NMF Soundness Consultation

1 message

Bill Freeman [redacted] 10 May 2016 at 21:21
To: adurplanningpolicy@adur-worthing.gov.uk
Cc: [redacted]

Blind copies to members/residents

Dear Adur Planning Policy,

Please find attached our submission to the reg. 19 consultation on New Monks Farm allocation.

Also attached are a number of documents which are referenced by the comment in the representation.

As mentioned to Moira Hayes, there's one I cannot email or reduce in size and I'll drop this into the office tomorrow on a CD for Moira's attention.

Could you kindly confirm receipt of this submission and also, later, could Moira kindly confirm that she has received the CD.

As ever, appreciate your support in this.

Kindest Regards,

Bill Freeman

Chair

Adur Floodwatch Group

Run by the community for the community

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7 attachments

Soundness representation - final.doc
182K

Drainage report to Adur 1.2.16.pdf
493K

WSCC CH2MHill lancing_swmp_final_technical_report (4).pdf
3762K

WSCC CH2MHill Non Technical (Hi light).pdf
509K

Waterco final w10055-160510-Document Review.pdf
558K

Groundwater Flooding Report 2016-043-001-002.pdf
1402K

Lancing petrol stn.Decision - refusal.pdf
232K

Amendments to the Proposed Submission Adur Local Plan (2016)

Representation Form

Return Address:adurplanningpolicy@adur-worthing.gov.uk

Or:

Planning Policy Team, Adur and Worthing Councils, Town Hall, Chapel Road, Worthing, BN11 1BR

Or hand in at:

- **Shoreham Centre, 2 Pond Road, Shoreham-by-Sea, BN43 5WU or**
- **Portland House, 44 Richmond Road, Worthing, BN11 1HS**

Please return to Adur District Council by midnight on 11th May 2016
Late representations will not be considered.

Please note that at this stage, representations are only being sought on whether the amendments to the Plan are sound and/or legally compliant.

Use of your information: Respondent details and representations will be forwarded to the Secretary of State for consideration when the Adur Local Plan is submitted for examination. All documents will be held by Adur District Council and representations will be published including on the internet e.g. www.adur-worthing.gov.uk. Personal contact details (address, email and phone number) will be removed from published copies of representations. Your information will be handled in accordance with Data Protection Act 1998.

Contact details will be added to the Adur Planning Policy consultees database to keep you informed on the progress of the Adur Local Plan and other related documents.

☐ Please tick if you do **not** want to be informed.

This form has two parts:

i. Part A - Respondent Details. You only need to fill this in once.

ii. Part B - Your representation(s). Please fill in a separate sheet for each representation you make.

It is recommended that you read the Guidance Notes provided for an explanation of terms used in this form.

Part A – Personal Information

You only need to complete this section once

Personal Details

First name	Bill
Last name	Freeman
Organisation (where applicable)	Adur Floodwatch Group
Address line 1	[redacted]
Address line 2	
Address line 3	[redacted]
Post Code	[redacted] Telephone [redacted]
Email address	[redacted]

Agent's Details (if applicable)

First name	
Last name	
Organisation	
Job Title	
Address line 1	
Address line 2	
Address line 3	
Post Code	Telephone
Email address	

Part B – Representation

Please use separate sheets for each representation

1. Which Amendment(s) to the Adur Local Plan does this representation relate to?

Amendments relating to:

Policy No.	5	Paragraph No.	
Map		Other section (please specify)	Sequential & Exception Tests 2016 SWMP Pages 36/39

2. Do you consider the Amendment(s) to be: (tick as appropriate)

2.1 Legally Compliant Yes ☐ No ☐

2.2 Sound Yes ☐ No ☐X

Please read the Guidance Note for guidance on legal compliance and soundness.

If you have ticked no to 2.1, please continue to Q4.
If you have ticked no to 2.2, please continue to Q3.
If you have ticked yes to 2.1 and 2.2 please go to Q7.

3. Do you consider the Amendment(s) to the Adur Local Plan to be unsound because it is not: (tick as appropriate)

3.1 Positively Prepared ☐X

3.2 Justified ☐X

3.3 Effective ☐X

3.4 Consistent with National Policy ☐X

4. If you consider the Amendment(s) to the Adur Local Plan to be unsound or not legally compliant, please explain why in the box below:

Adur Floodwatch Group is an alliance of community groups across Adur District, formed following the flooding issues of winter 2012/13, it serves the community in all matters concerning drainage and is established with the National Flood Forum and a member of the West Sussex Flood Action Group. With county financial support, it has run community 'Teach Ins' to help residents prepare and be personally resilient in emerging flood situations.

Background

As stated in earlier submissions, AFG members know that the New Monks Farm allocation and the amended plan for now 600 homes and business development is in an inappropriate location because of the potential it will create for increased flood risk for the Lancing area both north, west and south of the site.

This has been communicated many times to the authority in consultation submissions, at full council meetings, meetings with the planning team, with the support of local councillors and considerable comment in the media during the previous 3 years. The authority has failed to react to these community concerns for increased flood risk.

This lack of listening to the community in itself does not comply with para 155 of the NPPF which states " A wide section of the community should be proactively engaged so that local plans, as far as possible, reflect a collective vision and set of agreed priorites for the sustainable development of the area…"

Following the Lancing drainage issues of 2012/13, West Sussex County Council, the lead drainage authority, commissioned an in depth study of the drainage of the Lancing Gap within which New Monks Farm is located. This was carried out by CH2MHill and published in October 2015.

The study was to cover the geological and drainage influences and structure of the Lancing area**. Categorically, it did not include work in the light of further development of sites within the study area which includes the New Monks Farm allocation.**

A copy is attached of both the CH2MHill technical and non technical reports. We draw your attention particularly to the latter which, highlighted on page 3, concludes that in extreme weather Lancing will always be vulnerable to groundwater flooding no matter what mitigation is undertaken. It states:-

"Policy, construction and maintenance mitigation measures to alleviate the impacts of flooding in Lancing have been considered.
Even with all of these measures in place Lancing will still be at risk of flooding during more extreme weather events. This is because drainage systems (both natural and man-made) and any other flood risk infrastructure will become overwhelmed during extreme weather events. In addition, Lancing is highly vulnerable to groundwater flooding (or drainage is affected by groundwater levels), which is significantly more technically and economically challenging to manage."

The CH2MHill technical report clearly shows the 'at capacity' of the complicated, ditch

network which manages the drainage of the whole area into tidal sluices into the River Adur at Shoreham – drainage from the South Downs, all the local roads, the properties, gardens and their soakaways and even the A27 trunk road, the site itself plus the whole of Lancing Gap. The ditch network has virtually no gradient, 1:2000 across 1.5 miles.

The Lancing Gap and parts of the south and north west conurbations are in an area with an Environment Agency Zone 3a rating high risk of flooding from fluvial and/or coastal influences. Even more significant, the whole area of the Lancing Gap has a >75% risk of flooding from groundwater influences Almost all of New Monks farm is situated within this area.

in extreme weather, groundwater and surface water flows, particularly from the South Downs are major contributors to flooding problems for the whole of Lancing.

Climate change is becoming ever more evident. Lancing, both north, west and south of New Monks Farm, has experienced flooding and drainage issues throughout every one of the last 4 winters.

Attached is an AGM presentation which confirms this both pictorially and with comment slides.

Flooded, unusable gardens and roads, road lane closures, and severe ground water infiltration of sewers with loss of foul waste facilities are now experienced during every winter.

Please see attached the emailed drainage report to the Adur Technical Team submitted February 1st during the winter 2015/16 event for North Lancing area.

Policy 5 – Why the SWMP is unsound (Sequential & Exception Tests 2016 SWMP Pages 36/39)
The SWMP for New Monks Farm, whilst it indicates the methods to manage and attenuate surface water flows from the proposed site, totally fails to demonstrate that there will be no increased flood risk elsewhere for the lifetime of the development as required by stage 2 of the exception test, NPPF, para 102. It completely fails to show sustainability of the suggested methods of surface water drainage into the existing network of ditches (Lancing Brooks) which flow, when the tide permits, through the sluices into the River at Shoreham. It also mentions SuDs attenuation but once again shows no quantified proof how this will be sustainable.

As per NPPG guidance which states: "Determine all the variation in risks from all sources of flooding across their areas, and also the risks to and from surrounding areas in the same catchment."

As it stands the SWMP takes no account of off-site influences for both surface, ground water and in the case of areas to the south, added coastal tidal influences

NPPF Para 102 clearly states that all sources of water flows must be taken into account both on and offsite. Drainage sustainability must be clearly demonstrated before inclusion of the allocation in the Local Plan.

All the right words are in the SWMP – but to comply with para 102, flow data, capacities

and a proposed, quantified and calculated drainage method has not been included to demonstrate its sustainability.

At the very least, to comply with rule 102, a full, site specific drainage plan must be carried out before the allocation is set in the plan. This should demonstrate the absolute methods to be taken with support of full data on capacities, flows, drainage influences (both from on and off site) and effects to justify it would work.

This SWMP completely fails to do that and is therefore not sound.

Expert Evidence (Sequential & Exception Tests SWMP Pages 36/39)

Adur Floodwatch Group, together with CPRE, The Campaign to Protect Rural England, jointly commissioned the Waterco consultancy to produce an independent hydrology assessment report of the SWMP.

A copy of this report with an additional groundwater report is attached.

This report critiques the SWMP. We draw your attention to its conclusions which are shown below :-

"From the EA mapping the majority of the New Monks Farm site is identified as being at significant risk from tidal flooding. The site is also identified at risk from surface water and groundwater sources. Both the SFRA and the Surface Water Management Plan acknowledge this.

The site has been assessed as having passed the NPPF Sequential Test, on the basis that there are no alternative sites in the area at lower flood risk which could accommodate a development of this size.

Further work is required to assess and determine the impacts of the proposed development on flood risk elsewhere. The principal mitigation measure proposed in the core strategy is land raising; but this could amount to raising levels by some 2-3 metres over the majority of the site area. The proposition that this can be done without affecting flood risk elsewhere has not been substantiated and may prove to be both impractical and unviable.

Further work also appears to be required to establish whether the existing sewerage network can accommodate the development, or if infrastructure upgrades are required. Any potential infrastructure upgrades may be of significant scale to accommodate a development of 600 dwellings and may impact of development timescales.

The assessments, as presently offered, appear to be incomplete and inadequate and do not provide a sufficiently robust basis for supporting the site allocation within the Adur Local Plan."

The Waterco assessment conclusions absolutely confirm this community group's comments that the SWMP is unsound, neither consistent with National Policy, nor justified and effective.

The report also highlights that further work should be undertaken with the water

company (Southern Water) in respect of sewerage. In our experience, the local sewer network, which is for foul waste only, particularly at times of extreme weather, is consistently vulnerable to ground water inundation and failure of foul waste facilities. The last 4 winters confirm that.

In our opinion significant infrastructure for handling this foul waste element should also be considered and be proven to be manageable before this allocation is set in the Local Plan. This is another reason that the plan is unsound.

If an adequate SWMP is not carried out, exception tests have failed and New Monks Farm should not be included in the Adur Local Plan.

Other Relevant Comment

1) Inconsistency
The plan allocations include a particular site for 8 homes called The Lancing Petrol Filling Station (ADC/083/13).
This location is immediately north of the A27 and directly opposite to the north west of the New Monks Farm site.

An application (AWDM/1128/14) to build 6 homes on The Lancing Petrol Filling Station was refused by Adur DC in October 2015. There were 5 main points of refusal. The first of these was because of concerns of increased 3rd party flood risk from ground water disruption together with an inadequate surface water management plan.

The refusal document for this application is attached

Point 1 – the authority has refused building permission for this small site because of drainage issues and yet it proposes development of a major 600 homes/10,000 sq m business development site in the same area with an even greater potential for increased flood risk. Its SWMP has failed to produce and demonstrate that there will be no increased flood risk to the site or elsewhere for the lifetime of the development.

Point 2 – if Lancing Petrol Station site has been refused planning approval, why is this site still in the Adur Plan? – and for 8 homes not 6?

This lack of consistency once again confirms that in respect of the New Monks Farm allocation due diligence for the drainage has not been practised to comply with para 102 of the NPPF and part 2 of the exception test and both parts 1&2 of the exception test are therefore unsound.

2) A Further Developer Report (Sequential & Exception Tests SWMP Pages 36/39)

From a meeting with the planning policy team in November 2014, this community group was informed that the authority had requested a further study from the prospective developer following their submission of their Capita groundwater report.

The Authority were seeking further substantiation for the surface water management to confirm sustainability of the development. At that time the developer refused to undertake further work on such a report. Recently we have learned that there may now be a report submitted but there is no indication of when this will be available. Policy Planning Team do agree that such a report would be helpful at this stage, but they still feel confident that sufficient work has been done with the SWMP to confirm the allocation of New Monks Farm in the Plan.

Whether or not this further evidence for drainage sustainability does become available, the fact that the authority was pursuing further hydrological data on sustainability in 2014 clearly shows that they feel this is necessary to justify the allocation for the plan.

Yet the published SWMP (Sequential & Exception Tests SWMP Pages 36/39) still fails to provide such data and as such is unsound.

3) Viability – New Monks Farm Allocation

From previous 2014 consultation comment by a developer's planning agent it is clear that there is concern about the financial viability of the site. The submission in question pushes for 600 homes to be allocated and not the lower figure in the range (450 – 600) featured in the 2014 plan stage.

The arguments for the highest number are based on financial viability of the development bearing in mind infrastructure costs of the drainage, the roads/A27 roundabout.

600 homes have now been included for this potential allocation.

As required by NPPF para 173 which states:-
"To ensure viability, the costs of any requirements likely to be applied to development, such as requirements for affordable housing, standards, infrastructure contributions or other requirements should, when taking account of the normal cost of development and mitigation, provide competitive returns to a willing land owner and willing developer to enable the development to be deliverable."

The question to be asked, therefore, has viability of the site been fully calculated to ensure that with all the extra burden of infrastructure costs, particularly drainage & sewerage, the development can be deliverable?

These surely cannot be calculated until a comprehensive, quantified and specific drainage scheme has been produced. The same applies to the infrastructure for sewerage. Until these are carried out for this difficult site, the viability statement cannot be deemed to have reasonable accuracy.

Based on a mix of 600 homes, the Viability Statement shows a margin of £10.1m for residential and just £148k for business development. On the lower figure of 450 homes, the Viability Statement shows a margin of £5.3 m.

Based on the above developer's push for 600 homes are these margin expectations feasible and realistic? The return on 450 homes the authority says will yield £5.3m but the developer who was, in 2014, looking for the full 600 has obvious doubts about the site's viability based upon the lower figure which throws doubt on the margin expectations shown in the Viability Statement for 450 homes. By the same token, is not the margin stated for the 600 homes questionable also?

The developer obviously realises that there will be inevitable extraordinary infrastructure costs, particularly for drainage and sewerage, which must be of concern for viability.

This is another reason that a fully worked SWMP must be developed to comply with both paras 102 and 173 of the NPPF to better calculate viability to ensure developer deliverability.

So, the question remains – Is this site realistically viable?

Adur Floodwatch Group believes that the authority may well be aware that a full, substantial, well qualified SWMP may well indicate non viability of the site because of the inordinate costs of the methods needed to sustainably manage the drainage without increased flood risk within, upstream and downstream of the site and also the sewerage.

The Adur Plan has a 2200 homes shortfall against its OAN. In its concern for that, the perception is that the authority has produced a less than substantial SWMP in an endeavour to create site validation for the exception tests, part 1 and 2. Adur DC is trying to obtain government inspector approval and leave the design and sustainable management of the drainage to the development application stage.

This is of great concern to the community because, after all its communication with the authority on flood risk, the authority has failed to do due diligence on the drainage for New Monks Farm to protect the community from increased flooding,
it is passing off its responsibility to the developer when under the NPPF, para 102, it is clearly their responsibility.

5. Please explain in the box below what change(s) you consider necessary to make the Amendment(s) to the Adur Local Plan legally compliant and sound having regard to the reason you identified above.

(You will need to say why this change will make it legally compliant or sound. It will be helpful if you are able to put forward your suggested or revised wording. Please be as precise as possible).

Re: Sequential & Exception Tests 2016 SWMP Pages 36/39

To comply with the NPPF para 102, the Adur Floodwatch Group asks that a further comprehensive, site specific SWMP should be undertaken.

This should demonstrate the absolute methods to be taken with support of full data on capacities, flows, drainage influences (both from on and off site) and effects to justify it would work.

If this revised SWMP can demonstrate sustainable management of site drainage both for surface water run off and sewerage and that flood risk is not increased, either for the site or elsewhere (as required by the exception test part 2) then the Viability Statement should be revisited to take into account the costs associated with this full drainage scheme to demonstrate deliverability.

If it shows that increased flood risk cannot be sustainable and/or the site is not viable, to satisfy NPPF paras 102 & 173, then the New Monks Farm allocation should be excluded from the local plan.

6. If your representation concerns soundness or legal compliance and is seeking a change, do you consider it necessary to attend and give evidence at the hearing part of the examination? (tick as appropriate)

No, I wish to communicate through written representations ☐

Yes, I wish to speak to the Inspector at the hearing sessions ☐X

Please note: The Inspector will determine the most appropriate procedure to hear those who have indicated that they wish to participate at the hearing part of the examination.

7. If you wish to participate at the hearing part of the examination, please outline why you consider this to be necessary.

Adur Floodwatch Group wishes to attend the Government Inspector's hearing because the community has great concerns for increased flood risk from the development allocation above.

It has been communicating these concerns for over 3 years now to the local authority who has, in our opinion, failed to act appropriately upon these concerns to ensure that the safety and wellbeing of the community is being protected.

This is the opportunity, to express these concerns for independent adjudication.

8. Please tick if you do not wish to be informed of the following:

When the Plan has been submitted for Examination ☐

When the recommendations from the Examination have been Published ☐

When the Local Plan has been adopted ☐

What happens next?

Representations made to the Council will be passed to the Inspector for consideration.

Once this has happened, the Inspector will commence the examination and give notice of the start of the hearing sessions.

Interested parties will be informed of the start date of the hearing sessions and the matters to be considered.

Thank you for your representation.

New Monks Farm, Adur

Strategic Document Review

May 2016

Waterco Ltd, Eden Court, Lon Parcwr Business Park, Ruthin, Denbighshire LL15 1NJ
Tel: 01824 702220 **Email:** enquiries@waterco.co.uk **Web:** www.waterco.co.uk

w10055-160510-Document Review

DOCUMENT VERIFICATION RECORD

CLIENT:	CPRE Sussex Countryside Trust & Adur Flood Watch Group
SCHEME:	New Monks Farm, Adur
INSTRUCTION:	The instruction to carry out this report was received from Kia Trainor of CPRE Sussex Countryside Trust

DOCUMENT REVIEW & APPROVAL

AUTHOR:	Aled Williams BSc (Hons)
CHECKER:	Pedr Jones BSc (Hons) MA
APPROVER:	Peter Jones BSc (Hons) CEng C.WEM FICE MCIWEM

ISSUE HISTORY

ISSUE DATE	COMMENTS
01/05/2016	First issue
09/05/2016	Second issue
10/05/2016	Third issue

Contents

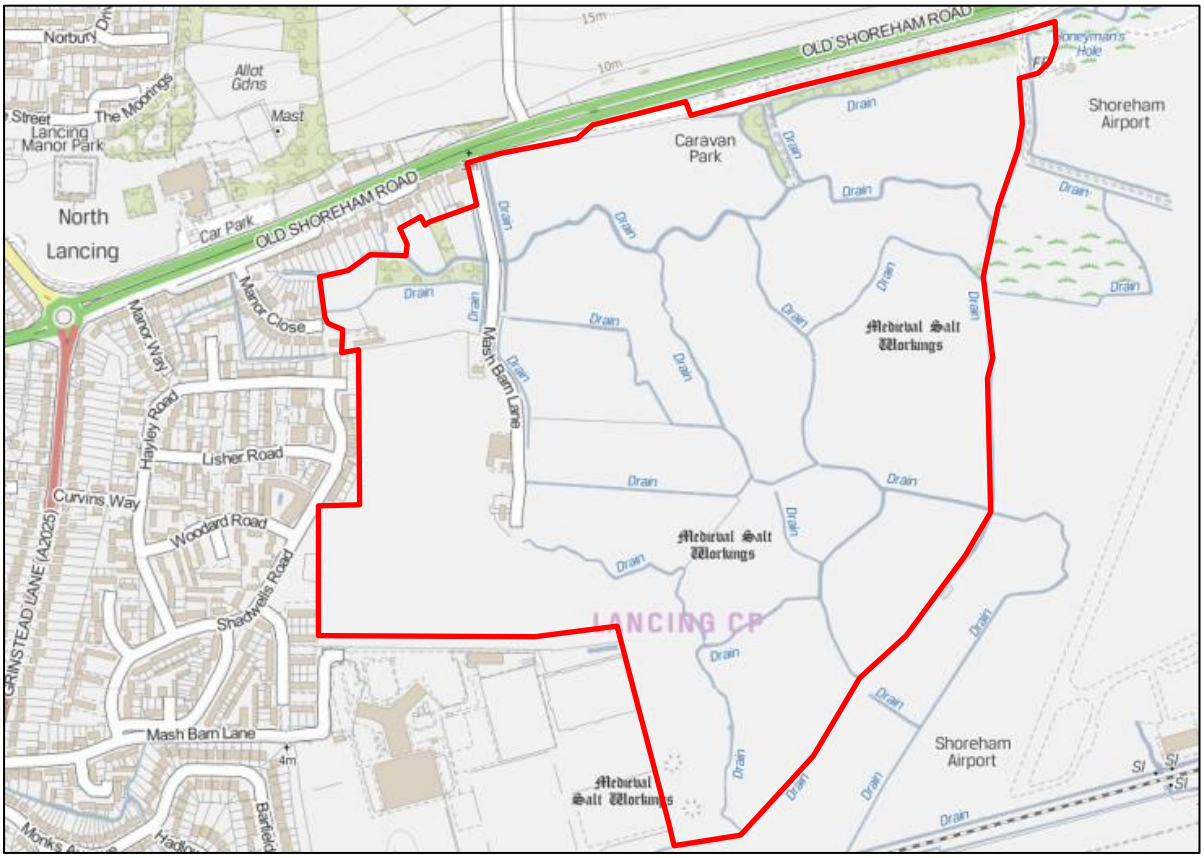
Figures

Introduction

Major site allocations have been proposed as part of the Adur Local Plan which was prepared for submission to the Secretary of State in 2015. The Adur Local Plan has been subject to a number of amendments and is now available for consultation.

Concerns in relation to flood risk and drainage have been raised in regards to a strategic site known as New Monks Farm. The site is located to the east of Lancing, Worthing at National Grid reference 519394E 105413N. A site location plan is provided as Figure 1 below:

Figure 1 – Location Plan – New Monks Farm



The allocation of the New Monks Farm site in the Adur Local Plan is supported by strategic documents including:

- Adur District and Worthing Borough Councils Strategic Flood Risk Assessment (SFRA) update (January 2012).
- SFRA Level 2 Core Strategy Site Flood Risk Assessment (January 2012) – New Monks Farm
- SFRA Level 2 Core Strategy Site Flood Risk Assessment (January 2012) – New Monks Farm Extension

Note – The Core Strategy Site Flood Risk Assessments combined cover the entirety of the New Monks Farm Site

- Sequential and Exception Test for the Proposed Submission Adur Local Plan (March 2016)

Waterco Consultants have been instructed by CPRE Sussex Countryside Trust & Adur Flood Watch Group to:

1) **Flood Risk:** Advise on the adequacy of the above assessments to; support the site allocation within the Adur Local Plan; demonstrate compliance with National Planning Policy Framework (NPPF) (paragraph 102) and the Planning Practice Guidance (PPG): Flood Risk and Coastal Change.

2) **Drainage:** Analyse the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015) to assess whether it supports the findings of previous studies, namely the Ambiental Flood Risk Assessment Report (November 2014) which concludes that:

   'the sustainability of the infrastructure requirements of draining potentially hundreds of new homes, plus commercial space and associated roads and car parking into mains drainage may be questionable.'

3) Assess whether suitable analysis / works has been undertaken to conclude that: it is possible to mitigate the flood risk present to an acceptable level without compromising the viability of the scheme and without impacting on flood risk elsewhere.

This report is supported by a Groundwater Assessment undertaken by Stephen Buss Environmental Consulting Ltd (Document number: 2016-043-001-001 dated 28/04/2016).

Flood Risk

SFRA Core Strategy Site Flood Risk Assessments

The Core Strategy Site Flood Risk Assessments undertaken by JBA consulting as part of the Level 2 SFRA have been reviewed and a summary of findings is provided below:

Approximately 85% of the site is located within Flood Zone 3a on the Environment Agency Flood map for Planning (Rivers and Sea) – an area considered to be at high risk of tidal flooding with a 0.5% annual probability or greater of flooding in any given year.

Approximately 11% of the site is shown in Flood Zone 1, and therefore outside of the extreme 0.1% annual probability flood extent.

The existing tidal flood defences offer a standard of protection of less than 1 in 20 years. This means that the flood defences would be overtopped during tidal flood events with a 1 in 20 annual probability of occurrence or during more extreme events i.e. a 1 in 100 annual probability event. There are proposals to improve the tidal flood defences to offer a present day 1 in 200 years (0.5%) standard of protection. A residual risk of defence breach remains.

Significant tidal flood risk is estimated when accounting for climate change and wave overtopping. The entire site is shown at risk during the defended 0.5% annual probability event when applying climate change up to the years 2056, 2070 and 2115.

The SFRA states that the majority of the site is at low risk of surface water flooding, which is consistent with online Environment Agency surface water flood risk mapping. However localised areas of intermediate risk are shown adjacent to drainage channels (part of Lancing Brooks) and within the northern extent of the site.

The site is located within a 1km² grid cell that has a greater than 75% susceptibility to groundwater emergence.

Sequential and Exception Test for the Proposed Submission Adur Local Plan

The aim of the Sequential Test is to steer new development into areas with the lowest probability of flooding i.e. areas outside of the 0.1% annual probability.

Where the Sequential Test is passed, the Exception Test should be applied. As stated in Paragraph 102 of the NPPF, for the Exception Test to be passed:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and
- a site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The Sequential and Exception Test for the Proposed Submission Adur Local Plan (March 2016) document has been reviewed and a summary of findings is provided below:

In relation to flood risk the document states that 'although this site is partly located within Flood Zone 3a, it has passed the sequential test, due to a lack of available alternative sites within the district to meet housing needs which are not at risk of flooding. However, a site specific sequential test needs to be undertaken to ensure the most vulnerable uses are directed to areas at least risk of flooding'.

The document also states that new development on site will have to be designed to minimise flood risk without increasing it elsewhere and that It should also be noted that this site suffers from significant surface water and groundwater flooding issues.

In order to comply with Paragraph 102 of NPPF (the Exception Test), which states that development must be safe for its lifetime without increasing flood risk elsewhere, the document recommends a number of mitigation measures including:

Tidal flooding mitigation

- completion of the Adur Tidal Walls scheme
- develop the site in a sequential approach with the most vulnerable uses located in areas of lowest risk
- raise floor levels above the 1 in 200 year floor level for 2115 and / or
- raise land above the 1 in 200 year floor level for 2115
- provide emergency plans
- provide flood resilient construction

Surface water flooding mitigation

- develop a surface water drainage strategy using SuDS principles
- maintain overland flow routes
- ensure runoff rates from the new development are below that prior to development
- incorporate the recommendations of the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015)
- increase storage in the on-site ditch network
- safely manage rainfall events in excess of the 1 in 100 year plus climate change event.

Groundwater flooding mitigation

- provide engineering options to prevent interaction between the surface water or perched groundwater layer and the deeper groundwater associated with the chalk strata
- avoid infiltration
- provide additional capacity in the surface water system for additional flows from groundwater
- maintain existing capacity and conveyance between springs/groundwater and the ditch network.

Adequacy of Documents

The documents identify that the site is at risk of flooding and highlight the need to provide mitigation against the identified flood risk to ensure the development is safe for its lifetime. Currently 85% of the site is in a high risk tidal Flood Zone 3. The entire site is shown at risk of tidal flooding when accounting for climate change.

However, there is currently lack of detail given in regards to maximum on-site water levels and flood depths / velocities for the design tidal flood event (0.5% annual probability plus 100 years climate change allowance tidal flood event – including defence failure) in order to assess the viability of the mitigation measures.

The SFRA states that as part of the River Adur Tidal Walls modelling, the Tidal Walls will be constructed to a height of 4.84m AOD in the model for present day scenarios and an elevation of 5.53mAOD for scenarios beyond 50 years in the future. This indicates that extreme tide levels for the 0.5% annual probability tidal event when accounting for future climate change will be in the region of 5.5m AOD. A review of LiDAR levels indicates that a significant area of the site is situated below

3m AOD. Higher ground situated at approximately 4m AOD is located in the western extent. There is therefore potential for significant flood depths during the 0.5% annual probability plus 100 years climate change allowance tidal flood event.

The SFRA Core Strategy Site Flood Risk Assessments and 'Sequential and Exception Test for the Proposed Submission Adur Local Plan (March 2016)' state that the development should be resilient to future climate change and that floor raising and / or localised land raising above the 1 in 200 (0.5%) annual probability flood level for the year 2115 will be required to ensure the development is safe for its lifetime. Given the difference in potential extreme tidal levels and site levels, there may be limited scope to raise floor levels and significant land raising will be required. Land raising across a large extent of the site would likely lead to displacement of flood storage and increase in flood risk elsewhere.

Further Works in relation to flood risk

At this stage a study into the impacts and viability of the required mitigation measures (raising the development platform) should be undertaken.

The study should establish:

- Maximum water levels, flood depths, velocities and hazards for the 0.5% annual probability plus 100 years climate change allowance tidal flood event, including for a failure of flood defences;
- The risk from a number of combined flood drivers i.e. the risk from surface water flooding from local ditches (Lancing Brooks), when outfalls becomes tide locked, combined with groundwater flooding;
- Design levels i.e. required land heights to ensure development is above the 0.5% annual probability plus 100 years climate change allowance tidal flood event;
- Means of safe access / egress and flood risk along such routes;
- The hydrological impact of localised ground raising on the existing groundwater and surface water regime;
- The impact of localised ground raising on flood risk elsewhere including a strategy to compensate for any potential loss of flood storage.

The above works will also identify the land take required for flood compensatory storage and the remaining land available for development.

Drainage

CPRE Sussex Countryside Trust commissioned Ambiental Technical Solutions Limited to undertake a Flood Risk Assessment focusing on surface water and groundwater flooding. The report concluded that:

'the sustainability of the infrastructure requirements of draining potentially hundreds of new homes, plus commercial space and associated roads and car parking into mains drainage may be questionable.'

The West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015) (which covers the New Monks Farm development) has been undertaken to:

- confirm the catchment boundaries and comment on any differences with previous studies;
- gain a better understanding of the existing drainage network, connectivity, and ownership;
- understand the causes of flooding across Lancing from a range of sources including surface water, foul water, groundwater, watercourses, and tidal influence;
- understand the performance of the Lancing Brooks ditch network and identify how and when future maintenance of the ditches needs to be undertaken, and;
- identify any capital works required to mitigate flooding in Lancing

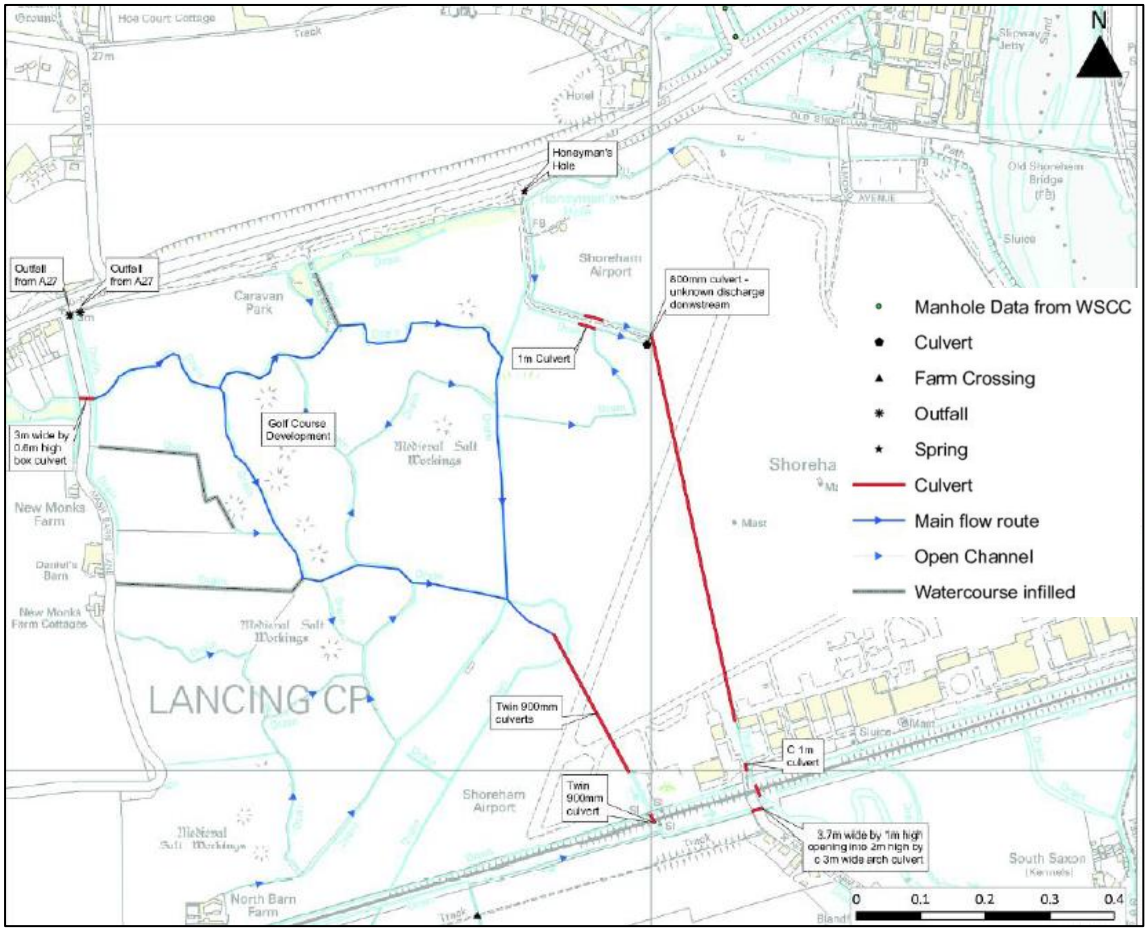
A review of the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015) has been undertaken to assess whether it supports the findings of the Ambiental Flood Risk Assessment. A summary of findings is provided below:

The majority of the catchment drains towards a series of ditches (part of Lancing Brooks) within the New Monks Farm site. There are formal outfalls into the ditches from surrounding urban areas, however it is understood that the majority of properties in the surrounding area are drained by soakaways. The ditches discharge into a twin 900mm culvert which flows south beneath the airport and railway line. There is also an 800mm culvert which flows south beneath the airport and railway line. This culvert accommodates surface water runoff from local ditches as well as a proportion of spring water from Honeyman's Hole spring.

South of the railway, flows are directed eastward and into the Tidal River Adur. Tidal sluice gates are shown on the outfall to the Adur. Outflow from Lancing Brooks is dependent on tide levels. Figure 2

below, extracted from the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015), shows the drainage regime for Lancing Brooks and New Monks Farm.

Figure 2 – Existing Drainage Regime



Localised issues with the foul drainage network have been identified, with groundwater ingress causing flooding.

Localised surface water flooding issues are also identified with the cause of flooding attributed to undersized drainage features (culverts and bridges causing throttle to flows), siltation of drainage ditches (Lancing Brooks), groundwater, and lack of maintenance (de-silting, clearing of drains and gullies and vegetation management).

A number of actions have been undertaken to alleviate flooding in the catchment. This includes:

- Clearance of Lancing Brooks (de-silting and vegetation clearance)
- Improvements (repairs, clearing and sealing) to the foul sewerage network
- Improvements to surface water drainage networks including; pipe clearing, de-silting of storage tanks, clearing of root infestation and repairs to the highway drainage system.

The West Sussex County Council Lancing Surface Water Management Plan Non Technical Summary (CH2M Hill) states that even with the mitigation measures in place, Lancing will still be at risk of flooding during more extreme weather events. This is because drainage systems (both natural and man-made) and any other flood risk infrastructure will become overwhelmed during extreme weather events.

Hydraulic modelling of Lancing Brooks has been undertaken to provide an overview of the conveyance of flows through the ditch system, and identify where there are pinch points in the system. The modelling found that:

- Silt build up within the ditch network greater than 150mm will cause significant impact on water levels.
- There is evidence of significant siltation or capacity constraints at several culverts, bridges and farm crossings
- Improvement works (maintenance and capital) to existing culverts significantly reduce the flood risk.

The report identifies a number of options to mitigate the flooding. Suggested mitigation measures include: upsizing of drainage features to provide additional attenuation and reduce any restriction to flows; and, frequent maintenance of drainage features (highway gullies & Lancing Brooks) including de-silting and vegetation clearance. Maintenance would be formalised through establishing a maintenance regime.

Adequacy of Documents

The West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015) sets out a strategy to mitigate an existing flooding issue. Mitigation measures to improve the drainage of Lancing Brooks are proposed. Regular maintenance of Lancing Brooks including de-silting and vegetation clearance is essential to minimise the flood risk.

The West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015) does not set out a strategy to accommodate future flows from major development. Surface water runoff from future development would need to be managed within the site through use of attenuation storage and flow control, ensuring no increase in off-site runoff rates. A detailed drainage strategy would be required in support of a planning application.

Further Works in relation to drainage

The following conclusion of the Ambiental Flood Risk Assessment is not intended to be addressed by the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015).

'the sustainability of the infrastructure requirements of draining potentially hundreds of new homes, plus commercial space and associated roads and car parking into mains drainage may be questionable'

Given the size of the development and issues identified within the foul drainage network by the West Sussex County Council Lancing Surface Water Management Plan (CH2M Hill, September 2015), it would be prudent to undertake an assessment of the capacity of the local sewerage infrastructure to accommodate a major development prior to allocation in the Adur Local Plan. The study, undertaken by / in conjunction with Southern Water should establish:

- The capacity of the existing sewer network
- The capacity of the existing waste water treatment works
- The works required to the existing sewerage network to accommodate a major development at New Monks Farm including costs and timescale for implementation.

Conclusions

From the EA mapping the majority of the New Monks Farm site is identified as being at significant risk from tidal flooding. The site is also identified at risk from surface water and groundwater sources. Both the SFRA and the Surface Water Management Plan acknowledge this.

The site has been assessed as having passed the NPPF Sequential Test, on the basis that there are no alternative sites in the area at lower flood risk which could accommodate a development of this size.

Further work is required to assess and determine the impacts of the proposed development on flood risk elsewhere. The principal mitigation measure proposed in the core strategy is land raising; but this could amount to raising levels by some 2-3 metres over the majority of the site area. The proposition that this can be done without affecting flood risk elsewhere has not been substantiated and may prove to be both impractical and unviable.

Further work also appears to be required to establish whether the existing sewerage network can accommodate the development, or if infrastructure upgrades are required. Any potential infrastructure upgrades may be of significant scale to accommodate a development of 600 dwellings and may impact of development timescales.

The assessments, as presently offered, appear to be incomplete and inadequate and do not provide a sufficiently robust basis for supporting the site allocation within the Adur Local Plan.

Stephen Buss
Environmental Consulting Ltd

Further comment on groundwater flooding within the Adur Local Plan area

Version control log

Document number	Date	Issued by	Issued to	Comments
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Client: WaterCo Consultants Ltd

Dated: May 2016

www.hydro-geology.co.uk

71 Canon Street, Shrewsbury SY2 5HH

Registered in England and Wales number 08595273

DISCLAIMER

This report has been prepared by Stephen Buss Environmental Consulting Ltd (SBEC) in its professional capacity as hydrogeologist, in a manner consistent with the level of care and skill ordinarily exercised by members of the geological and engineering professions practising at this time, within the agreed scope and terms of contract, and taking account of the manpower and resources devoted to it by agreement with its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole. As with any environmental appraisal or investigation, the conclusions and observations are based on limited data. The risk of undiscovered environmental impairment of the property cannot be ruled out. SBEC cannot therefore warrant the actual conditions at the site and advice given is limited to those conditions for which information is held by SBEC at the time. The findings are based on the information made available to SBEC at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time.

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The findings do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

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1. Introduction

1.1 Project Background

Major site allocations have been proposed in the Adur Local Plan (consultation draft). There are local concerns that surface and groundwater flooding has not been adequately taken into account by the Council and that the key strategic sites at New Monks Farm, land west of Sompting, and Shoreham Airport are therefore not demonstrably deliverable.

Stephen Buss Environmental Consulting Ltd (SBEC) was previously instructed by Ambiental Technical Solutions Ltd, on behalf of the Campaign to Protect Rural England (CPRE) to review evidence made available in November 2014, to prepare an overview of the sensitivity of the location with respect to groundwater flooding, and to identify any omissions from the Adur Local Plan and its supporting documents. A review of the findings of that report is given in Section 1.2 below.

New supporting material has since been submitted to CPRE, in particular:

- Interpretative Hydrogeological Report on Groundwater Levels and Influencing Factors for New Monks Farm Developments Ltd[1] (Capita Symonds, April 2014), and,
- West Sussex County Council Lancing Surface Water Management Plan[2] (CH2M Hill, September 2015).

SBEC was therefore instructed in April 2016 by WaterCo Consultants Ltd, on behalf of CPRE again, to review the former document and make comment on any hydrogeological aspects raised in the latter.

This report has been prepared by Dr Stephen Buss MA MSc CGeol. Dr Buss is a UK-based independent hydrogeologist with more than 15 years' consulting experience in solving groundwater issues for the Environment Agency, water companies and other private sector organisations. Dr Buss's CV and publications list is available at www.hydro-geology.co.uk.

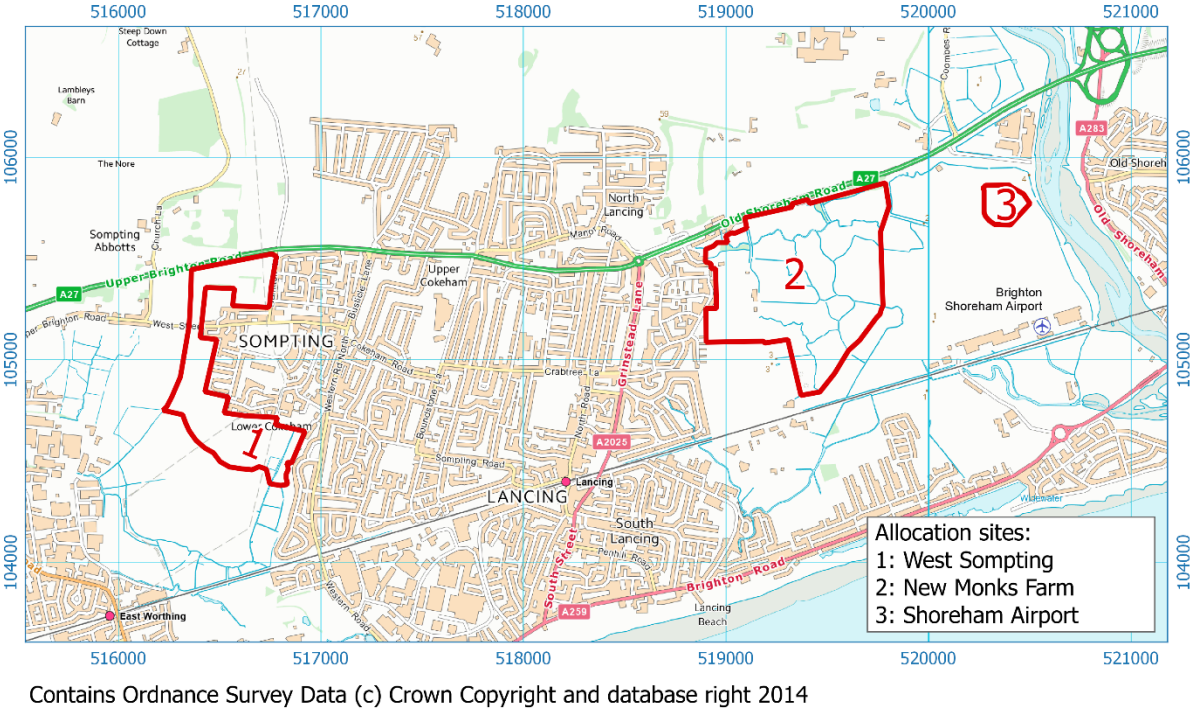
Disclaimer: Dr Buss has in the past worked with Trevor Muten, who was checker for Capita Symonds (2014) interpretative hydrogeological report for New Monks Farm; and with hydrogeology specialists at CH2MHill who will have had input to the Lancing SWMP (CH2MHill, 2015). Dr Buss is currently a technical advisor to CH2MHill on a groundwater model of the Oxford flood plain. No conflict of interest is perceived.

[1] http://www.adur-worthing.gov.uk/media/media,130203,en.pdf
[2] https://www.westsussex.gov.uk/media/6139/lancing_swmp_final_technical_report.pdf

1.2 Previous Findings

Context

The Adur Local Plan[3] identifies three greenfield sites for development: New Monks Farm, land west of Sompting, and Shoreham Airport (Figure 1.1).



Contains Ordnance Survey Data (c) Crown Copyright and database right 2014

Figure 1.1 Allocation areas

Historical groundwater flooding events are mapped in the Strategic Flood Risk Assessment (SFRA)[4]. A handful of events are mapped around the headwaters of the Teville Stream just outside of the West Sompting allocated area. However, there is more information on groundwater flooding in the New Monks Farm area, in the Sequential and Exception Test document[5], which states that, '…this site suffers from significant surface water and groundwater flooding issues. These issues have been investigated further by the developer and the draft interim conclusions indicate that these issues can be mitigated. These draft conclusions have also been agreed by West Sussex County Council as the Local Lead Flood Authority'. This investigation was not seen by SBEC at the time of preparation of the review report (in late 2014), but this has been reviewed for the present study (Section 2.1).

Physical setting

All three sites lie on the coastal plain south of the South Downs, either side of the town of Sompting. The plain is low lying and, other than a small area of the West Sompting site, the elevation of the sites is less than 10 m above Ordnance Datum (AOD). Local hydrology (Figure 1.2) is dominated by the tidal River Adur, to the east of the sites, and the proximity to the coast. Shoreham Airport is in the functional floodplain of the River Adur. New Monks Farm is also within the flood plain area of the River Adur but actually comprises the extensively-drained catchment of the Willow Brook which flows through South Lancing (depth of the drains is indicated well in the terrain map above). West Sompting is in the upper catchment of the Teville Stream, which separates East Worthing and Lancing.

[3] www.adur-worthing.gov.uk/adur-local-plan-2014/
[4] www.adur-worthing.gov.uk/media/media,87182,en.pdf
[5] www.adur-worthing.gov.uk/media/media,127799,en.pdf

Bedrock geology at all three sites comprises Chalk (Figure 1.2), which is a very permeable rock and forms the principal groundwater supply for Southern and South East England. West of Sompting the Chalk is overlain by Head, which is a superficial deposit comprising mixed sand, silt and clay that develops from sub-aerial weathering of the hills that for the South Downs. East of Lancing the Chalk is overlain by alluvium. This is, again, a mixed sand, silt and clay deposit, which forms by deposition from rivers. Extensive drainage in the Willow Brook catchment suggests that the alluvium has in places rather low permeability.

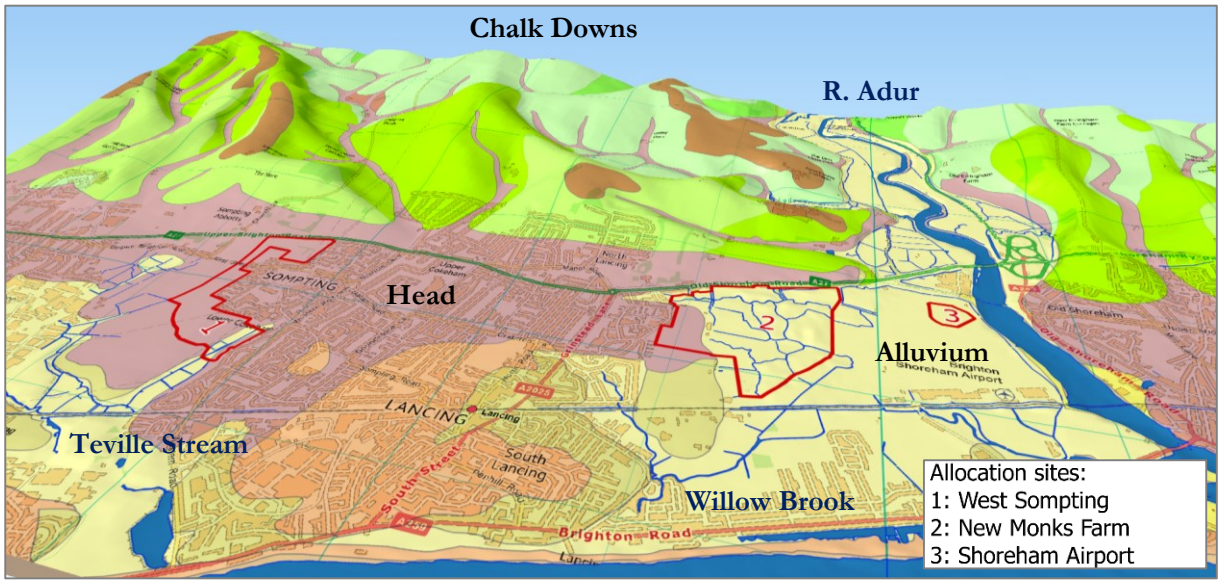


Figure 1.2 Geology and hydrology (2.5 x vertical exaggeration)

Hydrogeology

The conceptual model presented for the Lancing Surface Water Management Plan (CH2MHill, 2015) is a good cross-section of the site geology (Figure 1.3). This shows groundwater moving southwards from the topographic high of the South Downs, underneath the low permeability sediments of the coastal plain. Springs emerge at the position where the chalk outcrop dips under the superficial sediments (Honeymans Hole Spring here) and at any location where there is a permeable pathway out to the coast.

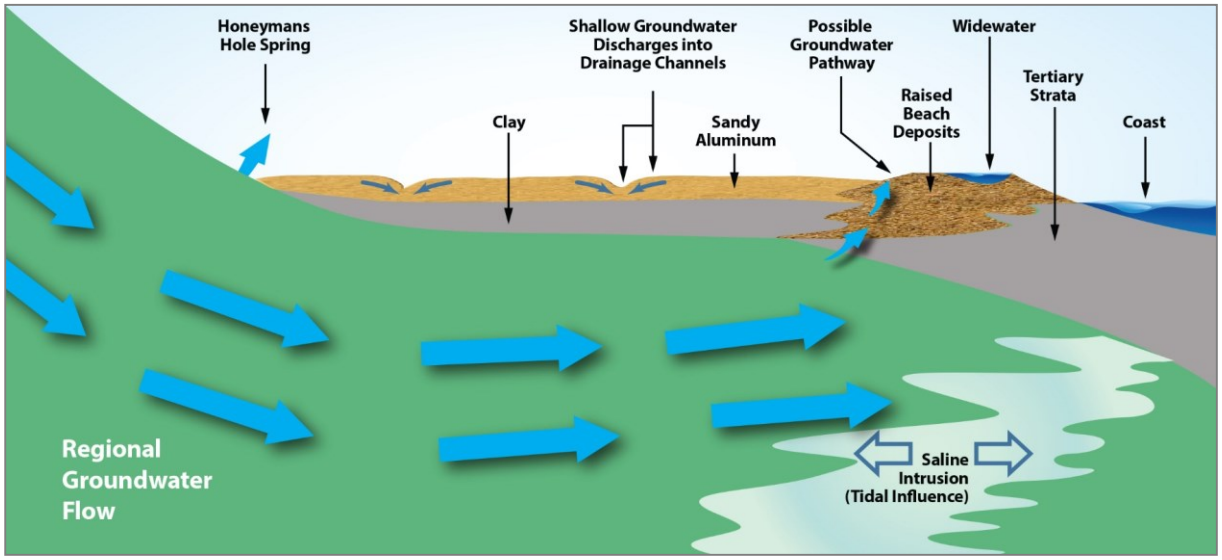


Figure 1.3 Schematic north-south cross-section of site geology

Conclusions

There is a spring line at the foot of the South Downs, where the Chalk aquifer dips below a cover of low permeability superficial deposits. There is firm evidence of groundwater emergence along this geological boundary (roughly along the route of the A27). Emergence of groundwater here already causes local flooding issues. Superficial deposits communicate tidal and river levels inland from the water bodies. In this environment, where river, coastal, surface water and groundwater flooding interact it is essential to develop a firm understanding of the inter-dependencies.

Up to November 2014 it appeared that modelling and strategic flood risk assessments take into account each flood mechanism as an isolated event. Convergence of several flood drivers (e.g. high groundwater levels plus high rainfall) may combine to cause unanticipated levels of flooding. Review of the developer's investigation on surface water and groundwater flooding at New Monks Farm site (which was not seen at that stage) was required to better understand the work that has already been done.

It was clear that most if not all of the allocated areas are going to be unsuitable for infiltration SUDS and all developments will need to use attenuation SUDS or be connected to mains drainage.

2. Review of New Supporting Material

2.1 Interpretative Hydrogeological Report… for New Monks Farm (Capita Symonds, 2014)

Ten pairs of shallow and deep boreholes were installed within the area of the New Monks Farm development. Shallow boreholes targeted groundwater in superficial deposits, and the deep boreholes targeted groundwater levels in the underlying chalk aquifer. Several stream stage monitoring points were also established within and around the development area. The monitoring period (February to March 2014) was relatively short but serendipitously that period followed extremely high, and long duration, rainfall; at that time groundwater flooding was experienced in North Lancing and across southern England.

It was found that groundwater flooding did not happen within the development area during early 2014 despite the extreme rainfall, and instances elsewhere on the South Coast. There was groundwater flooding and a risk of sewer flooding in North Lancing close to the A27. This excess water was pumped into the surface water drainage to discharge via the Lancing Brooks to the River Adur or the sea. (This was repeated in winter 2015/16 – Bill Freeman pers. comm.)

The key finding of the study was that the chalk and superficial aquifers do not exchange significant amounts of groundwater. This was based on groundwater level data only, not on an assessment of water fluxes in and out of the system (i.e. a water balance), which is important: strong control of superficial groundwater levels by the surface water drainage system may mask effects that arise from weaker control by chalk heads. Nevertheless, borehole logs consistently record a layer of low permeability deposits between the chalk and the near-surface superficial deposits, so the inference of limited groundwater exchange is likely to be sound.

There were two key recommendations from the study.

- Developers must preserve the surface water drainage capacity within the development site. The report cites tidal flows, perched groundwater storage, discharge from groundwater springs, and pumping from outside the catchment as additional sources of water to the drains.
- Developers must not breach the sealing layer of low permeability deposits that confine the chalk aquifer. This prevents artesian groundwater from the chalk rising into the drainage system during periods of high groundwater levels, and also prevents contamination of the drinking water resource during periods of low groundwater levels.

2.2 Lancing Surface Water Management Plan (CH2MHill, 2015)

The Lancing SWMP (CH2MHill, 2015) properly recognises the importance of groundwater to the hydrological system and goes into depth explaining the process of groundwater flooding and its incidence in the area. The study area of CH2MHill (2015) does not include the Shoreham airport or West Sompting allocation sites.

Section 2.3.3 of CH2MHill (2015) reviews the interpretative hydrogeological report for New Monks Farm (Capita Symonds, 2014). (And it includes a slightly more detailed summary than is provided above.) The findings of Capita Symonds (2014) are not contradicted by the findings of the CH2MHill (2015).

Section 5.2 of CH2MHill (2015) describes the processes of drainage via Lancing Brooks, which is the area to be partly occupied by any development at New Monks Farm. Section 6 describes a hydraulic modelling study of the Lancing Brooks. The purpose of the model was to understand conveyance, so flows were not based on detailed rainfall-runoff calculations undertaken for the study area, but were based on flow estimates for 1 in 10 and 1 in 100 year storms from a 1994 study by Monson Engineering[6] (which has not been reviewed for this study).

[6] Monson Engineering, 1994. Report on the Survey and Hydraulic Analysis of Lancing Drainage Ditches

One of the two key lessons from Capita Symonds (2014) was that flow into the Lancing Brooks arises from multiple sources as well as runoff: shallow groundwater, chalk groundwater, and pumping from outside the catchment. These are not likely to have been accounted for in the estimated flows from the Monson Engineering (1994) report (though tidal locking was considered) so the flows given for storms with specific return periods may be underestimated.

For instance if the design 1 in 100 year storm had occurred during February 2014, coincident with high chalk spring discharges into the Lancing Brooks catchment and pumping to reduce risk of sewer flooding in North Lancing, total flows in Lancing Brook would have been rather higher than anticipated from the rainfall alone. In effect (and using estimated return periods for illustration only) the 1 in 100 year storm may have given rise to, say, 1 in 200 year flows.

This does not invalidate the findings of the CH2MHill (2015) modelling, because the flow rates used were not critical to the aims of the study. However, it illustrates how the external water inputs identified by Capita Symonds (2014) can be overlooked in modelling studies.

As a result of the modelling a number of recommendations are made for improving the conveyance of water through the Lancing Brooks catchment.

3. Conclusions and Recommendations

3.1 Conclusions

Two documents have been reviewed that have been released since the compilation by SBEC (2014) of a review of the three proposed major site allocations in the Adur Local Plan.

The interpretative hydrogeological report for New Monks Farm (Capita Symonds, 2014) reports on a study from borehole data at the New Monks Farm site over a limited time during which there was, serendipitously, considerable rainfall. No groundwater flooding was observed at the site and there were no indications that it would be imminent. The hydrogeology of the site is well characterised except that a water balance is omitted; a water balance with the available data would be very difficult to quantify with certainty, so it is not an omission (though it would help if the limitations that prevent development of a water balance were presented).

The two key recommendations from the Capita Symonds (2014) study were sensible. Firstly, developers must preserve the surface water drainage capacity within the development site. The report cites tidal flows, perched groundwater storage, discharge from groundwater springs, and pumping from outside the catchment as additional sources of water to the drains. Secondly, developers must not breach the sealing layer of low permeability deposits that confine the chalk aquifer. This prevents artesian groundwater from the chalk rising into the drainage system during periods of high groundwater levels, and also prevents contamination of the drinking water resource during periods of low groundwater levels.

The Lancing Surface Water Management Plan (CH2MHill, 2015) goes into more depth on groundwater than is usual in a SWMP, which is appropriate given the importance of groundwater to flooding in the area. Findings of CH2MHill (2015) do not contradict the findings of the interpretative hydrogeological report for New Monks Farm (Capita Symonds, 2014). The conclusions of CH2MHill (2015) do not appear to bear influence on the specific proposals for development at New Monks Farm.

3.2 Recommendations

Recommendations from Capita Symonds (2014) are supported by the evidence reviewed in this report and the previous one by SBEC (2014). Flows in the Lancing Brooks are not just a result of rainfall-runoff or of groundwater alone. Therefore traditional rainfall-runoff modelling would tend to underestimate flows in the ditches for a given return period.

Any flood risk modelling submitted for the New Monks Farm development must take account of groundwater discharge and emergency pumping of water from outside the catchment, as well as rainfall-runoff, when estimating discharge capacities. This is a key part of ensuring that, post-development, the developers preserve the surface water drainage capacity within the development site. Discharge locations and rates for these external inputs to the drainage system should be proposed based on the findings of Capita Symonds (2014) and of CH2MHill (2015).

The second recommendation of Capita Symonds (2014) was that developers must not breach the sealing layer of low permeability deposits that confine the chalk aquifer. This is considered appropriate.

To clarify a recommendation made in the previous report written by SBEC (2014), it is clear that most if not all of the allocated areas are going to be unsuitable for infiltration SUDS and developments will need to be connected to attenuation SUDS or to mains drainage. The design discharge rate for attenuation SUDS must take into account the possible presence of other sources of water in the receiving watercourses.

To summarise, there appears to be no reason to prevent development at the New Monks Farm site on the basis of risk of groundwater flooding alone. Appropriate drainage works will be able to convey water away from the site. However, the applicants must robustly demonstrate that all contributions to flooding have been considered when devising flood management.

Final Technical Report

Lancing Surface Water Management Plan

Prepared for

West Sussex County Council

September 2015

ch2m:
Burderop Park
Swindon, Wiltshire
SN4 0QD

Contents

Acronyms and Abbreviations

BH	Borehole
BHAFC	Brighton and Hove Albion Football Club
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EAP	Emergency Action Plan
FEH	Flood Estimation Handbook
FCRM GiA	Flood and Coastal Erosion Risk Management Grant in Aid
FRA	Flood Risk Assessment
GIS	Geographic Information System (ArcGIS used in this study)
IRP	Infiltration Reduction Plan
LIDAR	Light Detection and Ranging
LFRMS	Local Flood Risk Management Strategy
mAOD	metres Above Ordnance Datum
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SW	Southern Water
SWMP	Surface Water Management Plan
WSCC	West Sussex County Council
1D	One Dimensional (hydraulic model)

Introduction

1.1 Project context

Lancing Surface Water Management Plan (SWMP) has been undertaken as part of a commission to develop SWMPs for five areas of West Sussex which have a history of significant flooding from surface water, groundwater and drainage systems. The five study areas were:

- Easebourne;
- Lancing;
- Manhood Peninsula;
- Upper Lavant Valley, and;
- West Chichester, including Fishbourne and Parklands.

These areas were selected as part of West Sussex County Council's (WSCC) response to the severe flooding in the summer of 2012, known as Operation Watershed[1], although it is recognised that many of these areas have suffered flooding on multiple occasions.

A SWMP is described as a framework through which key local partners with a responsibility for surface water and drainage in their area work together to understand the causes of surface water flooding and agree the most cost effective way of managing that risk. The purpose is to make sustainable surface water management decisions that are evidence based, risk based, future proofed and inclusive of stakeholder views. Managing surface water flooding requires a range of partners, organisations and individuals to work together. The roles and responsibilities for those involved in helping to manage surface water flooding are described in Appendix A.

1.2 Background to Lancing SWMP

Lancing is an area which is exposed to flooding from a range of sources including pluvial, overtopping of watercourses (including the River Adur), sewers, and groundwater. In addition, there are tidal influences within the catchment which affect discharge from the Lancing Brooks and discharge of regional groundwater to the sea. Due to the relatively flat gradient within the system and the influence of groundwater on flooding, Lancing is particularly vulnerable to flooding during winter months. Flooding is generally confined to highways and gardens, and there are few properties which flood internally. Nevertheless, given the complexities of flooding mechanisms in Lancing this SWMP has been undertaken to understand the causes of flooding and identify any capital improvements or ongoing maintenance needed to reduce the impacts of flooding to people and infrastructure.

1.2.1 Objectives

The primary objectives of the Lancing SWMP were to:

- confirm the catchment boundaries and comment on any differences with previous studies;
- gain a better understanding of the existing drainage network, connectivity, and ownership;
- understand the causes of flooding across Lancing from a range of sources including surface water, foul water, groundwater, watercourses, and tidal influence;
- understand the performance of the Lancing Brooks ditch network and identify how and when future maintenance of the ditches needs to be undertaken, and;
- identify any capital works required to mitigate flooding in Lancing.

1.2.2 Scope

The scope for this SWMP was established during the early part of the overall project programme through discussions with WSCC, a rapid assessment of available data, and early establishment of the flooding issues and mechanisms. A scoping document was prepared in March 2014 and agreed by WSCC. The scope is outlined in detail below. It should be noted that the scope of work broadly follows the SWMP

[1] For more information on Operation Watershed see: http://www.westsussex.gov.uk/default.aspx?page=36724

Technical Guidance published by Defra in 2010, ensuring the work was aligned with the national best practice. The SWMP Technical Guidance describes a four step process, as outlined in Figure 1-1.

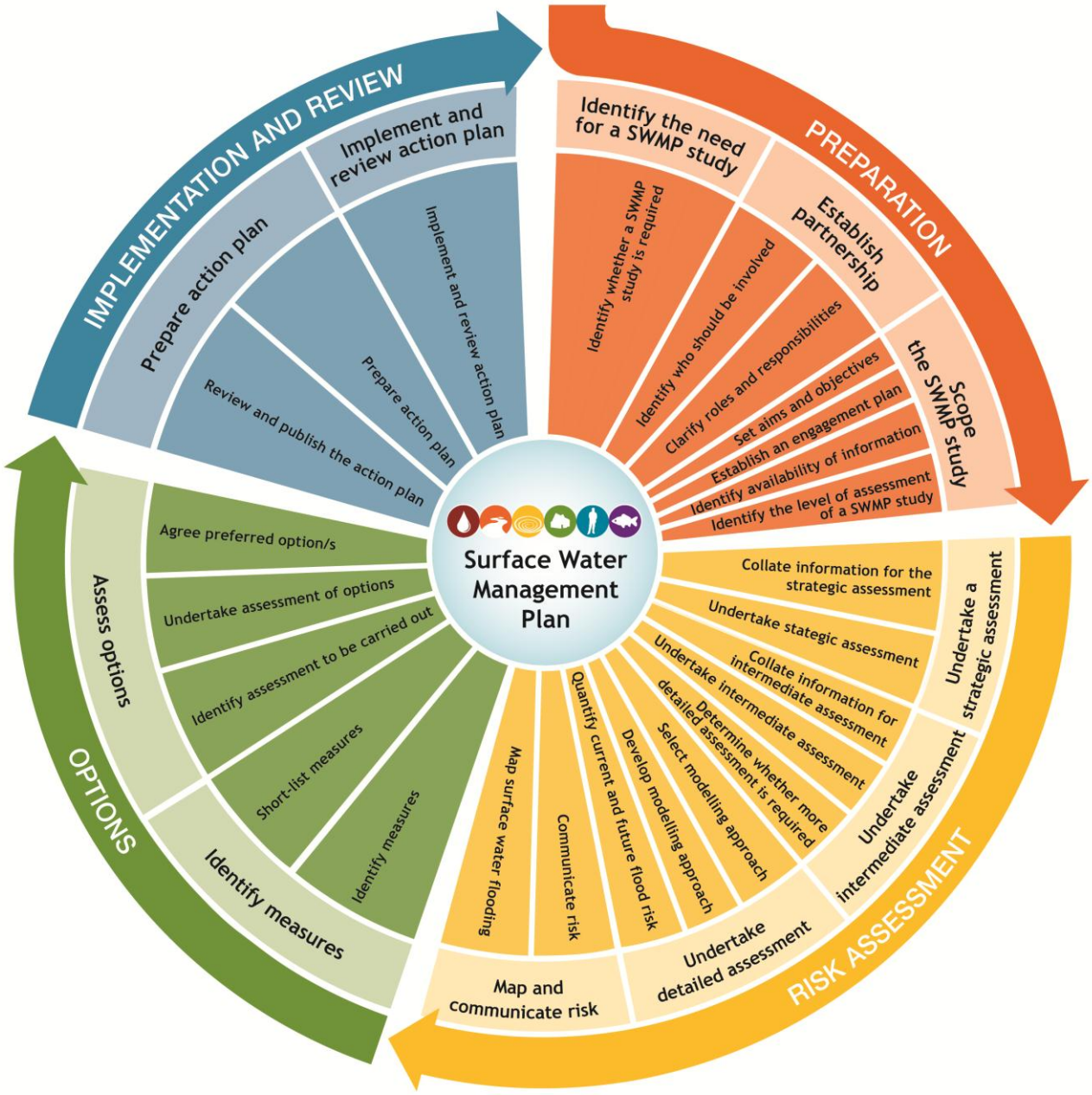


Figure 1-1 SWMP Process

Stage 1 – Data collection & review

Stage 1 consisted of data collection, compilation, and review. This included collecting and compiling flood incident data, obtaining third party data sets (e.g. Southern Water, WSCC, Highways Agency, Shoreham Airport drainage data, and any borehole data), and reviewing existing studies and reports relevant to Lancing (e.g. Monson Engineering study, Royal Haskoning study). During this stage, the extent of the drainage catchment was established.

Stage 2 – Understanding the water balance of the system

To investigate the capacity of the drainage networks, it is important to understand the magnitude of flows arising from the catchment. A conceptual hydrological and hydro-geological analysis was undertaken to understand the inflows and outflows from the drainage system and possible conveyance measures in “pinch point” locations.

Stage 3 – Undertake surveys

Following data review and site specific investigation, surveys were undertaken in key areas of Lancing, including:

- walkover and connectivity surveys in October 2014;
- cross-section survey of the entire ditch network in December 2014 and January 2015, and;
- limited manhole and level survey in West Beach Estate in March 2015 and April 2015.

Analysis undertaken during the first three stages was used to establish a comprehensive understanding of the causes and effects of flooding in Lancing.

Stage 4 – Identify options to mitigate flooding

The final stage of the study identified proportionate and cost effective mitigation measures to alleviate flooding in Lancing. It included a water level management plan, which included operational rules for ditch clearances, dredging, vegetation management and future maintenance recommendations.

1.2.3 Study area

The study area covers the entire catchment from the west which drains towards the Lancing Brooks. The most northerly location of the study area is the open space to the north of Firle Road (in North Lancing). To the east the River Adur forms a natural catchment boundary and the Lancing Brooks discharge into the Adur. To the south the sea forms another natural catchment boundary. A map of the study area is provided in Figure 3-1 and Appendix B.

1.2.4 Key stakeholders

A stakeholder engagement strategy was prepared which identified who to engage with, when, and how. Stakeholder engagement is an important part of the overall approach to the development of the Surface Water Management Plan and is integral to the agreed methodology for the study as a whole. The approach aimed to ensure that professional stakeholders, landowners, parish councils and other relevant groups were given an opportunity to help shape the study. Engagement, in different forms, was undertaken throughout the study to:

- ensure the study was robust and that the data used to underpin it were as accurate as possible
- ensure that best use is made of local knowledge and that the analysis of flood risk matches local experience;
- ensure the study addresses the key problems that are of the most concern to local communities;
- generate greater understanding about, and support for, the way in which local flooding will be managed, and;
- help to encourage stakeholders and the general public to take actions to help protect themselves against flooding.

The key stakeholders identified for this SWMP are:

- West Sussex County Council as the Lead Local Flood Authority and Highways Authority;
- Adur and Worthing Councils as the Land Drainage Authority and Local Planning Authority;
- The Environment Agency in relation to springs and groundwater issues in the catchment;
- Riparian owners and local flood action groups particularly at Mash Barn Lane, Manor Close (known as the Lancing Manor (S.E) Residents Network) and West Beach and Widewater;
- Shoreham airport;
- Highways England, and;
- Southern Water as the statutory sewerage undertaker.

A list of engagement activities undertaken during the Lancing SWMP are described in Table 1-1.

Table 1-1 Engagement activities for Lancing SWMP

Activity	**Purpose/Detail**	**Timescale**
Initial meeting with WSCC and Adur and Worthing Councils	To agree the scope of the work	March 2014
Technical discussions with WSCC	To understand the function of the highways drainage system	Throughout study
Technical discussions with representatives from Adur and Worthing Councils	To understand local land drainage constraints	Throughout study
Technical discussions with Environment Agency Staff	To understand groundwater issues, and ongoing capital/maintenance work in the catchment	Throughout study
Engagement with Southern Water	To understand operational issues in the foul sewer network due to infiltration, actions taken over the recent wet winters, and future plans to manage infiltration	Throughout study
Meeting with local representatives	To understand local flooding issues and gain an insight into current measures being taken to alleviate flooding	October 2014
Attendance and presentation at Adur Floodwatch event	To give an overview of the SWMP to the Adur Floodwatch event and seek feedback on local flooding issues	October 2014
Walkover survey and site visits (with representatives from Adur and Worthing Councils)	To understand the catchment flows and local issues	October 2014
Discussions with local representatives	To gain a continued understanding of flooding issues throughout the study	Throughout study

SECTION 2

Review of existing data, studies and actions

2.1 Data collected for SWMP

2.1.1 Data collected for SWMP

A summary and analysis of the data received for the Lancing SWMP is provided in Table 2-1. It includes a summary of data quality issues.

SECTION 2

Table 2-1 Data received for Lancing SWMP

Dataset	Data received from	Comments	Data Quality Issues
Common data received across all five study areas			
Bedrock and Superficial Geology	British Geological Society	Maps of the bedrock and superficial geology	-
Digital Terrain Model (DTM)	EA	This is a model of the ground surface, used by the Environment Agency for their national surface water mapping	The data is a composite of LiDAR and NextMap. The NextMap has a much lower accuracy which makes it less reliable as a data source
Flooded Properties Register (DG5)	Southern Water	This is the register of flooded properties held by Southern Water which are the result if hydraulic capacity issues in the public sewer network	-
Flood Map for Planning	EA	National fluvial flood map provided by the EA	Only shows flooding from watercourses where the upstream catchment is >3km^2
Flood Map for Surface Water	EA	National surface water flood mapping provided by the EA for the 1 in 30 year, 1 in 100 year and 1 in 1000 year rainfall probability events	This is the most comprehensive surface water mapping available, but given the mapping is at a national scale there are a number of generic assumptions which may not be locally relevant.
Groundwater Susceptibility Mapping	WSCC	A groundwater flood risk map provided by WSCC, dividing areas into low, moderate and high groundwater flood risk	
Highway drainage data	WSCC	Details of the public highway network	This dataset only contains the location of highway gullies, but does not include details of the pipework
Historic Flood Outlines	EA	Recorded flood outlines from fluvial flooding collated by the EA	
Historic flooded properties	WSCC	A point dataset showing the location of flooded properties	Known limitations with this dataset, as there are many properties not recorded on this dataset which have flooded. The data goes back to 2012
Historic flooded roads	WSCC	A point dataset showing the location of flooded roads	Known limitations with this dataset, as there are many roads not recorded on this dataset which have flooded. The data goes back to 2012
June 2012 Flood Investigation	WSCC	Investigation into June/July 2012 flooding incidents across West Sussex	-

Local Flood Risk Management Strategy	WSCC	A statutory document produced by WSCC as part of their responsibility as a LLFA	-
National Receptor Dataset	EA	Provides location and details of residential, non-residential properties, and critical infrastructure	-
Operation Watershed details	WSCC	Details of the schemes completed or ongoing as part of Operation Watershed	-
Public Sewer Network data	Southern Water	Location, connectivity and details of the public sewer network	Asset details of the surface water sewer system are generally of poorer quality than for the foul or combined system
River network	EA	Location of watercourses	This is a national dataset and there are some assumptions about the routes of watercourses, especially where watercourses go into culverted sections
Data received bespoke to Lancing SWMP			
A27 design drawings	Highways Agency	Design drawings from improvement works on A27	Thought to be missing 1 x outfall from the A27
Brighton and Hove Albion Planning Information	Adur and Worthing Councils	Borehole report and drainage design	-
Borehole information	Environment Agency	Borehole information for Daniels Barn and Sussex Pad	No data available for Daniels Barn since 2010
DG5 Register	Southern Water	Details of the foul flooding in Lancing	-
Evidence from local residents	Local residents	Information on flooding locations and times from local residents. Included pictures and videos where relevant	-
Golf course planning application	Local residents	Details on the planning application for the golf course development	
Haskoning Study	Adur and Worthing Councils	Royal Haskoning Study on Lancing Brooks	-
Historic Maps and books	Various	Range of historic maps and historical information about Lancing	-
Lancing Brook Outfalls	Halcrow	Information on the hydrology, modelling and design for the re-design of the Lancing Brook Outfalls	-

Monson Report	Adur and Worthing Councils	1994 Monson Report into the Lancing Brooks, including recommendations about future capital and maintenance needs	-
Network Rail Culverts	Network Rail	Details of Network Rail culverts in the study area	-
New Monks Farm hydro-geology report	WSCC	Report for New Monks Farm development on Hydro-geology of proposed development	-
Rainfall data	Environment Agency / WSCC	Rainfall data from Applesham Farm, and Skyview dataset	-
Shoreham Airport drainage	Adur and Worthing Councils	Details of drainage at Shoreham Airport	-
Surveys from WSCC	WSCC	WSCC surveys of West Beach/Widewater and Manor Way	-
Tidal data	-	Tide levels at Shoreham	-
Watercourse clearance details	Adur and Worthing Councils	Details on the Lancing Brooks ditch clearance undertaken by Adur and Worthing District Councils (2010-2014)	-
West Beach survey	WSCC	A survey of roads levels on West Beach Estate, using temporary benchmark datum	
Widewater	WSCC	Information on the operation and monitoring of Widewater Lagoon	-

SECTION 2

2.2 Existing studies

2.2.1 Strategic Flood Risk Assessment

An update of the Strategic Flood Risk Assessment (SFRA) was produced by Adur and Worthing Councils in January 2012, and is available via the following link:

http://www.adur-worthing.gov.uk/planning-policy/adur-and-worthing-background-studies-and-info/floodrisk/#sfra.

The SFRA provides an overview of all sources of flood risk including fluvial, tidal, surface water, groundwater and sewer flooding. It also summarises the key flood risk issues for all development sites identified in the Core Strategy (e.g. Shoreham Airport).

Relevant extracts from the SFRA are provided in Table 2-2. The SFRA identifies Lancing as being at risk from tidal, surface water, groundwater and sewer flooding. The findings of the SFRA must be considered in the context of other local investigations (e.g. New Monks Farm hydrogeological investigations which is described in Section 2.3.3) and actions already taken by relevant organisations to reduce flood risk (see Section 2.4).

Table 2-2 Extracts from SFRA relevant to Lancing

Source of flood risk	Extract from SFRA
Tidal	"In Adur, the tidal flood zones are more extensive, covering parts of South Lancing, Shoreham by Sea, Shoreham Harbour and Shoreham Airport. The tidal flood zones continue north of the A27 along the River Adur." With respect to Shoreham Airport: "The Adur Tidal Walls scheme will improve the defences along the west bank and the standard of protection afforded to the area. Following construction the area will no longer be inundated during the 1 in 20-year flood event, the extent of the area no longer inundated is shown in Map 17. Consequently, in the future it will be appropriate for this area to be considered non-functional and will lead to the redefinition of Flood Zone 3b. It is understood that the impact of the scheme on flood risk on the east bank will be mitigated through local improvements to the east bank defences." With respect to the new Adur Tidal Walls: "From information provided during the preparation of this SFRA it is suggested that the SoP of these defences will decrease under the impacts of climate change with some inundation of the floodplain behind the defences expected in a future (2115) 1 in 200 year return period event."
Surface water	"The area to the south of the A27 is affected by surface water ponding along roads and streets. The significant areas include, immediately south of the Old Shoreham Road in North Lancing…" "The Lancing Brook Flood Investigation report (2010) also assessed the potential consequences of flooding from surface water sources in the Lancing area. The areas at shown to be at risk in the Lancing Brook study largely agreed with the area identified in the FMfSW. The receptors that were highlighted as having experienced flooding were mainly agricultural and scrub land, local residential roads and the gardens of a small number of residential properties. However, it was highlighted that anticipated changes in climate may increase the risk of localised flooding and may increase the flood risk to Shoreham Dogs Trust and several residential properties. An update to this report stated that the cause of flooding referred to in the report was identified during dredging to be a

	manmade dam immediately east of the northeast property in Willowbrook Park, which was erected to hold water in the ditches of Willowbrook Park as a water feature and as a consequence raised water levels considerably upstream."
Groundwater	"The majority of Adur District is susceptible to groundwater flooding. The only areas that don't appear to be susceptible to groundwater flooding are the north west and north east parts of the district which are mainly rural. The central area of the district between the A27 and to Shoreham-by-Sea is more susceptible to groundwater flooding with a high-risk category (>=75%); the rest of the area is covered by a range of risk categories (< 25% to <75%)."
Sewer	"There have been recorded incidences of sewer flooding in Adur and Worthing. The lack of any significant gradient in the low-lying coastal areas means that sewer networks often rely on pumping to drive flow. Consequently, failure of pumping stations can lead to rapid sewer flooding."

2.2.2 Local Flood Risk Management Strategy

Under the Flood and Water Management Act (2010) WSCC is required to develop, maintain, apply and monitor a Local Flood Risk Management Strategy (LFRMS) for the county. The LFRMS sets out WSCC's objectives for managing flood risk from surface water, ordinary watercourses and groundwater, an understanding of the current level of flood risk, roles and responsibilities of organisations, and the actions required to manage flood risk from surface water, ordinary watercourses and groundwater. The LFRMS has identified that over 100,000 properties are in areas susceptible to flood risk within the county.

The LFRMS has identified Lancing as one of the area's most susceptible to surface water flooding. It also recognises the vulnerability of North Lancing to groundwater flooding. The LFRMS action plan identifies a series of actions in Lancing, including the need for a Surface Water Management Plan in North Lancing.

A full copy of the LFRMS is available via WSCC's website: https://www.westsussex.gov.uk/media/1595/local_flood_risk_management_strategy.pdf.

2.2.3 Monson Engineering study

The Monson Engineering study was prepared in 1994 for Adur District Council. The study included cross-sections of the drainage ditches to establish the hydraulic capacity of the system and to identify local options to reduce flood risk. Cross-sections of the drainage ditches were taken every 100m or where there were changes in cross-sections[2]. Furthermore spot levels of land were taken 30m either side of ditch centre lines. Subsequently the report calculated inflows and outflows from the system to understand the water balance and hydraulic capacity of the network. Key findings from the study are:

- the outfall from the system to the estuary of the River Adur has sufficient capacity to discharge flows;
- flooding therefore arises due to hydraulic deficiency in the upstream network;
- the maximum time of flow from the most northerly to southerly points in the catchment was estimated to be 7 hours, which demonstrates the slow velocities of the network in this area;
- the risk of flooding could be reduced up to and including the 1 in 10 year design event through the following works at an estimated cost of £160,000:
  1. clearance of ditches and obstructions in vicinity of Manor Close and Manor Way;
  2. construction of a relief culvert south of New Salts Farm Road bridge, and;
  3. general improvements over the longer term to ditches through regrading, upsizing of culverts at farm crossings, and removal of vegetation.

[2] We recognise that given the surveys were undertaken in 1994 the bed levels of the ditch network will have changed due to siltation and/or maintenance over this period.

2.2.4 Royal Haskoning study

In 2010 Royal Haskoning were commissioned by Worthing Borough Council to undertake a detailed investigation of the Lancing Brook ditch network south of the railway line. The work considered the existing condition of the drainage system using the Environment Agency's Condition Assessment Manual (2006). Using this approach Royal Haskoning identified 8 of the 17 reaches to be in 'very poor' condition and a further 4 to be in 'poor' condition. The report cited heavy vegetation, siltation and blockages caused by trees. Subsequently the report outlined a series of remedial measures to restore the performance of the drainage network, which included localised clearance, vegetation clearance, silt removal, re-grading, structural improvements, and re-instating disused ditches and outfalls.

2.2.5 National surface water mapping

In December 2013 the Environment Agency produced and published updated national surface water mapping to identify areas which were naturally susceptible to surface water flooding. This mapping is based on a modelling approach which applies rainfall onto the surface and allows runoff to be routed depending on the natural topography of the land. The rainfall is factored to account for losses to the ground, and the presence of existing drainage systems which will capture some rainfall. The model was simulated for three rainfall probabilities to comply with the Flood Risk Regulations 2009 (1 in 30 year, 1 in 100 year, 1 in 1000 year). In Lancing the national surface water mapping indicates that North Lancing is most significantly at risk of surface water flooding to properties, gardens and the highway. In Barfield Park and Monks Avenue predicted flooding is limited to the highway and gardens of residential properties.

The national surface water map can be accessed via the Environment Agency's website: http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=ufmfsw#x=357683&y=355134&scale=2. An extract of the national surface water mapping for Lancing is shown in Figure 2-1. This includes the predicted flooding for the 1 in 30 year ("High") and 1 in 100 year ("Moderate") rainfall probabilities.

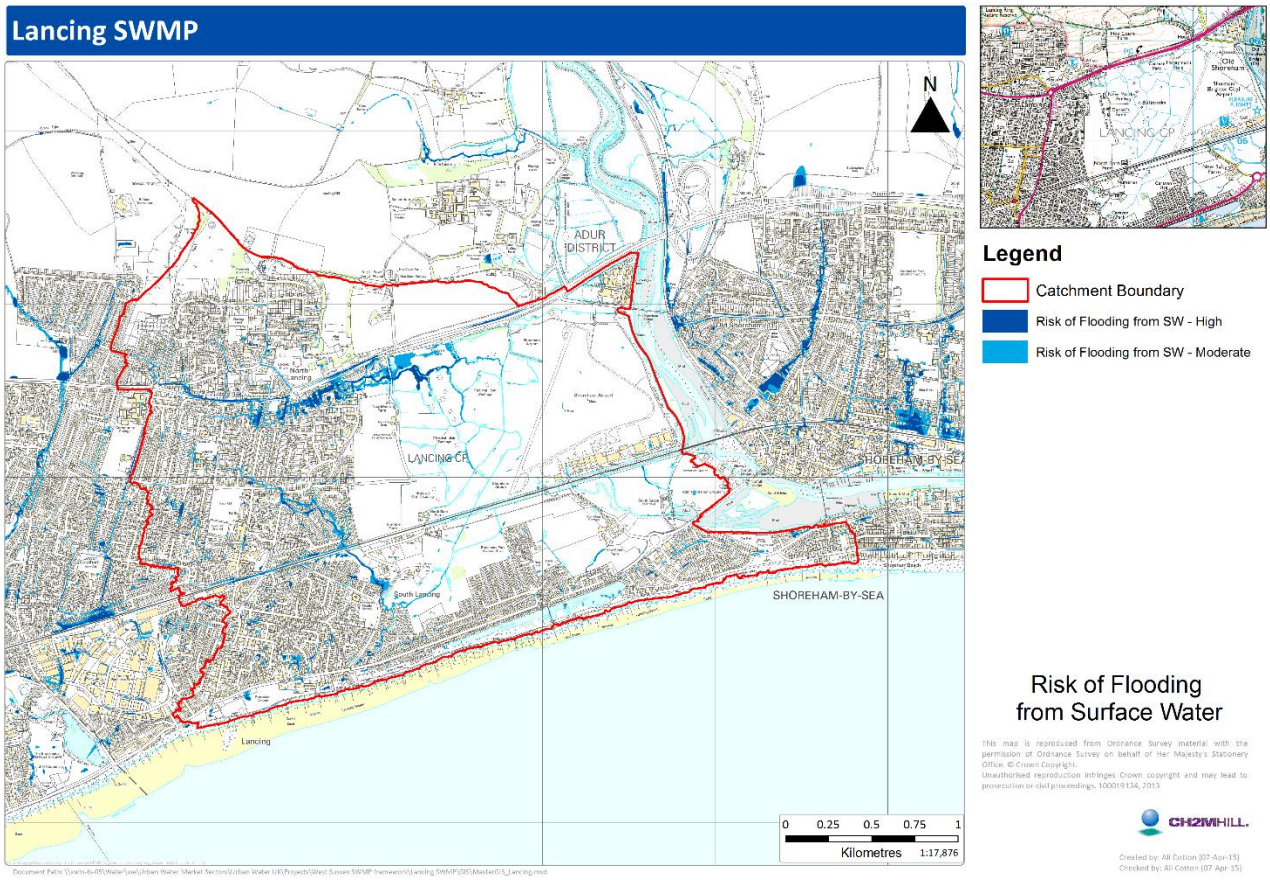


Figure 2-1 Risk of Flooding from Surface Water

2.3 Recent development in the catchment

2.3.1 Golf course development

In 2005 planning permission was granted for an 18 hole golf course east of Mash Barn Lane. The golf course has not been completed at the time of writing this report, although the ground level has been raised by 1m-3m with inert waste material in preparation for the golf course. With respect to drainage and flood risk management one of the schedule of conditions attached to the planning permission was that:

"No development approved by this permission shall be commenced until a scheme for the provision and implementation of compensatory flood storage works has been submitted and approved in writing by the Local Planning Authority. The scheme shall be implemented in accordance with the approved programme and details prior to use of the golf course"[3].

In 2006 a water level management plan was prepared which identified the proposals to provide compensatory flood storage once the golf course was constructed[4] to mitigate for the impact of raised ground levels. This water level management plan estimated that during a high spring tide where there is no discharge from the site, the 100 year flood storage volume would be in the region of 37,000 m^3. The proposals to achieve this (and whether they have been implemented) are described in Table 2-3.

[3] Adur District Council Planning Permission, Application Number L/87/00/TP

[4] Stuart Michael Associates (2006), New Monks Farm, Lancing, Water Level Management Plan

Table 2-3 Proposals and implementation of the water level management plan

Proposal from Water Level Management Plan	**Consideration whether the proposal has been implemented**
Clear, widen and re-profile the existing ditches in the golf course, and where backfalls exist these were to be re-graded[5]	The watercourses have been widened, deepened and well maintained. Indeed, the landowner undertakes maintenance of the watercourses on an annual basis, with the most recent works undertaken in January 2015.
Control flows at the downstream end of the site to mitigate the improved hydraulic capacity of ditches[6]	The water level management plan identifies that "it was recommended within Stuart Michael Associates' 1999 report that in order to mitigate downstream flooding stop logs should be installed in the control structure where the ditches enter the airfield site. These were introduced during watercourse mitigation proposals within the airfield and this has increased water levels within the Golf Course site by 500mm." However, these have now been permanently removed at the Environment Agency's request[7].
Provision of flood storage in 12 offline balancing ponds[8]	The proposed balancing ponds have not been constructed

Because of the complexities of the Lancing Brooks network it is difficult, without detailed 1D/2D hydraulic modelling, to fully evaluate the impacts of the water level management plan not being fully implemented to date. This is outside the scope of this SWMP. However, it is possible to qualitatively describe the potential impacts. The clearance, widening and re-profiling of the ditches will increase peak flow rates through the golf course site[9], thus enabling flows to drain away from Manor Close more effectively. During more frequent rainfall events flow in the ditches will remain 'in bank'. The widening, deepening and improved maintenance of the ditches will ensure flows can be conveyed away without an increase in flood risk upstream. It remains unclear how an increase in flows through the site will affect downstream flood risk.

During more extreme rainfall events, where the watercourses would naturally flow out of bank, this is no longer possible because of the loss of floodplain storage. Without the compensatory balancing ponds, water could back up in the ditch network and may increase flood risk to properties upstream.

Despite two of the wettest winters on record in recent years there is no confirmed evidence that flooding has increased upstream or downstream of the development site. Analysis of rainfall data from Applesham Farm over these winters indicates that the most rainfall in a single day was 30mm on 12th January 2015. The theoretical depth of a 1 in 10 year rainfall event with a 7 hour duration[10] in this location is 44mm. This

[5] Stuart Michael Associates (1999), New Monks Farm, Lancing Proposed Golf Couse, Land Drainage Considerations (appended to Water Level Management Plan (2006)

[6] *Ibid.*

[7] Ken Argent, *pers. comm*.

[8] Stuart Michael Associates (2006), New Monks Farm, Lancing, Water Level Management Plan

[9] The 1999 Stuart Michael Associates report considered the cleared, widened and re-profiled ditches would have capacity to convey more than 4 m^3/s, which is greater than the capacity of the upstream ditches in Manor Close

[10] This has been assumed to be the critical duration event in line with the Monson Engineering Report

analysis indicates that the ditch system may not yet have been tested for an extreme rainfall event since the development of the golf course site.

2.3.2 Brighton and Hove Albion development

In 2013 Brighton and Hove Albion Football Club (BHAFC) completed construction of a new training ground near Mash Barn Lane. The drainage strategy for the development was outlined in the flood risk assessment (FRA) for the planning application. The proposals in the FRA outlined a combination of drainage direct to ground (e.g. car parking areas, grass pitches and training areas) to mimic the natural drainage, and water storage onsite to store (and reuse) surface water runoff from the main training facility building, the maintenance building and the covered indoor pitch.

Linked to the surface water drainage strategy was the irrigation strategy for the pitches. This comprises of water from a grey water recycling facility, an abstraction borehole, and water stored from surface water runoff. It is supplemented by a mains water supply in periods of insufficient rainfall.

Since the construction of the training ground there have been concerns from local residents that it has increased local flooding and the volume of water within the Lancing Brook ditches. The concerns have centred on two elements: onsite drainage issues, and changes to the groundwater regime as a result of the development.

Appendix E provides a detailed summary of the investigation into geology and hydrogeology in Lancing. With respect to the BHAFC training ground nine boreholes were installed by Soils Limited to assess the geology and monitor groundwater levels. At all but one of these boreholes there were clayey head deposits overlying the chalk at various levels of thickness (2.5-4m). Only in BH3, in the extreme south east, are Raised Beach Deposits (1.8m thick) identified between the overlying Head (1.3m thick) and underlying Chalk. These clayey head deposits form an “aquiclude” which acts as a confining layer and prevents or limits movement between the two aquifers. Owing to the depths of the clayey head deposits, and the ground raising (between 1-2m) undertaken during construction of the training ground it is not considered that the site is affected by, nor influences, the flow of regional chalk groundwater.

Local residents have raised concerns to BHAFC about onsite tankers and overpumping into local ditches. BHAFC responded to these concerns identifying that the additional tankering, observed by local residents, was to bring more water onto the site and not related to drainage issues on site. This is a matter for further consideration by the local planning authority and is not considered any further in this report.

2.3.3 New Monks Farm hydrogeological investigations

As part of a proposed development at New Monks Farm the site developer commissioned a detailed hydro-geological investigation into the groundwater levels and other influences[11]. The purpose of the investigation was to test whether the site would be at high risk of groundwater flooding, as identified in preliminary mapping undertaken by the Environment Agency, and in the SFRA. The report is primarily based on the findings from ten boreholes drilled at the site between the 23rd January 2014 and 5th February 2014. In boreholes BH1, BH2, BH4, BH6, BH7 and BH10 water monitors were placed to measure ground water level in both the underlying bedrock (Chalk) and superficial layer (clay and alluvium).

The geology was found to be consistent with that shown on the British Geological Survey (BGS) online database. Typically this consisted of 0.5-2.0m of made ground underlain by 2.5-4.0m of clay/alluvium underlain by chalk bedrock. During drilling, in all boreholes, groundwater was struck in the Chalk only after the superficial layers had been penetrated. Where groundwater was also encountered in the Superficial Deposits (in 7 of the boreholes) this was in addition and separate to the water strikes in the Chalk. It was concluded that the clay/alluvium layer acts as an aquiclude to groundwater contained within the underlying Chalk. This conclusion was made based on the drilling record and on the two distinct water levels observed

[11] Capita Symonds Ltd (2014), New Monks Farm, Interpretive Hydrogeological Report on Groundwater Levels and Influencing Factors

in the aquifers during the period of groundwater measurement. The monitoring showed that the aquifers layers respond separately to the influence of recharge and discharge, with a time lag in response between the two layers. Additionally, due to the clay/alluvium acting as an aquiclude the pressure in the Chalk aquifer was found to be artesian after the period of heavy rainfall during February. The Chalk aquifer in this location was therefore behaving as a confined aquifer with groundwater in the superficial layer acting as a perched water table. Based on this evidence, there is no significant contribution to surface water flows from the underlying Chalk in this location. There was found to be a tidal influence in the Chalk aquifer at BH07. The groundwater level was found to react quickly to the diurnal tidal cycle. Elevated levels of sodium and chloride were recorded for BH07D only. It was concluded that this was representative of a more direct and deeper hydraulic link to groundwater in the Chalk beneath the Adur estuary or beneath the coast.

The report recommended that the development site was not at risk of groundwater flooding, provided that the development did not disturb the geological units (i.e. development did not extend into the Chalk formation. As part of the review for the SWMP there is no evidence that would counter the conclusions of the New Monks Farm hydrogeological investigations. A summary description of the geology in the area can be found in Section 3.4.

2.4 Actions taken to alleviate flooding in the catchment

2.4.1 Clearance of Lancing Brooks

Collectively, the Monson and Royal Haskoning studies have considered the drainage ditch network in considerable detail to understand pinch points and remedial works required. Significant ditch clearance work was carried out by Adur and Worthing Councils and landowners in 2010 and 2013. In 2010 extensive ditch clearance was undertaken on the northern floodplain east of Mash Barn Lane[12], and on the southern floodplain south of the railway line (downstream of Barfield Park). Furthermore in 2013 the ditch sections which run through residential areas were dredged and cleared (beds lowered by up to 500mm)[13]. The ditch clearance work addresses most of the recommendations of the Monson and Royal Haskoning reports.

As part of the SWMP new and comprehensive cross-section survey of the ditch network was undertaken in in December 2014 and January 2015 to understand the current flow regime and levels of siltation and vegetation. The purpose of this was to assist WSCC and Adur and Worthing District Councils in identifying an optimal maintenance regime. The findings of the cross-section survey are described in Section 6. In January 2015 the landowner of the golf course development undertook a comprehensive clearance of the ditches.

2.4.2 Improvements to foul sewerage network

Since the winters of 2013/13 and 2013/14 Southern Water have undertaken a number of actions to reduce the risk of foul sewer flooding, including:

- developing an Infiltration Reduction Plan (IRP) for North Lancing which sets out the strategy for managing infiltration into the sewer network;
- sealing of the sewer network to reduce infiltration;
- installation of a level alert system which triggers a tanker call out when sewer levels go above a certain threshold, and;
- production of an Emergency Action Plan (EAP) which identifies trigger levels and associated actions depending on sewer levels and forecast flooding.

[12] In January 2015 the landowner also undertook ditch clearance of the northern floodplain within the golf course area

[13] Ken Argent, *pers. comm.*

2.4.3 Improvements to surface water drainage network

There is a 300mm pipe which flows through the garden of No. 4 Old Shoreham Road (where it becomes open for a short section[14]) and then discharges to the ditch known locally as the 'doctors ditch' to the rear of number 9 Manor Way. Historically there has been flooding from the 300mm pipe, caused by a blockage. This was cleared by WSCC following the winter 2013/14 flooding.

Historically, flooding on The Paddocks occurred regularly following heavy rainfall, affecting garages and the highway. During the past 18 months WSCC has de-silted the storage tanks under The Paddocks, cleared root infestation in the surface water drainage pipes, and de-silted the stream to which the drainage discharges into. It is understood that this has significantly mitigated the flooding at this locations

Furthermore, following flooding on the A27 in 2012 the Highways Agency have undertaken significant remediation work, which was completed in 2013. This has included pipe remediation, patch lining, lateral grinding and root cutting, to improve conveyance capacity of the system.

2.4.4 Shoreham Adur tidal walls scheme

The Environment Agency is currently developing a scheme to improve the standard of protection from the Adur tidal walls. This will reduce tidal flood risk to Shoreham-by-Sea and Lancing. Further details on this scheme are available at: https://www.gov.uk/government/publications/shoreham-adur-tidal-walls-scheme/shoreham-adur-tidal-walls-scheme.

[14] It becomes an open section due to damage to the pipe, Ken Argent, *pers. comm.*

SECTION 3

Catchment characteristics

3.1 Catchment boundary

The Monson and Royal Haskoning studies have identified different catchment boundaries, particularly to the west. The Royal Haskoning catchment boundary was derived from FEH analysis, as there was no LiDAR available at the time, whilst the Monson report used contoured Ordnance Survey maps.

To define the natural catchment boundary an extension tool in ArcGIS software was used. The analysis is based on LiDAR data. This analysis was used to create a refined catchment boundary and flow pathway. A map of the revised catchment boundary is included in Appendix B and Figure 3-1. This analysis shows the catchment boundary is a further 1km west than the Monson catchment boundary. The western edge of the catchment boundary is the college on Upper Boundstone Lane. These findings have been verified against Highways Agency (flow direction) and Southern Water data (cover levels of manholes), which corroborates the revised catchment boundary. It is worth noting two issues:

- surface water from the business park at the far north-east of the catchment may drain to the River Adur directly, and;
- the area at the far south-east of the catchment is on a shingle spit and is believed to discharge surface water direct to the sea

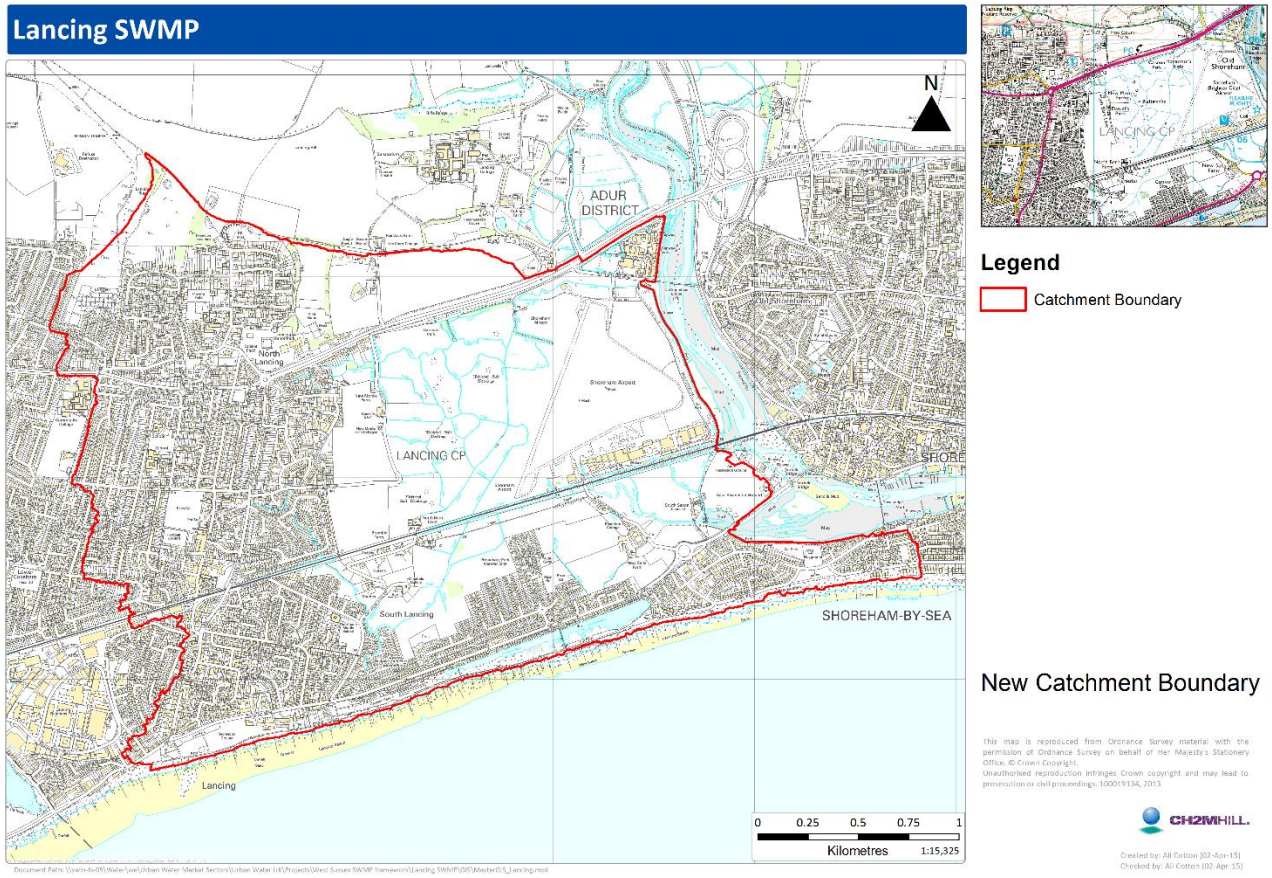


Figure 3-1 Catchment Boundary

3.2 General description of catchment and drainage

An overview of the key drainage features of the Lancing catchment is shown in Figure 3-2. Surface water runoff from residential areas to the west of the catchment boundary drain to the Lancing Brooks via soakaways (which will discharge to ground and ultimately flow towards the Brooks) or piped drainage. In addition, surface water runoff from the A27 drains via a series of outfalls into the Lancing Brooks.

The Lancing Brooks flow via a series of ditches which all ultimately drain to an outfall downstream of the Dogs Trust rehoming centre near New Salts Farm Road. North of the railway the Brooks flow through the golf course development, before discharging into a twin 900mm culvert under the airport. The Brooks emerge for a short section before re-entering a culvert to take flows under the railway. South of the railway the Brooks emerge from Barfield Park and flow in a south easterly direction until Willowbrook Caravan Park. Downstream of the caravan park the Brooks flow in a generally easterly direction before joining flows from the northern floodplain near New Salts Farm Road. Outflows from the Lancing Brooks is dependant on tide levels.

Groundwater is a key feature of the drainage system in Lancing. Regional groundwater flows are predominantly towards the east and south, as shown in Figure 3-2. The flow and influence of groundwater is complicated in Lancing, and the geological characteristics are described in detail in Section 3.4.

A more detailed description of the drainage system and associated flood risk issues is provided in Section 5 of this report.

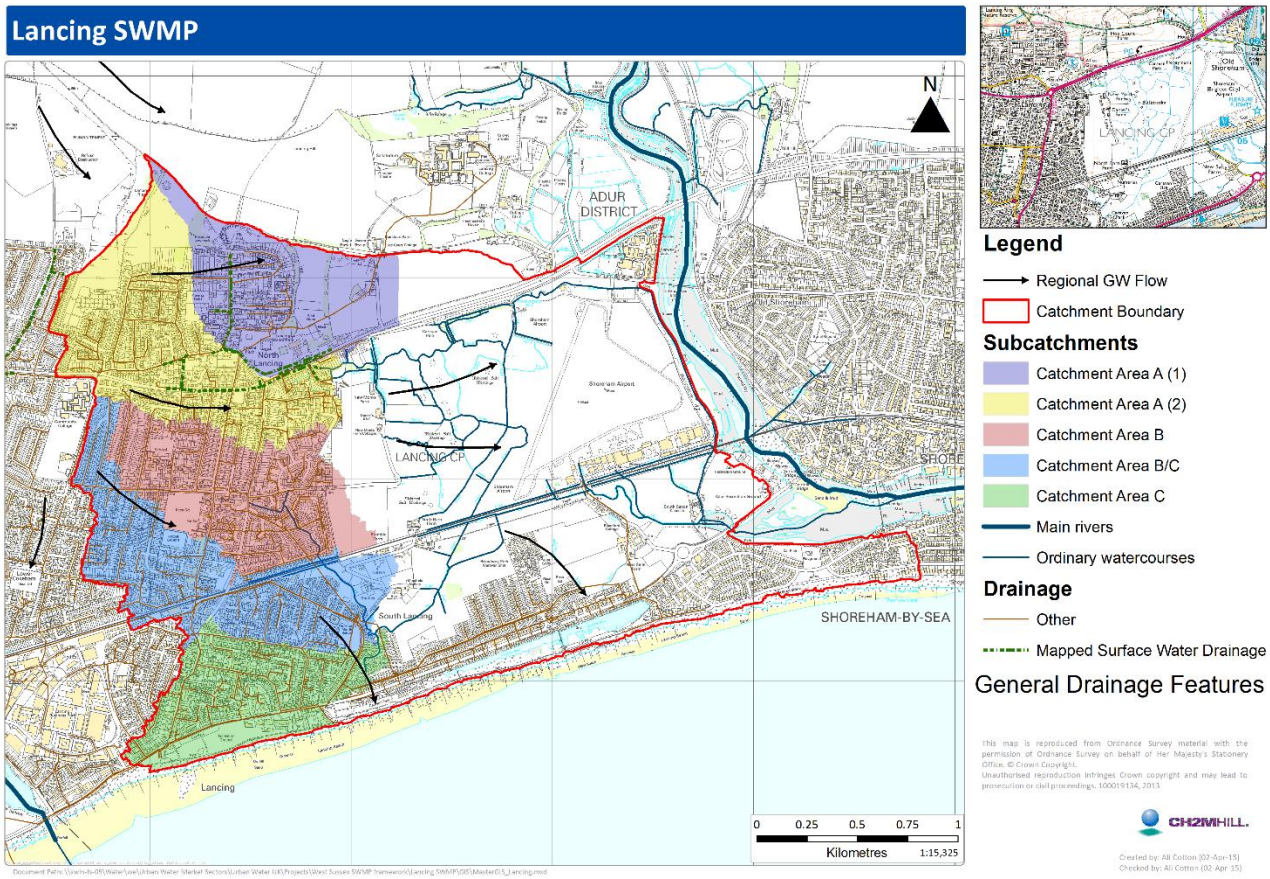


Figure 3-2 General drainage features of Lancing

3.3 Rainfall

There is a rain gauge at Applesham Farm (519486, 107183) which has captured daily rainfall totals since 1964. Based on these recorded data the average annual rainfall is nearly 820mm, with the wettest year on record seeing more than 1200mm of rain (2000). Given recent wet weather and flooding in this catchment it has been decided to specifically consider the rainfall over the past two wet winters, 2012/13 and 2013/14. Based on the rain gauge data, the total rainfall from December to February over these two winters was far in excess of the long term winter average for the same period. A summary of the key statistics is shown in Table 3-1. In fact the winter of 2013/14 was the wettest winter over the 50 year record from the Applesham rain gauge, with over 470mm of rainfall falling over this period.

Table 3-1 Rainfall totals at Applesham rain gauge over past two winters

Date	Rainfall total (mm)		% of long-term average (1964-2014)	
	2012/13	2013/2014	2012/13	2013/14
December	206	159	222%	172%
January	107	168	121%	190%
February	58	146	93%	237%
Sum	**371**	**473**	**153%**	**195%**

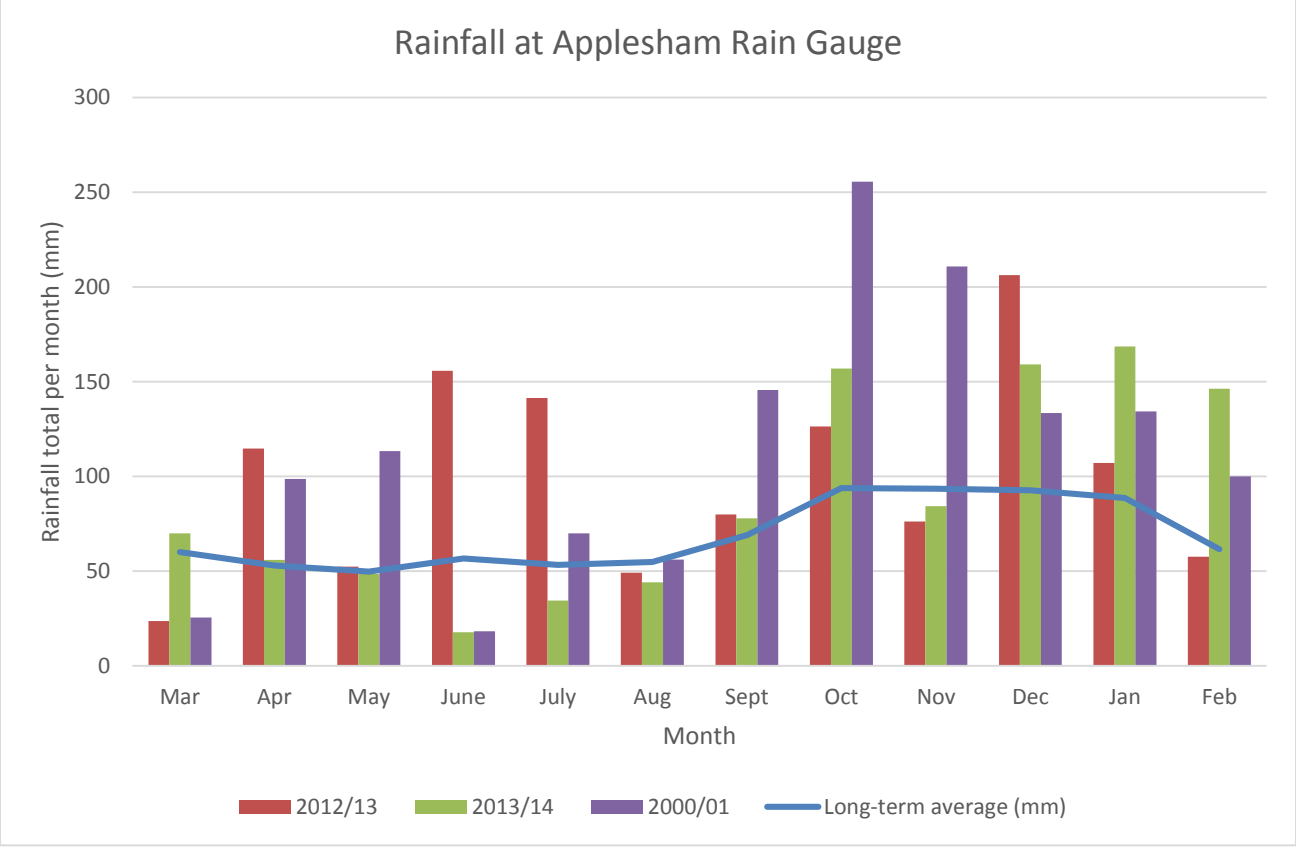


Figure 3-3 Rainfall at Applesham Rain Gauge for 2000/01, 2012/13 and 2013/14 compared to long-term average

The heavy summer rainfall in June and July 2012 is also evident from Figure 3-3 above, and the total monthly rainfalls are similar to those experienced in the recent 2013/14 winter. However, the winter events are associated with elevated groundwater levels, and flooding in Lancing predominantly occurs during winter when groundwater levels in the alluvial deposits and the underlying Chalk are high. There is some anecdotal

evidence of flooding during the summer 2012 storms on the West Beach Estate, however it is not as widespread as during winter events. This indicates flooding is not wholly the result of short duration intense rainfall events (which would normally overwhelm urban drainage systems), but rather the result of the impact of long duration events over the winter. The superimposition of shorter term rainfall over these longer term events exacerbates any flooding condition.

3.4 Geology and hydrogeology

A detailed technical note about the geology and hydrogeology in Lancing is included in Appendix E. The most salient points model are described in Sections 3.4.1 to 3.4.2.

3.4.1 Geological setting

3.4.1.1 Solid Strata

The whole of the study area is underlain by Chalk strata of Cretaceous age. Influenced by regional structural trends, these strata dip down toward the coast from the South Downs in the north, as illustrated by the regional cross section below (Figure 3-4). This structure has implications for regional groundwater flow

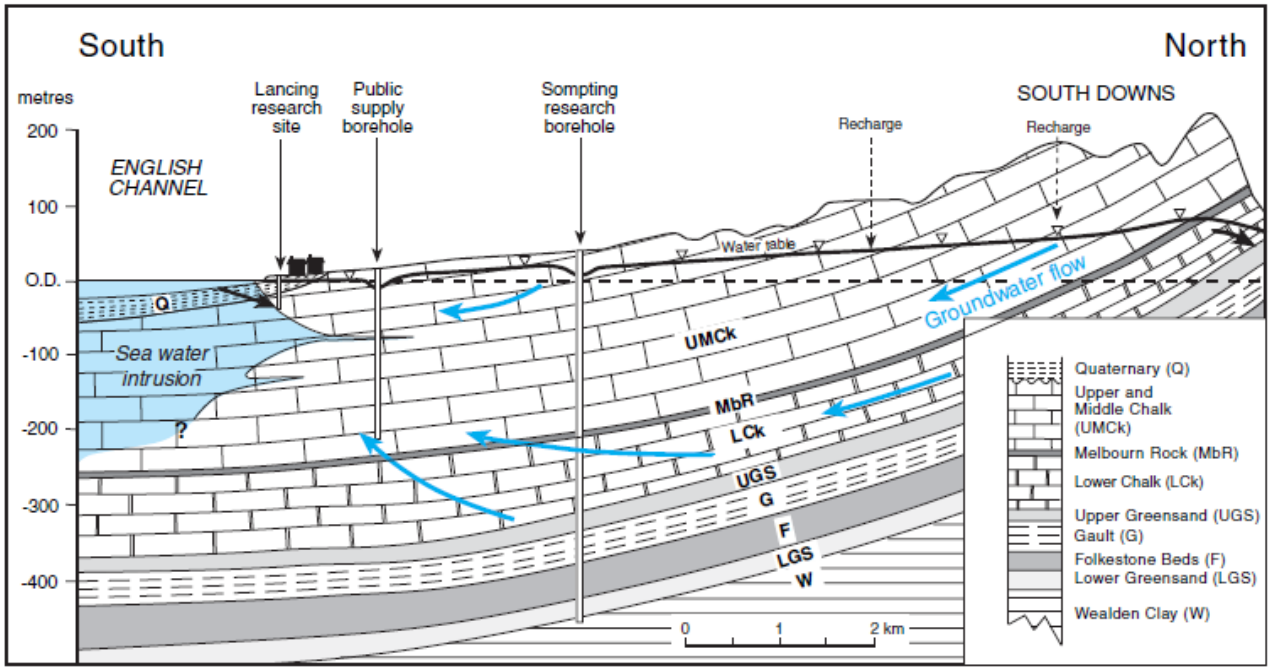


Figure 3-4 Generalised regional geological section. Note that the Chalk nomenclature used on the cross section has now been superceded. (From: "The Chalk Aquifer of the South Downs". Hydrogeological Report Series of the British Geological Survey. British Geological Survey 1999

To the extreme south of the study area beneath the West Beach Estate and Widewater Lagoon, the younger (Palaeogene) Lambeth Formation occurs. This overlaps the Newhaven Chalk, and thins rapidly northward. Based on BGS borehole evidence, this formation may be up to about 10-15m thick toward the coast particularly at the western end of West Beach estate and Widewater.

3.4.1.2 Superficial Deposits

Although the underlying strata have a significant bearing on groundwater flow through the study area, they are not exposed at outcrop, other than to the north of the A27, as the hills rise to the Chalk downs. Younger, unconsolidated Superficial Deposits occur right across the study area. These are the result of more recent geological and geomorphological processes (Quaternary age up to circa 3 Million years ago) and comprise a number of different deposits. The age relationships between these deposits is not always clear, particularly

between alluvium and tidal flat deposits. The Head and Raised Beach Deposits are more prevalent underlying the higher ground to the west of the study area.

In addition to the above natural Superficial Deposits, there is some Made Ground present. This is material reworked or deposited by man's activities and may have been emplaced for ground levelling or other landscaping, engineering or development purposes. It is most prevalent in the north, beneath the golf course, where it is between 2.2 and 3.5m thick. The area developed as part of BHAFC training grounds has been levelled using found material[15], although borehole evidence suggest no Made Ground occurred in this area before the development. There also appears to be Made Ground to the west beneath the housing estates, presumably as a result of ground levelling associated with the historic development of housing. It is also likely to be moderately widespread beneath Shoreham Airport.

3.4.2 Hydrogeological conceptual model

The hydrogeology is described in detail in Appendix E. This section includes an overview of the hydrogeological conceptual model, which is used to express the characteristics and processes inherent in the groundwater system based on evidence accumulated from geological and hydrogeological mapping, site observations and investigations, groundwater monitoring, rainfall and other data sources. The model identifies the broad understanding of how groundwater beneath the site behaves. Based on the evidence provided above, the conceptual model can be summarised as follows, and in the schematic cross section in Figure 3-5.

Groundwater occurrence	Groundwater is present in the "regional" Chalk aquifer and in more permeable localised and discontinuous layers in the Superficial Deposits, primarily Alluvium. Across the central and western parts of the study area these lower (Chalk) and upper (Alluvium) aquifers are separated by layers of clay forming an "aquitard" which acts as a confining layer and prevents or limits movement between the two aquifers. There may be areas across the study area wherein this separation is less marked, i.e. in permeable "windows" between the Chalk and upper aquifers.
Recharge/ Discharge	Groundwater in the Chalk is recharged across the Downs to the north and west. The recharge, topography and Chalk structure imparts a west to east regional groundwater gradient towards the River Adur, which acts as an area of regional groundwater discharge. There is a more southerly element to this gradient near the coast.
Groundwater levels, flow and emergence	Groundwater flow in the Chalk occurs primarily from west to east in response to regional groundwater gradient. The rate of flow depends upon both the gradient and the permeability of the Chalk, which tends to be at its greatest at shallow depths where the Chalk has been subject to dissolution in areas of water level fluctuation. These areas are often associated with the boundary between different Superficial Deposits and the boundaries of Superficial Deposits with the Chalk. Under conditions of high winter recharge and elevated groundwater levels in the Chalk and in response to upward groundwater pressure from the underlying Chalk, there may be upward leakage from the Chalk to the upper aquifer and surface water. This occurs through more permeable windows in the Superficial Deposits (as described above). Where there is partial connectivity between the two aquifers, the upper alluvial aquifer may become

[15] This is imported fill

more permanently saturated, leading to areas of marshy ground. These mechanisms are most likely to occur in the southern part of the study area.

The upward groundwater movement is primarily a response to pressure (piezometric) differentials established in the Chalk, where the confining layer is absent, Chalk groundwater will rise to the piezometric level, which, when this is above the surface, can lead to emergence of groundwater.

The upper superficial aquifer is recharged directly from rainfall and discharges through evapotranspiration and through lateral flow to surface waters. The characteristics of the Superficial Deposits suggest that although this shallow aquifer may provide some baseflow to the surface water channels, this is likely to be only a relatively small contribution to the overall flow in the surface water channels. There may also be some emergence of shallow groundwater at boundaries with less permeable deposits.

Tidal influence

The tide prompts a pressure response in the Chalk groundwater towards the coast, which causes diurnal changes in the Chalk piezometric surface such that groundwater levels near the coast rise and fall in response to tide levels.

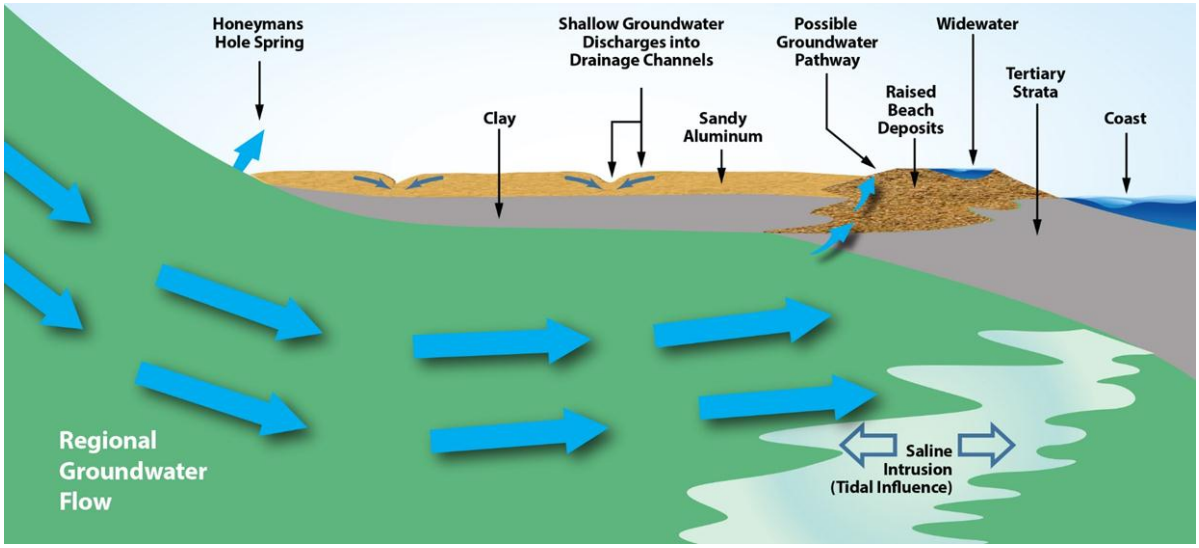


Figure 3-5 Conceptual Model- Sectional view showing interaction between regional flow in Chalk, shallow groundwater and groundwater emergence

3.5 Environmental characteristics

A summary of the environmental constraints based on a preliminary desk-based study are provided in Appendix I. This enables an assessment of the environmental effects of the drainage and flood management strategy for Lancing. An Environmental Features Plan has been created to show the environmental constraints and opportunities in and around the study area for the Lancing SWMP. This can also be found in Appendix I.

SECTION 4

Flooding history

4.1 Summary of flooding

There is good anecdotal evidence of flooding within Lancing from the wet winters of 2012/13 and 2013/14, and ongoing reporting from local residents throughout 2014 and 2015. Local residents have provided detailed information on the timing, location and impacts of flooding in Lancing. This has enabled a comprehensive picture of flooding to be established over the past two to three years. Flooding in Lancing has been a long-standing problem, but the best anecdotal evidence of flooding is from the last two to three years. Given that 2013/14 was the wettest winter on record it is reasonable to assume that the available anecdotal evidence from the past two to three years provides a good basis to assess the flooding impacts. Table 4-1 provides an overview of the key locations affected by flooding in Lancing.

Table 4-1 Locations affected by flooding in Lancing

Location	No. properties flooded internally[16]	Other impacts	Dates of flooding
Grinstead Lane, Manor Way, Manor Close	Two garages flooded in Manor Way	Extensive flooding on Grinstead Lane (impassable), restricted toilet use, garden flooding, and overpumping of foul network into ditch network	December 2012 and December 2013 January 2015 although flooding impacts significantly reduced
Old Shoreham Road[17]	None	Flooding on Old Shoreham Road Garden flooding	December 2012 and December 2013, January 2014 and 2015
Barfield Park and Monks Avenue	1 home affected on Barfield Park 1 property flooded near Monks Avenue/Hadlow Way	Garden flooding in other locations	December 2013, Summer 2014
The Paddocks	None, but some garages affected	Flooding on the highway	Flooding occurred regularly following heavy rainfall (until work completed (see Section 2.4.3)
West Beach Estate	None	Flooding across most of The Broadway, and parts of Westway and Prince Avenue	Flooding occurs regularly
A27	None	Northern carriageway of A27 flooded	December 2013
Shoreham Airport	None	Airport flooded, although main runway was still operational	December 2013

[16] Defined as flooding within a building, and includes the main buildings / garages of a property

[17] This refers to the cul-de-sacs south of the A27 (NB: The A27 is also known as Old Shoreham Road)

SECTION 5

Description of drainage system and associated issues

5.1 Inflows

This section focuses on inflows to the Lancing Brooks watercourse network from the residential estates, the A27, Honeyman's Hole and Widewater Lagoon. The residential areas to the west of the study area all drain towards the Lancing Brooks via either positive drainage (e.g. highway drainage) or soakaways which will discharge to the ground and ultimately flow towards the Brooks. The residential areas have been divided into three principal catchments based on the location of discharge to the Lancing Brook ditches, as illustrated in Figure 5-1.

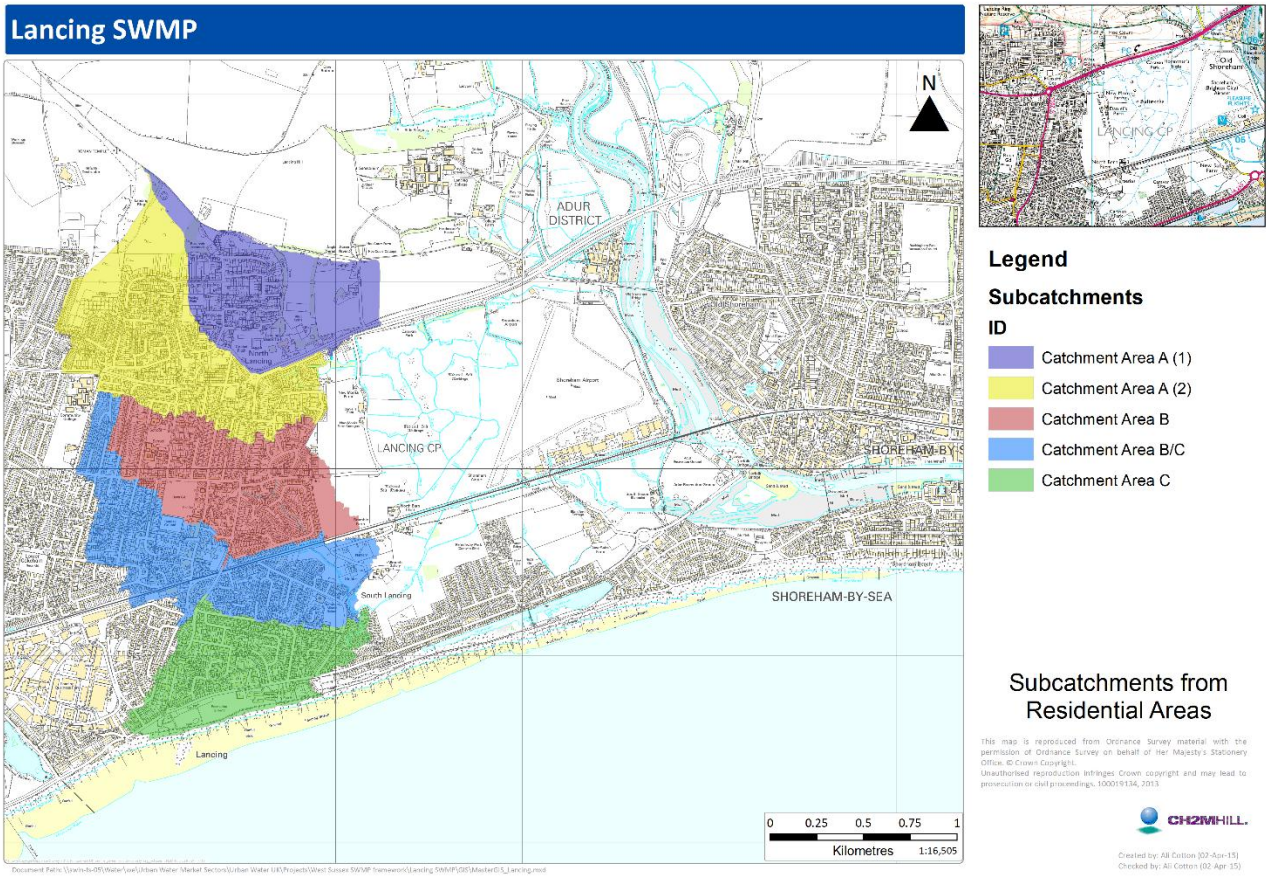


Figure 5-1 Subcatchments from residential areas

5.1.1 Manor Way / Grinstead Lane Area (Catchment Area A)

5.1.1.1 Surface water drainage

This catchment flows from the west of Grinstead Lane and north of the A27 towards the ditch network which runs to the rear of properties on Old Shoreham Road and Manor Close. For the most part residential properties and highways drain via soakaways, but there are locations of piped drainage within this area. It is difficult to understand what proportion of flows in the urban area drain to soakaway without detailed survey of every street.

Surface water piped drainage collects to a 300mm pipe which flows east between numbers 5-7 Grinstead Lane, through the garden of No. 4 Old Shoreham Road (where it becomes open for a short section[18]) There are three connections to the 300mm pipe:

- a 225mm pipe which flows north from Grinstead Lane;
- a 300mm pipe which flows from Manor Road, under the A27 roundabout (NB: there is a 225mm overflow pipe on the Manor Road system which passes excess flows under the northern verge of the A27 via a 225mm system, ultimately discharging to a manhole at the northern end of Manor Close), and;
- part of the A27 drainage from the west flows towards the 300mm although there is also a continuation pipe which flows towards the same manhole at the northern end of Manor Close.

At the end of No.4 Old Shoreham Road there are two outlet pipes, a 225mm and 300mm, which both discharges to the ditch known locally as the 'doctors ditch' to the rear of number 9 Manor Way.

Historically there has been flooding from the 300mm pipe, caused by a blockage. This was cleared by WSCC following the winter 2013/14 flooding. However, analysis undertaken for the SWMP indicates that the pipe size is insufficient to cope with the estimated flows from the upstream catchment. The analysis indicates that the capacity of the 300mm is estimated to be 112 l/s[19]. Using the Rational Method (where Q = 2.78 * coefficient * rainfall intensity * area) to estimate inflows to this network the pipe is likely to be exceeded on a frequent basis, as frequently as during a 1 in 5 year rainfall event[20]. Where the capacity of the 300mm pipe is reached it will cause backing up and flooding on Grinstead Lane and other locations. Options to reduce the risk of flooding from this is described in Section 8.

5.1.1.2 Watercourses

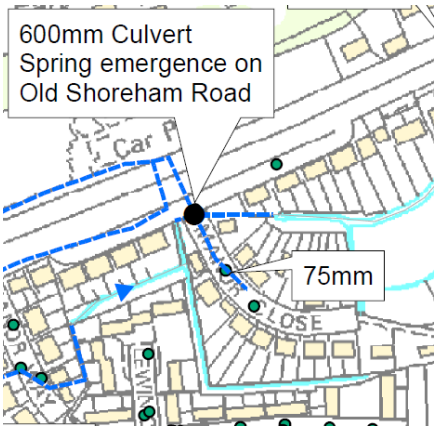


Figure 5-2 Drainage layout on Manor Close

The upstream network discharges into the 'doctors ditch'. This ditch network is initially very constrained but widens further downstream. The ditch then enters a culvert to pass under Manor Close, which has a 450mm opening. During the site visit in October 2014 the manhole in Manor Close was lifted to confirm the location of the culvert. The main line of the culvert passed through the manhole in a 600mm diameter pipe (NB: the manhole was heavily silted). There was an additional pipe entering from the north (which is the overflow pipe from Manor Road system and discharge location from the A27) and a minor 75mm diameter pipe entering from the south (see Figure 5-2). The culvert emerges behind houses on Manor Close and Old Shoreham Road. The ditch in this location varied between 0.5m wide by 0.5m deep and 1.5m wide by 0.5m deep.

The ditch continues to run parallel to Old Shoreham Road until it passes under Mash Barn Lane and enters land owned by a private developer. There are outfall from the A27 along this section.

5.1.1.3 Foul sewerage

Within this area there has also been flooding from the foul sewerage network attributed to groundwater ingress into the sewerage network. During the winters of 2012/13 and 2013/14 this caused the pumping station on Grinstead Lane to cease functioning, which caused restricted toilet use and foul sewer flooding onto Grinstead Lane, Manor Way, Manor Close and Old Shoreham Road. As a mitigation Southern Water

[18] Through No.4 Old Shoreham Road the pipe becomes open because of its condition, Ken Argent, *pers. comm*.

[19] Using Colebrook-White formula to calculate pipe flows for full pipes assuming there are no effects on downstream controls. We have assumed a culvert size of 300mm, a gradient of 1:100, and a roughness of 0.6 which is typical for surface water sewers

[20] Although we note that the Rational Method over-estimates flows because it does not consider headlosses or storage in pipes

over-pumped flows into the ditch network. Since these events Southern Water have undertaken a number of actions to reduce the risk of foul sewer flooding, which have been outlined in Section 2-7.

5.1.1.4 Groundwater influence

Based on the evidence from the local residents and from Southern Water, flooding of the Manor Way/ Old Shoreham Road area commenced in late January 2014 and continued through most of February. As shown in Figure 5-3, this coincided not only with a series of rainfall events of >20mm /day, but also with groundwater levels (at Sussex Pad) in excess of 2.8mAOD (peaking at around 3.2mAOD). The areas of groundwater emergence along the A27 and at the property adjacent to the roundabout at Old Shoreham Road/Grinstead Lane are adjacent to a Chalk/Superficial Deposit boundary. As noted, these boundaries typically represent areas of enhanced and rapid groundwater flow. These areas will always be susceptible to flooding under conditions of high groundwater level.

Flooding recorded in January 2015, appears to represent a slightly different event. Groundwater levels were generally lower (circa 2.6m, peaking at around 2.8mAOD) but there were at least two days of rainfall in excess of 20mm. This demonstrates that groundwater levels locally respond very rapidly to winter rainfall recharge and via west to east regional groundwater flow. It is concluded that groundwater makes a significant contribution to flooding in Manor Way / Grinstead Lane.

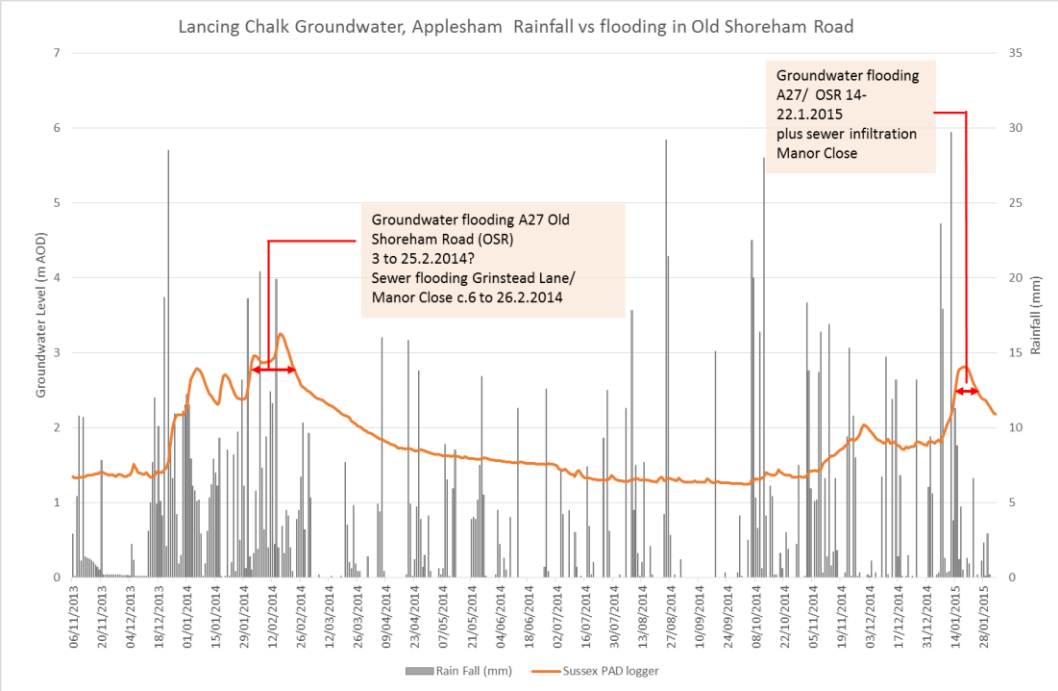


Figure 5-3 Groundwater Levels and Rainfall vs flooding recorded in Old Shoreham Road/ Manor Way area

5.1.2 Barfield Park Area (Catchment Area B)

5.1.2.1 Surface water drainage

Surface water runoff from residential areas west of Grinstead Lane drain to a ditch network which flows through Monks Avenue, Hadlow Way and Barfield Park, before flowing under the railway towards The Paddocks. The majority of runoff from residential properties and highways drain to soakaways, but there is a piped highway drainage system flowing under Grinstead Lane and into the ditch network to the rear of properties on Monks Avenue. This piped highway drainage network was inspected during a site visit in October 2014 near the outlet (adjacent to the ditch headwall opposite the Harvester pub on Grinstead Lane). This identified three inlets draining from Grinstead Lane to the north and the south, and Crabtree

Lane. The contributing area draining to this network compared is unknown. There is no evidence of flooding from this piped highway drainage network at this point, so no mitigation measures are proposed.

On Monks Avenue, Barfield Park and Hadlow Way highway drainage is a mixture of gullies, soakaways and piped drainage to the watercourses. Historically there has been garden flooding near Monks Avenue / Hadlow Way because of blockages to a highway gully and the drainage being unable to discharge into the ditch network.

5.1.2.2 Watercourses

Downstream of Grinstead Lane the ditch is approximately 2m wide by 0.5m deep and flows in an easterly direction along Monks Avenue where it is joined by a further ditch which flows from Mash Barn Lane. The ditch continues to flow under Monks Avenue via two 600mm diameter pipes. The ditch passes behind houses on Hadlow Way.

The ditch continues to flow behind houses to a twin 600mm diameter culvert under North Farm Road. Local residents noted the ditch has flowed out of bank during previous winters however they had not experienced flooding in the house. From this point the ditch runs through a 550mm (high) by 900mm (width) brick arch culvert under the railway to The Paddocks. The existing ditch network seems to be operating effectively. Variations in local maintenance seem to be causing areas of storage of water due to vegetation or overly deep channels.

5.1.2.3 Groundwater influence

One resident in the north east corner of Barfield Park reported significant groundwater emergence from a soakaway in their drive, as well flooding in the rear garden. Other properties in Barfield Park suffer waterlogged gardens. A rapid response to rainfall was reported, with levels remaining high through the winter of 2014/2015. Evaluation of the geology in this area suggests this property lies at or near a geological boundary between Alluvium, Head and Raised Beach deposits. These boundary areas may be associated with high flow zones in the Chalk, with a possible surface exposure to groundwater in the underlying Chalk. Further, it may be that the construction of the soakaway has penetrated the more impermeable clay layers, creating a more rapid flow path from the underlying chalk. In this scenario groundwater emergence may occur as the groundwater pressure surface rises in response to recharge in the Downs.

5.1.3 The Paddocks / Willowbrook Area (Catchment Area C)

5.1.3.1 Surface water drainage

This catchment covers the residential area south of the railway and west of The Paddocks. As in catchment areas A and B the majority of drainage is via soakaways. There was historic flooding at The Paddocks following heavy rainfall. Surface water drainage flows from The Paddocks towards the Lancing Brooks ditches. Clearance work on the surface water drainage network has significantly mitigated the flooding at this location.

5.1.3.2 Watercourses

The ditch system drains in a south-easterly direction past The Paddocks, where it passes under Old Salts Farm Road. The culvert under Old Salts Farm is significantly smaller than the cross-sectional area of the ditches upstream and downstream, which could result in backing up of flows. This is considered further within the hydraulic modelling section of the report (Section 6). Downstream of Old Salts Farm Road the ditch flows east and subsequently north-east through the southern floodplain. A further ditch joins from the Willowbrook Caravan Park[21]. There is a historic pond at the head of this system, which no longer exists. It is possible this is now a spring which contributes flows to the ditch through Willowbrook Caravan Park.

[21] There is repeated blocking of the watercourse near the Willowbrook Caravan Park. This is a local enforcement issue under the Land Drainage Act 1991

5.1.3.3 Groundwater influence

Based on geological data from boreholes in the New Salts Farm and Old Salts Farm areas there is evidence for the occurrence of "windows" in the confining clay layer and hence there is a mechanism for the emergence of "regional" groundwater from the underlying Chalk. This regional groundwater can therefore discharge into the surface water channels across the southern part of the Lancing Brook flood plain. Furthermore, the Old Salts Farm area is also associated with widespread waterlogged ground, further evidence suggestive of emerging groundwater.

5.1.4 West Beach Estate, including A259

5.1.4.1 Surface water drainage

The West Beach Estate suffers regular flooding primarily to The Broadway and Westway, although other parts of the Estate can be affected (e.g. Prince Avenue). Flooding is contained within the highway and no properties are known to have flooded.

The current surface water drainage on West Beach Estate is a combination of soakaways and piped drainage. There are three WSCC highway gullies on The Broadway which drain to a soakaway just north of the A259, via one inlet. WSCC has confirmed (February 2015) that the three gullies and the soakaway are clear (NB: the soakaway was full of water in February 2015, but there was limited silt buildup). North of these gullies, all drainage within West Beach Estate is privately owned and therefore not the responsibility of WSCC to manage and maintain.

Further north on The Broadway there are further gullies draining to a soakaway on the corner of The Broadway/Orient Road. Again a recent survey by WSCC identified that the soakaway was full of water but there was limited silt. The soakaway is more than 2m deep.

On the section of The Westway between The Broadway and Bristol Avenue there is a series of gullies are believed to drain to soakaway. From this point west the drainage is all piped, with the main network flowing underneath the roads which run are believed to flow south to north (e.g. Bristol Avenue, George V Avenue). On each of these roads there are surface water pipes which drain the roads and also take some runoff from The Westway. The drainage plan for West Beach Estate is presented in Appendix D.

Data collected for the SWMP (road levels and pipe depths) indicates that that whilst there is very little gradient on the pipe network (less than 1:1000), the pipes appear to have been designed to flow from south to north. At the southern end of Bristol Avenue the soffit level of the pipe is approximately 0.95m (temporary benchmark datum), whereas at the northern end the soffit level is approximately 0.9m[22]. It is believed that the outfalls from the roads which run south to north were supposed to be connected to the ditch network further north when the estate was built in the 1930s[23]. Local residents have uncovered and cleared the outfalls at Bristol Avenue and George V Avenue, and anecdotal evidence indicates this has alleviated flooding on these roads. Despite limited gradient clearing the outfalls will alleviate flooding because when the pipes are full it allows the system to discharge into the floodplain rather than backing up and flooding out of manholes.

[22] This is within the bounds of survey inaccuracy.

[23] The Second World War meant further development north was never built

Throughout the estate the condition and silt levels in the pipe network varies. On Bristol Avenue and George V Avenue the pipes there was little evidence of silt (October 2014). Along The Westway some pipes were clear and some were almost up to 50% silted, particularly on the far east of the estate. Road gullies were in bad condition throughout, approximately 10% were completely cracked/broken, 10-20% were choked (full of sediment) and a further 30% had standing water (although it had been raining heavily the day before the site visit in October 2014).

Figure 5-4 Photo of manhole on A259 (taken by WSCC)

The A259 is drained via a 300mm pipe system which flows in an easterly direction under the northern pavement of the A259. The system flows past Adur Close where the network drains to a soakaway. A WSCC survey team inspected the A259 drainage near the junction with The Broadway in February 2015. This identified that the gullies were clear of silt, and the network was freely flowing, as shown in Figure 5-4. Water levels in the manhole chambers were approximately 300mm above the invert level of the pipe. This water level corresponds to the water level in the two soakaways on The Broadway.

Because West Beach Estate is lower than the A259 any runoff which exceeds the capacity of the current A259 drainage system will flow onto the West Beach Estate, most noticeably through alleyways (twittens) and on The Broadway north of the junction with the A259. There is some anecdotal evidence of this occurring to a small extent but it is not considered to be a significant contributor to flooding.

5.1.4.2 Groundwater influence

The geological setting beneath the West Beach comprises Chalk at depth, overlain in part (to the south) by Lambeth Group (variously clay and silt) then in turn by superficial deposits, mostly dominated by Alluvium, although there is evidence for the occurrence of River Terrace or Raised Beach Deposits, particularly to the east end of the estate (see further below).

Groundwater may occur in the Raised Beach Deposits, coarser (sandy) horizons in the Alluvium and in the underlying regional Chalk aquifer. The Lambeth Group and more fine grained superficial deposits (clay, silt) prevent upward movement of groundwater from across much of the area. However there is strong circumstantial evidence that there are more permeable windows in the superficial deposits that may allow Chalk groundwater to impact groundwater levels in the area, for example by maintaining high levels in any upper aquifer. Borehole data (see Appendix E for further details) were used to generate a conceptual cross section (refer to Figure 5-5 below). What this section shows is that the gravel (Superficial Deposits) aquifer appears to be in hydraulic continuity with the sea. Groundwater levels in this aquifer will be significantly influenced by tide. Outward (southerly) groundwater discharge will be limited and high tides may cause the groundwater to “back up” at least maintaining groundwater levels at a high level beneath the Broadway area.

In this area groundwater levels in the Chalk will be influenced by a number of factors including:

- the regional southerly and easterly groundwater flow toward the sea;
- diurnal variations caused by the pressure response from tidal influence;

- confined conditions from the cover of Lambeth Group and finer superficial deposits, and;
- possible discharge at the Lambeth Group Boundary and through permeable windows in the superficial deposits.

Groundwater levels in the Superficial Deposits will be influenced by:

- upward groundwater movement from the Chalk brought on by a response to changing groundwater pressure;
- local recharges and discharges (including drainage to soakaways);
- the small amount of groundwater storage available due to the limited extent and nature of the superficial deposits, and;
- response to tidal influence, preventing seaward discharge through the gravels and backing up groundwater levels inland.

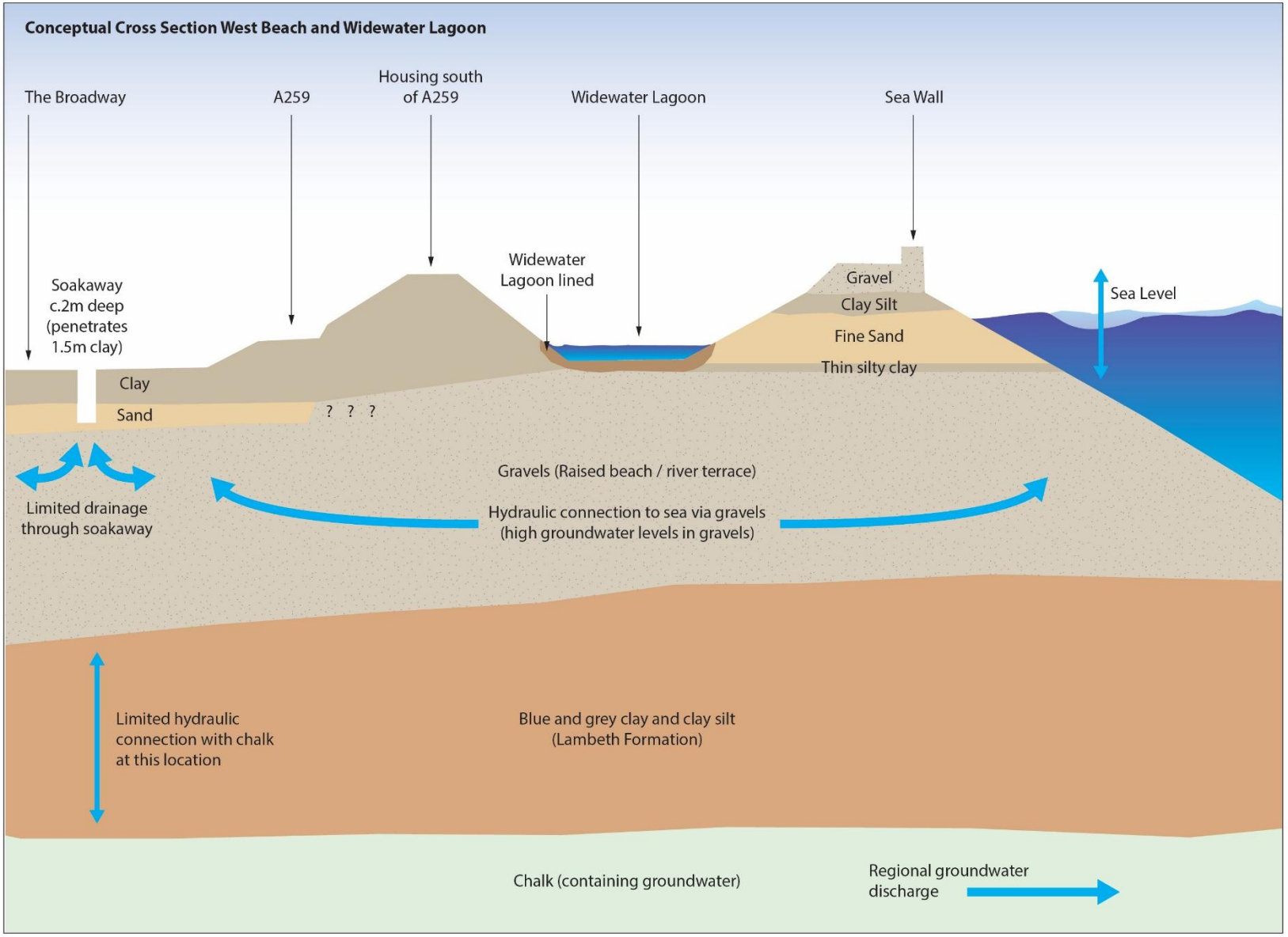


Figure 5-5 Cross-section of geology near Widewater Lagoon and West Beach Estate

SECTION 5

Seasonal groundwater level variation in the area (particularly in the Chalk) is most likely to occur as a pressure response, but as this is an area primarily of discharge of regional groundwater flow , these seasonal variations are likely to be less marked than further inland (i.e. there will be a lesser variation between maximum and minimum levels). Supported both by upward leakage from the Chalk and local recharge, groundwater levels in the superficial deposits are likely to remain high most of the year, although there will be some recession through the autumn months. On this basis, groundwater levels recorded at Sussex Pad may not be wholly representative of groundwater behaviour in the Chalk beneath West Beach Estate. However, there remains value in comparing monitored groundwater levels with tidal levels, rainfall and the occurrence of flooding (see Figure 5-6 below).

These hydrograph data suggest that groundwater levels are not the sole influence on flooding at West Beach, which appears to be combined with the response to rainfall and surface water flooding. However, where drainage is to soakaways (as along Broadway), which discharge directly into the underlying sands and gravels, high groundwater levels will prevent the soakaways from functioning and prevent any surface water from draining away. It is evident that diurnal water level variations and raised groundwater levels brought on by high tides also impact significantly on the ability for these areas to drain. There is likely to be a lag time between the tidal high and any high in the groundwater levels.

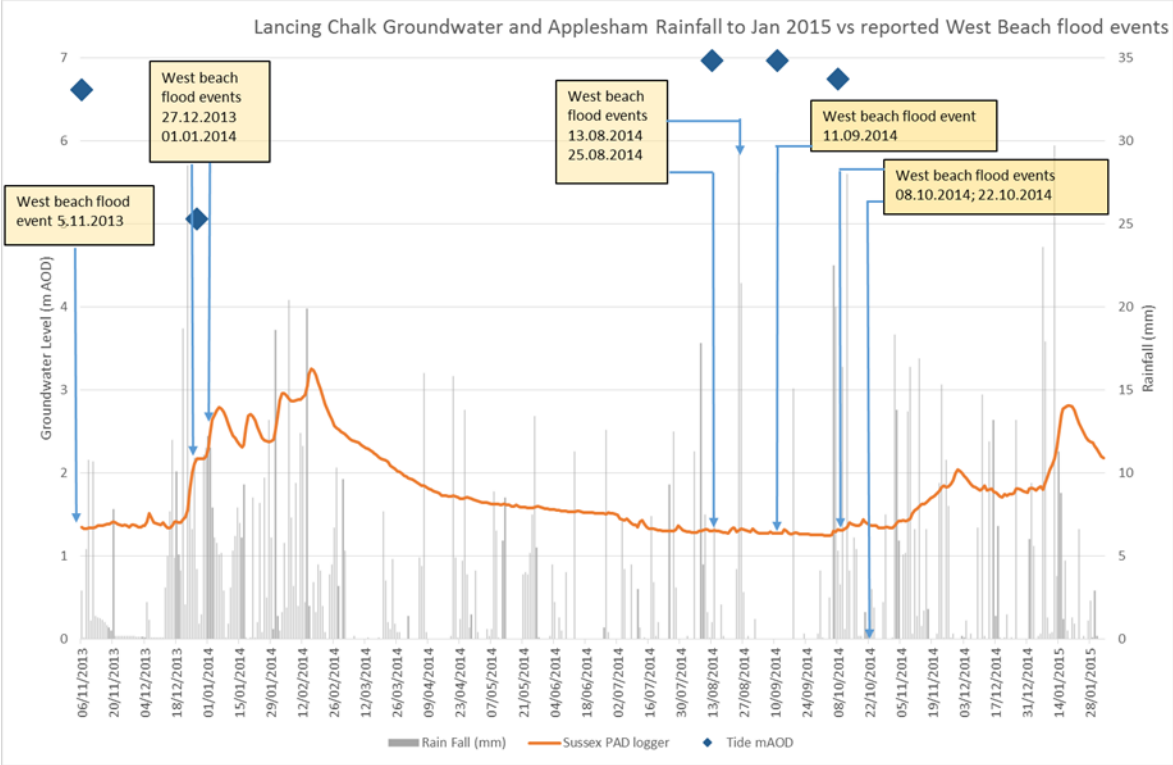


Figure 5-6 Groundwater and Tidal Levels and Rainfall vs flooding recorded in West Beach Area (NB: not all reported flood records are displayed on this graph)

5.1.4.3 Causes of flooding

There are a number of local drainage issues that are playing a significant role in flooding on the West Beach Estate. These include:

- a significant number of gullies which are cracked/broken, or full of sediment, siltation in the surface water pipes along Westway, and potential siltation of soakaways;

- blocked surface water drainage outfalls – local residents have confirmed that since the outfalls on Bristol Avenue and George V Avenue were cleared the flooding has reduced, but other outfalls remain blocked, and;
- high groundwater levels (as demonstrated by the water level in the soakaways) which means that water cannot drain away after heavy rainfall events (for further details see Section 5.1.4.2).

The high water levels encountered in the soakaways (and the A259 pipe) supports the view that there is a high water table beneath the Estate. With consistently high groundwater levels, there is no capacity for water to drain away from the gullies during rainfall events, which will therefore contribute towards flooding on The Broadway. In addition the soakaways are likely to be acting as conduits for groundwater to come towards the surface. A local history book notes that "much of the development *[West Beach Estate]* was over the beds of beach, and when soak-pits were dug to take away the reverse took place at high tide, when water came out of the gullies instead of running into them. The water went down with the tide"[24]. As the soakaways have limited capacity to drain more surface water (due to the high water table) the result is that flooding remains on The Broadway for several days following heavy rainfall. In addition, heavy rainfall will also cause significant problems on the estate because the main surface water drainage pipes do not have functioning outfalls for the most part.

24 reports of flooding from residents of West Beach Estate since November 2013 has been analysed for this SWMP, although most of the evidence is related to Autumn 2014 and Winter 2014/15, as shown in Table 5-1. Because flooding in the West Beach Estate lasts for several days due to reasons noted above flooding reports within five days of each other have been grouped. These are shown in bold, italic type font in Table 5-1, resulting 16 unique flooding incidents reported by local residents. For each of these flooding incidents we have examined the level and timing of high tides, groundwater levels in the Chalk at Sussex PAD, and rainfall data at Applesham Farm (NB: antecedent rainfall up to two days was also considered).

Of the 16 unique flooding incidents, 12 of these are related to wet weather (>10mm rainfall) on the day of flooding and often also due to antecedent rainfall in the preceding two days. High tides can exacerbate the flooding. Of the remaining four unique flooding incidents, there is no rainfall data for two of the incidents and there are two incidents associated with very high tides and no rainfall (11th September 2014 and 23rd January 2015). For the incidents associated with very high tides and no rainfall, water was observed to be 'bubbling up' through the tarmac on Westway (near George V Avenue), causing isolated flooding to the parts of the highway. There was no documented flooding on The Broadway.

In summary, flooding primarily occurs following heavy rainfall. A combination of rainfall and high tides will exacerbate flooding because it will cause the groundwater table to rise and reduce the capacity of the drainage system (gullies, soakaways and pipes) to discharge surface water. Very high tides during dry conditions (>6.8m AOD) can also cause isolated flooding because the water table rises above the surface.

[24] Kerridge, R.G., (1979), A History of Lancing

SECTION 5

Table 5-1 Summary of flooding reports from residents of West Beach Estate (bold & italic text identifies a linked event)

ID	Date/Time flooding	Date/time high tide	What is flooded? And to what extent? (All are quotes from local residents)		Other useful information	Level of high tide (mAOD)	Groundwater level at Sussex PAD (mAOD)	Rainfall total (Applesham Farm)	Dry / Wet	Tide level at time of flood
			The Broadway	The Westway						
1	05/11/2013 2:30pm	05/11/2013 12:05pm				6.61	1.36	25.6mm two days earlier2.2mm	Wet	High
2	27/12/2013 7:00am	27/12/2013 05:43am	The Broadway is continually flooded from the entrance to the crossroads 6-9 inches deep		The flood Plain behind West Beach is pooling on Old Salts Farm	5.06	2.17	4.2mm on 27/11, 10.9mm on 26/11	Wet	Low
3	01/01/2014 2:00pm	01/01/2014 10:49am	Was flooded to the centre of the road but numerous cars including a lowered mini was able to enter/exit the estate area		All areas were deep, making it difficult to drive through	6.51	2.29	12.2mm on 01/01, 11.5mm on 31/12	Wet	High
4	10/08/2014 Time Unknown		The Broadway is continually flooded	West beach is continuing to flood badly all this week		Tide >6m	1.31	17.8mm on 08/08 and 4.5mm on 09/08 and 7.5mm on 10/08	Wet	High
4a	***13/08/2014 4:10pm***	***13/08/2014 1:59pm***	***Unknown***	***Flooding either side of Westway above ankle deep, but not to middle of road***		***6.96***	***1.30***	***1mm on 13/08, 12/08 dry***	***Dry***	***High***
5	25/08/2014 7:00am				Flooding of woodland area	Tide <6m	1.31	29.2mm on 25/08	Wet	Low
6	11/09/2014 3:00pm	11/09/2014 1:38pm		Flooding either side of Westway limited to one side of the road	Water bubbling up onto Westway (video). Water drained away by 5.30	6.96	1.27	Dry	Dry	High
7	08/10/2014 1:00PM	08/10/2014 11:50am	Unknown	Flooding across most of width of Westway. Fairly deep in places	The flood plain behind west beach is now flooded. Prince Avenue flooded	6.74	1.32	5.3mm 08/10 and 20.0mm on 07/10	Wet	High
8	22/10/2014 1:30PM	22/10/2014 11:06am			Prince Avenue flooded across whole width of road	5.66	1.37	Unknown	Unknown	Low
9	03/11/2014 09:00am	03/11/2014 7:50am	Broadway flooded, extent / depths unknown	Westway also flooded, extent unknown?	Roads were at 9am. About a foot of concrete was not under water. Water still sitting in Westway and Broadway at 6pm	5.62	1.40	18.3mm on 02/11 and 13.8mm 03/11	Wet	Low
9a	***07/11/2014 12:15pm***	***07/11/2014 11:13am***	***Broadway flooded, extent / depths unknown***	***Westway flooded, half way across the road but quite deep. Also looks to be flowing***		***6.54***	***1.42***	***5.1mm on 06/11 and 5.2mm on 07/11***	***Dry***	***High***
9b	***08/11/2014 1:30pm***	***08/11/2014 11:54am***	***Broadway flooded, extent / depths unknown***	***Flooding across most of width of Westway. Fairly deep in places***	***Also flooded 9th November 2014, high tide was 6.32m AOD***	***6.49***	***1.43***	***13.7mm on 08/11***	***Wet***	***High***

ID	Date/Time flooding	Date/time high tide	What is flooded? And to what extent? (All are quotes from local residents)		Other useful information	Level of high tide (mAOD)	Groundwater level at Sussex PAD (mAOD)	Rainfall total (Applesham Farm)	Dry / Wet	Tide level at time of flood
			The Broadway	The Westway						
9c	***10/11/2014 3.25pm***	***10/11/2014 1:13pm***	***Broadway badly flooded across whole length of road, buses couldn't stop at edge of road***		***Orient Road flooded near junction with Broadway***	***6.05***	***1.51***	***0.3mm on 10/11***	***Dry***	***High***
10	23/11/2014 1:00pm	23/11/2014 11:26am	The Broadway / Orient Rd are flooding badly again. Flooding almost across the total width of the road	Limited flooding on Westway?	Broadway north of junction also flooded one side of the road	6.24	1.83	9.4 on 22/11 and 15.3mm on 23/11	Wet	High
10a	***28/11/2014 Time Unknown***		***Refer to previous photographs of the flooding on the Broadway and crossroads of Westway / Orient Road***		***The flooding has been constant and not abated ,yesterday it was across the entire road and causing problems with the flow of traffic especially smaller cars which have to travel down the centre of the road***	***Tide <6m in afternoon***	***1.91***	***10.8mm on 25/11, .88mm on 26/11 and 0.3mm on 28/11***	***Wet***	***Low***
11	12/12/2014 09:30am		Broadway and crossroads Orient Road and Westway almost across road near junction with A259		Just to keep you informed The Broadway is still partially flooded 2 days after the precipitation	Not linked to high tide	1.85	14.7mm on 11/12 and 0.2mm on 12/11	Wet	Low
11a	***17/12/2014 3:30pm***		***The Broadway is badly flooded nearly to the middle of the road but still passable. Corner of Orient Flooded***	***No flooding on Westway***	***Low tide but heavy precipitation.***	***Tide <5m***	***1.76***	***13.2mm on 16/12 and 1.4mm on 17/12***	***Wet***	***Low***
11b	***19/12/2014 12:00pm***		***Broadway flooded, but less water compared to 2 days earlier. Still across most of road***			***Tide <5.5m***	***1.72***	***6.8mm on 18/12 and 0.1mm on 19/12***	***Dry***	***Low***
12	03/01/2015 Time Unknown		The Broadway badly flooded , cascading water off A 259 , reaching middle of road etc as previous	No flooding on Westway	Unsure of time of flood, email was as 12:47pm	Tide <5.75m	1.81	9.4mm on 02/01 and 5.6mm on 03/01	Wet	Low
13	08-01-2015 11:00am		The Broadway badly flooded , cascading water off A 259 , reaching middle of road etc as previous	Flooding Westway half way across road, focussed on area between George V and Bristol Avenue		Not related to tide level	1.88	23.6mm on 07/01 and 17.9mm on 08/01	Wet	Low
14	14-01-2015 3:35pm		The Broadway junction floods in all four directions (into Orient Rd, up and down Broadway as well as into the Westway). If it rains heavily, the whole junction floods heavily	Not flooded		Low tide 2 hours earlier	2.50	11.3mm on 14/01	Wet	Low
14a	***17-01-2015 11.30am***		***Majority of Broadway flooded***	***Not flooded***		***High tide @ 8am, only 5.2m AOD***	***2.79***	***4.7mm on 17/01***	***Dry***	***Low***
15	23-01-15 2.30pm	23-01-15 @1.30pm	Flooding but still receding	Water bubbling up through Westway, but only isolated flooding		6.83	2.60	6.6mm on 23/01	Dry	High

ID	Date/Time flooding	Date/time high tide	What is flooded? And to what extent? (All are quotes from local residents)		Other useful information	Level of high tide (mAOD)	Groundwater level at Sussex PAD (mAOD)	Rainfall total (Applesham Farm)	Dry / Wet	Tide level at time of flood
			The Broadway	The Westway						
16	13-02-2015 4.00pm		The Broadway is flooded to about a quarter due to surface water runoff from the A 259 after precipitation this	pooling significantly along the curbs to a quarter of the Broadway and orient / Westway		High tide 4.97 @ 5pm	Data not yet available	Data not yet available	Unknown	Unknown

5.1.5 A27 Drainage

The A27 catchment which contributes flows towards Lancing Brook ditches is in proximity to the junction with Berriedale Drive to the west and the crossing over the River Adur to the east. The A27 drains to the ditches via kerb offlets, gullies, edge and surface channels, filter drains and pipework to a series of outfalls into the Lancing Brook ditches. The outfalls from the A27 are outlined below (from west to east):

- south of the Manor Road / Grinstead Lane roundabout where flows drain to the 300mm pipe which flows through No.4 Old Shoreham Road;
- on Manor Close where the A27 drainage flows into a manhole which also conveys the flows from the ditches under Manor Close;
- into a small ditch near 68A Old Shoreham Road[25];
- two outfalls into the ditch immediately east of Mash Barn Lane;
- outfall into the lagoon south of the A27, which is known to be heavily silted, and;
- a further unknown outfall into Withy Patch caravan park.

Following flooding on the A27 in 2012 the Highways Agency undertook significant remediation work, which was completed in 2013. This has included pipe remediation, patch lining, lateral grinding and root cutting, to improve conveyance capacity of the system.

5.1.6 Honeyman's Hole

Honeyman's Hole is a spring located immediately south of the A27 (co-ordinates 519088, 105881). It is not possible to quantify its contribution of flow to the Lancing Brooks with any certainty, but it flows all year round. Honeyman's Hole discharges into a ditch network which runs both east towards a sluice gate into the tidal Adur, and south into a culvert which runs under Shoreham Airport (via a large brick arch culvert[26], as shown in Figure 5-7). During low tide approximately 50% of flows from Honeyman's Hole drains towards the sluice gate, with the remainder flowing south. During tide-lock situations all flows from Honeyman's Hole will flow south towards the brick arch culvert.

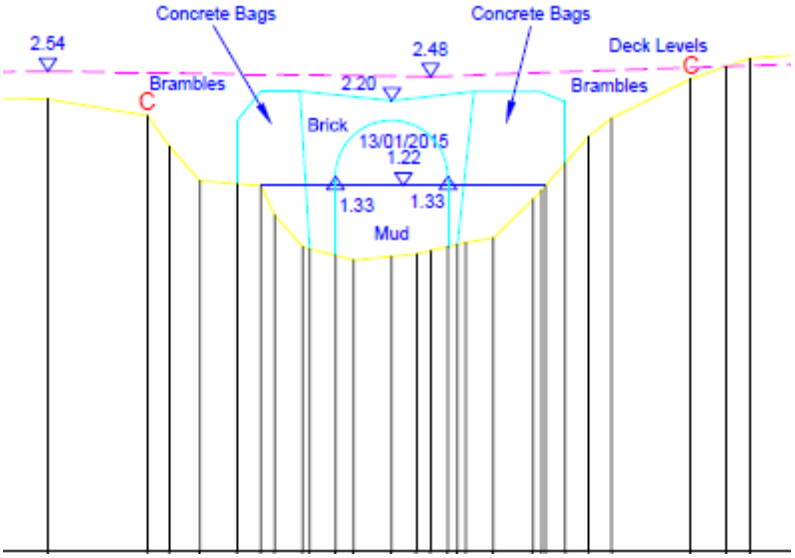


Figure 5-7 Culvert under Shoreham Airport from Honeyman's Hole (from Cross-Section Survey)

5.1.7 Widewater lagoon

Widewater is a shallow lagoon approximately 1.1km long and up to 80m wide at the eastern end. It is an important location for nature with many rare species and attracts a wide range of interest from the general

[25] This is the cul-de-sac on the southern side of the A27

[26] Approximately 3m into the culvert it appear to change to a 1m diameter culvert, but this could not be confirmed during the survey without confined space entry.

public for recreation. The Widewater Management Plan (2009-2014) contains a significant level of background information about Widewater which is not repeated in this report[27].

For the SWMP the key issue is whether Widewater Lagoon contributes to flooding at West Beach Estate. WSCC undertook a survey from the Widewater Lagoon to the junction of The Broadway with Orient Road/Westway in April 2014 to establish ground levels across the section (using Temporary Benchmark Datum). The bed of Widewater Lagoon was approximately 150mm lower than the low point on The Broadway (near the local shops). The water level in April 2014 was approximately 500mm higher than the low point on The Broadway. The water level in the Lagoon is affected by:

- seawater percolation through the shingle bank;
- overtopping of the defences during storms;
- inlet pipe, which can increase salinity where required;
- rainfall and surface water runoff from properties adjacent to the Lagoon, and;
- water loss via evaporation, and some percolation through the lagoon bed[28].

With respect to the latter point the Widewater Management Plan notes that "there has been bubbling observed from the base of the lagoon at normal high tides, indicating that some flow of air and/or seawater occurs through the shingle bank and via the bed of the lagoon"[29]. However, the clay layer at the bottom of the Lagoon will have a significant effect of limiting the amount of seepage into the Lagoon during high tides, and limiting seepage out of the lagoon during low tides. There is no evidence of significant reductions in water levels during low tides which would occur each and every time if there was significant seepage through the lagoon bed. The majority of seepage into and out of the lagoon will be via the shingle bank.

The evidence available does not suggest that there is significant seepage through the lagoon bed. Any minor seepage would be discharged into underlying strata beneath Widewater, which will flow towards the sea in keeping with the regional groundwater flows (as described in Section 3.4). Widewater Lagoon is not considered to be a contributory factor in flooding on West Beach Estate.

5.2 Lancing Brooks watercourses

Due to the presence of the railway line the catchment can broadly be divided into the northern floodplain and southern floodplain, before converging south of the railway near Shoreham Airport.

The route and connectivity of the Lancing Brooks has changed on several occasions over the past 400 years, based on analysis of historic maps dating back to 1622. Historically the Teville Stream, which now flows through Worthing (discharging to the sea) used to flow east and discharge into the tidal Adur. The Lancing Brooks connected to the Teville Stream south of Old Salts Farm and New Salts Farm. This was the case until between 1870 and 1898 when Widewater Lagoon was constructed and the Teville Stream was diverted to outfall to the sea further west. Historically, the lost ditch north of Adur Close is likely to have been the ditch that discharged flows from Teville Stream into the tidal Adur although this cannot be confirmed based on the resolution of the historic mapping. The railway also seems to have affected the Lancing Brooks. Before the railway there is evidence of a flow connection from the southern floodplain towards the northern floodplain east of Old Salts Farm. This no longer occurs as the ditches south of the railway do not flow into the northern floodplain. Development during the 20th century has also affected the route of the ditches, which have at times been altered. In addition, this development has constrained the natural floodplain of the ditches, which are now heavily constrained through the urban areas of Lancing.

[27] http://www.lancingparishcouncil.gov.uk/council/item/21

[28] *Ibid.*

[29] *Ibid.*

In the subsequent sections a brief overview of the connectivity and outfall of the Lancing Brooks is provided, as it flows today.

5.2.1 Northern floodplain

The ditches west of Mash Barn Lane have been described in Section 5.1.1.2. East of Mash Barn Lane the ditches flow through the golf course development. The primary ditch runs east until near the boundary with Shoreham Airport where the ditch flows south towards the twin 900mm culvert, which flows under Shoreham Airport, before emerging for a short open section and then flowing under the railway via a brick arch culvert. Immediately upstream of the twin 900mm culvert is a small pond. At various points throughout the golf course there are connecting ditches. This includes a ditch network which drains flows from the Brighton and Hove Albion football club development. The landowners of the golf course clear the ditches on an annual basis to maximise conveyance through the ditches. In addition to flows from the Manor Way area and the golf course, the northern floodplain also includes flows from Honeyman's Hole, as described in Section 5.1.6. Figure 5-8 provides an overview of the northern floodplain.

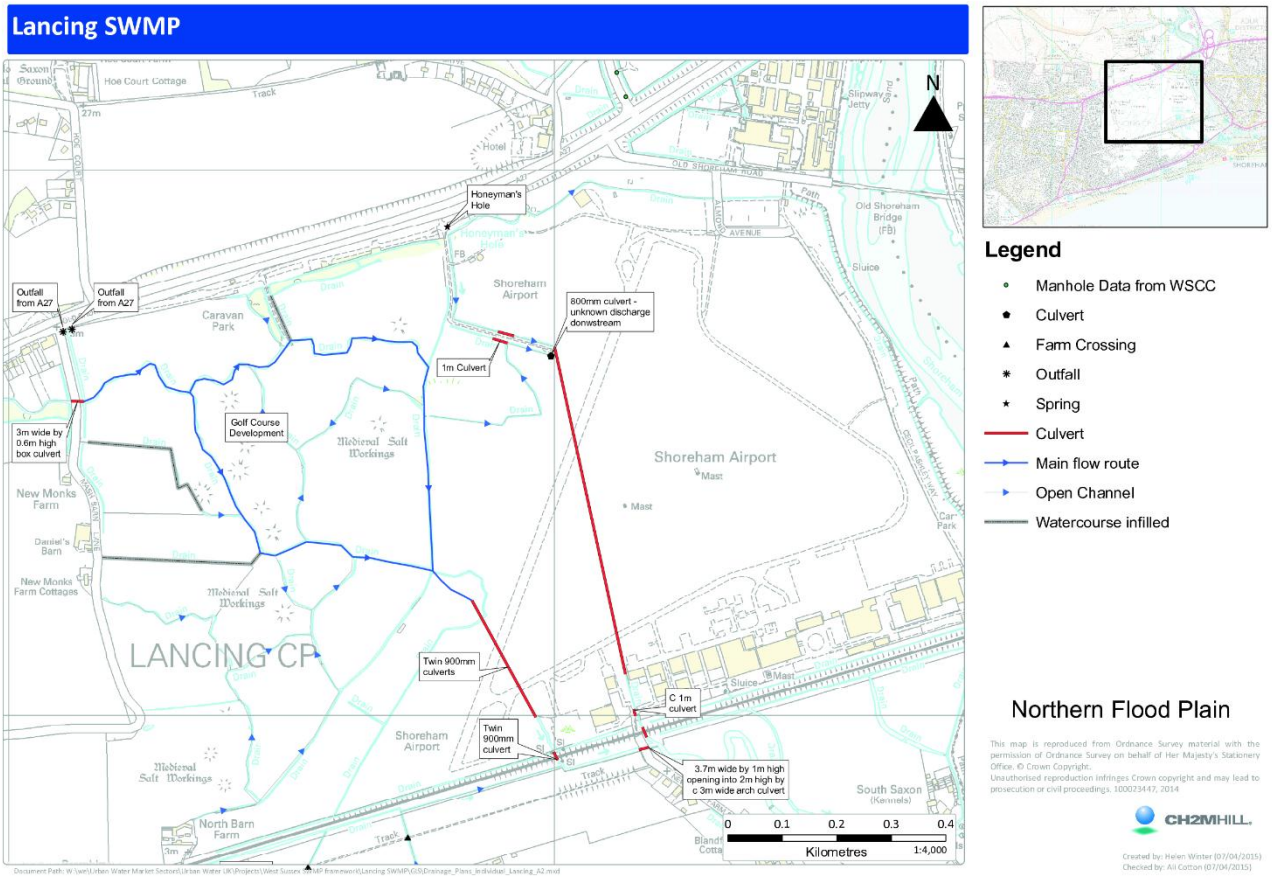


Figure 5-8 Northern floodplain layout

5.2.2 Southern floodplain

Inflows to the southern floodplain are primarily from the ditch which flows from Barfield Park, the ditch which flows from Willowbrook Caravan Park, and groundwater emergence. With respect to Barfield Park, Section 5.1.2 describes the connectivity of ditches. Downstream of the railway the Brooks continue to flow in a southerly direction where it is joined by flows from Willowbrook Caravan Park. At this point the ditch turns to flow in a north-easterly direction until a bifurcation in flow north of the West Beach Estate. The primary flow pathway is east until the ditch reaches the end of Broadway Park Homes where the ditch turns abruptly north towards the railway. The ditch continues to flow along the southern edge of the railway

before crossing under New Salts Farm Bridge (NB: two bridges at this location), before flowing towards the Lancing Brooks outfall by the Dogs Trust.

5.2.3 Outflows

The Lancing Brooks Outfall collates all flows from the northern and southern floodplain and discharges into the tidal Adur[30]. The outfall was re-built in 2010. Prior to this the twin northern outfalls had failed completely due to siltation. The report[31] prepared to support the business case notes: "the existing trash screens are not effective, causing debris to be caught in the flap valve in the past. Access to maintain the trash screen is very poor, and there is no access to maintain or clear the tidal flap valves." To alleviate the problem a series of options were considered:

1. Do nothing
2. Do minimum
3. Option D; replace southern outfall and decommission northern outfall
4. Option D(s); as option D with additional flood plain storage
5. Option E; Replace southern outfall with increased capacity and decommission northern outfall
6. Option F; Pumping station with 3 x 250 l/s pumps to lift water from Lancing Brook into tidal lagoon

Option D was the preferred option and taken forward for design and construction in 2009 and 2010. Local residents have expressed concerns that the new outfall is insufficient and causes backing up of the water into the floodplain. The hydraulic modelling and design of the outfall has therefore been considered, in the context of its impact on discharge from the Brooks.

When the Lancing Brooks Outfall was re-designed the capacity of the discharge was increased, and the invert level at the outfalls was also lowered. The invert levels for construction were lowered by 100mm to -0.25m AOD at the inlet and -0.31m AOD at the outlet. During initial design the proposal was to do a like for like replacement of the twin 900mm culverts on the southern outfall. However, during construction the twin culverts were actually upsized to 1200mm culverts, thus increasing the peak flow discharge from the outfall. The pipe full capacity pre and post scheme is shown in Table 5-2, which have been calculated using *Tables for Hydraulic Design of Pipes and Sewers*, By HR Wallingford.

Table 5-2 Capacity of the Lancing Brooks Outfall pre and post scheme

Parameter	Pre-scheme (southern outfall)	Post-scheme (southern outfall)
Gradient, S_0	1/300	1/300
Hydraulic roughness, k_s, mm	0.03	0.03
Pipe diameter, mm	2 x 900	2 x 1200
Pipe full flow, m^3/s	1.438	3.053
Pipe full velocity, m/s	2.26	2.70

This calculation assumes that the flap valves at the downstream end of the twin 1200mm culverts are full opened, which will only occur if there is sufficient hydraulic head within the system to force the flap valves open. If the hydraulic head in the system is insufficient to fully open the flap valves then upsizing or lowering the invert level of the culverts would not be effective in increasing the discharge capacity. It is not

[30] With the exception of some flow from Honeyman's Hole which drain east towards the tidal sluice, and some flows from the airport which drain to a surface water pumping station (which in turn pumps flows into the tidal Adur).

[31] Halcrow Group Ltd (2008), Lancing Brook Outfalls, Project Appraisal Report

considered that any changes to the Lancing Brooks Outfall is required to mitigate flood risk to people and property in Lancing.

The change in upstream water level in the hydraulic model used to support the re-design of the outfall has also been considered. The results of modelling demonstrate a reduction in peak water level post-development of between 11 and 15 cm. This is as expected due to the lowering of the southern outfall allowing more water to drain from the catchment on the low tide.

SECTION 6

Modelling of Lancing Brooks

6.1 Introduction

A comprehensive cross-section survey was undertaken, which was used to develop a simplified 1D ISIS hydraulic model. The purpose of the modelling was to provide an overview of the conveyance of flows through the ditch system, and identify locations where there are pinch points in the system. However, the hydraulic model is not intended to be a verified flooding model, principally because of the complexities of accurately representing inflows to the ditch system, as noted in the Monson Engineering study report[32].

6.2 Cross-section survey

During December 2014 and January 2015 a comprehensive cross-section survey was undertaken of the Lancing Brooks. More than 85 cross-section surveys were taken of the Lancing Brooks from its emergence in the urban areas around Manor Close and Barfield Park, to the outfall east of New Salts Farm. The location of cross-sections for the survey were determined in collaboration with the district drainage engineer from Adur and Worthing Councils, and experience of the survey team.

Cross-sections were surveyed at all key structures (e.g. bridges, farm crossings, culverts), where ditches converged, and at other suitable locations throughout the network. Cross sections extended 10m beyond the river bank into the flood plain, wherever possible although in some of the residential areas the channel was heavily constrained and the top of the watercourse bank was deemed acceptable. For upstream elevations of bridges and culverts, the downstream soffit, top of parapet, invert, bed level and bank crests were surveyed. Weirs, drop structures and all other structures were also surveyed. Outputs from the survey were in ISIS format, and XYZ files. Long sections were provided for any structures which are considered to effect flow and CAD format drawings of hydraulic structures were supplied by the survey contractor. The outputs from the survey are provided in Appendix F.

6.3 Hydraulic model build

The cross-section survey was used to build a one-dimensional (1D) ISIS hydraulic model of the Lancing Brooks ditches. The 1D model represents changes in water levels throughout the system and locations where this may cause flows to reach the top of the bank of the watercourse or overtop the bank. However, a 1D model does not seek to represent the flows once they are out of bank (i.e. how water travels over the floodplain, causing flooding to properties and infrastructure). All structures from the cross-section survey were represented in the model to assess the impact of these on water levels. At all structures a ‘spill’ unit was included in the model, with the level set to road or bank level. The spill unit represents out of bank flow at these key structures, which is subsequently discharged to the downstream section.

As the purpose of the model was to broadly understand the conveyance of flows through the ditches, the model was run with nominal steady state inflows, rather than based on detailed FEH rainfall-runoff calculations. Inflows were provided at head of each reach into the system. To ensure that the total inflows into the ditch system were broadly appropriate previous work was considered, which has quantified the total inflows to the system for a range of design storm events.

The Monson Engineering study estimated that on average runoff arriving at the New Salts Farm Road culvert was approximately 1.25 m^3/s during a 1 in 10 year design storm with a 7 hour critical duration. Furthermore, to support the re-design of the Lancing Brooks Outfall total flows arriving at the outfall were estimated to be

[32] Monson Engineering (1994), Report on the Survey and Hydraulic Analysis of Lancing Drainage Ditches

approximately 1 m^3/s during a 1 in 10 year design storm (with a critical duration of 12 hours[33]), and 1.5 m3/s for a 1 in 100 year design storm[34].

The hydraulic model has been run with two sets of steady state inflows of 1 m^3/s and 1.5m^3/s to test the conveyance of flows through the network. These have been applied proportionately at the head of each reach, with the largest inflows included at the head of the ditch system at Manor Way and Barfield Park.

6.4 Model simulations

The hydraulic model was simulated for a range of scenarios to understand pinch points in the system, and the effectiveness of different mitigation measures on water levels across the Lancing Brooks. The following scenarios were run in the hydraulic model.

- Baseline (BL) – this scenario is based on bed and bank levels from the cross-section survey, and are considered to represent the current day scenario.
- Scenario 0 (SC_0) – this scenario represents the impact of no maintenance on water levels. For this scenario a range of increased bed levels were represented in the residential areas and southern floodplain ditches to identify what the optimal maintenance regime would be for the ditches. The ditches within the Golf Course are maintained on an annual basis and were therefore left unchanged for this scenario. No change was made to culverted sections, because in many places there is already significant increases in bed levels at culvert inlets under roads/bridges due to siltation.
- Scenario 1 (SC_1) – this scenario represents maintenance improvements at key structures which have the greatest impact on water levels. The bed levels for road bridges at Mash Barn Lane and Old Salts Farm were lowered to provide a consistent bed level upstream and downstream of these structures.
- Scenario 2 (SC_2) – this scenario represents capital improvements at key structures which have the greatest impact on water levels. The culvert inlet on Manor Close was increased from a 450mm to a 600mm, and 600mm diversion culverts were implemented parallel to the Old Salts Farm Road Bridge and Mash Barn Lane. For these scenarios the bed levels at Mash Barn Lane and Old Salts Farm Road bridges were unchanged from the baseline scenario, to identify mitigation options for upgrading the road bridges in case it is not possible to lower the bed levels without affecting the structural integrity of the bridges.

The model simulations are identified in Table 6-1. A summary of the modelling results are presented in the subsequent sections, and full modelling results are presented in Appendix G. All modelling results have been compared against Scenario 0 (no maintenance) to represent the effects of a 'do nothing' scenario[35].

Table 6-1 Baseline model scenarios

Scenario ID	Total inflows to model		Outfall condition	
	1 m^3/s	1.5 m^3/s	Outfall open	Outfall closed
SC_0a	✓		✓	
SC_0b	✓			✓
SC_0c		✓	✓	
SC_0d		✓		✓
BL_a	✓		✓	
BL_b	✓			✓

[33] Initially a critical storm duration of 6 hours was used, however this is subject to change when tide-lock conditions were considered.

[34] Halcrow Group Ltd (2007), Lancing Brook Outfall, Hydrology Technical Note

[35] As per Environment Agency (2010), Flood and Coastal Erosion Risk Management appraisal guidance, http://webarchive.nationalarchives.gov.uk/20131108051347/http:/a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho0310bsdb-e-e.pdf

Scenario ID	Total inflows to model		Outfall condition	
	1 m^3/s	1.5 m^3/s	Outfall open	Outfall closed
BL_c		✓	✓	
BL_d		✓		✓
SC_1a	✓		✓	
SC_1b	✓			✓
SC_1c		✓	✓	
SC_1d		✓		✓
SC_2a	✓		✓	
SC_2b	✓			✓
SC_2c		✓	✓	
SC_2d		✓		✓

6.4.1 Scenario 0 - Do nothing scenario

This scenario seeks to investigate the impact of a lack of maintenance on water levels in the Lancing Brooks. The following adjustments were made to the open channel cross-sections within the baseline model:

- bed levels were increased in the residential areas were increased by 150mm, and 250mm to represent different levels of siltation buildup, and;
- bed levels were increased in the southern floodplain (from the railway culvert to New Salts Farm Road bridge) were increased by 150mm and 250mm.

Culverts and farm crossings were not adjusted because in most cases there is existing siltation at these structures, which causes constrictions to flows.

Table 6-2 summarises the changes in water level across the Barfield Park and Manor Way reaches with 150mm and 250mm siltation, compared to the baseline scenario. With 150mm siltation in the system the maximum increase in water levels in upstream of Mash Barn Lane, and downstream of the railway bridge near Old Salts Farm was approximately 80mm.

However, for the same reaches siltation in the order of 250mm resulted in increases in maximum water levels of 150mm downstream of the railway bridge near Old Salts Farm and more than 200mm upstream of Mash Barn Lane. This will increase the risk of overtopping of the watercourses because the conveyance capacity is reduced in the channels. The evidence from the modelling therefore suggests that siltation of up to 150mm will have a limited impact of water levels, but siltation up to 250mm will have a more significant impact.

Table 6-2 Changes in water level under Scenario 0 compared to the baseline results

Reach	Maximum increase in Water Level (mAOD) compared to Baseline scenario			
	150mm siltation		250mm siltation	
	1 m^3/s inflows	1.5 m^3/s inflows	1 m^3/s inflows	1.5 m^3/s inflows
Barfield Park – Lancing Brooks Outfall	0.081	0.033	0.148	0.069
Manor Way – Lancing Brooks Outfall	0.082	0.03	0.222	0.065

6.4.2 Baseline scenario

The model results indicate that for the low tide baseline scenario with 1 m^3/s inflows (BL_a) there are numerous structures (e.g. bridges, culverts) which have a significant impact on upstream water levels, due to headloss in the system at these structures. This is demonstrated by sharp increases in water levels upstream of some key structures, including the Old Salts Farm Road Bridge and Mash Barn Lane Road Bridge.

The cross-section survey identified significant constrictions at these road bridges due to siltation which has elevated the bed level, and pipe crossings which affect the soffit level. The effect of siltation and pipe crossings is to reduce the cross-sectional area of these road bridges significantly, compared to the upstream and downstream open channel sections. Appendix E contains the cross-section survey data, which demonstrates the constrictions in flows at these road bridges.

Under scenario BL_c (low tide baseline scenario with 1.5 m^3/s inflows) there are additional structures which have a more significant impact on upstream water levels, most notably at the 450mm Manor Close culvert inlet, the twin 600mm culverts under Monks Avenue and North Farm Road culvert, and the brick arch culvert under the railway south of North Farm Road. At these structures the cross-section survey did not identify significant siltation, therefore any flow constriction is related to the sizing of these structures, rather than maintenance and sediment buildup. The Manor Close culvert has a more significant impact on upstream water levels than either of the twin 600mm culverts at Monks Avenue and North Farm Road, and the railway culvert. Whilst the twin 600mm culverts at Monks Avenue and North Farm Road and the railway culvert do effect water levels and cause some constriction in flow, there is no evidence from this modelling that they contribute to out of bank flooding from the ditches. Therefore improvement works should focus on the Manor Close culvert.

The Monson Engineering study identified the New Salts Farm Road Bridge to be a major restriction in the system. The model results presented in this study do suggest some increase in water levels upstream of this structure, but it is less significant that the effects of structures further upstream. There is also evidence of siltation around at the New Salts Farm road bridge[36]

The bed levels from the cross-section survey suggest a relatively good gradient from the upper parts of the ditches to the outfall. There are some sections which have been over-deepened through ditch clearance (e.g. southern floodplain to the north of the West Beach Estate, and sections of the golf course), but these will not serve to restrict flow. More importantly, there appear to be few sections of open channel where the bed level increases sharply, which would have an impact on upstream water levels. In summary, the baseline model scenarios suggest structures are having a greater impact on water levels than the current maintenance of the Lancing Brooks.

With the Lancing Brooks Outfall closed, to represent a high tide scenario (BL_b), the model results show a significant rise in water levels throughout the ditch network. This corroborates local evidence that water levels as far north as Mash Barn Lane rise during high tide. In addition, during a high tide the water level is significantly less affected by flow restrictions at structures, because water level equalises over the whole ditch network in the absence of any discharge from the system.

6.4.3 Scenario 1 – Maintenance improvements at structures

This scenario represents maintenance improvements at key structures which have the greatest impact on water levels, namely the Mash Barn Lane and Old Salts Farm road bridges. Within the ISIS model the bed levels at these structures was lowered to provide an improved gradient upstream and downstream of these structures. At this stage no consideration has been made of the structural integrity of the road bridges, and

[36] Bed levels at the downstream face of New Salts Farm road bridge were 0.25m AOD at the time of survey. The bed levels at the nearest surveyed upstream section (just before the Brooks flow alongside the railway) were 0.991m AOD. Downstream of the bridge bed levels drop to below sea level as the Brooks flow through open fields, although these sections appear to be over-deepened.

the potential impact of de-silting, although it may be possible to re-design the bridges at the point of maintenance to make them easier to clear and reduce silt buildup through their design.

With respect to Barfield Park the model results indicate a significant drop in water levels in the ditches upstream of Old Salts Farm Road bridge. Under scenario SC_1a (low tide scenario with 1 m^3/s inflows) the water level drops by more than 300mm (compared to scenario 0 with a 250mm silt buildup) in the cross-section immediately upstream and downstream of the railway, because of the reduction in headloss when the cross-sectional area of the road bridge is increased by lowering of the bed level. The impact of improving the conveyance capacity of the Old Salts Farm Road bridge extends to the head of the ditch network on Barfield Park, which is the headwall to the east of Grinstead Lane. Under scenario SC_1c (low tide scenario with 1.5 m^3/s inflows) lowering the bed level at Old Salts Farm Road bridge is less significant (c.150mm compared to scenario 0 with 250mm silt buildup). Therefore, the modelling indicates that improved conveyance at Old Salts Farm Road bridge will have an impact on upstream water levels, and hence reduce the risk of out of bank flooding. The model results for SC_1b and SC_1d (high tide scenarios) indicate limited reduction in water levels with the improvements to Old Salts Farm Road bridge.

With respect to Manor Way the model results indicate a modest reduction in water levels with the improvement to the Mash Barn Lane bridge. Under scenario SC_1a (low tide scenario with 1 m^3/s inflows) water levels drop by more than 300mm immediately upstream of the bridge (compared to scenario 0 with a 250mm silt buildup), which reflects the constriction of the bridge on local flows. Further upstream, near the Manor Close culvert modelled water levels do not change with these improvements in place. This is because of the further constriction upstream, associated with the Manor Close culvert. Under scenario SC_1c (low tide scenario with 1.5 m^3/s inflows) the improvement works to the Mash Barn Lane bridge have little impact on upstream water levels (c.100mm). The model results for SC_1b and SC_1d (high tide scenarios) indicate limited reduction in water levels with the lowering of bed levels at the Mash Barn Lane bridge.

6.4.4 Scenario 2 – Capital improvements at structures

This scenario represents capital improvements at key structures which have the greatest impact on water levels. The following changes were applied to the model for this scenario:

- the culvert inlet on Manor Close was increased from a 450mm to a 600mm;
- a 600mm diversion culvert was implemented parallel to the Old Salts Farm Road Bridge, and;
- a 600mm diversion culvert was implemented parallel to the Mash Barn Lane bridge.

No change was made to the bed levels at Mash Barn Lane and Old Salts Farm Road bridges.

With respect to Barfield Park the implementation of an additional 600mm culvert adjacent to the Old Salts Farm Road bridge has a similar impact on water levels as scenario 1, where the bed level of the road bridge was lowered. With the tidal gates closed, water levels are unaffected by the proposed mitigation measures, as per scenario 1.

On Manor Way the combined improvement measures at the Manor Close culvert inlet and Mash Barn Lane bridge result in a reduction in water levels from Mash Barn Lane to the head of the model, which is the doctors ditch. Under scenario SC_2a (low tide scenario with 1 m^3/s inflows) the reduction in water levels immediately upstream of Mash Barn Lane are similar to the results from scenario 1. However, further upstream, near the Manor Close culvert, the model results for this scenario suggest a significant reduction in water levels of nearly 500mm as a result of improvements to the Manor Close culvert inlet.

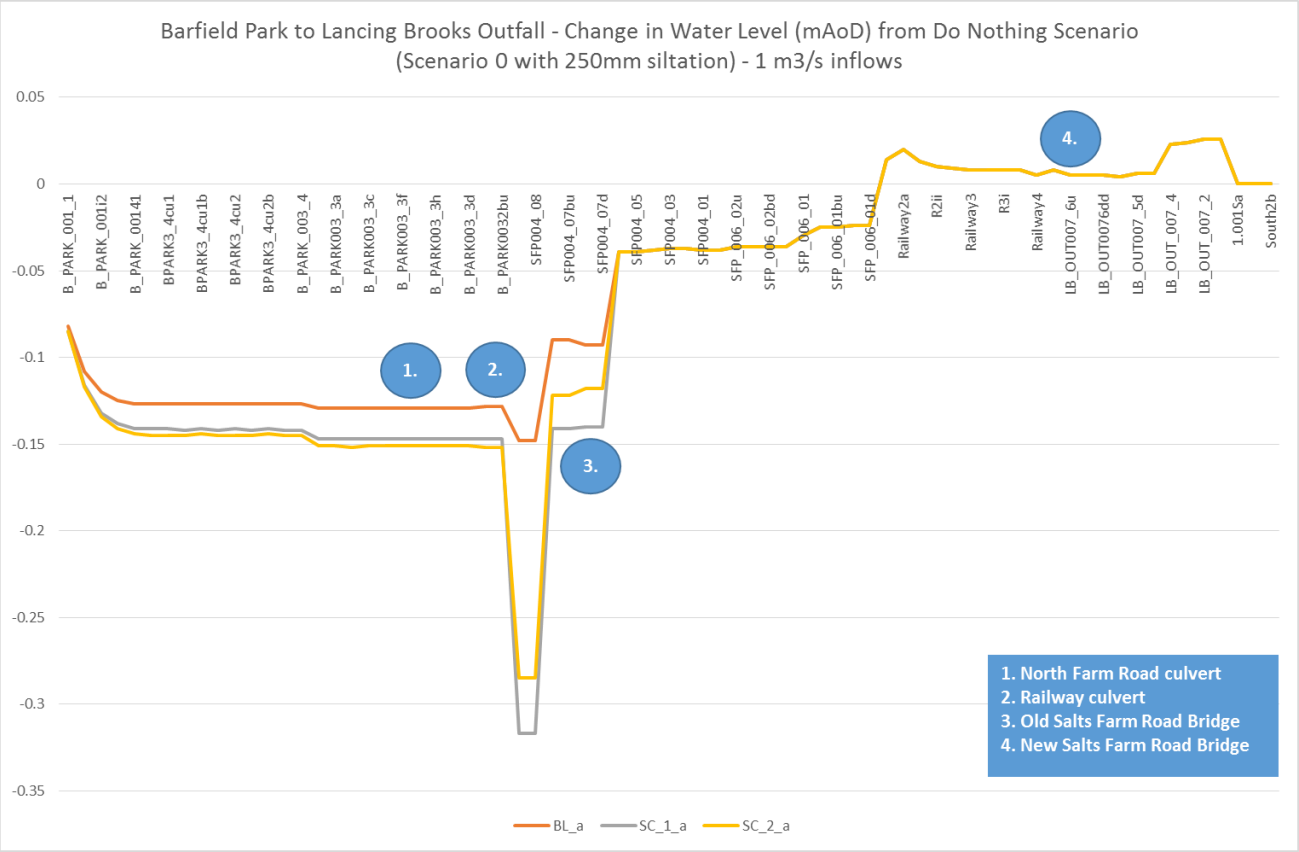


Figure 6-1 Barfield Park to Lancing Brooks Outfall - Change on water level from scenario 0 (250mm siltation) for 1m3/s inflows scenario

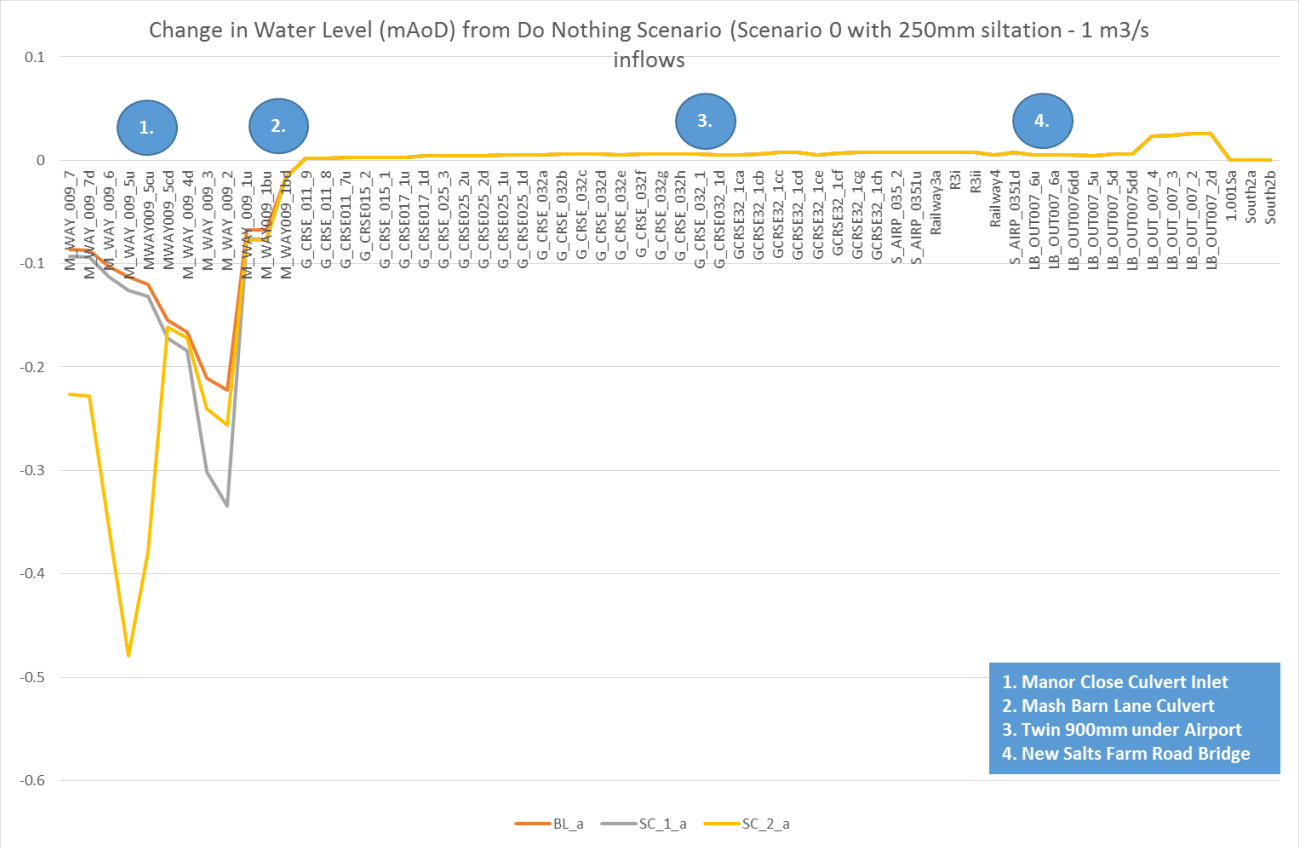


Figure 6-2 Manor Way to Lancing Brooks Outfall - Change on water level from scenario 0 (250mm siltation) for 1m3/s inflows scenario

6.5 Summary of hydraulic modelling

The salient findings from the hydraulic modelling are:

- silt buildup within the ditch network in residential areas and the southern floodplain greater than 150mm will cause a significant impact on water levels;
- there is evidence of significant siltation or capacity constraints at several culverts, bridges, road/farm crossings including Manor Close culvert, Mash Barn Lane road bridge and Old Salts Farm road bridge;
- the twin 600mm culverts under Monks Avenue and North Farm Road, railway culvert to the south of North Farm Road and the New Salts Farm Road Bridge cause some additional backing up of flows and increases in water levels, and;
- improvement works (maintenance and capital) to Manor Close culvert, Mash Barn Lane road bridge and Old Salts Farm road bridge have been modelled and demonstrate reductions in water levels up to 600mm.

SECTION 7

Summary of causes and impacts of flooding

The analysis presented in Sections 5 and 6 have demonstrated the causes of flooding in Lancing. This analysis is summarised in Table 7-1.

Table 7-1 Summary of causes and impacts of flooding

Location	Internal Property Flooding	Garden Flooding	Road Flooding	Other Infrastructure Flooding	Properties at risk of surface water flooding during a 1 in 30 year rainfall probability[37]	Causes of flooding
Grinstead Lane, Manor Way, Manor Close & Old Shoreham Road		✓	✓		15-20 properties	• High sensitivity to groundwater emergence • Influence of high groundwater on the performance of foul and surface water drainage systems, contributing to foul flooding and failure of the Grinstead Lane pumping station. Southern Water has implemented a number of actions following 2012/13 and 2013/14 including: development of a IRP, sealing of some sewers, installation of a level alert and production of an Emergency Action Plan • Culverts on Manor Close and Mash Barn Lane which impede flow of the Lancing Brooks • Maintenance of the Lancing Brooks • Under-sized drainage around Manor Way which can exacerbate flooding along Grinstead Lane • Risk that incomplete water level management plan for golf course development could exacerbate flood risk during extreme flooding events.
Barfield Park and Monks Avenue	✓ (2)	✓	✓		None	• High sensitivity to groundwater emergence • Highway drainage at junction of Monks Avenue / Hadlow Way

[37] Based on the Environment Agency's national surface water flood mapping, http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=ufmfsw#x=357683&y=355134&scale=2

Location	Internal Property Flooding	Garden Flooding	Road Flooding	Other Infrastructure Flooding	Properties at risk of surface water flooding during a 1 in 30 year rainfall probability[37]	Causes of flooding
						• Culverts on Monks Avenue and North Farm Road, and the railway culvert have some impact on water levels, but do not cause out of bank flows. • Maintenance of the Lancing Brooks
The Paddocks	Garages		✓			• Siltation in the storage tanks, root infestation, and siltation in the ditch network. This has been cleared by WSCC during the past 18 months
West Beach Estate			✓		None	• A significant number of gullies which are cracked/broken, or full of sediment, siltation in the surface water pipes along The Westway, and potential siltation of soakaways. • Blocked surface water drainage outfalls • High groundwater levels (as demonstrated by the water level in the soakaways) which means that water cannot drain away after heavy rainfall events
A27			✓		N/A	• Condition of the piped drainage, which has since been addressed through remedial works undertaken by the Highways Agency in 2013. This has included pipe remediation, patch lining, lateral grinding and root cutting, to improve conveyance capacity of the system. It is outside of the scope of this report to recommend additional drainage measures on the A27, and therefore this is not considered further in this report.
Shoreham Airport				✓	N/A	• Failure of the River Adur tidal wall during a tidal surge in December 2013[38]. The Environment Agency is developing the business case for long term improvements to the tidal wall, and therefore this is not considered further in this report.

[38] http://www.bbc.co.uk/news/uk-england-sussex-25267611

SECTION 8

Options to mitigate flooding

8.1 Introduction

The level of investment to mitigate flood risk must be proportional to the damage to property and infrastructure caused by flooding. In Lancing few properties are currently affected by internal flooding, and therefore the proposed mitigation measures are reflective of this. Policy, capital and maintenance mitigation measures to alleviate the impacts of flooding in Lancing have been considered and are described in Sections 8.2 to 8.5. It is critical to understand that even with all of these measures in place Lancing will still be at risk of flooding during more extreme weather events. This is because drainage systems (both natural and man-made) and any other flood risk infrastructure will be completely overwhelmed during extreme weather events. This concept is described in Figure 8-1 and defines different flood risk management approaches dependant on the rainfall event within a catchment. For 'everyday rainfall' the drainage system should function according to its natural or designed capacity to limit the impact of any flooding. Conversely during extreme events, it is recognised that drainage systems (both natural and man-made) and any other flood risk management infrastructure will be completely overwhelmed and therefore emergency response is the most appropriate management technique to reduce the impacts of flooding. The measures in this report focus on ensuring the drainage systems are functioning as designed for the 'everyday rainfall' and 'drainage design rainfall' through capital and maintenance investment. For the exceedance rainfall and extreme rainfall scenarios mitigation against flooding will rely on emergency intervention by WSCC, Southern Water and Adur District Council, and local residents taking action to reduce the impacts of flooding to property.

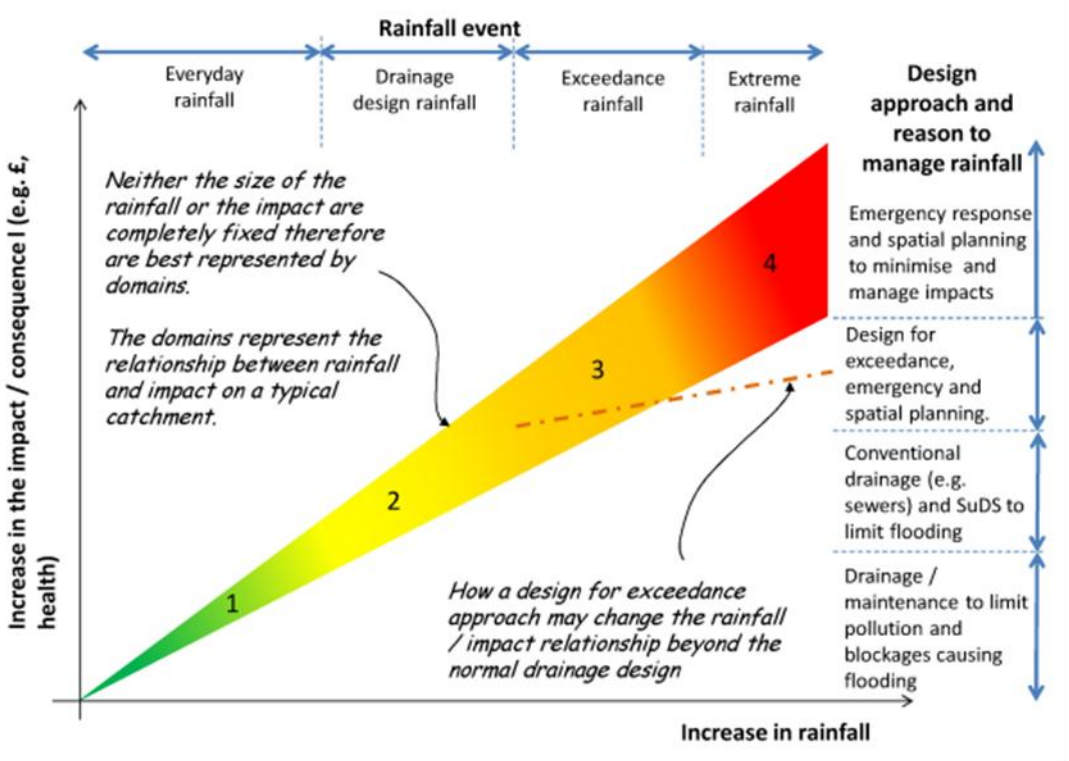


Figure 8-1 Flood risk management concept (taken from CIRIA's Designing for Exceedance guidance[39])

[39] Digman, C.J., Ashley, R.M., Hargreaves, P. and Gill, E. (2014a) *Managing urban flooding from heavy rainfall - Encouraging the uptake of designing for exceedance – recommendations and summary*, CIRIA, C738a.

8.2 Grinstead Lane, Manor Way, Manor Close & Old Shoreham Road

8.2.1 Under-sized drainage near Manor Way

8.2.1.1 Conceptual options

As identified in Section 5.1.1.1 the 300mm pipe which flows east between numbers 5-7 Grinstead Lane, through the garden of No. 4 Old Shoreham Road has limited capacity to drain surface water flows from the upstream catchment to the doctor's ditch downstream. This will exacerbate surface water flooding in Grinstead Lane and Manor Way. To reduce flood risk at this location the primary option[40] is to disconnect the 300mm pipe which flows from Manor Road, and pass more flows through the existing overflow system which flows along the northern verge of the A27. The existing overflow system will need to be upsized to accommodate the additional flows, and flow control will be required to prevent an increase in flow rates to the Manor Close culvert.

To upsize the existing overflow system there are two options available. Conceptual drawings of these options are provided in Appendix H.

- Option 1 – this option involves constructing a dual pipe system along the route of the current overflow system, with pipe sizes between 600mm to 900mm. The pipes would need to be laid in concrete surround to avoid groundwater infiltration. At the downstream end of the overflow system a flow control device would be constructed to limit flows to the existing discharge rate, hence avoiding any increase in downstream flood risk. There are some constraints to this option because of the proximity of construction to the A27 carriageway, and the possibility of construction temporarily affecting the bus stop.
- Option 2 – this option involves constructing a geocellular attenuation tank (with concrete surround) in the grass verge on the north east of the A27/Manor Road roundabout to store flows. Flows from the geocellular attenuation tank would be limited to avoid any increase in downstream flood risk, and the pipework downstream would also be upsized/re-laid. The pipes would need to be laid in concrete surround to avoid groundwater infiltration. This option avoids the risk of any construction work directly affecting the A27.

There are a large number of assumptions included at this stage, which need to be considered during further design stages. First, the exact catchment area draining to the existing 300mm pipe is unknown, although evidence from Southern Water surface water sewer records suggests the catchment area is in the region of 1 hectare. Secondly the condition or storage capacity within the existing system is unknown. To confirm catchment area, condition and sizes of the upstream network will require a CCTV survey[41]. The CCTV survey should also include the 300mm continuation pipe and the 225mm overflow pipe to confirm condition and levels. Once these data have been collected a hydraulic model should be built to test the capacity of the current system. A further uncertainty at this stage is the presence of utilities and other services along the northern verge of the A27. A services search should be undertaken as a priority action to confirm there is sufficient space to implement the proposed upgrade to the 225mm overflow system.

8.2.1.2 Costs and benefits of options

Due the number of assumptions at this stage it is difficult to provide a cost estimate for these options. However, a provisional construction cost estimate, using bills of quantities and the SPONS pricing book, suggests the construction costs could be in the region of £200,000 for Option A and £100,000 for Option B. This assumes that all pipework and attenuation tanks are laid in concrete surround which approximately

[40] Other options, such as upsizing the pipe are likely to present significant technical challenges because they pass through residential gardens

[41] The manhole survey will capture cover, invert and soffit levels of the network.

doubles the cost estimate for these components of construction. In addition, the cost estimate is based on SPONS pricing books, which are national estimates. Whoever takes this action forward may have access to different construction rates from contractors. An outline of the bills of quantities and construction cost estimates are provided in Appendix H. The cost estimate does not include a consideration of survey and design costs.

It is difficult to monetise the benefits of specific measures in the Lancing catchment, because there is limited property flooding, and it is only a combination of mitigation measures that will reduce flood risk. Qualitatively, the improvement works to the drainage around Manor Road and Manor Way the benefits will be reduced flooding on Grinstead Lane, which has a significant on local residents living in the area. In addition, whilst there has not been any direct internal property flooding there has been garden flooding, which again causes disruption to local residents.

8.2.2 Other measures required

Mitigation measures for the Lancing Brooks are considered in the water level management plan in Section 8.5. Other mitigation measures relevant to Grinstead Lane, Manor Way, Manor Close & Old Shoreham Road, include:

- Adur District Council to further consider the impact of the golf course water level management plan not being fully implemented as set out by the planning application conditions;
- Southern Water to implement their Infiltration Reduction Plan (IRP) to reduce infiltration into the sewer network, and ensure measures are fully communicated with stakeholders and local residents;
- Southern Water to activate the Emergency Action Plan (EAP) when required;
- Adur Floodwatch Group and Adur District Council to work with local residents and communities to prepare individual and community flood plans, and;
- Adur District Council to discourage the use of new soakaway drainage in the affected area unless site specific investigations demonstrate there is capacity with respect to groundwater levels. In certain areas soakaways will not function during periods of high groundwater levels and may also allow upward emergence of groundwater from the Chalk.

8.3 Barfield Park & Monks Avenue

Within Barfield Park and Monks Avenue there are no significant capital works related to highway or surface water drainage proposed within the SWMP. This is because the majority of flood risk is related to the conveyance capacity of the ditches and emergence of groundwater. For the most part groundwater emergence causes some waterlogging of gardens on Barfield Park, and no mitigation is proposed to these properties. There are one or two properties that experience flooding inside their properties due to groundwater emergence, some of which occurs through soakaways which act as a conduit for groundwater to flow towards the surface. For these properties it is recommended that roof and yard drainage is positively connected to the nearest drainage system (highway drainage or ditches), rather than to soakaways, and that soakaways are infilled to reduce the risk of groundwater emergence.

In addition there is evidence that the highway drainage at the junction of Monks Avenue and Hadlow Way results in garden flooding to one property. WSCC should investigate this further and clear any blocked gullies and/or install a new outlet into the ditch network.

8.4 West Beach Estate

8.4.1 Conceptual options

8.4.1.1 Quick win measures

On the West Beach Estate there are several quick win measures which would alleviate flooding to the roads.

- First, enhanced maintenance of existing road gullies is required. From the site visit in October 2014 10% were completely cracked/broken and 10-20% were choked (full of sediment). These should be

prioritised for repair where the gullies are cracked/broken, and jetting where the gullies are full of sediment.

- Secondly, jetting of the pipe network and any soakaways which are heavily silted should be undertaken.
- Thirdly, the outfalls from the piped drainage on Boundary Road and Prince Avenue should be uncovered and cleared, to enable discharge from the network, with permission from the land owner[42]. Uncovering/creation of an outfall at the northern end of roads will help to alleviate flooding. Without any outfalls the piped drainage will become surcharged with surface runoff (and any direct infiltration due to high groundwater levels), and contribute to flooding on the highway. The outfalls will act to relieve surcharging in the piped drainage, and therefore reduce the risk of flooding.
- Fourthly, at the end of each outfall on Bristol Avenue, George V Avenue, Boundary Road and Prince Avenue it is recommended that a shallow depression be constructed to store (and infiltrate, where possible) flows from the Estate, with permission from the land owner. It is not considered necessary to connect the outfalls to the Lancing Brooks directly, via a more extensive ditch network, because:
  - when water levels in the main channel through the southern floodplain are high (during winter months and/or high tides) it would inhibit flows discharging into the main channel from the West Beach Estate[43], and;
  - the costs of a more extensive ditch network are more significant than constructing shallow depressions at the end of each outfall, for little, if any, additional benefit.

8.4.1.2 The Broadway

In addition to the quick win measures, additional capital works may be required to alleviate flooding on The Broadway, which is the most persistent flooding problem affecting the Estate. Evidence from surveys undertaken by WSCC in February 2015 demonstrates that the two existing soakaways on The Broadway can become full of water following heavy rainfall, during winter months when groundwater levels are high, and/or during high tides (which can push groundwater towards the surface). As gullies on The Broadway are connected to the two existing soakaways there is no capacity for water to drain away from the gullies during rainfall events, which will therefore contribute towards flooding on The Broadway. To alleviate this flooding, a proposed option has been considered as part of the SWMP, which is described below. Conceptual drawings of these options are provided in Appendix H. Options which have been discounted are shown in Table 8-1.

Figure 8-2 Photo of soakaway near the shops on The Broadway

The proposed option seeks to reduce flooding on The Broadway through gravity drainage. The three gullies to the north of the shops currently drain to a soakaway on the corner of the crossroads. Under this option these gullies would be connected to a new piped network (c.150mm) which would flow west and connect up

[42] The evidence indicates that piped drainage on West Avenue flows south towards WestWay and then into Prince Avenue. Therefore, it is not considered necessary to locate and create/uncover an outfall on West Avenue.

[43] Based on ground levels at the end of Bristol Avenue (1.62m AOD based on LiDAR) and the data from the cross-section survey (bed level -0.37m AOD, water level 0.66m AOD) any pipe or open channel connection to the main Brooks would be submerged during winter months, thereby rendering any outfall ineffective.

the existing manhole at the southern end of Bristol Avenue. Due to the shallow pipe depth on Bristol Avenue the new piped network would be very shallow, with a relatively flat gradient. The viability of this option would depend on further topographic survey to prove the ground levels and invert levels of the pipe drainage on Bristol Avenue. Due to the shallow gradient or the pipe there would be risks of blockages and/or siltation, which would need to be considered during design.

Further south on The Broadway there is a proposal to install slot drains on the publicly adopted highway to the south of the shops. The slot drains would intercept any localised runoff and any minor exceedance from the A259. The slot drains would be connected via a pipe network (150mm) to the 300mm drainage system on the A259. Further topographical work is required to establish the exact location of the slot drains to enable the system to drain back to the A259 (at the soffit level of the 300mm pipe) via gravity.

Finally, a water level sensor and conductivity meter should be installed in the soakaways on The Broadway to continuously monitor water levels and salinity. This will help to provide further evidence of how water levels are affected by groundwater in the superficial layer (gravels), and the amount of saline influence within the soakaways. It is likely that groundwater levels in the superficial layer remain high most of the year, but monitoring of the soakaways would help to confirm this.

Table 8-1 Discounted options on The Broadway

Description	Reasons for discounting
Provide an overflow piped system from the soakaway near the shops on The Broadway, which flowed north to the cross-roads and then west to connect up to the Bristol Avenue pipe network. The piped network would also include an overflow from the soakaway on the crossroads of The Broadway / WestWay	There is insufficient gradient and pipe depth to create a piped network along this length.
Provision of additional gullies on The Broadway	This will be ineffective at reducing flooding during periods of high groundwater (in winter months), where there is limited capacity for water to drain away
Upsize the 300mm network on the A259	This is not contributing significant flooding to The Broadway, and would not be effective in reducing flooding

8.4.2 Costs of proposed measures

No cost estimate has been prepared for the quick win measures. For the proposed measures on The Broadway a provisional cost estimate suggests the construction costs would be in the region of £70,000, with an appropriate allowance for risk (30%). A breakdown of this cost estimate is provided in Appendix H.

8.4.3 Implementation of proposed measures

On the West Beach Estate the proposed measures within the publicly adopted highway should be added to WSCC's highways prioritisation log, and funded by WSCC. All proposed measures within the private parts of the Estate should be taken forward the owners of the estate in collaboration with the local residents. In addition the land owners of the fields to the north of West Beach Estate must be engaged to secure agreement to the clearance of the outfalls from the Estate, prior to any works being undertaken.

8.5 Water Level Management Plan for Lancing Brooks

This water level management plan (WLMP) sets out the short-term remedial measures, ongoing maintenance and monitoring which is required to improve the conveyance of the Lancing Brooks. It is based

on the findings of the cross-section survey (Appendix F), the hydraulic modelling (Section 6), and observations from site visits. There are necessarily a number of assumptions built into the WLMP, and therefore ongoing monitoring will be required to verify the WLMP, and adjust where necessary. In particular, it is not possible to quantify the rate of sediment buildup within the Lancing Brooks, something which can only be done through establishing a monitoring regime. The monitoring frequency may change as further knowledge is gained about system performance, so annual monitoring could become less frequent.

8.5.1 Short-term remedial measures

The cross-section survey and hydraulic modelling undertaken for this SWMP has identified several constrictions to conveyance of the Lancing Brooks. This is mostly related to culverts and structures under roads throughout the study area. The baseline model scenario (see Section 6.4.2) identified the following key constrictions to flow (in order of impact):

- Old Salts Farm Road bridge, due to significant siltation at the structure, and a pipe crossing under the road bridge;
- Mash Barn Lane bridge, due to significant siltation at the structure, and a pipe crossing under the road bridge;
- the Manor Close culvert has a 450mm inlet structure, which limits the upstream hydraulic capacity;
- the twin 600mm culverts under Monks Avenue and North Farm Road, which cause some flow constriction and increase upstream water levels. Despite this, there is no evidence that the hydraulic capacity of the structure causes out of bank flows;
- the railway culvert to the south of North Farm Road, although this does not cause significant constriction to flow, and;
- the New Salts Farm Road Bridge, which is predicted to have some impact on water levels but these are less significant that the effects of structures further upstream.

As the twin 600mm culverts under Monks Avenue and North Farm Road, and the railway culvert to the south of North Farm Road are not considered to have hydraulic capacity constraints which contribute to a risk of out of bank flows, the WLMP does not consider any short-term remedial measures at these locations.

The hydraulic modelling (Scenario 1 and 2, as outlined in Section 6) has considered the impact of de-silting and upsizing the Old Salts Farm Road bridge, the Mash Barn Lane bridge and the Manor Close culvert. Based on the modelling, and consideration of capital and maintenance costs of different approaches, it is recommended that the following measures are implemented at the Mash Barn Lane and Old Salts Farm Road bridges:

- de-silting, of up to 0.5m, to provide a consistent bed level with upstream and downstream cross-sections,
- development of a hard bed to reduce roughness, increase flow velocity and hence the reduce the potential for silt deposition;
- structural re-inforcement of the bridges, where necessary, once the bed level is lowered;
- construction of a small access track from the roads to the structures, to facilitate future maintenance (including local de-silting), and;
- potential design and construction of silt ponds immediately upstream of the structures to capture sediment, which would be easier to clear than underneath the structure (NB: this is only worthwhile if it can be demonstrated there is a disproportionate buildup of sediment at these structures because of a drop in velocity, compared to other parts of the Brooks and that silt would be deposited preferentially in the silt ponds as opposed to the “main channel”)

Furthermore, it is recommended that the Manor Close culvert inlet is upsized to a 600mm, from a 450mm. The outlet from this 80m long culvert is significantly larger than the 450mm opening, and it is not known how the structure of the culvert changes along its length. At this stage it has been assumed that the 450mm section is for 40m, for the purposes of a provisional cost estimate.

8.5.2 Maintenance of Lancing Brooks

Defining an optimal maintenance regime for the Lancing Brooks is very difficult, in particular because the rate of sediment buildup and the source sediment are unknown. Primarily, it is considered that the sources of sediment to the Lancing Brooks will be due to runoff from hard standing areas (roads in residential areas and the A27), erosion of banks, and decomposition of vegetation following autumn dieback. The area of hard standing area draining to the Lancing Brooks is relatively small, and therefore the sediment contribution from this source is expected to be low. It is more likely that bank erosion and decomposition of vegetation are contributing more significantly to the buildup of sediment and silt.

The rate of sediment buildup is particularly difficult to establish. However, there is some evidence available from the clearance work undertaken by Adur and Worthing District Councils in 2010 (southern floodplain) and 2013 (ditches in residential areas), the clearance work undertaken by the golf course landowner in January 2015, and the cross-section survey undertaken in December 2014 to January 2015. The findings from the cross-section survey suggest a relatively good gradient in the Lancing Brooks from the upper parts of the catchment to the outfall, as described in Section 6.4.2. The hydraulic modelling also suggests that the main channel bed levels of the Lancing Brooks are not currently causing significant changes in upstream water levels, or headloss in the system. Indeed, even with a 150mm increase in bed levels throughout the ditches in the residential areas the net impact on water levels was minimal (up 100mm in the Barfield Park ditches). Further modelling is planned for the final report, to identify the impact of a further increase in bed levels. This evidence suggests that:

- the clearance work undertaken in the recent past remains effective, and;
- some buildup of silt will not have a significant impact on water levels in the ditches, although it remains unclear what is the “tolerance” of the channel flow to the buildup of silt.

This evidence is important because de-silting and disposal of silt from the ditches is a costly activity. Therefore it should be undertaken only when (and where) it is required to reduce flood risk to properties and infrastructures, particularly within the residential areas where the cost for de-silting is very high and the access if extremely difficult.

8.5.2.1 Annual vegetation clearance

As a balanced approach, it is recommended that an annual vegetation clearance is undertaken throughout the Lancing Brooks. Given that vegetation is likely to be a key contributor to silt buildup (as it reduces flow velocity and encourages the deposition of suspended silt load), this will in turn reduce the need for de-silting.

In addition, to reduce silt buildup in the ditches, it is recommended that silt traps are installed on the highway drainage to capture sediment from the hard standing areas before runoff discharges into the ditches. This should be achieved by replacing manhole chambers with catchpits at key locations within the highway drainage that can be maintained as necessary. Maintenance of catchpits is more straightforward than maintenance of the ditches in the residential areas. Three locations have been provisionally identified:

- manhole on Grinstead Lane opposite the Harvester Pub, which is immediately upstream of the discharge of the highway drainage system into the Barfield Park ditches;
- manhole on the pavement outside no.5-7 Grinstead Lane, before discharge into the 300mm pipe which flows through No.4 Old Shoreham Road, and;
- manhole on Manor Close, which takes flows from the A27 and overflows from the Manor Road system.

8.5.2.2 Monitoring and de-silting

On an annual basis (at least) monitoring of silt levels at key locations in the Lancing Brooks should be undertaken to build up a comprehensive picture of the rate of silt buildup across the catchment. The monitoring could be plotted against the cross-section survey undertaken in December 2014 to January 2015, as a means to visualise the silt buildup since the cross-section survey. It is recommended that monitoring is

undertaken at the upstream face of structures, where there is readily available access, and in areas most sensitive to silt buildup[44]. This monitoring can be undertaken using simple and readily available equipment (e.g. staff) to measure silt levels. The following structures are considered appropriate locations to measure silt buildup:

- at the end of the doctor's ditch, upstream of the Manor Close culvert;
- upstream of Mash Barn Lane bridge;
- Inlet to the twin 900mm culvert under Shoreham Airport;
- Inlet to the twin 600mm culverts on Monks Avenue and North Farm Road;
- upstream of Old Salts Farm Road bridge;
- at the farm crossing to the north of The Broadway Park Homes;
- upstream of New Salts Farm Road bridge, and;
- upstream of the culvert under the Dogs Home access road (which has not been surveyed as part of the cross-section survey).

It is difficult to ascertain an acceptable level of silt buildup before the hydraulic performance of the Lancing Brooks is compromised, which would increase flood risk to properties and infrastructure. However hydraulic modelling undertaken to support this SWMP has represented silt buildup of 150mm and 250mm. Results suggest a significant increase in water levels with silt buildup of 250mm, and less so with 150mm silt buildup. Therefore, silt buildup between 150-250mm within the channels (in residential areas) is likely to start to affect flood risk.

Given that the majority of structures in the residential area are relatively small (e.g. 450mm on Manor Close, twin 600mm on Monks Avenue) it is logical siltation of more than 150mm is likely to start significantly reducing the conveyance capacity of these structures, causing more backing up of flow, which will increase flood risk and result in more deposition of silt (as velocities decrease). In addition, silt removal within the residential areas will become more difficult as the depths of silt increases, as evidenced during the ditch clearance on Manor Way in 2013. It is therefore recommended that once silt buildup at the structures outlined above becomes greater than 150mm from the bed level identified during the cross-section survey, de-silting is undertaken along the specific reaches affected. Given it has been two years since the last clearance in the residential areas, it is considered that that de-silting may need to take place once every five years. De-silting may not be required across the entire catchment every five years, as some locations may be more susceptible to silt buildup. This can only be confirmed through the annual monitoring. It should be noted that the frequency of ongoing monitoring should also be dictated by the rate of silt buildup. For example, some locations may warrant a more frequent monitoring interval, others less frequent. This frequency may be refined as the evidence base is gathered.

8.5.3 Costs of proposed measures

A provisional construction cost estimate for the short-term remedial measures is £120,000, allowing for a 60% risk contingency at this stage. This cost estimate includes an allowance for the silt ponds upstream of Mash Barn Lane and Old Salts Farm Road bridges, which may not be required. The provisional cost estimates are outlined in Table 8-2. A further breakdown of the costs, by bills of quantities, is provided in Appendix H.

Table 8-2 Provisional cost estimate for short-term remedial works

Item	Provisional Cost Estimate
Manor Close culvert reconstruction	£11,500
Re-design of Mash Barn Lane and Old Salts Farm Road bridges	£36,000

[44] Especially where the cross-sectional area of the structure is less than the upstream open channel

Item	Provisional Cost Estimate
Construction of 2 x silt ponds (if required)	£26,500
Risk Contingency @ 60%	£44,500
Total	**£118,500**

The provisional costs of annual vegetation clearance has been estimated from SPONS[45], with a 2x multiplier added for the ditches in residential areas to account for access difficulties. The provisional cost estimate on an annual basis is illustrated in Table 8-3, based on lengths for different parts of the Lancing Brooks network.

Table 8-3 Estimated annual vegetation clearance costs

Location	Estimated length of ditch (m)	Unit cost £/m	Total (inc. 60% risk contingency[46])
Residential ditches	1000	£1.26	£2,720
Southern floodplain from railway culvert to outfall ditches	2700	£0.63	£4,625[47]
Golf course ditches	5000	£0.63	£8,570
Airport ditches (excluding culverts, which would incur significant additional expense)	1500	£0.63	£2,570
Total	**10,200**	**-**	**£18,485**

A provisional cost estimate for the de-silting is provided in Table 8-4 and includes a 2x multiplier for de-silting in the residential areas. The cost estimate assumes all the ditches will require clearance of 150mm of silt. Further detailed are provided in Appendix H.

Table 8-4 Estimated de-silting costs (per occasion)

Location	Estimated length of ditch (m)	Unit cost £/m[48]	Total (inc. 60% risk contingency[49])
Residential ditches	1000	£21.63	£33,300
Southern floodplain from railway culvert to outfall ditches	2700	£19.03	£75,600
Golf course ditches	5000	£19.03	£140,000

[45] SPONS Civil Engineering and Highway Works Price Book 2013, edited by Davis Langdon, an AECOM Company. 27th Edition

[46] Includes some mobilisation and de-mobilisation costs

[47] Due to higher amounts of reed growth in this section the costs of initial vegetation clearance could be higher than forecast using standard cost estimation methods

[48] Includes for disposal of excavated material, which is fixed irrespective of whether the de-silting is from residential areas or other parts of the catchment

[49] Includes some mobilisation and de-mobilisation costs

Airport ditches (excluding culverts, which would incur significant additional expense)	1500	£19.03	£42,000
Total	**10,200**	**-**	**£290,900**

8.5.4 Implementation of the WLMP

Different components of the WLMP will be funded by various organisations. With respect to the short-term remedial measures it is recommended that these are funded by WSCC, or the landowners of the structures which need to be upgraded or maintained. It may be possible to attract Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)[50], where it can be demonstrated that the proposed works will reduce flood risk to properties and achieve pre-defined outcomes needed to attract FCRM GiA funding.

With respect to ongoing maintenance (vegetation clearance and de-silting), under the Land Drainage Act (1991) riparian owners are responsible for ensuring the free passage of flow for all watercourses which are within their ownership. Outside of the residential areas in Lancing it is more straightforward for landowners to undertake vegetation and/or de-silting works because access to the ditch is easier, and the land either side of the ditch is often owned by the same landowner.

However, in the residential areas the ditches will have multiple riparian owners, and access to the ditches is extremely difficult. Furthermore, unless clearance work is coordinated across the entire length of the ditches the works will be relatively ineffective. Co-ordinating actions will also reduce the total costs because of efficiencies such as contractor mobilisation/de-mobilisation. It is therefore recommended that local residents who live in the Barfield Park and Manor Way areas, who will benefit from coordinated actions, should work together to fund the vegetation and de-silting. Lancing Parish Council, the Adur Floodwatch Group and/or WSCC Principal Community Officers could play a key role in helping to co-ordinate funding and the de-silting works.

8.6 Next steps

It is recommended that within three months of publication of this report that WSCC produce an implementation plan. WSCC should work with the responsible bodies, landowners and other relevant affected parties to develop this plan. The implementation plan will set out who will undertake the recommended actions from the SWMP, the timetable for doing so, and the possible funding mechanism.

50 https://www.gov.uk/government/collections/flood-and-coastal-defence-funding-for-risk-management-authorities

Appendices

Appendix A Roles and responsibilities

1. Roles and Responsibilities for LFRM

Appendix B Catchment boundary

1. Lancing - Catchment Boundary
2. Lancing - Flow Pathway Analysis

Appendix C Site Visit Notes

1. Site Visit Notes Oct 2014 (Zone A)
2. Site Visit Notes Oct 2014 (Zone B)
3. Site Visit Notes Oct 2014 (Zone D)
4. Site Visit Notes Oct 2014 (Zone F)

Appendix D Drainage Plans

1. Manor Way_OSR Drainage Plan
2. Northern Floodplain Drainage Plan
3. Southern Area Drainage Plan
4a. West Beach Drainage Plan
4b. Lancing_ZoneD_Drainage Plan_v3

Appendix E Geology and Hydrogeology

1. Geology and Hydrogeology Technical Note
2. Figure 3-2 - Solid Geology
3. Figure 3-3 - Superficial Geology
4. Figure 3-4 - Groundwater Flow & Emergence

Appendix F Cross-section survey

1. Cross-Section Survey.zip

Appendix G Hydraulic modelling results

1. Barfield Park (Scenarios).xls
2. Manor Way (scenarios).xls

Appendix H Conceptual drawings and costs

1. Manor Road (Option 1).pdf
2. Manor Road (Option 2).pdf
3. Manor Road construction cost estimates.xls
4. West Beach Estate (Option).pdf
5. West Beach Estate construction cost estimates.xls
6. WLMP Cost Estimates.xls

Appendix I Environmental Constraints

1. Environ. Constraints Plan

2. Environ. baseline and constraints

Lancing Surface Water Management Plan (SWMP)
Non Technical Summary

What is a SWMP?

Surface Water Management Plans, or SWMPs for short, look at flooding that occurs in response rainfall when:

- sewers and drains become inundated;
- waterlogged ground leads to runoff from land;
- small rivers and/or ditches overflow, and;
- water contained within rocks under the ground rises up above the surface (this is called groundwater flooding).

A SWMP sets out a long-term action plan for dealing with types of flooding.

The Lancing SWMP

The SWMP for the Lancing has been prepared by CH2M HILL on behalf of West Sussex County Council. Work began in July 2014 and the final report was issued in October 2015.

The study area is shown in Figure 1 below. The study area covers the entire catchment from the west which drains towards the Lancing Brooks. The most northerly location of the study area is the open space to the north of Firle Road (in North Lancing). To the east the River Adur forms a natural catchment boundary and the Lancing Brooks discharge into the Adur. To the south the sea forms the natural catchment boundary.

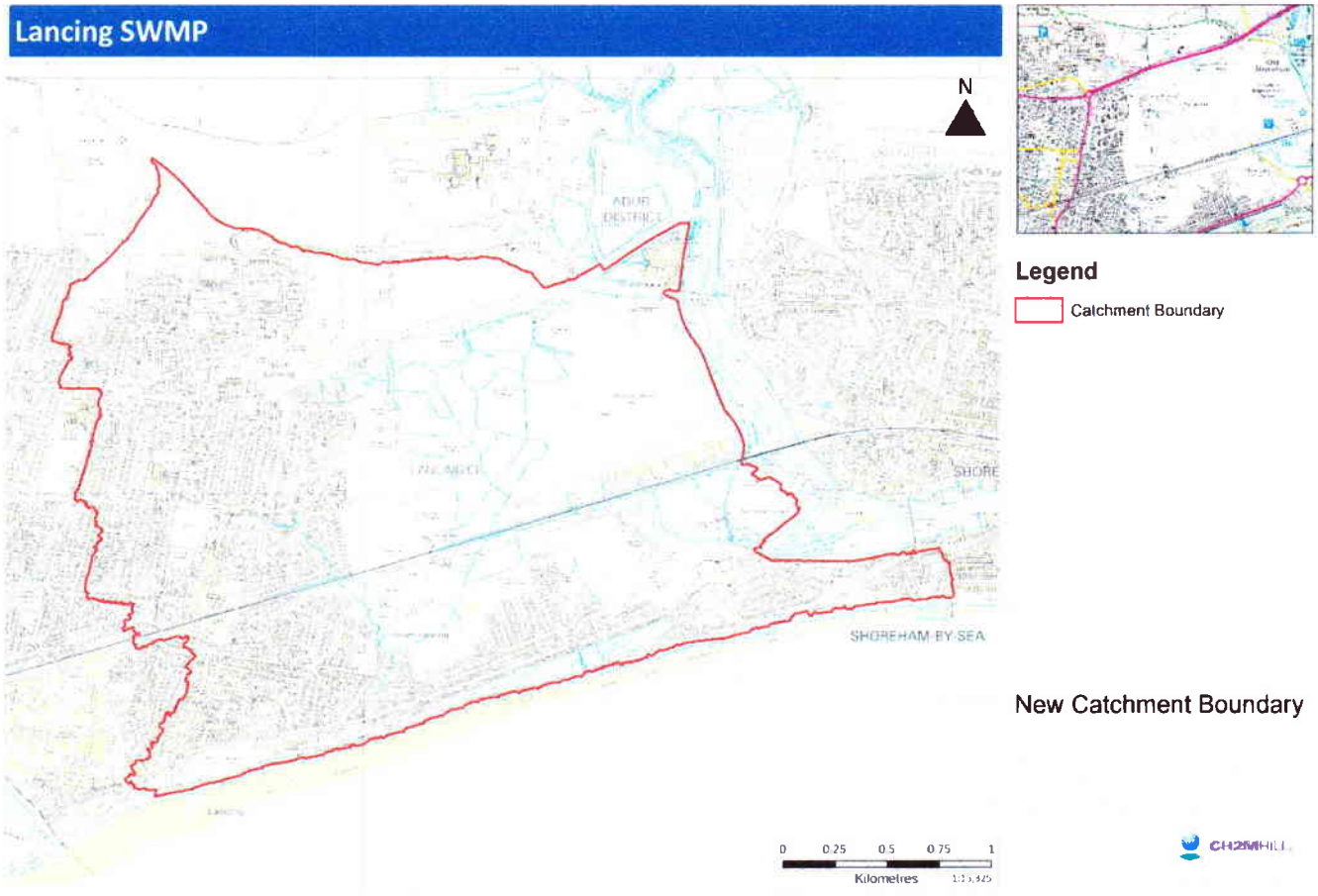


Figure 1 – Lancing SWMP Catchment Boundary

Lancing Surface Water Management Plan (SWMP)

During the development of the SMWP there has been engagement with key stakeholders, including West Sussex County Council (WSCC), Adur and Worthing Councils, the Environment Agency, Southern Water, local flood action groups, and Shoreham Airport.

Objectives

The objectives of the Lancing SWMP were to:

- confirm the catchment boundaries and comment on any differences with previous studies;
- gain a better understanding of the existing drainage network, connectivity, and ownership;
- understand the causes of flooding across Lancing from a range of sources including surface water, foul water, groundwater, watercourses, and tidal influence;
- understand the performance of the Lancing Brooks ditch network and identify how and when future maintenance of the ditches needs to be undertaken, and;
- identify any construction works required to mitigate flooding in Lancing.

Methodology

The methodology for the project broadly follows the SWMP Technical Guidance published by Defra in 2010. The key project stages were as follows:

1. Data collection and review
   - Define the study area
   - Consider historic flooding
2. Consider inflows and outflows from the system
   - Identify 'pinch points' within the catchment
   - Engage with stakeholders
3. Site vists and surveys
4. Consider options to alleviate flooding
   - Develop Water Level Management Plan

Data

A wide range of data were collated and analysed to help understand the local flooding issues. This included data from previous studies in Lancing (e.g. Royal Haskoning Watercourse Study, Monson Engineering Study), historic flooding data, and information on historic rainfall, topography and drainage. All this information was compiled and mapped using computer based Geographic Information Systems.

Flooding in West Beach Estate

Recent flooding issues

There is good anecdotal evidence of flooding within Lancing from the wet winters of 2012/13 and 2013/14, and ongoing reporting from local residents throughout 2014 and 2015. Flooding in Lancing has been a long-standing problem, but the best anecdotal evidence of flooding is from the last two to three years. Given that 2013/14 was the wettest winter on record it is reasonable to assume that the available anecdotal evidence from the past two to three years provides a good basis to assess the flooding impacts. The table below provides an overview of the key locations affected by flooding in Lancing.

Location	No. properties flooded internally	Other impacts
Grinstead Lane, Manor Way, Manor Close	Garages flooded on Manor Way	Extensive flooding on Grinstead Lane (impassable), restricted toilet use, garden flooding, and overpumping of foul network into ditch network
Old Shoreham Road (cul-de-sacs south of A27	None	Flooding on Old Shoreham Road Garden flooding
Barfield Park and Monks Avenue	1 home affected on Barfield Park 1 property flooded near Monks Avenue/Hadlow Way	Garden flooding in other locations
The Paddocks	Garages flooded	Highway flooding
West Beach Estate	None	Flooding across most of The Broadway, and parts of Westway and Prince Avenue

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Lancing Surface Water Management Plan (SWMP)

Location	No. properties flooded internally	Other impacts
A27	None	Northern carriageway of A27 flooded
Shoreham Airport	None	Airport flooded, although main runway was still operational

Causes of flooding

The causes of flooding have been identified through site visits, stakeholder engagement, cross-section and limited manhole surveys, and hydraulic modelling. Lancing is vulnerable to flooding from multiple causes including surface water, groundwater, sewer flooding, and due to capacity constraints in the Lancing Brooks. The table below summarises the key causes of flooding to the locations which are most vulnerable to flooding in Lancing

Location	Causes of flooding
Grinstead Lane, Manor Way, Manor Close & Old Shoreham Road	• High sensitivity to groundwater emergence • Influence of high groundwater on the performance of foul and surface water network • Culverts on Manor Close and Mash Barn Lane • Maintenance of the Lancing Brooks • Under-sized drainage around Manor Way which can exacerbate flooding along Grinstead Lane
Barfield Park and Monks Avenue	• High sensitivity to groundwater emergence • Highway drainage at junction of Monks Avenue / Hadlow Way • Culverts on Monks Avenue and North Farm Road, and the railway culvert have some impact on water levels, but do not cause out of bank flows. • Maintenance of the Lancing Brooks
The Paddocks	• Siltation in the storage tanks, root infestation, and siltation in the ditch network. This has been cleared by WSCC during the past 18 months
West Beach Estate	• Gullies which are cracked/broken, or full of sediment, siltation in the surface water pipes along The Westway, and potential siltation of soakaways. • Blocked surface water drainage outfalls • High groundwater levels and tidal influence which affects discharge of runoff via soakaways
A27	• Condition of the piped drainage, which has since been addressed through remedial works undertaken by Highways England in 2013
Shoreham Airport	• Failure of the River Adur tidal wall during a tidal surge in December 2013. The Environment Agency is developing the business case for long term improvements to the tidal wall, and this is not considered further in this report.

Potential measures

In recent years, there has been a significant amount of work undertaken by WSCC, Adur and Worthing Councils, Southern Water and local residents to reduce flooding to people, property and infrastructure in Lancing. This has included:

- clearance of the Lancing Brooks in 2010 and 2013 by Adur and Worthing Councils and landowners, and further ditch clearance in the golf course development in January 2015;
- improvements to the foul sewerage network buy Southern Water, including development of an Infiltration Reduction Plan, sealing of the sewer network, installation of a level alert system, and production of an Emergency Action Plan;
- clearance of the surface water drainage near No. 4 Old Shoreham Road;
- works by local residents in West Beach Estate, and;
- de-silting of storage tanks and clearance of root infestation at The Paddocks.

Lancing Brooks in North Lancing

The SWMP has considered potential additional measures to reduce flood risk. The level of investment to mitigate flood risk must be proportional to the damage to property and infrastructure caused by flooding. In Lancing few properties are currently affected by internal flooding, and the proposed mitigation measures are reflective of this. Policy, construction and maintenance mitigation measures to alleviate the impacts of flooding in Lancing have been considered.

Even with all of these measures in place Lancing will still be at risk of flooding during more extreme weather events. This is because drainage systems (both natural and man-made) and any other flood risk infrastructure will become overwhelmed during extreme weather events. In addition, Lancing is highly vulnerable to groundwater flooding (or drainage is affected by groundwater levels), which is significantly more technically and economically challenging to manage.

In Grinstead Lane, Manor Way, Manor Close & Old Shoreham Road the proposed measures in the SWMP to manage flooding are:

- improve the management of surface water flows arriving at Grinstead Lane;
- Adur District Council to further consider the golf course development site;

- Southern Water to implement their Infiltration Reduction Plan (IRP) to reduce infiltration into the sewer network, and ensure measures are fully communicated with stakeholders and local residents;
- Southern Water to activate the Emergency Action Plan (EAP) when required;
- Adur Floodwatch Group and Adur District Council to work with local residents and communities to prepare individual and community flood plans, and;
- Adur District Council to discourage the use of new soakaway drainage unless site specific investigations demonstrate there is capacity with respect to groundwater levels. In certain areas soakaways will not function during periods of high groundwater levels and may also allow upward emergence of groundwater from the Chalk.

Within Barfield Park and Monks Avenue there are no significant proposed construction works related to highway or surface water drainage. For the properties which experience groundwater emergence it is recommended that roof and yard drainage is positively connected to the nearest drainage system (highway drainage or ditches), rather than to soakaways, and that soakaways are infilled to reduce the risk of groundwater emergence.

In addition there is evidence that the highway drainage at the junction of Monks Avenue and Hadlow Way results in garden flooding to one property. WSCC should investigate this further and clear any blocked gullies and/or install a new outlet into the ditch network.

On the West Beach Estate there are several quick win measures which should be taken forward by local residents with appropriate consent from the relevant landowners:

- enhanced maintenance of road gullies, several of which are cracked, broken or heavily silted;
- jetting of the pipe network and any soakaways where there is heavy siltation;
- uncover and clear the outfalls from the piped drainage on Boundary Road and Prince Avenue to enable discharge from the network, and;
- at the end of each outfall on Bristol Avenue, George V Avenue, Boundary Road and Prince Avenue it is recommended that a shallow depression be constructed to store flows from the Estate.

In addition, on The Broadway an option has been proposed to reduce flooding through additional gravity drainage. The details of this are presented in the main technical report and Appendix H.

Finally, the SWMP has developed an initial Water Level Management Plan to identify the short-term remedial measures, ongoing maintenance and monitoring which is required to improve the flows of the Lancing Brooks. This recommends improvement works at Old Salts Farm Road bridge, the Mash Barn Lane bridge and the Manor Close culvert. In addition the Water Level Management Plan outlines the need for vegetation clearance, monitoring of silt build-up, and de-silting (as required).

Implementation plan

It is recommended that within three months of publication of this report that WSCC produce an implementation plan. The implementation plan will set out who will undertake the recommended actions from the SWMP, the timetable for doing so, and the funding mechanism.

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Bill Freeman

From: Bill Freeman [redacted]
Sent: 01 February 2016 11:26
To: 'Ken Argent'
Cc: 'David Lambourne'; 'Liz Haywood'
Subject: Drainage update report
Attachments: image016.jpg; image018.jpg; image020.jpg; image022.jpg

Dear Ken,

I promised to provide you with a report on the January's experiences of drainage issues in this North Lancing area.

Once again, the big issue here is ground water - totally confirming the CH2MHill report findings.

Old Shoreham Road – the start of the problems
The usual indication that problems are about to begin is the emergence of ground water streams pushing up in the Old Shoreham Road mini crescent. As we all know this means the aquafers in the Downs above are fully saturated and ground water streams start pushing water southwards to the lower levels. This was first noted, as confirmed to you on the 6th January, As I write this is continuing.

A27 mini crescent

Grinstead Lane
This was followed on Sunday 10th with the manholes for the sewers in Grinstead Lane surcharging immediately opposite the pumping station. Southern Water put in tankering on that night. The overflows were being allowed to flow into the road gullies and presumably would find their way into the Lancing Brooks ditches somewhere further down Grinstead Lane (route not identified).

Southern Water checked the pumps and although one was not kicking in, the other was working. Obviously ground water was leaking into the sewers both within and above Grinstead Lane from Manor Road, Mill Road and pumping capacity was exceeded, hence the surcharges in the manholes.
The faulty pump switching has since been repaired I think.

Because items of raw sewage had been reported to SW, a sand bag arrangement was put in place to direct the flow into the road drains and a one way working traffic light control installed which continues as I write to protect public contact as pedestrians were being splashed by cars with potentially contaminated water. SW had tested for degree of pollution, of course.

Inevitably this has resulted in constant traffic jams in Grinstead Lane and backing up of traffic queues onto the Manor Roundabout above.

Grinstead Lane

This continues as I write.

Grinstead Lane – surface water drainage
The cleared culvert which runs from 5 GL through the back area of 4OSR into the Doctor's ditch seemed to be functioning for GL drainage. Levels in the 3 drainage pits in 4 OSR were very high at some points but not overflowing into the back area of that site. A video is available to show this which I'll make available through Dropbox because of size.

Because rain periods were spasmodic and not incessant, the breathing spaces this provided meant that apart from some pooling in the top of Grinstead Lane, there was not too much of a problem as in previous years.

Manor Way
A tanker driver checked with me the levels in the manholes in Manor Way about 10 days ago. After the 2013 lining and sealing of the sewers and laterals in this road, levels were empty in one and partially up the outflow pipe in the other but not excessive. The groundwater was not ingressing the system it appeared. The sealing seemed to have worked. We have no loo problems here in this road.

Manor Close
As ever, this road, particularly for nos 13 and 16, was as always experiencing severe loss of foul waste facilities. Tankering was started on Monday the 11th January and is still continuing as I write.
As usual, residents had to choose their time to flush toilets depending on whether there was a tanker present and the levels were safe to do so. Other than that, the risk was overtopping of the toilet pan. Also continual gurgling noises from toilets.

It was also found that the sensing device in the manhole they use for pumping in Manor Close was not operating and needed attention. Last winter this worked well to speedily get tankering on site almost before the residents knew they had an emerging problem.

Update this morning – situation now 3 weeks old. It's still causing considerable stress and concern. Tankers, to avoid noise, cease overnight but this means loos cannot be used. I'm about to discuss with SW the possibility of permanent overpumping since it looks like this is going to continue for some time with even more wet weather due this next weekend. This would be the only remedy to ensure continual use of this facility.

I did have one report of gurgling toilets in the OSR which strtches from Manor Close eastwards.

Garden Flooding
This started to occur around the same time as the sewer problems.
I list below the properties affected or at least those which were reported to me or noted by myself or our ward councillor David Lambourne. I have pictures for some as below.

Old Shoreham Road
4, 22, 24,26,28,36 52, 56, 58, 64, 68 These were predominantly back garden problems. One or two reported

front gardens as well.
68 reported that the ditch behind had overtopped and caused the rear end of the back garden to flood.

Manor Way

1, (Back/flooded aviary/loss of birds)
10. (Front/probably back/property unoccupied)
11. (Front)
12 (Back)

Manor Close

16 (back)

Hayley Road

Garage stand behind 4 OSR flooded.

Barfield Park

42, 43

I believe the above list is not exhaustive. Many residents choose not to publicise their problem for insurance reasons. Particularly as residents in this post code are now getting refusals of cover from some companies like Aviva or doubled insurance premiums. In one case a resident in GL was quoted £4000/5000 to provide annual cover. In the last 6 months, House sales have also failed as searches revealed drainage problems for the area. There were two in Manor Way.

1 Grinstead Lane

4 Old Shoreham Road

22 Old Shoreham Road

68 Old Shoreham Road

A27

Although not to a level to close the nearside lane, on and off, during this month's problems the nearside lane in the east bound carriageway has seen quite heavy pooling from obviously ground water. 'Beware of ice' signs have been positioned at the start of the road section affected to warn drivers when cold nights have caused icing of the road.

The ditches

The doctor's ditch

This has managed all flows throughout although, as it is right now, the level has risen to just under the little bridge.

46 Old Shoreham Road

This has managed similarly, although as you can see from Hazel Morris' picture below the levels have risen to the top of the ditch but not yet overtopped.

46 Old Shoreham Road

Mash Barn Lane
A resident, as reported to you on the 14th Jan.
'One of our residents has reported that the levels of the ditches which are next to the Mash Barn Lane (parallel with the northern section up to A27) are the highest she has ever seen them.'

That's about it at the moment. As discussed, I'll give you a separate note with pix on 4 Old Shoreham Road. I did mention the flooding to Gary P when I asked him a question last week and he confirmed he'd like the same info.

Best Regards,

Bill
Lancing Manor (S.E.)

Residents' Network

[redacted]

07/05/2016

Adur District Council

Development Management

Mrs Dawn Appleton
Henry Adams Planning Ltd
Rowan House
Baffins Lane
Chichester
West Sussex
PO19 1UA

PLANNING REFUSAL

TOWN AND COUNTRY PLANNING ACT 1990
TOWN AND COUNTRY PLANNING (DEVELOPMENT MANAGEMENT PROCEDURE)(ENGLAND) ORDER 2015
APPLICATION NUMBER: AWDM/1128/14

Details of Development
OUTLINE APPLICATION (INCLUDING DETAILS OF ACCESS, LAYOUT AND SCALE) FOR THE ERECTION OF 6 NO. 3 BEDROOM DWELLINGS

Location of Development
LANCING MANOR FILLING STATION OLD SHOREHAM ROAD LANCING WEST SUSSEX BN15 0QS

In pursuance of their powers under the above-mentioned Act and Order the Council hereby notify you that they REFUSE to permit the above development, in accordance with the application and relevant correspondence registered on 20th August 2014.

The reasons for the Council's decision to refuse to permit the development are stated on the attached schedule.

[redacted]
Gary Peck
Planning Services Manager
10/11/2015

Adur District Council
Adur District Council, Development Management, Economy Directorate,
Portland House, 44 Richmond Road, Worthing, West Sussex, BN11 1HS
Tel: 01903 221065 Fax: 01903 221072 Minicom: 01903 204500
DX: 142965 Worthing 10 Web: www.adur-worthing.gov.uk

SCHEDULE

Reasons for Refusal

01. The local planning authority is not satisfied that surface water from the proposed development can be satisfactorily drained without resulting in an increased risk of flooding elsewhere in the locality due to potential disturbance to the ground water flows as a result of the proposed underground water storage tanks and the lack of an adequate, functioning drainage connection to enable the safe discharge of surface water from the site. The proposal is therefore contrary to saved policy AP4 of the Adur District Local Plan and paragraphs 100-104 of the National Planning Policy Framework relating to flood risk.

02. The proposed development, due to its close proximity to the A27 trunk road and the resulting traffic noise, would result in a poor residential environment with unacceptable internal and external noise levels causing harm to the residential amenities and enjoyment of future occupiers. The proposal is therefore contrary to saved policy AH2 of the Adur District Local Plan and paragraph 123 of the National Planning Policy Framework relating to noise.

03. The proposed means of noise attenuation, indicated by 2.5m high acoustic fences on the submitted drawings, by reason of their height and position on the frontage of the development, would be visually harmful and intrusive features, out of character with the area and contrary to saved policies AG1 and AH2 of the Adur District Local Plan and paragraphs 56-66 of the National Planning Policy Framework relating to good design.

04. The development would have direct access onto the A27 trunk road and vehicles accessing and exiting the development would, as a result of traffic speeds along this stretch of the road, increase the risk of accidents to the detriment of highway safety. The proposal is therefore contrary to saved policy AH2 of the Adur District Local Plan and paragraph 32 of the National Planning Policy Framework which requires safe and suitable access to be achieved.

05. The site was formerly in use as a petrol filling station and is known to be contaminated. The local planning authority is not satisfied that the proposed residential development is an acceptable use of the land due to the high level of contamination. It has not been demonstrated that the site can be adequately remediated to secure a safe development without causing harm to public health. The proposal is therefore contrary to paragraphs 109 and 120-122 of the National Planning Policy Framework relating to contaminated land.

Cont…/

Informatives / Notes to Applicant

01. The Local Planning Authority has acted positively and proactively in determining this application by identifying matters of concern with the proposal and clearly setting these out in the reasons for refusal. The Local Planning Authority is willing to provide pre-application advice in respect of any future application for a revised development.

02. For avoidance of doubt this refusal relates to the following drawings/plans:-

Drawing No. 2013/32/01 B Title: Proposed Site Plan and Site Sections
Date received 20 August 2014

Drawing No. 201A Title: Drainage Layout
Date received 23 September 2015

Adur Floodwatch Group

Run by the community for the community

Bill Freeman

Lancing Manor SE Residents Network

Adur Floodwatch Group

Run by the community for the community

Supported by:

SOMPTING

NORTH LANCING

MASH BARN ESTATE

BARFIELD PARK

WEST BEACH

SHOREHAM

Resilience to Flooding Is the responsibility of the home owner

OPERATION WATERSHED
Investing in Flood and Road Repairs

west sussex county council

Prepared for the next Flooding Event?

Resilience to flooding is the responsibility of the homeowner - OFFICIAL

~ Spare a couple of hours to become fully informed ~

Come along to our **free** 'Teach-In' ... THE

Flood-Wise Home

Sat 25th April from 2 to 5pm

Ropetackle Centre, Shoreham-by-Sea BN43 5EG

- Practical ways to protect your home
- Who to contact for help
- Advice from specialists on home protection
- How the drainage works in Adur
- Q & A session for all your questions
- Flood defence products - how to use them

Shoreham Society
&
Adur Floodwatch Group

Run by the community for the community

west sussex county council

Funded through West Sussex Operation Watershed

OPERATION WATERSHED

The Adur Local Plan – Housing until 2031

Objectively Assessed Need (OAN)

Govt stats/GL Hearn

Evaluate sites – Amend for area constraints after exploring sustainability site by site

Current plan: **Build 3,800 homes 240 p.a.**

Current Status –

March Full Council Meeting

to approve latest amendments for soundness consultation and Govt. Submission by end 2016

New Rules of Preparation

New National Planning Policy Framework (NPPF)

Launched in 2012 - replaces 1000 page T&C Planning Document

Developer's charter

Major Community Concern

New Monks Farm Development

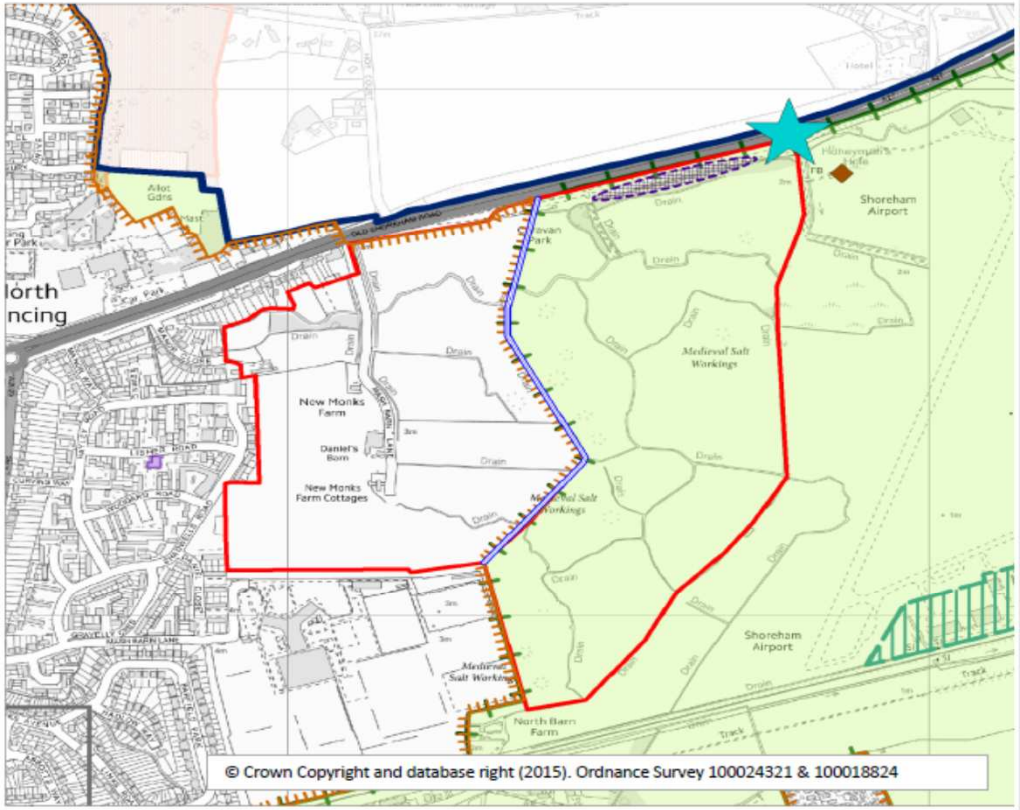
600 homes, 10,000 sqm commercial, school, community centre, road infrastructure, A27 roundabout

Shoreham Airport N.E.

15,000 sqm commercial

New Monks Farm

Proposed Amendments to Allocation at New Monks Farm



- Adur Local Plan Area
- Built Up Area (BUA) - Policy 2
- Indicative Built Up Area Boundary
- Strategic Site Allocations - Policies 5, 6, 7
- Potential Development Sites (in or on edge of Shoreham Town Centre) - Policy 11
- Protected Employment Sites - Policy 26
- Eastbrook Development Opportunities - Policy 12
- Shoreham Harbour Broad Location - Policy 8
- Proposed Roundabout (Indicative) - Policies 5, 7
- Site of Special Scientific Interest (SSSI) - Policy 32
- Site of Nature Conservation Importance (SNCI) - Policy 32
- Local Nature Reserve (LNR) - Policy 32
- Proposed Extension to SNCI - Policy 6
- Local Green Gap - Policy 14
- Countryside - Policy 13
- Ricardo Boundary - Policies 4, 13
- Safeguarded Wharves (as per WSCC Minerals Local Plan, 2003)
- Relocated Withy Patch site (indicative)
- Conservation Areas - Policies 17, 18
- Town Centre Boundaries - Policy 28
- Primary Shopping Area - Policy 28
- Primary Retail Frontages - Policies 9, 11, 12, 28
- Secondary Retail Frontages - Policies 9, 11, 28
- Local Shopping Parades - Policy 28
- Town Centre Blocks (Numbered) - Policies 9, 11
- Scheduled Ancient Monuments

This consultation exercise is being carried out under Regulation 18 of the Town and Country Planning (Local Planning) (England) Regulations 2012.

What is the concern?

Development in a flood plain

Lack of due diligence by the local authority to prove those sites are sustainable for drainage for their lifetime and will not increase flood risks to other properties elsewhere before allocating them in the local plan.

Rule 102 NPPF applies

Understanding the Issues

- History of last 4 winters (incl. this one)
- Flood risk areas and degrees of risk
- New knowledge to hand to ensure right decisions made - **WSCC CH2MHill Report**

Winter 2012-13

North Lancing

Winter 2012-13

A27 Lancing Stretch

Winter 2012-13
Sompting

Winter 2012-13

West Beach

Winter 2013-14

Shoreham Airport

Winter 2013-14
Shoreham

Winter 2013-14

A27 Lancing Stretch

Winter 2013-14
Grinstead Lane

Winter 2013-14
Sompting

Winter 2013-14

West Beach

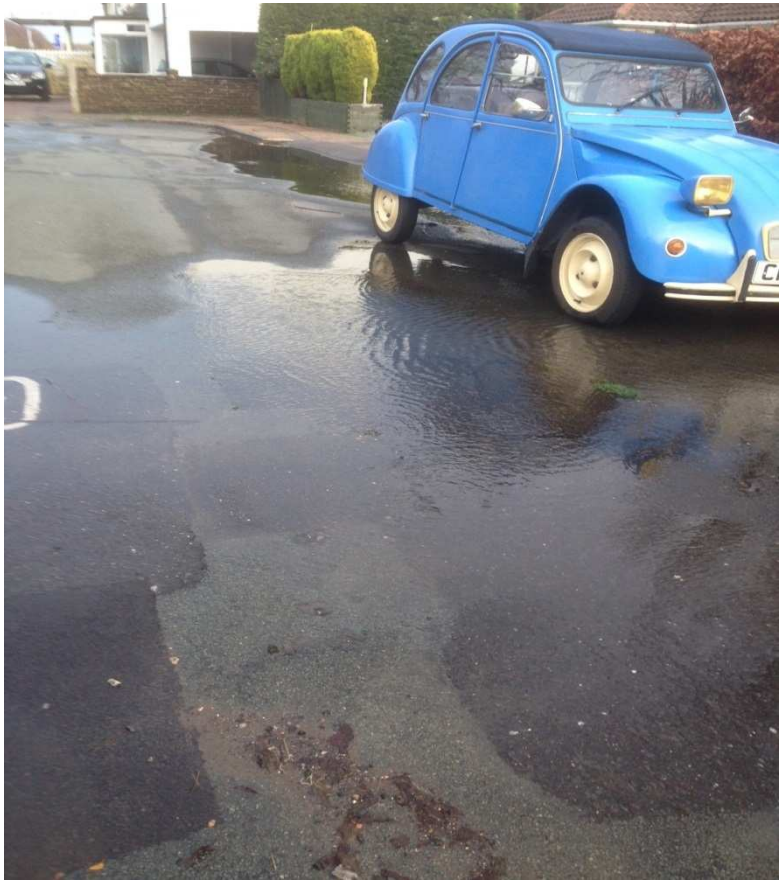
Winter 2013-14

The Albion at New Monks Farm

Winter 2013-14
High Street, Shoreham

Winter 2014-15

Manor Close &
Old Shoreham Road (A27)



Winter 2014-15

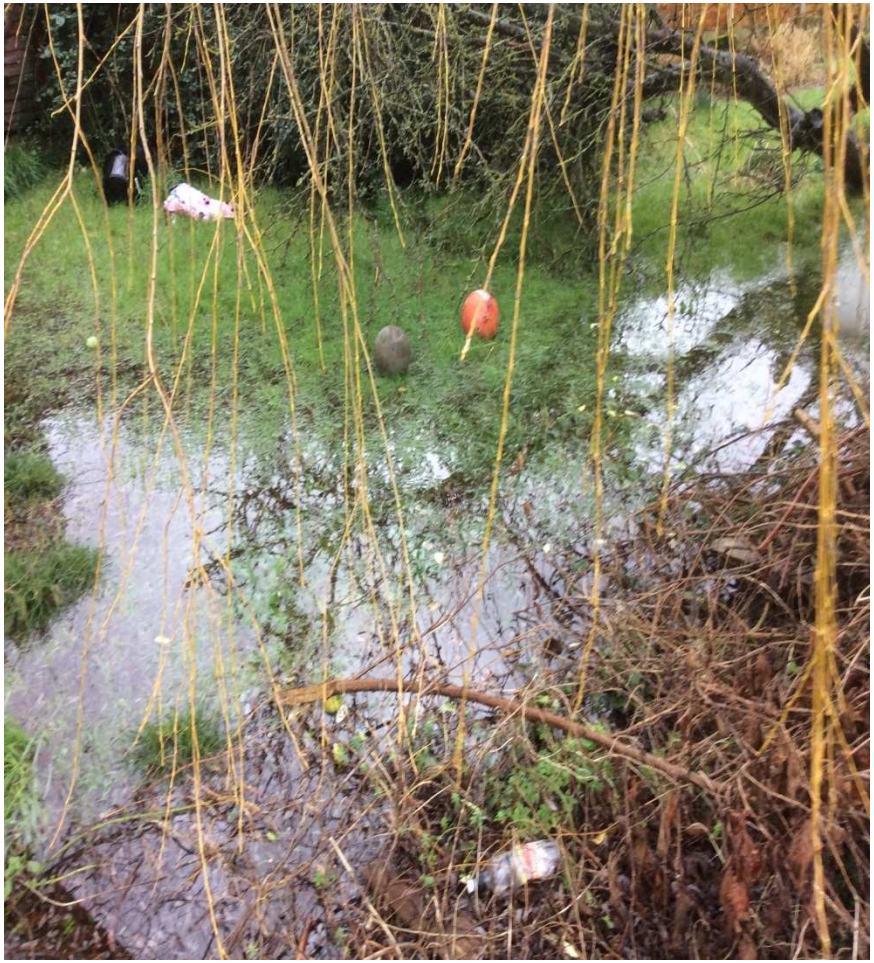
Grinstead Lane

Winter 2015-16
Grinstead Lane

Winter 2015-16

Manor Close

Winter 2015-16
North Lancing



CH2MHill Report

Lancing will always be vulnerable to groundwater flooding

– no matter what mitigation

The Lancing Brooks are under capacity for the drainage of the area

Adur DC still not taking this report into account

Drainage Issues

The Causes

Created by combination of:-

Ground water – major contributor
The South downs

Surface Water Run Off

Coastal & River influences

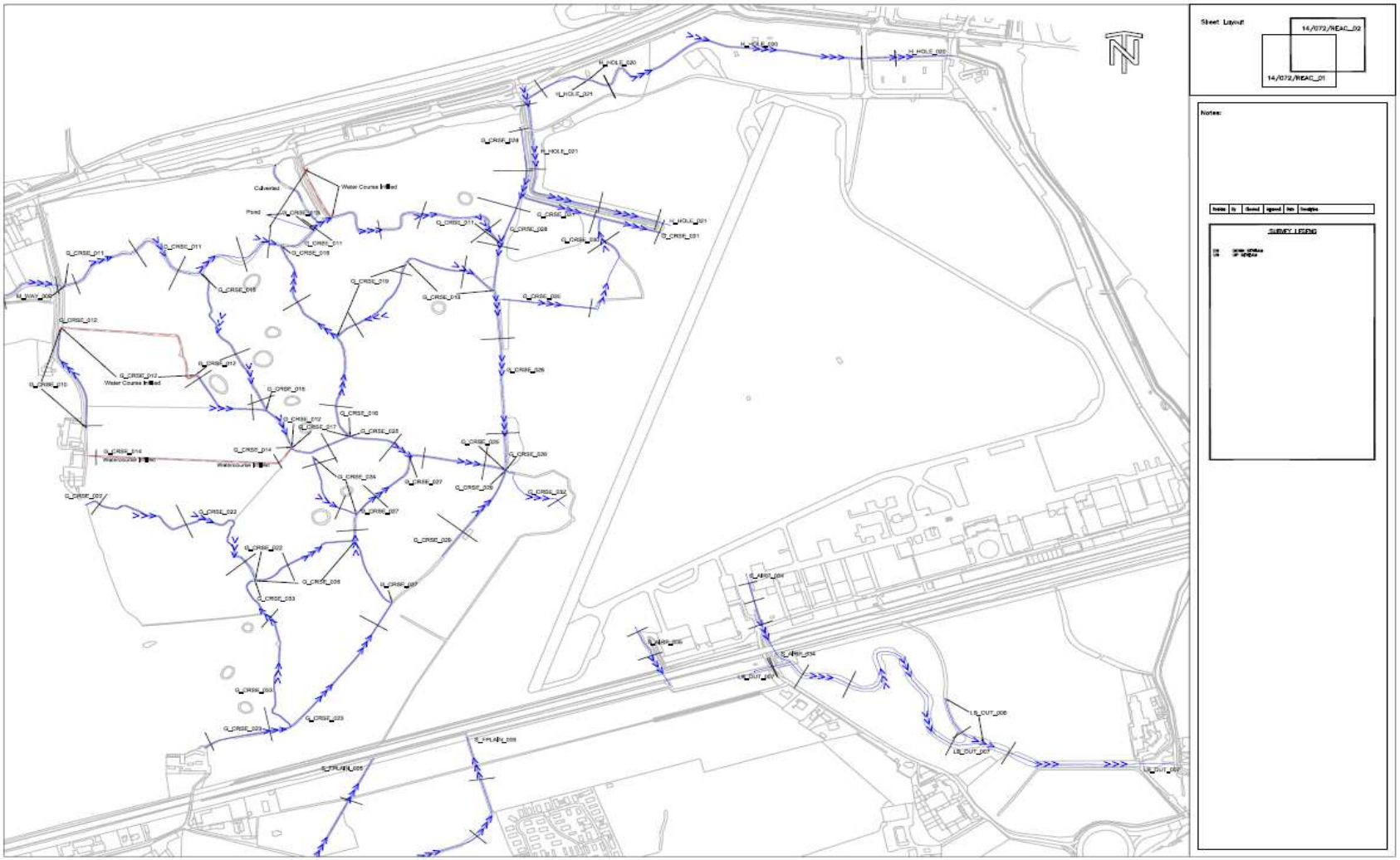
Drainage in Lancing

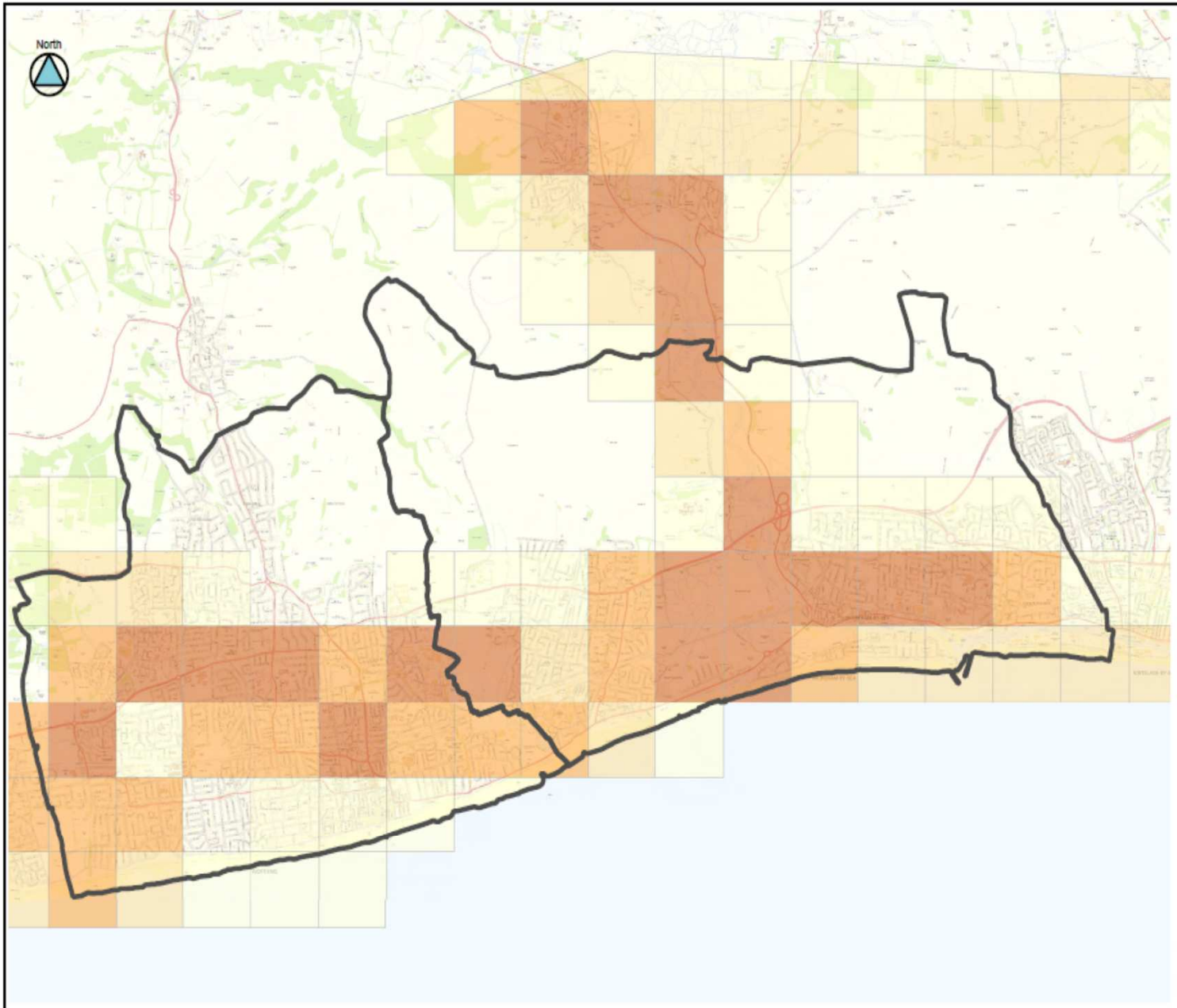
All surface water, ground water, roads, A27 drain into the Lancing Brooks Flood Plain

1 in 2000 – very slow gradient

Drains through Shoreham Sluices 2 x a day only when tide is out.

Lancing Brooks





Worthing Borough Council

Adur District Council

LEGEND

Adur and Worthing Boundary

AStGWF

>= 75%

>= 50% <75%

>= 25% <50%

< 25%

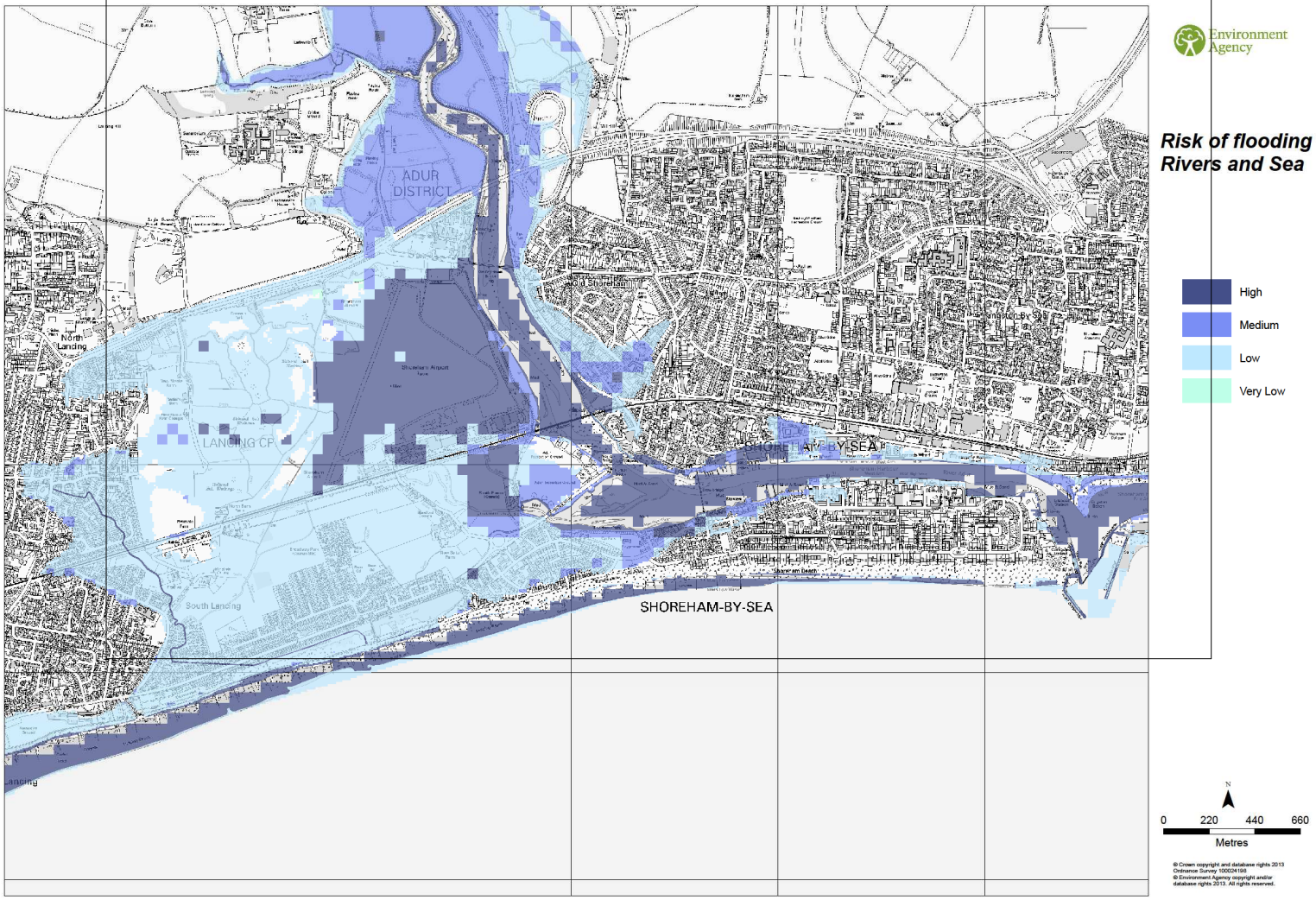
Areas Susceptible to Groundwater Flooding is a strategic scale map showing groundwater flood areas on a 1km square grid. The data is annotated to show what percentage of the 1km area is susceptible to groundwater flood emergence.
This provides an indication as to the degree of risk from groundwater flood risk within an area.

JBA consulting

Map 15
Indicative Groundwater Flood Risk (Areas Susceptible to

River/Coastal Flood Risk

- Significant property and land at risk of flooding



New Monks Farm – Winter 2002/3

Major Community Concern

Adur Floodwatch Group says

“These allocations should be deleted”

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Thanks for listening