Monthly water situation report

England

Summary – December 2013

Following a month of below average rainfall in November, December was in marked contrast, with England receiving 140% of the December long term average (LTA) rainfall. Significant rainfall over the Christmas period led to widespread flooding across England, particularly in the south. Monthly rainfall totals were *notably high* or *exceptionally high* for the time of year across southern, south east and the far north west of England. Soil moisture deficits decreased in all areas during December. Monthly mean river flows for December were *normal* or *above normal* for the time of year in most areas and *exceptionally high* at four of our indicator sites in south east England. Groundwater levels increased at three quarters of our indicator sites and were *above normal* or *notably high* at a third of sites. Reservoir stocks increased at all but one reported site during December, with storage in England as a whole at 94% of total capacity at the end of the month.

Rainfall

The first ten days of December were fairly dry, particularly in southern England; by contrast, the latter part of the month was extremely wet. During the 7-day period before Christmas Day, our South East Region received 110% of the average monthly rainfall, whilst all our other regions received between 50 and 75%. Rainfall totals for December were highest in our North West and South West Regions at approximately 180 mm. In our other regions, totals ranged from 51 mm (Anglian Region) to 148 mm (South East Region) (Figure 1.1). Locally, the highest rainfall totals (more than 250 mm) fell across Cumbria and south Devon. The lowest rainfall totals (less than 50 mm) fell across parts of Norfolk, Lincolnshire and East Yorkshire.

December rainfall totals were *above normal* or higher for the time of year across southern and northern England, and *exceptionally high* across the far south east and north west. Across most of central and eastern England, December rainfall totals were *normal* or lower; rainfall across parts of East Yorkshire and Lincolnshire was classed as *notably low*. Cumulative rainfall totals for the past three months were *above normal* or higher for the time of year across most of England; in contrast, cumulative totals for the past six and 12 months were *normal* or lower across most of England (Figure 1.2).

Monthly rainfall totals as a percentage of the December long term average (LTA) were near or above average in all our regions, ranging from 93% in our Anglian Region to 196% in our South East Region (Figure 1.3). England as a whole received 140% of the LTA rainfall. It was the wettest December in our South East Region since 1978 and the 8th wettest on record[1]. The three month period October to December was the wettest in our South East Region since 2002 and the 6th wettest on record.

On a more local scale, December 2013 was within the top two wettest Decembers on record in four Cumbrian catchments in our North West Region and the fourth wettest on record in the Tyne catchment in our Yorkshire and North East Region. December was also within the top ten wettest on record in a number of catchments covering parts of Dorset and Wiltshire in our South West Region, as well as the majority of catchments in our South East Region.

Soil moisture deficit

Soil moisture deficits (SMDs) continued to decrease in all six of our regions during December. At the end of the month, SMDs were less than 10 mm across most of the country, although parts of central southern England had slightly higher SMDs ranging between 11 and 40 mm. (Figure 2.1). Month end SMDs were within 5 mm of the LTA across most of England, but were 6-50 mm less than the LTA in around a third of the MORECS squares reported on, covering parts of central, eastern and south east England. SMDs were 6-25 mm greater than the LTA in seven MORECS grid squares mainly covering parts of Yorkshire, Lincolnshire and Nottinghamshire (Figure 2.1).

At the beginning of December, SMDs ranged from 2 mm in our North West Region to 28 mm in our Anglian Region. During the early part of the month, SMDs increased slightly in response to the dry weather in all but our

[1] The rainfall record covers a period of 104 years, starting in January 1910

South West Region. SMDs then decreased throughout the remainder of the month and by the end of December, ranged from zero in our South West Region to 18 mm in our Anglian Region. SMDs in all our regions were less than the LTA (Figure 2.2).

River flows

Monthly mean river flows for December increased compared to November at all but nine of our reported indicator sites across England. Nearly three quarters of sites showed an increase in monthly mean flows for December expressed as a percentage of the LTA (Figure 3.1).

Monthly mean river flows for December were *normal* or *above normal* for the time of year at more than three quarters of our indicator sites across England. Flows at four sites in our South East Region were *exceptionally high* for the time of year – the rivers Darent, Medway, Eastern Rother and Western Rother. Flows in the Eastern Rother were the highest on record for December. Flows at a further two sites, one in each of our South East and North West Regions, were *notably high*. In contrast, monthly mean flows were *notably low* in the River Lud in our Anglian Region and *below normal* in the rivers Dove (Midlands) and Derwent (Yorkshire and North East) (Figure 3.1).

River flows at six of the seven regional index sites were *normal* or *above normal* for the time of year. The River Dove in our Midlands Region was *below normal* (Figure 3.2).

Groundwater levels

During December, groundwater levels increased at over three quarters of our indicator sites, including all those in our North West and South West Regions and all but one in each of our Midlands, South East and Yorkshire and North East Regions. Levels at the remaining sites continued to decline during the month.

At the end of December, groundwater levels were *normal* or higher for the time of year at all but two of the sites reported on. Levels at nine sites (a third of the total number) were *above normal* or *notably high*, with five of these sites located in chalk aquifers in southern England. Groundwater levels were *below normal* for the time of year at Wetwang and Dalton Holme, both in the Hull and East Riding chalk aquifer in our Yorkshire and North East Region (Figures 4.1 and 4.2).

Groundwater levels continued to be classed as *exceptionally high* in relation to historic values for this time of year at Priors Heyes (West Cheshire Sandstone) in our North West Region because the aquifer is recovering from the effects of historic abstraction.

Reservoir storage

During December, reservoir stocks increased or remained unchanged at all but one of the reported reservoirs and reservoir groups. Increases were greater than 10% of full capacity at nearly half of the reservoirs or reservoir groups; notably in our South West Region Blagdon and Stithians both increased by 19%, whilst in our South East Region Ardingly increased by 18% of full capacity. Reservoir stocks are *normal* or higher for the time of year at all of the reported sites (Figure 5.1).

At a regional scale, reservoir stocks increased in all our regions by between 4% and 13% of full capacity. At the end of December, regional reservoir stocks remained lowest in our South West Region at 85% of total capacity and were highest in our North West Region at 97%. Overall reservoir storage for England increased during November to 94% of total capacity (Figure 5.2).

Forward look

Following the very wet start to January in many parts of England current indications point towards changeable conditions persisting late into the month; however they are not expected to be as stormy as the start of the month. This would mean outbreaks of rain mainly affecting the northwest; the best of the dry and brighter weather should remain in southern and eastern England. Further ahead, near or just above average rainfall totals are most probable for the period January to March, with signs that February and March might be a little drier than average in contrast to January[2].

Scenario based projections for river flows at key sites [3]

[2] Source: Met Office

[3] Information produced by the Water Situation Forward Look group led by Environment Agency in partnership with the Centre for Ecology and Hydrology, British Geological Survey, Met Office.

March 2014: With average (100% of the LTA) rainfall between January 2014 and the end of March 2014, river flows are likely to be *normal* at two thirds of our modelled sites, and *above normal* or higher at a third. With 120% of the LTA rainfall, river flows are likely to be *above normal* or higher at more than three quarters of the modelled sites. With 80% of the LTA rainfall river flows are likely to be *normal* at more than three quarters of the modelled sites (see Figure 6.1).
September 2014: With average rainfall between January 2014 and the end of September 2014, river flows are likely to be *normal* at more than three quarters of our modelled sites. With above average rainfall (120% of the LTA), flows are likely to be *above normal* or higher at more than three quarters of our modelled sites. With below average rainfall (80% of the LTA), river flows are likely to be *below normal* or lower at more than half of the modelled sites (see Figure 6.2).

Probabilistic ensemble projections for river flows at key sites [4]
March 2014: At more than two thirds of the modelled sites, there is a greater than expected chance of *above normal* flows at the end of March 2014. There is also a greater than expected chance of *normal* flows at more than half of the modelled sites (see Figure 6.3).
September 2014: There is a greater than expected chance of *normal* flows at the end of September 2014 at half of the modelled sites. There is also a greater than expected chance of *below normal* flows at one fifth of the modelled sites (see Figure 6.4).

Scenario based projections for groundwater levels in key aquifers[4]
March 2014: With average rainfall (100% of the LTA) from January 2014 to March 2014, groundwater levels are likely to be *normal* or higher for the time of year at four fifths of the modelled sites, and *above normal* or higher at nearly two thirds of modelled sites. With above average rainfall (120% of the LTA) groundwater levels will be *above normal* or higher at more than two thirds of the modelled sites. With 80% of the LTA rainfall, more than three quarters of the modelled sites are likely to have *normal* or higher groundwater levels for the time of year (see Figure 6.5).
September 2014: With average rainfall (100% of the LTA) from January 2014 to September 2014, groundwater levels are likely to be *normal* or higher for the time of year at four fifths of the modelled sites. With above average rainfall (120% of the LTA), levels are likely to be *above normal* or higher for the time of year at nearly two thirds of the modelled sites. With below average rainfall (80% of the LTA), groundwater levels are likely to be *normal* or higher at three quarters of our modelled sites (see Figure 6.6).

Probabilistic ensemble projections for groundwater levels in key aquifers [4]
March 2014: More than a half of all modelled sites have a greater than expected chance of *exceptionally high* groundwater levels for the time of year. Less than a quarter of all modelled sites have a greater than expected chance of *below normal* groundwater levels for the time of year (see Figure 6.7).
September 2014: More than half of the modelled sites have a greater than expected chance of levels being *above normal* for the time of year. A quarter of the modelled sites have a greater than expected chance of *normal* groundwater levels for the time of year. Less than a quarter of all modelled sites have a greater than expected chance of *below normal* groundwater levels by the end of March 2014 (see Figure 6.8).

Authors: Karen James and Tom Schnetler (Hydrology – Water Resources Technical Services)

[4] Information produced by the Water Situation Forward Look group lead by Environment Agency in partnership with the Centre for Ecology and Hydrology, British Geological Survey, Met Office.

Rainfall

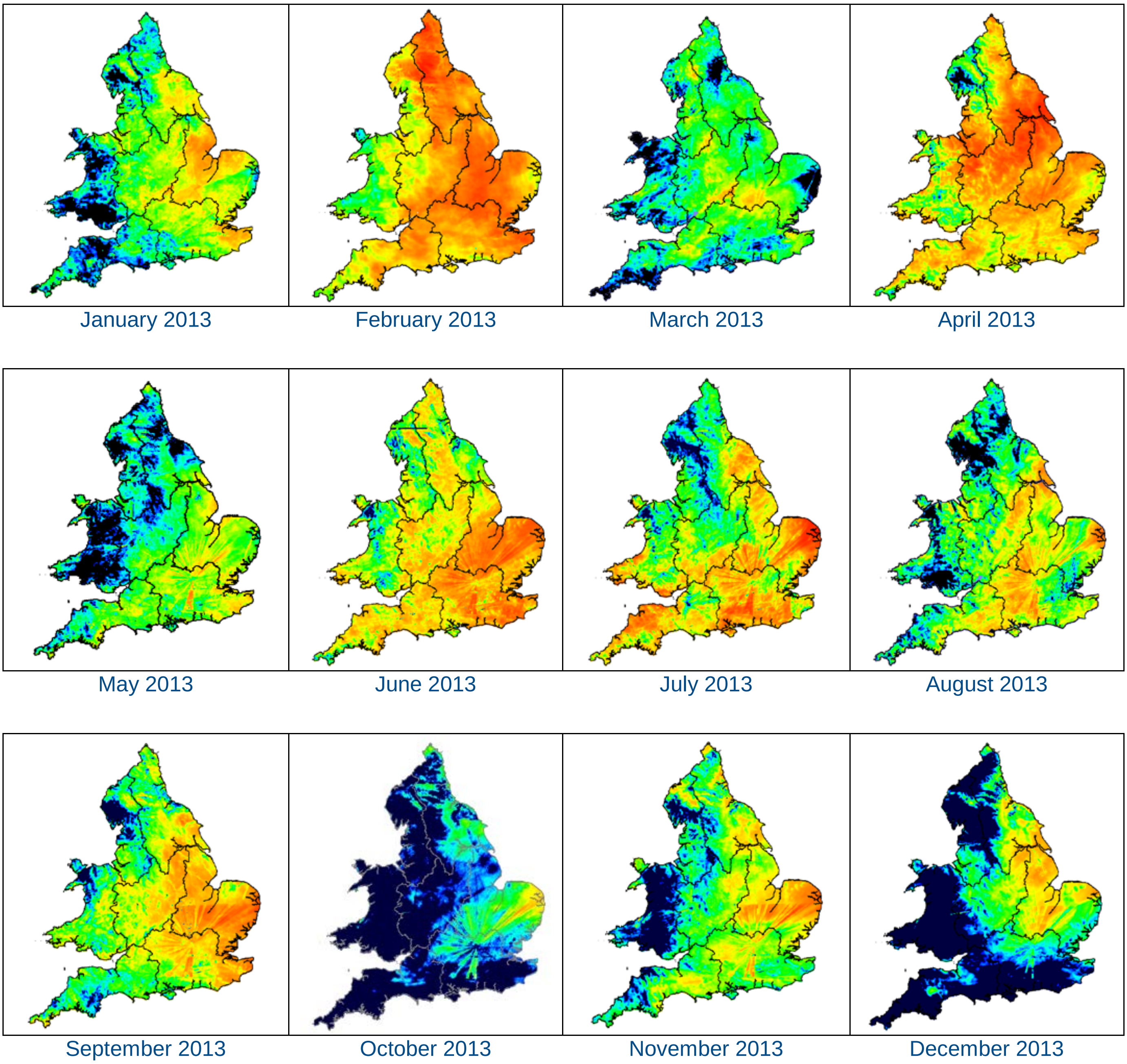
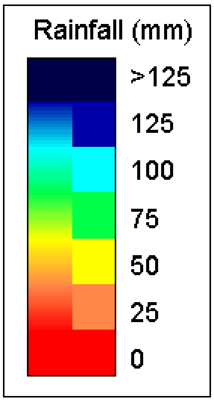


Figure 1.1: Monthly rainfall across England and Wales for the past 12 months. UKPP radar data (Source: Met Office © Crown Copyright, 2014). Note: Radar beam blockages in some regions may give anomalous totals in some areas. Crown copyright. All rights reserved. Environment Agency, 100026380, 2014.



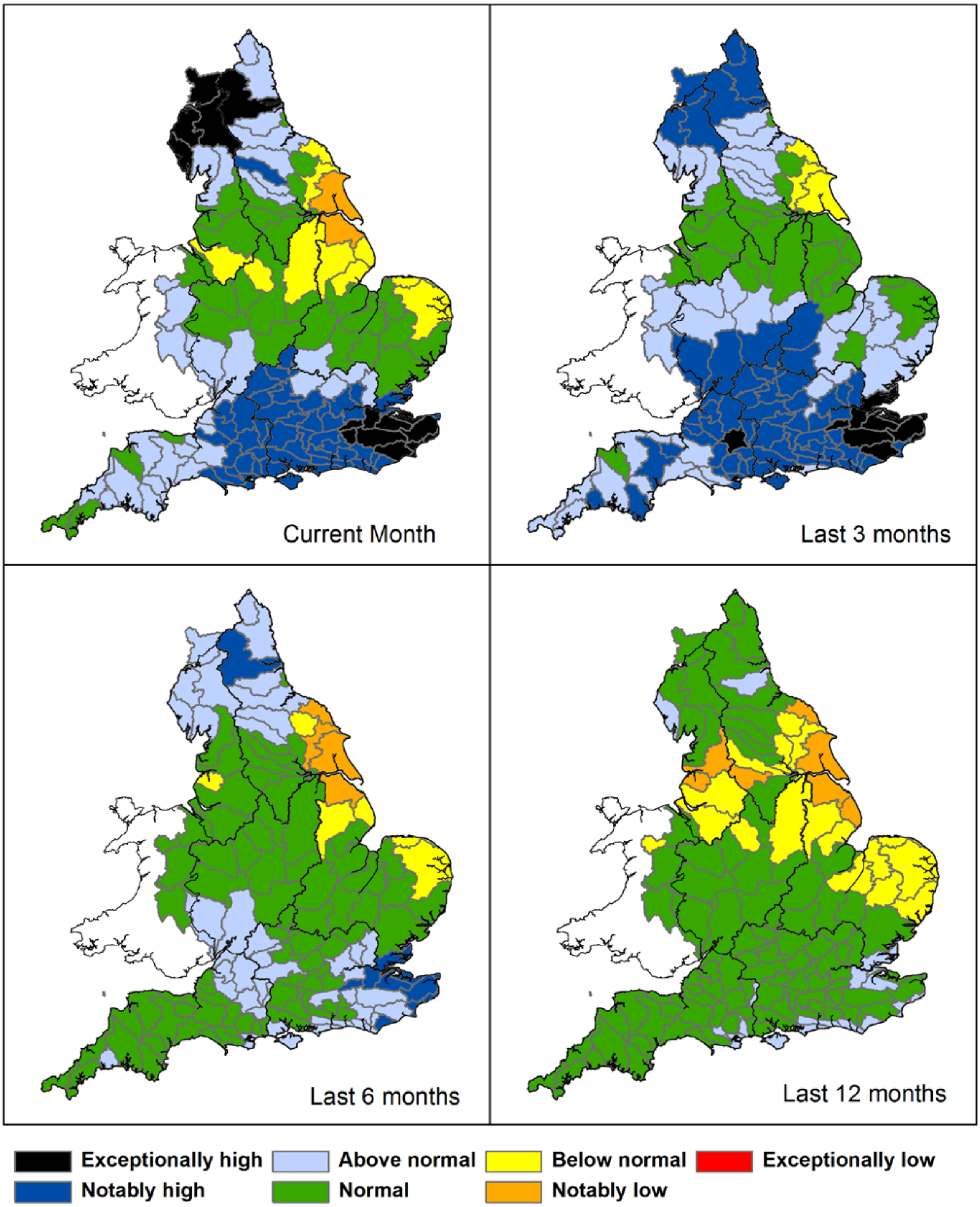


Figure 1.2: Total rainfall for hydrological areas across England for the current month (up to 31st December), the last three months, the last six months, and the last 12 months, classed relative to an analysis of respective historic totals. Final and provisional NCIC (National Climate Information Centre) data based on the Met Office 5km gridded rainfall dataset derived from rain gauges *(Source: Met Office © Crown Copyright, 2014).* Crown copyright. All rights reserved. Environment Agency, 100026380, 2014.

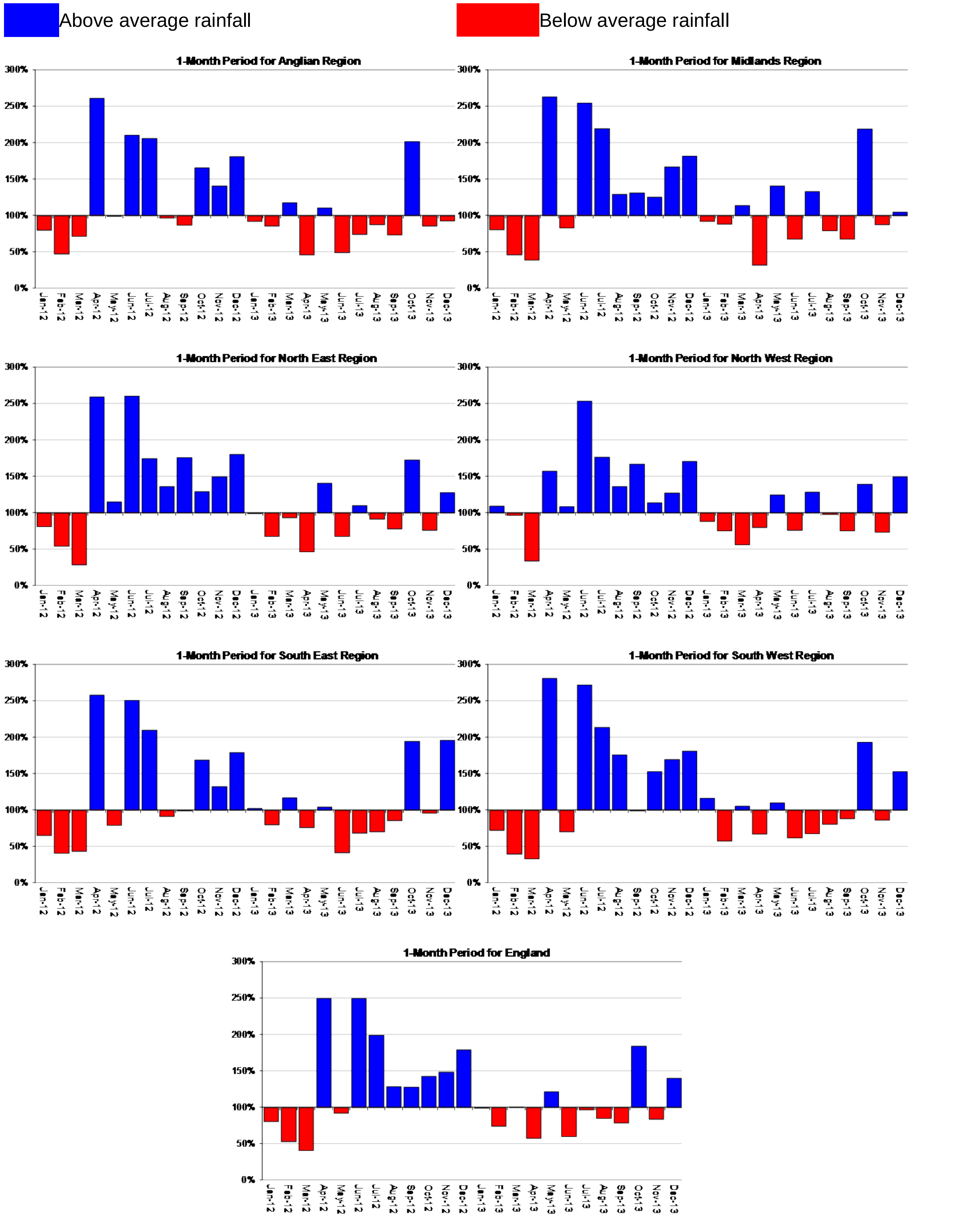


Figure 1.3: Monthly rainfall totals for the past 24 months as a percentage of the 1961 – 1990 long term average for each Environment Agency Region and for England. NCIC (National Climate Information Centre) data. (Source: Met Office © Crown Copyright, 2014).

Soil moisture deficit

End of November 2013[1]	End of December 2013[2]

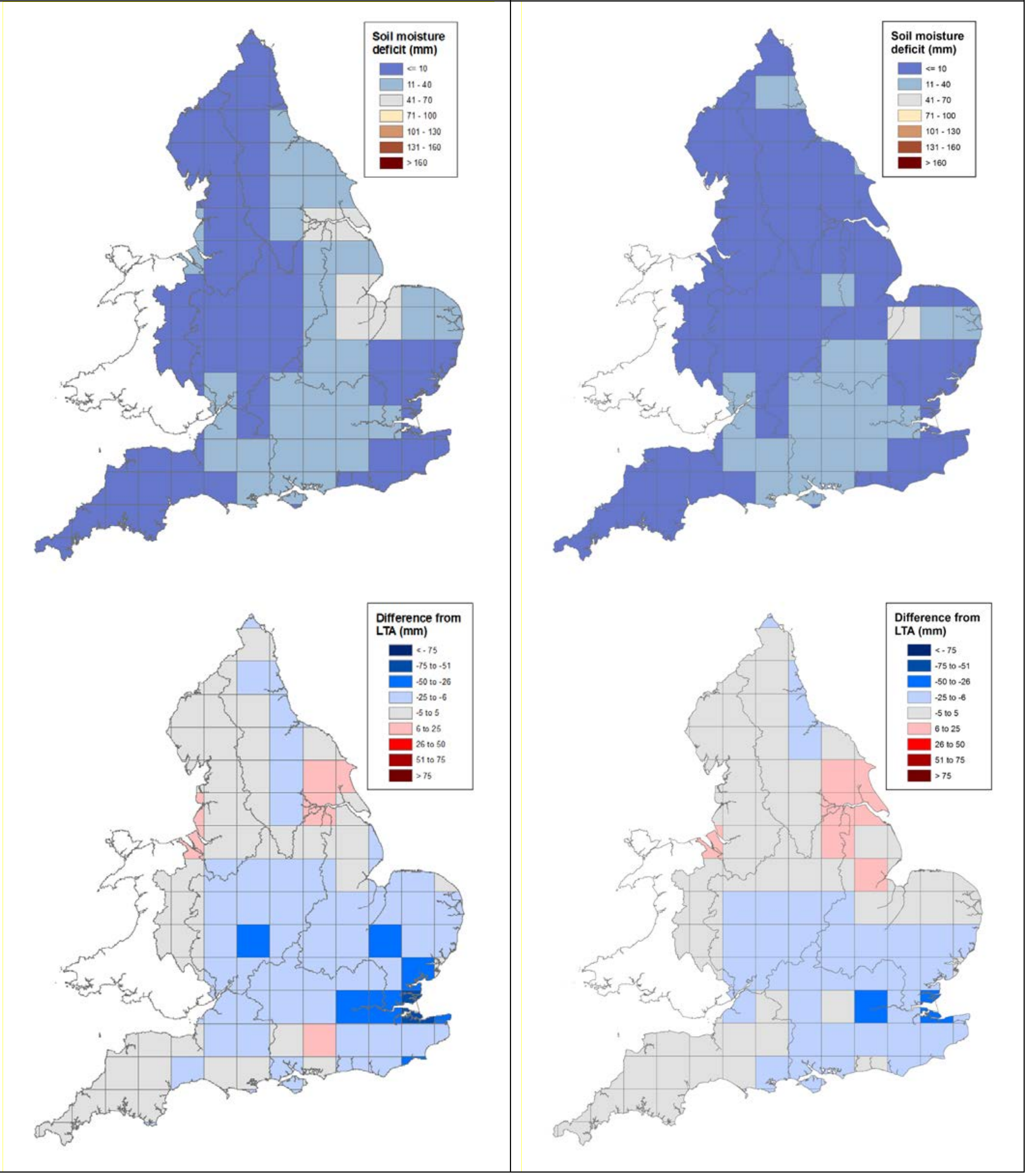


Figure 2.1: Soil moisture deficits for weeks ending 26 November 2013 [1] (left panel) and 24 December 2013 [2] (right panel). Top row shows actual soil moisture deficits (mm) and bottom row shows the difference (mm) of the actual from the 1961-90 long term average soil moisture deficits. MORECS data for real land use (Source: Met Office © Crown Copyright, 2014). Crown copyright. All rights reserved. Environment Agency, 100026380, 2014

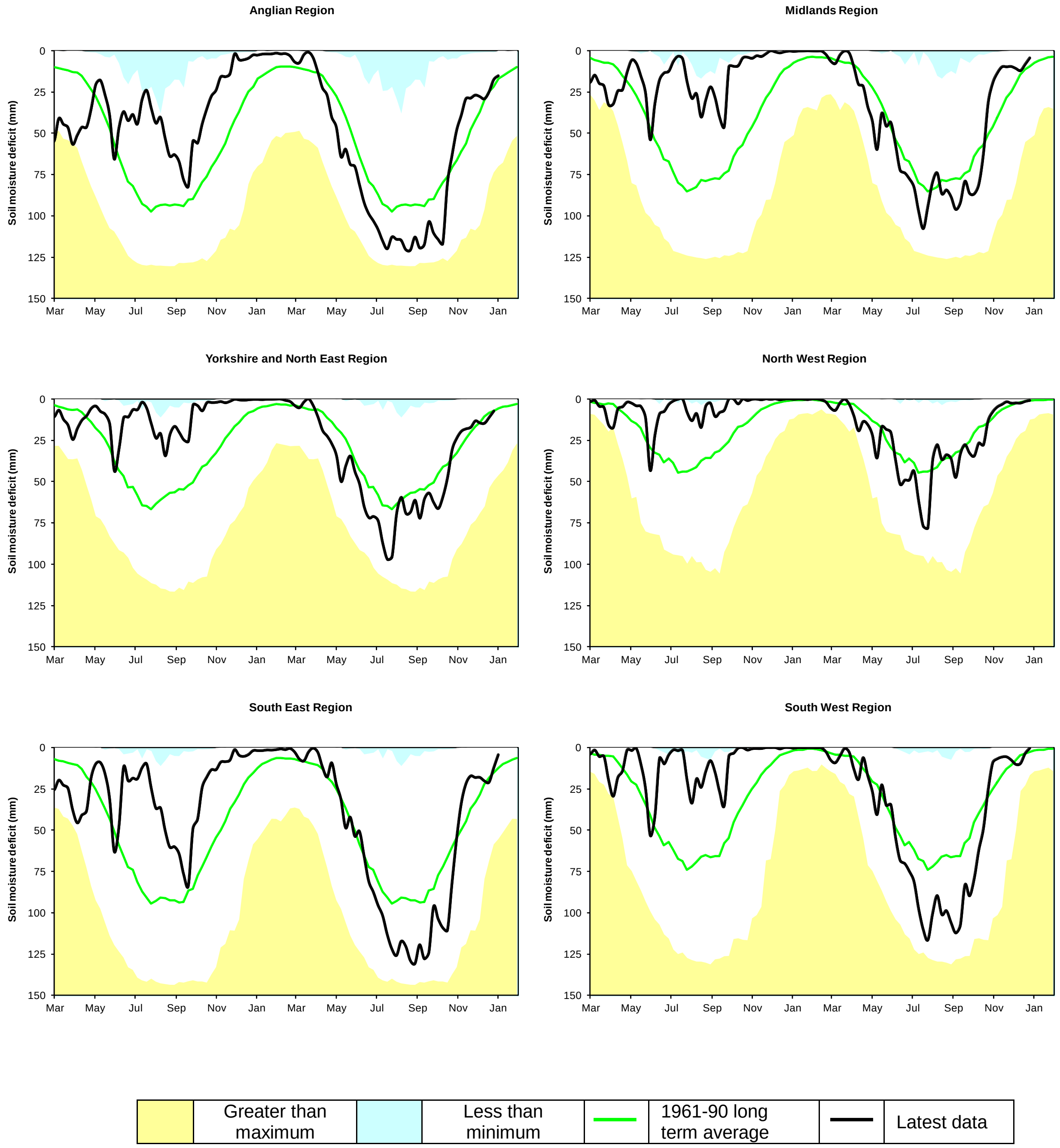
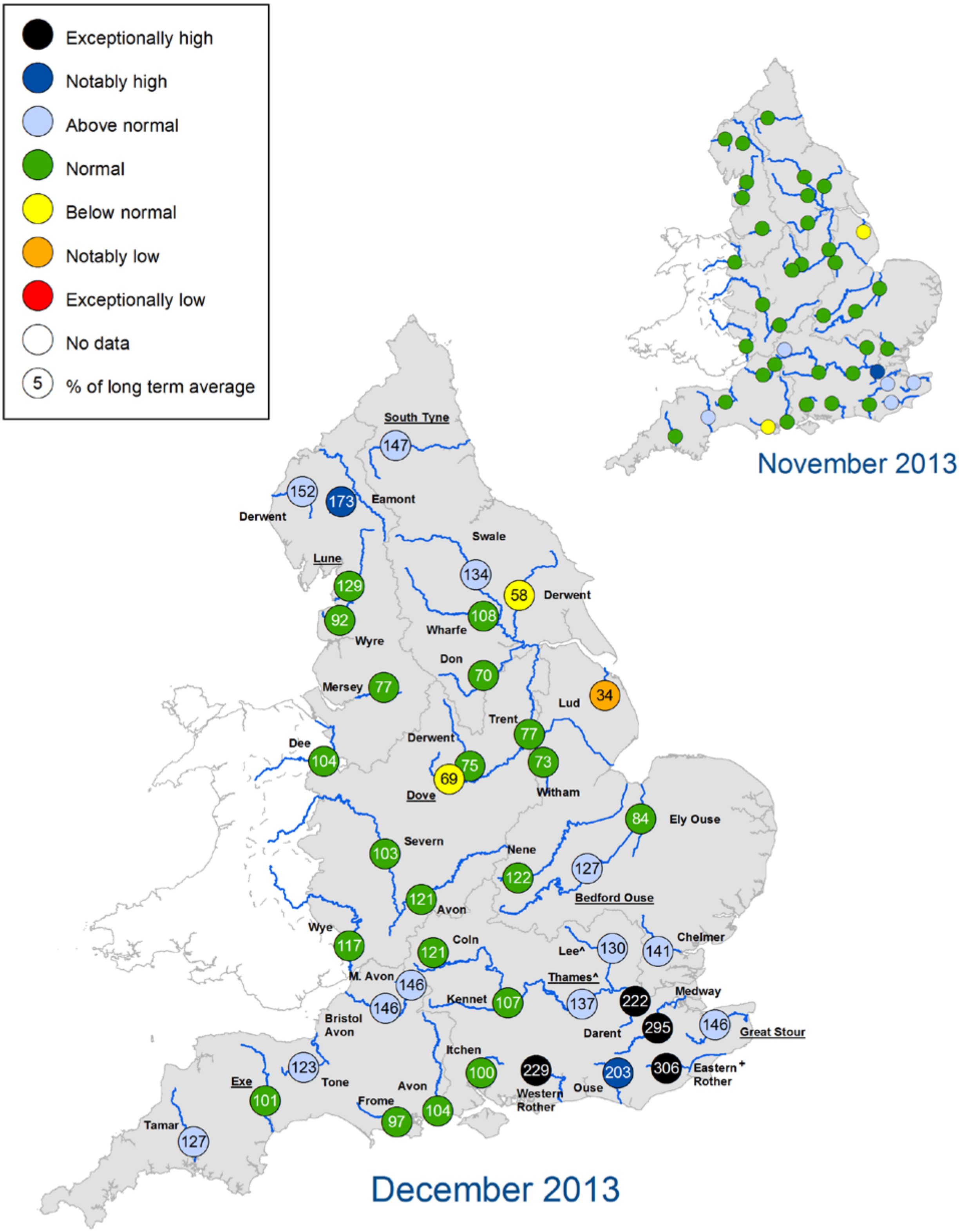


Figure 2.2: Latest soil moisture deficits for all Environment Agency Regions compared to maximum, minimum and 1961-90 long term average. Weekly MORECS data for real land use. (Source: Met Office © Crown Copyright, 2014).

River flows



^ "Naturalised" flows are provided for the 'Thames at Kingston' and the 'Lee at Feildes Weir'

* Monthly mean flow is the highest/lowest on record for the current month (note that record length varies between sites)

Underlined sites are regional index sites and are shown on the hydrographs in Figure 3.2

Figure 3.1: Monthly mean river flow for indicator sites for November 2013 and December 2013, expressed as a percentage of the respective long term average and classed relative to an analysis of historic November and December monthly means (Source: Environment Agency).

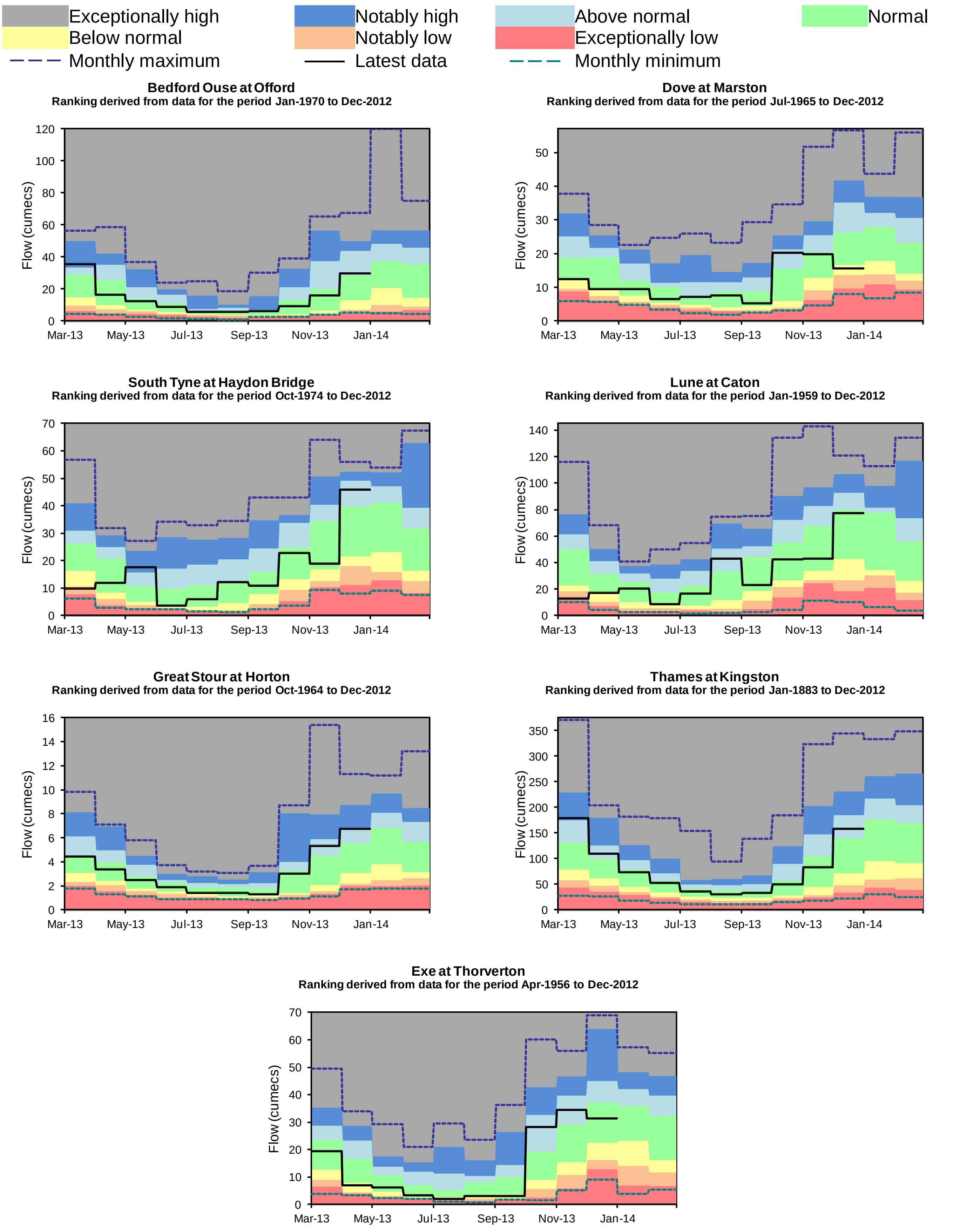
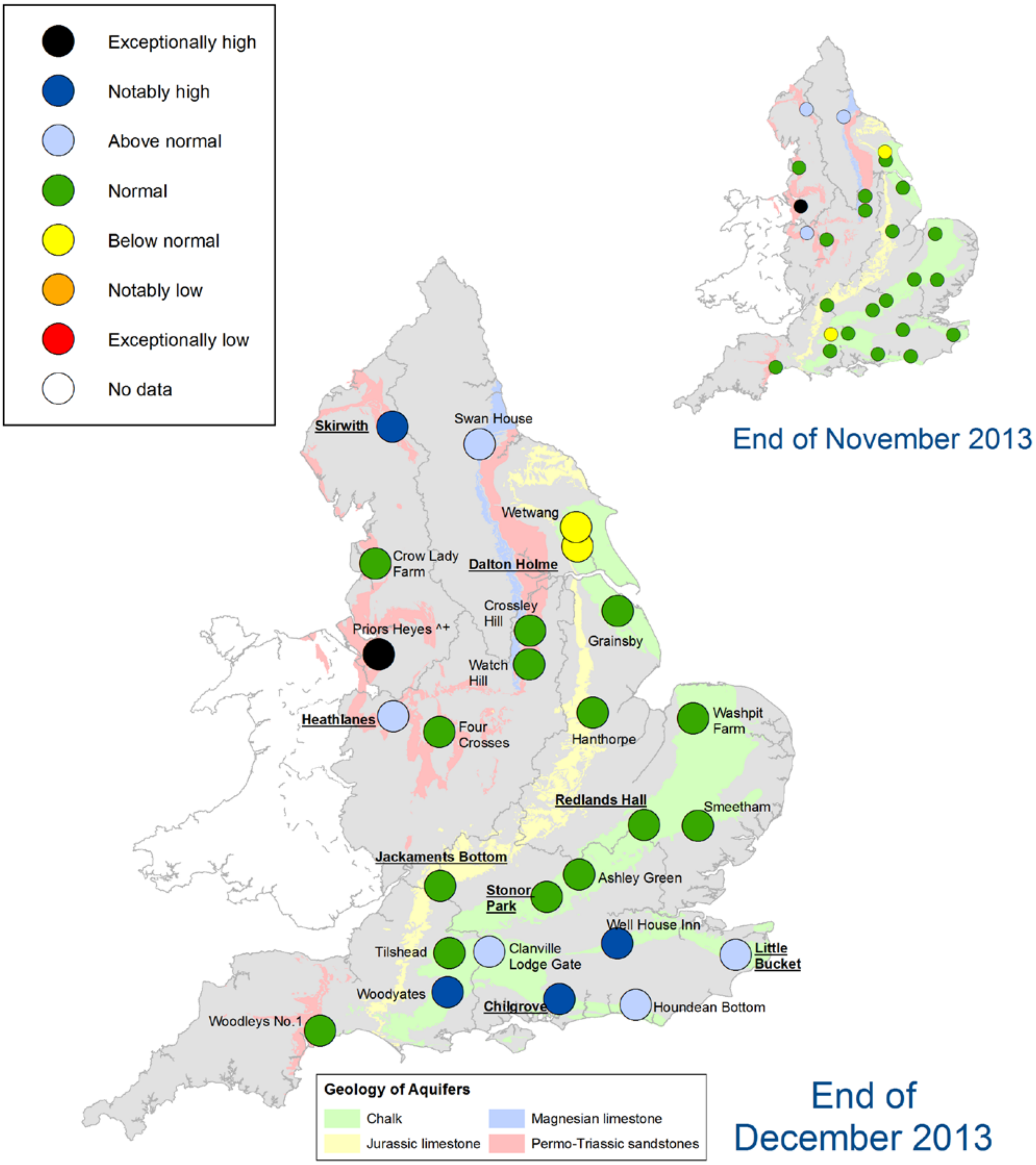


Figure 3.2: Index river flow sites for each Environment Agency Region. Monthly mean flow compared to an analysis of historic monthly mean flows, long term maximum and minimum flows. (Source: Environment Agency).

Groundwater levels



^ The level at Priors Heyes remains high compared to historic levels because the aquifer is recovering from the effects of historic abstraction.
End of month groundwater level is the highest (+) and lowest (-) on record (note that record length varies between sites).
Highlighted sites are major aquifer index sites and are shown in the groundwater level charts in Figure 4.2

Figure 4.1: Groundwater levels for indicator sites at the end of November 2013 and December 2013, classed relative to an analysis of respective historic November and December levels (Source: Environment Agency). Geological map reproduced with kind permission from UK Groundwater Forum, BGS © NERC. Note: groundwater levels are reported at different times during the month and therefore may not be fully representative of levels at the month end. Crown copyright. All rights reserved. Environment Agency, 100026380, 2014.

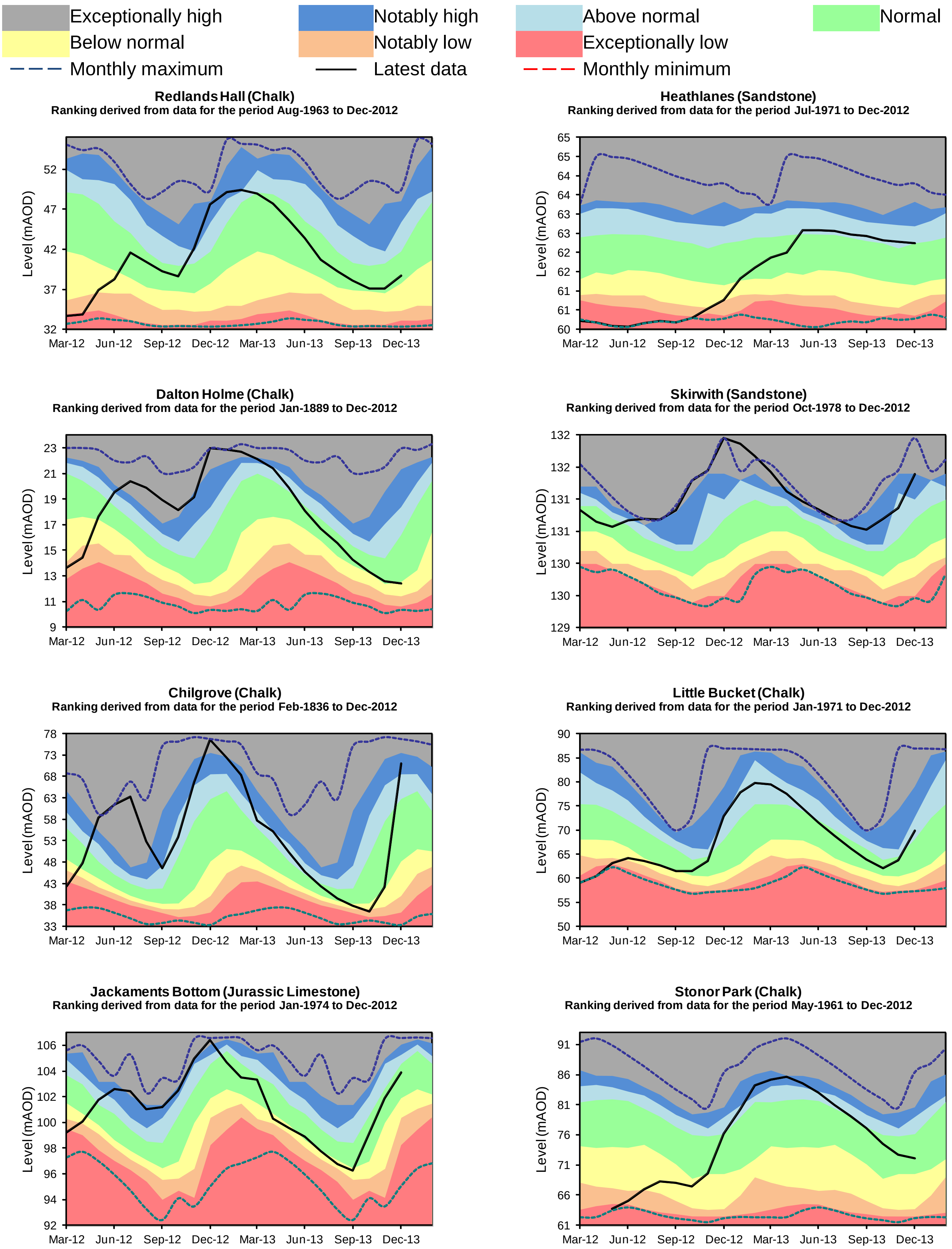
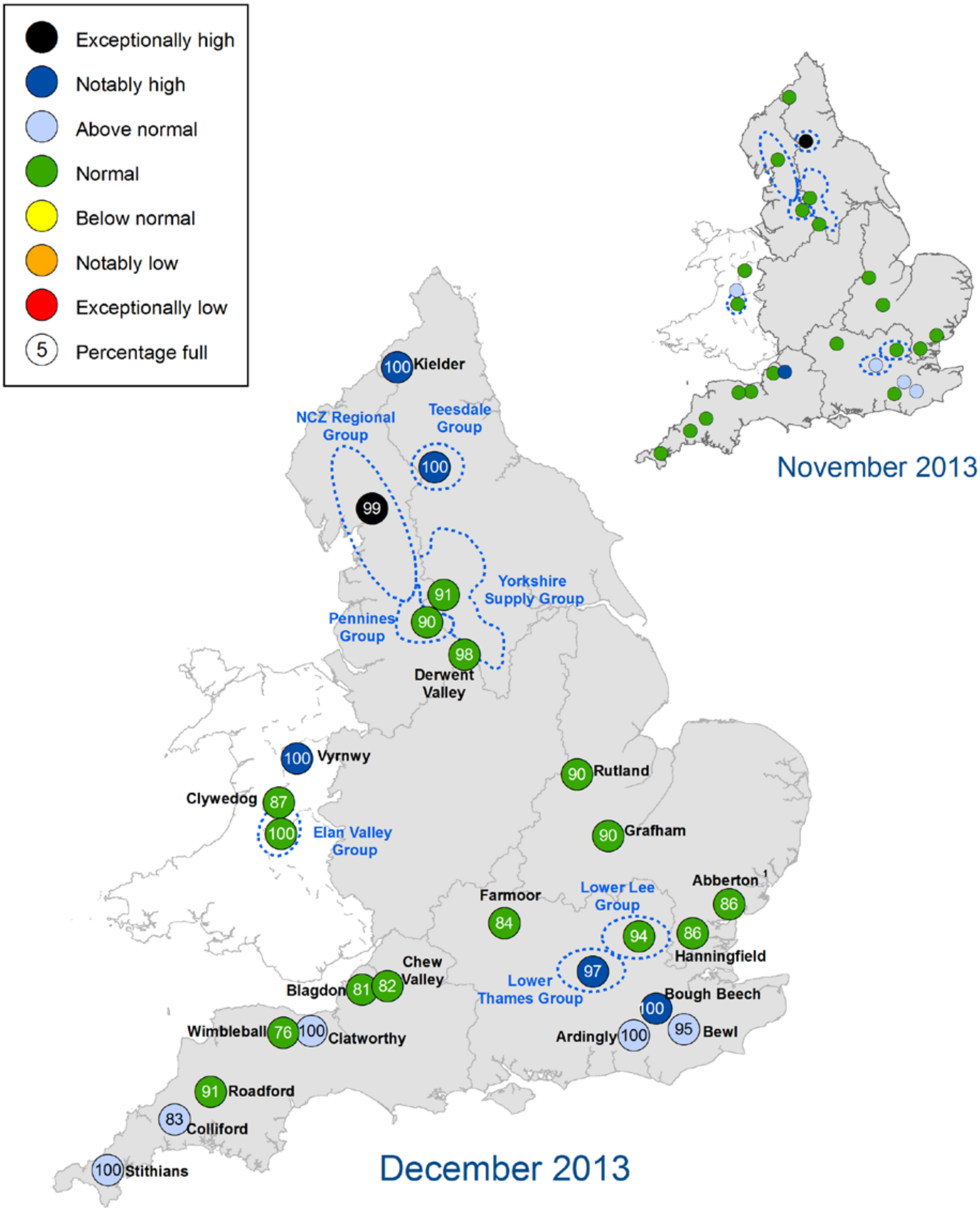


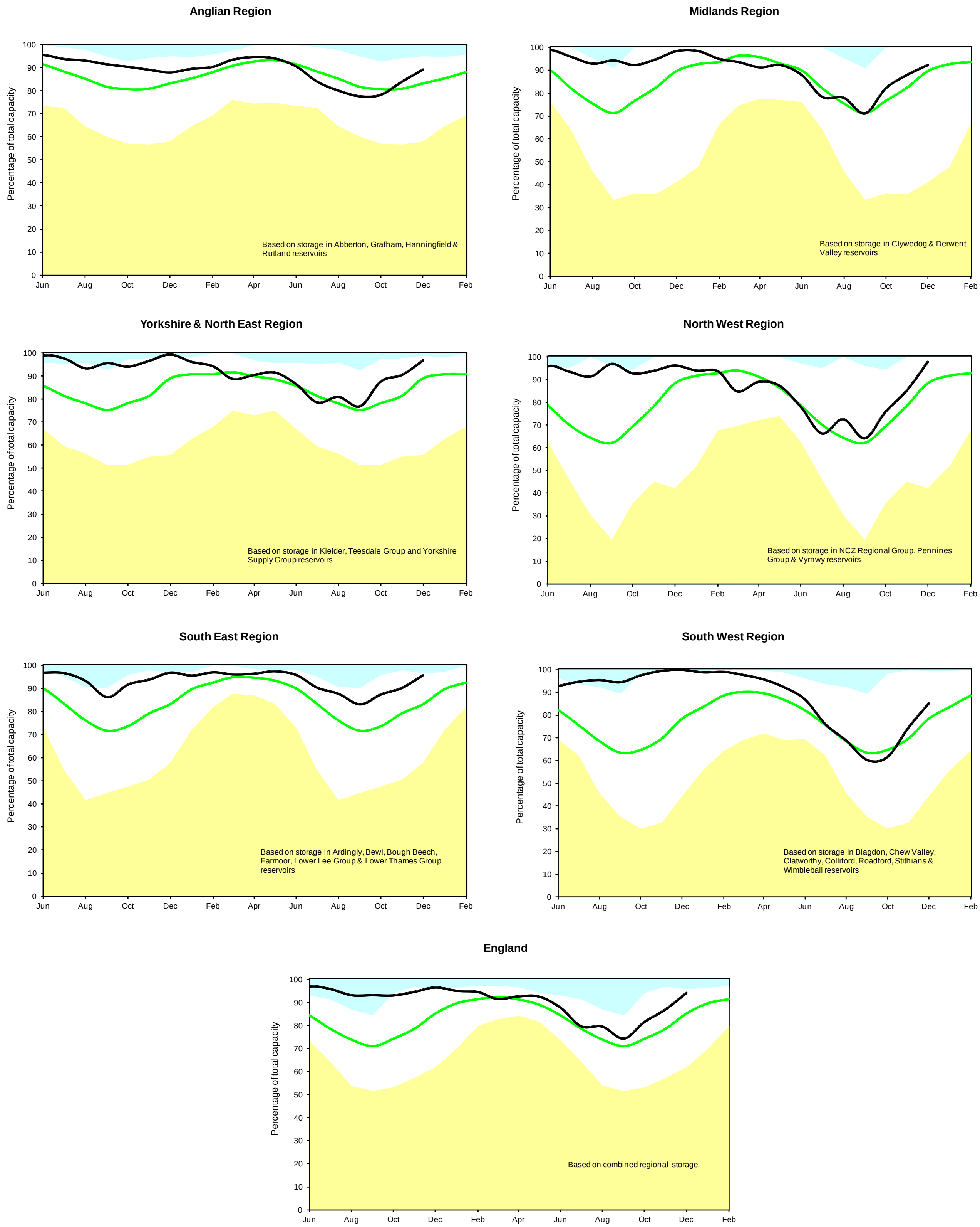
Figure 4.2: Index groundwater level sites for major aquifers. End of month groundwater levels months compared to an analysis of historic end of month levels and long term maximum and minimum levels. (Source: Environment Agency, 2014).

Reservoir storage



1. The level at Abberton Reservoir in Anglian Region is affected by ongoing engineering works to increase capacity by 60%.
2. Vyrnwy, Clywedog and Elan Valley reservoirs are located in Wales but provide a water resource to our Midlands and North West regions

Figure 5.1: Reservoir stocks at key individual and groups of reservoirs at the end of November 2013 and December 2013 as a percentage of total capacity and classed relative to an analysis of historic November and December values respectively (Source: Water Companies). Note: Classes shown may not necessarily relate to control curves or triggers for drought actions. As well as for public water supply, some reservoirs are drawn down to provide flood storage, river compensation flows or for reservoir safety inspections. In some cases current reservoir operating rules may differ from historic ones.



	Below minimum monthly level		Above maximum monthly level		Average		2011-2013

Figure 5.2: Regional reservoir stocks. End of month reservoir stocks compared to long term maximum, minimum and average stocks (Source: Water Companies). Note: Historic records of individual reservoirs/reservoir groups making up the regional values vary in length.

Forward look – river flow

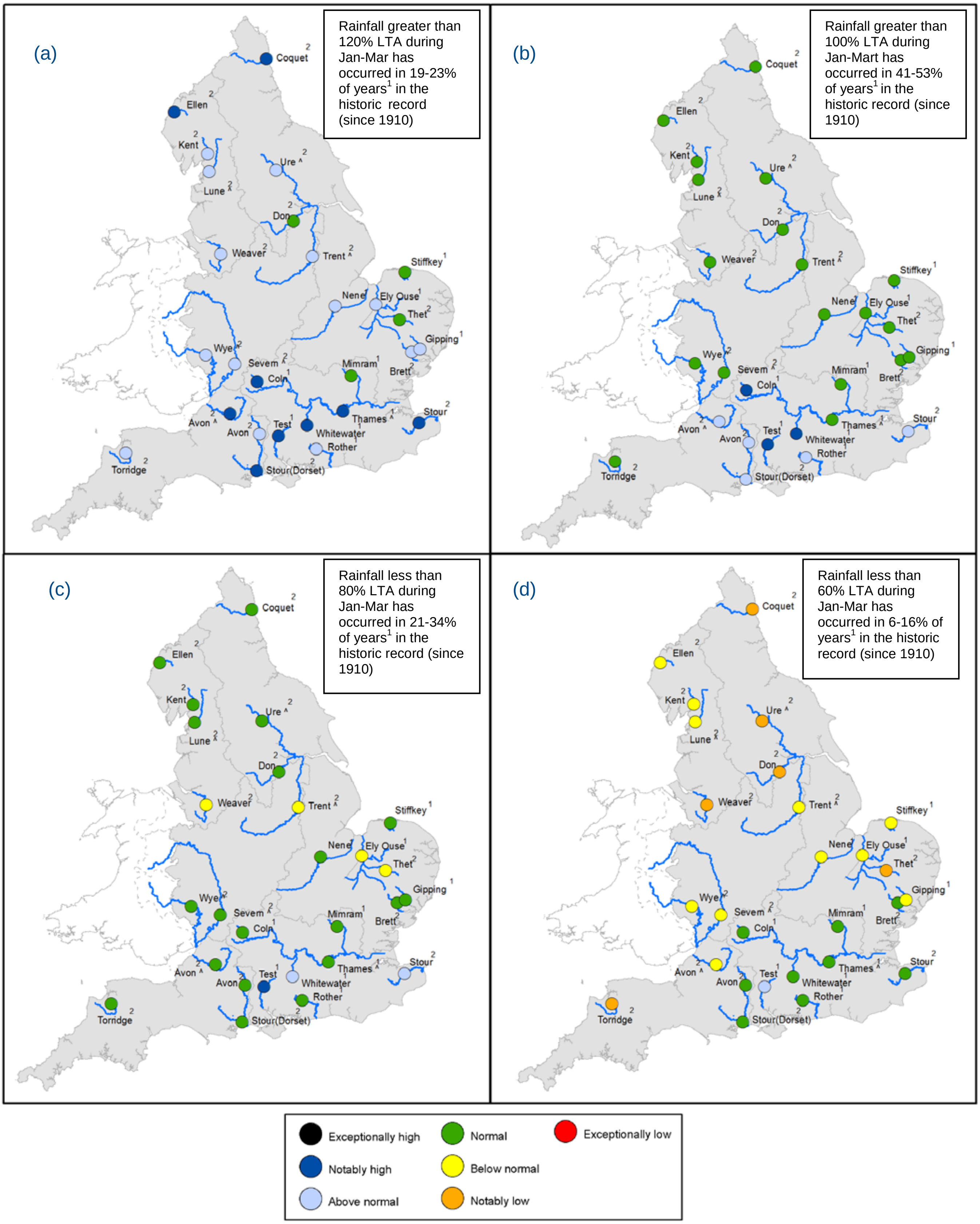


Figure 6.1: Projected river flows at key indicator sites up until the end of March 2014. Forecasts based on four scenarios: 120% (a), 100% (b), 80% (c) and 60% (d) of long term average rainfall between January 2014 and March 2014 (Source: Centre for Ecology and Hydrology, Environment Agency)

[1] Projections for these sites are produced by the Environment Agency
[2] Projections for these sites are produced by CEH,
[3] This range of probabilities is a regional analysis
^ *"Naturalised" flows are projected for these sites*

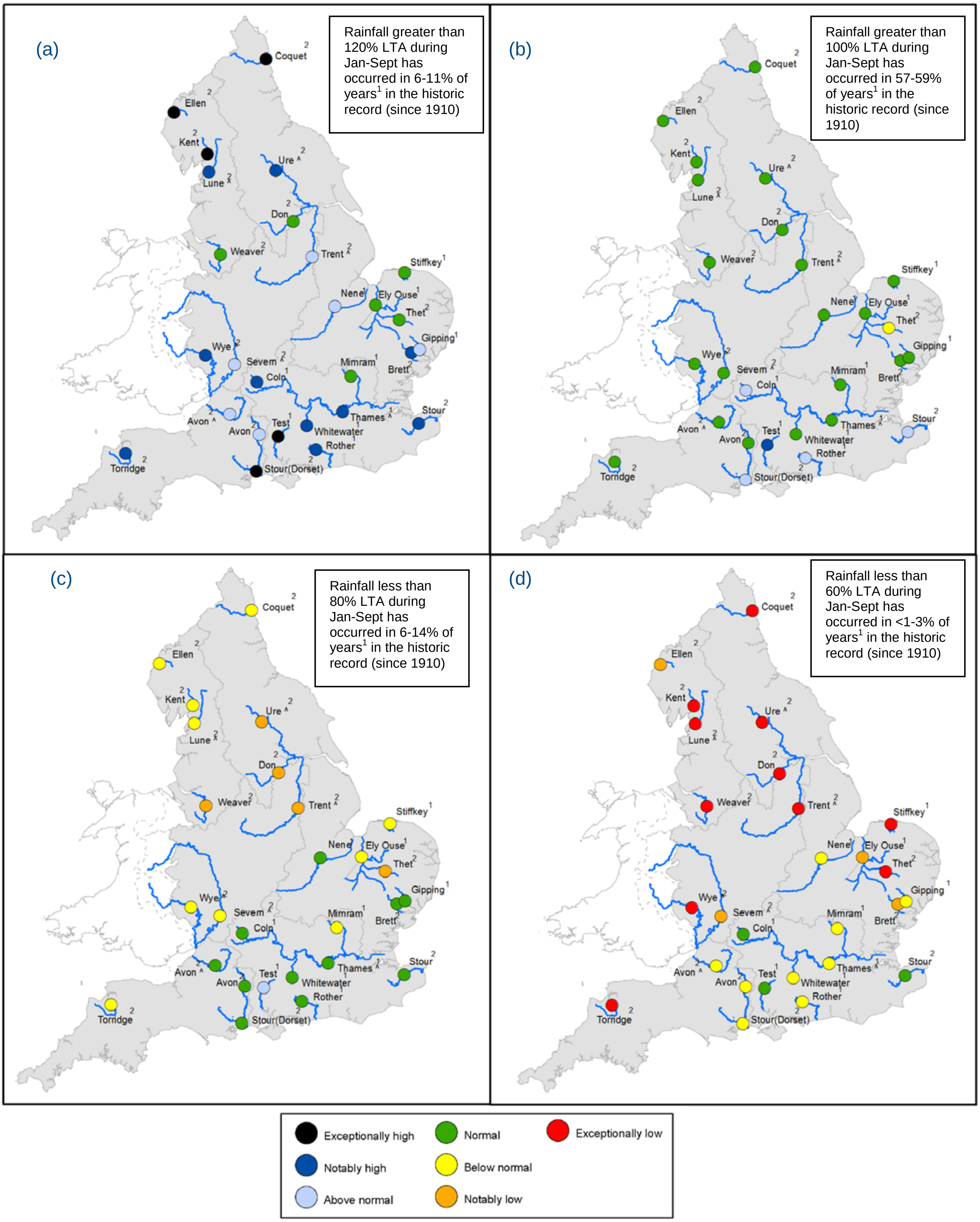


Figure 6.2: Projected river flows at key indicator sites up until the end of September 2014. Forecasts based on four scenarios: 120% (a), 100% (b), 80% (c) and 60% (d) of long term average rainfall between January 2014 and September 2014 (Source: Centre for Ecology and Hydrology, Environment Agency)

[1] Projections for these sites are produced by the Environment Agency

[2] Projections for these sites are produced by CEH

[3] This range of probabilities is a regional analysis

^ *"Naturalised" flows are projected for these sites*

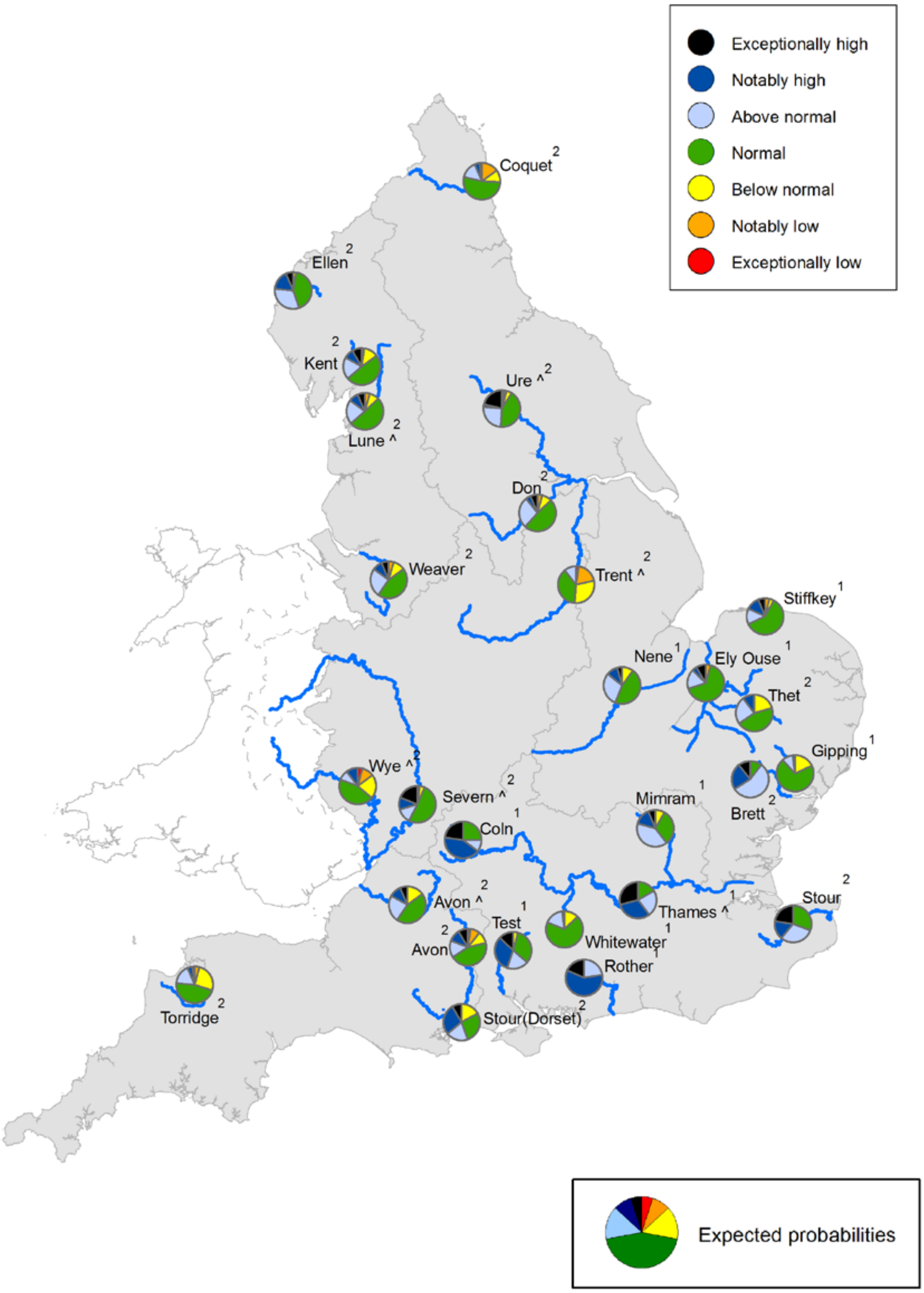


Figure 6.3: Probabilistic ensemble projections of river flows at key indicator sites up until the end of March 2014. Pie charts indicate probability, based on climatology, of the surface water flow at each site being e.g. exceptionally low for the time of year. (Source: Centre for Ecology and Hydrology, Environment Agency).

Exceptionally high or low levels are those which would typically occur 5% of the time within the historic record. Notably high or low levels are those which would typically occur 8% of the time. Above normal or below normal levels are those which would typically occur 15% of the time. Normal levels are those which would typically occur 44% of the time within the historic record.

^ "Naturalised" flows are projected for these sites'

[1]Projections for these sites are produced by the Environment Agency,[2] Projections for these sites are produced by CEH

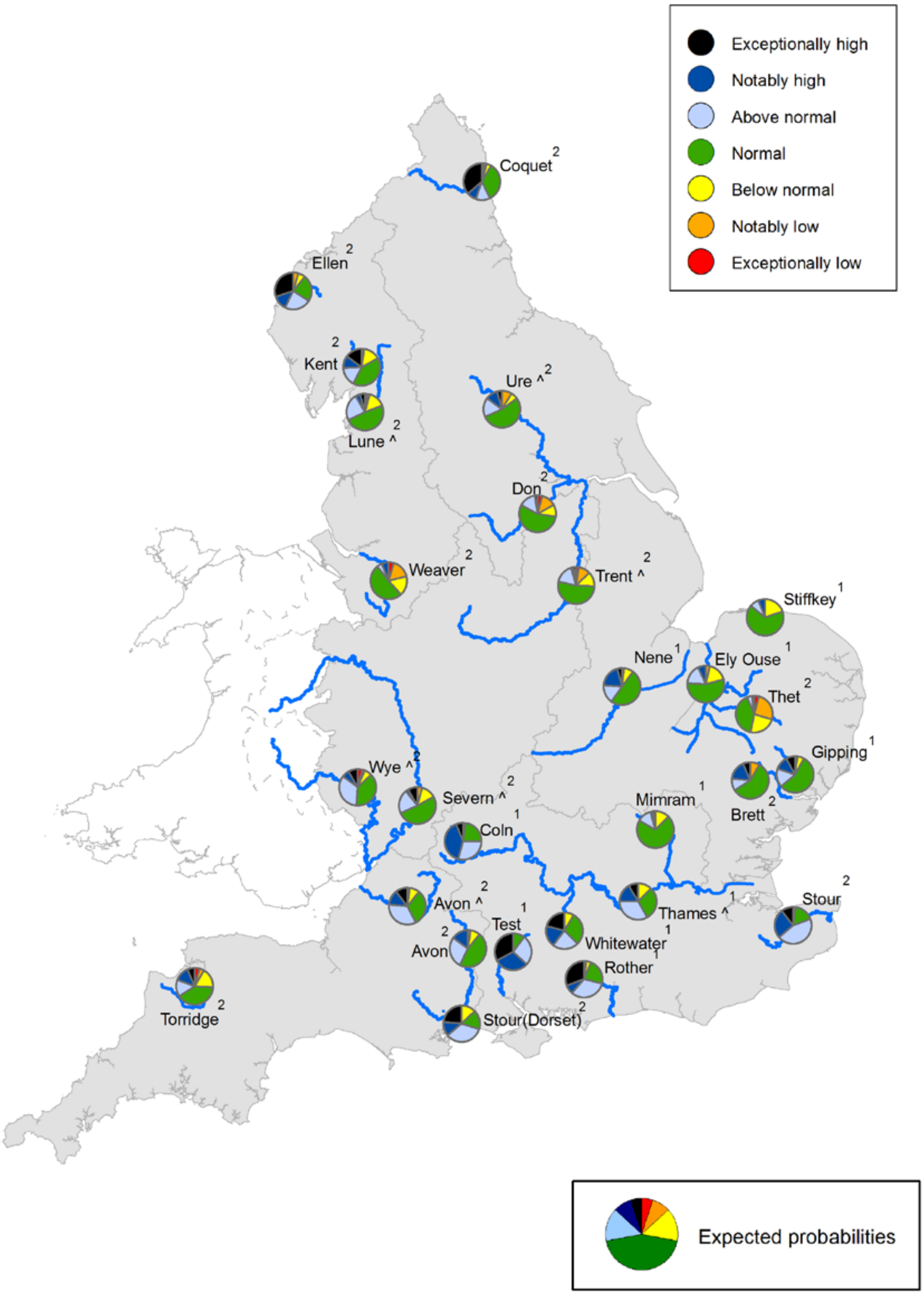


Figure 6.4: Probabilistic ensemble projections of river flows at key indicator sites up until the end of September 2014. Pie charts indicate probability, based on climatology, of the surface water flow at each site being e.g. exceptionally low for the time of year. (Source: Centre for Ecology and Hydrology, Environment Agency).

Exceptionally high or low levels are those which would typically occur 5% of the time within the historic record. Notably high or low levels are those which would typically occur 8% of the time. Above normal or below normal levels are those which would typically occur 15% of the time. Normal levels are those which would typically occur 44% of the time within the historic record.

^ *"Naturalised" flows are projected for these sites*

[1]*Projections for these sites are produced by the Environment Agency,*[2] *Projections for these sites are produced by CEH*

Forward look - groundwater

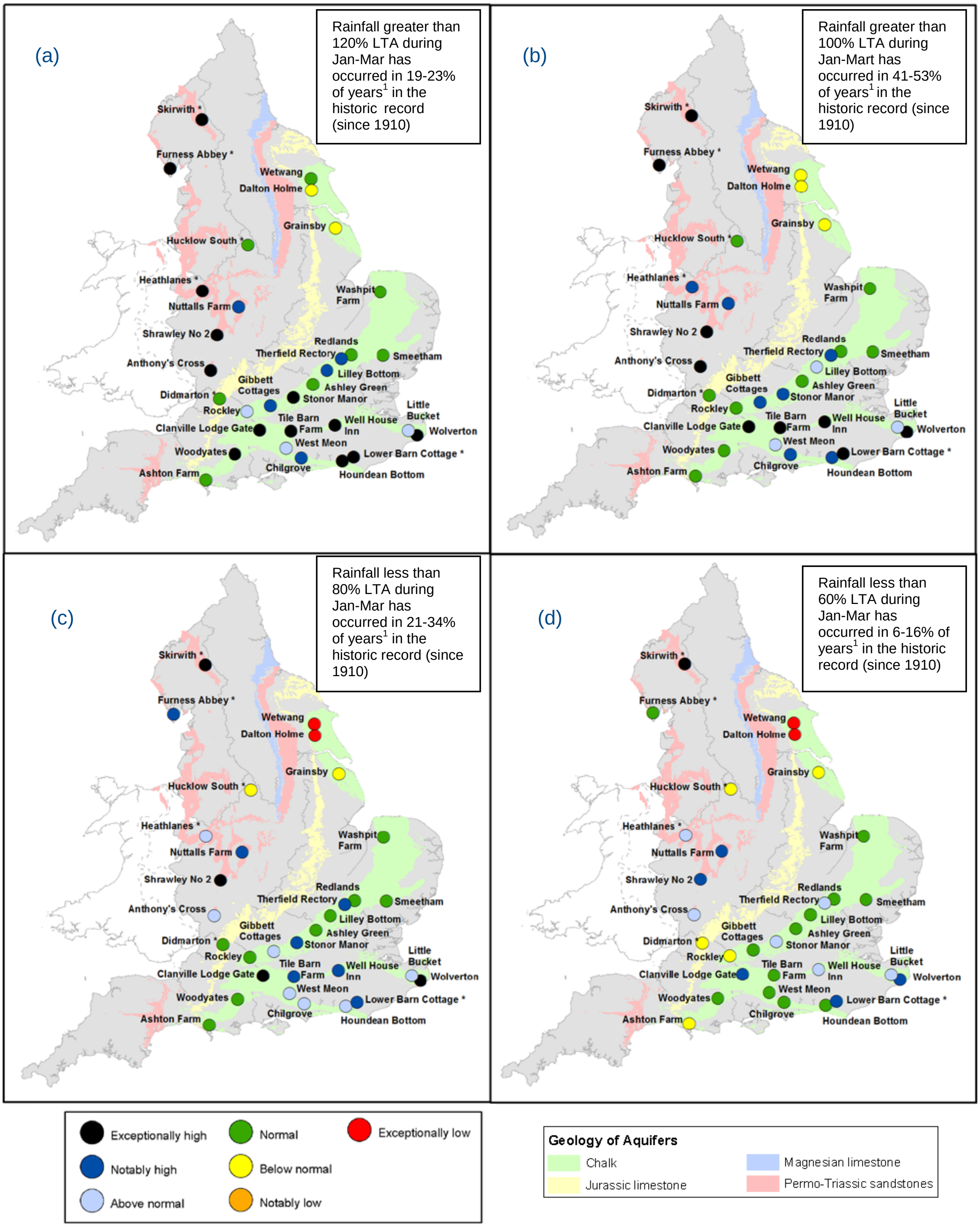


Figure 6.5: Projected groundwater levels at key indicator sites at the end of March 2014. Forecasts based on four scenarios: 120% (a), 100% (b), 80% (c) and 60% (d) of long term average rainfall between January 2014 and March 2014 (Source: Environment Agency) Geological map reproduced with kind permission from UK Groundwater Forum BGS © NERC. Crown copyright all rights reserved. Environment Agency 100026380, 2014.

Projections at the following sites start from 09 Jan 2014: *Ashton Farm, Chilgrove, Clanville Lodge gate, Houndean Bottom, Little Bucket, West Meon, Wolverton and Woodyates*. All others begin 01 Jan 2014.

* Projections for these sites are produced by BGS
[1] This range of probabilities is a regional analysis

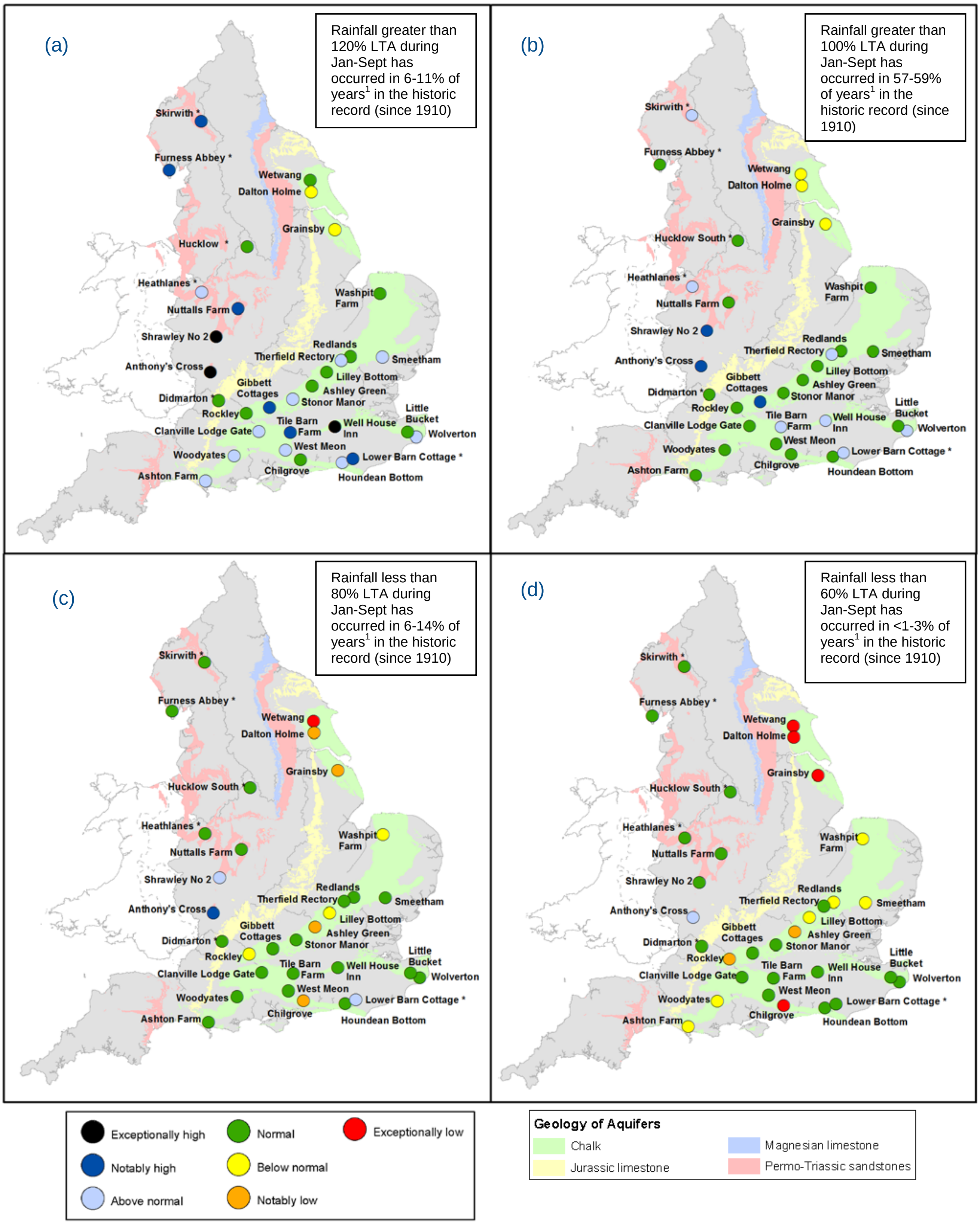
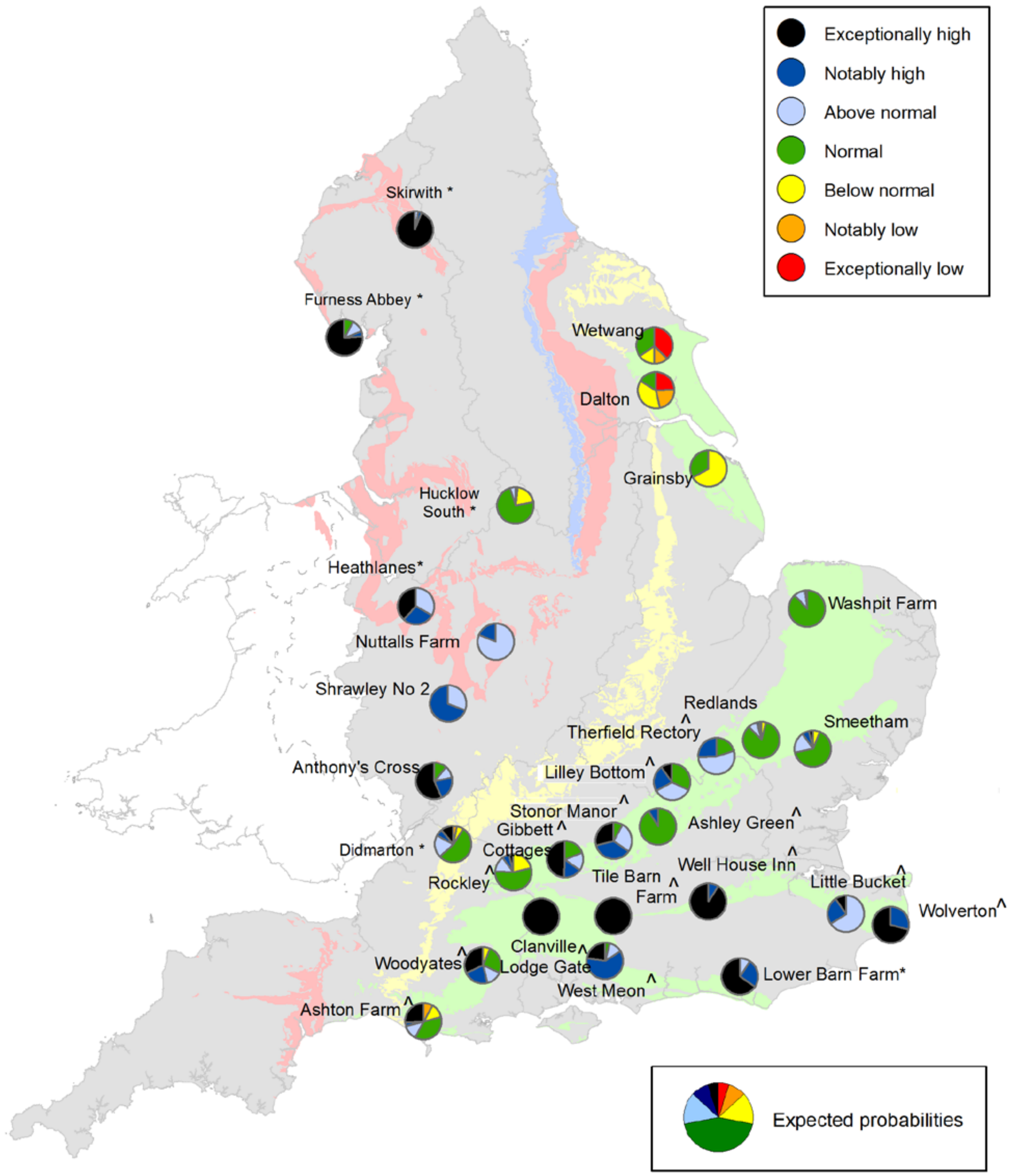


Figure 6.6: Projected groundwater levels at key indicator sites at the end of September 2014. Forecasts based on four scenarios: 120% (a), 100% (b), 80% (c) and 60% (d) of long term average rainfall between January 2014 and September 2014 (Source: Environment Agency) Geological map reproduced with kind permission from UK Groundwater Forum BGS © NERC Crown copyright. All rights reserved. Environment Agency 100026380 2014.

Projections at the following sites start from 09 Jan 2014: *Ashton Farm, Chilgrove, Clanville Lodge gate, Houndean Bottom, Little Bucket, West Meon, Wolverton and Woodyates*. All others begin 01 Jan 2014.

* Projections for these sites are produced by BGS

[1] This range of probabilities is a regional analysis

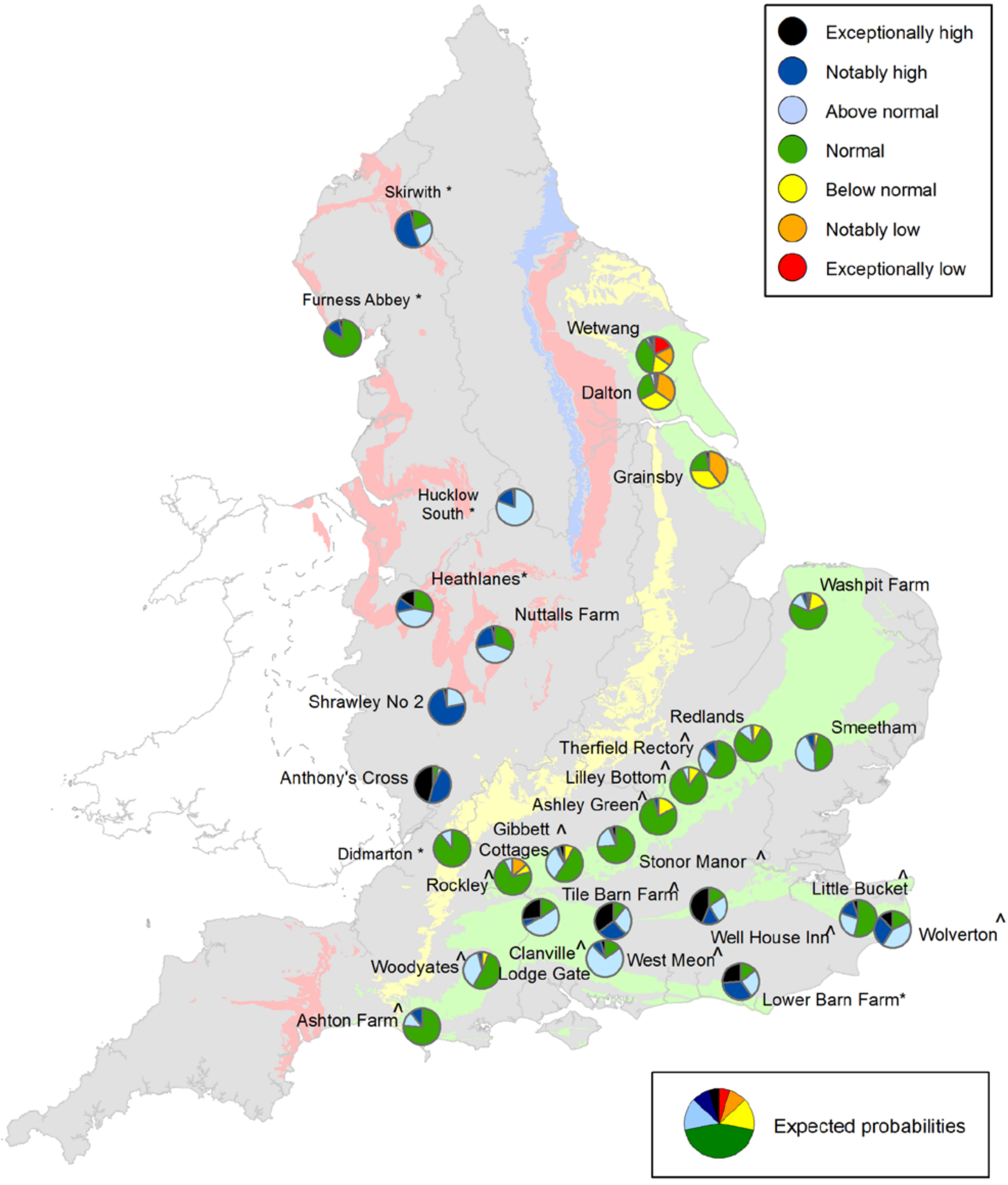


Exceptionally high or low levels are those which would typically occur 5% of the time within the historic record. Notably high or low levels are those which would typically occur 8% of the time. Above normal or below normal levels are those which would typically occur 15% of the time. Normal levels are those which would typically occur 44% of the time within the historic record.

Figure 6.7: Probabilistic ensemble projections of groundwater levels at key indicator sites at the end of March 2014. Pie charts indicate probability, based on climatology, of the groundwater level at each site being e.g. exceptionally low for the time of year. (Source: Environment Agency) Geological map reproduced with kind permission from UK Groundwater Forum, BGS © NERC. Crown copyright. All rights reserved. Environment Agency, 100026380, 2014.

** Projections for these sites are produced by BGS*

^ Projections for these sites start from 09 Jan 2014. All other sites Begin 01 Jan 2014



Exceptionally high or low levels are those which would typically occur 5% of the time within the historic record. Notably high or low levels are those which would typically occur 8% of the time. Above normal or below normal levels are those which would typically occur 15% of the time. Normal levels are those which would typically occur 44% of the time within the historic record.

Figure 6.8: Probabilistic ensemble projections of groundwater levels at key indicator sites at the end of September 2014. Pie charts indicate probability, based on climatology, of the groundwater level at each site being e.g. exceptionally low for the time of year. (Source: Environment Agency) Geological map reproduced with kind permission from UK Groundwater Forum, BGS © NERC. Crown copyright. All rights reserved. Environment Agency, 100026380, 2014.

* Projections for these sites are produced by BGS

^ Projections for these sites start from 09 Jan 2014. All other sites Begin 01 Jan 2014

Figure 7.1: Environment Agency Region Location Map

Glossary

Term	Definition
Aquifer	A geological formation able to store and transmit water.
Areal average rainfall	The estimated average depth of rainfall over a defined area. Expressed in depth of water (mm).
Effective rainfall	The rainfall available to percolate into the soil or produce river flow. Expressed in depth of water (mm).
Groundwater	The water found in an aquifer
Recharge	The process of increasing the water stored in the saturated zone of an aquifer. Expressed in depth of water (mm).
Reservoir live capacity	The reservoir capacity normally usable for storage to meet established reservoir operating requirements. It is the total capacity less that not available because of operating agreements or physical restrictions. Only under abnormal conditions, such as a severe water shortage might this additional water be extracted.
Soil moisture deficit (SMD)	The difference between the amount of water actually in the soil and the amount of water that the soil can hold. Expressed in depth of water (mm).

Categories

Exceptionally high	Value likely to fall within this band 5% of the time
Notably high	Value likely to fall within this band 8% of the time
Above normal	Value likely to fall within this band 15% of the time
Normal	Value likely to fall within this band 44% of the time
Below normal	Value likely to fall within this band 15% of the time
Notably low	Value likely to fall within this band 8% of the time
Exceptionally low	Value likely to fall within this band 5% of the time

Units

cumecs	Cubic metres per second ($m^3 s^{-1}$)
mAOD	Metres Above Ordnance Datum (mean sea level at Newlyn Cornwall).