige K brokjes
rooiige K brokjes
Humues K brokje
Humues K brokje gr. 2 mm bijm.
gr. 2 mm bijm.

K brokje
K brokje gr. 30 mm
Fijn grind laagje
ca. 2 mm gr.
ca. 2 mm gr.
Zand grover
8 mm gr.
Houtskool/organisch mat brok

gm waars. Z waargenomen
gm waars. Z waargenomen
einde boring gm, Z waargenom

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Coördinaten		Hoogte		Diepte		KAARTEENHEID								Geomorfofenetische kaart:	
Xco	Yco	Z [m]		[cm]		Geologische kaart:								Grondwatertrap:	
158704	425069	4.81		540		Begroeiingskaart:								Bodemkaart:	
-60 m in verlengde ODM012,-1,5 m lager mv t.o.v. ODM012, -8 m vanaf heg, 50 m vanaf dijk. Monster = Mn. Bijm.= Bijmenging. Gr. = Grind. Guts 460-540: Half leeg Br Z verm. 420-600 met grind bijm. lijkt op laatste guts ODM012.															
Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden	
10	MK				o			0	0		1				
20	MK				o			0	0		1				
30	MK				o			0	0		1				
40	MK				o			0	0		1				
50	MK				o			0	0		1				
60	MK				o			0	2		2				
70	MK				o			0	2		2				
80	MK				o			0	2		2				
90	ZK				o			0	2		2				
100	ZK				o			0	2		2				
110	ZK				o			0	2		2				
120	ZK				o			0	2		2				
130	ZK				o			0	2		2				
140	ZK				o			0	2		2				
150	ZK				o			0	2		2				
160	ZK				o			0	2		2				
170	ZK				o			0	2		2				
180	ZK				o			0	2		2				
190	ZK				o			0	2		2				
200	ZK				o			0	2		2				
210	ZK				o			0	2		2				
220	ZK				o			0	2		2				
230	MZ				o		300-420	0	2		2				
240	ZK				o			0	2		2			/1 ZK-MZ	
250	MZ				or		210-300	0	0		0			Zeet uniform Z geen bijm.	
260	MZ				or		210-300	0	0		0			Zeet uniform Z geen bijm.	
270	MZ				or		210-300	0	0		0			Zeet uniform Z geen bijm.	
280	MZ				or		210-300	0	0		0			Zeet uniform Z geen bijm.	
290	MZ				or		300-420	0	0		0			Zeet uniform Z geen bijm.	
300	MZ				or		300-420	0	0		0			Zeet uniform Z geen bijm.	
310	MZ				or		300-420	0	0		0				
320	MZ				or		300-420	0	0		0				
330	MZ				or		300-420	0	0		0				
340	MZ				or		300-420	0	0		0			Grover minder uniform Z	
350	MZ				or		300-420	0	0		0				
360	GZ				or	3	420-600	0	0		0			Gr. 8 mm K brokje	
370	GZ				or	3	600-850	0	0		0			Gr. 8 mm K brokje	
380	GZ				r	5	600-850	0	0	GW	0			Gr. 2-20 mm, K Brokje	
390	GZ				r		420-600	0	0		0			Gr. 2-20 mm	
400	GZ				r		420-600	0	0		0			Gr. 2-20 mm	
410					r			0	0		0			# gm Z gevoeld	
420					r			0	0		0			gm Z gevoeld	
430					r			0	0		0			gm Z gevoeld	
440					r			0	0		0			gm Z gevoeld	
450					r			0	0		0			gm Z gevoeld	
460					r			0	0		0			# gm Z gevoeld	
470					r			0	0		0			# Zie opmerkingen	
480					r			0	0		0			idem	
490					r			0	0		0			idem	
500					r			0	0		0			idem	
510					r			0	0		0			idem	
520					r			0	0		0			idem	
530					r			0	0		0			idem	
540					r			0	0		0			# idem, einde boring.	

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Coördinaten	Hoogte	Diepte	KAARTEENHEID	Geomorfofenetische kaart:
Xco Yco	Z [m]	[cm]	Geologische kaart:	Grondwatertrap:
158622 424806	6.4	420	Begroeiingskaart:	Bodemkaart:

acc. 7.2 m. einde dag in rand afgraving, parallel aan Maas. Monster = Mn. gr. = grind. Nota bene: Coördinaten ditmaal reeds in RD nieuw.

Diepte	Textuur	Org	Plr	Kleur	Redox	Grind	M50	Ca	Fe	GW	M	LKL	Strat	Bijzonderheden
10	LK			br				0	0		0			
20	LK			br				0	0		0			
30	ZZL			br				0	0		0			
40	MZL			br				0	0		0			
50	MZL			br				0	0		0			
60	MZL			br				0	0		0			
70	MZL			br				0	0		0			
80	MZL			br				0	0		0			
90	MZL			br				0	0		0			
100	MZL			br				0	0		0			
110	MZ			wi			300-420	0	0		0			
120	MZ			wi			300-420	0	0		0			
130	LZL			brgr				0	0		0			
140	LZL			brgr				0	0		0			
150	LK			brgr				0	0		0			
160	LK			brgr				0	0		0			
170	LK			brgr				0	0		1			
180	MK			brgr				0	0		1			
190	MK			brgr				0	0		1			
200	LK			brgr				0	0		1			
210	LK			brgr				0	2		2			
220	MK			brgr				0	2		2			
230	MK			brgr				0	2		2			
240	MK			brgr				0	2		2			
250	MZ			gr			210-420	0	2		2			?
260	LK			gr				0	2		2			
270	ZK			gr				0	2		2			
280	ZK			gr				0	2		2			Gr. 1 cm
290	ZK			gr				0	2		2			
300	ZK			gr				0	2		2			
310	ZK			gr				0	2		2			
320	ZK			gr				0	2		2			/1 ZK -> Roestig Z laagje 1 cm
330	LK			blgr				0	0		0			Boven 5 cm ZK -> MK
340	FG			brwi			5-16mm	0	0		0			
350	FG			brwi			5-16mm	2	0		0			Brokje Kalkconcr? Borrelet
360	FG			brwi			5-16mm	2	0		0			Houtskool, K Brokjes
370	FG			brwi			5-16mm	2	0		0			K brokjes
380	FG			lgrbr			5-16mm	2	0		0			
390	FG			lgrbr			5-16mm	2	0		0			
400	FG			lgrbr			5-16mm	2	0		0			
410	FG			lgrbr			5-16mm	2	0		0			K brokjes.
420	FG			lgrbr			5-16mm	2	0		0			Einde boring, gat valt dicht.