	Representation Form **Southbourne Parish Neighbourhood Plan Review 2019-2037** **The Neighbourhood Planning (General) Regulations 2012 - Regulation 16**

Southbourne Parish Council has prepared a Neighbourhood Plan Review. The plan sets out a vision for the future of the parish and planning policies which will be used to determine planning applications locally.

Copies of the Southbourne Parish Neighbourhood Plan Review and supporting documents are available to view on Chichester District Council's website:

http://www.chichester.gov.uk/neighbourhoodplan.

All comments must be received by 5:00 pm on 3 June 2021.

There are a number of ways to make your comments:

- Complete this form on your computer and email it to: neighbourhoodplanning@chichester.gov.uk
- Print this form and post it to us at: **Neighbourhood Planning East Pallant House 1 East Pallant Chichester PO19 1TY**

Use of your personal data

All comments in Part B below will be publicly available and identifiable by name and (where applicable) organisation. Please note that any other personal information included in Part A below will be processed by Chichester District Council in line with the principles and rights set out in the General Data Protection Regulation 2016 (GDPR) and the Data Protection Act 2018, which cover such things as why and for how long we use, keep and look after your personal data.

<u>How to use this form</u>

Please complete Part A in full in order for your representation to be taken into account at the Neighbourhood Plan examination.

Please complete Part B overleaf, identifying to which paragraph your comment relates by completing the appropriate box.

PART A	**Your Details**
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Position (if applicable)	Director
Date	01 June 2021

PART B

To which part of the document does your representation relate?

Paragraph Number		Policy Reference:	SB2, SB4, SB13, SB20, SB21, SB22, Masterplan Briefing Report and Basic Conditions Statement.

Do you support, oppose, or wish to comment on this paragraph? (Please tick one answer)

Support   Support with modifications **X**   Oppose   Have Comments **X**

Please give details of your reasons for support/opposition, or make other comments here:
Please see attached document. (Continue on separate sheet if necessary)

What improvements or modifications would you suggest?
Please see attached document. (Continue on separate sheet if necessary)

If you have additional representations feel free to include additional pages. Please make sure any additional pages are clearly labelled/addressed or attached.

Southbourne Neighbourhood Development Plan Review

Regulation 16 Consultation

Representations on behalf of Metis Homes

June 2021

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Contents

Appendices

1. Introduction

1.1 These representations have been prepared by Nova Planning Limited on behalf of Metis Homes (hereafter referred to as 'Metis') who control land south of the railway line falling within the Land East of Southbourne allocation under draft policy SB2. These representations support and supplement separate representations that have been submitted on behalf of the Consortium (including Metis).

1.2 As set out in previous representations, Metis is working with other developers, Seaward Properties and Wates Developments Limited, to promote the wider land holding within the proposed allocation under a Consortium Agreement All parties are committed to delivering a comprehensively masterplanned development together with the associated infrastructure made necessary by the development. Similarly, Metis is committed to working collaboratively with the Neighbourhood Plan Steering Group and other key stakeholders to ensure that strong place-making principles of the emerging Neighbourhood Plan Review are reflected in the proposals that emerge over time.

1.3 Metis supports the overarching principles of the Southbourne Neighbourhood Development Plan Review (SNDP), including the strong emphasis on a sustainable and environmentally responsible development. Metis is also supportive of the allocation of its land as part of policy SB2 and measures within the policy that seek to properly integrate the allocation under SB2 with the existing settlement to create a single community.

Strategic Policy Context

1.4 As set out in previous representations on behalf of the consortium, Policy 2 of the adopted Chichester Local Plan (CLP) makes clear that Southbourne is identified as a high order settlement capable of accommodating strategic growth, acting as a Settlement Hub that provides services for the surrounding communities.

1.5 This approach is maintained in Policy S2 of the draft Chichester Local Plan Review (CLPR). Whilst the emerging CLPR remains in draft (Preferred Approach), the overarching principles of spatial strategy and settlement hierarchy remain consistent and the strategic allocation at Southbourne under Policy AL13 reflects this.

1.6 The provision of 1,250 hew homes in Southbourne represents a significant portion of the housing provision in the emerging CLPR and the progress of the Neighbourhood Plan Review allocating land for this housing will assist CDC in arguing the soundness of their Plan at Examination in due course. The progress of the Neighbourhood Plan Review will also have potential benefits in dealing with CDC's existing short term (0-5 years) housing land supply position. Providing measures that allow for early delivery will be crucial in this regard but equally it is accepted by Metis Homes that early delivery needs to be in a form that does not undermine the comprehensive masterplanning of the allocation or hinder the provision of necessary infrastructure.

The Metis Land

1.7 The Metis land comprises three adjoining parcels shown edged red on the plan at **Appendix 1**. The land is located south of the railway line and north of the A259. It has unique characteristics to the other parcels within the wider allocation in that it comprises part brownfield land (existing Breakers Yard), it has an existing access to the A259, it has a direct relationship with the Ham Brook. For these reasons we feel that the site can make an important contribution to realising the objectives of SB2. The key strategic benefits of the Metis land are as follows:

- Facilitate a vehicular crossing to connect land north of the railway line and the A259;
- Opportunities to relieve pressure on the Ham Brook through redevelopment of the scrapyard and create a soft landscaped edge to the watercourse; and
- Provide early housing delivery due to the presence of an existing access to the A259

1.8 The unique location and nature of the site presents a number of additional opportunities, including:

- **Reduced contamination and regeneration of a brownfield non-conforming use –** The proposal would result in the remediation of contaminated soils associated with the site's use as a scrapyard. This would provide immediate betterment for the local environment and help towards reducing the risk of contaminants entering Chichester Harbour SPA.
- **Improved drainage –** The proposal includes a number of potential drainage benefits which, if implemented, would provide flood alleviation benefits for the village of Southbourne.
- **Reduced visual impact –** The site is currently authorised for the unrestricted open storage of disused vehicles, meaning that vehicles can be stacked on top of one another to a significant height. The Metis proposal would ensure that potential significant visual impacts on the AONB are avoided.

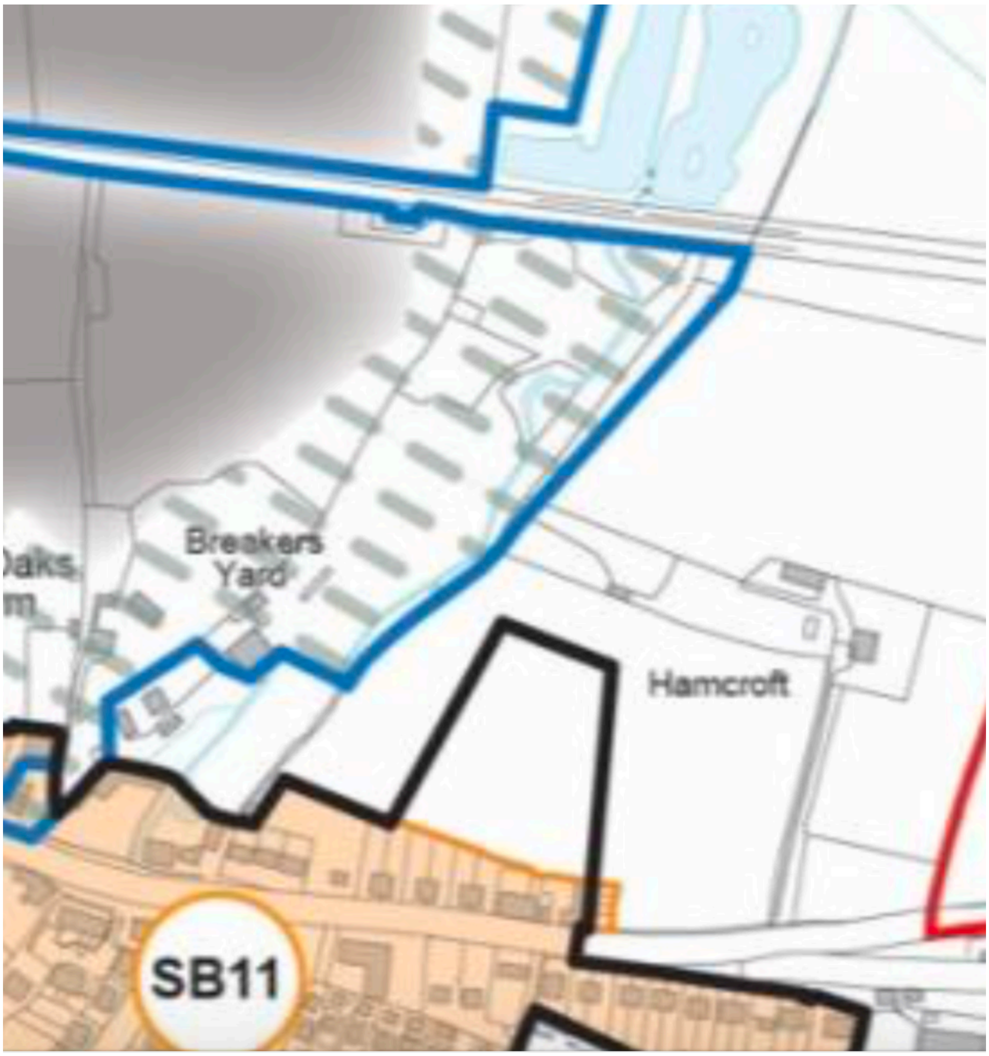
1.9 The following sections of the report provide comment to support the proposed allocation and its effective delivery in the future. Alongside these representations, the submission also includes the following:

2. Representations on Policy SB2

2.1 As set out in Section 1.0, Metis is supportive of the allocation of its land within policy SB2 and the aspirations of the Neighbourhood Plan Steering Group to deliver a sustainable, responsible and well-integrated development.

How the Metis Land is presented in the allocation

2.2 The extent and nature of the allocation as shown on Policies Map Inset 1 is generally supported by Metis and it is recognised that the Map is relatively indicative at this stage and pending detailed masterplanning. However, there are fundamental concerns over the extent of green space currently shown on the Metis land. This includes all of the Harris Scrapyard site, which is currently an operational Breakers Yard comprising an expanse of hardstanding with vehicle storage and associated buildings (see extract below).



Extract from Policies Map Inset 1

2.3 Paragraph 117 of the NPPF directs plan makers to use policies which make more efficient use of land and seek to maximise opportunities to redevelop previously developed land ('brownfield land'). Paragraph 118 acts as an extension to this objective and states that policies should support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land.

2.4 Clearly Harris Scrapyard occupies an important area within the wider allocation, given the site's direct interface with the Ham Brook and similarly Metis recognise that the allocation represents an opportunity to improve a relationship that is significantly compromised by the existing use of the land. However, it is neither practical nor commercially viable for a landowner to release land in an existing commercial use solely for green space. Furthermore, delivering the green space envisaged would require engineering works to clear existing hardstanding and decontamination measures, which bring associated costs that need to be recovered by the development.

2.5 Metis is confident that the biodiversity and green infrastructure objectives of the allocation can be achieved through a sensitively designed residential redevelopment that incorporates a generous landscaped edge to the Ham Brook, including opportunities for biodiversity enhancement and recreation. With this in mind, an initial assessment has been undertaken which confirms that a minimum of 10% Biodiversity Net Gain can be achieved alongside a commercially viable residential development.

2.6 For these reasons, it is recommended that the extent of green space area shown on Policies Map Inset 1 and the Green Infrastructure Network Policy Map should be reduced in size to reflect the extent of the proposed Wildlife Corridor area shown coloured green on Green Infrastructure Network Policy Map.

<u>Specific Comments on Criteria</u>

2.7 As a general point, whilst the criteria contained within the policy are clearly aligned toward these positive aspirations, in some cases the specific requirements need to be benchmarked against national standards, and the standards within the adopted CLP and emerging CLPR. The CLPR will be accompanied by an independent Viability Assessment which tests the viability of development against the policy requirements of the Plan as a whole, taking into consideration sustainability requirements with affordable housing provision and CIL. Applying more onerous requirements through the SNDP could potentially undermine the deliverability of the allocation and by association undermine the soundness of the CLPR which relies on the allocation.

2.8 **Criteria SB2 a)** - Metis Homes welcome the revised approach to the delivery of development in the allocated site, whereby planning applications can come forward on individual land parcels within the allocated site provided that they do not prejudice the comprehensive masterplanning of the wider allocation.

2.9 **Criteria SB2 b) –** As per previous representations by the consortium, it is suggested that the density of development should not be predetermined and instead this should be based on an assessment of the context for a given planning application. This is particularly the case for an allocation of this size where the pattern and grain of development change, e.g. more developed context in the southern portion of the allocation given that relationship to existing development within the settlement, whereas development on the northern edge of the site has little context and has a stronger relationship to open countryside. There needs to be flexibility in the allocation to reflect these differences and to deliver character areas.

2.10 **Criteria SB2 c) –** Policy SB5 links self-build provision to the CDC Self Build Register and as such it is questionable whether this criteria is required. If reference is made to Self Build then it should be based on an assessment of recorded demand on Part 1 of CDC Self and Custom Build Register, with trends on demand projected forward over the Plan period and dealt with proportionately across the site.

2.11 **Criteria SB2 d) –** whilst the provision of education facilities as part of the overall infrastructure package is supported, the specific requirements in terms of land take and size of facility will require a detailed analysis that is not present within the draft Plan or the supporting evidence base. Policy AL13 of the emerging CDLPR refers to provision of *'up to a 2FE Primary School'* whereas the draft SNDP refers to *'a 2FE expandable to a 3FE'*. With this in mind we suggest that the criteria be amended to refer to education provision based on a thorough assessment of need to be undertaken in consultation with the Education Authority, West Sussex County Council (WSCC).

2.12 **Criteria SB2 B e)** - As per the consortium's previous representations, the evidence document *SB3.EV10 Southbourne Surgery* includes a statement from the local surgery who advised they would prefer any expansion to be through extension to the existing surgery. It is understood that the surgery has submitted a project for feasibility. Until such a time as the surgery's approach to expansion has been confirmed, a more flexible approach to the neighbourhood plan policy to allow for either on site delivery as part of a community building or contributions towards enhancements of existing off-site facilities, is suggested.

2.13 **Criteria SB2 B g) –** With regard to the Station Car Park, the provision of parking at the station would undermine the sustainability objectives of the Plan. As set out in the consortium's pervious representations, this parking is likely to be used for out commuting rather than serve the proposed development. In line with the general principles of the Plan, which promote walking and cycling, it would be more sustainable to provide better links within the development to allow for connections to the station in this way. This would have the added benefit of reducing traffic generated by the development. Regarding the provision of a footbridge in Phase 1 of the development, the 2015 Neighbourhood Plan sought a footbridge across the railway line and a route has been safeguarded for this purpose. However, this has been superseded by the level of development now proposed and the requirement for a road bridge which can perform the same function.

2.14 **Criteria SB2 C i)** As set out in previous representations, Metis supports the aspiration of a Green Ring and wider green infrastructure networks, and as outlined in Section 1.0 the Metis land has a crucial role to play in achieving many of the Green Infrastructure aspirations given the interrelationship between Harris Scrapyard and the Ham Brook.

2.15 The requirement for 60% wildlife friendly green and blue space does not appear to be based on any established standards or robust evidence to warrant a departure from established standards. As set out in previous representations, appropriate, Metis is keen to engage with local residents to understand their aspirations for the green infrastructure network and this feedback will be balanced with other ecological, landscape and drainage requirements to understand how best to deliver an overall green infrastructure strategy.

2.16 As noted in previous representations, the term 'wildlife friendly green and blue space' is ambiguous and as there is no definition of what is considered wildlife friendly space. Paragraph 16d of the NPPF requires that policies are unambiguous. There is a separate requirement within criteria m) of SB2C and Policy SB14 of the emerging Plan that developments achieve 'Biodiversity Net Gain', and therefore wildlife friendly green and blue space, is already achieved in this regard. This requirement also aligns with Policy DM29 of the Preferred Approach Plan. The same consideration applies with regard to the references to woodland creation. Whist Metis does not object to the principle of woodland planting where this is beneficial for landscape reasons or forms part of a nutrient neutrality strategy, there is no basis to require this within the policy.

2.17 **Criteria SB2 C q**) Detailed flood risk information in respect of Harris Scrapyard was submitted with previous representations. This included detailed modelling work by Mayer Brown, which confirms a significantly reduced extent of flood risk than that shown on the Environment Agency's (EA) indicative mapping. This modelling has been approved by the EA and information is submitted at **Appendix 2** for the avoidance of doubt and as a reference for separate comments to follow on the emerging masterplan.

3. Representations on Other Policies

3.1 **Policy SB4 C** The requirement for the provision of 1Ha of land for a community-led housing and references to a Local Lettings Plan are inconsistent with the adopted CLP and emerging CLPR affordable housing policies. Mechanisms for the delivery of affordable homes to local people should be secured through a section 106 agreement at the time of an application, in liaison with the district council and registered providers. This will ensure that the provision best fits the identified need at that time.

3.2 **Policy SB13** Metis is supportive of the 'Green Ring' principles that were established through the currently adopted Neighbourhood Plan. Metis also recognises the importance of the Ham Brook wildlife corridor in this approach and the role of their land in delivering Green Infrastructure networks in Policy SB2. As currently drafted, the policy wording defines this area by reference to the associated 'Green Infrastructure Network Policies Map'. Having reviewed this Map, Metis has the following comments:

- 'Ham Brook Chalk Stream Wildlife Corridor' – the location and alignment reflects the Ham Brook, which is obviously logical. However, the extent of this area should be informed by the masterplanning process having regard to other environmental considerations and the position of key movements corridors.

- 'SB2 Green Space and Biodiversity Gain Opportunity Area' – As above, the extent of this area should be informed by the masterplanning process. However, the area currently shown the Map indicates that the existing Harris Scrapyard site would revert to undeveloped green space, which is not practical and certainly not viable. The site has an existing commercial use with an associated value and redevelopment would require engineering works to clear existing hardstanding and decontamination. Metis is confident that the objectives of the policy can be achieved through a residential redevelopment that incorporates a generous landscaped edge to the Ham Brook with opportunities for significant environmental enhancement. However, the policy needs to acknowledge the existing characteristics of the site and at present the area shown does not.

3.3 To address these issues, it is recommended that the policy wording be amended as follows – *"The Neighbourhood Plan designates a Green Infrastructure Network, as shown **indicatively** on the Policies Map".* This will allow the masterplanning process to determine the extent of the area. Alongside this, the hatched green space area on the associated map should be reduced in size to reflect the existing use and nature of the site. This could reflect the Wildlife Corridor area in green.

3.4 **Policies SB20 – SB22 (Adapting to Climate Change)** As set out in previous representations, Metis agree with the motivations and objectives of these policies. However, it is important that there is consistency between the emerging Neighbourhood Plan Review, and the adopted (Policy DM40) and emerging (Policy DM19 – Preferred Approach). Buildings Regulations on energy requirements change regularly and in the interests of providing a deliverable development and a Neighbourhood Plan that remains up to date, we would suggest a more flexible approach that sets out the energy performance that references national planning policy and policies within the CLP and CLPR, whilst also referencing building regulation requirements.

3.5 Furthermore, as discussed under 'Basic Conditions Statement', whilst Metis shares the objective of minimising, where feasible, the carbon emissions from the proposed development, it is important that policies within the Neighbourhood Plan continue to conform with the strategic policies of the Chichester Local Plan, and the emerging Plan. This is required by the basic conditions as more stringent emissions reductions are independently assessed and tested against the wider policy requirements to ensure deliverability, and viability of the plan as a whole. In this case, it is particularly important in light of the wider infrastructure requirements for the allocation site.

3.6 Whilst the aspirations are commended, on balance an alternative approach to achieve the basic conditions is recommended whereby the policy is revised to align with the strategic policies of the Local Plan, with any requirement for passivhaus/zero-carbon supported and encouraged, but not required.

Southbourne Masterplan Briefing Report

3.7 We note that the Neighbourhood Plan Steering Group has prepared a Masterplan Briefing Report, as set out in Appendix B. Overall, the principles of that sought within the allocation site, such as a Green Ring, community infrastructure and employment use, are supported by the Consortium. The Masterplan Briefing Report provides a helpful starting point for setting out the aspirations of the Neighbourhood Plan Group. Metis intends to work with the Parish Council, Steering Group and local community, as well as technical consultees, to evolve proposals such that these proposals align with the Masterplan and Delivery Framework, as required by Criterion Ba). These proposals will be technically robust, align to community aspirations and be deliverable.

3.8 To allow for ongoing evolution of the masterplan, as further community and stakeholder engagement is progressed, it is suggested that the wording of the policy is revised to be clearer that any masterplanning and delivery framework should *have regard to* the Masterplan Briefing Report. In this manner, the policy will allow for changes to the principles contained in the Masterplan Briefing Report, where necessary as the scheme evolves.

3.9 Metis is generally supportive of the layout and design principles set out within the document. Whilst it is acknowledged that illustrative masterplans contained within the report are indicative, there is a concern over the extent of land shown as green space within the Harris Scrapyard parcel (referenced as P3 within the report). For the reasons discussed at paragraphs 2.2 to 2.6 of these representations, it is impractical and unviable to allocate an operational Breakers Yard solely for green space. There is sufficient land within this parcel to accommodate the objectives outlined at page 8 of the report alongside a sensitively designed residential redevelopment. Metis is keen to engage with the Neighbourhood Plan Steering Group and local residents in order that the initial concept plans for the site can be tabled. We are confident that the initial proposals will provide confidence to all parties that a redevelopment can be delivered in a form which is environmentally responsible and provides betterment to the wider community.

4. Supporting Evidence Base

Basic Conditions Statement

4.1 As stated previously, we are supportive of the Neighbourhood Plan Groups progress, and the efforts made to produce a plan that can be taken through Examination. Having reviewed the Statement in detail, there is a common theme to the assessment of compliance with the NPPF and policies within the Development Plan. The document states at paragraph 2.4 that *"The policies combine a site allocation and other proposals, and development management matters that seek to refine and/or update existing policies".* This justification is carried forward within the assessment of individual policies where standards, specifically those policies dealing with biodiversity and climate change, exceed those in the adopted CLP and emerging CLPR.

4.2 As a general point, paragraph 8 of Schedule 4B to the 1990 Town & Country Planning Act sets out the Basic Conditions that need to be satisfied in the preparation of a Neighbourhood Development Plan. Condition e) requires that the Plan "*is in general conformity with the strategic policies contained in the development plan for the area of the authority"* (Chichester District Council). Whilst we recognise there may be some flexibility to comply with this test, it is important that in refining policies, they do not fall outside of the term 'general conformity'. Where Neighbourhood Plan policies exceed the requirements of strategic policies, there is a risk that they would not meet the basic conditions, which could delay the Plans progress through examination, and onto referendum. CDC will no doubt provide comments on these points as part of this consultation.

4.3 In addition to these procedural points, Metis is concerned that the application of policies ahead of a fully understanding the extent of other contributions associated with other policy requirements. It is important that the policies do not undermine the viability of development as this could potentially prejudice and undermine the allocation. This concern is more pronounced due to the infrastructural requirements of the allocation and associated costs. As the allocation forms a significant proportion of planned housing within the emerging CDCLPR, this also has potential impacts of the soundness of the CDCLPR.

4.4 Whilst is clear that policies should be seeking to incorporate measures to address the climate change emergency, this needs to be balanced with viability considerations and robustly assessed by an independent qualified authority. This is the process that is undertaken as part of Local Plan preparation as referenced at paragraph 2.7 of these representations. For these reasons, it is recommended that the requirements of these policies be realigned with strategic policies within the CLP and CLPR so as to ensure general conformity.

5. Conclusions

5.1 These representations support and supplement separate representations on behalf of the wider Consortium.

5.2 The progress of the Neighbourhood Plan Review is commended. Metis Homes support the objectives of the plan and the intention to deliver a sustainable and well-integrated extension to the existing settlement. The identification of an allocation, including Metis land, to the east of Southbourne is welcomed and supported. The site is sustainably located with excellent links to the village and provides opportunities to deliver significant benefits to the village, thereby contributing to the achievement of sustainable development.

5.3 The principles of the proposed allocation are supported. However, Metis has some concerns regarding how the Harris Scrapyard land parcel is presented in the draft Plan and also some concerns regarding the requirements of specific policies. These concerns can be addressed through minor amendments to the Plan and as such should not delay the plan-making process.

5.4 Metis is most fundamentally concerned over the presentation of the entirety of Harris Scrapyard, an operational Breakers Yard, as green space. in Policies Maps. This previously developed land cannot be brought forward in this form, i.e. without any development. It would neither be practical or viable for the landowner to make their land available on this basis. In addition, reverting previously developed land to undeveloped land in this form would be completely at odds with the intentions of the NPPF in seeking to make efficient use of land.

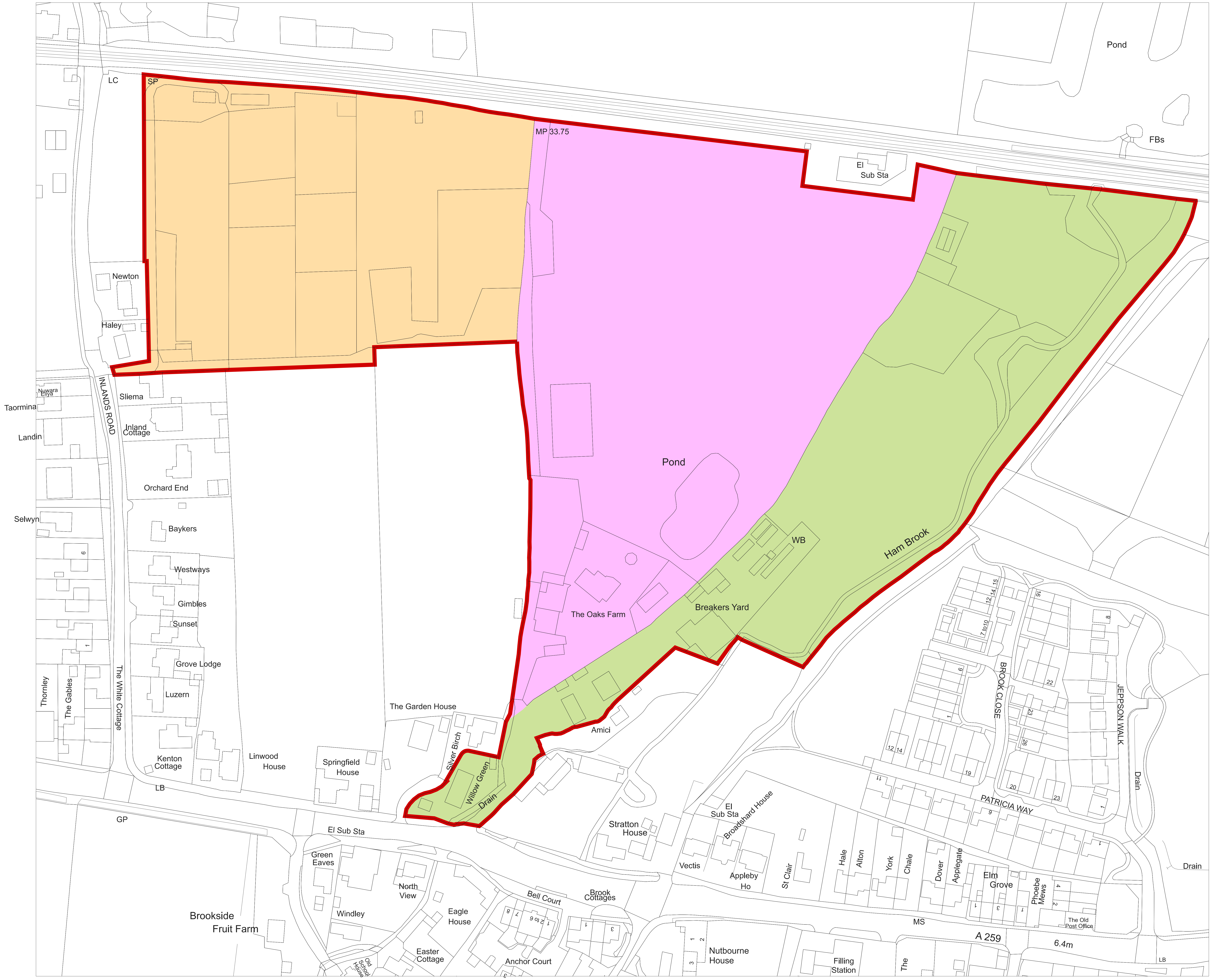
5.5 As noted in Sections 1.0 and 2.0, the Metis land which comprises three adjoining land parcels will play an important role in the overall allocation. These land parcels are located south of the railway line and benefit from an existing direct access to the A259. This context provides opportunities for early phases of housing and associated infrastructure (including green and blue infrastructure in the short term). This would make a positive contribution to CDC's current housing land supply shortfall whilst providing the Parish Council with a stronger basis to resist speculative planning applications within an area which is inherently sustainable and therefore more susceptible to such applications.

5.6 The 'Harris Scrapyard' land parcel comprises previously developed land and this parcel has a direct relationship with the Ham Brook. Redevelopment of this parcel presents opportunities for decontamination of land adjacent to the Ham Brook and the creation of a landscaped wildlife corridor along the western side of the watercourse in accordance with the objectives of the emerging Neighbourhood Plan Review.

5.7 The 'Hoey Land' land parcel is located on the alignment of the proposed railway bridge and principal access route. Development of this land parcel can provide early housing alongside facilitating the delivery of the railway bridge when this is required as part of the allocation.

5.8 As set out in Section 2.0, Metis is keen to open engagement with the Neighbourhood Plan Steering Group to set out initial concept proposals for the Metis land and to discuss how these proposals can contribute positively to the comprehensive development of the allocation, including the provision of infrastructure on a proportionate basis.

5.9 The detailed policies and the intention to deliver sustainable and environmentally responsible development is supported by Metis. Representations have been made in relation to specific policies. Generally, these representations seek amendments to bring these policies in line with the national and local planning policies. These amendments are considered necessary to ensure policies are consistent with the basic conditions.



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Key

- Harris Scrapyard
- Oaks Farm
- Hoey Land
- Site Boundary

Rev	Date	Description	Drawn	Chkd
D01	03.06.21	Minor Amendments	LAB	CI
-	03.06.21	First Issue	LAB	CI

Drawing Status
DRAFT

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Project
Harris Scrapyard & The Oaks Farm

Drawing Title
Site Location Plan
Different Parcels Indicated

Scale @ A2 1:1250 Job Ref. 01293
Drawing No. 01293 _ S03 Revision D01
Scale Bar 0 10 20 30m

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14 March 2018

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Dear Patrick

G&R Harris Scrapyard Site – Chichester District Council Addendum Flood Risk HELAA Submission

We have been working in respect of the G&R Harris Scrapyard site in Nutbourne to accurately determine the flood risk and the possible impacts on its redevelopment.

Background

The Environment Agency (EA) flood map identifies the site is partially located in a high-risk flood zone 3 and medium risk flood zone 2 with the remainder located in a low risk flood zone 1. Initially when we reviewed the flood risk it was considered the sole means of access was in a Flood Zone 3. Refer to Appendix A for the EA flood maps.

Information Gathering

Mayer Brown wanted to establish the actual flood risk at the site (including flood levels etc.). The EA flood model was based on JFLOW data and was not considered sufficient by the EA to accurately assess the flood risk, subsequently a Flood Hydrology study was undertaken to determine the flood depths and extent of flooding. The Flood Hydrology Study (model) was informed by a site specific topographic survey including culvert sizes and several sections along the Ham Brook. The model was submitted to and approved by the EA to determine the flood levels. Refer to Appendix B for the approved Flood Hydrology Study and associated correspondence.

Flood Model Conclusions

The conclusion of the model is that the 1in100 and 1in1000-year flood extents are similar but slightly less extensive than the EA's flood maps. The majority of the site is located within the low risk flood zone 1, with sections along the eastern boundary (adjacent to the Ham Brook) located in the high-risk Flood Zone 3.

At the time of preparing the model and the initial investigations the main flood risk constraint was a safe mean of access / egress during flood conditions. Circumstances have since changed that mean the adjacent dwelling will form part of the application site, and subsequently a safe means of access / egress can be achieved without significant land raising.

Post Development Scenario

1. **Safe Access / Egress**

The access within the site boundary would be completely dry. The maximum modelled flood depth on the adjacent highway would be a maximum of 3cm (for up to the modelled 1in100yr event including 105% allowance for climate change).

This would provide safe access / egress during flood conditions and would be achieved by slightly raising the levels within a small area of the site (300mm approx.) and providing adequate flood compensation to ensure the flood storage volumes remains neutral.

2. Sequential Approach

The sequential approach would be followed such that no development will be located in the high risk flood zone 3 area and the floor levels would be set 300mm above the maximum modelled flood level, thus ensuring the development would be safe its lifetime.

3. Surface Water Drainage

The existing site contains a scrapyard and is considered to discharge directly to the Ham Brook at an unrestricted rate. Should the site be developed a series of sustainable drainage (SuDS) features would be included in the drainage design that would reduce the discharge rate and improve the quality of water discharging into the Ham Brook.

4. Additional Benefits

Southbourne Parish Council are currently exploring possible options to alleviate flooding in the village as part of Operation Watershed. We consider that the re-development of the G&R Harris scrapyard provides an opportunity to implement a number of measures that will provide flood risk benefits downstream.

There is an existing ditch that passes through the site along the western boundary that coveys surface water flows from upstream catchments. The development provides the opportunity implement some form of flow control and attenuation within the site boundary, which would reduce the flows discharging downstream and subsequently provide flood risk benefits.

In addition to the above, as mentioned in point 3 the re-development of the site provides an opportunity to implement sustainable drainage (SuDS) features that will reduce the discharge rates from the site itself, improve water quality and therefore provide further benefits to flood risk downstream. Refer to Appendix C for the Flood Risk / Water Quality Benefits Overview Drawing.

Conclusions

To conclude, the G&R Harris site is partially located in a Flood Zone 2 and 3, with the remainder in a low risk Flood Zone 1. A flood hydrology study has been undertaken and the flood levels have been agreed with the EA. The agreed flood levels would not constrain the redevelopment of the site for the following reasons:

- Safe access / egress to the site will be achieved for up to the 1in100yr event plus 105% climate change (and subsequently the 1in1000yr event as the flood level is less than for the 1in100yr plus 105% level).
- The site will adopt the sequential approach and no dwellings will be placed in the high risk flood zone 3 area. All floor levels will be set 300mm above the 1in100yr plus climate change flood level to ensure the properties will be safe for their lifetime.

Yours sincerely

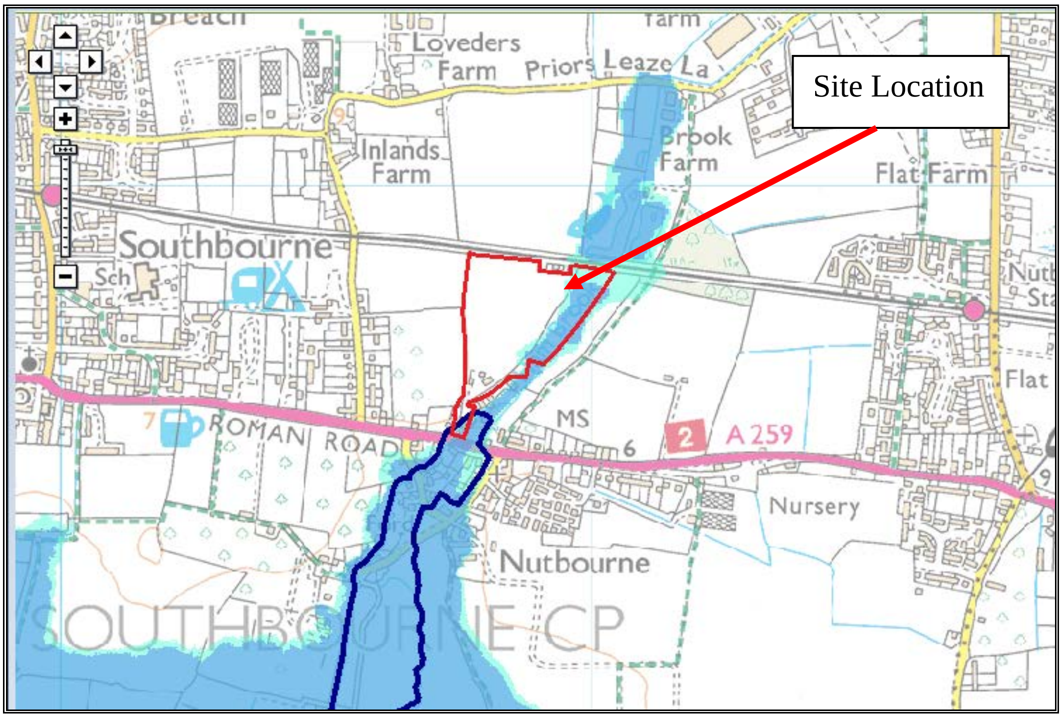
[redacted]

Steven Lecocq
Engineer
mobile [redacted]
email [redacted]
enclosure

- Appendix A – EA Flood Maps
- Appendix B – Flood Hydrology Study (final submission and subsequent EA correspondence)
- Appendix C – Flood Risk / Water Quality Benefits Overview Drawing

Appendix A
EA Flood Maps

ENVIRONMENT AGENCY FLOOD MAP
(December 2016)
Nutbourne, Chichester



Chichester District Council, Post code: PO18 8RL Co-ords: E477834, N105530

1. Floodplain

A floodplain is the area that would naturally be affected by flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.
There are two different kinds of area shown on the Flood Map. They can be described as follows:-

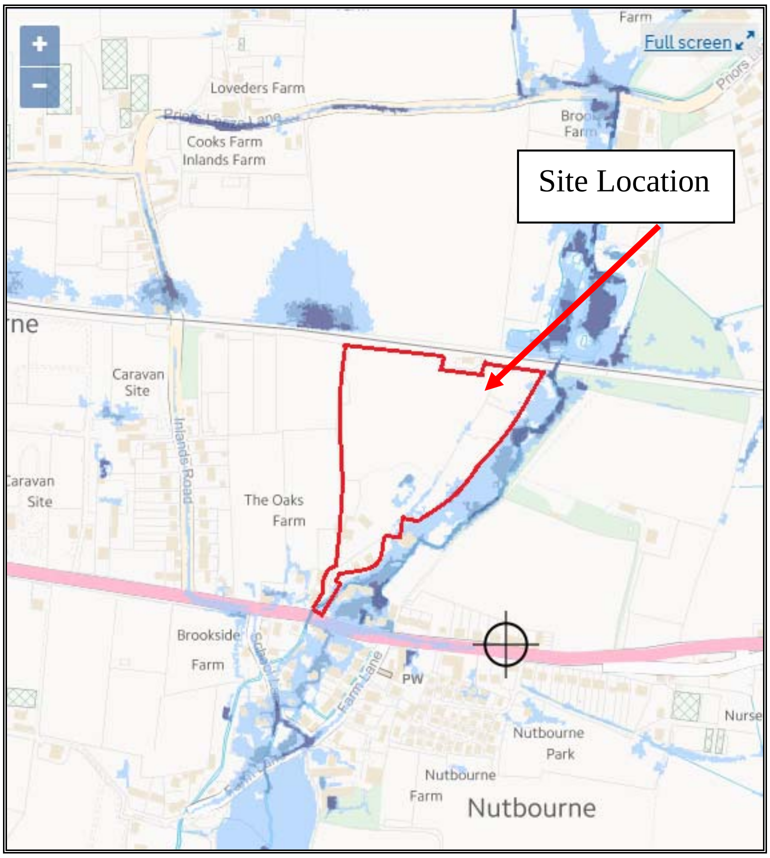
- Dark blue ▪ shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:
- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year
- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.
- Light blue ▫ shows the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.
For a fuller explanation of flood likelihood, follow the link at the bottom of the page.

2. Flood Defences
The purple line shows all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods. Flood defences that are not yet shown, and the areas that benefit from them, will be gradually added.

Hatched areas benefit from the flood defences shown, in the event of a river flood with a 1% (1 in 100) chance of happening each year, or a flood from the sea with a 0.5% (1 in 200) chance of happening each year. If the defences were not there, these areas would be flooded.

ENVIRONMENT AGENCY SURFACE WATER FLOOD MAP
(December 2016)
Nutbourne, Chichester



Chichester District Council, Post code: PO18 8RL Co-ords: E477834, N105530

Risk of Flooding from Surface Water

Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead.

The shading on the map shows the risk of flooding from surface water in this particular area.

There are four different kinds of area shown on the Flood Map. They can be described as follows:-

- High Risk Area – Each year this area has a greater than 1in30 (3.3%) chance of flooding from surface water:
- Medium Risk Area – Each year this area has between a 1in100 and a 1in30 (1%-3.3%) chance of experiencing flooding from Surface Water:
- Low Risk Area – Each year this area has a between a 1in1000 and 1in100 (0.1%-1%) chance of experiencing flooding from Surface Water.
- Very Low Risk Area – Each year this area has a less than 1in1000 (0.1%) chance of experiencing flooding from Surface Water.

Appendix B

Flood Hydrology Study - Final submission and subsequent EA correspondence

Steven Lecocq

From: Griggs, David [redacted]
Sent: 26 July 2017 14:07
To: Steven Lecocq
Cc: Sean Foley; Ivan Cosmai
Subject: RE: PAC/SLTSDN/00183 - Oaks Farm, Nutbourne, Chichester

Hi Steven,

I can confirm we're satisfied that this is a sensible and acceptable approach to addressing flood hazard for the site.

Kind regards,
David

David Griggs
Planning Advisor | Sustainable Places
Environment Agency | Solent & South Downs
Telephone: 02030 259625

Environment Agency
Romsey Office
Canal Walk
Romsey
SO51 7LP

From: Steven Lecocq [redacted]
Sent: 17 July 2017 11:25
To: Griggs, David [redacted]
Cc: Sean Foley [redacted]; Ivan Cosmai [redacted]
Subject: RE: PAC/SLTSDN/00183 - Oaks Farm, Nutbourne, Chichester

Good Morning David,

Thanks for your email.

We are pleased that the model is deemed suitable for the purpose of informing the water levels for the site.

We consider that the best approach (based on your response) is to ensure the proposed access is located above the modelled flood levels, this way ensuring that the flood hazard rating would be low (and not the velocities would not be required).

The modelled flood level for the lowest point in the access is 4.82m AOD. The channel of the existing road is approximately 4.79m AOD. Therefore the flood depth at this point would be approx. 3cm.

With the above in mind if the flood depth is 3cm for a short section of road at the tie in, would it be acceptable to assume a conservative velocity (based on a safety factor applied to the modelled velocity) to inform the hazard rating for this small section?

The reason we ask is because it seems excessive to build an entire 2D model for a small section of road that has a flood depth of only 3cm (approx.).

Many Thanks,

Steven

creating a better place

Mr Steven Lecocq
Mayer Brown
Lion House
147 Oriental Road
Woking
Surrey
GU22 8AR

PAC ref: PAC/SLTSDN/00183
DPS ref: HA/2017/119135/07-L01

Your ref: A/MHNUTBOURNE.10

Date: 6 December 2017

Dear Mr Lecocq

Review of flood modelling for residential development

Land at Oaks Farm, Nutbourne

Thank you for accepting the Environment Agency's offer to provide detailed planning advice. We have reviewed the updated modelling (submitted 27 October 2017) and Flood Hydrology Study (dated October 2017), and have the following advice.

Environment Agency Advice

In the context of the site and with the addition of freeboard **we are satisfied that the model is acceptable for use in a site specific Flood Risk Assessment (FRA)**.

However, the model remains of limited quality and these limitations will need to be considered when preparing the FRA and designing the development.

Flood model
The addition of photographs and a watercourse description helps and the model revisions have improved its acceptability.

The hydraulic model is likely to provide conservative levels, albeit the design flows are highly uncertain. Flood (flow) estimation on small, ungauged catchments comes with high uncertainty, and so therefore must the flood level/ extent estimation.

Use of modelling to support assessment of safe access and egress
Whilst we believe the modelling is suitable to provide flood levels for this site it is not suitable for assessing flood hazard or to revise current Flood Zone mapping.

These caveats should be considered when designing and assessing the development and mitigation measures, e.g. by taking a cautionary and conservative approach to safe access and egress.

Next Steps
I hope the above advice is helpful. If there is any further work you anticipate needing our detailed advice on in relation to this project please let me know so it can be incorporated into this charging agreement.

Please submit this letter with your formal planning application as confirmation that we find the flood modelling acceptable.

Yours sincerely

Mr David Griggs
Planning Advisor

Direct dial 02030 259625
Direct e-mail PlanningSSD@environment-agency.gov.uk

Steven Lecocq

From: Griggs, David [redacted]
Sent: 06 December 2017 14:59
To: Steven Lecocq
Subject: RE: Oaks Farm, Nutbourne
Attachments: PAC_SLTSDN_00183 - EA advice 2017-12-06.pdf; RE: PAC/SLTSDN/00183 - Oaks Farm, Nutbourne, Chichester

Hi Steve

Please find attached our advice on the model.

This advice has been provided under Agreement PAC/SLTSDN/00183. Please note we have taken 7 hours to review and provide our advice on these documents which is as estimated in our Programme of Works. The revised total (in addition to previous work) will now be £2,184, which is payable on receipt of our invoice.

Hopefully our confirmation that we find the model fit for purpose for an FRA will allow you to confidently use the modelling to support a planning application. As discussed previously, the model would not provide a suitable basis for determining a flood hazard rating but we are satisfied with the approach you have suggested to address this (see attached email).

Kind regards
David

David Griggs
Planning Advisor | Sustainable Places
Environment Agency | Solent & South Downs
Telephone: 02030 259625

Environment Agency
Romsey Office
Canal Walk
Romsey
SO51 7LP

Our **climate change allowances** for planning were updated on 19 February 2016. The guidance is accessible here: Flood risk assessment: Climate change allowances

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From: Steven Lecocq [redacted]
Sent: 06 December 2017 09:36
To: Griggs, David [redacted]
Subject: RE: Oaks Farm, Nutbourne

Good Morning David,

I hope you are well.

Could you please advise when we should expect to receive a response on the Nutbourne model?

Thanks,

Steven

From: Griggs, David [redacted]
Sent: 27 October 2017 17:22

Flood Hydrology Study

G & R Harris, Main Road, Nutbourne, West Sussex PO18 8RL

October 2017

Dr Paul Garrad
Consultant Hydrologist
66 Charlock Way
Guildford
Surrey
GU1 1XZ

Flood Hydrology Study
G & R Harris, Main Road, Nutbourne, West Sussex PO18 8RL

Contents

1 INTRODUCTION

1.1 Proposed Development

The proposed development is located at G & R Harris on Main Road, Nutbourne in West Sussex (Figure 1.1). The existing site is a car breakers yard accessed from the A259 as shown on an aerial photograph of the site (Figure 1.2) and is under the same ownership as the adjacent private house and garden. The proposed development relates to the east parcel of land (Figure 1.3) between the A259 and the railway line to the north with a small watercourse, Ham Brook, running southwards along the eastern boundary (Figure 1.1).

A topographical survey (Figure 1.4) shows that ground levels vary from 6.6m OD in the north west corner of the site to 5.38m at the site entrance and generally fall 0.4m to 0.7m from west to east towards Ham Brook. Ground levels alongside this ditch fall from 4.95m OD at the railway culvert to 3.67m OD to the south at the culvert below the access driveway. The watercourse splits into two channels in the gardens of the adjacent cottage with most flow occurring in the east branch and the smaller west branch flowing under the site entrance in a culvert. The Ham Brook is the main potential source of flooding of the site and the EAs flood map (Figure 1.5) show that parts of the site is located in Flood Zones 2 and 3.

The application is for a residential development but the number and location of dwellings will depend on issues such as flood risk and the purpose of this report is to identify these constraints.

1.2 EA Flood Mapping

The EA often do not undertaken detailed flood risk modelling and mapping for small watercourses less than 3km^2 such as the Ham Brook. The EAs flood map at this location (Figure 1.5) is therefore based on the National Generalised Jflow model which uses automated flow calculations and aerial survey ground level or LiDAR data and this coarse scale model is not usually considered suitable for a site specific Flood Risk Assessment. In such cases a more detailed flood hydrology and river modelling study is required to confirm flood flows, flood levels, extents and flood zones more accurately than the EAs Jflow model and to provide a better estimate of the flood risk to a development site. The EA usually require such a study to include:

- Confirm the contributing catchment area of the watercourse using FEH, OS Mapping and/or topographical survey data,
- A hydrological assessment to confirm extreme flood flows on the watercourse using industry standard hydrological methods such as FEH and/or ReFH.
- A survey of the watercourse based on cross sections of the channel and flood plain taken at regular intervals including a survey of all structures and culverts. All topographic survey data must be provided to Ordnance Datum.
- An estimate of the channel and flood plain roughness.
- Construct a hydraulic model of the watercourse to confirm the capacity of the channel and consider the flood extents and flood zones for the 20 year, 100 year, 100 year with climate change and the 1000 year flood flows.

- Once the flood levels over the site have been established consider whether flood mitigation measures such as raised floor levels, flood warning or evacuation plans will be required.
- Provide plans and cross-sections showing the predicted flood levels and extents.

This report considers the above approach and provides a detailed analysis of extreme flood flows for this watercourse with a hydraulic model to confirm flood levels and flood zones and hence to give a more accurate representation of flood risk on the site than the EAs flood mapping.

1.3 EA Comments

A previous report was submitted to the Environment Agency in July 2016 and on the basis of the EA's letter of 4 September 2017 and subsequent correspondence the issues raised (Table 1.1) are considered in this revised report.

Table 1.1 Comments from EA and Response

No	EA Comment	Response
1	What model approach has been adopted? Is it appropriate?	EA initially suggested a 2D model was required but have since confirmed that a 1D model is suitable for flood levels on this simple river system.
2	Software used, including versions?	HECRAS V5.0.3
3	Have appropriate distances between sections and/or nodes been used?	Report provides details on the locations of cross sections and spacing.
4	Are out of bank flows represented in 1D? If so, how has it been done and is it appropriate?	HECRAS 1D can provide flood plain out of bank flow and velocity
5	Do the cross sections and bed profiles look reasonable?	As discussed in point 3.
6	Does conveyance look appropriate?	Report to include check on model conveyance values and adjust if necessary.
7	What approach to channel roughness has been used?	Channel roughness values are subjective as there is no flood level data to calibrate the model. However, this will be reconsidered as part of the watercourse description (Pt 15) and assessed as part of the sensitivity analysis.
8	Have appropriate locations been chosen for the downstream model extents ?	Survey did not extend downstream of main road hence a variety of DS conditions are assessed.
9	Are all structures represented? If not have explanations for structures not modelled been given in the log/report?	Flow split is considered in revised model. Watercourse description (Pt 15) included as an Appendix include a commentary on structures.
10	Are invert levels correct compared to survey data?	Yes
11	If there are any moveable structures have they been modelled correctly?	None
12	Have appropriate roughness and loss coefficient values been used?	To be reconsidered and tested as part of sensitivity analyses.
13	Errors/Comments/Warnings?	The HCRAS errors and warnings are fairly

		common and have been addressed in more detail. Cross section interpolation will reduce these warnings.
14	Have appropriate model parameters been chosen for sensitivity testing?	Manning's 'n', Flow and DS boundary condition to be tested.
15	Technical overview of model and watercourse description.	A technical overview/ background of the model now included as an Appendix D. This includes a description of the watercourse divided into representative reaches with photographs of the channel and flood plain, identification of Manning's values; all relevant structures; risk of blockage and likely bypass routes. This is not a usual requirement hence was not included in the original flood modelling report.
16	EA consider survey extents (points 3, 5 and 8) and merging of LiDAR with ground level survey data at some sections, and interpolation of the channel shape at others is inappropriate.	The incomplete survey was due to overgrown and very dense vegetation which restricted access for surveying. It is quite usual in a modelling study to merge topo survey data of the river channel with LiDAR data of the flood plain but for this site the EA consider the merging is inexact as the survey was not georeferenced. The EA consider this merging is therefore unacceptable as, without geo-referenced cross sections, there is no confidence in the resultant flood levels and extents. The EA consider that using LiDAR data alone is preferable. At the EAs request the model has therefore been revised based on LiDAR data only.

These issues are considered in this revised report.

1.4 Report Structure

The definition of flood levels and zones is a two stage process and requires:

- The derivation of extreme fluvial flood flows for the watercourse using industry standard methods from the Flood Estimation Handbook (FEH) such as the Revised Statistical method and the Revitalised Flood Hydrograph Method (ReFH).

- The conversion of flood flows to flood levels using a hydraulic model such as HECRAS or ISIS based on a ground level survey of the watercourse, the flood plain and all relevant structures.

The flooding history and the derivation of flood flows is described in Section 2 whilst the HECRAS hydraulic model to convert flows to levels is considered in Section 3. The implications of these flood levels and zones on the proposed development is given in Section 4 and the conclusions are presented in Section 5.

2 FLOOD FLOWS

2.1 Available Data

The main potential source of fluvial flooding of the site is the Ham Brook which runs along the east boundary of the site (Figure 1.1). This watercourse drains the area around Hambrook and Woodmancote to the north through the fishing pond and flows under the railway line to the north, under the A259 to the south and towards Chichester Harbour 750m to the south of the site.

To confirm the flood zones requires the derivation of extreme flood flows for the 20 year, 100 year and 1000 year return periods for this watercourse. This is based on the methods detailed in the Flood Estimation Handbook (FEH), as required by the Environment Agency's FEH Guidelines, using the Revised Statistical Method and/or the Revitalised Flood Hydrograph Method (ReFH). Both require the use of FEH catchment descriptors and measured flow data as detailed below.

2.1.1 Catchment Descriptors

The Flood Estimation Handbook (FEH) CD version 3 provides the catchment delineation (Figure 2.1) which agrees with the EAs pluvial flood map (Figure 2.2) and OS Maps (Figure 1.1). The adopted catchment descriptors are provided at the railway line crossing upstream and the A249 downstream (Table 2.1) and these indicate that at the downstream point the catchment is small (5.35km^2) and rural (URBEXT1990 < 0.018) and with a moderate percentage runoff (SPRHOST = 26.2%). These catchment descriptors suggest there are no obvious reasons for not using FEH methods for flood flow estimation. A full definition of these FEH parameters is given in FEH Volume 5.

Table 2.1 FEH Catchment Descriptors for the Ham Brook at Nutbourne

Parameter	US	DS
GRID REF	SU 78000 05800	SU 77850 05650
AREA	4.73	5.35
BFIHOST	0.740	0.733
FARL	1.0	1.0
PROPWET	0.34	0.34
DPLBAR	2.14	2.25
DPSBAR	20.90	19.50
SAAR	770	768
SPRHOST	25.53	26.16
URBEXT1990	0.0132	0.0177
URBEXT2000	0.0339	0.0390

The catchment areas are similar and hence flow calculations are provided for the downstream end of the site only.

2.1.2 Measured Flow Data

The EA have no available measured flood level data for the Ham Brook but operate two river flow measurement stations nearby - the Ems on the Westbourne 3km to the west and the Lavant at Graylingwell 8km to the east (Table 2.2).

Table 2.2 EA Gauging Stations near Nutbourne

CEH Ref	Watercourse	Location	Start Date	End Date	No Years	QMED ?	Pooling ?
41015	Ems	Westbourne	13-Jul-68	11-Sept-14	47	Yes	No
41023	Lavant	Graylingwell	17-Feb-71	18-Sept-14	39	Yes	Yes

The EAs HiFlows database (version 4.1, May 2016) indicates:

- 41015, Ems at Westbourne. Comprised of two Crump weirs of 0.61m and 4.12m width which are modular throughout the flow range and all flows are contained with a structure limit of 5.08 m^3/s. One rating is applied across the period of record which appears to overestimate flows. The rating shows a reasonable fit to gaugings hence the flow records are considered to be suitable for QMED. However there are few high flow gaugings and the rating cannot be validated beyond QMED hence the accuracy of higher flows (pooling) is unknown.

- 41023, Lavant at Graylingwell. A 5m wide flat-V weir with a capacity $6m^3/s$ which is bypassed during extreme events. The structure underestimates higher flows but this has been accounted for by hydraulic modelling to provide the upper rating limbs. Flow records are suitable for QMED and pooling as gaugings show a good fit to rating.

This study does not allow for a detailed analysis of the high flow ratings at these two gauging stations but as the flow data is considered suitable for QMED at both sites these station data are used in the flood estimation process described below. Despite the possible inaccuracies of high flow measurements detailed above the available flow records show the largest floods at both stations occurred in December 2000 (Table 2.3).

Table 2.3 Largest Floods at Local EA Gauging Stations

Rank	41015		41023	
	Date	Flow (m^3/s)	Date	Flow (m^3/s)
1	09-Dec-00	6.78	14-Dec-00	8.1
2	18-Apr-75	6.013	12-Jan-94	7.8
3	11-Aug-12	5.652	14-Feb-14	6.17
4	30-Dec-93	5.566	05-Jan-03	5.35
5	10-Feb-13	5.08	28-Dec-12	4.81

There are no known records of the site having flooded on these dates although this should be confirmed.

2.2 FEH Statistical Method

As the site of interest is ungauged as a first approach it is convenient and appropriate to use the FEH Statistical method. The alternative Revitalised Flood Hydrograph Method (ReFH) is considered further below. The Statistical method is based on a two stage approach;

- Calculation of the index flood (the median annual flood, QMED) which at an ungauged site is derived from catchment descriptors, but which is then adjusted using the ratio of QMED from catchment descriptors and flow data at a nearby (donor) gauging station.

- The fitting of various extreme value distributions to a pooled group of annual maximum flow data from hydrologically similar sites (pooling group) to estimate the T year flows.

The procedure is described in the following sections.

2.2.1 FEH Index Flood (QMED)

The FEH catchment descriptors for the subject site are used to derive QMED at the downstream end of the site (Table 2.4) using the Revised Stats Method QMED equation[1].

Table 2.4 QMED from Catchment Descriptors

Site	QMED RURAL (m^3/s)	QMED URBAN (m^3/s)
DS	0.58	0.61

The EAs FEH guidelines recommend the urban adjusted QMED is used which is 0.61m^3/s.

(i) Donor Ratio

The catchment descriptor derived QMED at an ungauged site is then adjusted using the ratio between QMED from catchment descriptors and flow data at a suitable local donor gauging station. As detailed above the two EA gauging stations both have flow records suitable for QMED. In selecting a suitable donor gauging station FEH provides hydrological similarity criteria as follows;

- AREA – a factor of 4 or 5
- FARL – a difference of 0.05.
- BFIHOST – a difference of 0.18
- SAAR – a factor of 1.25
- SPRHOST – difference of 15

A comparison of the catchment descriptors at the two gauging stations with the subject site (Table 2.5) suggests both are outside the bounds of hydrological similarity in terms of catchment area and soil type (BFIHOST and SPRHOST) and hence neither gauge is ideal as a donor.

[1] *Improving the FEH statistical procedures for flood frequency estimation. CEH Science Report SC050050, July 2008*

Table 2.5 Catchment Descriptors at Flow Estimate Site and Donor Gauging Stations

Site	AREA	FARL	BFIHOST	SAAR	SPRHOST	URBEXT 1990
DS	5.35	1.0	0.733	768	26.16	0.0177
41023	86.29	1.0	0.935	922	7.25	0.0057
41015	57.92	0.976	0.904	899	9.27	0.0087

However in the absence of any other suitable donor gauges the catchment descriptors and annual maximum flow data at both gauges are used to calculate QMED and the QMED ratio as a check on the accuracy of the FEH method. This shows that the FEH CD method overestimates QMED from flow data at both gauges (Table 2.6).

Table 2.6 QMED from Flow Data and CDs at Gauging Stations

CEH Ref	QMED –CDs (m3/s)	QMED –AMAX (m3/s)	Ratio
41023	3.399	1.465	0.431
41015	2.464	2.156	0.875

Station 41015 is closest to the site of interest and the ratio of 0.875 indicates that a correction factor of 87.5% should be applied to the QMED from CDs at the ungauged site of interest on Ham Brook.

(ii) Donor Adjustment

However the Revised Stats method requires that this QMED donor ratio is further adjusted based on the distance between the centroids of the subject site and the donor gauge catchment and this gives a revised ratio of 0.942 at 41015 (Table 2.7) or 94%.

Table 2.7 QMED Ratio at Donor Gauging Stations

Site	Centroid East	Centroid North	Distance (km)	Ratio	Revised Ratio
US	478402	107548			
41023	487719	113373	10.99	0.431	0.731
41015	478470	113230	5.68	0.875	0.942

However due to the reservations given above about the suitability of these two gauging stations as donors the QMED from catchment descriptors at Nutbourne is not adjusted by this ratio. Rather an adjustment of 1.0 is used to give a final QMED as from CDs (Table 2.8) which can be regarded as a conservative estimate

Table 2.8 Revised QMED at Nutbourne

Site	QMED Rural	QMED-urban	QMED adjustment	Final QMED
US	0.51	0.53	1.0	0.53
DS	0.58	0.61	1.0	0.61

2.2.2 Flood Frequency Curve

The calculation of a flood frequency curve and the peak flows for a range of return periods at the flood estimation point requires the construction of a pooling group and the fitting of an extreme value distribution to the pooled group of flow data using WINFAP. The initial pooling group for the downstream site contains 14 stations with 500 station years of record. No stations were removed for having less than the required 8 years of data.

Examination of the pooling group indicates it is strongly heterogeneous and a review considered essential (H2 = 4.576). The component stations were reviewed and three stations removed for having convex growth curves (42011 Hamble at Frog Mill, 39028 Dun at Hungerford and 43028 By Brook at Middlehill). With the addition of three replacement stations (51001 Doniford Stream at Swill Bridge, 48007 Kennal at Ponsanoth and 25603 Foston Brook at Foston Mill) the revised pooling group contains 14 stations with 527 station years of record. This group was also heterogeneous and a review considered desirable but the H2 is reduced to 2.474. The component stations were reviewed again but there was no valid reason for the removal of any other stations and this revised pooling group was considered acceptable.

The component stations (Table 2.9) in the pooling group indicates that this includes several stations with relatively steep and several with relatively flat growth curves (Figure 2.3) hence some discordancy may be expected.

Table 2.9 Component Stations of Pooling Group

Station	No Yrs	L-CV	L-Skew	L-Kurt	Discord	Dist
44008 (South Winterborne @ W'bourne St)	33	0.395	0.332	0.221	1.937	1.135
39089 (Gade @ Hemel Hempstead Bury Ml)	39	0.232	0.099	0.131	0.461	1.153
39033 (Winterbourne @ Bagnor)	50	0.336	0.369	0.363	1.068	1.163
40033 (Dour @ Crabble Mill)	31	0.246	0.292	0.318	1.035	1.201
44003 (Asker @ East Bridge Bridport)	30	0.253	0.221	0.154	0.320	1.285
53023 (Sherston Avon @ Fosseway)	36	0.206	0.121	0.136	0.458	1.432
25019 (Leven @ Easby)	35	0.356	0.384	0.279	0.680	1.504
45816 (Haddeo @ Upton)	19	0.324	0.434	0.282	1.273	1.535
49004 (Ganel @ Gwills)	43	0.252	0.116	0.032	1.501	1.552
49002 (Hayle @ st Erth)	55	0.245	0.243	0.186	0.313	1.584
26802 (Gypsey Race @ Kirby Grindalythe)	14	0.253	0.216	0.254	0.495	1.612
51001 (Doniford Stream @ Swill Bridge)	46	0.325	0.396	0.362	0.793	1.615
48007 (Kennal @ Ponsanooth)	44	0.180	0.185	0.155	1.344	1.615
26003 (Foston Beck @ Foston Mill)	52	0.243	-0.015	0.080	2.323	1.624

The use of WINFAP3 was also considered but it is often found that this provides pooling groups that are even more discordant than WINFAP2. This arises because WINFAP3 uses the FEH parameters FARL and FPEXT to generate a pooling group, which are measure of flood storage and attenuation, whereas WINFAP2 is based on the soil or geology as reflected in BFIHOST. It is considered that WINFAP3 will always provide a more discordant pooling group as the shape of the growth curves of the component stations is more likely to be a function of the geology. WINFAP2, which uses geology to locate similar stations, is therefore preferred.

Two extreme value distributions are often used on the pooled group data (i) the Generalised Logistic (GL), and (ii) the General Extreme Value (GEV) distribution both fitted to the annual maximum data by the method of L-Moments. FEH indicates that the GL distribution often provides the best fit to extreme value flood series and in this case WINFAP indicates the GL provides the most acceptable distribution and suggests (Table 2.10) a 100 year flood of 2.07 m^3/s.

Table 2.10 Estimated Pooled Group Flood Flows at Nutbourne

Site	Return Period (Years)					
	2	5	10	20	50	100
US	0.53	0.78	0.97	1.18	1.51	1.81
DS	0.61	0.89	1.10	1.34	1.72	2.07

2.3 ReFH

An alternative approach to flood estimation is to use flood hydrograph methods. The original FSR/FEH rainfall runoff method (RR) underwent significant modification in 2006 taking advantage of new data and more advanced hydrological modelling techniques since the original method was developed. The improved or Revitalised Flood Hydrograph model (ReFH) retains the overall structure of the earlier FSR/FEH approach but with various improvements and ReFH is now preferred to RR. ReFH is therefore used to derive peak flows for the specified design events based on the time to peak (Tp) and critical storm duration (Table 2.11) for the catchment, adjusted to an odd multiple of the selected time step to give an adopted critical storm duration of 5.75 hours.

Table 2.11 ReFH Time to Peak and Critical Storm Duration

Site	Tp	Cmax	BL	BR	Storm duration	Time Step	Adopted Duration
DS	3.37	575.5	43.8	1.819	5.95	0.25	5.75

Flows for the required design events at the DS site (Table 2.12) shows that the ReFH QMED and all other flows are slightly lower than the FEH Stats Method with a 100 year peak flow of 1.80 m^3/s.

Table 2.12 ReFH and Stats Method Flood Estimates (m^3/s)

Site	Return Period (Years)					
	2	5	10	20	50	100
ReFH	0.58	0.79	0.97	1.16	1.48	1.80
Stats	0.61	0.89	1.10	1.34	1.72	2.07

The ReFH and the statistical method flood estimates are reasonably similar and either could be adopted in this study. The use of the QMED donor ratio of less than 1.0 as detailed above would provide more similar results but this has been discounted. As a conservative estimate the Stats method estimates are preferred. If a flood hydrograph is required the usual approach is to adopt the ReFH hydrographs shape and force the peak flows to fit the Stats method estimates, referred to as the hybrid method.

2.4 Extension to the 1000 year

The Environment Agency's Flood Estimation Guidelines[2] provide two suggestions for calculating extreme floods up to the 1000 year event.

- Using a larger 200 year pooling group in the Statistical method as an intermediate between the more usual 100 year group and the potentially less homogeneous 1000 years although more recently a simple extension of the 100 year has been proposed.
- The use of ReFH growth curves is also considered below but this is not advocated due to known errors in the extreme rainfall data set.

The Stats method flood frequency curve is therefore extended to the 1000 year return period using the same GL distribution as above and shows (Table 2.13) a 1000 year peak flow of 3.76 m^3/s. This compares to ReFH of 3.74 m^3/s and the ReFH growth curves method of extension of 4.30 m^3/s. These flows are reasonably similar (Figure 2.4) with ReFH flows slightly lower than the Stats method.

Table 2.13 Estimated Extended Flood Flows at Nutbourne

Method	2	5	10	20	50	100	200	1000
Stats	0.61	0.89	1.10	1.34	1.72	2.07	2.48	3.76
ReFH	0.58	0.79	0.97	1.16	1.48	1.80	2.21	3.74
Stats+ReFH	0.61	0.89	1.10	1.34	1.72	2.07	2.54	4.30

A comparison of the flood growth curves (Table 2.14 and Figure 2.5) suggest for most flows this is due ReFH having a flatter growth curve than the Stats method rather than any difference in the QMED estimates which are very similar (Table 2.13).

Table 2.14 Flood Growth Curves

Method	2	5	10	20	50	100	200	1000
Stats	1.00	1.46	1.80	2.20	2.82	3.39	4.07	6.16
ReFH	1.00	1.36	1.67	2.00	2.55	3.10	3.81	6.45
Stats+ReFH	1.00	1.46	1.80	2.20	2.82	3.39	4.17	7.05

As the Stats method growth curves is considered to be more robust and based on fewer assumptions these flood estimates are adopted.

2.5 Climate Change

Due to the uncertainties in flood estimation and expected climate change impacts, the hydrological analysis of flood flows and definition of defence standards should include an allowance for increased river flow due to climate change. The earlier guidance[3] provided in PPS25 and NPPF suggested a 20% increase in river flows by 2115 for the 100 year design life of most

[2] *Environment Agency's Flood Estimation Guidelines (2008)*
[3] *Flood and Coastal Defence Appraisal Guidance, Supplementary Note to Operating Authorities – Climate Change Impacts (October 2006)*

developments. The EAs revised climate change allowances (February 2016) now vary by river basin for the South East these revised allowances (Table 2.15) should be used.

Table 2.15 Estimated Change in Peak River Flows for the South East Region

Allowance category	The '2020s' (2015 to 2039)	The '2050s' (2040 to 2069)	The '2080s' (2070 to 2115)
Upper	25%	50%	105%
Higher central	15%	30%	45%
Central	10%	20%	35%

The revised EA guidance suggests that the peak river flow allowances (Upper, higher central or central) should be based on the relevant flood zone and the appropriate flood risk vulnerability classification (Table 2.16).

Table 2.16 Allowance Categories to be Adopted

Vulnerability Classification	Flood Zone		
	2	3a	3b
Essential infrastructure	Higher central and upper	Upper	upper
Highly vulnerable	Higher central and upper	Should not be permitted	Should not be permitted
More vulnerable	Central and higher central	Higher central and upper	Should not be permitted
Less vulnerable	Central	Central and higher central	Should not be permitted
Water compatible	none	central	central

This as the proposals are for a "more vulnerable" residential development and in Zone 2 or 3a the FRA should consider the higher central and upper allowances which suggest an increase in peak flows of 45% and 105% respectively up to 2115 over the 100 year design life of the development. These allowances provide the adopted flood flows (Table 2.17) which are used in the analyses considered in Section 3 to define design flood levels. The designation of flood zones is for the present day and therefore does not include this climate change allowance.

Table 2.17 Adopted Flood Flows

Method	2 yr	20 yr	100 yr	100 yr + 45%	100 yr + 105%	1000 yr
Stats	0.61	1.34	2.07	3.00	4.24	3.76

3 FLOOD LEVELS AND FLOOD ZONES

3.1 HECRAS River Model

The conversion of flood flows to flood levels is based on the construction of a 1 dimensional HECRAS hydraulic model (version 5.0.3) of the watercourse. The EA suggested after a review of the original model that a 2D model was required but have since confirmed that a 1D model is suitable for deriving flood levels on this relatively simple river system where flood plain flows are in the same direction as in the channel and there are no significant areas of storage downstream of the railway line. HECRAS 1D can provide flood plain out of bank flows and velocities

The model is based on the EAs 1m resolution LiDAR ground level data (Figure 3.1) which is interrogated to provide cross sections of the river channel and flood plain at regular intervals. In the original model this data was combined with the topographical survey (Appendix A) at the available cross sections of the river channel. However this survey was incomplete due to the overgrown channel and flood plain where the very dense vegetation restricted access for surveying. It is quite usual in a modelling study to merge a topo survey of a river channel with LiDAR data of the flood plain but for this site the EA consider this merging is inexact as the survey was not georeferenced. The EA therefore consider that the merging of the two data sets gives no confidence in the resultant flood levels and extents and that using LiDAR data alone is preferable. At the EAs request the model has therefore been revised and is based on LiDAR data only.

The EA also requested an overview and background of the model based on a description of the watercourse, with division into representative reaches, photographs of the channel and flood plain, identification of Manning's values; all relevant structures; the risk of blockage and likely flood bypass routes. This is not a usual requirement hence was not part of the original flood modelling report but is now included as Appendix D to this report.

3.1.1 Model Structure

The HECRAS model is based on a simple structure upstream of the scrap yard with a division into two channel downstream of the cottage near the site entrance (Figure 3.2). The model consists of 14 sections upstream of this channel division and with 10 sections on the east and 10 on the west channels downstream, thus with 34 sections of the watercourse and flood plain. Further sections were interpolated at smaller intervals to aid model stability.

The model therefore extends from the north end of the fishing lake 100m upstream of the railway line to below the ford on School Lane over a distance of 1066m (Table 3.1). The location of the LiDAR sections (Figure 3.3) is provided. The cross sections and bed profiles look reasonable as shown in Appendix C and Figure 3.4 although there are some differences between LiDAR and survey data at the culverts.

Table 3.1 HECRAS Model Cross Sections

XS ID	Description	Distance (m)	Chainage (m)	Min Bed Level (m OD)
1066	North Lake	44.42	1065.77	6.38
1021	Middle Lake	43.16	1021.34	6.43
978	South Lake	16.83	978.18	6.20
970	Weir		970.00	
961	North Railway	68.85	961.35	6.11
892	Crest Railway	41.52	892.49	7.27
851	South Railway	69.14	850.98	5.35
782	Scrap yard K	61.69	781.83	5.45
720	Scrap yard 1st O	45.96	720.14	4.78
674	Scrap yard B	40.08	674.18	4.93
634	Scrap yard M	86.08	634.10	5.05
548	Scrap yard H	41.77	548.02	5.18
506	South Scrap yard	19.23	506.25	4.57
487	Cottage – North	29.43	487.02	4.43
East Channel				
458	Cottage Garden	40.01	457.59	4.11
418	South Garden	10.90	417.58	3.81
407	Sluice	23.51	406.68	3.54
383	US A259	15.03	383.17	3.69
368	Crest of Road	52.99	368.14	4.08
315	DS A259	81.53	315.16	4.04
234	Church	62.35	233.63	3.50
171	DS	51.28	171.28	3.27
120	DS	120.00	120.00	2.47
0	DS Boundary		0.00	2.30
West Channel				
458	Cottage Garden	50.51	457.59	4.11
407	South Garden	18.89	407.08	4.08
388	Access Drive	26.48	388.19	4.08
362	US A259	29.58	361.71	4.08
332	Crest of Road	53.62	332.13	4.32
279	DS A259	77.84	278.51	3.91
201	Church	73.74	200.67	3.64
127	DS	49.68	126.93	2.70
77	DS	77.25	77.25	2.07
0	DS Boundary		0.00	2.00

The proposed development site and the existing scrap yard is located on the main channel between sections 548 and 782.

The model includes the main culverts on the Ham Brook where the dimensions and invert levels are taken from the topo survey (Table 3.2) and this includes the railway culvert, the two culverts below the main road and below the access road to the scrap yard.

Table 3.2 HECRAS Model Structures

Item	Railway Culvert	Site Entrance	A259West	A259 East
Shape	Circular	Box	Box	Box
US Invert Level (m OD)	5.092	3.768	3.315	3.391
DS Invert level (m OD)	4.954	3.568	3.302	2.884
Diameter (mm)	900	1.08 x 0.4	1.0 x 0.62	1.0 x 0.84
Deck Level (m OD)	7.920	4.285	4.681	4.645
Length (m)	22	12	20	35

There are no moveable structures on this watercourse included in the model. All structures are represented in the model part from the informal corrugated iron barrier which is used to divert flows between the two downstream channels and as this has a crest level below the top of the banks this is probably irrelevant during flood conditions. The EA mentioned the sluice on the downstream east channel but this is a non moveable structure which forms a permanent blockage on a former bend in the stream channel to prevent water entering this now redundant section of channel rather than a sluice. Appendix D includes details and photographs of these structures.

3.1.2 Model Calibration

In all river modelling studies it is usual to calibrate the model by comparing known flows, or generating flows from a recorded sequence of rainfall data, and adjusting the channel and flood plain roughness until a good fit is achieved between observed and modelled flood levels and extents. However there are no known flood marks, levels or flows and no available rainfall data and hence the model is not calibrated. This is not unusual in rural situations. The Manning's roughness values for the channel and the flood plain are therefore estimated and a value of 0.06 adopted for the channel and the flood plain. Channel roughness values are subjective as there is no historical flood level data with which to calibrate the model and this is considered as part of the watercourse description (Appendix D) and assessed as part of the sensitivity analysis below. As recommended by the HERCAS Manuals contraction and expansion coefficients of 0.1 and 0.3 were adopted.

3.1.3 Downstream Boundary Conditions

The downstream boundary of a model should be located a suitable distance downstream of the site of interest so that any change or variation in the adopted boundary condition does not affect the estimated water levels upstream based on the "backwater length". This is calculated to be between 70m and 190m and the model is therefore extended to 350m downstream of Main Road to the ford on School Lane. The model is then run with a normal depth with a bed slope of 0.00645 and with a critical depth boundary condition and the water levels at the sections upstream of the downstream boundary then compared (Table 3.3). This shows that for the 20 year, 100 year and 1000 year flows there is no difference between the critical and normal depth boundary condition at the section 171m upstream of School Lane and hence there is no difference in the estimated water levels at Main Road and upstream at the sections adjacent to the site.

Table 3.3 Difference in Water Levels for Different Boundary Conditions (Normal – Critical Depth)

Channel	Station	2 yr	20 yr	100 yr	1000 yr
West	0	0.05	0.08	0.10	0.13
	120	-0.01	-0.02	-0.03	-0.03
	171	0.0	0.0	0.0	0.0
	233	0.0	0.0	0.0	0.0
East	0	0.07	0.09	0.11	0.12
	77	-0.02	-0.02	-0.02	-0.02
	127	0.0	0.0	0.0	0.0
	201	0.0	0.0	0.0	0.0

The downstream boundary is therefore far enough downstream so that either condition could be used with minimal effect on the estimated water levels at the site or upstream of Main Road. The normal depth condition is used as this is considered to be the most realistic condition for this watercourse. This is considered to be an appropriate location for the downstream model boundary being more than the estimated backwater length downstream of the site.

3.1.4 Error Message and Warnings

The initial run of the HECRAS model provides a number of error warnings and notes (Table 3.4) which are quite usual and these are addressed or considered before the model is used.

Table 3.4 HECRAS Errors Warning and Notes for the 100 year flow

Warning	XS	Resolution
A flow split was encountered.	Main: 487	This is the channel division in the model
Divided flow computed for these cross-section.	Main: 1066, 850, 781, 720, 674, 634, 548, 506, 487 East: 407, 127, 77, 0 West: 315, 233	To be expected once river side flood banks are exceeded
During the culvert inlet control calcs the program could not balance the culvert/ weir flow. The reported inlet energy grade answer may not be valid.	Main: 890 Culvert #1 East: 250 Culvert #1 West: 370 Culvert #1 West: 350 Culvert #2	Due to flood flows going over wide bridge deck
During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth.	Main: 487 East: 127 West: 171	There is not a valid sub critical answer. The program defaulted to critical depth.
The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.	Main: 850, 781, 674, 634, 548 506 East: 407, 332, 201, 127, 77 West: 407. 233, 171, 120	Insert additional cross sections
Cross-section end points had to be	Main: 1066, 1021,	Extend if possible. Due to

extended vertically for the computed water surface.	978, 850 East: 407, 388, 362, 332	backing up upstream of railway line
Energy equation could not be balanced within the specified number of iterations.	Main: 487 East: 127 West: 171	The program used critical depth for the water surface and continued with the calculations
Energy loss was greater than 1.0 ft (0.3 m) between the current and previous cross section.	Main: 850, 548 East: 201, 127 West: 315, 233, 171	Insert additional cross sections
Weir over culvert is submerged	West: 370	To be expected

Cross section interpolation at 10m intervals was therefore used to reduce these warnings.

3.2 Model Runs

3.2.1 Model Results

The model is run in steady state backwater profile mode and the model output (Appendix B) and cross sections (Appendix C) show that the LIDAR cross sections are mostly sufficiently extensive and all flow is constrained to within the model lateral boundaries except where identified above. The longitudinal profile of maximum water levels (Figure 3.4) shows the Main Road and Railway culverts have sufficient capacity for the 20 year flood flow but the 100 year flood and above the bridge decks as it will exceed the culvert capacity. This will influence flood levels upstream, particularly at the access road and the lower parts of the site. This is not unexpected as the road culverts are seldom designed for the 100 year flood or more. At most sections there is only a small difference between the 100 and 1000 year flood levels (Table 3.5) as wide flood plain flow occurs. A check suggests the conveyance values are appropriate.

Table 3.5 HECRAS Model Flood Levels

XS	River Station	2 yr	20 yr	100 yr	100 yr + 35%	100 yr + 70%	1000 yr
West	0	2.01	2.07	2.11	2.15	2.20	2.18
West	120	2.26	2.33	2.39	2.45	2.50	2.48
West	171	2.85	2.90	2.95	2.99	3.03	3.01
West	233	3.78	3.81	3.83	3.85	3.87	3.98
West	315	4.45	4.48	4.50	4.52	4.54	4.53
West	350	A259 Road Culvert					
West	368	4.47	4.60	4.69	4.72	4.73	4.71
West	370	Access road culvert					
West	383	4.47	4.60	4.69	4.73	4.73	4.71
West	407	4.47	4.60	4.69	4.73	4.73	4.72
West	418	4.48	4.60	4.69	4.73	4.73	4.72
East	0	2.44	2.51	2.56	2.61	2.65	2.64
East	77	2.68	2.76	2.82	2.87	2.91	2.89
East	127	3.40	3.46	3.49	3.53	3.57	3.56
East	201	3.82	3.93	4.01	4.08	4.15	4.12

East	250	A258 Road bridge					
East	278	4.17	4.21	4.63	4.67	4.70	4.69
East	332	4.30	4.38	4.63	4.68	4.70	4.69
East	362	4.31	4.39	4.63	4.68	4.70	4.70
East	388	4.32	4.40	4.63	4.68	4.71	4.70
East	407	4.32	4.40	4.63	4.68	4.71	4.70
Main	487	4.61	4.69	4.75	4.81	4.85	4.83
Main	506	4.86	4.97	5.02	5.07	5.12	5.10
Main	548	5.37	5.42	5.46	5.50	5.54	5.53
Main	634	5.52	5.61	5.66	5.71	5.77	5.74
Main	674	5.54	5.63	5.69	5.74	5.80	5.78
Main	720	5.55	5.64	5.70	5.76	5.83	5.80
Main	781	5.63	5.72	5.78	5.84	5.90	5.88
Main	850	5.96	6.04	6.08	6.13	6.17	6.15
Main	890	Railway Embankment					
Main	961	6.33	7.02	7.88	7.91	7.93	7.93
Main	978	6.54	7.02	7.88	7.91	7.93	7.93
Main	1021	6.64	7.02	7.88	7.91	7.93	7.93
Main	1066	6.67	7.02	7.88	7.91	7.93	7.93

The 1000 year flood extent (Figure 3.5) is similar if slightly less extensive than the EAs flood map (Figure 1.5) and this is also shown by superimposing flood extents onto the LiDAR data (Figure 3.6). The lower parts of the site are in Zone 3, but this flood extent covers a smaller area than the EAs flood map due to the land raising that has occurred over the site. The main issue is ponding of water upstream on Main Road and the provision of a safe escape route.

3.2.2 Sensitivity Analyses

As part of a model development it is usual to include some form of sensitivity testing on the following parameters:

- Manning's 'n' +/- 30%
- Flow +/-20%
- DS boundary conditions, critical depth and normal depth.

The downstream boundary condition was considered in Section 3.1.3 and showed that the choice of critical depth or normal depth made no difference to the estimated water levels upstream of section 171 and hence no difference in the estimated water levels upstream of Main Road and the sections adjacent to the site.

To test sensitivity to channel and flood plain roughness the model is run for the conditions described above and with Manning's 'n' changed by 30% - increased to 0.08 and reduced to 0.04 (Table 3.6). The results show a maximum change of +/- 70mm

Table 3.6 HECRAS Model Flood Levels with Changes to Mannngs 'n'

Reach	River	Profile	Water Surface Elevation			Change in Water Level	
	Stn		n = 0.06	n = 0.08	n = 0.04	n = 0.08	n = 0.04
Nutbourne	487	2 yr	4.61	4.61	4.61	0	0
Nutbourne	487	20 yr	4.69	4.69	4.69	0	0
Nutbourne	487	100 yr	4.75	4.75	4.75	0	0
Nutbourne	487	100yr+45%	4.81	4.81	4.81	0	0
Nutbourne	487	100yr+105%	4.85	4.85	4.85	0	0
Nutbourne	487	1000 yr	4.83	4.83	4.83	0	0
Nutbourne	506	2 yr	4.86	4.91	4.81	0.05	-0.05
Nutbourne	506	20 yr	4.97	5.00	4.93	0.03	-0.04
Nutbourne	506	100 yr	5.02	5.06	4.97	0.04	-0.05
Nutbourne	506	100yr+45%	5.07	5.11	5.02	0.04	-0.05
Nutbourne	506	100yr+105%	5.12	5.17	5.06	0.05	-0.06
Nutbourne	506	1000 yr	5.10	5.15	5.05	0.05	-0.05
Nutbourne	548	2 yr	5.37	5.38	5.35	0.01	-0.02
Nutbourne	548	20 yr	5.42	5.44	5.39	0.02	-0.03
Nutbourne	548	100 yr	5.46	5.49	5.43	0.03	-0.03
Nutbourne	548	100yr+45%	5.50	5.53	5.46	0.03	-0.04
Nutbourne	548	100yr+105%	5.54	5.58	5.5	0.04	-0.04
Nutbourne	548	1000 yr	5.53	5.56	5.49	0.03	-0.04
Nutbourne	634	2 yr	5.52	5.55	5.49	0.03	-0.03
Nutbourne	634	20 yr	5.61	5.64	5.56	0.03	-0.05
Nutbourne	634	100 yr	5.66	5.70	5.61	0.04	-0.05
Nutbourne	634	100yr+45%	5.71	5.76	5.66	0.05	-0.05
Nutbourne	634	100yr+105%	5.77	5.81	5.71	0.04	-0.06
Nutbourne	634	1000 yr	5.74	5.79	5.69	0.05	-0.05
Nutbourne	674	2 yr	5.54	5.57	5.50	0.03	-0.04
Nutbourne	674	20 yr	5.63	5.67	5.59	0.04	-0.04
Nutbourne	674	100 yr	5.69	5.73	5.64	0.04	-0.05
Nutbourne	674	100yr+45%	5.74	5.79	5.69	0.05	-0.05
Nutbourne	674	100yr+105%	5.80	5.85	5.74	0.05	-0.06
Nutbourne	674	1000 yr	5.78	5.83	5.72	0.05	-0.06
Nutbourne	720	2 yr	5.55	5.58	5.51	0.03	-0.04
Nutbourne	720	20 yr	5.64	5.68	5.59	0.04	-0.05
Nutbourne	720	100 yr	5.70	5.75	5.65	0.05	-0.05
Nutbourne	720	100yr+45%	5.76	5.81	5.70	0.05	-0.06
Nutbourne	720	100yr+105%	5.83	5.88	5.76	0.05	-0.07
Nutbourne	720	1000 yr	5.80	5.86	5.74	0.06	-0.06
Nutbourne	781	2 yr	5.63	5.66	5.61	0.03	-0.02
Nutbourne	781	20 yr	5.72	5.76	5.67	0.04	-0.05
Nutbourne	781	100 yr	5.78	5.82	5.72	0.04	-0.06

Nutbourne	781	100yr+45%	5.84	5.89	5.77	0.05	-0.07
Nutbourne	781	100yr+105%	5.90	5.96	5.83	0.06	-0.07
Nutbourne	781	1000 yr	5.88	5.93	5.81	0.05	-0.07
Nutbourne	850	2 yr	5.96	5.99	5.93	0.03	-0.03
Nutbourne	850	20 yr	6.04	6.07	6.00	0.03	-0.04
Nutbourne	850	100 yr	6.08	6.11	6.05	0.03	-0.03
Nutbourne	850	100yr+45%	6.13	6.16	6.08	0.03	-0.05
Nutbourne	850	100yr+105%	6.17	6.21	6.12	0.04	-0.05
Nutbourne	850	1000 yr	6.15	6.19	6.11	0.04	-0.04

To test sensitivity to river flow the model is run for the conditions described above and with flows changed by +/-20% (Table 3.7). The results show a maximum change of +/- 40mm in flood levels.

Table 3.7 HECRAS Model Flood Levels with Changes to River Flow

Reach	River	Profile	Water Surface Elevation			Change in Water Level	
	Stn		Q * 1	Q + 20%	Q – 20%	Q + 20%	Q – 20%
Nutbourne	487	2 yr	4.61	4.62	4.59	0.01	-0.02
Nutbourne	487	20 yr	4.69	4.72	4.66	0.03	-0.03
Nutbourne	487	100 yr	4.75	4.79	4.72	0.04	-0.03
Nutbourne	487	100yr+45%	4.81	4.83	4.79	0.02	-0.02
Nutbourne	487	100yr+105%	4.85	4.87	4.83	0.02	-0.02
Nutbourne	487	1000 yr	4.83	4.86	4.82	0.03	-0.01
Nutbourne	506	2 yr	4.86	4.89	4.84	0.03	-0.02
Nutbourne	506	20 yr	4.97	4.99	4.95	0.02	-0.02
Nutbourne	506	100 yr	5.02	5.05	5.00	0.03	-0.02
Nutbourne	506	100yr+45%	5.07	5.10	5.05	0.03	-0.02
Nutbourne	506	100yr+105%	5.12	5.15	5.09	0.03	-0.03
Nutbourne	506	1000 yr	5.10	5.13	5.08	0.03	-0.02
Nutbourne	548	2 yr	5.37	5.38	5.36	0.01	-0.01
Nutbourne	548	20 yr	5.42	5.44	5.41	0.02	-0.01
Nutbourne	548	100 yr	5.46	5.48	5.44	0.02	-0.02
Nutbourne	548	100yr+45%	5.50	5.52	5.48	0.02	-0.02
Nutbourne	548	100yr+105%	5.54	5.57	5.52	0.03	-0.02
Nutbourne	548	1000 yr	5.53	5.55	5.51	0.02	-0.02
Nutbourne	634	2 yr	5.52	5.54	5.51	0.02	-0.01
Nutbourne	634	20 yr	5.61	5.63	5.59	0.02	-0.02
Nutbourne	634	100 yr	5.66	5.69	5.64	0.03	-0.02
Nutbourne	634	100yr+45%	5.71	5.74	5.69	0.03	-0.02
Nutbourne	634	100yr+105%	5.77	5.79	5.73	0.02	-0.04
Nutbourne	634	1000 yr	5.74	5.78	5.72	0.04	-0.02
Nutbourne	674	2 yr	5.54	5.56	5.52	0.02	-0.02
Nutbourne	674	20 yr	5.63	5.66	5.61	0.03	-0.02
Nutbourne	674	100 yr	5.69	5.72	5.66	0.03	-0.03
Nutbourne	674	100yr+45%	5.74	5.77	5.72	0.03	-0.02

Nutbourne	674	100yr+105%	5.80	5.83	5.77	0.03	-0.03
Nutbourne	674	1000 yr	5.78	5.81	5.75	0.03	-0.03
Nutbourne	720	2 yr	5.55	5.57	5.53	0.02	-0.02
Nutbourne	720	20 yr	5.64	5.67	5.62	0.03	-0.02
Nutbourne	720	100 yr	5.70	5.73	5.68	0.03	-0.02
Nutbourne	720	100yr+45%	5.76	5.80	5.73	0.04	-0.03
Nutbourne	720	100yr+105%	5.83	5.86	5.79	0.03	-0.04
Nutbourne	720	1000 yr	5.80	5.84	5.77	0.04	-0.03
Nutbourne	781	2 yr	5.63	5.65	5.62	0.02	-0.01
Nutbourne	781	20 yr	5.72	5.74	5.69	0.02	-0.03
Nutbourne	781	100 yr	5.78	5.81	5.75	0.03	-0.03
Nutbourne	781	100yr+45%	5.84	5.87	5.81	0.03	-0.03
Nutbourne	781	100yr+105%	5.90	5.94	5.87	0.04	-0.03
Nutbourne	781	1000 yr	5.88	5.91	5.85	0.03	-0.03
Nutbourne	850	2 yr	5.96	5.98	5.95	0.02	-0.01
Nutbourne	850	20 yr	6.04	6.06	6.02	0.02	-0.02
Nutbourne	850	100 yr	6.08	6.10	6.07	0.02	-0.01
Nutbourne	850	100yr+45%	6.13	6.15	6.10	0.02	-0.03
Nutbourne	850	100yr+105%	6.17	6.20	6.15	0.03	-0.02
Nutbourne	850	1000 yr	6.15	6.18	6.13	0.03	-0.02

3.2.3 Model Caveats

The estimated flood levels are based on an uncalibrated model of the watercourse and with estimated channel and flood plain roughness but this is often the best that can be achieved in rural catchments. The adopted approach is considered appropriate for the allocated time scale which is essentially a scoping report to assess if flood risk is likely to be an issue to developing the site for residential uses. A more detailed study such as a FRA might also consider the impact of blockage of the road culverts on flood level upstream. However the use of FEH derived flows and a dedicated topographical survey supplemented with the EAs LiDAR data provides a better estimate of flood levels and extents than the EAs flood maps.

The use of an unsteady state model based on rising and falling hydrographs may be an option and is often used when storage occurs such as where there are ponds, lakes or upstream of under capacity culverts. This may result in slightly lower flood levels and extents but the basic principles detailed above would be the same - a slightly less extensive flood plain but that safe escape through ponded water in the north side of Main Road may be a major issue.

4 IMPLICATIONS FOR THE PROPOSED DEVELOPMENT

Specific recommendations are normally included in the development proposals to minimise damage to property, infrastructure and the risk to life in case of flooding.

4.1 Flood Zones and Appropriate Development

As detailed above the 100 year, 100 year with climate change and the 1000 year flood will encroach onto the lower parts of the site close to the watercourse and these mark the Zone 1, 2 and 3a boundaries and provide constraints for developing the site. The 20 year flood does not extend onto the site which is therefore not inside the Zone 3b functional flood plain. Residential development would have to consider the exception test in Zone 3a but is appropriate in Zones 1 and 2 (Table 4.1). Although the present day Zone 3 is used for development control purposes the site layout and design would need to consider the Zone 3 flood levels with climate change which is similar to the 1000 year flood extent.

Table 4.1 NPPF Appropriate Land Use by Flood Zone

Classification	Zone			
	1	2	3a	3b
Essential Infrastructure	Appropriate	Appropriate	Exception test	Exception test
Highly Vulnerable	Appropriate	Exception test	Not permitted	Not permitted
More Vulnerable	Appropriate	Appropriate	Exception test	Not permitted
Less Vulnerable	Appropriate	Appropriate	Appropriate	Not permitted
Water Compatible	Appropriate	Appropriate	Appropriate	If it has to be there

4.2 Floor Levels

Residential dwellings should have a raised ground floor slab a minimum of 300mm above the 100yr + CC flood level to protect against the risk of flooding and to ensure any potential damage to the properties is minimised.

4.3 Flood Resilience and Resistance Measures

Flood risk can also be managed either by reducing the probability of flood water entering the building or structure (flood resistance) or reducing the consequences when a site or building is flooded (flood resilience). Providing the dwellings are located outside or above the 100 year +CC flood extent or level then no other specific flood resistance or resilience measures to protect against fluvial flooding are necessary. If the building floor level is less than 300mm above the design flood level then additional flood resistance and resilience measures may be required based on the CLG guidance "Improving the flood performance of new buildings". This can include raised electrical circuits, switches and sockets wired down from the ceiling rather than up from the floor. A raised door threshold will provide additional protection but raised floor slabs are preferred.

4.4 Safe Escape

Under FD2320 a safe dry escape route should ideally be available although an escape route through a shallow depth of flood water of less than 250mm can be safe to wade through providing the velocity is low (Figure 4.1).

The HECRAS model shows the 20 year flood would affect the escape route to around 400mm (Table 4.2) but with a low velocity of 0.05m/s which is danger for some (Figure 4.1). The 100yr without climate change suggests a flood depth of up to 484mm at the site entrance which is not safe to wade through but again with a low velocity. With increased flow due to climate change the flood depths are 514mm to 524mm which is again is danger for some (Figure 4.1).

Table 4.2 Flood Depths on Escape Route (m)

Location	Section	Ground Level (m OD)	20 yr	100 yr	100 yr + 45%	100 yr + 105%	1000 yr
			4.60	**4.69**	**4.72**	**4.73**	**4.71**
Main Road	315	4.681	-	0.009	0.039	0.049	0.029
Access Road	368	4.206	0.394	0.484	0.514	0.524	0.504
Access Road	383	4.290	0.310	0.400	0.430	0.440	0.420
Car Park	407	4.517	0.083	0.173	0.203	0.213	0.193
Entrance	418	5.351	-	-	-	-	-

The HECRAS model provides a low velocity of between 0.02m/s to 0.28m/s (Table 4.3) as water ponds on the access road due to the limited capacity of the two culverts until it overtops the main road. However this depth of flood water on the site access may be a constraint.

Table 4.3 Flood Velocities on Escape Route (m/s)

Location	RS	20 yr		100 yr		100yr+45%		1000 yr	
		L	**Rt**	**L**	**Rt**	**L**	**Rt**	**L**	**Rt**
Main Road	315	0.16	0.19	0.20	0.22	0.23	0.26	0.25	0.28
Access Road	368	0.05	0.03	0.05	0.03	0.07	0.05	0.09	0.06
Access Road	383	0.05	0.04	0.06	0.04	0.08	0.05	0.10	0.06
Car Park	407	0.04	0.02	0.05	0.04	0.07	0.05	0.09	0.06
Entrance	418	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08

Various mitigation options have been considered:

- Install a larger capacity culvert under the access road but it is also the culvert below the Main Road which is an issue. Increasing its capacity would increase flood risk to properties downstream and this may not be acceptable.

- Divert more flow from this smaller watercourse to the west to the larger channel to the east but this could also increase flood risk to properties downstream and may not be acceptable.

- Raise the site entrance road so it is above the estimated flood level although this could increase flood levels immediately upstream and this will require flood storage compensation measures to offset any loss in flood plain storage. There is ample space upstream to provide such compensation. A raised road with voids beneath would allow the transmission of flood water and provide a dry or shallow access and escape route.

- The time this access road will be flooded will be limited. If flooding does not occur for the 20 year flood with its peak flow of 1.35m^3/s then the period of inundation for more extreme flood events is limited to flow above this threshold (Figure 4.2). This suggests (Table 4.4) that the period of flooding would last for between 5 and 10 hours which is not excessively long but which may not be acceptable.

Table 4.4 Period of Inundation of the Access Road

	100 yr	100 yr + 45%	100 yr + 105%	1000 yr
Start of Flooding (hrs)	5	4.25	3.75	4
End of Flooding (hrs)	10	12	13.75	13.25
Time Period (hrs)	5	7.75	10	9.25

- Consider an alternative escape route to the west.

5 CONCLUSIONS

- The proposed development site is located at G & R Harris on Main Road, Nutbourne in West Sussex currently a car breakers yard which is accessed from the A259. The application is for a residential development but the number and location of dwellings will depend on issues such as flood risk and the purpose of this report is to identify these constraints.

- The site lies between the A259 and the railway line to the north with a small watercourse, the Ham Brook, running north to south along the eastern boundary. The watercourse splits into two at the lower end of the site with most of the flow in the east branch and the smaller west branch flowing under the site entrance in a culvert. The two branches of this watercourse flow under the A259 and into Chichester Harbour 750m to the south of the site.

- The EAs flood map shows the site is located in Flood Zones 2 and 3 based on their National Generalised Jflow model which is a coarse scale and indicative model which is not usually considered suitable for a site specific FRA. The EA do not often undertake detailed flood risk modelling and mapping studies for small watercourses less than 3km^2 such as this. The aim of this report is therefore to provide a more detailed flood hydrology and river modelling study to confirm flood flows, flood levels, extents and flood zones more accurately than the EAs Jflow model and to provide a better estimate of the flood risk to a development site.

- The estimation of extreme flood flows is based on the Flood Estimation Handbook (FEH) Revised Statistical method and the Revitalised Flood Hydrograph Method (ReFH). The Stats method, based on an unadjusted QMED and the frequency curve derived using WINFAP, provides a 100 year peak flow of 2.07 m^3/s with compares to ReFH of 1.80 m^3/s. These are reasonably similar and either could be adopted but the Stats method is preferred and this is extended to give a 1000 year peak flow of 3.76 m^3/s. The EAs revised climate change allowances (February 2016) are included and are 45% and 105% for the next 100 years.

- The conversion of flood flows to flood levels is based on a 1 dimensional HECRAS hydraulic model of the watercourse based on a combination of the EAs 1m resolution LiDAR ground level data and the topographical survey to provide 16 cross sections of the river channel and flood plain at regular intervals. The model extends from 390m downstream of Main Road to 20m upstream of the railway line over a distance of 930m. The model includes the main culverts on the Ham Brook where the dimensions and invert levels are available on the topo survey and this includes the railway culvert and the two culverts below the main road.

- In the absence of any known flood marks, levels or flows the model is not calibrated but this is not unusual in rural situations. The Manning's roughness values for the channel and the flood plain are therefore estimated and 0.06 is adopted for the channel and the flood plain. The downstream boundary of the model is located a suitable distance downstream and based on the normal depth condition as this is considered to be the most realistic condition for this watercourse.

- The model is run in steady state backwater profile mode and the model output shows the cross sections are sufficiently extensive and all flow is constrained to within the lateral boundaries. The result show that the Main Road and Railway culverts have sufficient capacity for the 20 year flood flow but the 100 year flood and above will exceed the culvert capacity. At Main Road the 100 year with CC and the 1000 year will exceed the level of the road deck and this will influence flood levels upstream, at the access road and also on the lower parts of the site. This is not unexpected as the road culverts are seldom designed for the 100 year flood or more.

- The 100 and 1000 year flood extents are similar if slightly less extensive than the EAs flood map and shows the lower parts of the site are in Zone 3. The site is not inside the Zone 3b functional flood plain. Although the present day Zone 3 is used for development control purposes the site layout and design would need to consider the Zone 3 flood levels with climate change which is similar to the 1000 year flood extent.

- The main issue is ponding of water upstream of Main Road and the provision of a safe escape route. Under FD2320 a safe dry escape route should ideally be available although escape through a shallow depth of flood water of less than 250mm can be safe to wade through providing the velocity is low. The 100yr without climate change for the present day suggest a shallow flood depth at the site entrance which is safe to wade through. However the increased flow due to climate change will increase flood depths and a depth of 594mm is not safe to drive or wade through. This depth of flood water at the site access may be a major constraint to developing the site. The period of inundation for more extreme flood events would last for between 5 and 10 hours which the EA and LPA may not find acceptable.

- Various mitigation options have been considered but installing a larger capacity culvert or diverting flows to the east watercourse could increase flood risk to properties downstream and this may not be acceptable. It may be possible to raise the site entrance road so it is above the estimated flood level although this could increase flood levels immediately upstream and this will require flood storage compensation measures to offset any loss in flood plain storage. There is ample space upstream to provide such compensation. A raised road with voids beneath would allow the transmission of flood water and provide a dry or shallow access and escape route.

Appendix A Topographical Survey

Notes

1. The survey was carried out using Leica TPS 1203/1205 and GPS 1200 instruments.
2. North relates to OS Grid North.
3. All co-ordinates relate to OS GB36 Datum at Stn 1. The rest of the site is orientated to OS Grid North but has been surveyed on a flat grid with no scale factor. All heights relate to OSGB 36 datum and have been computed using the OSTN(02) Geoid model.

LEGEND

- Survey Station
- IC - Inspection Cover
- CA - Cable TV Cover
- FH - Fire Hydrant
- SV - Stop Valve
- GV - Gas Valve
- PB - Post Box
- TCB - Call box
- TC - TCSU Cover
- PT - Parking Ticket Machine
- ER - Earthing Rod
- TB - Traffic Bollard
- Litter Bin
- Gully
- MH - Manhole Triangular
- MHC - Manhole Circular
- PB - Post Box
- P Gate Post
- TP Telephone Pole
- EP Electricity Pole
- RS Road Sign
- TL Traffic Light
- B Bollard
- FP Flag Pole
- LP Lamp Post
- C Camera
- Gate
- Tree (Coniferous - girth and spread to scale)
- Tree (Deciduous - girth and spread to scale)
- Tree (Dead/diseased - girth and spread to scale)
- Spot Level
- Top of Wall Height
- Apex Height
- soffit level

- Kerb
- Drop Kerb
- Road Edge (channel)
- Track Edge
- Change of Surface
- Road Centre Line
- Double Yellow Lines

- Wall
- Fence
- Edge of Hedge
- Vegetation Edge
- Metal Railings

- Building
- Apex Line
- Eave Line
- Parking Bay

- Overhead Power Cable
- Open Channel
- Top of Bank
- Bottom of Bank
- Major Contour Interval - 1.0m
- Minor Contour Interval - 0.1m

rev.	amendment	checked	date

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project
G & R HARRIS,
NUTBOURNE, W. SUSSEX.

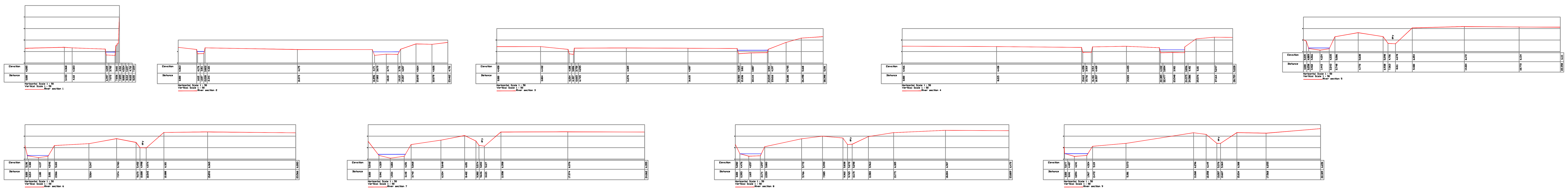
scale 1:500@A0	drawn by GC	checked by RW

date 27TH JUNE 2016	cad file IR.MHNUTBOURNE.21

title
DETAILED
TOPOGRAPHICAL
SURVEY

drawing number
IR.MHNUTBOURNE.21_01

rev.



LEGEND

River Section

Water Level

rev.	amendment	checked	date

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scale	1:200@A1	drawn by	GC	checked by	RW
date	27TH JUNE 2016	cad file	IR.MHNUTBOURNE.21		

title
RIVER
SECTIONS

drawing number	rev.
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Appendix B HECRAS Model Output

HECRAS Model Output

Reach	River Sta	Profile	Q Total	Min Ch Elev	W.S. Elev	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m/s)	(m2)	(m)	
West	0	2 yr	0.21	1.87	2.01	0.26	0.81	9.38	0.28
West	0	20 yr	0.44	1.87	2.07	0.33	1.32	10.56	0.30
West	0	100 yr	0.70	1.87	2.11	0.39	1.80	11.54	0.31
West	0	100yr+45%	1.00	1.87	2.15	0.44	2.29	12.27	0.32
West	0	100yr+105%	1.44	1.87	2.20	0.49	2.95	13.32	0.33
West	0	1000 yr	1.26	1.87	2.18	0.47	2.68	12.92	0.33
West	120	2 yr	0.21	2.07	2.26	0.17	1.26	10.40	0.15
West	120	20 yr	0.44	2.07	2.33	0.21	2.06	11.88	0.16
West	120	100 yr	0.70	2.07	2.39	0.25	2.82	13.12	0.17
West	120	100yr+45%	1.00	2.07	2.45	0.28	3.56	14.87	0.18
West	120	100yr+105%	1.44	2.07	2.50	0.33	4.57	21.81	0.19
West	120	1000 yr	1.26	2.07	2.48	0.31	4.12	17.03	0.18
West	171	2 yr	0.21	2.70	2.85	0.37	0.56	6.44	0.40
West	171	20 yr	0.44	2.70	2.90	0.47	0.94	7.64	0.43
West	171	100 yr	0.70	2.70	2.95	0.51	1.38	10.54	0.45
West	171	100yr+45%	1.00	2.70	2.99	0.56	1.79	11.97	0.45
West	171	100yr+105%	1.44	2.70	3.03	0.64	2.33	17.26	0.47
West	171	1000 yr	1.26	2.70	3.01	0.62	2.08	14.26	0.47
West	233	2 yr	0.21	3.64	3.78	0.34	0.80	22.66	0.39
West	233	20 yr	0.44	3.64	3.81	0.39	1.50	25.68	0.38
West	233	100 yr	0.70	3.64	3.83	0.44	2.10	27.32	0.39
West	233	100yr+45%	1.00	3.64	3.85	0.49	2.67	30.84	0.41
West	233	100yr+105%	1.44	3.64	3.87	0.55	3.60	37.80	0.42
West	233	1000 yr	1.26	3.64	3.87	0.53	3.26	36.02	0.41
West	315	2 yr	0.21	4.33	4.45	0.28	0.97	22.89	0.31
West	315	20 yr	0.44	4.33	4.48	0.33	1.87	34.18	0.32
West	315	100 yr	0.70	4.33	4.50	0.37	2.64	37.19	0.33
West	315	100yr+45%	1.00	4.33	4.52	0.41	3.38	41.17	0.33
West	315	100yr+105%	1.44	4.33	4.54	0.45	4.43	47.13	0.34
West	315	1000 yr	1.26	4.33	4.53	0.43	4.02	44.70	0.34
West	350		Culvert						
West	368	2 yr	0.21	3.91	4.47	0.08	3.46	22.76	0.04
West	368	20 yr	0.44	3.91	4.60	0.09	7.73	47.48	0.04
West	368	100 yr	0.70	3.91	4.69	0.09	13.05	66.34	0.04
West	368	100yr+45%	1.00	3.91	4.72	0.11	14.80	67.18	0.05
West	368	100yr+105%	1.44	3.91	4.73	0.15	15.42	67.56	0.06
West	368	1000 yr	1.26	3.91	4.71	0.14	14.59	67.08	0.06
West	370		Culvert						

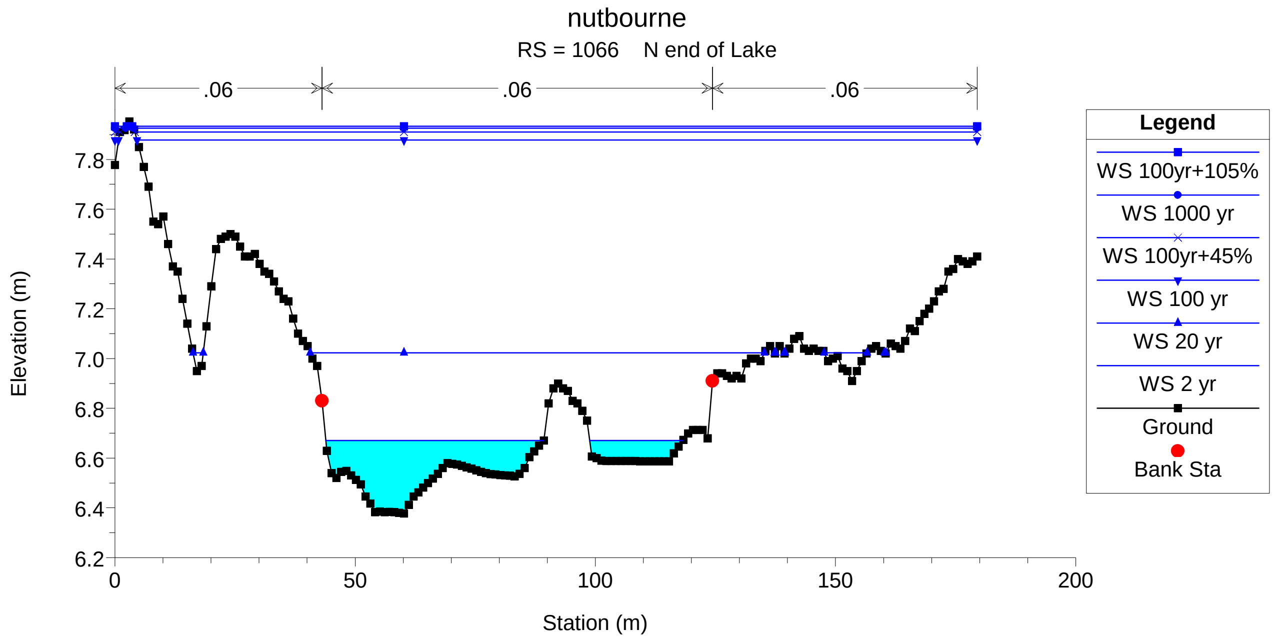
West	383	2 yr	0.21	4.08	4.47	0.09	2.76	17.87	0.05
West	383	20 yr	0.44	4.08	4.60	0.11	5.67	31.11	0.05
West	383	100 yr	0.70	4.08	4.69	0.11	9.48	49.25	0.05
West	383	100yr+45%	1.00	4.08	4.73	0.13	11.37	51.89	0.06
West	383	100yr+105%	1.44	4.08	4.73	0.19	11.24	51.67	0.08
West	383	1000 yr	1.26	4.08	4.71	0.18	10.61	51.04	0.08
West	407	2 yr	0.21	4.08	4.47	0.04	5.53	22.71	0.02
West	407	20 yr	0.44	4.08	4.60	0.06	8.83	31.10	0.03
West	407	100 yr	0.70	4.08	4.69	0.07	11.92	33.70	0.03
West	407	100yr+45%	1.00	4.08	4.73	0.10	13.22	34.81	0.04
West	407	100yr+105%	1.44	4.08	4.73	0.14	13.24	34.82	0.06
West	407	1000 yr	1.26	4.08	4.72	0.12	12.79	34.44	0.05
West	418	2 yr	0.21	4.08	4.48	0.05	4.42	18.21	0.03
West	418	20 yr	0.44	4.08	4.60	0.07	6.76	19.85	0.03
West	418	100 yr	0.70	4.08	4.69	0.08	8.72	21.21	0.04
West	418	100yr+45%	1.00	4.08	4.73	0.11	9.54	21.84	0.05
West	418	100yr+105%	1.44	4.08	4.73	0.16	9.57	21.86	0.07
West	418	1000 yr	1.26	4.08	4.72	0.14	9.28	21.64	0.06
East	0	2 yr	0.40	2.27	2.44	0.34	1.24	11.19	0.30
East	0	20 yr	0.90	2.27	2.51	0.45	2.30	17.51	0.33
East	0	100 yr	1.37	2.27	2.56	0.52	3.11	19.69	0.34
East	0	100yr+45%	2.00	2.27	2.61	0.58	4.27	27.80	0.35
East	0	100yr+105%	2.80	2.27	2.65	0.64	5.90	43.59	0.36
East	0	1000 yr	2.50	2.27	2.64	0.62	5.27	39.42	0.35
East	77	2 yr	0.40	2.47	2.68	0.25	1.71	13.24	0.20
East	77	20 yr	0.90	2.47	2.76	0.33	3.18	20.15	0.22
East	77	100 yr	1.37	2.47	2.82	0.38	4.53	30.14	0.22
East	77	100yr+45%	2.00	2.47	2.87	0.42	6.51	44.36	0.23
East	77	100yr+105%	2.80	2.47	2.91	0.46	8.63	48.93	0.23
East	77	1000 yr	2.50	2.47	2.89	0.45	7.84	47.34	0.23
East	127	2 yr	0.40	3.27	3.40	0.44	1.02	13.58	0.45
East	127	20 yr	0.90	3.27	3.46	0.56	2.01	24.03	0.45
East	127	100 yr	1.37	3.27	3.49	0.61	2.89	25.74	0.44
East	127	100yr+45%	2.00	3.27	3.53	0.65	3.94	27.51	0.43
East	127	100yr+105%	2.80	3.27	3.57	0.73	5.10	31.15	0.44
East	127	1000 yr	2.50	3.27	3.56	0.69	4.63	29.08	0.44
East	201	2 yr	0.40	3.50	3.82	0.35	1.15	7.33	0.28
East	201	20 yr	0.90	3.50	3.93	0.44	2.04	8.88	0.30
East	201	100 yr	1.37	3.50	4.01	0.50	2.75	10.53	0.31
East	201	100yr+45%	2.00	3.50	4.08	0.56	3.56	11.86	0.33
East	201	100yr+105%	2.80	3.50	4.15	0.64	4.41	13.86	0.35
East	201	1000 yr	2.50	3.50	4.12	0.61	4.11	12.65	0.34

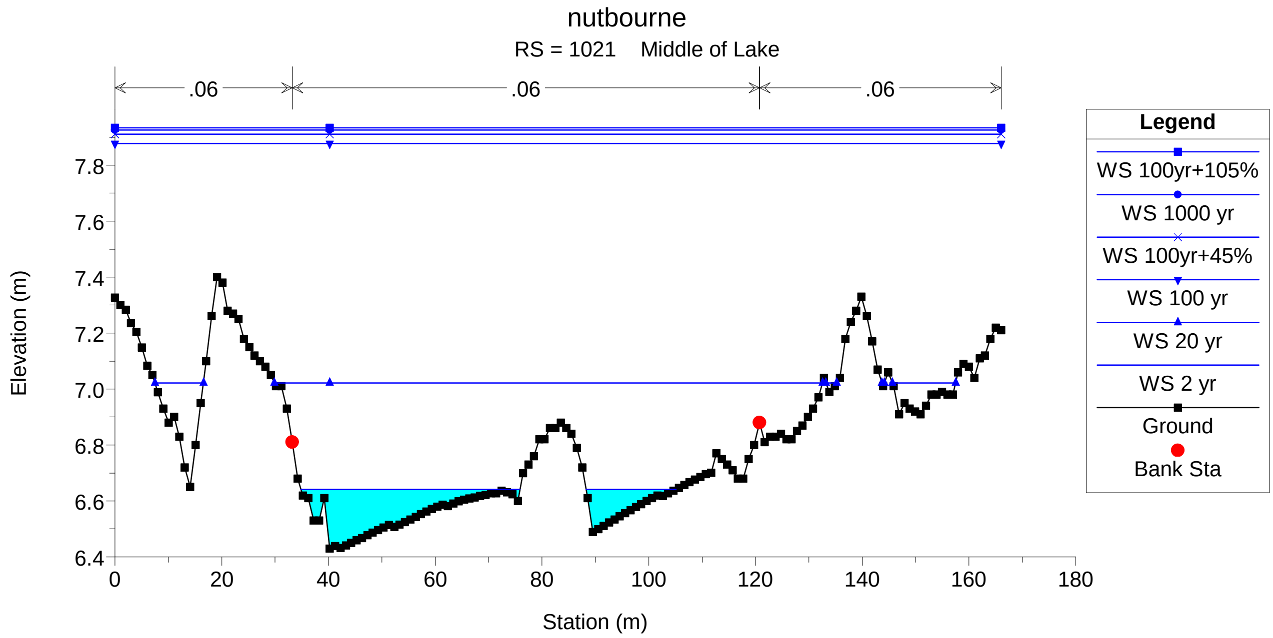
East	250		Culvert						
East	278	2 yr	0.40	4.04	4.17	0.76	0.53	10.06	0.97
East	278	20 yr	0.90	4.04	4.21	0.94	1.02	12.84	0.96
East	278	100 yr	1.37	4.04	4.63	0.09	22.30	84.68	0.04
East	278	100yr+45%	2.00	4.04	4.67	0.11	26.38	91.79	0.05
East	278	100yr+105%	2.80	4.04	4.70	0.14	28.43	92.41	0.06
East	278	1000 yr	2.50	4.04	4.69	0.13	27.85	92.25	0.05
East	332	2 yr	0.40	3.69	4.30	0.16	3.32	43.66	0.08
East	332	20 yr	0.90	3.69	4.38	0.20	7.73	64.94	0.10
East	332	100 yr	1.37	3.69	4.63	0.08	27.93	88.58	0.03
East	332	100yr+45%	2.00	3.69	4.68	0.10	32.06	88.88	0.04
East	332	100yr+105%	2.80	3.69	4.70	0.12	34.24	89.05	0.05
East	332	1000 yr	2.50	3.69	4.69	0.11	33.60	89.00	0.04
East	362	2 yr	0.40	4.08	4.31	0.12	4.22	40.86	0.10
East	362	20 yr	0.90	4.08	4.39	0.15	8.09	61.97	0.09
East	362	100 yr	1.37	4.08	4.63	0.07	25.15	79.06	0.03
East	362	100yr+45%	2.00	4.08	4.68	0.09	28.89	80.04	0.04
East	362	100yr+105%	2.80	4.08	4.70	0.11	30.93	80.21	0.05
East	362	1000 yr	2.50	4.08	4.70	0.10	30.32	80.16	0.04
East	388	2 yr	0.40	3.54	4.32	0.04	10.60	36.63	0.02
East	388	20 yr	0.90	3.54	4.40	0.08	13.77	42.06	0.03
East	388	100 yr	1.37	3.54	4.63	0.07	24.83	51.89	0.02
East	388	100yr+45%	2.00	3.54	4.68	0.09	27.32	53.23	0.03
East	388	100yr+105%	2.80	3.54	4.71	0.13	28.74	54.16	0.04
East	388	1000 yr	2.50	3.54	4.70	0.11	28.30	53.88	0.04
East	407	2 yr	0.40	3.81	4.32	0.11	4.36	22.64	0.06
East	407	20 yr	0.90	3.81	4.40	0.17	6.48	28.07	0.09
East	407	100 yr	1.37	3.81	4.63	0.12	13.73	35.35	0.05
East	407	100yr+45%	2.00	3.81	4.68	0.16	15.49	38.67	0.06
East	407	100yr+105%	2.80	3.81	4.71	0.21	16.56	39.78	0.08
East	407	1000 yr	2.50	3.81	4.70	0.19	16.23	39.63	0.07
Main	487	2 yr	0.61	4.43	4.61	1.03	0.59	5.54	1.01
Main	487	20 yr	1.34	4.43	4.69	1.19	1.15	9.05	0.95
Main	487	100 yr	2.07	4.43	4.75	1.28	1.73	11.87	0.92
Main	487	100yr+45%	3.00	4.43	4.81	1.21	2.83	24.44	0.86
Main	487	100yr+105%	4.24	4.43	4.85	1.31	3.88	27.14	0.85
Main	487	1000 yr	3.76	4.43	4.83	1.29	3.43	26.03	0.87
Main	506	2 yr	0.61	4.57	4.86	0.40	1.52	9.32	0.32
Main	506	20 yr	1.34	4.57	4.97	0.47	2.90	16.33	0.33
Main	506	100 yr	2.07	4.57	5.02	0.56	3.90	21.55	0.35
Main	506	100yr+45%	3.00	4.57	5.07	0.66	5.20	30.33	0.38
Main	506	100yr+105%	4.24	4.57	5.12	0.74	6.83	33.59	0.39
Main	506	1000 yr	3.76	4.57	5.10	0.71	6.24	32.86	0.39

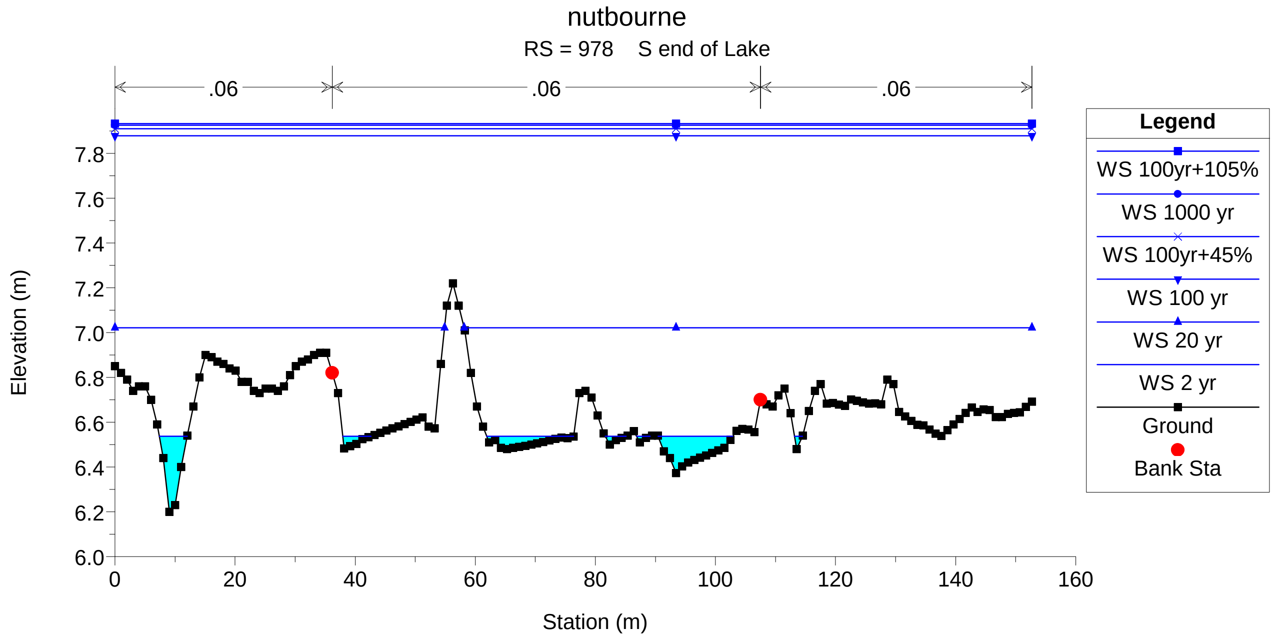
Main	548	2 yr	0.61	5.18	5.37	0.37	2.02	27.07	0.34
Main	548	20 yr	1.34	5.18	5.42	0.45	3.87	40.95	0.34
Main	548	100 yr	2.07	5.18	5.46	0.50	5.80	50.55	0.35
Main	548	100yr+45%	3.00	5.18	5.50	0.53	7.95	56.45	0.34
Main	548	100yr+105%	4.24	5.18	5.54	0.56	10.33	59.21	0.33
Main	548	1000 yr	3.76	5.18	5.53	0.56	9.46	58.95	0.33
Main	634	2 yr	0.61	5.05	5.52	0.20	3.82	33.22	0.12
Main	634	20 yr	1.34	5.05	5.61	0.26	7.42	56.32	0.14
Main	634	100 yr	2.07	5.05	5.66	0.30	10.77	75.64	0.15
Main	634	100yr+45%	3.00	5.05	5.71	0.32	14.89	86.21	0.15
Main	634	100yr+105%	4.24	5.05	5.77	0.35	19.70	91.72	0.15
Main	634	1000 yr	3.76	5.05	5.74	0.33	17.68	88.96	0.15
Main	674	2 yr	0.61	4.93	5.54	0.12	6.86	39.44	0.06
Main	674	20 yr	1.34	4.93	5.63	0.17	10.67	44.84	0.08
Main	674	100 yr	2.07	4.93	5.69	0.21	13.27	47.14	0.09
Main	674	100yr+45%	3.00	4.93	5.74	0.26	16.00	53.72	0.11
Main	674	100yr+105%	4.24	4.93	5.80	0.31	19.34	60.89	0.12
Main	674	1000 yr	3.76	4.93	5.78	0.29	17.88	55.36	0.12
Main	720	2 yr	0.61	4.78	5.55	0.08	8.53	27.93	0.04
Main	720	20 yr	1.34	4.78	5.64	0.15	11.47	34.10	0.06
Main	720	100 yr	2.07	4.78	5.70	0.20	13.77	41.54	0.07
Main	720	100yr+45%	3.00	4.78	5.76	0.25	16.42	48.62	0.09
Main	720	100yr+105%	4.24	4.78	5.83	0.30	20.01	62.77	0.10
Main	720	1000 yr	3.76	4.78	5.80	0.28	18.40	56.86	0.10
Main	781	2 yr	0.61	5.45	5.63	0.35	1.77	17.26	0.33
Main	781	20 yr	1.34	5.45	5.72	0.38	4.14	36.81	0.27
Main	781	100 yr	2.07	5.45	5.78	0.39	6.78	48.87	0.24
Main	781	100yr+45%	3.00	5.45	5.84	0.39	9.94	60.40	0.22
Main	781	100yr+105%	4.24	5.45	5.90	0.41	14.26	72.01	0.21
Main	781	1000 yr	3.76	5.45	5.88	0.40	12.40	67.52	0.22
Main	850	2 yr	0.61	5.61	5.96	0.25	3.32	32.00	0.18
Main	850	20 yr	1.34	5.61	6.04	0.29	7.82	107.75	0.18
Main	850	100 yr	2.07	5.61	6.08	0.29	12.77	116.04	0.16
Main	850	100yr+45%	3.00	5.61	6.13	0.29	17.77	122.63	0.15
Main	850	100yr+105%	4.24	5.61	6.17	0.30	23.19	127.41	0.15
Main	850	1000 yr	3.76	5.61	6.15	0.29	21.21	124.76	0.15
Main	890		Culvert						
Main	961	2 yr	0.61	6.33	6.33		0.56	5.08	0.00
Main	961	20 yr	1.34	6.33	7.02	0.02	74.86	151.73	0.01
Main	961	100 yr	2.07	6.33	7.88	0.01	204.84	151.73	0.00
Main	961	100yr+45%	3.00	6.33	7.91	0.02	209.71	151.73	0.00
Main	961	100yr+105%	4.24	6.33	7.93	0.02	213.17	151.73	0.01

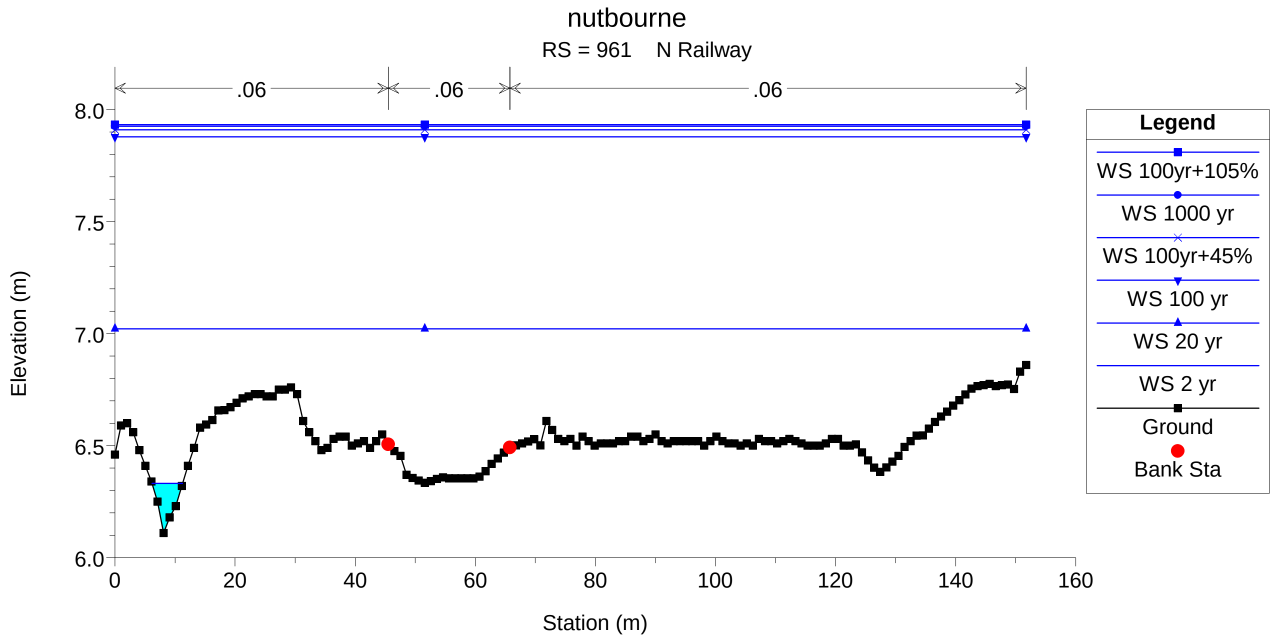
Main	961	1000 yr	3.76	6.33	7.93	0.02	212.03	151.73	0.00
Main	978	2 yr	0.61	6.37	6.54	0.16	2.61	43.22	0.23
Main	978	20 yr	1.34	6.37	7.02	0.03	58.76	149.42	0.01
Main	978	100 yr	2.07	6.37	7.88	0.01	189.21	152.71	0.00
Main	978	100yr+45%	3.00	6.37	7.91	0.02	194.11	152.71	0.00
Main	978	100yr+105%	4.24	6.37	7.93	0.02	197.59	152.71	0.01
Main	978	1000 yr	3.76	6.37	7.93	0.02	196.44	152.71	0.01
Main	1021	2 yr	0.61	6.43	6.64	0.12	4.93	57.86	0.14
Main	1021	20 yr	1.34	6.43	7.02	0.04	39.50	126.07	0.02
Main	1021	100 yr	2.07	6.43	7.88	0.01	175.77	166.01	0.00
Main	1021	100yr+45%	3.00	6.43	7.91	0.02	181.10	166.01	0.01
Main	1021	100yr+105%	4.24	6.43	7.93	0.03	184.89	166.01	0.01
Main	1021	1000 yr	3.76	6.43	7.93	0.02	183.64	166.01	0.01
Main	1066	2 yr	0.61	6.38	6.67	0.07	8.64	64.76	0.06
Main	1066	20 yr	1.34	6.38	7.02	0.04	36.81	106.46	0.02
Main	1066	100 yr	2.07	6.38	7.88	0.01	170.62	175.66	0.00
Main	1066	100yr+45%	3.00	6.38	7.91	0.02	176.28	176.42	0.01
Main	1066	100yr+105%	4.24	6.38	7.93	0.03	180.34	178.37	0.01
Main	1066	1000 yr	3.76	6.38	7.93	0.02	179.00	177.91	0.01

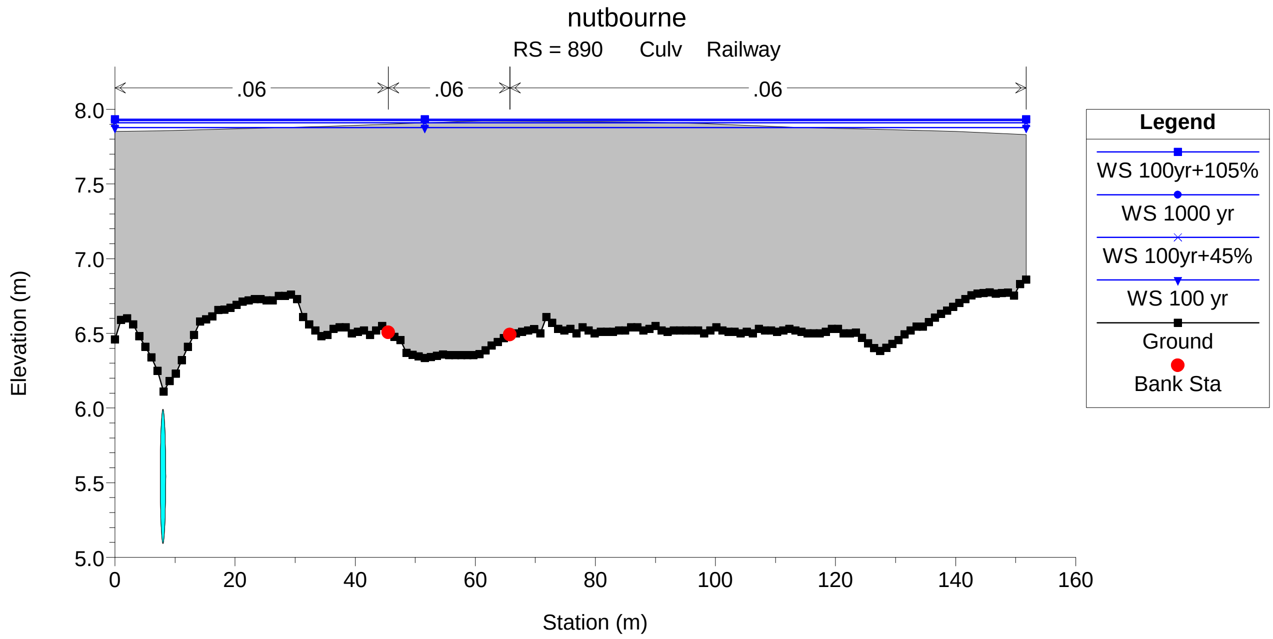
Appendix C HECRAS Model Cross Sections (Each XS Viewed from Upstream)

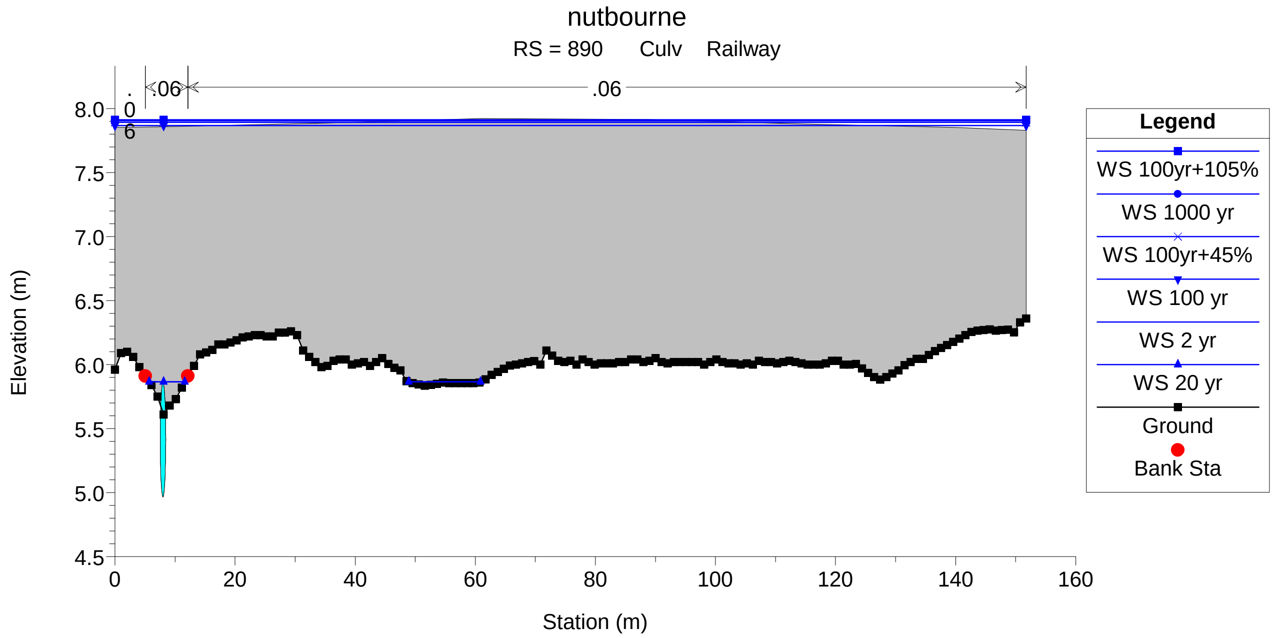

nutbourne
RS = 1066 N end of Lake
.06
.06
.06
Elevation (m)
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
0
50
100
150
200
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

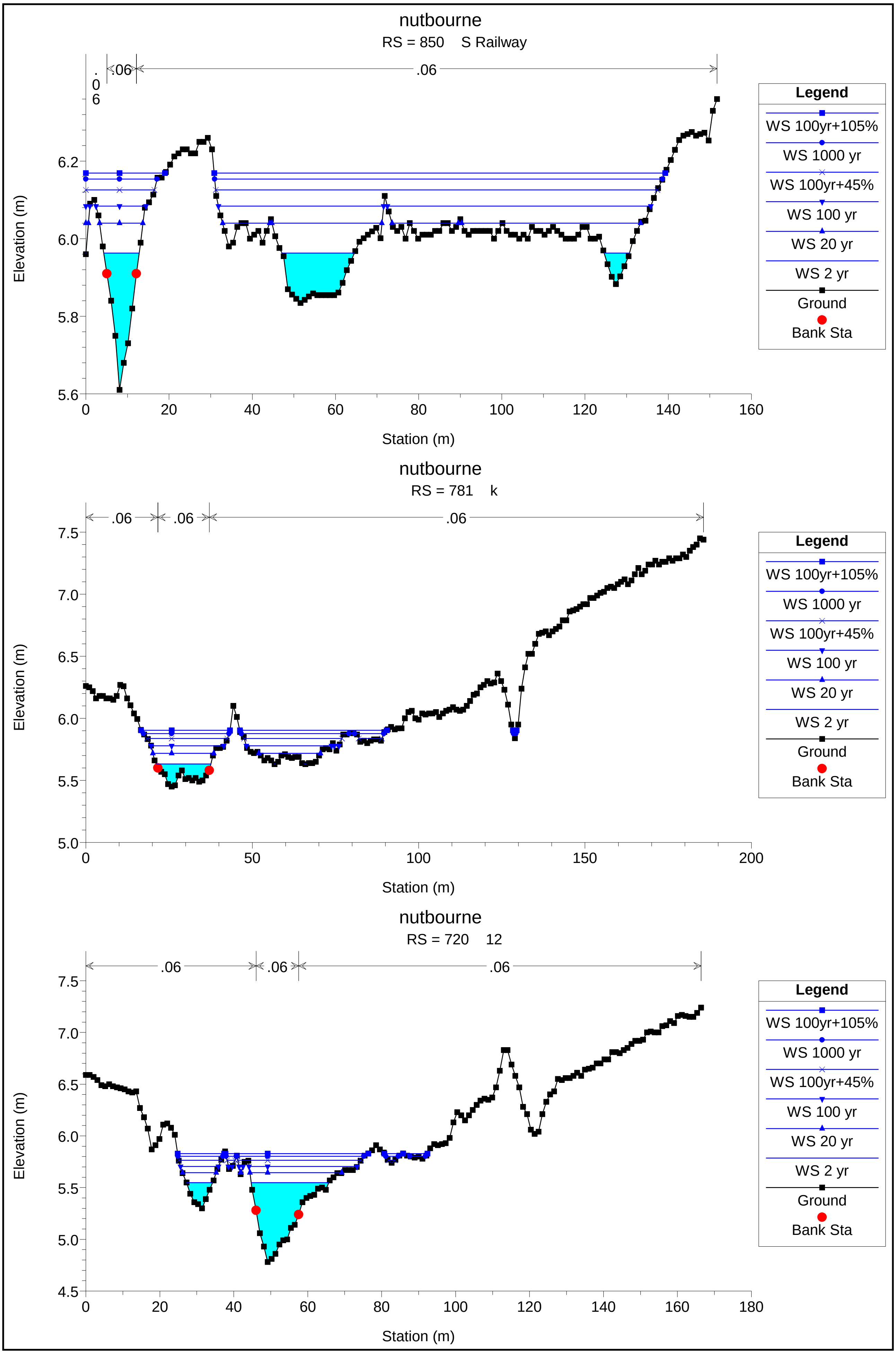

nutbourne
RS = 1021 Middle of Lake
.06
.06
.06
Elevation (m)
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
0
20
40
60
80
100
120
140
160
180
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

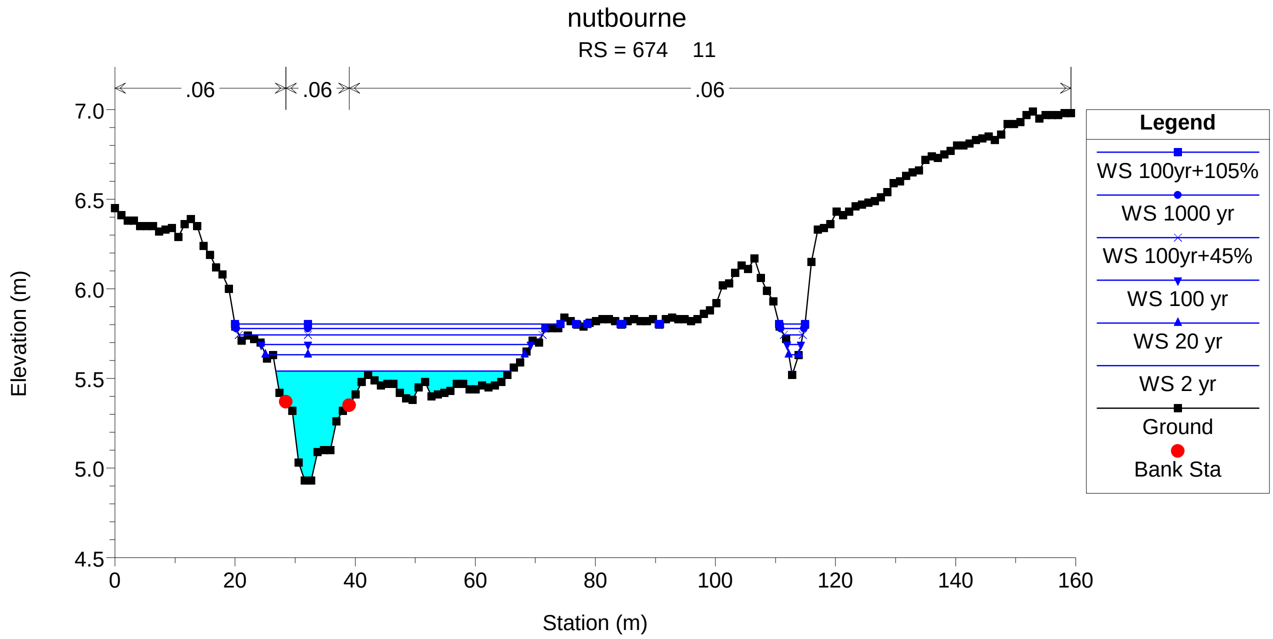

nutbourne
RS = 978 S end of Lake
.06
.06
.06
Elevation (m)
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
0
20
40
60
80
100
120
140
160
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

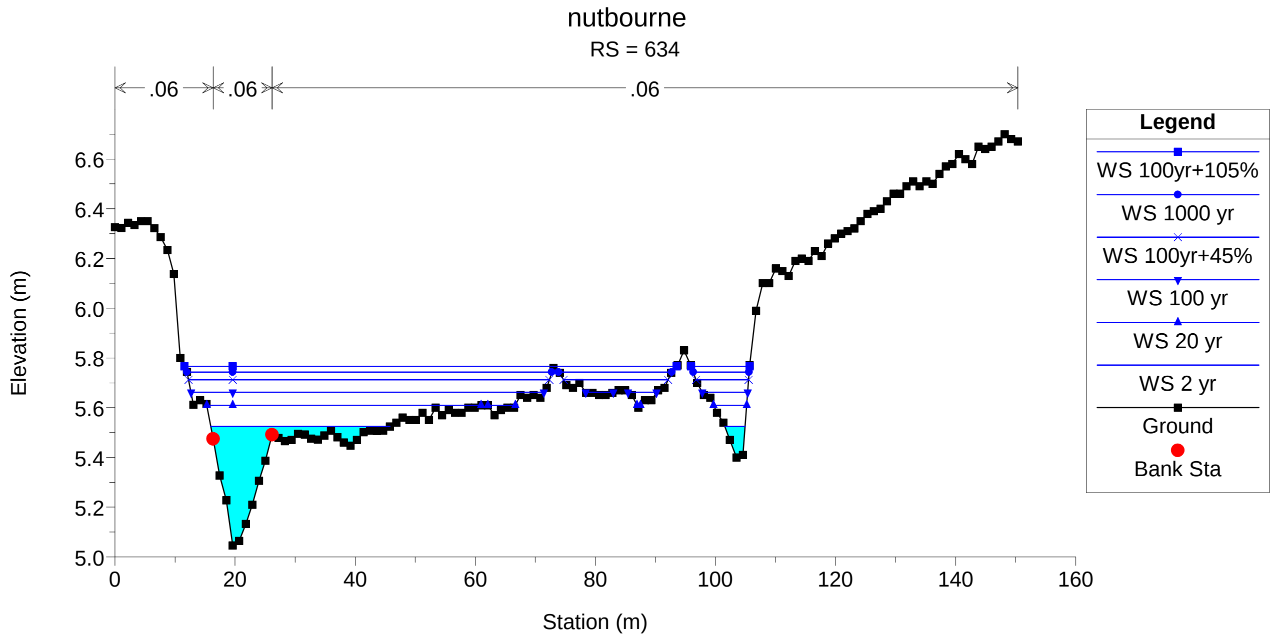

nutbourne
RS = 961 N Railway
.06
.06
.06
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

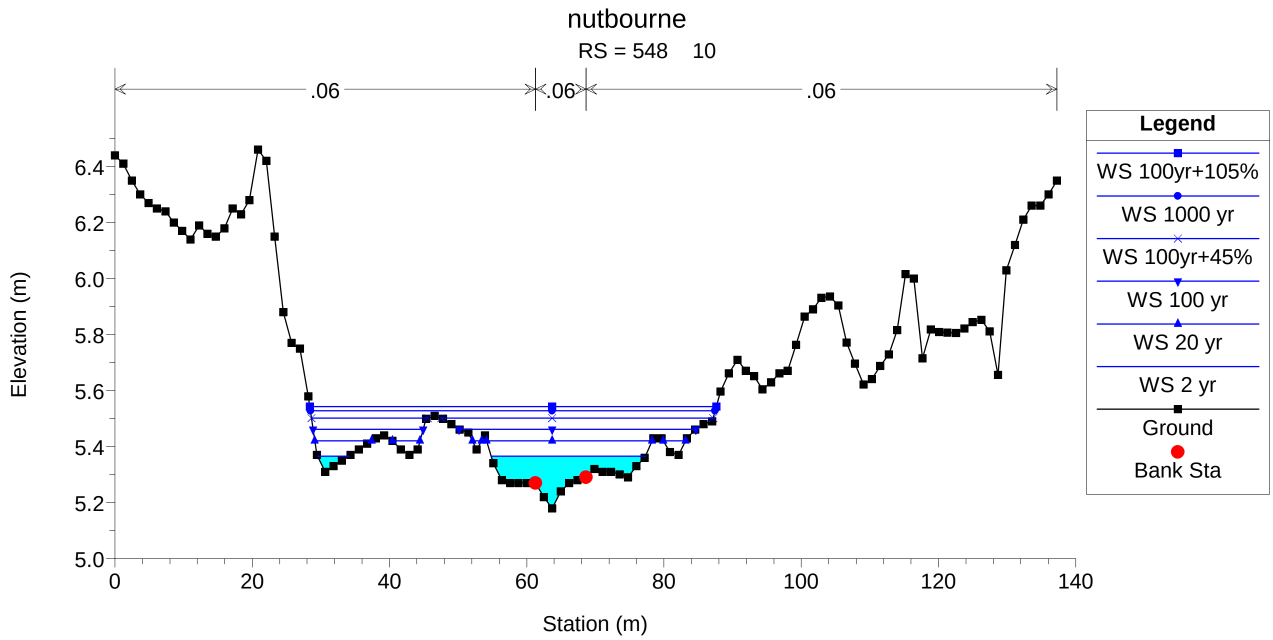

nutbourne
RS = 890 Culv Railway
.06
.06
.06
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
Ground
Bank Sta

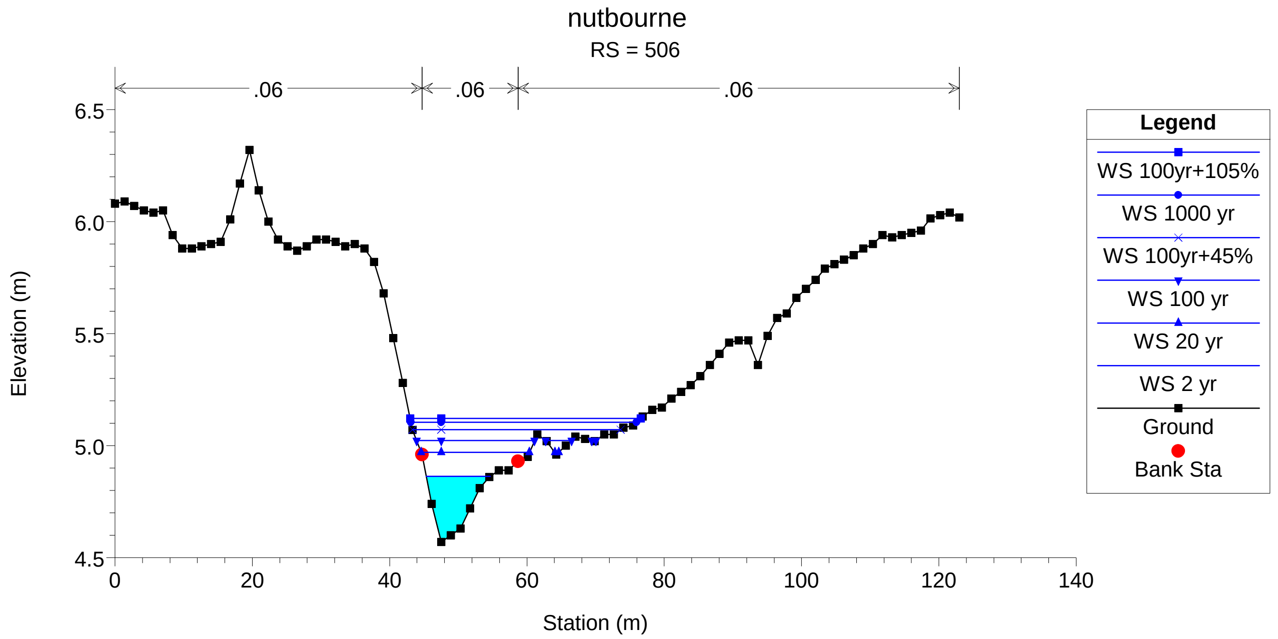

nutbourne
RS = 890 Culv Railway
.06
.06
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 2 yr
WS 20 yr
Ground
Bank Sta

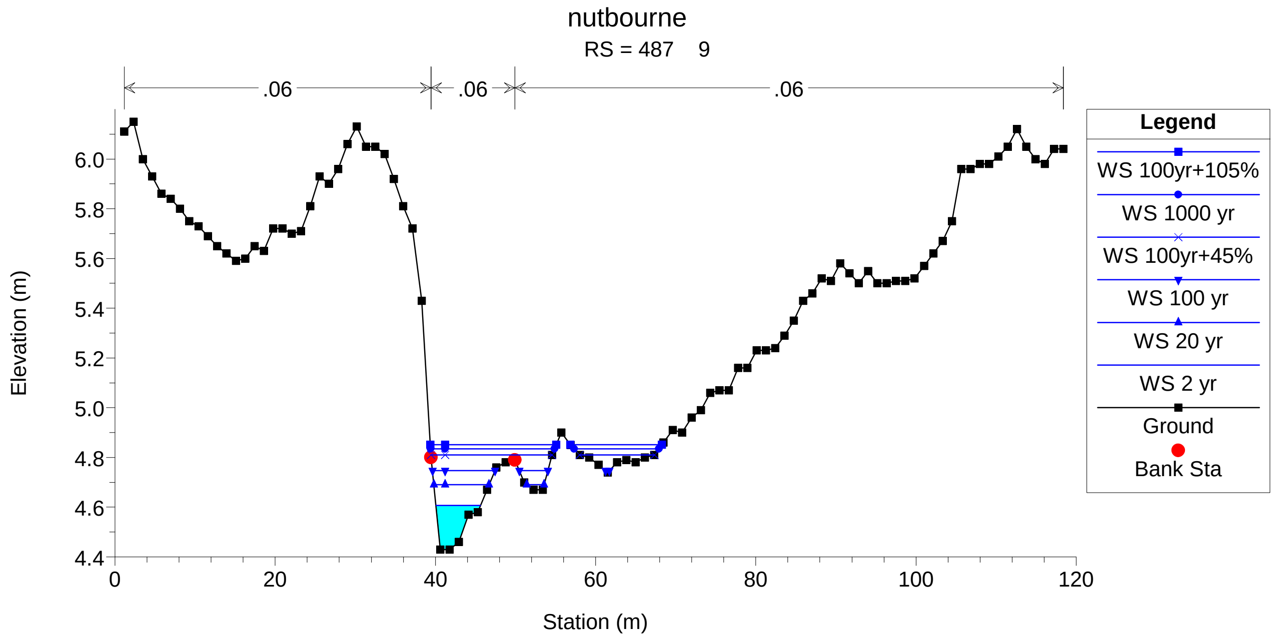

nutbourne
RS = 850 S Railway
.06
.06
.06
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
Elevation (m)
Station (m)
nutbourne
RS = 781 k
.06
.06
.06
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
Elevation (m)
Station (m)
nutbourne
RS = 720 12
.06
.06
.06
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
Elevation (m)
Station (m)

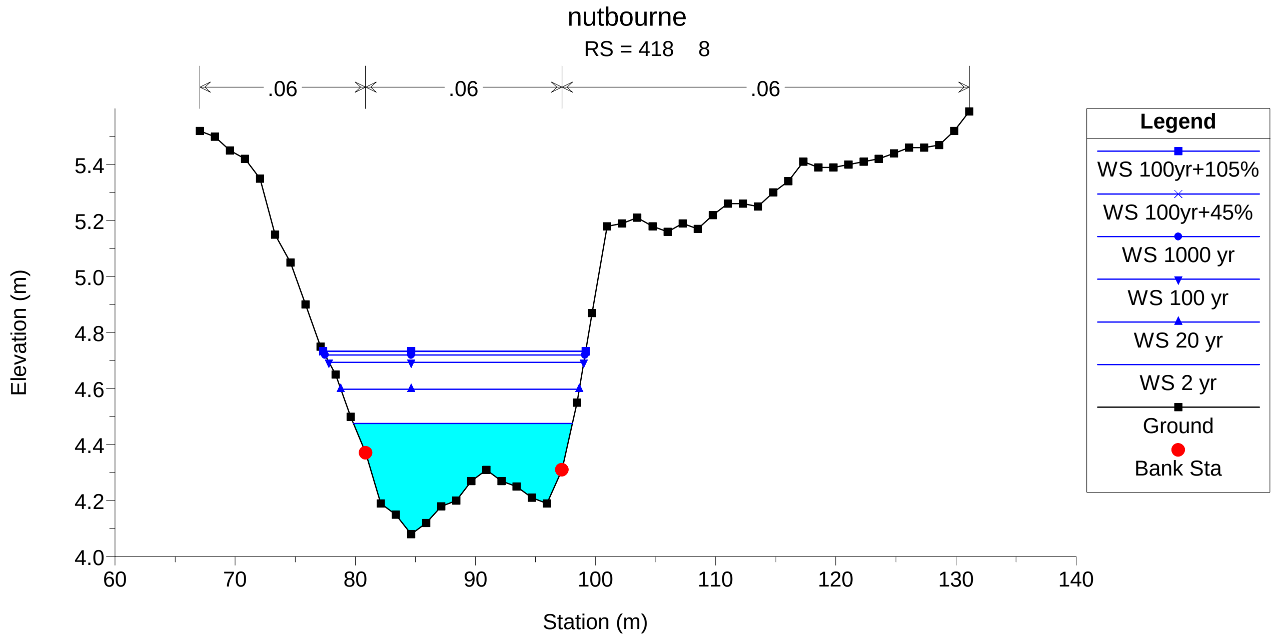

nutbourne
RS = 674 11
.06
.06
.06
7.0
6.5
6.0
5.5
5.0
4.5
Elevation (m)
0
20
40
60
80
100
120
140
160
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

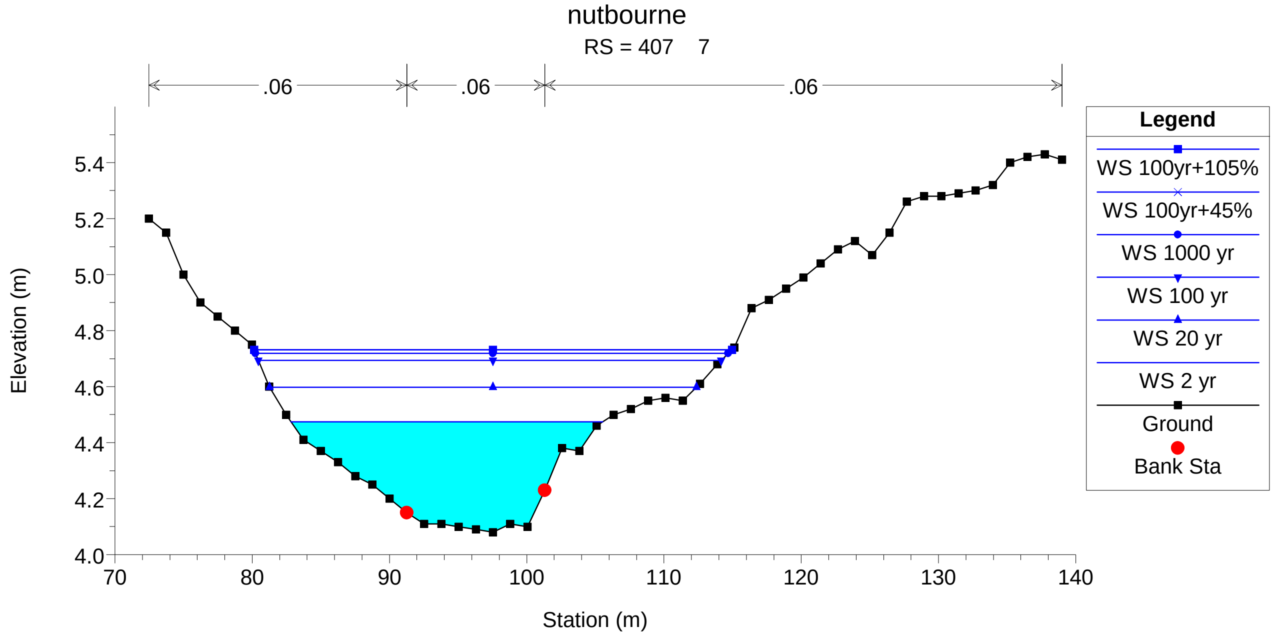

nutbourne
RS = 634
.06
.06
.06
6.6
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0
Elevation (m)
0
20
40
60
80
100
120
140
160
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta


nutbourne
RS = 548 10
.06
.06
.06
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0
Elevation (m)
0
20
40
60
80
100
120
140
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

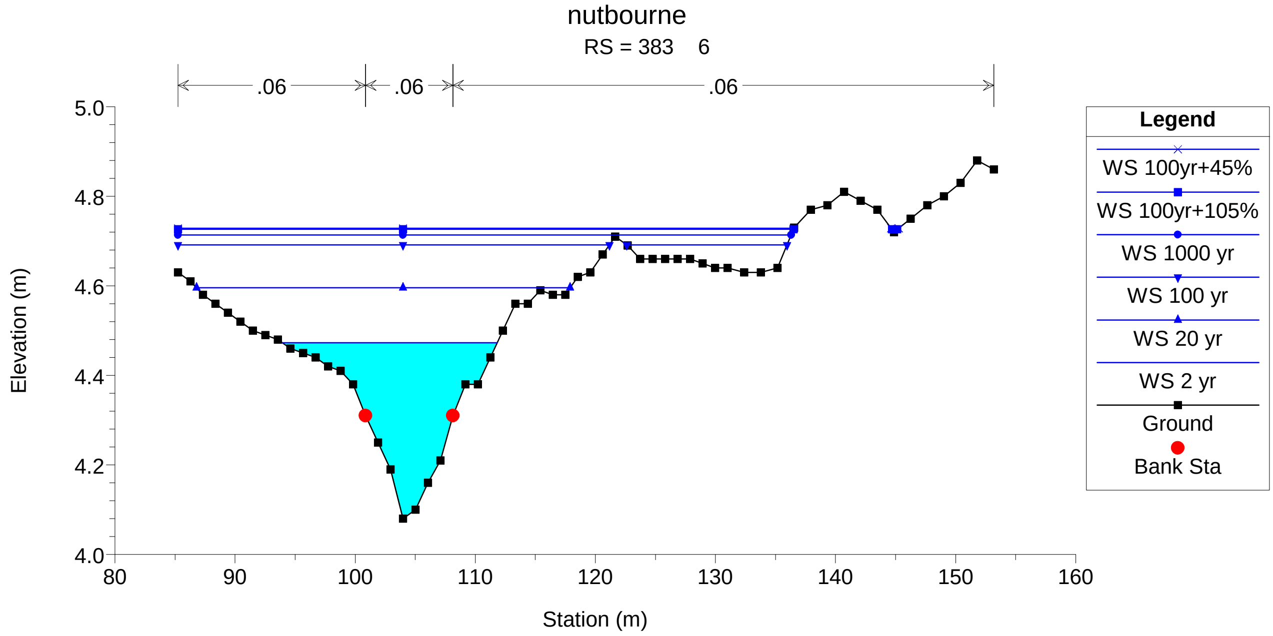

nutbourne
RS = 506
.06
.06
.06
6.5
6.0
5.5
5.0
4.5
0
20
40
60
80
100
120
140
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta


nutbourne
RS = 487 9
.06
.06
.06
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
0
20
40
60
80
100
120
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

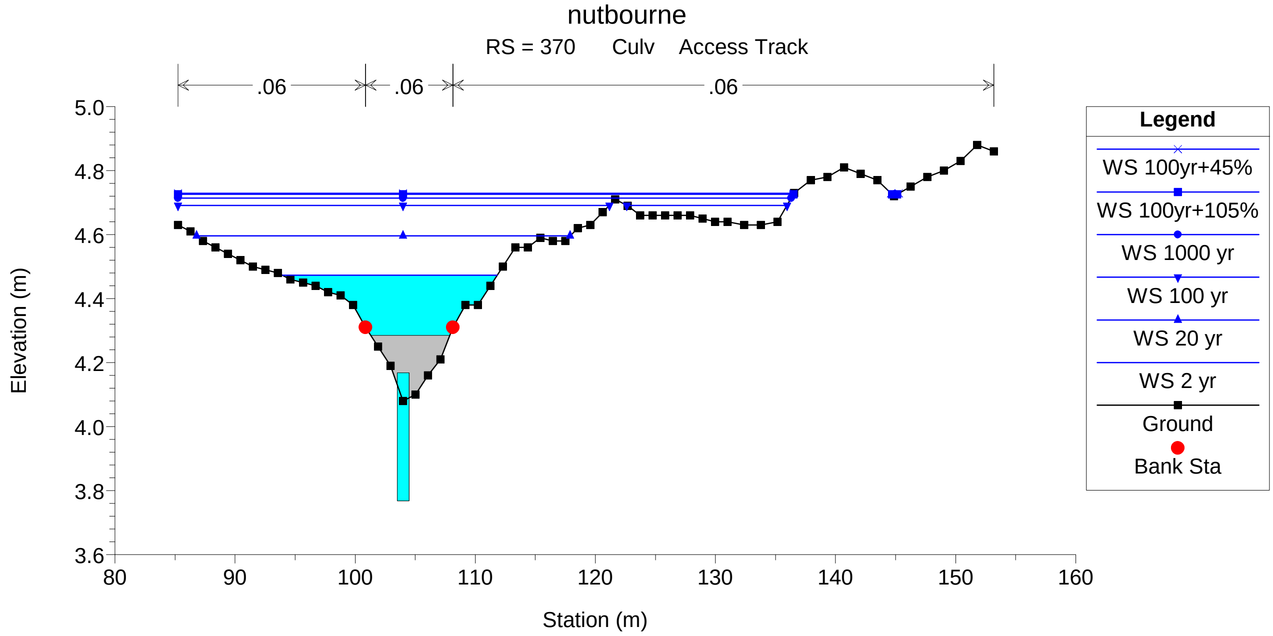

nutbourne
RS = 418 8
.06
.06
.06
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
60
70
80
90
100
110
120
130
140
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 100yr+45%
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta



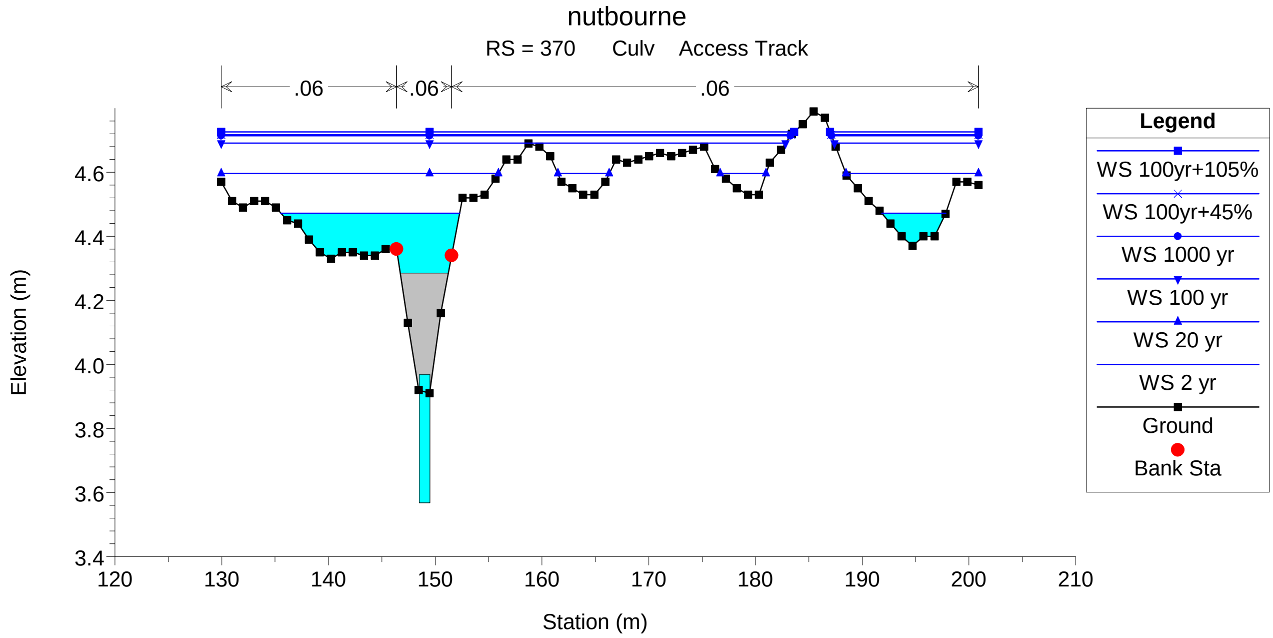
nutbourne
RS = 407 7
.06
.06
.06
Elevation (m)
Station (m)
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
70
80
90
100
110
120
130
140
Legend
WS 100yr+105%
WS 100yr+45%
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

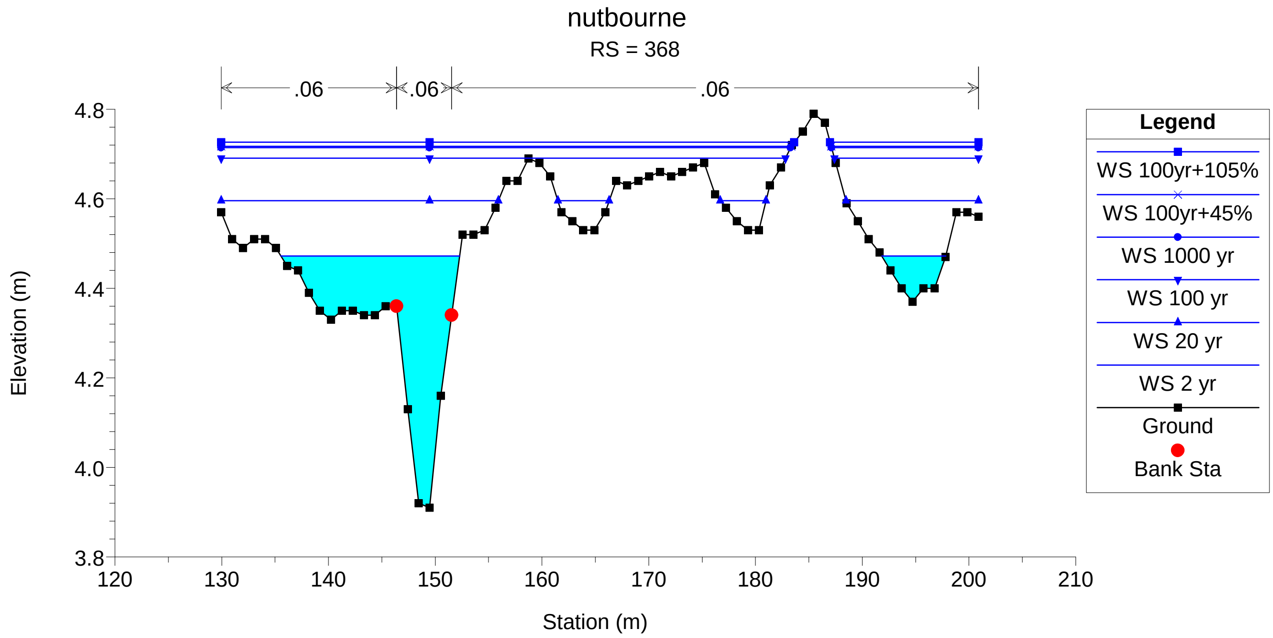


nutbourne
RS = 383 6
.06
.06
.06
Elevation (m)
Station (m)
5.0
4.8
4.6
4.4
4.2
4.0
80
90
100
110
120
130
140
150
160
Legend
WS 100yr+45%
WS 100yr+105%
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta



nutbourne
RS = 370 Culv Access Track
.06
.06
.06
Elevation (m)
Station (m)
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
80
90
100
110
120
130
140
150
160
Legend
WS 100yr+45%
WS 100yr+105%
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta


nutbourne
RS = 370 Culv Access Track
.06
.06
.06
Elevation (m)
Station (m)
Legend
WS 100yr+105%
WS 100yr+45%
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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Station (m)
Legend
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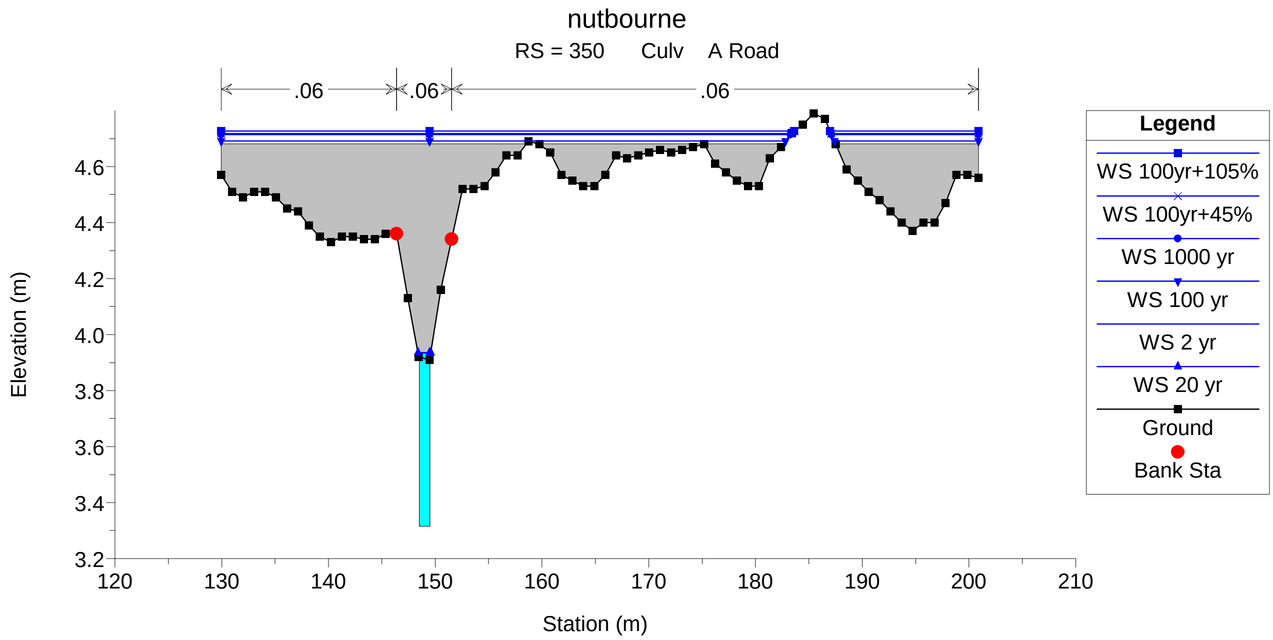
WS 1000 yr
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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Legend
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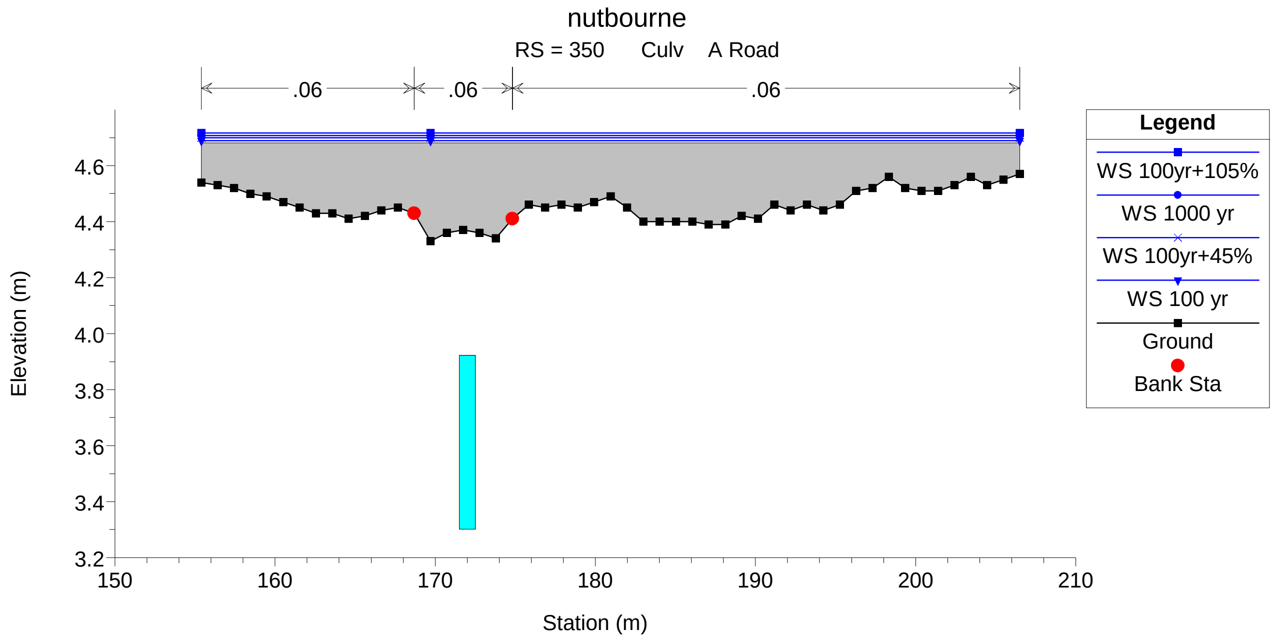
WS 100 yr
WS 2 yr
WS 20 yr
Ground
Bank Sta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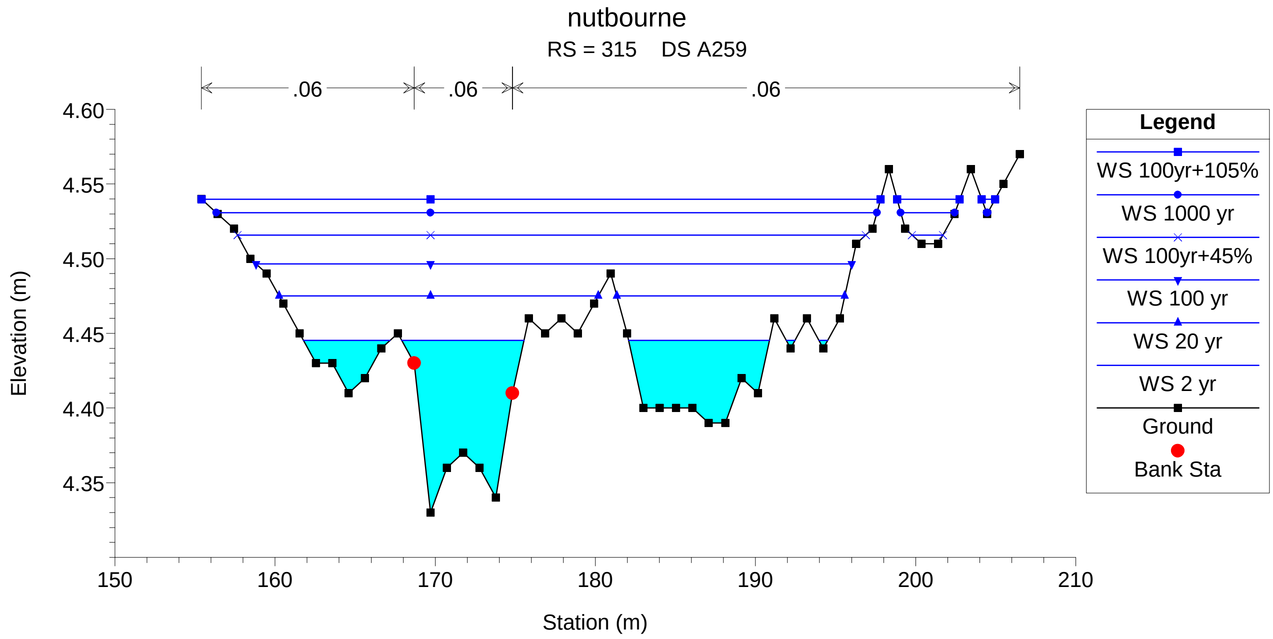
WS 100 yr
Ground
Bank Sta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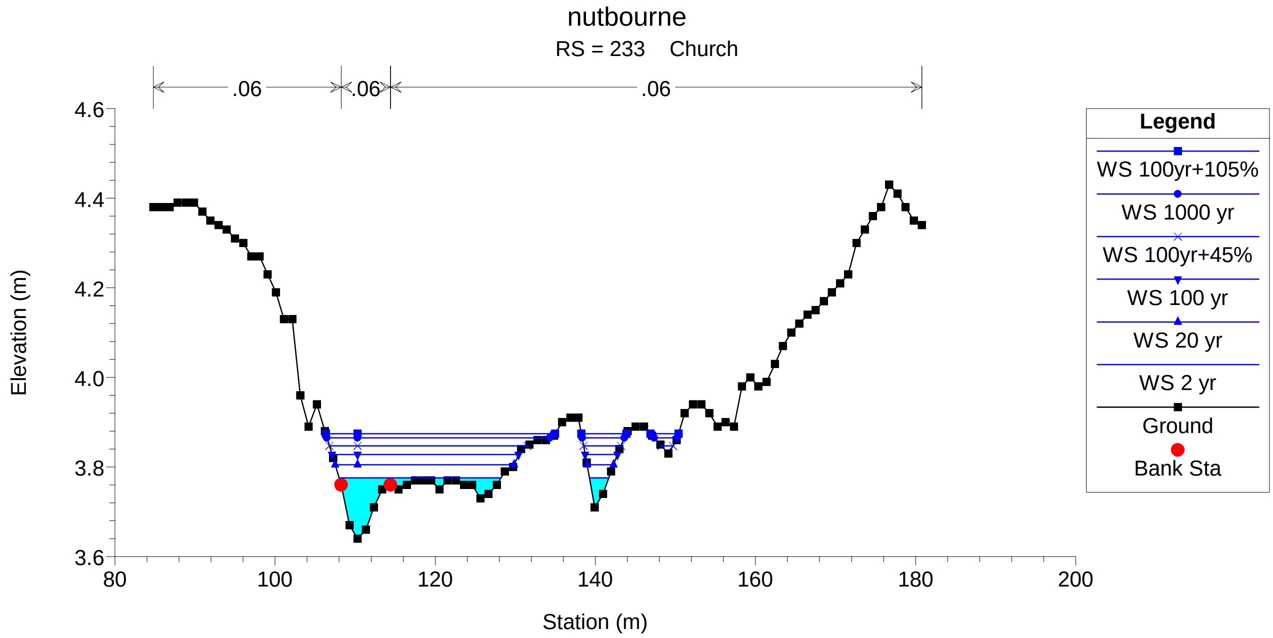
WS 20 yr
WS 2 yr
Ground
Bank Sta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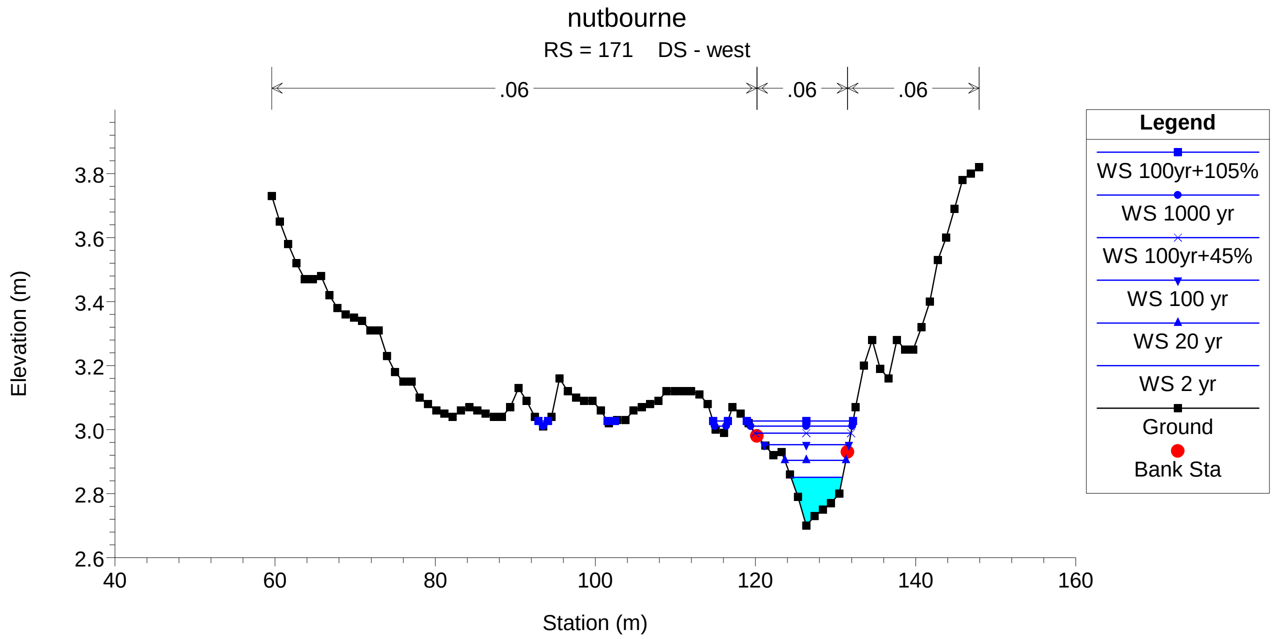
WS 2 yr
Ground
Bank Sta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120
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Legend
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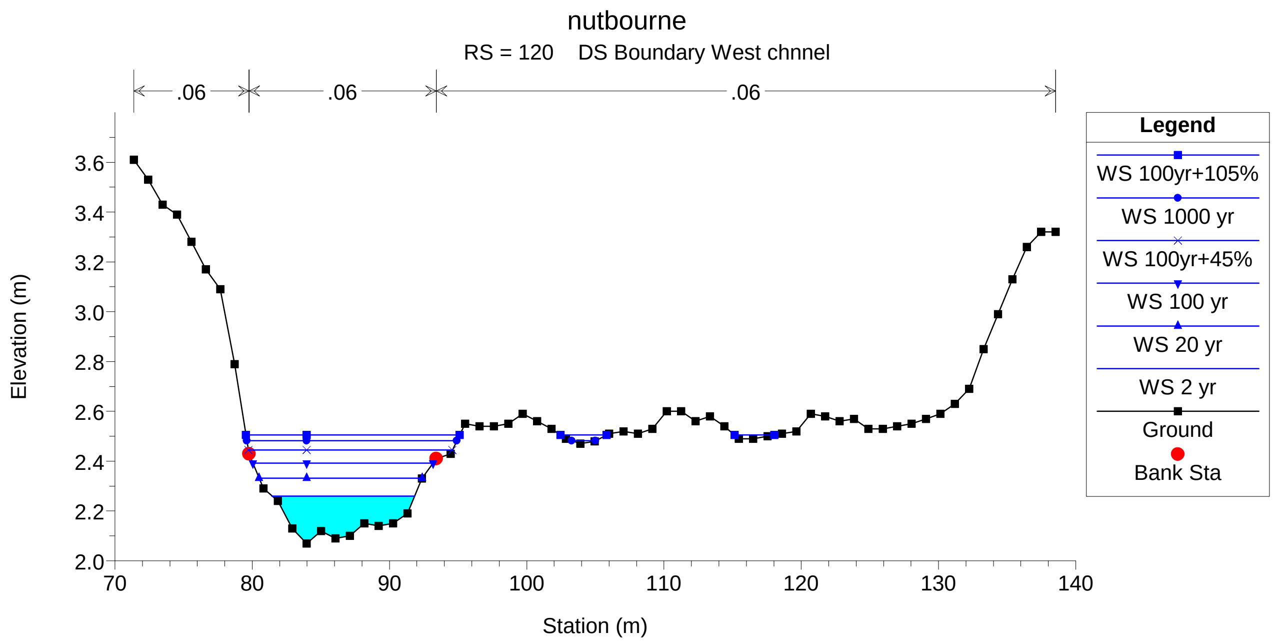
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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.06
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Station (m)
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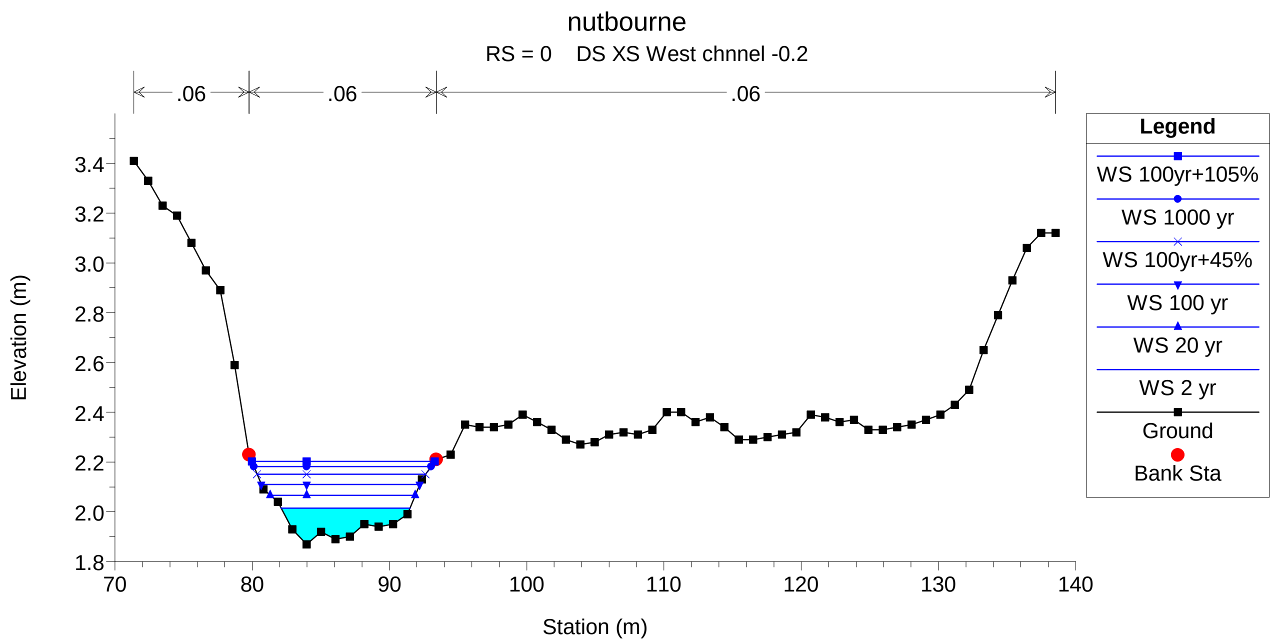
2.8
2.6
2.4
2.2
2.0
70
80
90
100
110
120
130
140
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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.06
.06
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Station (m)
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3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
70
80
90
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Legend
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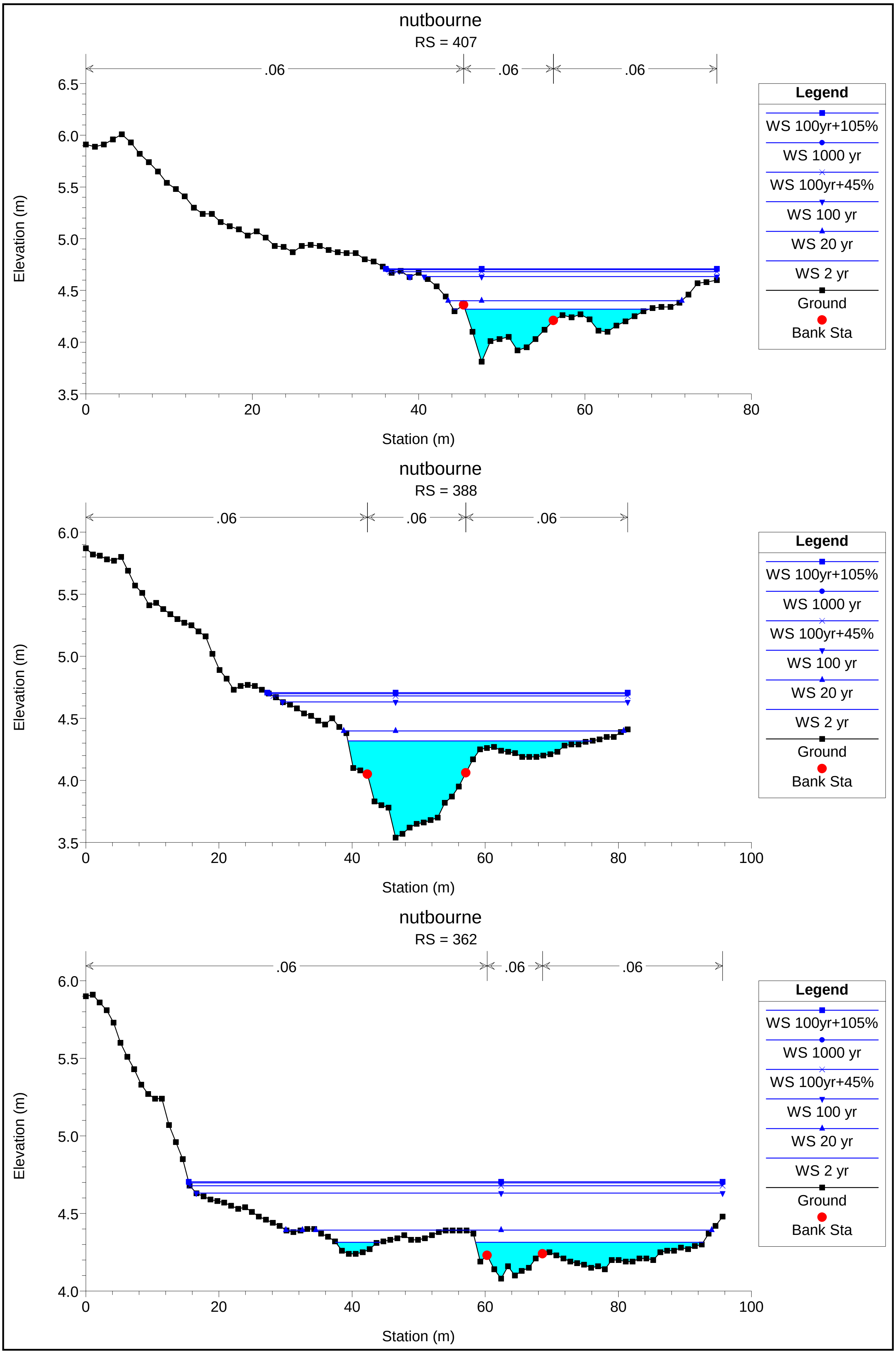
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
nutbourne
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.06
.06
Elevation (m)
Station (m)
Legend
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WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
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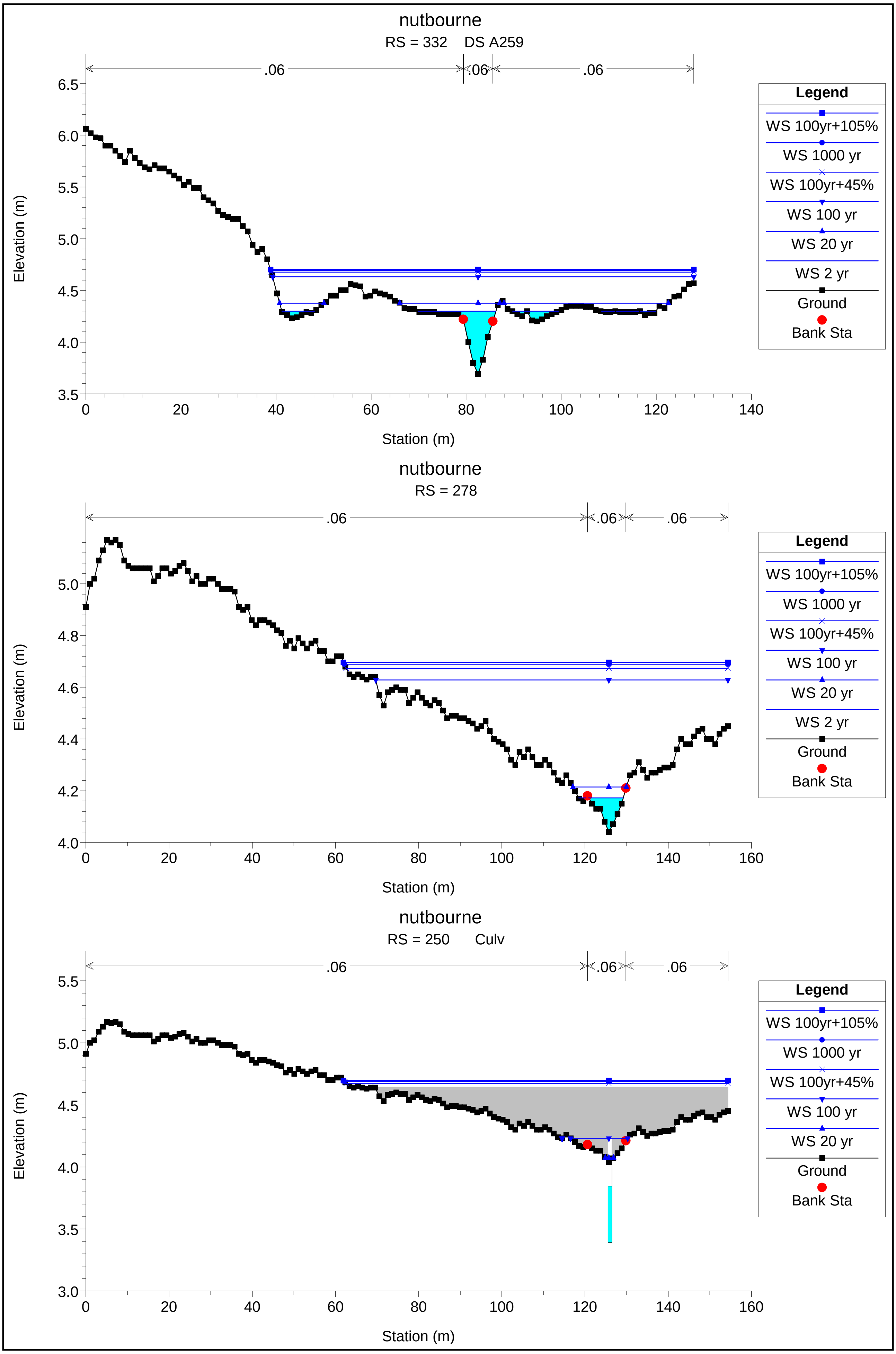
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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Station (m)
Legend
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WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
nutbourne
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Station (m)
Legend
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WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta
nutbourne
RS = 250 Culv
.06
.06
.06
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Station (m)
Legend
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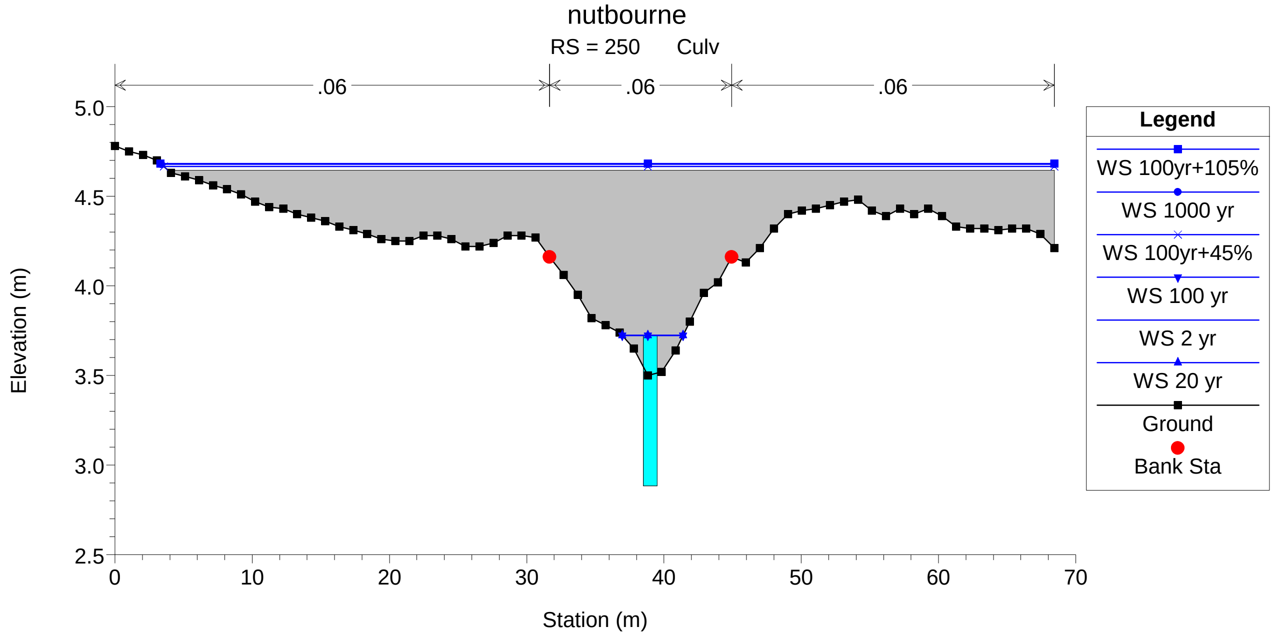
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
Ground
Bank Sta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20
30
40
50
60
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Station (m)
Legend
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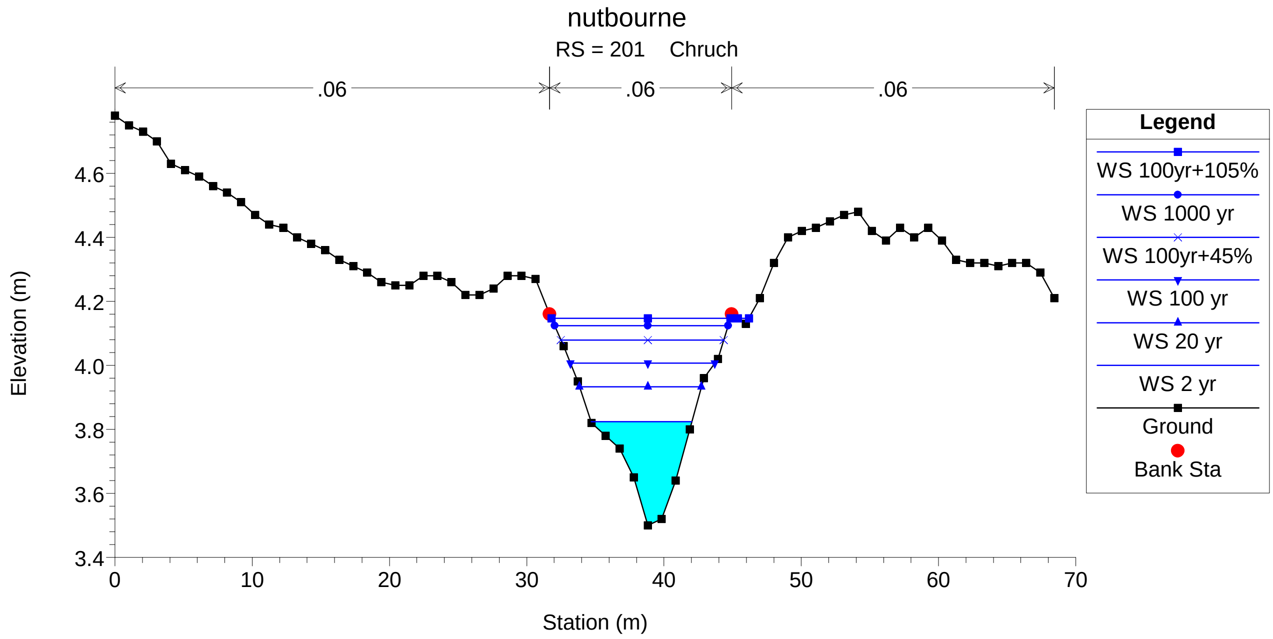
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 2 yr
WS 20 yr
Ground
Bank Sta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3.4
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10
20
30
40
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Station (m)
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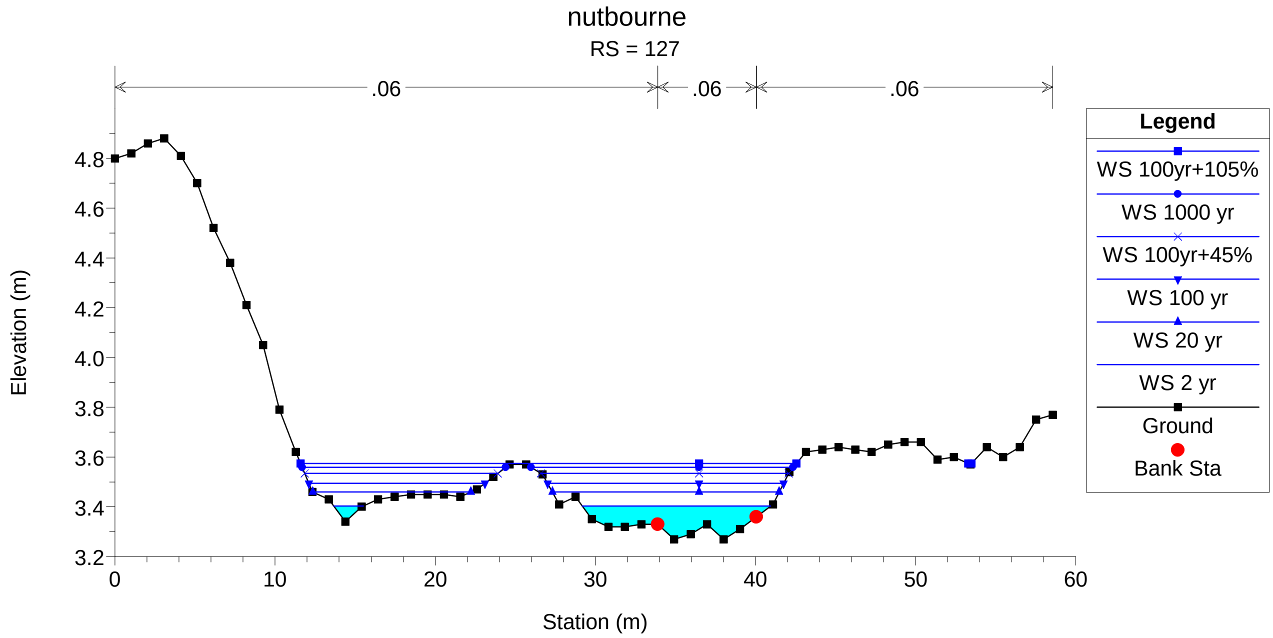
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta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Station (m)
Legend
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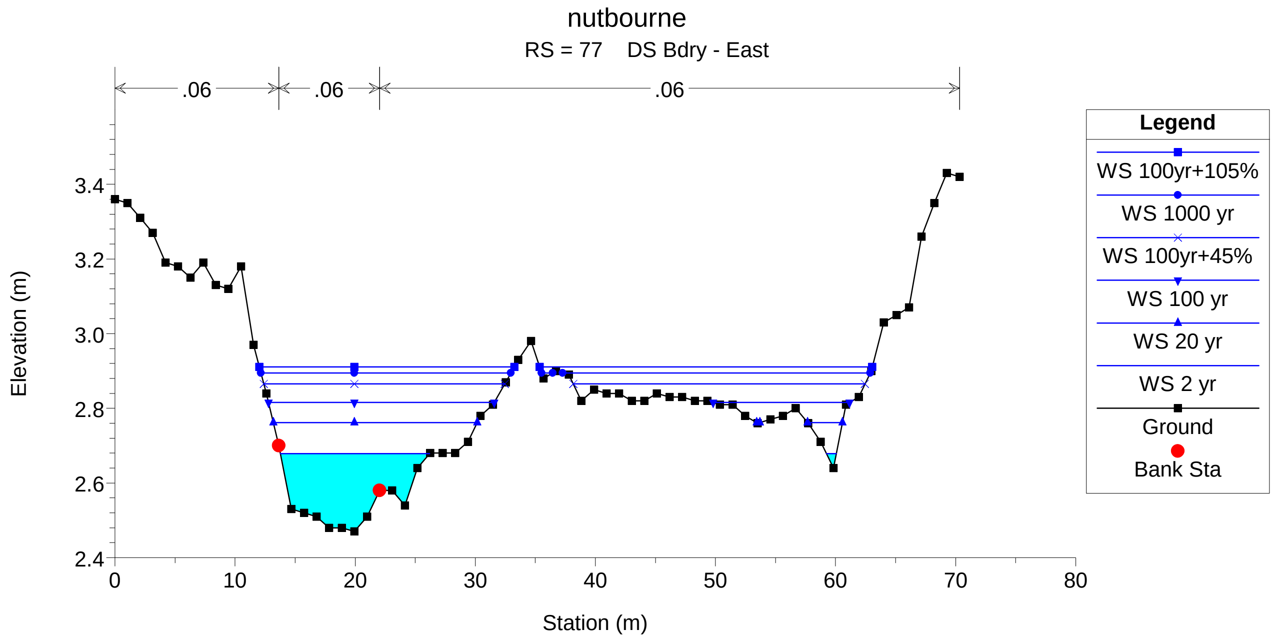
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta



nutbourne
RS = 77 DS Bdry - East
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.06
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Elevation (m)
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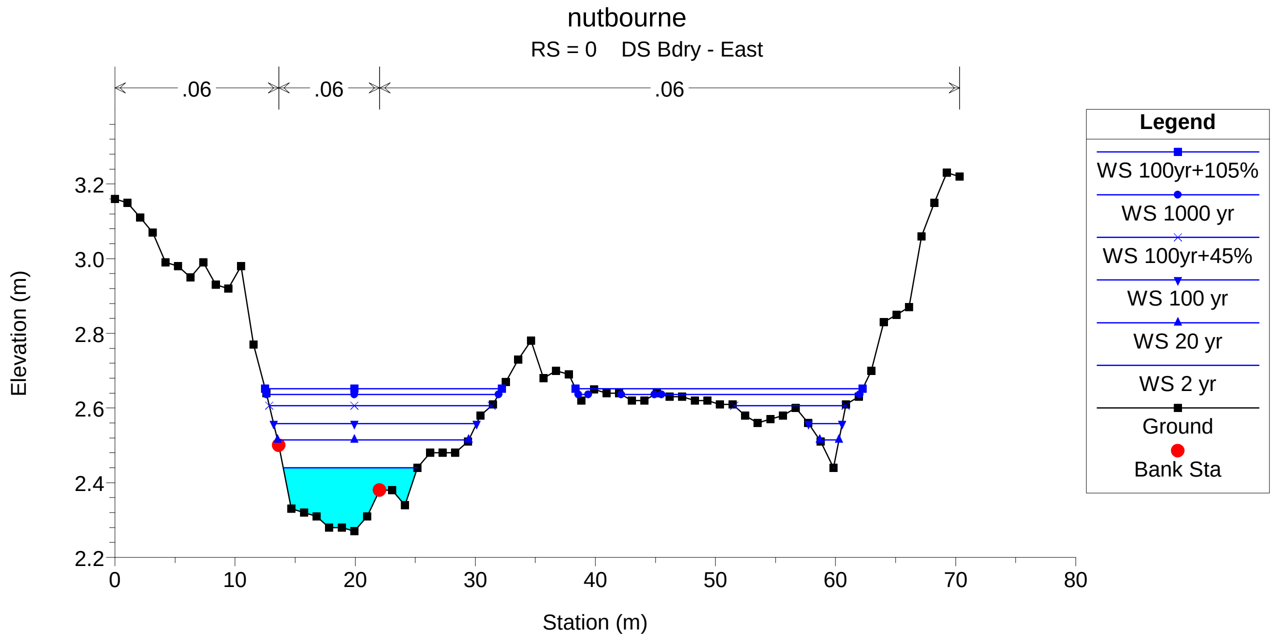
2.6
2.4
0
10
20
30
40
50
60
70
80
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta



nutbourne
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.06
.06
Elevation (m)
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3.0
2.8
2.6
2.4
2.2
0
10
20
30
40
50
60
70
80
Station (m)
Legend
WS 100yr+105%
WS 1000 yr
WS 100yr+45%
WS 100 yr
WS 20 yr
WS 2 yr
Ground
Bank Sta

Appendix D - Watercourse Description- HAM BROOK AT NUTBOURNE, WEST SUSSEX

Ham Brook at Nutbourne, West Sussex

Contents

1 INTRODUCTION

1.1 Objectives

As part of a flood modelling study for Ham Brook the EA has requested a technical overview of the watercourse to provide a background for the model and that this is provided as this Appendix to the Main Report. As requested this includes a description of the watercourse divided into representative reaches along with photographs of the channel and flood plain, identification of Manning's values; the inclusion of all relevant structures and details the risk of blockage of key structures and likely bypass routes.

1.2 Site Visit and Surveys

A site visit and survey of the study reach was undertaken on 19th May 2016 and again on 15th September 2017 with the reaches walked from upstream to downstream noting features of interest throughout. This included indicators of channel stability, barriers to flow such as weirs and culverts and a photographic record of key features.

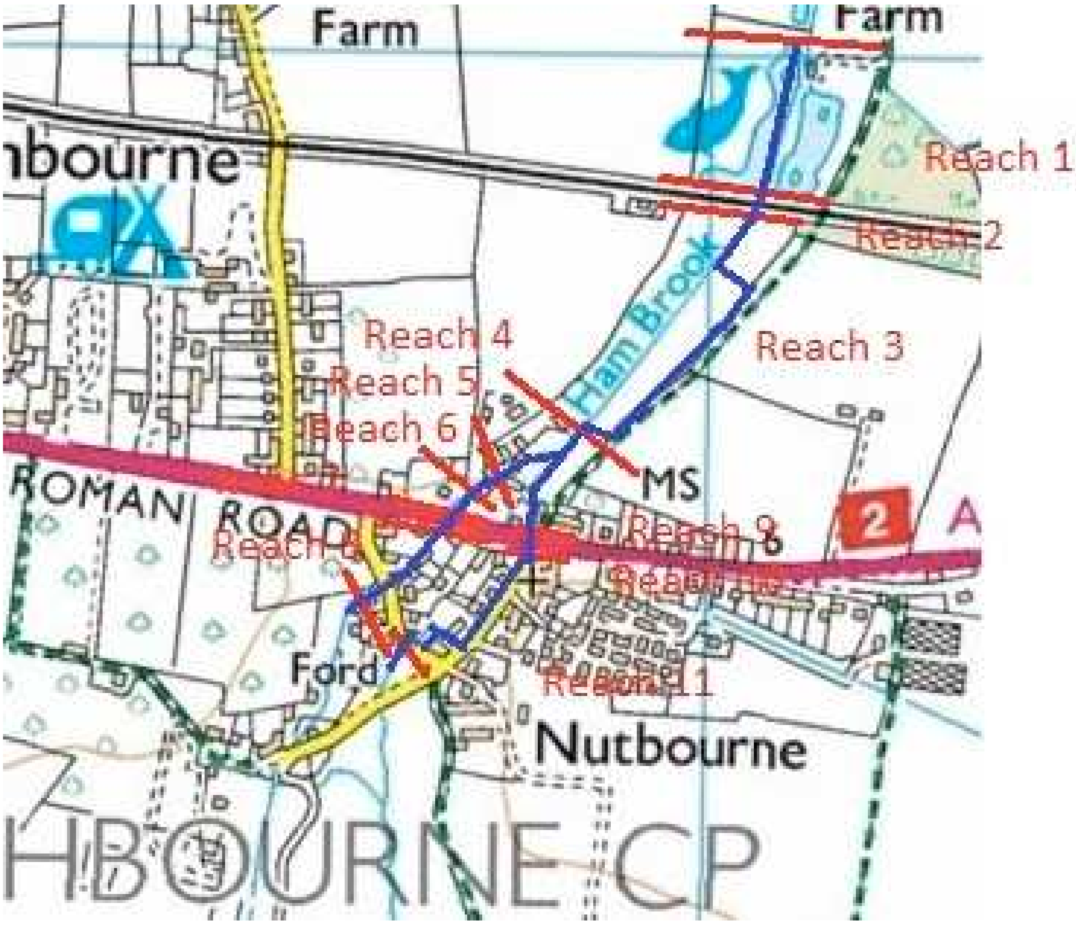
1.3 Reach Identification

Ham Brook is typically about 2m wide and shallow (generally <50cm deep) with a substrate of silt and vegetation. It flows north to south and the description and inspection of the channel morphology starts at the upstream end at Ham Brook fishing lake and continues downstream to the ford the downstream end of the village. On the basis of common features the watercourse has been sub-divided into 11 representative reaches (Figure 1.1) from the upstream to the downstream end of the study reach, with one culvert under the railway line, two under the A259 and one under the site access road (Table 1.1). The channel divides in the cottage garden into an east and west channel of which the east channel takes the larger proportion of flow.

Table 1.1 Watercourse Reaches

Reach No	Channel	Reach	Length (m)	Description
1	Main	Upstream of Railway Culvert	125	Fishing lake upstream of railway line
2	Main	Railway Culvert	20	Culvert
3	Main	Downstream Railway Culvert	392	Adjacent to Breakers Yard
4	Main	Cottage and Gardens	65	Private Gardens
5	West	Cottage to Site Entrance	24	Small channel with culvert
6	West	Site Entrance to A259	32	Adjacent to Site Entrance
7	West	A259 Road Crossing	21	Culvert
8	West	Downstream of A259	91	To the downstream of School Lane
9	East	Cottage to A259	48	Alongside Caravan Sales
10	East	A259 Road Crossing	35	Culvert
11	East	Downstream of A259	210	To the Ford downstream of village

Figure 1.1 – Watercourse Location and Reach Definition



2 REACH DESCRIPTION

The key issues and a description of each reach and relevant structures as noted during the walkover are detailed below.

2.1 Upstream of Flow Split

2.1.1 Reach 1 – Upstream of Railway Line

Reach 1 runs from the north end of the fishing lake (Photo 1.1) to the railway culvert 125m downstream.

Photo 1.1 Ham Brook Lake	
Reach:	1
Description:	Fishing Lake upstream of railway line occupying flooded river valley
Mannings	0.035 to 0.06
	

The lake overflow is a 2.25m weir under a footbridge (Photo 1.2) with a further series of drops to the entrance of the culvert below the railway line. The topographical survey (Figure 2.1) shows:

- Weir crest =6.758m OD
- Weir Width = 2.25m OD
- Base of Weir = 5.639m OD

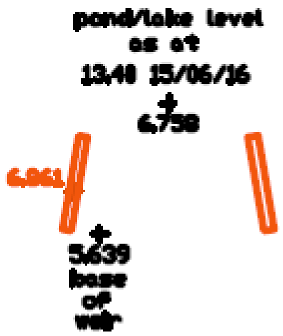
Figure 2.1 Topo Suvey of Lake Overflow Weir


Photo 1.2 Lake overflow at Weir	
Reach:	1
Description:	Fishing Lake overflow weir upstream of railway culvert
Mannings	0.03
	

The lake is tree lined with a short grassed area alongside on the left and right flood plains to allow access by fishermen (Photo 1.3).

Photo 1.3 Ham Brook Flood Plain	
Reach:	1
Description:	Grassed Flood Plain on east bank of tree lined Fishing Lake
Mannings	0.060

2.1.2 Reach 2 – Railway Culvert

A few metres downstream of the lake overflow weir the brook flows through the railway culvert below the railway line but the upstream entrance to this culvert is obscured by dense vegetation and is not visible or accessible. Only the downstream end of the culvert is visible (Photo 2.1).

Photo 2.1 Railway Culvert Downstream	
Reach:	Railway Culvert
Description:	Exit of Railway culvert
Mannings	0.025
	

The approach to the culvert exit is also excessively overgrown with vegetation (Photo 2.1 and 2.2) making access very difficult.

Photo 2.2 Railway Culvert Downstream	
Reach:	2
Description:	Railway culvert Exit
Mannings	0.025
	

This is a 20m long 900mm masonry lined culvert with masonry head walls (Photo 2.3).

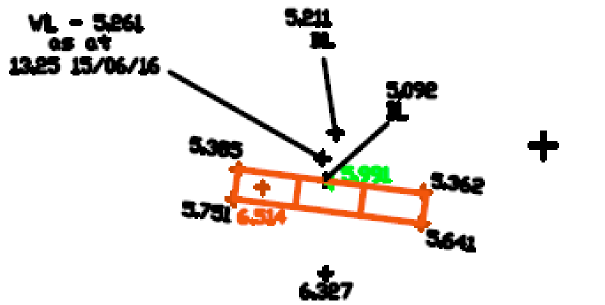
Photo 2.3 Railway Culvert Exit	
Reach:	2
Description:	Railway culvert exit
Mannings	0.025
	

The topographical survey (Figure 2.2) provides the culvert dimensions:

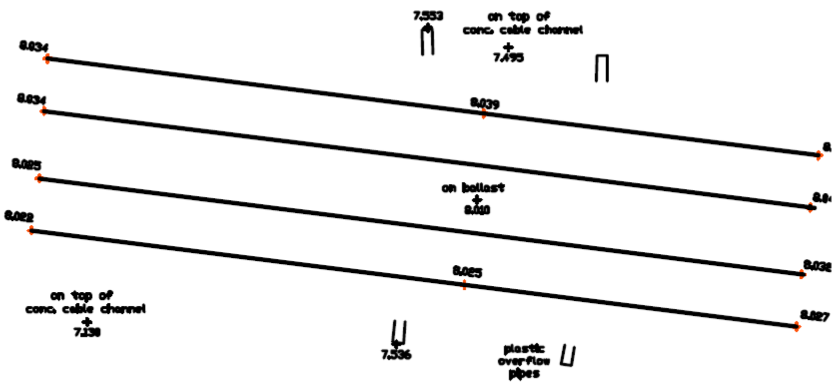
Item	Topo	HECRAS
US Invert Level (m OD)	5.092	5.092
US Soffit (m OD)	5.994	
Diameter (mm)	900	900
Top of Head Wall (m OD)	6.514	
Crest of railway line (m OD)	8.034	8.034
DS Invert level (m OD)	4.954	4.954
DS Soffit (m OD)	5.839	
Diameter (mm)	900	900
Top of Head wall (m OD)	6.336	
Length (m)	20	20
Mannings		0.025

Figure 2.2 Topo Survey of Railway Culvert

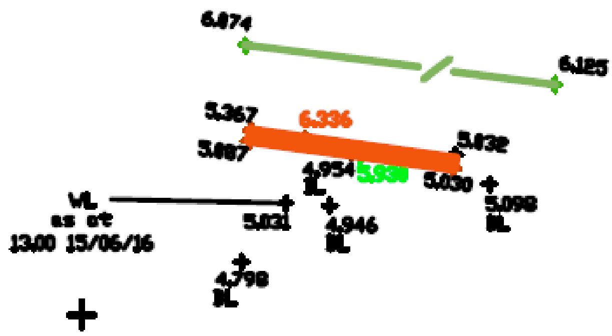
Upstream



Track



Downstream



The plastic overflow pipes on the survey and photographs (Photo 2.1) are more likely to be track drainage and if these were overflow pipe as suggested on the survey they would only operate if water levels upstream were to reach 7.772m OD or 2.5m above the culvert invert level which seems unlikely. Compared to the main culvert these are small diameter and at too high a level to have any impact during a major flood.

2.1.3 Reach 3 – Alongside Breakers Yard

Downstream of the culvert outfall from the railway line the watercourse runs alongside the east boundary of the Breakers Yard as far as the cottage to the south over 392m (Figure 1.1). Throughout this section Ham Brook is densely covered by brambles, shrubs and trees (Photos 3.1, 3.2 and 3.3) where access to the channel and flood plain is limited or not possible. It was not possible for the surveyor to access this river channel in this area. The alignment of the channel suggests it may have been artificially straightened and OS maps (Figure 1.1) that it has possibly been re-routed from its original course further to the east.

Photo 3.1 Alongside Breakers Yard	
Reach:	3
Description:	Bramble covered flood plain and watercourse downstream of railway culvert
Mannings	0.10
	

Photo 3.2 Overgrown River Channel Alongside Breakers Yard	
Reach:	3
Description:	Bramble and tree lined watercourse downstream of railway culvert
Mannings	0.10

Photo 3.3 Overgrown Flood Plain Alongside Breakers Yard	
Reach:	3
Description:	Bramble and tree lined flood plain downstream of railway culvert
Mannings	0.10
	

2.1.4 Reach 4 – Cottage and Garden

The channel emerges through the dense undergrowth upstream of the cottage and passes for 65m through a grassed garden area with scattered shrubs and small trees (Photo 4.1).

Photo 4.1 Cottage and Gardens	
Reach:	4
Description:	Cottage and Garden
Mannings	0.060
	

The watercourse divides in this garden at an informal sluice structure (Photo 4.2) into two channels downstream referred to as east and west.

Photo 4.2 Division of Watercourse in Cottage Garden	
Reach:	4
Description:	Informal Sluice in Cottage Garden which splits channel downstream
Mannings	0.060
	

The west channel is 0.5m wide and 0.5m deep (Photo 4.3) with the sides supported by corrugated sheets towards the downstream end. This flows cross the middle of the garden and toward the entrance gate near the main access road to the breakers yard (Photo 4.4).

Photo4.3 West Channel in Cottage Garden	
Reach:	4
Description:	West Channel in Cottage and Garden
Mannings	0.045
	

Photo 4.4 West Channel in Cottage Garden	
Reach:	4
Description:	West Channel in Cottage and Garden
Mannings	0.045

The larger east channel is around 2.2m wide and 0.7m to 1.0m deep (Photos 4.5 and 4.6) and the east bank flood plain is covered by dense vegetation where the ground level appears to have been raised.

Photo 4.5 East Channel in Cottage Garden	
Reach:	4
Description:	East Channel in Cottage Garden
Mannings	Channel = 0.04, Right bank = 0.035, Left Bank = 0.15
	

Photo 4.6 East Channel in Cottage Garden	
Reach:	4

Description:	East Channel in Cottage Garden
Mannings	Channel = 0.04, Left bank = 0.035, Right Bank = 0.15
	

2.2 West Channel Downstream of Flow Split

2.2.1 Reach 5 - DS Cottage to Culvert at site entrance

Concrete channel between the cottage garden and the upstream end of culvert below site entrance access road (Photo 5.1) over 24m. The channel is overgrown.

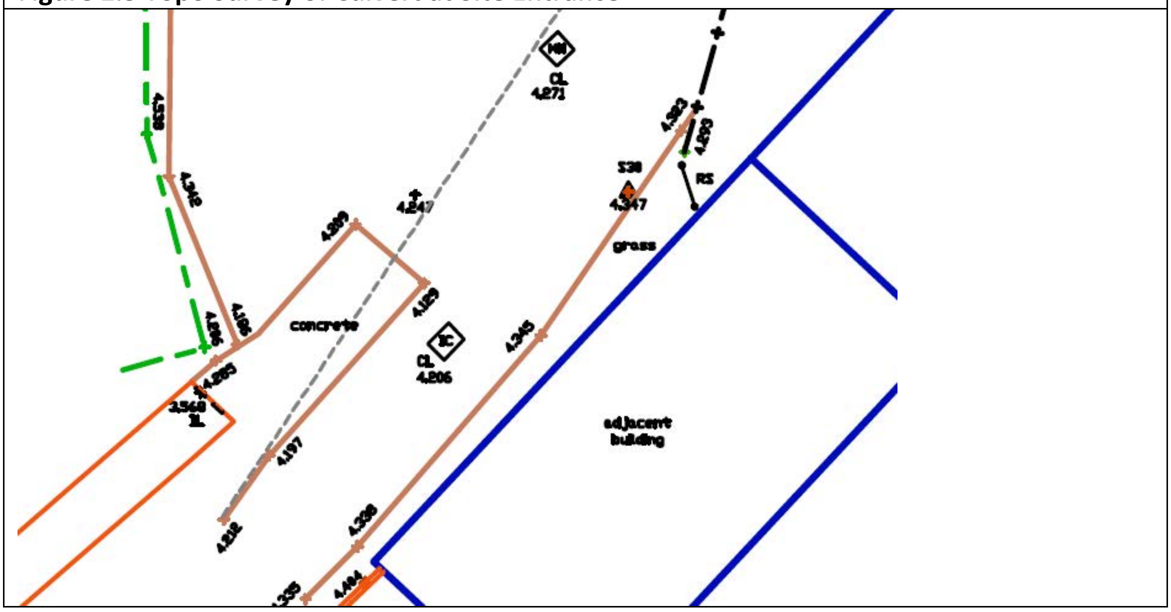
Photo 5.1 West Channel Downstream of Cottage	
Reach:	5
Description:	Concrete channel at the upstream end of culvert below site entrance access road, A259 in distance. Channel overgrown
Mannings	0.08
	

The exit of culvert (Photo 5.2) is also overgrown.

Photo 5.2 West Channel Downstream of Cottage	
Reach:	5
Description:	Concrete channel at downstream end of culvert below site entrance
Mannings	0.035
	

This is a box culvert which was included in the HECRAS model as part of the A259 culvert as it was not fully surveyed (Figure 2.3).

Figure 2.3 Topo Survey of Culvert at Site Entrance



Item	Topo	HECRAS
Width		1.0
Height		0.4
US invert		3.768
US soffit		
DS Invert	3.568	
DS Bridge deck	4.285	
Deck Level	4.247	
Culvert length		

2.2.2 Reach 6 - Site Entrance to A259

From the south end of the site entrance culvert the watercourse flows in small channel with concrete side walls for 32m along the west side of the entrance (Photos 6.1 and 6.2) and enters the culvert under the A25 (Reach 7).

Photo 6.1 West Channel Downstream of Cottage	
Reach:	6
Description:	Concrete Channel between Site Entrance and A259
Mannings	0.06
	

Photo 6.2 West Channel Downstream of Site Entrance	
Reach:	6
Description:	Concrete Channel between Site Entrance and A259
Mannings	0.060

2.2.3 Reach 7 – A259 Road Crossing

The watercourse then flows under the A259 in a 20m long box culvert (Photo 7.1) emerging to the south in a private garden (Photo 7.2).

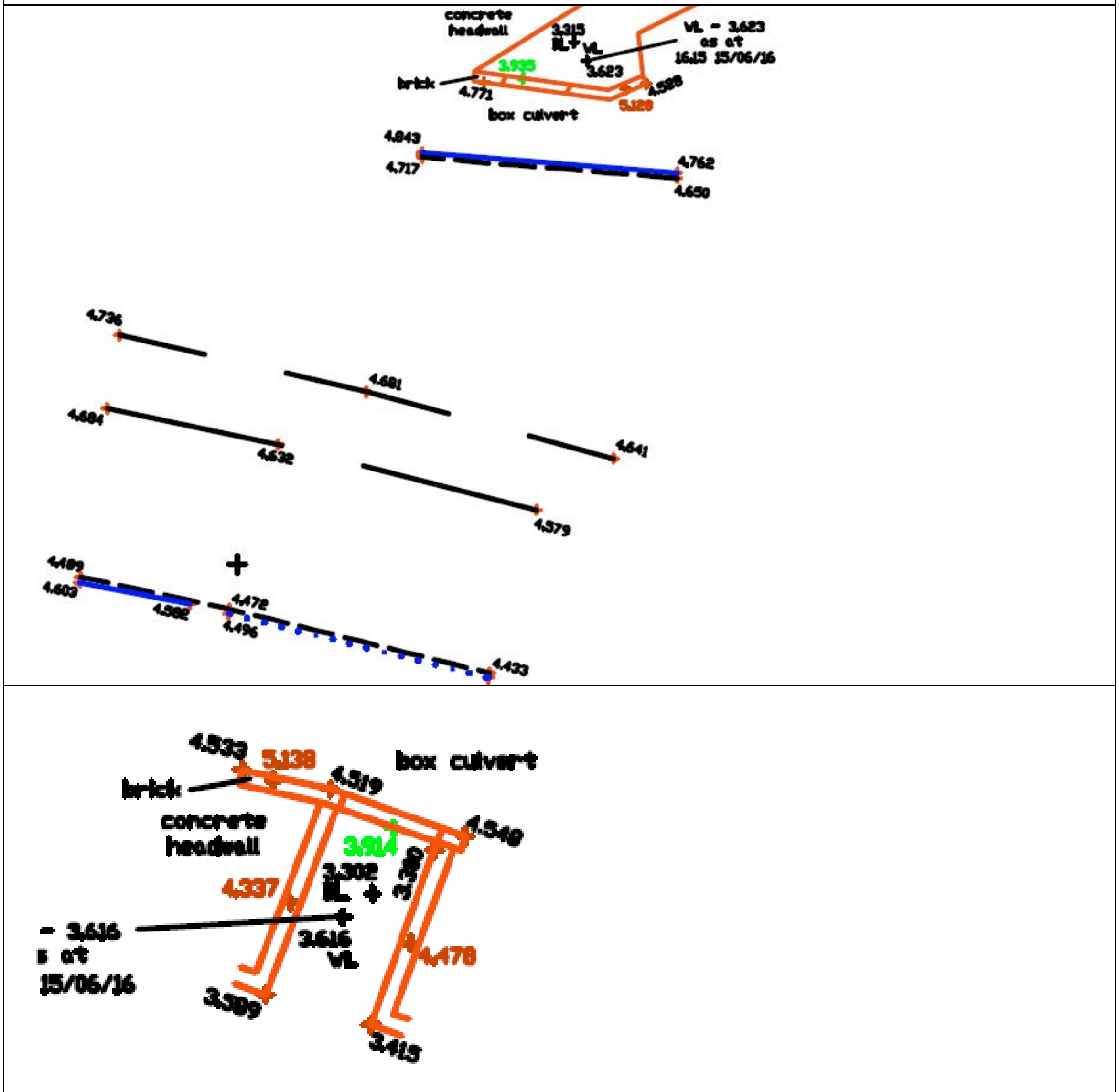
Photo 7.1 Upstream of A259 Culvert	
Reach:	7
Description:	Entrance to culvert under A259 – west channel
Mannings	0.060
	

Photo 7.2 Downstream of 259 Culvert	
Reach:	7
Description:	Channel downstream of A259 culvert – west channel
Mannings	0.060
	

The box culvert dimensions are:

Item	Topo	HECRAS
US Invert (m OD)	3.315	3.315
US Soffitt (m OD)	3.935	
Width (m)		1.0
Height (m)		0.62
US Headwall (m OD)	4.771	
A259 road level (m OD)	4.681	
Culvert Length (m)		20
DS Invert Level (m OD)	3.302	3.302
DS Soffit Level (m OD)	3.914	
DS Headwall (m OD)	4.519	
Mannings		0.03

Figure 2.4 Topo Survey of A259 Crossing (west)



2.2.4 Reach 8 – Village Downstream of A259

Downstream of the A259 the watercourse runs in a concrete channel (Photo 8.1) between the gardens of domestic properties (Photo 8.2) emerging in School Lane 91m to the south east

Photo 8.1 Downstream of A259	
Reach:	8
Description:	Concrete channel downstream of A259
Mannings	0.06

Photo 8.2 Channel in Village	
Reach:	8
Description:	Channel between gardens through the village
Mannings	0.045
	

2.3 East Channel Downstream of Flow Split

2.3.1 Reach 9 - Cottage to A259

The channel splits in the cottage garden and this allows the majority of flow to pass down the east channel. Beyond the cottage garden the channel runs for 48m to a second crossing under the A259 alongside the caravan sales site. There a sluice on the left bank (Figure 2.5), referred to by the EA, which prevents water from entering a short ox bow lake on the left bank but serves no purpose for the control of flow in the main channel (Photo 9.1).

Figure 2.5 Topo Survey of Sluice

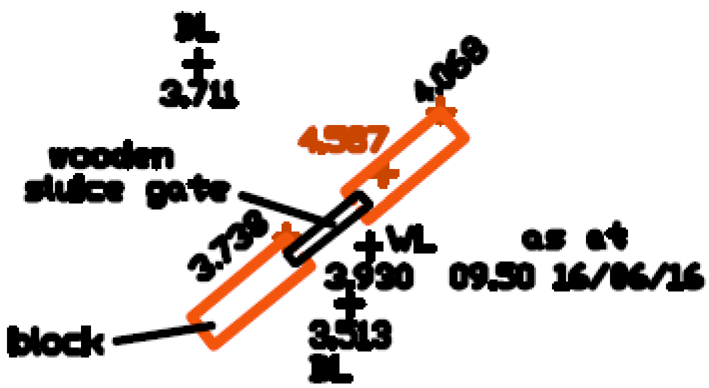


Photo 9.1 Sluice	
Reach:	9
Description:	Sluice on Ox Bow lake
Mannings	0.035
	

The channel in this reach has concrete side wall alongside the caravan sales site (Photo 9.2).

Photo 9.2 West Channel upstream of A259	
Reach:	9
Description:	Channel upstream of A259 crossing - east channel
Mannings	0.060
	

2.3.2 Reach 10 – A259 Road Crossing

The box culvert below the A259 (Photo 10.1) runs diagonally for 35m under the road and emerges to the south east (Photo 10.2).

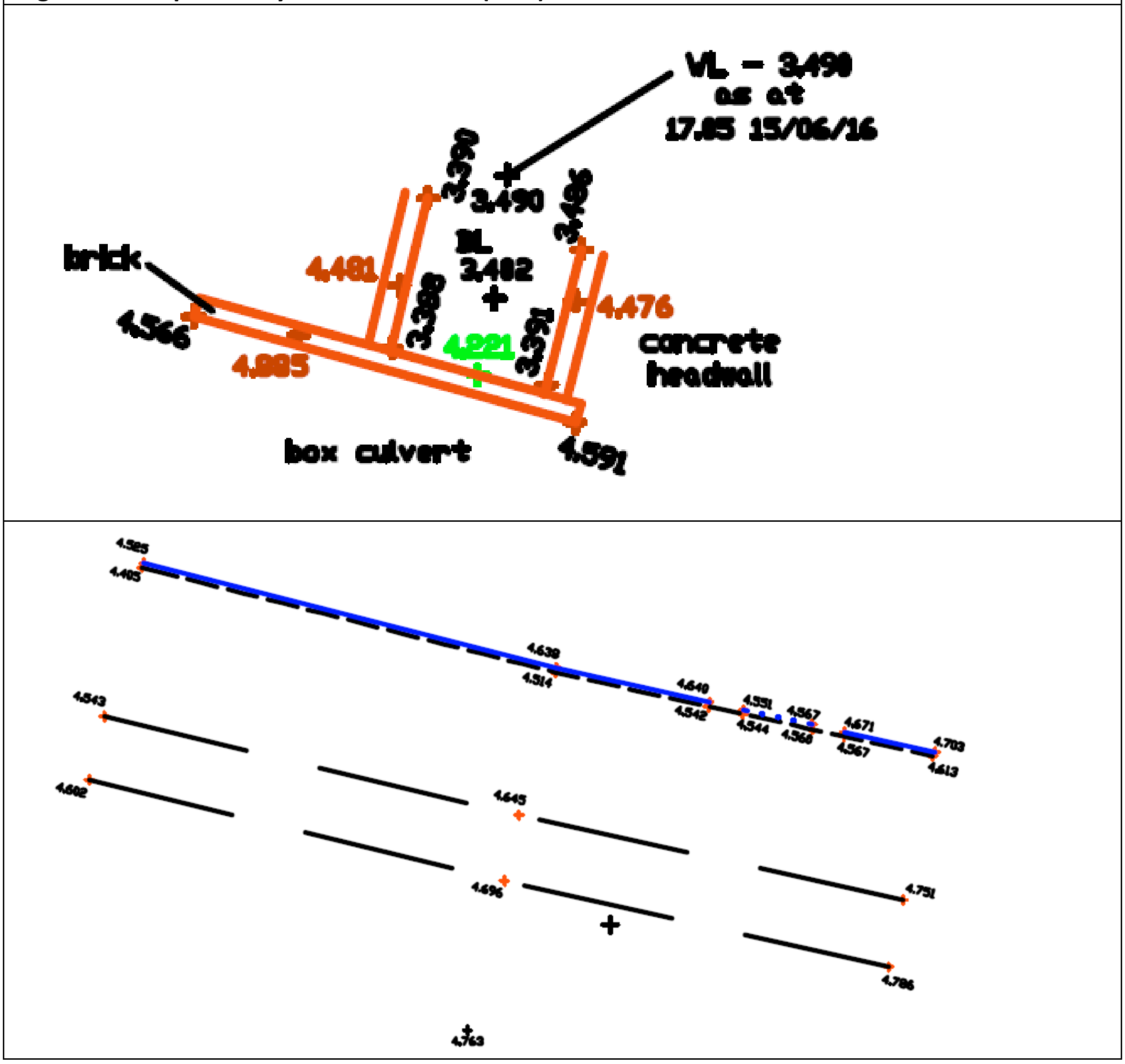
Photo 10.1 A259 Culvert – East Channel	
Reach:	10
Description:	Entrance to culvert under A259 – East Channel
Mannings	0.035

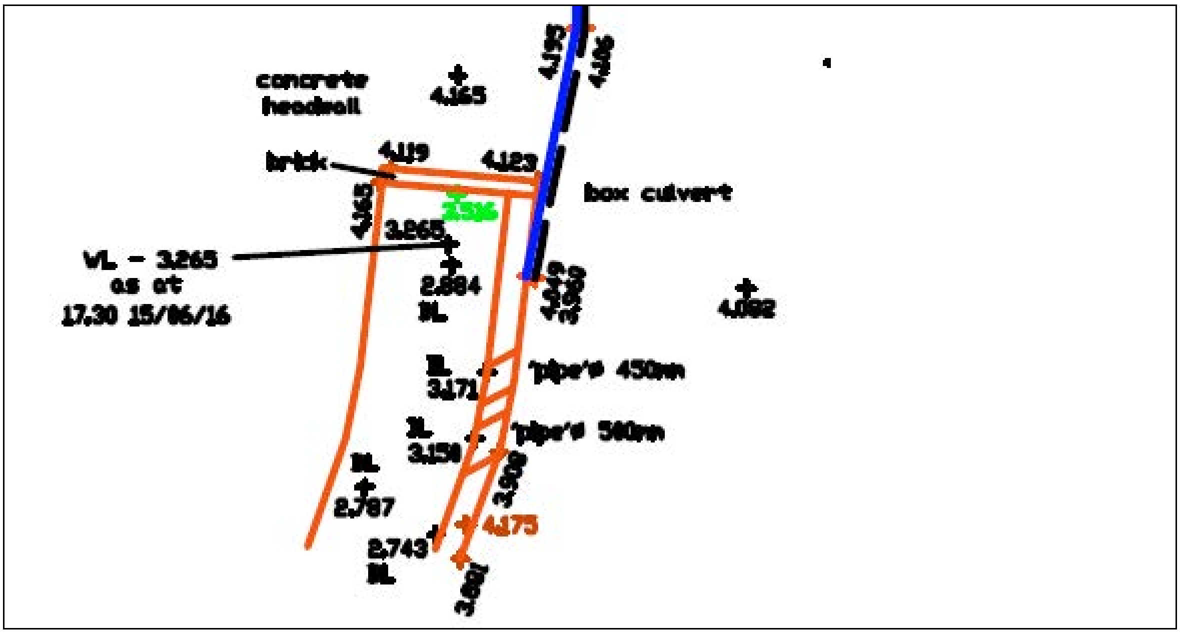
Photo 10.2 A259 Culvert Exit	
Reach:	10
Description:	Exit to culvert under A259 – East Channel
Mannings	0.035

The survey provides the following:

Item	Topo	HECRAS
Box culvert		
Width	N/a	1.0
Height	N/a	0.84
US Invert	3.391	3.391
US Soffit	4.221	
US Headwall	4.591	
Deck Level	4.645	
DS Invert	2.884	2.884
DS Soffit	3.516	
DS Headwall	4.123	
Culvert Length		20.0
Mannings		0.03

Figure 2.6 Topo Survey of A259 Culvert (East)





2.3.3 Reach 11 – Village Downstream of A259

Downstream of the A259 the channel flows through a 210m long reach with a gentle gradient (Photo 11.1) where the substrate is mainly sand and silt. The banks are lined with a narrow band of broad-leaved trees and shrubs and with several driveway crossings (Photo 11.2 and 11.3).

Photo 11.1 Village Downstream of A259	
Reach:	11
Description:	Downstream of A259 on Farm Lane
Mannings	0.035

Photo 11.2 Village Downstream of A259	
Reach:	11
Description:	Alongside Farm Lane
Mannings	0.035
	

Photo 11.3 Village Downstream of A259	
Reach:	11
Description:	Alongside Farm Lane
Mannings	0.035
	

Photo 11.4 Village Downstream of A259	
Reach:	11
Description:	Between Farm Lane and School Lane
Mannings	0.035
	

The watercourse then flows west towards School Lane where it crosses the road as a ford (Photo 11.5).

Photo 11.5 Village Downstream of A259	
Reach:	11
Description:	Downstream of Ford on School Lane
Mannings	0.035
	

2.4 Blockage and Bypass Routes

The risk of blockage and likely bypass routes is considered for each major structure.

- Lake weir. The lake and the outlet weir will store and attenuate flood flows but with low water velocities through the lake the erosion of large volumes of sediment is unlikely but fallen trees could cause blockage. If this did occur flood water would flow around the side or over the top of the weir structure with only a small difference in flood levels in the lake upstream.

- The railway culvert is protected from blockage by the lake weir upstream but this could occur. The 900mm diameter culvert is large and would take a significant amount of debris to block but if this did occur water would rise and overtop the weir and lake upstream before the railway embankment is overtopped.

- The Flow Division Structure in the grounds of the cottage is an informal structure of corrugated iron sheets held by vertical stakes which the current site owner has raised by placing bricks below. In a flood event this structure would be overtopped and by-passed.

- The culvert below the site access road is a small box shape with dense vegetation in the channel upstream and if this was blocked water would run over the top of the culvert and over the access road to the channel downstream.

- A259 – West. A box culvert and due to the higher elevation of the A259 if this culvert did become blocked flood water would pond on the upstream side and accumulate until it reaches the level of the A259 at which point flow over the road would occur. This could cause significant ponding upstream on the site access road.

- Sluice. This structure prevents water entering a former ox bow lake and serves no purpose for the control of flow in the main part of the river.

- A259 – East. A box culvert which if it did become blocked would cause flood water to pond until the crest of the road was reached at which point it would overtop.

- The various residential access bridges in the village are small and if blocked water would flow around each structure and onto the adjacent road. It is likely that site owners would undertake clearance fairly quickly.

3 CONCLUSIONS

The Ham Brook at Nutbourne is a heavily modified watercourse and includes:

- Lake impoundment upstream of the railway line with a weir which will attenuate flood flows.
- Railway embankment with a 900mm culvert which may also restrict food flows
- Straightened and diverted watercourse alongside the Breakers Yard.
- Historical land raising of the left and right bank flood plains.
- Flow division into two channels.
- Significant vegetation growth in and alongside the channel and the flood plain,
- Culverted below the raised elevation of the A259 at two locations
- Concrete channel downstream of the A259

However on the basis of two site visits the watercourse has been split into 11 representative reaches with a a photographic record as detailed in this report to allow channel lengths and Manning's 'n' values to be determined. This provides the basis of the hydraulic river model described in the main report.

Figures

Figure 1.1 Location Map

Figure 1.2 Aerial Photograph

Figure 1.3 Proposed Development Site Location

Figure 1.4 Topographical Survey

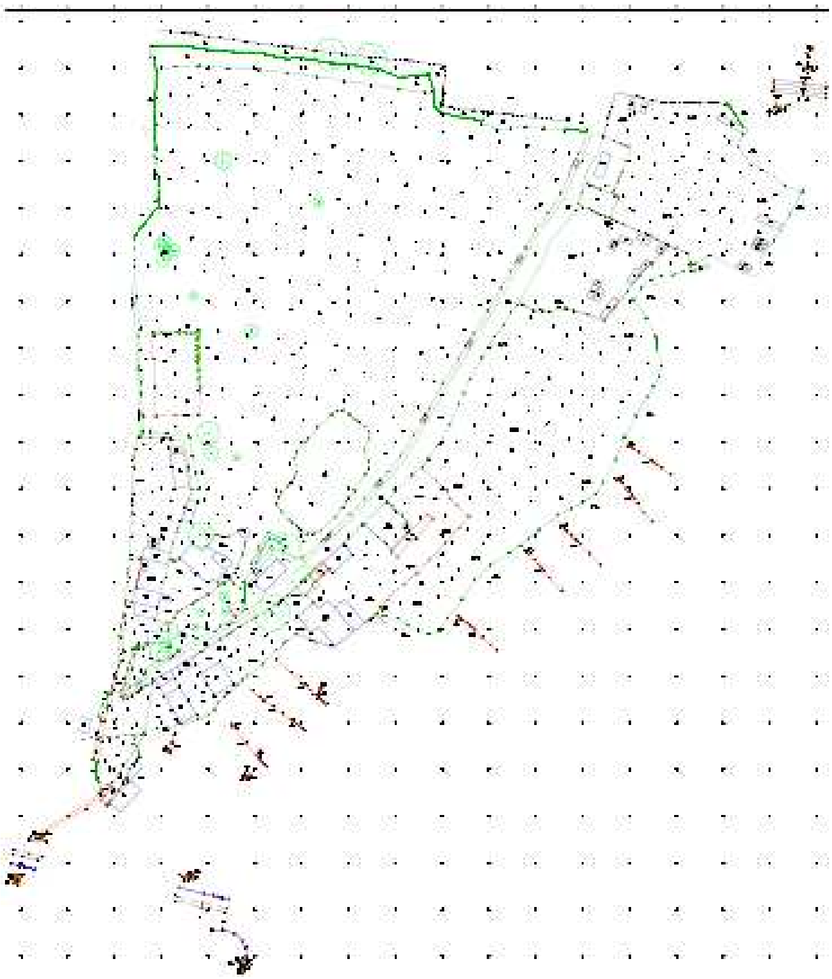


Figure 1.5 EA Flood Map

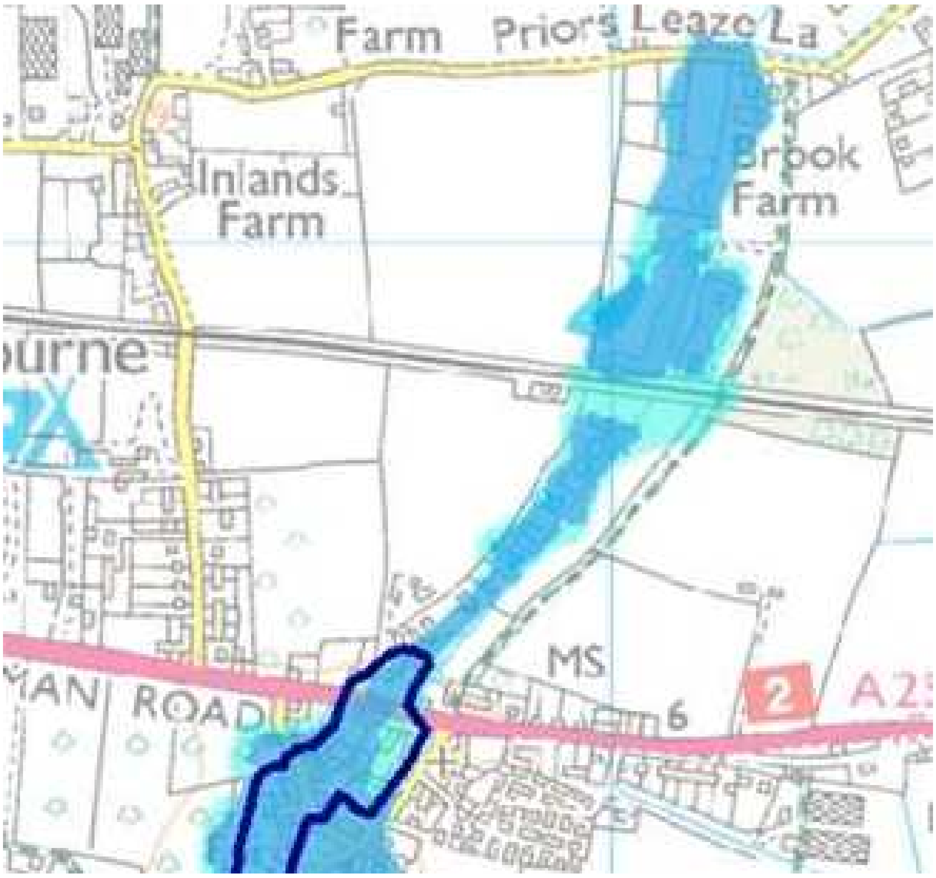


Figure 2.1 FEH Catchment Delineation

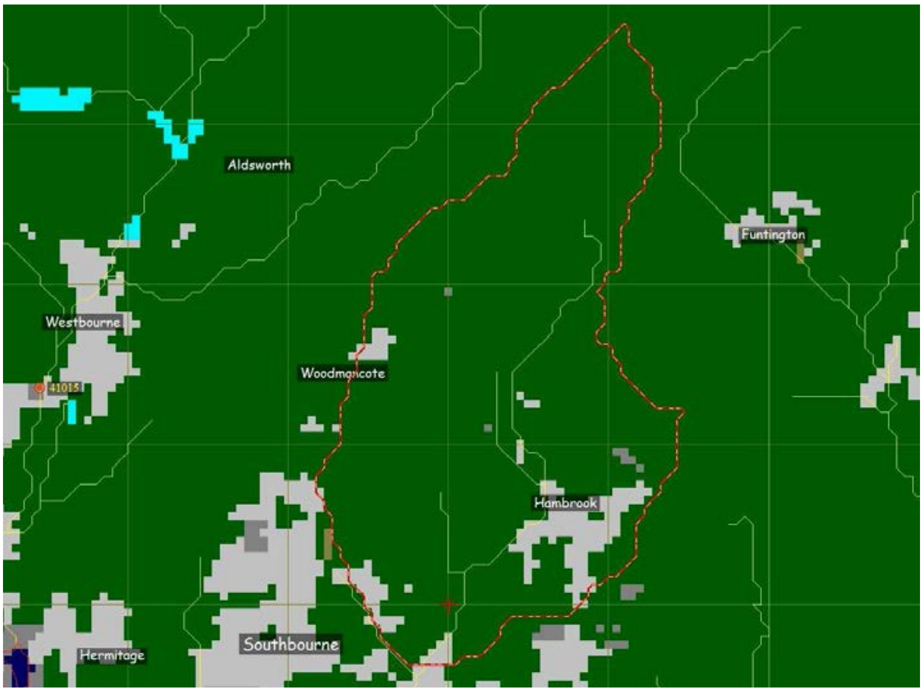


Figure 2.2 EA Map of Flooding from Surface Water

Figure 2.3 WINFAP Component Stations

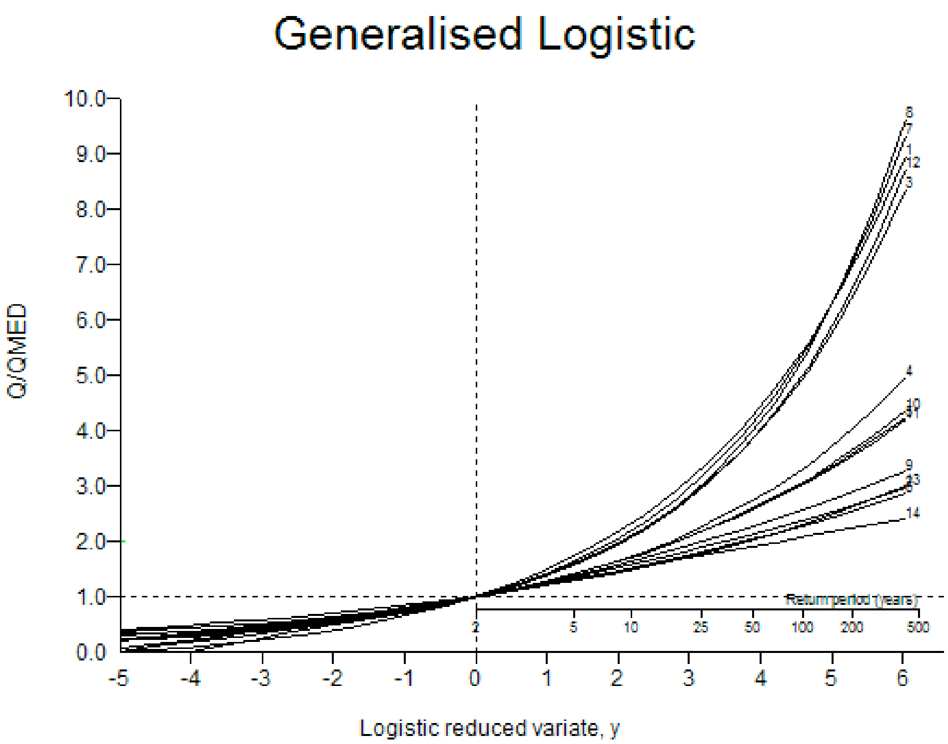


Figure 2.4 Flood Frequency Curve

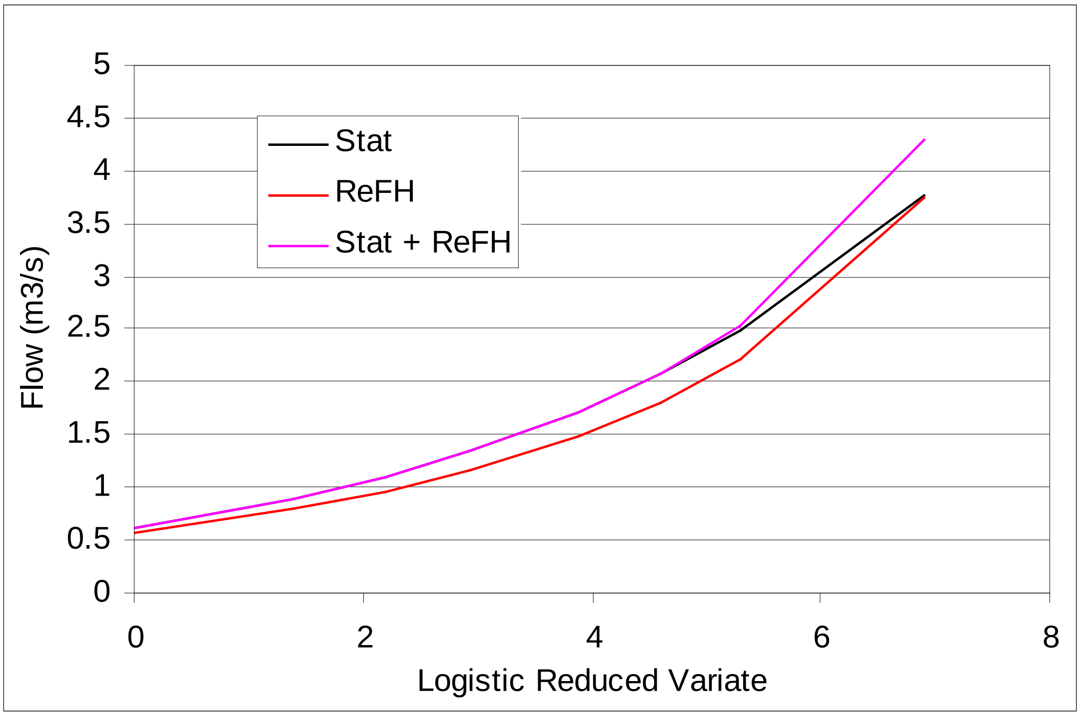


Figure 2.5 Flood Growth Curves

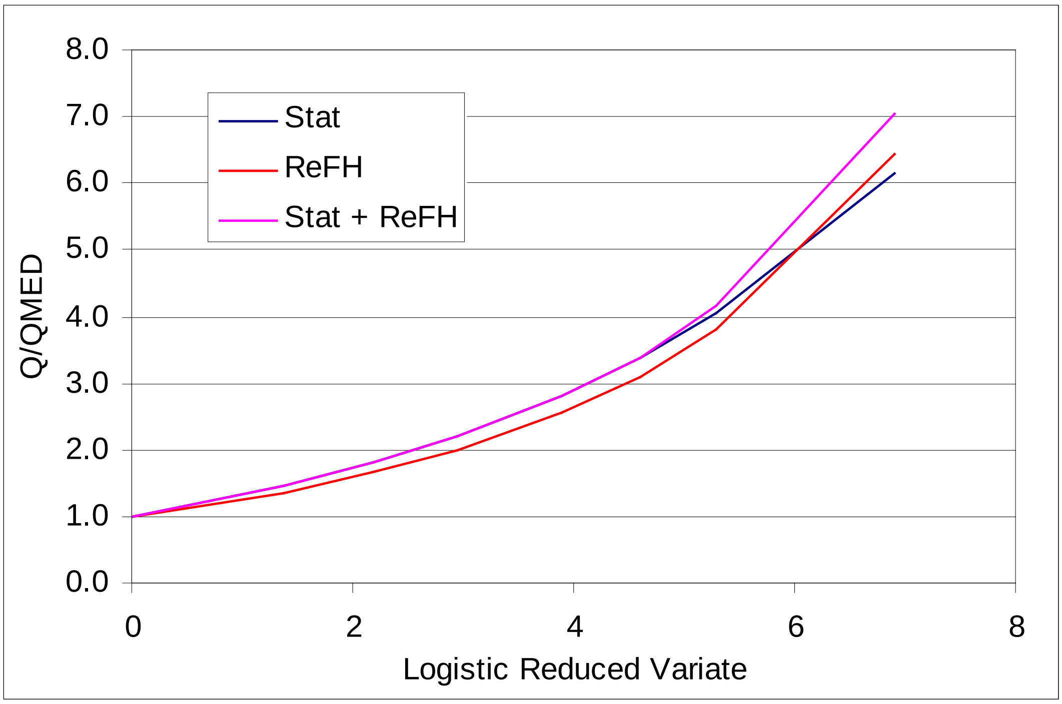


Figure 3.1 EA LiDAR Data

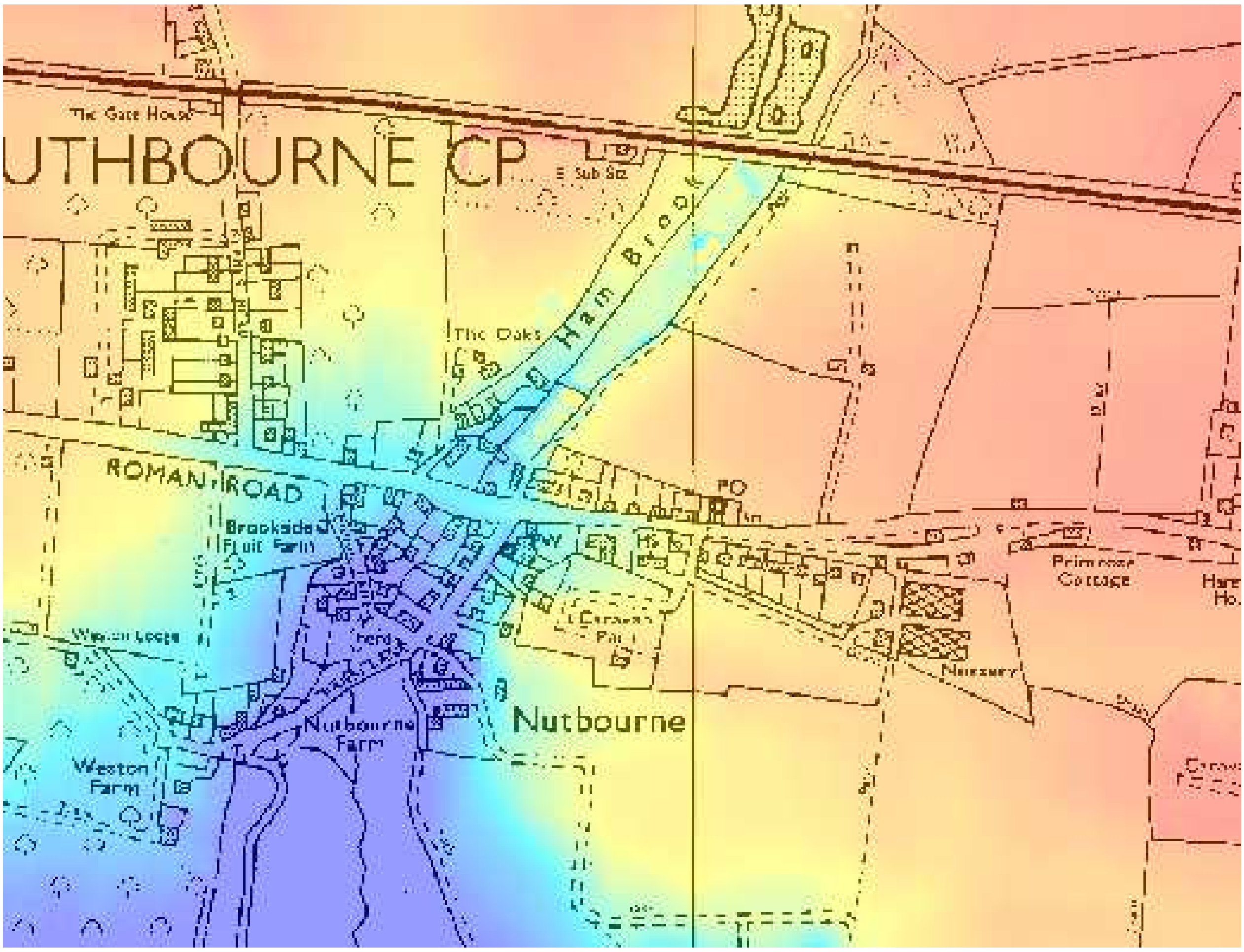


Figure 3.2 HECRAS Model Structure

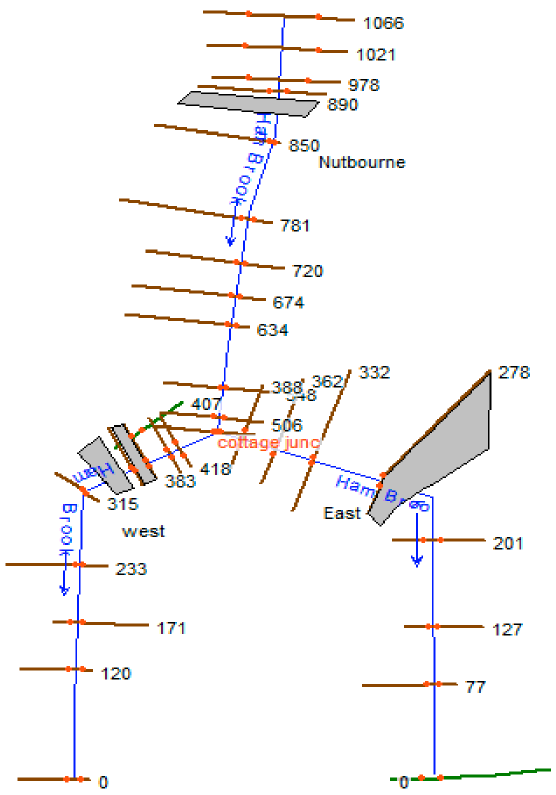


Figure 3.3 HECRAS Cross Section Locations

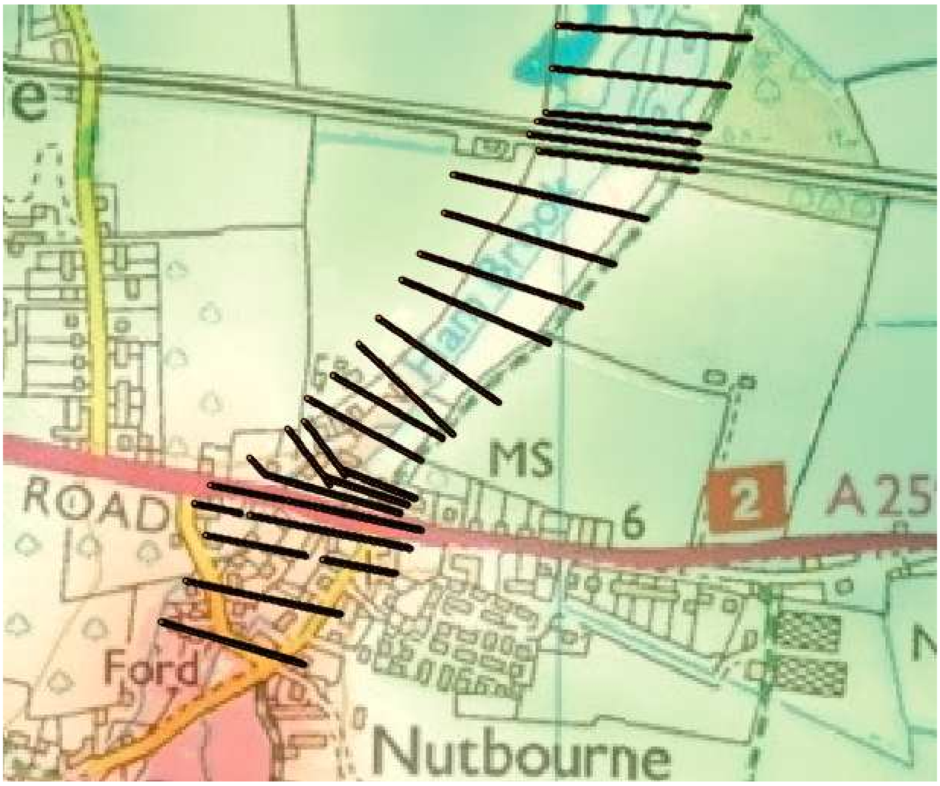
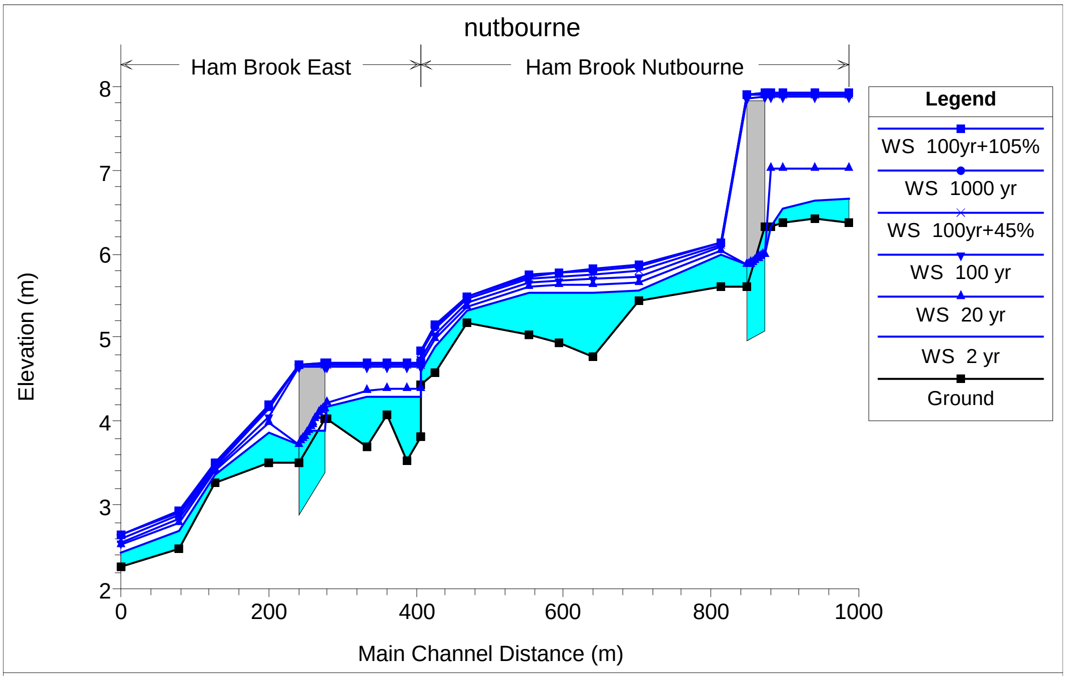


Figure 3.4 Longitudinal Water Surface Profiles

Main +East



West

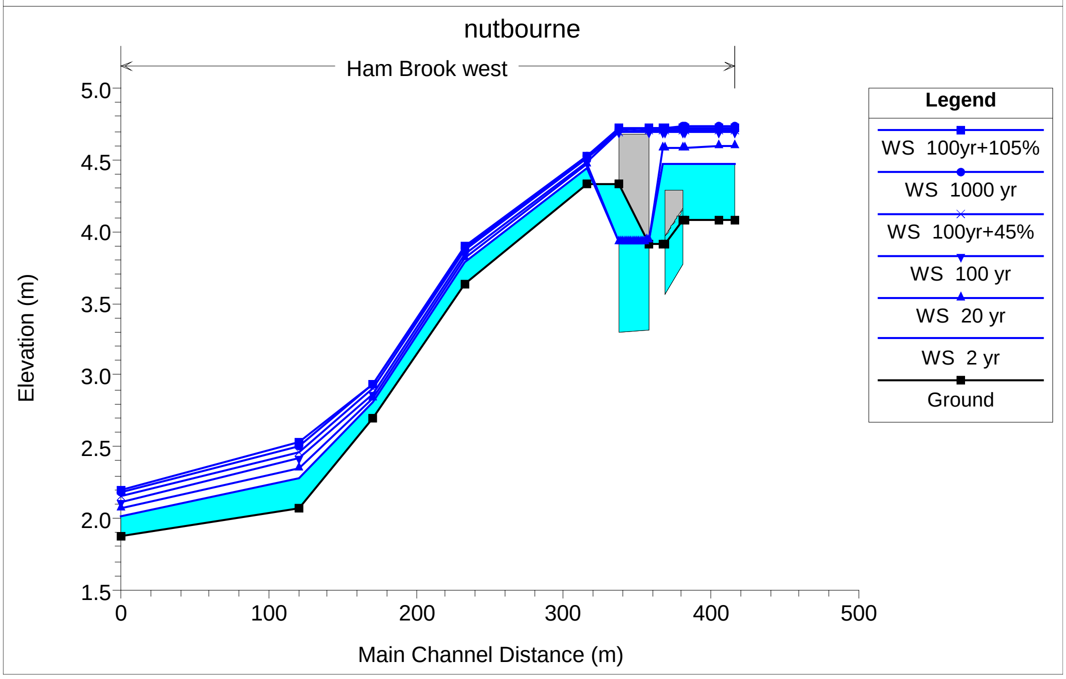
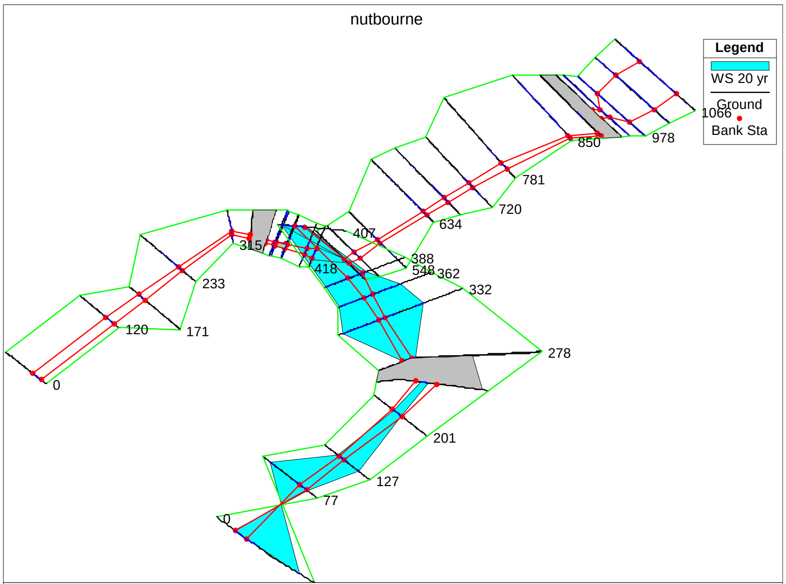
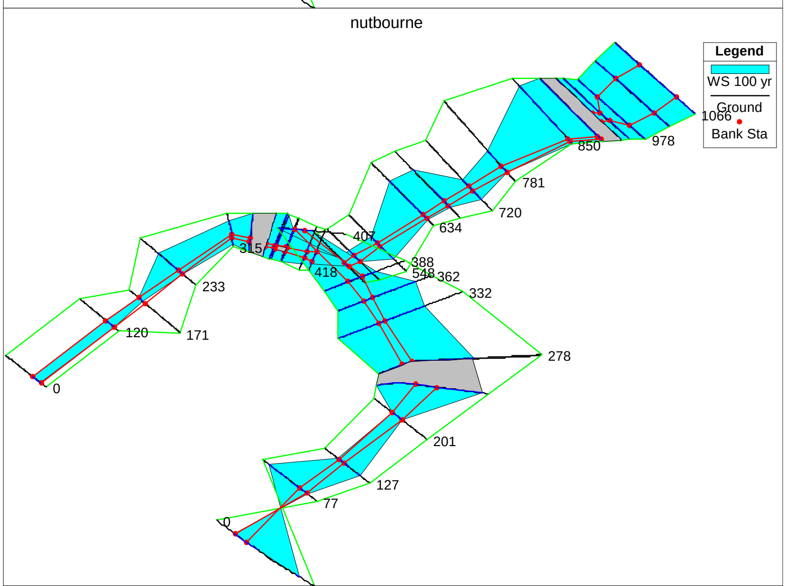


Figure 3.5 3D Water Surface Profile

20 yr



100 yr



1000 yr

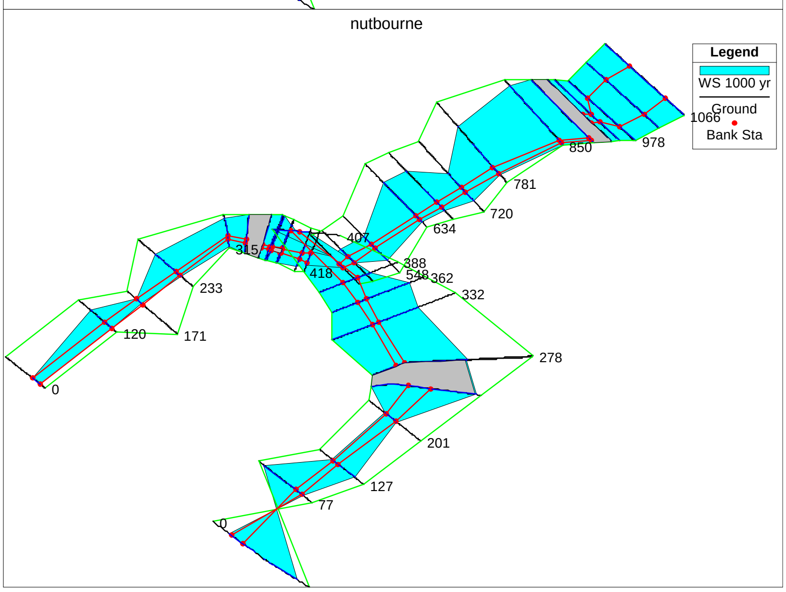
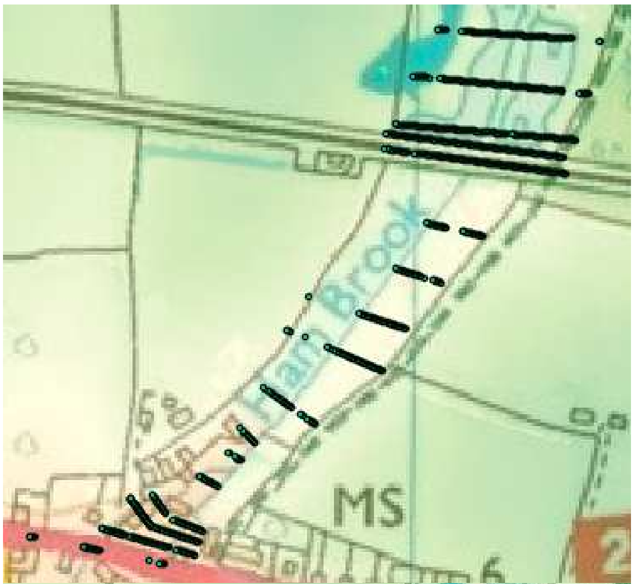


Figure 3.6 Flood Extents

20 yr



100 yr

1000 yr

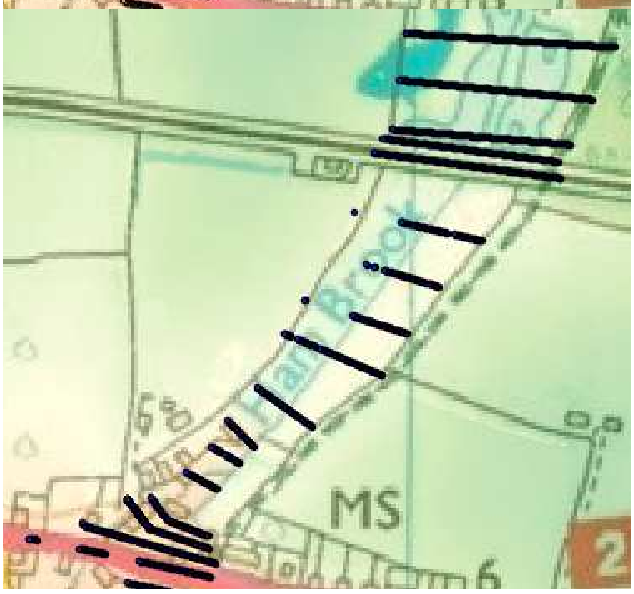


Figure 4.1 FD2320 Flood Matrix

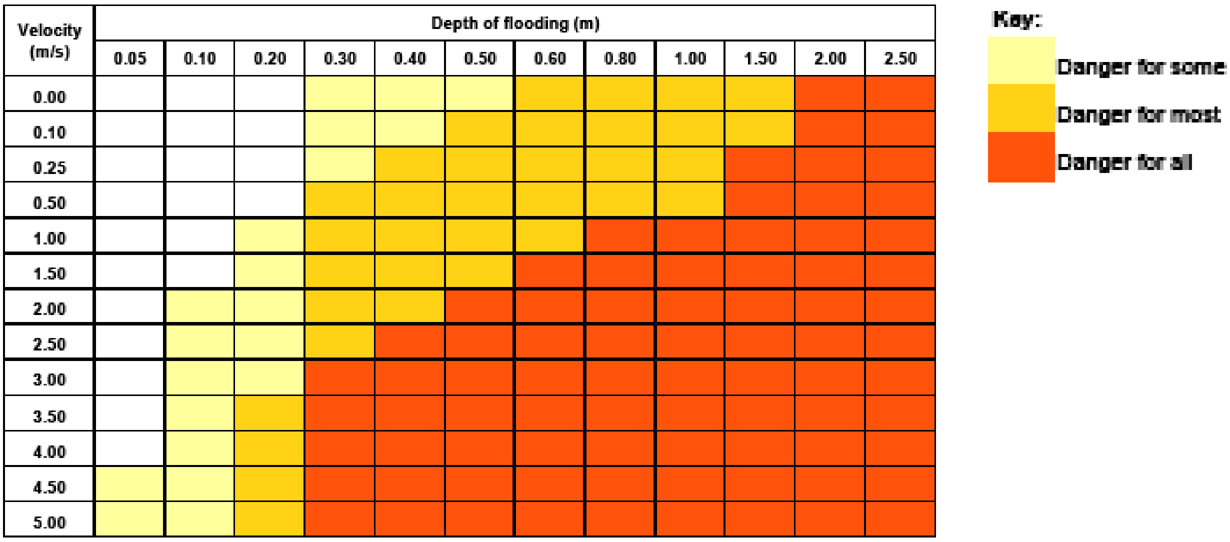
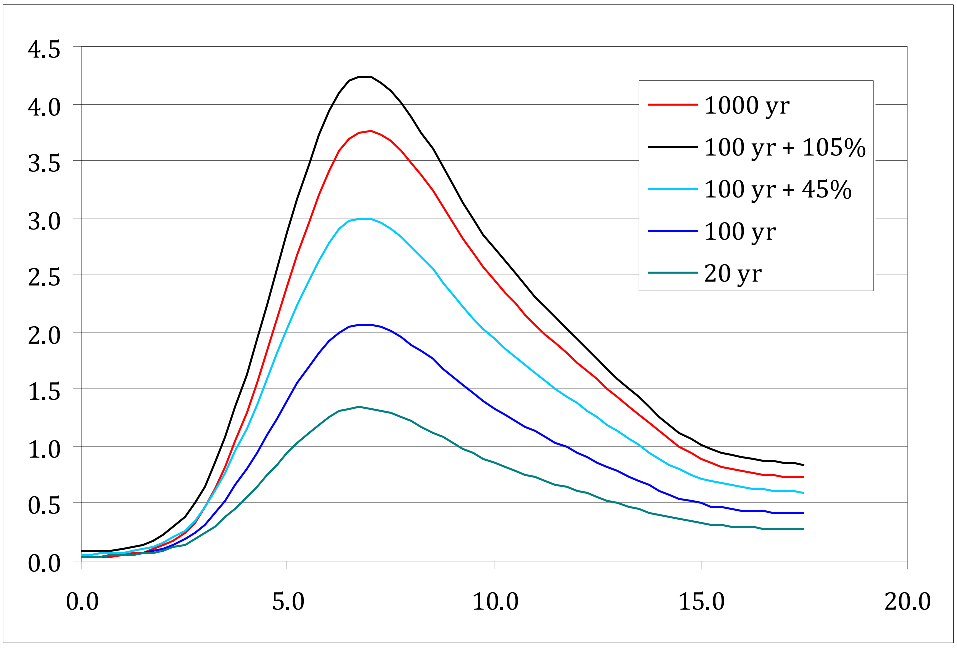
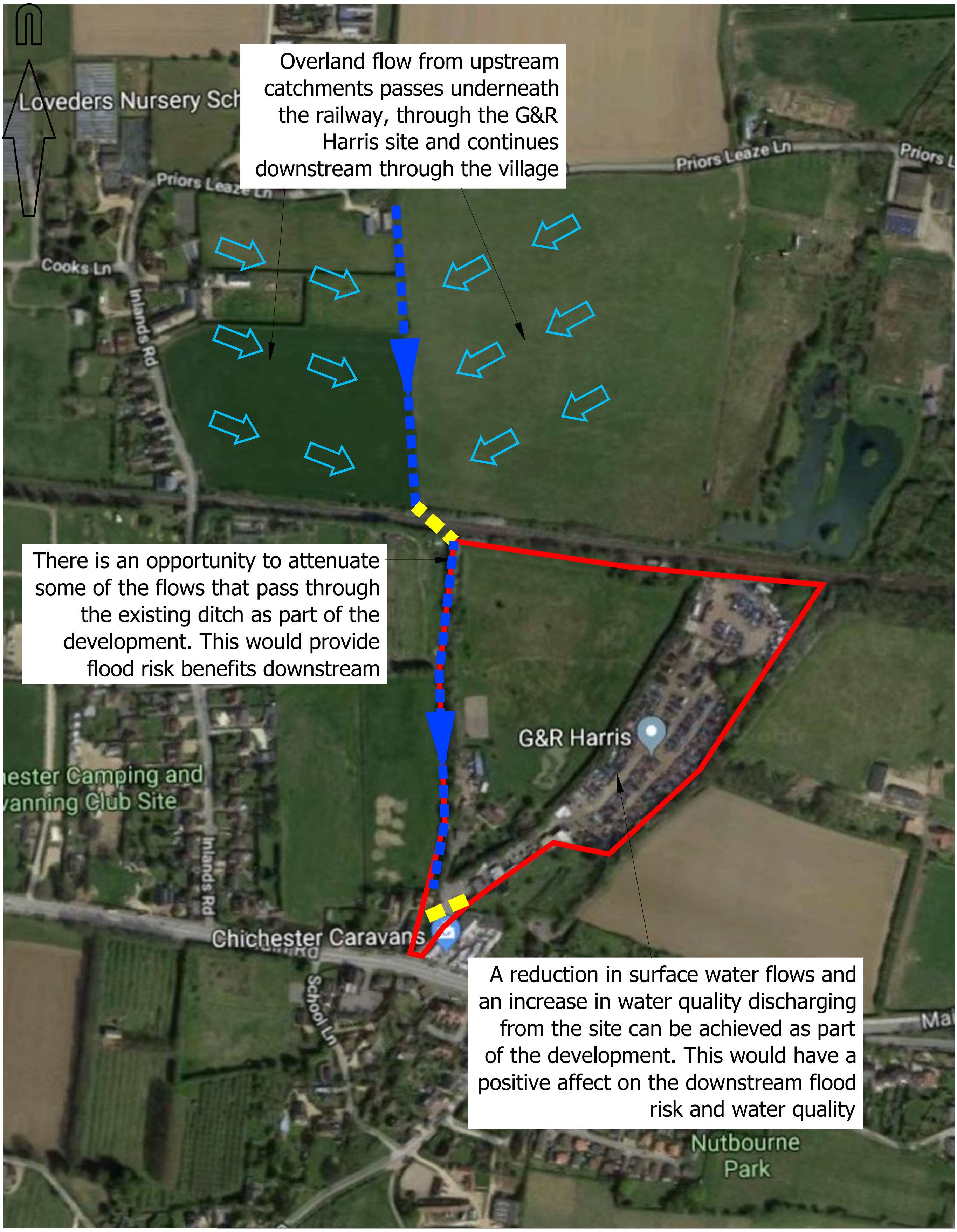


Figure 4.2 ReFH Hydrographs



Appendix C

Flood Risk / Water Quality Benefits Overview Drawing



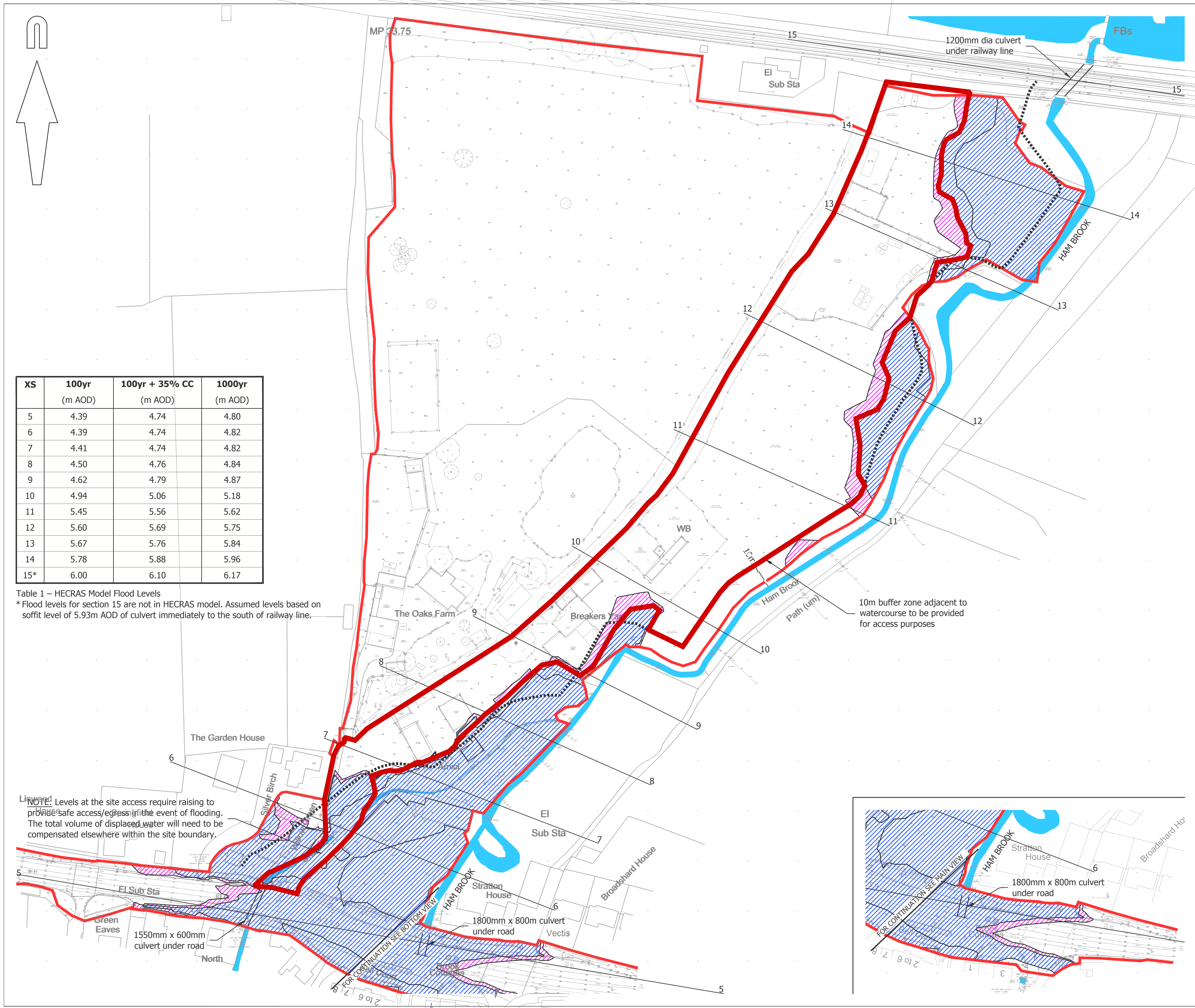
mayer brown

Metis Homes
Land at Nutbourne
Flood Risk / Water Quality Benefits
Overview Drawing

N.T.S

MBSK180222-1 P2

DRAFT



XS	100yr (m AOD)	100yr + 35% CC (m AOD)	1000yr (m AOD)
5	4.39	4.74	4.80
6	4.39	4.74	4.82
7	4.41	4.74	4.82
8	4.50	4.76	4.84
9	4.62	4.79	4.87
10	4.94	5.06	5.18
11	5.45	5.56	5.62
12	5.60	5.69	5.75
13	5.67	5.76	5.84
14	5.78	5.88	5.96
15*	6.00	6.10	6.17

Table 1 – HECRAS Model Flood Levels
* Flood levels for section 15 are not in HECRAS model. Assumed levels based on soffit level of 5.93m AOD of culvert immediately to the south of railway line.

Notes:
Do not scale from this drawing.
All contractors must visit the site and be responsible for taking and checking Dimensions.
All construction information should be taken from figured dimensions only.
Any discrepancies between drawings, specifications and site conditions must be brought to the attention of the supervising officer.
This drawing and the works depicted are the copyright of JTP.

This drawing is for planning purposes only. It is not intended to be used for construction purposes. Whilst all reasonable efforts are used to ensure drawings are accurate, JTP accept no responsibility or liability for any reliance placed on, or use made of, this plan by anyone for purposes other than those stated above.

Key
Site Boundary

A2 ORIGINAL

KEY

- EXTENT OF FLOOD WITH 1% (1in100) OR GREATER CHANCE OF HAPPENING EACH YEAR PLUS 35% CLIMATE CHANGE ALLOWANCE
- EXTENT OF FLOOD WITH 0.1% (1in1000) OR GREATER CHANCE OF HAPPENING EACH YEAR
- EXTENT OF ANALYSIS
- WATERCOURSE 10 METRES BUFFER ZONE

NOTES:

1. Drawing based on Paul Garrad's 'Flood Hydrology Study' report prepared on June 2016 that calculated flood levels at different sections taken along Ham Brook using HECRAS river modelling software.
2. Flood levels interpolated between cross sections.
3. Flood extents overlaid onto topographic survey to be confirmed and accepted by the EA.

PRELIMINARY
NOT FOR CONSTRUCTION

rev.	amendment	checked	date
B	Flood plains updated to include additional survey areas. (IC)	SF	14/09/16
A	Buffer zone included. (IC)	SF	26/07/16

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client: METIS HOMES

project: LAND AT NUTBOURNE

scale: 1:1000 | drawn by: IC | checked by: SF

date: JULY 2016 | cad file: MASTER.DWG

title: MODELLED FLOOD EXTENTS

drawing number: MBSK160725-1

Rev	Date	Description	Drawn	Chkd
-	25.02.19	First Issue	CI	

Drawing Status

Client
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Project
Harris Scrapyard

Drawing Title
Site Location Plan

Scale @ A2 1:1250 | Job Ref. 01293
Drawing No. 01293 _S02 | Revision -
Scale Bar 0 10 20 30m