3. Baseline Information

Following completion of the strategic assessment the south of the Cotswold District from Somerford Keynes to Lechlade-on-Thames was identified as having potentially high risk in terms of groundwater flooding. There are a number of contributing factors including permeable superficial deposits, multiple springs present and the presence of formations associated with groundwater flooding including the Cornbrash Formation.

There is also the public perception in this area which has also led this intermediate assessment. The current perception is that the quarrying activity and the cumulative effects of gravel extraction increases potential flood risks in the area. This relates to the south of the Local Authority boundary including Cirencester, Siddington, South Cerney, Lechlade on Thames and Fairford. Sewer flooding has also been recorded as a problem within these areas and investigations by Thames Water have identified that high groundwater levels are a contributing factor to this flooding.

In order to identify key areas or situations where groundwater flooding may occur within the south of the Cotswold District it is necessary to outline the baseline conditions of the area. The interaction of the topography, geology, hydrogeology and hydrology within the area can result in some areas or situations that may be more susceptible to groundwater flooding. The following Section outlines the baseline conditions throughout the area. The boundaries of the area covered are shown on Drawing 5125400/COTS/001 presented in Appendix B.

3.1. Topography and Land Use

This area of the intermediate assessment within the south east of the Cotswold District is to the south of the Cotswold Hills and includes largely the rural landscape and the following urban centres; Cirencester, Siddington, South Cerney, Lechlade on Thames and Fairford.

The topography of the District is influenced by the interbedded nature of the limestones and clays of the Inferior and Great Oolite Group. Within the south of the District the catchments of the Rivers Churn, Coln, Leach, Windrush and Evenlode form the landscape at approximate elevations of c.165 m AOD at the headwaters and slope down to the south where the River Thames drains the majority of the Cotswold District at an elevation of c.82 m AOD. The landscape is wider and flatter as it follows the course of the River Thames.

There are a number of low hills which generally rise between 10 and 20 m above the surrounding ground level. These low hills include; Horcott Hill (102m AOD) to the south of Fairford; further west there is Hailstone Hill (100m AOD) to the north west of Cricklade; Ashton Down (102m AOD) to the south west of South Cerney; and North End (88m AOD) to the north of Ashton Keynes and to the east of Eysey (85m AOD). The majority of these are coincident with outcrops of the Oxford Clay that rise above the surrounding river terrace deposits.

South of Cirencester is the Cotswold Water Park which expands across the boundary of Gloucestershire, Wiltshire and West Oxfordshire. The Cotswold Water Park covers 40 square miles and has over 150 lakes which were created over the last 50 years by extraction of gravel and flooded naturally after working ceased in the 1970s.

3.2. Geology and Hydrogeology

The superficial and bedrock geology has been summarised in Drawings 5125400/COTS/002 and 5125400/COTS/003 and presented in Appendix B. The geological formations and Environment Agency aquifer designations have also been summarised in Drawings 5125400/COTS/004 and 5125400/COTS/005.

The geology of the Cotswold Hills is made up of three different geological stages of the Jurassic period; the oldest of which comprises the Lias Group (previously called the lower, middle and upper) overlain by the Inferior Oolite and subsequently the Great Oolite. The stratigraphy of the Jurassic Limestone of the Cotswolds is presented in Table 3–1.

Table 3–1 Cotswold Geological Sequence

Mapped Unit	Thickness and Lithology		
	South west	Chippenham	North East
Great Oolite Group 50-100 m oolitic limestone	Cornbrash Formation (up to 10 m)		
	Forest Marble Formation (up to 35 m)		
	Great Oolite Formation 20-30m	Athelstan Oolite (up to 25m)	White Limestone Formation (20m)
	Upper Fuller's Earth Formation (up to 28m)	Tresham Rock (up to 18m)	Hampen Formation (up to 10m)
	Fuller's Earth Rock Formation (up to 5m)	Hawkesbury Clay (up to 10m)	Taynton Limestone Formation (up to 12m)
	Lower Fuller's Earth Formation (10-15m)		Fuller's Earth/Sharp's Hill Formation (up to 25m)
			Chipping Norton Limestone Formation (up to 12m)
Inferior Oolite Group	10-110 m Oolitic Limestones	10-110 m Oolitic Limestones	10-110 m Oolitic Limestones
Upper Lias	Cotswold/Midford Sands (up to 75m)		
	Mudstones (up to 80 m)		
	Junction Bed (0.5m)		
Middle Lias	Marlestone Rock Formation (up to 7m)		
	Dyrham Siltstone Formation (up to 50m)		
Lower Lias	Mudstone (200m)		
	Mudstone with Limestone Bands (up to 100m)		

Taken from The Physical Properties of Major Aquifers in England and Wales[5]

In the Cotswolds the thickness of the Upper Inferior Oolite (from the Mendips, south of the study, to the Vale of Moreton to the north) is relatively constant and variations in thickness reflect the variations of the Lower and Middle Inferior Oolite, which are only present from Old Sodbury (southwest of the area boundary) to Stow-on-the-Wold (north east of the area). Between Cirencester and Moreton-in-the-Marsh (north east of the area), the Lower Fuller's Earth of the Great Oolite Group, is progressively replaced by limestone units. The Chipping Norton Limestone has a maximum thickness of 12 m identified in Snowshill Quarry, within Snowshill, to the north of the Cotswold District Council area.

South of Cirencester, the geological sequence in the study area is similar however the formations have different names. Between Starveall and Nailsworth the Upper Fullers Earth Formation comprises the Hawkesbury Clay, overlain and laterally replaced by the Athelstan Oolite. Overlying this is the Forest Marble Formation which has a thickness of 20 m at Cirencester. The overlying Cornbrash Formation typically comprises 3-4 m of fine grained limestone with thin clays and marls. To the northeast the Chipping Norton Limestone at the base of the Great Oolite is hydraulically separated from the Great Oolite aquifer by the Fuller's Earth Formation. Recharge of the Great Oolite is typically via rivers and streams crossing the outcrop, with surplus water flowing down the valley or overflowing as springs at the junction with the underlying Fuller's Earth Formation.

In the Cotswolds, groundwater storage is limited to the north and northwest where the Great and Inferior Oolites outcrop.

[5] British Geological Survey and Environment Agency. 1997. The Physical Properties of Major Aquifers in England and Wales.

An important part of determining the potential for groundwater emergence or flooding is in understanding the underlying geology and the potential for it to store and transmit groundwater. The Environment Agency aquifer classification maps are split into two different types of aquifer designation; the superficial deposits which include permeable unconsolidated deposits (e.g. sands and gravels) and the bedrock geology comprising of solid permeable formations (e.g. sandstone, chalk and limestone)[6].

The Environment Agency designations[7] are as follows:

- Principal Aquifer - These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- Secondary A Aquifer - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
- Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.
- Secondary Undifferentiated - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type.
- Unproductive Strata - These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The geology across the south of the Cotswold District includes an outcrop of the Cornbrash Formation (Limestone) in the southern extent of the Cotswold District Council boundary which extends from Somerford Keynes moving north east toward Fairford. The Cornbrash Formation is present at South Cerney, Siddington, Driffied, Ampney St Peter and Fairford.

To the north the bedrock geology includes the Forest Marble Formation, both Limestone and Mudstone. To the south of the Cornbrash outcrop is the Kellaways Clay Member and the Oxford Clay Formation, both Mudstones.

The Cornbrash Formation and Forest Marble Formation (Mudstone) are designated as Secondary A aquifers and the Forest Marble Formation (Limestone) is designated a Principal Aquifer. The Kellaways Clay Member and the Oxford Clay Formation are both designated as Unproductive Strata.

Superficial deposits are present within the south of the Cotswold District which are associated with the surface watercourses present within the area. The deposits include the following; Northmoor Sand and Gravel Member, Summertown-Radley Sand and Gravel Member, Wolvercote Sand and Gravel Member, Hanborough Gravel Member, Head and Alluvium. The superficial deposits are designated as Secondary A aquifers. It is likely that groundwater in these superficial deposits is recharged by infiltration from rain, runoff and surface water, and also via groundwater from underlying aquifers, such as the Cornbrash.

Borehole logs available via BGS GeoIndex[8] identify that the Cheltenham Sand and Gravel is present in at least part of the area, recorded to depths of between 1.6 m and 4.2 m below ground level.

3.3. Springs

It has been possible to identify locations that are recorded as springs from the OS mapping. The springs that have been recorded on OS maps have been mapped and are shown on Drawing 5125400/COTS/008 in Appendix B. The location of springs within the areas can be useful in determining areas where groundwater is already known to emerge from the ground. The spring line can also give an indication of where groundwater may emerge in the future and where groundwater may already be close to surface and therefore pose a potential groundwater flood risk.

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[6] British Geological Survey and Environment Agency. 1997. The Physical Properties of Major Aquifers in England and Wales
[7] http://www.environment-agency.gov.uk/homeandleisure/37793.aspx viewed January 2014
[8] British Geological Survey Onshore GeoIndex viewed January 2014
http://www.bgs.ac.uk/GeoIndex/home.html

There are a number of springs present on the OS mapping within the south of the Cotswold District which feed the many of the surface watercourses present. The springs are concentrated within the Cornbrash Formation and Forest Marble Formation to the north of this area. The springs are shown to be present at the boundaries between the Cornbrash Formation, Forest Marble Formation (Limestone) and Forest Marble Formation (Mudstone). The springs occur on the southerly slope away from the Cotswold Hills where the water is likely to be artesian (confined by the mudstones) and groundwater reaches the surface via faults and fissures through the confining layers.

In periods of heavy rainfall, an increase of water issuing from springs in these locations could increase the volume of water in the rivers and low lying areas to the south of the valleys. Therefore areas around the south of the Cotswold District may be at greater flood risk from this emerging groundwater flow. The low lying areas to the south are underlain with lower permeability bedrock (mudstones) and so the ability for infiltration of the water produced by the springs is limited which could result in increased risk of surface water flooding or recharge of the superficial deposits.

3.4. Source Protection Zones/Abstractions

Groundwater Source Protection Zones (SPZ) are used as a key part of the Environment Agency's policy and approach to controlling the risk to groundwater supplies from potentially polluting activities and accidental releases of pollutants[7].

SPZ's have been defined for a number groundwater sources such as wells, boreholes and springs used for public drinking water supply. It is likely that where SPZ's are located there may be associated abstractions. The main priority of the zones is to show the risk of contamination from any activities that might cause pollution in the area; the closer the activity, the greater the risk. The Environment Agency SPZ maps show three main zones (inner, outer and total catchment) and a fourth zone of special interest, which occasionally applies to a groundwater source. SPZs can be from shallow or deep aquifers but highlight the presence of a groundwater source which could pose a risk in relation to groundwater flooding depending on the other area conditions.

There are two SPZ1 to the south of the District, proximal to Cerney Wick and Mersey Hampton; both extend out over the mudstone (Oxford Clay) present within this area. The abstractions associated at these locations are likely from the Oolitic Limestone present beneath the mudstone. The mudstone present is likely to be confining the groundwater present within the underlying limestone aquifer however thicknesses of the mudstone vary locally with thicknesses recorded of 44 m at Ashton Keynes pumping station and 10 m at Somerford Keynes[8].

There is an additional SPZ1 in the area surrounding North Cerney which is likely to be related to abstractions from the limestone underlying this area. Pumping from these wells may reduce the potential risk from water issuing as springs present by reducing groundwater levels. However the converse is true in that a cessation of pumping may result in an increase the groundwater levels and therefore an increase in groundwater flooding and the number of springs present.

3.5. Hydrology

Within the south of the Cotswold District, there are a number of significant surface watercourses present, including the Rivers Churn, Coln, Leach, Windrush and Evenlode which flow south from the Cotswold Hills and join the River Thames. The rivers are all 'main rivers' and therefore managed by the Environment Agency. The watercourses have associated flood plains which are designated as Flood Zones 2 and 3 respectively.

Flood Zone definitions are set out in the National Planning Policy Guidance[9]:

- Flood Zone 2 - land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year

[9] Communities and Local Government (March 2012) National Planning Policy Framework

- Flood Zone 3 - land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year

There is potential for surface water flooding in relation to these watercourses and the watercourses may influence the shallow groundwater aquifers in the superficial geology in the area and subsequently may influence groundwater flood risk, increasing the risk.

3.6. Historic Flood Maps

Historic flood maps have been provided by the Environment Agency. The Historic Flood Map shows the combined extents of known flooding from rivers, the sea and groundwater. The maps do not differentiate between the sources of flooding. Areas recorded as flooding historically are considered to be a reliable source of flooding information and a strong indication of where flooding may occur again.

The historic flood maps show there has been extensive flooding along the southern boundary of the District associated with the Cotswold Water Park and the extensive alluvium and sand and gravel deposits. The historical flooding is shown in Drawing 5125400/COTS/006. The source of this flood water is not identifiable but it could be considered to relate to the surface watercourses present throughout this area and the superficial deposits in continuity with the surface watercourses. Therefore there is no indicative information to show historical groundwater specific flooding events.

The historic flooding is recorded to cover the full extent of the superficial alluvium deposits and extends within the sands and gravel deposits. The alluvium is likely to be in hydraulic continuity with the watercourses and therefore flooding within this area is likely to have been from a fluvial source. However, some of the flooding, particularly in areas of sand and gravel, could be the result of high groundwater levels either emerging at surface or limiting infiltration thus resulting in groundwater flooding. The results do not differentiate between flood sources therefore determining the source is not possible.

3.7. Groundwater Levels

Groundwater level data in the Cotswold District was available from the Environment Agency on request. Data was available for a total of 26 monitoring locations; however 8 of the locations had either incorrect coordinates or did not have ground levels in order to analyse the data. The monitoring locations and data for 18 of the monitoring locations have been summarised below in Table 3-2 and are shown on Drawing 5125400/COTS/007. The data provided did not state where the groundwater level was taken from i.e. top of well or ground level therefore there is a degree of uncertainty within the data.

Table 3-2 Groundwater Monitoring Locations in the Cotswold District

Environment Agency Monitoring Station	Ground level (m AOD)	Groundwater Level			Exceedance of Ground Level	Bedrock Geology at Surface	Superficial Deposits
		Min (m AOD)	Max (m AOD)	Range (m)			
Brimpsfield Bh New	230.75	201.139	202.209	1.07	0	Salperton Limestone Formation	-
Campdenhill Farm	225.49	218.831	220.92	2.089	0	Forest Marble Formation (Mudstone)	-
Holt Farm	257.4	254.88	255.5	0.62	0	Forest Marble Formation (Limestone)	-
Lechlade Obh	72.14	70.738	71.944	1.206	0	Oxford Clay Formation	Alluvium

Environment Agency Monitoring Station	Ground level (m AOD)	Groundwater Level			Exceedance of Ground Level	Bedrock Geology at Surface	Superficial Deposits
		Min (m AOD)	Max (m AOD)	Range (m)			
Spotted Cow Obh	77.36	74.823	76.429	1.606	0	Oxford Clay Formation	Northmoor Sand and Gravel Member, Lower Facet
Whelford Obh	78.87	77.142	78.145	1.003	0	Oxford Clay Formation	Northmoor Sand and Gravel Member
Castle Eaton Stw	75.8	74.041	75.486	1.445	0	Oxford Clay Formation	-
Cricklade Obh	79	56.474	82.035	25.561	64	Oxford Clay Formation	Alluvium
Down Ampney Obh	85.25	52.946	85.266	32.32	3	Oxford Clay Formation	Northmoor Sand and Gravel Member, Upper Facet
Siddington Obh	102.6	76.217	91.761	15.544	0	Cornbrash Formation	-
Ashton Keynes S.Wks.	89.01	75.97	90.125	14.155	2	Oxford Clay Formation	-
Shorncote Sewage Wks	92	76.2	90.303	14.103	0	Kellaways Clay Member	Northmoor Sand and Gravel Member
Spine Road Obh	87.02	75.427	89.003	13.576	76	Kellaways Clay Member	Northmoor Sand and Gravel Member
Upper Up Obh	92.62	90.641	91.124	0.483	0	Kellaways Clay Member	Northmoor Sand and Gravel Member
Fairford Obh	89.45	79.231	92.507	13.276	72	Kellaways Clay Member	-
Hampton Field Obh	103.65	86.439	97.052	10.613	0	Forest Marble Formation (Mudstone)	-
Kemble Wick Obh	108.9	91.207	101.141	9.934	0	Forest Marble Formation (Mudstone)	-
College Farm Obh	127.1	98.278	110.758	12.48	0	Forest Marble Formation (Limestone)	-

The groundwater level data has been summarised graphically in Appendix C. Groundwater level data has been shown along with the ground level for each location. The long term groundwater level data gives an indication of seasonal fluctuations and the range of the water table.

The bedrock geology at the surface for 14 of the monitoring stations is recorded as mudstone or clay which is confining the Oolitic Limestone aquifer below. These 14 monitoring stations comprise; Campdenhill Farm, Lechlade Obh, Spotted Cow Obh, Whelford Obh, Castle Eaton Stw, Cricklade Obh, Down Ampney Obh, Ashton Keynes S.Wks, Shorncote Sewage Wks, Spine Road Obh, Upper Up Obh, Fairford Obh, Hampton Field Obh and Kemble Wick Obh.

The majority of the monitoring wells do not show upward trends in the groundwater level data. The monitoring stations Brimsfield, Campdenhill Farm, Holt Farm, Spotted Cow, Whelford, Lechlade, Castle Eaton and Upper Up have a small range in groundwater level of between 0.5 and 2 m taken over a monitoring period greater than 10 years with the exception of Brimsfield (3 years). Whilst the groundwater levels may be close to ground level, within Upper Up and Holt Farm groundwater levels at a maximum are 1.5 m and 2.5 m below ground level (bgl) respectively. However, the groundwater level range within these monitoring wells over 10 years of monitoring is 0.5 m and 0.6 m respectively indicating the groundwater does not fluctuate greatly beyond the seasonal variation.

Groundwater levels at Siddlington, Hampton Field, Kemble Wick and College Farm have a greater range however; the minimum depth to ground water recorded at Hamptonfield was 6 m below the ground level. The maximum groundwater levels for Kemble Wick and Collage Farm were 8 m and 16 m bgl respectively. There are no indications of increasing groundwater levels within the data provided for Hampton Field, Kemble Wick and College Farm. The groundwater level data for Siddlington indicates that there is a rising trend in the groundwater levels with summer groundwater levels not declining to the same level as those recorded before 2004 however, the minimum depth to groundwater recorded at Siddlington was 10 m bgl.

The data provided for Cricklade, Spine Road and Fairford observation wells indicates many exceedances of the ground level recorded. Whilst there is likely to be some error in the ground level at these locations they have data that is highly variable, with ranges over 10m. This would suggest confined groundwater with a varying pressure head and potential for emergence at surface were the confining layer to be breached. There is a clear indication of an upward trend in the groundwater level data for Cricklade, Spine Road and Fairford. Following the winter of 2004, there is an increase in groundwater level at Cricklade in the December 2004 monitoring data, and the groundwater levels remain higher until the final data point in November 2011. The increase in groundwater levels at the point does not coincide with a significant flood event. The recharge season began early in the autumn of 2004 however; the November and December 2004 rainfall data had been noted to be dry[10] with increased rainfall in January and a very dry February[11]. Never the less there is a change in the data range at this point. Such increased pressure heads will need to be considered when assessing groundwater flooding potential.

Groundwater is shown to exceed the ground level at Down Ampney on 3 occasions; 1st April 2010, 1st February 2011 and 1st March 2011. Whilst it is not possible to determine if groundwater emergence occurred in these instances there is a visible indication of an increase in groundwater levels within the monitoring station. Similarly to Cricklade, following the winter of 2004 there was an increase in groundwater level and the groundwater levels continue at this level until the final data point in November 2011.

Groundwater levels at Shorncote have a range of 14 m over an 18 year period. The minimum depth to groundwater was recorded 1.5 m bgl. The groundwater level data indicate that there is a potential rising trend, with summer water levels remaining higher since the summer of 2004.

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[10] CEH/BGS. (2004) Hydrological Summary for the United Kingdom December 2004
[11] CEH/BGS. (2004) Hydrological Summary for the United Kingdom February 2005

4. Factors Influencing Groundwater Flood Risk

4.1. Superficial Deposits

Groundwater flooding may be associated with the extensive sand and gravel deposits present within the south of the Cotswold District. The bedrock geology within the south of the District is mainly low permeability mudstones, which can influence the risk of flooding from groundwater from sands and gravels superficial deposits, particularly during periods of high rainfall where groundwater levels approach ground level. This is a result of the underlying mudstones having low permeability and limit vertical movement of water present in the sands and gravels. Consequently there is the potential for a risk of groundwater flooding within this area for perched groundwater within the sands and gravels to pose a risk to properties with basements or cellars, which have been constructed within the area of superficial geology.

Where there are the granular superficial deposits such as the sands and gravels, these superficial deposits might appear suitable for infiltration SuDS for new and existing developments, however, additional infiltration from such systems could result in raised groundwater levels and potential for groundwater flooding. The underlying bedrock is generally low permeability which may prevent the groundwater infiltrating further resulting in a build up of water in the sands and gravels above and therefore lead to an increased risk in groundwater flooding. Therefore in such areas the superficial deposits can provide storage, particularly if they have limited continuity with local watercourses, resulting in localised flooding of basements or seepages through cuttings in the superficial deposits or local bedrock.

Groundwater flooding may be associated with the Alluvium deposits which are associated with the surface watercourses, including the Rivers Churn, Coln, Leach, Windrush and Evenlode and Thames, where they are in hydraulic continuity with surface watercourses. Historical flood maps indicate that the flood events that have occurred extended throughout the area of the superficial deposits, mainly the alluvium. Stream levels may rise following high rainfall events but still remain "in-bank", and this can trigger a rise in groundwater levels in the associated superficial geology. Consequently there is the potential for a risk of groundwater flooding within this area. However, this risk is likely to be outweighed by the fluvial flood risk as the deposits are limited to within the floodplain.

4.2. Bedrock Geology

The underlying bedrock geology can influence the potential for groundwater flooding. Highly permeable formations can provide a source for groundwater flooding and low permeability formations can prevent or reduce infiltration of groundwater from superficial deposits. The underlying bedrock geology and the potential for it to influence groundwater have been considered within the south of the Cotswold District.

Within the south of the Cotswold District there are aquifers that are confined by the overlying geology. Groundwater within these confined aquifers may be artesian, however, the groundwater is prevented from reaching the surface by the overlying low permeability geology. Groundwater levels recorded in boreholes within these areas may appear to be above ground level but would not do so unless the confining layer is penetrated.

There is an outcrop of the Cornbrash Formation in the southern extent of the Cotswold District Council boundary which extends from Somerford Keynes north east toward Fairford. There is potential for a perched groundwater table to exist within the Cornbrash Formation[12]. Such conditions are likely to exist owing to the higher permeability of the Cornbrash Formation than the underlying lower permeability mudstones of The Forest Marble Formation, the latter of which is considered to reduce the ability for vertical migration of groundwater and act as a barrier to flow. As a result there is a potential risk from groundwater flooding following periods of prolonged rainfall within the areas of this outcrop.

[12] URS Trowbridge Surface Water Management Plan, Intermediate Assessment of Groundwater Flooding Susceptibility, Phase 2. November 2011.

The spring data from the OS mapping indicates the spring lines are present at the boundary between the permeable limestone formations and the low permeability mudstones. The springs appear to feed into the local surface watercourses. The spring line can give a good indication of a groundwater source and where groundwater may emerge in the future and where groundwater may already be close to surface.

Within the south of the area there is the potential for groundwater flooding to occur where groundwater springs generate minor flows and ponding over impermeable strata where there is poor drainage. This mechanism may occur as a result of natural (e.g. rainfall) or artificial (e.g. water main leakage) recharge and could occur where the low permeability silt and clay areas appear downslope of aquifer outcrop, such as the southern boundary of the Cotswold District which is downslope of the Cotswold Hills in the north.

4.3. Groundwater Level Information

Where available, the groundwater levels present within the formations has been summarised for the south of the Cotswold District. This information has been obtained from the Environment Agency and the data and graphs are presented in Appendix C.

A number of springs and SPZ associated with abstractions are shown to be present within the area. Changes to pumping regimes or usage may influence the groundwater levels with increased abstraction lowering levels and the cessation of pumping resulting in raised groundwater levels and therefore increasing the risk of groundwater flooding.

The Environment Agency and Gloucestershire County Council do not currently monitor groundwater levels in all of the aquifers that outcrop in area however groundwater level data is available for the Principal bedrock aquifers. The long term groundwater monitoring data provided identifies seasonal fluctuations and potential trends within the data. Groundwater level data has indicated that there is the potential for groundwater levels to be above, at or approaching the ground level in a number of locations; Cricklade, Spine Road, Fairford, Down Ampney and Shorncote. The aquifers monitored at these locations are likely to be confined by the overlying Oxford Clay Formation or Kellaways Clay Member. Groundwater within these confined aquifers may be artesian, however, the groundwater is prevented from reaching the surface by the overlying low permeability geology. Groundwater levels recorded in boreholes within these areas may appear to be above ground level but would not do so unless the confining layer is penetrated at the point of monitoring.

4.4. Land Use

There has been extensive extraction of the sand and gravel in the southern extent of the Cotswold District. There is the perception that this has lead to increased flooding and the historic flood maps indicate flooding has occurred in this area. The Cotswold Water Park has been created from land previously utilised for extraction and has been restored to open water. Restoration to open water provides a degree of flood alleviation and allows the groundwater to resume its previous level following the cessation of pumping used during excavation. However, some of these former quarries have been infilled, at least in part. These infilled quarries can provide a blockage to groundwater flow and increase the risk of groundwater flooding if the resultant risks are not carefully mitigated.