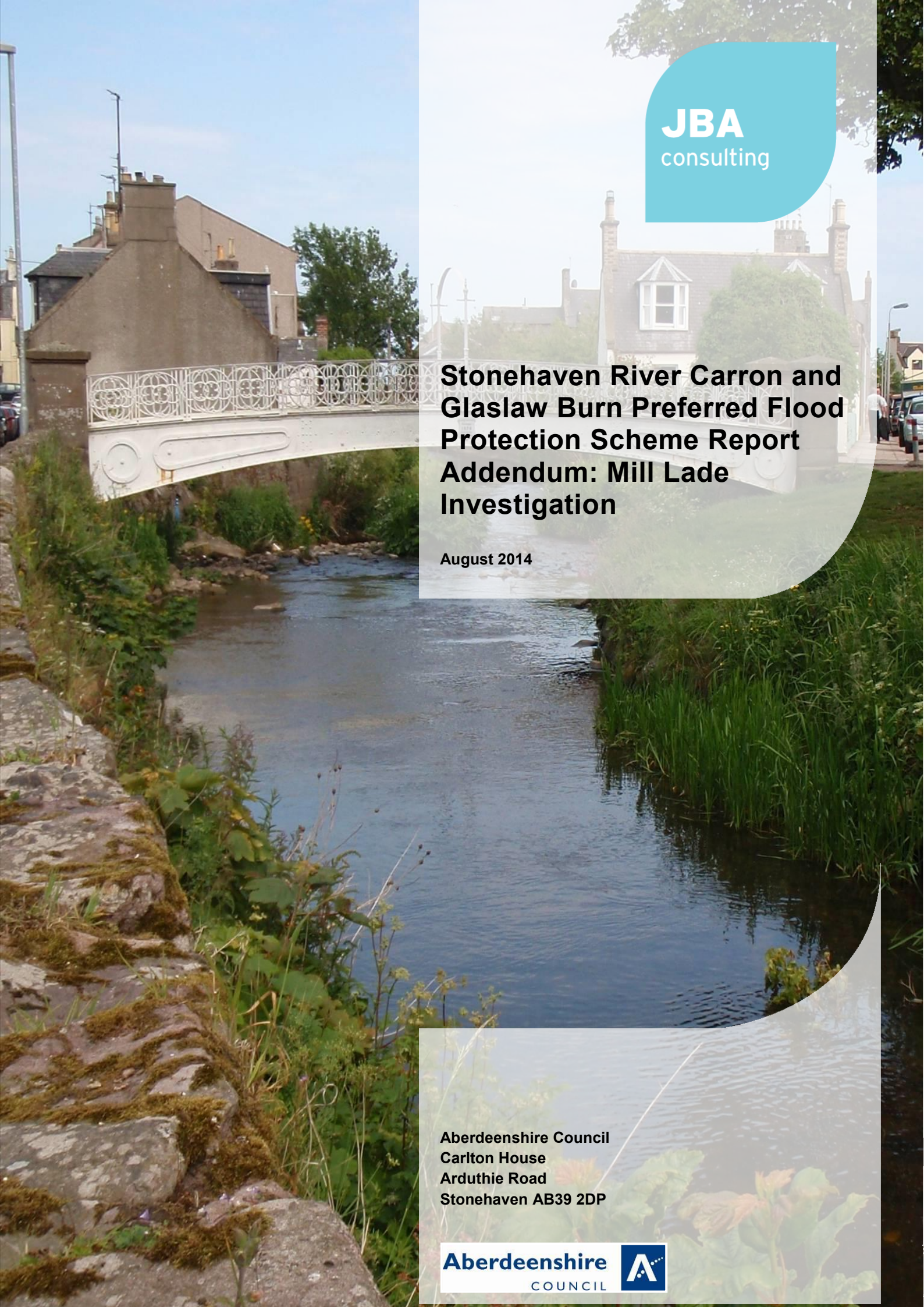

Stonehaven River Carron and Glaslaw Burn Preferred Flood Protection Scheme Report Addendum: Mill Lade Investigation

August 2014

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Revision History

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Final	n/a	Rachel Kennedy

Contract

This report describes work commissioned by Willie Murdoch, on behalf of Aberdeenshire Council, by a letter dated 14 March 2013. Aberdeenshire Council's representative for the contract was Rachel Kennedy. Mark McMillan Angus Pettit and Caroline Anderton of JBA Consulting carried out this work.

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Purpose

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Abbreviations

FPS ..... Flood Protection Scheme

1 Introduction

Serious flooding in 2009 and 2012 caused significant damage to low lying areas of Stonehaven. In 2009 water left the River Carron and flooded areas including the High Street and The Town Square. In 2012 water from the River Carron and Glaslaw Burn caused similar areas to flood with more significant damages in the High Street area. Water also flowed overland from the Bervie Braes increasing the depth of flooding to the south of the River Carron. In the light of the recent flooding Aberdeenshire Council have proposed the construction of a Flood Protection Scheme which will alleviate flooding in Stonehaven from the River Carron and the Glaslaw Burn.

Aberdeenshire Council commissioned JBA Consulting to assess viable options for alleviating flooding and put forward a preferred scheme taking into account various elements including economic analysis, risk of failure, ease of construction and environmental impact. The conclusion of the study promoted a scheme which consisted of direct defences on the banks of the River Carron and Glaslaw incorporated with bridge raising and alterations to the river channel. In addition JBA Consulting were commissioned to assist in the design of short term measures to help reduce the impact of flooding before the scheme can be constructed. These included the following:

- Coarse debris screen upstream of Walker's Bridge (River Carron).
- Coarse debris screen upstream of Carron Gardens (Glaslaw Burn).
- Re-profiling of the of the river channel immediately upstream of the White Bridge.

Despite the short term measures Stonehaven is still at risk of flooding with serious concerns that flooding will occur again before the scheme can be constructed. Therefore Aberdeenshire Council has commissioned JBA Consulting to investigate the possibility of reopening the Mill Lade along the right bank of the River Carron to provide extra capacity during extreme flows.

The purpose of this study is as follows:

- Construct a hydraulic model of the Mill Lade from available information and determine its capacity
- Determine the impact the Mill Lade will have on peak water levels.
- Assess the feasibility of reopening the Mill Lade and the implications this would have on flooding in Stonehaven.

This report should be considered an addendum to JBA's Stonehaven Preferred Scheme Report[1]

[1] Stonehaven River Carron and Glaslaw Burn Flood Protection Scheme Report, November 2013, JBA Consulting

2 Mill Lade

Historically, flow from the River Carron was used in industry to power the corn mill south of the River Carron between Arbuthnott Street and Dunnottar Avenue. Flow from the river was diverted downstream of the Green Bridge using a weir across the river. This created a permanently full pond that fed the lade intake. The mill lade was predominately open channel, however it included short culverted reaches, including the discharge to the River Carron at the beach. The route of the old lade is displayed in Figure 2-1.

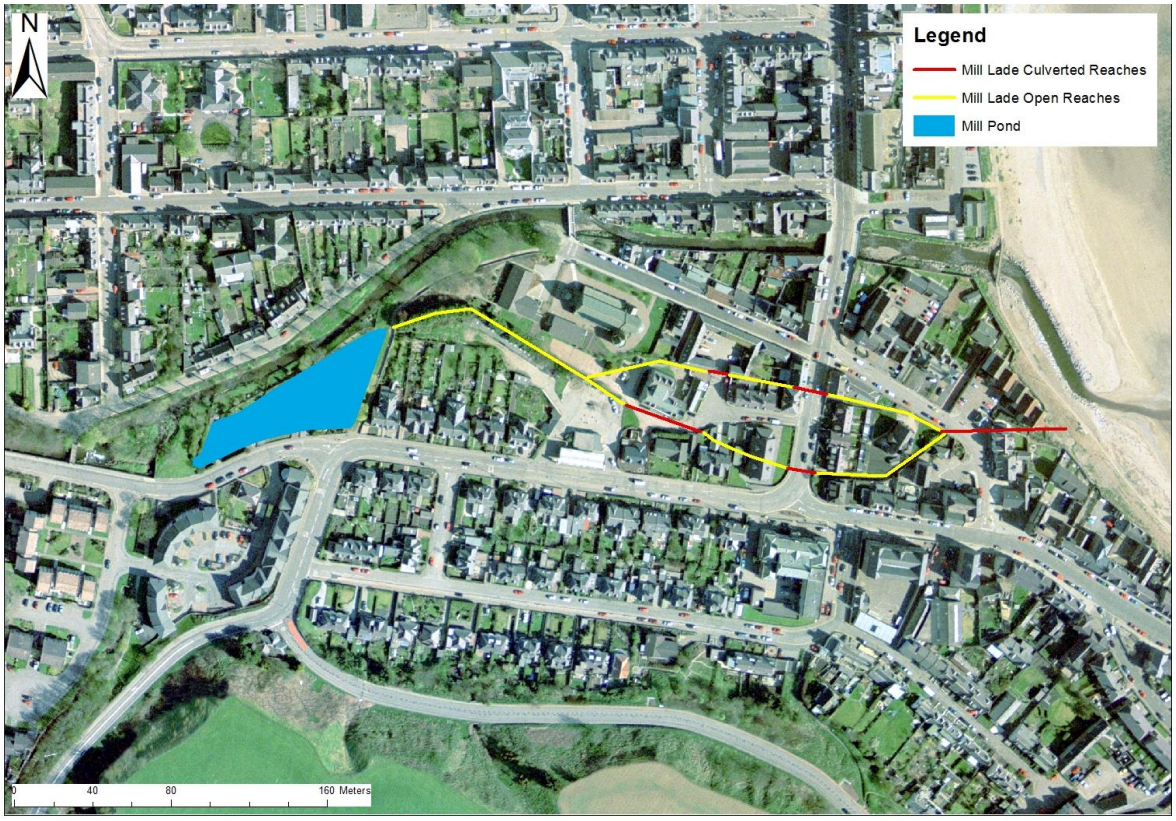

Figure 2-1: Route of Historic Mill Lade

In recent times the lade has become disused and filled in, whilst development in Stonehaven has continued. What remains of the Mill Lade runs from Bridgefield to its culverted outlet under Arbuthnott Place to the beach where it currently discharges through a soakaway. The location of the existing Mill Lade is displayed in Figure 2-1 and photographs of the lade are displayed in Figure 2-2.

Figure 2-2: Photographs of Existing Mill Lade

3 Hydraulic Modelling

It has been suggested by members of the community that by reopening the former Mill Lade the risk of flooding in Stonehaven would be reduced by offering additional capacity to carry extreme flows through the town. To quantify the impact this would have on peak water levels in the River Carron, a hydraulic model of the Mill Lade has been constructed to determine its hydraulic capacity. This has then been incorporated into the Flood Protection Scheme (FPS) model to determine the potential benefits of utilising the Mill Lade.

3.1 Mill Lade Model

3.1.1 Geometry

The existing Mill Lade has been included in the topographical survey carried out as part of the Flood Protection Scheme design. The survey picked up banks levels bed levels allowing a number of hydraulic sections to be created from the survey.

Unfortunately there is little information available for the rest of the Lade that has been filled in. Therefore the following assumptions have been made when constructing the full length of the Mill Lade.

- The channel width and height of the existing lade varies slightly on route to the outfall. Flow within the Lade will therefore be constricted by the point in the channel that has the minimum flow area. The channel at this point has width of approximately 1.1m and depth of 0.65m. This geometry has been applied where no information of the Lade is available.
- The average slope of the channel from the upstream extent of the existing Mill Lade to the outfall has been assumed to be constant throughout the Lade. This has been used to determine bed levels in the sections where no information is available.
- The geometry of the culvert that carries flow from the Lade to the beach has been assumed to be consistent with the downstream section of Mill Lade channel. Additionally it has been assumed that the existing soak away outfall will be replaced with a conventional discharge.
- That flows can access the head of the Mill Lade. The Lade used to be fed from the weir, which was demolished in the 1970s. Reconnecting the Lade would require a new channel or pipe.

The geometry of the Mill Lade Model is displayed in Figure 2-3.

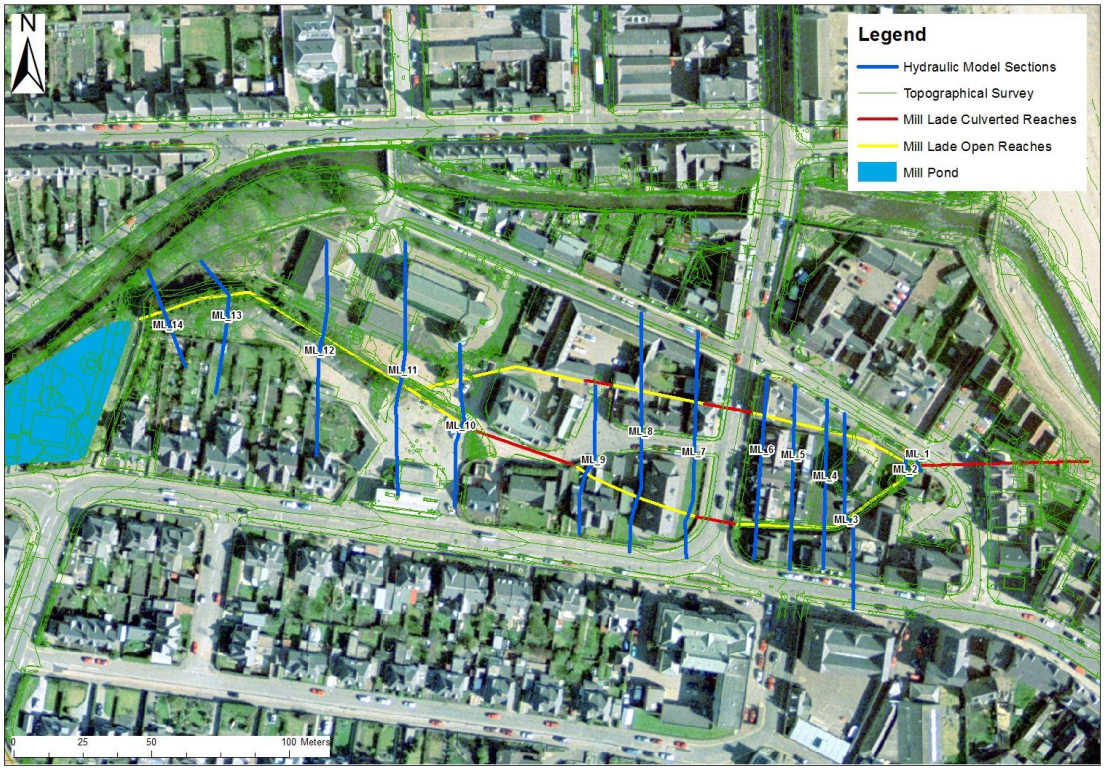

Figure 3-1: Hydraulic Model Sections

3.1.2 Capacity

To determine the capacity of the Mill Lade, the model has been run in a pseudo steady state by using a hydrograph with a constant flow. As the information regarding the Mill Lade is scarce it is possible that any works to re-open it could also increase the capacity of the Lade by incorporating banks into surrounding ground levels. Therefore a range of flows were used to estimate the potential capacity the Lade could offer. The results are displayed in Table 3-1.

Table 3-1: Mill Lade Peak Water Levels for a range of flows

Sections ID	Bed Level (mAOD)	Left Bank Level (mAOD)	Right Bank Level (mAOD)	Peak Water Level (0.5m³/s)	Peak Water Level (1m³/s)	Peak Water Level (1.5m³/s)	Peak Water Level (2m³/s)
ML_1	2.47	3.24	5.00	3.11	3.39	3.68	3.70
ML_2	2.44	3.08	5.00	3.12	3.42	3.71	3.73
ML_3	2.54	3.29	3.30	3.30	3.48	3.73	3.75
ML_4	2.65	3.28	3.36	3.32	3.49	3.73	3.75
ML_5	2.69	3.42	3.34	3.36	3.51	3.73	3.75
ML_6	2.74	3.57	3.79	3.39	3.50	3.74	3.76
ML_7	3.13	3.78	3.78	3.53	3.71	3.89	3.88
ML_8	3.23	3.88	3.88	3.75	4.03	4.12	4.05
ML_9	3.34	3.99	3.99	3.89	4.07	4.16	4.16
ML_10	3.62	4.27	4.27	4.18	4.33	4.54	4.51
ML_11	3.93	4.58	4.58	4.38	4.56	4.66	4.70
ML_12	4.25	4.90	4.90	4.71	4.99	5.21	5.21
ML_13	4.48	5.13	5.13	5.03	5.19	5.25	5.25
ML_14	4.66	5.31	5.31	5.19	5.35	5.38	5.45

The depth of the existing Mill Lade ranges from 0.65m to 0.83m. Table 3-2 shows the average depth of flow through the lade for the range of flows shown in Table 3-1.

Table 3-2: Average Depth of Flow in Mill Lade

Flow Rate (m3/s)	Average Depth of Flow (m)
0.5	0.58
1	0.77
1.5	0.95
2	0.96

This would indicate that the Mill Lade may have had the potential to convey between 1 and 1.5 m^3/s.

3.2 Impact on Peak Water Levels

Until the Flood Protection Scheme is completed, properties in Stonehaven remain at flood risk. The short term measures implemented by the Council will contribute to alleviating some of this risk. The proposal of re-opening the Mill Lade may also contribute to reducing this risk. Therefore the impact of reopening the Mill Lade has been analysed for the existing scenario as well as a means of reducing the height of the proposed flood walls.

3.2.1 Existing Conditions

Reopening the Mill Lade will effectively divert the maximum capacity of the Lade from the River Carron during periods of extreme flow. As the Mill Lade contains sections of open channel, it would be vital that a flow control be placed on its inlet to prevent more flow than it can convey from being passed through and therefore increasing flood risk to others. As flow is taken from the Carron, flow in the reach downstream of the Mill Lade inlet will be reduced. This will have no impact on water levels upstream of the lade inlet. The sections that represent the reach downstream of the Lade Inlet are displayed in figure 3-2.

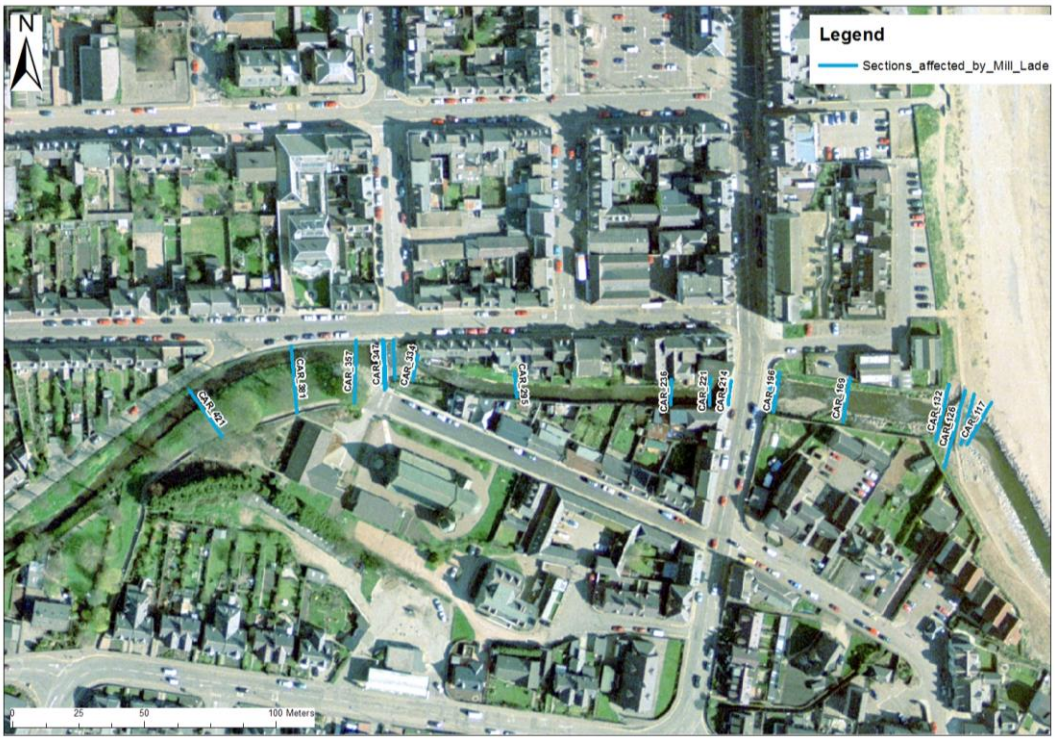

Figure 3-2: Hydraulic Model Sections Downstream of Mill Lade Inlet

In recent years Stonehaven suffered from flooding from the River Carron twice. In November 2009 flows of approximately 37 m^3/s caused flood water the leave the river and then again in December 2012 when flows of approximately 24 m^3/s were experienced. Table 3-1 shows the capacity of the sections displayed in Figure 3-2. Had the Mill Lade been able to contribute its full capacity of 1.5 m^3/s to conveying these flows then the peak flows at these sections would have been 35.5 m^3/s and 22.5 m^3/s respectively.

Table 3-1: Capacity of Sections downstream of Mill Lade Inlet.

Section ID	Channel Capacity
CAR_421	29
CAR_381	36
CAR_357	44
CAR_347	39
CAR_346	39
CAR_343	52
CAR_334	61
CAR_295	61
CAR_236	**19**
CAR_221	**22**
CAR_214	34
CAR_200	56
CAR_198	56
CAR_196	40
CAR_169	27
CAR_132	35
CAR_126	41
CAR_122	46
CAR_117	60

It can be seen from the table above that the reopening of the Mill Lade would not have prevented water from leaving the River Carron at section CAR_236 and CAR_221. Additionally, flood waters from these events overtopped the rivers banks further upstream at the Green Bridge. Flood waters were then routed through the town along High Street and Arbuthnott Street. In particular during the December 2012 event, the Green Bridge became partially blocked which exacerbated the problem.

3.2.2 Flood Protection Scheme

The proposed Flood Protection for Stonehaven consists of channel modifications, bridge raising and direct defences. The direct defences (flood walls) have the potential to have an impact on the aesthetic nature of Stonehaven. By using the Mill Lade to convey flows, the heights of the walls downstream of the lade inlet have the potential to be reduced. Table 3-2 shows the impact the reduction of the peak water levels with the scheme in place and the potential reduction by utilising the Mill Lade.

Table 3-3: Potential reduction in Peak Water Levels by Utilising the Mill Lade (FPS)

Section ID	Peak Water Level (FPS) (mAOD)	Peak Water Level (Mill Lade) (mAOD)	Reduction (m)
CAR_421	5.91	5.86	0.05
CAR_381	5.88	5.83	0.05
CAR_357	5.82	5.77	0.05
CAR_347	5.82	5.77	0.05
CAR_346	5.82	5.77	0.05
CAR_343	5.74	5.69	0.05
CAR_334	5.54	5.49	0.05
CAR_295	5.49	5.44	0.05
CAR_236	5.19	5.14	0.05
CAR_221	5.17	5.11	0.06
CAR_214	5.06	5.00	0.06
CAR_200	4.92	4.86	0.06
CAR_198	4.92	4.86	0.06
CAR_196	4.80	4.75	0.06
CAR_169	4.71	4.65	0.06
CAR_132	4.69	4.63	0.06
CAR_126	4.71	4.64	0.06
CAR_122	4.42	4.37	0.06
CAR_117	4.37	4.31	0.06

It can be seen from the table above that the Mill Lade has a very limited ability to reduce the height of the flood walls.

4 Conclusions

Reopening the Mill Lade and connecting it to the River Carron would result in additional capacity of between 1 and 1.5m^3/s in the Mill Lade. This will not significantly reduce flood flows or levels in the River Carron and is equivalent to 3-4% and 4-6% of the peak flow in 2009 or 2012 respectively. In the period until the FPS is constructed, any reduction in potential peak flood levels may be seen as beneficial. However, allowing flow to pass in to the Mill Lade would require checks on the existing drainage capacity, a new lade to be constructed under housing and a new connection to the River Carron.

Reopening of the Mill Lade would prove a difficult and potentially expensive task, especially when considering incorporating it into the proposed Flood Protection Scheme. The constraints are listed below

- The inlet to the Lade would require a flow control unit to ensure that flows in the Lade would not exceed the capacity of the Lade.
- Substantial works would be required to form a gravity connection to allow flows form the River Carron to pass into the Mill Lade. This would likely require the construction of a high head Weir and Fish pass downstream of the confluence with the Glaslaw Burn.
- As most of the Lade will be open channel there is potential for it to increase flood risk to others. It is a requirement of all work in watercourses that flood risk to others is not increased.
- Since the Mill Lade has been infilled, properties have been developed on the historic route, as can be seen in Figure 2-1. To open the Mill Lade and allow subsequent monitoring and maintenance of it, it is likely that land purchases would be required.
- The Mill Lade is now used to drain lower areas of the town - no account of the capacity required for the drainage has been made as this would require significant investigations into pipe connectivity.
- Extensive survey work would be required to gain an understanding of how the drainage network in Stonehaven is connected to the Lade and the impact of using the Lade for flood flows would have on performance of the drainage network during flood events.
- There may have been an additional storage capacity associated with the Mill Dam, but this has not been estimated, as it is sensitive to assumptions in the geometry of the pond which are not available.

Given the above constraints and likely costs it is suggested that it is unlikely that providing a new Mill Lade and associated works would prove beneficial.

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