792 or 793? Charlemagne’s canal project: craft, nature and memory

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In autumn 793, Charlemagne visited the fossatum magnum (the ‘big ditch’ or canal) between the Rhine and Danube. Excavations, dendrochronology and a re-reading of Carolingian Annals shed new light on the chronology and setting of this canal, which was planned in 792, initiated in 793, and abandoned later that year. The abandonment is attested by both written and archaeological evidence. The different versions of the annals offer a unique opportunity for comparison with the archaeological record. Evidence that works of Vitruvius circulated in the Carolingian court suggests that Charlemagne’s advisers were drawing on classical tradition when they pitched the idea of digging the canal.

Introduction

Under AD 793 the Annales regni Francorum say that King Charles ‘in autumn-time made a journey from Regensburg with boats to the great ditch between the rivers Altmühl and Rednitz’. This fossatum magnum is the only pre-modern attempt to bridge the main European watershed except for a never realized project for a connection between the rivers

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1 Annales regni Francorum, s.a. 793, ed. F. Kurze, MGH SRG 6 (Hanover, 1895), p. 92: ‘Rex autumnali tempore de Reganesburg iter navigio faciens, usque ad fossatum magnum inter Alcmana et Radantia pervenit.’

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Moselle and Sâone in AD 55/56 (Fig. 1).\(^2\) The archaeological remains of Charlemagne’s canal are still visible between the rivers Altmühl and Rezat south of the modern town of Nuremberg (Bavaria) (Fig. 2).\(^3\) The total length of the ditch with clear proof for digging is about 3 km.\(^4\) The s-shaped canal course has been carefully surveyed in order to

\(^2\) Cf. L. Werther, L. Kröger, A. Kirchner, C. Zielhofer, E. Leitholdt, M. Schneider, S. Linzen, S. Berg-Hobohm and P. Ettel, ‘Fosata Magna – a Canal Contribution to Harbour Construction in the 1st Millennium AD’, in C. von Carnap-Bornheim, F. Daim, P. Ettel and U. Warnke (eds), *Harbours as Objects of Interdisciplinary Research. Archaeology + History + Geosciences*, RGZM Tagungen 34 (Mainz, 2018), pp. 355–72, at pp. 355, 365. See also J. Bond, ‘Canal Construction in the Early Middle Ages: An Introductory Review’, in J. Blair (ed.), *Waterways and Canal-Building in Medieval England*, Medieval History and Archaeology Series (Oxford, 2007), pp. 153–206, at pp. 158–62, 170–5.

\(^3\) S. Berg-Hobohm, L. Werther, ‘Das rezente Erscheinungsbild des Karlsgrabens’, in P. Ettel, F. Daim, S. Berg-Hobohm, C. Zielhofer, E. Leitholdt and L. Werther (eds), *Großbaustelle 793. Das Kanalprojekt Karls des Großen zwischen Rhein und Donau. Mosaiksteine. Forschungen am Römisch-Germanischen Zentralmuseum 11* (Mainz, 2014), pp. 9–12.

\(^4\) A. Kirchner, C. Zielhofer, L. Werther, M. Schneider, S. Linzen, D. Wilken, T. Wunderlich, W. Rabbel, C. Meyer, J. Schmidt, B. Schneider, S. Berg-Hobohm and P. Ettel, ‘A Multidisciplinary Approach in Wetland Geoarchaeology. Survey of the Missing Southern Canal Connection of the Fossa Carolina (SW Germany)’, *Quaternary International* 473 (2017), https://doi.org/10.1016/j.quaint.2017.12.021. S. Linzen and M. Schneider, ‘Der Karlsgraben im Fokus der Geophysik’, in Ettel *et al.* (eds), *Großbaustelle 793*, pp. 29–32.
minimize earthmoving. The altitude difference between the Altmühl River and the watershed lies at c. 13 m and drillings indicate that the canal was constructed as a stepped chain of ponds with a summit level. Therefore, it is a connection canal with an advanced hydrological concept. The banks of the navigable fairway, which had a clear diameter of c. 5.2–5.6 m, were stabilized by wooden timbering which had been hammered down into the sandy subsurface. Classical inspiration may have been behind the idea that to use this kind of watertight revetment was feasible.

Despite comparatively detailed information in the Carolingian Annals as well as a lot of (geo-)archaeological work, fundamental questions such

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5 J. Schmidt, L. Werther and C. Zielhofer, ‘Shaping Pre-modern Digital Terrain Models. The Former Topography at Charlemagne’s Canal Construction Site’, *PloS One* (2018), https://doi.org/10.1371/journal.pone.0001677, pp. 17–18.
6 Werther et al., ‘Fossata Magna’, p. 365. C. Zielhofer, E. Leitholdt, L. Werther, A. Stele, J. Bussmann, M. Schneider, S. Linzen, C. Meyer, S. Berg-Hobohm and P. Ettel, ‘Charlemagne’s Summit Canal: An Early Medieval Hydro-engineering Project for Passing the Central European Watershed’, *PloS One* 9.9 (2014), https://doi.org/10.1371/journal.pone.0108194
7 Werther et al., ‘Fossata Magna’, pp. 358, 363–5.
8 Werther et al., ‘Fossata Magna’, pp. 364–5. L. Werther, ‘Großbaustelle Karlsgraben: Eine Chaîne opératoire für den Umgang mit der Ressource Holz in der Karolingerzeit’, *Mitt. der Deutschen Gesellschaft für Archäologie des Mittelalters und der Neuzeit* 29 (2016), pp. 103–12. L. Werther, S. Berg, P. Ettel, S. Linzen, J. Schmidt and C. Zielhofer, ‘Fossa Carolina / Karlsgraben’, in *Historisches Lexikon Bayerns*, published 26.06.2019, http://www.historisches-lexikon-bayerns.de/Lexikon/Fossa_Carolina_/Karlsgraben
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as the chronology and the setting of the canal are still in discussion.9 Archaeological excavations in 2013 and 2016 have shed new light on Charlemagne’s canal. They also allow for a re-reading of different versions of the Carolingian Annals.10 On the basis of the new archaeological data and selected historiographical sources, several key questions will be discussed in this paper. First, where did the idea come from? Second, when did work start at the construction site and when did Charlemagne give the order to build the canal? Third, when did work stop? Fourth, how do different versions of the Carolingian Annals remember and describe the canal construction?

First, the idea. One of Britain’s best-known pro-Brexit politicians, Michael Gove, infamously said, ‘People in this country have had enough of experts.’11 Charlemagne (reigned 768–814), by contrast, appreciated his experts, the men with expertise, or craft. According to a slightly later and revised version of the Annals,

He had been persuaded by certain men who professed themselves expert in the matter (qui id sibi compertum esse dicebant), that if a channel capable of carrying ships were to be constructed between the rivers Rednitz and Altmühl, it would be possible, quite conveniently (percommode), to navigate between the Danube and the Rhine.12

Charlemagne gave them the chance to apply and demonstrate their expertise in hydraulic engineering. These experts knew about the European Watershed or Continental Drainage Divide, and they had

9 The best starting points for historical research on the canal are now A.T. Hack, ‘Der Bau des Karlsgrabens nach den Schriftquellen’, in P. Ettel et al. (eds), Groβbaustelle 793, pp. 53–62, and J. Nelson, ‘Charlemagne’s fossatum magnum: Another Look’, in D. Moreau and R. Gonzalez Salinero (eds), Academica Libertas: Essais en l’honneur du professeur Javier Arce – Essais en honor del profesor Javier Arce (Turnhout, 2020), pp. 315–26. The most important and comprehensive early work is F. Beck, Der Karlsgraben: eine historische, topographische und kritische Abhandlung (Nürnberg, 1911).
10 For the results of the excavation in 2013 cf. P. Ettel et al. (eds), Groβbaustelle 793 and L. Werther, C. Zidhofer, F. Herzig, E. Leitholdt, M. Schneider, S. Linzen, S. Berg-Hobohm, P. Ettel, A. Kirchner and S. Dunkel, ‘Häfen verbinden. Neue Befunde zu Verlauf, wasserbaulichem Konzept und Verlandung des Karlsgrabens’, in T. Schmidts and M. Vužetić (eds), Häfen im 1. Millennium AD. Bauliche Konzepte, herrschaftliche und religiöse Einflüsse, RGZM Tagungen 22 (Mainz, 2015), pp. 151–85. The earlier archaeological research is summed up in R. Koch and G. Leininger (eds), Der Karlsgraben – Ergebnisse neuer Erkundungen. Bau intern. Special Issue Fossa Carolina (Munich, 1993) and R. Koch, ‘Fossa Carolina. Neue Erkenntnisse zum Schifffahrtskanal Karls des Großen’, in K. Elmshäuser and D. Ellmers (eds), Häfen, Schiffe, Wasserwege. Zur Schiffahrt des Mittelalters, Schriften des Deutschen Schiffahrtsmuseums 58 (Hamburg, 2002), pp. 54–70.
11 Michael Gove, quoted Financial Times, 3 June 2016.
12 Annales qui dicuntur Einhardi, s.a. 793, ed. F. Kurze, MGH SRG 6 (Hanover, 1895), p. 93. English translation P.D. King, Charlemagne. Translated Sources (Lambrigg, 1987), p. 125.
understood the location’s unique potential for linking Bavaria with Franconia by means of a *fossatum magnum* – a great ditch, or great canal. The project, as is made clear below, began late in 792 and continued until the late autumn/early winter of 793, when the site was abandoned.\(^{13}\)

A near-contemporary source, the reviser of the *Annales regni Francorum*, in his annal for 793 explained both the project and its failure:

because of the continuous rain and the boggy ground which was completely water-logged, and given the excessive wetness the work naturally (*naturaliter*) could not hold firm and as much of the earth as was excavated by the diggers during the day slid back again into the soil during the night.\(^{14}\)

Nature beat the experts. The word *naturaliter* was unusual in contemporary Latin. The annal-writer (and other contemporary writers of cognate annals) never raised the question of divine punishment or suggested that human error or incompetence explained the failure. A rational explanation was available: it was encapsulated in the word *naturaliter*.

Other words in another context complemented the ‘natural’ explanation. That other context was the *Libri Carolini* of Theodulf of Orléans. His understanding of Scripture was typological: he compared and contrasted the two parts of the biblical canon – a series of Old Testament events with New Testament events, *nova antiquitas* with *antiqua novitas*. He also proceeded *rationabiliter*. He alluded to St Paul’s text, *Omnia autem probate* (‘But test everything’, I Thessalonians V.21); he also cited St John, *Probate spiritus si ex Deo sint* (‘Test whether the spirits are [or are not] from God’, I John IV.1). Theodulf memorized, questioned and tested. His was, in his own way, an exemplar of an age of reason – of Carolingian rationalism.\(^{15}\)

The hydraulic engineers, who were Theodulf’s contemporaries, used the memory of the classical past to apply the methods of Vitruvius (1st century BC). The earliest manuscript of Vitruvius’ *De architectura* (British Library, Harley 2767) was arguably produced in the late eighth century and held in Charlemagne’s library. It was known to Alcuin,

\(^{13}\) For further discussion of the context in which digging the canal began, with emphasis on famine and the need to move food supplies as fast as possible, and on the wider frame of political unrest, see Nelson, ‘Charlemagne’s *fossatum magnum*. Another Look’, pp. 318–21.

\(^{14}\) *Annales qui dicuntur Einhardi*, s.a. 793, pp. 93–5.

\(^{15}\) H. Liebeschütz, ‘Wesen und Grenzen des karolingischen Rationalismus’, in *Archiv für Kulturgeschichte* 33 (1950), pp. 17–45; cf. J. Nelson, ‘Why “Das karolingische Imperium” Still Needs to be Read’, in A. Schwarz and K. Kaska (eds), *Urkunden – Schriften – Lebensordnungen* (Vienna, 2015), pp. 113–22.
and also to Einhard (840). A copy of the work was also at the court. It is possible to compare parts of Vitruvius’ writings with the archaeological excavations at the site of the fossatum magnum, and finally to connect remembered classical engineering with the approach of Charlemagne and his contemporaries.

Two of Vitruvius’s ten books are especially relevant to the present enquiry: Book VIII on water supply and Book V on public buildings. The two passages that follow specifically concern the construction of harbours and shipyards.

Deinde tunc in eo loco, qui definitus erit, arcae stipitibus robusteis et catenis inclusae in aquam demittendae destinandae firmiter; deinde inter ea ex trastilis inferior pars sub aqua exaequanda et purganda [. . .] Sin autem propter fluctus [. . .] tunc ab ipsa terrae sive crepidine pulvinus quam firmissime struatur [. . .] isque pulvinus exaequata struatur planitia [. . .]

In the place marked out, cofferdams formed of oak piles and tied together with chains are to be let down into the water and firmly fixed. Next, the lower part between them under the water is to be levelled and cleared with a platform of small beams laid across [. . .] But if on account of the waves [. . .] the supports cannot uphold the dams then a platform is to be laid as firmly as possible [. . .] with a level top [. . .]

In quibus autem locis pulvis non nascitur, his rationibus erit faciendum uti arcae duplices relatis tabulis et catenis conligatae in eo loco, qui finitus erit, constituantur, et inter destinas creta in eronibus ex ulva palustri factis calcetur. Cum ita bene calcatum et quam densissime fuerit, tunc cocleis rotis tympanis conlocatis locus qui ea septione finitus fuerit, exinaniatur succeturque, et ibi inter septiones fundamenta fodiuntur.

16 Alcuin, Epistolae, no. 308, ed. E. Dümmler, MGH Epp. 4 (Berlin, 1895), p. 472, n. 3; Einhard, Epistolae, no. 57, ed. K. Hampe, MGH Epp. 5 (Berlin, 1899), p. 138, n. 3.
17 D. Bullough, ‘Charlemagne’s Court Library’, ed. D. Ganz, Early Medieval Europe 12.4 (2003), pp. 339–64, at p. 359, suggested that the manuscript was in the Aachen library but did not suggest exactly when.
18 All references will be to the following edition: Vitruvius: On Architecture, ed. and trans. F. Granger, 2 vols, Leob Classical Library (London and Cambridge, MA, 1931 and 1934). Here V.12 ‘On Harbours and Shipyards’, section 3, pp. 312–13.
But where such earth is not to be found, for the following reasons this must be done, namely that double cofferdams bound together with planks and chains are to be put in the place marked out. Between the supports, clay in hampers made of rushes is to be pressed down. When well pressed down and as closely as possible, the places marked by the enclosure is to be emptied with waterscrews and waterwheels with drums and so dried. Here the foundations are to be dug.19

Recent excavations have been photographed, and can now be compared with these passages from Vitruvius. To the present authors, the connections of the text with the material remains are evident. The efforts of archaeologists in the field along with the textual historian’s salvaging of key passages of the De architectura present a convincing example of interdisciplinary collaboration. Craft, nature, memory: may interdisciplinarity flourish in temporibus nostris!

The Frankish sources

Let us now examine the Frankish sources to see how the experts’ idea was put into action. The narrative sources that touch upon the canal project are the Annales regni Francorum and the slightly later revised version of these Annales, often cited as the Annales qui dicuntur Einhardi since it was at one time believed that they were written by Einhard, Charlemagne’s biographer. In addition there are the Annales Laureshamenses, the Annales Guelferbytani (also known as the ‘Wolfenbüttel Annals’) and the Annales Mosellani. These last three works are often termed ‘the minor annals’. Finally come the Annales Alamannici. We will look in order at these sources to see what they have to say about the canal project.

The re-reading of selected versions of the ‘notoriously complicated’ Carolingian Annals in this paper particularly relies upon the recent contributions of Achim Hack and Jinty Nelson on the fossatum magnum, which have identified the most important and more or less contemporary sources.20 The relevant part of the original version of the Annales regni Francorum for the years 792 and 793 was ‘written in the 790s contemporary to the events they describe, perhaps even being

19 Vitruvius, On Architecture, V.12 ‘On Harbours and Shipyards’, section 5, pp. 314–15.

20 R. McKitterick, Perceptions of the Past in the Early Middle Ages. The Conway Lectures in Medieval Studies (Notre Dame, 2006), p. 65 states that ‘The manuscript tradition of all these annal texts is also notoriously complicated.’ Cf. Hack, ‘Der Bau des Karlsgrabens’; Nelson, ‘Charlemagne’s fossatum magnum’.
composed at the end of each particular year.²¹ According to Achim Hack, when the entry for 793 was written, therefore, the outcome of the attempt to build the canal was perhaps not yet foreseeable.²² Under the year 793 the Annales regni Francorum say:

The king in autumn-time made a journey from Regensburg with boats to the great ditch between the rivers Altmühl and Rednitz, and there papal envoys were presented [to him] with large gifts. There a messenger reported that the Saxons had again broken their faith. Thence via the Rednitz he reached the Main by a boat journey, and celebrated Christmas at St Kilian at Würzburg.²³

The Annales qui dicuntur Einhardi or revised version of the Royal Frankish Annals were written roughly one generation after the events, most likely in the first years after the death of Charlemagne.²⁴ Their description of the canal construction, briefly cited above, is worth quoting in full, this time bearing in mind the chronology as well as the fact that the failure of the project was put down to nature rather than human error:

And when [the king] had been persuaded by certain men who claimed to be expert in this matter, that if ditches capable of carrying boats were to be dug out between the rivers Rednitz and Altmühl, it would be possible to navigate very readily between the Danube and the Rhine since one of those rivers flowed into the

²¹ Hack, ‘Der Bau des Karlsgrabens’, p. 58. Cf. R. McKitterick, History and Memory in the Carolingian World (Cambridge, 2004), pp. 101–19. R. McKitterick, Charlemagne. The Formation of a European Identity (Cambridge, 2008), pp. 31–43. S. Kaschke, ‘Annales regni Francorum’, in R.G. Dunphy (ed.), The Encyclopedia of the Medieval Chronicle (Leiden and Boston, 2010), p. 81.

²² Hack, ‘Der Bau des Karlsgrabens’, p. 58: ‘Wahrscheinlich war es jedoch noch nicht abzusehen, ob man das Unternehmen im neuen Jahr fortführen würde oder ob es – wie dann tatsächlich geschehen – endgültig aufgegeben werden müsste.’

²³ Annales regni Francorum, s.a. 793, pp. 92–4: ‘Rex autumnali tempore de Reganesburg iter navigio faciens, usque ad fossatum magnum inter Alcmana et Radantia pervenit, ibique missi apostolici cum magnis muneribus praesentati sunt. Ibi missus nuntiavit, Saxones iterum fidem suam fefeliisse. Inde per Radantiam in Mohin navale iter peragens, natalem Domini celebivit ad sanctum Chilianum in Wirzin burg’. Translation after J. Nelson, ‘Evidence in Question: Dendrochronology and Early Medieval Historians’, in O. Kano and J.-L. Lemâitre (eds), Entre texte et histoire: études d’histoire médiévale offertes au professeur Shoichi Sato (Paris, 2015), pp. 227–49, at p. 221.

²⁴ Hack, ‘Der Bau des Karlsgrabens’, pp. 54–5. See also Nelson. ‘Evidence in Question’, p. 222 and the more general discussion of R. Collins, ‘The “Reviser” Revisited: Another Look at the Alternative Version of the Annales Regni Francorum’, in A.C. Murray (ed.), After Rome’s Fall. Narrators and Sources of Early Medieval History (Toronto and London, 1998), pp. 191–213. Cf. S. Kaschke, ‘Annales qui dicuntur Einhardi’, in Dunphy (ed.), The Encyclopedia of the Medieval Chronicle, p. 64.
Danube and the other into the Main, he came without delay to this place, and his whole court with him, and after he had gathered a great multitude of men, spent the entire autumn on this project. Thus a ditch was dug between the afore-mentioned rivers which was 2,000 paces [i.e. some 10,000 ft] in length and 300 ft wide. But in vain. For because of the continual rain and the bogginess of the land which was in the nature of things completely waterlogged, the work that was being done could not hold firm, given the excessive wetness, and as much of the earth as was excavated by the diggers during the day slid back again and sank into the soil during the night [. . .] He returned to Francia and celebrated Christmas at St Killian on the banks of the river Main, but he spent Easter at Frankfurt on the same river, where he had also wintered.\textsuperscript{25}

The relevant sections of the \textit{Annales Laureshamenses}, \textit{Annales Guelferbytani} and \textit{Annales Mosellani} are ‘as (nearly) contemporary as the “original” \textit{Annales regni Francorum} and present independent accounts’.\textsuperscript{26} The earlier part of the \textit{Annales Laureshamenses} up until 785 was most likely written in Lorsch, but for the following years and especially 792 and 793 ‘nothing [. . .] demonstrates any Lorsch connection’.\textsuperscript{27} Under the year 793 the \textit{Annales Laureshamenses} have:

And the lord king, after spending Easter at Regensburg, in the summer had wanted to get to Francia by boat, and had given orders that a certain canal should be made between two rivers, namely the Altmühl and the Rednitz, and had stayed at that place for a long time [. . .]

\textsuperscript{25} \textit{Annales qui dicuntur Einhardi}, s.a. 793, pp. 93–5: ‘Et cum ei persuasum esset a quibusdam, qui id sibi compertum esse dicebant, quod si inter Radantiam et Alomonam fluvios eiusmodi fossa duceretur, quae esset navium capax, posse percommode a Danubio in Rhenum navigari, quia horum fluviorum alter Danubio, alter Moeno miscetur, confestim cum omni comitatu suo ad locum venit, ac magna hominum multitudine congregata, totum autumni tempus in eo opere consumpsit. Ducta est itaque fossa inter praedictos fluvios duum milium passuum longitudine, latitudine trecentorum pedum; sed in cassum. Nam propter iuges pluvias et terram, quae palustris erat, nimi humore naturaliter infectam, opus quod tenuit consistere non potuit; sed quantum interdum terrae a fossoribus fuerat egustum, tantum noctibus, humo iterum in locum suum relabente, subsidebat [. . .] in Franciam reversus est, celebravitque natalem Domini apud sanctum Chilianum iuxta Moenum fluvium, pascha vero super eundem fluvium in villa Franconovurd, in qua et hiemaverat.’ Translation after Nelson, ‘Evidence in Question’, p. 222.

\textsuperscript{26} Nelson, ‘Evidence in Question’, p. 223.

\textsuperscript{27} R. Collins, ‘Charlemagne’s Imperial Coronation and the Annals of Lorsch’, in J. Story (ed.), \textit{Charlemagne. Empire and Society} (Manchester, 2005), pp. 52–70, at p. 57. See also R. Pokorny, ‘Die Annales Laureshamenses in einer neu aufgefundenen Teilüberlieferung’, \textit{Deutsches Archiv für Erforschung des Mittelalters} 69.1 (2013), pp. 1–44, at p. 9. Cf. Kaschke, ‘Annales Laureshamenses’, pp. 69–70.
But the king, with Christ’s help, came from that place to Francia and reached Frankfurt by boat, and stayed there for the winter.  

For the *Annales Guelferbytani*, Ildar Garipzanov suggests a connection to Regensburg and therefore they offer ‘local information’. Their entry for 793 states:

Charles stayed at Regensburg and from there sent out his special troops to where it was necessary; and moving out from there he came by boat into the Sualafeld to the great ditch; and as winter was starting, he came to Frankfurt with those boats, both dragged overland and also travelling by the rivers, and there he stayed.

The *Annales Mosellani* under 793 explain:

[In 793 the king] resided there [at Regensburg] for almost the whole year, except that in about autumn-time he moved to a certain canal which he had begun to construct between the river Danube and the river Rednitz, and there he pressed on in determined fashion with the project above-mentioned, and he remained there for almost the whole of the remaining part of that year, except that a few days before Christmas he went to St Kilian [Wurzburg] leaving the above-mentioned project unfinished, and there he celebrated Christmas and the end of that year and the beginning of the next.

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28 *Annales Laureshamenses*, s.a. 793, ed. G.H. Pertz, *MGH SRG* 1 (Hanover, 1826), p. 35: ‘Et domnus rex cum apud Reganesburg iterum, celebrassat pascha, et in estivo tempore voluisset cum navibus venire in Franciam, et ali quem fossatum iussisset facere inter duo flumina, id est inter Alcmona et Ratanza, et ibi multum demorasset [. . .] Rex tamen, Christo adiuvante, de eodem loco navigio pervenit ad Franconofurt, et ibi ipsum hiemem resedit.’ Translation after Nelson, *Evidence in Question*, p. 222.

29 I.H. Garipzanov, ‘*Annales Guelferbytani*: Changing Perspectives of a Local Narrative’, in R. Corradini and M. Diesenberger (eds), *Zwischen Niederschrift und Wiederschrift. Hagiographie und Historiographie im Spannungsfeld von Kompendienüberlieferung und Editionstechnik*, Denkschriften, Österreichische Akademie der Wissenschaften, Philosophisch-Historische Klasse 405 (Vienna, 2010), pp. 123–38. An example of such local information is the unique mention of the Sualafeld, see Nelson, ‘Evidence in Question’, p. 224.

30 *Annales Guelferbytani*, s.a. 793, ed. W. Lendi, ‘Untersuchungen zur frühalemannischen Annalistik. Die Murbacher Annalen’, *Scrinium Friburgense* 1 (Freiburg, 1971), p. 169: ‘karolus rex resedit reganespuruc. inde transmisit scara sua ubi necesse fuit. post hec egrediens navigio pervenit in sualafeld ad fossatum magnum. hieme inchoante cum illis navibus et per terram tractis et per flumina venit ad franchonofurt et ibi hiemavit.’ Translation after Nelson, ‘Evidence in Question’, p. 223. See also J.R. Davis, *Charlemagne’s Practice of Empire* (Cambridge, 2017 edn).

31 *Annales Mosellani*, s.a. 793, ed. J. M. Lappenber, *MGH SS* 16 (Hanover, 1859), p. 498: ‘Hoc anno idem Karlus rex in praefata urbe nativitatem Domini celebrate totum pene sequente anno ibidem resedit, except quo circa tempus automni ad quondam aquaeductum quem inter Danuvium fluvium et Radantium alveum facere caeperat, secessit ibique praefato opera sedulus insistens, partem huius anni que supererat pene perstetit; praeter quo paucis diebus ante natale Domini ad Sanctum Kilianum praefatum opus imperfectum derelinquens adventit ibique eandem natalem Domini cum fine huius anni et initio alterius celebravit.’ Translation after Nelson, ‘Evidence in Question’, p. 223.
The relevant section of the *Annales Alamannici* up until 799 offers, according to Walter Lendi, individual and reliable information. It was written in Murbach and seems to be more or less contemporary, too. In the 792 entry, the *Annales Alamannici* state:

King Charles was in Regensburg. The Saxons and the Frisian broke faith. And Pippin was tonsured and those of the Francs, who had advised wickedness against King Charles, were tortured and hanged. And he gave order to build a canal.

Under 793 they say:

Wilhelm fought with the Saracens at Narbonne and lost many men there and he killed a king of theirs together with many Saracens. And Bishop Gerhoh was granted the monastery of Murbach.

In his important discussion of the construction of the Fossa Carolina in the light of written sources, Achim Hack comes to the conclusion ‘that the description in the two main sources, the Royal Frankish Annals and the so-called Annals of Einhard, is not to be doubted. [. . .] Only the Wolfenbüttel Annals provide noteworthy addenda as regards content: all other sources could be ignored for the reconstruction of the events’. Furthermore, Hack postulates that the entry in the *Annales Alamannici* is ‘by mistake dated to 792’, which he explains with chronological confusion and false correlation of dates and events. Nevertheless, the new archaeological data, which was not yet available to Achim Hack when he came to this conclusion in 2014, points to the fact that some of the minor Annals also contain noteworthy

32 W. Lendi (ed.), ‘Untersuchungen zur frühalemannischen Annalistik. Die Murbacher Annalen. Mit Edition’, *Scrinium Friburgense* 1 (Freiburg, 1971), pp. 125–6. Cf. Kaschke, ‘Annales Alamannici’, p. 53. A new edition of the *Annales Alamannici* has just been published by Roland Zingg, who also confirmed the more or less contemporary entries up to 799 (personal communication). Cf. *Die St. Galler Annalistik*, ed. and trans. by R. Zingg (Ostfildern, 2019), pp. 42–85.

33 *Annales Alamannici*, s.a. 792–3, ed. W. Lendi, ‘Untersuchungen zur frühalemannischen Annalistik. Die Murbacher Annalen’, *Scrinium Friburgense* 1 (Freiburg, 1971), pp. 166–7: ‘792 rex karolus regenesbure. saxones et frisones mentiti sunt. et pipinus comam capitis deposuit et quosdam de francis occisi et suspensi propter consilium pessimum quod fecerunt super karolum regem. et fossatum iussit facere.’ ‘793 vuillihelmus pugnavit cum saracenos ad narbona et perdidit ibi multos homines et occidit unum regem ex ipsis cum multitudine saracenorum. et gerho episcopo muarbach monasterium datum est.’ Parts of the translation after King, *Charlemagne. Translated Sources*, p. 158.

34 Hack, ‘Der Bau des Karlsgrabens’, p. 62: ‘an den Darstellungen der beiden Hauptquellen, den Fränkischen Reichsannalen sowie den sogenannten Einhardsannalen, [ist] nicht zu zweifeln [. . .] Bemerkenswerte sachliche Ergänzungen bringen nur die Wolfenbütteler Annalen, alle anderen Quellen sind für die Rekonstruktion der Ereignisse vernachlässigbar.’
information – and the description under 792 in the *Annales Alamannici* might not be a mistake.

The most important archaeological data concerning chronological questions comes from a large group of timber and wood waste. More than eighty early medieval oak samples from three different archaeological trenches have been dated by dendrochronology and offer a reliable base for chronological analysis. Thirty-nine of these samples are large timbers which formed part of the bank revetments of the canal, or belong to a group of ready-to-use timbers, which were deposited horizontally on the base of the ditch. Forty-three samples are chips and small pieces of wood waste (Fig. 3).

Some characteristics of dendrochronological dating and tree growth are crucial for interpreting these timbers: every year, a tree builds a new tree-ring. Growth starts in spring with the vegetation period (*circa* April) and ends in autumn (*circa* September), so tree-rings get wider and wider week by week during this period. When a tree is cut down, growing ends and the appearance of the terminal tree-ring before felling allows one to determine the season of felling. Therefore, when the terminal tree-ring is preserved, in many cases not only the year but also the season of woodworking can be determined precisely. Furthermore, tool marks and the condition of the wood surface as well as the state of decay and fungal attack indicate whether the timber was stored for a longer or shorter time before it was deposited in anaerobic conditions, which stops further decay.

35 Werther *et al*., ‘Häfen verbinden’, pp. 165–73, and Werther, ‘Grossbaustelle Karlsgraben’. For the excavation of 2016 cf. Werther *et al*., ‘Fossa Carolina’, L. Werther, ‘Karlsgraben doch schiffbar? Aktuelles aus der Landesarchäologie’, *Archäologie in Deutschland* 5 (2017), pp. 41–2, and S. Linzen, M. Schneider, S. Berg-Hobohm, L. Werther, P. Ettel, C. Zielhofer, J. Schmidt, J. Fassbinder, D. Wilken, A. Fediuk, S. Dunkel, R. Stolz, H.-G. Meyer and C.S. Sommer, ‘From Magnetic SQUID Prospection to Excavation – Investigations at Fossa Carolina, Germany’, in B. Jennings, C. Gaffney, T. Sparrow and S. Gaffney (eds), *AP2017: 12th International Conference of Archaeological Prospection. 12th–16th September 2017, University of Bradford* (Oxford, 2017), pp. 144–5.

36 The dendrochronological results of the timber that was excavated in 2013 are published in Werther *et al*., ‘Häfen verbinden’, pp. 169–76 and Werther, ‘Grossbaustelle Karlsgraben’. The dendrochronological results of the timber that was excavated in 2016 are not yet published. First results have been compiled for this paper.

37 See F.H. Schweingruber, *Tree Rings. Basics and Applications of Dendrochronology* (Dordrecht and Lancaster, 1988), p. 145; K. Haneca, K. Čufar and H. Behreckm, ‘Oaks, Tree-rings and Wooden Cultural Heritage: A Review of the Main Characteristics and Applications of Oak Dendrochronology in Europe’, *Journal of Archaeological Science* 36.1 (2009), pp. 1–11, at p. 4, DOI: 10.1016/j.jas.2008.07.005, and D. Eckstein, ‘Human Time in Tree Rings’, *Dendrochronologia* 24.2–3 (2007), pp. 53–60, at p. 55–60, DOI: 10.1016/j.dendro.2006.10.001

38 Cf. K.G. St. Cartwright and W.P.K. Findlay, *Decay of Timber and its Prevention* (London, 1958); Schweingruber, *Tree Rings*, pp. 146–8.
Forty-three of the wood samples – among them thirty large timbers – had the terminal tree-ring preserved (Fig. 4). The following discussion is based only on the thirty timbers with a terminal tree-ring, because the smaller wood waste is mainly cut off from these timbers and where the terminal tree-ring is missing samples cannot be precisely dated.

Fig. 3 Excavation of the canal in 2016, wooden revetments and wood waste. 1: Bank revetments. Scale bar: 1 metre. 2: Prepared wood for bank revetments, wood waste and a wattle mat. 3: Wood chips. Scale bars with centimeter subdivision. (Images: L. Werther, 2016). [Colour figure can be viewed at wileyonlinelibrary.com]
When did work start at the construction site and when did Charlemagne give the order to build the canal?

The different versions of the Annals (see above) offer varying details on the question of when work started at the construction site and when Charlemagne gave the order to build the canal.

The *Annales regni Francorum* do not specify what happened, before the king came to the fossatum in autumn 793.\(^{39}\) The *Annales Guelferbytani* do not provide any chronological information except of the year 793 and the fact that the king left the construction site when winter was starting.\(^{40}\) In contrast, all the other versions offer additional details and point to things that happened earlier. The revised version of the *Annales regni Francorum* specifies that before the king arrived in autumn 793, he had been persuaded by certain men who claimed to be experts, but specific dates when this happened are not given.\(^{41}\) The *Annales Mosellani* say that before the king travelled to the canal in autumn 793, he had already begun to construct it: ‘aquaeductum [. . .] facere caeperat’.\(^{42}\) The *Annales Laureshamensis* say, in a similar way, that in summer 793 the king had already given orders to build the canal, before he went to the site: ‘fossatum iussisset facere’.\(^{43}\) The *Annales Alamannici* have almost the same information – ‘fossatum iussit facere’ – but for the year 792, and with the additional small but

\(^{39}\) *Annales regni Francorum*, s.a. 793, pp. 92–4.
\(^{40}\) *Annales Guelferbytani*, s.a. 793, p. 169.
\(^{41}\) *Annales qui dicuntur Einhardi*, s.a. 793, pp. 93–5.
\(^{42}\) *Annales Mosellani*, s.a. 793, p. 498.
\(^{43}\) *Annales Laureshamenses*, s.a. 793, p. 35.
The crucial grammatical difference that the verb *iussere* is used in another tense than in the *Annales Laureshamensis*.\(^{44}\)

Considering these different perceptions of the events in 792 and 793, there are clear hints that something happened before the king arrived in autumn 793.\(^{45}\) The crucial question is whether the *Annales Alamannici* can be believed in dating the order to build the canal to 792. The dendrochronological dating of the timber used for the canal’s construction helps to answer this question. All thirty timbers with preserved terminal tree-rings have been dated either to the year 792 or to the year 793 (Fig. 5). All the timber excavated in 2013 in trench 1 dates exclusively to late summer/autumn 793.\(^{46}\) The terminal tree-rings end with the late wood and the end of deposition is imminent. Signs of storage, such as fungal attack, have not been observed, and the timber must have been hammered into the ground very soon after felling (Fig 6, no. 3). Most of the timber used in trench 2, which was excavated in 2016, dates to spring 793.\(^{47}\) The associated terminal

\(^{44}\) *Annales Alamannici*, s.a. 792, p. 166.

\(^{45}\) Only the *Annales Laureshamenses* ascribe the journey – or rather the wish/decision for the journey – from Regensburg to the canal to summer 793. *Annales Laureshamenses*, s.a. 793, p. 35: ‘in estivo tempore voluisset cum navibus venire in Franciam’.

\(^{46}\) Described as ‘c. September’ in the graphs, following the expert knowledge of Franz Herzig. Cf. Schweingruber, *Tree Rings*, p. 146.

\(^{47}\) Described as ‘c. April’ in the graphs, following the expert knowledge of Franz Herzig. Cf. Schweingruber, *Tree Rings*, p. 146.

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tree-rings end with the early wood and deposition had just started. The timber which was hammered into the ground for the bank revetment exclusively dates to spring 793, and as in trench 1 there are no signs of storage (Fig 6, no. 4). Only two ready-to-use timbers which had not been driven into the ground provide earlier dates: one was cut between the growing seasons of 792 and 793, and the second one sometime in 792 without precise seasonal information. In trench 3, excavated in 2016 at the northern end of the canal very close to the river Rezat, most of the timber was cut in 792. Three samples which were cut in 792 offer no seasonal information, three were cut between the growing seasons of 792 and 793, two were cut in spring 793, and one had already been cut in spring or summer 792.

Many of the timbers which had been cut before spring 793 show clear signs of fungal attack at the surface (Fig 6, no. 2). The tree which had been cut in spring or summer 792 shows the most advanced signs of
fungal attack, which confirms a longer storage. As this sample is the only one dating so early and belongs to a thin stake and not to one of the massive piles, it has to be considered that the corresponding tree was perhaps initially cut for another purpose, without a connection to the canal.\textsuperscript{48}

To summarize, of the total sample of thirty timbers, nine had been cut before \textit{circa} April 793 and thirteen were cut around April 793. Therefore it is clear that felling started on a significant scale in the period of growth dormancy between \textit{circa} October 792 and \textit{circa} March 793. Unfortunately, it is not possible to determine when exactly in this period the trees were felled. All this timber was stored for a certain time, which is clearly documented by signs of fungal attack.

In early spring 793, felling intensified and the stored timber was used together with freshly felled timber to construct the first bank revetments. As the trees that had been cut in spring 793 do not show signs of fungal attack, they must therefore have been hammered into the ground at the base of the fairway soon after felling. Thus digging also must have started no later than early spring 793. If felling started in winter 792 to 793 and digging started in spring 793, decision-making, planning and surveying must have started significantly earlier.\textsuperscript{49}

Comparing the archaeological dating with the written sources, a very coherent overall picture emerges. In 792, the king gave the order to build the canal, as the \textit{Annales Alamannici} have it. Before he gave this order, he must have been persuaded that the construction of the canal was possible, as the revised version of the \textit{Annales regni Francorum} says. After he gave the order, surveying was done and the first timber was prepared in winter 792 to 793, as archaeology and dendrochronology suggest. In spring 793, digging started and felling intensified. As the \textit{Annales Mosellani} say, work on the site had started before autumn 793.

Furthermore, the descriptions of Charles giving the order to build the canal – dated to 792 by the \textit{Annales Alamannici} and 793 by the \textit{Annales Laureshamensis} – are not in conflict. The \textit{Annales Alamannici} describe an order that was given in 792 by using the verb \textit{iubere} in the perfect tense: \textit{iussit}.\textsuperscript{50} In contrast, the \textit{Annales Laureshamensis} describe an order that was given significantly earlier by using the past perfect: \textit{iussisset}.\textsuperscript{51} This is a very small grammatical detail, but taking

\textsuperscript{48} The spatial distribution of felling dates points to a progress of work from the northern end and the river Rezat (spring 793), towards the watershed and the canal summit (autumn 793). This topic will be discussed in a separate paper.

\textsuperscript{49} Concerning the high-level surveying of the canal cf. Schmidt, Werther and Zielhofer, \textit{Shaping Pre-modern Digital Terrain Models}, and Werther \textit{et al.}, \textit{Häfen verbinden}, p. 153.

\textsuperscript{50} \textit{Annales Alamannici}, s.a. 792, p. 166.

\textsuperscript{51} \textit{Annales Laureshamenses}, s.a. 793, p. 35.
the archaeological record into account it seems possible that this difference in tense is no accident but is instead the result of different ways of remembering and describing the event in both versions of the Annals.

Considering the strong arguments that the decision to build the canal was taken in 792, some other details in the written sources appear in a new light, too. To give an example, the original *Annales regni Francorum* say that in 792 a mobile pontoon bridge was constructed when Charles stayed in Regensburg. This is high-level military engineering and perhaps it is no coincidence that both construction schemes date to the same year and were intended to improve infrastructure and mobility along and across rivers.

When did work stop at the construction site?

As with the question of when work started, the different versions of the Annals (see above) again offer varying details as to when work stopped at the construction site. The *Annales regni Francorum* say that the king left the *fossatum* after autumn 793 and celebrated Christmas in Würzburg.52 The *Annales Laureshamensis* contain almost the same information, without giving further details.53 The *Annales Guelferbytani* state that Charles left the site as winter was starting, dragging the boats overland on his way to Frankfurt. That points to the fact that the canal was not ready to use.54 The *Annales Mosellani* are more precise and have it that a few days before Christmas the king went to Würzburg, leaving the canal unfinished, an *opus imperfectum*.55

The revised version of the *Annales Regni Francorum* have the most detailed description and specify why the canal was never more than this *opus imperfectum*. According to the reviser, the king spent the entire autumn on this project, but all the effort was in vain, *sed incassum*. Heavy rain and unstable and wet ground caused severe technical problems, and ‘what was excavated by the diggers during the day slid

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52 *Annales regni Francorum*, s.a. 793, pp. 92–4.
53 *Annales Laureshamenses*, s.a. 793, p. 35.
54 *Annales Guelferbytani*, s.a. 793, p. 169. I.H. Garipzanov, ‘Regensburg, Wandalgarius and the *novi denarii*: Charlemagne’s Monetary Reform Revisited, *Early Medieval Europe* 24 (2016), pp. 58–73, at p. 68 assumes that the ships were dragged ‘through the unfinished canal from an affluent of the Danube to a tributary of the Rhine’. That is possible, but rather unlikely considering the very limited archaeological proof for ready-to-use sections of the canal and the fact that the *Annales Guelferbytani* talk about dragging the ships *per terram* and moving on *per flumina*, which does not give any hint on using the canal.
55 *Annales Mosellani*, s.a. 793, p. 498: ‘praeter quod paucis diebus ante natale Domini ad Sanctum Kilianum praefatum opus imperfectum derelinquens advenit ibique eandem natalem Domini cum fine huius anni et initio alterius celebravit’.
back again and sank into the soil during the night’. The king left the unfinished construction and moved towards Würzburg, where he celebrated Christmas.\(^{56}\)

In contrast to the other versions of the Annals, the *Annales Alamannici* do not describe what happened in 793 at the site, but only the planning and decision-making in 792. Nevertheless, they have a very interesting detail in the entry for 793, which may have an immediate connection to the *fossatum*. In this year, the monastery of Murbach, where this section of the Annals was written, was granted to Bishop Gerhoh of Eichstätt.\(^{57}\) Eichstätt is located very close to the *fossatum*, which was in Gerhoh’s bishopric (Fig. 7). It is almost unthinkable that Gerhoh was not strongly involved in the project, but what role he may have played is a topic for a paper on its own.\(^{58}\)

Concerning the archaeological sources, the answer to the question of when the construction was halted is very clear. The youngest wood which has been excavated so far was cut in late autumn 793, immediately before the growing season ended (Fig. 6, no. 3). Not a single piece of timber was cut later and it is absolutely clear that in 794 nobody any longer worked at the site, or at least not in the sections that have hitherto been excavated. There is also no evidence for any kind of maintenance or repair, and several archaeological features point to the fact that some sections were left behind in the middle of work, with half-finished timbers and revetments (Fig. 3, no. 2). This sharp and definite terminal date does correspond with the written sources. Furthermore, the remains of this disastrous backfill, which are described vividly in the revised version of the Royal Annals, have been found in several drillings and also in trench 1, which was excavated in 2013.\(^{59}\) The status of an *opus imperfectum* is also emphasized by the fact that the connection of the canal to the river Altmühl at the southern end was most likely never realized.\(^{60}\)

\(^{56}\) *Annales qui dicuntur Einhardi, s.a. 793*, pp. 93–5. Translation after Nelson, ‘Evidence in Question’, p. 222.

\(^{57}\) *Annales Guelferbytani, s.a. 793*, pp. 125–6.

\(^{58}\) A. Wendehorst, *Das Bistum Eichstätt*, Germania sacra Neue Folge 45 (Berlin and New York, 2006), p. 33 mentions that the monastery was perhaps granted for ‘besondere Dienste’ (special services) for the king. Cf. W. Störmer, ‘Die innere Entwicklung. Staat, Gesellschaft, Kirche, Wirtschaft’, in A. Kraus (ed.), *Geschichte Franken bis zum 18. Jahrhundert*, Handbuch der bayerischen Geschichte 1 (Munich, 1997), pp. 209–330, at p. 217. S. Weinfurter (ed.), *Eichstätt im Mittelalter: Kloster – Bistum – Fürstentum* (Regensburg, 2010), pp. 33–7.

\(^{59}\) Zielhofer et al., ‘Charlemagne’s Summit Canal’; Werther et al., ‘Häfen verbinden’, pp. 158, 162–7; J. Schmidt, J. Rabiger-Völlmer, L. Werther, U. Werban, P. Dietrich, S. Berg, P. Ettel, S. Linzen, A. Stele, B. Schneider and C. Zielhofer, ‘3D-Modelling of Charlemagne’s Summit Canal (Southern Germany) – Merging Remote Sensing and Geoarchaeological Subsurface Data’, *Remote Sensing* 11.9 (2019), pp. 1–21, at p. 17, DOI: 10.3390/rs11091111

\(^{60}\) Kirchner et al., ‘A Multidisciplinary Approach’.
To sum up, the written sources as well as the archaeological record are very much in accordance with each other concerning the abandonment of the project. In the last months of 793, the site was given up and left behind as a ruin, partially buried under backfill and mud.

Concluding remarks

To conclude, there are strong arguments that the decision to build a canal to connect the Rhine and Danube was made in 792. The *Annales Alamannici* are therefore correct in dating the order to this year. Work on the construction site started long before the king arrived, and a survey of the construction site and on-site planning must have been carried out no later than winter 792 to 793. During this period, or
more precisely before April 793, the felling and preparation of timber started on a significant scale. In spring 793, digging started and this timber was placed in the trench to stabilize the banks of the fairway. In summer and autumn 793, digging, felling and woodworking ran parallel on a large scale. The abandonment of the project before Christmas 793 is not only documented in the written sources, but also in the archaeological record, which also confirms details such as the disastrous backfill.

The different versions of the Frankish Annals offer individual stories and remember different chronological and technical details of the construction, which are not in conflict with each other. Furthermore, the Royal Frankish Annals, the revised version of the Royal Annals and the Annales Guelferbytani do not tell the whole story, as Achim Hack postulated. The Annales Alamannici, the Annales Laureshamenses and Annales Mosellani contribute important and sometimes exclusive details. Therefore, the fossatum magnum offers a unique opportunity for re-reading and re-analysing different versions of the Carolingian Annals and their formation in the light of the archaeological and dendrochronological record.61

Finally, the new dating of decision-making and the onset of work at the fossatum to 792 sheds a new light on the political setting in which this decision was made. ‘In the summer of 792 [. . .] or in the winter months, probably of 792/3’, a conspiracy by his son Pippin the Hunchback against Charlemagne caused a deep crisis.62 Ildar Garipzanov suggested that this crisis ‘must have exposed a need for a faster, waterborne connection with the Frankish heartlands along the Rhine’.63 In the same year, a severe famine, which continued in 793, is reported in the Annales Mosellani.64 As one of the authors of this paper, Jinty Nelson, has argued elsewhere, this ‘series of acute harvest shocks’ and the acute need ‘to bring food-supplies as quickly as possible [. . .] from a region unaffected by famine to, in particular, famished Francia’ may have been another reason for the decision to build the canal.65

Furthermore, the Annales regni Francorum 792 entry states that a mobile pontoon bridge was being constructed at the same time that

61 Cf. Nelson, ‘Evidence in Question’.
62 Annales regni Francorum, s.a. 792, p. 90: ‘Coniuratio contra regem a filio eius Pippino facta, detecta et compressa est.’ See the discussion in Garipzanov, ‘Regensburg’, p. 70.
63 Garipzanov, ‘Regensburg’, p. 70.
64 Annales Mosellani, s.a. 792–3, p. 498. Cf. Nelson, ‘Charlemagne’s fossatum magnum’. The Annales Laureshamenses mention the famine in 793, too (see s.a. 793, p. 35).
65 Nelson, ‘Charlemagne’s fossatum magnum’.

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Charles was staying in Regensburg. The revised version of the Royal Annals says that this construction was part of preparations for a campaign against the Avars. This is high-level military engineering and perhaps it is no coincidence that both construction schemes, the canal and the pontoon bridge, were reported in the same year and were intended to improve infrastructure and mobility along and across rivers. It has often been said that one of Charlemagne’s great strengths was his logistical skill in moving men and materials over great distances. The canal project certainly underlines this. But it also shows Charlemagne’s readiness to take advice from experts and his ability to turn their ideas into concrete action.

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66 Annales regni Francorum, s.a. 792, p. 92: ‘Pons super navigia flumina transeuntia factus est, anchoris et funibus ita cohaerens, ut iungi et dissolvi possit’. Cf. Nelson, ‘Evidence in Question’, p. 227.

67 Annales qui dicuntur Einhardi, s.a. 793, p. 179: ‘Rex autem propter bellum cum Hunis suspectum in Baioaria sedens, pontem navalem, quo in Danubio ad id bellum uteretur, aedificavit.’

68 On Carolingian military engineering cf. B.S. Bachrach, ‘Carolingian Military Operations: An Introduction to Technological Perspectives’, in R.O. Bork and A. Kann (eds), The Art, Science, and Technology of Medieval Travel, AVISTA Studies in the History of Medieval Technology, Science and Art 6 (Aldershot, 2008), pp. 17–30; B.S. Bachrach, Early Carolingian Warfare. Prelude to Empire (Philadelphia, 2001).