
Executive Summary Church Beck

A phase 1 (scoping report) on the flooding issues was undertaken in 2003 for the Church Beck catchment. At that stage it was determined that a more detailed options appraisal report was justified. This report represents an in-depth study that has been undertaken to determine the causes, extents and frequency of flooding. Mitigation options have also been assessed and costed.

General Conclusions

Flooding to the properties around Carr Lane, Hackness Road and Scalby Beck Road is frequent and extensive and justifies the designation of Church Beck as a Critical Ordinary Watercourse. The most recent severe flood occurred in October 2000 when flooding was experienced on roads and by approximately 24 residential properties to a depth of up to 1m. This event has been estimated to have a return period of 15-20 years.

Hydrological assessments have determined that the flow along Church Beck is $4.9 \text{ m}^3/\text{s}$ for the 100 year return period event and $5.8 \text{ m}^3/\text{s}$ for the 200 year event. Coldgill Beck contributes $1.5 \text{ m}^3/\text{s}$ and $1.8 \text{ m}^3/\text{s}$ respectively to these flows.

Hydraulic modelling predicts that flooding is first experienced by 3 properties for a 1 in 10 year return period. Church Beck Cottage and Brook View flood as a result of culvert incapacity under Carr Lane and 113 Hackness Road floods as a result of channel incapacity along the stretch that had been restricted by the recent piling works. This rises to 28 properties for the 25 year event and 35 properties for 100 year event. Flood depths of up to 1.55m are predicted for some properties for the 1 in 100 year event as confirmed by recent flooding incidents.

Specific Causes of Flooding

The hydraulic analyses have revealed that there are a number of contributing factors to flooding in the area caused by various mechanisms. The table below summarises the causes, extents and locations of the flooding and these are described in more detail in subsequent paragraphs.

Summary of the locations, causes and mechanisms of flooding in the study area

Location	No. of Properties affected	Causes	Return Period for Start of flooding
Hackness Road	7	Limited capacity of Low Hill footbridge (CHU_00282) and incapacity of channel along Hackness Road	10 – 50 years
Properties around the Church Beck and Coldgill Beck confluence	6	Limited capacity of small weir and ornamental bridge at Church Beck Cottage (CHU_00427) and the twin arched Carr Lane culvert around the confluence of Church Beck and Coldgill Beck (CHU_00423)	10 years
Scalby Beck Road	22	Limited capacity of channel along Hackness Road with flooding from left bank across field	25 years
Carr Lane		Incapacity of culvert under Carr Lane	10 years
Hackness Road		Low Hill footbridge obstruction to flow and general channel incapacity	10 years
Field adjacent to Hackness Road		General channel incapacity	5-10 years

The incapacity of key structures is a direct cause of flooding. The small weir and ornamental bridge at Church Beck Cottage (CHU_00427) and the twin arched Carr Lane culvert around the confluence of Church Beck and Coldgill Beck (CHU_00423) both limit flow capacity and thus act as hydraulic controls leading to flooding. The properties affected at both these locations (that occur in close proximity) are Church Beck Cottage, Brook View School House, Dainton, Homestead and Toad Cottage.

The capacity of the channel at Low Hill footbridge (CHU_00282) is also limited as the footbridge acts as an obstruction to the flow. This causes flooding of the footpath and Hackness Road.

The reach of Church Beck along Hackness Road has limited channel capacity as a result of bank subsidence and stabilisation works. Even with the recent piling works undertaken on the right bank the channel still cannot accommodate flows greater than a return period of 10-25 years. Flooding originates in the field adjacent to Hackness Road due to the lower elevation of the left bank compared to the right bank over much of the beck's length along the road. The field slopes down away from the channel providing a flow path towards the properties on Scalby Beck Road. Flooding also occurs along Hackness Road by this mechanism.

Mitigation Measures Proposed

A number of mitigation measures were assessed, tested and costed as summarised in the table below. (Options 1 and 2 represent do nothing and do minimum but have been rejected.) A range of return periods were also assessed and the 200 year Standard of Protection was considered to be the most cost-beneficial for the preferred scheme.

Summary of mitigation measures and cost benefit assessments

Option	3 (Flood Storage)	4 (Channel Widening)	5 (Options 3&4)
Protecting properties at Coldgill/Church Beck confluence	<ol style="list-style-type: none"> 1. Replace culvert under Carr Lane with larger capacity culvert, incorporating wildlife ledge. (Appx. 15m length.) 2. Extend culvert upstream a distance of appx. 20m to counter channel incapacity along this stretch. 3. Undertake scour protection works to right bank along Church Beck to counter increased storm flows out of culvert under Carr Lane. 		
Protecting Properties along Hackness Road	<p>Re-design Low Hill Road footbridge to facilitate storm flows.</p> <p>Channel stabilisation works will remove most serious constriction that currently causes flooding. (Already undertaken by SBC.)</p>	<p>Re-design Low Hill Road footbridge to facilitate storm flows.</p> <p>Undertake channel widening of Church Beck along Hackness Road (appx. 200m length), using adjacent field to accommodate wider 2-stage channel.</p> <p>Replace existing hedge with new species rich hedgerow.</p>	<p>Re-design Low Hill Road footbridge to facilitate storm flows.</p> <p>Construct embankments along Church Beck to contain the flow in-bank.</p> <p>Undertake limited widening of channel along Hackness Road (appx. 200m length).</p> <p>Replace existing hedge with new species rich hedgerow.</p>
Protecting Properties along Scalby Beck Road	<p>Allow flooding to field and contain floodwaters as storage.</p> <p>Construct flood bund to protect Scalby Beck Road flooding from the field.</p>	<p>Enlarge outfall to Sea Cut, incorporating steps for wildlife access.</p>	<p>Construct flood bund to protect properties along Scalby Beck Road.</p>
Church Beck Channel Stabilisation along Hackness Road	<p>Drive steel sheet piling along right bank (length 100m).</p>	<p>Undertaken as part of channel widening.</p>	<p>Undertaken as part of channel widening.</p>
Cost Benefit Ratio range (200 yr SoP)	2.6 – 3.4	4.0 – 5.1	4.0 – 5.1
Defra Priority Score (200 yr SoP)	10.1 - 11.6	12.5 – 14.7	13.6 – 15.8

Ecological considerations

The ecological benefits of the three schemes have been considered in order to make a decision on the preferred option. For Option 3 and 5 the flood storage in the improved grassland field could increase the diversity of species within the sward and create areas of marshy grassland that would benefit both invertebrates and birds. Options 4 and 5 will widen the watercourse enabling the colonisation of limited aquatic and some marginal flora. Option 4 will include an enhancement to an enlarged Sea Cut Outfall by means of a stepped structure which will be beneficial to wildlife, e.g otters.

There is little to separate the options from an ecological viewpoint as channel widening and flood storage are both able to enhance the ecology.

Selection of Proposed Scheme

There is little to separate the schemes (especially options 4 and 5) in terms of costs. Therefore cost benefit ratios and a consideration of the risks associated with the schemes have been considered in order to make a decision on the preferred option.

In conclusion, option 4 is the preferred scheme based on the higher cost benefit ratio, the fewer risks associated with the scheme and the greater ecological benefit. This scheme designs flooding out of the system by widening (replacing) the existing culvert under Carr Lane and extending it upstream by a distance of approximately 20m. It also widens the channel from its current 1.5-2m to 5-6m and includes the construction of flood banks. The new channel is proposed as a two-stage system accommodating normal and storm flows without detriment. Channel stabilisation is inherent in the shallowing of the slopes of the left and right banks and a larger outfall structure can be designed to be more sympathetic to wildlife. It is recommended that a 200 year standard of protection is adopted throughout this scheme.

Recommendations

In terms of the selection of freeboard and factors of safety regarding channel design, a Manning's n of 0.08 (to simulate a highly vegetated channel) indicated increased water levels of 200-300mm for the 100 year design event. It is recommended that this robustness should be accommodated for in the design as freeboard along the proposed floodbanks.

Note that High water levels in Sea Cut have been considered in this assessment but these are required to be confirmed and re-assessed once final design levels have been determined by the EA.

It is also recommended that a series of trash screens be constructed along the watercourse and at all culvert entrances and that a strict maintenance regime is adopted to ensure that the design remains .

It should be noted that the model has not been calibrated although it has been verified. As the watercourse is considered to be small with a rocky/gravelly bed, a higher Manning's n than would normally be utilised should be assigned in design and that robust and adequate factors of safety considered.

The major risks associated with the proposed solution are the ecological constraints (presence of otters) and the requirement to purchase land adjacent to Church Beck along Hackness Road. Consultations with all relevant bodies will also be a requirement. There is, therefore, a risk that the preferred option could be subject to change.

Finally, it should be noted that the indicative flood plain maps indicate that Scalby Beck Road is within the floodplain for the Sea Cut. It is understood that the EA are currently undertaking a flood plain mapping exercise for Sea Cut and so it is critical that consideration must be made for that work otherwise Scalby Beck Road may still be at risk of flooding from Sea Cut.