# Research on the effects of relative sea-level change on the River Exe estuary in the mid-1st century: implications for the location of Roman sea-port and barge-quay facilities serving the Neronian fortress of *Legio II Augusta* at Exeter

Stephen J. Kaye and John Pamment Salvatore

## Preamble

I first met Paul Bidwell in April 1972 when he was leading the excavation of the newly discovered Roman military bath-house in the Cathedral Close at Exeter. As a novice excavator of the then fledgling Exeter Museums Archaeological Field Unit (EMAFU) I was assigned first to Paul's bath-house excavation and thence, shortly thereafter, to the Exeter Guildhall site directed by the late Christopher Henderson. The combined excavations (revealing respectively a military bath-house and a series of legionary cohort barracks) proved beyond doubt that Exeter had been the site of a Roman legionary fortress. Following these excavations, Paul went on to publish the very first volume of the Exeter Archaeological Reports series dealing with the legionary bath-house and its evolution into a town basilica (Bidwell 1979). Subsequently, he published the first written account of the development of Roman Exeter from fortress to town (Bidwell 1980). Although Paul left Exeter to pursue a highly successful archaeological career in the north, notably on Hadrian's Wall, at South Shields (*Arbeia*) and at Wallsend (*Segedunum*), Paul's interest in the Roman pottery of the South West remained undiminished and in the early 1990s, together with Neil Holbrook, he published *Roman Finds from Exeter* (Holbrook and Bidwell 1991). In addition to all of his many other projects, Paul has continued to work extensively on Roman military pottery supply to the legionary fortress at Exeter and its satellite sites, most recently, in 2021, publishing a number of significant contributions within the volumes produced for the *Exeter: a Place in Time Project* (Bidwell 2021).

It was a privilege therefore, nearly 50 years after my first encounter with Paul, to be asked to contribute to this Festschrift, along with my colleague Dr Stephen Kaye. In doing so, we have chosen a subject which builds upon something of Paul's work at Exeter and I am greatly indebted to Stephen Kaye for bringing his special expertise to bear in the pages below. Indeed, the greater part of the paper and the arguments which have subsequently evolved are his.

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(*Isca Dumnoniorum MMXXI*).

## Introduction

The present-day River Exe and its tidal estuary are very different in comparison to the 1st century Roman era equivalents. Two thousand years ago the River Exe, the valley it flowed through, and the estuary were still in a near-natural state. Certainly, anthropogenic changes had occurred, for example the development of farmland since the Bronze Age had increased land erosion and the consequential increase in siltation of the river system. However, the river and estuary had not yet been considerably changed by weirs, traps, leats, canals, dredging, reclamation of salt-marsh, the draining of land and the latter-day hemming in of the estuary by rail and road embankments. These man-made changes have greatly altered the more natural fluvial and tidal regimes of the 1st century.

In addition, there is one planetary scale phenomenon that has caused significant change to the River Exe and estuary: Glacial Isostatic Adjustments (GIA) following the removal of the last ice sheets from the British Isles *c.* 11,000 years ago. These on-going topographic elevation adjustments may have had a significant impact on the location of Roman military-period infrastructure, especially supply-chain elements such as sea-ports and barge-quays.[1]

This paper will attempt to unravel two millennia of such changes in order to re-create a picture of the estuary and the tidal regime of the River Exe as it might have appeared when the Roman military *agrimensores* surveyed the area in preparation for the siting of the fortress at Exeter and its contemporary ancillary civilian sites and the associated road system which connected them. Crucially, the paper attempts to demonstrate that the mid-1st century topography and the tidal regime of the period would have placed limitations on the Roman military with regard to their choice of the location for both barge-quay and sea-port facilities.

[1] For the purposes of this paper the Roman military period is taken as being the currently accepted occupation period of the Roman army in the far south-west of Britain (*c.* 55 – *c.* 85). Note however that the Second Augustan Legion is believed to have transferred from Exeter to Caerleon in *c.* 75.

## Previous work

The archaeologist C.A. Ralegh Radford postulated a Roman military port and supply base on the River Exe as early as the 1930s based on the recovery of imported pottery from the Exeter Road area of Topsham at the head of the Exe Estuary (1937: 7-11); this was before any Roman military sites in the Exeter area had been discovered. Some 50 years later, Christopher Henderson (the then director of the Archaeological Field Unit) had produced a ground plan of the Exeter legionary fortress based on the excavations of the 1970s and 1980s (Henderson 1991: 74). In order to understand how the fortress might have been supplied with the samian ware, fine wares and other imported ceramic and glassware discovered during the course of these excavations, he went on to study the question of the navigability of the River Exe before the creation of weirs blocked the channel in the 13th century. Henderson concluded that the difficulty of the passage caused by changing mud banks and the frequency of delays in times of drought or spate would have made river transport above Topsham (some 6 km south of the fortress) very unreliable; he went on to state that: 'There must therefore have been an early Roman port on the estuary to handle supplies destined for the fortress at Exeter and the forts in its hinterland' (Henderson 1988: 92). Another commentator, publishing in the same year, suggested that: 'At Exeter, it seems logical to assume that the bulk of the *prata legionum* (essentially, that territory surrounding the legionary base which was specifically required for the needs and resources of the legion) lay in the valley of the Exe, almost certainly extending as far as Topsham' (Mason 1988: 168).

The matter did not receive much further attention until the excavation in 2000 of Roman military-style defensive ditches of what was thought to be a possible Roman fort or fortlet sited on a projecting piece of land on the east bank of the River Exe at Topsham School, just north of the modern town of Topsham (Sage and Allan 2004). Subsequent excavation at the same site has made the fort interpretation less likely (Brown and Hughes 2018). Nevertheless, one of the authors of the first report (Allan) drew attention to the previous recovery, in relative significant quantities, of imported 1st-century Roman pottery from the limited scale excavations carried out in the 1930s in and around Exeter Road at Topsham (this was the material which had aroused the suspicions of Radford). In addition, Allan noted that the material from another site further to the north-west (where a Roman building complex occupied from the period *c.* 50-55 to 70-75 was discovered) contained more imports and unusual wares than contemporary groups from the fortress. He observed that such finds assemblages are a typical feature of ports; the implication being that the pottery had travelled not far from its point of arrival. Allan went on to suggest that the unloading of shipments of supplies in the Roman military period could have taken place at a site about 50 m north-west of Topsham School. Allan stated that 'a Roman settlement may have grown around a quayside upstream from the modern Topsham Quay. If so, it is possible that the old river channel, conceivably with evidence of port facilities, survives…' (Sage and Allan 2004: 17-20).

## Glacial isostatic adjustment, eustacy and relative sea-level change in the Exe estuary

The Last Glacial Period, known in the UK as the Devensian, lasted from about 27,000 to 11,300 years ago. During this time the Celtic Ice Sheet covered most of the British Isles, excluding southern England and the South West peninsula, extending southwards to the northern border of the Bristol Channel. This weight of ice bore down on the *c.* 30-35 km of semi-rigid crust which, in turn, caused the underlying, more mobile mantle to flow away from under the weighted crust. The result was that the Earth surface (both land and seabed) under the ice sheet was lowered, while the surface beyond the periphery of the ice sheet rose. The South West was part of this forebulge such that, for example, approximately 10,000 years ago the land surface was *c.* 25 m higher, relative to the present Ordnance Survey Datum (OD), than it is today. Once the Celtic Ice Sheet retreated the process reversed: the land formerly under ice rose and the forebulge began to sink. These movements are on-going with the land surface of the South West peninsula still sinking as the forebulge collapses.

Another significant variable during and after the Devensian was the eustatic sea-level which is a measure of the total mass, or volume, of the oceans. When the Celtic Ice Sheet was at its greatest extent and thickness the eustatic sea-level was *c.* 130 m OD lower than it is today. As the ice sheet melted the volume of sea-water increased which, in turn, raised the sea-level – first rapidly and then more slowly, such that for the last 10,000 years the sea-level rise has been low at *c.* 1.0 mm per year, or less. It is only in the modern era that the rise has accelerated to about 4 mm per year, largely due to thermal expansion of the oceans.

The combination of the eustatic sea-level values and GIA through time is accomplished by the study of Relative Sea Level (RSL), which is the sea-level observed, in the cases discussed here by excavation stratigraphy, with respect to the land surface. The values of RSL can change due to both eustatic sea-level change and GIA. For the British Isles there exists a database of over 2100 data points of age and elevation that records RSL changes over the last 20,000 years (Shennan 2018), and which allows a vision of how the sea-level has changed since the Roman era in the River Exe valley and estuary.

Figure 1 shows the RSL for Devon from *c.* 10,000 B.P. to the Middle Ages and displays the forebulge collapse due to the removal of the Celtic Ice Sheet. The polynomial line through the data points shows that the RSL was approximately -25 m to -20 m OD some 12,000 years ago, meaning that the land surface was that much higher than the same point is today. By the 1st century the RSL is at *c.* -2.5 m OD and the land continues to subside through the remaining time period.

In summary, the topographic surface of the River Exe valley and estuary was *c.* 2.5 m OD higher during the 1st century than it is today. The possible consequences for the fluvial and tidal regimes are considerable, with concomitant effects on the navigability of the Exe and the placement of a sea-port and/or barge-quay that might have served the fortress of *Legio II Augusta* at Exeter.

**The River Exe: historical evidence of tidal regimes**

Determining the tidal regime at any point in time is important because it is the tide that enhances the depth of rivers and provides a motive force to vessels moving upstream. In the River Exe valley and estuary these two factors, coupled to the natural topography of the river bed, places limits on how goods were moved upstream, for example by sea-vessels with deep draughts, or by flat-bottomed barges. This section will provide a generalised description of the Exe and also note historical references, or inferences, of the tidal regime.

From the Bronze Age through to the present-day the River Exe (which may have been split into a number of main channels in the early period) has migrated west to east across the floodplain (Bennett *et al.* 2014). There are no historical records of changes to, or the use of, the lower River Exe during the Roman period. However, a single legion arriving at Exeter, in excess of 5000 legionaries and accompanied by significant numbers of pack animals, might have required in the region of 110,000 litres of water per day during the summer months which would have necessitated a flow rate of about 0.0012 cubic metres per second (cumecs) from a nearby source.[2] Prior to the construction of the legionary fortress and its aqueduct, only the River Exe with a calculated, natural flow of *c.* 1.95 cumecs could

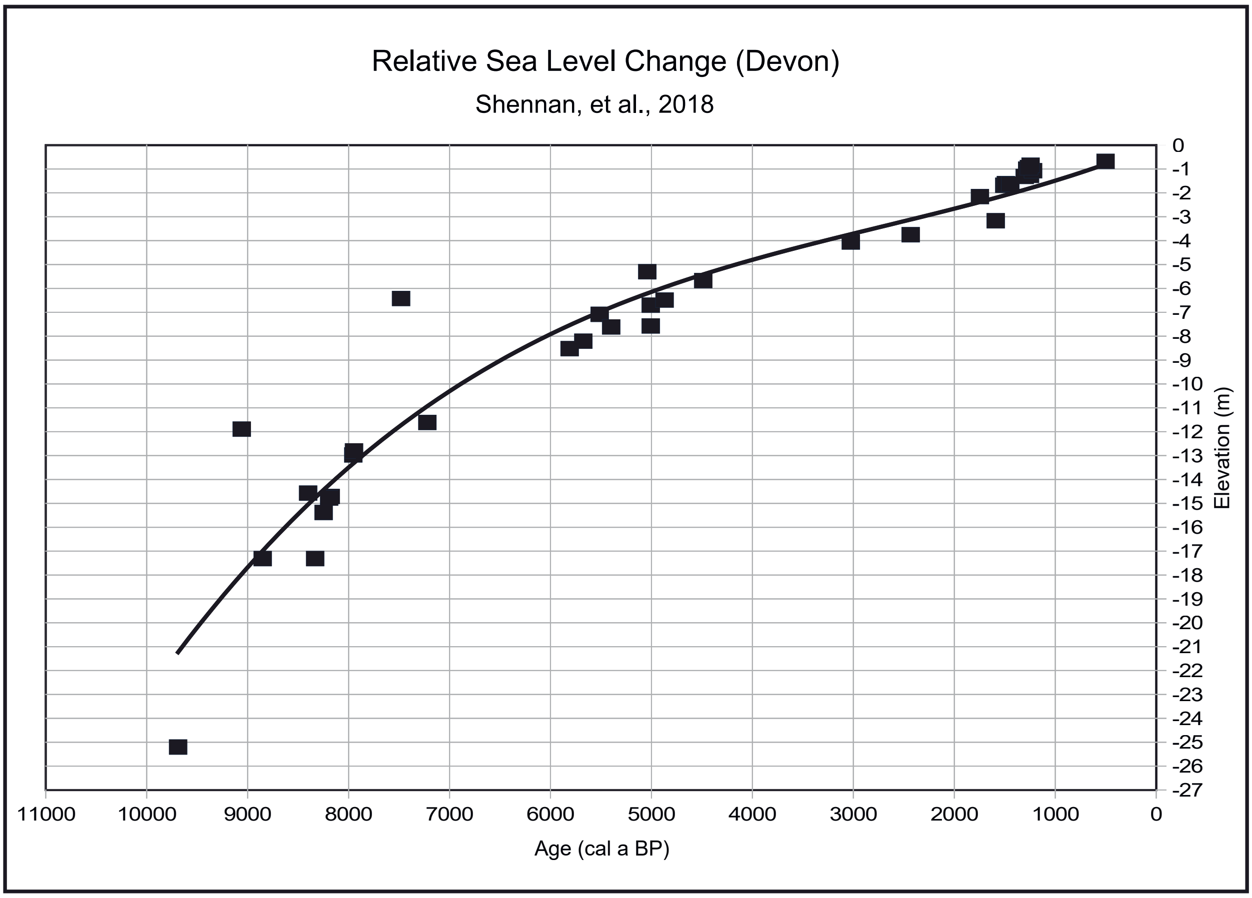


*Figure 1. Age – elevation plot for the South-West (Devon) of sea-level index points taken from Shennan* et al. *2018.*

[2] Roth (1991) suggests that the number of men in a legion should be increased by up to 25% to allow for non-combatants. He also estimated about 900 mules and 400 oxen for a full-strength legion.

have guaranteed such quantities.[3] Furthermore, the need to cross the River Exe upstream of muddy, daily twice-tidal banks might also have been an important consideration in placing the fortress. Therefore, it is reasonable to conclude that the Exeter fortress was probably situated upstream of the then tidal limit.

Following the Roman era there are no known, clear references to the tidal regime until the end of the reign of Edward I (1272-1307) as found in a letter written in 1838 (Delagarde 1840), who made use of John Hooker's (or Hoker, also known as Vowell, 1526?–1601) writings on the 'Haven of Exeter' from a set of manuscripts in the possession of the Corporation of Exeter. Delagarde reports:

> The river Exe is naturally only navigable for large vessels as far as Topsham, on the left bank of the river, four miles below Exeter. Smaller craft, however, and large barges, could with the tide ascend to the water-gate of the city, in sufficient numbers to supply the wants of the inhabitants. Thus, stood matters in the reign of Edward the First.
>
> At that time the Lady Isabella de Fortibus, Countess of Aumerle and of Holdernesse, of the Isle of Wight and of Devon, who owned the village and port of Topsham, as well as lands on both sides of the Exe, erected Countess-weir.

Therefore, in about 1300 the sea-port that served Exeter may have been located adjacent to the Medieval urban core near Fore Street in Topsham, some 6 km downstream from the city. The inference from the report is that cargo was off-loaded from sea-vessels onto barges and then transported upstream on the tide to a barge-quay at the Water Gate, Exeter. It is noteworthy that, even though Exeter and Topsham had been joined by a road since at least the Roman era, the more favourable economics of barge transportation still prevailed over cart and horse even for such a relatively short distance. Unfortunately, the wording of the report does not explicitly say that the tide progressed all the way to the Water Gate, but it is probably safe to assume it did. Furthermore, either due to natural and/or man-made obstacle(s), the tide seems not to have progressed beyond the Water Gate in the following centuries. Evidence for this claim arises from the tenter racks (drying frames) for cloth, the production of which requires fresh-water, on the floodplain adjacent to Exeter and upstream of the Water Gate shown on maps from 1587, 1625, 1709 and 1805 (Bennett *et al.* 2014). Figure 1 shows that the RSL in 1300 was *c.* -1.0 m OD; that is an approximately -1.5 m difference compared to the 1st century figure, i.e., the land surface was *c.* 1.5 m higher during the latter, which adds further weight to the idea that the Roman fortress was located upstream of the furthest tidal reach.

In conclusion, the positions of the *c.* 1300 sea-port and barge-quay are crucial data points in the RSL calculations that might help place limits on the 1st century Roman equivalents.

### The 1st century River Exe and estuary

The 1st century River Exe and estuary were yet to be significantly altered by embankments, weirs, traps, diversions, leats, reclamation of salt-marshes, and the Exeter Ship Canal. Today the Exe is artificially deepened in places, as water is held back for the ship canal and flood-relief purposes, and elsewhere flows at very restricted rates; for example, adjacent to Topsham the fluvial flow depth, i.e., non-tidal, is approximately 0.1 to 0.2 m deep. In addition, the substantial changes to the margins of the natural flood-plain, especially the railway embankments on both sides of the estuary (Figure 3, grey lines) and the ship canal, have hemmed in the tidal influx causing it to be unnaturally deeper and, in theory if not in reality due to various weirs etc., to be capable of reaching further upstream.

In contrast, calculations of the near-natural, fluvial state in the 1st century indicate that the bankfull depth (the river would overflow its banks beyond this depth) was *c.* 2.0 m and that the normal flow depth was closer to 0.5 m from Exeter downstream to beyond Topsham. Clearly this was not a great depth of water; sufficient for barges but not so for Roman sea-vessels of 1.0 to 2.0 m draught (Marsden 1976; Boris Rankov *pers. comm.*). Furthermore, and as alluded to in the previous paragraph, the near-natural tidal flux occupied an estuary *c.* 2.5 m OD higher and was unconstrained by human activity. Therefore, the present-day depth of the River Exe and the extent of the tidal flow are probably not directly applicable to the 1st century, especially when examining the question of where a Roman sea-port may have been located.

#### *Positioning of a Roman barge-quay and sea-port by calculations of slope and RSL*

There are many complex, natural, interactions that occur between a body of tidal-water and an estuary, all of which alter the state of the tidal flow and, for example, how far upstream the tidal head will reach. As mentioned, the tidal head in 1300 was probably at the Exeter Water Gate which implies that, due to the continuing submergence of the land, that the present-day, natural tidal head might be north of Exeter, i.e., further upstream and inland. That it is, instead, located just north of the M5 bridge is a result of man-made

[3] The actual water requirement for the fully operating fortress would have been much higher. Once the bath-house had been constructed this building alone was estimated to require 320,000 litres per day – brought into the fortress by way of an aqueduct (Bidwell 1979: 43).

interventions, most of which occurred post-1300, i.e., the river and estuary were in a semi-natural state between the Roman era and 1300. From the 1st century to 1300 the land has submerged, shown by the *c.* -1.5 m RSL change, which implies that the tidal head in the Roman era was further south, further downstream and by a distance controlled by the differential RSL value and a slope up which the tidal wave ingresses. The measurement and use of this slope will now be described.

To reiterate, the RSL changes are in part a consequence of the forebulge collapse since the end of the Devensian. This submergence has affected the slope of the underlying bedrock surface in the River Exe valley and estuary. The British Geological Survey (BGS) maintains a database of boreholes (Figure 3 for locations) from which the Permian bedrock elevation was calculated and gridded to provide a surface along which slope values were measured (Figure 2). This gave a slope value of 0.01 degrees (from the mouth of the estuary northwards). It might be thought this slope value should be preferred when calculating the location of barge-quays and sea-ports in the 1st century. However, it does not reflect the slope generated by the river and tides that are flowing over, and interacting with, the overburden deposits. Plus, where the river does, or has, acted directly on the bedrock the resultant slopes are usually greater than 0.01 degrees. That is, the 0.01 degree value is not applicable to the dynamics of river and tide. Nevertheless, the 0.01 slope angle was retained in the following calculations because it placed a lower limit on the range of possibilities.

The *c.* -2.5 m collapse of the forebulge since the 1st century has resulted in the sinking of the ria that the estuary occupies. In doing so it has filled with detritus, the overburden shown in Figure 2, from erosional products brought downstream by the river and those imported through the mouth of the estuary by the tide. Essentially the river and tide have flowed across their own, ever growing product, reworking it and producing a slope within the confines of the estuary and river valley. Utilising LiDAR and multibeam sonar profiling along a number of transects provided topographic slopes within the river valley and estuary that fall within 0.02 to 0.03 degrees (again, from the mouth of the estuary northwards). Similar measurements along

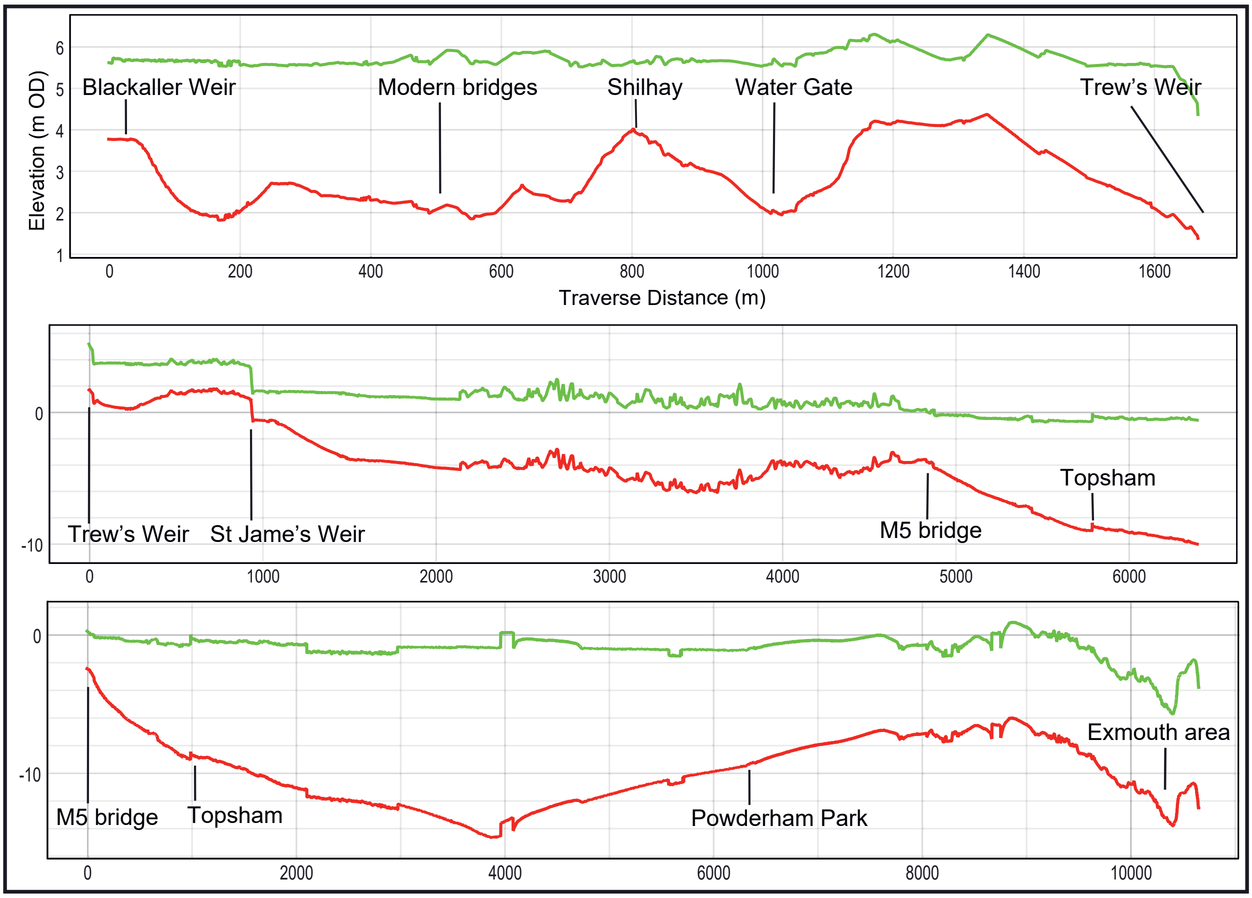


*Figure 2. Present-day bedrock (red line) and overburden top surface (green) profiles along a North to South transect of the River Exe valley and estuary. The Exe estuary is a ria, an unglaciated river valley which starts in the north at the M5 bridge. Elevation values (left margin; note the variable scales) and distances are in metres OD. The bedrock profiles are derived from a British Geological Survey (BGS) borehole database. The overburden surface is of LiDAR and multibeam sonar topography.*

the River Clyst valley, to the east of the Exe and tidal and flowing into the River Exe estuary, also produced slope values of 0.02 – 0.03 degrees.

Further slope information was derived from the High-Water Mark (HWM) data, supplied by the Ordnance Survey, along the east bank of the estuary and river from Exmouth to Topsham (note: the HWM upstream of Topsham and the west bank of the estuary are very unnatural being greatly influenced by man-made structures). These data were digitised, topographic elevations assigned from LiDAR data and then graphed to derive a slope of 0.02 degrees, a value common to the topographic measurements of slope.

Therefore, 0.02 degrees appeared to be a reasonable slope value to apply to the reconstruction of positions along the river and estuary going back through time. Nevertheless, a range of slope values, i.e., 0.01, 0.02 and 0.03, were used in this study to better apply plausible limits to the modelling of the 1st-century river and estuary.

The other parameter to be discussed in this section is the RSL. As already described, the best estimate of the RSL change since the 1st century was -2.5 m (Figure 1), however, there are a number of measurement uncertainties associated with these data which suggested that plausible limits to the modelling should also be applied. Hence, RSL values of -1.5 to -3.0 m, in 0.5 m intervals, were used in the following modelling.

The aim of the modelling was to use the slope ranges associated with the influx and ebb of the tide to calculate the fall distance of tidal locations, for example the head, due to the RSL changes since the 1st century, i.e., starting from the present-day topographic elevations, how far has the tidal body fallen down the slope as time retrogressed to the Roman era? For any tidal point Table 1 shows these fall distances for the range of slope and RSL values under consideration. Taking the best estimates of slope and RSL, 0.02 degrees and -2.5 m respectively, the fall distance was 7,161.97 m, that is, any present-day tidal location might have been over seven kilometres further south in the 1st century.

*Table 1. Fall distances (in metres), from the present-day to the 1st century for RSL values of -1.5 to -3.0 m, in -0.5 intervals, and slope values of 0.01, 0.02 and 0.03 degrees.*

| RSL values 1st century | -1.5 m | -2.0 m | -2.5 m | -3.0 m |
|---|---|---|---|---|
| Slope 0.01 | 8,594.37 | 11,459.16 | 14,323.94 | 17,188.73 |
| Slope 0.02 | 4,297.18 | 5,729.58 | 7,161.97 | 8,594.37 |
| Slope 0.03 | 2,864.79 | 3,819.72 | 4,774.65 | 5,729.58 |

The calculation method used to produce Table 1 was then applied to the *c.* 1300 historical locations of the barge-quay at the Water Gate, Exeter and the sea-port at Topsham to give Table 2, the differential fall distances for those locations between 1300 and the 1st century. For 1300 the RSL change is *c.* -1.0 m (Figure 1) which gave a difference of -0.5, -1.0, -1.5 and -2.0 m to the selected 1st century values; slope values were maintained at 0.01, 0.02 and 0.03 degrees.

For example, for a differential RSL of -1.5 m and slope of 0.02 – the best estimate values – for both the barge-quay and sea-port locations the likely fall distance was 4297.18 m further south in the river valley and estuary. Assuming that the tidal head was at the Water Gate in 1300 then, under all combinations of RSL and slope, there probably was no barge-quay at Exeter in the 1st century because the tide did not reach that far upstream. Instead, the calculations indicate that the most northerly point for a 1st century barge-quay was located just north of the M5 bridge. Furthermore, and with the assumption that the 1300 sea-port at Topsham was located as far upstream as practical, a Roman-era sea-port may only have been located south of the line Powderham – Lympstone for the same RSL and slope values (Figure 3).

Figure 4 displays the indicative, most upstream, or northerly, locations for a Roman barge-quay and sea-port, and for all the differential RSL and slope combinations previously described. The use of the extended limits, in this example a RSL of -3.0 m and slope of 0.01 degrees, places the barge-quay and sea-ports in locations that might seem unlikely, with the seaport being approximately five kilometres south of Exmouth in the English Channel. However, the form of the estuary and shoreline in the 1st century is poorly understood in this area; it may be possible that it was similar to the coast between Bognor Regis and Worthing where the shoreline is thought to have been three to four kilometres further offshore of the present-day equivalent (Beaches at Risk (BAR) Project 2008).

*Table 2: differential fall distances (in metres), from 1300 to the 1st century for RSL values of -1.5 to -3.0 m, in -0.5 intervals, and slope values of 0.01, 0.02 and 0.03 degrees.*

| RSL differentials | -0.5 m (1st c. -1.5) | -1.0. m (1st c. -2.0) | -1.5 m (1st c. -2.5) | -2.0 m (1st c. -3.0) |
|---|---|---|---|---|
| Slope 0.01 | 2,864.79 | 5,729.58 | 8,594.37 | 11,459.16 |
| Slope 0.02 | 1,432.39 | 2,864.79 | 4,297.18 | 5,729.58 |
| Slope 0.03 | 954.93 | 1,909.86 | 2,864.79 | 3,819.72 |

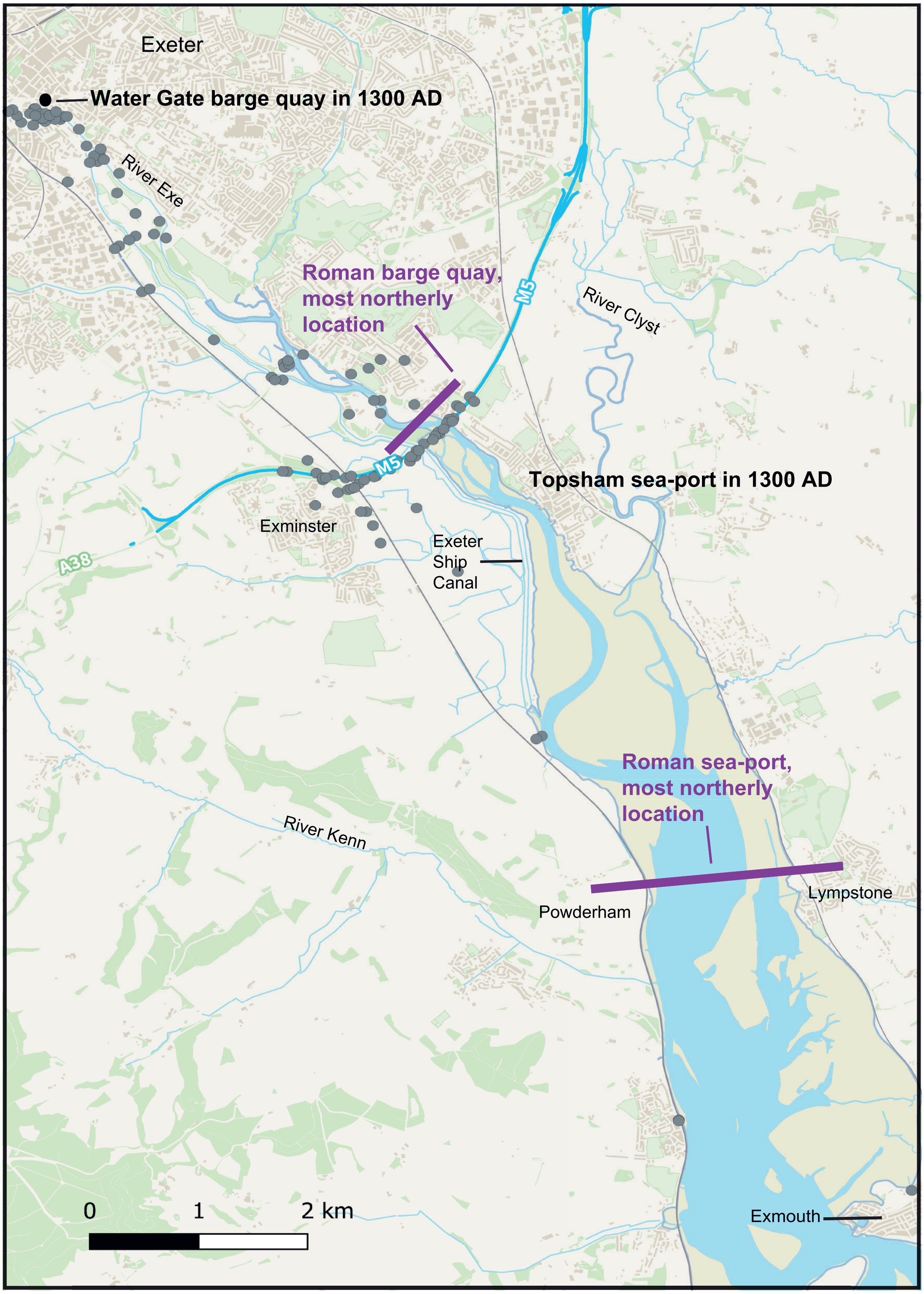


*Figure 3. Map of differential fall distances to the most northerly, or upstream, locations in the 1st century AD for the AD 1300 barge-quay located at Exeter and the sea-port at Topsham. The differential RSL and slope values used were the best estimates at -1.5 m and 0.02 degrees, respectively, and resulted in a differential fall distance of 4,297 m. Grey dots are BGS boreholes. See Figure 4 for the locations of all the differential RSL and slope values.*

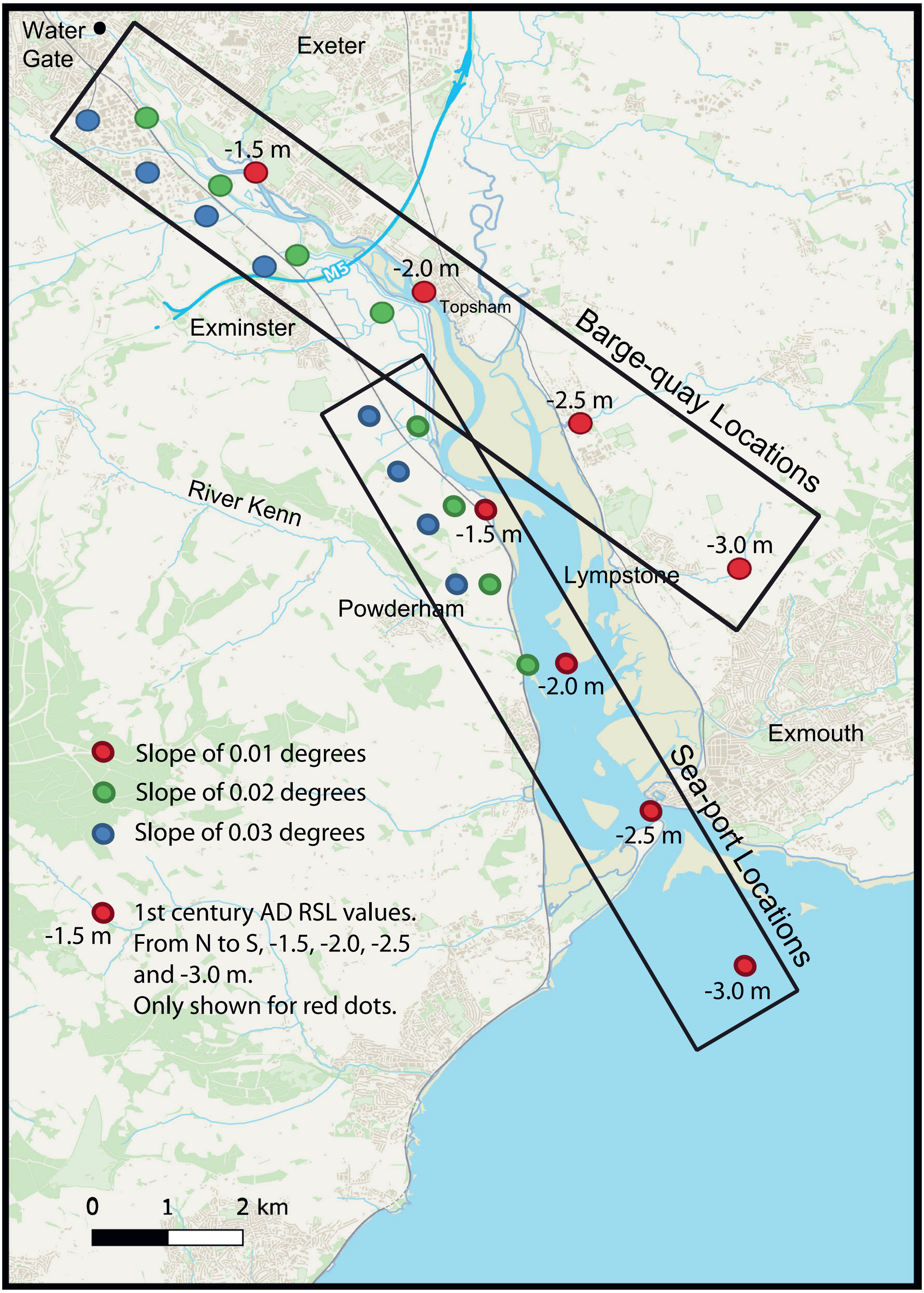


*Figure 4. Map of most northerly, or upstream, limits of 1st century AD barge-quays and sea-ports. Differential fall data, from AD 1300 to the 1st century AD, taken from Table 2. For any combination of slope and RSL value the barge-quay or sea-port could not be placed further upstream than the relevant coloured dot.*

### *Positioning of a Roman barge-quay and sea-port by simulation of the tidal inflow*

The following simple methodology simulated a tidal inflow into the Exe estuary and river valley; it further supported the findings of the previous section by way of generating an additional set of limits on the positioning of the 1st century barge-quay and/or sea-port.

In preparing for the modelling the present-day elevations (LiDAR) of the Ordnance Survey HWM were extracted, i.e., at a water depth of 0.0 m, at four, approximately equally distanced points, along the estuary from Exmouth northwards to a point north of Topsham. Note that the present-day HWMs are not natural – the tide could encroach further inland if not for the flood defences, rail lines, the Exeter Ship Canal and many other man-made structures, or alterations, to the natural environment. Hence, the water depth at each point was conservatively increased to 0.1 m to mimic a more natural tidal influx and, to aid a more natural flow regime, the topographic surface of the estuary and river valley was filtered to diminish and breach the man-made structures.

The modelling consisted of running a lake flooding algorithm at the four HWM points, a method which effectively simulated the upstream influx of a tidal wave. The resulting map (Figure 5A) shows that many areas would be tidally inundated today if not for the anthropogenic structures. Even without a complete breaching of existing structures, e.g. rail lines and the Exeter Ship Canal, the model tide extended into the River Kenn valley south of Powderham, covered much of the Exe river plain between Topsham and Exminster and likely would have reached the Water Gate at Exeter but was checked in the calculations by weirs.

The modelled tide depth at Topsham was *c.* 2.4 m which matched the tide gauge data and corresponded with reports of modern vessels of 2.0 m draught reaching the port on the highest of tides, but then being tied to a quay to stop them "falling over in the mud" once the tide recedes. Assuming that the naturalised River Exe did have a normal flow depth of *c.* 0.5 m suggested that Topsham had always been a difficult seaport for large vessels; a quay, or wharf, would probably have always been required. Of course, this is the case today when the natural tidal range is the highest it has ever been.

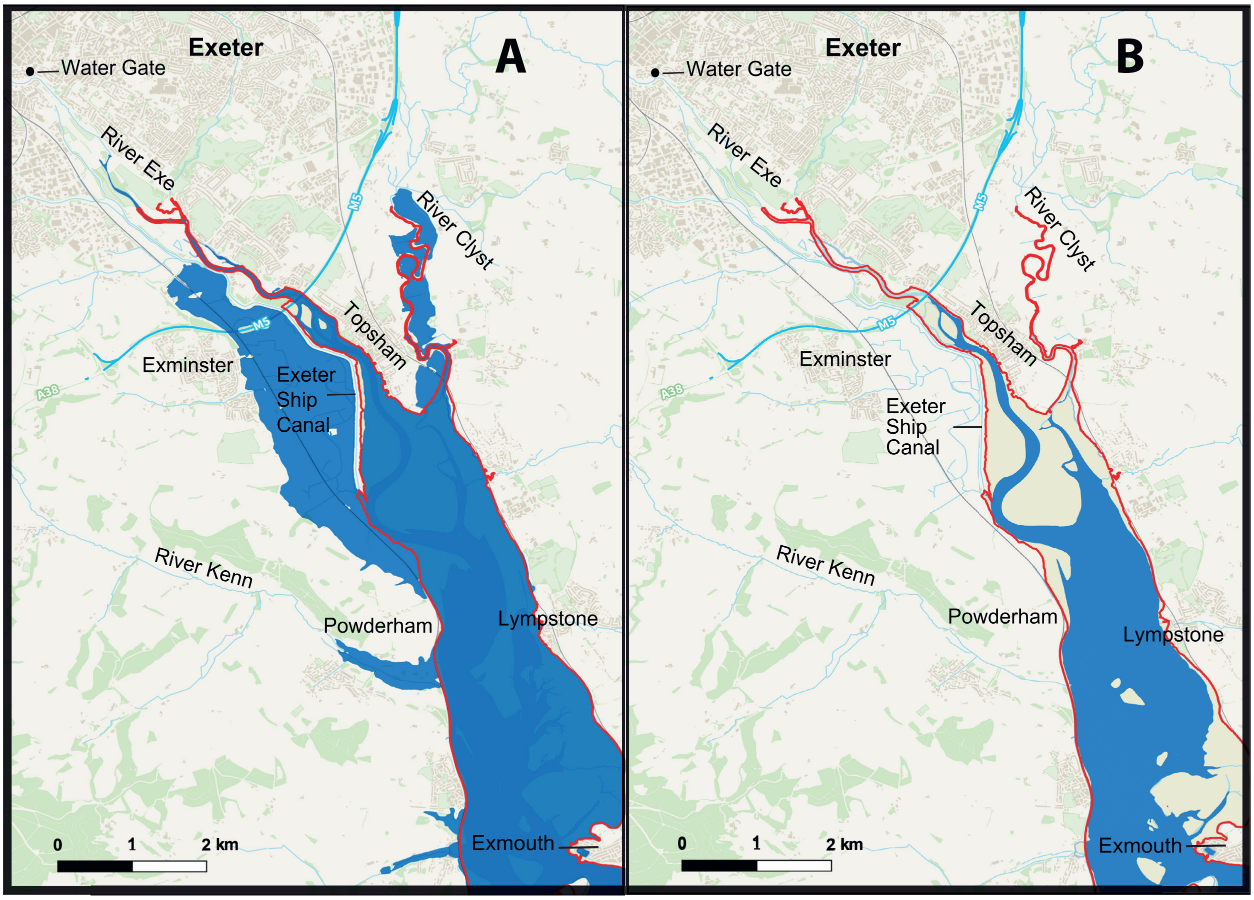


*Figure 5. A) simulated tidal influx for the present-day after the partial removal and breaching of anthropogenic structures. Red line is the Ordnance Survey HWM. Grey lines are of the railways.*

*B) simulated tidal influx for the 1st century AD. RSL -2.0 m. Note that the modern anthropogenic structures have been partially removed and breached and may still restrict the 1st century AD flow, e.g., the River Kenn may have been tidal in its lower reaches.*

However, as previously mentioned, the river channel and estuary have silted over time which may restrict the inflow of even this greater tidal range.

The tidal situation in 1300 was modelled by raising the topography by 1.0 m to reflect the -1.0 m RSL value for that time. In which case the tide depth at Topsham was *c*. 1.5 m; combining this with the natural flow of the Exe of 0.5 m gave a total water depth of *c*. 2.0 m which supported the account of Topsham being a sea-port at this time.

Retrogressing the tidal model back to the 1st century and a RSL of -2.0 m, rather than the best estimate of -2.5 m, required a further 1.0 m of topographic elevation. The resulting map (Figure 5B) shows that the tidal head did not reach the M5 bridge and at Topsham the tidal water depth was only *c*. 0.5 m deep (note: a RSL of -2.5 m, the best estimate, would result in lower depths).

Even allowing for less siltation in the 1st century, and the addition of the 0.5 m River Exe water depth, Topsham probably would not have had the tidal range to allow sea-vessels to reach this far upstream, i.e., this modelling does not support the idea that Topsham was a sea-port in the 1st century. At the latitude of Powderham the tidal water depth had increased to *c*.1.0 m and by the Dawlish – Exmouth area there was enough depth for sea-vessels.

In summary, this simple modelling of tidal depths, extents and ranges of the past from the present-day HWM produced results which broadly corresponded with the earlier examinations of RSL change and slopes.

## Discussion

### *Summary of the tidal and topographical research*

The modelling methods described in this paper were entirely desk-based and constrained by a lack of present-day data; for example, most Exe estuary tidal gauges usually do not record a Low Water Mark because the water depth at low tide is below the gauge. The exception is the Exmouth gauge where the measured tidal range is c. 1.5 to 3.0 m. Additional modelling constraints arose from anthropogenic changes and the present-day hydrological management regime. Siltation over time was also a variable that could not be confidently modelled, and which may alter the probability of a 1st century sea-port being at Topsham, for example, siltation may have in-filled a deeper thalweg, or pool of deeper water, sited at Topsham in the Roman era. This is thought unlikely, but cannot be dismissed. The essence of the modelling problem was that the sparse, present-day, discrete parameters, and human-controlled form of the river valley and estuary, precluded the direct production of a model of the 1st-century equivalents. Of necessity, the simple methods described earlier which make use of bulk parameter sets, for example the Ordnance Survey HWM and slope values derived from the gross topography, did allow the production of plausible, limited locations for the 1st-century barge- and sea-ports.

The volume of the tidal bulge in the English Channel that gives rise to the tidal prism that flows into the Exe estuary has probably not changed significantly since the 1st century. However, the *c*. -2.5 m RSL value suggests that the mouth was further south than it is today and may have contained more sand banks and restrictions to the tidal influx (SCOPAC 2004). How these differences might have altered the tidal prism are not known, but they might suggest that the total volume of the tide inflowing to the inner estuary was limited which, of course, might lower the depth of available tidal water for sea-vessels. Conversely, the River Exe was not then restricted in volume, and would possibly have been deeper throughout its length to the estuary mouth. In conclusion, there are many unknowns concerning the mouth of the estuary which are beyond the scope of this paper to resolve.

The simple, limited modelling of RSL values, slopes and tidal ranges produced results which can plausibly question the concept of a Roman sea-port at Topsham. That is, the total water depth required, for Roman sea-going cargo vessels of *c*. 1.5 m draught, was probably insufficient. Furthermore, a 1st-century sea-port was more likely to have existed in the Exe estuary somewhere south of the Powderham – Lympstone line. No archaeological evidence has yet been found to support this concept.

The modelling also suggested that the fortress site at Exeter was significantly above the tidal limit during the 1st century; hence, no barges could reach the fortress on the tide, instead, goods from the Continent may have been transported on the Exeter to Topsham road. However, as described, Topsham was probably tidal and, instead of being the site of a sea-port, may have been the location of a barge-quay, or barge-port. In this case sea-vessels from the Continent may have berthed somewhere south of the Powderham – Lympstone line, off-loaded their cargoes to barges that then travelled up the tidal estuary to the Topsham barge-quay and hence onwards by road to Exeter.

Another plausible scenario is that there was no sea-port in the estuary but, instead, sea-vessels used the protected waters as a haven, simply anchoring within the estuary and from there off-loaded to barges before they travelled on the tide to Topsham. This may partially explain the lack of archaeological evidence of any Roman structures within and alongside the estuary.

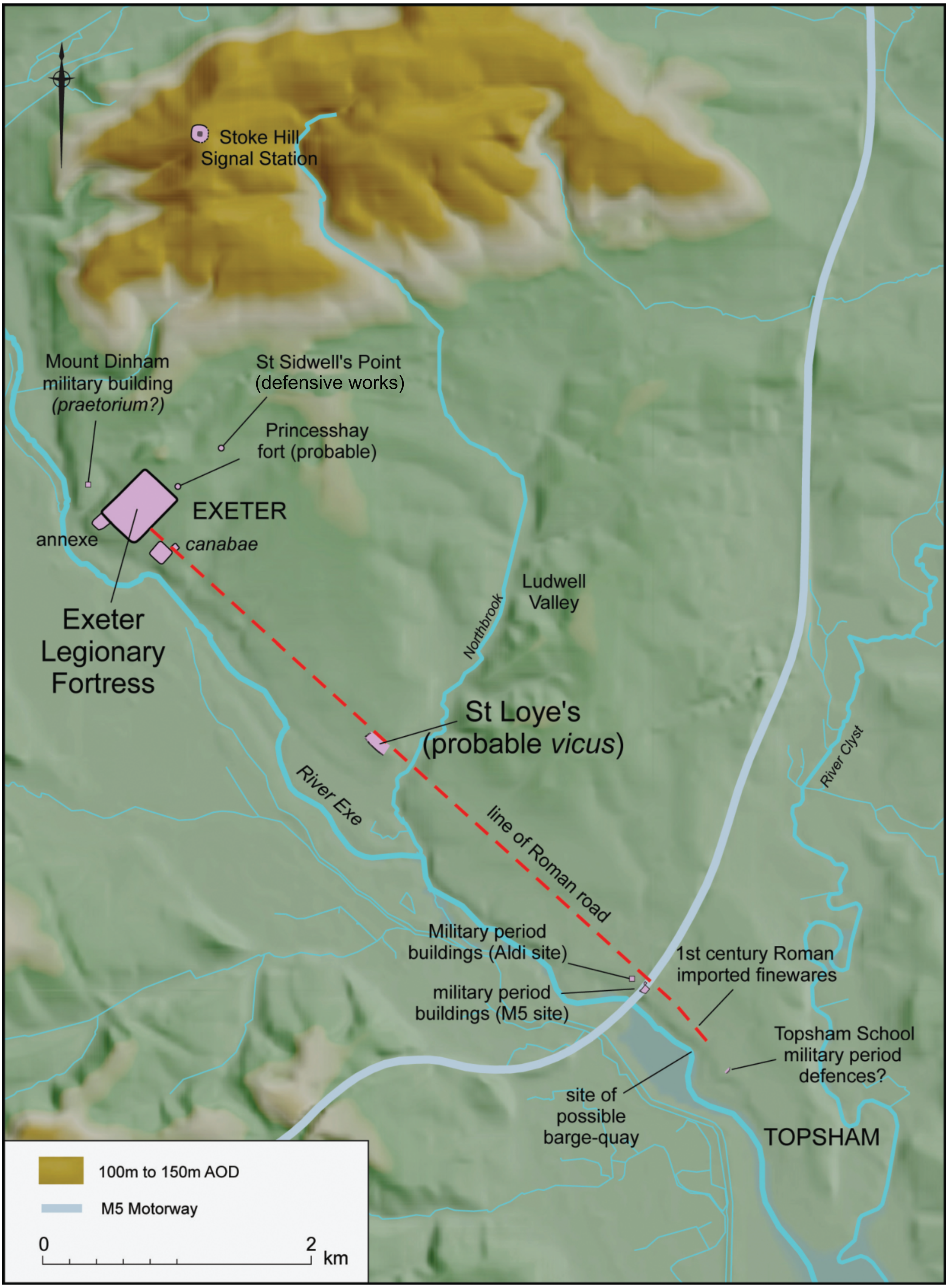


*Figure 6. Roman military period sites located between the legionary fortress at Exeter and the Topsham School site showing approximate suspected site of barge-quay (T. Ives Illustrations).*

It is noteworthy that both the Exe and Clyst were found to be tidal in the 1st century to a latitude between Topsham and the M5 bridge (Figure 6). This might explain why there are no Roman archaeological findings on the Topsham peninsula south of the Topsham area, there being no adequate supply of fresh water for large infrastructures and may, possibly, have negatively influenced the positioning of a Roman sea-port at Topsham.

***Implications for the Roman military period sites at Exeter and Topsham***

A generally accepted date for the construction of the fortress at Exeter is *c.* 55-60 with occupation lasting until around 75 at which time the legion departed for a new base at Caerleon in South Wales. The demolition of the fortress buildings, with the exception of the converted bath-house, is thought to be complete by *c.* 80 (Holbrook and Bidwell 1991: 7). Significantly, for the purposes of this paper, Henderson demonstrated that the known Roman road from Topsham to Exeter was aligned directly with one of the main streets of the fortress – the *via principalis,* and that the two must have been planned and constructed contemporaneously – i.e. *c.* 55-60 (Henderson 2001: 49-56). This observation confirmed the early importance of the road and its role in facilitating the transport of supplies to the fortress from a suspected port facility in the Topsham area. Almost certainly contemporary with the construction of the fortress were a number of Roman establishments either adjacent to or astride the aforementioned road (Figure 6). Those which have been investigated include two extra-mural compounds which were constructed beyond the south gate (*porta principalis sinistra*) of the fortress; these sites are believed by Bidwell (2021) to represent elements of the civilian *canabae* (Figure 6). The so-called upper compound sits on the slightly higher ground to the north-east of the road whilst on the opposite side, the lower compound occupies a gentle slope leading down towards the River Exe; the extent of both compounds is unknown. On current evidence, they are likely to have fulfilled very different functions. The upper compound had a series of well-constructed buildings which may be described as domestic in nature and well-appointed, some with small individual courtyards, whilst the lower compound (at least within the area excavated) appeared to contain only workshops and open areas (Salvatore 2021: 177-81). Further down the road from the *canabae* and some 2.5 km from the fortress was a site excavated at the former St Loye's College (Figure 6). This site was originally interpreted as a Roman military supply base (Salvatore and Steinmetzer 2018). Subsequent research undertaken by Bidwell (2021) has determined that the site is more likely to be a civilian town (*vicus).* This may have seen the site functioning primarily as a commercial trading base with certain types of imported supplies under civilian rather than direct military control. Such transactions between the inhabitants of the settlement and the military authorities would have been conducted by merchant *negotiatores.* Bidwell has pointed out that the significant amounts of *amphorae* sherds associated with the occupation of the site might indicate that part of the function of the site was as a distribution centre for imported liquids, presumably goods such as olive oil and wine in particular, whilst *defrutum* (wine sweetener) and *garum* (fish sauce) as well as fruits and olives could also have featured (Salvatore *et al.* forthcoming). The St. Loye's settlement may then have been receiving all manner of goods from the Continent for onward distribution to the fortress and presumably to those inland forts connected by the road network to Exeter.[4] Closer to the Topsham end of the road was a rectangular house of timber construction located about 1.5 km to the north-west of the modern town of Topsham and *c.* 5.2 km from the fortress. The site was excavated in advance of the construction of the M5 motorway crossing of the River Exe and is identified as the M5 site on Figure 6. The excavators suggested that the remains displayed the characteristics of an early Roman settlement occupied from *c.* 50-55 to 70-75 at which time it was abandoned (Jarvis and Maxfield 1975: 228). This site may have been part of a larger complex, another part of which was excavated at the Aldi site in 2015-16, where four open-ended strip-buildings were excavated just north of the M5 crossing of the Exe (Figure 6). The buildings were interpreted as warehouses forming part of a small storage complex. They lay some 50 m to the south-west of the modern Exeter Road which has long been thought of as reflecting the line of the Roman road from Topsham to the fortress. However, if the open-fronted buildings were designed for loading carts then it might be expected that they would be located closer to the road. No evidence for road metaling was discovered immediately to the north-east of the buildings but an alignment for the road which would see it deviate from the modern road-line, pass close to the warehouses, and head towards the suspected quay facility in The Retreat area becomes an attractive possibility.[5] Significantly, the excavators of the Aldi site went on to state that: '... the structures, and possibly those found in adjoining sites to the south-east, were built by the Roman military but controlled or run by civilian traders who

[4] Elsewhere in Britain, Anderson has argued most forcefully that the forts of North-East England were supplied primarily by road: '...most supplies with production sites long distances away would have been shipped in by sea...these materials would then have been carted or transported by pack animals over the Roman road system to each fort' (1992: 88).

[5] The modern road from Exeter to Topsham, whilst mirroring the Roman road for the greater part of its route, is unlikely to do be doing so when it approaches Topsham itself given the latter's medieval origins.

attached themselves to the legion in order to provide goods via trade' (Garland and Orellana 2018: 103-10). If this is correct, the site would have functioned in exactly the same way as that suggested for St. Loye's, with the difference being that it would have been much closer to any barge-quay facility if this had existed north-west of Topsham School (Figure 6).

## Conclusion

All of the archaeological evidence so far recovered points to a port location somewhere in the area north-west of modern Topsham. The concept of a port facility at Topsham in the early Roman period was first mentioned in the 1930s by Radford (see above) who postulated a military sea-port. The arguments presented in relation to the tidal reach and depth of the River Exe in the mid-1st century in this paper have clearly demonstrated that, rather than a sea-port, the greater likelihood is that any facility in the Topsham area would have seen a barge-quay operating in tandem with a sea-port further down river. Such a barge-quay could have seen the off-loading of supplies which had been transferred onto barges at a sea-port located south of an imaginary line across the estuary between Powderham and Lympstone (see Figure 3) or, just conceivably, by direct ship to barge transfer, and then assisted by tide upriver. Whilst the site of a Roman barge-quay could lie anywhere south of the most northerly limit (illustrated on Figure 3 and the tidal limit on Figure 5B), the area around The Retreat just to the south-east of the modern M5 motorway (at NGR SX 95808877) may be seen as a strong candidate for such a facility (see Figure 6). This argument is supported by the findings of more imported and 'exotic' mid-1st-century pottery in this area than is found at the legionary fortress further upriver, and by the Roman military period buildings and sites located at the M5/Aldi sites just to the north-west of The Retreat. Whilst no quayside remains have yet come to light in this area, this could be due to the Relative Sea-level change, meaning that they may be *c.* 2.5 m below the present-day HWM, and to river-bank erosion which has demonstrably removed significant amounts of the cliff-face at the Topsham School site.

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