Taunton Deane Borough Council

Executive - 12 November 2014

Taunton Strategic Flood Risk Options Study

Report of the Assistant Director Planning and Environment
(This matter is the responsibility of Executive Councillor Mark Edwards)

1. Executive Summary

The purpose of this report is to inform Members of the outcomes of a study which has been commissioned to better understand existing and future flood risk and the impact of future development taking into account the impacts of climate change.

The study concludes that it is possible to implement proposed new development in the town centre provided that additional measures are included to mitigate potential adverse effects in the short term with more strategic solutions in the longer term to address climate change effects.

Whilst no single option can alleviate the climate change impacts, the study has shown that the priority option is the construction of a large storage area at Bradford on Tone and that this needs to be in place by 2026.

The study also shows that new development does not materially affect flood risk downstream of the town centre, provided that the appropriate storage options are implemented.

The Executive is recommended to accept the findings of the report and agree to the setting up of a Project Team to take forward the proposals for upstream flood mitigation.

2. Background

2.1 The original Taunton Vision proposals were supported by a 'Flood Risk Management Guidance' document. As part of the evidence base for the Council's Core Strategy a Strategic Flood Risk Assessment (SFRA) was published in May 2011. The modelling to support this demonstrated that the flood risk in Taunton Town Centre was worse than previously identified and that further modelling was necessary.

This improved version of the model (The Taunton Deane Model 2014) is the one that has been used to investigate the effects of climate change and to consider the

effectiveness of various strategic solutions.

3. Taunton Strategic Flood Risk Management Phase 1 Options Study

3.1 The report has been prepared by JBA Consulting and a copy is attached as an Appendix.

3.2 The report concludes that climate change effects significantly increase the risk of flooding to existing and new development in the town centre.

3.3 However, it is possible to implement new development identified in the Town Centre Area Action Plan and the Taunton Town Centre Rethink document provided that this is accompanied by appropriate mitigation measures.

3.4 Whilst the proposed new development in the town centre and Core Strategy sites does not have an adverse effect on downstream flood conditions, climate change effects will increase the volume of water discharging to the Levels and Moors.

3.5 The report goes on to advise on further work that is necessary. A priority action must be to commence a programme to establish the feasibility and design details of a large strategic storage pond at Bradford on Tone.

3.6 However, this is not the only solution. It will be necessary to use a combination of Strategic Options to provide the appropriate standard of protection from flooding in 2106 and an Investment Strategy Approach should be used to ensure that funding arrangements are put in place and opportunities for contributions are not missed.

3.7 Securing funding for more detailed studies and design development (Phase 2 study) is a priority, as is securing funding for the required measures. A bid to the Heart of the South West Local Enterprise Partnership has been submitted and an outcome is expected early in 2015.

3.8 The Phase 2 study should consider a further option that combines flood risk management improvements in Taunton with new infrastructure that supports economic growth and improved leisure and open space amenities closer to the town centre.

3.9 The report was considered by the Community Scrutiny Committee on 4 November 2014 and comments will be reported at the Executive meeting.

4. Finance Comments

4.1 Funding is in place to pay for the work already undertaken by JBA consulting and project initiation stages of the detailed work to take the Phase 1 study finding forward. Additional ‘Growth Deal’ funding is currently being sought through the Heart of the South West Local Enterprise Partnership to support this work and outcome on bids is expected early in 2015.

5. Legal Comments

5.1 The contents of this report reflect the responsibilities which local authorities now hold in relation to flood risk management pursuant to the Flood and Water Management Act 2010 Part 1 and the Flood Risk Regulations 2009

6. Links to Corporate Aims

6.1 Dealing with flood risk and climate change impacts are essential if the Council is to deliver its growth ambitions

7. Environmental Implications

7.1 This report represents a major step forward in terms of understanding flood risk for Taunton and climate change effects. It identifies a range of solutions, a combination of which will be necessary in order to start to address these impacts

8. Community Safety Implications

8.1 None

9. Equalities Impact

9.1 The impacts of flooding affect all groups, and the options identified in this report will not impact disproportionally on any one group.

10. Risk Management

10.1 The options set out in this report are designed to minimise risk in terms of flooding and also in terms of the ability for new development to come forward. Detailed risk assessment will be necessary as strategic solutions are worked up in more detail

11. Partnership Implications

11.1 This work has a range of Partnership implications and will require close working with the Environment agency and potential funding bodies. It is also a key component of the urban Water Management work stream of the Somerset Flood Action Plan.

12. Recommendations

12.1 The Executive is **recommended** to note the findings of the study and to give officers a mandate to set up a Project Team to ensure that Governance arrangements are in place to take proposals identified in the study forward, including Phase 2 detailed options appraisal and design for a large strategic storage pond at Bradford on Tone.

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Taunton Strategic Flood Risk Management
Phase 1 Options Study

FINAL DRAFT
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Revision History

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Final Draft-V1.6/01-10-2014	Amendments agreed at meeting on the 24th September 2014	B Cleere T Burton
Final V2.0 / 24-10-2014	Updated appendices	B Cleere T Burton

Contract

This report describes work commissioned by Tim Burton, on behalf of Taunton Deane Borough Council, by a letter dated June 2014. JBA's representative for the contract was Oliver Francis of Alastair Dale and Oliver Francis of JBA Consulting carried out this work.

Prepared by ..... Oliver Francis MEng MSc

Reviewed by ..... Alastair Dale BSc PGDip MIAHR

Purpose

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JBA Consulting has no liability regarding the use of this report except to Taunton Deane Borough Council.

Acknowledgements

JBA acknowledge the support and assistance of Taunton Deane Borough Council, the Environment Agency and Somerset County Council during the preparation of this report.

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Executive Summary

This first phase of a study to understand the existing and future flood risk at Taunton examines the effects of intended town centre development, wider development over and beyond the Local Plan period and climate change. The study has also considered the benefits that can be gained from six strategic options to manage flood risk. The study has largely involved the development and use of an improved computer model of the River Tone that will be the basis for assessing the effect of new development being brought forward in Taunton.

The first phase of the study has identified that the level of protection provided by the existing defences is very variable and substantial areas of North Town are already at risk from flooding during an event with a 1% chance of happening in each and every year. In addition the results show how flood risk will change over time and in particular what flood risk conditions are predicted to be like in 2026, 2066 and 2106.

The first phase of the study has shown that it is possible to implement proposed new development in the town centre provided that additional measures are included to mitigate potential adverse effects. Analyses for proposed development sites at the Cattle Market, Coal Orchard and Tangier can all be implemented but in the long term would need to be accompanied by strategic solutions that addressed climate change effects that affect existing and new development.

The assessment of the strategic options has concluded that no single option can alleviate the increase in severity of flooding caused by climate change and provide the necessary margin of safety from overtopping of the defences. Consequently it will be necessary for a combination of strategic options to be delivered. The study has shown that the priority option is the construction of a large flood storage area at Bradford on Tone and that this should be in place before 2026 to prevent a doubling of the number of existing properties at risk.

The study shows that new development does not materially affect flood risk downstream of the town centre, provided that the appropriate strategic options are implemented.

Finally the study identifies that it is an urgent priority to prepare more thorough assessments of the strategic options so that the designs and proposals of preferred measures are detailed enough to enable them to be delivered when the opportunity arises. By having a number of alternative schemes ‘ready to build’ the options that can potentially attract the most funding at the earliest opportunity can be delivered and thus provide the most affordable overall solution.

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1 Introduction

1.1 Purpose of this report

This report describes the results and conclusions from the first phase of a two stage study to investigate how future flood risk might change in Taunton as a result of:

- Planned new development in the town centre and Core Strategy sites.
- Climate change
- The implementation of a combination of different strategic options that must be put in place so that flooding at Taunton does not happen too often or have more severe effects than have ever been experienced in the past.

Much of the work to prepare the report has involved improvement of the Environment Agency's River Tone computer model and modification of the model so that it can be used by Taunton Deane Borough Council to test a range of future conditions and investigate the effectiveness of a number of strategic options that reduce the risk of flooding. The results show that no single strategic option by itself provides an appropriate standard of protection from climate change flood risk. It is only by combining more than one of the options that an acceptable standard of protection can be obtained. It should also be remembered that even if all the strategic options were put in place there would still be a small chance of flooding from a flood event which is worse than that used for the design of the defences.

Understanding the contribution to the reduction in flood risk made by each of the strategic options makes it possible to identify which ones are priorities, which ones should be progressed if the opportunity arises and what must be done to secure the funding that is required to deliver the measures in the required time scale. This flexibility is essential and is the best way of making sure that opportunities to obtain funding are seized and available money is not diverted elsewhere. This report and the results from the computer model developed by Taunton Deane Borough Council (referred to as the Taunton Deane Model-2014) can then enable:

- Further detailed assessments to be performed in the second phase of the study.
- Identification of the actions required to secure the necessary funding.
- The detailed assessment of proposed new development in Taunton town centre and Core Strategy sites, using the 'Taunton Deane Model-2014' (TDM-2014).

The Phase 1 study has also identified that there are some existing flooding problems, such as those associated with flooding from the Mill Lease stream that should be addressed directly and not necessarily as part of strategic proposals that provide wider benefits.

1.2 How report is structured

Table 1-1 describes where information can be found in this report:

Table 1-1: Report structure

Location	Content
Chapter 2	Existing flood risk and predicted future change
Chapter 3	Development that is planned for the future
Chapter 4	Strategic options for managing flood risk
Chapter 5	Summary conclusions
Appendix A.1	Frequently Asked questions (FAQs)
Appendix A.2	Background to Phase 1 study
Appendix A.3	Assessment of flood risk
Appendix A.4	Condition of existing defences
Appendix A.5	Potential effect of runoff from Core Strategy sites
Appendix A.6	Descriptions of scenarios and options considered

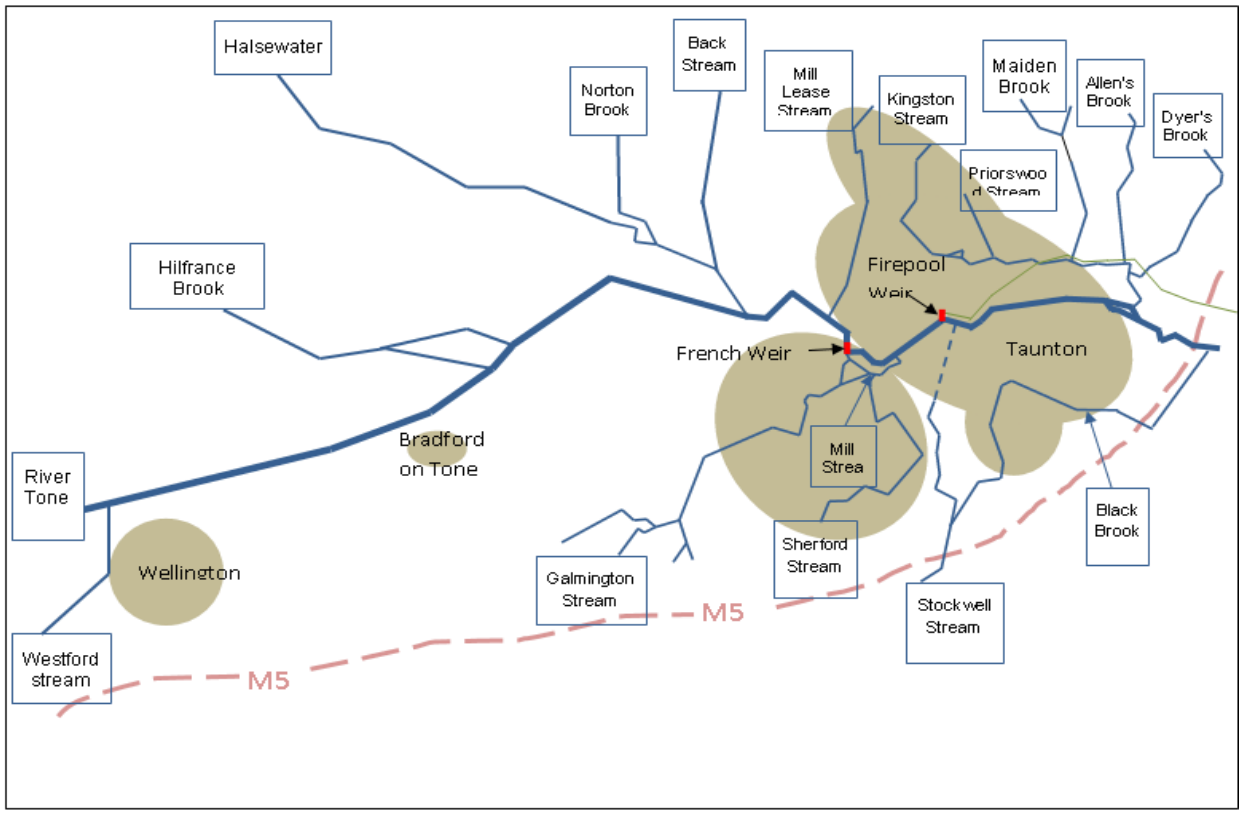
2 Existing flood risk and predicted future change

2.1 Why the flood risk in Taunton has been reviewed

2.1.1 Introduction

The underlying need to consider flood risk at Taunton now and in the future is due not only to its situation in the flood plain of the River Tone but also because it is the place where a number of major tributaries flow through the town to discharge to the river. Figure 2-1 shows how Taunton is located next to the River Tone and a number of major tributaries.

Figure 2-1 The River Tone and its tributaries at Taunton



The town centre and many existing properties rely heavily on the degree of protection resulting from the existing flood defence embankments and structures. The condition of these Flood Risk Management (FRM) features is very variable, many will need to be replaced as their condition has deteriorated, as illustrated in Figure 2-2. None of the defences will provide an appropriate standard of protection under climate change conditions and they do not include a 'safety margin' or 'freeboard' which is essential in circumstances where so much property and business could be affected by small changes in the predicted flood water levels.

Figure 2-2 Illustration of condition of existing defences at Taunton

The four principal reasons for this initial review of flood risk at Taunton are to:

- Understand the level of existing flood risk affecting the town centre.
- Identify the implications of flood risk for new development planned in the town centre and Core Strategy sites for the short medium and longer time frame.
- Demonstrate how climate change (increased flow magnitudes and frequency of flooding) will potentially affect existing communities
- Examine the requirement for a combination of strategic options to deliver acceptable standards of protection to the town centre now and in the future.

When examining these key issues consideration has also been given to the potential effects of climate change, new development on land downstream of Taunton and the timing priorities for measures that might be required to maintain appropriate standards of protection. The underlying reason is to provide basic information to identify actions for a programme of works that will deliver the desired outcome. It is the intention that the Phase 1 study described in this report will be followed by a more detailed and comprehensive Phase 2 study. The Phase 2 project will involve more detailed analysis using the TDM-2014 and establish a committed programme of actions and measures to secure the sustainability of existing and proposed development at Taunton.

2.1.2 Background

The following initiatives have shaped the need for the present study:

- The Project Taunton proposals initiated in 2000 were supported by a document that gave 'Flood Risk Management Guidance' so that proposed development was safe and did not make flooding worse for others.
- In 2011 the latest Development Plan (Core Strategy) was approved by the Inspector at an Examination In Public (EIP). The allocation sites identified in the Local Plan were supported by a Strategic Flood Risk Assessment (SFRA) that was published in May 2011.

To prepare the SFRA the Environment Agency model of the River Tone was improved. This improved version of the model showed that the flood risk in the town centre was worse than had previously been predicted at the time of preparation of the Project Taunton proposals and also highlighted that proposed land raising could lead to potential adverse effects in the town centre.

In the light of this new information Taunton Deane Borough Council commissioned further studies to improve the model by collection of additional survey data and making sure that full account was taken of the effect of all sites that had already been granted planning consent. This improved version of the model (the Taunton Deane Model-2014) is the one that has been used to investigate the effects of climate change and to consider the effectiveness of alternative strategic options.

More detail on the background can be found in Appendix A.2

2.2 How flood risk is assessed at Taunton and the level of risk

2.2.1 How risk is defined

Definition of flood risk

A flood is formally defined in the Flood and Water Management Act[1] as follows:

"*where land not normally covered by water becomes covered by water and can be the result of water emanating from a number of sources*". It is possible to define flood risk as:

Flood Risk = (Probability of a flood) x (scale of the consequences)

The analyses have also included estimates of how the severity of flooding might be expected to change as a consequence of climate change. In the future it is expected that the magnitude of flows and depth of flooding will increase due to climate change and so the severity of a flood with a specified chance of being experienced will also increase.

Sources of flooding

The main sources of flooding affecting the town centre are surface water flooding and river flooding. The areas at risk from surface water flooding are shown in Figure 2-3.

Figure 2-3 Flood Map for Surface Water

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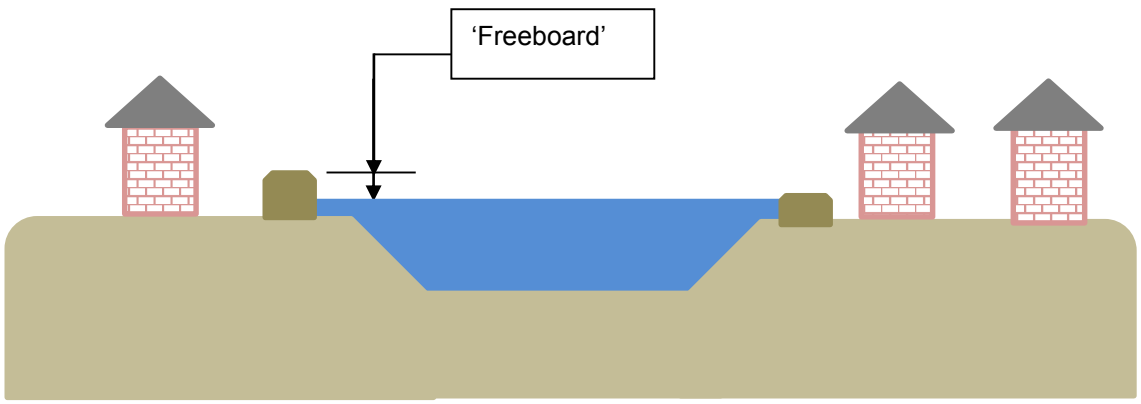
The main source of flooding in Taunton is from the River Tone. Through the town the river is contained by a series of flood banks and the risk of flooding to property is either as a result of the banks failing or the water level in the river being higher than the flood bank. In either case the flooding experienced would happen relatively rapidly and would potentially affect a lot of properties in the town. Figure 2-4 shows how properties are potentially affected by the risk and how the flow constriction caused by the flood banks constraining the width of the flood extent will lead to relatively large changes in water level for small changes in the river flow.

Figure 2-4 Illustration of flood risk at Taunton



[1] Flood and Water Management Act (2010) text available at http://www.legislation.gov.uk/ukpga/2010/29/contents

2.2.2 How risk is assessed using the computer model TDM-2014

The assessment of flood risk has involved the following two exercises:

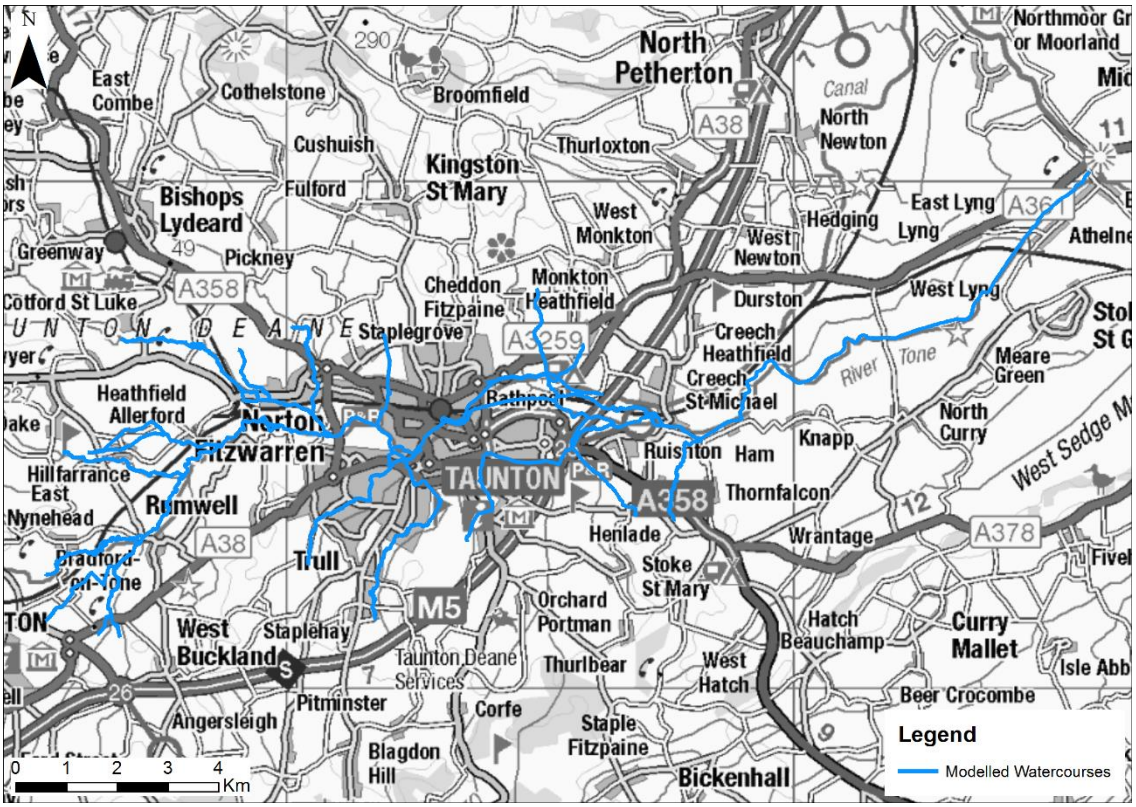
- Firstly the magnitude of the flood flows that are predicted to flow off the land following heavy rainfall have been prepared using methods described in the Flood Estimation Handbook (FEH)
- Then the water levels in the river channels and on the flood plains in the catchment of the River Tone have been calculated using a computer model.

Flow estimates have been prepared not only for conditions as they are today but also for conditions as they will be in the future when climate change affects the severity and frequency of flooding that will be experienced. The predicted climate change effects have been prepared using guidance taken from the Environment Agency publication 'Adapting to Climate Change: Advice for Flood and coastal Erosion Risk Management Authorities' (Environment Agency, 2011) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297379/geho0711btzu-e-e.pdf . The effect of climate change is to increase the size of the flood flows and the volume of floodwater generated in the River Tone catchment. Estimates of the gradual increase in flows due to climate change has been estimated for the years 2026, 2066 and 2106.

The TDM-2014 includes the appropriate assumptions on the features that exist or are known to be planned. Details of these developments are given in Appendix A.3.

The River Tone hydraulic model encompasses 29km of the River Tone, from Ash Bridge at East Nynehead to the confluence with the River Parrett at Burrowbridge, and a further 58km of the tributaries that discharge flows to the main channel. Figure 2-5 shows the extent of the model used to assess the risk at Taunton.

Figure 2-5 Extent of Taunton Deane Model-2014



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2.3 The predicted level of risk in Taunton today

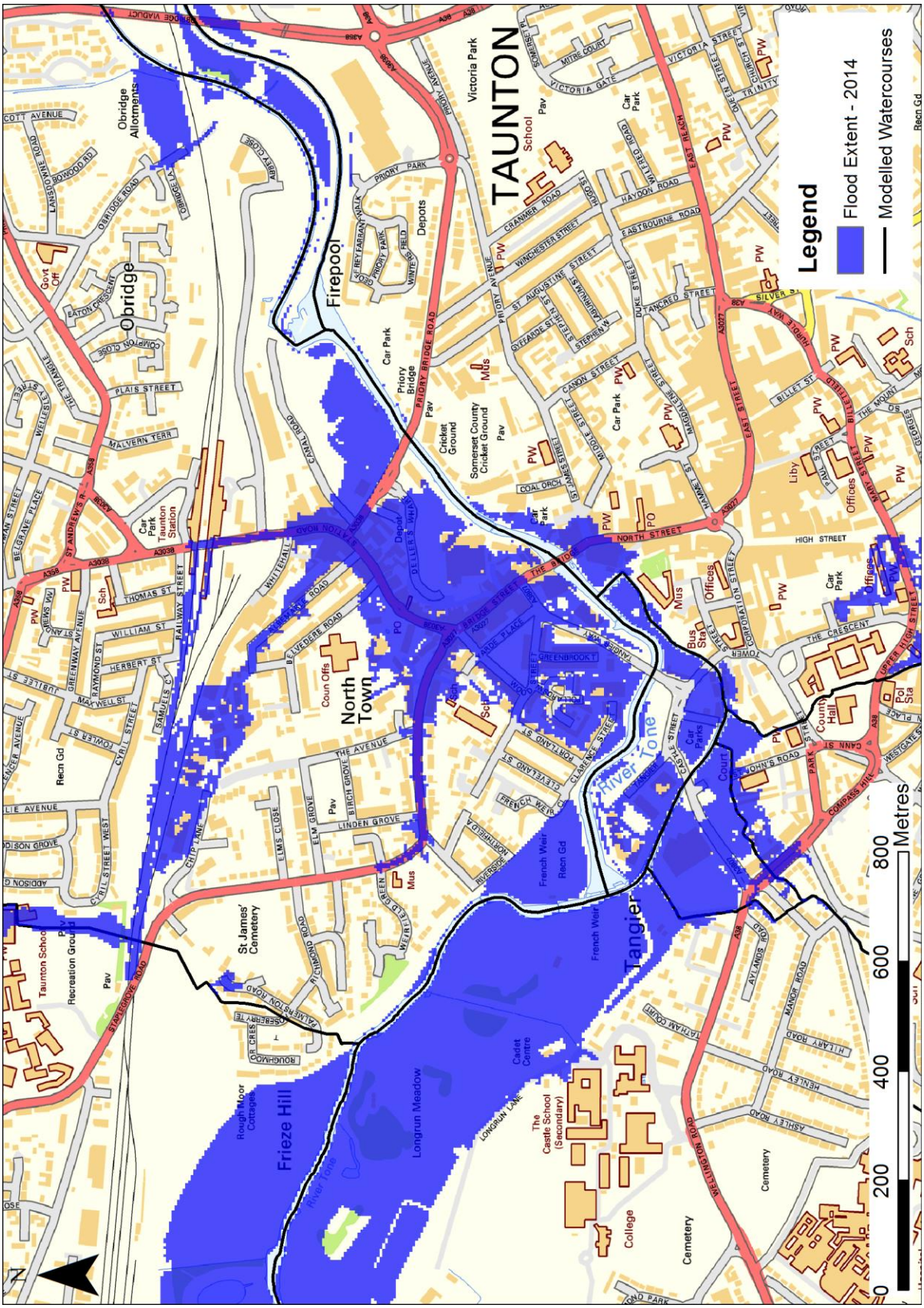
2.3.1 The level of risk predicted using the TDM-2014

The Taunton Deane Model-2014 has been used to prepare predicted results for the flood risk as it exists at the moment. As a baseline the present day (2014) flood risk has been assessed using the TDM-2014 for the flood event with a 1% chance of being exceeded in each and every year. All other scenarios are compared against this baseline. The results from this version of the model include allowances for developments with planning consent, but not necessarily implemented, as described in Appendix A.3. The model assumes that the existing defences are maintained and in position in the future and the increase in flooding is a consequence of the defences being overtopped in the future by the increased climate change flows. These assumptions have been agreed with the Environment Agency and describe what is known as the 'Do Minimum Scenario'.

The results of this analysis show that a significant area of Taunton is predicted to be at risk of flooding during this event (see Figure 2-6) and 972 properties are affected. The majority of these properties are situated in North Town although Tangier is also affected. Overtopping of the existing River Tone defences does occur in some isolated sections between French Weir and Town Bridge although a significant proportion, approximately 370 properties in total, of the flooding in North Town is a result of flood water from the Mill Lease Stream.

Flood depths in excess of 300mm can be experienced across extensive areas of Taunton.

Figure 2-6 Existing flood risk in Taunton 2014



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Throughout this report comparisons of different scenarios and epochs will be made against the present day baseline described above. To ensure a consistent comparison we have included a figure that shows either the change in flood extent or, for the town centre sites where extents do no change significantly, the change in flood depth. In addition to the figures we have used three key indicators to describe the changes. These include:

1. Number of properties affected – a count of the number of properties (commercial and residential) shown to be within the flood extent. This includes upper floor properties in blocks of flats or above shops as flooding potentially prevents access to the property.
2. The water level at Priory Road Bridge. This location has been chosen as it corresponds with the location of the Environment Agency gauge. The water level in this locations is also not affected by the bridge structure itself (unlike Town Bridge the other potential comparison point).
3. The volume of flood water in the River Tone passing under the M5 during the flood event. This provides a method for assessing the effect on downstream receptors such as the Somerset Levels and Moors. The River Tone crossing is one of four watercourses passing beneath the M5 but accounts for approximately 90% of the total volume. The volume is specific to the design flood event but is a good indicator for understanding the impact downstream.

For the present day scenario:

- **972** properties are affected.
- The water level at Priory Road Bridge is **14.92mAOD**.
- The volume passing downstream is **12.4 million m^3**.

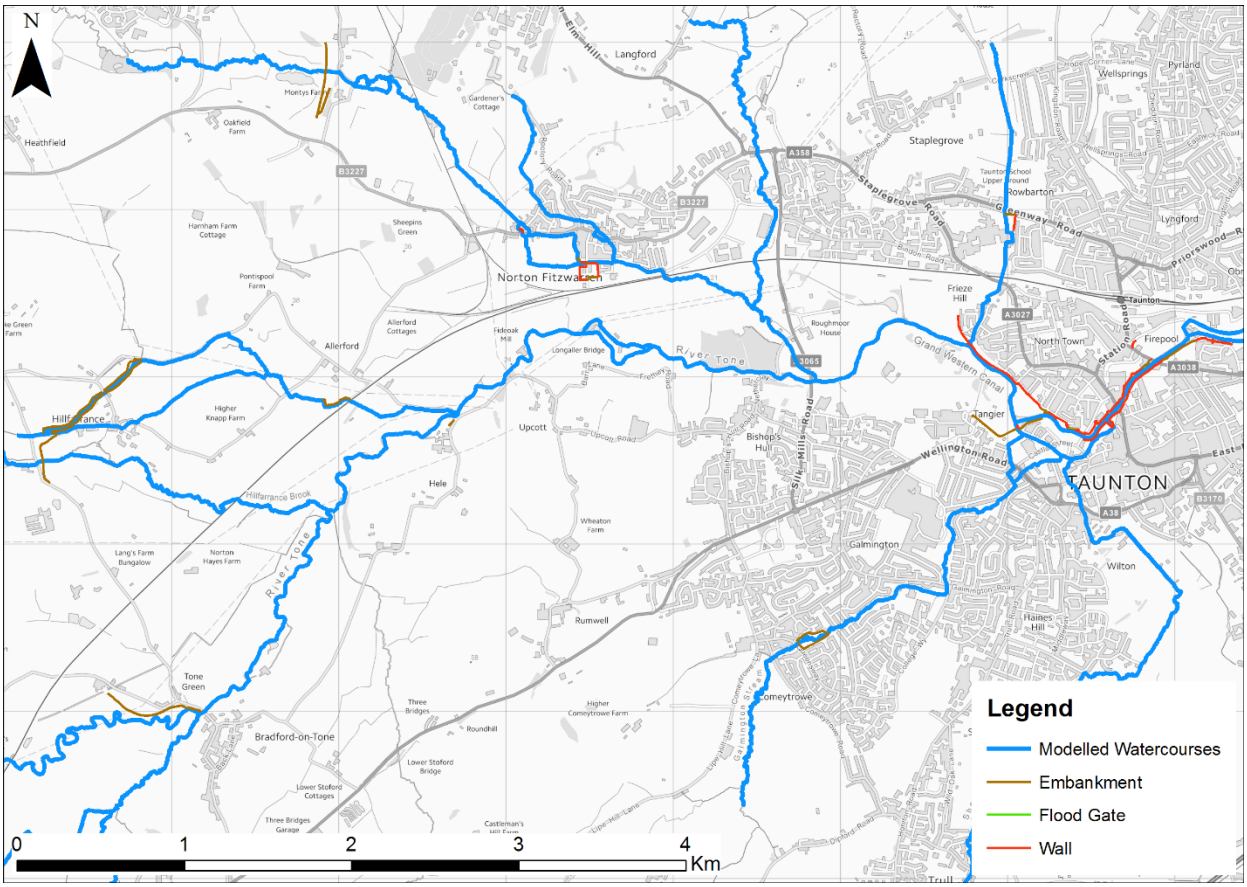
2.3.2 The condition of the existing defences

The Environment Agency has provided information on the condition of the existing defences in Taunton and these are shown in Appendix A.4. When the existing defences are replaced in future, probably in conjunction with other strategic options it will be essential that they are constructed to include the appropriate 'Freeboard' allowance and also take account of necessary allowances for climate change effects (see Figure 2-4 for a description of 'freeboard').

The location of these existing defences is shown in Figure 2-7. No defence assets downstream of the M5 have been considered in the Phase 1 study as they are assumed not to have an effect on the flood risk in the town centre at Taunton. When considering the future conditions it has been assumed that the following defence assets will be continued to be maintained:

- Norton Fitzwarren Dam
- Longrun Farm
- Hillfarrance FAS
- Glasses Mead Flood Storage Area

Figure 2-7 - Location of existing flood defences in Taunton



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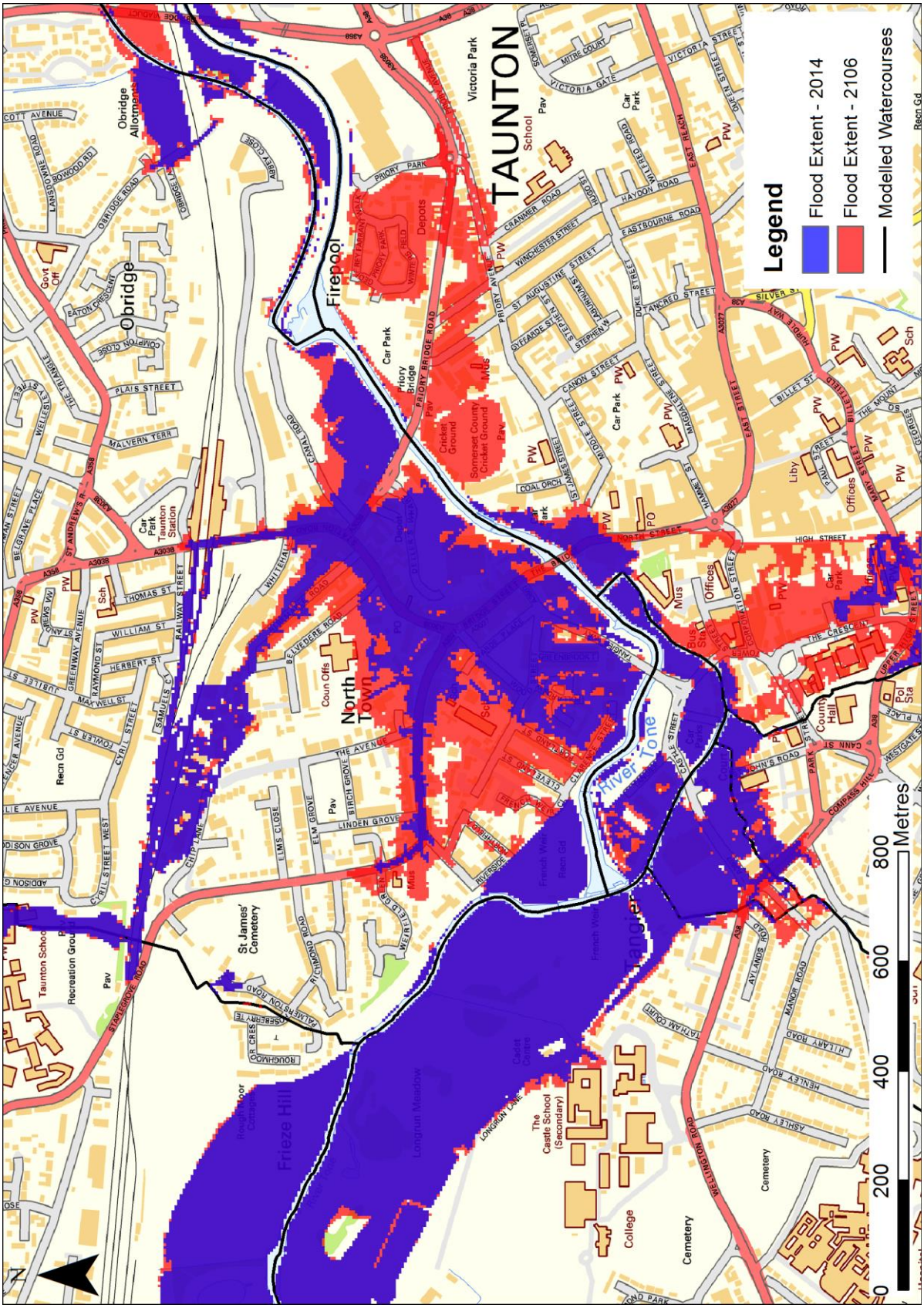
2.4 How flood risk might change in the future

2.4.1 How flood risk changes if there is no new development

The predicted effect of climate change is to increase the size of the flood flows that are experienced in the River Tone at Taunton. The results for conditions as they are predicted to be in 2106 have been estimated using the TDM-2014 model. The increased flows used in the model use Environment Agency guidance and make it possible to show how the flooding will change if there was no new development and nothing was done to the existing defences to reduce the risk or severity of flooding. For the purpose of this assessment it is assumed that all existing flood defences are maintained to their current standard. Figure 2-8 shows how the flood risk is predicted to increase between 2014 and 2106 if no new development is brought forward. It is evident from the results that a significant increase in flood risk will be experienced just as a consequence of climate change.

Figure 2-8 How flood risk increases due to climate change without any new development



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2.4.2 Summary of predictions using Taunton Deane Model-2014 (TDM-2014)

Even without any further development the effects of climate changes result in a significant increase in the level of flood risk to Taunton with a notable increase in flood extent through the town centre. Additional flooding occurs in North Town, the Priory Park development, Somerset County Cricket Club, and the area around the High Street.

For the 2106 'without development' scenario:

- The number of properties affected by flooding increases from **972** to **2334**.
- The water level at Priory Road Bridge increases by 310mm to **15.23mAOD**.
- The volume passing downstream increases 18% to **14.7 million m^3**.

3 Development that is planned for the future

3.1 Town centre development

3.1.1 Introduction

The 'Town Centre Rethink' has recently replaced Project Taunton. It is now envisaged that there are three key areas to be redeveloped at:

- Cattle Market
- Coal Orchard
- Tangier

It is important to understand how the implementation of this development could affect flood risk in the town centre and what measures should be included so that conditions are not made worse for the existing community.

3.1.2 What are potential effects of proposed town centre development

The starting point for this exercise has been to assume that development at the three sites involves raising ground levels above the predicted future flood level, as was set out for Project Taunton. The flood levels were originally set as part of the Taunton Vision and were for the flood event with a 1% chance of occurrence in any year plus a 600mm allowance for climate change and freeboard.

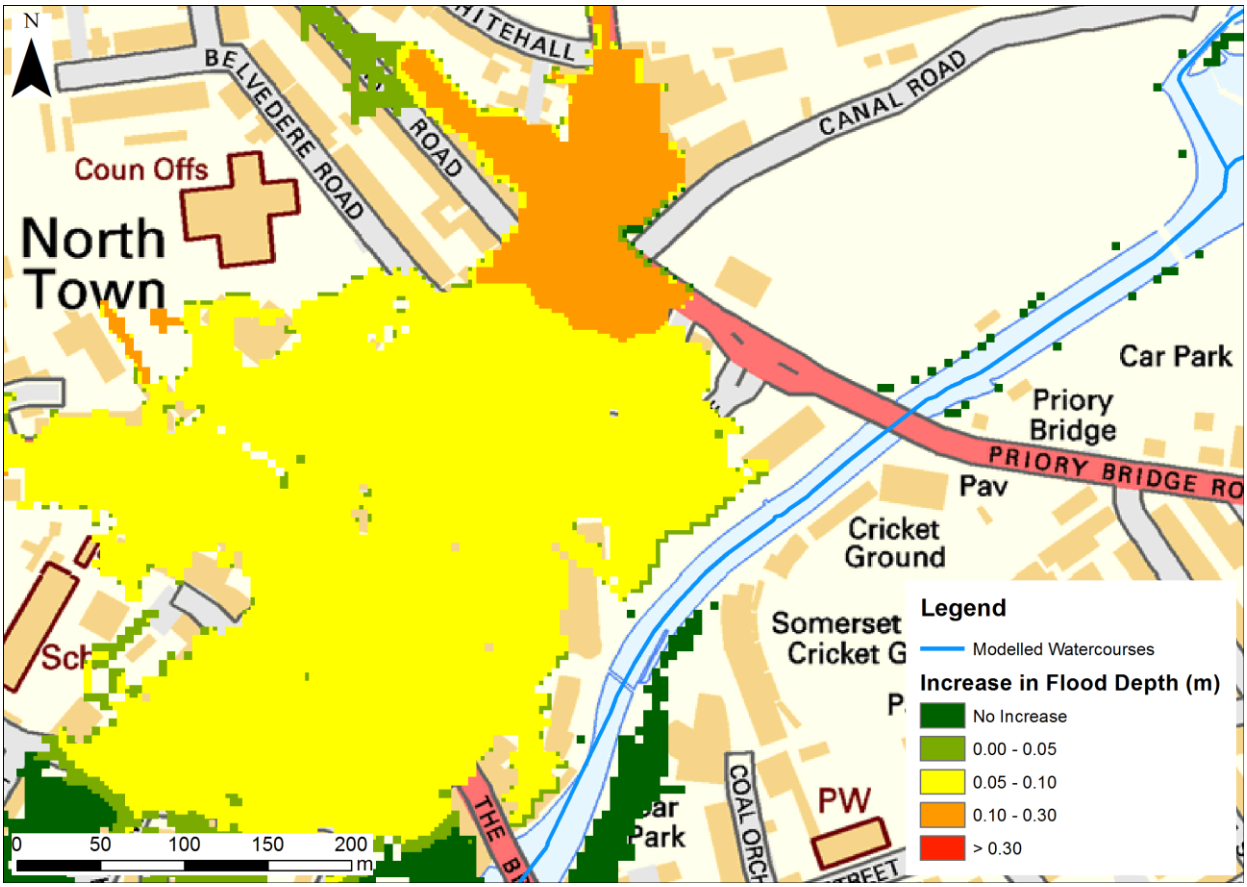
All three sites are within the floodplain to differing extents and will reduce the capacity of the floodplain. This loss of volume has already been compensated for through the construction of Longrun Farm flood compensation facility. The TDM-2014 makes it possible to understand how the raised ground affects flood flows in the town and how these flows and flood levels could potentially change if development is implemented. Having identified that there is a potential change it is then possible to use the model to investigate mitigation measures so that the actual effects are not significant.

3.1.3 Cattle Market

Raising ground levels across all of the Cattle Market site would potentially have a significant effect on water levels in North Town during a flood event. The reason for this is that the land raising prevents the flow of floodwater that is predicted to discharge from the Mill Stream and flow across North Town in an easterly direction to the River Tone. The raised land would create a dam so the depth of flooding in North Town would potentially be increased. This flood mechanism is the same for 'surface water flood risk' and so consideration would need to be given to the surface water flood flows even if there was no river flooding. Figure 3-1 shows the potential effect of land raising at the Cattle Market site.

If the ground levels at the site were raised to the levels described in Project Taunton there would still be a risk of flooding under climate change conditions at the Cattle Market site. There is no significant change in the predicted water levels in the River Tone and the compensatory storage at Longrun Farm means there is no net increase in flood volume downstream of Taunton.

Figure 3-1 Potential effect of land raising at cattle Market site



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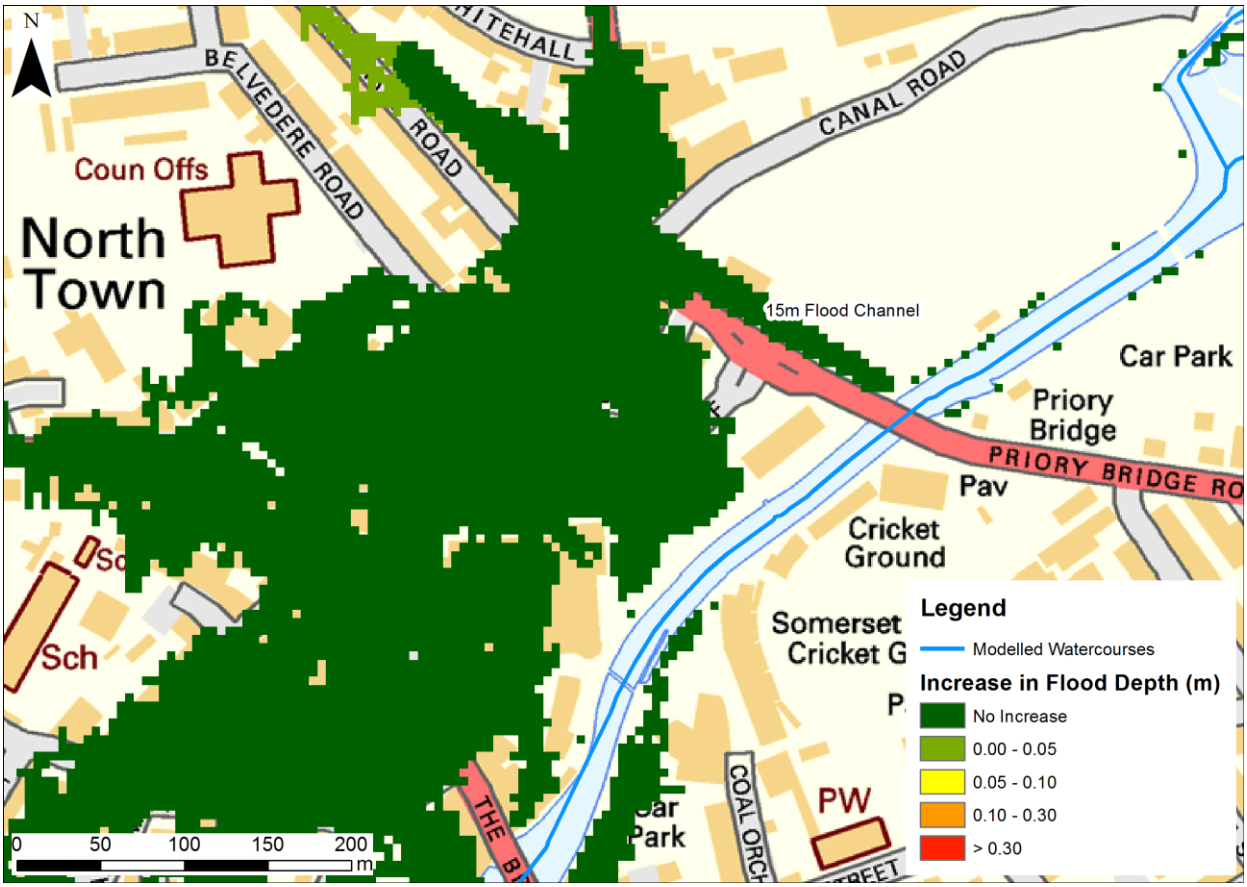
The TDM-2014 has been used to investigate the measures required at Cattle Market so that there are no significant effects in North Town. By including an area of lowered land 15m wide across the Cattle Market site, or a culvert beneath the raise ground it is possible to preserve the existing flood flow route and avoid significant effects at North Town, as shown in Figure 3-2.

When longer term solutions are implemented to address climate change effects the predicted flooding will not be experienced during design conditions. However, the interim measures put in place offer the additional advantage of providing a way of managing flood risk if an event is experienced in future that is greater than the design capacity of the defences (known as a residual risk event).

Figure 3-2 Effect of mitigation measures at Cattle Market site



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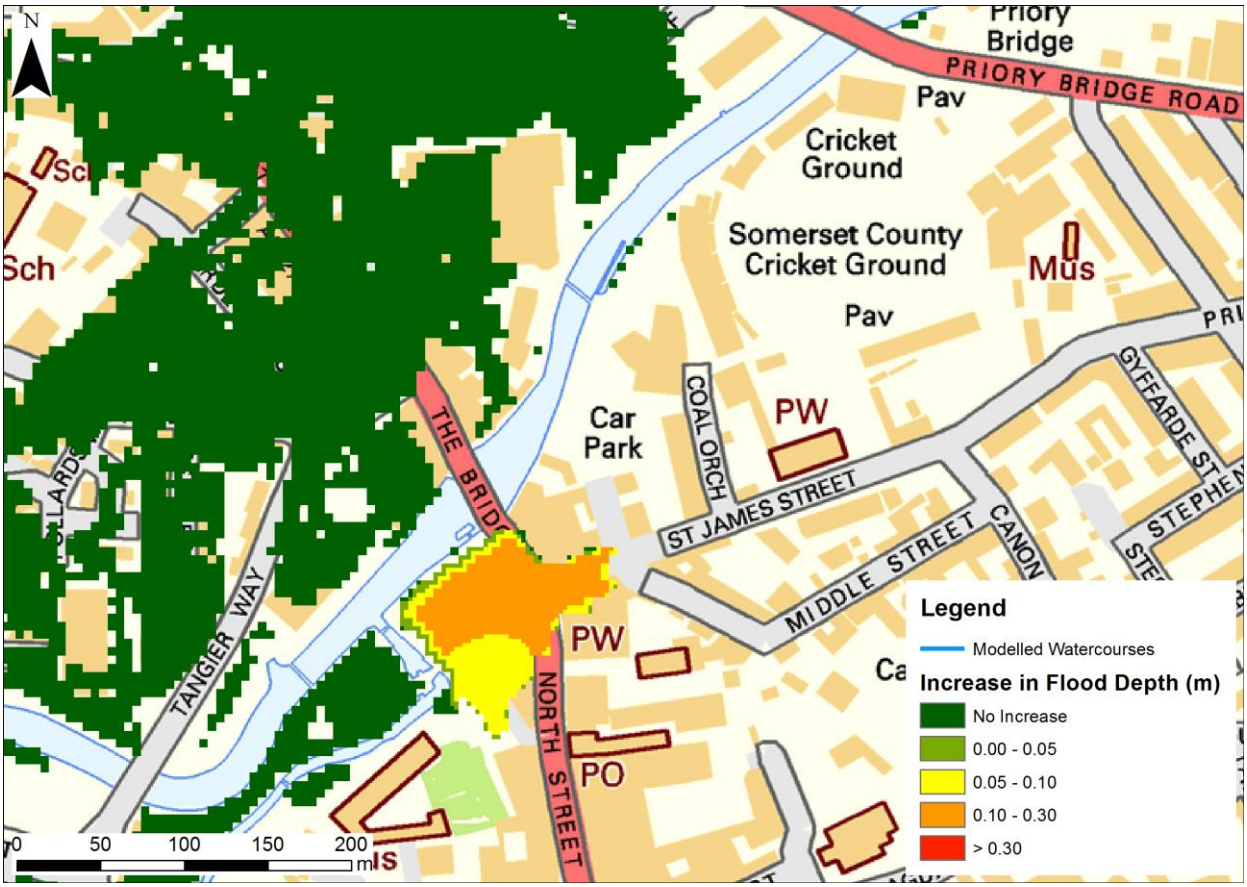
3.1.4 Coal Orchard

Raising ground levels across all of the Coal Orchard site would potentially block off an existing overland flow route from the Mill Stream through the Debenhams service yard. The flood water is not from the River Tone but instead has spilled over low sections of wall on the Mill Stream and flowed in an easterly direction through Debenhams. The land raising potentially results in a small increase in flood extent throughout the town centre. There is also potentially a sizeable increase of up to 300mm in flood depth in North Street and the area between Goodland Gardens and Coal Orchard. Figure 3-3 shows the potential increase in flood depth.

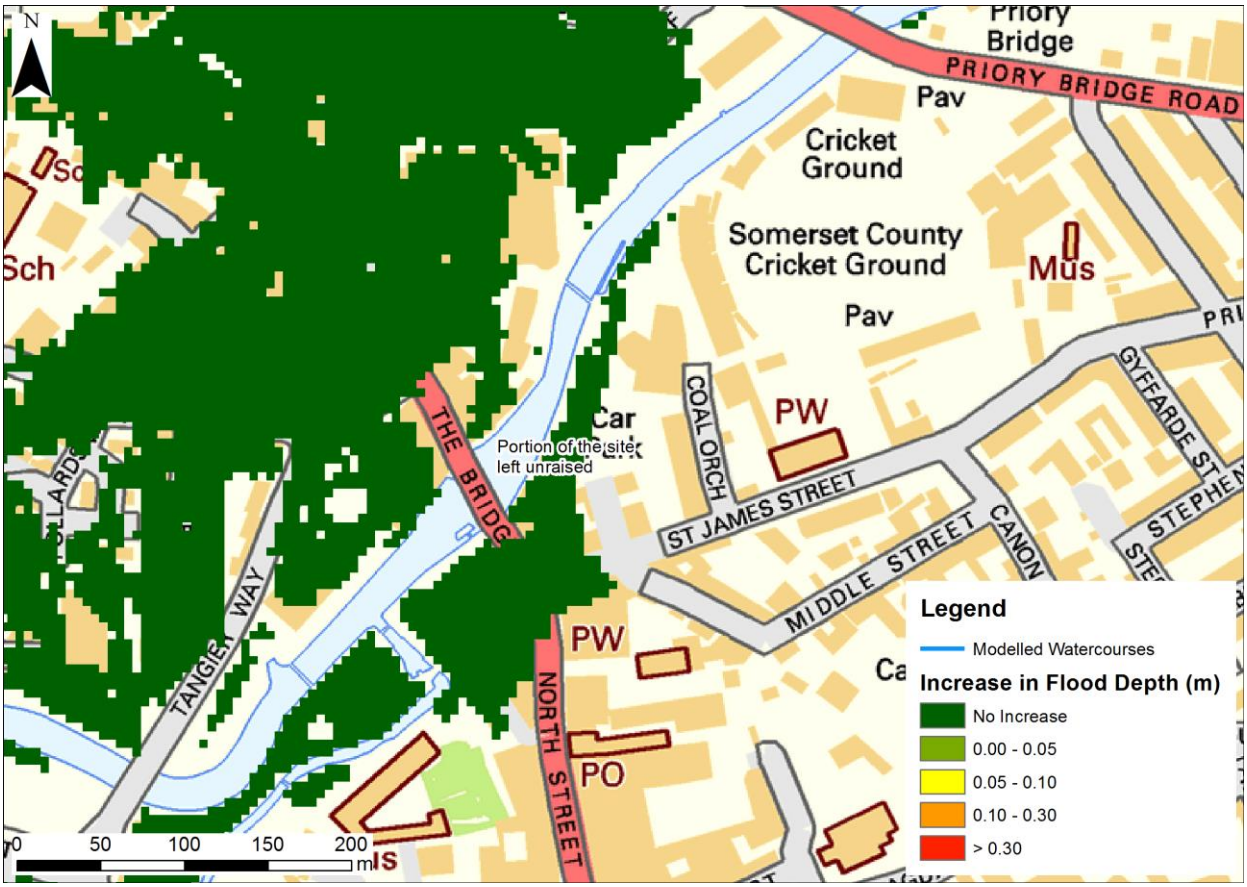
Figure 3-3 Potential flood increase at Coal Orchard



The increase in flooding is caused by the local displacement of water by the proposed land raising. This effect is easily addressed if some of the land at the Coal Orchard site is not raised and space is retained to collect the flood water and pump it back in to the River Tone, as shown in Figure 3-4.

Provision has been made at Longrun Farm for the loss of volume resulting from land raising and thus there is no net increase in the volume of water flowing downstream as a result of the development. When longer term solutions are implemented to address climate change effects the predicted flooding will not be experienced during design conditions. However, the interim measures put in place will provide a way of managing flood risk if in future an event is experienced that is greater than the design capacity of the defences (known as a residual risk event).

Figure 3-4 – Effect of mitigation measures at Coal Orchard



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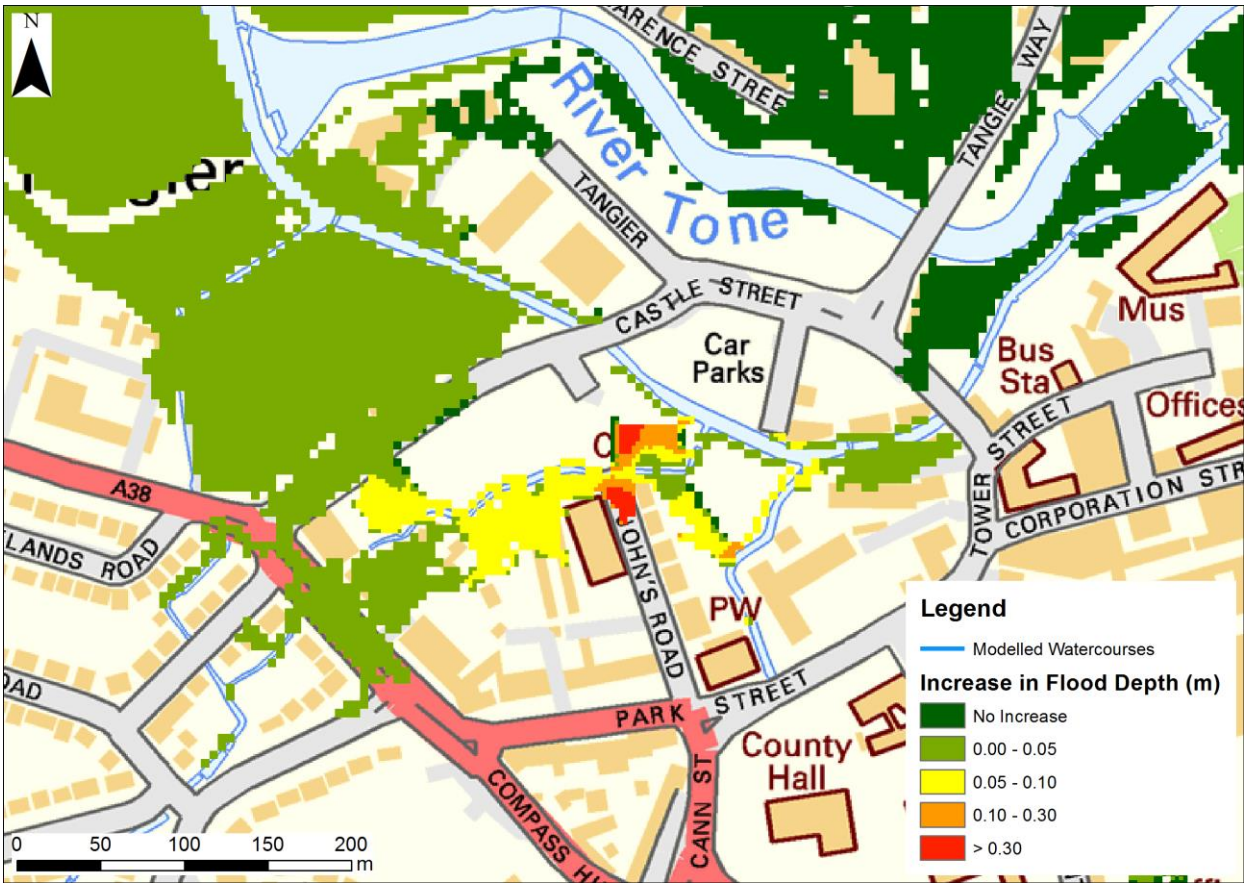
3.1.5 Tangier

Tangier is a much more critical site in terms of flood plain flow across the ground as the watercourse network is complex where the Mill Stream is joined by the Sherford Stream and the two branches of the Galmington Stream. At present the sites comprising Tangier provide overland flow routes for flood water that has discharged from the Mill Stream and between the Sherford Stream and the eastern branch of the Galmington Stream. Land raising potentially results in increases in flood depth that are most pronounced in the Butterfly Car parks area with local increases of up to 300mm. In fact part of the Butterfly Car Parks site adjacent to the Galmington Stream remains at risk of flooding even after raising the site, as shown in Figure 3-5.

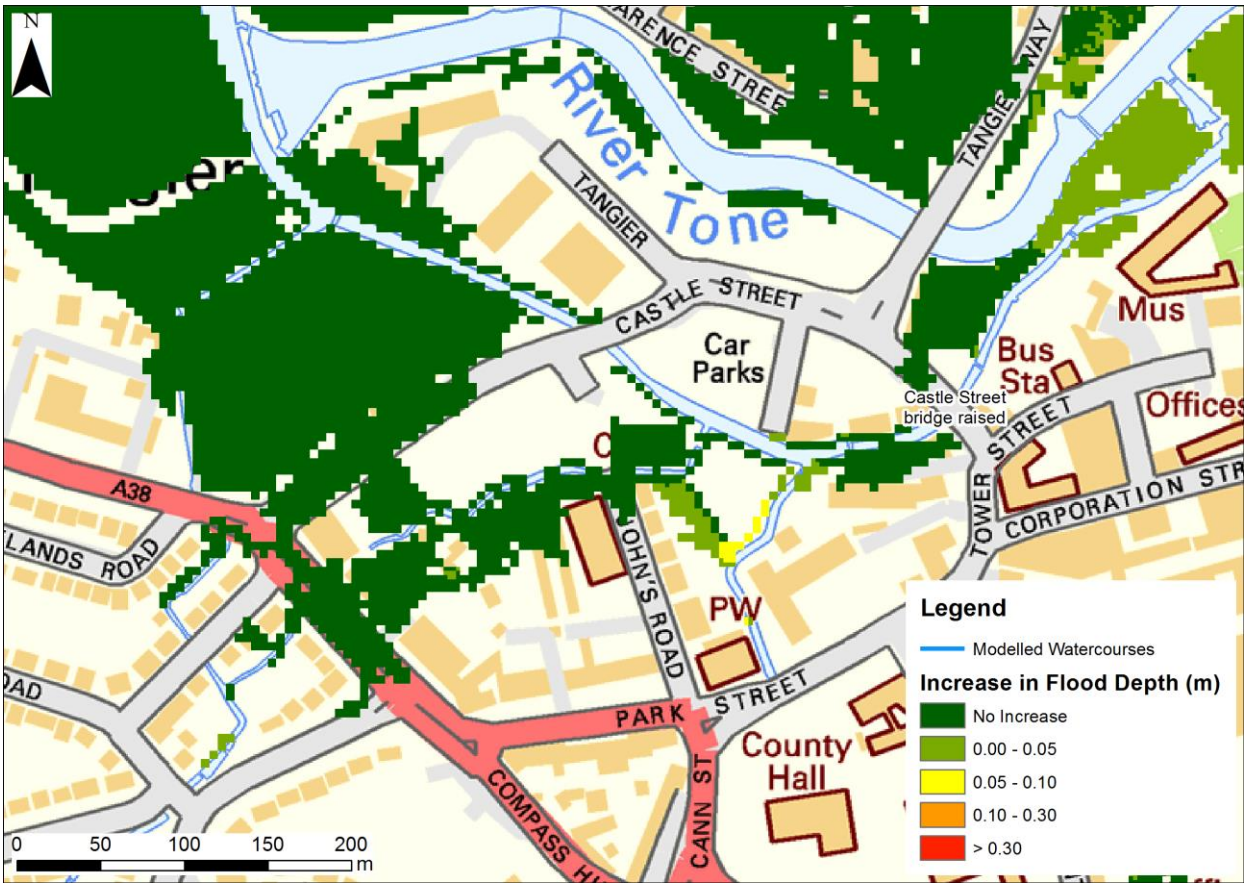
Figure 3-5 Potential flood increase at Tangier site



Three mitigation measures were considered to offset the development of Tangier. Of these measures the amendments to the Barrier Wall and the removal of the Goodland Gardens sluices were found to have negligible effect. However the raising of the soffit of Castle Street Bridge enables implementation of new development without significant effects as shown in Figure 3-6.

Provision has been made at Longrun Farm for the loss of volume resulting from land raising and thus there is no net increase in the volume of water flowing downstream as a result of the development. When longer term solutions are implemented to address climate change effects the predicted flooding will not be experienced during design conditions

Figure 3-6 Effect of mitigation measures at Tangier



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3.2 Core Strategy sites

3.2.1 Introduction

The location of the Core Strategy sites are shown in Figure 3-7 and Figure 3-8.

Figure 3-7: Taunton urban extensions

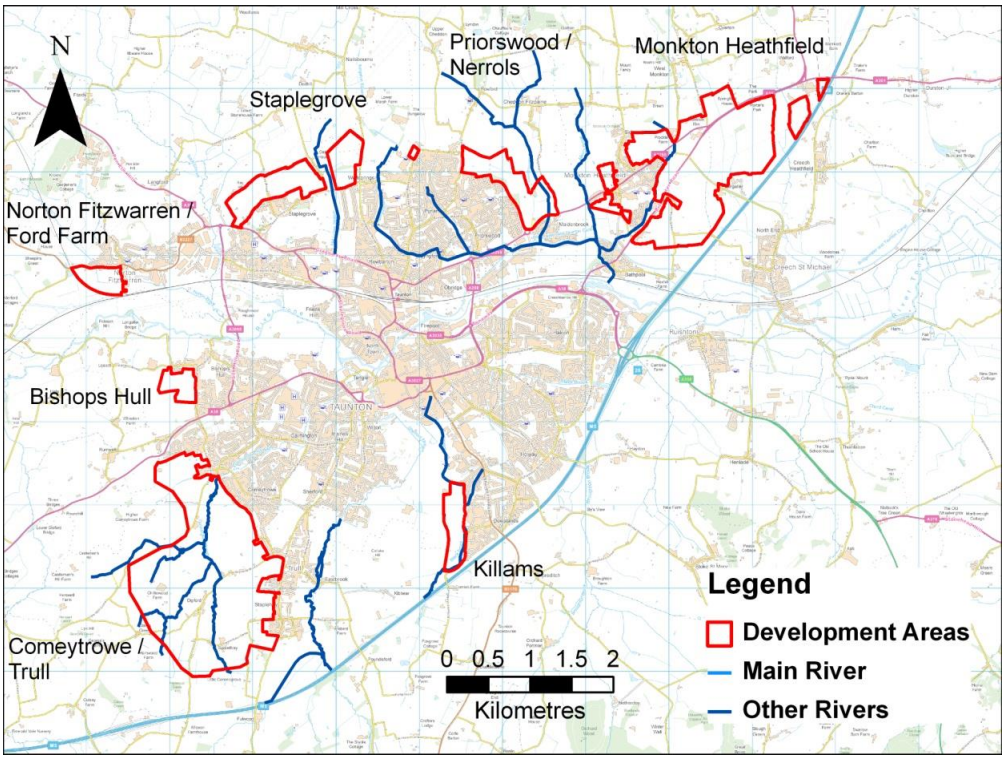

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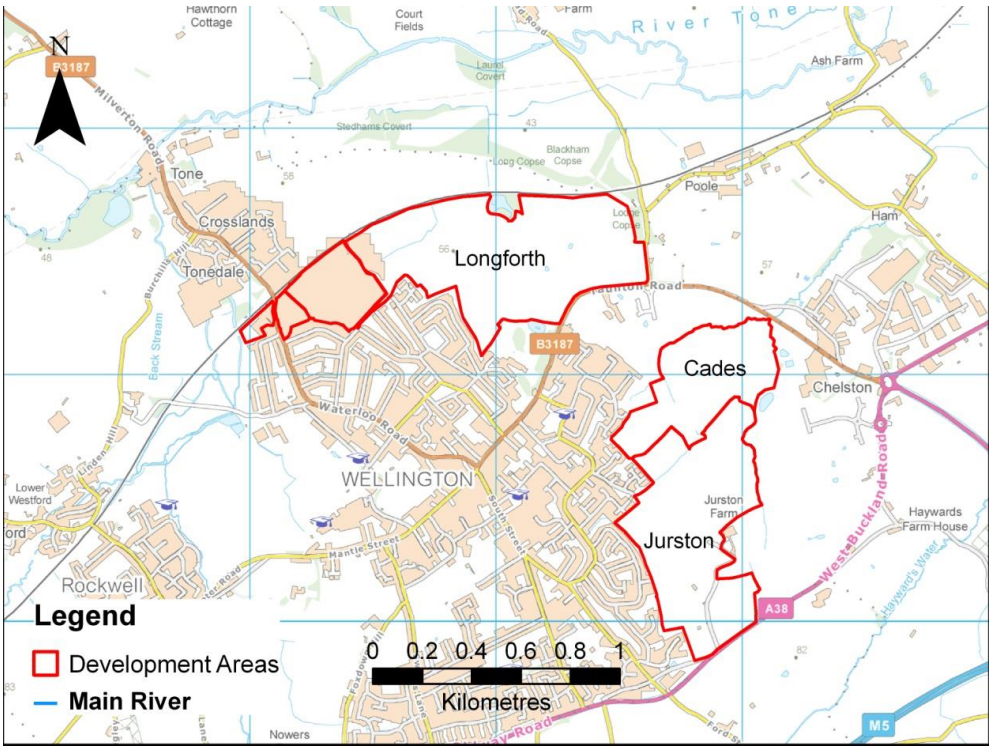
Figure 3-8 Wellington urban extensions



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3.2.2 What are potential effects of proposed development

These are reviewed and described in detail in the SFRA prepared in support of the Examination In Public (EIP) in 2011. In summary the potential effects are:

- Increased peak flows in the tributaries flowing through the town centre
- Increased flood volumes contributing to the River Tone at the town centre
- Increased risk of flooding due to high flows in the River Tone tributaries
- Increased risk of flooding due to overtopping of the flood defences in the town centre

3.2.3 What can be done to reduce the risk

The SFRA identified the requirement for the following provisions to be included in all proposed new development:

- The Core Strategy sites must include provision for Sustainable urban Drainage Systems (SuDS). These features will be designed so that the peak flows generated by the new impermeable areas do not exceed the existing flows in the watercourses and thus they do not contribute to making things worse at downstream locations along the tributaries.
- A strategic surface water storage area is proposed at Bradford on Tone. This storage area is designed to provide additional storage of flood water upstream of the town centre during significant flood events. This extra storage provides compensation for the extra volumes of water generated by runoff from the Core Strategy sites and thus the net effect on flood water levels in the river Tone at Taunton is zero. The additional benefit of the scheme is that no additional volumes are passed downstream during times of flood.
- Wherever possible proposed open space was designed to store water during times of significant rainfall, potentially reducing the risk of surface water flooding in the town centre.

Further detail on the potential effects of the Core Strategy sites is provided in Appendix A.5.

4 Strategic options for managing flood risk

4.1 Introduction and background

4.1.1 Why strategic options are being assessed

The model results show that climate change effects will make flood risk in Taunton significantly more severe and more frequent. The consequences of this increased flood risk make it more likely that the flood events will cause extensive damage and disruption to existing and planned communities and so it is essential to have a strategy to manage this risk.

By taking a strategic approach it is possible to identify how best to provide an appropriate standard of protection from flooding to existing communities and new development within Taunton together with the adaptations required to address the significant changes caused by climate change.

4.1.2 Options that have been included and how they are assessed

To assess the benefits of alternative options a comparison must be made against a 'baseline case'. The conventional way to do this is to consider the following scenarios:

- A 'Do Nothing' scenario which assumes that most of the usual arrangements for maintenance and repair are not carried out.
- A 'Do Minimum' scenario that assumes that the existing defences are maintained as usual but not improved at all.
- A 'Do Something' scenario that considers a number of strategic options that can be used to manage the flood risk. For the purpose of the Phase 1 study six strategic options have been considered and the results of the analyses using the TDM-2014 model are described in this section of the report.

The scenarios and options are tested to examine how they are predicted to perform in the future. The Phase 1 study has involved the preparation of results for the following years in order to understand how the risk changes over time and what the effects are:

- Present day
- 2026
- 2066
- 2106

Proposed scenarios and options were prepared and submitted to the Environment Agency and details of the scenarios are contained in Appendix A.6. The options included are:

- Option 1 - Large storage area at Bradford-on-Tone
- Option 2 - Medium storage area at Bradford on Tone
- Option 3 - Sherford Stream storage area
- Option 4 - Improving existing defences
- Option 5 - Combination of Medium storage area at Bradford-on-Tone with defence improvements
- Option 6 - Improved conveyance

4.1.3 How scenarios have been compared

For consistency all of the scenarios have been compared against the equivalent results for the Do Nothing scenario although it is recognised that in there is not much difference between the Do Nothing and the Do Minimum scenarios. For the present day (2014) the Do Nothing scenario is equivalent to the Do Minimum scenario as represented by the Baseline TDM-2014 results presented in Chapter 2. All scenarios considered assume that future development up to 2106 is brought forward as set out in Appendix A.5.

For the Phase 1 study the performance of the scenarios is only being judged on a single flood event (the flood with a 1% chance of occurring in any given year). A more detailed options

appraisal as envisaged in Phase 2 of the study would consider the benefits over a full range of flood events.

4.2 Do Nothing scenario

The Do Nothing scenario considers the progressive failure in defences. As discussed in Section 2.1.1 the condition of defences through Taunton is variable but none of them are considered to be at imminent risk of failure. Therefore in this study the Do Nothing scenario is the same as the Do Minimum scenario for the present day and 2026 epochs. The failure of defences is assumed to happen between 2026 and 2066 with all the defences assumed to have failed by 2106.

The results for the present day scenario are as presented in Section 2.3.1. The increased flows predicted under climate change for 2026 and 2066 result in a significant increase in the number of properties affected by flooding.

For the 2026 Do Nothing Scenario:

- The number of properties affected by flooding increases from **972** to **1774**.
- The water level at Priory Road Bridge increases by 140mm to **15.05mAOD**.
- The volume passing downstream increases 11% to **13.8 million m^3**.

For the 2066 Do Nothing Scenario:

- The number of properties affected by flooding increases from **972** to **2475**.
- The water level at Priory Road Bridge increases by 230mm to **15.15mAOD**.
- The volume passing downstream increases 13% to **14.2 million m^3**.

The results for the 2106 Do Nothing scenario which assume the failure of all raised defences through Taunton by the year 2106 is illustrated in Figure 4-2. They demonstrate the significant change from the present day baseline across the Taunton Area. All lower lying areas of North Town are completely underwater and a sizeable area surrounding the redeveloped Priory Bridge Car Park site is also inundated. Flood depths across parts of North Town are significantly in excess of 1m.

The changes through the epochs for both the Do Nothing and Do Minimum scenarios are shown in Figure 4-1. It clearly demonstrates that a substantial increase in flood risk is predicted by 2026 which demonstrates the need for implementing a strategic option at the earliest possible date.

For the 2106 Do Nothing Scenario:

- The number of properties affected by flooding increases from **972** to **2443**.
- The water level at Priory Road Bridge increases by 260mm to **15.18mAOD**.
- The volume passing downstream increases 19% to **14.8 million m^3**.

Figure 4-1: Comparison of properties flooded in each epoch for the Do Nothing and Do Minimum Scenarios

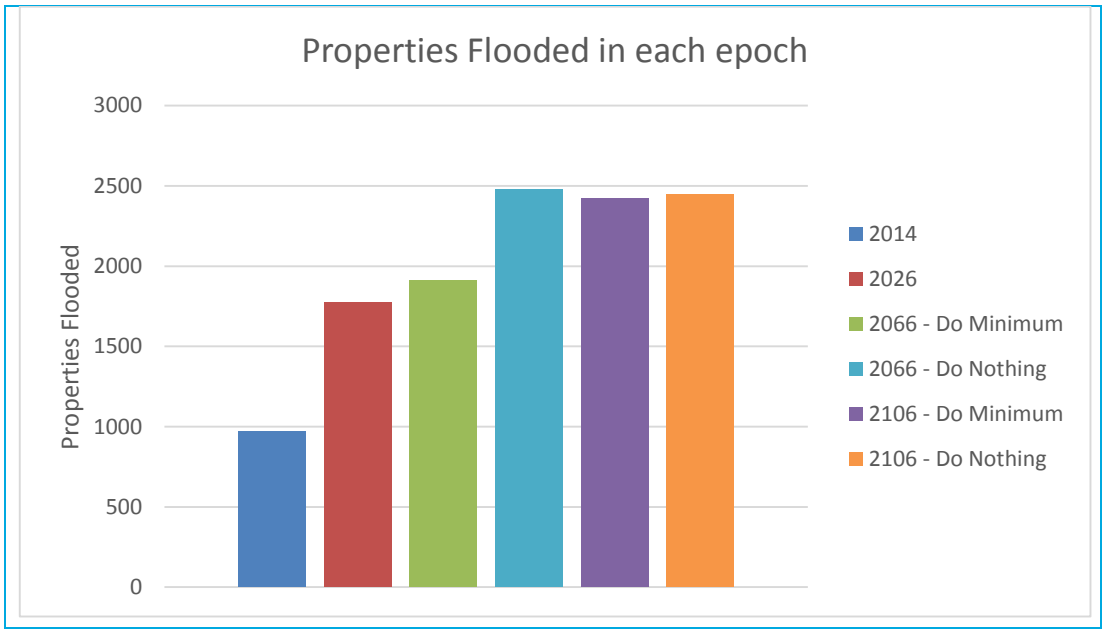
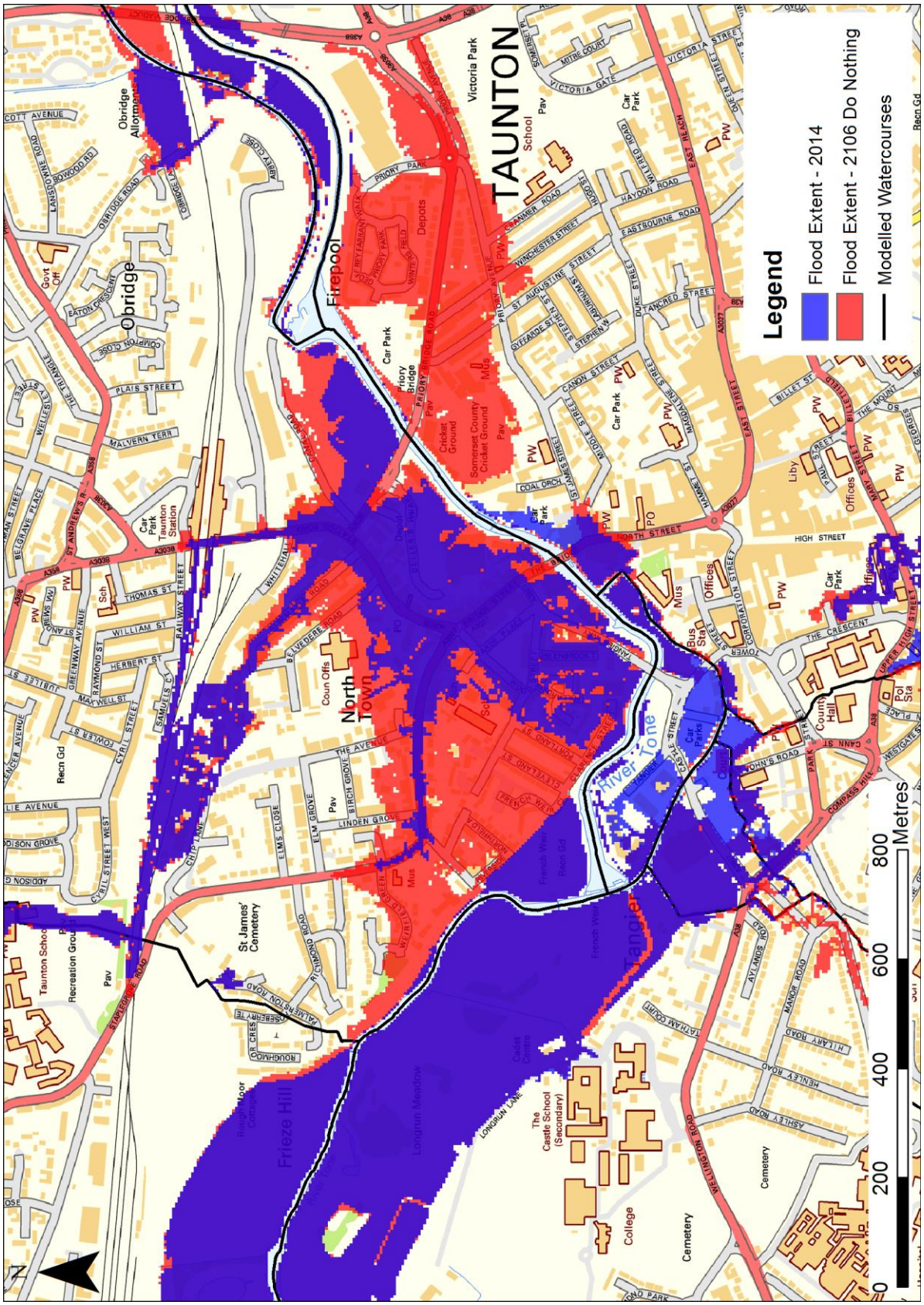


Figure 4-2: Flood extent for the Do Nothing Scenario in 2106



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4.3 Do Minimum Scenario

For the present day situation (and for 2026) the Do Minimum scenario is the same as the Do Nothing scenario and therefore no comparison is required.

Benefits and comparison of Do Nothing and Do Minimum

The Do Minimum scenario offers only a small benefit over the Do Nothing Scenario. When considering the 2106 epoch the Do Minimum is only protecting 21 of the properties at flood risk. It is necessary to remember that this assessment is only considering a single magnitude of flood event. The Do Minimum scenario will provide relatively greater benefits against the Do Nothing scenario when considering less severe events.

In Figure 4-4 the red shading shows the areas continuing to benefit from defences in 2106 as part of the Do Minimum scenario. However it is also evident that there is a sizeable area in the vicinity of Taunton High Street and the Riverside Chambers buildings that do not flood when the defences have all failed.

For the 2106 Do Minimum Scenario:

- The number of properties affected by flooding reduces from **2443** to **2422**.
- The water level at Priory Road Bridge increases by 50mm to **15.21mAOD**.
- The volume passing downstream is unchanged at **14.8 million m^3**.

The 2106 Do Minimum scenario includes the effect of new development and comparing against the 2106 'No development' scenario considered in Section 2.4 allows the effect of the urban extensions and town centre sites redevelopment to be considered.

By 2106 the effect of the proposed development will be to:

- Increase the number of properties affected by flooding by **88**.
- Reduce the water level at Priory Road Bridge by **20mm**.
- Increase the volume passing downstream by 1% to **14.8 million m^3**.

The changes in the metrics between the 'with development' and 'without development' cases are very small particularly when compared against the effects of climate change which over the period from 2014 to 2106 will:

- Increase the number of properties affected by flooding by 1362.
- Increase the water level at Priory Road Bridge by 310mm
- Increase the volume passing downstream by 19%

These changes are displayed graphically in Figure 4-3.

Figure 4-3: The effects of development on properties flooded and volume of floodwater passing beneath the M5

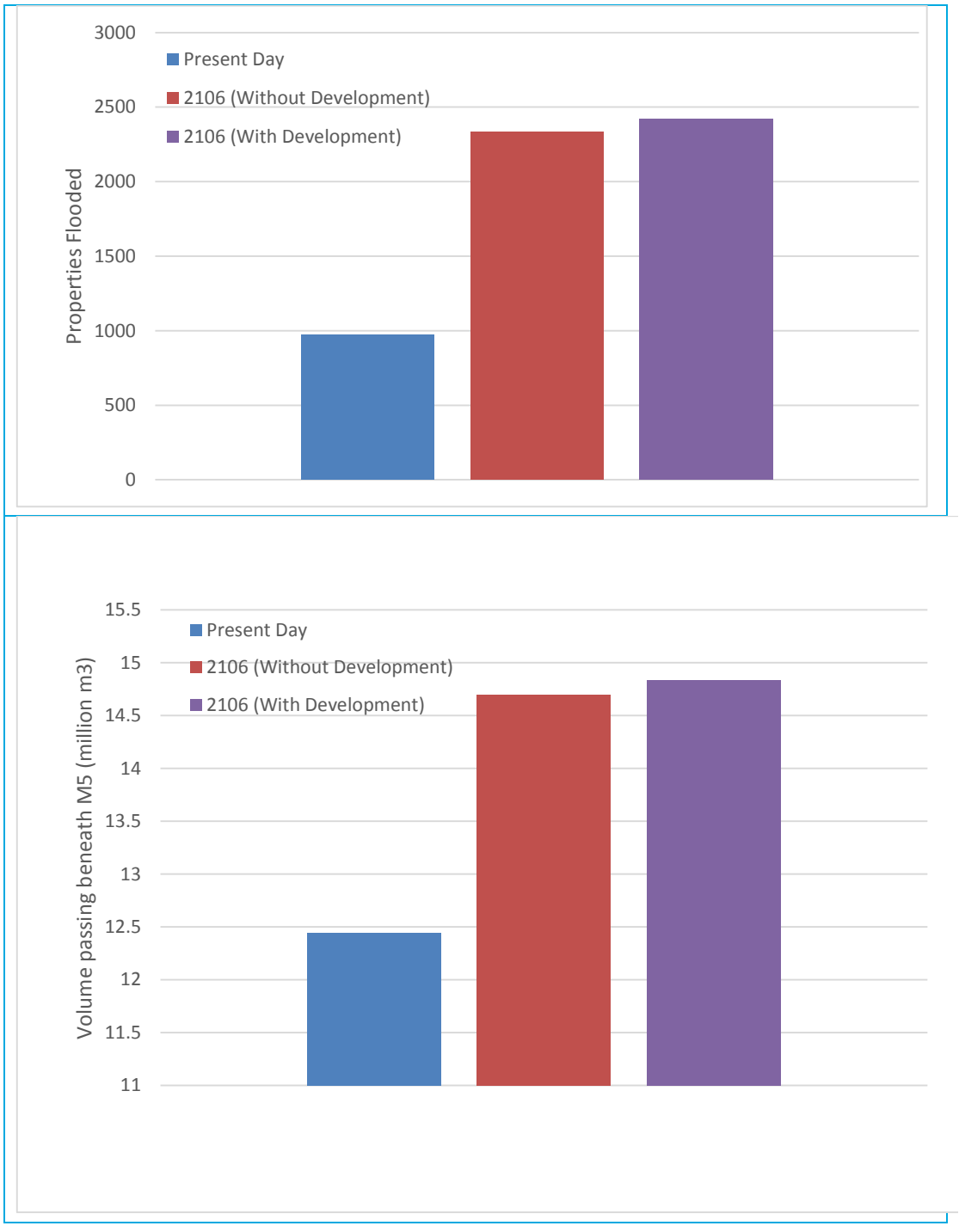
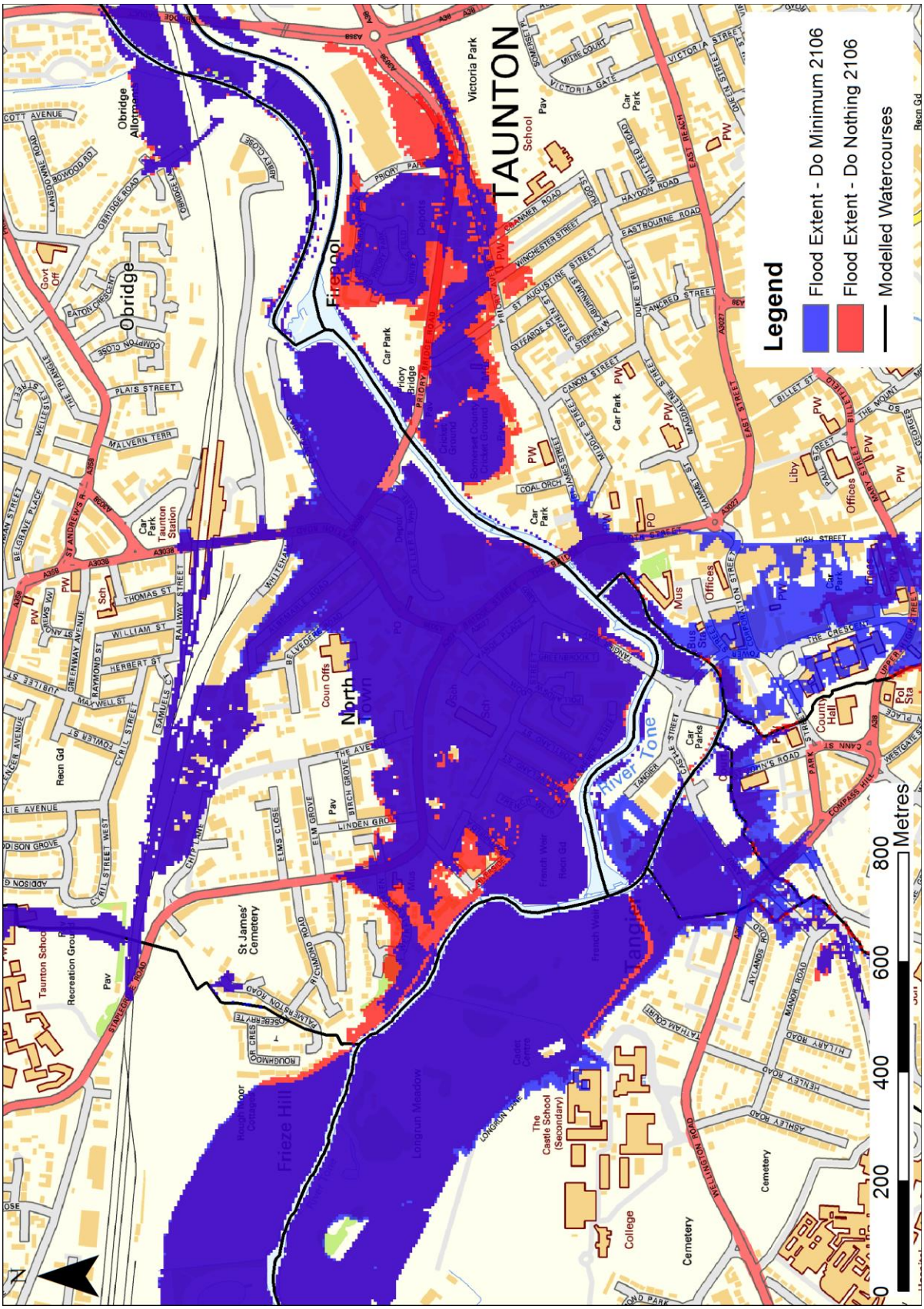


Figure 4-4: Comparison of the Do Minimum and Do Noting scenarios - 2106



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4.4 Do Something Scenarios

4.4.1 Option 1 - Large storage area at Bradford-on-Tone (the 'superpond')

This option is for a flood storage area at Bradford on Tone assumes that an embankment to a level of 36.0mAOD will be constructed. The presence of this structure allows a substantial volume of water to be stored on the floodplain upstream of Bradford-on-Tone. As can be seen in Figure 4-5, there is a substantial reduction in flood extent resulting in a near halving of the number of properties at risk for the present day. This option results in a large reduction in water level through the town centre but is unable to protect all of the town centre. By 2106 Option 1 is still capable of giving a water level and volume passing under the M5 lower than the present day baseline. The option goes a long way to offsetting the effects of climate change but does nothing to address the lack of freeboard in the existing town centre defences.

For Option 1 – present day:

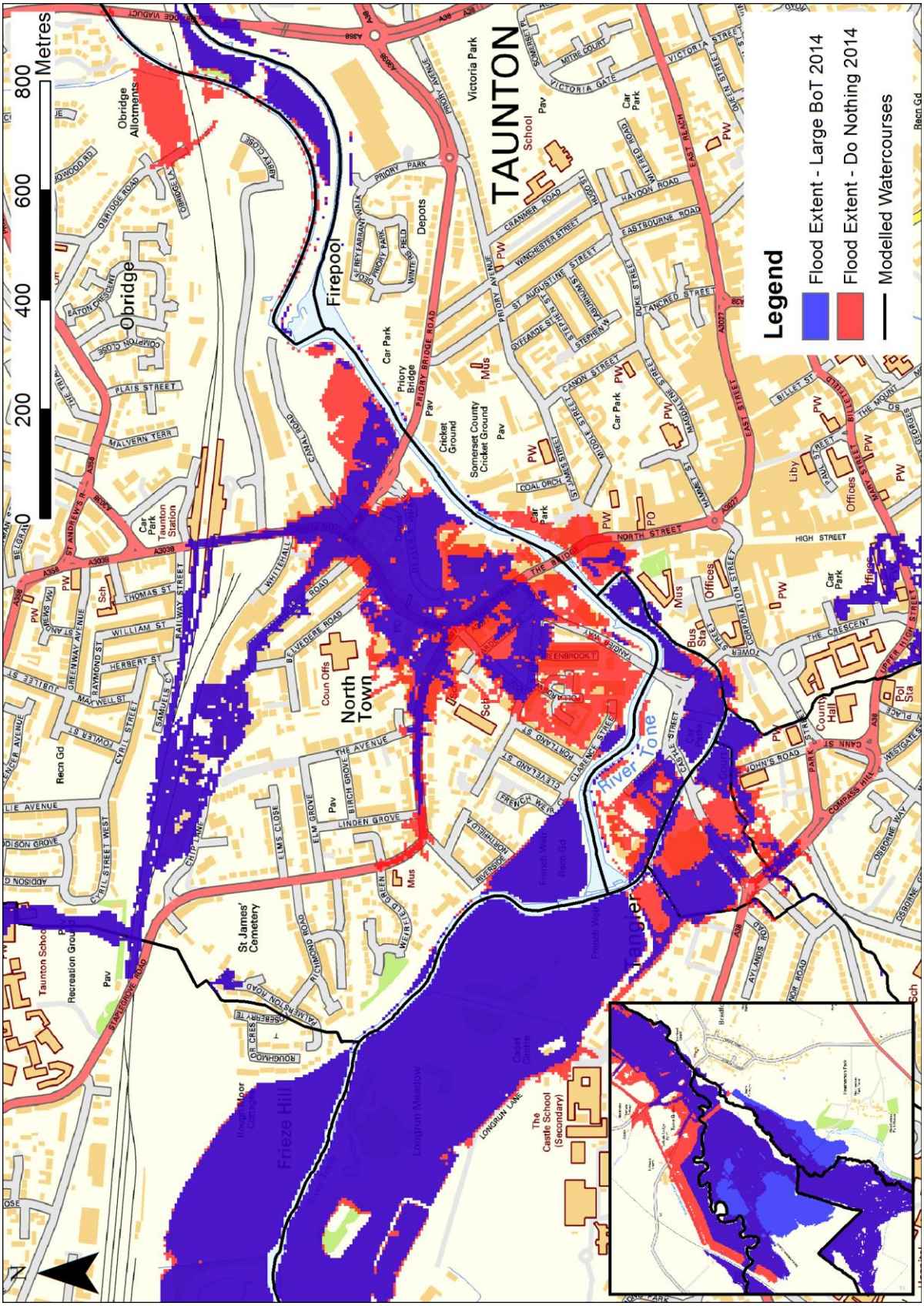
- The number of properties affected by flooding decreases from **972** to **527**.
- The water level at Priory Road Bridge decreases by 384mm to **14.53mAOD**.
- The volume passing downstream decreases 21% to **9.8 million m^3**.

This assessment has not sought to optimise the performance of the storage area and it might be possible to increase the performance slightly further during the Phase 2 study.

For Option 1 - 2106:

- The number of properties affected by flooding reduces from **2442** to **1144**.
- The water level at Priory Road Bridge decreases by 390mm to **14.77mAOD**.
- The volume passing downstream decreases 21% to **11.7 million m^3**.

Figure 4-5: Comparison of the large Bradford on Tone storage area with the Do Nothing scenario - 2014



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4.4.2 Option 2 - Medium storage area at Bradford on Tone

For this option the storage area at Bradford on Tone it is assumed that an embankment to a level of 34.25mAOD has been constructed. In practice this smaller storage area could be designed to allow for a future raising of level by designing the base of the embankment to be wide enough to support a higher crest. The presence of this structure allows a substantial volume of water to be stored on the floodplain upstream of Bradford-on-Tone.

As can be seen in Figure 4-6, there is a reasonable reduction in flood extent resulting in a reduction in the number of residential properties at risk for the present day situation. This option can still provide some benefits in 2106 although the reduction in water levels achieved indicate that this would need to be combined with another option to make a viable long term strategy.

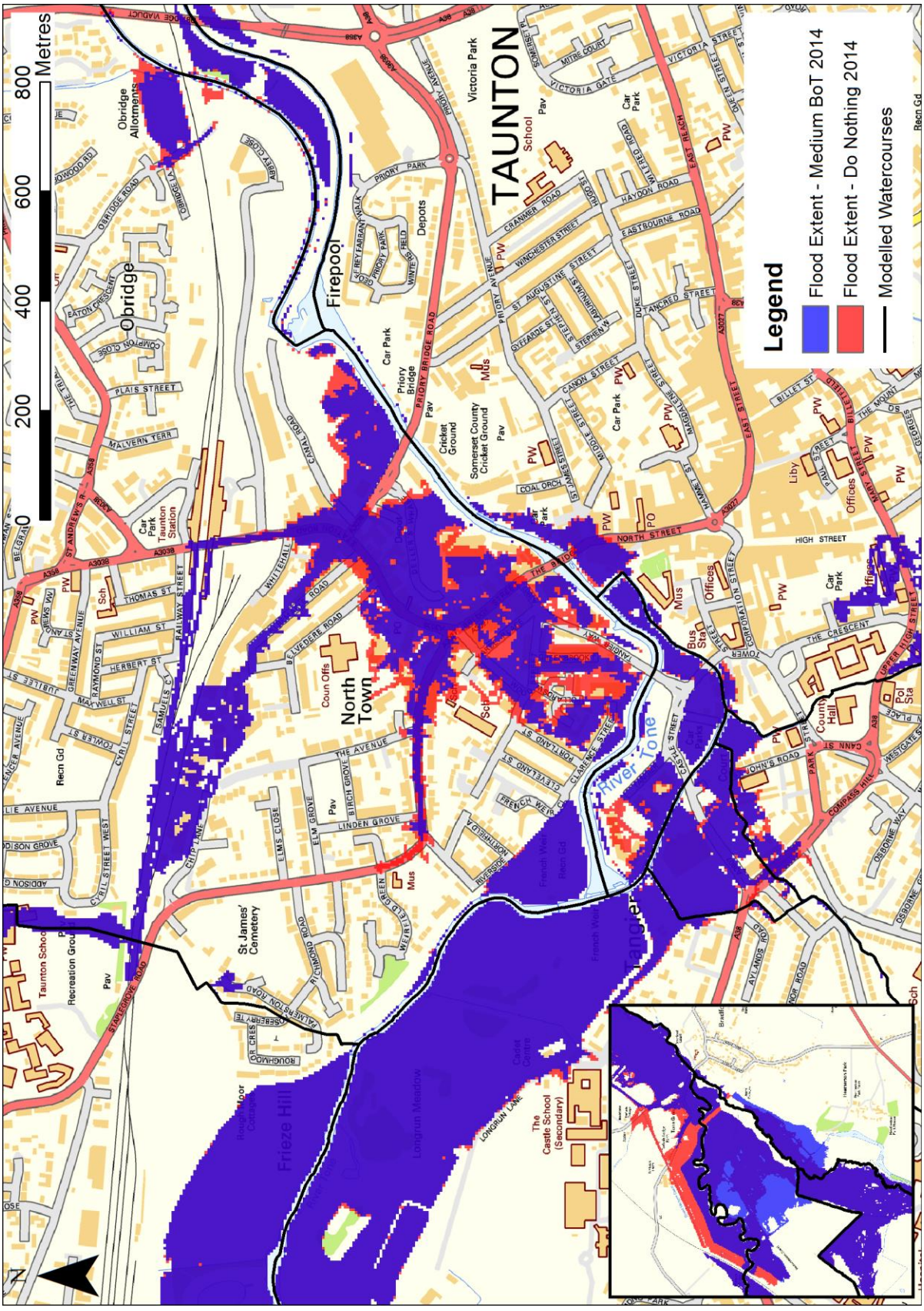
For Option 2 – present day:

- The number of properties affected by flooding decreases from **972** to **735**.
- The water level at Priory Road Bridge decreases by 80mm to **14.84mAOD**.
- The volume passing downstream increases 2% to **12.6 million m^3**.

For Option 2 - 2106:

- The number of properties affected by flooding reduces from **2442** to **1927**.
- The water level at Priory Road Bridge decreases by 120mm to **15.04mAOD**.
- The volume passing downstream decreases 2% to **14.5 million m^3**.

Figure 4-6: Comparison of Medium storage area at Bradford-on-Tone with Do Noting scenario



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4.4.3 Option 3- Sherford Stream storage area

This option has considered the construction of an upstream flood storage area close to Wild Oak Lane on the Sherford Stream, an idea originally conceived as part of the Taunton Vision. For this scenario it has been considered that an embankment with a crest level of 34.5mAOD has been constructed which can retain water with the Sherford Stream catchment. This option has been coupled with lowering the setting of the sluice on the Norton Fitzwarren dam and thus using the available storage volume more effectively.

Figure 4-7 shows a reduction in flood extents in North Town, a similar reduction is achieved in Norton Fitzwarren and in the vicinity of Vivary Park. The scenario results in slightly fewer properties at risk of flooding and reduces water levels at Priory Bridge. Additional analysis would be required to determine whether the primary benefit comes from the Wild Oak Lane storage area or the Norton Fitzwarren amendments. Whilst the overall benefit is relatively small this option may still be worthy of further consideration particularly if it could be tied to new development at the Comeytrowe site in the neighbouring subcatchment.

For Option 3 – present day:

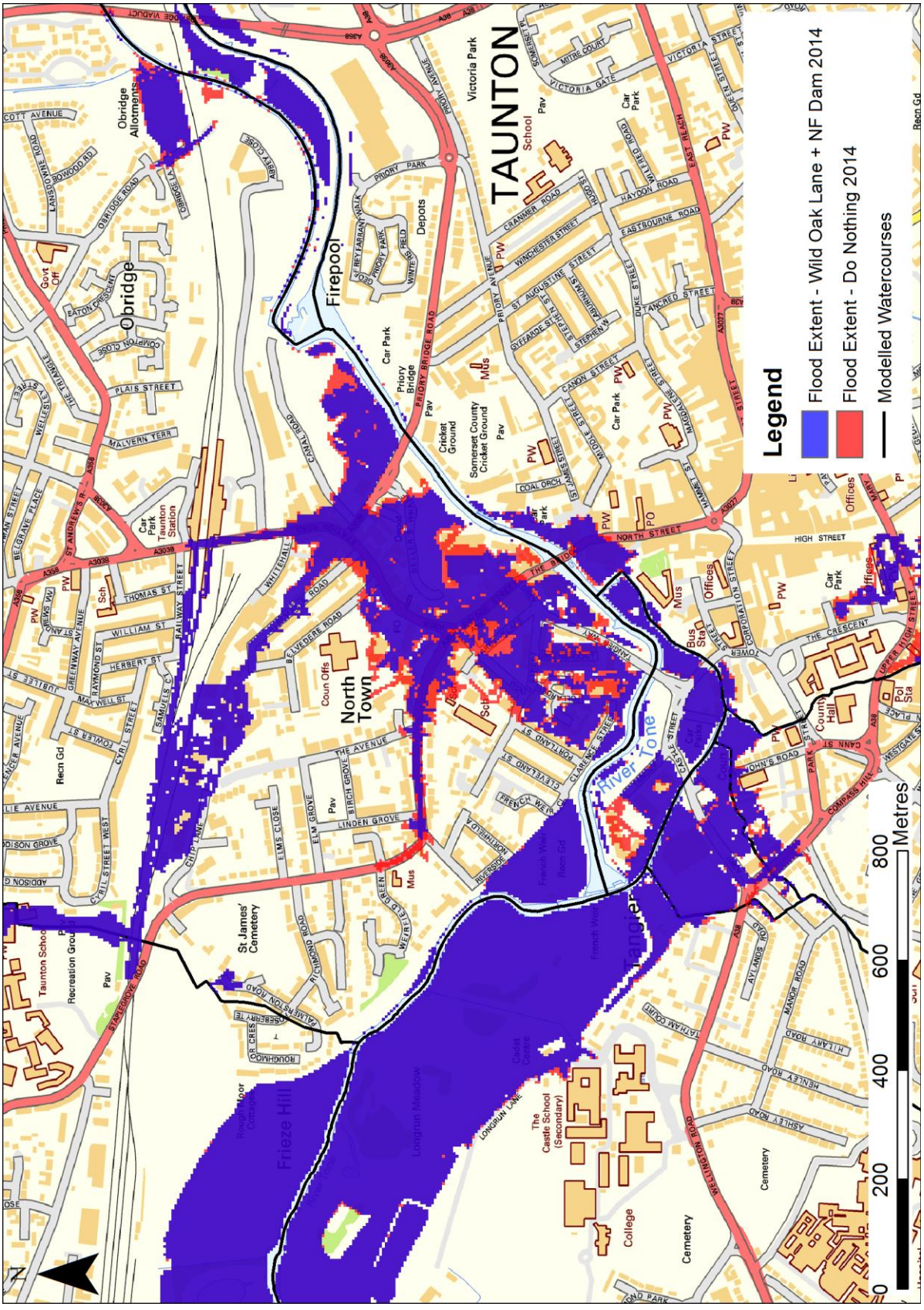
- The number of properties affected by flooding decreases from **972** to **783**.
- The water level at Priory Road Bridge decreases by 60mm to **14.86mAOD**.
- The volume passing downstream decreases 1% to **12.3 million m^3**.

For Option 3 - 2106:

- The number of properties affected by flooding reduces from **2442** to **1932**.
- The water level at Priory Road Bridge decreases by 30mm to **15.12mAOD**.
- The volume passing downstream decreases 1% to **14.6 million m^3**.

As with Option 2 this option would need to be combined with other measures in order to provide a viable long-term solution.

Figure 4-7: Comparison of Sherford storage and sluice lowering at Norton Fitzwarren dam with the Do Nothing scenario



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4.4.4 Option 4 - Improving defences

For this scenario the existing defences through Taunton have been assumed to be raised to the flood level for the event with a 1% chance of flooding in any given year plus an allowance for freeboard and climate change. Raising defences is a more complex option as whilst a number of the defences are already high enough they will require replacement in the future because they are in poor condition or not structurally capable of resisting the high water levels experienced during a flood (they would fail or fall down).

The raising of the existing defences offers a direct way to protect the town centre from flood risk and by raising them to an appropriate level they could provide a suitable standard of protection now and into the future. However raising existing defence can result in flood risk to third parties both upstream and downstream at locations where no defences are present or where the existing defences would be affected by the resulting increase in flood water levels. For the present day scenario this raising of water levels is only 8mm but this rises as the flows are increased for the different epochs. Figure 4-8 shows the reduction in flood extent around North Town and Coal Orchard which reduces the number of properties at risk by 25%.

For the present day epoch the water levels in the River Tone vary from 16.55mAOD downstream of French Weir to 14.91m AOD upstream of Firepool Weir when defences are raised. These levels represent an increase of upto 50mm on the Do Nothing scenario and would overtop small sections of the existing defences along the left bank including the telephone exchange and a more significant section along the right bank. Where defences need to be raised it would be by 120mm on average with a maximum increase of 500mm. These figures exclude a freeboard allowance and a further provision of 300mm is advised. Raising the right bank defences on the River Tone in the vicinity of Tangier would not protect any further properties as flooding would occur form the Mill Stream which has no formal flood defences.

For the 2106 epoch the increase in water levels over the 2014 epoch is typically 400mm (with a maximum of 600mm). This is significantly greater than the 300mm increase for the Do Minimum scenario over this time frame as raising the defences constrains the flows to the channel raising water levels further. For this epoch the raising of the defences would be substantial and the freeboard allowance would still be required on top. It is considered that raising the defences to protect to the 2106 water levels would not be deliverable unless in combination with another option that reduces the peak flows (and levels) through the town centre.

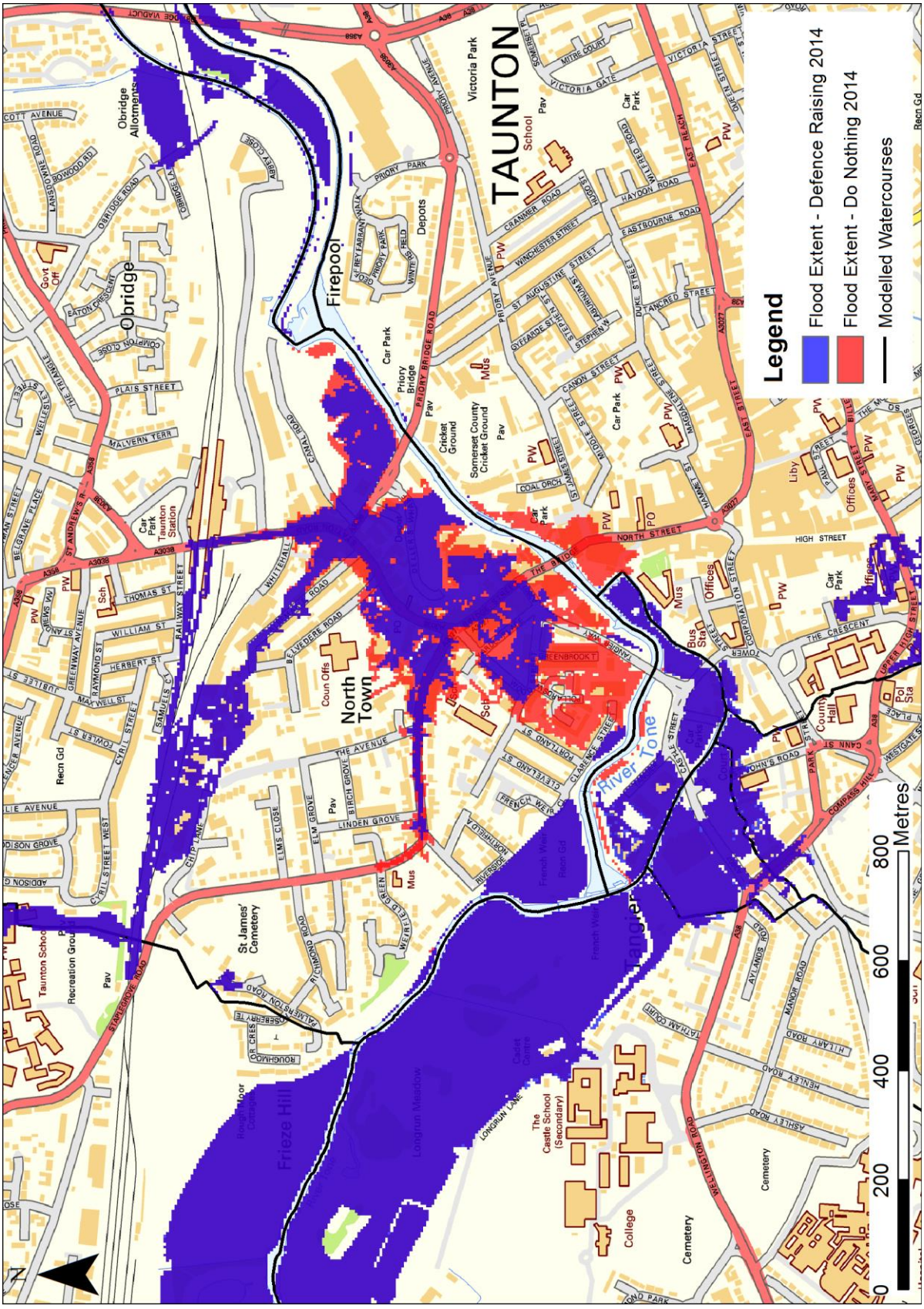
For Option 4 – present day:

- The number of properties affected by flooding decreases from **972** to **735**.
- The water level at Priory Road Bridge increases by 10mm to **14.93mAOD**.
- The volume passing downstream is unchanged at **12.4 million m^3**.

For Option 4 - 2106:

- The number of properties affected by flooding reduces from **2442** to **1467**.
- The water level at Priory Road Bridge increases by 30mm to **15.19mAOD**.
- The volume passing downstream decreases 1% to **14.7 million m^3**.

Figure 4-8: Comparison of Improving existing defences with the Do Nothing scenario



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4.4.5 Option 5 - Combination of Medium storage area at Bradford-on-Tone with defence improvements

This scenario has been considered in order to improve Option 4 –raised defences as by including a storage area it can offset the rise in water levels for the present day epoch. It should also help to lower the degree of raising of the defences required. The reduction in extents for the present day scenario are shown in Figure 4-9 and a substantial reduction in flood risk in the southern portion of North Town and through Coal Orchard is observed reducing the number of affected properties by more than a third.

This option considers to provide a substantial benefit in 2106 almost halving the number of properties at risk and demonstrates that combined options can be an effective solution in managing long-term flood risk.

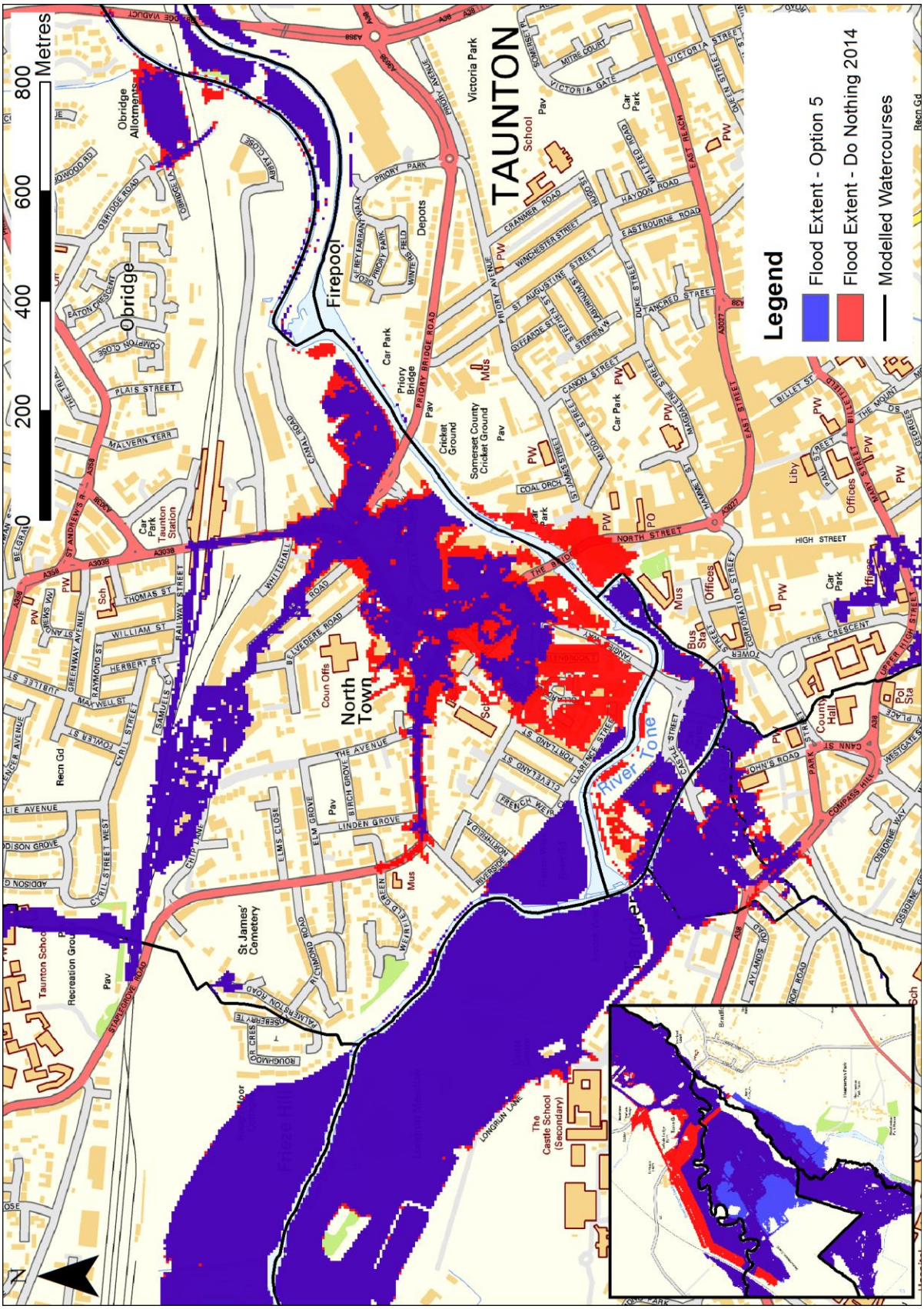
For Option 5 – present day:

- The number of properties affected by flooding decreases from **972** to **602**.
- The water level at Priory Road Bridge decreases by 70mm to **14.85mAOD**.
- The volume passing downstream increases 1% to **12.6 million m^3**.

For Option 5 - 2106:

- The number of properties affected by flooding reduces from **2442** to **1310**.
- The water level at Priory Road Bridge decreases by 80mm to **15.07mAOD**.
- The volume passing downstream decreases 2% to **14.5 million m^3**.

Figure 4-9: Comparison of Option 5 with the Do Nothing scenario



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4.4.6 Option 6- Improved conveyance

This option has sought to increase conveyance of flood water through the town centre by removing or substantially lowering French Weir and Firepool Weir. In addition Town Bridge a major constriction to flow on the River Tone has been raised by 200mm. The resulting changes in flood extent for the present day scenario can be seen in Figure 4-10. There is a small reduction in the number of properties at risk despite the water level at Priory Road bridge decreasing by a reasonable amount. This option performs very poorly by 2106 as all of the benefit in improving the conveyance has been lost as a result of the increased flows under climate change.

This option is not consider to offer a benefit going forward although the concepts of amending the weirs could be pursued if there are plans to invest money in them through the town centre redevelopments.

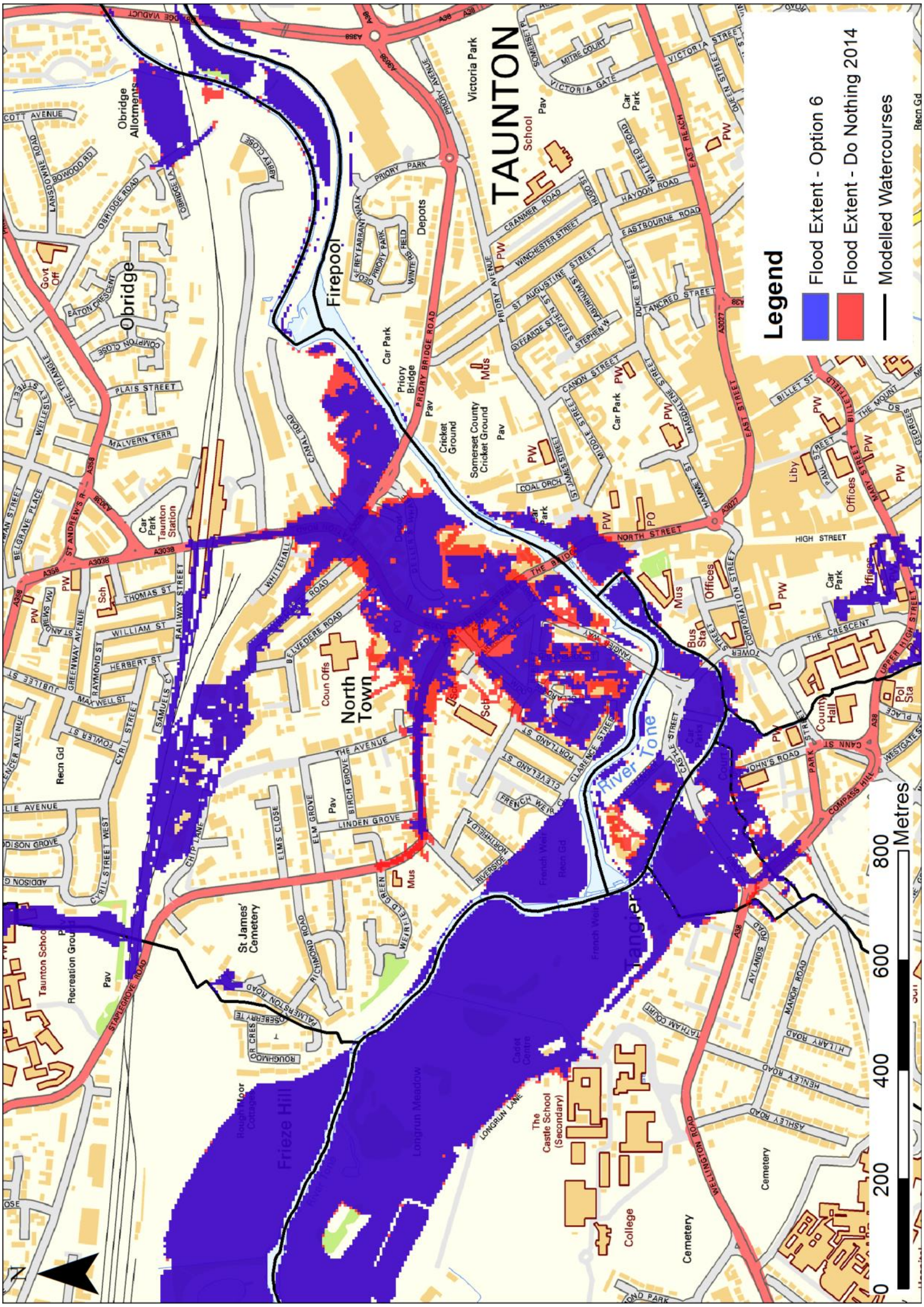
For Option 6 – present day:

- The number of properties affected by flooding decreases from **972** to **878**.
- The water level at Priory Road Bridge decreases by 90mm to **14.83mAOD**.
- The volume passing downstream is unchanged at **12.4 million m^3**.

For Option 6 - 2106:

- The number of properties affected by flooding reduces from **2442** to **2170**.
- The water level at Priory Road Bridge decreases by 40mm to **15.12mAOD**.
- The volume passing downstream decreases 1% to **14.7 million m^3**.

Figure 4-10: Comparison of Option 6 – Improved Conveyance with the Do Nothing scenario



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4.5 Summary of effects on downstream receptors

The effect on downstream receptors from all of the options is minimal for the present day epochs. All options except raising defences and increasing conveyance would be expected to show no difference or a slight reduction in peak water levels. The large Bradford-on-Tone storage area is predicted to reduce water levels upstream of Ham by 65mm which would be expected to provide some benefit to the surrounding communities. The increased conveyance and the defence raising show no significant increase in water levels downstream of the M5.

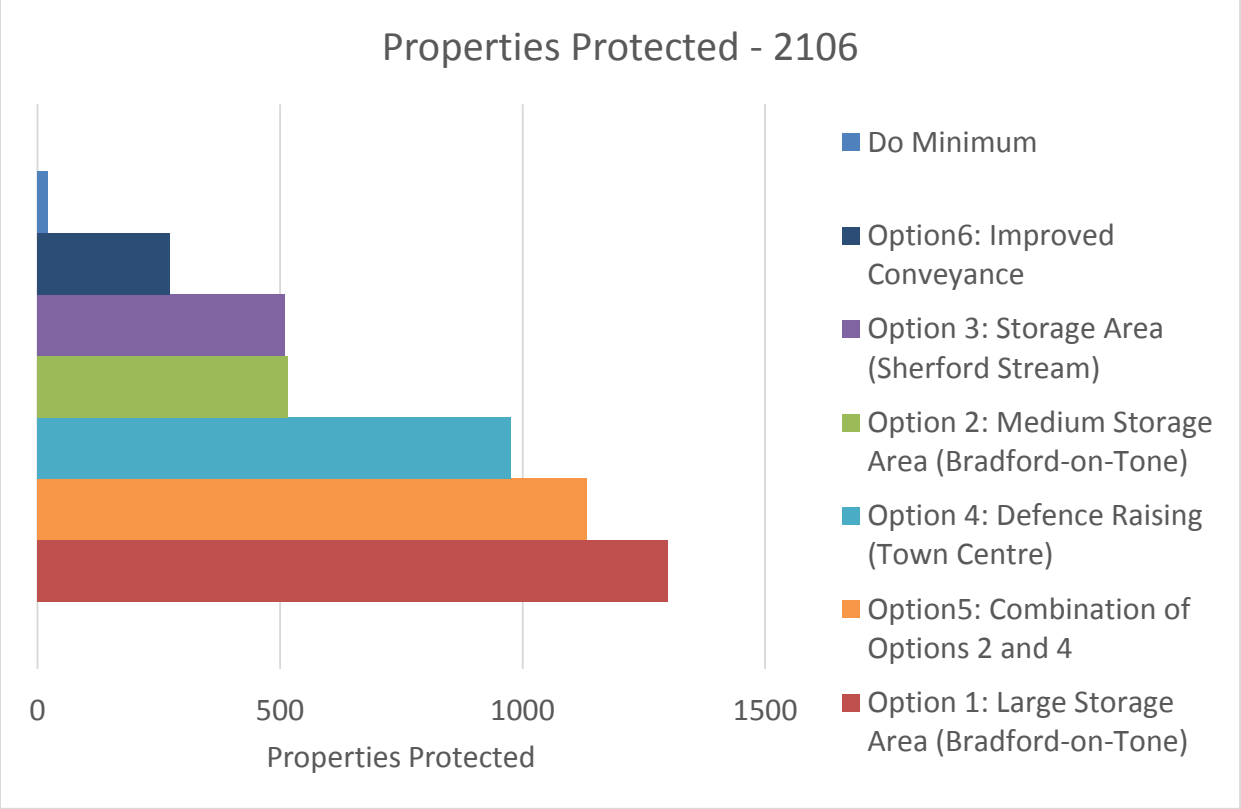
However with all of the options the total volume passing downstream cannot change. It may be that the storage areas detain water for long enough that the volume does not show on the event scale but it will eventually make its way downstream. The important point to notes is that the volumes of floodwater will increase significantly due to the effects of climate change. Under the events considered in this study there would be an additional 3 million m^3 of water passing through the M5 all being discharged to the Levels and Moors. The effects of increased volumes from proposed new development can be mitigated by the additional storage capacity in the large or medium storage areas and by the required SUDS measures.

4.6 Selection of the priority option and comparison of indicative budget costs

In a more detailed options appraisal the scenarios would be considered for a range of storm magnitudes and the decision would be an economic one focused on cost benefit. The findings of the phase one study strongly suggests that there is no one single option which could provide the total reduction in water level required to ensure that Taunton keeps pace with climate change and secures an appropriate standard of protection for existing communities.

The relative benefit of the alternative strategic options in terms of properties protected from flooding is shown in Figure 4-11. This shows that it is logical to make the Large Storage area the priority option. Indicative costs of the respective options are given in Appendix A.7.

Figure 4-11 Relative benefit in terms of property flooding of respective options

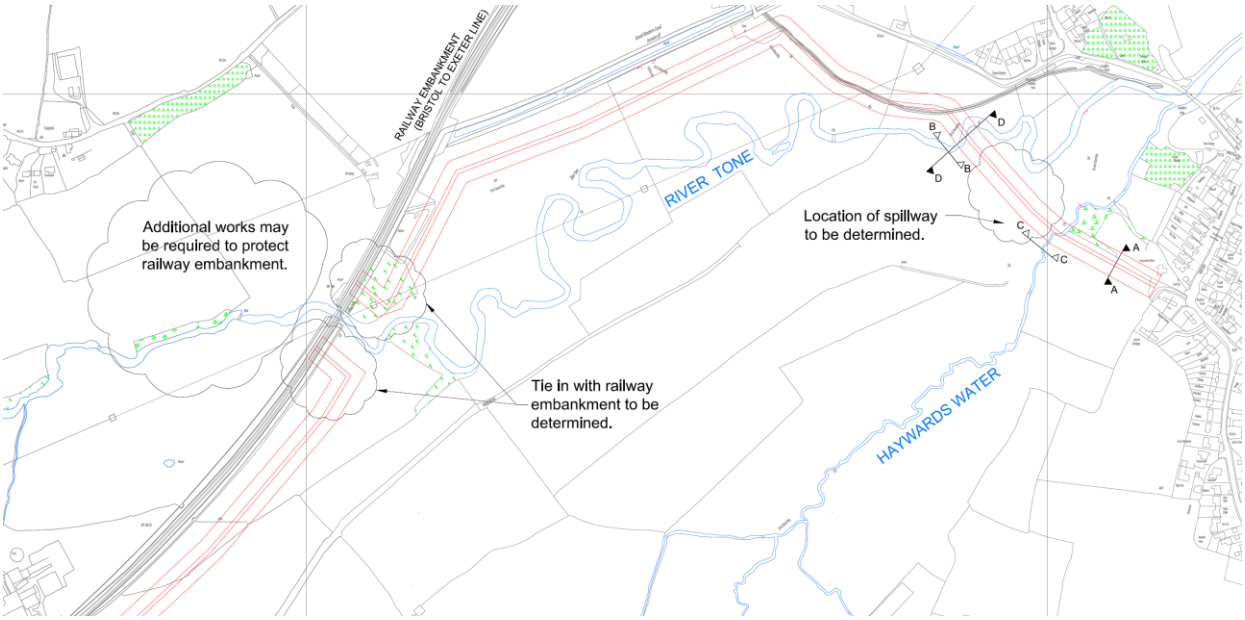


4.6.1 Details of the priority option – the 'superpond'

Figure 4-12 illustrates how a large storage pond could be located at Bradford on Tone. The concept of this option is to construct an embankment across the River Tone and Haywards Water.

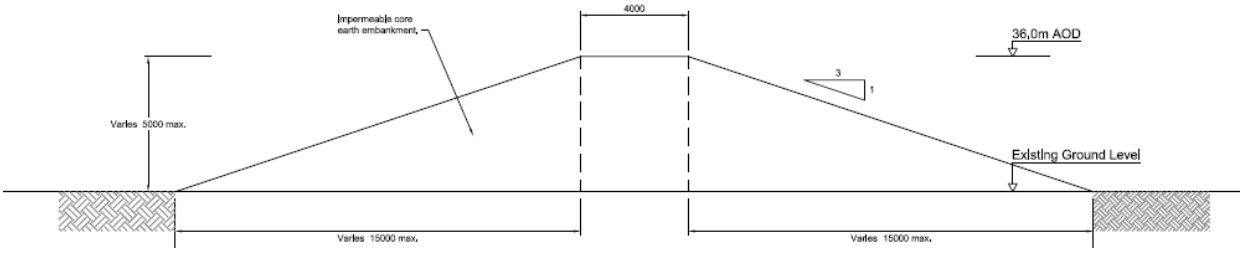
The embankment would be constructed to a maximum height of 36.0mAOD and would have a lowered spillway to prevent the whole of the embankment from overtopping if the structure were to completely fill with flood water. The embankment has been extended along the railway line as Network Rail are unlikely to permit their embankment to be used to store floodwater. If the storage area filled to its maximum safe level the structure could retain 1.8million m^3 of floodwater (Wembley has bowl volume of 1.14 million m^3 and the Millennium Stadium has a bowl volume of 1.5 million m^3).

Figure 4-12 Outline details of large flood storage pond



The embankment to contain the flood water would have a substantial footprint. A section through the embankment is shown in Figure 4-13.

Figure 4-13 Cross section through storage pond embankment



4.7 The way forward

4.7.1 Investment plan approach

It will be necessary to plan for the implementation of a combination of the strategic options to achieve the appropriate standard of protection to meet the climate change conditions. At this stage it is not possible to determine what combination of options is most appropriate as this does not only rely on their technical capacity but also on their cost and the availability of funds to deliver them. It will also be important to have flexibility with respect to the design of the riverside area and opportunities to improve the strategic flood risk provision whilst at the same time enhancing the visual and amenity value of the river corridor through the town centre. It would be preferable if the

investment in flood risk management measures at Taunton could be combined with the provision of new infrastructure to improve the economic well-being and amenity of the town and further options that deliver this outcome should be explored in Phase 2 of the study. A further refinement could be to consider the benefit to the Levels and Moors that could be achieved by further modification of the operation of the Large Storage area. It is conceivable that the storage could be used for the dual purposes of reducing the chance of occurrence of more frequent flooding in the Levels and moors whilst still providing the appropriate standard of protection to Taunton during less frequent, more severe events. This would require the implementation of a much improved flood forecasting system (which should perhaps be considered as appropriate in any case).

Whilst a combination of options is needed the Phase 1 study has identified that:

- The large storage scheme at Bradford on Tone provides:
    - A significant potential benefit and also establishes additional storage in the catchment upstream of Taunton to address the potential adverse effects of local protection on land and property downstream of the town centre.
    - The scheme can be constructed in phases and thus the capital investment required can be spread over a longer time frame.
    - Since the scheme is linked to the provision of new infrastructure in the Core Strategy it can potentially attract funding from the Infrastructure Development Plan (making it potentially more affordable than other options).
- The long term nature of the requirement makes it appropriate to adopt an investment plan approach to the provision of Flood Risk Management Measures. This will require a portfolio of schemes and approaches to be carried forward. Opportunities arising (maybe not identified here) should be seized and the maximum long term strategic benefit captured at all times.
- Capital investment opportunities should be seized, with priority given to the schemes which offer the greatest long term strategic benefit, which at this time is the Bradford on Tone storage scheme
- There will be a need to replace existing defences that are no longer structurally sound since these must be maintained to provide an appropriate standard of protection to the town centre. The sequence for this replacement will probably be directly linked to their condition.
- There are potential opportunities at riverside locations to improve the standard of protection to the town centre when bringing forward development in the current plan period (up to 2026).
- When bringing forward strategic proposals there will be a requirement to increase the 'freeboard' of the existing defences, as these are below appropriate standards (the freeboard is the height difference between the top of the predicted flood water level and the top of the defences. This is particularly important in Taunton since small changes to flow magnitudes result in large changes in the predicted flood levels).
- It is possible to reduce the risk of flooding in Taunton by modifying the operational arrangements of the flood storage facility on the Halsewater. Whilst this option does not provide the greatest benefit it is probably one that involves much less cost.

5 Summary Conclusions

The summary conclusions are:

- Climate change effects significantly increase the risk of flooding to existing and new development in the town centre.
- The flood risk is predicted to significantly increase over the next 10 years as the existing defences do not have any safety margin (freeboard) over considerable lengths.
- It is possible to implement new development identified in the 'Town Centre Rethink' provided that this is accompanied by appropriate mitigation measures.
- The proposed new development in the town centre and Core Strategy sites does not have an adverse effect on downstream flood conditions, but climate change effects will increase the volume of water discharging to the Levels and Moors.
- The phase 1 study has shown that the large storage area at Bradford on Tone is the priority option. As a matter of urgency action should be taken to commence a programme to establish the feasibility and design details for the large storage pond strategic option (the 'superpond').
- It will be necessary to use a combination of Strategic options to provide the appropriate standard of protection from flooding in 2106 and an Investment Strategy Approach should be used to ensure that funding arrangements are put in place and opportunities for contributions are not missed.
- Securing funding for more detailed studies and design development (Phase 2 study) is a priority, as is securing funding for the required measures.
- The phase 2 study should consider a further option that combines flood risk management improvements in Taunton with new infrastructure that supports economic growth and improved leisure and open space amenities closer to the town centre. Consideration should also be given to how modifications to the operation of the storage at Bradford on tone could potentially provide benefits to the Levels and Moors.

A Appendices

A.1 Frequently Asked Questions (FAQs)

Questions	Answers
What is the risk posed by flooding in Taunton at the moment?	Existing predicted flood risk in Taunton can be summarised as follows during a flood with a 1% chance of occurring in each and every year: • 972 properties affected by flooding • Water level at Priory road bridge is 14.92m AOD • The volume of flood water passing along the River Tone under the M5 bridge is 12.4 million cubic metres (see Section2.3.1 in report)
What state are Taunton's flood defences in?	Offer a very variable standard of protection. (see section 2.3.2)
What is the risk of flooding in future?	Future predicted flood risk a 100 years from now at Taunton can be summarised as follows during a flood with a 1% chance of occurring in each and every year: • The number of houses affected increases from 972 properties to 2334 • Water level at Priory road bridge increases by 310mm to 15.23m AOD • The volume of flood water passing along the River Tone under the M5 bridge increases by 18% to 14.7 million cubic metres (see Section2.4.1 in report)
How has account been made for climate change in modelling the impacts and benefits of the options?	Climate change has been taken into account and is estimated for different epochs (2026, 2066 and 2106) (see section 2.2.2)
How many properties are at risk if we do nothing now and into the future?	The number of properties predicted to be affected from flooding during an event with a 1% chance of occurring in each and every year increases from 972 to 2443 by 2106. (see section 4.2 in report)
If we do nothing, what will the impact be on the planned growth of Taunton and Town Centre developments, now and into the future?	The flood risk will increase significantly and both planned growth and existing communities will be severely affected. (see section 2.4.1)
In the absence of a major upstream alleviation scheme, are the current Town Centre flood defences up to the task?	The majority of the existing defences do not have any margin of safety from being overtopped during flood events with a 1% chance of occurring in each and every year. As such they do not provide the standard of performance that would be expected of appropriately designed defences. (see sections 2.1.1 and 2.2.1)
Can development in the Town Centre and elsewhere occur in the meantime?	Proposed development, as described by Taunton Rethink can be implemented provided appropriate mitigation measures are included and commitment is made to the provision of strategic solutions to address climate change effects. (refer to Chapter 3)
If development occurred as planned, but without any further flood mitigation works, how would communities downstream be impacted, particularly on the Levels and Moors?	The planned development will not adversely affect the Levels and Moors. The biggest factor is flood storage volumes and commitment has been made to provide additional flood storage compensation to address land raising in the town centre and surface runoff from the Core strategy sites. (refer to chapter 3)
What will the flooding impact of the growth of Taunton have on communities downstream?	The proposed growth does not result in any potential adverse impact. However, climate change effects will significantly increase the volumes of water discharging along the River Tone to the Levels and Moors. (refer to Chapters 3 and 4)
What practical approaches can be taken to allow development to happen in the meantime?	Proposed development, as described by Taunton Rethink can be implemented provided appropriate mitigation measures are included and commitment is made to the provision of strategic solutions to address climate change effects. (refer to Chapter 3)
What options have been looked at to reduce flood risk to Taunton?	Six options have been considered. They are: • Large storage area at Bradford on Tone • Medium storage area at Bradford on Tone • Storage area on Sherford stream • Improved flood defences • Improved flood defences in combination with

	medium storage area • Improved channel conveyance (refer to Chapter 4 and Appendix A.6)
What benefits will these options have for existing and planned development, now and in the future?	All the options reduce the number of properties that would be affected in the future as a consequence of climate change. The priority option with the most potential benefit is the large storage area. (refer to section 4.6 and Appendix A.6)
Will these options have impacts (positive or negative) downstream?	Apart from the option to raise the defences all the proposed options potentially offer a benefit or result in no detriment downstream. (refer to Chapter 4)
What improvements and expenditure would be needed to ensure the town centre defences delivered the required protection to properties and businesses now and into the longer term?	No single option by itself can deliver an appropriate standard of protection to meet the conditions as will be caused by climate change. It will be essential to implement a combination of options and select those that are most affordable and can meet the priorities. (refer to Section 4.7 and Appendix A.7)
What is the recommended approach (option) for managing the risks that have been identified and why?	The recommended approach is to implement a combination of options and select those that are most affordable and can meet the priorities. (refer to Section 4.7)
What are the benefits and impacts associated with the recommended option? (i.e. number of houses protected)	The priority option is the large storage area and if implemented this would reduce the number of properties affected during a flood with a 1% chance of occurring in each and every year from 2,442 to 1,144. (refer to section 4.4.1 and Appendix A.6)
When does the recommended option need to be in place?	The priority option should be in place by 2026. (refer to section 4.2)
What does the proposed superpond look like and how will it work?	The large storage area or superpond is simply a long embankment and control structure at Bradford on Tone. For the majority of the time it is not a 'pond', but the land could be maintained for agriculture or as an alternative used as an opportunity to create new ecological habitat. (refer to Section 4.6.1 for scale and outline details)
How big is the superpond?	The large storage area would involve the construction of en earth embankment to a level of 36.0mAOD. It could retain 1.8 million cubic metres of water during a flood event (Wembley stadium has a bowl volume of 1.14 million cubic metres) (refer to section 4.6.1)
How much will the preferred option cost?	The indicative cost of the preferred option is in the order of £12million to £16million. (refer to Appendix A.7)
Should other options remain on the table if the superpond is not deliverable for any reason?	No single option by itself can deliver an appropriate standard of protection to meet the conditions as will be caused by climate change. It will be essential to implement a combination of options and select those that are most affordable and can meet the priorities. (refer to Section 4.7)
What are the implications for current flood defences from your recommended option? Should they remain in place and be managed or improved?	The existing defence must be maintained and improved in the future to reinstate the appropriate margin of safety. Some of the defences are in poor condition and will need to be replaced as they will become structurally unsound. None of the strategic options offer a standard of protection that make it possible not to rely on the defences in future. (refer to Appendix A.4 and Chapter 4)

A.2 Background to Phase 1 Study

Work for Taunton Vision

In 2006 detailed Flood Risk Management (FRM) Guidance was published to support the town centre proposals identified in the Town Centre Area Action Plan, as promoted under the 'Taunton Vision' project that was initiated in 2000/2001. The FRM Guidance had been prepared to address flood risk issues identified in the flood mapping and modelling studies carried out in the early 2000's and at this time provisions were made for:

- Land raising at the location of proposed development sites to achieve appropriate standards of protection from the risk of flooding.
- Implementation of a flood volume storage scheme at Longrun Farm to provide compensatory flood storage to replace the flood volumes lost due to proposed land raising in the town centre. (This has been designed, constructed and installed). The Longrun Farm compensatory storage facility means that there is no displacement of floodwater downstream as a result of the proposed improvements in Taunton town centre and thus flood conditions in the Levels and Moors are not made worse
- Identification of other measures to mitigate the effect of increased flood water levels in the town as a consequence of land raising due to the introduction of obstructions to overland flood flows. The range of alternative measures that were presented as options included new flood flow routes and reservoir storage facilities on some tributaries of the River Tone (Whilst the need for these measures was identified none have ever been progressed, as the associated development has not taken place).

Work for the SFRA (Core Strategy)

In 2010 TDBC and the Environment Agency commissioned a project to update the Strategic Flood Risk Assessment (SFRA) to provide appropriate evidence to support the Core Strategy sites being promoted in the Local Plan. The SFRA was published in May 2011 and the modelling and assessment required to prepare the content also identified:

- Some of the conclusions and guidance contained in the FRM Guidance document were no longer valid as the enhanced 2D flood modelling prepared for the SFRA indicated that:
    - The standard of protection available from the existing defences was not as great as had previously been understood.
    - Whilst land raising at some of the town centre sites could deliver appropriate standards of protection, the effect of the raised land on some existing flood flow routes and existing properties was much greater than previously recognised (this effect is most notable at the Cattle Market site).
    - Some of the measures previously identified in the FRM Guidance as having the potential to mitigate for the impacts of land raising would not be very effective (although Longrun Farm remains appropriate in principle).
- The predicted water levels for present day conditions are very close to the top level of the flood banks along the River Tone at many locations in Taunton town centre (and overtopping at some) and there is no ‘safety margin’ or ‘freeboard’. Any small change in predicted level will result in exacerbation of flooding and the increased consequences will be significant for the town centre. For this reason it was concluded that the 'residual risk' (the risk of flooding for an event that is greater than that used in the risk assessment) was a material factor.
- To address the residual risk the SFRA identified that a strategic upstream storage area could provide strategic mitigation for the increase in the volume of run-off resulting from the implementation of the Core Strategy sites. A provision was made within the Infrastructure Development Plan (IDP) for the implantation of the strategic surface water storage area.
- The strategic surface water storage area not only enables the Core Strategy sites to be developed without increasing flood risk in the town centre but also means that there is no increase in flood risk to downstream communities in the Moors and Levels.
- By increasing the capacity and modifying the operation of the strategic surface water storage area (increasing the storage volume by a factor of 5) it can be used to store flood water from the River Tone and thus reduce the peak flows and water levels in Taunton

town centre. This provides greater benefits than simply mitigating against the potential effects of runoff volumes from new development.

Work for Taunton Rethink

Current plans for future growth in Taunton are shaped both by the adopted Local Plan and Core Strategy and the town centre proposals being formulated in the 'Taunton Rethink' initiative. These initiatives maintain the momentum to make Taunton a centre for growth and regenerate the town centre and will be supported by the outcome of the Phase 1 and Phase 2 flood studies.

The Somerset Levels and Moors Flood action Plan - 2014

This plan was drawn up after the flood events of 2013 and 2014. The Plan was requested by the Secretary of State for Food and Rural Affairs and actions in the plan are grouped under the following headings:

- Dredging and river management
- Land management
- Urban runoff
- Infrastructure resilience
- Building local resilience

There are clearly links between the strategic proposals for Taunton and the Urban runoff theme in the Levels and Moors Flood Action Plan. The investment in measures that address climate change effects at Taunton take consideration of the potential downstream impacts and involve strategic measures that will increase the upstream volume of flood storage in the catchment and include measures that address runoff from new development, not only at a local scale but also at a catchment wide level.

A.3 Assessment of flood risk

Definition of flood risk

A flood is formally defined in the Flood and Water Management Act[2] as follows:

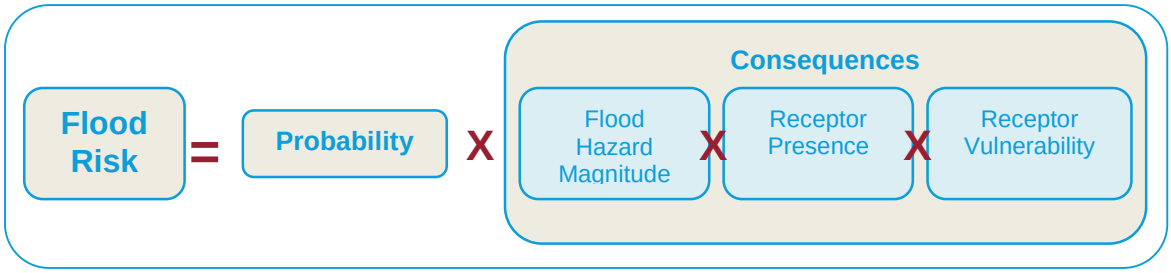
"*where land not normally covered by water becomes covered by water and can be the result of water emanating from a number of sources*".

Describing the level of flood risk in the town centre of Taunton must take account of:

- *The chance or probability of the flood happening*. High flows and water levels in the River Tone are not experienced very often and it is useful to understand the chance of a particular flow or water level being experienced in any one year. This report considers a range of floods, each with a different chance of happening in each and every year. The range of floods considered has included:
    - A flood with a 1 in 100 chance of being experienced in each and every year.
    - A flood with a 1 in 1000 chance of being experienced in each and every year.
- *The consequences that are experienced if flooding occurs*. The severity of the consequences is affected by the degree of hazard resulting from the depth and velocity of the flow of flood water and the vulnerability of the receptor that is affected by the flooding. Deep, fast flowing flood water is potentially more hazardous than shallow flood water that is just pooled or ponding as it can cause more damage to property and infrastructure and a greater threat to life. The risk is increased if people and property are affected by flooding rather than just fields or open land. it is possible to define flood risk as:

Flood Risk = (Probability of a flood) x (scale of the consequences)

The following expression is used to prepare estimates of how the risk varies:



Using this definition it can be seen that

- Increasing the probability or chance of a flood being experienced increases the flood risk. In situations where the probability of a flood being experienced increases gradually over time, for example due to the effects of climate change, then the magnitude of the flood risk will increase.
- The severity of the consequences can increase the flood risk.
    - **Flood Hazard Magnitude**: If the direct hazard posed by the depth of flooding, velocity of flow, the speed of onset, rate of rise in flood water or duration of inundation is increased (for example due to the effects of climate change), then the consequences of flooding, and therefore risk, is increased. New development can potentially increase the hazard if it causes an increase in surface runoff flows.
    - **Receptor presence**: The consequences of a flood will be increased if there are more receptors affected. Additionally, if there is new development that increases the probability of flooding or increased density of infrastructure then consequences will also be increased.
    - **Receptor vulnerability**: If the vulnerability of the people, property or infrastructure is increased then the consequences are increased. For example, old or young people are more vulnerable if they are caught up in a flood event.

The analyses have also included estimates of how the severity of flooding might be expected to change as a consequence of climate change. In the future it is expected that the magnitude of

[2] Flood and Water Management Act (2010) text available at http://www.legislation.gov.uk/ukpga/2010/29/contents

flows and depth of flooding will increase due to climate change and so the severity of a flood with a specified chance of being experienced will also increase.

Sources of flooding

The main sources of flooding affecting the town centre are surface water flooding and river flooding. The areas at risk from surface water flooding are shown on the Environment Agency Flood Map for Surface Water, as can be found on the Environment Agency web site (Ref: http://watermaps.environmentagency.gov.uk/wiyby/wiyby.aspx?topic=ufmfsw#x=357683&y=355134&scale=2). Figure 2-3 shows the flood map for surface water and the areas at risk from high intensity localised rainfall events

Figure A-1 Flood Map for Surface Water

(*waiting confirmation that license can be obtained to display mapping*)

Flooding from rivers happens when the flow generated by the catchment is greater than the capacity of the channel conveying the discharges. In circumstances where there is a natural channel the excess flood water that could not flow down the channel would be expected to gradually flow across the adjacent land, increase in depth and extent until the flood flow reached its maximum and then gradually subside until the flows could be accommodated in the river channel. However, where there are flood defence banks adjacent to the channel the extent and depth of flooding can occur much more rapidly, either when the flood banks are suddenly overtopped or if they fail or fall down (known as breach failure). It is this the sudden overtopping or breach failure that would be experienced in the town centre of Taunton.

Assessment of risk using the TDM-2014

The Taunton Deane Model-2014 has been used to prepare results that show the extent and depth of predicted flooding in the town centre at Taunton. The model is a linked 1 Dimensional - 2 Dimensional (1D-2D) model. This type of model can:

- Predict 1D results at discrete sections where the channel has been surveyed. At these locations or 'nodes' where the channel shape is known the computer calculations give results for the water levels and flows.
- Predict 2D results over a rectangular grid on flood plains where information is needed on the flows and water levels that are flowing over land and where water levels might be affected by hedges, buildings or other obstructions outside of the main channel of the watercourse. This gives a more precise representation of the flow of water in the flood plain and enables calculations to be performed to provide results for the depth and velocity of flow in the town centre and other critical locations such as the confluences of watercourses.

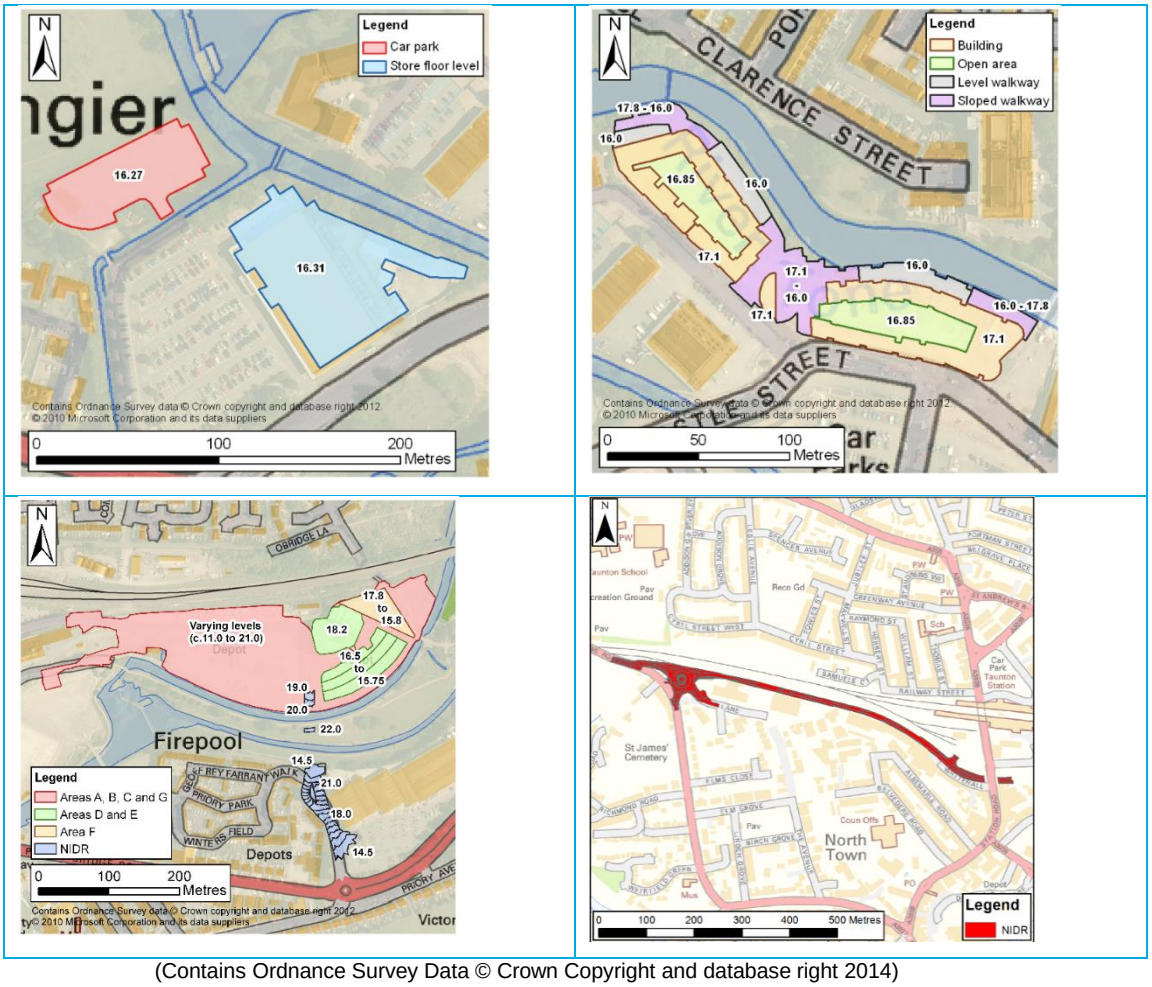
The TDM-2014 model also includes details of sites that have yet to be completed but have gained planning permission. These include:

- Extension to Tesco store

- Former gas works sites (previously known as the MIDAS site)
- Area F at Firepool Lock
- Selected lengths of the Northern Inner Distributor Road (NIDR) - NB following a meeting convened on the 26th June 2014 it is now understood the 'planning baseline' version of the model should include all of this proposed development.

Figure A-2 shows the location of the respective sites

Figure A-2 Tesco - Former Gas Works - Firepool Lock and NIDR locations



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A.4 Condition of existing defences

Table A-1 Condition of Flood Defences (provided by Environment Agency)

Asset Reference	Location	Target Condition	Actual Overall Condition	Aims Asset ID
1122190100310R02	D/S Firepool Weir, Priory Park, Taunton	3	2	47151
1122190100401R05	D/S OF PRIORY BRIDGE	3	2	40841
1122190100402L01	PRIORY BRIDGE	3	2	3453
1122190100402L02	PRIORY BRIDGE, U/S	3	2	40842
1122190100402L03	ADJACENT TO MORRISONS CARPARK	3	2	54605
1122190100402R01	PRIORY ROAD BRIDGE	3	2	54786
1122190100402R05	U/S OF SAFEWAY	3	2	1470
1122190100402R06	OPPOSITE DELLERS WHARF	3	2	1471
1122190100402R07	Somerset County Cricket Ground, Taunton	3	3	66066
1122190100402R08	PRIORY BRIDGE, U/S	3	2	146642
1122190100403L01	Deller's Wharf, Taunton. "THE BRIDGE" (NR DEBENHAM'S), D/S.	3	4	54386
1122190100403L02	"THE BRIDGE"	3	2	1472
1122190100403L03	"THE BRIDGE" (NR DEBENHAMS), U/S	3	2	1381
1122190100403R01	"THE BRIDGE" (NR DEBENHAMS), D/S	3	2	1382
1122190100404L01	WOOD STREET CAR PARK	3	2	176154
1122190100404L03	TELEPHONE EXCHANGE	3	2	1428
1122190100404L04	D/S OF CLARENCE STREET	3	2	1429
1122190100404R01	'THE BRIDGE'	3	2	1303
1122190100404R02	"THE BRIDGE' (NR DEBENHAMS), U/S	3	2	40843
1122190100405L01	PARALLEL TO CLARENCE STREET	3	2	54387
1122190100405L02	ADJACENT TO PIPE BRIDGE	3	2	163308
1122190100405L03	CLARENCE STREET AND CLEVELANDS STREET	3	2	40956
1122190100405R01	GOODLAND GARDENS	3	3	1304
1122190100406R01	GOODLANDS GARDENS, U/S	3	2	57751
1122190100406R02	GOODLAND GARDENS FOOT BRIDGE	3	2	54388
1122190100406R03	Upstream Wooden Bridge over Tone, Goodland Gardens, Taunton	3	3	1307
1122190100408R01	BEHIND RIVERSIDE CHAMBERS	3	2	152558
1122190100501R01	FRENCH WEIR	3	3	41604
1122190100501R02	BEHIND SOMERSET COLLEGE ARTS TECHNOLOGY	3	2	54389
1122190100502L01	ADJACENT ROUGHMOOR 3CRESENT	3	4	132201
1122116160102R06	STATION ROAD FLOOD WALL	3	3	72656
1122116160102R09	STATION ROAD ROAD HUMP	3	2	72659
1122116160102R10	STATION ROAD FLOOD WALL	3	2	72660

Asset Reference	Location	Target Condition	Actual Overall Condition	Aims Asset ID
1122116160102R11	STATION ROAD ROAD HUMP	3	2	72661
1122116160103L01	STATION ROAD FLOOD WALL	3	3	71948
1122116160103L02	STATION ROAD EMBANKMENT	3	3	71949
1122116160103L05	WASSAIL VIEW	3	3	71952
1122116160102L08	STATION ROAD ROAD HUMP	3	3	72910
1122190100605L02	TONE GREEN EMBANKMENT	3	2	54424
1122190100605L03	TONE GREEN EMBANKMENT	3	2	2910
1122190100605L04	TONE GREEN EMBANKMENT	3	2	41606

A.5 Potential effect of increased runoff from Core Strategy sites

How flood risk could change in future if new development is permitted

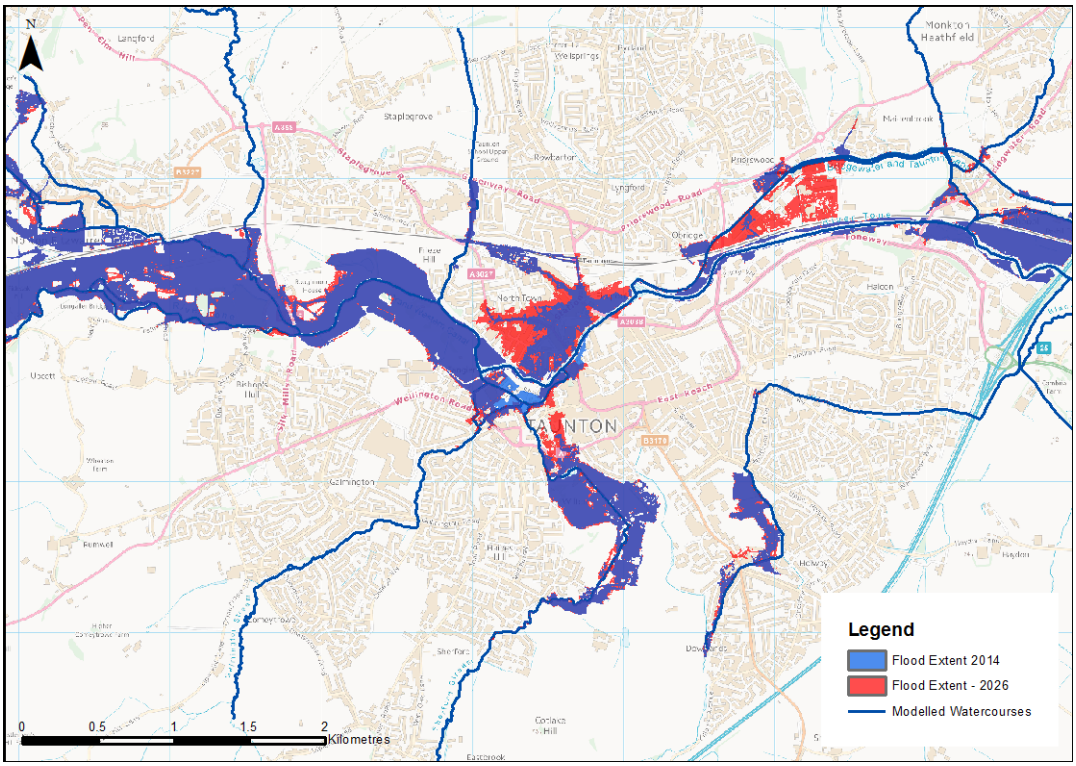
Using TDM-2014 it is also possible to predict how flooding would change under various climate change scenarios. To this end TDM-2014 has been run for 3 climate epochs: 2026, 2066, and 2106. Utilising the Environment Agency's advice on climate change peak flows have been increased by 15%, 20%, and 30% respectively. It should be noted that the effects shown are not just the result of proposed new development, but also due to the effects of climate change. It is probable that the effects of climate change have a more pronounced effect on the increase in flood risk than the proposed development.

In addition to the increase in peak flows the changes in urban extent as a result of the strategic urban extensions has been estimated. It has been assumed that 25% of the Comeytrowe development and all the remaining urban extensions will have been completed by 2026. The remaining 75% of Comeytrowe is included under the 2066 scenario. In addition to the specific changes relating to the urban extensions general urban spread across the River Tone catchment has been estimated using a national average urban growth model. A further focused increase in development has been applied to the subcatchments covering Henlade beyond 2026.

These climate change scenarios also assume that the town centre redevelopment sites have been completed by 2026. The results of each climate epoch are presented below.

2026

A significant increase in flood extent is observed in this event with increased flooding in North Town, Priorswood Industrial Estate and the High Street. The increased flood depths in North Town mean that the Cattle Market site remains at flood risk despite having been raised. The other notable item is the presence of a double peak in the flood hydrograph of the River Tone through the town centre.



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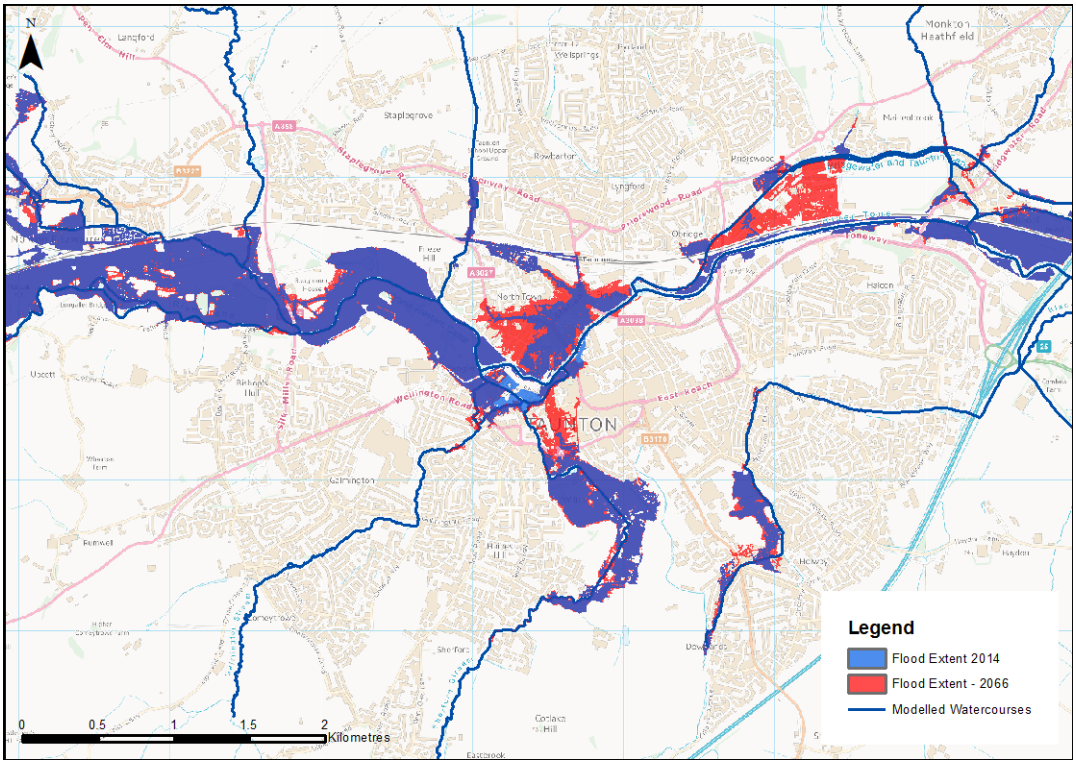
2066

The flood extent continues to increase in the same areas noted for the 2026 scenario. The double peak noted in the 2026 scenario is also still present.



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2106

Flood extent continues to increase during in the 2106 epoch in North Town, the Priorswood Industrial Estate, and the High Street. In addition the Cricket Ground flood defences have been overtopped resulting in flooding to Priory Park.

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A.6 Descriptions of Scenarios and options considered

The following characteristics describing the scenarios and options have been adjusted to reflect the Environment Agency's comments:

'Do Nothing' scenario

The 'Do Nothing' scenario assumes that no further maintenance or repair work is undertaken. At the request of the Environment Agency this scenario has been simplified. This scenario includes modifications to the model:

- That assume there is progressive failure of the defences within the epochs being considered (2026, 2066, 2106) based on the current assessment of defence condition (to be provided by the EA) with those at Grade 5 assumed to have failed by 2026, Grades 4 and 3 by 2066 and all by 2106.
- That assume Firepool weir will not be subject to failure as there is a legal agreement to ensure provision of water to the canal.
- That assume Norton Fitzwarren Dam and Longrun Farm will not fail as they are presumed to have long-term maintenance agreements in place.

'Do Minimum' scenario

These are the scenarios that have been described in Chapters 2 and 3. One option assumes that no new development will be brought forward and the other option assumes that new development is implemented, but no strategic measures are taken to address flood risk.

'Do Something' scenario - six options

Under this scenario the effect of the following six options has been evaluated:

Option 1 - Large Storage area at Bradford on Tone

The large storage area at Bradford on Tone assumes that an embankment up to a level of 36m AOD is constructed across the River Tone and Haywards Water. This scenario also requires some additional embankment to protect the railway line both sides of Pickings Bridge. Flow is throttled by two box culverts (one on each watercourse) installed through the embankment which seek to restrict the flow that can pass downstream. Whilst they could be used as part of this concept, the use of Hydrobrakes has not been considered.

Option 2 - Medium storage area at Bradford on Tone (BoT)

The medium sized storage area will be the same concept as for Scenario 1 except that the embankment will not be realised to its full height. The embankment would instead only be raised to a level of 34m AOD. It is assumed that this option would be designed such that it could be raised at a later stage if required. The box culverts will be of a larger dimension than used in Scenario 1. (Inclusion of this option potentially enables consideration of a phased construction of the storage at BoT which would be an additional option).

Option 3 - Storage area on Sherford Stream

Under this scenario we proposed to consider the construction of storage area on the Sherford Stream at Wild Oak Lane as identified within the Taunton Town Centre Area Action Plan (TTCAAP). As part of this scenario the penstock gate at the Norton Fitzwarren Dam will also be lowered to the 25% setting (from 50%) to allow a greater volume of water to be stored.

Option 4 - Improved flood defences

The improvement of the town centre defences will include representation of raising all existing defences and provision of new defences where required to the level of the 100 year + climate change event. This scenario will maintain the line of existing defences.

Option 5 - Combination of Option 2 and Option 4

For this combination scenario we will implement the medium sized storage area from Scenario 2 with a raising of the town centre defences. The defences will still be raised to the same standard (100 year + climate change event) although the absolute level would be lower due to the presence of the storage area.

Option 6 - Improved channel conveyance

The improved channel conveyance scenario will include raising the soffit level of Town Bridge by 200mm and removal of obstructions within the channel beneath. An additional component of considering amendments to Firepool and French weirs will also be considered within this option if permitted by the stability of the hydraulic model.

A.6.1 Model Results

The key model results have been presented in the main section of the report but it is not appropriate to provide results for every single epoch for all options considered. The number of properties affected by flooding and the peak water level at Priory Road Bridge are summarised in Table A-2.

Table A-2: Results from modelling of options

Scenario	Epoch	Properties affected	Priory Bridge Water Level (mAOD)
Do Nothing/Do Minimum	Present Day	972	14.918
Do Nothing/Do Minimum	2026	1774	15.054
Do Nothing	2066	2475	15.145
Do Nothing	2106	2443	15.182
Do Minimum	2066	1909	15.078
Do Minimum	2106	2422	15.211
Do Minimum (No Development)	2106	2334	15.229
Option 1: Large Storage Area (Bradford-on-Tone)	Present Day	527	14.534
Option 1: Large Storage Area (Bradford-on-Tone)	2026	866	14.645
Option 1: Large Storage Area (Bradford-on-Tone)	2066	1002	14.679
Option 1: Large Storage Area (Bradford-on-Tone)	2106	1144	14.767
Option 2: Medium Storage Area (Bradford-on-Tone)	Present Day	735	14.842
Option 2: Medium Storage Area (Bradford-on-Tone)	2026	1532	14.932
Option 2: Medium Storage Area (Bradford-on-Tone)	2066	1709	14.938
Option 2: Medium Storage Area (Bradford-on-Tone)	2106	1927	15.037
Option 3: Storage Area (Sherford Stream)	Present Day	783	14.856
Option 3: Storage Area (Sherford Stream)	2026	1621	15.017
Option 3: Storage Area (Sherford Stream)	2066	1702	15.037
Option 3: Storage Area (Sherford Stream)	2106	1932	15.124
Option 4: Defence Raising (Town Centre)	Present Day	735	14.926
Option 4: Defence Raising (Town Centre)	2026	1066	15.06
Option 4: Defence Raising (Town Centre)	2066	1214	15.084
Option 4: Defence Raising (Town Centre)	2106	1467	15.188
Option5: Combination of Options 2 and 4	Present Day	602	14.845
Option5: Combination of Options 2 and 4	2026	925	14.934
Option5: Combination of Options 2 and 4	2066	1065	14.947
Option5: Combination of Options 2 and 4	2106	1310	15.073
Option6: Improved Conveyance	Present Day	878	14.825
Option6: Improved Conveyance	2026	1763	15.019
Option6: Improved Conveyance	2066	1892	15.032
Option6: Improved Conveyance	2106	2170	15.116

A.7 Indicative Costing

In considering the relative merits of each option it is also necessary to understand the projected cost. This study has not sought to undertake a detailed component costing exercise for each option. Instead we have sought to utilise cost estimates produced in previous studies or for comparable schemes to provide indicative costs.

A comparison of indicative scheme costs and some comments on how the price has been arrived at are included in

Option	Cost Range	Comments
Option 1 – Large BoT	£12-16million	Estimate is based on the pricing of the surface water attenuation scheme costed in the SFRA and increased to account for the increased size and complexity associated with protecting the railway line.
Option 2 – Medium BoT	£10-13million	As option 1 with a slight reduction to account for the reduced amount of materials required and shorter construction time. Cost difference could be very minimal if it were designed so that it could be raised at a later date.
Option 3 – Sherford Stream	£4-6million	Based on the costs produced by B&V in the 2006 Taunton Vision Guidance (£2.5-4.5m) and increased for inflation and additional works at Norton Fitzwarren
Option 4 – Raise Defences	£4-6million	Cost estimates taken from EA study (River Tone, Taunton Investigation of Defences, August 2012). All costs included 60% optimism bias
Option 5 – Combine options 2 & 4	£14-18million	This price combines options 2 and 4. It is assumed that the combined cost would be slightly cheaper as the storage area would reduce the extent and height of the defence raising.
Option 6 – Improved Conveyance	£10-15million	This is the option that has the least confidence in pricing as the removal of the weirs and the associated works is difficult to estimate in advance of having undertaken a more detailed assessment.

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