SCARBOROUGH BOROUGH COUNCIL

Cayton Flood Alleviation Assessment

Final including Clients Comments

August 2004

Notice

Document History

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GLOSSARY OF TERMS

Term	***Meaning / Definition***
Agency	The Environment Agency
AOD	Above Ordnance Datum (Newlyn)
Atkins	WS Atkins Consultants Ltd.
BF	Base Flow (FEH term)
CH	Chainage
CIRIA	Construction Industry Research and Information Association
COW	Critical ordinary Watercourse
Defra	Department for Environment, Food and Rural Affairs (*Formerly MAFF)*
EA	The Environment Agency
FEH	Flood Estimation Handbook
ISIS	Mathematical modelling package
MCM	Multi Coloured Manual *A manual published by the Flood Hazard Research Centre at Middlesex Polytechnic containing data and costs for flood damage to a variety of properties in different scenarios.*
POS	Public Open Space
PR	Percentage Runoff (FEH term)
SBC	Scarborough Borough Council
T_P	Time to peak flow (an FEH term)

Executive Summary

Atkins were commissioned to undertake a preliminary feasibility assessment of the mechanisms of flooding in the Cayton area. This feasibility report was required to determine whether potential flood mitigation options were feasible to proceed to the more detailed assessment and modelling stage. In addition, Atkins were required to determine the impact of the drainage remedial works on the proposed A165 Scarborough Lebberston Diversion and the impact of upsizing 2 highway culverts.

On 10th August 2002 after an estimated 118mm of rainfall fell in the early morning, properties in Cayton and Eastfield were severely effected by flooding. In total 65 houses, a caravan site and factory within Cayton were flooded.

The main reason for flooding has been found to be insufficient capacity in the 2 main culverts along the watercourses of Coulston and Beck Hole which pass through Cayton. The event of August 2002 is estimated to be an extreme event in the order of 1 in 50-200 years. Increased run off from recent development further higher up the catchment may also have attributed to a more intense flashy regime. A combination of additional factors such as blocked trash screens culvert debris appear to have increased the severity of flooding.

The mitigation option which appears to have the most robust cost benefit ratio of 2.67, was the storage and upgrading option. This consists of 50,000m^3 of storage in 2 ponds combined with additional trash screens along the watercourse, regular maintenance and enhancement of the open channel section within Cayton. The storage is proposed in a field owned by McCains currently used for sports and all relevant land ownership issues would need to be addressed.

The outfall from the balancing pond on the Eastway Link is proposed to discharge into Coulston Watercourse. This study has found the existing watercourse to be seriously under-capacity and cannot accommodate a 1 in 5 year event. Therefore, unless flood alleviation measures are adopted along the system, additional flows should not be allowed to discharge into the existing system. The proposal to upgrade the section of 225mm diameter culvert under Lime Kiln Drive on Beck Hole Watercourse will help to increase the standard of protection to between a 1 in 50 to 1 in 100 year event.

The risks associated with the assessment are mainly due to the estimated 100 year flood envelope and the number of properties currently estimated to be affected. However, as this is based upon historical data combined with the robust benefit cost ratio, it is felt that this risk is within manageable limits. A detailed modelling exercise in the next phase should more accurately define the flood envelope and confirm flood storage requirements.

It is, therefore, recommended that this scheme is progressed to the detailed modelling and assessment phase.

1 Introduction

1.1 Aims and objectives

WS Atkins (Atkins) were commissioned by Scarborough Borough Council (SBC) to undertake a feasibility study for alleviating flooding in Cayton and to determine the impact of upsizing two highway culverts proposed by NYCC. This assessment is designed to collate and analyse the information such that a determination can be made whether to undertake a more detailed study to submit a scheme to Defra for grant funding.

1.2 Methodology

For this stage the following information was collected and analysed:

- A topographic survey of the critical areas for the study
- Site visits and a photographic survey
- A questionnaire sent to residents and relevant groups
- An initial consultation exercise to relevant environmental organisations
- A hydrological assessment of flows and return periods
- An hydraulic determination of culvert and channel capacities

Using the above information, flood mechanisms and the extent of potential flooding were assessed and preliminary engineering and economic appraisals undertaken.

1.3 Catchment Description

The route of the 2 watercourses flowing through Cayton, namely Coulston Hill Drain and Beck Hole Drain, and their key hydraulic / drainage features have been assessed from three main sources:

- the published OS data
- a walkover inspection
- a limited topographic survey

A location and study reach is presented in Figure 1.1.

For the purposes of this report these 2 watercourses and their catchments have been analysed individually as the issues associated with the flooding of each are considered to be separate.

Coulston Watercourse

The majority of the flooding issues in Cayton originate from this watercourse, which is relatively steep and has a low soil permeability. The upper reaches of the watercourse conveys flows from the Osgodby Estate along an open channel stretch to a 650mm culvert under the road by Eldin Hall. It then flows under the road and through an open channel to a 750mm culvert inlet at Jacksons Close from where it then flows through Cayton. From the culvert inlet it runs under gardens and then to an open channel that joins Main Street. It then goes into a 750mm culvert under gardens and West Garth where it changes into twin 675mm pipes for a short distance before continuing to West Garth cul-de-sac. At this location, it turns 90^{o} into a 750mm pipe and finally outfalls into an open channel at West Garth Gardens.

From a visual inspection, water entering the watercourse before it passes into the main culvert through Cayton is a mixture of urban surface water from the Persimmon's Estate (the new development on the Osgodby Estate) some road drainage and field water. During the site visit an odour of sewage was detected from the open sections of drain. It is possible that some sewage was entering the watercourse from badly or illegally connected drains at the Persimmon's Estate. It is recommended that this matter is further investigated.

Beck Hole Watercourse

This watercourse originates from Mill Hill just south of Cow Les Farm in the fields above of Cayton and flows through the fields as an open watercourse then passes through a pipe by the Cayton Caravan Park and back to open channel between Mill Lane and the Caravan park. It then flows through a 650mm pipe under Limekiln Lane which then reduces to a 225mm pipe under the road and then up to a 750mm dia pipe immediately after Lime Kiln Lane. The watercourse then flows under Main Road gardens and along Nesfield Close, under West Garth Street and into an open channel.

From a visual inspection it appears that water entering the watercourse before it passes under Cayton water is purely field and road drainage and is free form sewage.

2 Data collection & review

2.1 Data collected

As no previous studies have been carried out on the Cayton catchment, data for this report has been obtained from site visits and information from residents, Mr Green of Killerby Lodge Farm and SBC.

2.2 Site Walkover

A site visit and walkover inspection was undertaken by experienced river engineers in May 2004. The main objectives of the watercourse walkovers were to:

- Assess the general characteristics of the catchment;
- Identify hydraulic controls on the watercourse;
- Make an initial assessment of the likely limit of the floodplain and flood risk areas;
- Identify locations for which topographic survey data will be required.

Properties that were potentially at risk of flooding or were known to have flooded in the past were identified during the walkover survey. Where possible, information regarding flooding paths and mechanisms were gained through discussions with local residents and landowners.

Photographs of key features of the watercourse/catchment were taken during the site visit and can be found in Appendix A.

2.3 Topographic Survey

A topographic survey for Cayton was carried out by Survey Operations Ltd during March 2004. The aim of the survey was to establish a topography of Cayton in lieu of any other information.

The survey included spot levels of roads, cross sections of Coulston and Beck Hole Watercourses and property threshold levels in specified areas. The threshold level is defined as the lowest point where water can flood the property (e.g. basement window, brick grill, and front/back doors). This data was required in order to assess the cost and extent of flooding and the number of properties likely to be affected by internal flooding during a high flow event. The survey locations and results are presented in Figure 2.1 and 2.2.

2.4 Planning and development issues

The proposed diversion between Osgodby and Southcliff (Lebberston Diversion) includes contingencies for storage of any additional runoff from the new road to minimise any impact on the Cayton watercourses. It must be ensured though that the proposed balancing ponds have sufficient capacity to accommodate the runoff.

2.5 Consultations

A number of organisations were contacted to determine whether they had any interests regarding Cayton. The list of bodies contacted and their responses are reproduced in Appendix B and summarised in Table 2.1.

Organisation	Response
North Yorkshire County Council (Highways)	No response
Scarborough Borough Council (Planning)	No response
Cayton Parish Council	No response
Yorkshire Water	No response.
The Countryside Agency	No comment to make at this stage, would welcome being kept informed as the study progresses and reaches completion.
RSPB	No specific comment.
Yorkshire Wildlife Trust	No response.
Environment Agency	No formal response received. The watercourse is not designated as a critical ordinary watercourse be the Environment Agency.
English Nature	No comment to make at this stage.
English Heritage	No response.
National Farmers Union	No response.

Table 2.1 – Responses from Consultees

The major consultees felt that there was no need for further consultation until proposals for works on flood defence were at a more mature stage.

2.6 Responses from residents

Questionnaires were delivered to properties identified to be at possible risk of flooding as described above. A summary of the key information obtained is presented below.

(i) W Boyes at Eastfield said that no flooding has ever occurred at their site.

(ii) McCains factory at Cayton did experience flooding during the event however it is understood that this was due to large volumes of run-off from higher ground at the top end of the site overwhelming the surface water drainage system. To their knowledge this was the only flooding that has occurred in the last 35 years.

(iii) Cayton Village Caravan Park suffered bad flooding during the August 2002 event when 9 caravans in total where flooded. The reason for this flooding is understood to be the under-capacity of the 225mm diameter section of culvert passing under Lime Kiln Lane.

Table 2.2 below summarises the problems in the area as reported by the questionnaire responses.

No.	Location	Properties affected by Flooding	Frequency	Cause of Flooding
1	42, ,54, , 62, 64, ,51, 45, 53, Main Street	Gardens, under floors and Main Street flooded .	Only Flooded in the August 2004 event.	Incapacity of culvert
2	44, 44A,35, 33, 66, 70, 58, 31, 50	Residential properties, and Main Street flooded	Only Flooded in the August 2004 event.	Incapacity of culvert
3	27, 41, 45, 37, 35, 8 Harford Road	Gardens and some under floors Flooded	Only Flooded in the August 2004 event. 35 Nov 2000	Incapacity of culvert
4	33, 16, 14 Harford Road	Residential properties, and lower part of Harford Road flooded	Only Flooded in the August 2004 event.	Incapacity of culvert
5	23, 22 Shelly Close	Gardens and under floors Flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
6	4, 2, 1, 3, Shelly Close	Residential properties, and Shelly Close flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
7	1 Ivy Close	Residential Property and Shelly Close was flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
8	2, 3, 4, 7, 11, 12 Ivy House Close	Gardens and some under floors Flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
9	4, 3 Fenwick Close	Gardens Flooded.	Only Flooded in the August 2004	Incapacity of culvert

			event.	
10	24, 22 Beverly Close.	Gardens and under floors flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
11	7, 10, 9, 26 Beverly Close	Residential Property and some of Beverly Close was flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
12	20, 8, 16, 1, 10 Beverly Road.	Gardens and under floors flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
13	12 Beverly Road	Residential Property and much of Beverly Road was flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
14	137, 141, 98, 143, 131 West Garth	Gardens and under floors flooded.	Only Flooded in the August 2004 event. No 137 regularly has sewage overflowing from an adjacent manhole.	Incapacity of culvert
15	139, 129 West Garth.	Residential Property and some of West Garth was flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
16	31, 28, 24, 33, 34, 3, 21, 25, 26, 32 West Garth Gardens	Gardens and under floors flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
17	1, 29, 30, 19, 2 West Garth Gardens	Residential Property and much of West Garth Road was flooded.	Only Flooded in the August 2004 event.	Incapacity of culvert
18	Cayton Village Caravan Park	9 Caravans	Only Flooded in the August 2004 event.	Incapacity of culvert
19	Eldin Hall	2 Commercial properties	Only Flooded in the August 2004 event.	Incapacity of culvert

Table 2.2 – Summary of Historical Flooding Information

2.7 Recent flooding

It appears that flooding in the area has not previously been an issue and the severe flooding experienced in August 2002 was a result the combination of an extreme rainfall event and the incapacity in the existing system combined with debris/blockage issues.

Flooding in October/November 2000 was experienced but the extent has not been quantified.

3 Hydraulic and Hydrological Calculations

3.1 Culvert Capacities

To analyse the capacity of the culverts the Culvert design guide (CIRIA) was utilised. The method adopted was standard circular inlet controlled culverts which estimates the flow for various water levels upstream of the culverts.

3.2 Hydrology

Rainfall runoff models were constructed using FEH boundary units within ISIS hydraulic modelling software. The catchment area is determined using the catchment boundaries suggested by FEH-CDROM. The rainfall-runoff method estimates flows by explicitly examining the relationship between rainfall and the hydrological response of a catchment to a storm event. Three key parameters are used by the rainfall-runoff model to define the hydrological characteristics of a catchment. These are: Catchment response to rainfall (unit hydrograph time-to-peak, Tp); Proportion of rainfall which directly contributes to river flow (percentage runoff, PR); Quantity of flow in the watercourse prior to the storm event (base flow, BF). Figure 3.1 shows the catchment boundaries.

Since there is no flow gauge in the catchment, the parameters are derived using digital FEH catchment descriptors. This is quite appropriate and a standard approach to use under these circumstances. Rainfall is defined in terms of duration, depth and distribution (over time), and may relate to either a probabilistic design event, eg: 1 in 100 year return period, or an observed storm event (for calibration purposes).

The Cayton event FEH DDF modelling was used to generate a rainfall profile of a storm of 6hr duration with a total rainfall depth of 118mm.

The following conclusions were made comparing the FEH run off estimation with the culvert capacities estimated.

- The inlet culvert of the Coulston Watercourse appears to have insufficient capacity for the event. (it's capacity, surcharged to 1m, is estimated to be 1.34m^3/s). The FEH rainfall run off method estimates the 1 in 5 year event at this point to be approximately 1.5 m^3/s. This implies that this culvert is under capacity.

- The 225mm section of culvert under Lime Kiln Lane is insufficient capacity for the event or even minor rainfall events (its capacity surcharged to 1m is estimated to be 0.038m^3/s). The FEH rainfall run off method estimates the 1 in 2 year event at this point to be approximately 0.35 m^3/s. This implies that this culvert is seriously under capacity.

It should also be mentioned that the above calculations exclude channel blockages and restrictions which can be seen from recent events to significantly reduce the capacities of the channel and culverts. The return period flows from FEH are presented in Table 3.1 below, although it should be noted that being an un-gauged catchment, reliable figures are best gained from a long period of flow readings.

Return Period (yrs)	2	5	10	25	50	75	100
Coulston Watercourse Flow m^3/s	1.1	1.5	1.8	2.4	2.9	3.3	3.6
Beck Hole Watercourse Fow m^3/s	0.35	0.51	0.62	0.82	1.0	1.1	1.2

Table 3.1 FEH Flows for varying return periods

Figure 3.2 presents the flow/stage relationship at the Coulston Watercourse 750mm diameter section 1 from the inlet at the Jackson Close playing fields 180m to the open section before Main street. It also indicates the return period that the level corresponds to. As detailed, the culvert has a capacity of under a 1 in 5yr event.

Figure 3.3 presents the flow/stage relationship at the Coulston Watercourse 750mm diameter section 2 from the inlet at Main Street 490m to the outlet in the fields below Cayton. It also indicates the return period that the level corresponds to. As detailed the culvert also has a capacity of under a 1 in 5yr event.

Figure 3.4 presents the flow/stage relationship at the Beck Hole Watercourse under Lime Kiln Lane where the culvert section is only 225mm diameter. The figure also indicates the return period that the level corresponds to. As shown, the culvert capacity is less then a 1 in 2 yr event.

Figure 3.5 presents the flow/stage relationship at the Beck Hole Watercourse if the 225mm section was to be up-sizes to a 650mm section. It also indicates the flow required to surcharge the culvert by 1m is increased from $0.04m^3/s$ to $1.09m^3/s$. As shown, the culvert capacity would be increased to between a 1 in 50 and 1 in 100year event.

3.3 Proposed A165 Scarborough Lebberston Bypass

A balancing pond is proposed at the Eastern Link Road (Figure 3.6) for the above bypass. The pond has been designed for a 1 in 10 year event ($1,700m^3$ volume) and a maximum discharge of 10 litres/s, into Coulston watercourse. In the light of the findings of this study, any additional inflow into Coulston watercourse would adversely affect the flooding regime. While it could be argued that the additional impact would be negligible, the calculations for the balancing pond have only been undertaken for a 1 in 10 year event which implies that a more serious event would have a greater impact on flooding in Cayton. Thus, unless flood mitigation measures are put in place along Coulston watercourse, it is the recommendation

of this study that an already under capacity watercourse should not receive additional flows.

4 Assessment of Flooding Mechanisms

4.1 Historical Flooding

A number of properties and numerous gardens and roads were inundated in the August 2002 event. Historically it is understood that flooding has not occurred significantly in the past. A map indicating areas of flooding in the 2002 event is presented in Figure 4.1. It is considered that much of the inadequacies of the existing system are a result of insufficient capacity, blockages and possible silting up of the system.

Eldin Hall (The Old Water Works)

The upper section of the Coulston Watercourse flows onto a 650mm culvert under Church Lane at Eldin Hall. The inlet to the culvert has no screen and became blocked with debris during the event in August 2002. Debris also blocked the adjacent section culvert under Church Lane. Flood water unable to enter the culvert flooded out onto Lane and into the Eldin Hall property.

Flood waters then flower over Church lane and along the entrance road to the playing fields and flooding low - lying and the playing field garage/store room areas being trapped behind the existing flood embankment. The water then re-entered Coulston Watercourse in the open channel by the playing fields.

Another issue with Eldin Hall is an existing 450mm diameter field drain culvert which passes by the main house (the dd pump house) and joins the culverted section of Coulston Watercourse under Church Lane. This pipe also backs up when the main culvert under the road blocks and flows back up an existing open pipe into the basement of the house causing flooding.

Road gullies at Eldin Hall and at the entrance road to the playground also appear to flow into the culvert which will add to flows.

Jacksons Close Play Area.

This is one of the main areas for flooding. Coulston Watercourse flows into a 750mm culvert for a distance of 180m. The inlet does have a one-stage screen but this is small and is known to block easily. The drain banks at the entrance to the culvert are formed with large stone blocks which are known to fall into the channel blocking it. The arrangement of the screen also makes if very hard to clean under high flow conditions. Once blocked the water flows along 2 routes:

- Along Harford Road and flowing down towards Main Street and other low-lying side streets.
- Flow through properties over Shelly Close and back into the open drain section.

Main Street

The watercourse flows along an open channel and is culverted again for 220 m until it outlets below Cayton. This open drain has insufficient capacity to contain the high flows and so nearby gardens at Westend Court flood. The existing inlet has a basic trash/security screen but it is understood that most of the flooding originates from here. The culvert is under capacity for the flow of water expected. Water flowed onto main street during August 02 flood conditions. The topography of main street prevents floodwaters from draining to side roads and so the properties in the vicinity of the culvert inlet were severely flooded. Flood waters then flowed to Beverly Gardens flooding West Garth and West Garth Gardens.

Cayton Village Caravan Park

Water here is unable to enter the culvert under Lime Kiln Lane due to the 225mm section which runs under the road. From inspection on site the culvert also appeared to be heavily silted up. As a result low-lying areas of the caravan park and lime kiln Lane were flooded.

Road drainage also appeared to flow into the open section of drain downstream of the access road to the site.

4.2 The 100 year predictive flood outline

The catchment for this watercourse is steep with a relatively low permeability soil. The presence of a hill to the north of the watercourses combined with the large urban area of the Osgodby Estate in the upper reaches of the the catchment results in a rapid runoff regime, placing the drainage system under considerable strain. The culverts in the area do not appear to be designed appropriately to accommodate the degree of flow experienced and are consequently severely surcharged. This, combined with the incapacity of the open channel section above main street and blockages and debris in the system as a result non screened inlets provide the main reasons for flooding. A predictive 100 year flood outline is assumed to follow the historical August 2002 event with additional properties flooded within the known flooded areas. A representation of flow routes during flooding is presented in Figure 4.4.

4.3 Hydraulic restrictions present

To demonstrate the hydraulic constriction problems graphically, figure 4.2 and 4.3 presents the long sections of both Beck Hole and Coulston watercourses.

Coulston Watercourse

The main restriction is the actual size of the culvert that is under-capacity.

Beck Hole Watercourse

The main restriction is the 225mm diameter section of culvert under Lime Kiln Lane. The inlet to the culvert is 650 mm and then after the 225mm section the culvert up-sizes to a 750mm diameter section. It is unclear without detailed investigation what impacts would occur if the current section was upsized.

5 Proposed flood alleviation schemes

Three main options have been assessed to limit flood damage to the houses and roads. These are listed below and presented in Figure 5.1:

- Option A – Do minimum by upgrading the existing system through the installation of trash screens and cleaning the existing open drains and culverts.
- Option B – Upgrade the existing culvert, provide trash screens and undertake maintenance as for option A.
- Option C –. Construct 2 storage areas and upgrade the existing system as in Option A.
- Option D – Construct a diversion channel around Cayton.

(Note that all the above options require the existing section of culvert which is under capacity under Lime Kiln Lane to be replaced with an upsized section.)

5.1 Option A – Do Minimum

This option consists of upgrading the existing system with screens. Trash screens are to be provided to the following areas.

Location	Watercourse	Cost (K)
750mm Inlet – Eldin Hall	Coulston Watercourse	3
Blocking of disused pump-house pipe into Eldin Hall and replacement of burst section of 500mm culvert under the garden	Coulston Watercourse	1
Trash screen to be provided to the 750mm inlet at Jacksons Close Play Area.	Coulston Watercourse	5
Trash screen to be provided to the 750mm inlet at Main Street.	Coulston Watercourse	5
Reshaping of the existing open water course through the centre of Cayton for distance of 180m to increase its capacity.	Coulston Watercourse	50
Replacing the 9” section of culvert under Lime Kiln Lane with 650mm dia culvert pipe or twin pipes.	Beck Hole Watercourse	10

5.2 Option B – Provide Offline Storage

This option provides a solution to the incapacity of the Coulston Drain culvert via the storage of water in the playing fields site immediately upstream of Cayton, off Church lane. And within the abandoned field adjacent to Church Lane. The required volume of storage has been estimated to be 55,000m^3. This will require 2 ponds previously described and shown on Figure 5.1. It should be noted that the existing landowner of the playing fields McCains currently has plans of making a golf driving range at this location, and it is not it is quite possible that the 2 schemes can be integrated. The other area proposed for storage is currently owned privately.

Figure 5.2 shows the hydrographs for the 2, 10, 50 and 100 year event. The volume of water needed to be stored in this artificial reservoir will be the area under the graph - over the capacity of the existing culvert. The volume required to store flood water for the 100 year event is thus approximately 33,500 m^3. With factors of safety to allow for climate change, filling and emptying times and sustained events, a 50% excess volume has been allowed for, namely 50,000m^3. This corresponds to a water depth of approximately 1.5m within the 2 areas indicated on Figure 5.1.

There are safety implications to this option which would probably require the creation of large areas of ponds and raised embankment/walkways. This will ensure that members of the public are not put in any danger. There are also land-owner issues to be resolved.

5.3 Option C – New culvert replacing the existing culvert.

This option proposes the replacement of the entire culvert system through Cayton, along its present route. De-culverting will be provided where possible and the pipe will be enlarged to an appropriate diameter.

There are possible implications further downstream that may require investigation but these do not appear significant at this stage. This option will require permissions from numerous landowners and cause much disruption in the village. It is likely to meet significant opposition.

5.4 Diversion Culvert

This option proposes a diversion channel to the west of Cayton so taking storm waters away form the village. There are land-owner issues to resolve but less than the previous option.

6 Cost Benefit Assessment

Table 6.1 presents the Benefit Cost Ratios for the proposed schemes using the MCM manual. It should be noted that costs of flooding of roads are not included in the scheme costs and these would have the effect of increasing the benefit cost ratios. As part of a sensitivity assessment, a range of costs (minimum and maximum) were assessed to ascertain the robustness of the benefit cost ratios.

Option		Damage Prevented	Scheme Summary	Scheme Costs - £k	Cost Benefit Ratios
Beck Hole Lane	Replace the 225mm dia culvert under Limekiln Lane (all options)			included	-
A	Upgrade Existing System	Properties 300mm Flooding 21 Residential Properties Flooded. 3 Commercial Properties up to threshold flooding 44 Residential 1 Commercial	Installing screens and headwalls in 3 locations and reshaping the open section of channel upstream of Main Street	318	3.95
B	Flood Storage		Construct 2 flood storage areas	1,882	2.67
C	Upsize existing culvert		Replace 445m of existing culvert with a larger diameter culvert section.	6,360	0.79
D	New Culvert Bypass to replace existing culvert		Divert flows round to the west of Cayton by using and new 200m long culvert	2,563	1.96

Table 6.1: Benefit Cost Assessment Summary

The costs have been determined as presented in Appendix C, with maintenance of £4,000 – £6,000 per year allowed for and a contingency of 25% on gross costs. The average annual damage has been calculated as £208.7k with a present value of total damages of £5.1m.

It is advisable that schemes with a benefit cost ratio greater than 2 are worth presenting to Defra for grant aid assistance. On this basis options A and B are worth considering to be taken forward to a more detailed assessment.

A Defra prioritisation score assessment has also been undertaken and this provides scores for Options A and B of 18.7 and 8.9 respectively.

7 Conclusions & Recommendations

The schemes proposed have been shown to be robust with benefit cost ratios ranging from 1.96 to 3.95 and it is thus proposed that this scheme is taken forward to a more detailed mathematical modelling assessment. The following points are to be noted in this assessment.

1. The analyses undertaken in this reports are based upon spreadsheet and basic hydrological and hydraulic calculations. A more detailed mathematical modelling exercise proposed could change the findings and thus the recommendations.

2. The existing capacities of the Coulston and Beck Hole watercourses are less than 1 in 5 and 1 in 2 year return periods respectively.

3. The options favoured currently (do minimum and storage) both require public and wider consultation.

4. The channel enlargement option is clearly too expensive, although the diversion option should be considered again during the next phase.

5. The storage option requires consents from two landowners for implementation, although using one of the areas of land (the playing field) may be sufficient.

6. It is recommended that a CCTV survey is undertaken of both watercourses to determine the exact condition of the culvert systems. While it is not expected that major blockages will be found, exact dimensions, material and hydraulic and structural condition have to be assessed conclusively to ensure any design undertaken is reliable.

7. It would be advisable to gauge these watercourses for long-term flow statistics and verification of modelling.

8. It is recommended that in light of the findings of this report, any additional flows into the system from the A165 Scarborough Lebberston Diversion should not be allowed. Additional flows into an already seriously under-capacity watercourse would adversely affect the flooding regime in Cayton.

Figures

Appendix A: PHOTOGRAPHIC SURVEY

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Appendix B: RESULTS OF CONSULTATIONS & QUESTIONNAIRES

Appendix C: COST BENEFIT SPREADSHEETS