

5. FUTURE DEVELOPMENT AND THE SEQUENTIAL TEST

A sequential risk-based approach to determining the suitability of land for development in flood risk areas is central to government policy, and should be applied at all levels of the planning process.

Local Planning Authorities allocating land in Local Development Documents should always apply the Sequential Test to demonstrate that there are no reasonably available sites in other areas with a lower probability of flooding.

This Chapter addresses one of the core requirements of the SFRA, namely to apply a sequential risk approach to the allocation of potential development land identified by the LPA. Evidence and guidance in this Chapter will be of use both to the Local Planning Authority in preparing Local Development Documents (LDDs).

Developers should also consult this section to identify in broad terms where potential development sites are least and most affected by flood risk issues within Herefordshire.

5.1 Assessment of Development Pressures

5.1.1 Growth Point Status and Housing Projections

Herefordshire is one of 45 locations in the country to be granted New Growth Point status by the government. New Growth Points will deliver a substantial number of new homes to help first time buyers onto the property ladder and enable towns and cities to grow their economies by creating new jobs and encouraging business development.

Herefordshire Council currently aims to build approximately 8,500 homes by 2016. New transport infrastructure will be provided in association with the new housing development and the Edgar Street Grid area of Hereford will be regenerated. Housing proposals have also been put forward for the county's market towns, enabling them to meet their needs and aid rural regeneration.

The Regional Spatial Strategy 'Spatial Options, January 2008) requires Herefordshire Council to provide in the order of 16,600 dwellings between 2006 – 2026 (Option 1). Of these, some 8,300 will be in and around Hereford. It should be understood that the process of public examination and approval by the Secretary of State could still result in the figure being amended (either up or down). Options 2 and 3 identified an increase in growth rates requiring 20,500 houses to be developed within the County up until 2026.

5.1.2 Herefordshire Potential Development Sites Database

Herefordshire Council has prepared throughout 2007 a major database of potential development sites³. The availability of this database also in GIS format greatly

enhances the capacity of the Sequential Test to be demonstrated in an open and transparent way, an essential requirement of PPS 25 ¹.

Assessment of the sites in the database in accordance with the hierarchy of flood management measures is one of the core outputs of the Strategic Flood Risk Assessment. It can be stated that all of the Evidence Maps and supplementary tools of the SFRA are intended to support the transparent application of this hierarchy, including the Sequential Test.

This database incorporates the following principal sources:

- Housing land allocated under the policies **H2** (Housing Land, Hereford and Market Towns) and **H5** (Housing Land, Main Villages) of the Herefordshire Unitary Development Plan (UDP, March 2007)
- Employment land allocations **E1** (Rotherwas), **E2** (Moreton on Lugg) and **E3** (Other Land) of the Herefordshire Unitary Development Plan (March 2007)
- **HCAA Sites** (Herefordshire Housing Land Availability Assessment ³) was commissioned in 2007 to identify all potential housing development sites. Many of these sites may be considered inappropriate for development
- **Officer Sites** includes sites identified by Herefordshire planning officers as part of the HCAA study, with no official status and with the process of assessment continuing.
- **Housing Capacity Study** is derived from
- **UDP Representation Sites** includes sites submitted as objection sites to the UDP. These were considered inappropriate for the UDP but are now being reassessed for the Local Development Framework.

Evidence Map 5-1 summarises all of these potential development sites, superimposed on the Environment Agency Flood Zones 3 and 2. All of the above data sources are represented separately for clarity.

The SFRA has produced a single GIS database layer entitled **HSFRA Development Sites** that includes all sites on a single layer.

Figure 5-1 – Housing Land Availability Assessment ‘Call for Sites’


The screenshot shows the website's navigation menu on the left, with 'Local Development Framework' selected. The main content area is titled 'Evidence base' and 'Herefordshire Housing Land Availability Assessment'. It contains three paragraphs of text describing the assessment's purpose, its role in future planning, and an invitation to submit sites.

Source: Herefordshire Council

5.2 A Hierarchy of Flood Risk Management Measures

In respect of flood risk, development land should be allocated through a hierarchy of flood management measures. In essence the Sequential Test (see 5.3) is merely the framework procedure to demonstrate that this hierarchy has been considered.

The SFRA delivers the evidence base and the interrogation tools to facilitate application of the sequential test.

Table 5-1 summarises the sequential risk hierarchy that should be considered by the LPA². At the top level of the hierarchy, the obvious strategy is to place development sites in areas of least flood risk, defined by fluvial flooding, groundwater flooding and generalised surface flooding.

Where flood risk persists, the next alternative is to substitute less vulnerable development for more vulnerable development which may be more compatible with the likely degree of flood risk.

These sequential approaches of avoidance and substitution form the higher level policy for LDDs, and are the primary focus of this Chapter.

At the site and building scale, if developments are still unavoidably exposed to flood risk, more specific measures can be sequentially applied, namely control and mitigation.

Control may entail catchment scale proposals to reduce flood risk to existing or future developments (such as farming practice or strategic attenuation schemes), or local scale proposals such as site-specific flood defences.

As a ‘policy of last resort’, mitigation can be used to counteract residual risks (the remaining risk after other flood management practices have been implemented). Flood mitigation will most commonly be implemented through flood resistance and flood resilience design of specific sites and buildings. Site and building resilience to flood risk is the main focus of **Chapter 5**.

Table 5-1– Hierarchy of Flood Risk Management Measures

Overview of the flood risk management hierarchy			
Flood Risk Management Measure	Description	Example tools and measures	Key responsible parties
Avoidance/ Prevention	Allocate developments to areas of least flood risk and apportion development types vulnerable to the impact of flooding to areas of least risk	Regional Flood Risk Appraisals (RFRAs), Strategic Flood Risk Assessments (SFRAs), Flood Risk Assessments (FRAs) and application of the sequential approach	Planning bodies
Substitution	Substitute less vulnerable development types for those incompatible with the degree of flood risk		Planning bodies and developers
Control	Implement measures to reduce flood frequency to existing developments Appropriate design of new developments	River Basin Management Plans (RBMPs), Catchment Flood Management Plans (CFMPs), Shoreline Management Plans (SMPs), Flood Risk Management Strategies, appraisal, design and implementation of flood defences	Environment Agency and other flood and coastal defence operating authorities, developers and sewerage undertakers
Mitigation	Implement measures to mitigate residual risks	Flood risk assessments. Incorporating flood resistance and resilience measures. Emergency Planning Documents. Implementation of flood warning and evacuation procedures	Planning bodies, developers, the Environment Agency, other flood and coastal defence operating authorities and sewerage undertakers

Source: Table 1.2 – Development & Flood Risk: Practice Guide Companion to PPS25

5.3 The Sequential Test for Flood Risk

As part of the Growth Point partnership with Government, studies such as the SFRA must inform sustainable decisions on appropriate levels and locations of growth, and appropriate mitigation and improvement measures. With regard to flood risk and flood risk management, the primary purpose of the SFRA is to assist in delivering the policy guidance of Planning Policy Statement 25 (PPS 25) ¹, and in particular the Sequential Test, with regard to new development.

This approach is a simple decision-making process designed to ensure that sites at little or no risk of flooding are developed in preference to areas at higher risk.

LPA's allocating land in LDDs for development should apply the Sequential Test (see PPS 25 Annex D and Table D.1) to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed. A sequential approach should also be used in areas known to be at risk from other forms of flooding.

“The overall aim of decision-makers should be to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, decision-makers identifying broad locations for development and infrastructure, allocating land in spatial plans or determining applications for development at any particular location should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should decision-makers consider the suitability of sites in Flood Zone 3, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required”. Source: Planning Policy Statement 25 Annex D, (D5)

The Flood Zone delineations have been explained in **3.1.3** and shown in **Evidence Map 3-1** and **Evidence Map 5-1**.

5.4 Site Vulnerability and the Exception Test

Within each Flood Zone, new development should be directed first to sites at the lowest probability of flooding and the flood vulnerability of the intended use matched to the flood risk of the site, e.g. higher vulnerability uses located on parts of the site at lowest probability of flooding.

Table D.3 of PPS 25 (see Table 5-2) summarises the five categories of intended use in terms of vulnerability to flood risk, as defined by PPS 25 Table D.2

Table 5-2 – Flood Risk Vulnerability of Intended Use

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	x	Exception Test required	✓
	Zone 3b 'Functional Floodplain'	Exception Test required	✓	x	x	x

Key:

✓ Development is appropriate

x Development should not be permitted

Source: Planning Policy Statement 25: Annex D, Table D.3

5.4.1 Appropriate Development

Table 5-2 illustrates that all intended uses of land are appropriate in Zone 1 (land external to the fluvial floodplains). The LPA and developers alike must however still demonstrate that the sequential approach has been applied even within Zone 1 in respect of other forms of flooding.

Table 5-2 illustrates that provided the sequential approach has been applied, and no other more appropriate sites are available, 'less vulnerable' development such as shops, offices, general industry, warehousing and distribution ARE appropriate types of development in Flood Zone 3a.

If, following the application of the Sequential Test, it is not possible for development to be located in a zone with a lower probability of flooding AND the intended use is 'More Vulnerable' to flood risk, the Exception Test should be applied. The Exception Test makes provision for sites where flood risk is outweighed by wider sustainability considerations and is designed to ensure that the flood risk posed to such sites is controlled and mitigated to an acceptable level, taking account of climate change, without increasing flood risk elsewhere.

The criteria needed to pass the **Exception Test** are defined under PPS 25. For the Exception Test to be passed:

- a) it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by an SFRA where one has been prepared.
- b) the development should be on developable previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land
- c) a detailed FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere and where possible will reduce flood risk overall.

5.4.2 Safe Development Assessed within FRAs

Irrespective of the appropriateness of the land-use in the particular flood zone, Local Development Documents must specifically address the issue of 'safe development'. It is a policy requirement to ensure that all new development in flood risk areas is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed.

The impact of a flood on the particular uses identified within the Flood Risk Vulnerability classification of Table 5-2 will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

Where development sites are in a higher risk flood zone, a site specific Flood Risk Assessment must address the issues of safe development and residual risk through site location, layout and design. Further methodology guidance is included in **Flood Risk Assessment Guidance for New Development** ⁴

A site specific FRA must explicitly consider:

- the vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification (see PPS 25 Annex D), including arrangements for safe access.
- include the assessment of the remaining (known as ‘residual’) risk (see PPS 25 Annex G) after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development or land use

Whilst flood resistance and resilience measures can and often should be used within new developments, they should not be used in isolation to justify development in inappropriate locations or to offset the residual risk.

The aims for all development and a requirement for “more vulnerable” and “highly vulnerable” development are to provide a safe flood free route for people and vehicles, from the site on land at or above the 1% plus climate change flood level. Highly vulnerable development should remain operational in the 0.1% flood event plus climate change.

The requirements for safe access and exit from new developments in flood risk areas are as follows, in decreasing order of preference:

- Safe dry route for people and vehicles at or above the 1% plus climate change flood level.
- Safe flood free route for people, at or above the 1% plus climate change flood level, including consultation with the Emergency Services/Planners.
- If a flood free route is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause a risk to people, including consultation with the Emergency Services/Planners and consideration of a Flood Evacuation Management Plan.
- If a flood free route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles, including consultation with the Emergency Services/Planners and consideration of a Flood Evacuation Management Plan.

Whilst all development should aim for the above, “less vulnerable” and “water compatible” development may consider alternative flood risk management solutions which may be acceptable.

All FRAs for major development, or ‘more vulnerable’ and ‘highly vulnerable’ development should include an assessment of the impacts of flood risk for the 0.1% annual probability flood event. More and Highly vulnerable developments should remain preferably dry during this event. Safe flood free access during this

event is also preferable. Table FD2321 gives guidance regarding flood hazard vulnerability. Where flood hazard is an issue during the 0.1% annual probability flood event then the Emergency Planners and Emergency Services should be consulted through the Local resilience forums.

For a given development, a site specific FRA must investigate whether safe exit and access constitutes dry access routes or depth and velocity combinations that are below appropriately precautionary thresholds. This decision needs to be made by the LPA in consultation with the Emergency Services and will need to take into consideration the proposed use of the development, the vulnerability of the occupants and the availability of emergency services and flood forecasting.

Three levels of complexity in approach are recommended for assessing safe access:

- 1) Simple Approach, which is based on providing a dry route up to an acceptable flood level. This approach is most precautionary and generally will be most appropriate for small and relatively low risk sites. However, any raising of ground levels to ensure safe exit and access will need to be considered in the FRA to ensure that there is no obstruction to flood flow routes and that there is no loss of flood storage capacity.
- 2) Intermediate Approach, which is intended to identify a route with acceptable flood hazard if a dry route is not possible. This approach is based on analysis of the flood hazard (a combination of depth and velocity). This approach is also precautionary and can be applied to most sites. However, costs of site design might make it worthwhile for developers to consider the detailed approach.
- 3) Detailed Approach, which is based on a more rigorous analysis of the flood hazard based most probably derived from detailed 2-D hydraulic modelling.

As an example of the approach that will most probably be required of site specific FRAs in higher flood risk areas, the Intermediate Method assesses flood hazard as a combination of flood depth and velocity. Hydraulic modelling or the use of results from an existing assessment is therefore needed to predict flood depth and velocity.

The Flood Risks to People⁵ project (HR Wallingford) has developed the following equation to relate the flood hazard to flood depth and velocity:

$$\text{Flood Hazard Rating} = ((v + 0.5) * D) + DF$$

where:

v = velocity (m/s)

D = depth (m)

DF = debris factor (taken as 0.5 for depths <0.25m, and 1.0 for depths > 0.25m)

Based on this, the hazard rating equation has been applied to various combinations of flood depth and velocity to produce a matrix of hazard ratings. Applying thresholds to these hazard ratings defines the danger to people at various depths and velocities as shown in Table 5-3. Therefore, if depths and

velocities have been determined for the site, then this table can be used to estimate the danger to people.

Table 5-3 – Danger to People for Combinations of Depth & Velocity

Velocity (m/s)	Depth of flooding (m)											
	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00												
0.10												
0.25												
0.50												
1.00												
1.50												
2.00												
2.50												
3.00												
3.50												
4.00												
4.50												
5.00												

Key:

- Danger for some
- Danger for most
- Danger for all

Source: Table 13.1 – DEFRA/EA Flood Risk Assessment Guidance for New Development FD2320

The outputs of the Flood Risk to People project indicate that flood depths below 0.25 m and velocities below 0.5 m/s are generally considered low hazard. When designing safe access and exit routes, the combinations of depth and velocity on the routes should correspond to the white boxes in the above diagram. As flood depth and/or velocity increase the hazard to people increases.

The following provides a very simplified guide as to the groups of people that should be considered as falling into these danger classifications:

- Danger for some – includes children, the elderly and the infirm
- Danger for most – includes the general public
- Danger for all – includes emergency services

Within individual sites, the sequential approach should be applied to the layout and design of particular developments. More vulnerable uses should be directed to parts of the site at less probability and residual risk of flooding. The lower floors of buildings in areas at medium and high probability of flooding should be reserved for uses consistent with PPS 25 Table D.1 of Annex D. Those proposing development should seek opportunities to use multi-purpose open space for amenity, wildlife habitat and flood storage uses. Opportunities should be taken to lower flood risk by reducing the built footprint of previously-developed sites and using sustainable drainage systems (SUDS)

5.4.3 Development behind Flood Defences

Flood defences reduce the risk of flooding, but do not eliminate flood risk completely. Residual risk is relatively high behind flood defences and must be specifically addressed in Level 2 type SFRAs or detailed FRAs. In this context, the defended areas at Leominster, Hereford and Hampton Bishop pose a relatively high degree of residual risk to existing and new development.

The presence of flood defences per se does not necessarily enable new development behind them. The Sequential and Exception Tests would still apply to new development, assuming the absence of the defence. Permitted development must still meet safe criteria (see 5.4.2 above), taking into account breach and overtopping scenarios.

Following application of the Sequential Test and Exception Test (see PPS 25 Annex D), development should not normally be permitted where flood defences, properly maintained and in combination with agreed warning and evacuation arrangements, would not provide an acceptable standard of safety taking into account climate change.

The reduction in flood risk that the defence provides depends on the standard of protection (SoP) and the performance and reliability of the defence. Flooding may still occur in defended areas if the defence is overtopped or breached, or if flooding occurs as a result of non-fluvial sources such as groundwater flooding or poor drainage. Development behind defences should therefore be planned with due regard to the flood risk in the defended area.

In this context it may be necessary for the LPA, if it has short-listed some potential development sites falling within either Flood Zone 3 or where the development type is likely to require the Exception Test, to prepare a Level 2 type SFRA for these collective sites, or alternatively a series of preliminary detailed FRAs for specific sites.

Such studies must address explicitly the management of the residual risk by quantifying:

- The actual probability of inundation or overtopping
- Characteristics of the inundation
- What and who is likely to be affected by the inundation
- What are the economic, social and environmental impacts

Tables 12.1 and 12.2 from DEFRA/EA [Flood Risk Assessment Guidance for New Development](#) ⁴ address by the simple method the general level of danger (hazard) to people based on the distance from the defence, as illustrated below in Table 5-4 and Table 5-5.

5.4.4 Identified Sites behind Defences

The potential sites database [HSFRA All Development Sites](#) has been interrogated to assess the number of sites potentially lying behind established flood defences. The purpose of this assessment is to transparently identify all those sites that will require additional assessment in terms of safe development, either by means of a Level 2 SFRA or by site specific hydraulic modelling. Since most sites behind defences are typically infill sites, and therefore may be small, all sites within the database are listed in [Table 5-14](#).

There are 29 sites identified. 17 of these lie fully within Flood Zone 3, raising particular issues about safe development and flood free access. Initially, SEQUITIR could be used to identify alternative sites in zones of lesser flood risk.

Table 5-4 – Danger to People from Overtopping of Defence

Distance from defence (m)	Head above crest level (m)			
	0.5	1	2	3
100	Yellow	Red	Red	Red
250	Yellow	Red	Red	Red
500	Yellow	Yellow	Red	Red
1000	Yellow	Red	Red	Red
1500	Yellow	Yellow	Yellow	Red
2000	Yellow	Yellow	Yellow	Red
2500			Yellow	Yellow
3000			Yellow	Yellow
3500			Yellow	Yellow
4000			Yellow	Yellow
4500				Yellow
5000				Yellow

Key:
 Danger for some
 Danger for most
 Danger for all

Source: Table 12.1 - DEFRA/EA Flood Risk Assessment Guidance for New Development FD2320

Table 5-5 - Danger to People from Breaching of Defence

Distance from breach (m)	Head above floodplain (m)						
	0.5	1	2	3	4	5	6
100	Yellow	Yellow	Red	Red	Red	Red	Red
250	Yellow	Yellow	Red	Red	Red	Red	Red
500	Yellow	Yellow	Yellow	Red	Red	Red	Red
1000	Yellow	Yellow	Yellow	Yellow	Red	Red	Red
1500		Yellow	Yellow	Yellow	Yellow	Red	Red
2000			Yellow	Yellow	Yellow	Yellow	Red
2500			Yellow	Yellow	Yellow	Yellow	Yellow
3000				Yellow	Yellow	Yellow	Yellow
3500					Yellow	Yellow	Yellow
4000						Yellow	Yellow
4500							Yellow
5000							Yellow

Key:
 Danger for some
 Danger for most
 Danger for all

Source: Table 12.2 - DEFRA/EA Flood Risk Assessment Guidance for New Development FD2320

These “danger to people” classifications are most suitably applied to the identification of the least risk areas within the area being considered in order to apply a sequential approach to allocating land for development and for determining suitable types of development.

If the simple breach modelling matrix is inappropriate, it may be necessary to undertake a more detailed modelling approach (including 2D modelling).

5.4.5 Identified Sites Probably Requiring Exception Testing

It is not a requirement of a Level 1 SFRA to provide extensive details on the flood-risk issues pertaining to individual sites, particularly when the LPA has not yet short-listed preferred development sites.

However, it is considered useful to identify from the potential sites database all of those sites falling fully within the Flood Zone 3. This short-list will identify to the LPA and the EA sites that are likely to be the subject of greater scrutiny and evaluation within the sequential test, and may indeed require application of the Exception Test.

For example, under Table D.3 of PPS 25, Highly Vulnerable type development would not normally be permitted in this zone, and should be actively discouraged as a policy measure. More Vulnerable development may be appropriate (if meeting policy tests a) and b) of the Exception Test (see 5.4). However, in this case it will also be necessary to provide a more detailed Level 2 type SFRA or a site specific FRA prior to the site being short-listed for development by the LPA.

The FRA will in particular have to demonstrate that the development will be safe, following the guidance of 5.4.2.

A relational search query has been conducted of the **HSFRA Development Sites** and the **HSFRA Zone 3 Climate Change** GIS layers to identify all potential sites falling fully within Flood Zone 3. Such sites are likely to either:

- a) Fully preclude the presence of Highly Vulnerable development
- b) require the Exception Test to be passed for More Vulnerable development

In either case it is useful for the LPA to have a short-list of these greater risk sites before preparing a candidate list of preferred development sites. (As an approximation, it is assumed that sites falling partially within Flood Zone 3 and Flood Zone 2 will have a greater range of options for safe access and distribution of development types within the site, and therefore will not necessarily require the same level of detail to assess safe development as for those fully within Zone 3 prior to short-listing as part of the Local Development Framework).

At planning application stage, every site nevertheless is still subject to the Sequential Test and the requirements of PPS 25 Appendix E8 – E10.

The analysis indicates that some 353 sites impinge on the Zone 3 + climate change flood extent. Of these, 333 potential development sites fall significantly within the Flood Zone 3 + climate change flood outline. These sites, together with summary details of the site location and various flood risk indices are listed in Section 11.6 and Table 11-1. Of these the significant majority are less than 1.0 ha. in extent and will not be examined further in detail in this SFRA.

Table 11-1 further distinguishes those sites that fall entirely within flood zone 3 (3aF), and those that fall partially within flood zones 3 and 2 (3aP and 2P). Obviously those sites falling entirely within flood zone 3 are likely to present greater difficulty with regard to access and safe development, and hence are less likely to meet the Exception Test.

The more strategically useful of these sites (deemed to be of areas ≥ 2.5 ha.) have been extracted into Table 5-6 below for further consideration. 40 key sites have been identified. Particular issues pertinent to more detailed Level 2 type investigations (particularly if the Exception Test is to be met) include whether the site lies behind existing flood defences, whether the site area benefits from an existing hydraulic model, and whether there is scope to lessen the existing level of flood risk in the locality.

Table 5-6 – Principal Potential Sites > 2.5 ha within Flood Zone 3

Site Ref	Site Name	Location	Area (ha)	Existing Model?	Behind Defences ?
Leo/436/LP	E of Ridgemoor Road	Leominster	2.577	Yes. Atkins S105 model	Yes. Marsh Cut
HLAA/027/003	Field 8892, adj. River Lugg	Leominster	6.282	Yes. Atkins S105 model	Yes. Marsh Cut
O/Leo/001	Adjacent River Lugg	Leominster	2.292	Yes. Atkins S105 model	Yes. Marsh Cut
O/Leo/002	Adjacent River Lugg	Leominster	2.204	Yes. Atkins S105 model	Yes. Marsh Cut
HLAA/123/001	Corner Meadow North Road	Leominster	2.606	Yes. Atkins S105 model	Yes. Marsh Cut
HLAA/142/001	North of Bodenham	Bodenham	10.85	No	No
HLAA/169/001	South of Canon Ford Avenue	Eardisley	11.27	No	No
HLAA/149/005	West of Seward James Close	Bodenham	16.60	No	No
HLAA/215/001	Adjacent to Holme Lacy Road	Hereford	3.484	Yes. Atkins Hereford FDS	No
HLAA/215/005	Adjacent Rotherwas Chapel	Hereford	2.306	Yes. Atkins Hereford FDS	Rotherwas SFMP applies
HLAA/197/003	East of Hereford City	Hereford	43.45	Yes. Atkins Hereford FDS	No
HLAA/123/002	North Road	Leominster	9.158	Yes. Yes. Atkins S105 model	Yes. Marsh Cut
O/Bod/003	Land adjacent Millcroft Road	Bodenham	5.482	No	No
O/Mol/006	Land north of St Peters Close	Moreton on Lugg	6.997	No	No
O/Well/010	Land adjacent to A49	Wellington	4.092	No	No
O/Mord/001	Land at Garlands Farm	Mordiford	2.511	Yes. Atkins Hereford FDS	No
O/Ross/004	Land east of A40	Ross on Wye	7.841	Yes. Halcrow RoW FAS model	Yes
O/Ross/010	Land south of Bridstow Bridge	Ross on Wye	9.588	Yes. Atkins S105 Model	No
O/Ross/011	Land north of Bridstow Bridge	Ross on Wye	9.253	Yes. Atkins S105 Model	No
O/Cou/005	Land adjacent Bailey Brook	Coughton	2.646	No	No
O/Cred/001	Land off Station Road	Credenhill	3.617	No	No
O/K/031	Land north of Arrow Grange	Kington	4.785	Yes. Atkins S105 model	No
O/Her/035	Land adjacent Newtown Road	Hereford	2.587	Yes. Capita ESG model	Potentially
O/Her/026	Rotherwas Estate	Hereford	14.00	Yes. Atkins	No

	east of STW			Hereford FDS	
O/Her/030	Land adjacent A4103 Victoria Pk	Hereford	3.765	No	No
O/Her/029	Land adjacent A465 Victoria Pk	Hereford	8.067	No	No
O/Her/027	Land off Hampton Park Road	Hereford	10.95	Yes. Atkins Hereford FDS	Yes. The Stank
O/Her/025	Rotherwas Estate west of STW	Hereford	40.38	Yes. Atkins Hereford FDS	No
H/A1/1	Rear of Greyhound	Hereford south	3.770	Yes. Atkins Hereford FDS	Yes. Hereford FDS
Leo/12	Duplicate site Leo/436/LP				
P372	Land west of Arrow Bridge	Eardisland	27.89	Yes. Atkins S105 model	No
O/Eardd/001	Land at Glanarrow Mill	Eardisland	2.239	Yes. Atkins S105 model	No
P535	Land adjacent west of A44	Kington	7.27	Yes. Atkins S105 model	No
P1081	Land at Lower Bullingham	Hereford	82.23	Yes. Atkins Red Brook model	No
P1036	Moreton On Lugg Depot central	Wellington	16.1	No	No
P1036	Moreton On Lugg Depot north	Wellington	8.05	No	No
P944	Cadburys Marlbrook	Newton	8.55	No	No
H/569e	Land north of Holme Lacy Road	Hereford	4.13	Yes. Rotherwas SFMP	No
H/407e	Twyford Road north	Hereford	3.42	Yes. Rotherwas SFMP	No

Site Leo/436/LP lies in the Leominster centre on the south bank of the Marsh Cut, centred around the Marsh Sports Ground. The site is within a defended area, but this is not to the 1% + climate change standard. In a breach or overtopping scenario, this area is inundated with flood zone 3, and is likely to be problematic with regard to safe access and high flood depths. The site benefits from the availability of the WS Atkins hydraulic model of Leominster (see [3.4.3](#)) which will provide further detail on flood depths and velocities.

Site HLAA/027/003 lies on the north bank of the Marsh Cut, and is also inundated with zone 3 floodplain. It is likely that this green-field area will be regarded as functional floodplain by the EA and will be very problematic to develop. The site benefits from the availability of the WS Atkins hydraulic model of Leominster (see [3.4.3](#)) which will provide further detail on flood depths and velocities.

Site O/Leo/001 is adjacent to site HLAA/027/003 and similar reservations and conditions apply. Site O/Leo/002 is immediately adjacent to the east of site O/Leo/001 and the same conditions and reservations apply.

Site HLAA/142/001 lies partially (75%) within flood zone 3 of the River Lugg at Bodenham. Zone 2 parts of the site offer good access and probably safe flood depths, but the zone 3 areas of the site are likely to require significant new flood defences or floodplain improvements in order to be developable. In conjunction with adjacent sites HLAA/149/005 and O/Bod/003, there may be scope for strategic flood risk improvements in this area. There is currently no hydraulic model available.

Site HLAA/169/001 lies west of the village centre in green-field land and is within the floodplain. Site access via Woodseaves Road is also flooded. This site is unlikely to pass the Exception Test. There is currently no hydraulic model available.

Site HLAA/149/005 lies partially within the floodplain of the River Lugg, and the same conditions and reservations apply as for Site HLAA/142/001 and O/Bod/003. These sites will be very problematic to develop, but the three sites in conjunction may offer scope for strategic flood risk reductions.

Site HLAA/215/001 lies 250m from the River Wye on the southern edge of Holme Lacy Road. The EA flood map of this area (April 2008 issue) is believed to be incorrect for the Bullingham area. Nevertheless some 60% of the site is believed to lie at or below the 52m contour, which is the prevailing flood level in this locality. The principal influence on flooding is from the backing up of the Red Brook to the south. Safe egress from the site is likely to be problematic as both Watery Lane and Holme Lacy Road are heavily flooded in events with a 1 in 50 year return period. Raising of the entire land parcel would feasibly bring the site out of the floodplain but substantial floodplain storage compensation would be required nearby. The site benefits from a WS Atkins model of the Red Brook (see [3.4.1](#)).

Site HLAA/215/005 is located within the Rotherwas Industrial Estate immediately east of the Rotherwas STW and the viability of this site will emerge from the separate investigations into the Rotherwas Strategic Flood Management Plan. The proximity of the site to the river, and the likely flood depths and velocities are likely to preclude most forms of development however. Extensive details on flood depths and velocities are available from the WS Atkins model, see [3.4.1](#) (subject to licence arrangements).

Site HLAA/197/003 is a substantial area of open fields north of the Eign STW. Modelling studies clearly show that this entire area to be part of the functional floodplain of the River Wye. Flood depths are in excess of 2m over most of the site, and flood velocities will be high. Consequently most forms of development are likely to be precluded from this area.

Site HLAA/123/001 lies immediately adjacent to the Leominster Flood Alleviation channel north of the town. It is highly likely that the EA will regard this area as functional floodplain. It also exhibits difficult access conditions, as all approach roads are within the Zone 3 flood extent. The site benefits from the availability of the WS Atkins hydraulic model of Leominster (see [3.4.3](#)) which will provide further detail on flood depths and velocities.

Site O/Bod/003 is located within the floodplain of the River Lugg, lying midway between Bodenham and Bodenham Moor, upstream of Bodenham Bridge. There are numerous local flood reports. Since the entrance to the site is via Millcroft Road which is also within the floodplain, safe access to and from the site is likely to be problematic. Some localised flood improvement may be feasible by hydraulic improvements to Bodenham Bridge downstream. There is no existing hydraulic model of this area.

Site O/Mol/006 lies on the western edge of the Lugg floodplain, and although most of the site is inundated flood depths are probably low. There are no recorded local flooding reports. Importantly the site lies outside the defined functional floodplain, so it is feasible that the site could be brought above the flood level to provide safe development. This would still require a substantial storage compensation area to be found in the locality to offset the development. Safe access appears feasible to several roads to the south.

Site O/Well/010 lies immediately west of the A49 at Wellington and borders the Wellington Brook. Some 40% of this site lies within the functional floodplain; the remainder is outside the flood zone 3 outline and should be developable, with safe access to the north. Assuming that some local flood risk improvements could be effected in combination with storage compensation, it may be feasible to develop some 50% of the site for residential purposes. There is no currently available hydraulic modelling in the area.

Site O/Mord/001 is on the left bank of the River Lugg immediately downstream of Mordiford Bridge. This site is also heavily affected by the Wye floodplain, and lies within the functional floodplain. Consequently it is unlikely to be developable.

Site O/Ross/004 lies within the floodplain of the Rudhall Brook upstream of the A40 crossing. As identified in [3.6.7](#) this land is now designated as flood storage area as part of the Ross-on-Wye Flood Alleviation scheme, and hence is unlikely to be developable.

Site O/Ross/010 lies on the left bank of the Wye immediately south of Bridstow Bridge. This land is probably within the functional floodplain, and will be subject to considerable flood risk. Safe residential development is probably not feasible in this area.

Site O/Ross/011 lies on the left bank of the Wye immediately north of Bridstow Bridge. This land is probably within the functional floodplain, and will be subject to considerable flood risk. Safe residential development is probably not feasible in this area.

Site O/Cou/005 lies on the north (right) bank of the Bailey Brook. Whilst the site offers safe egress to the north, some 70% of the site is currently within the zone 3 flood outline. Raising of the land or provision of flood defences would feasibly provide safe development to part of the site, but a storage compensation area would have to be provided in equal measure.

Site O/Cred/001 is on the north (left) bank of the Yazor Brook. Although there are no local flood reports, the site is fully within the zone 3 outline and a significant proportion is likely to be part of the functional floodplain. Safe development will be problematic at this site because all access routes appear to be also within the floodplain.

Site O/K/031 lies adjacent to the River Arrow predominantly on the south bank but with a small area to the north. Some 80% of the site lies within the zone 3 flood outline, much of which is likely to be functional floodplain. Southern parts of the site might be partially developable with safe access to Kingswood Road to the south, but this would probably require local hydraulic improvements to Bridge

Street bridge, flood defences and/or extensive storage compensation zones. The site benefits from the HR Wallingford hydraulic model completed in 1995 which would provide further (see [3.4.5](#)).

Site O/Her/035 is located in the centre of Hereford adjacent to the Widemarsh Brook. There are significant local flood reports downstream at Merton Meadows car-park. Whilst the site is fully inundated under present conditions, general flood risk improvements associated with the Edgar Street Grid development may reduce flood risk to this site also, most notably if an upstream diversion of the Yazor Brook proceeds as planned (see [9.6.3](#)). Currently it would appear infeasible to provide safe development on this site.

Site O/Her/026 is within the Rotherwas Industrial Estate and the same conditions and reservations apply as for Site HLAA/215/005. This land lies immediately adjacent the right bank of the River Wye, and is therefore likely to be regarded as functional floodplain. Extensive details on flood depths and velocities are available from the WS Atkins model, see [3.4.1](#) (subject to licence arrangements).

Site O/Her/030 lies on the west edge of the Lugg floodplain, immediately adjacent to the A4103/A465 intersection. Some 60% of the site falls within the zone 3 outline but this could potentially be reduced with remedial works. Flood depths are likely to be shallow, and safe access is feasible from the south direct to the A4103 and if a storage compensation scheme could be effected a significant proportion of the site may be developable.

Site O/Her/029 lies adjacent to the A465 south of O/Her/030 and similar conditions apply. Potentially land in either site could be used to provide compensatory storage for development in the other.

Site O/Her/027 lies on the north bank of the River Wye off Hampton Park Road. The southern 40% of the site is within the functional floodplain of the River Wye and is on the river side of the major flood defence known as The Stank. This area is un-developable as residential. The northern side is however protected by The Stank, and subject to a detailed assessment of the residual risks, northern parts of the site may be developable.

Site O/Her/025 is a substantial (40 ha.) area of land on the right bank of the River Wye at Rotherwas Estate. Modelling studies show this land to be virtually all functional floodplain. Flood depths and velocities will be substantial, and most access routes will encounter high levels of flooding. Furthermore, the Rotherwas Flood Management Strategy has identified a large storage compensation zone in this area needed to provide mitigation to Rotherwas Futures development phases 1, 2 and 3. This site is very unlikely to be developable under any circumstances. Flood depths and velocities can be obtained from the Atkins Hereford FAS model.

Site H/A1/1 falls within a re-development area between immediately east of the new Asda superstore. Some of this zone has been occupied by the Asda store and associated parking. The remaining area is currently scheduled to remain as allotment land and general public open space, but this may change with future strategies. This area benefits directly from the construction of the new defences of the Hereford (Belmont) Flood Defence Scheme. Residential development, if considered for this area in future, would have to take detailed account of the

residual risks as set out under [5.4.3](#). Table 5-5 suggests however that due to the proximity of the site to the defences (<200m), there would be danger to all residents from a breach situation.

Site Leo/12 is a duplicate reference in the [HSFRA Development Sites](#) GIS layer to site Leo/436/LP (see above).

Site P372 occupies the zone 3 floodplain east of Eardisland on the Arrow, sited immediately upstream of Arrow Bridge at Arrow Green. Some 60% of the site is likely to be classed as functional floodplain. The balance on the southern edge may have some scope for residential development with appropriate flood defences and storage compensation. Hydraulic improvements may be feasible to Arrow Bridge to further reduce flood risk. The site benefits from the availability of the WS Atkins hydraulic model of the River Arrow at Eardisland (see [3.4.3](#)).

Site O/Earrd/001 lies close to Glanarrow Mill in the centre of Eardisland. Site access will be particularly difficult as all approach roads fall within the Zone 3 flood outline. There are numerous local flood reports in and around Eardisland. The site benefits from the availability of the WS Atkins hydraulic model of the River Arrow at Eardisland (see [3.4.3](#)).

Site P535 is a large site occupying the floodplain upstream of the A44 Bypass at Kington. Approximately 50% of the site may prove to be functional floodplain, but there is potential scope for safe development on the northern and southern edges of the site. Safe access is feasible from both the north and south, but depths and storage compensation would have to be assessed from the available HR Wallingford hydraulic model.

Site P1081 is a significantly large (82 ha) area of land south of the railway embankment in Lower Bullingham, bounded on the west by the Withy Brook and to the east the Red Brook. Large proportions of the site are outside the zone 3 flood outline, although the eastern edge and north-east corner of the site is inundated with the floodplain of the Red Brook. Large parts of the site will be developable, as the land rises to the south towards the new Rotherwas access road. Whilst local fluvial flood issues are likely to be entirely manageable, the most significant restrictive issue is likely to be one of surface water management. Runoff from this site has the potential to massively overload the receiving watercourses of the Withy and Red brooks. The downstream urban areas of Lower Bullingham have encountered significant flooding in recent years, primarily due to the floodplain of the River Wye. Additional flows from upstream development, without mitigation, will exacerbate this risk. Significant attenuation on site is also problematic, as the delayed timing of runoff may actually conflict with the later peaks of the River Wye. If taken forward as a candidate site, this area will have to be the subject of a detailed Surface Water Management Plan to resolve a host of problematic and conflicting surface water and flood risk issues.

Sites P1036 (central) and P1036 (north) are situated entirely within the zone 3 floodplain of the River Lugg, and will probably be classed as functional floodplain. It is unlikely that these sites would be developable for anything other than essential water based infrastructure.

P944 lies adjacent to the right bank of the River Lugg east of the A49 at Newton. The site is almost entirely within the zone 3 floodplain, and although safe access is available to the west, the entire site is probably functional floodplain and therefore not developable. The narrowness of the floodplain at this location suggests that it will be difficult to provide mitigation or compensatory works that would not adversely affect the active conveyance of the floodplain

Site H/569e is located within the Rotherwas Industrial Estate immediately east of the Rotherwas STW and the viability of this site will emerge from the separate investigations into the Rotherwas Strategic Flood Management Plan. It is proposed that safe commercial development will be provided by raising floor levels above the 1% + climate change level, with egress via the Rotherwas Access Road. Flood depths and velocities are not expected to be significant.

H/407e is also located within the Rotherwas Industrial Estate, and is believed to have been already developed. Raised ground levels in this area are in the order of 51.7 mAOD which is above the worst case expected flood levels from both the River Wye and Red Brook.

Table 5-6 and the above commentary should assist Herefordshire Council to identify those principal sites where Highly Vulnerable or More Vulnerable development is likely to not meet the requirements of the Exception Test. Where existing river hydraulic models are available, it will be relatively straightforward to identify basic issues of flood depth and velocity to determine appropriate safe uses of land within the sites, and thus indicate if the development is likely to be 'safe' (part C of the Exception Test).

Where hydraulic models are not available, but residential development is a strong possibility, it will be necessary for Herefordshire Council to not only demonstrate that all other options in lesser flood risk areas have been discounted, but sufficient hydraulic information is available to prove the criterion of 'safe' development. This may require the commissioning of local hydraulic studies for this purpose.

5.5 Environment Agency and the Sequential Test

On receipt of a development application, the LPA will consult the Environment Agency in accordance with Article 10 of the Town and Country Planning (General Development Procedure) Order 1995 ('the GDPO'). The GDPO was amended in October 2006 to make the Environment Agency a statutory consultee for specified categories of development where flood risk is an issue as follows:

- development other than minor development in Flood Zones 2 & 3
- development in Flood Zone 1 where there are critical drainage problems
- development within 20m of the bank top of a Main River
- any culverting operation or development which controls the flow of any river or stream
- any development exceeding one hectare in extent.

The degree of interaction necessary between the LPA and the Environment Agency is clearly set out on the web-based facility of the Agency's **Flood Risk Standing Advice for England (PPS25)**⁶. This highly useful source should always be referenced when considering site specific requirements.

Site allocations made by the LPA which may encounter some degree of fluvial and/or other flood risk will be reviewed on the extent to which they comply with the Sequential Test. **Table 5-7** summarises the procedure that the EA will use to conduct the review in a systematic manner.

5.6 A Systematic Approach to Evaluating Development Impact

5.6.1 Objectivity and Transparency

The key to a successful implementation of the Sequential Test is to attain transparency and objectivity in the evaluation of alternative sites. A significant failure of the Sequential Test some other Local Development Frameworks (LDFs), and hence continuing objections from the EA has been the lack of these two criteria with respect to site allocations.

It is relatively straightforward (and transparent) to determine whether or not a site lies within the floodplain. It is more difficult to identify whether there are other equally problematic issues related to a particular site, such as runoff impacts on adjacent sites, local flooding issues, downstream channel restrictions or inadequate storm sewerage. All of these factors can constrain a site in flood risk and drainage terms, and in the first instance, alternative sites should be considered. Many SFRAs have simply ignored these other issues, a criticism raised in the EA report on the 2007 summer floods⁸.

This SFRA innovatively proposes a simple check-list of 'flood and drainage issues' that should be objectively considered within the Sequential Test. These issues can be considered singly or in combination between alternative sites. It may be concluded for example that site runoff impacts from a particular site are considered more problematic than an alternative site that lies partially within Flood Zone 3a, and hence the Sequential Test would determine that it is the latter site that has a lower level of flood risk.

In this context, the key requirements to comply with the Sequential Test are:

- A full list of comparable alternative sites is transparently identified
- All of the flood risk and drainage issues are identified where possible
- An objective process is demonstrated by which the 'least flood risk' site is selected

A significant number of useful databases, GIS maps and appraisal tools have been provided to assist the LPA with this process

Table 5-7 – EA Review of Sequential Test Transparency

Environment Agency checklist to provide a framework for transparent demonstration of the application of the Sequential Test to planning applications		
Question	Answer Yes/No	Sequential Test – passed or failed?
1. Is this application consistent in scale, development type and location, with a site allocation that has already been sequentially tested and included in the Local Development Document (LDD)?	If yes, state which allocation and the location in the development plan. If the answer is 'No' go to Question 2.	If the answer is Yes the Sequential Test has been passed – FINISH HERE
2. Does the application site fall within an area identified for 'windfall' development that has been agreed as part of the LDD in association with a Strategic Flood Risk Assessment (SFRA)?	If yes, state the location in the LDD. If the answer is 'No' or there are no such areas identified in the LDD, go to Question 3.	If the answer is Yes the Sequential Test has been passed – FINISH HERE
3. Does the LDD or background documents contain reasonably available, alternative site allocations that are situated in a lower flood risk zone?	If yes, state which allocation(s) and the location in the development plan. If the answer is 'No' go to Question 4	If the answer is Yes the Sequential Test has been failed – FINISH HERE
4. Does the development plan or background documents contain reasonably available, alternative site allocations that are within the same Flood Zone and subject to a lower probability of flooding from all sources as detailed by the SFRA?	If yes, state which allocation(s) and the location in the development plan.	If the answer is No to Questions 3 and 4 the Sequential Test has been passed. If the answer is Yes to Question 4, the Sequential Test has been failed – FINISH HERE

Source: Development and Flood Risk: Practice Guide Companion to PPS 25

5.6.2 Site check-list of flood and drainage issues

To assist in a systematic evaluation of sites, a standardised methodology is proposed that compares alternative sites within a check-list of 16 possible issues. For many sites, some of the issues will not be relevant, or there will be no information on this issue.

Whatever IS known about the site is brought into the appraisal process. What is unknown may require further investigation via a detailed FRA, or it may be inferred that these other issues are unlikely to be critical on the basis of anecdotal knowledge. The key point is that the methodology allows for this flexibility. The 'knowns' and the 'unknowns' are systematically identified.

The recommended check-list is as follows:

1. **Site area** – sites must initially be compared on the basis of similar size. It would not be practical or reasonable to assume that development and infrastructure opportunities for an 8 ha site could equally be achieved by 4 x 2 ha sites. However, the LPA must demonstrate that the range of alternative sites selected is not unreasonably small.
2. **Location** – proximity of sites may also be a key limiting factor in finding alternatives. It cannot be assumed that a 4 ha site in Leominster can simply be relocated to Ross-on-Wye. Again, if the list of alternative sites is identified by either Postcode or catchment, the transparency of the process is evident.
3. **Flood Zone** – identification of whether the site intersects with either Flood Zone 2 or 3 or both is the primary check with regard to fluvial flooding.
4. **Flood depth** – where it is possible to identify say 1% AEP + climate change flood depths in the lowest part of a site, this may be a determining factor in the Sequential Test. For example, if there is an option of only two alternative sites for an intended use, and both are in Flood Zone 3, it would be logical to select the site with the lowest flood depth. This process is a valid application of the Sequential Test.
5. **Fluvial Flood Risk Index** – development in a catchment area with a lower Fluvial Flood Risk Index would be preferable to one with a higher FFRI. Even if the site is not within the floodplain, increased development within the same catchment may increase general pressure on runoff, sewerage capacity or emergency infrastructure. In the absence of any other indicators, the FFRI could be used to demonstrate the Sequential Test. The FFRI is built into the [HSFRA All Catchments](#) database and GIS.
6. **Catchment Flood Hazard Index** - development in a catchment area with a lower Catchment Flood Hazard Index would be preferable to one with a higher CFH. Even if the site is not within the floodplain, the site may be at increased risk of flooding due to higher local soil impermeability, adjacent flooding, or flash flooding, the principal parameters used to compile this particular Index. The CFH Index is built into the [HSFRA All Catchments](#) database and GIS.
7. **Flood Timing and Evacuation Index** – development in or near a floodplain are always at risk of flooding, even if this risk is minimal. The FTE Index is an attempt to rank all catchments by the time to peak of the flood hydrograph. Catchments (and developments) that have a high ranking (1, 2 etc.) will have less lead warning time in the event of a major flood. Flood warning notice period and the evacuation time required for the site will become a critical issue if the site is likely to be cut off completely in a major flood. In this instance, it might be difficult.

Flood risk is potentially reduced if the development is sited in a catchment with a longer warning period or if there remains a permanent route of egress from the site above extreme flood level. The FFT Index is built into

the **HSFRA All Catchments** database and GIS.

8. **Climate change factor** – sensitivity of a site to climate change (defined as increased extent of the floodplain and perhaps runoff volumes and flash flooding) is another relevant factor. It is intuitively preferable to develop a site that is less susceptible to climate change than the initially preferred site. In the SFRA climate change impact can be principally identified by comparing the baseline Flood Zone 3 outline to the Zone 3 climate change outline specially commissioned for this SFRA (see **5.10.3**).
9. **Defended Site** – if the site lies behind existing defences, or depends significantly on other flood infrastructure (such as a strategic attenuation facility upstream), the residual risk of flooding remains relatively high. These defences may be breached or overtopped or fail in some other way. Intuitively therefore, a site that does NOT rely on flood defences is at lesser risk than a site that does. Controlled flooding of an unprotected site may actually be preferable to uncontrolled flooding of a protected site. Existing flood defences and areas benefiting from defences are readily established from the **HSFRA Flood Defences** GIS layer.
10. **Upstream runoff** – a site may be at risk, presently or in the future, from increased runoff from upstream sites, manifested either in terms of increased discharges in local watercourses, or increased floodplain extent. Quantification of these effects would require a detailed FRA, but for Sequential Test purposes it would be sufficient to identify if the site is within the direct drainage path of upstream urban areas (existing and new).
11. **Sewerage constraint** – the capacity of the receiving storm sewers may form a constraint to local drainage. An enquiry of Welsh Water (or Severn Trent in the eastern borders of Herefordshire) would be needed to confirm this.
12. **Local Flooding** – if there are a significant number of local flooding reports within the catchment, this is symptomatic of increased risk. Local flooding is taken as flooding outside the main flood zones. In the absence of any other data, the number of local flood reports as identified under GIS layer **HSFRA Flood Reports** could be used as part of the Sequential Test as a proxy for general increased risk. The number of flood reports has been incorporated into the **HSFRA All Catchments** GIS layer.
13. **High Runoff Impact** – large sites have significant potential to increase local flood risk by increased volumes of runoff, reduced times to peak and higher peak flows. Such sites may not themselves be at risk, but they may create substantial increased flood risk to adjacent or downstream sites. Such an issue could be part of the Sequential Test.
14. **Downstream restrictions** – runoff from sites may be constrained by downstream restrictions, most commonly channels and culverts with inadequate capacity. If site runoff cannot be limited to green-field equivalents (either because of policy or technical constraints), downstream restrictions might increase local flood risk, and this would be a constraint

under the Sequential Test.

15. Sustainable Drainage Systems – SuDS are an increasing focus of sustainability requirements for drainage, lessening the impact load on receiving sewers and watercourses. Where SuDS are found to be inappropriate, this implies greater pressure on these flood pathways. Hence, a site which has potential for SuDS is intuitively likely to be at lesser risk of flooding itself, and is also less likely to create flood-risk elsewhere.

16. Attenuation inappropriate – surface water attenuation to minimise downstream flood risk is frequently a condition of site development. However, widespread attenuation within a catchment without due regard for the long-term strategic impacts can be a flawed policy⁷. It may be the case that the local drainage policy evolves to be one of 'direct discharge to watercourses with downstream improvements'. In this case, if a site could NOT contribute to such improvements, and on-site attenuation is contrary to policy, an alternative site would have to be found.

If the target site and all reasonably available alternative sites with their associated issues are summarised in a simple matrix form, the sequential test can be relatively easily applied, and transparently demonstrated. This is the intention of the SEQUITIR analysis tool described in the next section.

5.7 SEQUITIR – A Tool to Assist the Sequential Test

SEQUITIR (Sequential Test Indicative Report) is an innovative and extremely powerful methodology to interact with the Herefordshire Council sites database, uniquely developed for the Herefordshire SFRA. It is a systematic methodology to identify, compare and sequentially test sites on the basis of the key flood risk issues identified above in 5.6

Its primary purpose is to assist Herefordshire Council planners to allocate sites for development with appropriate levels of flood risk, in compliance with PPS 25. Furthermore SEQUITIR is explicit and transparent in the way it operates. Hence it can be used as part of the evidence base in supporting why specific sites have been selected or allocated for a particular use in Local Development Documents (LDDs), especially to satisfy potential EA transparency concerns.

The SEQUITIR form can be used either as a hard-copy pro-forma, or more usefully, in the EXCEL electronic version. In the latter, Visual Basic based queries can automatically search for alternative sites and itemise various flood risk issues for direct comparison to the subject site. **Figure 5-2** is an example of a SEQUITIR assessment applied to potential development

5.7.1 Intended Use Check

Details of a target site are entered at the head of the form. The output of Table D.3 of PPS 25 (permitted development in the Flood Zone and/or the Exception

Test) are automatically calculated for the site, allowing the LPA or EA to assess the appropriateness of the intended use within the zone in which the site lies.

Since all intended uses are built into the form, and are selectable from a drop-down list, it is easy to assess alternative uses for a particular site and assess their suitability. This is one important facet of the Sequential Test i.e. appropriateness of use. If a site is located within Flood Zone 3a for example, 'More Vulnerable' development (such as dwelling houses) would require the Exception Test, and would generally not be an appropriate use. However, changing the intended use to an office use ('Less Vulnerable' development) would be considered an appropriate use in flood zone 3a (subject to no other sites being available in other lower risk flood zones).

5.7.2 Alternative Sites Filters

To compare the target site with other alternative sites, a filter mechanism can be applied to search the database, selecting one or all of the following filters:

- **Site area** – obviously, comparative sites will primarily have to be of similar size. A % +/- range can be applied. The extent to which the sensitivity range is restricted is a matter of judgement for the LPA. A very small range (e.g. +/- 10%) may be considered by the EA to be insufficiently flexible in finding 'reasonably available' alternative sites. Equally, it would not be realistic to search for alternative sites with a +/- 50% filter, as the development potential and infrastructure issues are likely to be fundamentally different between sites of such a wide range.
- **Postcode** – to confine alternative sites to the locality, a Postcode filter will restrict the search to only the specified Postcode. The GIS layer **HSFRA Flood Reports** could be first used to check alternative Postcodes with no flood reports for example, and SEQUITIR then used to find alternative sites within that Postcode.
- **Catchment** - Since flood risk is primarily catchment related, a catchment filter will restrict the search to alternative sites within the specified catchment (which does not have to be the same as the target site). The individual rankings or the **Catchment Flood Hazard** Index of Table 4-1 could be used to identify alternative catchments with lower potential flood risk than that of the target site, in conjunction with GIS layers **HSFRA Flood Timing** or **HSFRA Flood Runoff**.
- **Flood zone** – the final filter will restrict the database search to only those sites within the specified flood zone. Hence, accordance with the Sequential Test, a search could be executed for ALL alternative sites in Zone 1, to within say 25% of the target site's size. If this search confirms that there are no other sites available in this lowest flood risk zone, the next search can be conducted in flood zone 2 etc.

Since the filters can be used singly or in combination, and it is obvious what filters have been applied, SEQUITIR provides a highly flexible but always transparent confirmation of how the Sequential Test has been applied.

5.7.3 Comparative Sites Assessment

Following the alternative sites filters, SEQUITIR provides a powerful summary of all alternative sites found within the database. The sites are listed in the order found, not by any degree of prioritisation. Up to 12 alternative sites can be listed. The key attributes of site area, postcode and flood zone are automatically listed for comparison. Also extracted from the database is the Fluvial Flood Risk Index as described in 3.6.3, the Catchment Flood Hazard Index as described in 4, and a Flood Warning & Evacuation Index which is derived from Table 4-1.

A check-list should then be completed identifying 9 further possible 'flood risk issues' related to that site, where these are known. A ● selected indicates that particular issue is relevant and problematic to that site. For example, the site may be behind existing flood defences, and there may be downstream channel or culvert restrictions that might restrict site runoff. The more issues identified, the more difficult the site is likely to be in terms of runoff impact, flood risk or drainage.

In the example of Figure 5-2, a site of 6.74 ha in Bosbury is being assessed. It is identified as being in Flood Zone 3b, and is therefore not appropriate for the housing use being proposed. Filters are then applied to find all other sites of $\pm 25\%$ within the Lower Leadon catchment.

This finds seven other potentially suitable sites, one of which is also in Flood Zone 3. Since all sites are within the Leadon catchment, they all have the same fluvial and flood hazard indexes. A systematic review then takes place for each site, identifying as many flood risk issues as possible, where this information is known.

There are three sites falling within Flood Zone 1, and in the normal sequential process, the LPA should be selecting one of these sites for the proposed development as opposed to the target site.

The review may however highlight that are significant surface water flood risk issues with the sites in zone 1, and it may therefore be entirely appropriate that that the eventually selected site is in Flood Zone 2, because in fact this has a lower overall flood risk. The SEQUITIR output would make clear why and how this decision had been arrived at.

The SEQUITIR output matrix is an extremely powerful and transparent way of comparing all of the flood and drainage issues (where they are known) pertaining to the target and its alternative sites. An objective sequential process of identifying the most appropriate site from a range of issues is easily undertaken. A summary of the reasons for selecting (or rejecting) the target site can be provided in the last section.

Figure 5-2 – Example Output from SEQUITIR

SEQUITIR - PPS25 Sequential Test Indicative Report



Details

Enter Site Code Status Postcode Date
 OR
 Planning Ap.No. Proposed Use? PPS25 Code

Attributes

Site Area Catchment Sub-catchment
 Settlement Nearest AH Flood Zone
 PPS25 Vulnerability Flood Zone Compatibility

- The site is in Flood Zone **3b** and the risk of fluvial flooding may be **Very High**
- The proposed use is **Not Appropriate** on the basis of the relevant Flood Zone.
- PPS25 Exception Test **will not apply** for this development in this Flood Zone.

Alternative Sites
 SEQUITIR can search for alternative sites in the database with various filters, for further investigation.

Filter by
 Site Area +/- % Postcode Catchment Flood Zone
e.g. HR9 Selectable 1,2,3a

Flood Risk Issues of Similar Sites Report

ID	Site Code	Area	Postcode	Flood Zone	Flood Depth	Fluvial Flood Prob. Index	Catchment Flood Based Index	Flood Timing Index	Climate change	Defended Site	Upstream runoff	Sewerage Constraint	Local flooding	High runoff impact	Downstream restrictions	SUDS Inappropriate	Appropriation
	Subject Site	6.740	HR8	3b	0.70	20	6	33									
Comparative Sites																	
1	HLAA/026/001	6.035	HR8	1		20	6	33	=	=	=	=	•	=	=	=	
2	O/Bos/002	6.560	HR8	3b		20	6	33	•	=	•	•			•	•	
3	O/Bos/005	6.133	HR8	2	1.20	20	6	33	•	=	•	•			•	•	
4	O/Bos/006	6.581	HR8	2		20	6	33	•	=	•	•			•	•	
5	O/Led/001	8.295		1		20	6	33	=	=	=	=	•	•	=	=	
6	HLAA/065/001	6.033		2		20	6	33	•	=	•	•	•	=	=	•	•
7	O/Led/012	6.852		1		20	6	33	=	=	•	•	=	=	=	=	•
8																	
9																	
10																	
11																	
12																	

Status of Target Site after Review

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5.8 Strategic Appraisal of Development Impact

This key section brings together the identified development pressures, the flood management hierarchy and various essential Evidence Maps and support tools to assist the LPA in its allocations and policies for Local Development Documents. A systematic review of the principal sites identified under the **HSFRA Development Sites** database and GIS layer is conducted, which has used the SEQUITIR approach outlined in 5.6 and 5.7.

5.8.1 Housing Land Pressures on Floodplain

The amount of potentially available land identified under H2, H5, and HLAA proposals (as of April 2008) amounts to approximately 5560 ha, see Table 5-8. A significant proportion of this land may not be developable due to constraints.

Historically average densities in the County have been low (around 15 per ha) but this has been "skewed" due to large numbers of single dwellings coming forward. In recent years Herefordshire Council has started to increase densities in accordance with Government policies to make the most efficient use of land. In 2007 37% of new dwellings were completed at less than 30 dwellings per hectare, 36% completed at between 30 and 50 per hectare and 27% at over 50 per hectare. The densities in the urban areas tend to be higher than rural areas and the average is over 30 per ha in urban areas but below 30 per ha in rural areas.

Assuming a County wide average of 30 dwellings/ha, and assuming a full take up of 16,600 dwellings under the Regional Spatial Plan, 553 ha. of residential land is required to meet growth targets. This represents 10.5% of potentially available housing land. Not all of this land will be reasonably available, and many sites will be inappropriate for development. Nevertheless, this small proportion suggests that there is significant scope to allocate housing land outside Flood Zone 3 and Flood Zone 2 land in compliance with the Sequential Test.

Table 5-8 – Potential Development Land Impinging on Flood Zone 3

Site Source	Locality	No of Sites	Total Area (ha)	** No in FZ3	Area of Sites (ha)
H2	Hereford & Market Towns	23	87.23	9	30.30 (34%)
H5	Main Villages	18	16.74	2	1.57 (9.4%)
E1, 2, 3	Hereford, Market Towns, Moreton-on-Lugg	22	132.3	9	92.8 (70.1%)
HLAA	Sites throughout Herefordshire	510	1984	90	806.6 (40.6%)
Officer Sites	Sites throughout Herefordshire	597	1443	104	382.8 (26.5%)
Housing Study	Sites throughout Herefordshire	594	170.4	59	26.2 (15.3%)
UDP Rep Sites	Sites throughout Herefordshire	611	1727	80	1490 (86%)
Total		2375	5560.7	353	2830

Note: ** Sites within Flood Zone 3 means any part of each site intersecting with Flood Zone 3. Substantial parts of the site(s) may lie outside the flood zone.

Note: Some sites contained within UDP Representation Sites overlap the HLAA study. Hence UDP Rep sites are a slight over-estimate.

Table 5-8 illustrates that under Policy H2, 9 of 23 sites have some degree of intersection with Flood Zone 3. These sites account for 30.3 ha. or 34% of the total allocated area under the H2 policy. It is likely that all of these sites will require a detailed Flood Risk Assessment as defined by PPS 25 Annex E, although substantial parts of each site may lie outside the flood zone. Detailed consideration should be given to the 23 sites that intersect with the Flood Zone 3, with a view to re-distributing affected land to lower risk sites. However, since the H2 sites are primary sites already allocated under the UDP framework, there may be limited scope to find alternative sites.

Under Policy H5, only 2 out of 18 possible sites interact with Flood Zone 3. Housing allocations for Policy H5 are unlikely to be problematic with regard to fluvial flood risk.

Although only 90 out of 510 possible sites identified under the Herefordshire Housing Land Assessment (HLAA) interact with Flood Zone 3, the site areas account for a disproportionately high percentage of the total land identified in the HLAA (40.6%). Many of the sites are literally marginal to the flood zone and a significant proportion of this land may be developable even with 'Highly Vulnerable' and 'More Vulnerable' uses. Nevertheless, there would appear to be significant scope to apply the Sequential Test to assess alternative sites other than these that have a lower level of flood risk.

Of 597 'Officer identified' sites, 104 interact in some way with Flood Zone 3. The total area of these sites is 26.5% of the sub-total of 1443 ha. Again there would appear to be significant scope to locate sites away from the fluvial floodplains.

The Housing Capacity Study land assessments are particularly promising with regard to fluvial flood risk. Only 10% of the sites interact with Flood Zone 3, and they represent 15% of the total area covered by the Capacity study.

Although the number of UDP 'Representation Sites' interacting with Flood Zone 3 is modest, (some 80 sites out of 499), they account for a significant proportion (86%) of the total available area. Whilst a significant proportion of each site individually may lie outside the 1% AEP (Flood Zone 3), the land total in question indicates that UDP 'Representation Sites' may encounter a disproportionate amount of detailed Flood Risk Assessment, or outright objection from the Environment Agency.

5.8.2 Employment Land Pressures on Floodplain

Table 5-8 illustrates that there are 22 key employment sites identified under the Local Development Framework. Of these, 9 impinge on the 1% AEP floodplain, accounting for 70% of the total employment area.

However, in several cases e.g. Leominster Industrial Estate, Moreton-on-Lugg Depot, the sites are marginal to the floodplain and the great proportion of these sites should be developable. The 1% + climate change flood outline should always be taken as the definitive measure of the floodplain.

In the case of Rotherwas Industrial Estate, this is the subject of an ongoing Flood Management Strategy (Consultant Reports www.waterconsultant.com 1109-FR1 and FR2, 2008). The strategy is more precisely identifying the floodplain extents in and around Rotherwas, alternative sources of flooding from the Red Brook to the south, and has identified feasible areas of land around Bullingham Railway Bridge that can be used as strategic storage compensation areas.

5.8.3 Detailed analysis of Sites under H2 Policy

It is clearly prohibitive to analyse in any detail all 2375 potential development sites identified within the **HSFRA Development Sites**. The evidence base and the tools to interrogate it have been supplied as part of the Strategic Flood Risk Assessment, and this will be an ongoing part of the preparation of Local Development Documents.

However, for all of the more significant sites (> 2.0 ha), an overview assessment of potential risks has been carried out for each site under Policies H2, H5 and E1-3 using the SEQUITIR approach. This not only provides detailed evidence (such as it is known) for each site, but also demonstrates the SEQUITIR method as it could be applied to any potential site needing to be sequentially tested.

Table 5-9 summarises the key issues that may affect development for each site.

H/599 – Bradbury Estate, Hereford

This site falls outside the flood zone 3 and 2 areas. However, there is a significant floodplain immediately downstream of the site, and there are local flood reports in this area. The Fluvial Flood Risk Index is the highest at rank 1, indicating significant property locally at flood risk. The site will probably attempt to drain to the Norton Brook which has capacity problems. The Lower Bullingham area is a known high flood risk area, and therefore site discharge will have to take careful account of downstream restrictions. SUDS and limited attenuation may be appropriate on the site provided the storage empties before the time of the peak of the River Wye.

Lower Bullingham – South of railway, Hereford

This site falls outside the flood zone 3 and 2 areas. However, there is a significant floodplain immediately downstream of the site, and there are local flood reports in this area. The site will probably attempt to drain to the Norton Brook which has capacity problems. The Lower Bullingham area is a known high flood risk area, and therefore site discharge will have to take careful account of downstream restrictions, especially the railway culvert. SUDS and limited attenuation may be appropriate on the site provided the storage empties before the time of the peak of the River Wye.

Leo/182 - Barons Cross Camp, Leominster

This site falls outside the flood zone 3 and 2 areas. However, there are significant local flood reports adjacent to the site. The most appropriate drainage policy is likely to be one of direct unattenuated discharge to the River Arrow to the south, subject to receiving watercourse capacity, which may require offsite channel improvements.

R/295 – Site A, Tanyard Lane, Ross-on-Wye

This site falls outside the flood zone 3 and 2 areas. Prior to the implementation of the Ross-on-Wye Flood Alleviation Scheme, the downstream areas encountered significant local flood risk. However, subject to capacity checks, the most appropriate drainage policy is likely to be one of direct discharge to the Rudhall Brook to benefit from its recently increased capacity.

Holmer, Land adjacent to A1043, Hereford

This site falls outside the flood zone 3 and 2 areas and there are no significant local flood reports adjacent to the site. The most appropriate drainage policy is likely to be one of direct unattenuated discharge to the River Lugg to the east, subject to receiving watercourse capacity, which may require offsite channel improvements. There may be a channel restriction at the Burcott Farm railway culvert.

Porthouse Farm, Bromyard

This site lies outside the flood zones, although adjacent to Flood Zone 2. Flood risk is not generally thought to be a significant issue. The most appropriate drainage policy is likely to be one of direct unattenuated discharge to the River Frome to the east. The site has a low ranking in terms of fluvial flood risk, catchment flood hazard and flood timing. Pressure on flood risk infrastructure is therefore likely to be minimal.

Leo/436/LP, Land east of Ridgemoor Road, Leominster

This site lies within a defended area, and falls within flood zone 3 and 2. There are local flood reports, but the Fluvial Flood Risk Index for this area is relatively low, indicating that there should be relatively sufficient time to anticipate flooding and implement evacuation measures. This site Leominster is problematic in that it is surrounded by floodplain, and therefore flood warning and evacuation plans are critical to the site. The most appropriate drainage policy is likely to be one of direct unattenuated discharge to the River Lugg to the east.

R/297, Vine Tree Farm, Ross-on-Wye

This site is unlikely to be problematic in flood risk terms, subject to local sewerage and channel capacities. SUDS and limited attenuation may be appropriate on the site provided the storage empties before the time of the peak of the River Wye.

Whitecross School, Hereford

The site lies within the 1% flood zone, immediately adjacent to the Yazor Brook, which has persistent flood reports in this locality. Drainage impact from the site will be neutral, as it is brown-field. However, the site is at risk from increased discharges upstream. The Fluvial Flood Risk Index is very high at 2, indicating that flood warning and evacuation plans are critical to the site.

Belmont Pool, Hereford

The site lies outside the fluvial flood zone, but immediately adjacent to the Newton Brook. Site runoff may therefore affect the receiving watercourse and downstream properties, and the Fluvial Flood Risk is the highest at rank 1. However, Flood Warning & Evacuation Index is the lowest at 47, indicating that there should be more than sufficient warning and evacuation capability for downstream areas. SUDS and limited attenuation may be appropriate on the site provided the storage empties before the time of the peak of the River Wye.

5.9 Site Specific Flood Risk Assessments

Within Local Development Documents, it should be indicated whether or not a Flood Risk Assessment is required for individual sites. Sites intersecting or marginal to the Flood Zone 3 and Zone 2 indicative floodplain will always require a Flood Risk Assessment, the minimum requirements being specified in PPS 25 Annex E ¹.

This SFRA has demonstrated however that a significant proportion of feasible development sites within Herefordshire are outside or marginal to the Zone 3 and 2 flood zones, and consequently fluvial flood risks should be manageable on most sites.

There is a more significant problem with runoff management however. Herefordshire appears to have a disproportionate amount of surface water flooding, emanating either directly from fields or the numerous smaller watercourse prevalent in the County. There will be significant requirement therefore for all development sites larger than 1 ha to address specifically runoff issues upstream and downstream of the site, and to confirm how this runoff will interact not only with the receiving watercourse, but the next sequential watercourse.

The most appropriate test to decide if a development site external to the fluvial floodplain requires a detailed FRA will be to assess the quantity of local flood reports (**HSFRA Flood Reports**) downstream and upstream of the site within say 1 km radius. If there are more than 5 such reports, this should trigger the requirement for a detailed FRA for the site AND a drainage assessment for the locality.

Site specific FRAs specific in the LDDs should basically conform to the CIRIA C624 guidelines ¹¹, incorporating:

- quantitative appraisal of the potential flood risk to the development
- quantitative appraisal of the potential impact of development site on flood risk elsewhere
- quantitative demonstration of the effectiveness of any proposed mitigation measures.

The 'flood issues' check-list developed under this SFRA in **5.6.2** should be systematically addressed within the FRA.

An FRA toolkit is available to download from the CIRIA website (<http://www.ciria.org/downloadsarchive.htm>). This includes a flowchart that guides the user through the tiered FRA process. Further details about the methodologies and approaches to FRA may be found in CIRIA publication C624.

The PPS Companion Guide ² further recommends a standard pro-forma check-list to be completed for all site specific FRAs (see Appendix C Pro-forma), and the LPA should adopt this pro-forma approach as part of its LDF.

Table 5-9 – Identification of Principal Flood Risk Issues – H2 Policy Sites

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUDS (j)	ATT (k)
V. Large	Sites > 10 ha																
H/599	Bradbury Estate, Hereford	19.77	○	○		1	44	47		○	○		●	●	●	○	●
H/	Lower Bullingham, Her.	13.04	○	○		1	44	47		○						○	●
Leo/182	Barons Cross Camp, Leo.	11.91	○	○		28	17	35		○			●	○	○	○	●
Large	> 5 ha < 10 ha																
	Holmer, Hereford	9.379	○	○		4	30	46		○	○		○	○	●	○	●
R/295	Site A, Tanyard Lane, R-o-W	8.063	○	●		8	14	6		●	○		○		●	○	●
Medium	> 2.5 < 5 ha																
	Porthouse Farm, Bromyard	3.695	○	○		40	40	22		○	●		○	○	○	○	●
Leo/436	E. of Ridgemoor Rd, Leo.	2.577	●	●		13	47	37		●	●		●	○	●	○	●
R/297	Vine Tree Farm	2.469	○	○		1	44	47		○	○		○	○	○	○	○
	Whitecross School	2.069	○	●		2	11	24			●		●	●	●		●
	Belmont, Hereford	2.000	○	○		1	44	47		○	●		○	●	●		

KEY: ● = This issue is likely to be a significant constraint; ○ = This issue is NOT likely to be a significant constraint; Blank = This issue is unknown

KEY: **FFR Index** = Fluvial Flood Risk Index (rank of the catchment of 47 total with regard to number of properties located within the 1% AEP floodplain (1 is highest risk))

CFH Index = Catchment Flood Hazard Index (rank of the catchment of 47 total with regard to generalised flood hazard (1 is highest risk))

FTE Index = Flood Timing and Evacuation Index (rank of the catchment of 47 total with regard to likely speed of response of flood hydrographs (1 is highest risk))

KEY: (a) Parts of site within Flood Zone 3 (b) Parts of site within Flood Zone 2 (c) Site may be sensitive to climate change (d) The site benefits from flood defences (e) Upstream runoff may affect site (f) Sewer capacity is limited (g) Local flooding is significant (h) Runoff from the site may affect adjacent sites (i) There may be downstream drainage capacity restrictions (j) SUDS may not be feasible (k) Attenuation may not be feasible or acceptable

5.9.1 Detailed Analysis of Sites under H5 Policy

For all of the more significant sites (> 2.0 ha), an overview assessment of potential risks has been carried out for each site under the SEQUITIR approach. This not only provides detailed evidence (such as it is known) for each site, but also demonstrates the SEQUITIR method as it could be applied to any potential site needing to be sequentially tested.

Table 5-10 summarises the key issues that may affect development for each site.

Land opposite Sutton School, Sutton St Nicholas

The site lies outside the fluvial floodplains. However there are several local flood reports which may indicate surface water drainage problems.

Site 1, adjacent The Birches

The site appears relatively free of fluvial and surface water flood risk. Site runoff may however impact on existing residential areas downstream in Shobdon. The site lies at the head of the catchment, and attenuation and SUDS may be fully appropriate.

5.9.2 Detailed Analysis of Sites under E1-3 Policy

E2 – 150/437e/LP, Moreton-on-Lugg Depot, Moreton-on-Lugg

This major site lies partially within the Flood Zone 3 and 2 extents. A detailed fluvial Flood Risk Assessment will be required to assess the extent of inundation. Storage compensatory measures are likely to be required if the site is to be raised or defended. Site drainage should preferably discharge direct to the River Lugg to the east, subject to local watercourse capacities. The Fluvial Flood Risk Index is very high at 4, but this derives largely from property sited upstream in Leominster. The general flood hazard and warning indices are low, indicating that this site is appropriate for development

E3 - Leo/429e/LP, Leominster Industrial Estate

A small part of the site encroaches onto the flood zone 2 floodplain. Access via the Southern Avenue is likely to be cut off during floods. However, there is good egress to the west to Hereford Road. The appropriate drainage policy will be to have direct discharge to the River Lugg via surface drains to the south-east.

E1 – 11 Sites, Rotherwas Industrial Estate

These sites at Rotherwas lie within the Flood Zone 2 floodplain, but outside the zone 3 floodplain. 1 site (H/407e) lies within the zone 3 due to flooding arising from the railway culvert on the Red Brook, but is believed to be already developed. There is good egress to the south for all of the Rotherwas Industrial Estate via the new Rotherwas Access Road (completed summer 2008).

Currently the true extent of the Zones 3 and 2 floodplains at Rotherwas are being disputed with the Environment Agency, who it is believed has over-estimated the extents when compared to the outputs of the Wye hydraulic model (see 3.4.1).

Sites draining to the south and west via Red Brook may exacerbate local flooding downstream of the railway in Watery Lane area. SUDS and limited attenuation may be appropriate on these sites provided the storage empties before the time of the peak of the River Wye.

Sites draining north to the River Wye should discharge directly to the Wye, preferably without attenuation, subject to receiving watercourse capacity checks.

E3 – LBY/426e/LP, Land north of railway, Ledbury

This site lies beyond the zone 3 and 2 floodplains. However, surface water flooding is a problem in this locality, and the CFH Index is relatively high at 6. There are local flood reports. The site is unlikely to impact downstream sites, but the preferred discharge policy should be to drain direct to the River Leadon without attenuation.

E3 – Model Farm, Ross-on-Wye

This substantial site lies upstream of the new strategic attenuation facility of the Ross-on-Wye Flood Alleviation Scheme. It lies beyond the fluvial floodplain, but the change from green-field may create significant localised runoff. There may be capacity restrictions at the dismantled railway culvert. This runoff should not compromise the effectiveness of the FAS. Hence the appropriate policy will be to attenuate surface water as much as possible on the site. SUDS should be strongly preferable.

E3 – Land south of Linton Trading Estate, Bromyard

This site is free of fluvial flood risk. The Catchment Flood Hazard Index is relatively high at rank 6, suggesting a possibility of surface water flooding. This relatively large site may create local flooding problems if the receiving watercourse capacity is exceeded. There are local flooding reports downstream on the River Frome. The downstream Sewage Treatment Works may also be affected. Prolonged attenuation on the site should be avoided as this may conflict with the later timing of the River Frome. Subject to downstream capacity, the drainage policy should be direct discharge.

E3 – Lby/427e, Land at Lower Road Trading Estate, Ledbury

A small part of the site lies within the Flood Zone 3 and 2. The site should discharge direct to the River Leadon without attenuation, subject to local capacity constraints. There are reports of local flooding, and Lower Road is a known flood risk area. The Flood Risk Index is low, hence flood warning and evacuation is not a critical issue. However, flash flooding and surface water runoff is a reported problem in this area.

E3 – H432e/LP, Legion Way, Hereford

This site falls outside the flood zone 3 and 2 areas and there are no significant local flood reports adjacent to the site. The most appropriate drainage policy is likely to be one of direct unattenuated discharge to the River Lugg to the east, subject to receiving watercourse capacity, which may require offsite channel improvements. There may be channel restrictions at the railway culvert.

E3 – Whitestone Business Park, White Stone

This site is outside the fluvial floodplains and has relatively little flood risk. Runoff may affect the downstream receiving watercourse; hence SUDS and attenuation may be appropriate.

E3 - 107/440e, Gooses Foot Industrial Estate, Kington

This site lies at the head of the Cage Brook catchment, and is relatively free from flood risk. All flood Indexes are relatively low.

5.9.3 Detailed Analysis of Largest Sites under HLA

HLAA/203/001 – Land at Bullinghope

This major site (149 ha) will drain to both the Red Brook and the Withy Brook. There is fluvial flood zone 3 and 2 within the site, the former probably not being developable. The sites have the capability to discharge very large peak flows to downstream watercourses. These both flood substantially during flood events on the Wye, and there are significant local flooding reports. Substantial use of SUDS and attenuation facilities may be required to offset these flow increases.

However, excessive attenuation will prolong outflows and will increase the late flow rates in the receiving watercourses when the River Wye peaks, probably exacerbating flooding. Hence, sophisticated drainage design will be necessary to ensure that whilst local watercourse capacities are not exceeded, neither is the flood risk at the peak of the River Wye.

Detailed consideration should be given to providing alternative drainage routes direct to the east to the River Wye, rather than to the Red Brook and Withy Brook.

HLAA/197/004 – Land at Huntingdon, Hereford

This site (124.4 ha) is upstream of Hereford draining to the Yazor Brook. The Fluvial Flood Risk Index is very high at rank 2. This is due to the significant number of properties at flood risk in the catchment. Substantial parts of the site lie within the Zone 3 and 2 floodplains. Drainage of this site will substantially increase pressure on the Yazor Brook and exacerbate flood risk downstream.

Substantial attenuation facilities may be required on site. It may be preferable to establish a new diversionary drainage route to the south connecting to the River Wye. Detailed feasibility studies will be required to confirm the viability of this site.

HLAA/197/002 – Land at Whitecross Farm

This site (94 ha) lies partially within the Yazor Brook and the Lower Wye catchments. The site lies fully outside the Zone 3 and 2 floodplains. It is a preferred site in terms of drainage and flood risk, providing a direct discharge out to the River Wye via Broomy Hill can be provided. Drainage northwards to the Yazor Brook should be avoided.

HLAA/111/001 – Land at Credenhill

This site (50 ha) marginally encroaches the fluvial Flood Zone 3 and 2, but is subject to relatively little fluvial flood risk. The receiving watercourse of the

Yazor Brook has significant capacity problems downstream, and runoff from this site will exacerbate these risks without mitigation. A new diversionary drainage route southwards to the River Wye is recommended.

5.9.4 Analysis of General Housing Pressure – Hereford

Evidence Map 5-2 indicates that there is substantial potential housing pressure around Hereford. Unfortunately there are also significant flood risks in the related catchments. Whilst a significant number of these sites will not be allocated for housing, some 8300 houses have to be accommodated within Hereford environs by 2026. At average density of 30 units/ha, this suggests a minimum of 277 ha of land will be required.

A significant percentage of feasible sites around Hereford are very large (see Table 5-9). There are 4 sites > 50 ha, 36 sites between 10 and 50 ha, and 45 sites between 5 and 10 ha.

The Yazor Brook has a Fluvial Flood Risk Index of 2, the Lower Wye catchment an FFR of 1. Hence development pressure is significant in the two highest fluvial risk catchments i.e. where existing property is at high risk of flooding.

The strategic flood management issues in this area are complex. Development in the Yazor Brook generally will greatly increase the loading on the Yazor Brook. This has a confined channel through Hereford city, and frequently generates flooding in the Widemarsh area.

On the south side of the Wye feasible development sites in and around Bullingham will also greatly increase loadings on local watercourses, most particularly the Withy and Red Brooks. These watercourses encounter significant flooding at present, largely due to high tailwater levels arising from the River Wye itself.

The problematic issue is that even if these major sites are controlled by attenuation infrastructure (which is likely to be very large and strategic in nature) the widespread and prolonged flows discharging into the local watercourses are likely to conflict with the much later high flood levels in the Wye, and greatly increase residual risks of flooding due to secondary events. Hence, flood risk is likely to be increased, not decreased, in downstream urban areas as a result of excessive attenuation.

A detailed model-based **Surface Water Management Plan** is strongly recommended for the Hereford area, which should identify with some accuracy the timings of the various flood peaks arriving at Hereford, especially the Lugg, the Yazor Brook, Withy Brook and the Red Brook, and assess the extent to which attenuation is or is not feasible in the area. This study should identify feasible sites and routes for strategic attenuation reservoirs or new diversionary channels, and confirm in outline terms the extent to which site runoff discharges (whether attenuated or not) will exacerbate or reduce downstream flood risks.

In general terms, the larger the site the greater the opportunity to instigate major strategic drainage works. For example, sites in the Yazor Brook catchment should give very serious consideration to providing entirely new diversionary

drainage routes south to the Wye, as opposed to draining through the centre of Hereford. ESG proposals are currently investigating a diversion of the Yazor Brook to the River Wye. Similar considerations should be applied to the major development sites south of the Wye.

It is extremely unlikely that piece-meal isolated drainage strategies for the collective sites will achieve an acceptable degree of flood risk mitigation. This supports the contention that housing development in and around Hereford and its associated drainage policy will be more successfully implemented via larger development sites BUT these developments will have to provide directly OR contribute to substantial, coordinated strategic flood mitigation schemes, either in the form of major regional reservoirs or new diversionary flood channels.

The land acquisition issues are therefore likely to be very considerable and time consuming, and early consideration should be given to this issue.

5.9.5 Prospective Sites and Windfall Sites – Teme Catchment

Evidence Map 1-1 shows that small parts of north and east Herefordshire fall within the catchment of the River Teme. **Evidence Map 5-1** further shows that the number of prospective development sites within these areas is also limited. For this reason, it was considered uneconomic to carry out modelling investigations to provide the climate change and functional floodplain assessments as was done for the remainder of Herefordshire falling within the Wye catchment (see Sections 3.2 and 5.10).

The principal town affected where there are several feasible development sites is Ledbury, and the principal villages affected are Brampton Bryan, Leintwardine, Wigmore, Orleton, Brimfield, Cradley, Colwell and Bosbury.

Interrogation of the **HSFRA Development Sites** GIS layer indicates that there are a total of 51 considered development sites within the Teme river catchment intersecting to some degree with Flood Zone 3. Of these 51, 35 are larger than 1.0 ha. Of these, only two sites fall entirely within Flood Zone 3 (Site O/Bos/001 at Bosbury and Site P1065 at Orleton). For obvious reasons these sites are likely to be problematic to develop. The remainder lie only partially within Flood Zone 3, and may have greater scope for development flexibility.

For clarity and transparency, these 35 sites are explicitly listed in Table 5-13 in the usual SEQUITIR derived format. (The SEQUITIR tool could then be used to identify possible alternative sites outside Flood Zone 3).

For this SFRA, it should be noted that for these 51 specific sites, climate change and functional floodplain assessments have not been carried out. Consequently, it is a requirement of this SFRA that IF any of these sites are taken forward for development, either as part of the Local Development Framework or as windfall sites, additional hydraulic investigations are likely to be required to identify the functional floodplain and the effect of climate change.

In the absence of detailed modelling to prove otherwise, it is recommended that a buffer margin of 10m beyond current flood outlines is assumed to account for climate change for both Flood Zones 3 and 2.

Table 5-10 - Identification of Principal Flood Risk Issues – H5 Policy Sites

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUDS (j)	ATT (k)
Medium	> 2 < 5 ha																
194/311	Land opp Sutton School	2.774	○	○		4	30	46		○	○		●	●	●	○	○
181/301	Site 1, Shobdon	2.311	○	○		3	38	32		○	○		○	●	○	○	○

Table 5-11 - Identification of Principal Flood Risk Issues – Employment Sites

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUDS (j)	ATT (k)
V. Large	> 10 ha																
150/437	E2 – Moreton-on-Lugg Dep	60.80	●	●		4	30	46		○	●		○	○	●	○	●
Leo/429	E3 – Leominster Ind. Estate	16.60	○	●		4	30	46		○	○		●	○	○	○	●
	E1 - Rotherwas (10 sites)	10.51	○	●		1	44	47		○	○		●	●	●	○	○
Lby/426	E3 – Ledbury, n railway	12.20	○	○		20	6	33		○	●		●	○	○	○	●
	E3 – Model Farm, R-o-Wye	10.40	○	○		8	14	6		●	○		○	●	●	○	○
Large	> 5 < 10 ha																
	E3 – Linton TE, Bromyard	5.20	○	○		14	6	41		○			●	●	●	○	○
Medium	> 2 < 5 ha																
Lby/427	E3 - Land at Lower Rd TE	4.00	●	●		20	6	33		○	●		●	●	●	○	●
H/407e	E1 – Twyford Road North	3.42	●	●		1	44	47		○	●		●	●	●	○	○
	E3 – Legion Way, Hereford	2.60	○	○		4	30	46		○	○		○	○	●	○	●
	E3 – Whitestone BP	2.50	○	○		4	30	46		○	○		○	○	●	○	○
107/440	E3 – Gooses Foot IE	2.10	○	○		20	15	23		○	○		○	○	○	○	○

Table 5-12 - Identification of Principal Flood Risk Issues – Largest Sites under HLAA

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUD (j)	ATT (k)
Mega	> 50 ha																
HLAA/203	Land at Bullinghope, Her.	149	●	●		1	44	47		○	●		●	●	●	○	●
HLAA/197/	Land at Huntingdon, Her.	124	●	●		2	11	24		○	●		●	●	●	○	●
HLAA/197	Land at Whitecross Farm	94	○	○		2	11	24		○	○		○	○	●	○	●
HLAA/111	Land at Credenhill	50.3	●	●		2	11	24		○	○		●	●	●	○	●
V Large	> 10 < 50 ha																
	36 sites																
Large	> 5 < 10 ha																
	45 sites																
Medium	> 2 < 5 ha																
	95 sites																

KEY: ● = This issue is likely to be a significant constraint; ○ = This issue is NOT likely to be a significant constraint; Blank = This issue is unknown

KEY: **FFR Index** = Fluvial Flood Risk Index (rank of the catchment of 47 total with regard to number of properties located within the 1% AEP floodplain (1 is highest risk)

CFH Index = Catchment Flood Hazard Index (rank of the catchment of 47 total with regard to generalised flood hazard (1 is highest risk)

FTE Index = Flood Timing and Evacuation Index (rank of the catchment of 47 total with regard to likely speed of response of flood hydrographs (1 is highest risk)

KEY: (a) Parts of site within Flood Zone 3 (b) Parts of site within Flood Zone 2 (c) Site may be sensitive to climate change (d) The site benefits from flood defences

(e) Upstream runoff may affect site (f) Sewer capacity is limited (g) Local flooding is significant (h) Runoff from the site may affect adjacent sites

(i) There may be downstream drainage capacity restrictions (j) SUDS may not be feasible (k) Attenuation may not be feasible or acceptable

Table 5-13 – Sites within River Teme Catchment intersecting with Flood Zone 3

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUD (j)	ATT (k)
V Large	> 10 < 50 ha																
HAAA/121/001	Ledbury, n of Fairtree Farm	18.6	●	●		20	6	33									
HAAA/198/004	North of Ledbury viaduct	21.8	●	●		20	6	33									
O/Led/006	Land at Ledbury	15.6	●	●		20	6	33									
P444	Land at Colwall	13.4	●	●		24	23	20									
Large	> 5 < 10 ha																
HAAA/004/003	Colwall, s of Old Church Rd	6.6	●	●		24	23	20									
HAAA/024/001	Cradley, Land at Green Fm	7.7	●	●		24	23	20									
HAAA/065/001	Ledbury, B4216 Dymock R	6.0	●	●		20	6	33									
HAAA/150/002	Brimfield, adj to A49	7.7	●	●		11	31	39									
HAAA/144/001	Orleton, Old Corn Mill	5.9	●	●		11	31	39									
O/Bos/002	Bosbury	6.6	●	●		20	6	33									
O/Mmar/013		8.4	●	●		27	23	27									
O/Mmar/016		5.1	●	●		27	23	27									
P684	Cradley,	6.8	●	●		24	23	20									
P746	Ledbury, adj Rugby club	8.8	●	●		20	6	33									
Medium	> 2 < 5 ha																
O/Bos/001	Bosbury	2.9	●	●		20	6	33									
O/Bos/007	Bosbury	3.3	●	●		20	6	33									
O/Col/006		3.2	●	●		24	23	20									
O/Led/005		3.3	●	●		20	6	33									
O/Mmar/010		3.7	●	●		27	23	27									
O/Mmar/015		3.8	●	●		27	23	27									
O/Crad/008		2.5	●	●		24	23	20									
O/Crad/012		2.0	●	●		24	23	20									
P321	Colwall, Oddfellows PH	3.2	●	●		24	23	20									
P323	Colwall, Oddfellows PH	3.2	●	●		24	23	20									
LBY/427e/LP	Ledbury, Lower Road TE	4.0	●	●		20	6	23									

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUD (j)	ATT (k)
Small	>1 < 2 ha																
HLAA/043/001	Orleton, w of Primary Sch	1.61	●	●		11	31	39									
HLAA/067/002	Ledbury, Hazel Mill, B4216	1.24	●	●		20	6	33									
O/Mmar/008		1.95	●	●		23	27	23									
O/Mmar/009		1.17	●	●		23	27	23									
O/Mmar/014		1.39	●	●		27	23	27									
O/Led/007		1.57	●	●		20	6	33									
O/Led/008		1.32	●	●		20	6	33									
O/Led/009		1.76	●	●		20	6	33									
O/Crad/011		1.45	●	●		24	23	20									
P1065	Orleton, Land at Millbrook	1.45	●	●		11	319	39									

KEY: ● = This issue is likely to be a significant constraint; ○ = This issue is NOT likely to be a significant constraint; Blank = This issue is unknown

KEY: **FFR Index** = Fluvial Flood Risk Index (rank of the catchment of 47 total with regard to number of properties located within the 1% AEP floodplain (1 is highest risk)

CFH Index = Catchment Flood Hazard Index (rank of the catchment of 47 total with regard to generalised flood hazard (1 is highest risk)

FTE Index = Flood Timing and Evacuation Index (rank of the catchment of 47 total with regard to likely speed of response of flood hydrographs (1 is highest risk)

KEY: (a) Parts of site within Flood Zone 3 (b) Parts of site within Flood Zone 2 (c) Site may be sensitive to climate change (d) The site benefits from flood defences

(e) Upstream runoff may affect site (f) Sewer capacity is limited (g) Local flooding is significant (h) Runoff from the site may affect adjacent sites

(i) There may be downstream drainage capacity restrictions (j) SUDS may not be feasible (k) Attenuation may not be feasible or acceptable

Table 5-14 – Identified Sites lying behind Flood Defences

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUD (j)	ATT (k)
V Large	> 10 < 50 ha																
P70	Land at Hampton Bishop	54.8	●	●		4	30	46		●							
H/AA/134/003	Land off Hampton Park Rd	43.6	●	●		1	44	47		●							
W461	R-o-Wye, Tanyard Lane	15.1	●	●		8	14	6		●							
O/Her/027		10.9	●	●		1	44	47		●							
Large	> 5 < 10 ha																
R/295	R-o-Wye Tanyard Lane	8.1	●	●		8	14	6		●							
Medium	>2 < 5 ha																
LEO/436/LP	Leominster, e Ridgemoor R	2.6	●	●		13	47	37		●							
4ZPP	R-o-Wye	2.3	●	●		8	14	6		●							
H/A1/1	Hereford, Greyhound PH	3.8	●	●		1	44	47		●							
Leo/12	Leominster, e Ridgemoor R	3.0	●	●		13	47	37		●							
Small	> 1 < 2 ha																
P331	R-o-Wye, Land at Kyle St		●	●		8	14	6		●							
Very Small	< 1 ha																
H/AA/027/001	Leominster, Mill Street	0.29	●	●		13	47	37		●							
H/AA/055/001	Hampton Bishop, Church L	0.54	●	●		1	44	47		●							
H/AA/219/001	Hereford, St Martins St	0.18	●	●		1	44	47		●							
H/AA/260/001	R-o-Wye, 11-15 Kyle St	0.16	●	●		8	14	6		●							
O/Ross/015	R-o-Wye	0.28	●	●		8	14	6		●							
O/Leo/003		0.05	●	●		3	38	32		●							
O/Leo/004		0.10	●	●		3	38	32		●							
O/Leo/005		0.24	●	●		3	38	32		●							
O/Leo/008		0.06	●	●		13	47	37		●							
O/Ross/016		0.44	●	●		8	14	6		●							
O/Her/037		0.18	●	●		1	44	47		●							
H/A1/2	Hereford, Hunderton Rd	0.11	●	●		1	44	47		●							
H/B1/2	Hereford, St Martins St	0.19	●	●		1	44	47		●							
Leo/18	Leominster - Grahams	0.53	●	●		3	38	32		●							

Site Ref	Site Name	Area (ha)	FZ3 (a)	FZ2 (b)	Flood depth	FFR Index	CFH Index	FTE Index	CC (c)	FD (d)	UR (e)	SC (f)	LF (g)	RI (h)	DR (i)	SUD (j)	ATT (k)
Leo/19	Leominster, Bridge St	0.40	●	●		13	47	37		●							
P1102	Hereford, Field Farm	0.31	●	●		1	44	47		●							
P936	Hampton Bishop	0.18	●	●		1	44	47		●							
P1024	Hampton Bishop	0.12	●	●		1	44	47		●							
R/372	R-o-Wye	0.30	●	●		8	14	6		●							

KEY: ● = This issue is likely to be a significant constraint; ○ = This issue is NOT likely to be a significant constraint; Blank = This issue is unknown

KEY: **FFR Index** = Fluvial Flood Risk Index (rank of the catchment of 47 total with regard to number of properties located within the 1% AEP floodplain (1 is highest risk)

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FTE Index = Flood Timing and Evacuation Index (rank of the catchment of 47 total with regard to likely speed of response of flood hydrographs (1 is highest risk)

KEY: (a) Parts of site within Flood Zone 3 (b) Parts of site within Flood Zone 2 (c) Site may be sensitive to climate change (d) The site benefits from flood defences

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(i) There may be downstream drainage capacity restrictions (j) SUDS may not be feasible (k) Attenuation may not be feasible or acceptable

5.10 Climate Change Impact Appraisal

5.10.1 LPA Obligations under PPS 25

The Environment Agency Flood Map and Flood Zones do not currently take account of climate change impacts; PPS25 requires that the spatial planning process should. When completing Regional Flood Risk Appraisals (RFRAs) and Strategic Flood Risk Assessments (SFRAs), planning bodies will need to agree how to factor climate change into these studies and over what timeframe.

Policy in this area may best be defined at a regional level based on the nature of the development pressures and flooding problems across the region. It should be borne in mind that the costs and benefits of all publicly-funded flood alleviation schemes are considered over a 100 year time horizon, to help ensure that the preferred options take account of long-term sustainability issues.

Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term LPAs should consider whether there are opportunities in the preparation of LDDs to facilitate the relocation of development, including housing to more sustainable locations at less risk from flooding. Consideration of climate change issues is incorporated throughout Planning Policy Statement 25^{1,2} and it is a specific requirement of SFRAs that climate change issues be addressed. This applies equally to windfall sites that may fall outside the strategic assessment at a later date.

Table 5-15 summarises the precautionary changes in flood hazard parameters that may be expected over the next 100 years.

Table 5-15 – Recommended Precautionary Sensitivity Ranges

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Notes:

1. Refer to Defra FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006, for details of the derivation of this table.
2. For deriving peak rainfall, for example, between 2025-2055 multiply the rainfall measurement (in mm/hour) by 10 per cent and between 2055-2085 multiply the rainfall measurement by 20 per cent. So, if there is a 10mm/hour event, for the 2025-2055 period this would equate to 11mm/hour; and for the 2055/2085 period, this would equate to 12mm/hour. Other parameters in Table B.2 are treated similarly.

Source: PPS 25 Development and Flood Risk

5.10.2 Precautionary versus Adaptive Approach

DEFRA suggests two principal approaches for taking climate change into consideration in the design of flood risk management measures:

- **The Precautionary Approach:** This involves inclusion of a specific quantified allowance for changes in climatic variables based on the best scientific evidence currently available. This is most appropriate for setting design criteria which would be prohibitively expensive to alter in the future, such as finished floor levels or bridge dimensions.
- **The Managed Adaptive Approach:** This involves identifying the sensitivity of results based on existing climatic conditions to potential changes that could occur as a result of climate change impacts, in order to allow designers and decision-makers to identify an appropriate, location specific response. This approach is the more flexible and risk orientated approach, whereby increasing flood risk can be 'tracked', and site or infrastructure design can adapted accordingly. This is most appropriate for strategic flood management infrastructure such as flood meadows, flood reservoirs and diversionary channels, but it is essential that the full 'worst case' extent of the infrastructure is identified and reserved at the outset.

Precise assessment of climate change effects at all possible development sites is clearly beyond the scope of an SFRA, and will require the use of detailed hydrological (flood runoff) and hydraulic (flood level) models.

This SFRA has addressed climate change by provision of two objective tools:

- Specially commissioned output of the EA Generalised Flood Model increasing river flows by 20%, to provide a GIS based 1% AEP flood outline + climate change effects (**HSFRA Climate Change Outline**)
- Establishment of the **Catchment Flood Hazard Index**. The CFH Index was described in 4.1.2. This Index indicates the probable level of sensitivity of the overall catchment to future climate change. The derivation of the Index itself could be modified in future if more reliable and deterministic data become available.

Both of these assist in applying the managed adaptive approach as recommended by DEFRA.

5.10.3 Zone 3 Fluvial Floodplain Extent

The **HSFRA Climate Change Outline** is an alternative GIS layer to the currently issued Flood Zone 3 map available to all LPAs. As far as this SFRA is aware, this is a relatively innovative use of the national generalised model provided by JBA Consulting Ltd. To rapidly assess the possible change in extent of the fluvial floodplain, the climate change outline can be superimposed on the current Flood Zone 3 GIS layer. This will identify areas of land (and possibly affected sites) that may be subjected to inundation in a 1% AEP flood that are currently not within the floodplain.

This 'first pass' method is sufficiently detailed at SFRA stage to address broad issues of climate change for the Sequential Test for sites at risk of fluvial flooding. Sites that lie in or close to the 1% AEP flood outline will in all probability have to complete a detailed FRA, in which the sensitivity of climate change (both runoff and flood level) can be examined more precisely.

It is emphasised that the climate change extents are indicative only, not definitive. Therefore an appropriately conservative approach should be assumed when allowing for climate change influence. The degree of change between the current (2007) flood extents and the climate change forecast will however give a good indication of the sensitivity of the site with respect to climate change.

At Level 1 stage it is sufficient for the Sequential Test simply to identify between alternative sites which is the more likely to be susceptible to climate change on the basis of changes in the floodplain extent.

5.10.4 Zone 2 Fluvial Floodplain Extent

This SFRA has not provided a comparable GIS layer for climate change influence on Flood Zone 2. This is because in the great majority of cases for Herefordshire the plan extent of the floodplain is only marginally changed for Zone 3. Hence it follows that the changes arising in the Zone 2 areas are likely to be even more marginal.

Nevertheless, it is recommended that in the absence of site specific modelling, a nominal increase of 10m of floodplain extent should be assumed for all sites within Flood Zone 2. In view of the lack of change noted in 5.10.3 above, this is likely to be a very conservative assumption, which might be reduced if assessed by detailed site specific modelling.

5.10.5 Fluvial Flood Frequency

The SFRA climate change outline does NOT address the equally relevant issue of change in **frequency** of flooding. Sites that are already within the floodplain extent may not experience a significant change in floodplain extent or depth depending on the contouring of the site, BUT may be subjected to more frequent flooding than previously. This would constitute an increase in risk IF there is vulnerability to flooding on the site, because the same damage cost would be incurred but at a more frequent interval.

Such detailed assessments will require Benefit-Cost appraisal when specific sites come on line, and are beyond the scope of an SFRA.

5.10.6 Catchment Flood Hazard

The CFH Index comprises catchment rankings of the following hydrological parameters: Standard Percentage Runoff, Antecedent Wetness Condition, and Time to Peak of the fluvial hydrograph. These parameters were selected precisely because they are values most likely to alter as a result of climate change. Hence, the CFH, albeit a fairly coarse indicator, can at least identify

catchments that may currently generate high levels of general surface water flooding, AND may be the most sensitive to future climate change.

Hence, in a comparison of alternative sites under the Sequential Test, the CFH Index can be used to select a site that has a lower CFH ranking. In the absence of any other comparators, application of this Index would provide a sequential test.

5.10.7 Intra-urban Flash Flooding

Besides flooding from rivers and coasts, towns and cities will be increasingly subject to localised flooding caused by the sewer and drainage systems being overwhelmed by sudden localised downpours. Flash flooding occurs when the ground becomes saturated with water that has fallen too quickly to be absorbed.

The runoff rapidly flows downhill and collects in low-lying areas. This is particularly of concern in towns and cities where, because of the built environment, the ground has little capacity to absorb rainfall. In a flash flood drainage and sewerage systems, at best designed to take a 30 year storm, are overwhelmed causing flooding in vulnerable areas.

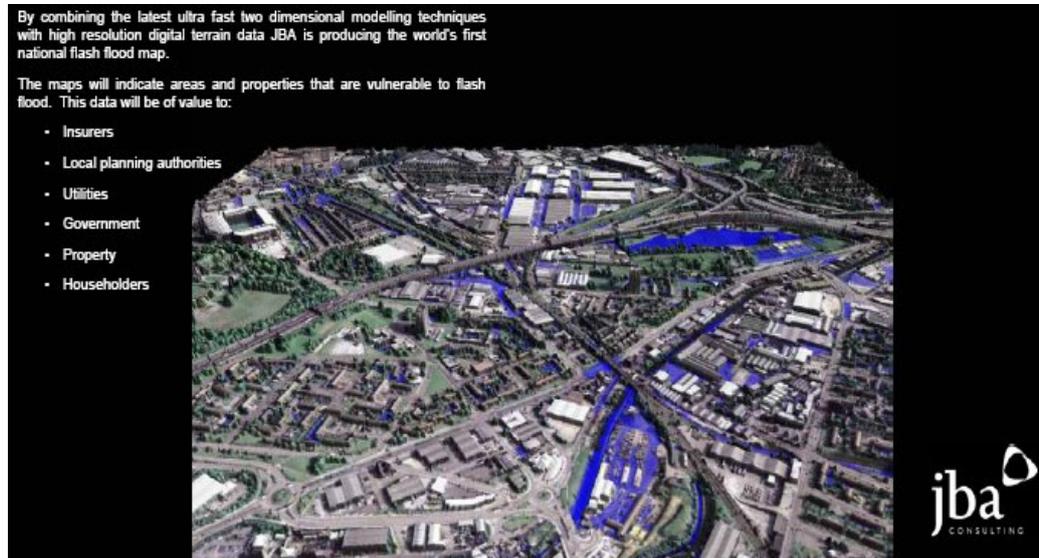
According to the **Foresight Future Flooding**⁸ report the potential damages could be huge, but more work needs to be done to quantify the potential problem of intra-urban flooding.

In the absence of reliable surface sewer models and urban flooding reports from Welsh Water generally, the Herefordshire SFRA notes the increasing relevance and impact on urban housing and infrastructure of this phenomenon of flash flooding. Herefordshire seems particularly susceptible to this hazard, as it has a preponderance of hilly upland catchments, and relatively impermeable sub-soils at shallow depth. Approximately 50% of the reported flooding incidents in Herefordshire are from sources other than fluvial flooding.

The Consulting firm JBA Ltd. has pioneered the modelling approach to flash flooding using similar Digital Terrain Models (DTMs) and methodologies as used for the EA generalised flood outline modelling. The assessments can be County wide, and are not excessively expensive.

It is therefore recommended that a strategic assessment be carried out into locations within Herefordshire most likely to be subjected to flash flooding. The outputs can be used to further inform the appropriateness of new development in certain locations, and identify appropriate mitigation measures.

Figure 5-3 – JBA Consulting Flash Flooding Methodology



Source: JBA Consulting, Flash Flood Analysis, 2007

5.11 Interactions with the EA Catchment Flood Management Plan

Since the CFMP should be risk based (i.e. identify objectives and target solutions in areas of greatest flood risk), the greater detail of the SFRA including the flood risk indicators developed for individual catchments within this SFRA should be used by the CFMP to support its own Draft Catchment Objectives.

In particular, the catchments with the highest general flood hazard (the Dore, Upper Arrow, Ell Brook, Upper Monnow and Back Brook should receive particular policy attention. Developments in these catchments will have to have very specific regard to the risk of generalised surface water flooding, urban drainage and flash flooding.

Catchments with the highest rankings of fluvial flood risk include the Lower Wye (mainly Hereford), Yazor Brook, Pinsley Brook, Lower Lugg and Letton Lake). These catchments contain the highest proportion of properties at risk, and future flood management policies should reflect this. Herefordshire Council and the Environment Agency should coordinate their respective proposed policies during the parallel consultation stages of the two studies during April – June 2008.

The CFMP is likely to contain useful guidance on future land management policies outside the scope of the SFRA, and these may be used to reinforce flood management strategy within the County.

5.12 Evidence Based Statements

- 1) A sequential risk-based approach to determining the suitability of land for development in flood risk areas is central to government policy, and should be applied at all levels of the planning process. Local Planning Authorities allocating land in Local Development Documents should always apply the Sequential Test to demonstrate that there are no reasonably available sites in other areas with a lower probability of flooding.
- 2) The Regional Spatial Strategy ‘Spatial Options, January 2008) requires Herefordshire Council to provide in the order of 16,600 dwellings between 2006 – 2026 (Option 1). Of these, some 8,300 will be in and around Hereford.
- 3) Herefordshire Council has prepared throughout 2007 a major database of potential development sites. The availability of this database also in GIS format greatly enhances the capacity of the Sequential Test to be demonstrated in an open and transparent way, an essential requirement of PPS 25 ¹.
- 4) In respect of flood risk, development land should be allocated through a hierarchy of flood management measures. In essence the Sequential Test is merely the framework procedure to demonstrate that this hierarchy has

been considered. The SFRA delivers the evidence base and the interrogation tools to facilitate application of the sequential test.

- 5) LPAs allocating land in LDDs for development should apply the Sequential Test to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed. A sequential approach should also be used in areas known to be at risk from other forms of flooding.
- 6) For a given development which may require the application of the Exception Test, a Level 2 SFRA or site specific FRA must investigate whether safe exit and access constitutes dry access routes or depth and velocity combinations that are below appropriately precautionary thresholds. This decision needs to be made by the LPA in consultation with the Emergency Services and will need to take into consideration the proposed use of the development, the vulnerability of the occupants and the availability of emergency services and flood forecasting.
- 7) Where development sites are in a higher risk flood zone, a site specific Flood Risk Assessment must address the issues of safe development and residual risk through site location, layout and design.
- 8) Irrespective of the appropriateness of the land-use in the particular flood zone, Local Development Documents must specifically address the issue of 'safe development'. It is a policy requirement to ensure that all new development in flood risk areas is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed.
- 9) To support sequential testing of other forms of flooding, this study has attempted to develop a generalised Catchment Flood Hazard Index (CFH) Index, based on the essential hydrological components of the identified sub-catchments. This Index focuses on catchments, not rivers, as rivers are but one source of potential flood risk. The summer floods of 2007 clearly showed that significant flood damage to numerous properties and infrastructure can arise from general surface runoff and groundwater.
- 10) The catchments deemed to have the greatest general flood risk are the Dore, Upper Arrow, Eil Brook, Upper Monnow and Back Brook. Developments in these catchments will have to have very specific regard to the risk of generalised surface water flooding, urban drainage and flash flooding. These are categorised as Category 1 Flood Hazard catchments.
- 11) The catchments of the Lower Leadon, Little Lugg, Middle Frome, Upper Lugg, Yazor Brook, Afon Llynfi, Letton Lake and Glynch Brook are in the next rank of generalised flood hazard, Category 2. These must have regard for the same issues as for Category 1, but to a lesser extent.
- 12) The key to a successful implementation of the Sequential Test is to attain transparency and objectivity in the evaluation of alternative sites. A significant failure of the Sequential Test some other Local Development Frameworks (LDFs), and hence continuing objections from the EA has

been the lack of these two criteria with respect to site allocations.

- 13) This SFRA innovatively proposes a simple check-list of 'flood and drainage issues' that should be objectively and transparently considered within the Sequential Test. These issues can be considered singly or in combination between alternative sites.
- 14) SEQUITIR (Sequential Test Indicative Report) is an innovative and extremely powerful methodology to interact with the Herefordshire Council sites database, uniquely developed for the Herefordshire SFRA. It is a systematic methodology to identify, compare and sequentially test sites on the basis of the 16 key flood risk issues identified.

The primary purpose of the SEQUITIR tool is to assist Herefordshire Council planners to objectively allocate sites for development with appropriate levels of flood risk, in compliance with PPS 25. Furthermore SEQUITIR is explicit and transparent in the way it operates. Hence it can be used as part of the evidence base in supporting why specific sites have been selected or allocated for a particular use in Local Development Documents (LDDs), especially to satisfy potential EA transparency concerns.

- 15) The amount of potentially available land identified under H2, H5, and HLAA, Housing Capacity and Officer Identified studies (as of April 2008) amounts to approximately 5560 ha. A significant proportion of this land may not be developable due to constraints. Assuming a County wide average of 30 dwellings/ha, and assuming a full take up of 16,600 dwellings under the Regional Spatial Plan, 553 ha of residential land is required to meet growth targets.
- 16) This represents 10.5% of potentially considered housing land. Not all of this land will be reasonably available, and many sites will be inappropriate for development. Nevertheless, this small proportion suggests that there is significant scope to allocate housing land outside Flood Zone 3 and Flood Zone 2 land in compliance with the Sequential Test.
- 17) Two further flood risk indicators have been developed for the study on the basis of catchments. The Fluvial Flood Risk Index is a ranking of all catchments on the basis of the property count within the 1% AEP floodplain for that catchment. Increased development pressure within a high risk catchment may therefore exacerbate general pressure on the flood protection infrastructure, critical services and evacuation plans. The FFR Index could be used as part of the Sequential Test to decide between alternative sites, the lower ranking catchment being preferred.
- 18) The third flood risk indicator is the Flood Timing and Evacuation Index. This ranks all catchments by the expected period of time between the centroid of the storm event and the peak of the resultant flood hydrograph. It can therefore be used as a comparative index to identify developments close to the floodplain which have a lesser degree of preparation time for flooding, and which will therefore be a greater risk.

- 19) The FTE Index can also be used to prepare a more effective catchment flood warning strategy, as it focuses on catchments most at risk from sudden fluvial flooding.
- 20) Although only 90 out of 510 possible sites identified under the Herefordshire Housing Land Assessment (HLAA) interact with Flood Zone 3, the site areas account for a disproportionately high percentage of the total land identified in the HLAA (40.6%). Many of the sites are literally marginal to the flood zone and a significant proportion of this land may be developable even with 'Highly Vulnerable' and 'More Vulnerable' uses.
- 21) Although the number of UDP 'Representation Sites' interacting with Flood Zone 3 is modest, (some 80 sites out of 499), they account for a significant proportion (86%) of the total available area. Whilst a significant proportion of each site individually may lie outside the 1% AEP (Flood Zone 3), the land total in question indicates that UDP 'Representation Sites' may encounter a disproportionate amount of detailed Flood Risk Assessment, or outright objection from the Environment Agency.
- 22) There are 22 key employment sites identified under the Local Development Framework. Of these, 9 impinge on the 1% AEP floodplain, accounting for 70% of the total employment area. However, in several cases e.g. Rotherwas Industrial Estate, Leominster Industrial Estate, Moreton-on-Lugg Depot, the sites are marginal to the floodplain and the great proportion of these sites should be developable. The 1% + climate change flood outline should always be taken as the definitive measure.
- 23) Evidence Map 4-2 indicates that there is substantial potential housing pressure around Hereford. Unfortunately there are also significant flood risks in the related catchments. Whilst a significant number of these sites will not be allocated for housing, some 8300 houses have to be accommodated within Hereford environs by 2026. At average density of 30 units/ha, this suggests a minimum of 277 ha of land will be required.
- 24) A significant percentage of feasible sites around Hereford are very large. There are 4 sites > 50 ha, 36 sites between 10 and 50 ha, and 45 sites between 5 and 10 ha. Most of these developments fall within the Yazor Brook and Lower Wye catchment areas.
- 25) The Yazor Brook has a Fluvial Flood Risk Index of 2, the Lower Wye catchment an FFR of 1. Hence development pressure is significant in the two highest fluvial risk catchments i.e. where existing property is already at the highest risk of flooding.
- 26) The strategic flood management issues in this area are complex. Development in the Yazor Brook generally will greatly increase the loading on the Yazor Brook. This has a confined channel through Hereford city, and frequently generates flooding in the Widemarsh area.
- 27) There are similar constraints arising from the Widemarsh and Red Brooks, which have very large possible development sites in their upper reaches, but which are susceptible to localised flooding and flooding from high river

levels in the Wye.

- 28) The problematic issue is that even if these major sites are controlled by surface water attenuation infrastructure (which is likely to be very large and strategic in nature) the widespread and prolonged flows discharging into the local watercourses are likely to conflict with the much later high flood levels in the Wye, or greatly increase residual risks of flooding due to secondary events. Hence, flood risk is likely to be increased, not decreased, in downstream urban areas as a result of excessive attenuation from these large sites.
- 29) A detailed model-based hydrological strategic assessment is strongly recommended for the Hereford area, which should identify with some accuracy the timings of the various flood peaks arriving at Hereford, especially the Lugg, the Yazor Brook, Withy Brook and the Red Brook, and assess the extent to which attenuation is or is not feasible in the area. This study should identify feasible sites and routes for strategic attenuation reservoirs or new diversionary channels, and confirm in outline terms the extent to which site runoff discharges (whether attenuated or not) will exacerbate or reduce downstream flood risks.
- 30) It is extremely unlikely that piece-meal isolated drainage strategies for the collective sites in and around Hereford will achieve an acceptable degree of flood risk mitigation. This supports the contention that housing development in and around Hereford and its associated drainage policy will be more successfully implemented via larger development sites BUT these developments will have to provide directly OR contribute to substantial, coordinated strategic flood mitigation schemes, either in the form of major regional reservoirs or new diversionary flood channels.
- 31) The Environment Agency Flood Map and Flood Zones do not currently take account of climate change impacts; PPS25 requires that the spatial planning process should. When completing Regional Flood Risk Appraisals (RFRAs) and Strategic Flood Risk Assessments (SFRAs), planning bodies will need to agree how to factor climate change into these studies and over what timeframe.
- 32) Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term LPAs should consider whether there are opportunities in the preparation of LDDs to facilitate the relocation of development, including housing to more sustainable locations at less risk from flooding. Consideration of climate change issues is incorporated throughout Planning Policy Statement 25 ^{1,2} and it is a specific requirement of SFRAs that climate change issues be addressed.
- 33) This SFRA has addressed climate change by provision of two objective tools:
- Specially commissioned output of the EA Generalised Flood Model increasing river flows by 20%, to provide a GIS based 1% AEP flood outline + climate change effects

Establishment of the Catchment Flood Hazard Index. This Index indicates the probable level of sensitivity of the overall catchment to future climate change. The derivation of the Index itself could be modified in future if more reliable and deterministic data become available.

- 34) Besides flooding from rivers and coasts, towns and cities will be increasingly subject to localised flooding caused by the sewer and drainage systems being overwhelmed by sudden localised downpours.
- 35) In the absence of reliable surface sewer models and urban flooding reports from Welsh Water generally, the Herefordshire SFRA notes the increasing relevance and impact on urban housing and infrastructure of this phenomenon of flash flooding. Herefordshire seems particularly susceptible to this hazard, as it has a preponderance of hilly catchments, and relatively impermeable sub-soils at shallow depth. Approximately 50% of the reported flooding incidents in Herefordshire are from sources other than fluvial flooding.

5.13 Evidence Based Recommendations

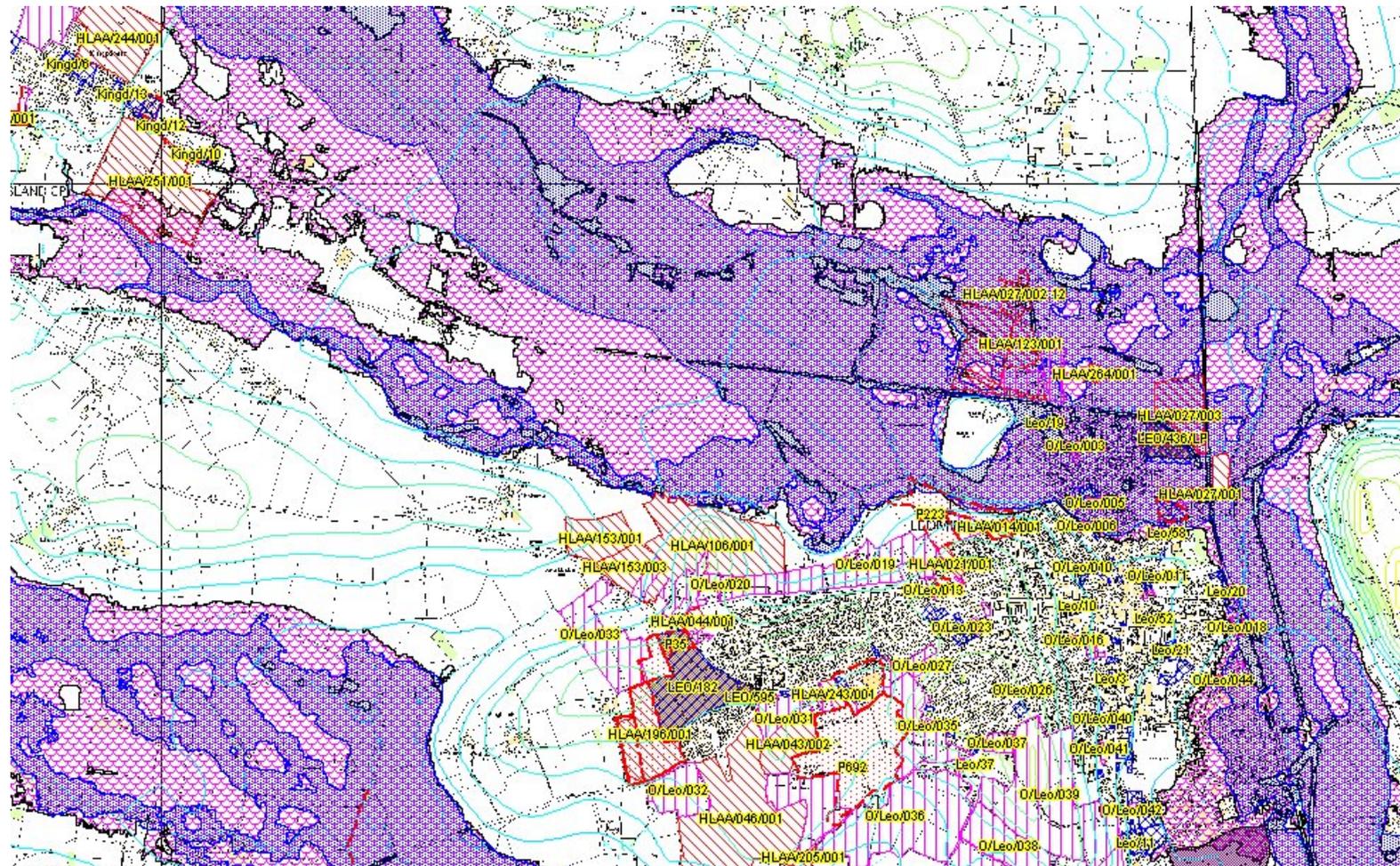
- 1) A detailed model-based Surface Water Management Plan is strongly recommended for the Hereford area, which should identify with some accuracy the timings of the various flood peaks arriving at Hereford, especially the Lugg, the Yazor Brook, Withy Brook and the Red Brook, and assess the extent to which attenuation is or is not feasible in the area. This study should identify feasible sites and routes for strategic attenuation reservoirs or new diversionary channels, and confirm in outline terms the extent to which site runoff discharges (whether attenuated or not) will exacerbate or reduce downstream flood risks.
- 2) It is therefore recommended that a further assessment be carried out into locations within Herefordshire most likely to be subjected to flash flooding. The outputs can be used to further inform the appropriateness of new development in certain locations, and identify appropriate mitigation measures, but also usefully inform ongoing critical infrastructure assessments and urban sewerage deficiencies.
- 3) Catchments with the highest rankings of fluvial flood risk include the Lower Wye (mainly Hereford), Yazor Brook, Pinsley Brook, Lower Lugg and Letton Lake). These catchments contain the highest proportion of properties at risk, and future flood management policies should reflect this. Herefordshire Council and the Environment Agency should coordinate their respective proposed policies during the parallel consultation stages of the two studies during April – June 2008.
- 4) The SEQUITIR pro-forma developed as part of this study should be used to systematically and transparently identify alternative sites in lower areas of flood risk, and together with a summary of the flood risk issues identified for each site, demonstrate how the sequential test has been applied. Ideally outputs from the SEQUITIR process could be included in Local Development Documents to show that the development is fully appropriate

in that location.

- 5) Within Local Development Documents, it should be indicated whether or not a Flood Risk Assessment is required for individual sites. Sites intersecting or marginal to the Flood Zone 3 and Zone 2 indicative floodplain will always require a Flood Risk Assessment, the minimum requirements being specified in PPS 25 Annex E.
- 6) Table 5-6 and its commentary should assist Herefordshire Council to identify those principal sites where Highly Vulnerable or More Vulnerable development is likely to not meet the requirements of the Exception Test. Where existing river hydraulic models are available, it will be relatively straightforward to identify basic issues of flood depth and velocity to determine appropriate safe uses of land within the sites, and thus indicate if the development is likely to be 'safe' (part C of the Exception Test).
- 7) Where hydraulic models are not available, but residential development is a strong possibility, it will be necessary for Herefordshire Council to not only demonstrate that all other options in lesser flood risk areas have been discounted, but sufficient hydraulic information is available to prove the criterion of 'safe' development. This may require the additional commissioning of local hydraulic studies for this purpose.
- 8) The 'flood issues' check-list developed under this SFRA in [5.6.2](#) should be systematically addressed within the FRA.
- 9) This SFRA has demonstrated however that a significant proportion of feasible development sites within Herefordshire are outside or marginal to the Zone 3 and 2 flood zones, and consequently fluvial flood risks should be manageable on most sites.
- 10) Herefordshire appears to have a disproportionate amount of surface water flooding, emanating either directly from fields or the numerous smaller watercourse prevalent in the County. There will be significant requirement therefore for all development sites larger than 1 ha to address specifically runoff issues upstream and downstream of the site, and to confirm how this runoff will interact not only with the receiving watercourse, but the next sequential watercourse.

Figure 5-4 – Fluvial Floodplain at Leominster with Climate Change

- KEY:**
-  1% AEP Floodplain
 -  1% AEP + Climate change



5.14 References and Additional Resources

The following published or web-based documentation has been referred to in this section, and may provide useful further reference material for the Local Development Framework.

- 1) **Planning Policy Statement 25 (PPS25): Development and Flood Risk** (DCLG, December 2006)
<http://www.communities.gov.uk/publications/planningandbuilding/pps25floodrisk>
- 2) **Development and Flood Risk: A Practice Guide Companion to PPS25 'Living Draft' - A Consultation Paper**, (DCLG, February 2007)
<http://www.communities.gov.uk/publications/planningandbuilding/developmentflood>
- 3) **Herefordshire Local Development Framework: HLAA Methodology Statement** (Herefordshire Council, August 2007)
http://www.herefordshire.gov.uk/docs/forwardplanning/HLAA_methodology_statement_August_2007.pdf
- 4) **Flood Risk Assessment Guidance for New Development – Phase 2** (DEFRA/EA R&D Technical Report FD2320/TR2, October 2005)
- 5) **Flood Risks to People - Phase 2** (DEFRA/EA R&D Technical Report FD2321/TR1, March 2005)
- 6) **Environment Agency Standing Advice, Development and Flood Risk – England** (Environment Agency, March 2007)
<http://www.pipenetworking.com/floodrisk/sequential.htm>
- 7) **Collier, C. G., Fox, N.I. (2003) 'Assessing the susceptibility of river catchments to extreme rainfall in the UK'**, (Journal of River Basin Management, Volume 1(3), 2003).
- 8) **Review of 2007 Summer Floods** (Environment Agency, December 2007)
<http://www.environment-agency.gov.uk/subjects/flood/1867303/>
- 9) **Faulkner, B.L. (1999) 'The Control of Surface Water Runoff from new Development – UK National Policy in need of review?'** (Urban Water, Volume 1 (3), Elsevier).
- 10) **UK Government – Future Foresight Programme, Flood & Coastal Defence**
http://www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/index.html
- 11) **Development and flood risk – guidance for the construction industry**
CIRIA C624

Evidence Map 5-1 – Possible Development Sites


Key

-  Wye Catchment
-  Herefordshire
-  Principal Rivers
-  Main Town
-  H2 Housing Sites
-  H5 Housing Sites
-  E1, E2, E3
Employment Sites
-  Land under HLAA study
-  Land Under Officer study
-  Land under Housing
Capacity study

Client

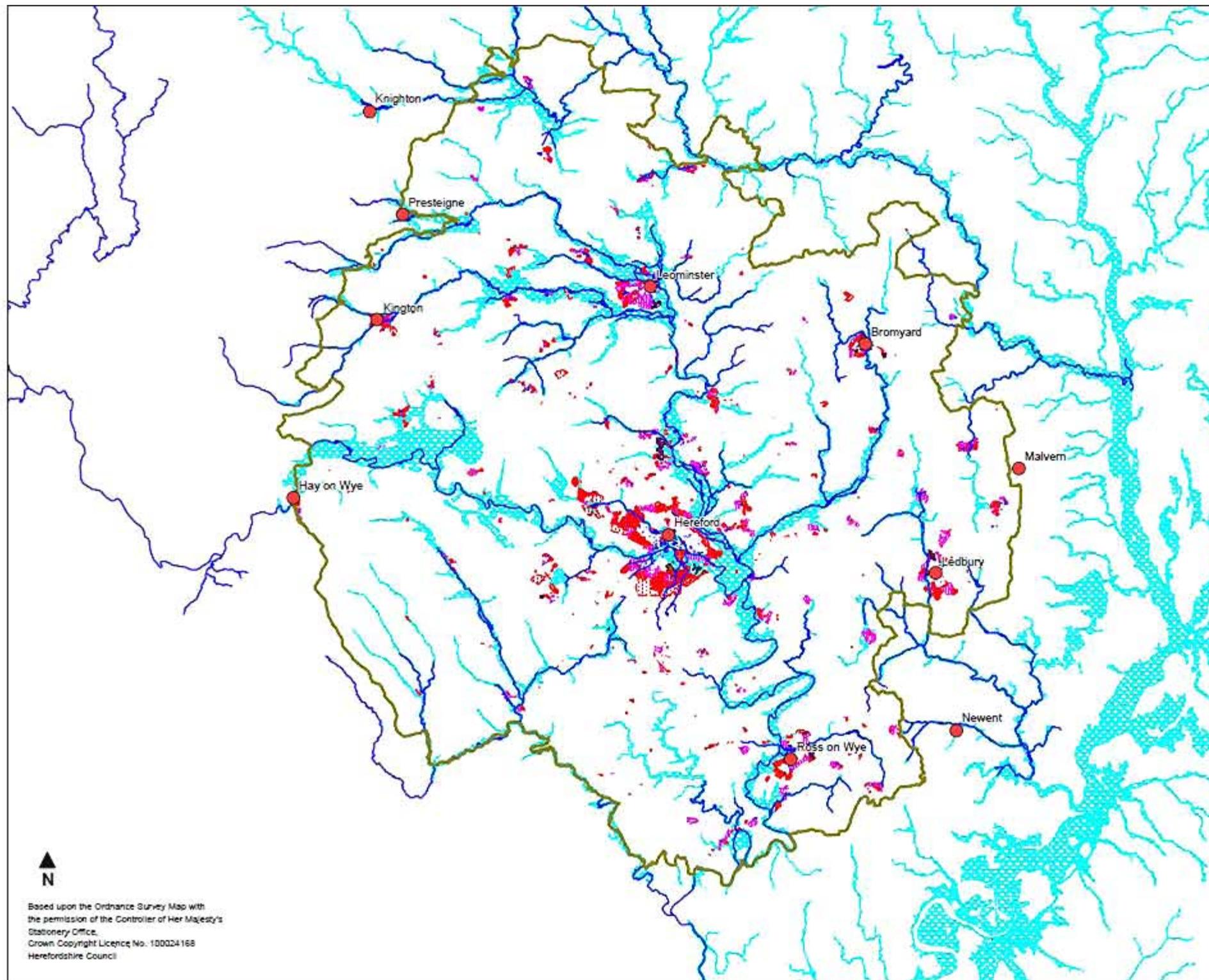
Herefordshire Council

Scheme

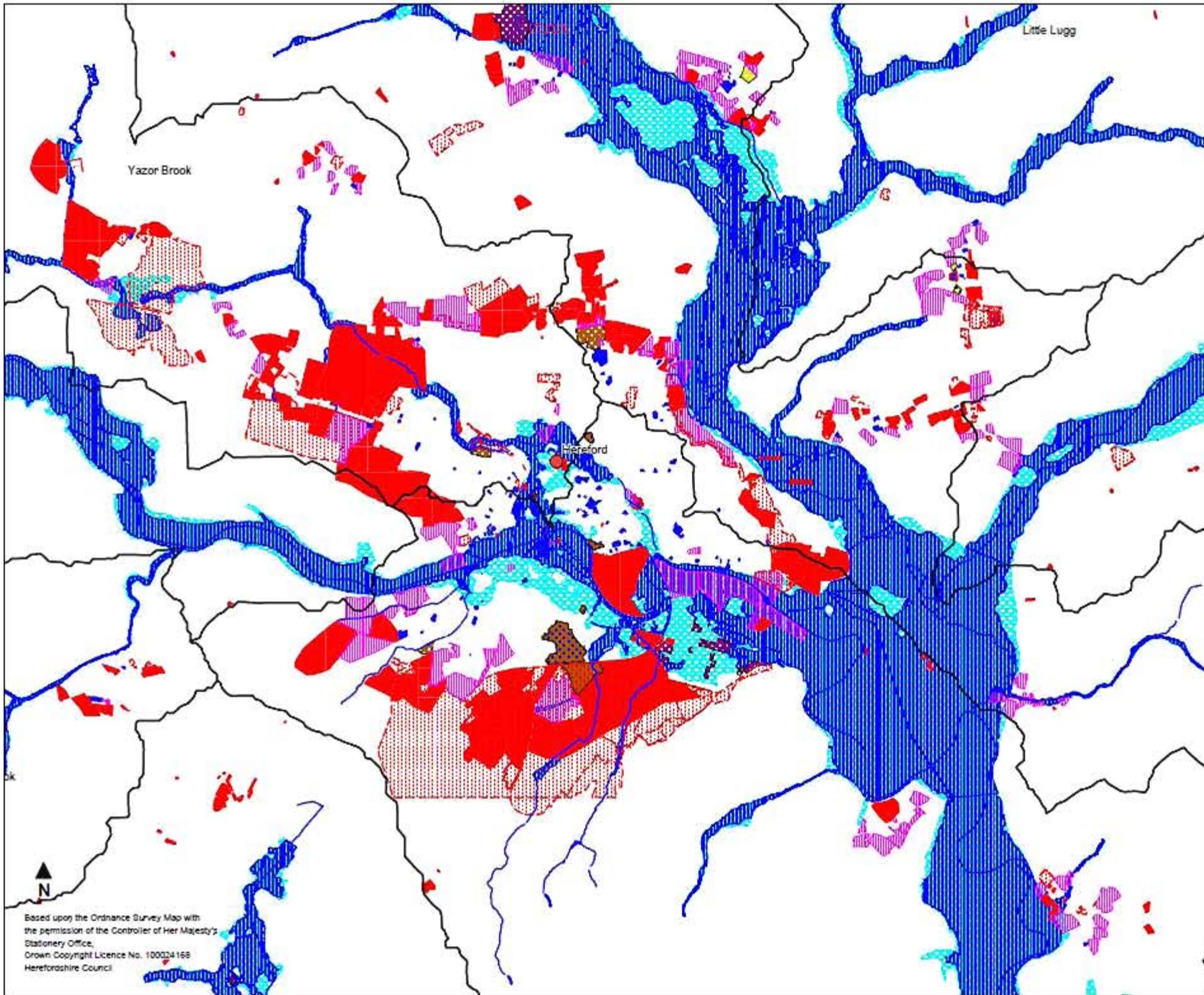
Strategic Flood Risk Assessment

Drawing

Title	Possible Development Sites
Subset	By study
No.	1110/EB/4-1/a
Date	24-1-2008
Check:	BF

Revisions
Scale : 1:NTS
Evidence Map S-1


Evidence Map 5-2 – Development Pressure around Hereford



Key	
	Wye Catchment
	Herefordshire
	Principal Rivers
	Main Town
	H2 Housing Sites
	E1, E2, E3 Employment Sites
	Land under HLAA study
	Land Under Officer study
	Land under Housing Capacity study
	Land under Representation

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing
Title Housing Pressures
Subset Hereford environs
No. 1110/EB/4-2/a
Date 24-1-2008
Check: BF

Revisions

Scale : 1:NTS

Evidence Map 5-2

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6. FLOOD WARNING SYSTEMS

The purpose of flood warning is to provide advice which permits those people vulnerable to impending flooding to take actions which lessen the consequences of inundation, should it be experienced. The Environment Agency operates a flood warning system across much of England and Wales and since 1996 has undertaken to disseminate warnings to people who are at risk, so that they can take action to protect themselves and their properties.

Whilst the EA predominantly focuses on flood warnings to protect life and property, there is also an increasing need for LPAs and emergency services to utilise timely flood-warnings to protect critical infrastructure.

This Chapter examines the status of the current flood warning system, and identifies where future improvements may be needed to lessen residual flood risk for both existing and future development and critical infrastructure.

6.1 Current Flood Warning Framework

6.1.1 Flood Warning Procedures

In England and Wales the Environment Agency operates a flood warning service in areas at risk of flooding from rivers or the sea. The EA monitor rainfall intensities and river levels at a range of meteorological and hydrometric monitoring stations, this information being used as inputs to flood forecasting procedures and ultimately the issue of flood warnings.

Warnings are issued using a set of four easily recognisable codes. Each of the four codes indicates the level of danger associated with the warning. The codes are not always used in sequence; for example in the case of a flash flood, a Severe Flood Warning may be issued immediately, with no other warning code preceding it.

Many parts of the country are covered by the Agency's full four stage Flood Warning Service. In areas where it is not possible to accurately forecast flooding from rivers or the sea, early alerts for possible flooding for all rivers, streams and watercourses are given Flood Watch status. Summary of the codes are below:



Flooding of low lying land and roads is expected.



Flooding of homes and businesses is expected.
Act now!



Act Now! Severe flooding is expected with extreme danger to life and property



No further flooding is expected. Water levels will start to go down.

The Environment Agency provides 'live updates' on their website where other useful flooding information can also be obtained by members of the public.

<http://www.environment-agency.gov.uk/flooding>

Herefordshire Council Emergency Planning Unit is responsible for coordination and planning for flood events. They liaise with the emergency services as well as the EA. The role of the Emergency Planning Unit (EPU) at other times is to prepare contingency plans, promote education and awareness and to respond to calls to queries or concern from the public.

The *National Flood Response Centre* provides support and guidance to the Government, EA, emergency services and local authority partners. It is designed to coordinate and disseminate timely information as well as collate and process data post events.

6.1.2 Flood Warning Network

Evidence Map 6-1 shows the full existing flood warning network within the SFRA area. Superimposed are the Flood Zone 2 floodplain, flood warning areas (see 6.1.3) and the primary locations of extensive flood reports.

The very earliest notice of extreme flooding will be generated by the telemetry raingauges which can monitor rainfall intensity. There are eight of these within the SFRA area. Generally Herefordshire is well served by a network of fluvial water level (stage) and/or flow monitoring stations which show the fluvial response of the various catchments to the meteorological inputs.

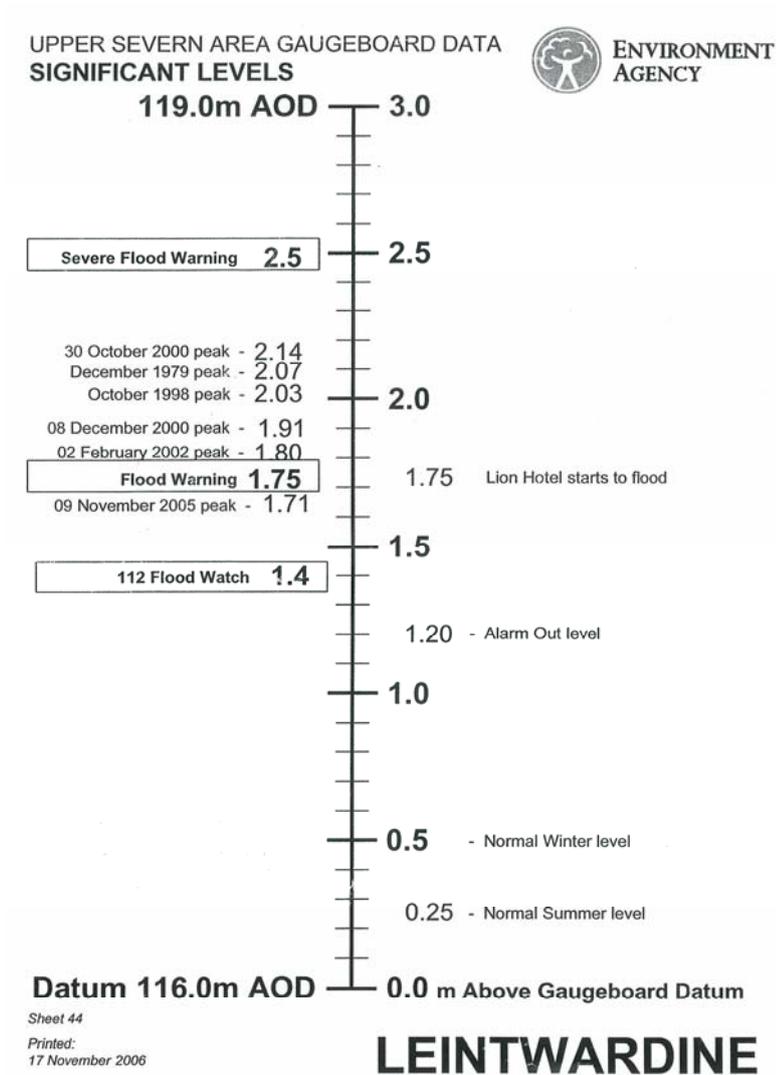
At most flood level warning stations, there is an established set of triggers that will activate issue of various severities of warning. For example at the Leintwardine gauge, a Flood Watch alert will be issued at a level of 1.4m on the local staff gauge. It is known that when the river level reaches a stage of 1.75m, the Lion Hotel will start to flood.

At a stage of 2.5m a Severe Flood Warning will be issued.

Imminence of flooding at Leintwardine on the River Teme (a known flood risk area) is more likely to be informed by the status of the two level stations higher up on the Red Brook.

Figure 6-1 shows the flood level triggers for the Leintwardine gauge as an example.

Figure 6-1 – Flood Trigger Levels – Leintwardine Gauge



6.1.3 Flood Warning Lead Time

Currently the EA nationally undertakes to provide a minimum of only 2 hours notice of a flood alert. This may surprise many people in view of the significant delay in the time to peak of most catchments after the peak of the rainfall event. A lack of sufficient warning is often cited by many flood affected residents as the main cause of significant damage to their belongings. The emergency evacuation from Linton Park, Bromyard in July 2007 is a case in point.

In many instances a river will have been on a state of alert for considerably longer than this e.g. at Flood Watch status, before upgrading to Flood Warning status, hence longer lead times are possible. However, downstream of impermeable catchments, or during summer type flash flooding, very little warning may be given.

It follows that this places an additional requirement on emergency services and the LPA generally to be as thoroughly prepared for short-notice flooding as possible. Critical infrastructure generally was not adequately prepared during the 2007 floods, and preparedness through timely flood warnings and good contingency planning is a key future issue for the LPA.

6.1.4 Flood Warning Areas

The Environment Agency operates six Flood Warning Areas in the SFRA area (see **Evidence Map 6-1**). These form part of the national network and the warning areas are publicised by Flood Warnings Direct. The take up of the current flood warning service is less than 50% in many instances.

Table 6-1 - Flood Warning Areas with FWD participation

Warning Area	Properties at Risk ¹	Properties registered ²	Service Take up
River Wye at Glasbury	132	66	50%
River Wye from Hay To Hereford	316	151	48%
River Wye at Hereford City	4640	1831	39%
River Wye from Hereford To Ross on Wye	439	233	53%
River Wye at Lydbrook	108	47	44%
River Lugg at Leominster	1087	416	38%
TOTAL	6722	2744	41%

Data supplied from FWD by Flood Warning Team, EA, Cardiff. December 2007

(1) This is the number of properties that the EA have identified to lie within the 1 in 100 year and 1 in 1000 year extreme flood outline (Zone 2&3).

(2) This is the number of properties that have registered with the EA Flood Warnings Direct

6.1.5 Flood Warnings Direct

The Environment Agency encourages as many people as possible that are in flood risk areas to register with Flood Warnings Direct. This is a free service whereby people register their names, addresses, telephone numbers, faxes, email etc, who then receive an automatic warning in line with the codes outlined above.

The EA employs a number of lines of communication to disseminate flood warnings. Targeted mail campaigns are aimed at those in flood risk areas along with electronic information on the EA website. Information is normally published in newspapers and disseminated through local radio.

6.2 Strategic Flood Warning Appraisal

6.2.1 Hydrological Evidence Base

The hydrological evidence based prepared for the SFRA can be used to critically identify weaknesses and needed improvements to the flood warning system. As with all resources and investments, these should be targeted at areas of greatest risk.

Of foremost used is the GIS layer **HSFRA Flood Timings**, prepared under Chapter 2, see **Evidence Map 2-3**. This analysis quantifies the theoretical time to peak of all 47 SFRA catchments, and is used in the derivation of the **Flood Timing and Evacuation Index** (FTE) describe in Chapter 4.

By combining for example, the fundamental hydrology of catchment response times against known flood risk hot-spots, flood warning areas and flood-warning gauges, a useful insight can be developed into where rapid floods may arise in future in areas of past OR future risk that are not adequately served by the flood warning network.

This information is contained in **Evidence Map 6-2 – Fluvial Flood Imminence**. The theoretical times to peak of all 47 catchments are presented in Table 4-1, with each catchment ranked accordingly. This rank forms the **Flood Timing and Evacuation Index** proposed in Chapter 4, which has considerable value not only in the Sequential Test for new development but also for existing flood risk, critical infrastructure, and emergency preparedness.

6.2.2 Practical Implications of Flood Timings

Significant lengths of the Wye and Lugg river systems have well established flood warning areas and associated gauges. It will be evident however from Table 4-1 that the River Wye takes 16 hours approximately to reach its peak at Hereford. This should allow sufficient warning time for emergency measures.

The most rapidly responding catchments in the SFRA area are the Wriggle Brook, Back Brook, Honddu, Lower Monnow and the Upper Leadon. Any development proposed adjacent to the floodplain in these catchments will have to take special account of flood risk imminence. The settlements most at risk from sudden flood peaks and which are most likely to be affected by inadequate warning are Kington, Ewyas Harold (Dulas Brook not modelled), Bosbury, Ledbury, and Bromyard.

Kington is partially served by a flood level gauge on the Upper Arrow, but the Back Brook is not monitored for fluvial levels. There is however a telemetry rain-gauge in the Back Brook catchment which might provide a very early indicator of possible flooding. There is no warning gauge within the upper or lower Leadon catchments; hence Bosbury is at particular risk of sudden floods as is Ewyas Harold by floods arising on the Dulas Brook.

The provisional flood-warning gauge recently installed by the EA above Bromyard might be more effectively replaced by improved use of the telemetry rain-gauge higher in the upper Frome catchment. The SFRA recommends that the LPA in conjunction with the EA studies the implications for flood warning in these localities, and makes improved contingencies.

(It must be emphasised that the flood peak response times used in this study are theoretical values derived from standard FEH procedures. They are indicative only of the likely degree of 'flood imminence'. In practice flood peaks take somewhat longer to arise than the theoretical values because of attenuation and restriction along the river systems. However, as a comparative

measure i.e. between different catchments, time to peak is an extremely useful and robust indicator).

Facing concern about the efficacy and timeliness of its flood warning system after the July 2007 floods, the EA acknowledged in its summary report ¹.

“Our professional partners have highlighted the need to be much clearer about the relationship between ‘triggers’ (for example, warnings and forecasts) and the related response (evacuation, distribution of resources). Issues include the amount of warning time professional partners need to take action and their willingness to accept that longer lead in times will lead to a higher level of false alarms and increased costs for their service.”

Recommendation 2. We will review ways of using rainfall forecasts in our flood forecasting system to provide more timely warnings in fast-responding catchments.

Recommendation 5. We will review our flood forecasting models and threshold levels where flooding was not forecast sufficiently in advance.

Recommendation 7. We will address the problems experienced in the floods by some of the public in obtaining an accurate picture of the flood situation on all our systems.

“Recommendation 9. We will review our professional partners’ specific needs, so that we and the Met Office provide forecasts and warnings which mean they can easily take action.

The SFRA therefore urges Herefordshire Council to coordinate with the Environment Agency in considering improved flood warning capability for the settlements of Kington, Bosbury, Ledbury and Ewyas Harold.

6.3 Interactions with the EA Catchment Flood Management Plan

In considering policy issues for the Herefordshire SFRA area, the Environment Agency might find **Evidence Map 6-2 Flood Imminence** useful in reappraising the extent and efficiency of its current flood warning system.

The provisional flood-warning gauge recently installed by the EA above Bromyard might be more effectively replaced by improved use of the telemetry rain-gauge higher in the upper Frome catchment.

The SFRA therefore urges Herefordshire Council to coordinate with the Environment Agency in considering improved flood warning capability for the settlements of Kington, Bosbury, Ledbury and Ewyas Harold.

There would appear to be significant inaccuracy and inconsistency with the EA data on flood affected properties. The CFMP indicates that there are 2900 properties at risk of flooding in a 1% AEP event in the upper Wye area. The

SFRA puts this figure at 4328. For a detailed breakdown see Table 4-1. This anomaly should be resolved.

6.4 Evidence Based Statements

- 1) Flood Warning Coverage Herefordshire is currently divided into six flood warning areas and a network of flood warning gauges monitored by the Flood Warning Team in Cardiff. At the end of December 2007, 6722 houses were registered with the Flood Warnings Direct service. However this constitutes only 35% of the potentially affected property across the warning areas.
- 2) Herefordshire Council forms part of the West Mercia Local Resilience Forum. The Civil Contingencies Act 2004 requires the Local Authority to take up civil protection duties and to ensure greater consistency and cooperation at the local level.
- 3) Whilst the EA predominantly focuses on flood warnings to protect life and property, there is also an increasing need for LPAs and emergency services to utilise timely flood-warnings to protect critical infrastructure.
- 4) Currently the EA nationally undertakes to provide a minimum of only 2 hours notice of a flood alert. It follows that this places an additional requirement on emergency services and the LPA generally to be as thoroughly prepared for short-notice flooding as possible. Critical infrastructure generally was not adequately prepared during the 2007 floods, and preparedness through timely flood warnings and good contingency planning is a key future issue for the LPA.
- 5) The hydrological evidence based prepared for the SFRA can be used to critically identify weaknesses and needed improvements to the flood warning system. As with all resources and investments, these should be targeted at areas of greatest risk.
- 6) The most rapidly responding catchments in the SFRA area are the Wriggle Brook, Back Brook, Honddu, Lower Monnow and the Upper Leadon. Any development proposed adjacent to the floodplain in these catchments will have to take special account of flood risk imminence. The settlements most at risk from sudden flood peaks and which are most likely to be affected by inadequate warning are Ewyas Harold (Dulas Brook not modelled), Bosbury, Ledbury, Bromyard and Kington.

6.5 Evidence Based Recommendations

- 1) Herefordshire Council should liaise closely with the Environment Agency to improve the take-up of the current Flood Warnings system. This could be achieved by an 'opt out' approach as opposed to an 'opt in' approach. Targets should be set to achieve say 80% registration by 2010.
- 2) Herefordshire Council Emergency Planning Unit, in partnership with the emergency services, should look to increase awareness through media

campaigns as well as working with the EA to promote the importance of timely actions with respect to flooding.

- 3) The most rapidly responding catchments in the SFRA area are the Wriggle Brook, Back Brook, Honddu, Lower Monnow and the Upper Leadon. Any development proposed adjacent to the floodplain in these catchments will have to take special account of flood risk imminence.
- 4) The SFRA therefore urges Herefordshire Council to coordinate with the Environment Agency in considering improved flood warning capability for the settlements of Kington, Bosbury, Ledbury and Ewyas Harold.

6.6 References and Additional Resources

The following published or web-based documentation has been referred to in the following sections, and may provide useful further reference material for the Local Development Framework.

- 1) **Review of 2007 Summer Floods** (Environment Agency, December 2007)
<http://www.environment-agency.gov.uk/subjects/flood/1867303/>

Evidence Map 6-1 – Flood Warning Systems within Herefordshire



- Key**
- Wye Catchment
 - Herefordshire
 - Principal Rivers
 - Main Town
 - Village
 - Flood Warning Area
 - EA Flood Zone 2
 - Extensive Flood Reports
 - EA Gauging Station
 - EA Level Warning Station
 - EA Telemetry Raingauge

Client
Herefordshire Council

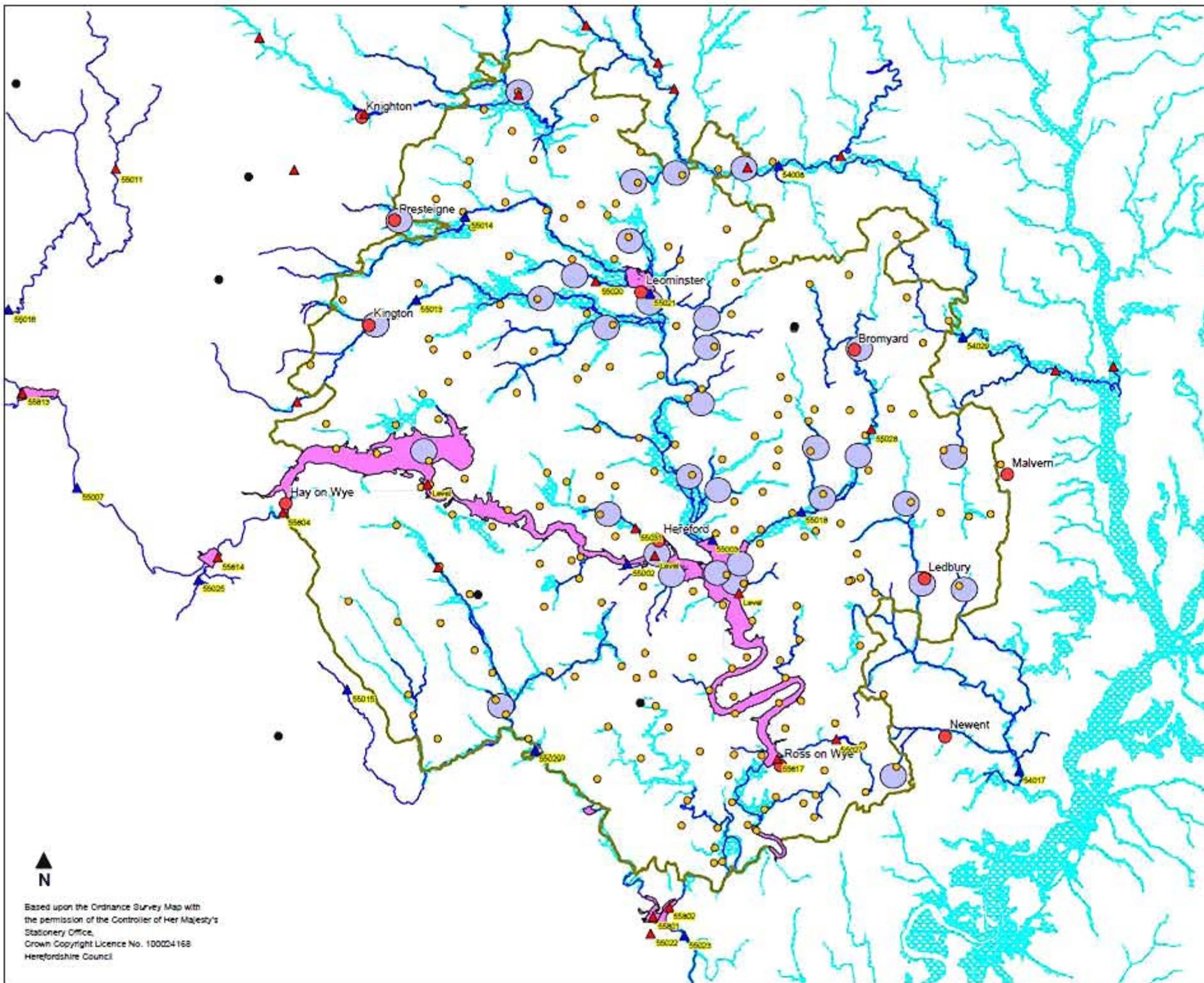
Scheme
Strategic Flood Risk Assessment

Drawing
Title Flood Warning
Subset Gauges and Areas
No. 1110/EB/6-1/a
Date 24-1-2008
Check: BF

Revisions

Scale : 1:NTS

Evidence Map 6-1



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Evidence Map 6-2 – Fluvial Flood Imminence

