Appendix D

Economic Report

Economic Appraisal – Technical note

1 Introduction

1.1 Aims and Objectives

This appendix presents the methodology and results of the economic appraisal carried out to assess potential options to reduce flood risk in Paddock Wood, Kent.

1.2 Background

Flooding south of the railway is generally associated with heavy rainfall on the Paddock Wood Catchment, resulting in flooding from surface water and watercourses that flow south to north through and adjacent to Paddock Wood. Due to the different sources of flooding a number of options have been proposed in different locations in the catchment to prevent flooding from the different sources. This has meant that some of the options cannot be compared for incremental cost benefit comparison as they protect different areas of the town. For example options to reduce flooding from Tudely Brook protect the west of the town, whilst options to reduce flood risk from Rhoden affect the east of the town. Figure 1-1 shows where all the proposed options are located in the catchment.

Following a short-listing process, the options considered in this economic appraisal are summarised here:

- **Do Nothing** - Assumes that no maintenance or clearance is made to interfere with the natural fluvial processes or sewer network in the catchment.
- **Do Minimum** - Assumes that the catchment is maintained as currently and maintenance is sufficient to result in preservation of the drainage network throughout the assessment period.
- **Do Something Option 1** – Tudeley Brook flood storage
- **Do Something Option 2** – Prevent over land flow from Tudeley Brook to Gravely Ways Stream
- **Do Something Option 3** – Rhoden East flood storage
- **Do Something Option 4** – Reduce overland flow from Rhoden East to Rhoden West
- **Do Something Option 6** – Paddock Wood Stream flood storage
- **Do Something Option *7*** – Gravely Ways Stream right bank defence

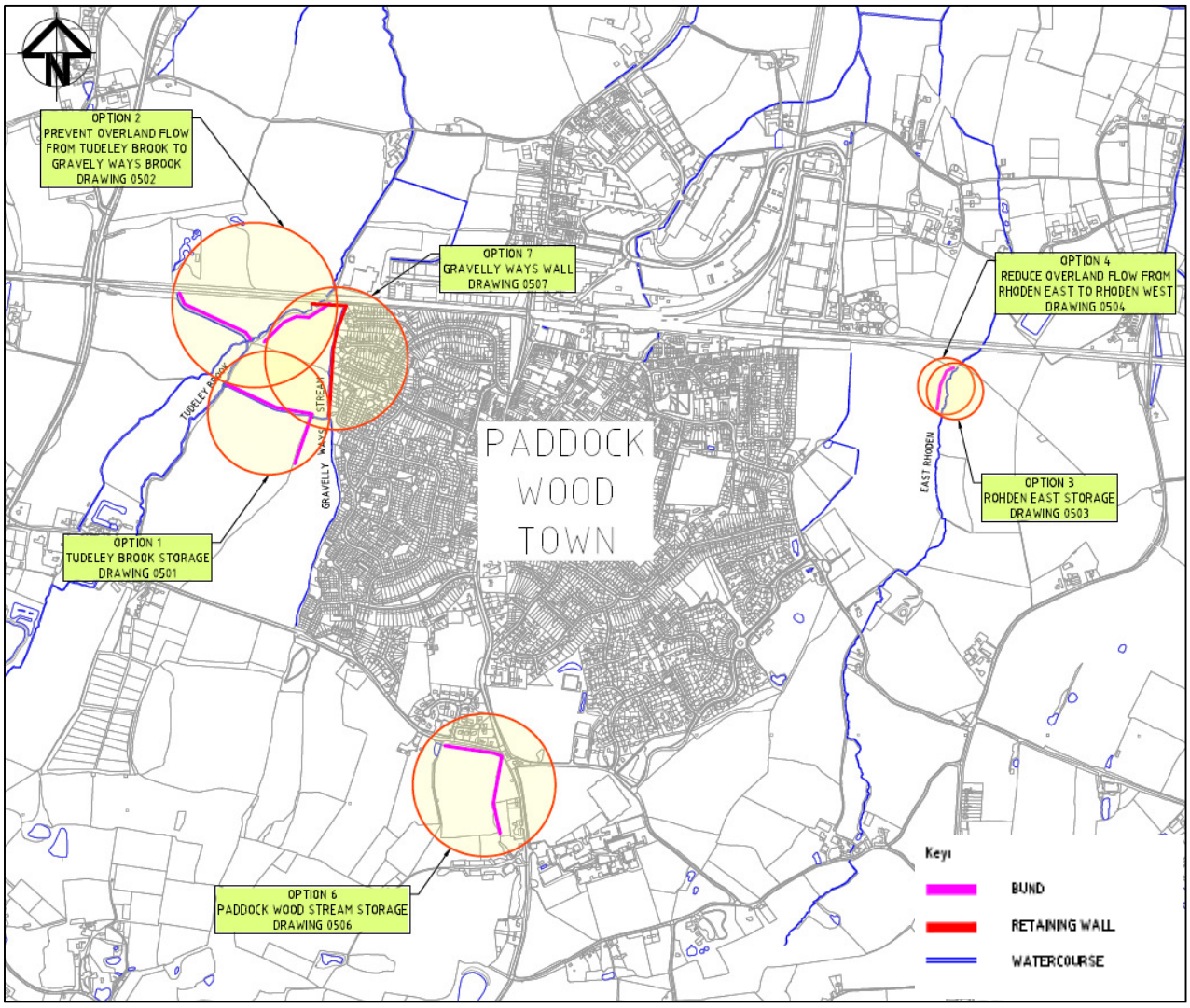

Figure Error! No text of specified style in document.**-1 Extract of the proposed options location in the catchment**

1.3 Zone of Influence

The model outputs for the do nothing and do minimum scenarios have been applied across the entire study area (i.e. to all properties). Where specific 'do something' options have been investigated, for economic analysis, the model outputs have only been applied to the area which benefit from the proposed option. This methodology was adopted to minimise errors and run times associated with running a large model for the whole catchment. For the purpose of this report we have called this specific area 'the zone of influence'.

The methodology to apply model outputs to each zone of influence is described below:

- A zone of influence was identified for each do something option by analysing the specific properties where flood depths reduced as a result of a proposed option. Using GIS software a 'cookie cutter' tool was used to cut out the area (the zone of influence) benefiting from an option in the do nothing/ do minimum maps.
- The results from the modelled do something options were transposed into each cut area or zone of influence.
- The do minimum scenario was applied to all areas outside of the zone of influence. This ensured all options were consistently compared across the study area and promoted efficiencies in the modelling and economics assessment.

A zone of influence for each do something option was developed using the methodology outlined above. Option 1 and Option 2 are located in the same geographical area and therefore the zone of influence is the same. Option 3 and Option 4 are also located in the same geographical area so again their zone of influence is the same. Option 6 and Option 7 are geographically distant and therefore have different zones of influence. Figure 1-2, Figure 1-3, Figure 1-4 and Figure 1-5 show where the zone of influences for each option are located in the catchment.

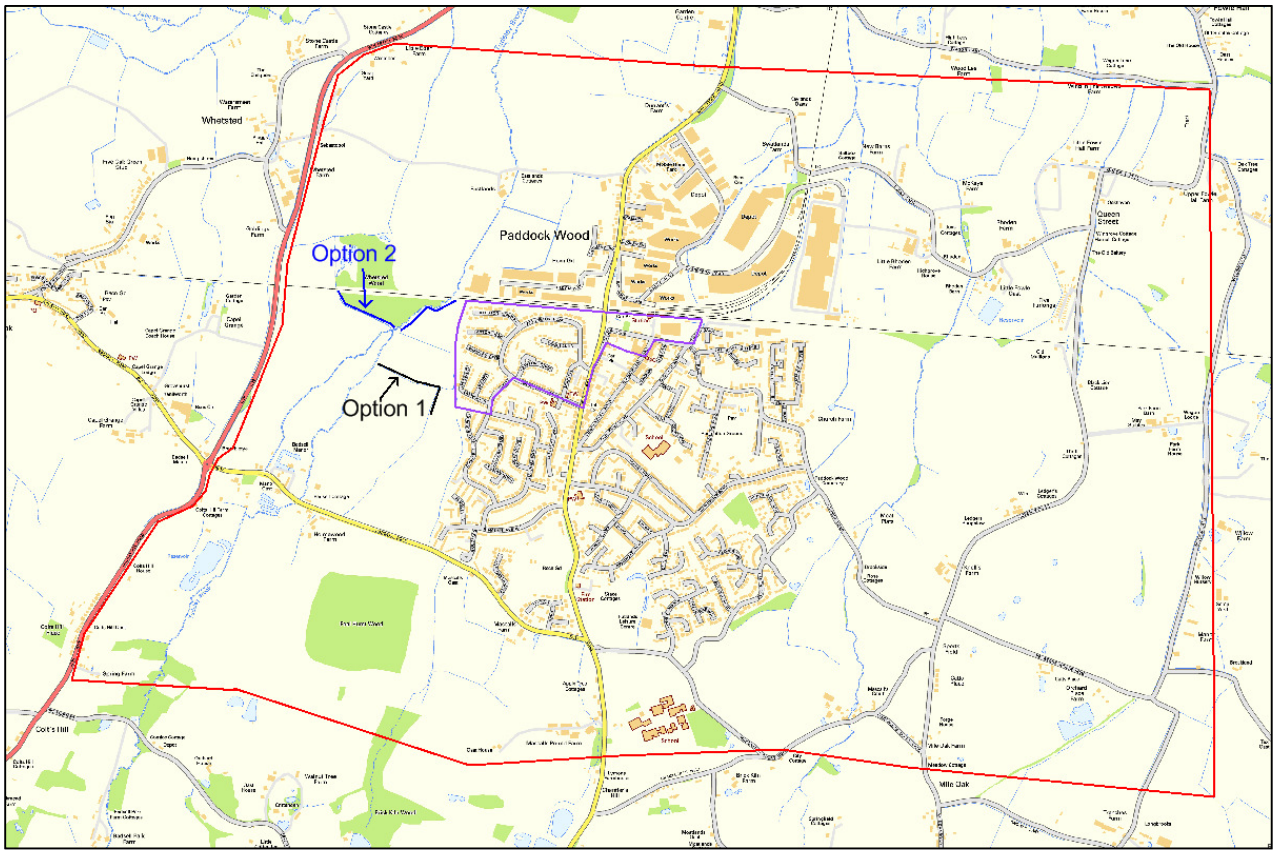

Figure 1-2 Zone of influence for Option 1 and 2

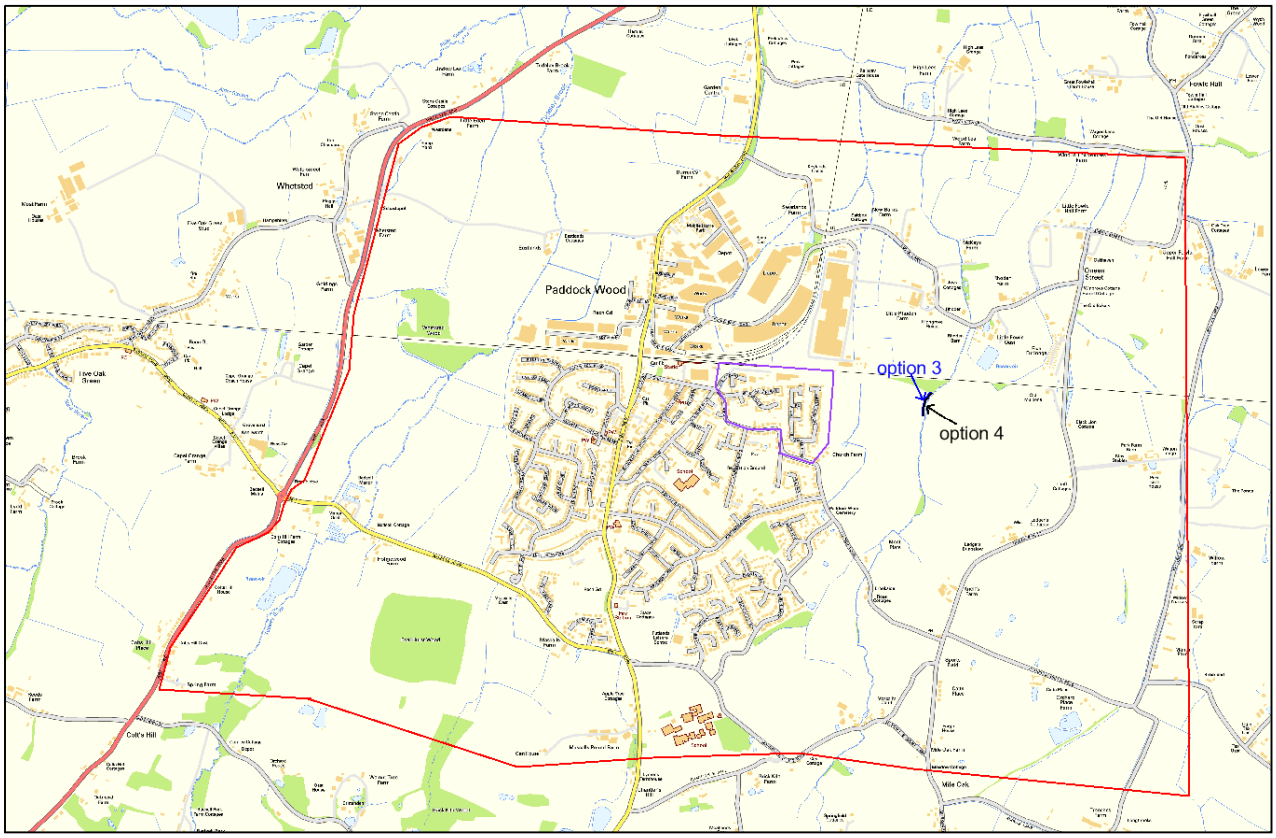

Figure 1-3 Zone of influence for Option 3 and 4

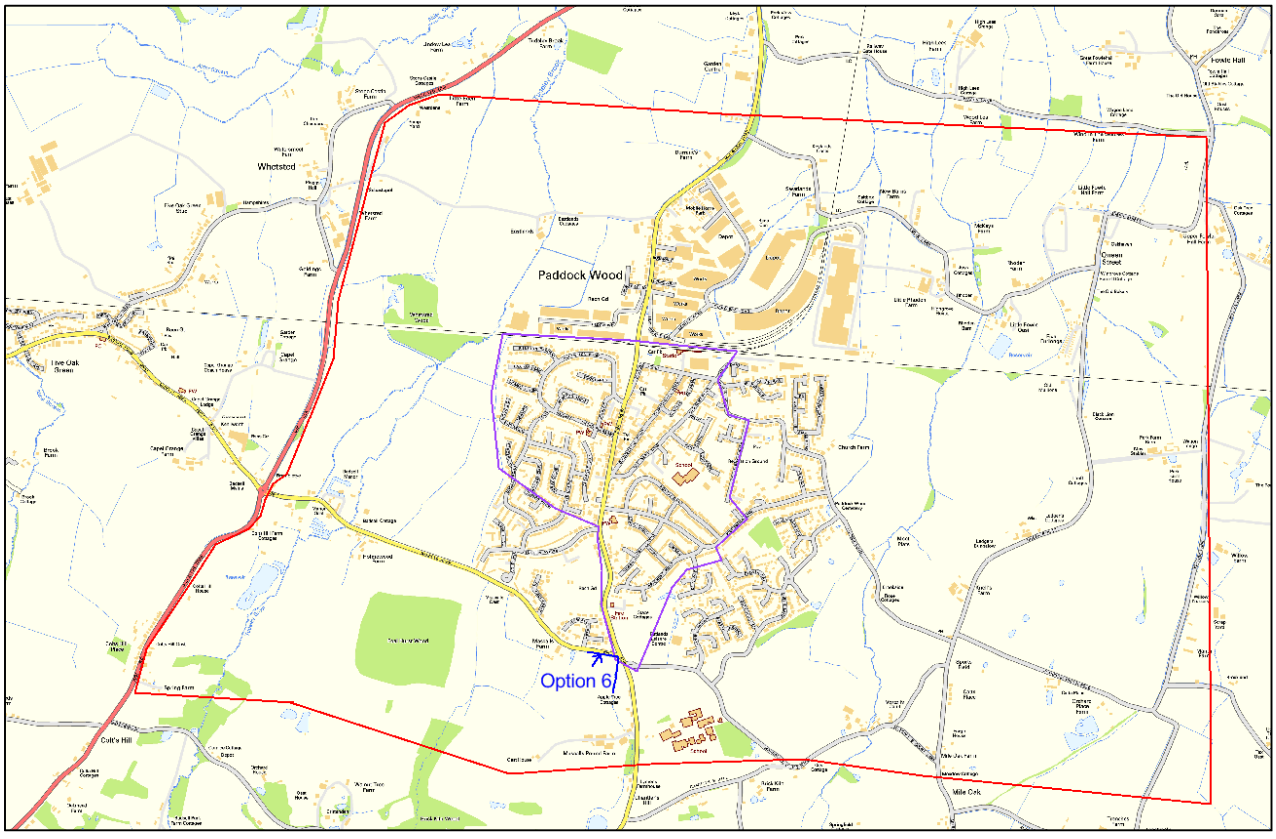

Figure 1-4 Zone of influence for Option 6

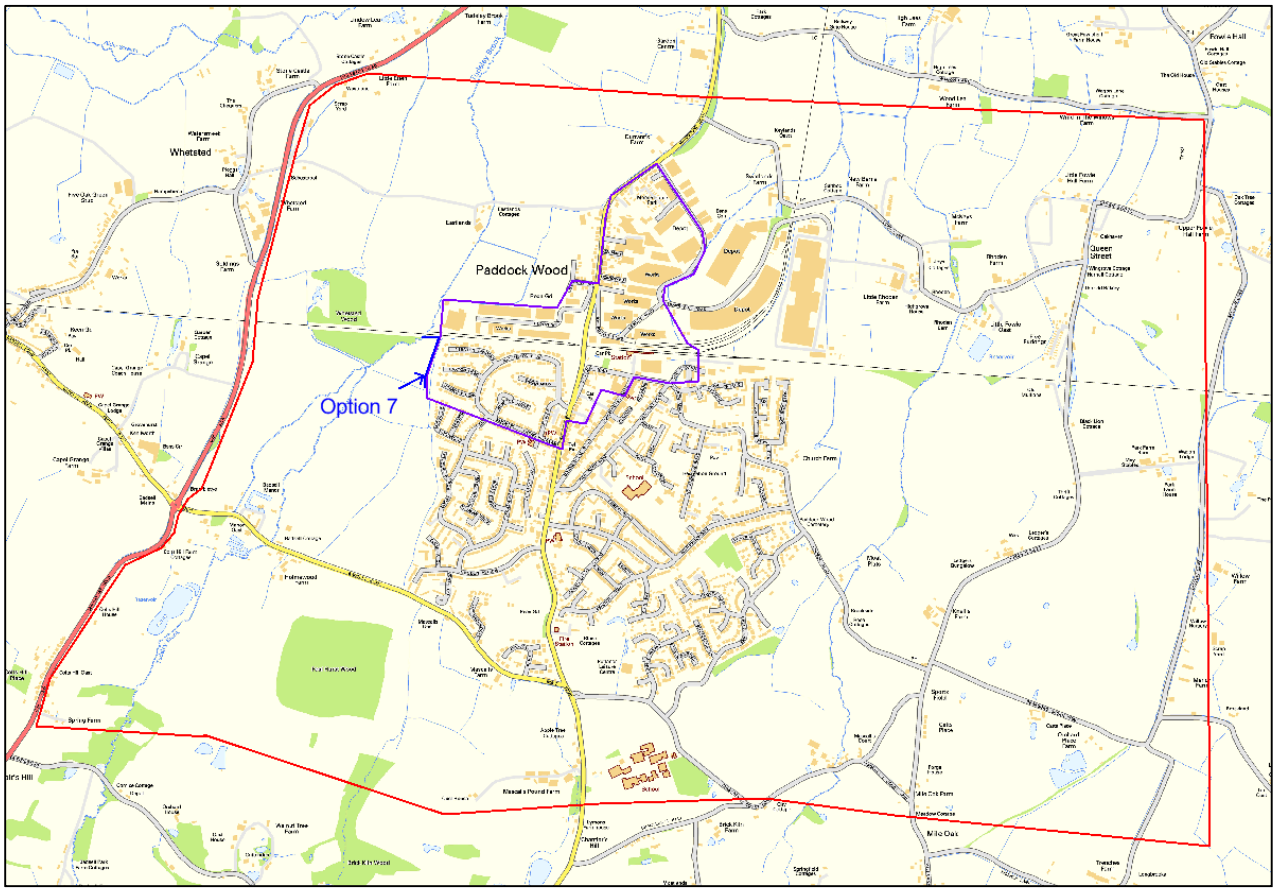

Figure 1-5 Zone of influence for Option 7

The economic appraisal was based on an ICM hydraulic model the details of which are discussed in the hydraulic modelling report found in Appendix A. The depth grids for the catchment were produced for each return period modelled (name the return periods used). Using the depth grid the depths were extracted for each NRD property point in the study area. The depth for each option used for the zone of influence and then the Do Minimum was used outside of the Zone of influence.

2 Methodology

2.1 Overview

This section provides details of the economic analysis carried out in support of Paddock Wood Flood Alleviation Study. The methodology used in this appraisal follows the principles of the recent Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG; Environment Agency, 2010a) the Multicoloured Manual (MCM; Flood Hazard Research Centre, 2005), the Multicoloured Handbook (Flood Hazard Research Centre, 2013) and the Treasury Green Book (HM Treasury, 2003).

A 100 year appraisal period has been used and future damages, costs and benefits have been discounted using HM Treasury discount rates beginning at 3.5%. The appraisal has been carried out using a base date for estimates of June 2014, the most recent date for which inflation information (based on the Commercial Prices Index, CPI) was available at the time of appraisal.

Flood damages from the MCM Handbook (price date May 2014) have been updated to the appraisal base date using CPI.

2.2 Property List

Kent County Council (KCC) provided the National Receptor Dataset (NRD) for use in this study. NRD data contains information on property type, floor area and floor level (differentiating between upper and ground flood properties, for example).

The NRD dataset includes a large number of property entries with '900' MCM codes, identified, for example, as 'electricity substations' and 'tanks'. Given the difficulties with estimating the value and assigning MCM depth-damage data to these types of 'property' within a large strategic study area, all those with '900' codes were removed from the assessment.

The NRD was mapped for Paddock Wood and properties located outside of the study area were removed from the assessment. All properties recorded as upper floor were also removed from the assessment. A total of 3,232 properties were included in the edited NRD dataset.

Property threshold levels could not be surveyed but in the modelling each threshold was assigned a standard level of 150mm above ground level. Therefore in the economics no property threshold was applied to any property.

For a large commercial property in the study area (shown in Fig 1-6) a MCM code of 210 was recorded within the NRD dataset. This is the code for general commercial properties, as the property was contributing a high percentage of the total damages Google Earth was used to verify the use of the commercial property. It was established that the property is a warehouse and therefore the use of flood damage data associated with the 210 MCM code was creating artificially high damages within the assessment. Therefore, the MCM code was changed to 410, the correct code for warehouses, to account for the current use of the property. As the property has a large GFA (19.5) and the GFA of the property is completely flooded for most of the return periods it generates large damages in the study area.

The options studied do not significantly reduce flood risk to this property.

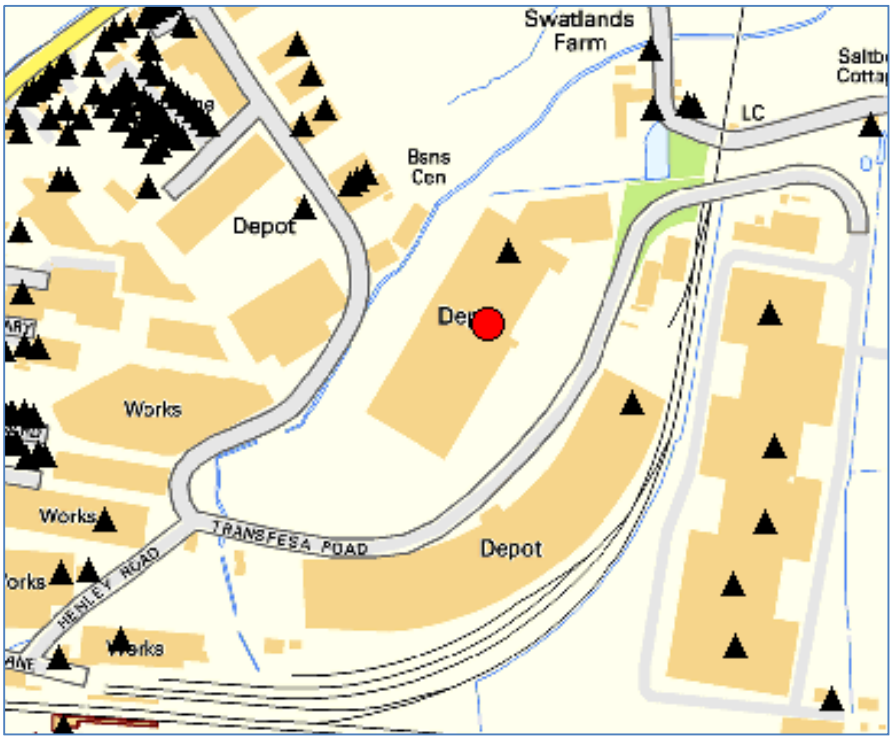

Figure 1-6 large warehouse in the catchment

2.3 Property Valuation and Capping

Properties were assigned a market value in order that individual property present value damages (PVd) were 'capped' if necessary, to prevent them exceeding that property's market value over the appraisal period. These 'capping values' were derived according to Environment Agency best practice (Environment Agency, 2008). Distributional impacts (DI) were considered, in order to remove social class bias from the property value estimates. A DI factor was calculated using Approximate Social Grade data for Tunbridge Wells Borough 001D lower layer super output area, available from neighbourhood.statistics.gov.uk. This method is presented in Table 1 below.

Table 1 – Derivation of Distributional Impact Factor, Tunbridge Wells Borough

Social Class	DI Weighting Factor	Count	%	Weighting x %
AB	0.74	23200	28.9	0.21
C1	1.12	26791	33.3	0.37
C2	1.22	10124	12.6	0.15
DE	1.64	20226	25.2	0.41
Total		80,343	100	**1.15**

Residential property valuations were based on regional average property sale prices for Paddock Wood for December 2011 (source: Land Registry), using the latest data available, multiplied by the DI factor of 1.15. This resulted in the capping values listed in Table 2 overleaf.

Table 2 – Residential Capping Values

Property Type	Capping Value including DI factor
All	£266,300
Detached	£387,500
Semi-detached	£238,333
Terraced	£229,000
Flat/Maisonette	£168,600* * This figure has been taken for values in Tunbridge Wells as there is no value in Paddock Wood

2.4 Property Damages

Property damages were calculated using the MCM depth damage data from the 2010 Multi-coloured Handbook (Flood Hazard Research Centre, 2010). Depth-damage data without basements was used. Flood duration of less than 12 hours was used in the assessment. Flood depths for individual properties were extracted using a point analysis of the modelling outputs.

Property Damages were capped if present value damages exceeded property market values.

Property annual average damages were calculated and discount factors applied to result in a single value of present value damages (PVd) for each scenario. It was assumed that present day conditions remain throughout the appraisal period. The potential for climate change to impact on the appraisal results is considered in the sensitivity section.

There is no tidal flooding in this appraisal so damages to account for the impacts of salt water were not included.

2.5 Emergency Services

Emergency services costs were incorporated in the assessment by adding 5.6% to all calculated property damages. This is as stated in the Multi-coloured Handbook, and is lower than used in previous assessment prior to 2010, reflecting the economies of scale found when providing emergency services provision to built up areas.

2.6 Assumptions

Assumption 1 – Property thresholds not surveyed across the study area, assumed that thresholds are 0.15m and there are no flooding below ground level will occur (i.e. assumed no basements).
Due to the number of properties across the study area it would not be possible to estimate threshold levels for each property. As such an assumption of a threshold level of 0.15m has been made for all properties where a survey is not possible. Furthermore it has been assumed that no damage occurs to property when the flood level at the property is below the threshold level. It is possible that flood water can still enter properties below the threshold level via airbricks but this is not considered in this damages assessment. This decision has been taken in part based on the direct rainfall modelling approach that has been applied, which means that all cells within the hydraulic model experience a depth of flooding (associated with rainfall landing on all areas modelled). In practice, this approach cannot account for the fact that sloping roofs and

drainage systems serve to direct rainfall initially away from properties, such that flooding causing damages should only occur when ponded rainfall reaches a property.

Assumption 2– Flooding in the 1 in 2 year event occurs under the Do Nothing scenario. If properties were shown as flooded under the 1 in 2 year Do Nothing scenario it was assumed that this was accurate. Based on knowledge of the existing drainage system it was thought that if the drains and culverts were not maintained, then blockages of the structures could occur and this would result in increases flooding to properties in Paddock Wood.

Assumption 3 – Zone of influences. As discussed earlier it was assumed that the do something options only reduced flood depths and provided benefit to properties in the respective zone of influence and not elsewhere.

Assumption 4 – Interpolation of flood depths for Option 2. Due to an unknown model instability we were unable to produce flood depths for the 1 in 10 event for Option 2. Flood depths used for the economic analysis for the 1 in 10 event were interpolated from the1 in 2 and 1 in 20 events. This is adequate for this study as all other results are valid.

Assumption 5– Option 4 results applied to Option 3. Due to an unknown model instability we were unable to produce flood depths for the 1 in 10 event for Option 4. As Option 3 is believed to be a relatively similar option to Option 4 for the 1 in 10 event the flood depths were taken from Option 3. This is adequate for this study.

2.7 Exclusions

The following key items were excluded from the assessment; in keeping with the approach in the FCERM-AG states that appraisal should be targeted at those items which are likely to influence the decision-making process:

Transport disruption: flooding within towns such as Paddock Wood has the potential for an impact on transport systems and networks, which could add to the economic impact of flooding. Economic consequences of transport disruption nationally is considered minimal as there are alternate routes. Therefore, the economic consequences of transport disruption have not been considered in this appraisal. If design costs increase and threaten the cost benefit, this could be reviewed.

Environmental Benefits: Consideration of environmental benefits associated with preventing surface water flooding has not been progressed in this appraisal. Whilst some environmental benefit can be attributed to surface water flooding measures such as retrofitting SUDS, they are not defined enough to include at this stage.

Risk to life: Although surface water flooding can occur rapidly and without significant warning, it is highly unlikely that depths or velocities would be observed that could lead to a measurable risk to life, as may be the case for fluvial or coastal flooding. Therefore this has not been considered further in this assessment.

2.8 Option Costs

Costs for each option were developed in the form of a capital construction costs and annual maintenance costs. The capital costs for each of the Do Something options were calculated using the sources detailed in Table 3.

The maintenance costs for Paddock Wood were provided by Medway Internal Drainage Board. The calculations of the annual maintenance costs are show in Table 3.

Table 3 –Maintenance Costs

Option	Present Value Maintenance Costs	Present Value Capital Costs	Source
Do Minimum	£9.1K	N/A	Medway Internal Drainage Board
Option 1	£9.1K	£332K	Contractor costed based on current industry rates.
Option 2	£9.6K	£319K	Contractor costed based on current industry rates.
Option 3	£9.5K	£201K	Contractor costed based on current industry rates.
Option 4	£9.4K	£164K	Contractor costed based on current industry rates.
Option 6	£9.6K	£234K	Contractor costed based on current industry rates.
Option 7	£9.1K	£625K	Contractor costed based on current industry rates.

The cost estimates reflect the high level nature of the assessment (i.e. concept design rather than detailed design). The costs are outline and provide indicative costs of the proposed works. As designs are only conceptual and additional cost allowance of 60% (Optimism Bias) has been built into the economics, to account for potential complications as design is progressed. If options are developed to outline or detained design then the estimated costs should be updated accordingly. Optimism bias of 60% has been applied to option costs, in line with HM Treasury Green Book policy, restated in 2010 in the Environment Agency FCERM-AG.

3 Results

3.1 Property Counts

The economic appraisal resulted in the following counts of properties affected by flooding. Below floor level damages have been excluded from this assessment. Within the assessment area there are 3,040 residential properties and 192 commercial properties. Table 4 presents the property counts for all options and Table 5 shows the number of properties removed from flood risk in the 1 in 30 event and the 1 in 100 event as well as the cost benefit for each option. It should be noted that a detailed break down of the construction cost can be found in Appendix A.

Table 4 –Properties accruing flood damages

Annual Probability	Annual Chance	Count of properties flooded							
		Do Nothing	Do Minimum	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7
50%	1 in 2	80	0	0	0	0	0	0	0
10%	1 in 10	146	58	59	58	59	59	58	59
5%	1 in 20	189	145	132	115	125	113	137	125
3.3%	1 in 30	230	195	180	154	170	152	187	170
2%	1 in 50	314	300	264	218	236	247	282	236
1.3%	1 in 75	364	363	339	286	280	318	343	280
1%	1 in 100	425	411	393	352	346	366	385	346

Table 5 –Cost benefit vs number of properties removed from flood risk

Annual Chance	Number of properties removed from flood risk						
	Do Minimum	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7
1 in 30	35	50	76	60	78	43	60
1 in 100	14	32	73	79	59	40	79
Total PV Costs £k	437	983	958	774	715	836	1452
Cost Benefit	56.8	27	30	35	37.9	37.7	24.4

Table 6 below presents the summary table, where present value damages (PVd) for the Do Something options are compared to generate benefits against the Do Nothing scenario. The benefit-cost ratio (BCR) is the ratio of the present value benefits provided by an option to the present value costs of providing that option. The incremental benefit-cost ratio (IBCR) compares each option to the previous option, when listed in terms of increasing cost, and indicates the value provided by an increase in expenditure. The Net present Value (NPV) is the discounted benefits minus the discounted costs.

Table 6 – Summary Table

Option number / Option name	Costs and benefits £k							
	Do Nothing	Do Minimum	Option C4	Option C3	Option C6	Option C2	Option C1	Option C7
COSTS:								
PV capital costs	0	0	164	201	234	319	332	625
PV maintenance costs	0	273	283	283	288	279	283	282
PV future construction	0	0	0	0	0	0	0	0
Optimism bias adjustment	0	164	268	290	313	359	369	544
Total PV Costs £k excluding contribution	0	437	715	774	836	958	983	1,452
BENEFITS:								
PV monetised flood damages	46,259	21,444	19,786	20,002	15,187	22,594	20,209	11,649
PV monetised flood damages avoided		24,814	26,473	26,257	31,072	23,665	26,050	34,610
HI Benefits			643	795	426	817	509	795
Total PV damages £k	46,259	21,444	19,786	20,002	15,187	22,594	20,209	11,649
Total PV benefits £k		24,814	26,401	26,277	3,962	24,482	26,559	35,404
DECISION-MAKING CRITERIA: ***Based on total PV benefits***								
Net Present Value **NPV**		24,377	26,401	26,277	30,662	27,420	25,576	33,953
Average benefit/cost ratio **BCR**		56.8	37.9	35.0	37.7	30	27	24.4
Incremental benefit/cost ratio **IBCR**			8.3	-1.1	71.6	-26	-72	18.9

It should be noted that the BCR values are relatively high. This is because in the Do Nothing scenario for the 1 in 2 event 80 properties are at risk of flooding. For all Do Something scenarios no properties are at risk of flooding in the 1 in 2 event. This is what is causing the high BCR values.

Following this economic review it is appropriate to take options forward to develop to outline and detailed design. As a minimum we recommend Options 2, 3, 6 and 7 are developed further. Option 3 as it reduces flooding to the east of Paddock Wood, Option 6 as it reduces flooding to the central area of Paddock Wood and Option 2 and 7 as they reduce flooding to the west of Paddock Wood.

Option 3 is the preferred option to the East of Paddock Wood, as the option is shown to result in present value benefits of £26,473 over the appraisal period and an average BCR of 35. This Option is more expensive than Option 4 which also protects properties to the East of Paddock Wood but it protects more properties than Option 4 which is why it is the chosen option.

Option 6 is the preferred option in the central area of Paddock Wood, as the option is shown to result in present value benefits of £3,962 over the appraisal period and an average BCR of 37.7:1. This option has been selected as it is the only option that protects some properties in the central/ south of Paddock Wood. Care would be taken not to double count properties in the Station Road area if taken forward in conjunction with other options.

Option 2 or Option 7 are the preferred options to the West of Paddock Wood. Option 7 is shown to result in present value benefits of £35,404 over the appraisal period and an average BCR of 24.4:1. This Option is more expensive than Option 1 and 2 which also protects properties to the West of Paddock Wood but it protects more properties than Option 1 and 2 and may require less maintenance, it also presents an opportunity to improve the Gravely Ways Stream trash screen (not included in costs).

3.2 Sensitivity Tests

To reflect those areas of the appraisal where assumptions were made or uncertainty was high, and to provide consequences in the decision rule applied, a number of sensitivity tests were carried out on the economic appraisal results. The sensitivity tests have been undertaken on the option with the highest BCR. These are summarised in Table 7.

Table 7 – Sensitivity Test Results

No	Sensitivity Test	Preferred Option PVb	Do Nothing (PVd)	Preferred Option. BCR
	Final Appraisal Values	**£19,786K**	**£46,258k**	**37.9:1**
1	Exclusion of human intangible benefits	**£20,002K**	**£46,259k**	**34.5:1**
2	Exclusion of emergency services	**£19,243K**	**£45,707k**	**37.9:1**
3	Exclusion evacuation costs	**£18,649K**	**£43,5207k**	**35.7:1**
4	25% increase in market value estimates for all property	**£19,786K**	**£51,464**	**45.2:1**
5	25% decrease in market value estimates for all property	**£19,786K**	**£41,054**	**30.6:1**
6	Assuming Do Nothing occurs in year 20	**£20,002K**	**£46,259k**	**34.5:1**
7	Increase costs by 50%	**No change**	**No change**	**35.0:1**

A number of inclusions, such as human intangible benefits, emergency services and evacuation costs have been incorporated. It can be seen that even by excluding significant items from the appraisal, for example excluding human intangible benefits, the preferred option is still predicted to result in £46,259k of benefits, with a benefit cost ratio of 34.5:1. Excluding emergency services and evacuation from the assessment has negligible impact and reduces the benefit cost ratio to 37.9:1 and 35.7:1 respectively. Due to the nature of flooding and the flood depths and velocities predicted within the study area it is considered that including human intangible benefits, emergency services and temporary accommodation within the assessment is appropriate.

The sensitivity analysis has shown that property prices have the greatest impact within the economic assessment. If property prices are increased by 25% the BCR increases to 45.2:1 and conversely if

property prices decrease the BCR is reduced to 30.6:1. This high level of sensitivity is due to the large proportion of properties predicted to be written off (at the risk free market value) due to erosion and frequent flooding under the Do Nothing scenario.

This assumption has been tested in the sensitivity analysis and assuming the do something scenario occurs later (year 20) results in 20,002K of damages and the BCR of the preferred option decreases to 35.0:1. It is considered appropriate that the do nothing scenario occurs in year 10.

4

4.1 Summary

This appendix has detailed the methodology and results of the economic appraisal for the surface water flooding mitigation options for Paddock Wood Flood Alleviation Scheme. The appraisal can be concluded as follows:

- Six potential options have been identified, modelled and costed for the study area. Option 1 involves Tudeley Brook Flood Storage, Option 2 involves preventing overland flow from Tudeley to Gravely Ways Stream, Option 3 involves Rhoden East flood storage, Option 4 involves reducing overland flow from Rhoden East to Rhoden West and Option 6 involves Paddock Wood Stream flood storage and Option 7 involves Gravely Ways Stream right bank defence.
- Option 1, 2 and 7 are located to the west of Paddock Wood, Option 6 is located to the south of Paddock Wood and Option 3 and 4 are located to the East of Paddock Wood.
- The FCERM-AG guidance recommends that for strategies unit rates can be used to give an indication of the scale of the costs. The estimated costs for the options should be updated when options are developed to outline design, they would need refinement for any future studies investigating similar options. Maintenance costs have been provided by Medway Internal Drainage Board.
- Property damages were calculated using the MCM depth damage data from the 2010 Multi-coloured Handbook (Flood Hazard Research Centre, 2010). Below floor level damages were excluded from the assessment and a standard 0.15m threshold level has been selected to use as the final appraisal value.
- Option 3 is the preferred option to the East of Paddock Wood, as the option is shown to result in present value benefits of £26,473 over the appraisal period and an average BCR of 35.0:1
- Option 6 is the preferred option to the South of Paddock Wood, as the option is shown to result in present value benefits of £3,962 over the appraisal period and an average BCR of 37.7:1
- Option 2 or 7 are the preferred options to the West of Paddock Wood. Option 7 (the more expensive option) is shown to result in present value benefits of £35,404 over the appraisal period and an average BCR of 24.4:1.

5 References

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