Kent County Council

Paddock Wood Flood Alleviation Study

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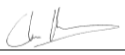
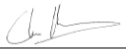
Checker	Christian Arias	
Approver	Christian Arias	
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1 NON –TECHNICAL SUMMARY

Kent County Council appointed JacksonHyder to undertake a Flood Alleviation study in Paddock Wood, Kent. This involved hydraulic modelling of the watercourses, public surface water sewers and surface water drainage of the town of Paddock Wood in Kent. A shortlist of options to mitigate flooding in Paddock Wood was developed and incorporated into the hydraulic model. The model results were then used to undertake an economic appraisal of the shortlisted options to put forward the preferred options. It should be noted that no model verification has been undertaken apart from a comparison to historical events. These compared relatively well compared to the model results.

The modelling study enhanced the existing hydraulic model produced by JBA in 2011 with the new channel survey of Paddock Wood Stream, Rhoden Stream, Alder Stream, Tudeley Brook and Graveley Way watercourse. Additional sewer network has been added in places to increase the model detail and network coverage. The model results highlight that the two highest contributing factors to flooding are the over land flows that affect residential properties in the north west and north east and the ability of the surface water network to discharge into the watercourses. The modelling study also illustrated that the flow through culverts under the railway is mainly controlled by downstream water levels. Of particular note the railway culverts on Tudeley Brook, Paddock Wood Stream and Rhoden East do not constrain flood flows. The public surface water system was shown to be surcharging in some areas of the model. Flow out of the surface water system is believed to be restricted when water levels in the receiving watercourses are high, this is especially relevant to flood risk in the areas of Allington Road and Dimmock Close.

A long list of options to reduce flood risk in Paddock Wood has been developed and discussed with Stakeholders. Then a shortlist of options were produced. The shortlisted options taken forward were selected on the basis that they had the potential to provide the most benefit to Paddock Wood. Additional modelling and an Economic assessment of the shortlisted options has been undertaken and identified several options that have a robust cost benefit that will justify capital investment. They are as follows : Option 2 (prevent over land flows from Tudeley Brook to Gravely Ways Stream), Option 3 (storage on Rhoden East), Option 6 (storage on Paddock Wood) and Option 7 (flood wall on right bank of Gravelly Ways Stream).

To manage and minimise flood risk in the future we also recommend the following in Paddock Wood:

- **Culvert improvement.** The shoring in Station Road culvert on Paddock Wood stream under the railway should be removed. It is understood that Network Rail are planning to line this culvert. The design of the liner should aim to improve conveyance, it should not reduce conveyance.

- **Maintenance and good housekeeping**. Maintenance of water courses and the surface water network is important to managing flood risk. Whilst planned and reactive maintenance is carried out by the IDB and the Environment Agency the local community should also be encourage to take responsibility for managing and reporting debris and vegetation that may affect flood flow.

Development. The Planning Authority should take a proactive stance with Developers and use the Source Pathway Receptor Model to inform the drainage plans for new development. It should not permit any additional surface water flow to enter existing systems. Paving of front gardens should not be permitted. Any new impermeable areas should manage surface water at source and not allow it to run off to adjacent land faster that it would in its natural state.

Opportunities to install sustainable drainage should be promoted wherever possible, be this new development or re-development.

2 INTRODUCTION

In January 2014 Kent County Council appointed JacksonHyder to carry out hydraulic modelling of the watercourses and surface water drainage of the town of Paddock Wood in Kent. The hydraulic model was then used to assess agreed options to mitigate flood risk. This study builds on the Level 1 Strategic Flood Risk Assessment undertaken by Scott Wilson in 2007, the level 2 Strategic Flood Risk Assessment undertaken by Scott Wilson in 2009 which focussed on flooding in Paddock Wood and the Paddock Wood Surface Water Management Plan undertaken by JBA in 2011

The modelling study enhanced the hydraulic model produced by JBA in 2011 with the new channel survey of the Paddock Wood Stream, Rhoden Stream, Alder Stream, Tudeley Brook and Graveley Way watercourse.

The project has been overseen by a Steering Group consisting of: Kent County Council (flood risk), Environment Agency (flood risk), Medway Drainage Board, Network Rail, Paddock Wood Town Council, Southern Water (surface water network) and Tunbridge Wells Council (planning).

2.1 Objective of Study

The key objectives of this study were to:

- Improve the pre-existing model to provide a better understanding of flood risk mechanisms (Main River, Ordinary Water Course, surface water sewers and surface water) and produce updated model outputs and mapping.
- Investigate potential solutions to flood risk.
- Provide evidence base and advice for future planning policy.

2.2 Terminology

Flood risk is a product of both the likelihood and consequences of flooding. Throughout this document, flood events are defined according to their likelihood of occurrence. Floods are described according to an ‘annual chance’, meaning the chance of a particular flood occurring in any one year. This is directly linked to the probability of a flood. For example, a flood with an annual chance of 1 in 100 (a 1 in 100 chance of occurring in any one year), has an annual probability of 1%.

Throughout this document the option appraisal considers a number of options. The terminology for these options defined as below:

- **Do Nothing** – This assumes that no flood protection measures are in place and is often known as the undefended scenario.
- **Do minimum** – This is the existing baseline where only the current flood protection measures are in place.
- **Do Something** – This is the term using for the Option testing where the proposed flood protection measures are in place.

2.3 Background

2.3.1 Study Area

Paddock Wood and the watercourses included in this study are shown on **Drawing (Section 7) 0010.**

Paddock Wood is situated on the Low Weald, which is a relatively flat area underlain by impermeable Weald Clay. This means that rainwater cannot easily drain as the soil is relatively impermeable so it cannot soak into the ground and the flat land means it cannot flow away quickly.

The Paddock Wood Stream flows through the centre of Paddock Wood from south to north, it is largely culverted south of the railway line. To the west of Paddock Wood are the Tudely Brook and Gravely Ways Stream and to the east are the two Rhoden watercourses, the East Rhoden and West Rhoden, these flow from south to north and are all open watercourses aside from the culverts or bridges under the railway. These local watercourses flow into the large regional rivers to the north of Paddock Wood, the Rivers Medway and Teise.

Paddock Wood is at risk from fluvial (river) flooding from these watercourses. The main rivers do not directly flood the land south of the railway line, but due to the flat nature of the land high water levels in them can reduce the rate the local watercourses drain. The local watercourses present a risk of fluvial flooding to the town both sides of the railway line. The town is also at risk from pluvial (surface water arising from non-frequent rainfall) flooding, when the amount of rainfall is too much for the sewers and watercourses to discharge quickly enough. Mechanisms of flooding are further described in Section 3.

2.3.2 Flood history

Flooding in Paddock Wood tends to be when the ground is saturated and the downstream watercourses are full (this is more likely in winter after a wet period), reducing the speed at which water falling on or entering Paddock Wood can get away.

The area to the north of the railway has been affected by flooding from the rivers Teise and Medway (flood events occurred in 1960, 1968, 2000/2001, 2013/14). Flooding has been recorded by Paddock Wood Town Council in Dec/Jan 2013/14 to the veterinary surgery in Maidstone Road and also a residential property in The Bines. Paddock Wood Town Council have also stated that the corner of Church Road, The Cedars and The Ridings floods every year but in Dec/Jan 2013/2014 the water level came within 1 inch of crossing the doorsteps. The historic flood map shows the approximate extent of flooding from these events.

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 (flood events occurred in 1999, 2000). In 2000 approximately 50 properties were flooded from Gravely Ways Stream and Tudeley Brook.

Specific historic flooding has been recorded at:

- Southern Water has records of flooding in Ribson Gardens in 1960, 1968, 1999, 2000 and 2013. Flooding is also to be believed have occurred in Woodlands in 1999. Surface water was also reported to be in a Ribston Gardens garage in 2014.

- Corner of Church Road, The Cedars and The Ridings floods which is reported to flood annually from surface water.

- In 2014 other sporadic flooding was reported, the cause of which is understood to have been blockages in ditches causing flows to go out of bank and flow overland and into properties. These are identified on the Historic Flood Map. **(Section 7, Drawing no 1100)**

3 FLOOD RISK (interpreted from model outputs)

The previous InfoWorks ICM hydraulic model, which was developed for the SWMP, was enhanced to improve the detail of the sewer and highway drainage network, river reaches, channels and structures. The topographic surface model was also enhanced and included in the updated model. Table 1 details where the new topographic survey was included in the updated model. Additional sewer network has also been added in places to increase the model detail and network coverage, including the representation of the highway drainage system.

The Hydraulic Model Build Report (Appendix A) provides a detailed description of the model and the urban catchment. This model was used to predict the flood risk to Paddock Wood from all sources of flooding.

Table 1 – Number of properties at risk of flooding at various return periods for the existing situation (various sources)

Location in Model	Watercourse	Survey provided by	Survey undertaken by	Survey completed in
River Medway to Brick Kiln Wood	Gravelly Ways Stream	The Environment Agency	Maltby Land Surveys Ltd	March/April 2013
Paddock Wood Stream – open channel	Paddock Wood Stream – open channel	The Environment Agency	Maltby Land Surveys Ltd	March/April 2013
Culverts located in the Cedars	Paddock Wood Stream	The Environment Agency	365 Environmental services	January 2009
Culverts located on Maidstone Road	Paddock Wood Stream	The Environment Agency	365 Environmental services	January 2009
Culverts located on Paddock Wood Stream	Paddock Wood Stream	The Environment Agency	365 Environmental services	January 2009
Paddock Wood Stream- From the cedars to Crossing Cottage	Paddock Wood Stream	The Environment Agency	Maltby Land Surveys Ltd	January 2012
Paddock Wood Stream- Mascalles Corner Cottage to Mascalles farm	Paddock Wood Stream	The Environment Agency	Maltby Land Surveys Ltd	January 2012
Rhoden Stream – Church Road to North of Lucks lane	Rhoden Stream	The Environment Agency	Murphy Surveys	April 2013

Rhoden Stream – Railway line to Rhoden Watercourse	Rhoden Stream	The Environment Agency	Murphy Surveys	April 2013
East Rhoden Stream	Rhoden Stream	The Environment Agency	Storm geometrics	July 2013
Tudeley Brook – From confluence with the River Medway to the B2017 Badsell Road Bridge	Tudeley Brook	The Environment Agency	Capital Surveys Limited	2013
Tudeley Brook – Knells Bottom to the Confluence with the River Medway	Tudeley Brook	The Environment Agency	Capital Surveys Limited	2005
Network rail culverts	Network rail culverts	Network rail	Amey	2013

The Source Pathway Receptor Map (**Section 7, Drawing no 0140**) shows flood routes and areas where the surface water system is surcharged as predicted by the model.

3.1 Existing situation – all sources

The 'do minimum' flood frequency map (Appendix B) shows the predicted flood extent from the updated ICM modelling for the existing situation at various return periods. This shows that approximately 400 properties are at risk in Paddock Wood from various sources during a 1 in 100 year return period. A summary of the number of properties at risk of flooding at various return periods for the existing situation (Do Minimum) is summarised in Table 2 overleaf.

An approximate description of the main sources of flood risk to Paddock is as follows:

- Tudeley Brook and Gravelly Ways Stream contribute to flooding to the western side of Paddock Wood (west of the B2160 (Maidstone Road)).
- Excess surface water from the west of the town tends to collect in a low area at Allington Road, flood risk in this area is further exacerbated from flooding arising from Tudeley Brook and Gravely Ways stream. Surface water drainage from this area drains out through Station Road, entering Paddock Wood Stream north of the railway.
- Paddock Wood Stream creates moderately low flood risk to the town, with the exception of flooding from the junction of B2160 with Badsell road, where floodwater running off the fields contributes to surface water flowing down the B2160.
- The Rhoden East and Rhoden West contribute to flood risk to the east of Paddock Wood, affecting the ability of surface water from the Dimmock Close area to discharge.

Table 2 – Number of properties at risk of flooding at various return periods for the existing situation (various sources)

Return period	10	20	30	50	75	100
Residential	52	134	178	277	333	374
Non-Residential	6	11	17	23	30	37
Total	**58**	**145**	**195**	**300**	**363**	**411**

3.2 Regional Watercourses

The Main Rivers **Teise** and **Medway**, north of the study area contribute to flood risk to the area north of Paddock Wood, and will affect the performance of the watercourses in this area. During very heavy rainfall the extent of flooding from the River Teise and Medway reaches fields along the west of Madistone Road, just north of the junction with Lucks Lane. Modelling indicates that the impact of these watercourses does not extend far enough upstream to significantly contribute to the urban area of Paddock Wood south of the railway line. However, high water levels in this area could reduce the speed at which water from Paddock Wood discharges.

3.3 Local Water Courses

Paddock Wood Stream (Main River downstream of the intersection with Badsell Road). The flood risk from the Paddock Wood Stream is minimal when it is well maintained. However it does have an indirect effect on the performance of the surface water drainage system along Maidstone Road, where water flows from the junction of Badsell Road and Maidstone Road northwards towards the railway. Highway gulley's drain some of this flow, however where land is lower than the road, surface water flows off the road and collects in low lying areas, causing some flooding as shown in the Source Pathway Receptor map. The model has identified that if water is removed from the Paddock Wood Stream by storing it upstream, that the surface water system was able drain more of this flow, so reducing flood risk remote from Paddock Wood Stream

Tudeley Brook has the larger catchment area of the two watercourses to the west of Paddock Wood. Within the study area it is tree lined and flows south to north, under Badsell Road, through relatively flat arable farmland, under the railway in a large box culvert and continues north to the River Medway. During flood events, the modelling shows water overtopping the right bank within farmland south and north of Badsell Road, this combines with rural runoff flowing both northeast and northwest and along existing field ditches and flows northwest contributing to the flood risk at Ribston Gardens and Allington Road.

Gravelly Ways Stream During dry periods Gravelly Ways Stream is dry. It reacts rapidly to heavy rain and contributes to flood risk at Ribston Gardens and Allington Road. The right bank of Gravelly Ways is typically lower, allowing water overtopping the banks to flow into residential gardens. The left bank is typically higher with undulating spoil banks (approx. 0.6m high). There are several surface water drains discharging into Gravelly Ways Stream, none of which have flap valves. The lack of flap valves will allow water to flow back up the pipes, potentially contributing to flood risk in the area. Immediately before Gravelly Ways Stream passes under the railway there is a screen that collects debris to reduce the risk of blockage in the culvert.

Should this become blocked, the flood risk to the properties will increase rapidly. The trash screen is difficult to access. However, it should be noted that the condition of the debris screen is checked and raked annually as part of the annual maintenance inspection by the Environment Agency.

Since the installation of a twin pipe culvert (in approximately 1990[1]) taking water from Gravelly Ways to Tudeley Brook there have been no reports of internal residential flooding directly from the Gravelly Ways Stream[1]. However the flood risk still exists for larger events.

There is a history of fly tipping on Gravelly Ways Stream, which increases flood risk from debris blocking the channel, debris screen and culvert. The effect of total blockage has not been modelled, but can be assumed to be similar to the 1 in 100 event flood outline.

Station Carpark Watercourse starts in the Station carpark. It has a short section of open watercourse before being culverted under the carpark and railway, then under Henley Way and into Paddock Wood Main River. It is thought to be fed solely from the surface water network. Modelling shows that surface water pools up adjacent to this watercourse and will contribute to local flooding.

If Station Road Culvert became blocked it will have an effect on the ability of surface water at Allington Road to drain away.

Rhoden West effectively commences at Church Road. The main inflows are surface water from the urban area which occurs when the drainage ponds overflow. Water flows approximately 500m into a pond that is approximately 200m east of the junction of Le Temple Road with Church Road. From here it flows north in a straight deep open channel to a 600 mm diameter concrete culvert under the railway line. Southern Water surface water network plans show that the surface water network from Dimmock Close and Le Temple Road discharges into Rhoden West culvert before it goes under the railway line. It is likely that when the watercourse is flowing full surface water from Dimmock Close and Le Temple Road is unable to effectively discharge, reducing the effectiveness of the highway gullies and increasing surface water flood risk in Dimmock Close, Ballard Way and Le Temple Road. The model has shown that some of the flooding on the Rhoden East does flow overland towards the Rhoden West during extreme rainfall events.

Rhoden East flows approximately south to north and is predominantly tree lined. Where trees fall into the watercourse, debris builds up and increases the risk of over land flow, which tends to flow towards Rhoden West. Immediately south of the existing railway is an old railway culvert. This provides a restriction to flow. During flood events water comes out of left bank to the south of the culvert and flows westwards towards the Rhoden West, so contributing to the surface water flood risk at this location. Out of bank flooding at the main railway culvert flows east and does not impact Paddock Wood town but could affect the property at the junction of the Railway line with Queen Street.

Note on Culverts

Modelling has shown that the main control affecting the ability of the culverts to discharge is the downstream water levels. Therefore increasing the size of Paddock Wood culvert would not reduce flood risk from Paddock Wood Stream. Section 3 discusses this in more detail.

Note on maintenance responsibilities

[1] Source Medway IDB

The responsibility for ensuring the unobstructed flow of water ultimately lies with the riparian owner (usually the owner of the land adjacent to the watercourse). In the case of Main Rivers the Environment Agency has permissive powers to act to reduce flood risk. The permissive powers for Ordinary Watercourses fall to the local authority or Internal Drainage Board (IDB).

In Paddock Wood the Environment Agency checks the debris screen on Paddock Wood Stream prior to and after heavy rainfall under their permissive powers.

The lower reaches of named Ordinary Water Courses listed above are maintained by the Upper Medway IDB. They carry out an annual cut of vegetation and check the trash screen on Gravelly Ways Stream following heavy rainfall.

The do minimum (existing case) and do something models assume that these are free of debris. Should debris cause a blockage, then the flood risk will increase and potentially alter the over land flow routes.

3.4 Surface water

The flood extents are shown in the Source Pathway Receptor map (**Section 7, Drawing 0140**). The maps also show where highway gullies are draining or surcharging.

3.4.1 Surface water overland flow

Within the urban area, overland flow routes tend to follow the road network, although there is some overland flow through gardens from Ringden Avenue to Alliance Way/Tutsham Way and on to Mount Pleasant, and from Forest Road on to Old Kent Road.

Badsell Road runs along the southern edge of the urban area and collects water from rural runoff originating in the fields to the south. Surface water near the junction with Maidstone Road is routed north along Maidstone Road. Overland flows are diverted off this road and into Warrington Road and Alliance Way, before continuing north, largely following the road network. Surface water in Badsell Road to the west of the junction with Maidstone Road flows into Goldings and Ringden Avenue, before pooling up in the Fuggles Close cul-de-sac. Some surface water in Ringden Avenue travels east and joins surface water travelling into Alliance Way.

A relatively large area of roof along Commercial Road generates surface water which will contribute to out-of-sewer flooding that impacts the Station Road area in larger events. Surface water in Station Road flows both east and west, the easterly pathway being larger and routing flows towards The Cedars and the adjacent small section of open channel. Surface water during more extreme rainfall is predicted to be deep enough to overtop the railway in this area and continue north into Transfesa Way.

3.4.2 Surface water drainage

Surface water drainage copes for the majority of the urban area, including most minor roads and distributor roads.

The Source Pathway Receptor map shows which gullies are surcharging and which are draining in the 1 in 100 event. (Note: most surface water drainage is designed for a 30 year event, therefore it is normal that for larger events gullies will be surcharging.)

The effectiveness of highway drainage in Dimmock Close and Le Temple Road is restricted due to high water levels at the outfall into Rhoden West, as discussed in Section 2.3

3.5 Constraints affecting flood risk

The following summarise the main constrictions affecting flood risk.

3.5.1 Surface Water Network Capacity

There are a number of lengths of the public surface water network which has been predicted to be under capacity. These have not been verified and have been passed to Southern Water to review against their records.

3.5.2 Culverts

In general the culverts under the railway do not increase flood risk. The performance of the main culverts under the railway is as follows:

- **Gravelly Ways Stream Culverts** – Reasonable capacity during frequent rainfall to accommodate Gravelly Ways Stream flows but becomes overwhelmed by flooding from the adjacent Tudelely Brook.
- **Station Road Culvert** – The 1,250mm dia. box culvert section of the Station Road culvert is slightly under-capacity, although not expected to significantly affect flooding upstream.
- **Rhoden West Railway Culvert** – This culvert becomes overwhelmed by surface water originating from Dimmock Close and overland flows from the Rhoden East, during more extreme rainfall. The performance of this culvert is also likely to be affected by the high ground water table that is thought to be present in this area, as well as high downstream levels.
- **Rhoden East old railway culvert** – Predicted to have insufficient capacity to pass fluvial flows greater than a 1 in 10 year event. This is south of the existing railway. The current railway culvert for Rhoden East has adequate capacity.
- The model shows that Paddock Wood and Tudeley Brook culverts have adequate capacity.
- It is important that all culverts are kept free of debris.

3.5.3 Landform

Existing topography affects the flow of surface water and out of bank flows. Of particular note is the line of the old railway in the Rhoden catchment, which forms a slight embankment which can be utilised for flood storage and the spoil bunds left bank of Gravelly Way, which are higher than the gardens on right bank and will act to increase flood risk to the properties, especially if the trash screen became blocked. If any of the bund options are taken forward a geotechnical ground investigation is recommended. An initial assessment has been made using public data provided by the British Geological Survey which has identified that the area is underlain mainly by Tunbridge Wells formation sandstone and siltstone with superficial deposits of River Terrace clay and silt.[2]

It should be noted that the urban area has not been surveyed in detail. The model uses LiDAR and OS Master Map to model the general topography. This is of sufficient detail to identify options to reduce large scale flood risk, but can result in local discrepancies being shown on the

[2] http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html

flood risk maps. This is of particular note where kerb lines or vegetation influence local flow direction and ponding. Some of these discrepancies are discussed below.

- Staces Cottages (behind the fire station in Station Road) are not shown on the flood map but have had problems for the last few years. In this case the model schematisation of road curbs across the catchment results in the majority of overland flows travelling north along the B2160, bypassing this area. Local inspection identifies small variations in the height and presence of road curbs that could substantially affect overland flows affecting the Staces Cottages. Such fine detail can't be explicitly modelled without local detailed topographic surveys.

- Corner of Church Road, The Cedars and The Ridings floods every year but is only predicted to flood in a 1 in 10 year event according to the model. It is thought this could be where there are localised blockages on the Rhoden West or condition issues which are not modelled.

- There is a broad band of land flooded on the Church Farm land, adjacent to railway line every winter, wider than that shown on the map. This area may be liable to ground water flooding, restricted by the presence of the railway. The model does not account for ground water flooding. It is also possible that the performance of the Rhoden may have been less than modelled due to local blockages / condition issues. Vegetation causing blockage in the Rhoden was removed in August 2014.

The Environment Agency have produced flood maps which shows their assessment of the likelihood of flooding from rivers based on the presence and effect of all flood defences in Paddock Wood. The Environment Agency flood maps may differ from the maps produced for this study as this study also includes the surface water drainage system as well as the local watercourses,

3.5.4 Other

The effect of the following features should also be noted:

The twin culvert from Gravelly Ways Stream to Tudeley Brook (entrance close to where public footpath crosses the stream). This was installed to reduce flood risk from Gravelly Ways by diverting water down a new twin culvert under the field. Since its installation no flooding from Gravelly Ways has been recorded.

The drain from Tudeley Brook going north-west to a small railway culvert has become silted up and is now heavily vegetated. It does not provide an effective flow route.

Surface water from the industrial area to the north may affect the downstream levels. Whilst modelling did not identify any direct links to flooding, it is likely that rainwater from the impermeable surfaces in the industrial area flows directly into the water course, which during a large event could affect the ability of the culverts under the railway to discharge effectively.

There are two trash screens in Paddock Wood (on Gravelly Ways Stream and Paddock Wood Stream, upstream of the railway), if these become blocked during a rainfall event upstream water levels will rise and potentially lead to flooding. Of greatest concern is the trash screen on Gravelly Ways Stream which is difficult to access and clear. If it became blocked water would flow over right bank and across gardens, and potentially cause flooding to properties.

4 OPTIONEERING

This section discusses the options that were considered to alleviate the flooding. Section 3.1 provides a summary of all options considered. Section 3.2 summarises the benefits of six options that were taken forward to economic analysis.

4.1 Long list of options

As summarised in Table 3 a long list of options was considered and discussed with Stakeholders. The shortlisted options taken forward were selected on the basis that they had the potential to provide the most benefit. An asterisk indicates the options that were taken forward for economic assessment and the comment column indicates the options benefits.

Table 3 –Summary of long list of options

Water course	Option	Comment
Tudeley Brook* (Option 1)	Storage	Modelling to inform benefits of storage.
Tudeley Brook* (Option 2)	Prevent over land flow from Tudeley to Gravely	Model demonstrated significant overland flow between Tudeley and Gravely on high order events. Modelled the effects of a bund placed to avoid this transfer of flow. This also required enhancing a channel to take flows through a separate existing railway culvert to the west of Tudeley Brook culvert.
Gravelly and Tudeley	Land West of Maidstone Road identified development opportunity	Development not progressing at this time. Land is at partial flood risk.
Gravelly Ways Stream	Remove bund on left bank	Baseline model to inform potential benefits. Not taken forward as a modelled option, as minimal benefits identified from the detail in the available topographic survey, however good practice would be to remove the bund.
Gravelly Ways Stream* (Option 7)	Place bund/wall on right bank	This option was modelled and identified good benefits. However, access restrictions from gardens to be considered in detailed design, along with requirements of network rail to avoid water being stored against their embankment.
Gravelly Ways Stream	Provide overland flow route to Tudeley Brook	The model shows greater flood risk from flows coming out of Tudeley into Gravelly. Option not considered further. IDB commented that existing twin culvert bypass works well (no reported flooding since bypass put in).
Gravelly Ways Stream	Improve railway culvert	Not taken forward. This option was discounted on 1st April because hydraulic modelling has not shown this railway culvert as causing major restrictions as previously though. However debris collecting on the trash screen will increase the flood risk significantly. It is believed that this option would be very expensive and provide little benefit.
Gravelly Ways Stream	Place flap on downstream face of culvert and surface water pipes (and Tudeley bypass) to prevent / reduce back flow	Not modelled. No flaps currently known of. Southern Water could consider flaps to prevent back flow if appropriate. If right bank wall built flaps would definitely be required.

Gravelly Ways Stream	Upstream Storage	Baseline modelling did not identify any benefits so this was not taken forward as option.
Gravelly Ways Stream	Improve conveyance downstream	Option not taken forward. Baseline modelling suggests that this would not reduce flood risk upstream, as conveyance greatly influenced by flat, flashy nature of topography (ie improved maintenance and channel widening would not significantly reduce flood risk)
Station Car park	Increase culvert size Station Road Culvert.	Only modelled to assess effect on flood risk upstream, effect of increased flood risk downstream not assessed. No notable change upstream. No cost benefit carried out for this option. Model assumes that blockage (shoring inside the culvert) is removed. It is recommended that the shoring in culvert is removed or investigated further.
Station Car Park	Surface water storage	Baseline modelling did not identify any benefits of storage at this location and this option was not taken forward.
Station Road	Commercial Road West – Development opportunity	This development now reduced in size. Not considered further as part of this study. Any future development at this site should promote sustainable drainage as good practice.
Paddock Wood* (Option 6)	Upstream Storage	This option was modelled and identified some economic benefits (though less than other options).Consideration should be given to taking this option forward in combination with other options.
Paddock Wood (Option 5)	Improve railway culvert Improved conveyance (reduced friction by lining)	This option was modelled by duplicating the existing culvert, effectively doubling the capacity. There was no notable difference in upstream flooding, indicating that flooding water levels are dictated by the flat topography downstream. Therefore this option was not taken any futher.
Paddock Wood	Increase culvert size Paddock Wood Culvert	This option was modelled. There was no notable difference in flood extent as illustrated in Figure 3.1 and Figure 3.2. Indicating that flooding the water levels are dictated by the flat topography downstream.
Paddock Wood Stream	Land at Mascalls farm – development opportunity	Baseline model identifies an overland flood route across this land. Any development should not place obstacles in the way of the natural flood route, or should manage potential water flows effectively.
Paddock Wood Stream	Improve conveyance down stream of railway	Not taken forward. Baseline model suggests that this would not offer cost beneficial improvements due to flat nature of topography. Channel should be maintained to allow efficient flow.
Rhoden Stream	Upsize Rhoden West Culvert	Only modelled to assess effect on flood risk upstream, effect of increased flood risk downstream not assessed. No cost benefit carried out for this option. This option does reduce flood risk in the area of Dimmock Close, but increases flood risk to High Lees Farm and land adjacent to Wagon Lane. Approximately 47 properties south of the railway benefit from reduced flood risk, however this option was not taken forward to the short list due to other options (option 3 and 4) being more beneficial and not increasing flood risk as much downstream.

Rhoden Stream	Increase storage (increase channel width)	Baseline model indicates that widening Rhoden East would have no benefits. This option was not taken forward for modelling.
Rhoden Stream* (Option 3)	Storage	Option to store water on Rhoden East reduced flooding at Dimmock Close.
Rhoden Stream* (Option 4)	Remove old railway arch on Rhoden East and prevent flow to Rhoden West	This option reduced flood risk to Dimmock Close but did increase flood risk slightly down stream.
Rhoden Stream	Little Rhoden Farm – development opportunity	The baseline model identifies small areas of flood risk. If development was promoted here, the flood risk should inform the drainage of the area and where development is constructed. Sustainable drainage (ideally managing surface water at source via bio retention features) should be promoted in any future development. An increase in surface water discharge off this area should be prohibited.
Rhoden Stream	Land at Church farm – development opportunity	The information provided by Rydon Homes for their proposed development, identified three storage ponds to the north of the site. No detail of how these would work was presented and ineffectiveness of storage ponds by silting should be taken into account. It is unlikely that they would reduce flood risk to the existing community and may encourage flow from Rhoden East to Rhoden west – so increasing flood risk. To reduce flood risk to existing community flow from Rhoden East to West needs to be prevented and storage should be upstream of the surface water network outfall, to allow Rhoden West to accept flow from the surface water network.
Rhoden Stream	Land off Mascalls Court – development opportunity	The baseline model identifies flooding along the line of existing field drains. With some shallow overland flow during larger events. Any development in this area should consider surface water management at the start of its master plan to ensure it is sufficient to not cause flood damage to properties or infrastructure. Sustainable drainage (ideally managing surface water at source via bio retention features) should be promoted in any future development. An increase in surface water run off in this area should be prohibited.
Surface water	Allington Road and Ribston Gardens and Station Road	Flood risk in this area arises from the urban area to the south and from Tudeley Brook and Gravely Ways Stream. Evidence suggests that the surface water network performs slightly better than shown (as less flooding reported that model indicates). Community led improvements could be considered to reduce surface water load on the network (prevent further increase in impermeable area, encourage bio retention features and use of water butts wherever new work proposed).
Surface water	Dimmock Close – increase SW drain	Increasing the size of the surface water drain is unlikely to reduce flooding as the main constriction to flow is at the outfall into Rhoden West. Flood risk in this area arises from the urban area to the north of Warrington Road and from water from Rhoden East and Rhoden West reducing the ability for the surface water network to discharge. Consider promoting community led improvements (prevent further increase in impermeable area, encourage

		bio retention features and use of water butts) to reduce the load on the surface water network (not modelled)
Surface water	Retrofit SuDS: green lane/ hunters chase	This area does not contribute to the primary flood risk and therefore benefits would be minimal. Surface water from this area discharges into a community owned Suds feature before entering Rhoden West, which then flows through another attenuation pond before entering the final channel towards the railway.
Surface water	Manage run off – roads (kerb raising, sleeping policemen, suds features)	The modelling identifies roads as primary flood routes. This is not a major problem other than where water flows from the road into properties. At such locations minor modifications to road / kerb and gulley location should be made to discourage flow towards properties.
Surface water	Manage run off – buildings	Where ever modifications are being made, incorporation of a SUDs feature (eg bio-retention feature) should be made as good practice. Promote community led improvements (not modelled)
Surface water	Proactive Planning Policy (new build, extensions, driveways)	Any increase in impermeable area should be prohibited. Any new development or modifications should be encouraged to reduce the contribution to surface water runoff.
Surface water	Additional gulley's	The source pathway receptor map identifies gullies that are draining and surcharging, along with over land flow routes. No obvious locations for additional gullies have been identified from the modelling. Future local reports of flooding should be investigated and if appropriate additional gullies considered as required.
Surface water	Design for exceedance (managed overland flows)	The source pathway receptor maps identifies over land flood routes. Other than the options considered to prevent surface water entering the urban area there are few options to set aside area for exceedance flows. The car parks adjacent to station road could be considered in future plans as they are natural storage areas at time of flooding. The roads that act as surface water flood routes should also be identified in the flood risk management plan.
Surface water	Incorporating SuDs in traffic calming measures	Not considered as part of this study, however, incorporation of bio-retention features should be considered as part of any future traffic calming measures.
Surface water	Surface Water Proactive Planning Policy	Should encourage developers to reduce the contribution to surface water runoff
	Property level resilience	Property level grant could be considered for lone properties that incur regular flooding.
	Pumping	Not to be taken forward (costs)
	Monitoring/warning	Potential for remote monitoring of trash screens to inform when they need clearing.
	Raise awareness – community improvements (water butts, driveways, water gardens etc)	Improve community knowledge – eg effects of paving front gardens and discarding of garden / other waste near watercourse
	Drain Maintenance	Recommend KCC share source receptor path ways plan with drainage partners to help inform maintenance and emergency response plans.

	Links to sewer flooding	Not considered as part of this study. Mapping output could be used to identify potential links.
	Impact of Teise and Medway on Paddock Wood	Modelling concluded that the Medway and Teise did not affect flood risk south of the railway.

Note: all models assume that culverts and channels are free of debris. Should debris cause a blockage, then the flood risk will increase and potentially alter the over land flow routes.

Increase culvert size Paddock Wood Culvert. Figure 3.1 shows the difference in flood extent for the 1 in 50 event for the Paddock Wood culvert capacity as is and the Paddock Wood culvert capacity doubled. Figure 3.2 shows the difference in flood extent for the 1 in 100 event for the Paddock Wood culvert capacity as is and the Paddock Wood culvert capacity doubled. The figures illustrate that the flood extent for the two events is the same. For the 1 in 50 there are some improvements around the car park but it's limited to around 200mm during a 1 in 50 year event and it will not prevent flooding or reduce the overall extent. For the 1 in 100 there is no difference in flood extent or flood levels. It is believed that for the higher return periods the water levels are dictated by the flat topography downstream of the culvert which is why upsizing the culvert has had no impact on flood levels.

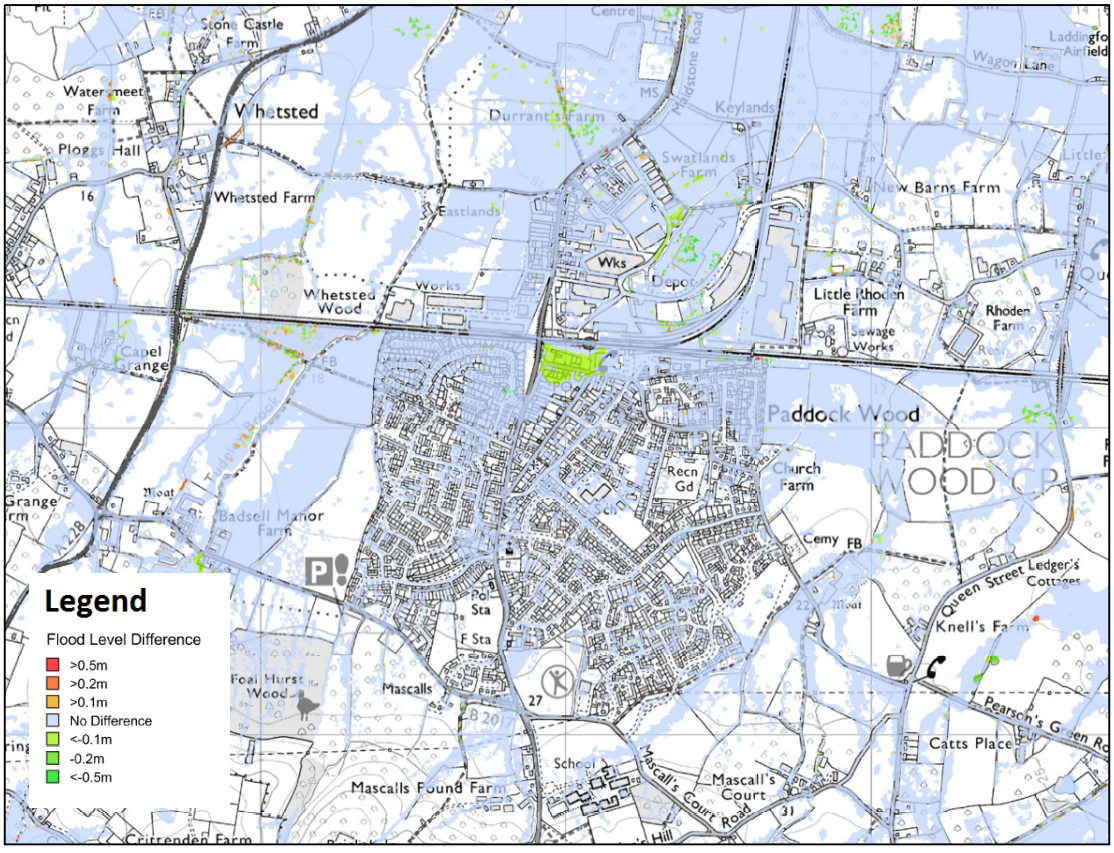

Figure 3-1 The Difference in flood extent for the 1 in 50 event for the Paddock wood culvert capacity as is and the Paddock Wood culvert capacity doubled

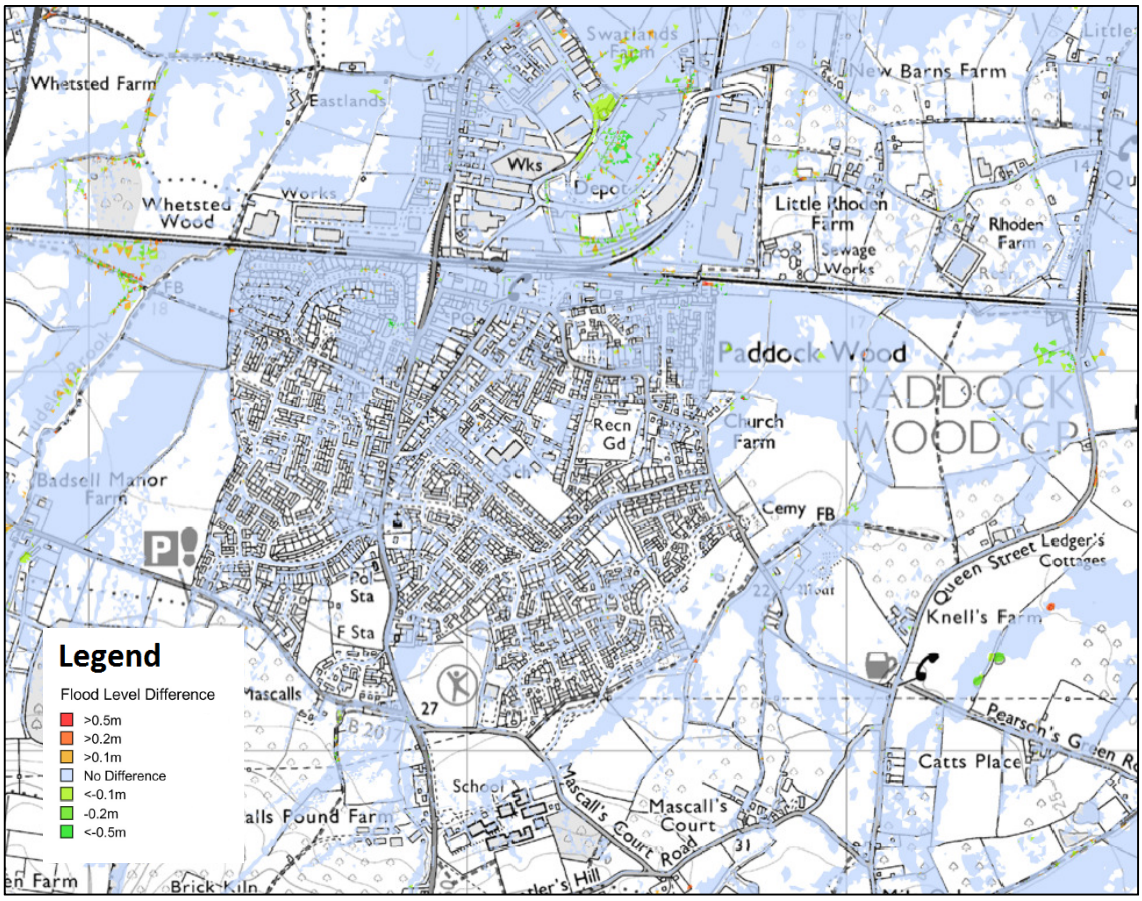

Figure 3-2 The Difference in flood extent for the 1 in 100 event for the Rhoden culvert capacity as is and the Rhoden culvert capacity doubled

Increase culvert size Rhoden Culvert. Figure 3.3 below shows the difference in flood depth for the 1 in 50 event for the Rhoden culvert capacity as is and the Rhoden culvert capacity doubled. Figure 3.4 shows the difference in flood depth for the 1 in 100 event for the Rhoden culvert capacity as is and the Rhoden culvert capacity doubled. The figures illustrate that the for the 1 in 50 and 1 in 100 there are some improvements around the Dimmock Close but it's limited to around 100mm and it will not prevent flooding or reduce the overall extent. It is believed that for the higher return periods the water levels are dictated by the flat topography downstream of the culvert which is why upsizing the culvert has had no impact on flood levels.

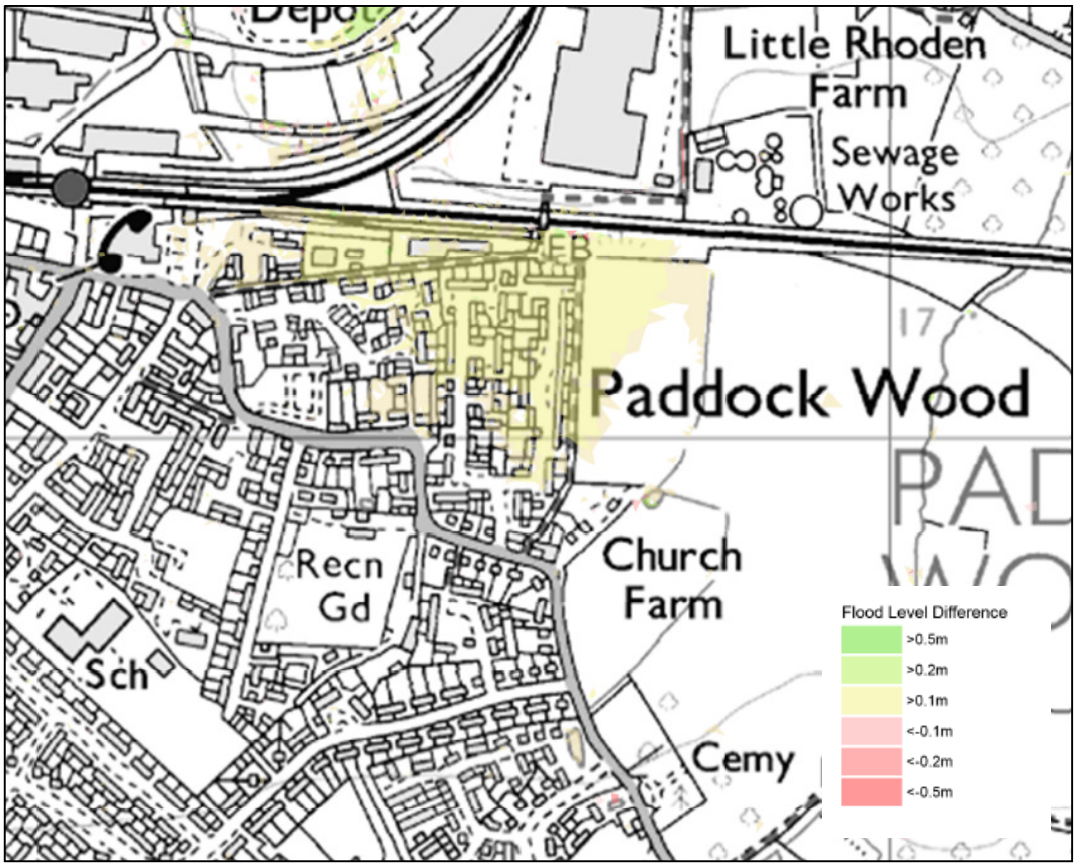

Figure 3-3 The Difference in flood depth for the 1 in 50 event for the Rhoden culvert capacity as is and the Rhoden culvert capacity doubled

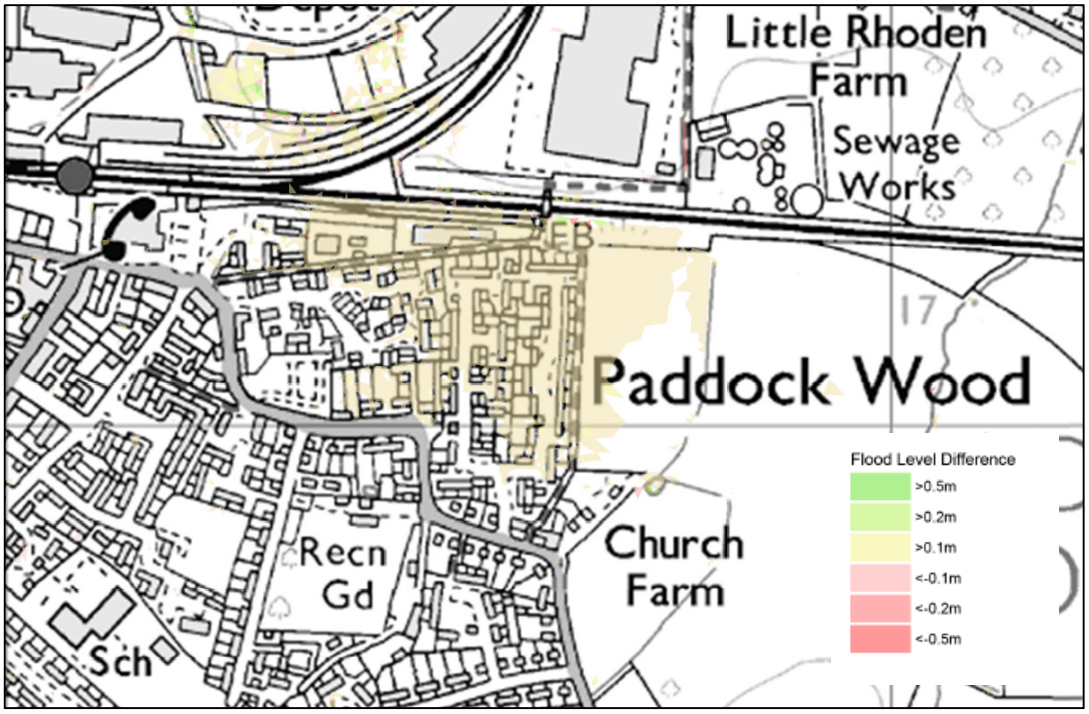

Figure 3-4 The Difference in flood depth for the 1 in 100 event for the Rhoden culvert capacity as is and the Rhoden culvert capacity doubled

4.2 Short List Options modelled and their benefits

- **Do Nothing** – this uses the present assets but assumes that no maintenance or clearance is undertaken on the drainage assets or watercourses in the study area, to simulate a scenario where the appropriate authorities do not exercise their powers. This involved assuming that up all the major culverts in the study area including the Paddock Wood culvert, Station Road culvert, Rhoden West culvert and Tudeley Brook culvert are not maintained an therefore water does not flow as fast though them.

- **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.

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

- **Do Something Option 1** – Tudeley Brook flood storage
- **Do Something Option 2** – Reduce overland flow from Tudeley Brook to Gravelly Ways
- **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 Wall

Please note that Option 5 was to improve conveyance by lining Paddock Wood culvert but was not taken forward as the modelling work showed that this had minimal impact on flood exents and water levels.

Figure 3.5 and the text overleaf summarises the benefits of the six options taken forward for economic analysis. These were selected after reviewing the results from initial modelling which indicated they had the potential to provide the most benefits.

Note: These are concept designs only, to allow modelling of the options for economic purpose. Further investigation and consultation is required to develop outline designs to qualify for funding bids.

Appendix B contains the flood frequency maps for each option

Appendix C contains the concept design for each option.

Appendix D includes the economic summary tables and cost build up for each option.

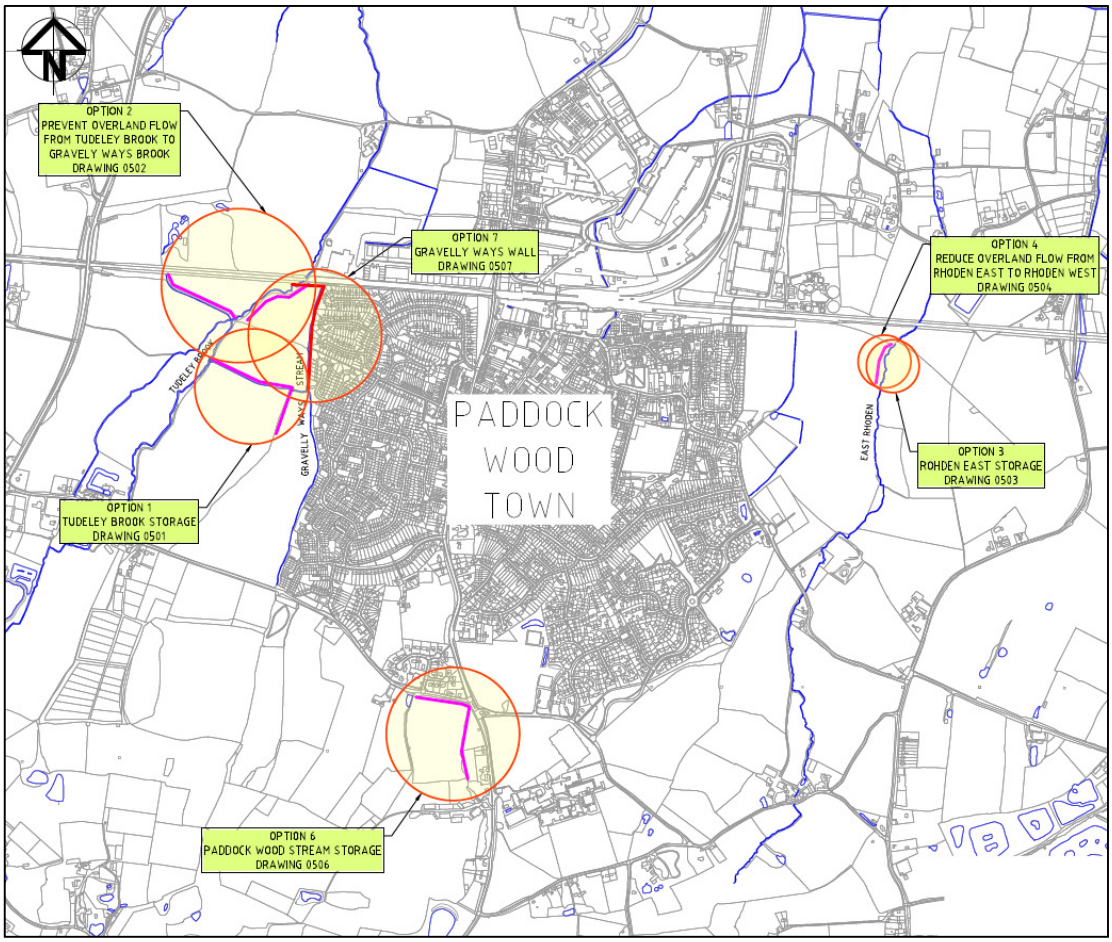

Figure 3-5 Extract of the proposed options location in the catchment

It should be noted that Option 1 and Option 2 provide benefits to the same geographical area and therefore only one of these could be taken forward (as they defend the same properties they cannot be used in conjunction to gain a joint benefit). Similarly Option 3 and Option 4 are located in the same geographical area so again only one could be taken forward. Option 6 and Option 7 are geographically distant and therefore have different zones of influence and both could be taken forward.

4.2.1 Option 1 – Tudeley Brook Storage

This option has a cost benefit of 27. It reduces flood risk to 32 and 50 houses in a 1 in 100 and 30 event respectively. It comprises of construction of an earth bund on land to the west of Paddock Wood, as well as construction of two flapped culverts as illustrated in Appendix C, Drawing 0501.

This bund collects surface water flow from the south west, reducing flood risk to the Ribston Gardens, Allington Road and Station Road areas.

If this option is taken forward then a service search, ground investigation and an environmental scoping is required to inform the outline design. As this option includes removal of trees we also recommend that a landscape and visual impact assessment, and ecology and nature conservation assessment (especially for reptiles and bats) is carried out.

4.2.2 Option 2 – Reduce overland flow from Tudeley Brook to Gravelly Ways

This option has a cost benefit of 30. It reduces flood risk to 73 and 76 houses in a 1 in 100 and 30 event respectively. It comprises construction of earth bunds, redefining draining ditches and constructing a flow control structure to prevent flow from Tudeley Brook entering Gravelly Ways Stream as illustrated in Drawing 0502, Appendix C.

This option prevents over land flow from Tudeley Brook entering Gravelly Ways Stream, reducing flood risk to the Ribston Gardens, Allington Road and Station Road area.

If this option is taken forward then a service search, ground investigation, landscape and visual impact assessment (for tree removal and public footpath), and environmental scoping is required to inform the outline design. An ecology and nature conservation assessment (esp for reptiles and bats) may also be required. This option results in more flood water adjacent to the railway embankment so early consultation with Network Rail is advised to inform outline design.

4.2.3 Option 3 – Rhoden East Flood Storage

This option has a cost benefit of 35. It reduces flood risk to 79 and 60 houses in a 1 in 100 and 30 event respectively. It comprises construction of an earth bund on left bank of Rhoden East that ties into the old railway culvert. Consideration should be given to including a defined area along the crest of the old railway embankment to control overtopping flow. This is illustrated in Drawing 0503, Appendix C.

This bund stores water from Rhoden East and prevents some over land flow from Rhoden East overloading the Rhoden West. It reduces flood risk to properties in the area of Dimmock Close and Le Temple.

If this option is taken forward then a service search, ground investigation and environmental scoping is required to inform the outline design. An ecology and nature conservation assessment may also be required.

4.2.4 Option 4 – Reduce overland flow from Rhoden East to Rhoden West

This option has a cost benefit of 37. It reduces flood risk to 59 and 78 houses in a 1 in100 and 30 year event respectively. It is similar to Option 3 and comprises constructing an earth bund on left bank of Rhoden East that ties into line of the old railways culvert, which in this case is removed. This is illustrated in Drawing 0504, Appendix C. Consideration should also be given to including a defined overtopping area along the crest of the old railway embankment to control overtopping flow and reduce erosion.

This bund stores water from Rhoden East and prevents over land flow from Rhoden East overloading the Rhoden West. It reduces flood risk to properties in the area of Dimmock Close and Le Temple. It does increase flood frequency slightly down stream and at the property adjacent to the railway on Queen Street.
If this option is taken forward then further work is required to understand and mitigate the downstream effects. It will also require a service search, ground investigation and environmental scoping to inform the outline design. An ecology and nature conservation assessment may also be required.

4.2.5 Option 6– Paddock Wood Stream Flood storage

This option has a cost benefit of 37. It reduces flood risk to 40 and 43 houses in a 1 in 100 and 30 year event respectively. It comprises construction of earth bunds and a flow control structure

to control the flows from upstream and the storage area into the downstream culvert. This is illustrated in Drawing 0506, Appendix C.

This bund stores water from Paddock Wood Stream and prevents some over land flow from overtopping the banks and travelling down the B2160. It reduces flood risk to sporadic properties that are affected from run off from the B2160 and surface water drainage not being able to discharge into Paddock Wood Stream and Station carpark watercourse.

If this option is taken forward then a service search, ground investigation and an environmental scoping is required to inform the outline design. As this option includes removal of trees we also recommend that a landscape and visual impact assessment, and ecology and nature conservation assessment (esp for reptiles and bats) is carried out.

The water course in this area does not fall under the permissive powers of either the Environment Agency or the Internal Drainage Board. Consideration of who will maintain this structure will be required as part of developing this option.

Note: there are overhead lines that cross the line of the bund and may impact construction methods.

4.2.6 Option 7 – Gravelly Ways Stream wall

This option has a cost benefit of 24. It reduces flood risk to 79 and 60 houses in a 1 in 100 and 30 year event respectively. It comprises construction of a wall along the border between the field with gardens and the railway. At it's maximum, the wall will need to be approximately 1.5m high. An additional culvert on Tudeley Brook and the addition of one way flow control flaps onto the surface water outfalls will also be required. If this options is taken forward, detailed design should also consider moving and improving the trash screen, as well as the potential to realign the watercourse to the west, to provide sufficient space to construct an earth bund rather than hard defence. However a hard defence is preferred as it will be easier to maintain, and less likely to be modified by residents. The line of defence does cross a public right of way, a crossing for which will need to be incorporated into the design. The line of this defence is shown in Drawing 0507, Appendix C.

This wall prevents the right bank of Gravelly Ways Stream from overtopping, so preventing overland flow down the back of Allington Road. Flood risk is reduced on Allington Road, Ribston Gardens, Laxton Gardens, Bramley Gardens, Woodlands, Newton Gardens, Mount Pleasant and Station Road.

If this option is taken forward then a service search, landscape and visual impact assessment, ground investigation and an environmental scoping is required to inform the outline design. An ecology and nature conservation assessment may also be required.

4.2.7 Summary table of benefits of short listed options

Table 4 overleaf 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 ratio for each option. The benefit-cost ratio is the ratio of the present value benefits provided by an option to the present value costs of providing that option. It should be noted that the benefit-cost ratio 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. It should be noted that more detail regarding the economic assessment of each option and of the construction costs can be found in Appendix D.

Table 4 –Cost benefit vs number of properties removed from flood risk

Annual Chance	Number of properties removed from flood extent						
	Do Minimum	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7
		Tudeley Brook		Rhoden East		Paddock Wood Stream Flood storage	Gravelly Ways Stream Wall
		Flood storage	Reduce overland flow to Gravelly Ways	flood storage	Reduce overland flow to Rhoden West		
1 in 30	35	50	76	60	78	43	60
1 in 100	14	32	73	79	59	40	79
Cost Benefit ratio	56.8	27	30	35	37.9	37.7	24.4

5 FLOOD RISK AND FUTURE DEVELOPMENT

The town of Paddock Wood will always be susceptible to flooding, as it is on relatively flat impermeable ground, both of which reduce the capability of surface water to be dispersed quickly. The existing surface water network is at capacity and any development should seek ways to allow the existing network to discharge without adding to it.

The Source Pathway Receptor drawing (**Section 7 Drawing 0140**) shows overland flood routes. This should be made available to developers to assist them in planning the drainage and surface water management of the proposed sites.

New development, regeneration (eg improvements to commercial road) or changes to existing impermeable areas should seek every opportunity to reduce surface water entering the existing system. SuDS such as bio-retention structure (tree pits, rain gardens) and attenuation features (ponds and swales) should be considered. In the case of Commercial Road, permeable paving could also be an option, if proper maintenance can be guaranteed. Soakaways are not suitable in Paddock Wood.

The Source Pathways Receptor Plan should be consulted when considering the Masterplan for new development sites. No obstructions should be placed in the ways of flows, unless specifically designed as an attenuation feature. Consideration should also be given to where exceedance flows will go (ie plan where potential flood water exceedance flows will go, to minimise the impact on infrastructure).

Specific comments on three development sites are provided below:

Land at Church Farm. This land is known to flood at its boundary with the railway. As well as being a natural low spot this area is also at risk of over land flow from water overtopping the right bank of Rhoden East. The existing surface water drainage that connects to Rhoden West is susceptible to backing up when Rhoden West is flowing at capacity. Option 3 and 4 identify opportunities to reduce the flows from Rhoden East contributing to flood risk on this land. This will reduce flood risk to this area and to Paddock Wood town in general. Any increase in surface water discharge would increase existing flood risk. Future development presents an opportunity to reduce existing flood risk by controlling the flows in Rhoden West, to enable the surface water system to discharge.

To reduce flood risk to the existing community, flow from Rhoden East to West needs to be prevented, to maximise the flows Rhoden West can accept from the existing surface water network.

Land off Mascalls Court Road.

The Source Pathways receptor map shows overland flow running approximately parallel to Green Lane. The wooded area to the west of Mascalls Court also shows some overland flow. Development plans should give consideration as to how to manage these over land flow routes in their master plan. Planned flow routes should be above ground, visible and away from properties/ infrastructure. Any increase in run off will increase flood risk south of the railway line and should be prohibited.

Sustainable drainage should be promoted in any future development. This could take the form of rain gardens (collecting and managing surface water at individual property level) and attenuation features (ponds and swales).

Land at Mascalls Farm. Baseline model identifies a diagonal overland flood route across this land trending from south west to north east. Any development should not place obstacles in the way of the natural flood route unless they are a designed attenuation feature. Paddock Wood Stream enters a culvert at the north east corner of this site. Following heavy rainfall water from the north east of the site flows onto the road and down the B2160 contributing to flood risk in Paddock Wood.

Development of this site could provide an opportunity to design a surface water management system to manage surface water from the site and reduce the flood risk to the north of the site and Paddock Wood town in general.

6 CONCULSION RECOMMENDATIONS

The integrated hydraulic model developed for this project provides a better understanding of flood risk in Paddock Wood. The Source Pathway Receptor plan (**Section 7 Drawing 0140**) summarises the outputs of this model and could be used to inform future planning advice. The two highest contributing factors to flooding are the over land flows that affect residential properties in the north west and north east and the ability of the surface water network to discharge into the watercourses.

Options to reduce flood risk. The Source Pathway Receptor model was used to inform options to reduce flood risk, as discussed in Section 3.2. The modelling has identified several options to reduce flood risk that appear to have a strong cost benefit to justify capital improvements.

Culverts. The flow through culverts under the railway is mainly controlled by downstream water levels. Of particular note the railway culverts on Tudeley Brook, Paddock Wood Stream and Rhoden East do not constrain flood flows.

Surface water and local watercourses. The surface water system is surcharging in some areas (see Section 2.5.1). Flow out of the surface water system is also restricted when water levels in the watercourses are high, this is especially relevant to flood risk in the areas of Allington Road and Dimmock Close. Maintenance of both the surface water system and watercourses is important to assisting the free flow of water to minimise flood risk.

Regional watercourses. The Medway and Tiese (to the north of Paddock Wood) affect water levels as far south as Lucks Lane. Modelling does not show any significant link to flooding from south of the railway.

Development. The Source Pathway Receptor map shows flood risk and flow routes across proposed development areas. Development should avoid placing obstructions to natural flow routes, unless they are a designed attenuation feature. Development should not be allowed to increase flows to the existing water network (this includes water courses) and should look at ways to alleviate existing flood risk by holding water back from the water courses, so allowing more time for the surface water network to discharge. Every opportunity should be taken to promote sustainable forms of drainage, this includes regeneration of commercial road and other sites that may be promoted for development/ change of use. Suitable SuDs features include; bio-retention features (eg water from highway being diverted to a tree pit).

7 RECOMMENDATIONS

To manage and minimise flood risk in the future we recommend the following be carried out.

Take options forward to outline design. This Flood Alleviation study has identified several options that have a robust cost benefit that will justify capital investment. Option 2 (prevent over land flows from Tudeley Brook to Gravely Ways Stream), Option 3 (storage on Rhoden East), Option 6 (storage on Paddock Wood) and Option 7 (flood wall on right bank of Gravelly Ways Stream) should be taken forward to develop outline design in consultation with the public and partners.

Culvert improvement. The shoring in Station Road culvert under the railway should be removed. It is understood that Network Rail are planning to line this culvert. The design of the liner should aim to improve conveyance, it should not reduce conveyance.

Maintenance and good housekeeping. Maintenance of water courses and the surface water network is important to managing flood risk. Whilst planned and reactive maintenance is carried out by the IDB and the Environment Agency the local community should also be encourage to take responsibility for managing and reporting debris and vegetation that may affect flood flow. Residents should not discard rubbish or garden waste adjacent to the watercourse, neither should they connect drains to the watercourses to aid drainage off their land without the approval of the authorities. This is particularly important on Gravelly Ways Stream. Should they see debris (this includes fallen trees and fencing posts) in the watercourse they should remove them if safe to do so or report it to the Town Council, who in turn will report it to the appropriate authority.

Surface Water Network. Further work should be carried out by Southern Water to understand the cause and investigate possible improvements to the stretches of the surface water network identified in section 2.5.1.

Development. The Planning Authority should take a proactive stance with Developers and use the Source Pathway Receptor Model to inform the drainage plans for new development. It should not permit any additional surface water flow to enter existing systems. Paving of front gardens should not be permitted. Any new impermeable areas should manage surface water at source and not allow it to run off to adjacent land faster that it would in its natural state. Opportunities to install sustainable drainage should be promoted wherever possible, be this new development or re-development (eg if Commercial Road is re developed then it should be designed to redirect surface water through bio-retention or attenuation features prior to discharging into the surface water system).