ARUP

File Note

Project title	NRW2 Glascoed
Job number	290049-00
File reference	
cc	
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Date	15 February 2024
Subject	Concept/Outline Design Report – Inlet Structure Replacement

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1. Introduction

The following note summarises the design development / rational for the replacement inlet structure at the Glascoed bypass channel scheme. Glascoed fish pass is an existing fish pass where the existing inlet structure has been subject to significant scour in the upstream section since construction and therefore the fish pass has been temporarily closed off to avoid further damage to the remaining sections of the pass. Arup have been commissioned to design a new inlet structure to allow the fish pass to function again.

2. Flows

In order to effectively design the new inlet structure an understanding of flows, both low and high, are required. As there is no gauged data in the catchment, there is a lot of uncertainty around flows. The Q95, Q50, Q10 from the original design were therefore utilised and the high flows were obtained from Arup Modelling (with uncertainty attached). We have assumed these flows are suitable for use and this has been agreed with the client.

3. Design Concept

Due to existing issues with erosion in the bypass channel, we have proposed the inlet and upstream end of this bypass channel are to be reconfigured and realigned. The purpose of this is to align the inlet structure to the direction of flow and also to allow for construction offline. Figure 1 shows the general arrangement concept of the proposed design. The design also includes a retaining wall in the pool immediately downstream of the inlet structure to allow for the pool to be widened for optimum size as a result of the reduction in pool length. This retaining wall will be designed to tie into the new inlet structure to increase overall stability. Rock armour will be designed to provide bank protection within the main river immediately upstream of the inlet structure. Rock armour or reuse of the existing inlet structure material will occur immediately downstream of the new inlet structure as well as for pool profiling. Access steps will be added immediately upstream of the inlet structure to allow maintenance and stop logs placement with the new inlet structure.

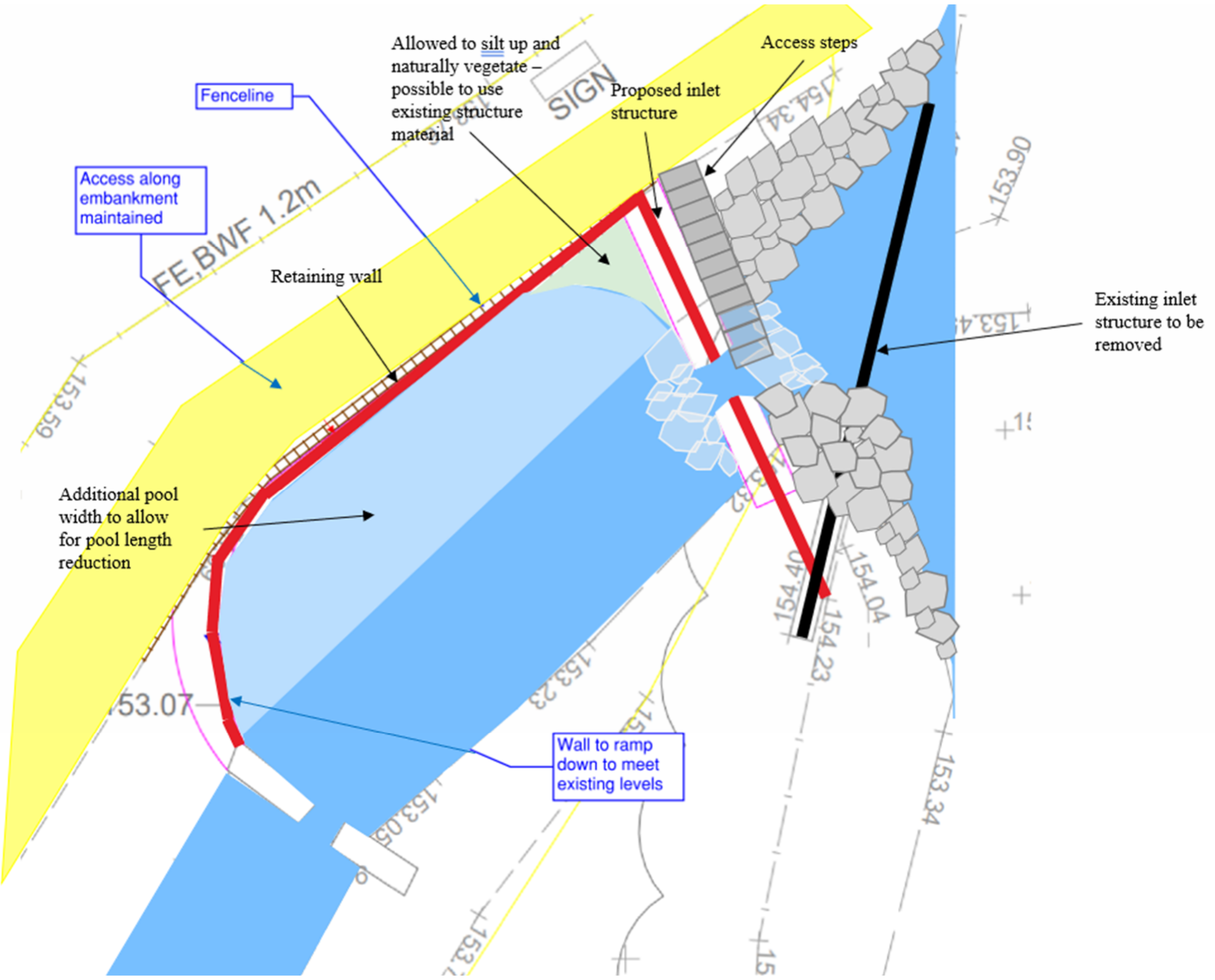


Figure 1 - Concept Design

The sketch below in Figure 2 shows the concept behind the new inlet structure construction and the retaining wall structure looking from the fish pass pool upstream towards the inlet structure. The new inlet structure will have an opening to allow low flows (Q95 to Q10) to pass down the fish pass. The top of the inlet structure will be level with the adjacent main river bank and is expected to overtop during flood flows in the same way as the adjacent river banks.

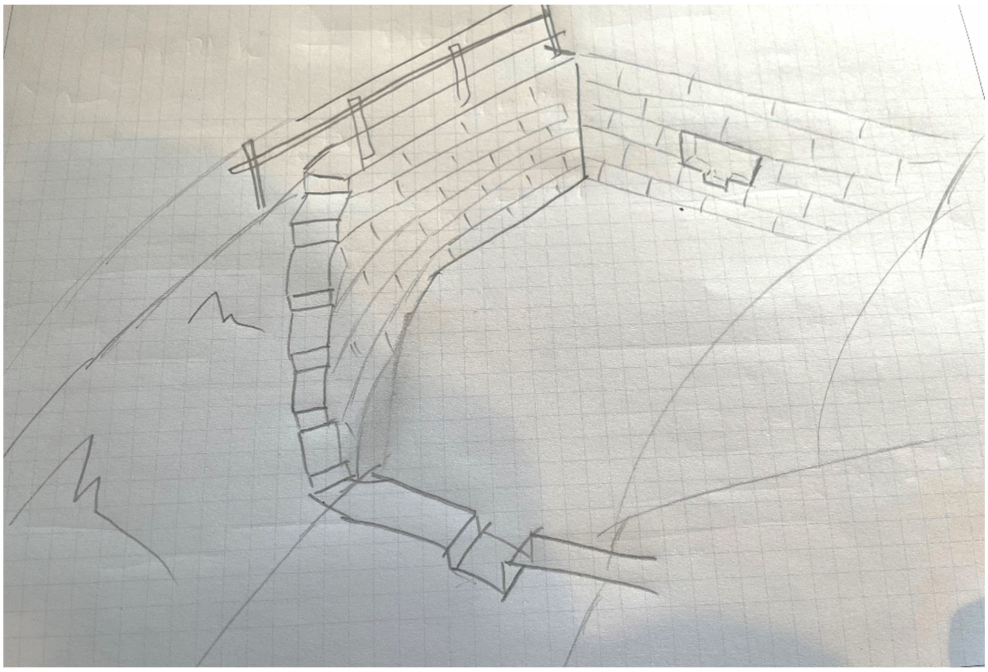


Figure 2 - Concept sketch of proposed structure

3.1 Inlet structure

It is believed that the position of the current inlet contributed to the significant erosion at the top of the bypass channel, therefore the location and angle of the new inlet structure has been modified – as seen in the Plan in Figure 1. This new location will allow any jetting flows through the orifice to be dispersed in the pool, rather than being directed at the bank of the bypass channel and causing erosion here – as was seen with the current set up.

3.1.1 Structure size

Through the concept design process and client discussions, it was considered to set the top level of the structure above the level of the top of the existing structure, due to rack marks visible after a previous significant flood event. However, due to the surrounding banks being lower than this level, and the need to provide scour protection to mitigate overtopping anyway – it was deemed not worthwhile to raise this level. Therefore the top of the structure will be set to ~ 154.5mAOD. The notch/orifice level is also to remain the same at 153.22mAOD. A concept image of this is shown in Figure 3.

3.1.2 Orifice

The inlet structure is to have an orifice to control the flows entering the bypass channel from the main river. The notch has been sized to balance flow depths and velocities. The calculations take account of low flow data in the main river, and using the cross sections / topographical survey in the area calculate the depth of flow at the varying flow regimes (Q95, Q50, Q10) – see Table 1 below.

Table 1 - River flows, levels and water depth.

Qmean	Flow (m3/s)	Depth of Flow (m)
Q10	2.036	0.140
Q50	0.446	0.259
Q95	0.070	0.415

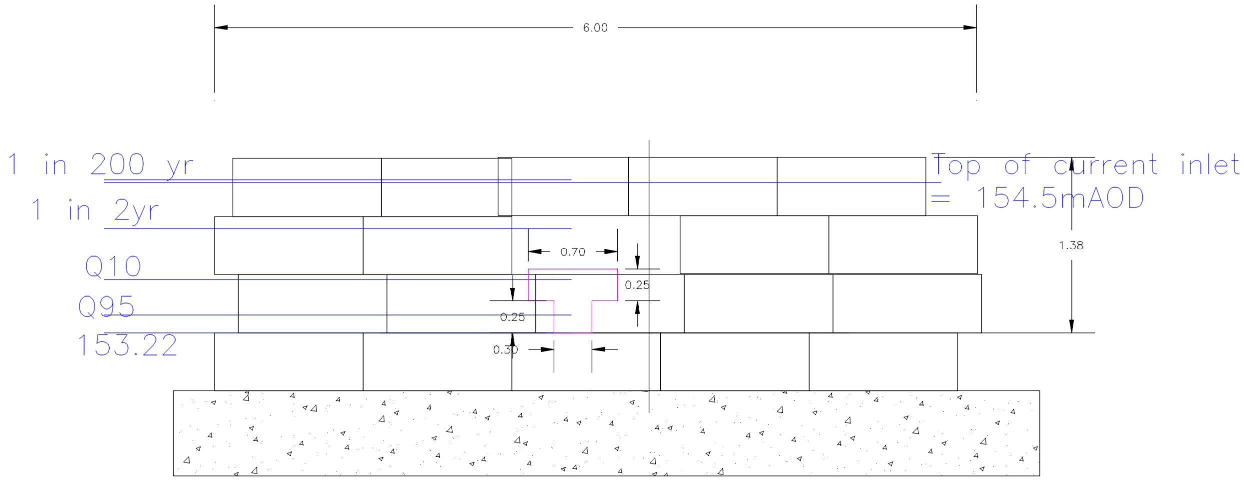


Figure 3 – Orifice size and water levels at inlet

An iterative notch sizing process has been undertaken to determine an appropriate orifice for the inlet structure. The client stated that the current impoundment license only allows for 50% of the Q95 flow to be directed through the bypass channel. The optimum size was found to be as below in Figure 4, resulting in flows and velocities as shown in Table 2. This shows the percentage of the main river flow that will be directed through the bypass channel, sometimes known as the attraction flow, which should ideally be above 10%. The calculations also show that velocities through the orifice will be low enough to allow fish passage up to at least the Q10 flows, as they do not exceed the Mean Burst Speed of most fish species (see extract from Fish Pass Manual in Table 3).

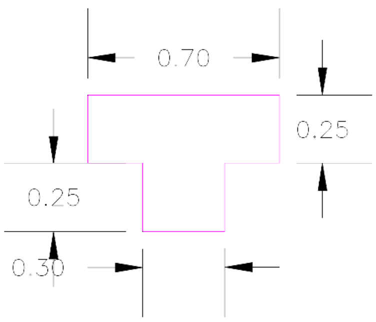


Figure 4 – Proposed orifice size

Table 2 - Flows and velocities

	Flow in main channel	Depth (m)	Flow in bypass (m3/s)	Velocity inlet (m/s)	% of river discharge
Q95	0.07	0.14	0.034	0.8	48.57
Q50	0.446	0.259	0.064	0.79	14.32
Q10	2.036	0.416	0.219	1.15	10.78

Table 2 from the fish pass manual states suggested burst speed and these are greater than the orifice velocity meaning likely success of fish passage through the orifice. Plus, this size is not too dissimilar to the original existing control structure notch which is believed to have been successful in fish passage.

Table 3 - Swimming speeds for some UK fish

Table 2 Examples of Swimming speeds for some UK fish of 15cms fork length at 10°C and eel of 30cms at 15°C (SWIMIT version3_3 Nov 2006)

Species	Mean Burst Speed		Median Sustained Speed		90%ile Sustained Speed	
	ms^{-1}	bls^{-1}	ms^{-1}	bls^{-1}	ms^{-1}	bls^{-1}
Roach	1.27	8.46	0.70	4.67	0.45	3.00
Dace	1.35	9.00	0.58	3.87	0.48	3.20
Chub	1.30	8.67	0.93	6.20	0.53	3.53
Trout	1.35	9.00	1.17	7.80	0.81	5.40
Eel	1.14	3.80	0.25	0.83	0.11	0.37

3.1.3 Closing the bypass

The Client also outlined their desire to be able to shut off flows to the bypass channel, to allow maintenance and inspections. Various options were investigated to facilitate this, taking into account operation and maintenance and health and safety factors. On balance it was found options that could be operated from the bank would be too costly and/or complicated, with too high a risk of siltation or damage from floating debris.

The placing of stoplogs was found to be the most sensible solution. The drawbacks of this option are that the stoplogs themselves need safe storage nearby, this can either be at a nearby depot or in a safe unit nearby the bypass channel itself.

The other issue is that to place the stoplogs, an operative will have to enter the main river. This was discussed with the Client and deemed acceptable, however as it is potentially the most significant risk of the design, the following mitigations are proposed:

- As the bypass only needs to be closed off for routine maintenance, operatives should only enter the main river during low flows to place the stop logs.
- Clipping on to the inlet structure will be facilitated by the addition of an anchor point bolted on in an appropriate place, to allow operatives to be attached to the structure and reduce the risk of them being swept downstream.
- Buoyancy aids could be worn if felt appropriate.
- The location of the stoplogs present a low risk of individuals being swept away by flow, as the entrance to the bypass channel would prevent them from being carried in this direction, and they would not fit through the orifice.
- Stable footing will be ensured at the bottom of the access steps, to allow operatives to have a safe location from which to place the stoplogs. Rip-rap will not be placed directly in this location.

It was confirmed with Redi-Rock that brackets can easily be facilitated within the structure to allow stoplogs to be installed.

3.1.4 Construction

Construction of the inlet structure is proposed to be of RediRock blocks, with appropriate finish to suit the surrounding environment. A suitable footing is required to provide toe support to the structure to counteract the lateral forces of water the inlet structure may experience, such as in Figure 5.A simple pad foundation will be constructed, with protruding starter bars. The structure itself should then be laid 2 courses at a time, with the concrete infill left to cure overnight before laying the next 2 courses – this is to avoid too much pressure and the concrete spilling out of the bottom of the blocks if all laid in one.

The orifice can be forced by use of half size blocks, potentially cut to size if required. RediRock offer blocks with 3 sides textured, which would allow the appropriate aesthetic to be maintained. Additional horizontal steel bars will be required between the blocks above the orifice.

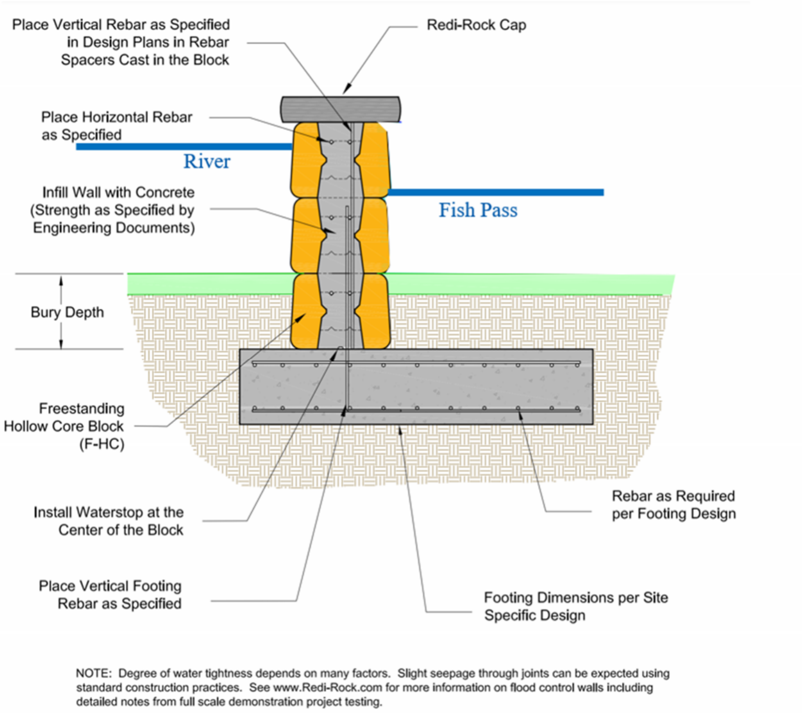


Figure 5 - indicative Redi-rock design for inlet structure.

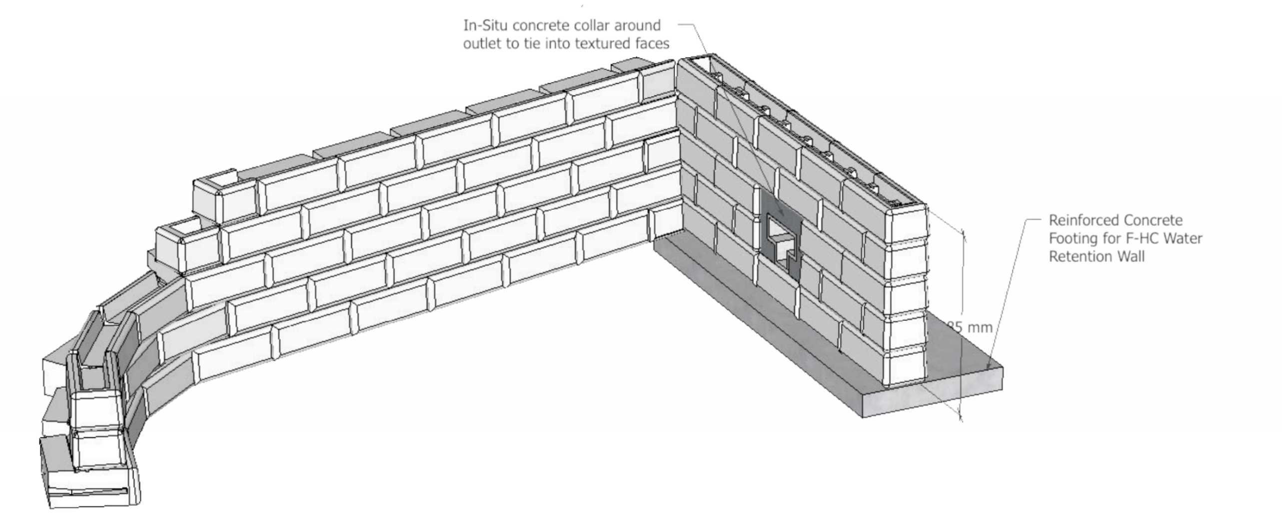


Figure 6 - 3D concept image from Redi-Rock

4. Top Pool

In order to reduce erosion risks in the fish pass, it is seen as beneficial to maximise the volume of the top pool in the bypass channel as this will disburse the energy of the flow. The location of the new inlet structure means the length of the pool is reduced, therefore the pool needs to be widened. To achieve this within the limited footprint of the site, it is proposed to replace the embankment slope on the righthand bank of the bypass channel with a vertical wall (see figure 1 showing plan of increased pool width). Figure 7 below shows the cross-sectional volume increase achieved through this modification. The volumes of the existing and proposed pools have been calculated, see Table 4, and satisfy the increase in pool size.

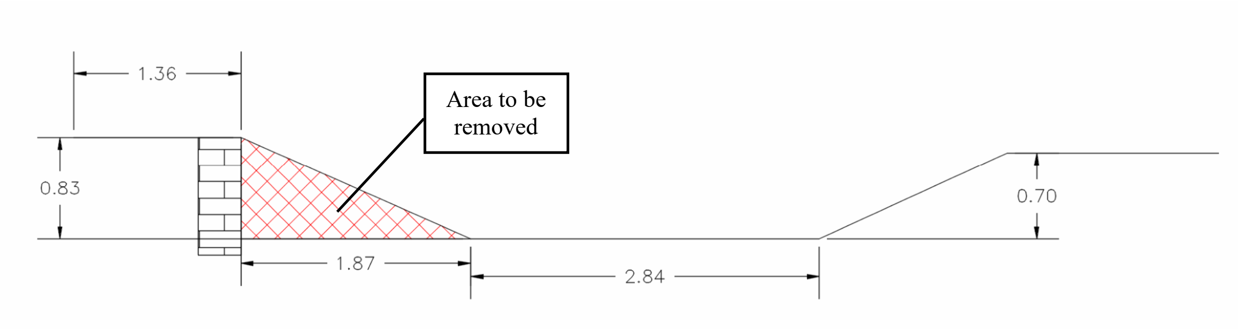


Figure 7 - Section through bypass channel

Table 4 - Pool sizing

	EXISTING Pool 1		Proposed pool 1	
Cross secti	3.35	m2	4.15	m2
L	10.18	m	8.37	m
Vol	**34.14**	m3	**34.72**	m3

This small retaining wall can also be constructed from Redi Rock blocks, such as in figure 8. The wall can gradually step down as it curves to tie in with the first check weir structure, to match the adjacent slope heights. Wooden fencing will need to be erected on top of the retaining wall to mitigate the risk of falls from height – RediRock have confirmed this is achievable and posts can be bolted directly to the blocks (see Photograph 1).

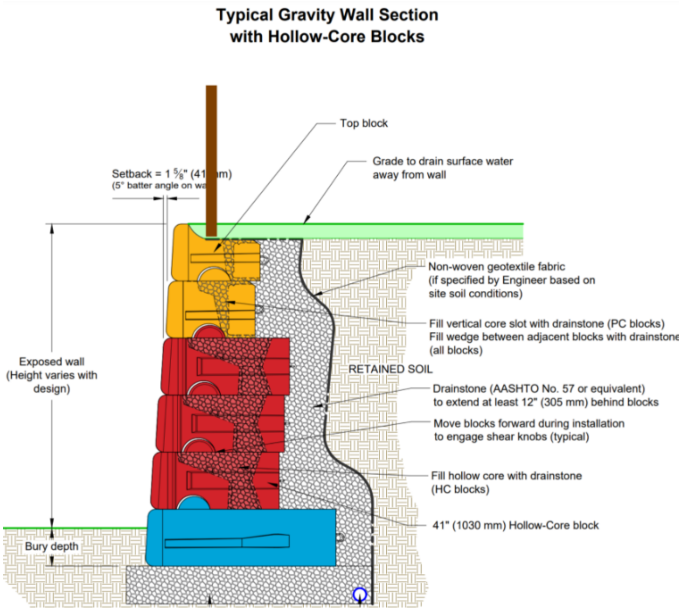


Figure 8 - Redi-rock design concept, retaining wall

Photograph 1 - example of fence posts fitted to Redi-rock blocks

5. Scour protection

Additional scour protection is needed around the inlet structure, as seen in Figure 1 and Figure 9.

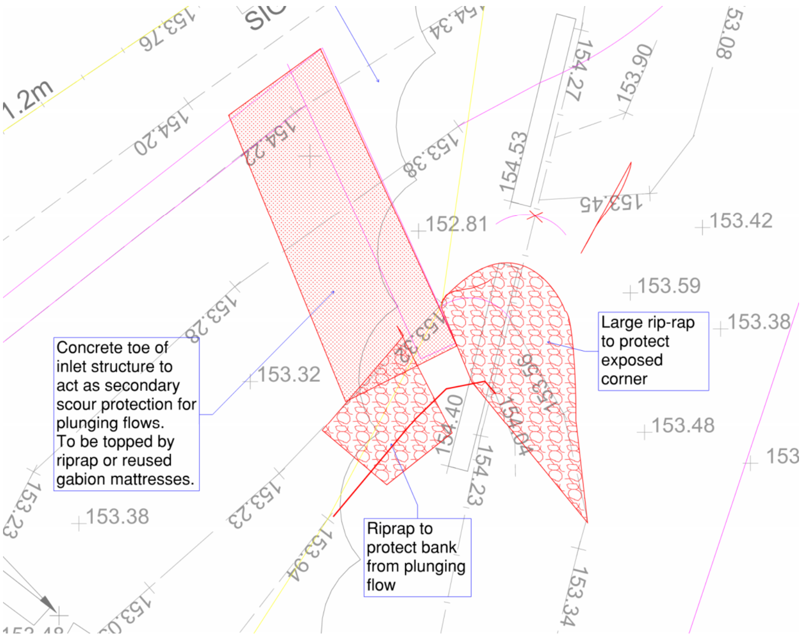


Figure 9 - Scour protection sketch

5.1 Tie in with main river

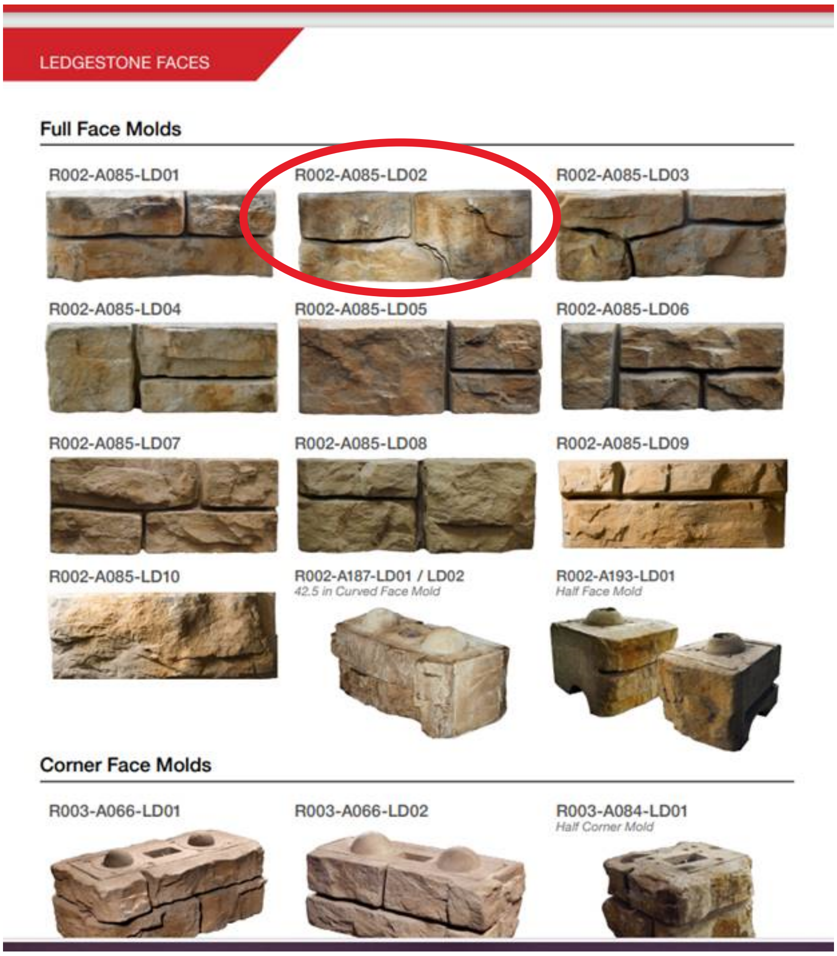
The new location of the inlet structure means that the southern side of the bypass channel entrance will be exposed to flows, and there is a risk of erosion. To mitigate this it is proposed to install rip-rap – which has been sized in the Hydraulic calcs spreadsheet. The Dn50 was calculated very conservatively due to uncertainty with the flood modelling, and was found to be 0.42m.

5.2 Downstream of inlet

There is also a risk of erosion from plunging flows should the inlet structure overtop. This will be mitigated by placing gabion baskets or riprap in front of the structure to disperse the energy of flows. The concrete footing of the inlet structure will also act as erosion protection should these other methods fail is very high flows.

6. Aesthetics

The Client is happy with the Redi-Rock aesthetic, and has provided a preference of style R002-A085-LD02 from the ledgestone range.


LEDGESTONE FACES
Full Face Molds
R002-A085-LD01
R002-A085-LD02
R002-A085-LD03
R002-A085-LD04
R002-A085-LD05
R002-A085-LD06
R002-A085-LD07
R002-A085-LD08
R002-A085-LD09
R002-A085-LD10
R002-A187-LD01 / LD02
42.5 in Curved Face Mold
R002-A193-LD01
Half Face Mold
Corner Face Molds
R003-A066-LD01
R003-A066-LD02
R003-A084-LD01
Half Corner Mold