TECHNICAL NOTE

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Contract	Tunbridge Wells SFRA
Client	Tunbridge Wells Borough Council
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Reviewer / Sign-off	Ben Gibson / Alastair Dale
Subject	Masterplan development modelling at Paddock Wood

Executive summary

Overview

To support Tunbridge Wells Borough Council and David Lock Associates with the preparation of a masterplan for future development in Paddock Wood and East Capel, JBA Consulting was commissioned to prepare updated flood risk modelling and mapping to inform the evidence base for two emerging masterplan options, referred to as Options 1 and 3. Option 1 has a larger total residential area, with residential areas predominantly positioned in Flood Zone 1 and some areas within Flood Zone 2, while Option 3 has a smaller total residential area, with residential areas positioned in Flood Zone 1.

The objective of the modelling assessment is to understand the potential effects of the two masterplan residential layout options on fluvial flood risk, compared with the existing 'baseline' condition, along watercourses flowing from south to north through Paddock Wood and East Capel (collectively referred to as the Paddock Wood Streams).

Flood model

The InfoWorks ICM model developed to support the Tunbridge Wells Borough Level 2 Strategic Flood Risk Assessment (SFRA), and from which the current Flood Zones adopted by the Environment Agency are derived, was modified to represent the potential change resulting from proposals to implement residential developments. This enabled predicted changes to fluvial flood risk in Paddock Wood and East Capel to be understood. Methods from the previous Strategic Flood Risk Assessment modelling have been retained for consistency, so that changes in predicted flooding relate to the representation of the revised development layout, rather than being due to changes in the modelling approach/schematisation.

Staged approach to refinement of the masterplan layout

A staged approach to decision-making relating to the masterplan layout and position of residential development has been adopted to this point, as summarised below:

1. **Level 2 SFRA:** Initial layout of SFRA development parcels tested through the hydraulic modelling and the predictions assessed
2. **Level 2 SFRA:** Revisions made to the location and/or orientation of commercial and residential areas within SFRA parcels to reduce the interaction of these with overland flow routes. The influence of strategic flood risk management options were also considered at this stage. Meetings were held with the Environment Agency, Kent County Council and council Planning Policy Working Group Members during this process to discuss the emerging findings.
3. **Masterplanning process:** Refinements were made to the development layouts to position residential development in lower risk Flood Zones (principally Zone 1 and also Zone 2). The approach was 'ownership blind' allowing greater flexibility with the positioning of development across the full masterplan area. During this process various meetings were held, enabling interested parties to voice their opinions on matters including flood and drainage matters. In particular, the 'Blue infrastructure' technical workshop held 10 September 2020 and a meeting convened with the Environment Agency on 19 November 2020 enabled the findings

from the SFRA assessment, and subsequent advances in the development layout planning, to be communicated.

4 **Masterplan layout modelling:** The modelling and mapping presented within this document was prepared using the same methods as the SFRA modelling assessment to evidence the changes in predicted flooding for two masterplan layout scenarios. This information forms the latest prediction of changes in flooding due to the development layouts. The assessment remains strategic in nature, and detailed assessment of individual site layouts, drainage, landscaping etc would refine how the development manages fluvial flows and surface water runoff.

Findings

Initial modelling of masterplan layout Options 1 and 3 showed unexpected increases in flood depths in some areas of Paddock Wood due to the obstruction of some of the existing overland flow paths. Inspection of the modelling revealed that some of these flow pathways are very shallow and related to surface runoff rather than fluvial flood risk. Surface water runoff would be expected to be managed through site drainage and landscape planning, which is not represented within the model. This should be considered when interpreting the results. Additionally, the simplistic approach used to represent the residential areas (raising their entire footprint above the maximum flood level) has been retained from the SFRA which would be expected to provide worst-case predictions. While this is unlikely to be representative of the practical approach to development of the sites, where flow pathways through the areas are likely to be incorporated into the layouts, it enables a strategic scale assessment of the potential impacts on flooding.

In light of the predicted increases in flooding, a relatively small number of conveyance routes were applied through residential sites in a refinement to the development scenarios. This begins to replicate the effects that localised drainage features would be expected to have on conveyance of water.

The modelling demonstrates the benefit of localised drainage measures and it is considered that more comprehensive drainage arrangements accompanied by more detailed analyses would enable the development of the residential sites outlined in Option 1 to be brought forward without any off-site increases in flood depths being predicted. The smaller scale of residential development associated with Option 3 lessens changes in flood depths compared with the baseline scenario, but in places localised drainage measures still need to be considered.

Conclusions

It is considered that masterplan development Options 1 and 3 are acceptable from the perspective of not increasing flood risk to third parties. The areas of residential development have been positioned in lowest risk flood zones (Flood Zones 1 and 2) and the modelling supports the benefit resulting from this by demonstrating the reduced changes in flooding compared with modelling prepared for the Tunbridge Wells Level 2 SFRA. Additionally, the modelling identifies the benefit that localised drainage measures can provide. On this basis it is considered that the principle of development can be supported for the layout described by Option 1, provided that appropriate provision is made for the layout of drainage and flow routes through the proposed development. These measures would need to be supported by more detailed analyses and evidence that reflected the level of design detail. Consideration

would need to be given to the long-term management and maintenance of the conveyance and drainage measures, so these were not inadvertently compromised for the lifetime of the development.

1 Introduction

As an extension to the preparation of the Strategic Flood Risk Assessment (SFRA), JBA Consulting was commissioned to prepare updated flood risk modelling and mapping to inform the evidence base for the emerging masterplan options for Paddock Wood and East Capel. The modelling made use of the InfoWorks ICM modelling used to inform the Strategic Flood Risk Assessment, but this was configured to represent the latest masterplan proposals within the model so the potential flood risk effects of these can be understood.

As part of the masterplanning process, various layout options for development have been prepared by David Lock Associates (DLA), who are leading on the masterplanning for Tunbridge Wells Borough Council. Two of these layout options, referred to as Options 1 and 3 were requested for testing within the flood risk mapping model.

- Option 1 has a larger total residential area, with residential areas predominantly positioned in Flood Zone 1 and some areas within Flood Zone 2
- Option 3 has a smaller total residential area, with residential areas positioned in Flood Zone 1

Included within both options are proposals for two primary schools and one sports hub.

At the time of preparing the masterplan modelling presented within this note, three primary schools were being considered within the masterplan area. Since finalisation of the modelling, one of these three primary schools, at the region of land at the southwest masterplan area has been removed. While the flood modelling presented here has not included this region of land as residential development, the findings of the modelling presented here are considered robust. The majority of the area formerly considered for a primary school and now taken forward for residential development is located within Flood Zone 1, and also is mostly located outside of the Flood Zone 3a extent when climate change effects on fluvial flows are considered (for both the allowances tested). Where fluvial flooding is predicted within the area assigned for residential development, this is at the perimeter of the area and it is considered that the form of development could be positioned to complement the direction of fluvial flood water and/or localised drainage measures could be incorporated into the form of development to help manage changes to flood risk (as evidenced by the conveyance route testing scenario presented in this document). In light of this, the results presented within this note remain those with the primary school represented in this region, rather than a residential area.

The objective of this modelling assessment is to understand the potential effects of the two masterplan residential layout options on fluvial flood risk, compared with the existing 'baseline' condition, along watercourses flowing from south to north through Paddock Wood and East Capel (collectively referred to as the Paddock Wood Streams).

Versions of the existing InfoWorks ICM model developed to support the Tunbridge Wells Borough Level 2 SFRA[1] have been modified to represent the potential change resulting from proposals to implement residential developments so the predicted changes to fluvial flood risk in Paddock Wood and East Capel can be understood.

1 JBA Consulting for Tunbridge Wells Borough Council, 2019. Tunbridge Wells Level 2 SFRA: Flood Risk Management Measures. Final Report, April 2019.

Consistent methods have been applied between this latest modelling and the modelling prepared for the SFRA, so that changes in predicted flood risk are associated with changes to the development proposals and schematisation and/or data issues do not introduce additional differences which could increase uncertainty in the interpretation of the results.

2 Hydraulic modelling

Flood modelling was prepared for the 5%, 1% and 0.1% Annual Exceedance Probability (AEP) design events (Flood Zones 3b, 3a, and 2, respectively) for the present day. In addition the effects of climate change were considered by applying uplifts of +35% and +70% to the input rainfall for the 1% AEP event, reflecting the Higher central and Upper end allowances for climate change in the Thames River Basin District as per the Environment Agency's latest guidance. Hydrological inputs were unadjusted from the SFRA modelling.

2.1 Masterplan options

2.1.1 Residential development

The residential developments have been represented within the existing InfoWorks ICM model in line with the approach used in the Level 2 SFRA. The extents of the residential developments provided by DLA were refined to maintain an 8m buffer from the watercourses within Paddock Wood. Additionally, refinements were made so that developments run along road boundaries where the extents intersected roads represented within the hydraulic model. The final layout of the residential developments in Option 1 and Option 3 are shown in Figure 2-1, but refer to DLA's main masterplan reporting for more detailed information.

The updated "SFRA baseline" model was used as the baseline scenario for the modelling. This model includes three large developments that had received planning permission at the time of the original model build. These sites are:

- Land at Church Farm
- Land at Mascalls Court Farm
- Land at Mascalls Farm

Options 1 and 3 were represented in separate scenarios, with the entire site areas of the residential developments shown in Figure 2-1 raised to a level above the maximum flood level, an approach consistent with the SFRA modelling. This approach prevents any overland flow passing through the area, and is an approach which is likely to produce worse-case predictions, given that water will be deflected around these areas, and in practice localised drainage features would be expected within the residential areas.

A limited runoff rate (outflow) from the residential areas was assumed, involving limiting the runoff to the greenfield runoff rate (taken as 4l/s/ha) as in the original modelling. Subcatchments were specified within the Option 1 and 3 scenarios covering the entire residential areas, with the outflow from the subcatchments set to discharge at the specified runoff rate into the adjacent watercourses at locations assumed to be most likely that drainage would discharge to.

For the masterplan option modelling, no form of flood management measure is applied along the eastern side of the southwestern area (west of Bramley Gardens, Laxton Gardens and Ribston Gardens). While some measure is included within the masterplan to help provide betterment in flood risk to Paddock Wood, the approach to achieve this has not yet been agreed. It is understood that a flood management measure here must provide reduced flood risk to Paddock Wood, but not increase risk to third parties (e.g. the railway line), meaning any changes to risk must be maintained within the masterplan area. The predictions from the model are focused on presenting the change in flooding due to the proposed development layouts alone, which strengthens the acceptability of the development tested in this latest modelling, as the additional benefits of the flood management measure are not accounted for. It is also helpful as it removes the possibility of representing a form of flood management measure that is not taken forward.

No other adjustments have been made to the "SFRA baseline" model from the Level 2 SFRA modelling. The primary school sites and sports hub within Option 1 and 3 have not been represented within the model, as it is assumed that the developments would include large areas of open space, and thus raising the levels of land within the areas would not be appropriate.

The proposed Masterplan layouts have not been assessed in the River Medway flood risk model, as modelling of development parcels prepared for the Level 2 SFRA indicated that the influence of development on flood risk from the Medway was smaller in scale than from Paddock Wood Streams. Flood risk from the River Medway is confined to the northern extent of the masterplan area (at the periphery of the River Medway floodplain), and potential impacts brought about by development are more influenced by potential loss of floodplain storage, compared with potential obstruction to flood flows as in Paddock Wood.

2.2 Masterplan options with conveyance routes

Initial model results showed that, while reductions in changes to predicted flooding were apparent when compared with the layouts considered at the SFRA stage, the representation of the residential developments in Options 1 and 3 (raising the site areas above the maximum flood level) blocked off some surface water flow paths, resulting in areas of increased flood risk 'upslope' of the sites. This is probably an unrealistic prediction given that it is not proposed for the entire residential areas to be raised and localised drainage arrangements that would most likely be in place will provide flow routes through the proposed development.

Therefore, a refined modelling scenario was prepared in which indicative conveyance routes were introduced to replicate the influence of localised drainage paths through development. This modified representation was considered to provide a more realistic representation of proposed masterplan development scenarios. The conveyance routes through the proposed development were configured to maintain some of the existing flow paths predicted by the modelling, which are often relatively shallow, so more closely reflect surface water flooding than accumulations of fluvial flows.

A total of nine conveyance routes were included within the option modelling (presented in Figure 2-2). The routes were trapezoidal in shape, 2m wide at the base and 4m wide at the top of the channel. These were set to be 0.5m deep, but discharge to

existing ground level at their downstream extent. The routes were selected to follow existing flow paths that cross some of the proposed residential developments. The conveyance routes were represented in the model as river reaches, allowing flows to pass through the residential developments.

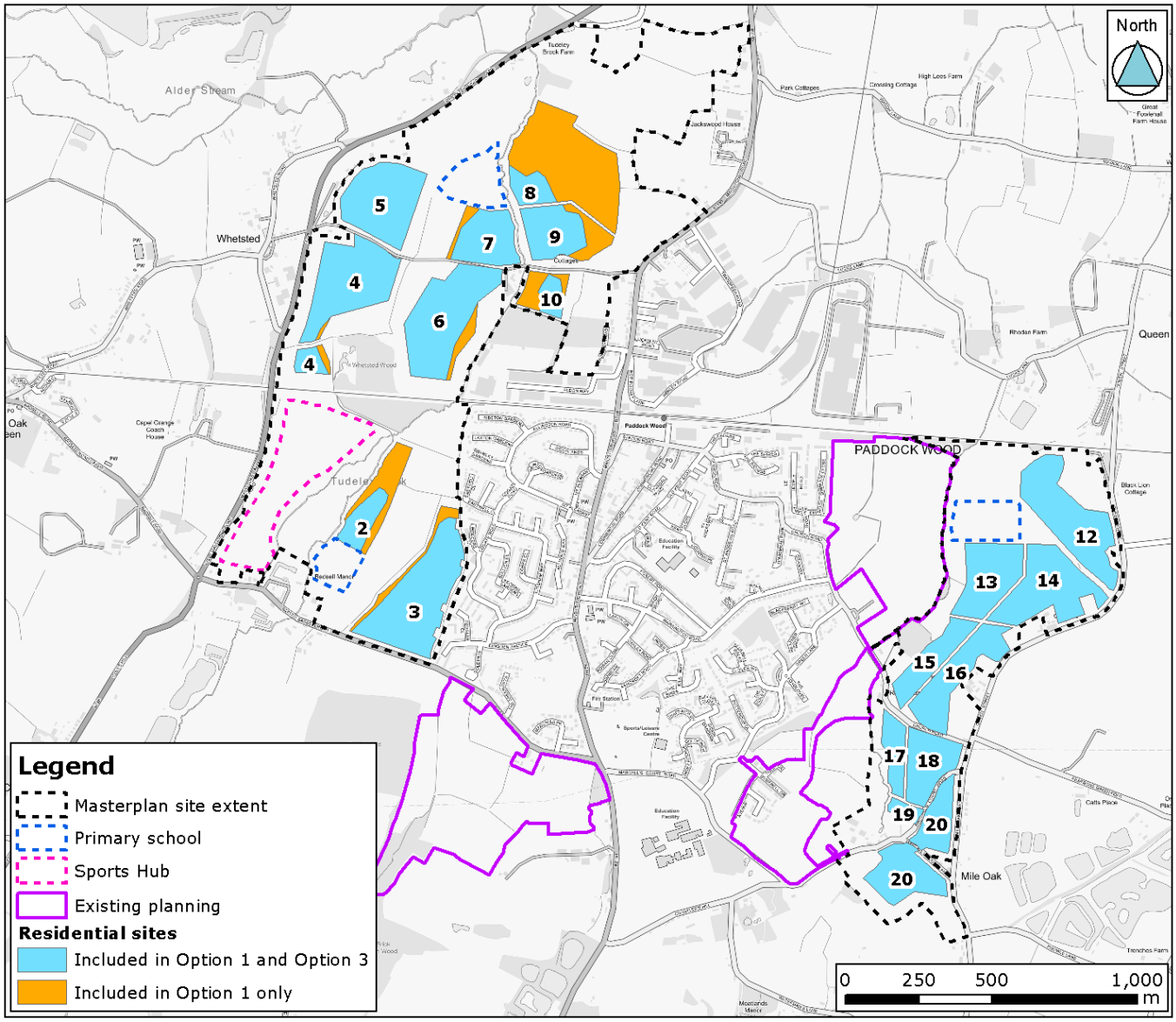

Figure 2-1: Masterplan sites

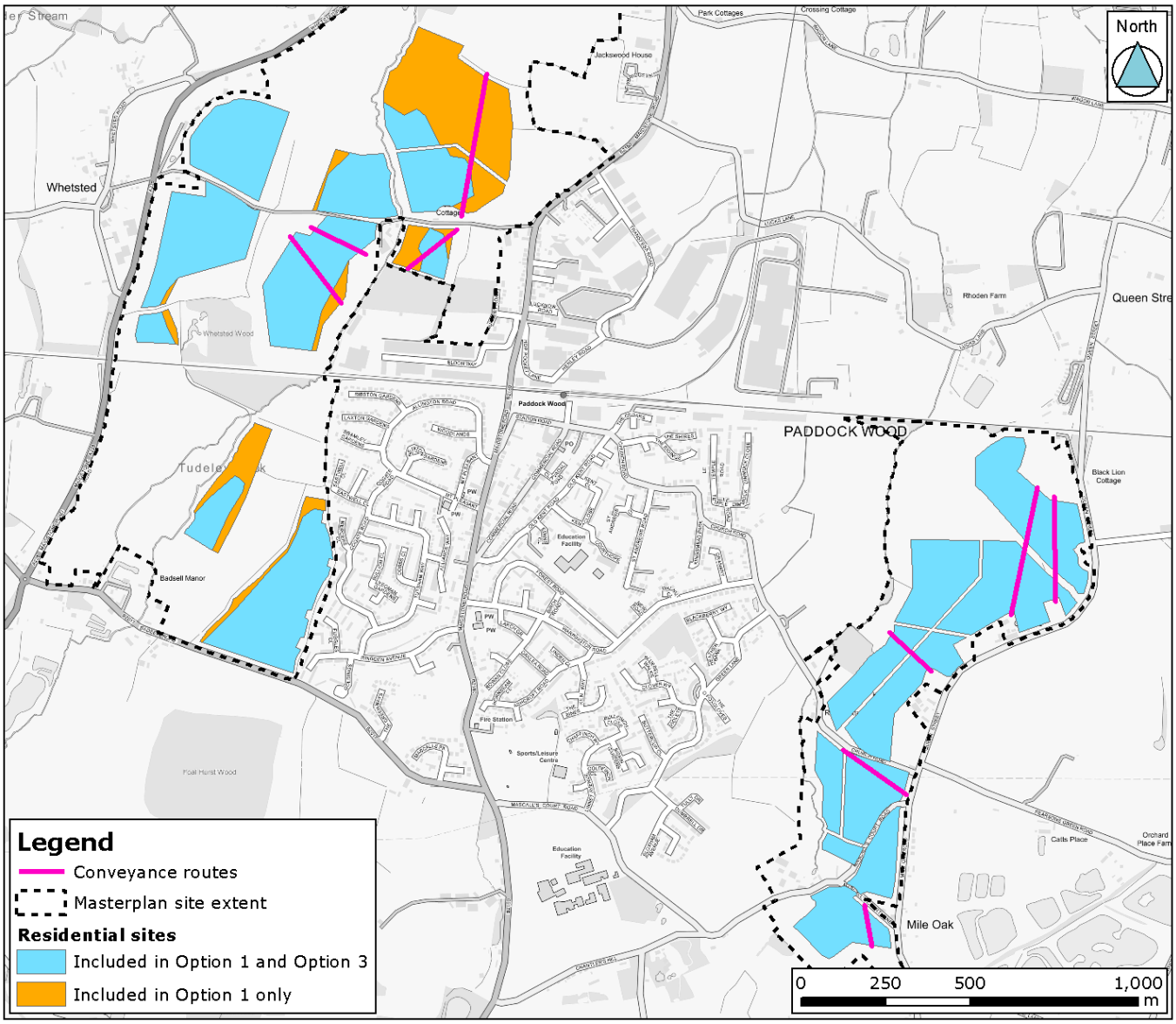

Figure 2-2: Conveyance routes

3 Changes in flood risk due to the proposed masterplan options

3.1 Overview

Predictions of maximum flood depth for each scenario were extracted from the model results. In keeping with the approach adopted for the Flood Zone mapping prepared for the SFRA, flooding was not reported for model elements (triangles representing ground levels throughout the floodplain) with depths of flooding less than 1cm and a hazard rating of less than 0.575 (hazard rating is a function of the depth and velocity of water, plus an assumed debris factor[2],[3]). This screening was conducted to remove shallow depths of flooding which might typically be associated with surface water runoff, resulting in pluvial (direct rainfall) flooding and not fluvial flooding which forms the basis of the Flood Zones.

A suite of maps was prepared to display the change in predicted flood depths between the masterplan options and the baseline simulations. Changes in flood depths due to the implementation of the masterplan options vs baseline are available in the following appendices:

- Appendix A: Masterplan Option 1 and 3 vs baseline
- Appendix B: Masterplan Option 1 and 3 with conveyance routes vs baseline

The Appendix B maps are the final predictions which should be assessed to understand the anticipated change in flood risk. Appendix A maps are included for context to the changes in flood risk resulting from the application of conveyance routes.

3.2 Results

This section provides commentary on some key trends identified with Options 1 and 3 tested with conveyance routes. Reference should be made to the mapping presented in Appendix B for visualisations of the change in flood depths.

For the purpose of this technical note, the impacts on flood predictions are presented for the residential developments (see Figure 2-1) in the following areas:

- Southwest Paddock Wood – sites 2 and 3
- Northwest Paddock Wood – sites 4 to 10
- Southeast Paddock Wood – sites 12 to 20

3.2.1 Masterplan options with conveyance routes

Southwest Paddock Wood

- No localised drainage features (conveyance routes) were applied in this area given that any increases to flood depths remain within the masterplan extent. Relatively small reductions in the eastward flow of water are predicted, resulting in relatively

2 Defra and Environment Agency (2006) The Flood Risks to People Methodology, Flood Risks to People Phase 2. FD2321 Technical Report 1, HR Wallingford et al. For Defra/EA Flood and Coastal Defence R&D programme.

3 Supplementary note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purposes - Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1.

small reductions in flood depths within Paddock Wood for each of the design events. This is most prominent for Option 1, given the extent of residential development is larger, and therefore more influential at retaining water on site and reducing easterly flow. In Option 1, the increased flood depths within the masterplan boundary appear to direct more water in a northerly direction, contributing to greater flood depths in the Northwest area, described below.

Northwest Paddock Wood

- The inclusion of conveyance routes through sites 6, 7, 8, 9 and 10 reduces the eastward deflection of existing surface water flow paths caused by the representation of the residential sites.
- In Option 1 increased peak flood depths are still predicted to occur to the east of sites 8 and 9 and south of site 10 for the 1% AEP events and larger magnitudes. Some of the increased flood depths predicted extend outside of the masterplan boundary. Given the reduction in flood depths predicted by applying the simplistic conveyance routes described, it is considered that it would be possible to introduce further measures to manage the potential flood risk offsite (so there was no increase is predicted flooding). The measures would most likely involve detailed drainage design features combined with creation of additional flow routes through areas of residential development. Localised drainage measures may also include the introduction of measures to capture surface runoff across a greater perimeter of the site, compared with the current approach of only one point of entry.
- Application of conveyance routes through sites 6 and 7, draining water from east to west, reduces the accumulation of water behind the raised residential areas, supporting the principle of the concept that localised drainage can be introduced as a means of providing appropriate flood pathways.
- Although less of a necessity for Option 3, the inclusion of the conveyance routes means increases in flood depths are generally contained within the masterplan layout, with small increases still predicted to occur south of site 10, where additional features to capture water and divert it around the residential area would likely provide further benefit.

Southeast Paddock Wood

- Development is largely positioned away from significant overland flow routes, although surface runoff is predicted to accumulate behind the raised residential areas.
- The implementation of the conveyance routes through the residential sites reinstates many existing flow paths, helping to reduce the areas of water accumulation at the 'upslope' side of the residential sites. This is most notable at sites 12, 14, and 16.
- These localised accumulations of water to the east of the residential areas results in reductions in flood depths to the west and north – indicating that localised storage as part of the development design may provide wider benefits.

4 Conclusions

Hydraulic modelling has been prepared to assess changes in predicted flood risk within Paddock Wood, from Paddock Wood Streams, when the proposed masterplan site layouts are configured.

Methods from the previous Strategic Flood Risk Assessment modelling have been retained for consistency, so that changes in predicted flooding relate to the representation of the revised development layout, rather than being due to changes in the modelling approach/schematisation. The simplistic approach used to represent the residential areas (raising their entire footprint above the maximum flood level) has been retained. While this is unlikely to be representative of the practical approach to development of the sites, where flow pathways through the areas are likely to be incorporated into the layouts, it enables a strategic scale assessment of the potential impacts on flooding. It would be expected that the simplified representation of proposed development will provide worst-case predictions when observing the predicted changes in flooding. This conservative approach should be kept in mind when making decisions relating to the principle of development e.g. it is expected that more detailed consideration of site drainage can further manage flood pathways, beyond that which can be resolved in the strategic scale modelling.

Initial modelling of masterplan layout Options 1 and 3 showed unexpected increases in flood depths in some areas of Paddock Wood due to the obstruction of some of the existing overland flow paths. Inspection of the modelling revealed that some of these are very shallow flow pathways relating to surface runoff rather than fluvial flood risk, which would be expected to be managed through site drainage and landscape planning. However, including conveyance routes through residential sites, which reflect indicative localised drainage features, enables many existing flow pathways to be maintained, reducing the potential increase in flood depths in surrounding areas.

While this strategic representation of the sites and conveyance routes still shows some areas with increased flood depths, the majority of these areas are within the masterplan area. The modelling demonstrates the benefit of localised drainage measures and it is considered that more comprehensive drainage arrangements accompanied by more detailed analyses would enable the development of the residential sites outlined in Option 1 to be brought forward without any off-site increases in flood depths being predicted. On this basis it is considered that the principle of development can be supported for the layout described by Option 1 provided that appropriate provision is made for the layout of drainage and flow routes through the proposed development. These measures would need to be supported by more detailed analyses that reflected the level of design detail and evidenced that the measures were appropriate. Consideration would need to be given to the long-term management and maintenance of the mitigation measures, so these were not inadvertently compromised for the lifetime of the development.

Masterplan development Options 1 and 3 are acceptable from the perspective of not increasing flood risk to third parties. However, the smaller scale of residential development associated with Option 3 lessens changes in flood depths compared with the baseline scenario, but in places localised drainage measures still need to be considered.

The layout, form and location of the conveyance routes has been chosen to provide a strategic understanding of the implications of proposed development and should not be used as the basis to define the detailed design or geometry of the measures that will need to be included in the preparation of more detailed development layout designs. It is also possible that there are other mitigation options or measures that could be considered, and the results of the study are not intended to imply that other options would not be appropriate.

Appendices

A Masterplan Option 1 and 3 vs baseline

5% AEP: Option 1

File:
2016s4793 - Paddock Wood Option 1 minus Baseline – 5pcAEP (v2 Dec 2020).pdf

1% AEP: Option 1

File:
2016s4793 - Paddock Wood Option 1 minus Baseline - 1pcAEP (v2 Dec 2020).pdf

0.1% AEP: Option 1

File:
2016s4793 - Paddock Wood Option 1 minus Baseline - 0-1pcAEP (v2 Dec 2020).pdf

1% AEP +35% climate change allowance: Option 1

File:
2016s4793 - Paddock Wood Option 1 minus Baseline - 1pcAEP_CC35 (v2 Dec 2020).pdf

1% AEP +70% climate change allowance: Option 1

File:
2016s4793 - Paddock Wood Option 1 minus Baseline - 1pcAEP_CC70 (v2 Dec 2020).pdf

5% AEP: Option 3

File:
2016s4793 - Paddock Wood Option 3 minus Baseline - 5pcAEP (v2 Dec 2020).pdf

1% AEP: Option 3

File:
2016s4793 - Paddock Wood Option 3 minus Baseline - 1pcAEP (v2 Dec 2020).pdf

0.1% AEP: Option 3

File:
2016s4793 - Paddock Wood Option 3 minus Baseline – 0-1pcAEP (v2 Dec 2020).pdf

1% AEP +35% climate change allowance: Option 3

File:
2016s4793 - Paddock Wood Option 3 minus Baseline - 1pcAEP_CC35 (v2 Dec 2020).pdf

1% AEP +70% climate change allowance: Option 3

File:
2016s4793 - Paddock Wood Option 3 minus Baseline - 1pcAEP_CC70 (v2 Dec 2020).pdf

B Masterplan Option 1 and 3 with conveyance routes vs baseline

5% AEP: Option 1
File:
2016s4793 - Paddock Wood Option 1 Conveyance minus Baseline - 5pcAEP (v1 Dec 2020).pdf

1% AEP: Option 1
File:
2016s4793 - Paddock Wood Option 1 Conveyance minus Baseline – 1pcAEP (v1 Dec 2020).pdf

0.1% AEP: Option 1
File:
2016s4793 - Paddock Wood Option 1 Conveyance minus Baseline - 0-1pcAEP (v1 Dec 2020).pdf

1% AEP +35% climate change allowance: Option 1
File:
2016s4793 - Paddock Wood Option 1 Conveyance minus Baseline - 1pcAEP_CC35 (v1 Dec 2020).pdf

1% AEP +70% climate change allowance: Option 1
File:
2016s4793 - Paddock Wood Option 1 Conveyance minus Baseline - 1pcAEP_CC70 (v1 Dec 2020).pdf

5% AEP: Option 3
File:
2016s4793 - Paddock Wood Option 3 Conveyance minus Baseline - 5pcAEP (v1 Dec 2020).pdf

1% AEP: Option 3
File:
2016s4793 - Paddock Wood Option 3 Conveyance minus Baseline - 1pcAEP (v1 Dec 2020).pdf

0.1% AEP: Option 3
File:
2016s4793 - Paddock Wood Option 3 Conveyance minus Baseline - 0-1pcAEP (v1 Dec 2020).pdf

1% AEP +35% climate change allowance: Option 3
File:
2016s4793 - Paddock Wood Option 3 Conveyance minus Baseline - 1pcAEP_CC35 (v1 Dec 2020).pdf

1% AEP +70% climate change allowance: Option 3
File:
2016s4793 - Paddock Wood Option 3 Conveyance minus Baseline - 1pcAEP_CC70 (v1 Dec 2020).pdf