Design Guide for Irrigation Reservoirs

Guidance on the planning and design of irrigation reservoirs in Kent

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Introduction

This document has been produced by the Kent Rural Board's Water Task Group. It is intended to support the development of irrigation water storage reservoirs in Kent by outlining some of the key issues that need to be considered when planning, designing and constructing irrigation water storage reservoirs, pointing readers towards additional sources of advice and highlighting the areas with the most suitable ground conditions for reservoir construction. It is also intended to support the Kent local planning authorities by highlighting the benefits that such reservoirs can provide and the issues that need to be considered when developing related policy that is aimed at striking a balance between supporting the rural economic growth, protecting landscapes and enhancing the local environment.

This document makes numerous references to additional sources of information and links to all of these can be found in the section 'Links to useful documents' on page 19.

In 2011 the Kent agriculture and horticulture sector had an estimated workforce of 14,000 and a gross output worth an estimated half a billion pounds. Kent produces some 40% the UK's top fruit, soft fruit production is also particularly significant and both are highly dependent on irrigation water to maintain productivity and to help meet the quality requirements of the major retailers. The sector mainly relies on water abstractions from rivers and groundwater but most of the Kent catchments are classified as 'over-abstracted' or 'over-licensed'. Licence restrictions on abstraction during summer months are becoming more common and the Environment Agency is encouraging irrigators to take water during high flows, predominantly during the winter, and to store this water in reservoirs for use during the growing season.

Kent is one of the driest parts of the UK and, as a result of changing climate, population and land use, these pressures on water resources are likely to become more severe into the future. In 2014 Kent County Council assessed these pressures and analysed their long term consequences for local water systems within the Kent Spatial Risk Assessment for Water. This study highlighted particular consequences for surface water availability for agriculture: Drier conditions and a longer growing season will mean greater demand and less water available in summer, while winters may be wetter and characterised by heavy rainfall events. The storage of water in winter for use in summer therefore appears to be an increasingly important strategy and one that will be crucial in helping to strengthen national food security.

Plant nursery in Kent irrigated entirely with harvested rainwater. Source: ADAS UK Ltd.

The irrigation water storage reservoirs described here are off-stream structures that receive no natural water inflow apart from rainfall. They are already commonplace in Kent and their number continues to increase as they are becoming an essential asset for horticultural businesses where the trend towards protected cropping means that production is completely dependent on irrigation. However, the storage of water for irrigation is not confined to agriculture and horticulture and is also important for other sectors, most notably golf courses and plant nurseries.

Improving water use efficiency should be the first response of any business that is facing water stress as this can generally save on water and energy costs at the same time as reducing impacts on the environment. The UK Irrigation Association provides a range of useful advisory leaflets on irrigation management. Improving the organic matter content of soils improves their water holding capacity and this can also help save irrigation water. The WRAP programme provides advice on the use of compost for this purpose. However, in some cases, efficiency gains may not be sufficient and additional water storage may be required.

Butyl lined reservoir for glasshouse irrigation. Source: ADAS UK Ltd.

Location and Siting Considerations

Designated Areas

Most of Kent's finest landscapes and most significant wildlife habitats are designated as Areas of Outstanding Natural Beauty (AONBs), Sites of Special Scientific Interest (SSSI) and other protected sites. These designated areas will have implications for the planning of irrigation reservoirs and their location can be checked using the 'Magic' mapping website.

Planning applications for new reservoirs within the AONBs are assessed with reference to the AONB management plans so it is important to check that your proposed reservoir is consistent with the Kent Downs AONB Management Plan or the High Weald AONB Management Plan.

If your proposed reservoir might impact on a protected species or site it will be important to check the guidance from Natural England and the Environment Agency. In cases where a reservoir is being constructed to support a shift away from water abstraction in summer or during low flows, this may have positive implications for nearby designated areas that would be important to highlight in your applications. The decision making organisations are encouraged to take this into account and to consider the net benefits of irrigation water storage reservoirs.

Land suitability

Lined reservoirs can be constructed in a wide range of ground conditions but the lining (usually butyl rubber sheeting) adds significantly to the costs. It is therefore advisable to first look for sites where the reservoir could be lined with clay. Most land owners will be aware of the location of clay sub-soils within their own land but it is well worth considering other nearby locations where a shared, unlined reservoir might offer a more cost effective alternative.

The Appendix to this document contains a set of maps based on the British Geological Survey (BGS) data that show areas of clay geology. The blue shaded areas are labelled as 'Potentially suitable for unlined reservoirs' and these highlight clay bedrock at shallow depth. In addition to this, areas identified by BGS as having 'clay and silt superficial deposits' are shaded in brown. These are also worth investigating but have a lower likelihood of being suitable for unlined reservoirs as they represent areas with deposits of eroded material that are inherently more variable. The maps also highlight the location of the flood plains where any potential reservoir location should be checked with the Environment Agency at an early stage to identify possible constraints.

In all cases, the final site selection clearly requires detailed site investigations under the advice of your reservoir engineer and needs to consider other factors such as:

- Proximity to a suitable electrical power supply;
- Absence of major underground cables or pipelines;
- Access for construction traffic;
- Minimising the visual intrusion of the reservoir on the local landscape.

Based on 'Land suitability for unlined irrigation reservoirs, Maidstone Borough Council Area', with the permission of British Geological Survey.

Water availability

Abstraction

The Environment Agency is responsible for managing the abstraction of water from the environment and this is guided by Catchment Abstraction Management Strategies (CAMS). There are five CAMS that cover Kent and most of the county is classified as either 'Over Licenced' or having 'No Water Available' in a 1 in 10 year dry summer. However, water may be available for abstraction in winter months for filling a storage reservoir. Before applying for a licence or planning changes to your abstraction regime it is advisable to contact the Environment Agency local office for advice. (See 'Links to Key Organisations').

The reliability of the abstraction will be an important consideration and it may also be useful to explore options for trading water with other local users.

Gutter system for polytunnel rainwater harvesting.
Source: ADAS UK Ltd.

Rainwater harvesting

Rainwater can be collected from the roofs of farm buildings, glasshouses and from polytunnels and this can be used to help fill irrigation reservoirs. For general information the Environment Agency document 'Rainwater Harvesting: an on-farm guide' is useful, while the AHDB document 'Water harvesting and recycling in soft fruit' provides a wealth of information on rainwater harvesting systems for soft fruit production. The contribution that harvested rainwater can make to irrigation water storage depends on the roof area available and the proximity to the reservoir but, for glasshouses in particular, it is possible for this to provide almost all the irrigation water needs. It is therefore worth considering the potential for rainwater harvesting when selecting a reservoir site.

Water company supplies

Over recent years some businesses have found it increasingly important to have an additional supply of treated mains water from their local water company. This might just be used as insurance in case of problems with other water sources or it might be used directly for irrigation or for topping up a reservoir. This water is expensive as it is treated to drinking water standards but in some locations around Kent the water companies may also be able to provide cheaper water directly from rivers or aquifers that is suitable for most irrigation requirements. Furthermore, in a few locations this water might be reliably available even in summer months and could be a viable alternative to building a reservoir.

Your water company's Water Resources Team may be able to provide further information (See 'Links to Key Organisations').

After April 2017 a new competitive market will mean that non-domestic water supplies can be purchased from a wider range of suppliers. Further information of this will be available on the Open Water website.

Climate change and its implications

A new reservoir is a significant, long term investment and it is important to consider how it will function over its entire life. Analysis of the impacts of climate change on water systems in Kent indicates that, on average, the need for summer irrigation is likely to steadily increase due to higher temperatures, increased crop growth and a longer growing season and, at the same time, the summer availability of surface water may decrease markedly. On average, winters are expected to become slightly wetter with more heavy rainfall events and this may provide additional surface water for abstraction. However, using this surface water for filling reservoirs may require larger capacity pumping equipment to make full use of shorter duration river flows in some catchments.

The availability of groundwater is expected to be less affected by climate change so may become more important for filling irrigation reservoirs.

Another significant implication of climate change for irrigation reservoir design is that the overall level of variability is projected to increase, with both droughts and floods becoming more frequent and more extreme. This means that additional capacity, over and above what is currently needed during droughts, would be a sensible precaution in designing a reservoir for the future.

Areas thought to be most at risk of increased competition for available surface water by 2050

Design Considerations

Key principles

Irrigation reservoirs provide both water resources and environmental benefits: Birds will quickly take advantage of the water and aquatic species such as newts and fish may also gradually colonise the reservoir but there are also specific design features that can further enhance the wildlife value of the reservoir. In considering these it is important to be mindful of water quality issues and the end use for the water. For example, for the production of ready-to-eat crops such as salads where the irrigation water will come in contact with the edible part of the crop, the reservoir water needs to be treated before use to remove pathogens. In this case, attracting birds to the reservoir may be inconsistent with the need to minimise crop contamination risks. Whereas, for drip irrigated fruit trees where irrigation water does not come in contact with the edible parts of the crop, or for non-food irrigation purposes such as watering golf courses, there will be more opportunity for encouraging plants and animals in and around the reservoir.

The key principle should be to design the reservoir to provide multiple benefits whilst minimising any negative impacts. In doing so your project is also more likely to attract grant funding.

Trickle irrigation of apple trees. Source: ADAS UK Ltd.

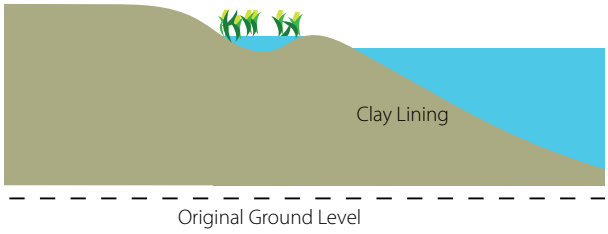
Design features

Finding a good reservoir design engineer is often best done by word of mouth but if your reservoir will have an 'escapable' volume of more than 25,000 cubic metres, you will need to appoint a Panel Engineer (See 'Links to useful Documents').

There are a number of features that can be included to enhance the environmental value of a reservoir. The following features would be worthwhile discussing with your reservoir design engineer.

Shape and profile

The shape of a reservoir has a bearing on its visual intrusion within the local landscape: straight lines tend to stand out against an irregular natural background and in some locations may be visible from distant hills, such as those of the Kent Downs AONB. A rectangular shape will generally be the least cost option and does not compromise the wildlife benefits of the reservoir. Visual intrusion can generally be avoided by careful site selection and planted screening but site conditions and personal preference will also influence the decision on reservoir shape.



Cross-section of embankment showing marginal shelf and vegetation

The inclusion of islands within a reservoir can provide valuable habitat for birds but profiled, earthen islands result in significant reductions in storage volumes. Where storage volume is the main objective, floating islands are a practical alternative that can significantly add to the wildlife value of the reservoir whilst also providing some wave attenuation benefits. For clay lined reservoirs the inclusion of a marginal shelf can also provide valuable habitat by helping to maintain a wet zone after the reservoir levels have been drawn down (see diagram above). These benefits will have to be weighed against any cost implications.

A shallow internal slope on the embankments may also give some environmental benefits but this has a major impact on the storage volume and construction cost. In most cases embankment slopes will need to be determined by engineering and costs considerations.

A certain amount of dead storage is necessary to prevent the clay lining from drying and cracking or to hold a synthetic liner in place but, in addition to this, providing a deeper area within the reservoir can form valuable refuge for fish when water levels are low. The benefits of this would need to be considered against the cost of the additional excavation involved.

Planting of embankments and margins

Careful consideration should be given to the type of vegetation to be established on the reservoir embankment and how it is to be managed. Farm reservoirs provide an ideal opportunity to provide additional wildlife habitat by creating new species-rich grassland and sources of pollen and nectar for important but declining species such as bumblebees.

Source: Kent Wildlife Trust

Choosing an appropriate grass mix is very important. For most grass and wildlife species the soil should not be too fertile; a mixture of top and subsoil is most suitable and will help to prevent weed species such as docks, thistles and nettles becoming established before the grass seed mix has a chance to get established and close the sward. It is important to choose a mix with the more traditional finer grasses that tiller well and to regularly cut the sward to encourage tillering. Chewing or Red Fescues are likely to be suitable as are many of the Bents (Agrostis). The close root system of the grass should help consolidate and bind the soil adding stability to the embankments and the grass mix can be supplemented with wild flower seed. A number of propriety wildflower mixes are available for different soil types and consideration could be given to planting different mixes on the top and sides of the embankment. The margin of the draw down zone could be given special attention with the opportunity to sow with a pond margin mix. There are also numerous commercial businesses offering proprietary seed mixes.

In the first year cutting may be needed four or more times to encourage the sward to close. After that, with low fertility soils, a traditional hay cut in late summer may suffice (with the arisings picked up). Occasionally an early spring and autumn cut may be necessary.

Cost effective wildflower establishment

It is possible to reduce costs by planting a basic grass mix over the whole site, supplemented in one place with a wildflower mix. Once establish, the wildflower patch can be cut as green hay and then spread over others areas of the site so that the seed is transferred before the hay is collected. This is a very efficient and cost effective method of creating species rich grassland.

The reservoir and any pumping infrastructure will normally require screening with trees and shrubs and, as far as possible, local species should be used for this. The Kent Landscapes Information System provides detailed information on the land suitability for different species native to the county (see 'Links to Useful Documents').

Safety and security

Reservoirs can present a serious risk to life and property. This risk is greatest for large reservoirs which could release significant volumes of flood water in the event of a dam failure. The Reservoirs Act 1975 applies to raised reservoirs that are capable of holding over 25,000m3 of water above the natural level of any part of the land and has since been amended by the Flood and Water Management Act 2010 which applies to structures capable of holding 10,000 cubic meters of water above the natural level of any part of the surrounding land. This legislation requires that proper attention is paid to the downstream flood risk for people, homes and businesses arising from such structures and that they should be registered with the Environment Agency. Detailed guidance on flood risk management for asset owners is available from DEFRA (See 'Links to useful documents'). More general advice on reservoir safety and maintenance requirements can be found in the Environment Agency owner's guide to reservoir safety but it must be noted that this document pre-dates the Flood and Water Management Act 2010.

Photo by Charles Tassell

One of the recommendations of this Environment Agency document is that animals (other than sheep or goats) should be excluded from the reservoir embankment. In some cases this will require fencing. Fencing is best sited a few metres from the foot of the embankment and, in order to keep rabbits away from the embankment, fencing will need to include chicken wire buried into the ground and turned outwards. If deer need to be excluded then 2 metre high sheep netting will be needed.

Water quality

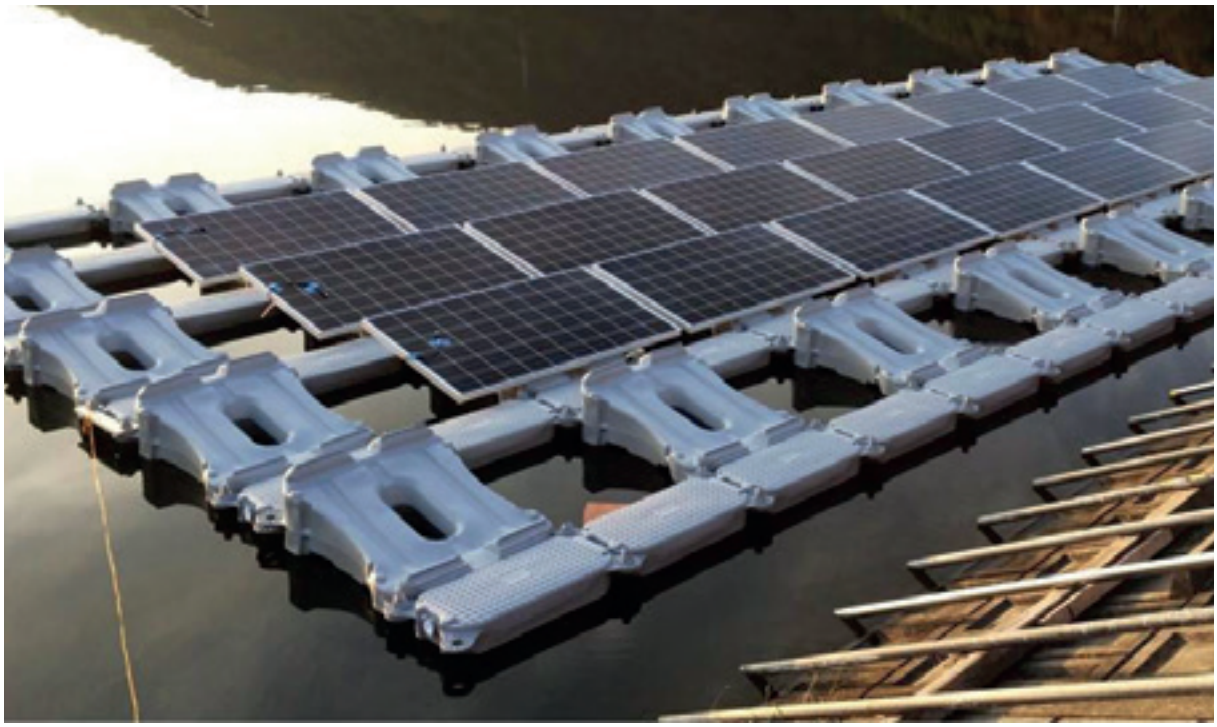
High levels of nutrients in the water can give rise to algae growth especially during warm weather, causing blockage of filters and pumps and killing other aquatic life by reducing oxygen levels in the water. The quality of the input water is the single most important factor that influences the quality of the reservoir water but this can sometimes be difficult to control. In extreme cases it may be necessary to install equipment to aerate the water by pumping a fine stream of air bubbles through it, and many proprietary systems are available for this. However, a more sustainable alternative can be the introduction of aquatic vegetation which can help to remove nutrients from the water, reducing the chance of algal blooms and blanket weed. Introducing appropriate vegetation can also increase the biodiversity value and help the reservoir to blend into the surrounding landscape. Marginal vegetation such as Yellow Flag Iris, Water Mint, Brooklime, Lesser Pond Sedge and Greater Pond Sedge are all species which can tolerate variable water levels and provide dense marginal cover. Care should be taken when choosing floating vegetation as some species can produce extensive root systems. Recommended species include Pond Water Crowfoot and Broad-leaved Pondweed. Vegetated floating islands planted with reed species also provide surface cover and shading whilst absorbing nutrients from the water. For further information contact Medway Valley Countryside Management Partnership (see 'Links to Key Organisations').

Renewable energy

The inclusion of floating solar panels may be worth considering for both new and existing reservoirs. Depending on the reservoir surface area, these can help power pumping equipment and provide additional income from any electricity exported to the grid. The timing of irrigation water demand is likely to be closely aligned with the power output of the panels and, by shading the water surface, floating panels may also reduce water temperature, thereby helping to reduce algae growth. Depending on the area of panels relative to the surface area of the reservoir, they could also help to reduce evaporation losses and wave erosion problems.

There is currently little practical experience of floating solar panels in the UK. The NFU Farm Energy Service and this Farming Futures Factsheet on Solar PV may provide some help but the maintenance requirements are difficult to anticipate at this stage and these could be high if nesting birds are attracted to use the panels or floats.

The response of Kent local planning authorities to the inclusion of floating solar panels on reservoirs is as yet untested: The panels would not cause any additional loss of agricultural land and their visual impact would be much less than for solar farms as the reservoir site selection and screening would have partly addressed that issue and the panels would be out of sight except from high elevations. Furthermore, floating solar panels could provide a small but positive contribution towards delivering local authority policies on renewable energy, carbon emission reduction, water conservation and environmental water quality. Given this balance of impacts and benefits, the Kent local planning authorities are encouraged to view floating solar panels on irrigation reservoirs favourably.



Floating solar panels and launch ramp. Source: Floating Solar UK

Planning your reservoir

This section focuses on the processes for obtaining the permissions that are required by the relevant authorities. Detailed guidance on all aspects of planning, design and construction can be found in the Cranfield University and Environment Agency document 'Thinking about an irrigation reservoir?'.

The entire process of planning and construction can be lengthy and, as a general rule, at least 2 years should be allowed from concept to completion. There are three main parts to the planning process: securing a water supply and obtaining EA permits; obtaining local planning authority permissions; and addressing archaeological and heritage concerns. These are considered in more detail below.

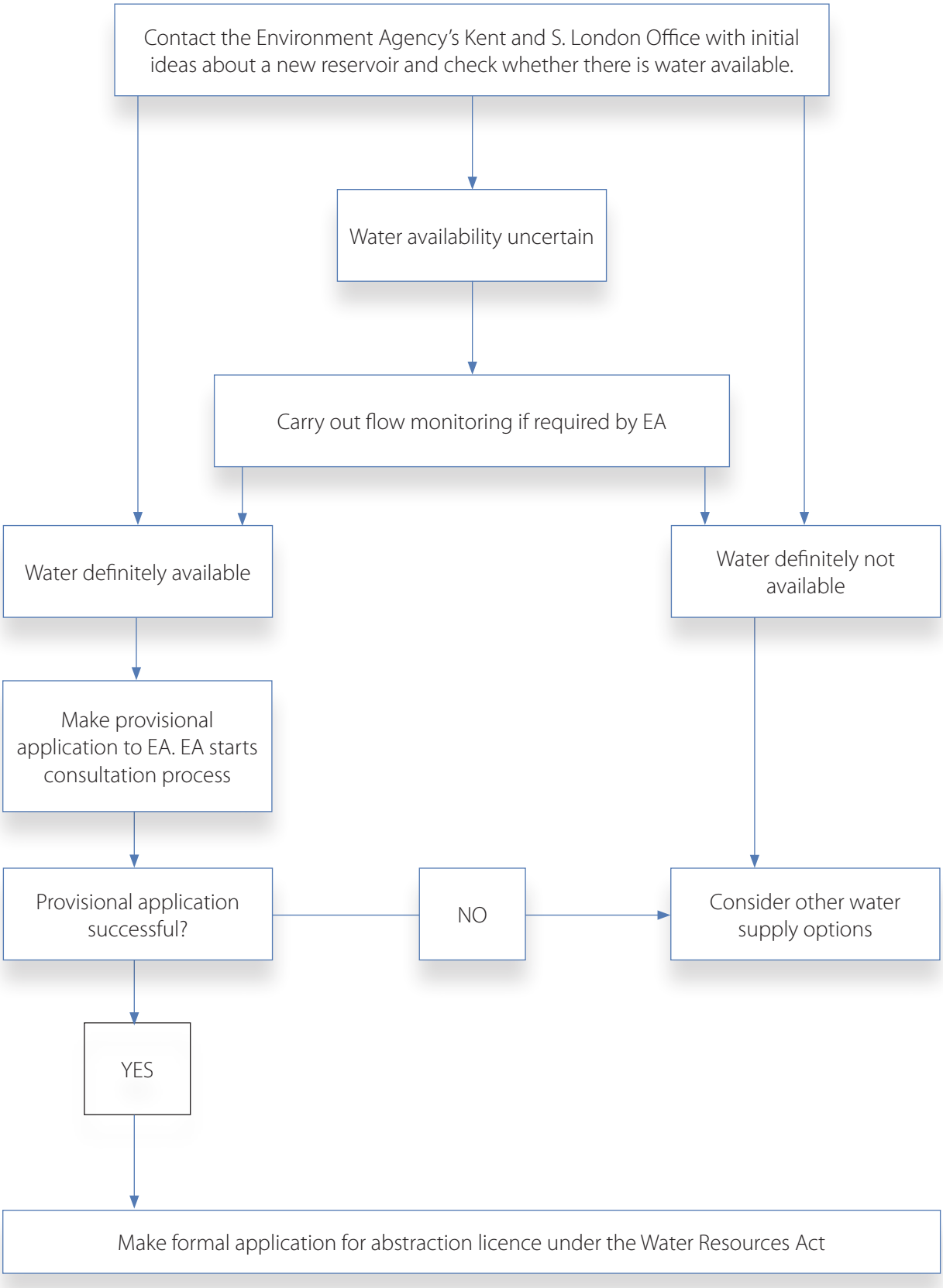
Securing a water supply

The Environment Agency plays the key role regarding water abstraction and is responsible for balancing the competing demands for water from people, businesses and the environment. The EA is generally supportive of irrigation reservoirs for storing water at times of high river flows, especially in cases where they involve reducing abstraction pressures during low flow conditions.

It is advisable to contact the local EA office at a very early stage in your planning as the EA holds detailed information on water availability that might influence your choice of site and size of reservoir or may mean that you should consider an alternative to building a reservoir (as explained in the earlier section entitled 'Water availability'). If your planned water source is a minor stream or ditch for which the EA does not have flow data, then it will important to start monitoring the flow as soon as possible as data for at least one winter season will be needed to support your application. A flow diagram for the process of obtaining an Abstraction Licence is provided in the following diagram and the EA document 'Water management: apply for a water abstraction or impoundment licence' provides useful guidance.

Photo by Charles Tassell

Flow chart showing Abstraction Licence application process



Local planning authority permissions

The Kent Local Planning Authorities have an important role to play in the development of irrigation reservoirs: They are encouraged to incorporate policies within their Local Plans that recognise the increasingly important role of irrigation water storage for the agricultural and horticultural sector and are supportive of the development of irrigation reservoirs, seeking landscape and environmental features within the design that are consistent with the primary function of commercial water storage.

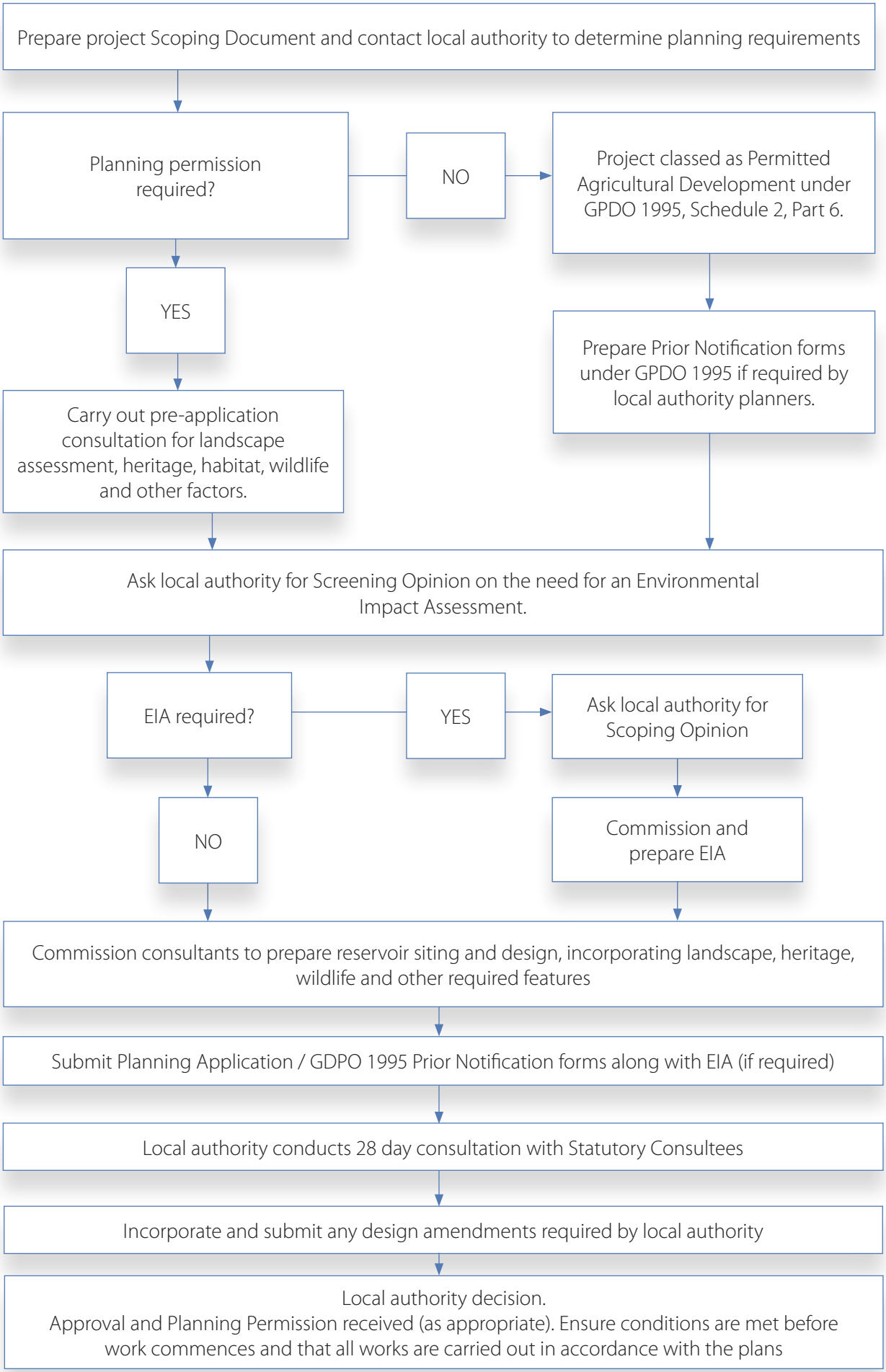
The size and construction methods of modern agricultural reservoirs mean that they are very likely to be considered as operational development and therefore require planning permission. However, provided that the requirements of Part 6 of Schedule 2 of the The Town and Country Planning (General Permitted Development) (England) Order 2015 have been complied with, farm businesses can apply for permission from their local planning authority by way of an Agricultural Prior Notification. See UK Government advice on permitted agricultural development for a full explanation.

Reservoirs in, or impacting on, environmentally sensitive sites such as SSSIs, SPAs, SACs and County Wildlife Sites will require Environmental Impact Assessments (under EU Directive 85/337 Environmental Impact Assessment).

The following flow chart explains the sequence of steps that are needed to obtain the relevant permission from your local planning authority. The timetable for this will vary depending on whether full planning permission is required and the need for any ecological studies (some of which may need run across all four seasons of the year). Pre-application discussion with your local planning authority will be helpful in determining the timetable for your specific application. Contact details can be found under 'Links to Key Organisations' at the end of this document.

Photo by Charles Tassell

Flow chart showing Planning Permission application process



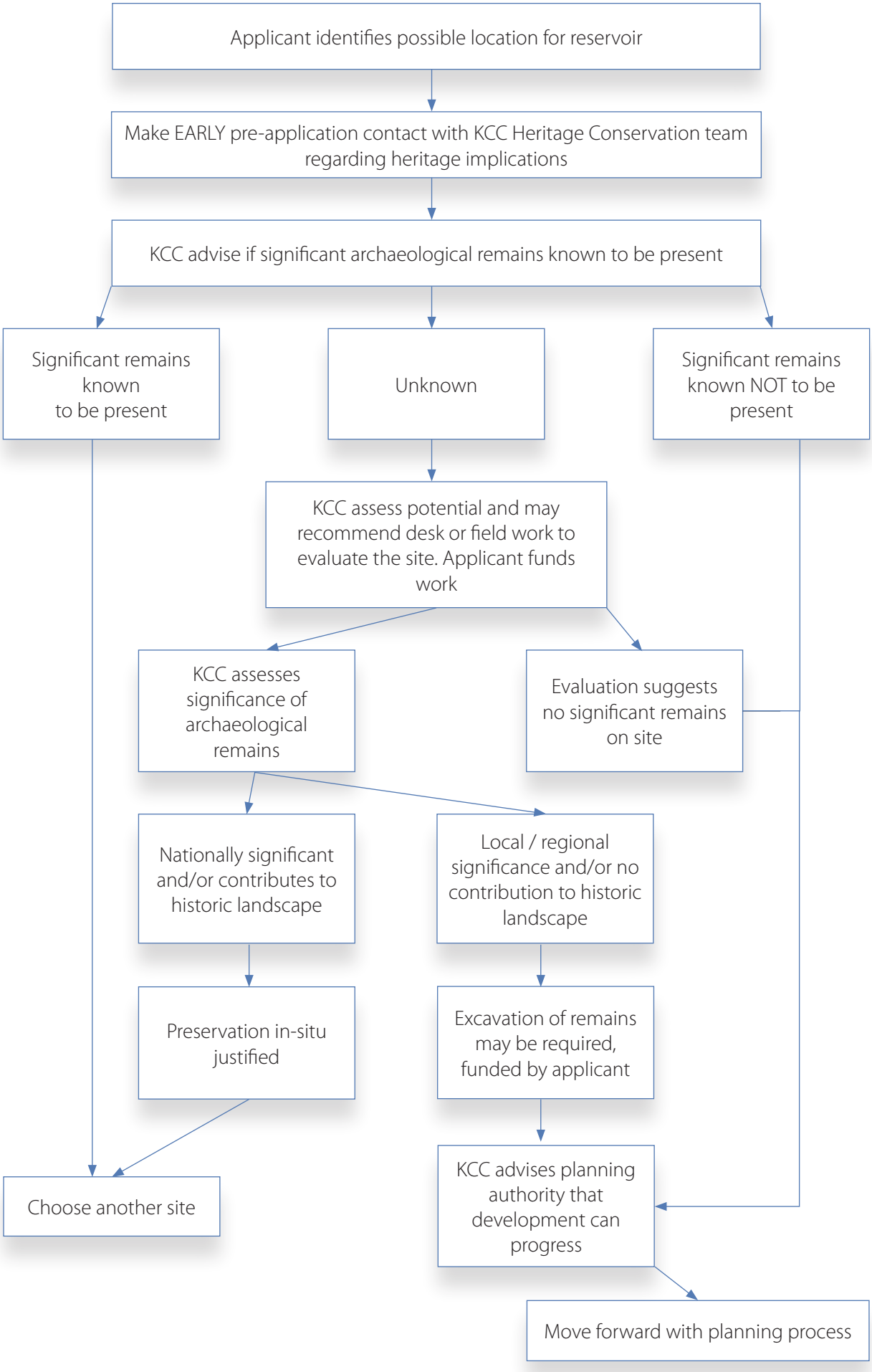
Addressing archaeological and heritage concerns

It is also advisable to seek early advice about the heritage interest in any area being considered for a reservoir even if there is no specific evidence of its importance in the location. The first step would be to assess the archaeological, built historic environment and historic landscape potential of the site through a desktop study. Trial trenching would also be advisable and this could possibly be done at the same time as engineering investigation of the soil and sub-soil conditions. If significant archaeological remains are identified, the need for excavation would add considerably to project costs and it would generally be advisable to find another site for the proposed reservoir.

The Kent County Council Heritage Conservation Team (see 'Links to Key Organisations') provides a service for most of the County and the following flow diagram shows the key steps in consulting with them. However, Canterbury City Council has its own Archaeological Officer who should be contacted if your reservoir site falls within that local planning authority area.

Photo by Charles Tassell

Flow chart showing Heritage Conservation approval process



Funding

Most funding programmes are time limited and they may or may not be open for application at the time you are planning your reservoir, so in some cases it may be worthwhile waiting for a new programme to open. It is always important not to start any part of a project that is subject to a grant application before you have received a decision on your application.

In searching for suitable funding schemes, a good starting point is to review the current priorities and grant schemes of the Rural Development Programme for England (RDPE), searching not just for grants for reservoir construction but also for any water management measures (such as rainwater harvesting) that might form part of your overall project. Some funding schemes may provide support for high level outcomes that your reservoir might contribute to, such as improved water use efficiency. In this case, you will need to emphasise how your reservoir project helps to deliver this outcome. It is also important to bear in mind that the way you organise your project may affect your eligibility for grants: for example a partnership venture with neighbours might also attract grants for collaboration or joint feasibility studies that may not be available to an individual business.

Current examples of funding sources are:

- The RDPE Countryside Productivity Scheme: Grants of up to 40% for farm reservoirs that form part of a plan to improve irrigation efficiency. Other components of irrigation infrastructure such as distribution pipelines and precision irrigation equipment may also be eligible.

- The ERDF LEADER Programme is focused on business growth and jobs. Under the LEADER Programme for 2015 to 2020 Kent is covered by three Local Area Groups: West Kent LEADER; Kent Downs and Marshes LEADER; and East Kent LEADER. It may be worthwhile checking the guidance documents for these programmes when they are available to check for any support for water management.

- The inclusion of floating solar panels within a reservoir would potentially be eligible for incentive schemes to support renewable energy generation such as the Feed-in Tariff. Further information may be available from the NFU Farm Energy Service.

NFU members can check for funding opportunities using the NFU Funding Tool. This provides a comprehensive search of all funding sources and is continuously updated by a team of experts.

Legislation affecting Irrigation Reservoirs

There is a range of legislation that needs to be considered when planning an irrigation reservoir. The following information provides a summary but this is not intended to be comprehensive. Full details of all relevant legislation can be found using the search function at http://www.legislation.gov.uk/.

The Countryside and Rights of Way Act 2000

This Act provides enhanced protection for Areas of Outstanding Natural Beauty in England and Wales. In Kent, this affects the impact of farm reservoirs on sensitive landscapes and biodiversity of the Kent Downs AONB and the High Weald AONB. It is administered by Natural England.

The Flood and Water Management Act 2010

This legislation is aimed at improving flood risk management for people, homes and businesses. It defines large raised reservoirs as 'structures capable of holding 10,000 cubic meters of water above the natural level of any part of the surrounding land' and requires that proper attention is paid to the downstream flood risk arising from such structures. These structures need to be registered with the Environment Agency.

The Land Drainage Act 1991

This legislation provides a consenting mechanism for any works that affect the flow of ordinary watercourses (drains, ditches and minor watercourses). This may include dams, sluices, weirs, culverts or diversions. It affects the ability of farmers to set up flow control works to feed reservoirs or to divert/culvert drains, ditches and minor watercourses. It is administered by the Internal Drainage Board and/or the Environment Agency.

The Reservoirs Act 1975

The Act ensures the public safety of reservoirs that hold at least 25,000 cubic metres of water above natural ground level. It affects the design and engineering of such reservoirs and requires annual inspection. It is administered by the Environment Agency.

The Town and Country Planning Act 1990

The Town and Country Planning (Environmental Impact Assessment) Regulations 1999;The Town and Country Planning (General Permitted Development) (England) Order 2015

This legislation controls the planning of farm reservoirs under the planning control system and the system of General Permitted Agricultural Development rights. It affects the planning and statutory consultation process involved in constructing farm reservoirs. These are administered by the relevant local planning authority and the statutory consultees include Natural England and the County Archaeological Service.

The Water Resources Act 1991 and The Water Act 2003

This legislation provides a management framework for water resources, including drought orders, water impoundment, and water management structures such as weirs and sluices. It affects the ability of farmers to abstract and impound water and is administered by the Environment Agency.

The Wildlife and Countryside Act 1981

This Act is the primary legislation for protecting animals, plants and certain habitats in the UK. It includes provision for designating Sites of Special Scientific Interest. It affects the impact of farm reservoirs on protected species and habitats and is administered by Natural England.

Links to useful documents

ADAS, Water harvesting and recycling in soft fruit. http://horticulture.ahdb.org.uk/publication/water-harvesting-and-recycling-soft-fruit

Cranfield University and Environment Agency, 2008. 'Thinking About an Irrigation Reservoir?' A guide to planning, designing, constructing and commissioning a water storage reservoir http://www.ukia.org/pdfs/Reservoirs.pdf

Cranfield University, Report FFG1112 'Water for agriculture: Collaborative approaches and on-farm storage. http://randd.defra.gov.uk/Document.aspx?Document=12008_FFG1112_Final_8April2014.docx

DEFRA guidance on flood risk management. https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities

DEFRA maps of designated areas. http://www.magic.gov.uk/

DEFRA planning advice on protected areas and species. https://www.gov.uk/protected-species-and-sites-how-to-review-planning-proposals

DEFRA Planning advice for farmers. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7656/143516.pdf

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Environment Agency advice on rainwater harvesting. http://www.rainwaterharvesting.co.uk/downloads/farming_environment_agency_guide.pdf

Environment Agency advice on reservoir safety: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/302050/owners_guide_to_reservoir_safety_English.pdf

Environment Agency guidance on applying for an abstraction or impoundment licence. https://www.gov.uk/guidance/water-management-apply-for-a-water-abstraction-or-impoundment-licence

European Commission report on wastewater reuse. http://ec.europa.eu/environment/water/water-urbanwaste/info/water_reuse.htm

Farming Futures advice on solar PV.
Factsheet 27: Solar PV
http://www.farmingfutures.org.uk/resources/factsheets/27-solar-pv

Feed-in Tariff Scheme. https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme

Government information on UK legislation: http://www.legislation.gov.uk/

High Weald AONB (2014),
Management Plan 2014 - 2019
http://www.highweald.org/high-weald-aonb-management-plan.html

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Kent County Council (2004),
The Landscape Assessment of Kent.
https://shareweb.kent.gov.uk/Documents/environment-and-planning/Wildlife%20and%20landscapes/Landscape%20Assessment%20of%20Kent%20October%202004.pdf

Kent Downs AONB (2014),
Management Plan 2014 – 2019
http://www.kentdowns.org.uk/guidance-management-and-advice/management-plan

Kent Landscapes Information System:
http://www.kent.gov.uk/klis

NFU Farm Energy Service.
http://www.nfuonline.com/membership/farmer-grower/member-services/nfu-farm-energy-service/farm-energy-service/

NFU funding tool. http://www.nfuonline.com/membership/farmer-grower/member-services/nfu-funding-tool/

Suffolk Coasts and Heaths AONB
Farm Reservoir Design Guide, 2015.
http://www.suffolkcoastandheaths.org/assets/Planning/SCH-Farm-Reservoir-leafletWEB.pdf

The Pond Book.
http://www.freshwaterhabitats.org.uk/habitats/pond/pond-book/

UK Government advice on permitted agricultural development. https://www.gov.uk/planning-permissions-for-farms/permitted-development

UK Irrigation Association advisory booklets.
http://www.ukia.org/irrigationbooklets

WRAP Guidance on digestate compost for soil amelioration: http://www.wrap.org.uk/content/digestate-compost-agriculture

Links to key organisations

Decision Makers

Environment Agency, Kent & South London, email enquiries: kslenquiries@environment-agency.gov.uk

Kent County Council, Heritage Conservation Team: www.kent.gov.uk/HER.
Email: heritage@kent.gov.uk

Kent Local Planning Authorities:
Ashford: http://www.ashford.gov.uk/making-planning-applications
Canterbury: https://www.canterbury.gov.uk/planning/
Dartford http://www.dartford.gov.uk/by-category/environment-and-planning2/new-planning-homepage
Dover: http://www.dover.gov.uk/Planning/Planning-Applications/Home.aspx
Gravesham: http://www.gravesham.gov.uk/services/environment-and-planning/planning
Maidstone: http://www.maidstone.gov.uk/business/planning
Sevenoaks: http://www.sevenoaks.gov.uk/services/housing/planning
Shepway: http://www.shepway.gov.uk/business
Thanet: https://thanet.gov.uk/your-services/planning/
Tonbridge & Malling: https://www.tmbc.gov.uk/landing/planning
Tunbridge Wells: http://www.tunbridgewells.gov.uk/business

Natural England: https://www.gov.uk/government/organisations/natural-england

Advisory Services

Country Land and Business Association: https://www.cla.org.uk/

Farming Futures. http://www.farmingfutures.org.uk/

Freshwater Habitats Trust. http://www.freshwaterhabitats.org.uk/

Kent Wildlife Trust: http://www.kentwildlifetrust.org.uk/what-we-do/advice-and-consultancy/conservation-land-management-advice

NFU Kent: http://www.nfuonline.com/about-us/our-offices/south-east/kent/

Funding bodies

LEADER Programme Local Area Groups:
http://www.westkentleader.org.uk/
http://www.kentruralnetwork.org.uk/leader
http://www.ruralkent.org.uk/ourwork/East-KentLeader.htm

RDPE Programme:
https://www.gov.uk/government/organisations/rural-development-programme-for-england-network

Other organisations

Kent Countryside Management Partnerships:
http://www.kent.gov.uk/about-the-council/partnerships/countryside-management-partnerships

Kent Rural Board: http://www.kentruralnetwork.org.uk/who-we-are

Medway Valley Countryside Partnership. http://www.medwayvalley.org/ Phone 03000 422997

Open Water. http://www.open-water.org.uk/

Water companies:

Affinity Water:
https://www.affinitywater.co.uk/for-business.aspx
South East Water:
http://www.southeastwater.co.uk/
Southern Water:
https://www.southernwater.co.uk
Sutton & East Surrey Water:
http://www.waterplc.com/index.asp
Thames Water:
http://www.thameswater.co.uk/

Acknowledgements

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Alan Turner (main author), Economic Development Officer, KCC;
Andrew Bowles, Leader of Swale Borough Council and KCC Member;
Charles Tassell, Campaign for the Farmed Environment;
Clive Pearman, KCC Deputy Cabinet Member for Environment and Transport;
Ed Uden, Team Leader, Groundwater and Hydrology, Environment Agency;
Helen Chapman, Supply Demand Manager, South East Water;
Dr Mark Else, Programme Leader, East Malling Research;
Matthew Balfour, KCC Cabinet Member for Environment and Transport;
Paul Dracott, WATERR Project Manager, East Malling Research;
Sean Holden (Chair), KCC Deputy Cabinet Member for Economic Development;
Tom Ormesher, Regional Environment and Land Use Adviser, NFU.

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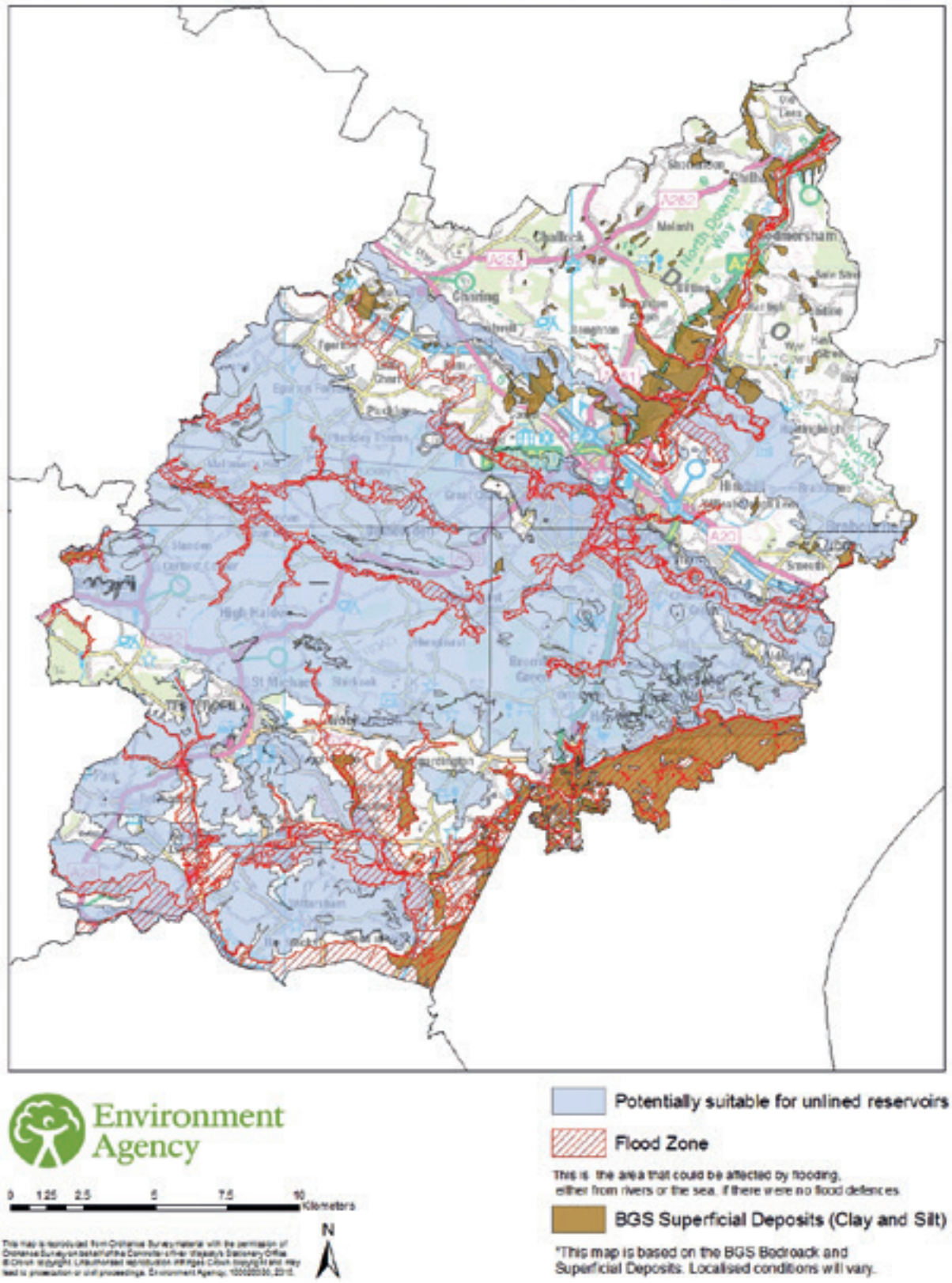
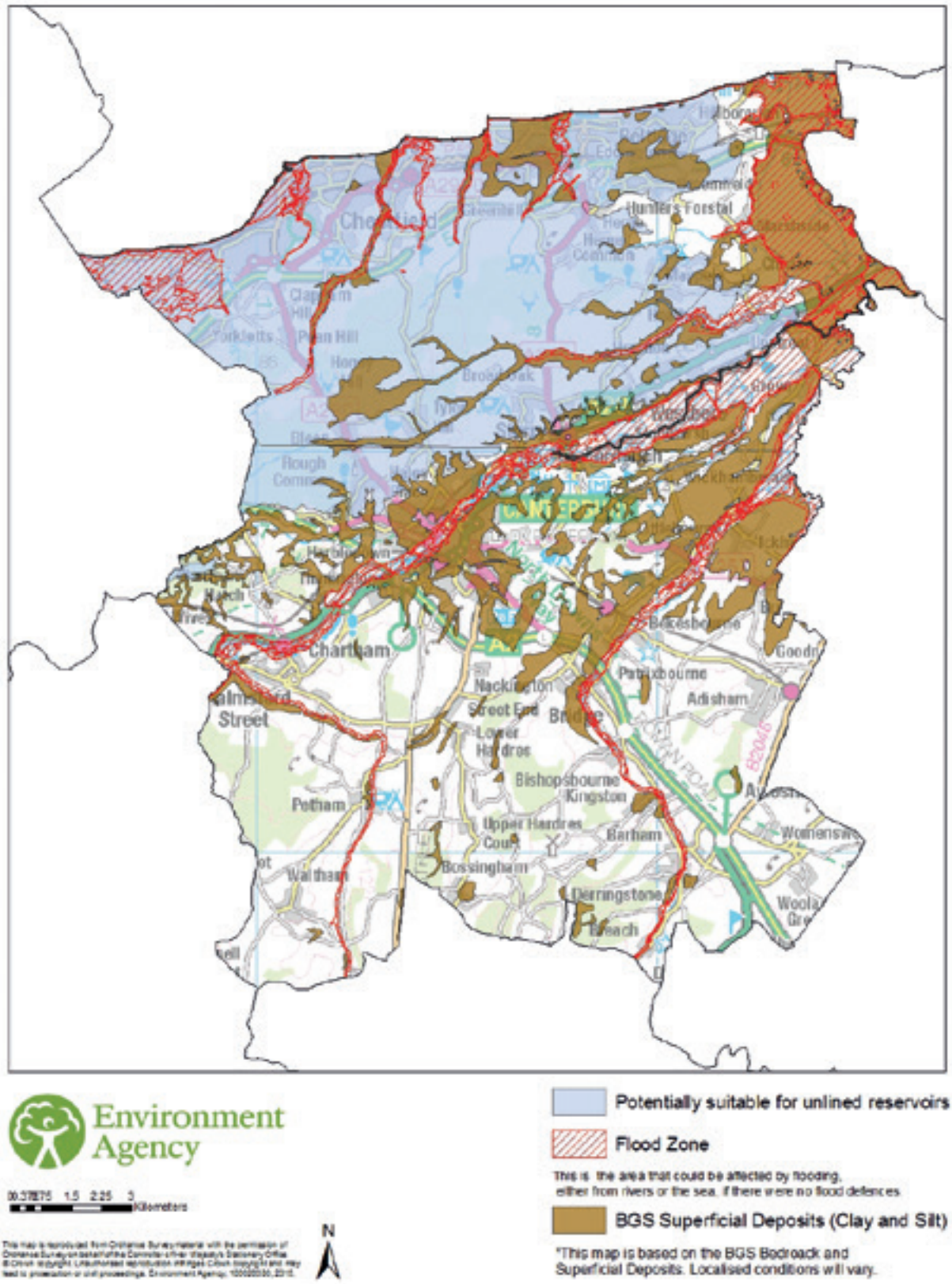
Appendix: Maps of Land Suitability for unlined irrigation reservoirs

Photo by Charles Tassell

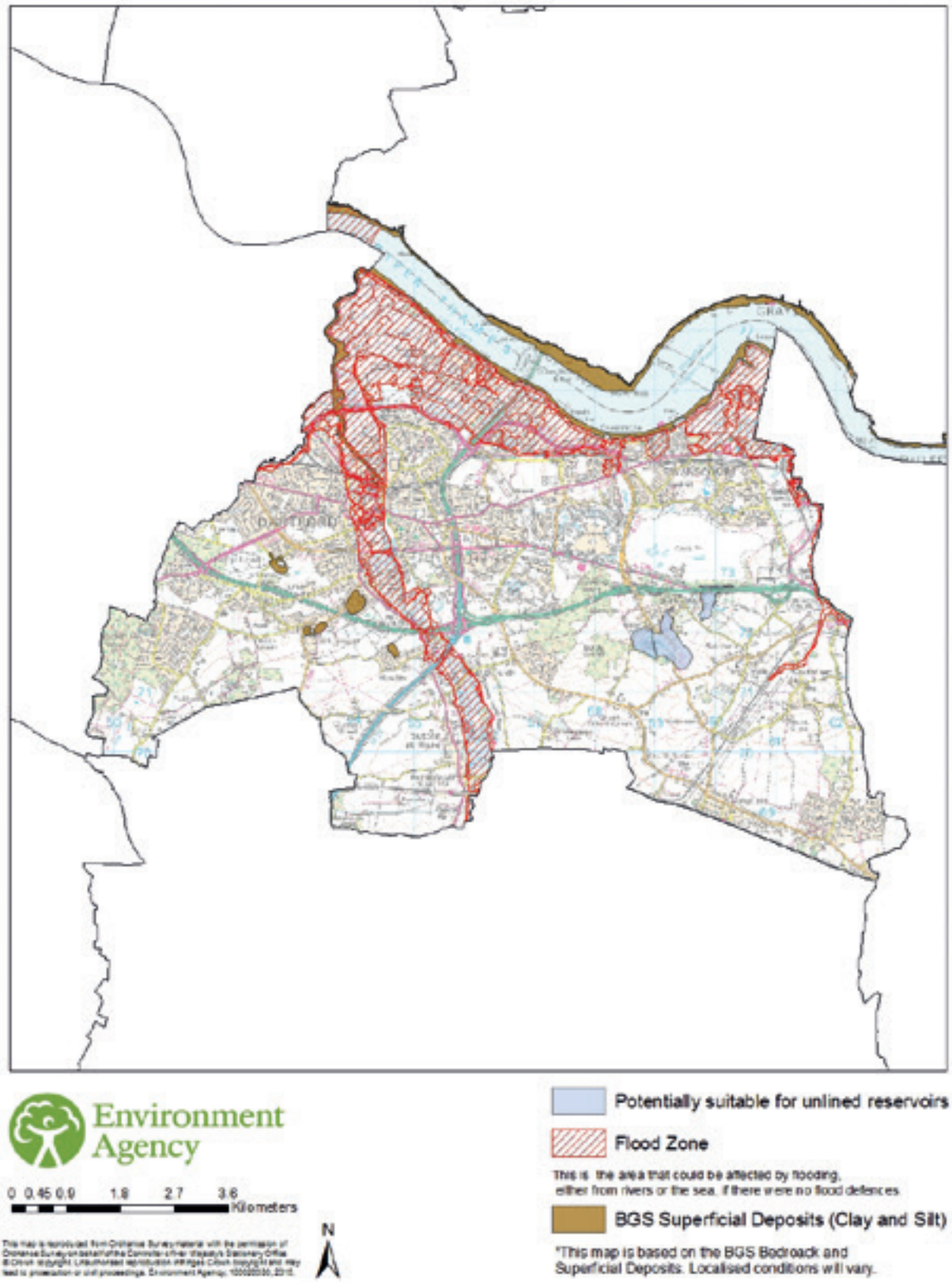
ASHFORD BOROUGH COUNCIL AREA



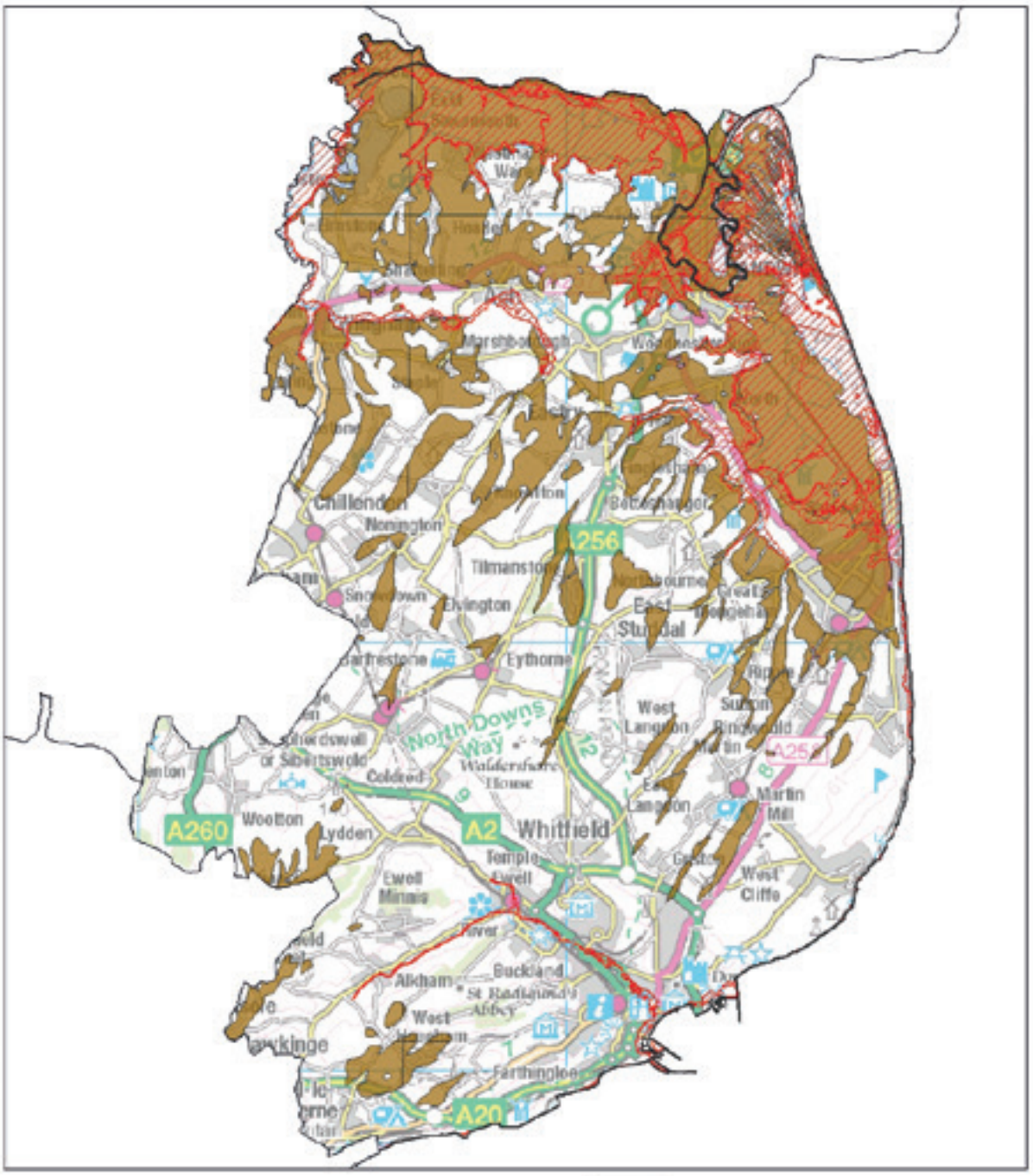
CANTERBURY CITY COUNCIL AREA



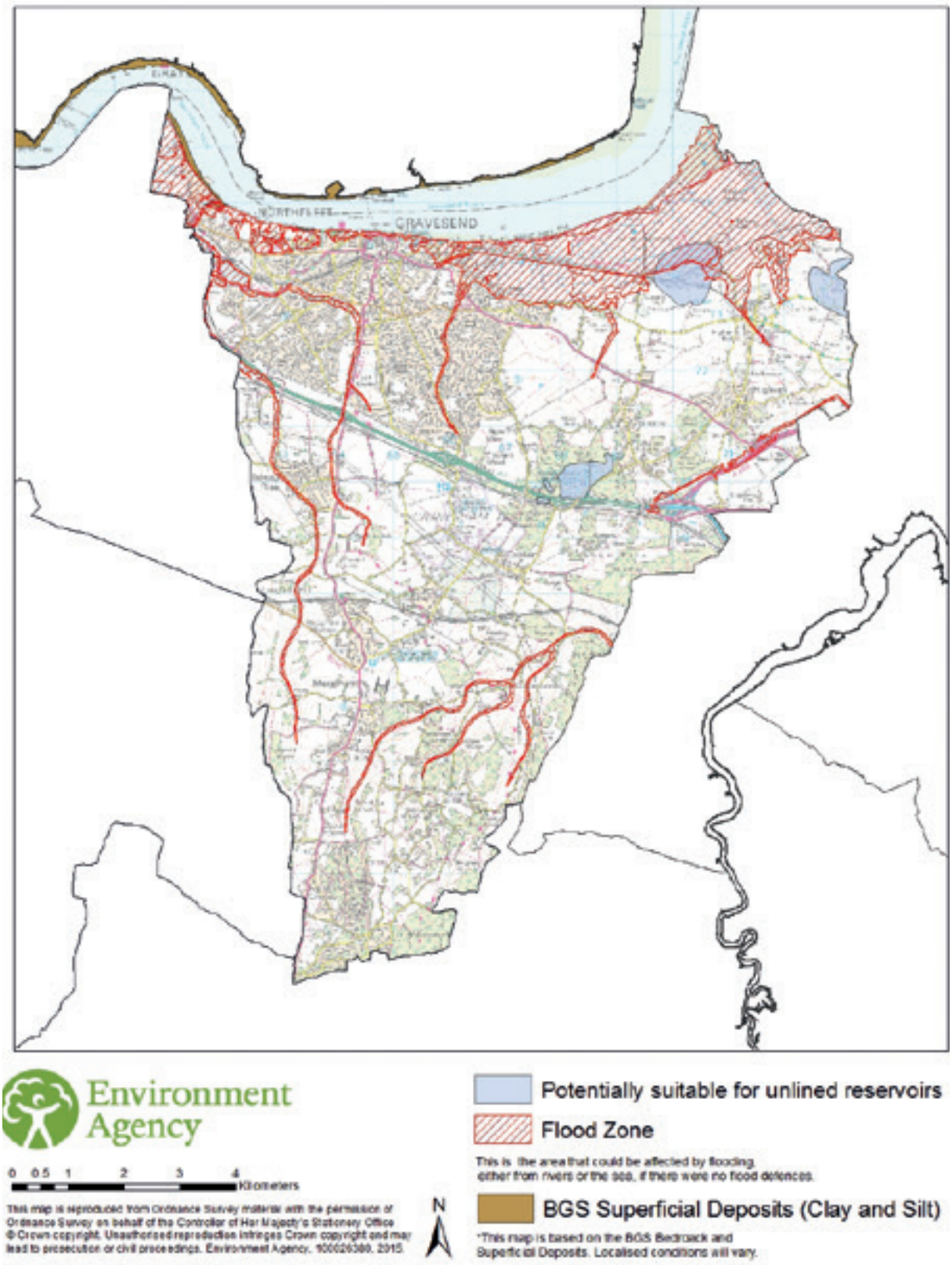
DARTFORD BOROUGH COUNCIL



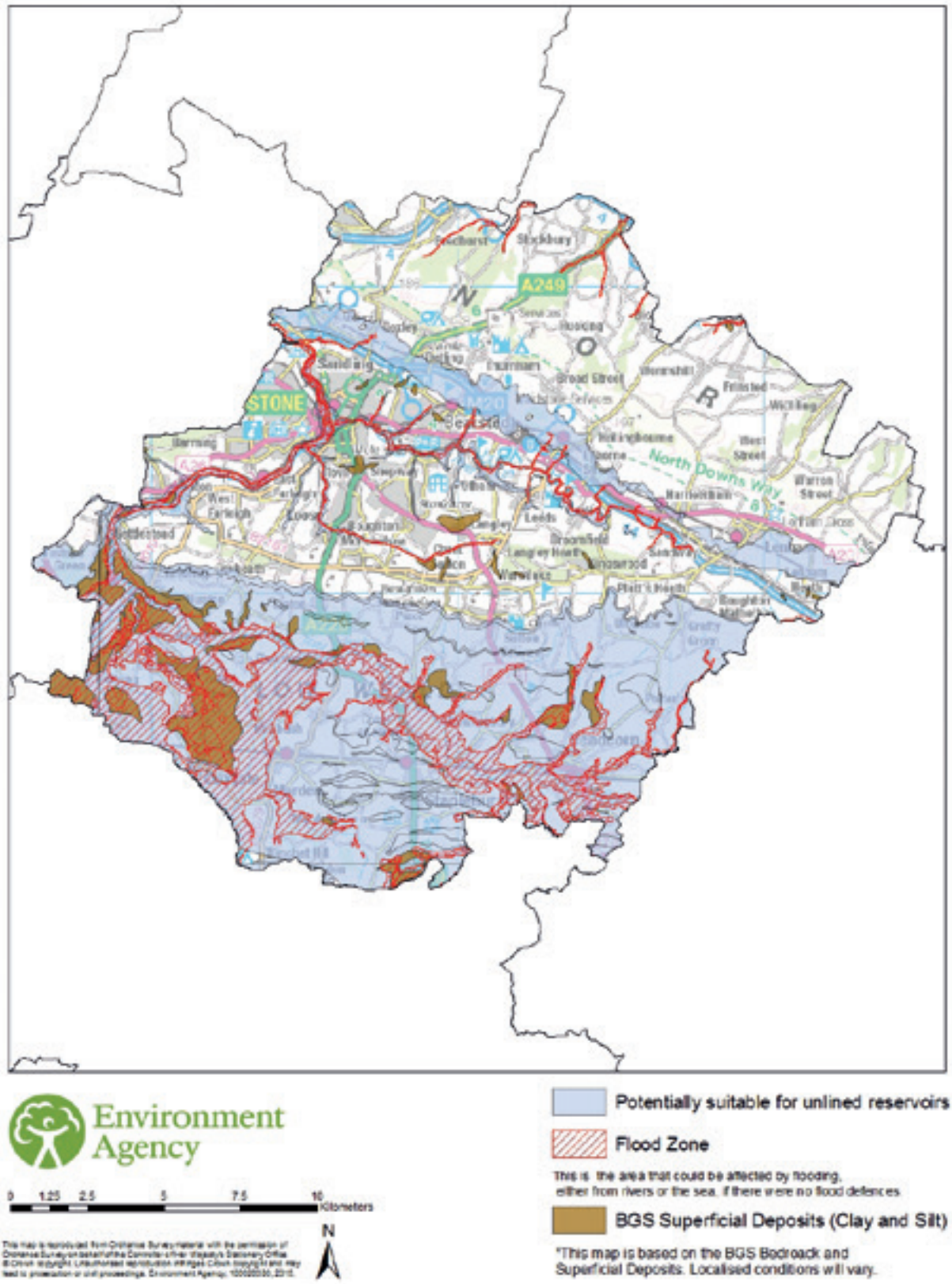
DOVER DISTRICT COUNCIL AREA



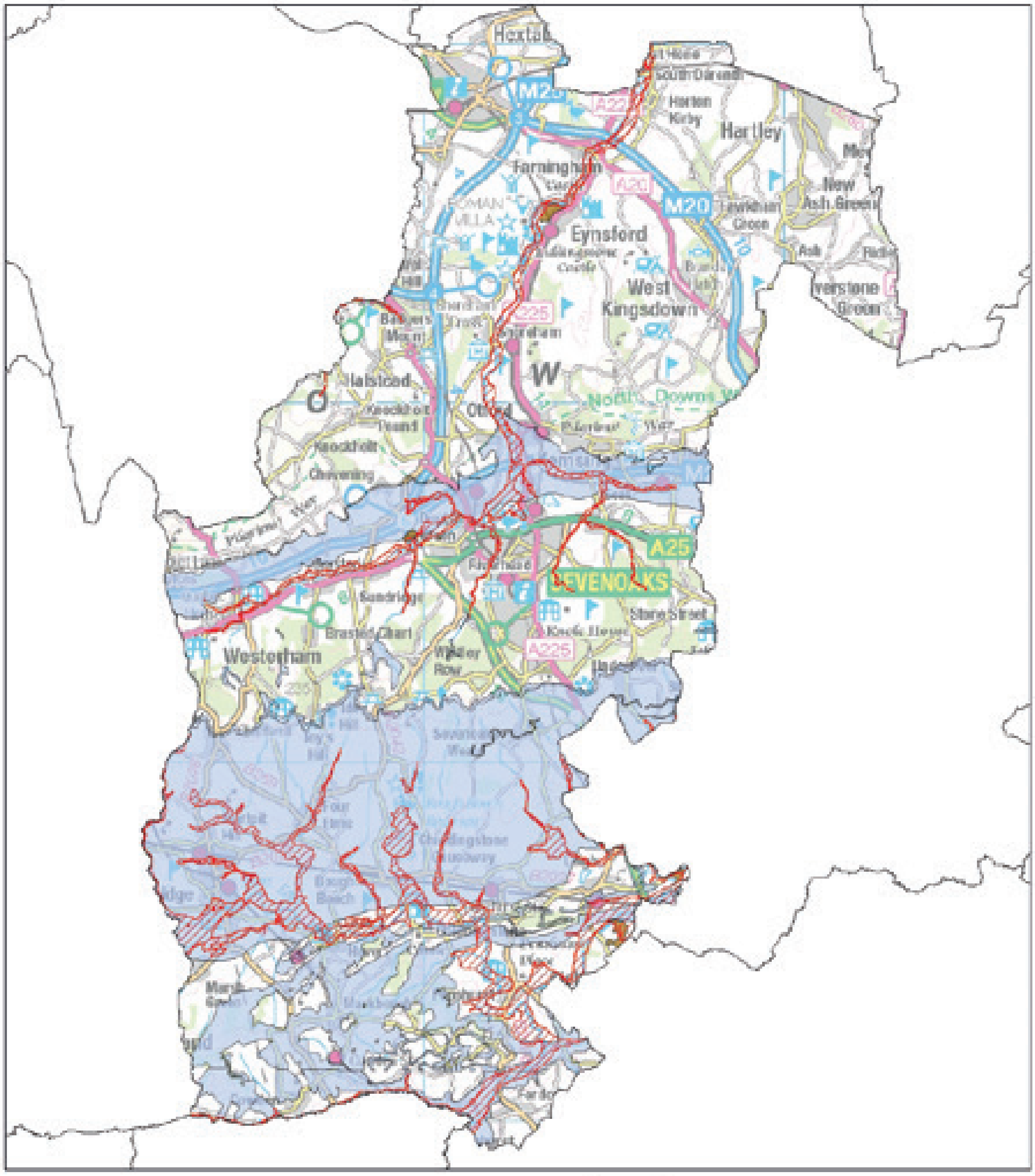
GRAVESHAM BOROUGH COUNCIL AREA



MAIDSTONE BOROUGH COUNCIL AREA



SEVENOAKS DISTRICT COUNCIL AREA



Environment Agency

0 0.5 1 2 3 4
Kilometers

N

Potentially suitable for unlined reservoirs

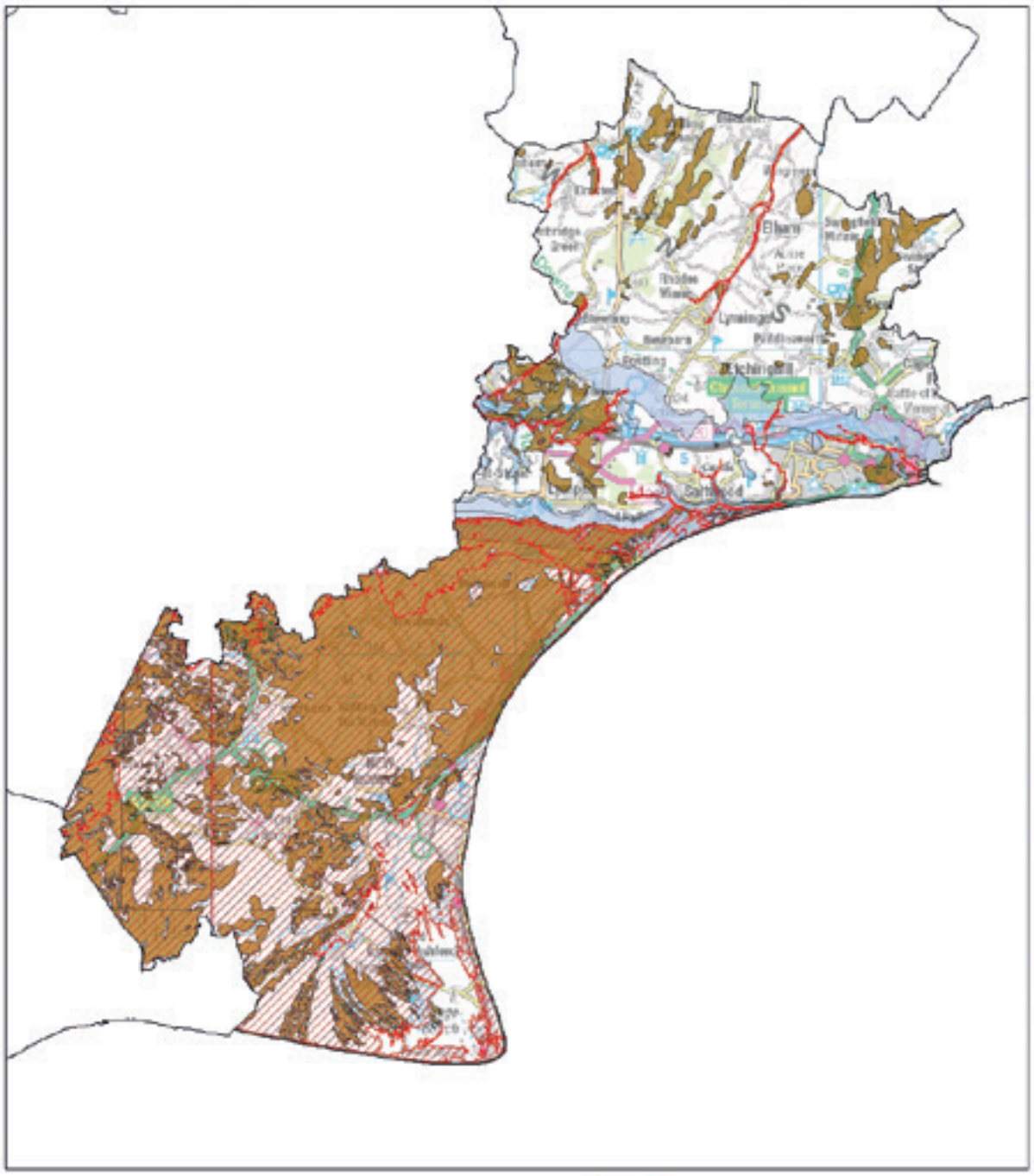
Flood Zone

This is the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences.

BGS Superficial Deposits (Clay and Silt)

*This map is based on the BGS Bedrock and Superficial Deposits. Localised conditions will vary.

SHEPWAY DISTRICT COUNCIL AREA



Environment Agency

0 1 2 4 6 8 Kilometers

N

Potentially suitable for unlined reservoirs

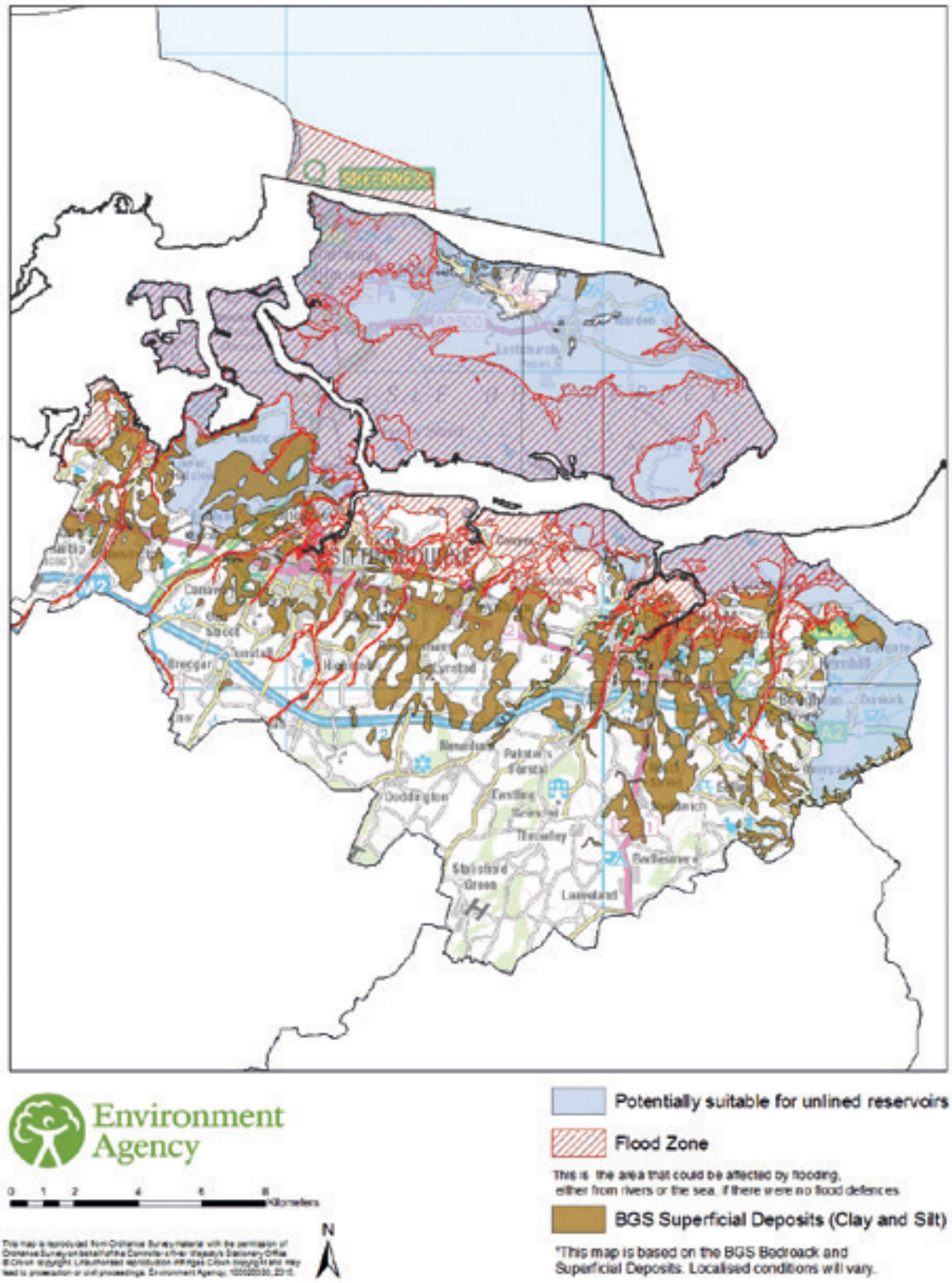
Flood Zone

This is the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences

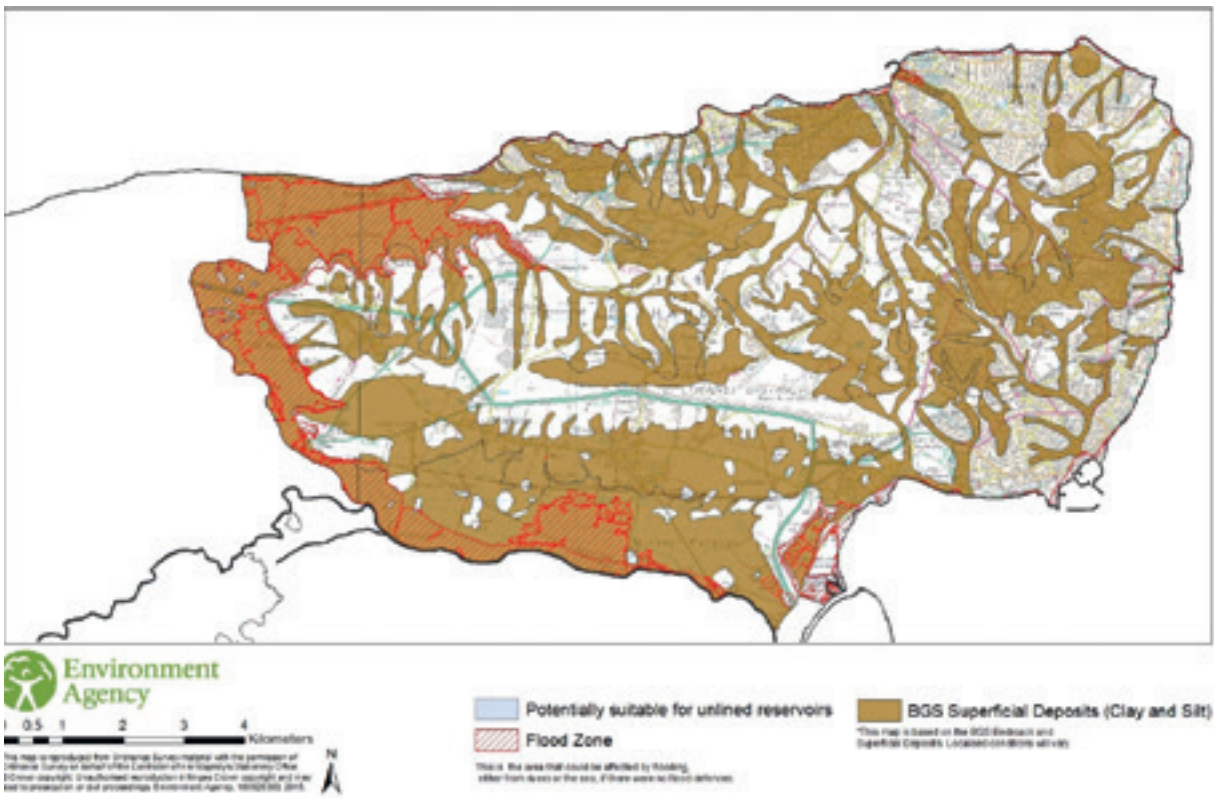
BGS Superficial Deposits (Clay and Silt)

*This map is based on the BGS Bedrock and Superficial Deposits. Localised conditions will vary.

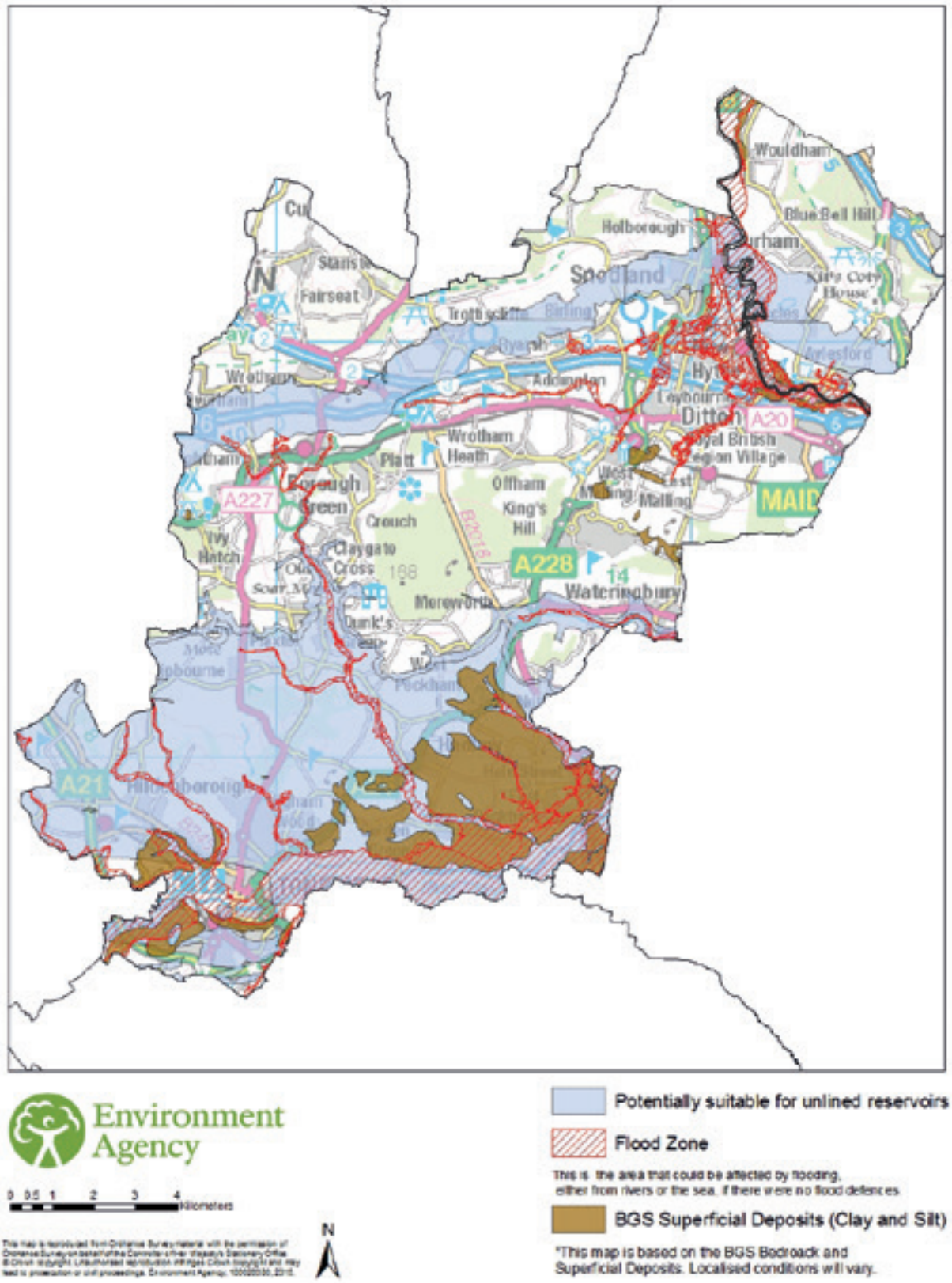
SWALE BOROUGH COUNCIL AREA



THANET DISTRICT COUNCIL AREA



TONBRIDGE AND MALLING BOROUGH COUNCIL AREA



TUNBRIDGE WELLS BOROUGH COUNCIL AREA