TECHNICAL NOTE

JBA Project Code	2017s5751
Contract	Weir Removals
Client	CBEC
Day, Date and Time	23/02/2018
Author	Katie Burnham
Reviewer / Sign-off	Mark Watson
Subject	Flood risk assessment for Bowston weir removal and rock ramp design

1 Introduction

1.1 Terms of Reference

JBA Consulting Limited was commissioned by CBEC Inc to undertake a Flood Risk Assessment (FRA) for the proposed removal of Bowston on the River Kent, Cumbria, and the subsequent re-naturalisation options.

2 Site Details

2.1 Site description and proposed works

The proposed site is located on the River Kent, in the Village of Bowston, Cumbria, approximately 4km north west Kendal (SD 49710 96811) (Figure 2-1).

The proposed works involved the removal of Bowston Weir (Figure 2-2), and the renaturalisation of the channel through the installation of a stepped rock ramp design (Figure 2-3).

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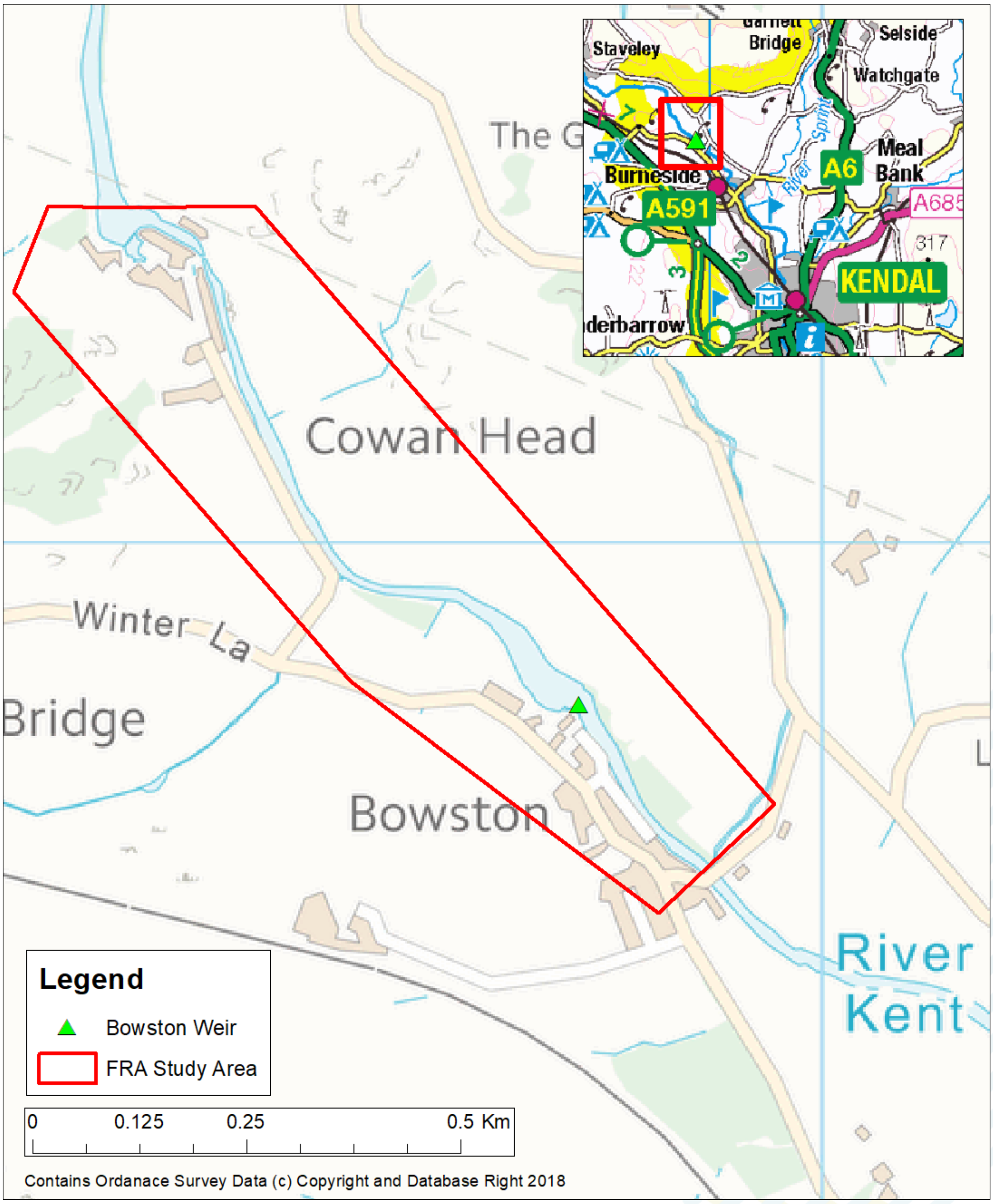

Figure 2-1: Bowston weir and location of proposed channel re-naturalisation

Figure 2-2: Bowston weir looking upstream

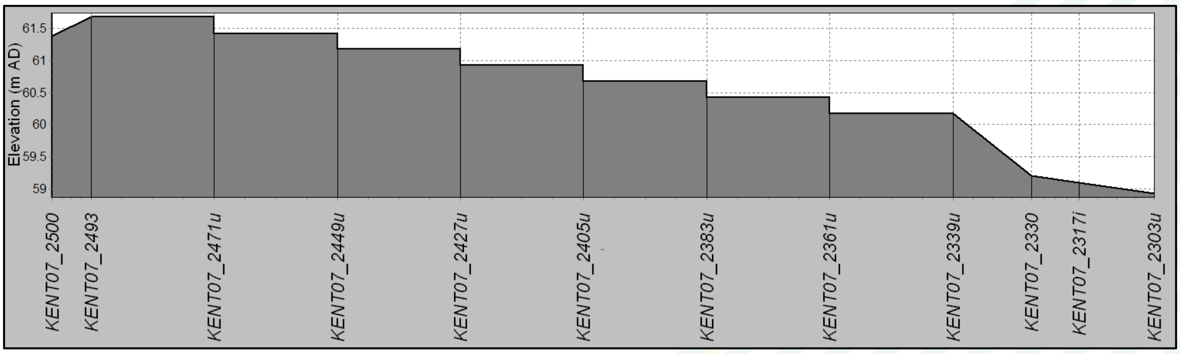

Figure 2-3: Long profile showing Bowston rock ramp design, extracted from 1d modelling software ISIS. Design extends from KENT07_2493 - KENT07_2339u, note vertical scale is exaggerated.

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3 Assessment of flood risk

3.1 Fluvial flood risk

The Environment Agency (EA) has developed a Flood Map which shows the risk of flooding in England and Wales for different return period events, Figure 3-1. This map provides the basis for the assessment of flood risk and development suitability according to the National Planning Policy Framework (NPPF).

The strategic flood risk assessment carried out by South Lakeland Council provides a more detailed assessment of flood risk by defining areas in Flood Zone 3 as either 3a High Probability; or 3b Functional Floodplain. Unfortunately, the SFRA does not include any flood risk mapping covering the Bowston area. As the site is located within the river channel is it assumed that it is categorised as Flood Zone 3b functional floodplain.

In the Bowston area the majority of properties are located within Flood Zone 2. One property, adjacent to the weir on the right bank, is situated within Flood Zone 3. Upstream at Cowan Head, the infrastructure closest to the river is located within Flood Zone 3.

In order to assess the local flood risk in greater detail, for both the baseline and design scenario, hydraulic modelling has been undertaken of the River Kent with results presented in Section 4.

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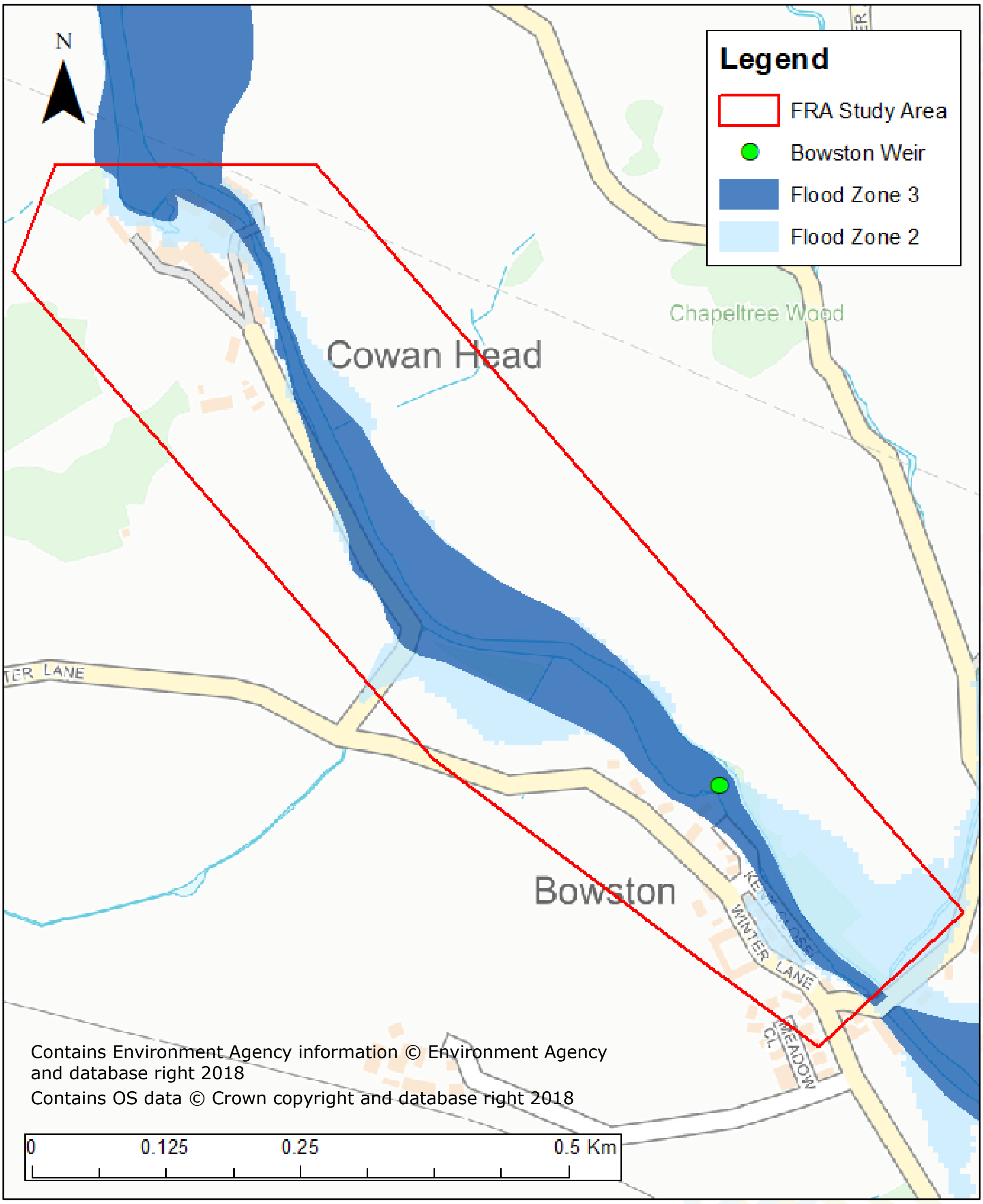

Figure 3-1: Bowston EA fluvial flood zones

3.1.1 Planning Context

The NPPF and Planning Practice Guidance was introduced by the Department for Communities and Local Government in March 2012 and supersedes the pre-existing Planning Policy Statements. The NPPF considers flood risk to developments using a sequential characterisation of risk, based on planning zones and the Environment Agency Flood Map.

The NPPF outlines that only 'water-compatible uses' and 'essential infrastructure' should be permitted within Flood Zone 3b. Since the proposed development is the removal of the weir, which will facilitate the re-naturalisation of the channel, remove a barrier to fish passage, and have a positive impact on flood risk upstream this would be categorised as a 'water-compatible' development and consequently will be permitted, in principal, under NPPF guidance.

It is also outlined in the NPPF and Planning Practice Guidance that any acceptable developments should be designed and constructed to:

- remain operational and safe for users in times of flood,
- result in no net loss of flood storage,
- not impede water flows; and
- not increase flood risk elsewhere.

The proposed development is assessed further in Section 4, to ensure there will be no enhanced flood risk as a result of the weir removal.

3.2 Surface water flood risk

Surface water flood risk to the site has been assessed using the national scale EA Risk of Flooding from Surface Water Map (Figure 3-2) which identifies areas where surface water flooding poses a risk, classified in four categories as follows:

- High – an area has a chance of flooding greater than 1 in 30 each year
- Medium – an area has a chance of flooding of between 1 in 30 and 1 in 100 each year
- Low – an area has a chance of flooding of between 1 in 100 and 1 in 1,000 each year
- Very Low – an area has a chance of flooding of less than 1 in 1,000 each year

The figure shows there is a medium to high risk within the study area. However, as all works are contained within the channel it is unlikely that the works will have any influence on the surface water flood risk, or impede surface water from entering the watercourse.

3.3 Groundwater flood risk

Groundwater flooding occurs when water table rises above ground level, especially after a prolonged rainfall when the soil becomes saturated and the storage capacity available within it is reduced. This is most likely to occur in low-lying areas that are underlain by permeable bedrock and superficial geology.

As the hydrology modelling has informed that water levels at the site do not increase as a result of the design, is unlikely that the groundwater risk will increase, thus no further assessment has been provided.

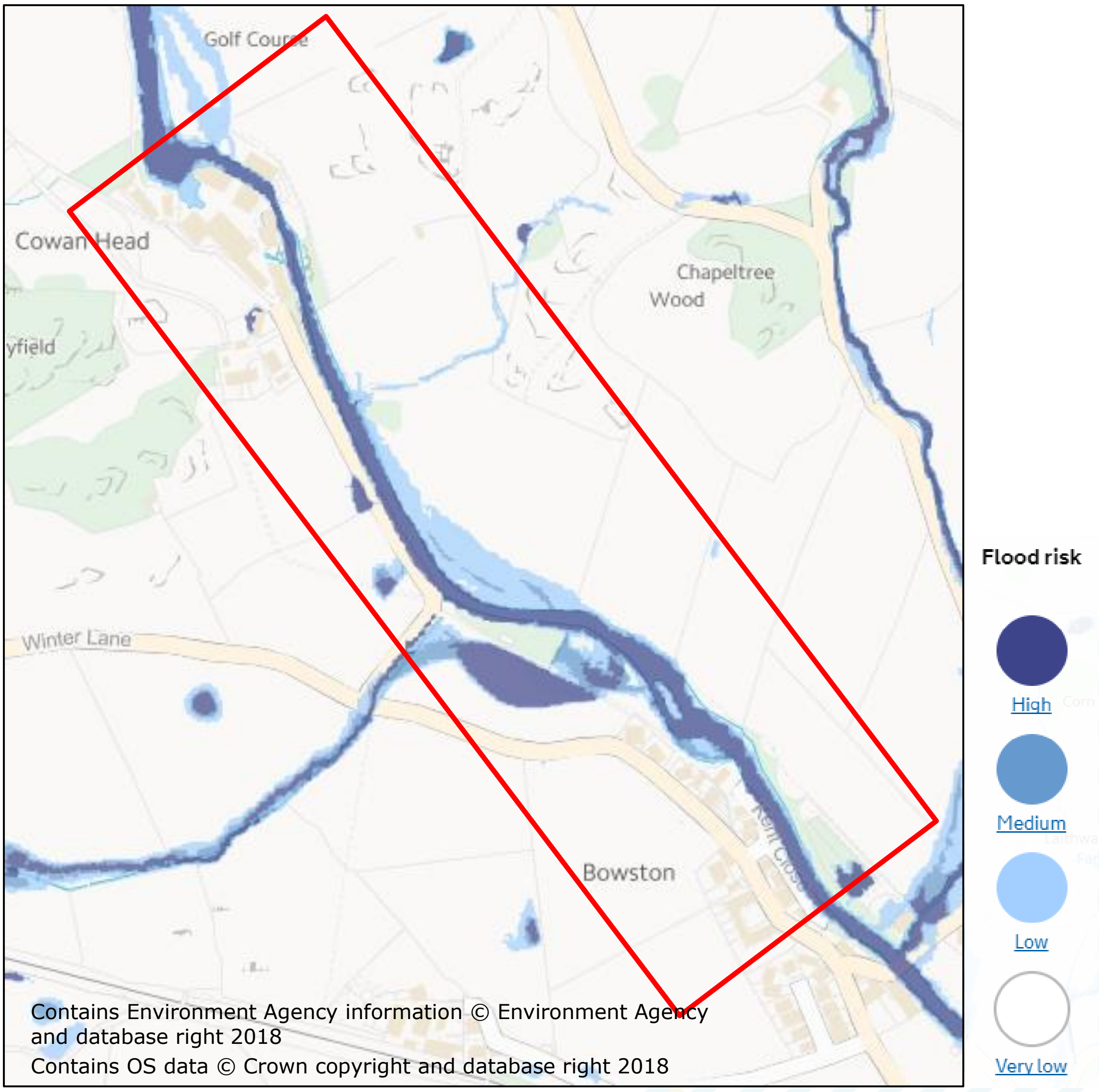

Figure 3-2: Bowston EA surface water flood zones[1]

1 Environment Agency, 2018, https://flood-warning-information.service.gov.uk/long-term-flood-risk/map. Accessed January 2018.

4 Hydraulic Modelling

4.1 ISIS Hydraulic Modelling

4.1.1 Existing model

The current EA 1D ISIS flood model was provided by the client for the purpose of the study. This model was originally built in 2000 by JBA Consulting but was updated in 2007[2] as part of a study to establish the existing standard of flood protection works in Kendal and assess the feasibility options for upstream storage. As part of the 2007 works the hydrology inputs in the model were updated using the Flood Estimation Handbook methods.

In the 2007 update, floodplains in the 1D model were represented using cross section extensions based on LIDAR data available. Several spot level surveys were undertaken in areas where LIDAR coverage was poor or did not provide a sufficiently accurate representation of ground levels.

4.1.2 Baseline model updates

For this study, the Hydraulic modelling has been undertaken using 1D ISIS software (version 3.7.0.233). The modelled supplied was trimmed at a suitable location, approximately 1655m downstream of Bowston weir (Bridge Street road bridge - SD505958) to reduce run times. The model can now be run in ISIS free in less than 5mins per simulation.

Three cross sections upstream of the weir, and five cross sections downstream of the weir were updated with Environment Agency survey data from 2016. Bowston weir crest was also updated with the new data. Where new cross-sections extensions were required, LIDAR data was used to represent the wider floodplain.

Interpolate section "KENT07_2501i" has been removed from the model and chainages have not been amended to accommodate for this removed section. This section is thought to have been left in the existing model in error, as the ISIS chainages did not match up with those expected when compared to both measured lengths in ArcGIS and the ISIS naming convention. Figure 4-1 shows the extent of the of the trimmed Bowston model and model node locations.

4.1.3 Design model updates

To represent the new channel design, all existing section data between KENT07_2500 and KENT07_2330 was removed, including Bowston weir. New sections were added to the model as per the rock ramp design provided by CBEC. Where new cross-sections extensions were required, LIDAR data was used to represent the wider floodplain. In total 20 cross sections were added, to the model to represent the six step design. For each step, three new ISIS sections were required, one spill unit, and two river sections, one upstream of the spill, and one downstream. Design cross section locations are shown in Figure 4-2.

2 JBA Consulting, 2007; 2005s1428 - Kendal Pre-Feasibility & S105 Update Report

4.2 Hydrology

Updating the model hydrology was outside the scope of the project works. Where the model has been trimmed, the downstream boundary conditions have been updated with a new stage / time boundary. This has been determined for each return period by extracting the stage hydrograph, for the given return period from the EA model results.

The 1-in-2 Year (50% AEP) and 1-in-100 Year (1% AEP) return period flood events were chosen as the most appropriate events to run within the hydraulic model. In addition, a consideration for climate change (CC) has been applied to the 1 in 100 Year (1% AEP) event.

In the existing EA model, a climate change allowance of 20% was represented. This figure is not up to date with current guidance. Therefore, a 35% allowance for climate change has been applied within the hydraulic model, based on the NPPF guidance, representing the 'Upper End' scenario for the North West, within the timeframe, for a design life for 50 years (i.e. Total potential change anticipated for the '2050s' (2040 to 2069))[3]. The guidance requests the use of the 'Upper End' allowance for water compatible infrastructure within Flood Zone 3b.

Note that the same downstream boundary stage hydrograph has been carried through from the 1 in 100 Year for use in the 1 in 100 plus CC (1% AEP+CC). Sensitivity testing has shown the downstream boundary is far enough downstream that changes at this location have no impact on modelled water levels at the site.

3 Environment Agency, February 2017. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Accessed 23 January 2018.

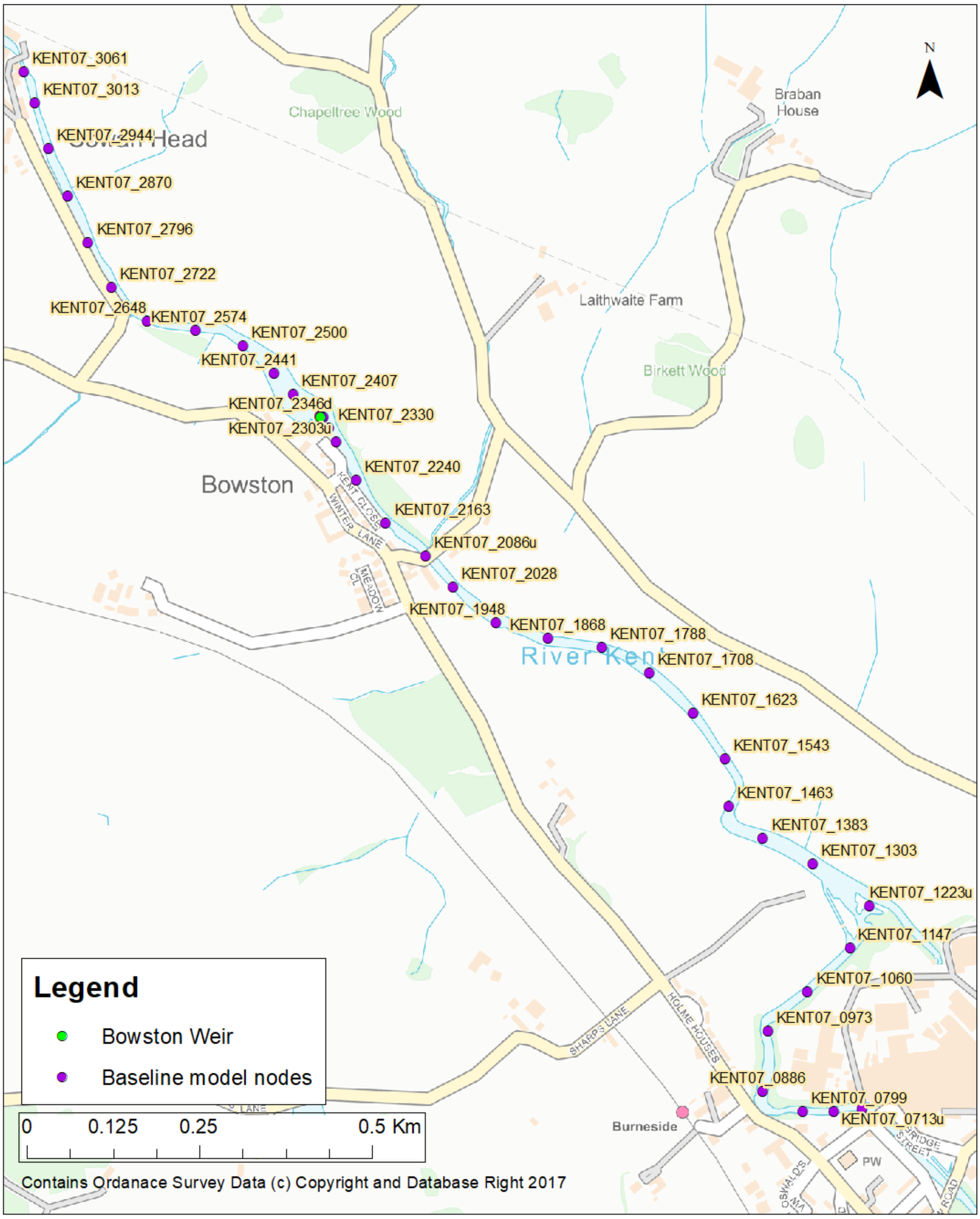

Figure 4-1: Modelling extent for trimmed Bowston Baseline model, with ISIS model node locations.

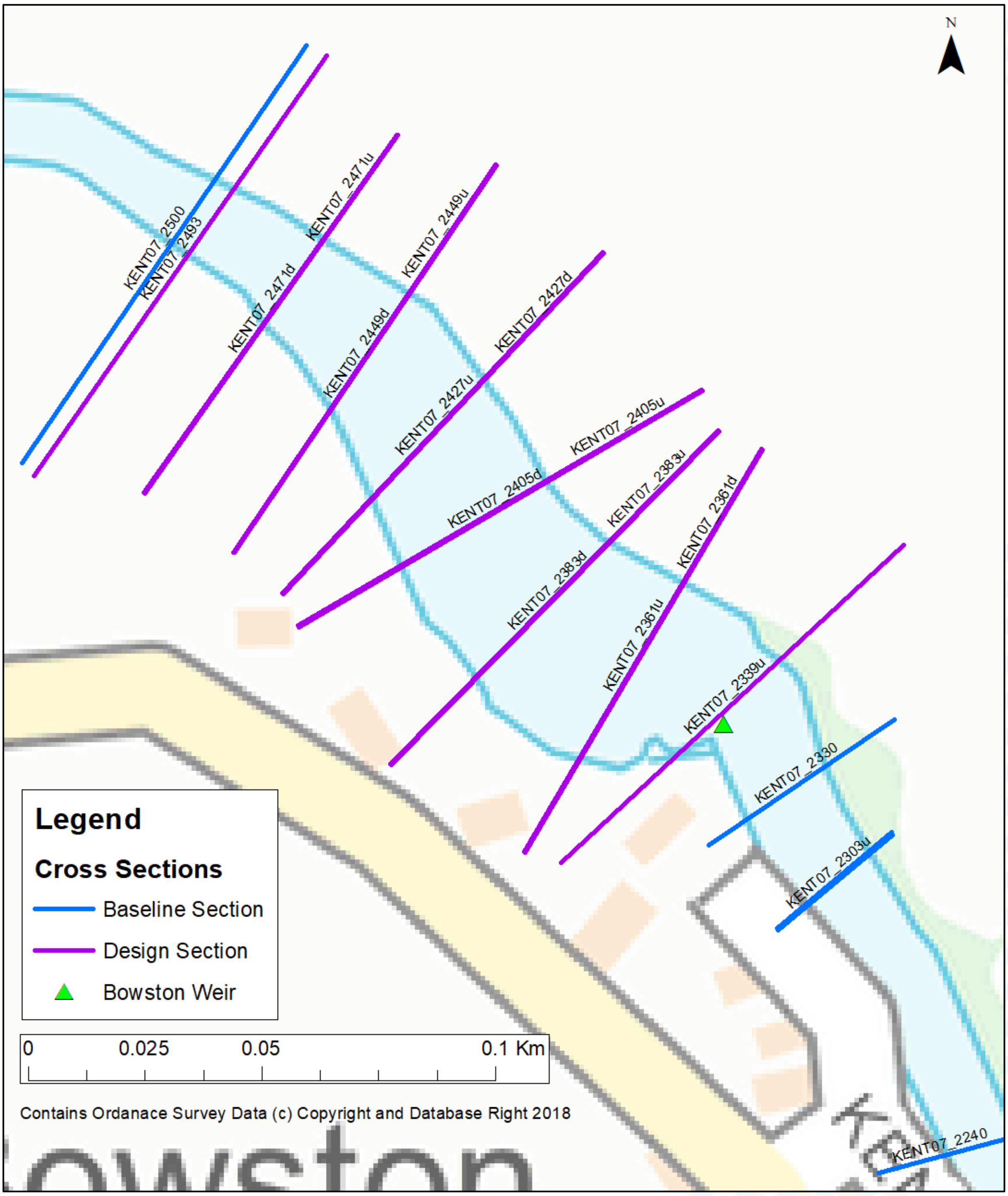

Figure 4-2: Modelled rock ramp cross sections for Bowston design model, with corresponding ISIS model node labels.

4.3 1d modelled results

The updated baseline model results have been compared to the Environment Agency baseline model results supplied alongside the model, for the 1 in 100 Year (1% AEP) event, Figure 4-3. Localised differences are noted between the maximum modelled water levels as a result of localised changes to the model geometry data described above, this is sensible.

To provide more detailed assessment of flood risk at the site location, the maximum modelled water surface elevations have been extracted from the hydraulic modelling results. The baseline modelled water levels are provided against the design modelled water levels in Table 4-1. Where possible level has been provided for nodes present in both models, where nodes are absent from the design model, the nearest upstream and downstream level (or the baseline model) are given. **Error! Reference source not found.** shows the direct comparison of the baseline and design maximum modelled water levels, for the 1 in 100 Year +CC (1% AEP+CC) model, in long profile between section KENT07_3013 and KENT07_2163.

Figure 4-5, shows the direct comparison of the baseline and design maximum modelled water levels, for the 1 in 2 Year (50% AEP model), in long profile between section KENT07_3013 and KENT07_2163.

Generally, the results show a decrease in water level upstream and a slight increase in the levels locally downstream of the weir crest, Figure 4-6.

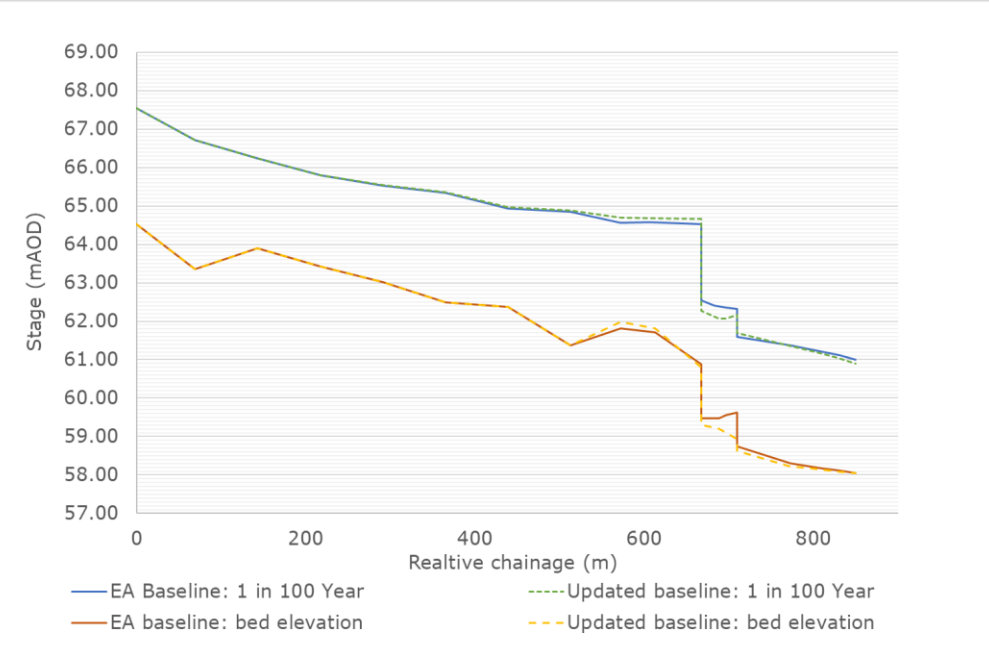

Figure 4-3: EA baseline maximum modelled water level, versus the updated baseline maximum modelled water level for the 1 in 100 Year event

Table 4-1 Maximum baseline and design modelled water levels

Cross section reference	Baseline: 1 in 2 Year	Design: 1 in 2 Year	Baseline: 1 in 100 Year +CC	Design: 1 in 100 Year +CC
KENT07_2574	64.27	63.88	65.30	64.98
KENT07_2500	64.21	63.30	65.22	64.58
KENT07_2449d	-	62.35	-	63.67
KENT07_2441	64.08	-	65.00	-
KENT07_2427u	-	62.27	-	63.66
KENT07_2427d	-	62.18	-	63.50
KENT07_2407	64.07	-	64.98	-
KENT07_2405u	-	62.04	-	63.37
KENT07_2361d	-	61.49	-	62.99
KENT07_2346u	64.06	-	64.96	-
KENT07_2346d	61.35	-	62.78	-
KENT07_2339u	-	61.34	-	62.83
KENT07_2330	61.11	61.11	62.61	62.61
KENT07_2303u	61.17	61.17	62.69	62.69

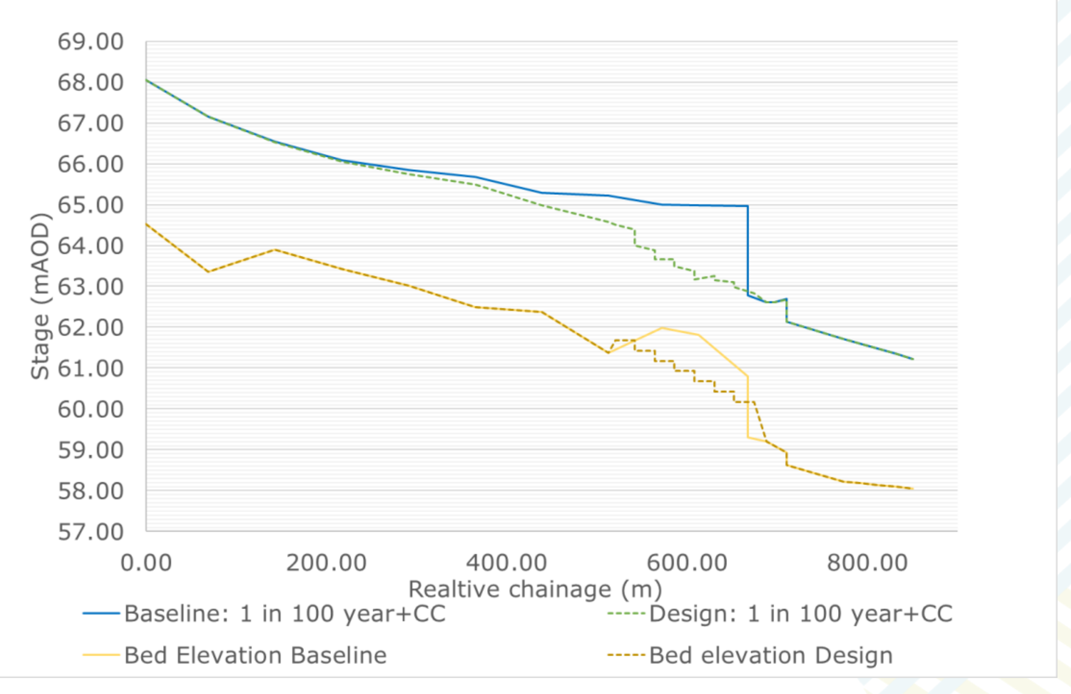

Figure 4-4:Baseline maximum modelled water level, versus design maximum modelled water level for the 1 in 100 Year+CC event

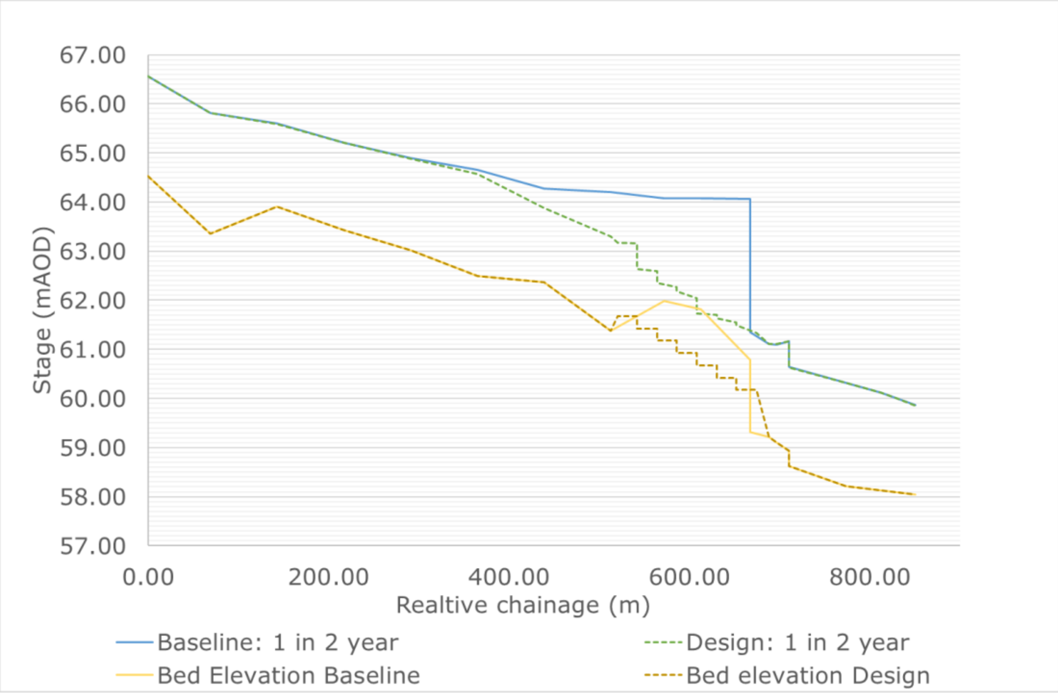

Figure 4-5: Baseline maximum modelled water level, versus design maximum modelled water level for the 1 in 2 Year event

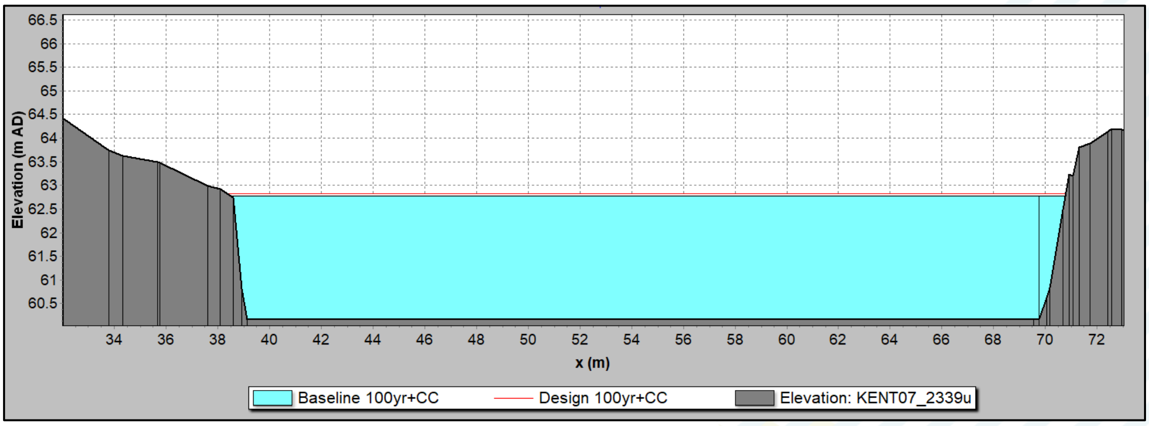

Figure 4-6: Comparison of the baseline and design maximum modelled water levels downstream of the existing weir, for the 1 in 100 Year +CC event.

4.4 Flood outlines

Using the 1d modelled outputs the maximum modelled flood extents have been generated for the 1 in 100 Year +CC (1%AEP+CC) results. The baseline extent has been compared to both the Environment Agency Flood Zone 3 (1% AEP) maximum extent (Figure 4-7), and the design maximum modelled extent (Figure 4-8).

The figures show that the new modelled baseline extent is in line with the Environment Agency Flood Zone 3. There are slight increases in the extent, however, as the modelled results are for the 1 in 100 Year +CC this is not unexpected.

The modelled design, results in localised changes. These are broadly reductions in the maximum flood extents upstream of the weir. There is no increase to the maximum modelled flood extents downstream of the weir location, despite the slight increase in the 1d water levels identified above.

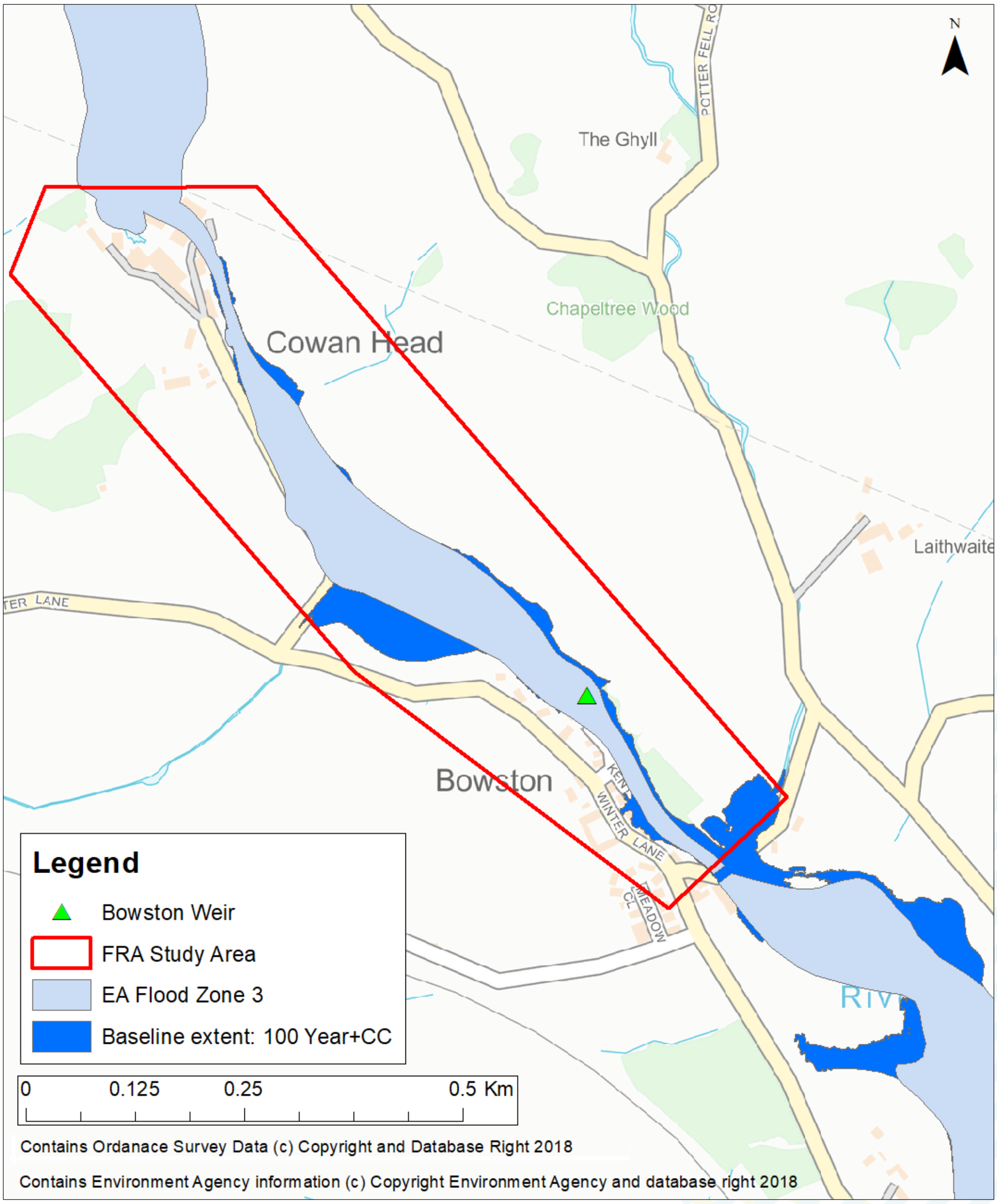

Figure 4-7: Baseline maximum modelled extent (1 in 100 Year +CC) compared to the Environment Agency Flood Zone 3 (1% AEP) extent.

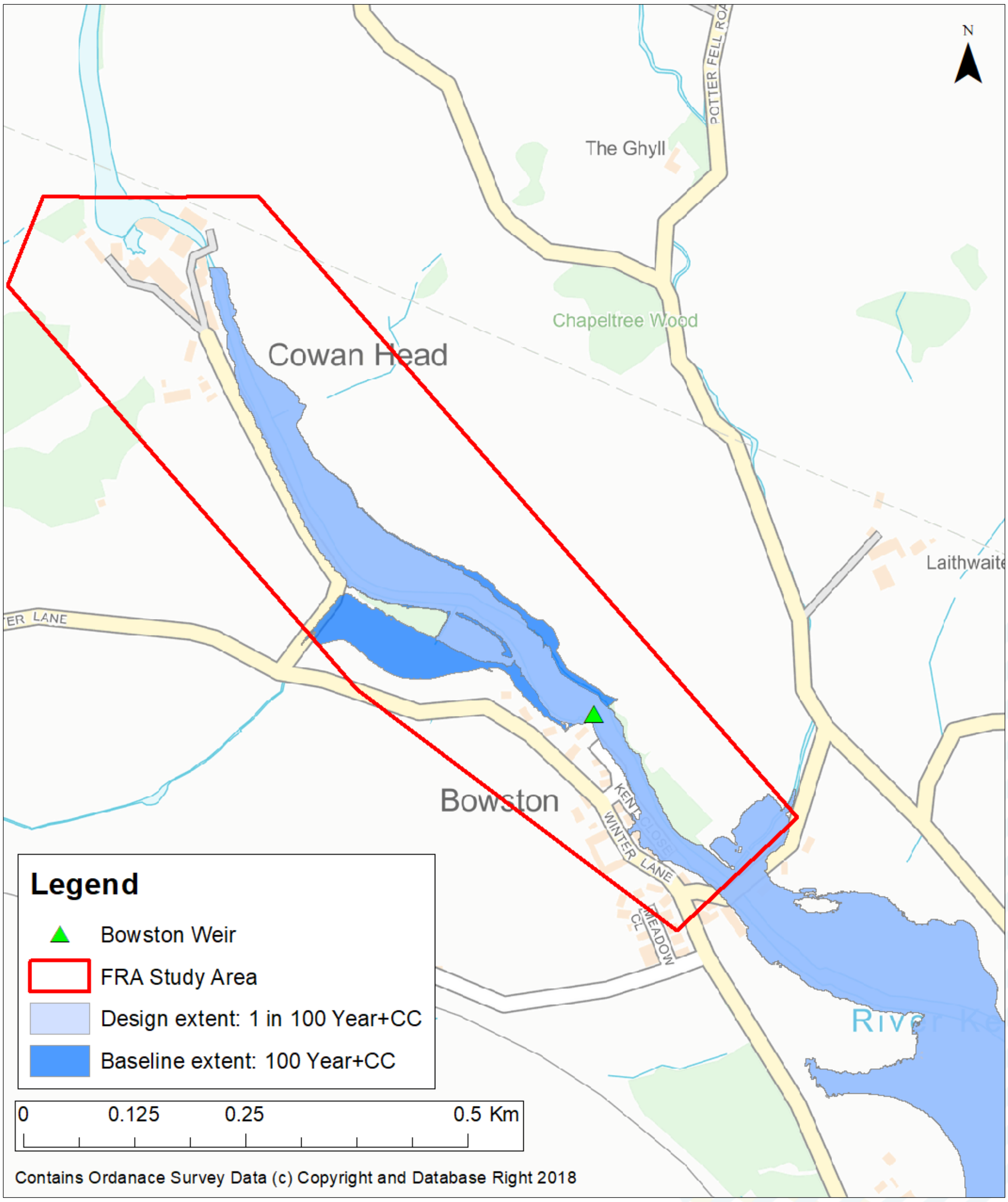

Figure 4-8: Baseline maximum modelled extent (1 in 100 Year +CC) compared to the design maximum modelled extent (1 in 100 Year +CC).

4.5 Flood Risk Appraisal

4.5.1 Fluvial Flood Risk

ISIS hydraulic modelling has been used to provide a detailed assessment of flood levels within the proposed site area, to determine the impact of the rock ramp design on the existing risk of flooding.

Modelled flood levels for the baseline 1-in-100 Year (plus 35% exceedance for climate change) event indicate that in the model peak flows largely remain in-bank or on adjacent flood plain around the Bowston weir site, Figure 4-8. On the south end of Kent Close some properties may be susceptible to flooding.

The introduction of the rock ramp design into the model resulted in a significant decrease in water level upstream (of the current weir location), and a slight increase in the water levels immediately downstream of the weir in both the 1 in 100 Year +CC and the 1 in 2 Year events, **Error! Reference source not found.** and Figure 4-5. This is predicted to be up to approximately 0.05m for up to 21m downstream of the weir in the 1 in 100 Year +CC event. However, as shown in Figure 4-6, water levels at this location are still contained within bank, consequently no new flood receptors will be impacted. This is supported in Figure 4-8, which shows no change in the maximum modelled extents downstream of the existing weir. A notable reduction in the maximum extent is documented upstream of the weir.

Overall, the fluvial flood risk assessment confirms that the development will cause no net loss of flood storage, not increase flood risk elsewhere, nor impede water flows, in accordance with the NPPF and Planning Practice Guidance. Flow rates have not been increased downstream of the design (to within two decimal places).

4.5.2 Surface Water Flood Risk

Whilst the area of the proposed wall reconstruction is located at 'high' risk of surface water flooding, no mitigation measures are deemed to be required since the works are confined within the channel.

4.5.3 Groundwater Flood Risk

As outlined in Section 3.3, the risk of groundwater flooding to the site is negligible and therefore no mitigation is required.

5 Key conclusions

- JBA Consulting were commissioned by CBEC to undertake a Flood Risk Assessment for a proposed rock ramp design, to be installed following the removal of Bowston weir.
- The FRA is in accordance with the National Planning Policy Framework (NPPF) and Planning Practice Guidance.
- According to the EA Flood Map, the site development is situated within Flood Zone 3b. Since the development is classified as 'water-compatible', in principal the development would be permitted under the NPPF.
- The rock ramp design has been provided by CBEC and modelled in 1d modelling software ISIS to identify fluvial flood risk. Considerations were also made for surface water and groundwater risk.
- The results of the analysis, show that the rock ramp design will result in a significant decrease in water levels and modelled extents upstream of the existing weir, in the 1 in 100 Year +CC event. Therefore, potentially resulting in a positive impact on flood risk upstream. As documented there is a slight increase in the levels downstream of the existing weir location. However, there is not thought to be an impact on the flood risk at the site as the increase is very localised and does not increase the maximum modelled extents.
- Water levels downstream of the existing weir could be increased by up to 0.05m for approximately 21m in the 1 in 100 Year +CC event before returning to the levels recorded in the baseline model. However, the levels remain in bank and no new receptors will be impacted.
- There will be no impact on surface water flood risk, since the works are in channel and will subsequently not enhance surface run-off rates.
- Groundwater flood risk at the site location is negligible and therefore no mitigation measures are necessary