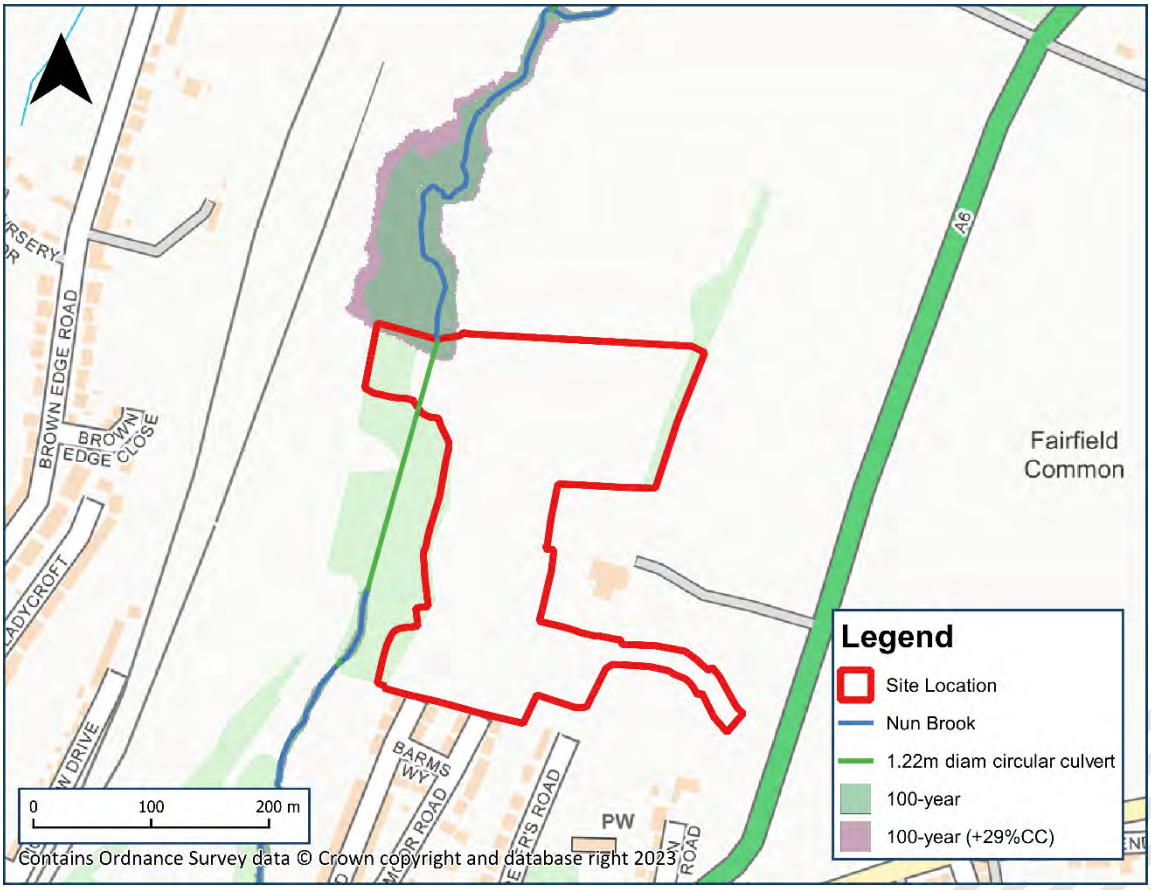

Figure 2-3: Baseline flood extent with climate change

2.2.2 Baseline flood depths

The flood depths within the site during the 100-year with 29% climate change flood event (i.e. the design event) are shown within Figure 2-4.

This shows that within the site, the maximum flood depths are upstream of the 1.22m diameter culvert inlet. The maximum flood depth in this area is 4.02m, within the area of low elevation surrounding the channel.

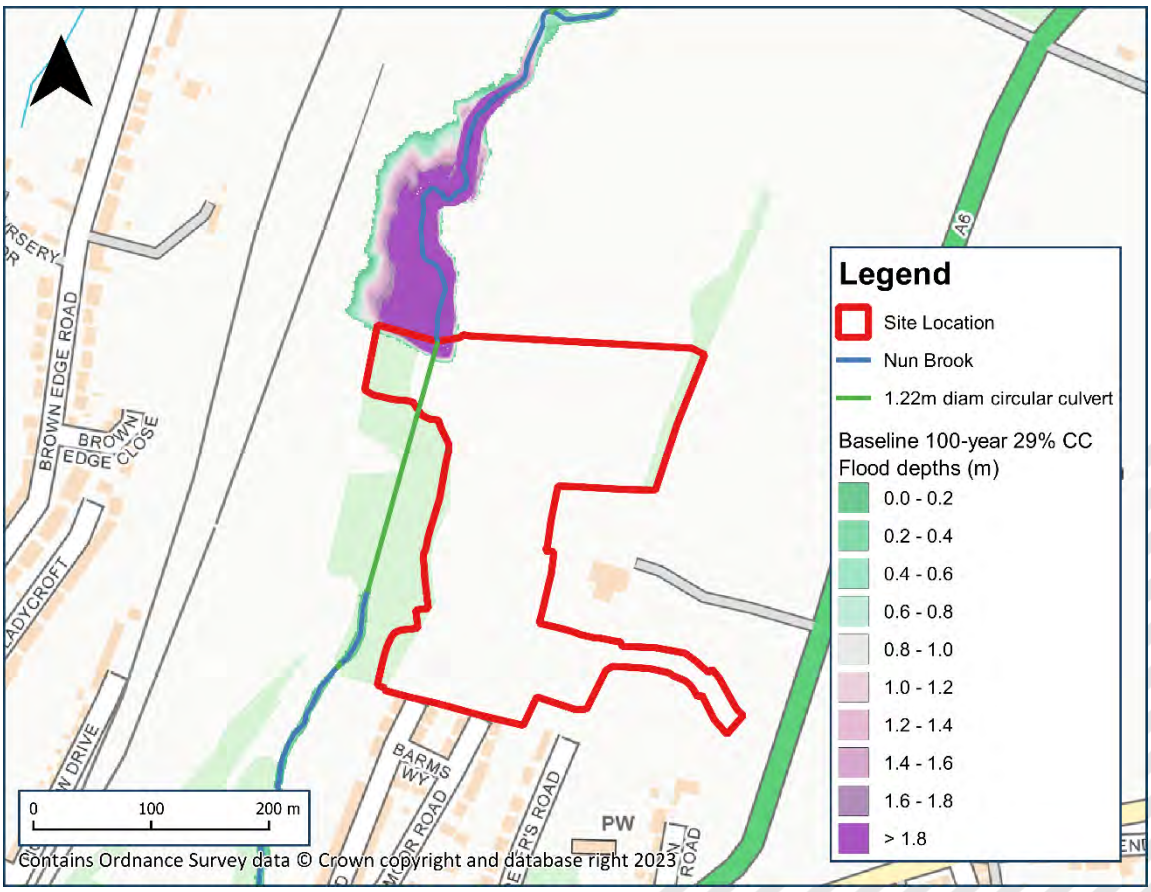

Figure 2-4: Baseline flood depths

2.2.3 Baseline water levels

The water levels during the baseline 100-year with 29% climate change are shown in Figure 2-5. During the baseline 100-year with 29% climate change event, the peak water level onsite and at the inlet of the culvert is 299.90m AOD.

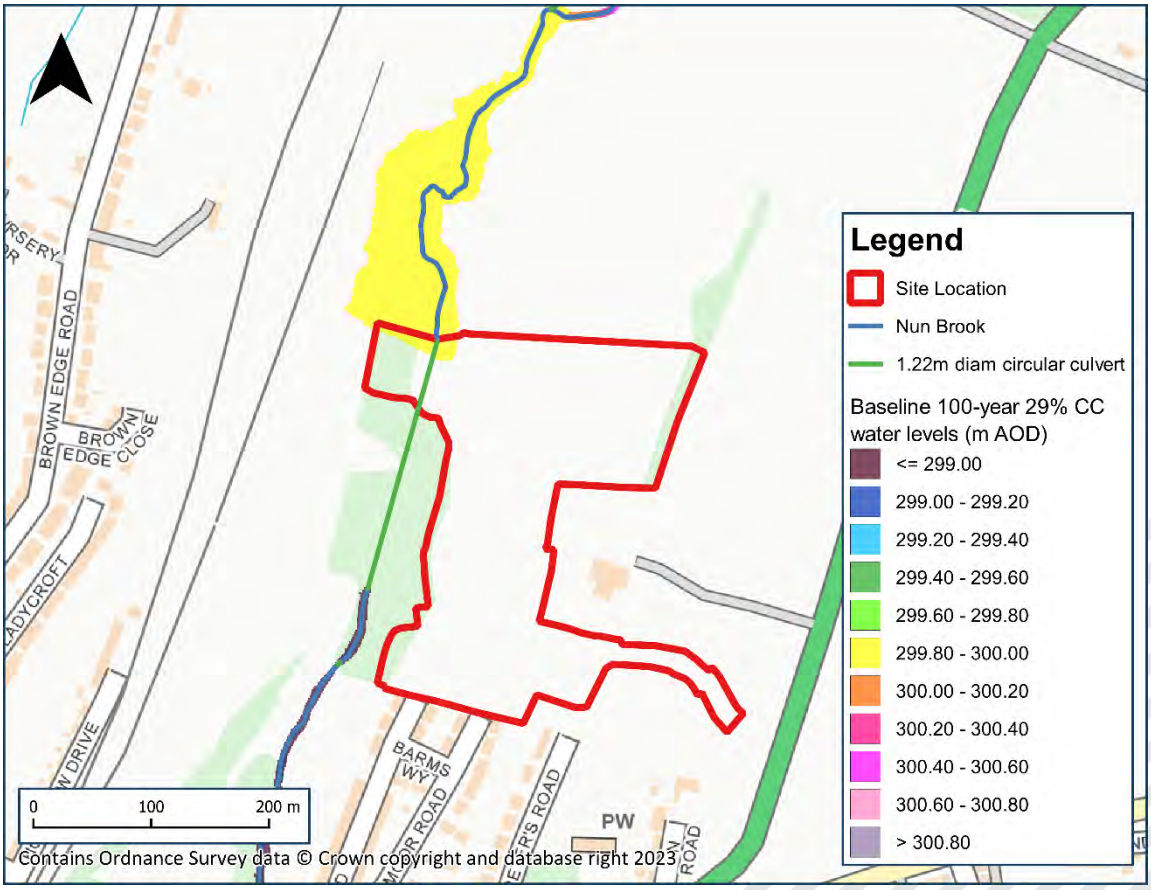

Figure 2-5: Baseline water levels

2.2.4 Baseline hazard to people

The fluvial hazard-to-people rating during a 100-year with 29% climate change flood scenario has been mapped using the formula as suggested in Defra's FD2321/TR2 "Flood Risk to People". The different hazard categories are shown in Table 2-1 and the hazard classification to the site during the 100-year with 29% climate change scenario is shown in Figure 2-6.

Table 2-1 Flood Risk to People Hazard to People

Flood hazard rating depth x (velocity+0.5) +DF	Level of Flood Hazard Description	Class label
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 to 1.25	Moderate	Dangerous for some (i.e. Children) "Danger: flood zone with deep or fast flowing water"
1.25 to 2.00	Significant	Danger for most "Danger: flood zone with deep fast flowing water"
>2.00	Extreme	Dangerous for all "Extreme danger: flood zone with deep fast flowing water"
Using the hazard equation HR = d*(v+0.5) + DF Where d = depth of flooding (m) v = velocity of floodwaters (m/sec) DF = debris factor		

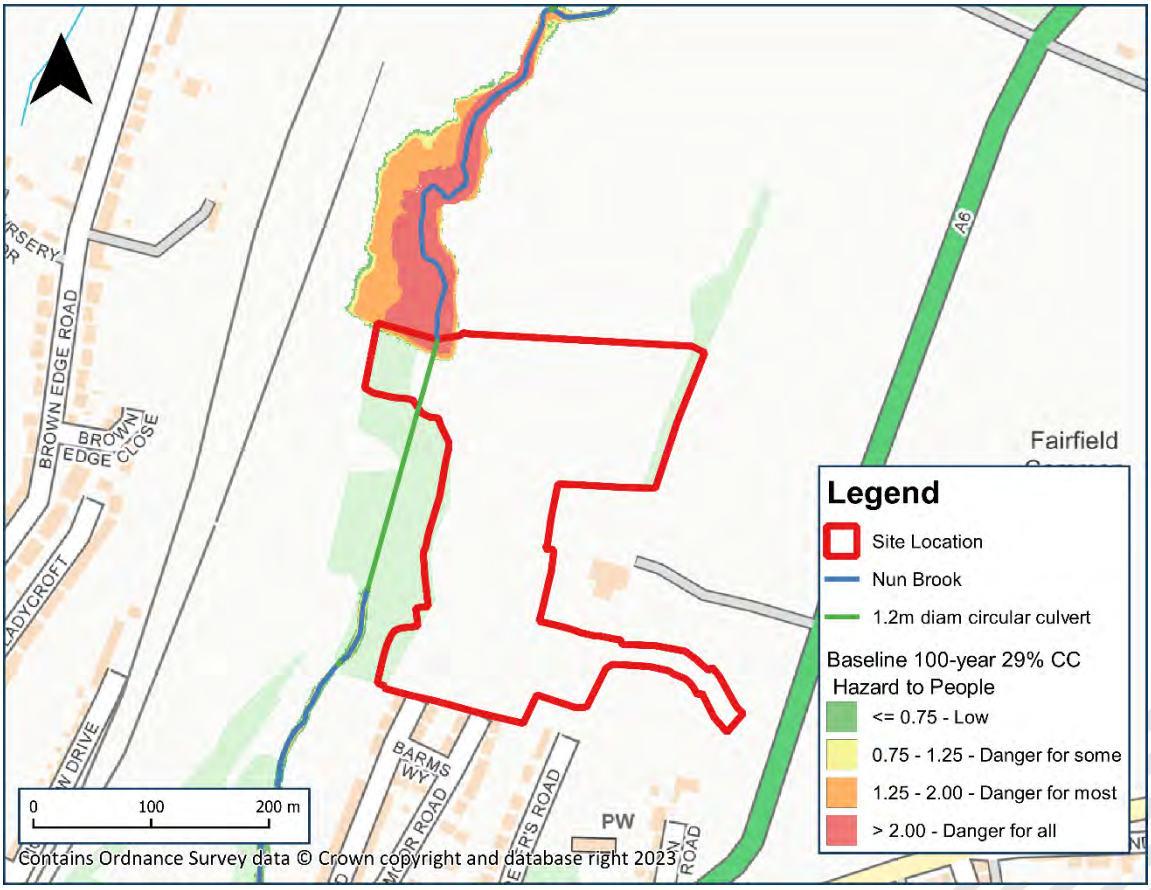

Figure 2-6: Baseline hazard to people

Figure 2-6 shows that during the baseline 100-year with 29% climate change event the north-western area of the site is partially within the 'danger for all' hazard category. However, this is primarily the channel and immediate floodplain of the Nun Brook.

2.3 Blockage analysis

The residual risk of a blockage at the inlet of the 1.22m diameter culvert has been considered as part of this study. In order to represent the worst-case scenario a 100% blockage at the structure has been modelled. Figure 2-7 shows the maximum flood extent during the 100% blockage at the structure during a 100-year with 29% climate change flood event. This shows that the flood extent is larger during this event where flows build up behind the inlet before eventually flowing overland to the downstream culvert extent where the Nun Brook becomes open channel.

Figure 2-8 shows the peak water levels associated with this residual event.

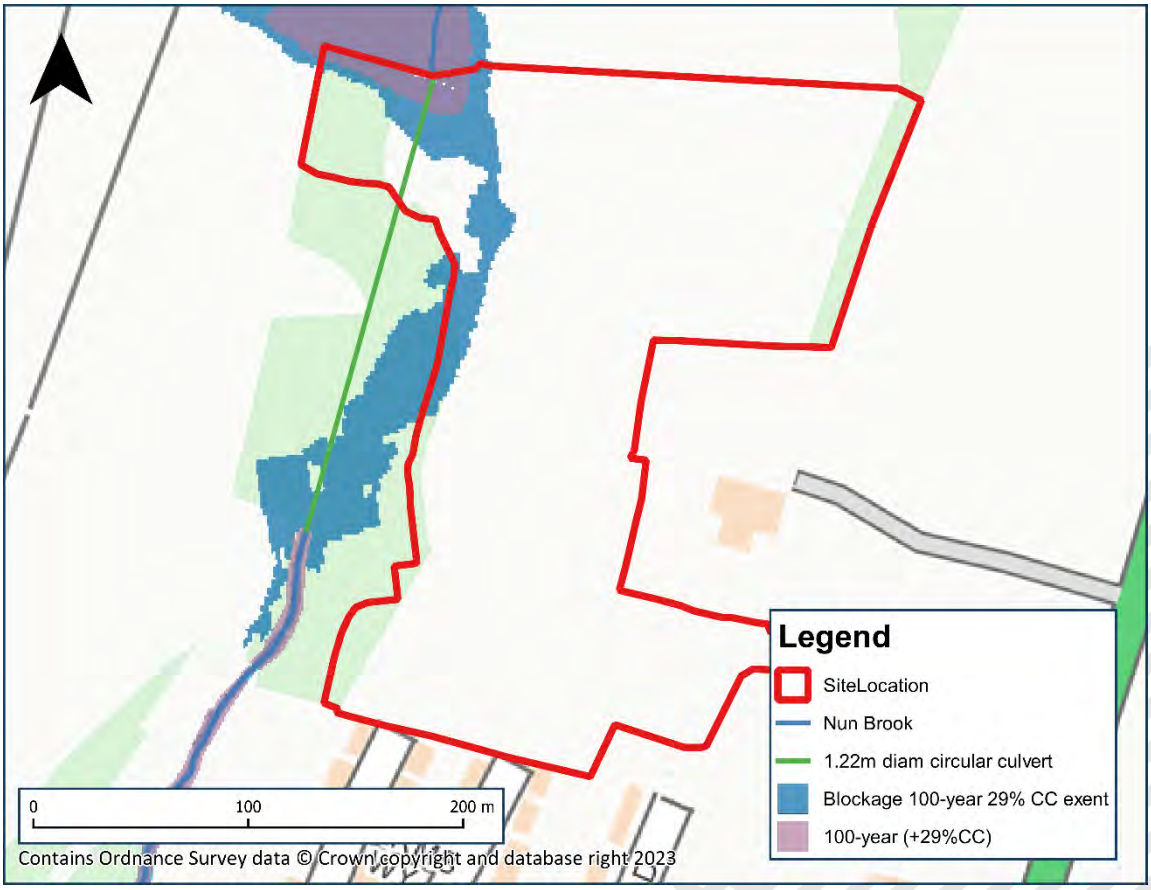

Figure 2-7: Blockage extent

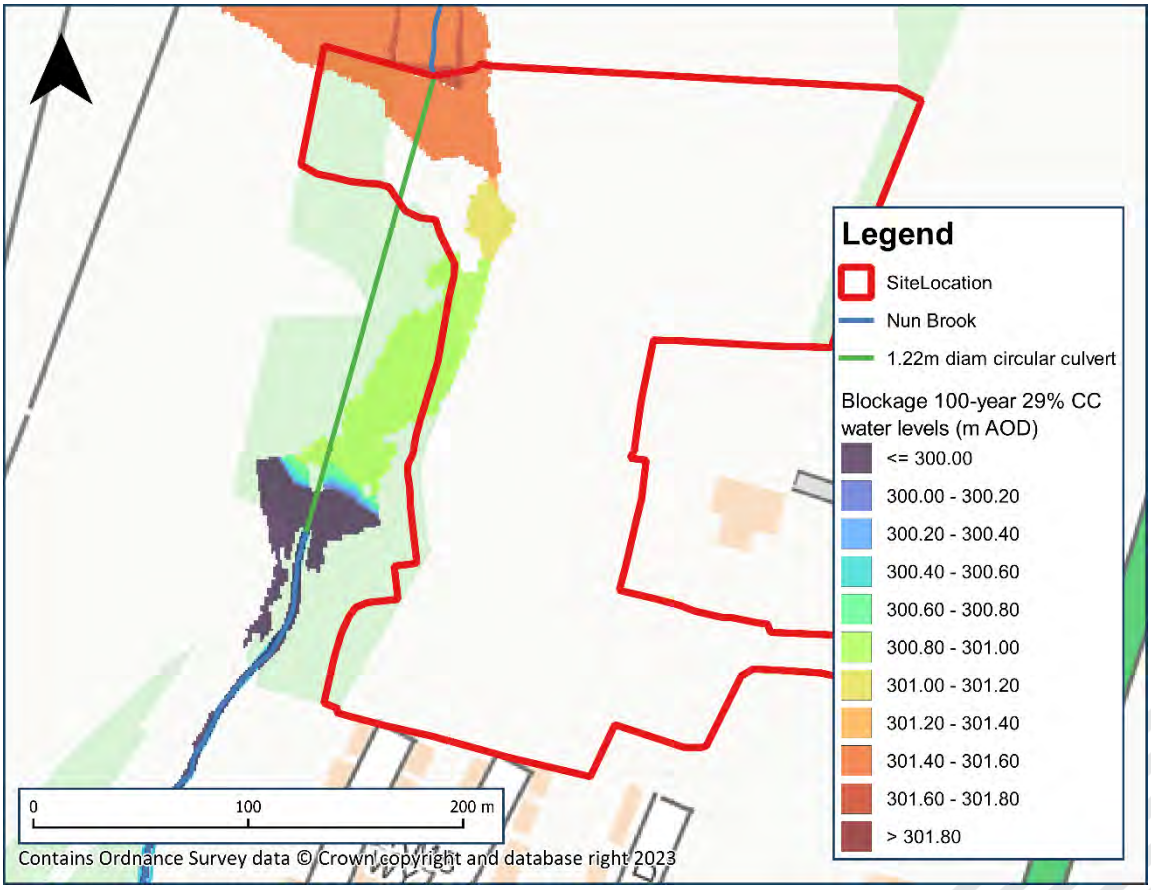

Figure 2-8: Blockage water levels

Figure 2-8 shows that during the 100-year with 29% climate change flood event with a 100% culvert blockage, the modelled peak water level is 301.78m AOD in the north-western area of the site. This is a 1.88m increase in peak water level compared to the baseline scenario.

3 On-site Surface Water Discharge Hydraulic Modelling

3.1 Modelling Approach

In order to assess the impact of the surface water drainage scheme proposed as part of the development, an assessment of the pre- and post- on-site surface water flows was completed using the baseline modelling described in Section 3.

3.2 Revised baseline reflecting current greenfield runoff flows

The existing greenfield run-off rates have been calculated as part of the proposed drainage strategy produced for the site by JPP Consulting. Appendix I of their report states that the peak greenfield runoff rate for the site for the 100-year rainfall event is 116.2 l/s. For the revised baseline scenario, this has been converted into m^3/s and read into the model as a lateral constant flow downstream of the 1.22m diameter culvert, inline with the ground levels within the site. In order to account for climate change, this inflow has been increased by 40%.

Applying the greenfield runoff from the site directly as a point inflow is a conservative approach as the existing model hydrology will account for the site runoff. Also, in reality, the flow would exhibit a hydrograph shape and would not be a constant. However, it was considered necessary to apply this to the baseline as the proposed drainage strategy discharge is to be applied to the post developed model scenario in a similar way.

The revised baseline model scenario was then run for the 100-year 29% climate change event.

3.3 Post-developed model reflecting the proposed on-site surface water outfall

The principal of the proposed drainage strategy for the development is for the whole site to drain to the watercourse, upstream of the 1.22m culvert via an attenuation basin. Discharge from the site into the watercourse will be restricted to 45.2l/s during the 100-year plus climate change (40%) rainfall event. In order to represent the impact of the proposed surface water discharge within the site, this has been modelled in a post-development model scenario.

During the post-development scenario, the proposed peak discharge (45.2l/s) has been applied as a constant flow upstream of the culvert as a lateral inflow to the watercourse. Note that this is conservative as in reality the flow would exhibit a flattened peak hydrography shape. The hydrology from the remaining model remains as per the baseline modelling but the greenfield runoff rate inflow applied to the revised baseline was excluded.

The post developed model scenario was then run for the 100-year 29% climate change event.

3.4 On-site Surface Water Discharge Hydraulic Modelling - Revised Baseline and Post-developed results

The results from the revised baseline modelling and post-development modelling were compared. The impact of the post-developed surface water drainage strategy on downstream flood extents is shown in Figure 3-1 below.

This shows that, with the proposed drainage strategy in place, there is a slight reduction in the flood extent downstream of the site as a greater proportion of the flow is held upstream of the 1.22m culvert. Figure 3-2 below shows the impact on flood depths during the 100-year with climate change event. It shows that there is a reduction in the flood depths downstream within the north-eastern area of Buxton. There is an increase in flood depths upstream of the site of up to 0.05m, however, the extent is unchanged.

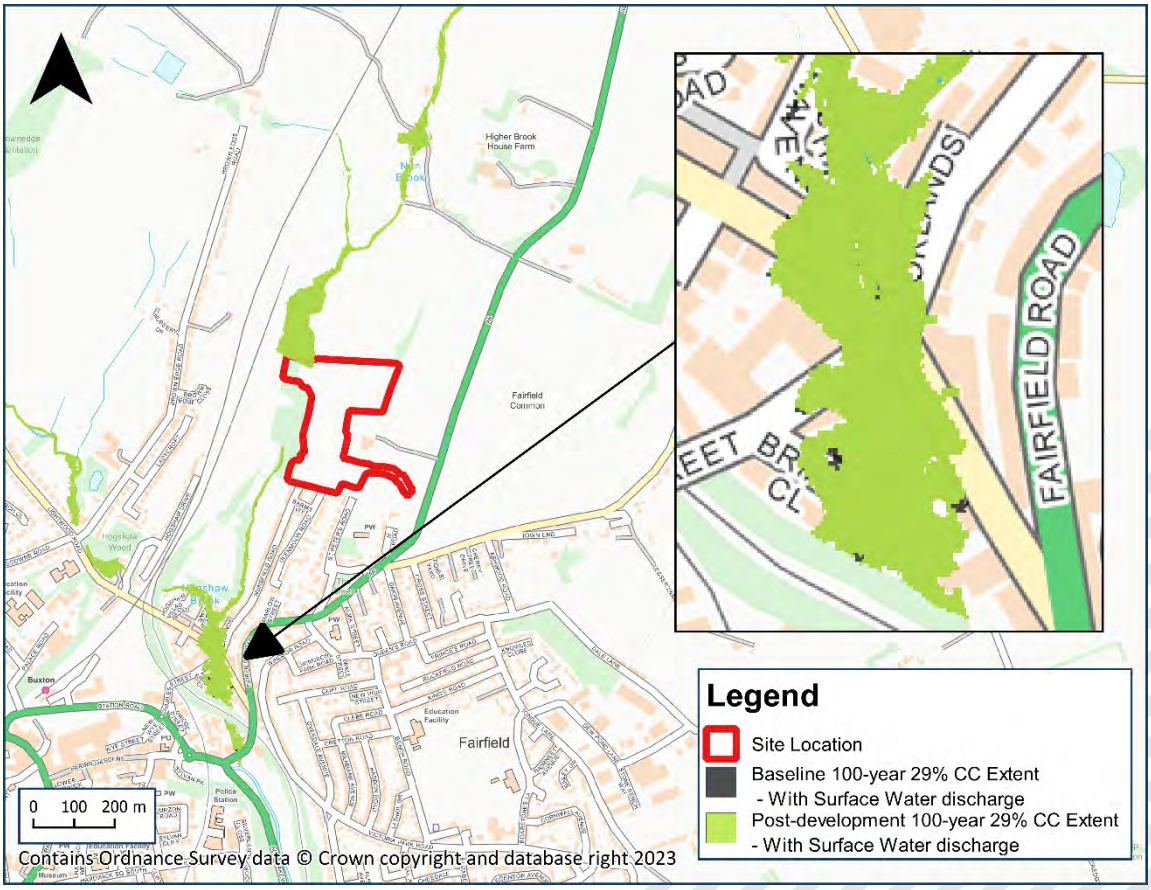

Figure 3-1: Impact on flood extents from surface water discharge amendment

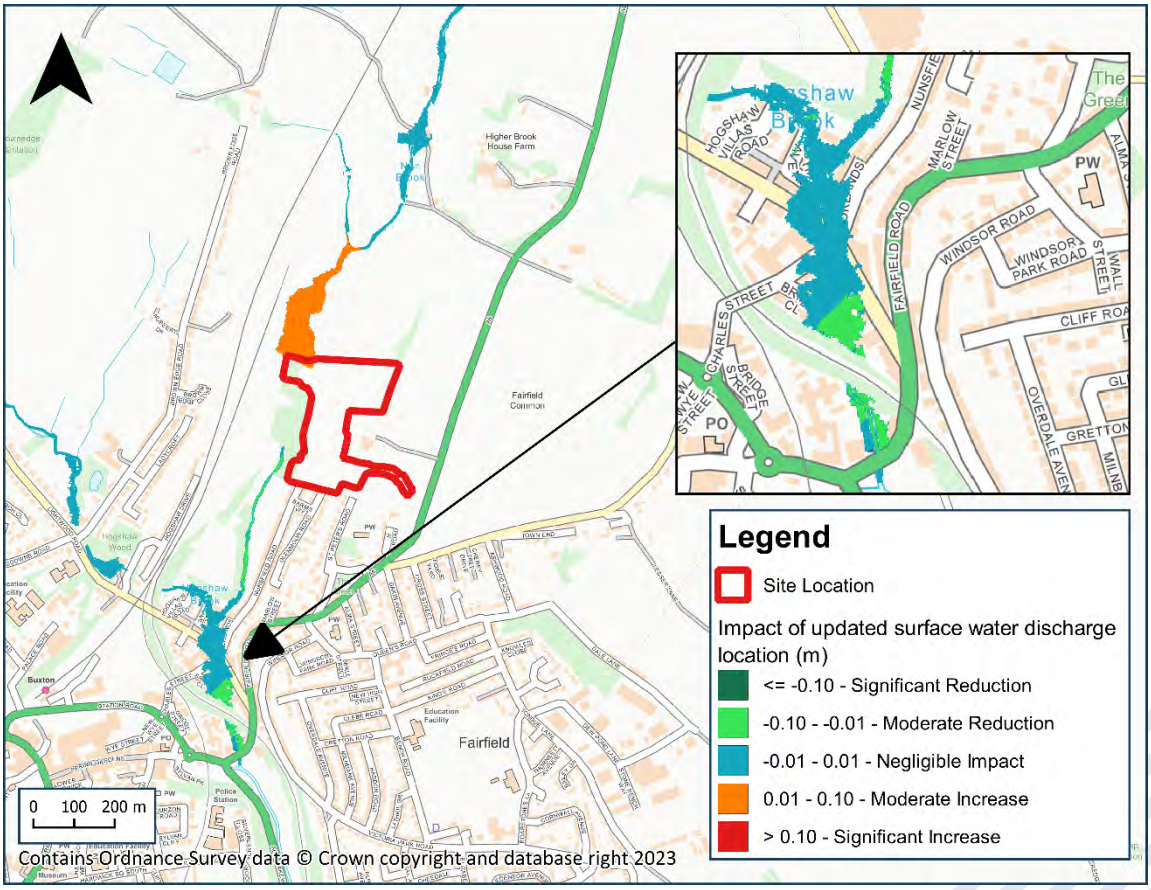

Figure 3-2: Impact on flood depths from surface water discharge amendment

4 Conclusion

- JBA Consulting were commissioned by JPP Consulting Ltd on behalf of Barratt Homes Manchester to undertake a fluvial hydraulic modelling study in order to support their planning application for a proposed development at their site at Hogshaw Farm, Buxton.
- The Nun Brook flows in a southerly direction through the north-western part of the site. The watercourse is culverted during this reach.
- A license to re-use the 1D-2D ESTRY-TUFLOW 2022 Hogshaw and Nun Brook hydraulic model was obtained from the Environment Agency for use in this study. The hydrology inflows, calculated in 2022 as part of the original modelling, were retained as these still reflect best practises.
- New topographic survey data representing the current ground levels within the site was integrated within the model.
- The updated and refined model was run with TUFLOW version 2023-03-AA-iDP-w64 for the 30-year, 100-year, 100-year with climate change (29%) and 1000-year fluvial flood events.
- Baseline model results show:
  - only the north-western area of the site is included with the maximum flood extent during all of the modelled flood extents. Model results show when 29% climate change is applied to the 100-year event, there is no impact on flood extents within the site. Upstream of the site, there is a slight increase in flood extent.
  - Within the site, the maximum flood depths can be found along the north-eastern area of the site upstream of the 1.22m diameter culvert. The maximum flood depth in this area is 4.02m.
  - During the baseline 100-year with 29% climate change event, the peak water levels is 299.90m AOD within the site.
  - The north-eastern areas of the site during the baseline 100-year with 29% climate change event the site is partially within the 'danger for all' hazard category.
- To represent the worst-case scenario, a 100% blockage at the 1.22m diameter culvert has been modelled for the 100-year with 29% climate change event. The blockage model results show that:
  - The flood extent is larger during this event where flows build up behind the culvert inlet before eventually flowing overland to the downstream culvert extent where the Nun Brook becomes open channel.
  - Within the site, during a 100% culvert blockage scenario, the peak water level will be 301.78m AOD in the north-western part of the site.
- In order to assess the impact of the surface water drainage scheme proposed as part of the development, an assessment of the pre- and post- on-site surface water flows was completed.
  - The existing greenfield run-off rates have been calculated as part of the drainage strategy produced for the site. A revised baseline model scenario was

set up which includes a lateral flow into the model to represent the greenfield 1 in 100 year plus climate change peak runoff (116.2 l/s). A review of ground levels within the site shows that the majority of this greenfield flow would enter the Nun Brook downstream of the 1.22m diameter culvert and therefore, this is where the lateral inflow has been applied for the revised baseline model scenario.

- During the post-development scenario, the proposed drainage strategy was represented by applying a lateral inflow at the proposed attenuated rate of 45.2l/s. In line with the proposed strategy, the lateral inflow in the post-developed model was applied upstream of the 1.22m.
- The pre- and post- on-site surface water modelling result show:
    - With the proposed drainage strategy in place, there is a slight reduction in the flood extent downstream of the site.
    - There is a reduction in the flood depths downstream within the north-eastern area of Buxton. There is an increase in flood depths upstream of the site of up to 0.05m however, the extent is unchanged.