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BGS Karst Report Series: C9. Karst in the Chalk of the Isle of Wight

Environmental Change, Adaptation and Resilience Programme

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Front cover

Phreatic tube exposed in Duxmore quarry. Photo A Farrant, BGS.

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Executive Summary

This report documents the evidence for karst and rapid groundwater flow in the Chalk of the Isle of Wight in Southern England. It is part of the BGS karst report series on those karst aquifers in England in which cave development is limited – principally the Upper Cretaceous Chalk and the Jurassic and Permian limestones. The series is the main output of the NERC funded Knowledge Exchange fellowship “Karst knowledge exchange to improve protection of groundwater resources”. The term “karst” applies to rocks that are soluble. In classic karst there are extensive caves and large scale surface karst landforms such as dolines, shafts, stream/river sinks, and springs. In the past, the Chalk and the Jurassic and Permian limestones of England were not considered karstic because they have limited cave development, and because karst features are generally small and have not been well documented. However, permeability in these aquifers is determined by their soluble nature and groundwater flow is predominantly through small-scale karstic solutional features. These reports provide data and information on karst in each area. Karst data are compiled from the British Geological Survey databases on karst, springs, and transmissivity; reports and peer reviewed papers; from geological mapping; and through knowledge exchange with the Environment Agency, universities, water companies and consultants.

This report shows that there is some evidence for karst in the Chalk of the Isle of Wight, but that karst may be less well developed than in some areas of the mainland. Overall there is more evidence for karst in the Central Chalk Downs than in the Southern Downs.

Dolines and dissolution pipes appear to be less common on the Isle of Wight than in some other areas of the Chalk, but dissolution pipes can be observed in Chalk coastal cliffs, and in excavated pits inland. Two stream sinks are recorded on the Isle of Wight. Springs occur in the Chalk at the boundaries with the overlying Palaeogene deposits, and underlying Upper Greensand Formation; and springs in the Upper Greensand Formation also discharge water from the Chalk where there is connectivity between the two aquifers. There are little data on spring discharge, and discharges are likely to have been substantially reduced by groundwater abstraction, but large springs appear to be rare. Caves are exposed in the Chalk coastal cliffs, and appear to have a predominantly marine origin, but there is evidence of some karstic development in some of these caves. Smaller conduits have been observed in inland quarries. Transmissivity data for the Chalk of the Isle of Wight are limited, with two sites where higher transmissivity indicates well connected solutional networks, but other sites indicating lower transmissivity than on the mainland. Coliforms have been occasionally detected in groundwater suggesting a rapid flow component.

Further work is needed to assess the extent of karstic conduit development in the Chalk of the Isle of Wight, which could include coastal surveys of conduits, consideration of karstic indicators at abstraction boreholes, investigations of spring discharges, and tracer tests.

Introduction to the BGS Karst Report Series

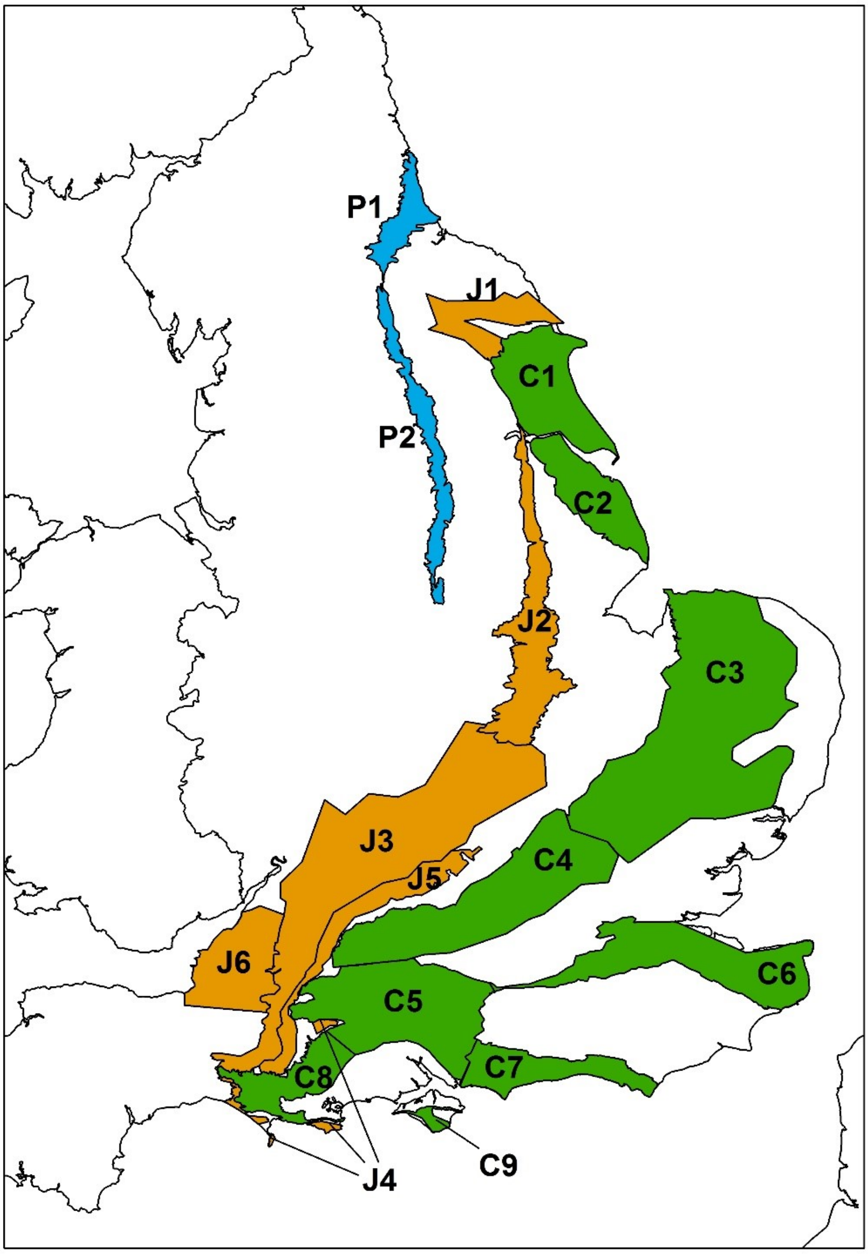
The BGS karst report series is focused on karst aquifers in England in which cave development is limited – The Chalk and the Jurassic and Permian limestones. The series is the main output of the NERC funded Knowledge Exchange fellowship “Karst knowledge exchange to improve protection of groundwater resources” undertaken between 2015 and 2022.

The term “karst” applies to rocks that are soluble. In classic karst there are extensive caves; and there are large scale surface karst landforms such as dolines, shafts, stream/river sinks, and springs. In the past the Chalk and the Jurassic and Permian limestones of England were not considered karstic because they have limited cave development, and because karst features are usually small and have not been well documented. However, permeability in these aquifers is determined by their soluble nature and groundwater flow is predominantly through small-scale karstic solutional features comprising small conduits ~ 5 to >30 cm diameter and solutionally enlarged fractures (fissures) of ~0.5- >2 cm aperture. There are some short caves in all three aquifers; they all have dolines, stream sinks and large springs; and rapid flow can occur over long distances. Karst is therefore an important feature of these aquifers.

The series comprises 17 reports which provide an overview of the evidence for karst in different areas of England. The Chalk is divided into nine regions, primarily based on geomorphology and geography. The Permian limestones are divided into two areas, comprising a northern and southern outcrop. The Jurassic limestones have more variable geology and are divided into six areas. J1 covers the Corallian Group of Northern England. J2 covers the Lincolnshire Limestone Formation of central England. J3 covers the Great and Inferior Group oolites of Southern England. J4 covers three small areas of the Portland and Purbeck limestones in Southern England. J5 covers the Corallian Group limestones of Southern England. J6 covers the Blue Lias limestones of Southwest England and comprises several small outcrops within a large area.

Karst data are compiled from the British Geological Survey databases on karst, springs, and transmissivity; peer reviewed papers and reports; and through knowledge exchange between 2015 and 2022 with the Environment Agency, universities, water companies and consultants. The data are not complete and further research and knowledge exchange is needed to obtain a fuller picture of karst development in these aquifers, and to investigate the detail of local catchments. The reports provide an initial overview of the evidence for karst and demonstrate that surface karst features are much more widespread in these aquifers than previously thought, and that rapid groundwater flow is common. Consideration of karst and rapid groundwater flow in these aquifers will improve understanding of how these aquifers function, and these reports provide a basis for further investigations of karst to enable improved management and protection of groundwater resources.

The reports are structured to provide an introduction to the area and geology, evidence of karst geomorphological features in the area (caves, conduits, stream sinks, dolines and springs); evidence of rapid flow from tracer testing, and other hydrogeological evidence of karst. Maps of the area show the distributions of karst features, and there is a quick reference bullet point summary.



Map of the locations of the Karst reports

C1) Karst in the Chalk of the Yorkshire Wolds
C2) Karst in the Chalk of Lincolnshire
C3) Karst in the Chalk of East Anglia
C4) Karst in the Chalk of the Chilterns and the Berkshire and Marlborough Downs
C5) Karst in the Chalk of the Wessex basin
C6) Karst in the Chalk of the North Downs
C7) Karst in the Chalk of the South Downs
C8) Karst in the Chalk of Dorset
C9) Karst in the Chalk of the Isle of Wight
J1) Karst in the Jurassic Corallian Group limestones of Northern England
J2) Karst in the Jurassic limestones of Central England
J3) Karst in the Jurassic Great and Inferior Oolite groups of Southern England
J4) Karst in the Jurassic Portland and Purbeck limestones in Southern England
J5) Karst in the Jurassic Corallian Group limestones of Southern England
J6) Karst in the Jurassic Blue Lias limestones of Southwest England
P1) Karst in the northern outcrop of the Permian limestones
P2) Karst in the southern outcrop of the Permian limestones

Introduction to Karst Data

This section provides background on each type of evidence for karst, the data sources used, and any limitations in the data. This introduction is general to all the BGS karst reports and further specific information on data sources is provided within the individual reports where applicable. A glossary is provided at the end of the report.

Stream sinks

Stream sinks provide direct evidence of subsurface karst and rapid groundwater flow because they are indicative of a network of solutional voids of sufficient size to transport the water away through the aquifer. Most stream sinks occur near to the boundary between the carbonate aquifer and adjacent lower permeability geologies, with surface runoff from the lower permeability geologies sinking into karstic voids in the carbonate aquifer at the boundary or through more permeable overlying deposits close to the boundary.

Data on stream sink locations in the Chalk and Jurassic and Permian limestones are variable and although there are many records, the dataset is incomplete, and further surveys are likely to identify additional stream sinks. Stream sink records are predominantly from the BGS karst database in which many were identified by desk study and geological mapping. Several stream sink field surveys have also been carried out, predominantly in areas of the Chalk in Southern England. Some additional records were obtained through knowledge exchange.

Most streams that sink have multiple sink points over distances of 10s to 1000s of metres. The sink point varies depending on flow conditions and also as some holes become blocked with detritus and others open up. Each individual sink point provides recharge into a solutional void in the underlying carbonate aquifer, and their locations therefore provide direct evidence of the locations of subsurface solutional features enabling rapid recharge. The sink points range from seepages through alluvial sediments in the stream bed and small holes in stream beds, to sink points located in karstic depressions of more than 10 m in depth and/or diameter. Some data sources report many/all individual sink points associated with a stream; whilst others report a single point for an individual stream irrespective of whether there are multiple sink points. The data presented here comprise all the sink point records that the studies report, but there are likely to be many more sink points in streambeds which have not yet been identified.

Further information on the discharge and nature of the stream sinks is generally sparse, but where available, information from reports and papers are summarised.

Some streams and rivers flowing over carbonate geologies have sections with substantial losses or which dry up in the middle of their course. These are also a type of karst stream sink providing recharge to solutional voids in the subsurface. Whilst some that sink into obvious holes in the riverbed have been identified, and there are some studies that provide evidence of river losses/drying, there has been no systematic study of the occurrence of karstic recharge through riverbeds in the Chalk, or Jurassic or Permian limestones. River flow data were not reviewed for these reports. The data presented are from a brief literature review, and there may be many other streams and rivers that provide point recharge into subsurface karstic features.

Caves and smaller conduits

Karstic caves (conduits large enough for humans to enter) occur in the Chalk and Jurassic and Permian limestones, providing clear evidence of the importance of karst in these aquifers. Caves were identified from literature review, predominantly from publications of the British Cave Research Association, and local and regional caving societies. Many chalk caves were identified by Terry Reeves of the Chelsea Spelaeological Society, who provided pictures and information about the caves, many of which are documented in the Chelsea Spelaeological Society Records.

Smaller conduits are observed in quarry walls and natural cliff outcrops, and in images of borehole walls. Conduits (~5 to >30 cm in diameter) and larger solutional fissures (apertures of > 2 cm) are commonly observed in images of abstraction and monitoring boreholes. However, there is no dataset on conduits, and they have generally not been studied or investigated, so it is not possible to assess their frequency or patterns in their distributions. Information on conduits from knowledge exchange and literature review are included, but the data are very limited in extent.

Dolines

Dolines provide direct evidence of karst, and may be indicative of rapid groundwater flow in the subsurface. They occur in the Chalk and Jurassic and Permian limestones. However, their identification can be challenging as surface depressions of anthropogenic origin (e.g. dug pits, subsidence features associated with the collapse of old mines, and dewponds) can appear similar to karst dolines. This is especially the case in the Chalk. The reports review the evidence for surface depressions in the area and discuss whether these are likely to be karstic or anthropogenic in origin.

Data on surface depression locations come from the BGS karst database in which they were identified by either desk study or during geological mapping. Other records of surface depressions were obtained through knowledge exchange and literature review, and studies of dolines in the area are summarised. In some areas there may be surface depressions/dolines that have not yet been identified.

Dissolution pipes

Dissolution pipes (a form of buried doline) only occur in karstic soluble rocks, and their presence is therefore evidence of karst. Their role in providing recharge into subsurface karstic features is poorly understood. Many of them appear to contain low permeability material and may be formed by in-situ bedrock dissolution and therefore may not be linked to larger dissolutional voids in the subsurface, but some may be associated with open solutional fissures in the subsurface.

Dissolution pipes occur at very high spatial densities in some areas, and are commonly encountered in engineering projects. Some data on dissolution pipes come from the Natural Cavities database. This is a legacy dataset held by the British Geological Survey and Peter Brett Associates. It is comprised of data from a range of sources originally commissioned by the Department of the Environment and reported by Applied Geology Limited (1993). In some areas dolines and dissolution pipes are not distinguished in the Natural Cavities database. Information from reports and papers with information on dissolution pipes in the area are summarised.

Springs

Large springs are indicative of connected networks of karstic voids to sustain their discharges. Data on spring locations were collated from the BGS karst and springs databases, and Environment Agency spring datasets. Further information on springs was obtained through knowledge exchange and literature review. The springs dataset presented in this report series is not complete, and there are likely to be more springs that have not been identified. In England there are very few data on spring discharges and most springs are recorded as of unknown discharge. However, in most areas some large springs with known discharges of > 10 or > 100 $l.s^{-1}$, have been identified. There are also some springs with no discharge data, but which are likely to be large (> 10 $l.s^{-1}$) based on visual observations during field visits, or based on their use as monitoring outlets in tracer studies. There remains much work to be done to develop a useful dataset on the discharges and characteristics of springs in the Chalk and Jurassic and Permian limestones, but the data presented here provide an initial overview, and suggest that large springs are common in these aquifers.

Tracer tests

Tracer tests provide direct evidence of subsurface karstic flowpaths in which groundwater flow is rapid. The development of cave-sized conduits is not a pre-requisite for rapid groundwater flow, and in these aquifers where cave development is limited, the karstic flowpaths may comprise connected networks of smaller conduits and solutional fissures.

Tracer test data were compiled from literature review and knowledge exchange. It is probable that most of the successful tests that have been carried out in these aquifers have been identified.

Other evidence of karst and rapid groundwater flow

This section provides an overview of other evidence of karst from literature review and knowledge exchange; and includes evidence from borehole monitoring or other hydrogeological studies.

There is substantial evidence of karst from groundwater abstractions from these aquifers. Whilst all successful abstractions are likely to be supplied by connected networks of solutional voids, the higher the transmissivity, the more widespread and well developed the karstic networks are likely to be (Foley and Worthington, 2021; Maurice et al., 2021). Transmissivity data from the national aquifer properties manual (Allen et al., 1997; MacDonald and Allen, 2001) are presented.

Knowledge exchange with water companies highlighted that in many areas water supply abstractions and springs have some characteristics that are indicative of karst. In some areas abstractions have indicators of low residence time groundwater and/or connectivity with surface water; for example high coliforms, high turbidity, detection of rapidly degrading pesticides, evidence of connectivity with the sea or surface rivers over long distances. These data are not presented to protect site confidentiality, but a general overview is provided where possible.

Acknowledgements

We thank Terry Reeve for providing information, pictures and surveys of the Isle of Wight sea level caves. We thank John Bloomfield at BGS for reviewing the report, and we thank staff from the Environment Agency, Southern Water and Wood PLC consultants for discussions on karst. This work was carried out under the Natural Environmental Research Council (NERC) Knowledge Exchange Fellowship Scheme, grant ref NE/N005635/1.

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1 Introduction

1.1 AREA/GEOLOGY

The C9 Chalk knowledge exchange area comprises the two areas of the Chalk on the Isle of Wight. Locations of towns and villages on the Isle of Wight, with the C9 boundary encompassing the two areas of Chalk are shown in Figure 1. The Chalk crops out in a thin east-west trending band in the centre of the Island which forms the Central Downs, and in the Southern Downs which form the high ground in the south of the Island (Figure 2). The area between these two chalk outcrop areas comprises the older deposits of the Selborne Group and the Lower Greensand Group which are non-karstic. The younger Palaeogene deposits overlie the Chalk outcrop of the Central Downs in the north. The geological structure of the island is complex, with faults, folds and steep dips, and is described in Hopson and Farrant (2015). The Central Downs comprises two zones of steeply dipping chalk to the east and west along major inversion structures, separated by an area of more gently dipping chalk in the middle forming a relay ramp structure. The Brighstone anticline occurs in the west, and the Sandown anticline in the east. The Chalk of the Southern Downs forms a series of flat or very gently dipping outliers of the Grey Chalk subgroup.

Most of the superficial deposits in the C9 area are Clay-with-Flints, which is present at topographical highs in the north and south (Figure 3). There are also alluvium and river terrace deposits around the streams and rivers and some sand and gravel on the interfluves. Landslip deposits are present in the south and far west.

There is little surface drainage on the Chalk, but the Chalk aquifer does contribute to some surface water courses. The two main river systems are the Yar and the Medina (Figure 2). These rivers rise on the Chalk of the Southern Downs and flow north across the non-karstic older geologies. They then cross the Central Downs where the Chalk may contribute some baseflow (Environment Agency, 2013; Island Rivers Partnership, 2021), with the River Yar crossing the Chalk north of Sandown, and the River Medina crossing the Chalk near Newport (Figure 2). These rivers then flow north over the younger non-karstic geologies to discharge into the Solent.

Just west of the River Medina, the Lukely Brook rises in the Bowcombe valley in the Central Chalk Downs and flows northeast across the Chalk joining the Medina at Newport (Island Rivers Partnership, 2021). The National River Flow Archive gives a base flow index of 0.85 between 1980 and 2020 (https://nrfa.ceh.ac.uk/data/station/meanflow/101003, Feb 2022). Further west, the Caul Bourne rises from Chalk springs near Calbourne and flows for a short section on the Chalk before reaching the overlying Palaeogene deposits (Island Rivers Partnership, 2021). In the south of the Central Chalk downs, the Buddle and Shorwell streams rise on the Chalk and flow south and west, joining to form the Brighstone stream which flows across the Lower Greensand to discharge into the sea at Grange Chine (Environment Agency, 2013).

There are numerous dry valleys on the Chalk of the Isle of Wight (Booth and Brayson, 2011; Allen and Crane, 2017), indicative of the capture of surface drainage into the subsurface.

1.2 WATER PROVIDERS AND REGULATORS

Southern Water is the only water provider on the Isle of Wight which is in the Solent and South Downs Environment Agency area.

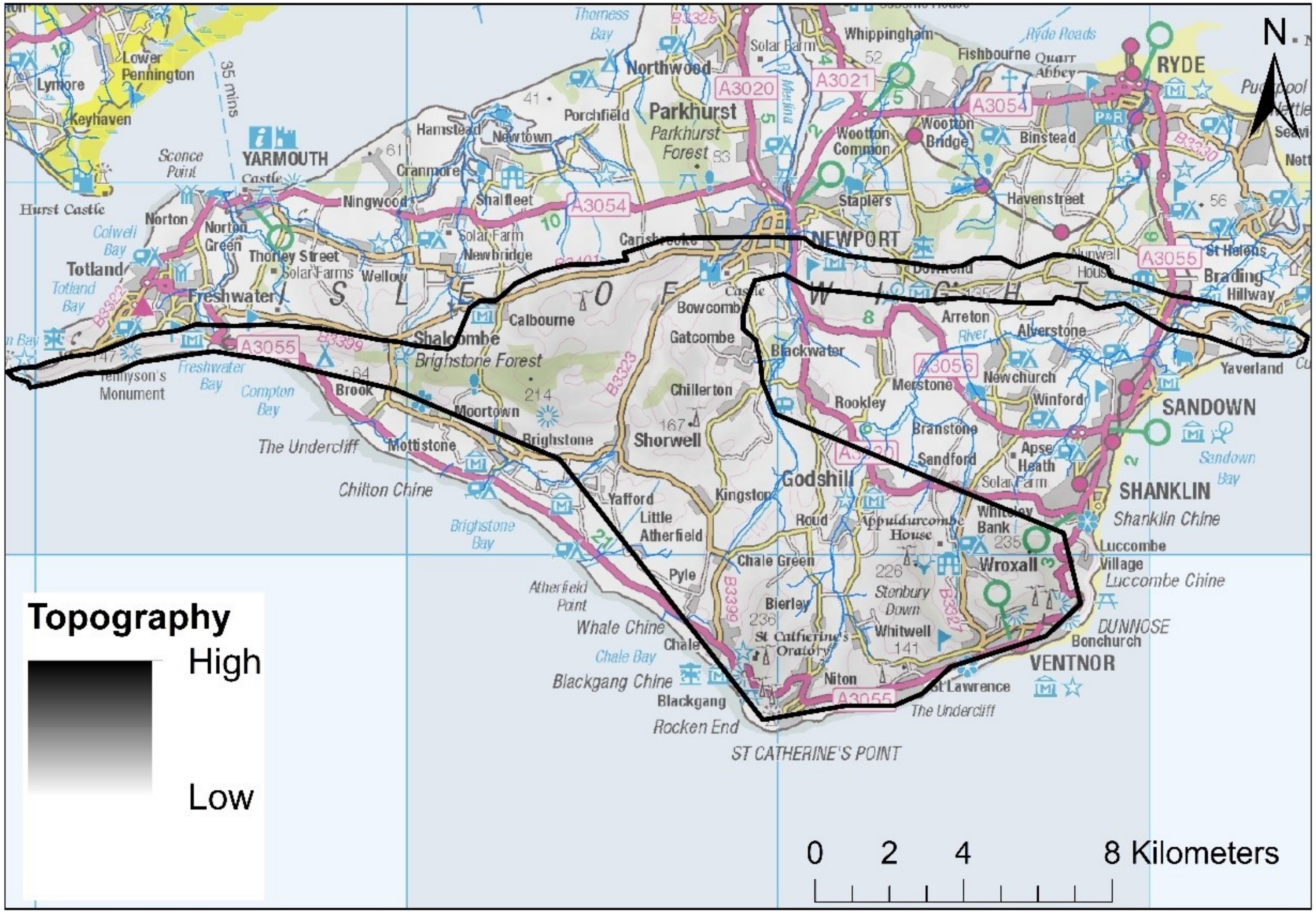

Figure 1. The Isle of Wight with the C9 area encompassing the northern and southern Chalk outcrops and the older geologies in between

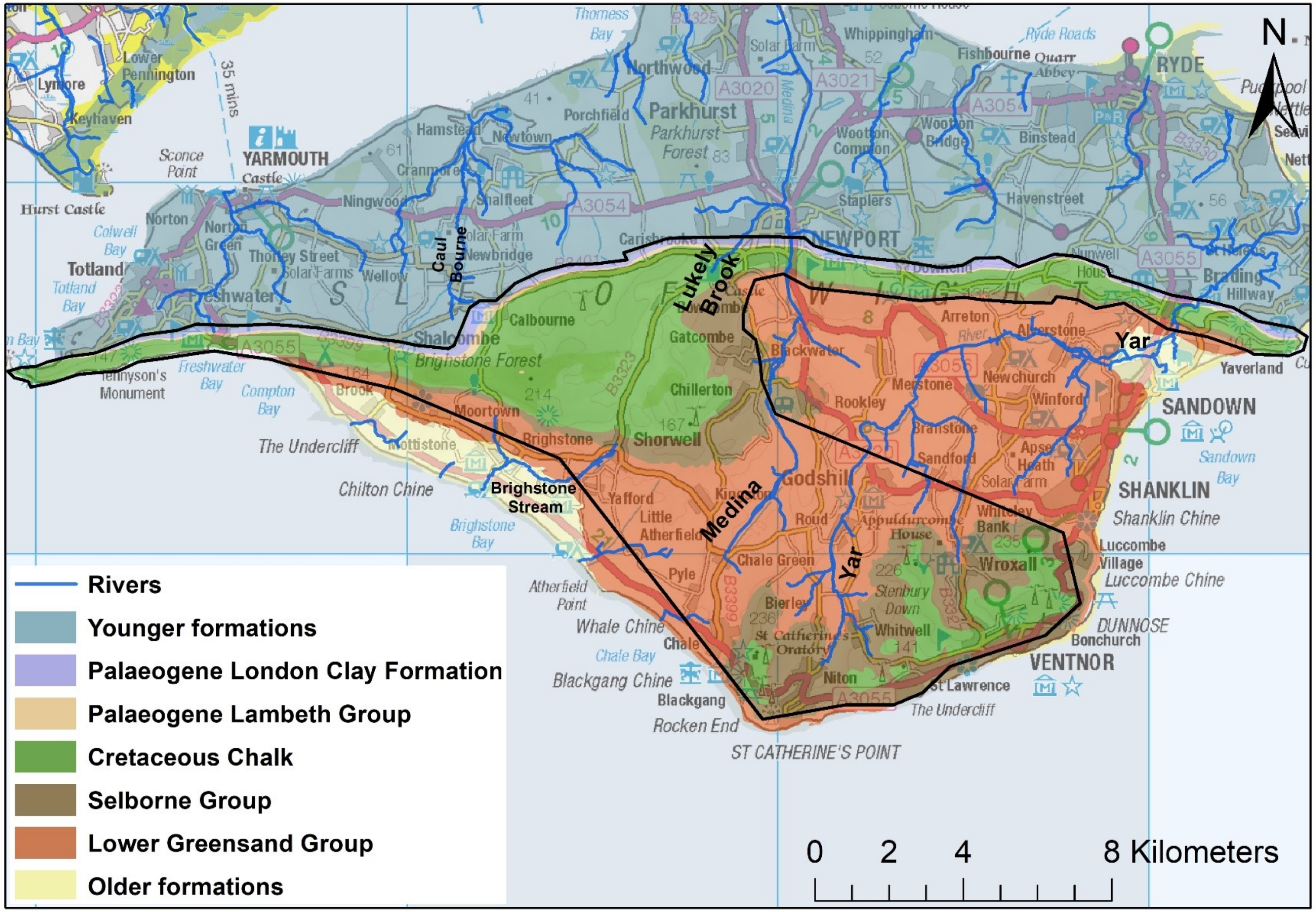

Figure 2. Bedrock geology and rivers on the Isle of Wight showing the northern (Central Downs) and southern (Southern Downs) Chalk outcrop areas

Table 1. Basic stratigraphy of Isle of Wight Chalk and adjacent geologies (Powell, 1998; British Geological Survey, 2013; Hopson and Farrant, 2015)

Group	**Formation**	**Lithology**	**Thickness**
Thames Group	London Clay Formation	Sandstone, siltstone and mudstone	70-73 m
Lambeth Group	Reading Formation	Mudstone	26-35 m
Chalk Group	Portsdown Chalk Formation	Chalk	< 110m
	Culver Chalk Formation		77-83 m
	Newhaven Chalk Formation		58-67 m
	Seaford Chalk Formation		73-95 m
	Lewes Nodular Chalk Formation		40-45 m
	New Pit Chalk Formation		14-27 m
	Holywell Nodular Chalk Formation		25-32 m
	Zig Zag Chalk Formation		35-57 m
	West Melbury Marly Chalk Formation		15-19 m
Selborne Group	Upper Greensand Formation	Sandstone and chert	33-46 m
	Gault Formation	Siltstone and mudstone	30-36 m
Lower Greensand Group	Monk's Bay Sandstone Formation	Sandstone	3-22 m
	Sandrock Formation	Sandstone and argillaceous rocks	0-70 m
	Ferruginous Sands Formation	Sandstone	0-140 m

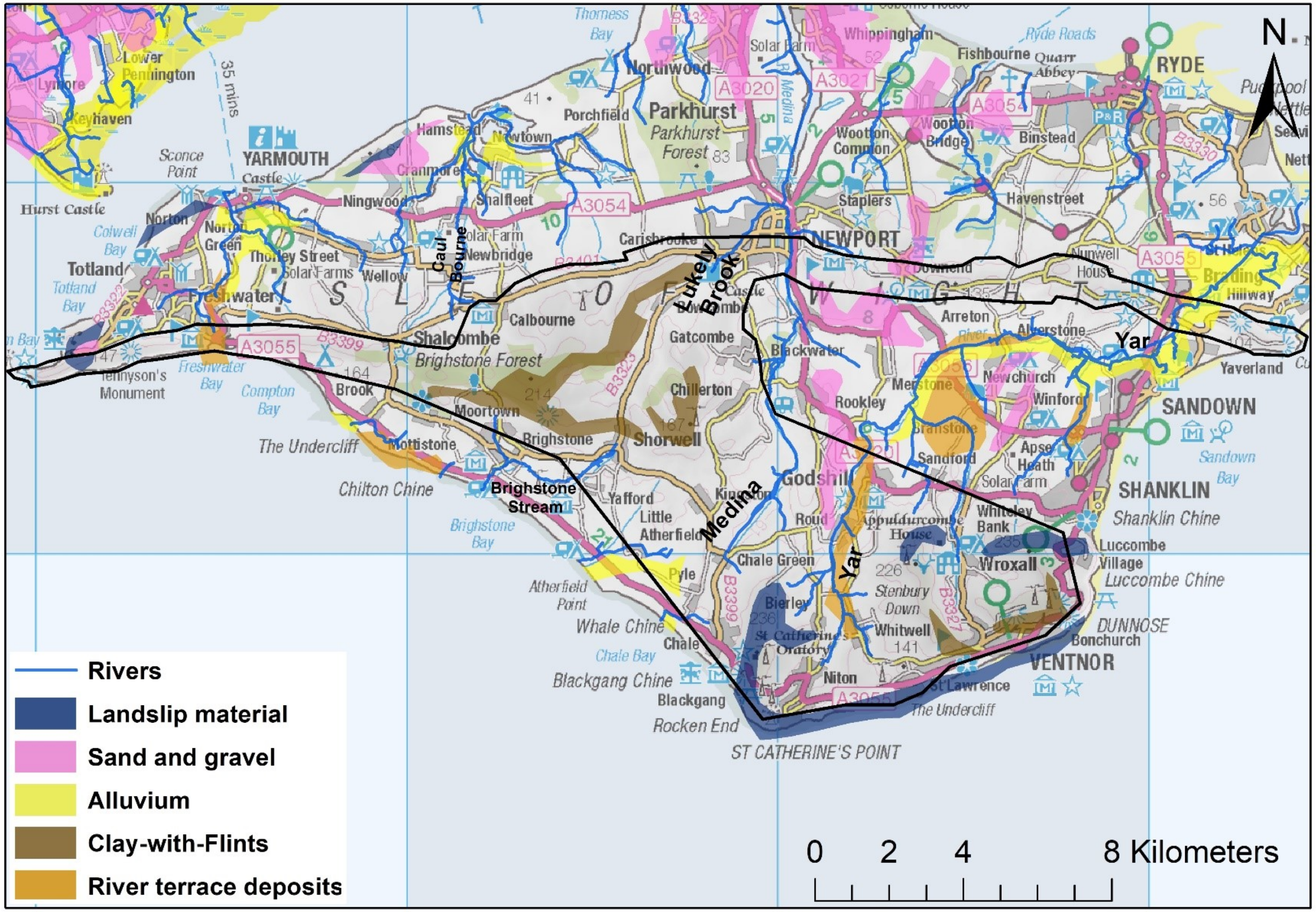

Figure 3. Superficial geology

2 Karst Geomorphology

2.1 CAVES AND CONDUITS

There is limited information on karstic conduit development in the Chalk of the Isle of Wight. Further assessment of borehole images to investigate the extent of conduit and fissure development would be useful; and further coastal surveys of Chalk cliffs would also provide more information on conduit development.

There are many coastal caves at sea level in the Chalk on the Isle of Wight (Reeve, 1982; 2021; Irving, 2006), and whilst these appear to be predominantly of marine origin, there may be some karstic component to them (Reeve, 1982; 2021). Irving (2006) reports on a survey of the Isle of Wight sea level caves that was conducted to determine the physical dimensions of the caves and the biological species present, but did not consider karst. Grid references are provided for 28 caves (20 west of Freshwater Bay, 5 East of freshwater Bay, and 3 in Culver Cliff at the eastern end of the Central Downs Chalk outcrop); along with surveys, photos and descriptions of the caves and their biology. Figure 4 shows the locations of these sea level caves recorded by Irving (2006). Reeve (personal communication 2017) has visited many of these sea level caves over the years and found that some caves have some evidence of karstic dissolution. He notes that there are more than 20 sea level caves, with Frenchmans Hole being the most extensive cave on the Isle of Wight. Details and pictures of this cave, and some general observations from Reeve (personal communication, 2017; 2022) on the sea level caves are provided below.

Conduits of fully karstic origin have been identified during recent BGS geological mapping, and the locations of these are also included in Figure 4. These comprise two sites in the Central Downs where small conduits are recorded in Chalk pits, and one site on the coast: Many small open and sediment filled karstic voids developed along fractures in the Lewes Nodular Chalk were observed in an old Chalk pit 350 m northwest of Arreton Manor (Figure 5). The chalk here dips at 50° to the north. A small, but well developed phreatic tube 0.2 m in diameter was noted in an active quarry near Duxmore Farm, 1.8 km NE of Arreton Manor. The conduit is in the Newhaven Chalk adjacent to a minor fault zone (Figure 6). At the west end of the island, several sediment filled conduits occur in the Portsdown Chalk immediately below the Palaeogene unconformity in the gully at the south end of Alum Bay (e.g. Figure 7).

In the valley west of Brighstone Down (Calbourne Bottom, pink triangle on Figure 4), a borehole [SZ48SW_1] revealed a 2 m high sediment filled cavity at 25-27 m depth. The sediment comprises yellowish brown very gravelly sand and clayey sand with some thin clay seams. This suggests significant karst development in the subsurface in this area.

Mortimore (2011) notes that karst and dissolution is associated with the main faults and fracture directions. He describes a fault in Cheverton Farm Quarry (SZ 455 846) noting that there is an "intense fracture zone and karst system along a strike of 290-312°". Mortimore (2011) also reports "dissolution along bedding features" in the Newhaven Chalk Formation at Ashengrove Farm New Pit, east of Calbourne in the Central Chalk. The locations of these conduits are also included in Figure 4.

All these karst conduits formed in the past and are not hydrologically active. But their presence, and the evidence for karstic dissolution in some of the sea level caves indicate the potential for karstic conduit development in the Chalk of the Isle of Wight. The extent of saturated zone conduit development is unclear and image logs for abstraction/monitoring boreholes that can reveal the presence of karstic conduits and fissures have not been considered in this report. However, the other evidence for karst presented in the report suggests that there is likely to be some karstic conduit development in the saturated zone.

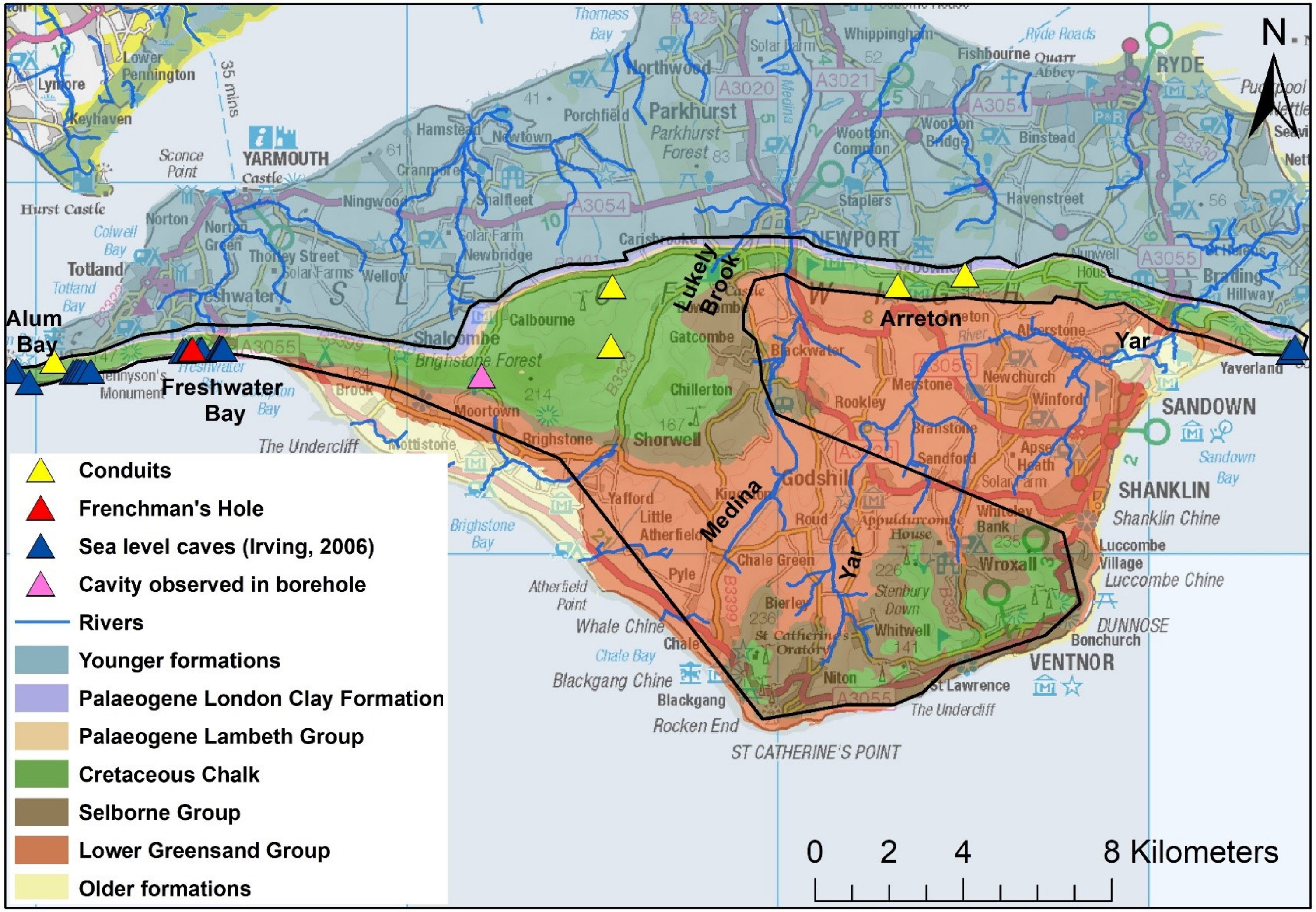

Figure 4. Locations of caves and conduits in the Isle of Wight Chalk

Figure 5. Conduits in an old pit near Arreton (photos A Farrant, BGS).

Figure 6. Phreatic tube exposed in Duxmore quarry (Photo A Farrant, BGS).

Figure 7. Cavities in the Portsdown Chalk, just below the Palaeogene unconformity, Alum Bay (Photo A Farrant, BGS).

2.1.1 Frenchman's Hole, Watcombe Bay, Isle of Wight

This cave is described in Reeve (1982; 2021); and during personal communication with Reeve (2017): Frenchman's Hole is also known as Watcombe Bay Cave, and is a system of roomy passages and very large interconnected chambers accessible by six entrances. The biggest chamber is 20 m long and 15 m wide. The cave has a total length of over 120 m and a floor area of 745 m^2 which makes it the biggest chalk cave on the Isle of Wight (Reeve, 1982). This cave is at sea level and so likely to have a marine rather than a karst origin. However, it is developed on a flint layer and solutional features on the walls together with the shapes of the passages could indicate karstic development. The Chalk is steeply dipping at this location.

2.1.2 Isle of Wight sea level caves

Caves within the Chalk sea cliffs of the Isle of Wight are described by Reeve (1982), who reports that 14 of the 21 known caves have been surveyed with a total length of about 530 m. Reeve also describes the Isle of Wight sea caves in CSS (1979). The Isle of Wight sea level caves are likely to be predominantly of marine origin. However, there is some evidence of karstic development with passage shapes that appear similar to phreatic (sub water table) karstic cave passages. For example, Arch Cave in Freshwater Bay has dome structures in the roof of a large chamber, which appear to be of a karstic origin; and Anemone Cave, also in Freshwater Bay, is about 60 m long, and has some sections which resemble classical phreatic karst (Reeve, 1982). There are also small conduits within Anemone Cave that appear to have been formed by freshwater karstic dissolution in the past, and a 2.5 m circular dimeter tube; and this cave may be a remnant of a karstic cave that has been invaded and enlarged by the sea (Reeve, personal communication, 2022).

In Mermaids Cave in Freshwater Bay, there is a high level side passage which goes up and links to another entrance 6 m above sea level (Reeve, 1982), and this complexity suggests a karstic rather than marine origin. Reeve (personal communication, 2022) notes that there are some sediment filled caves and cavities (not vertical pipes) between Arch Cave and Mermaid Cave in Freshwater bay which are clearly karst features; as well as some inaccessible chalk caves high up in the south face of Culver Cliffs. Reeve (personal communication, 2017) also suggested that there are some karstic caves on the coast where side passages are developed in the Ventnor area (the southeast of the Southern Downs Chalk, see Figure 4 for the location of Ventnor). Figure 8 to Figure 15 are some pictures of sea level caves provided by Terry Reeve, and surveys of some of the sea level caves which were drawn by Terry Reeve are provided in Appendix 1.

Figure 8. View to sea side entrance of Frenchman's Hole (photo courtesy of Terry Reeve)

Figure 9. One of the chambers of Frenchman's Hole (photo courtesy of Terry Reeve)

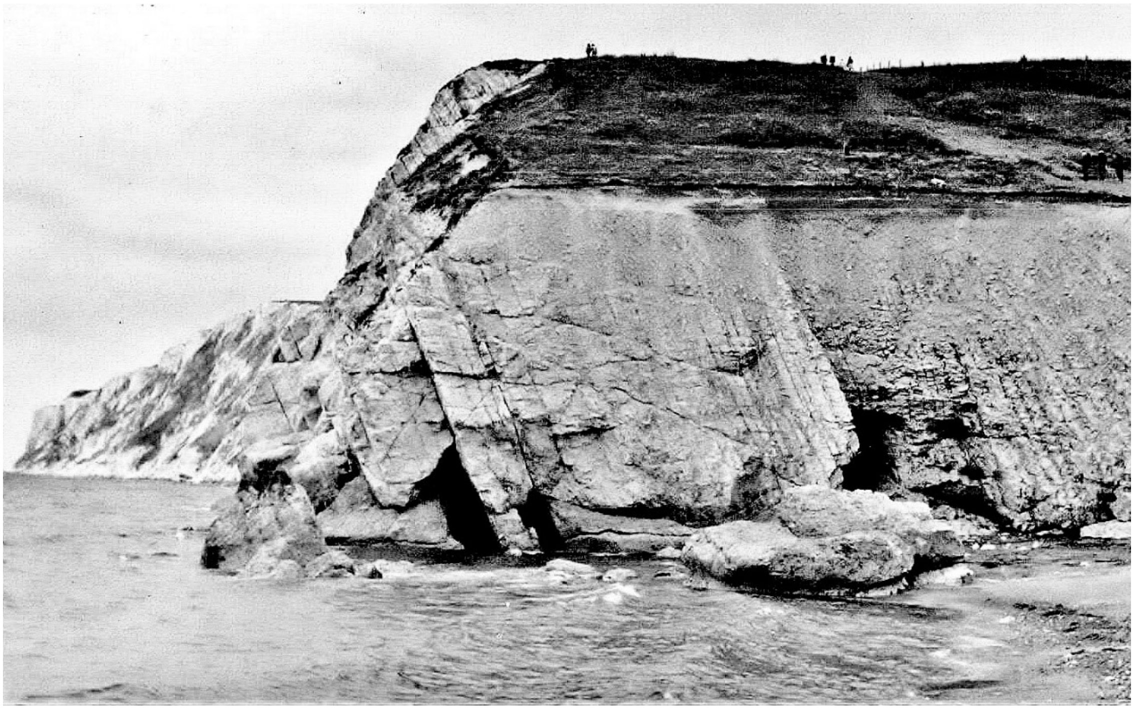

Figure 10. Side entrances to caves in Watcombe Bay (photo courtesy of Terry Reeve)

Figure 11. West entrance to arch cave (photo courtesy of Terry Reeve)

Figure 12. Seaward entrance to Arch Cave with arch beyond (photo courtesy of Terry Reeve)

Figure 13. The Arch with caves in Freshwater Bay in the distance (photo courtesy of Terry Reeve)

Figure 14. The nostrils cave entrances, Culver Cliff (photo courtesy of Terry Reeve)

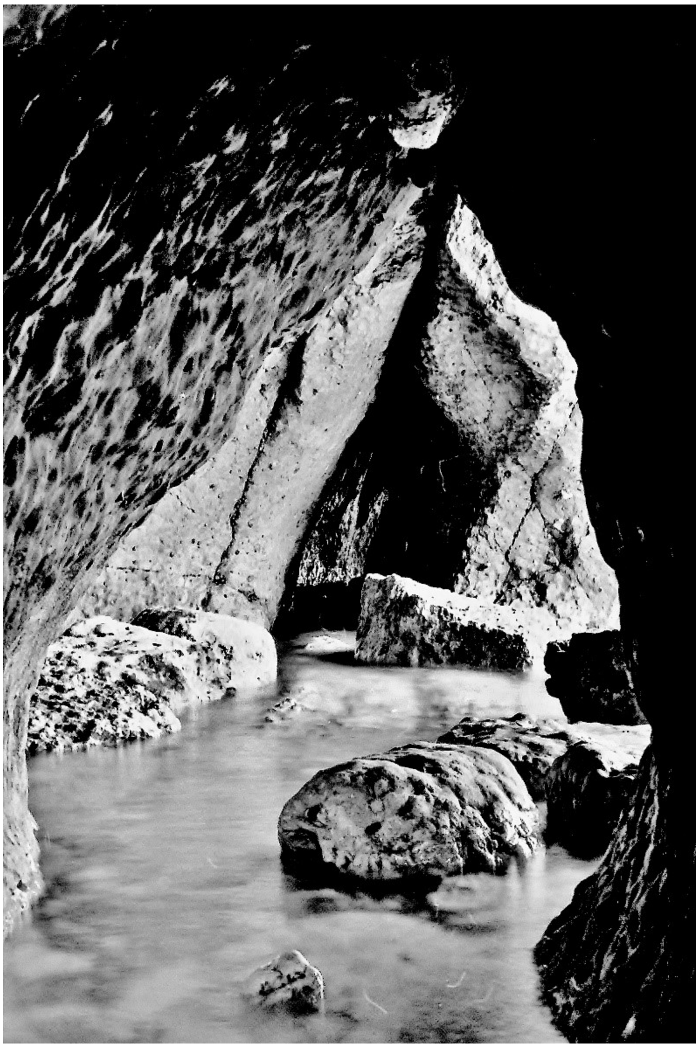

Figure 15. Anemone cave, Freshwater Bay (photo courtesy of Terry Reeve)

2.2 STREAM SINKS

Two stream sinks have been identified from geological mapping in the area east of St Georges Down (Hopson and Farrant, 2015). The locations are shown on Figure 16 and Figure 17. The largest is a sink 0.5 km south of Great East Standen Farm, 1.6 km WNW of Arreton Manor. Here a small stream draining the Lower Cretaceous strata seeps underground in nettle filled hollows where it crosses onto the steeply dipping Chalk (Figure 18). According to the farmer, small collapse dolines regularly appear in a valley to the north. A smaller, less well defined sink occurs in the adjacent valley to the east, near Great East Standen Manor. Here a small ephemeral stream seeps away underground, with some evidence of small dolines. The groundwater outlets for these stream sinks are unknown. Further work to examine the groundwater contours in this area and to identify the likely natural groundwater outlets (springs) would be useful, as well as determining any groundwater abstractions which may intercept these karst networks.

Allen and Crane (2017) report that "there is a flow of groundwater out of the high elevation 'Plateau gravels' at St George's Down, just east of Newport onto the Chalk and down a sinkhole". The "Plateau gravels" are the St Georges Down gravel member. It is not clear which feature this refers to, but it is likely to be the steam sink at Great East Standen Farm.

The Palaeogene overlies the Chalk in the north of the area. In other areas of England stream sinks are associated with this geological boundary where there is a thin Palaeogene cover overlying the Chalk. However, on the Isle of Wight, the steep dip means that the Palaeogene rapidly increases in thickness; and the topography is such that drainage from the Palaeogene does not flow onto the Chalk which lies at a higher elevation and therefore stream sinks are not associated with the geological boundary (Maurice et al., 2011).

It is unclear whether the few surface water courses that cross the Central Chalk outcrop (the Lukely Brook and the Yar and Medina rivers; see Figure 2) contribute any point recharge via losses to the Chalk aquifer, although some suggestion that the aquifer contributes to these rivers (See Section 2.4). The contribution of soakaways and SUDs (Sustainable Urban Drainage systems) to point recharge has also not been considered for this report, but if any of these have high infiltration rates to the Chalk they must be feeding into some sort of karstic solutional network.

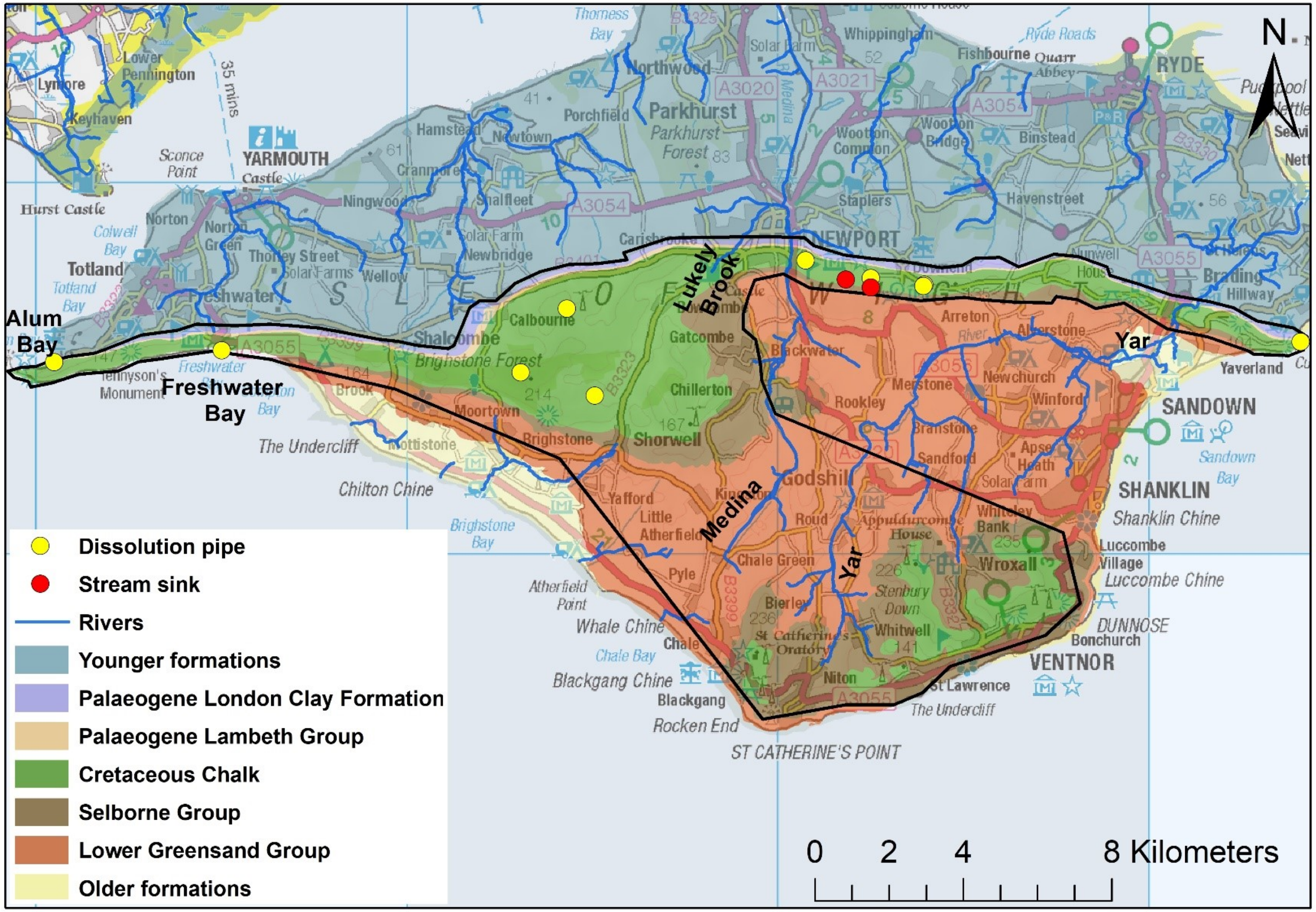

Figure 16. Locations of stream sinks and dissolution pipes in the Isle of Wight Chalk

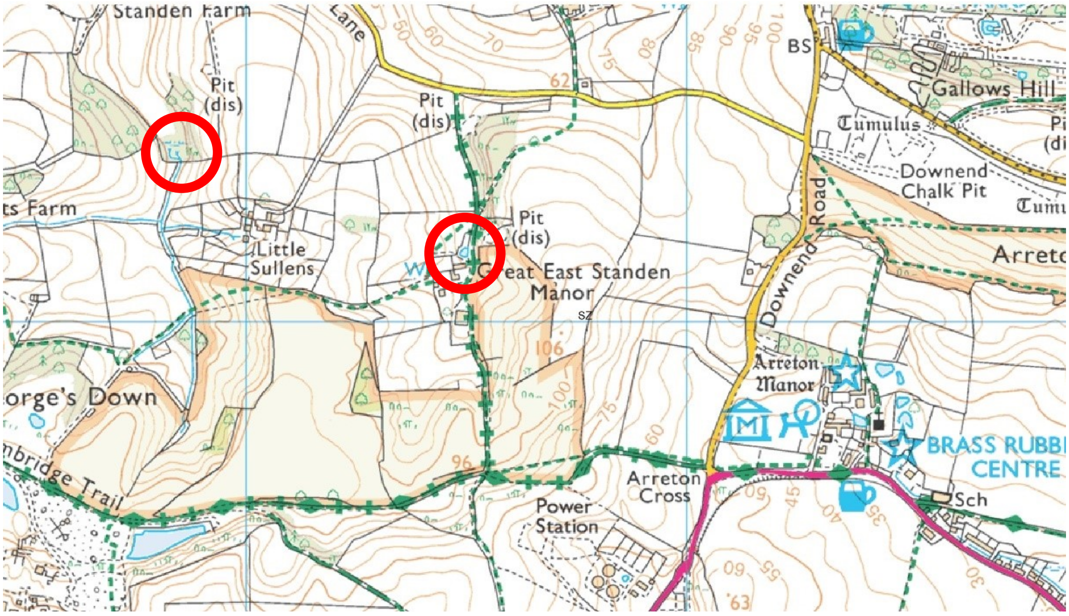

Figure 17 Stream sinks in the Central Downs.

Figure 18. Depression at Great Standen stream sink (Photo A Farrant, BGS).

2.3 DOLINES AND DISSOLUTION PIPES

There is some information on dolines and dissolution pipes on the Isle of Wight. In karst maps of the Chalk in England (McDowell et al., 2008; Edmonds, 2008), solution features, which include dolines and dissolution pipes, are shown to be present on the Isle of Wight, particularly associated with the Central Downs Chalk outcrop. Karstic dissolution features can be observed where the unconformity between the Chalk and the overlying Palaeogene Lambeth Group is exposed in the west at Alum Bay and in the east at Whitecliff Bay (McDowell et al., 2008; observations during BGS geological mapping). McDowell et al. (2008) report that at these locations the Chalk dips steeply and has a very irregular surface with sediment filled solution pipes. Hopson (2011) also notes that the sub-Palaeogene unconformity is extensively modified by dissolution of the underlying Chalk with "karst features in evidence in most exposures".

A complex network of dissolution pipes and sediment filled conduits is exposed in the south face of Downend quarry 450 m NE of Arreton Manor, developed within the Seaford Chalk (Figure 19), with another dissolution pipe exposed in the east face of the quarry. Similar dissolution pipes were exposed by quarrying activities beneath superficial gravel deposits on St Georges Down near Newport (Figure 20). The underlying Seaford Chalk is eroded into a very irregular pinnacled rockhead with deep pipes infilled with gravel.

A photograph of dissolution pipes at Ashengrove Farm New Pit in the Central Downs east of Calbourne is documented in Mortimore (2011). The same feature was noted during recent geological mapping (Figure 21). Mortimore (2011) also reports that there are "large depressions" associated with Clay-with-Flints deposits on the high ground of the Central Chalk Downs above Rowridge on Stainston Down and New Barn Down; and suggests that these may be dissolution pipes. They could also be old Chalk pits. They are not included on Figure 16 as the locations are uncertain.

In Brighstone Forest, a temporary exposure on a forestry track 250 m northwest of the triangulation point revealed a mass of Palaeogene sand and clay infilling a large dissolution pipe. Several other small depressions in the vicinity may be natural dolines. A few small dissolution pipes also occur in the south eastern corner of Freshwater Bay.

Overall, surface karst solution features appear to be less concentrated in the Isle of Wight Chalk than in many other Chalk outcrops in England. The map of solution features in the English Chalk from Edmonds (1983) gives an estimate of solution feature concentration of 5 to 10 features per 100 km^2 for the Central Downs chalk of the Isle of Wight, whilst the South Downs Chalk of the Isle of Wight appears to have less than 5 features per 100 km^2. This is largely due to the limited cover of Clay-with-Flints covering the Chalk outcrop, and the steep dip.

A new survey of surface karst features on the Isle of Wight using both desk based methods and field mapping was conducted by Wood Consultants in 2021.

Figure 19. Complex of sediment filled pipes and conduits in the Seaford Chalk, Downend Pit. (Photo A Farrant, BGS).

Figure 20. Dissolution pipes beneath gravel deposits, St Georges Down. (Photo A Farrant, BGS)

Figure 21. Dissolution pipes at Ashengrove Farm New Pit (photo A Farrant, BGS)

2.4 SPRINGS

There are 19 recorded springs in the Chalk of the Isle of Wight, and 31 which are within the Selborne Group (Figure 22). The latter are likely to be discharging from the Upper Greensand Formation (Table 1). On the Isle of Wight, in many places the Chalk and the underlying Upper Greensand Formation are thought to be in hydraulic continuity (and in many places the Chalk is unsaturated), with spring discharges through the upper permeable parts of the Upper Greensand Formation (Allen et al., 1997; Allen and Crane, 2017; Maurice et al., 2011). These Upper Greensand springs are therefore likely to discharge groundwater from the Chalk. Figure 22 also shows the locations of other springs located on younger and older strata from BGS records (red circles). It is possible but not likely that those that are close to the Chalk or Selbourne Group could be discharging some groundwater from the Chalk.

Several water courses on the Isle of Wight rise via springs in the Chalk. In the South Downs, the River Medina rises from springs near Chale and the Eastern Yar rises from springs near Nitton (Environment Agency, 2013). In the Central Downs Chalk, the Lukely Brook, the Caul Bourne stream, and the Buddle and Shorwell streams (which combine to form the Brighstone stream) rise from springs in the Chalk (Environment Agency, 2013; Mortimore, 2011; Allen and Crane, 2017). Mortimore (2011) reports that during a survey in flood conditions the source of the Lukely Brook seemed to be at the base of the Holywell Chalk at the contact with the Plenus Marls, with downstream springs associated with the Chalk/Upper Greensand boundary on the northeast side of the valley. Mortimore (2011) also reports that there are springs near Gotten Leaze near Calbourne.

The Island Rivers website (http://www.islandrivers.org.uk/the-rivers/west-wight-rivers/caul-bourne/) report that the main source of the Caul Bourne is from springs feeding a pond at Westover Manor on the edge of Calbourne village. The website also reports that the discharge from these springs increases substantially following prolonged rainfall and that this also causes new springs to emerge and normally dry channels to become active. This suggests that there are well developed networks of karstic fissures and conduits in this area.

Allen and Crane (2017) report that there are down-dip springs at Afton (Freshwater) and Brading; and overflow springs at Ashey, Knighton (historical), Shalcombe, Brighstone (Buddlehole) and some locations along the northern Chalk-Palaeogene contact; and suggest that the Chalk is “highly fractured” in these areas, which implies that there may be karstic solutional networks supplying these springs, although there is no information on the spring discharges. Booth and Brayson (2011) also suggest that there are springs near Calstone at the boundary between the Chalk and the overlying Palaeogene deposits. It has not been possible to locate these springs (or Calstone) using old topographical maps. Allen and Crane (2017) also report groundwater discharges in the Central Chalk-Upper Greensand area to the Sheat Stream (Chillerton), and the Gatcombe stream; and a spring at Froglands Farm (south of Carisbrook Castle) at the Upper Greensand-Chalk contact.

There are few data on spring discharges for the Chalk of the Isle of Wight, and given the reduced river flows due to groundwater abstractions (Environment Agency, 2013), it is likely that spring discharges have been substantially reduced. Three springs in the Southern Downs were reported to have discharges of between 2 and 6 $l.s^{-1}$ (Whitaker et al., 1910). Springs on the Isle of Wight are discussed by Maurice et al. (2011) who note that springs are common at the boundary between the Upper Greensand Formation and the underlying Gault Clay Formation, and have caused landslips, especially in coastal areas. Maurice et al. (2011) discuss a survey of 23 springs in the South Downs carried out by Lockett (1985) in the summer of 1985. Most of the spring flow observed during this survey was through the landslip deposits, with an estimated total of 124 $l.s^{-1}$. Most individual springs had flows of less than 5 $l.s^{-1}$, but there was one with a substantial flow of 21.7 $l.s^{-1}$. Maurice et al. (2011) report that small water supplies were obtained from springs in the Chalk-Upper Greensand aquifer prior to the development of mains supply; and that a few larger water supplies come from springs, although with yields augmented by adits and boreholes. Overall larger springs (> 20 $l.s^{-1}$) which occur commonly in the Chalk on the mainland appear to be rare on the Isle of Wight (Maurice et al., 2011), which may be because the Chalk outcrop is narrow and catchment areas are limited.

It is likely that there are additional springs which are not recorded on Figure 22. There are many records of springs on old Ordnance Survey maps, and these can be observed on the National library of Scotland side by side viewer of historic maps and LIDAR data (https://maps.nls.uk/geo/explore/side-by-side/#zoom=10&lat=50.67116&lon=-1.32822&layers=10&right=LIDAR_DTM_2m). These records were not systematically assessed to identify all springs discharging Chalk groundwaters on the Isle of Wight, although they were used to identify the locations of springs mentioned in the literature.

3 Tracer tests

There are no records of any tracer tests conducted in the Chalk of the Isle of Wight.

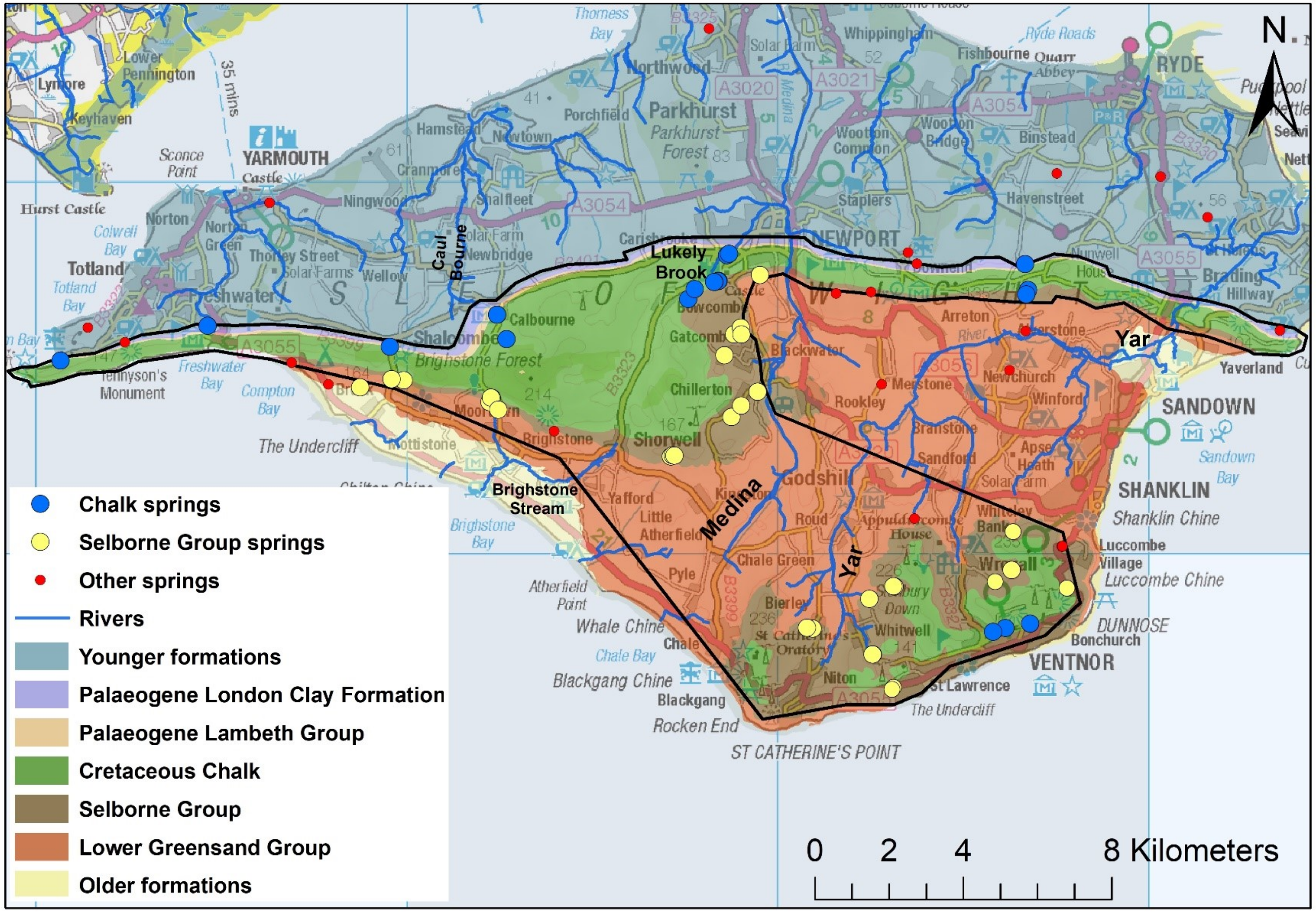

Figure 22. Locations of springs in the Isle of Wight Chalk and Selborne Group

4 Other evidence of karst and rapid groundwater flow

The BGS aquifer properties dataset (Allen et al., 1997) does not include many transmissivity estimates for the Chalk of the Isle of Wight (Figure 23). There is one datapoint with a high transmissivity of 3400 m^2/day (the large pink triangle on Figure 23), and four datapoints with much lower transmissivities of 140 to 300 m^2/day. Two of these sites are discussed further in Maurice et al. (2011) who report that there have been two prolonged constant rate pumping tests in the Chalk of the Central Downs at Shalcombe and Ashey, and that these indicate transmissivities of 220 to 280 $m^2.d^{-1}$, which is lower than the median transmissivity for the unconfined Chalk of England (920 $m^2.d^{-1}$ reported by MacDonald and Allen, 2001). Maurice et al. (2011) note that these sites are located in a narrow Chalk outcrop and are impacted by boundary effects and the steep dip, and may not be representative of the Chalk on the Isle of Wight more generally. Maurice et al. (2011) also report that a short term pumping test in the Bowcombe valley (location shown on Figure 23) where the outcrop is wider, indicated a transmissivity of 1500 $m^2.d^{-1}$ from the Chalk/Upper Greensand aquifer (Aquaterra, 2008). Maurice et al. (2011) report that yields from the Chalk on the Isle of Wight are generally lower than on the mainland (1-1.8 $Ml.d^{-1}$ compared to > 10 $Ml.d^{-1}$), suggesting that this could be because the outcrop area is small, the steep dip restricts the lateral extent of bedding dominated flow; and /or faults filled with impermeable material may create flow barriers. Maurice et al. (2011) also note that maximum and minimum groundwater levels occur early in the summer and winter suggesting limited storage.

Indicators of karst at abstraction boreholes (e.g. conduits observed in borehole images/adits; water quality indicators of rapid groundwater flow) have not been considered for this report. Maurice et al. (2011) report generally good bacteriological water quality, with coliforms occasionally present at some sides indicating a rapid groundwater flow component.

In a 2022 project for the Environment Agency, the BGS has created GIS based karst domains that reflect the likelihood of the presence of solutional pathways in the unsaturated zone connecting the surface to the saturated zone, based on currently available data and conceptual understanding. The project area includes the Isle of Wight.

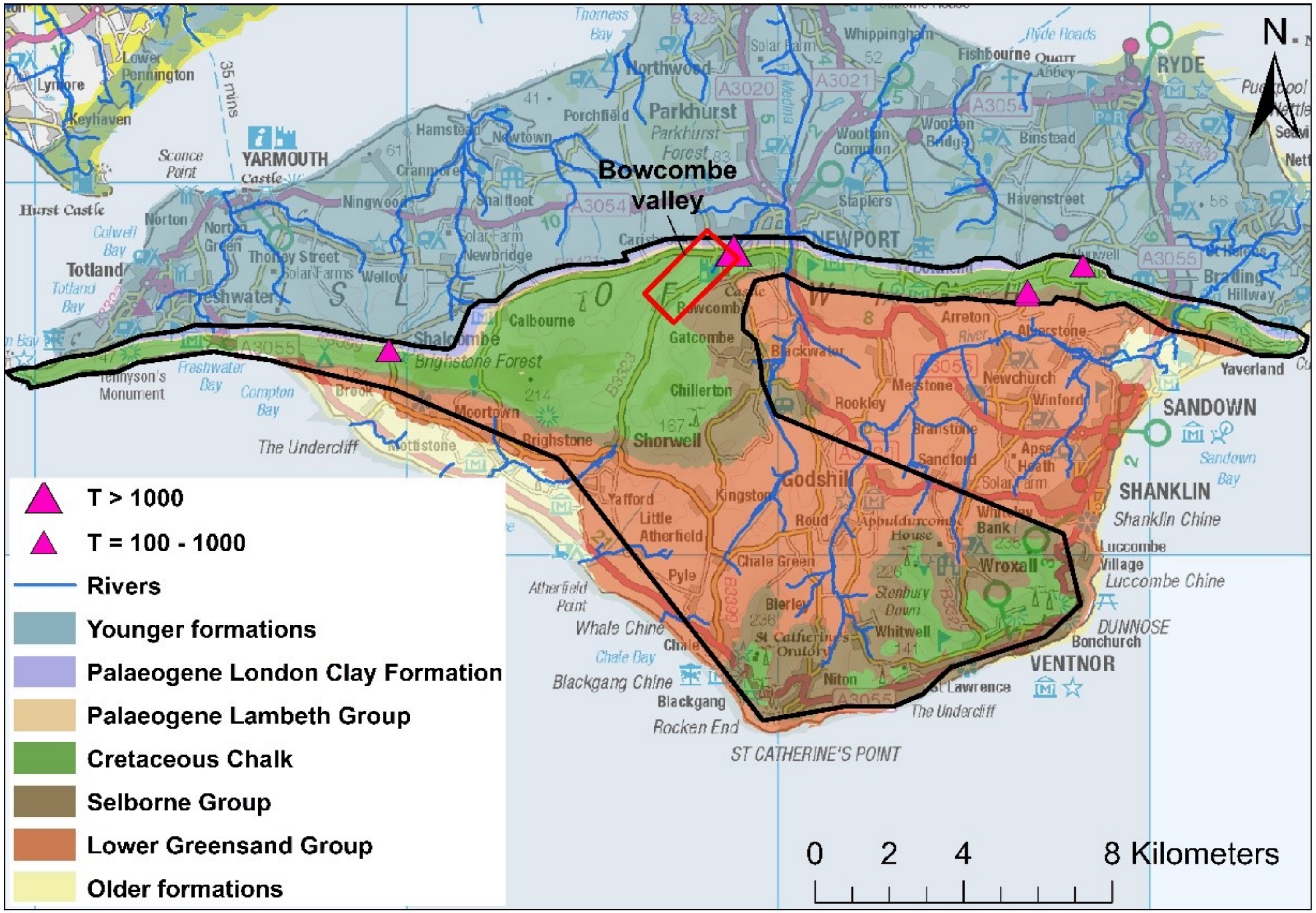

Figure 23. Transmissivity data for the Isle of Wight Chalk.

5 Summary

- There is evidence for karst in the Chalk of the Isle of Wight, with conduits, stream sinks, springs, dry valleys, dissolution pipes, and dolines present.
- The available data suggest that solutional karstic development of the Chalk may be more limited than in some areas of the mainland.
- Stream sinks are largely absent with the exception of two small stream sink on St George's Down in the Central Chalk Downs.
- Dolines and dissolution pipes appear to be less common than on the mainland, and distinguishing dolines from anthropogenic pits is difficult. However, some dissolution pipes and small dolines have been observed, mostly in the Central Chalk Downs.
- Small or sediment filled karst conduits have been observed in coastal outcrops, inland quarries, and a borehole.
- There are more than 20 sea level coastal caves in the Isle of Wight Chalk, some of which have some evidence of karst.
- Spring records are incomplete but 50 springs that rise on or are likely to be fed by the Chalk are reported here.
- Springs occur in association with the Chalk-Palaeogene boundary; at the boundary between the Chalk and the Upper Greensand; with further springs in the Upper Greensand discharging water from the Chalk where the two aquifers are in hydraulic continuity.
- There is little information on spring discharge, but larger springs appear to be rare.
- No tracer tests have been reported for the Isle of Wight.
- The small number of Chalk transmissivity values for the island suggest generally lower transmissivity than on the mainland, although two sites have transmissivities > 1000 $m^2.d^{-1}$, indicating well connected solutional networks.
- Occasional coliform detections in groundwater suggest some rapid groundwater flow.
- Further work is needed to assess the extent of karstic development in the Chalk of the Isle of Wight, which could include coastal surveys, consideration of karstic indicators at abstraction boreholes, investigations of spring discharges, and tracer tests.
- Coastal surveys and borehole imaging studies could be combined with geological data to investigate the extent of, and controls on, karstic conduit/fissure development.
- Indicators of rapid groundwater flow at abstractions, and tracer tests (single borehole dilution tests and point to point tracer tests) could be used to investigate where rapid groundwater flow is occurring.

Glossary

Cave: A subsurface solutional conduit large enough for humans to enter.

Conduit: A subsurface solutional void which is usually circular or cylindrical in cross section. In these reports the term is used predominantly for conduits which are too small for humans to enter.

Doline: A surface depression formed by karst processes.

Dissolution pipe: A sediment filled solutional void at rockhead in the subsurface, often with no surface expression.

Dissolution tubules: Networks of small cylindrical solutional voids ~ 0.5 cm in diameter found in the Chalk.

Estavelle: A karst feature in a stream or river which acts as a spring under high water levels and a sink under low water levels.

Fissure: An enlarged fracture with aperture of ~ 0.5 to > 2 cm, and a planar cross-sectional shape. In these reports the term is used for fractures that are enlarged by dissolution. Those developed on bedding partings may extend laterally both along strike and down dip.

Inception horizon: Lithological horizon which favours dissolution and the development of fissures, conduits and caves.

Karst: Term applied to rocks which are soluble and in which rapid groundwater flow occurs over long distances. The development of subsurface solutional voids creates characteristic features including caves, dolines, stream sinks, and springs.

Scallop: Small-scale dissolution features on cave walls caused by the flow of water which indicate the direction and relative speed of groundwater flow.

Sinkhole: Term widely used for surface depressions. These may be karstic in origin and synonymous with dolines, but can also arise from surface collapse into anthropogenic voids such as mines and pits. This term is not used for surface depressions in these reports due to the confusion arising from sinkholes of both karstic and anthropogenic origin. The term has also been used for the actual hole into which water sinks into karstic voids in the subsurface through the base of a stream or river, and may be used in this context in these reports.

Stream sink: A stream which disappears into solutional voids in a karst rock. The stream may fully sink into a closed depression or blind valley or may partially sink through holes in the stream bed. The term is used in these reports in preference to sinkhole which can be confused with dolines or depressions caused by collapse into anthropogenic voids.

Surface depression: The term used in these reports for all surface depressions where it is unclear whether they are karstic or anthropogenic in origin.

Swallow hole: Another term for stream sink, although it has been used in the past for dry dolines that do not contribute surface runoff to the aquifer. Therefore the term stream sink is generally used in these reports, as the presence of an active stream recharging the aquifer is directly inferred.

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British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://envirolib.apps.nerc.ac.uk/olibcgi.

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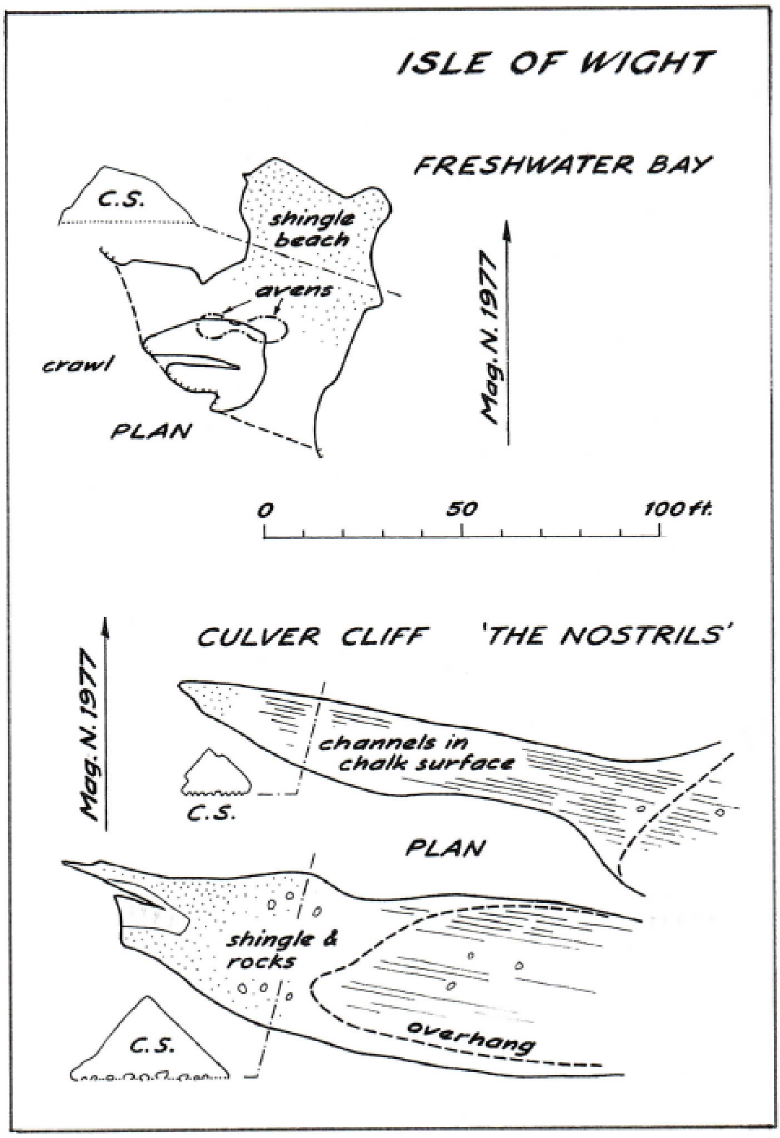
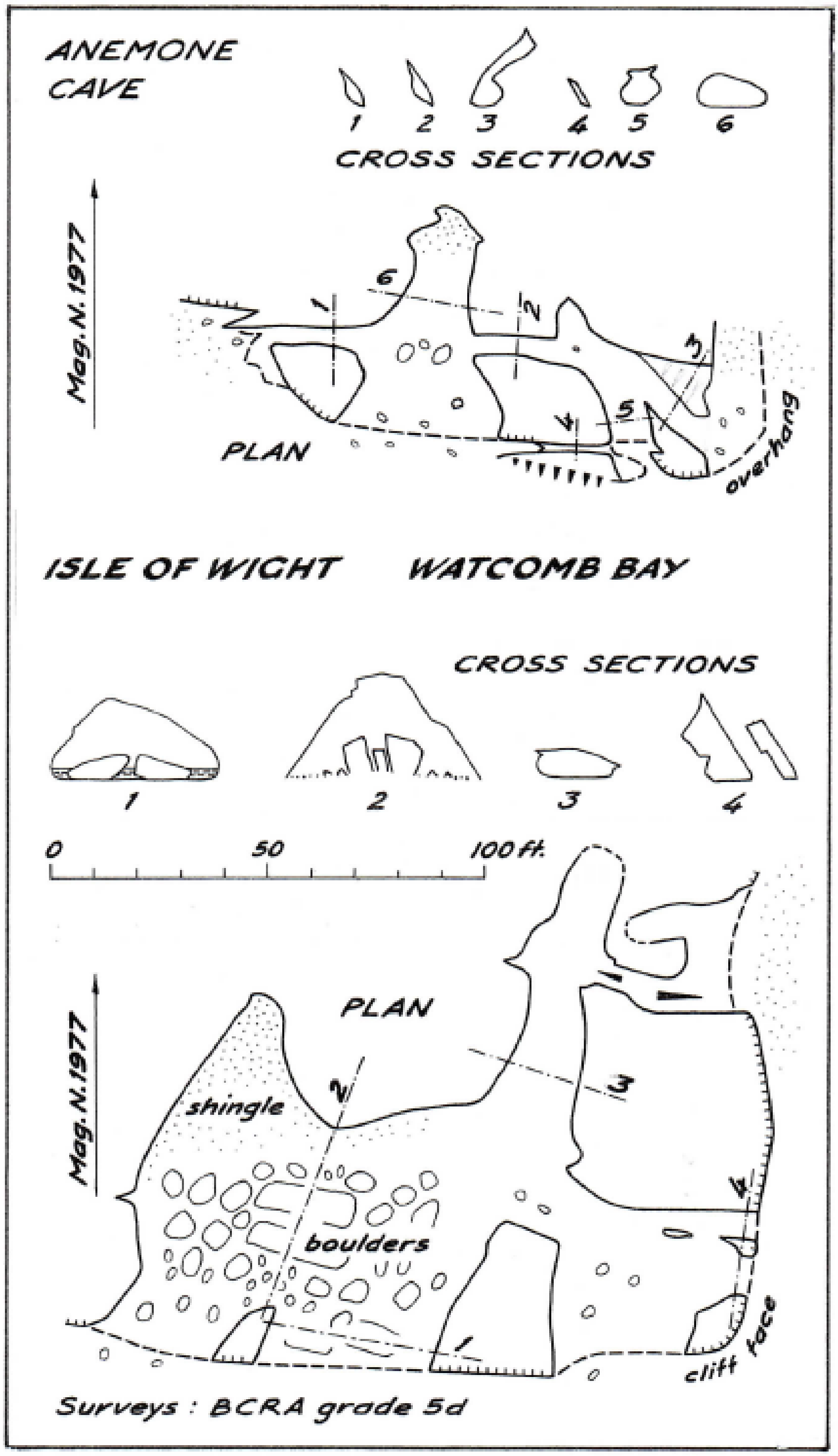
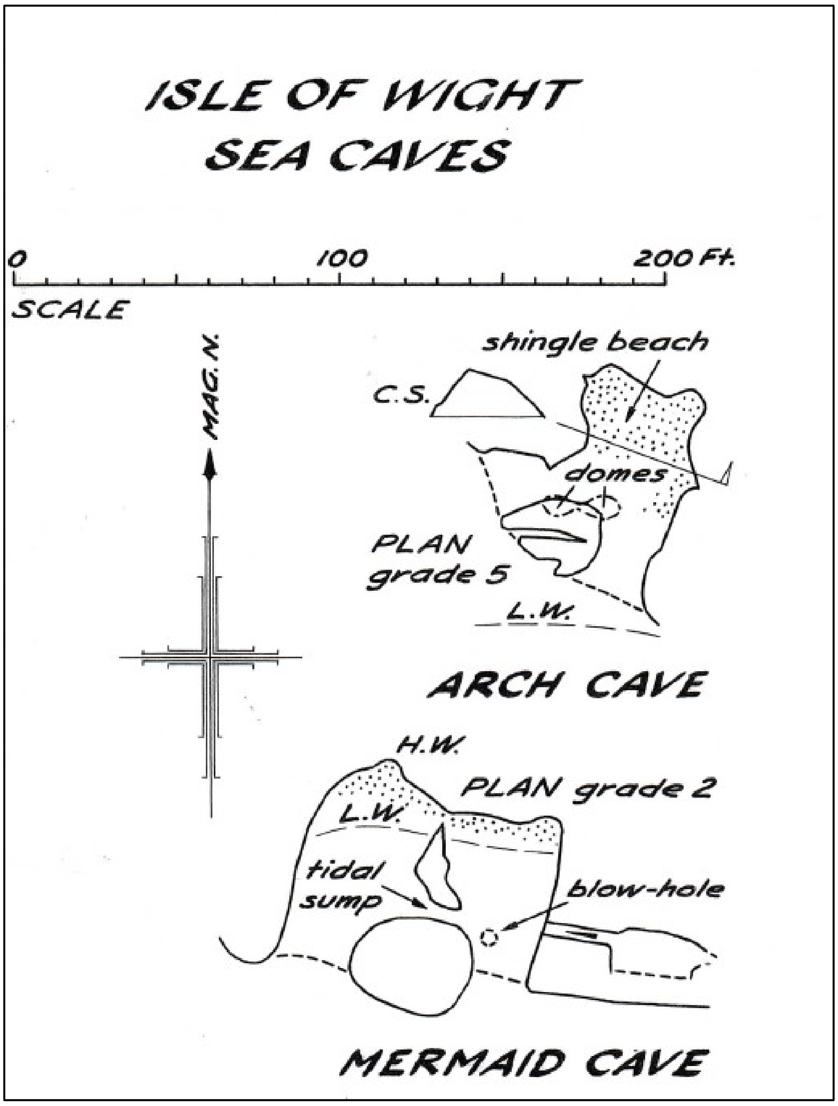
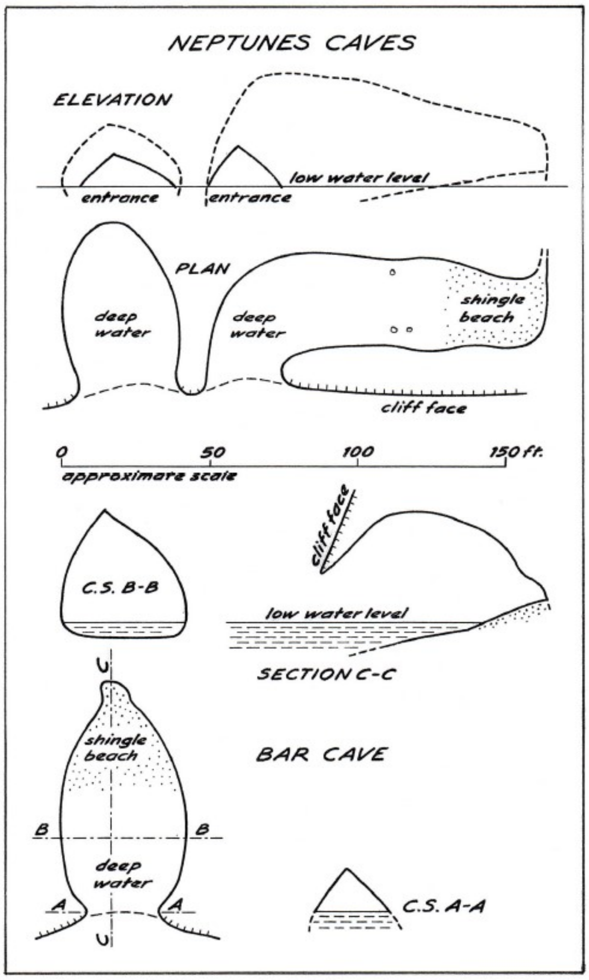
Appendix 1: Surveys of sea level caves from Terry Reeve

This appendix contains surveys of some of the sea level caves in the Chalk of the Isle of Wight. The surveys were provided for this report by Terry Reeve in 2022, but were drawn by him many years ago. Whist these caves are likely to be predominantly of marine origin, some evidence of karstic solutional processes were observed (see section 2.1).




ANEMONE CAVE
1 2 3 4 5 6
CROSS SECTIONS
Mag. N. 1977
PLAN
overhang
ISLE OF WIGHT
WATCOMB BAY
CROSS SECTIONS
1 2 3 4
0 50 100 ft.
Mag. N. 1977
PLAN
shingle
boulders
cliff face
Surveys : BCRA grade 5d


ISLE OF WIGHT
SEA CAVES
0
100
200 Ft.
SCALE
MAG. N.
shingle beach
C.S.
domes
PLAN
grade 5
L.W.
ARCH CAVE
H.W.
PLAN grade 2
L.W.
tidal
sump
blow-hole
MERMAID CAVE


NEPTUNES CAVES
ELEVATION
low water level
entrance
entrance
PLAN
deep water
deep water
shingle beach
cliff face
0
50
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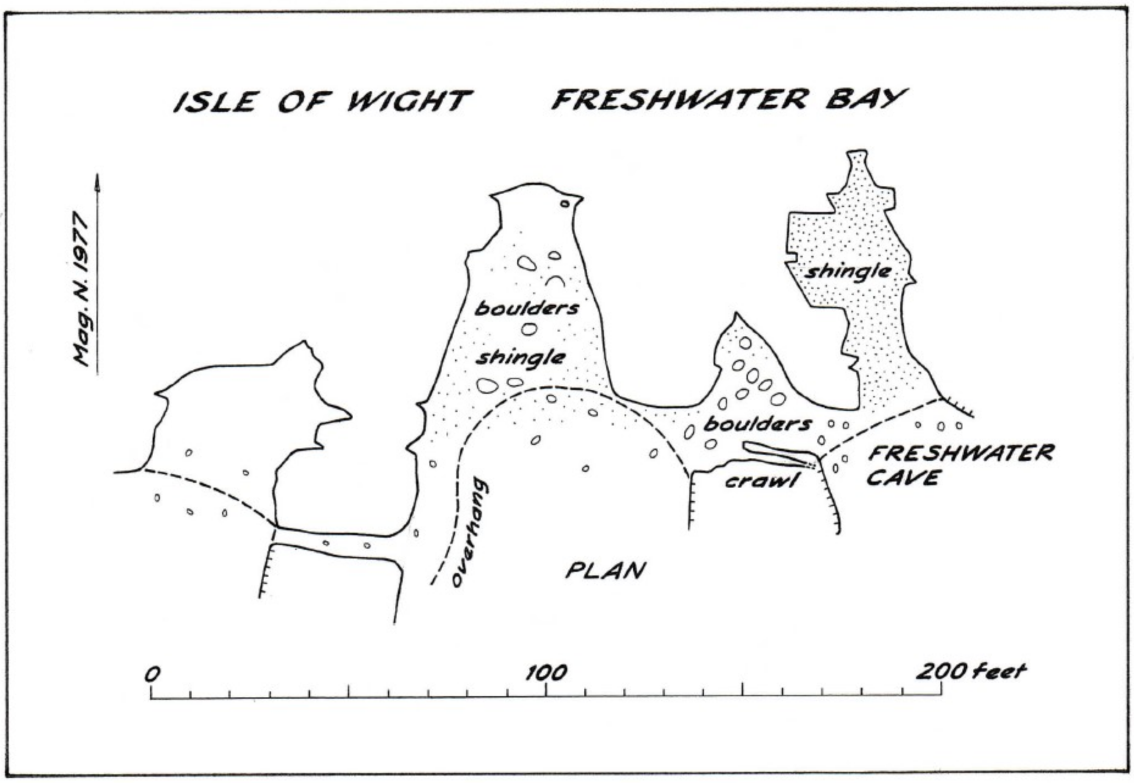
150 ft.
approximare scale
C.S. B-B
cliff face
low water level
SECTION C-C
shingle beach
BAR CAVE
B
B
deep water
A
A
C.S. A-A


ISLE OF WIGHT FRESHWATER BAY
Mag. N. 1977
boulders
shingle
shingle
boulders
crawl
FRESHWATER CAVE
overhang
PLAN
0
100
200 feet