

# **Dowies Mill Weir**

Structural Inspection

City of Edinburgh Council

Project number: 60589461

29/10/2018

# Quality information

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# **1. Introduction**

#### 1.1 Background / Site Location

There is an ongoing initiative to improve fish passage up the River Almond in order to extend the distribution of migratory fish in this catchment.

Dowie's Mill Weir is sited on the lower reaches the River Almond, approximately 1.7km upstream of the mouth of the river, where it enters the Forth estuary. The weir is approximately 1 km upstream of Fair-A-Far Weir and the recently constructed Fish Pass and is approximately 180 m downstream of the historic Category A listed Cramond Brig. The nearest address on the right hand bank is Dowie's Mill Lane, Cramond, Edinburgh, EH4 6DW (OS NGR NT17924 75652). Despite the existence of an existing channel bypass, this particular weir is considered by some to be an obstruction to migratory fish.

Dowie's Mill Weir was likely constructed in the 1600s to impound water for Dowie's Mill. The mill extended downstream from Dowie's Mill Cottages and has long since been demolished. The weir structure was breached and subsequently repaired in 1962. Later in that decade, a portion of the weir was removed then reinstated, to facilitate construction of the new A90 road bridge a little further upstream of Cramond Brig.

Dowie's Mill Weir is owned by City of Edinburgh Council and located in a designated public open space. The left bank is designated as a Designed Landscape and an Area of Outstanding Landscape Quality in Local Policy. The weir is adjacent to the River Almond Walkway, a popular footpath along the right hand bank of the river, extending downstream to the mouth of the river at Cramond village. The impounded water immediately upstream of the weir is known locally as the 'mill pond'.



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Figure 1: Dowie's Mill Weir Location

#### 1.2 Layout/Construction

Dowie's Mill Weir is a slightly curved diagonal weir extending across the River Almond and is approximately 70 m in length. The downstream face is of varying gradient (from mild to near-vertical). The height of the weir varies but is typically 1.2m to1.5 m, changing height as a result of irregularities in the riverbed downstream. Several surface sections have been repaired by concrete overlay, which appears to be mass concrete.

There is an existing 1.3m wide bypass channel built into the weir structure and sited immediately adjacent to the right-hand bank. The upstream entrance to the channel coincides with the weir crest and there is

evidence of steel framing for a sluice gate which is now redundant. The channel and watercourse immediately downstream was later modified in the 1980s to form a series of pools and traverses to aid fish passage. Subsequent studies have identified this arrangement as being sub-optimal for fish passage owing to the turbulent and confused flow and large head drops, resulting in limited usage.

The weir is no longer used to supply water to the mill, but provides a feature impoundment of water immediately upstream of the weir which slows river flows locally.

#### Structural Coring Investigation 2014

In 2014, consultants Mott Macdonald were commissioned to investigate the condition of Dowies Mill weir as part of a wider remit to study existing river bed conditions and the possible impact of removing this particular weir. Part of this study included work to establish the height of the weir from crest level to formation, the nature of the ground at formation and the materials used in its construction and subsequent repairs.

Structural cores through the weir were commissioned by Messrs Mott MacDonald in 2014 to identify the depth of the weir and materials used in the construction and repairs. This involved drilling a total of 4No 100mm diameter vertical/ inclined cores through the weir, undertaken by Messrs Geckotech. The location of the core samples were limited to areas where there was safe access and therefore cores were drilled down through the weir at selected positions nearest each river bank.

Core samples revealed the weir construction to be made up of large stone (boulders) and concrete. The weir is founded on the underlying river bed alluvium deposits (gravels) which overlie glacial till. The core samples revealed the existence of some voiding on both sides of the weir, with a total weir construction depth of 1.55 m to 2.0 m towards the west (left hand) bank and 1.3 m to 1.4 m on the east (right hand) bank.

#### Structural Inspection- Methods

The AECOM site inspection was carried out on Tuesday 12th June by an AECOM inspection team comprising two Structural Engineers. During the inspection, conditions were favourable and river levels were low following a period of a sustained dry weather. On the day of the inspection, the river level recorded at SEPA's Craigiehall gauging station (located 1.8km upstream at NGR NT 16538 75267) was approximately 0.22m.

This inspection was confined to a visual inspection of the weir arrangement viewed from safe accessible vantage points on the weir structure and immediately downstream. For safety reasons, the inspection team did not enter the water either upstream or downstream of the weir.

Findings were recorded by notes, hand sketches and digital photographs. Some very approximate distance and height measurements were taken deploying a survey ranging rod and hand tape to estimate weir plan dimensions and depths.

# 2. Weir Construction

The weir is thought to have been first established in the early 17<sup>th</sup> century to impound water for Dowie's Mill. The original weir construction and cross sectional profile is not known however it is likely to have been wholly constructed in stone, with locally recovered boulders/cobbles forming an inner core. The weir crest could have been formed with dressed masonry blocks and the upstream and downstream faces of the weir sloped down to the river bed with an outer layer of semi-dressed (or simply selected and packed) stone pitching. There is still evidence of pitching stone, although what is visible today may not be the original construction but a later modification - see Photograph No4 in Appendix A.

It seems likely the weir has been breached (and subsequently repaired) on several occasions since its inception. During this period, the weir cross section may have been altered / modified to become more robust and cope with the river flows. In more recent times, repairs and modifications have incorporated concrete infill material to seal voids and bind together individual stones. The earliest currently known record of a breach is in 1962, when the weir was breached after a flood, but subsequently repaired.

A few years later, to facilitate removal of an existing road bridge and construction of the new A90 road bridge crossing further upstream, a central portion of the weir was removed, presumably to lower river levels upstream in/around the works.

The earliest known photograph of the weir is held in Historic Environment Scotland (HES) archives and records indicate the photograph was taken in 1975. In that photograph (shown overleaf) the weir is breached around the middle of the river channel and there appears to be a concrete apron slab, both on the shallower pitched downstream face and steeper pitched upstream face. In the foreground, there is a raised concrete sill built off the top of the weir, forming the crest. A straight drop weir was subsequently constructed (existing today - see photograph overleaf) and we think this new section of weir was built across this breach, recorded in the photograph taken in1975.

There are reports of further breach in the early 1980s and in 1984, the old bypass channel was also modified to form a fish pass.

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HES Archive Photograph 1975



June 2018

## 3. Weir Condition

#### Straight Drop Weir- Condition

The straight drop weir is constructed in coursed masonry and is around 14.7m in length. The weir wall is formed with a vertical downstream face and features a top course of dressed stonework incorporating a curved profile crest block. The top of the crest was measured approximately 200mm below the crest level of the adjoining broad crested weir. At the time of this inspection, water levels were low and water overtopping was restricted to this section of the weir.

The straight drop weir is a relatively recent modification to the original weir and was constructed after 1975. This particular section of weir appears in fair condition with no visible structural defects in the masonry or obvious evidence of any localised damage. This particular section of weir wall appears sensibly plumb and level with no evidence of any significant vertical or horizontal displacement of the weir wall.

The masonry crest blocks appear to be set level with uniform water flows over the weir. In this particular location, there are some large boulders in the watercourse immediately downstream of the masonry weir which form obstructions to flow.

#### Broad Crested Weir- Condition

This construction exists to the east and west of the straight drop weir. The western broad crested weir is considered to be in fairly poor condition with the downstream toe being significantly eroded by river flows. This lower section has fragmented with stone material dislodged and washed downstream, the lower part of the concrete apron slab is now missing. Inspection revealed some significant undercutting beneath exposed bottom edge of the weir. General examples of these defects are shown in Appendix A - Photographs Nos 2-6 incl and 11-13 incl.

In one localised area, the concrete apron slab was found to be partially collapsed, with voiding below -see Photograph No 7 in Appendix A.

Elsewhere, many of the remaining parts of the concrete apron slab appear intact, however, although there may be no outward sign of defects, the apron slab may be 'bridging' across existing voids in the stone below.

The upstream face is largely underwater and concealed from view\*, covered with river silt and gravel deposits built up behind the weir. There is no visible sign of any scouring or partial collapse along the upstream face and the stone pitching and concrete apron (where visible) appear intact.

\*Note: A systematic probing using a ranging rod or similar) of all areas on the upstream face of the weir would be necessary to ascertain if there are any significant defects. This would require a means of accessing areas of deeper water by boat and/or the use of waders which at the time of this inspection, was not possible.

#### **Bypass Channel**

The upper section of the bypass channel is approximately 1.2m wide x 0.8m deep incorporating steeped inverts and is approximately 4m in length. The channel is thought to have been constructed in stone masonry. The masonry exhibits some slight weathering however side walls appear in fair condition with no evidence of any significant damage or movement and water flows through the channel appear unrestricted. The channel invert was not visible at the time of inspection.

The lower section of the channel widens out to around 2.5m-3.0m and incorporates a stepped invert and 200mm thick projecting fin walls to reduce the velocity of water flows.

# 4. Remedial Works

Significant scouring and undercutting exists along the downstream edge of the broad crested weir, occurring over much of its length. Scouring of the toe zone removes passive resistance and will continue to undermine the weir foundation. On inspection, the upper part of the weir appears largely intact and on the surface appears fairly substantial. However, there are some concerns about the condition of the stone fill material beneath the concrete apron. Further significant voiding may exist and remain undetected below the concrete slab which may be 'bridging' across voids.

Taking cognisance of the above, remedial works could be undertaken to further stabilise the weir and greatly reduce the risk of any catastrophic failure in the future which could lead to the uncontrolled release of river bed sediment from upstream and potential damage to existing structures.

As such, significant remedial works are considered to be required to ensure it remains in a serviceable condition for years to come. The nature of these remedial works (in order of priority) are described below

**Priority 1**- Stabilise toe of existing weir with mass concrete and larger size boulders (in addition to importing new stone, some may be retrieved from the riverbed immediately downstream)

**Priority 2**- Infill the localised void on the downstream face where concrete apron has collapsed (Photograph 7)

**Priority 3a-** Carry out systematic core drilling and concrete grouting operation to seal all voids beneath the concrete apron slab. This will be expected to be carried out on the downstream face, but when the upstream face is exposed, this may be extended if voids are encountered.

**Priority 3b-** Cast new reinforced concrete apron slab over existing slab with tie bar dowels anchored into the grouted rock fill.

#### Access for remedial works

Identifying an area for a site compound and means of accessing the working areas for remedial works is not straightforward. This is a relatively wide section of the river and direct access to both river banks would be desirable to carry out any remedial works to the weir. There is currently no direct vehicular access to the left hand bank at the weir location. At the northern approach to Cramond Brig, there is an existing track through private woodland which might be utilised; however some tree felling and ground improvement would be needed to create a safe access. This would require negotiation with the landowners and a number of residents to reduce impact on public access.

Vehicular access to the right bank downstream of the weir is available via Dowie's Mill Lane. Previous reports have highlighted that this road is not suitable for heavy vehicles, due to the narrow width, the poor condition of the river bank and its proximity to residential properties. However, an alternative access is identified from Braepark Road via a private garden, which would be subject to agreement with the owner and require some site clearance.

#### **River conditions**

The River Almond is flashy and river flows and water levels are known to rise rapidly according to weather conditions within the upstream catchment. Dowie's Mill Weir is known to exhibit fast turbulent flow immediately downstream of the weir and there is a high risk that any remedial works could be flooded for some periods during the course of any works.

The Contractor may plan to incorporate some degree of resilience into their working methods, however river inundation and disturbance of the works is considered likely. This will likely require some significant time and resources to carry out repairs and reinstatement prior to continuing the works. Accordingly, some allowance for additional resourcing and consequential delay should be included when planning and costing any remedial works.

A summary of remedial works anticipated to reinstate and stabilise the existing weir structure is set out below. Note: the following does <u>not</u> include for upgrading the fish pass.

West End Section (adjoining left hand bank)

- Clear vegetation including trees, vegetation (including hogweed) from the downstream face and lower reaches immediately downstream- approx. (approximately 20mx8m plan area)
- Break out areas of damaged concrete apron and remove off site (approximate plan area 6mx5m)
- Construct/reinstate rock/boulder toe along downstream face
- Infill voids between stones with concrete (approximate volume 6mx4m x 0.4m depth) and recreate surface profile

### Middle Section

- Construct/reinstate rock armour stone along the toe of downstream face (approximate volume 25m x 10mx1.2m depth)
- Concrete infill to voids between rock/boulder repairs (approximate volume 20m x 3m x 0.8m depth)
- Cast new concrete slab over rock/boulder repairs (approximate volume 20m x 7m in plan x0.4m depth)
- Core holes and pump concrete grout beneath existing concrete apron slab to seal all voids (estimated number of drill holes 18No, estimate grout volume 4m<sup>3</sup>)
- Surface capping repairs to damaged concrete apron (approximate volume 32m x 6m in plan x0.25m depth) include for dowelling into the weir structure (say 1.5m c/c throughout).
- Fill large exposed void below concrete apron slab (approximate volume 2mx3m in plan x 1m depth)
- Additional concrete and void infilling works along weir crest (32m x 0.7m in plan x 0.4m depth)

## East End Section (adjoining right hand bank)

- Remove large tree trunk on weir downstream face
- Rock works to reform weir profile (approximate volume 15m x 3m in plan x1m depth)
- Reinstate rock armour stone along downstream face to reform toe profile (approximate volume 4mx4m in plan x 1m depth)
- Concrete infill to voids between rock/boulder repairs (approximate volume 48m<sup>2</sup> area x 0.6m depth)
- Surface capping repairs to damaged concrete apron (approximate volume 16m x 6m in plan x0.25m depth) include for dowelling into the weir structure (say 1.5m c/c throughout)

## **Drop Weir Section**

 Move local river bed boulders out the base of the channel immediately downstream of weir (approximate 14m x 6m plan)

## Bypass Channel/Fish Pass

Infill undercut sections with mass concrete to shore up/protect existing stone wall (estimated volume 12m<sup>3</sup>)

# 5. Budget Costs

#### **Remedial Works**

Approximate Budget Costs (all excl VAT) for remedial works outlined in Section 4 -

This is a calculated estimate based on a 27week\* contract period (excl VAT) and includes a 5 week 'float' to cover for delays due to river flooding/inundation of the works

- 1. General items i.e. insurances, mobilisation, site huts/welfare, site staff/head office overheads, fencing, lighting, security, demobilisation etc. say 27 weeks @ £12k /week -: £324k
- General Items -Method Related Charges temporary river diversion and pumping works incl supply and operation of 2No 6" pumps & settlement tank, temporary dams, general purpose plant approx. £120k.
- Vegetation clearance and forming new access to left hand bank (including reinstatement)
  approx. £60k.
- **4.** Remedial Work Items (includes core drilling for grouting, supplying and placing approx. 540m<sup>3</sup> rock armour and approx. 295m<sup>3</sup> pump delivered mass concrete/concrete grout) **approx. £115k**

Total (1-4incl) **£619k** 

Budget Cost Allowance say £650-£700k (incl contingency allowance)

#### Future Maintenance

Further maintenance will be required to ensure the weir remains in an acceptable condition long term. A safety inspection should be carried out annually (coinciding with a dry period in low flows) to check for any localised scour or erosion, particularly along the toe of the downstream face. If inspections are routinely reporting the absence of defects and little deterioration, it may be possible to reduce inspection frequency in the medium term.

Vegetation with the potential to affect structural integrity should be removed regularly, particularly woody vegetation with deep roots which have the ability to cause damage to the weir structure. Minor repairs carried out annually might include localised filling of scour holes (bagged concrete) small scale concrete grouting to fill voids -pointing masonry, concrete patch repairs.

Whilst it is difficult to predict the scale of any future maintenance of a structure of this nature, an estimated budget allocation for an annual inspection and undertaking small scale manual maintenance works (as required) could be £15k-£20k (excl VAT)



# Appendix A

## Inspection Photographs- 12/06/2018



Photograph No1 – General view across weir from right hand bank



Photograph No2 – General View – weir downstream face at left hand bank (west end section)



Photograph No3 – General View – weir downstream face near right hand bank (west end section with vegetation established on weir face)



Photograph No4 – General View Weir West End Section Downstream Face (scour and heavy undercutting beneath stone pitching)



Photograph No5 – Middle Section General View Weir Downstream face (scour and deep undercutting along toe of downstream face)



Photograph No6 – Middle Section General View Weir Downstream face (scour and deep undercutting along toe of downstream face)



**Photograph No7** – Middle Section top of downstream slope Damaged section of concrete apron and scour hole (approx. 2mx2mx0.5mdeep)



Photograph No8 – Middle Section -general view looking towards left hand bank along weir crest



**Photograph No9** – Middle Section- general view looking towards right hand bank along weir crest (Note: large tree trunk washed downstream and resting on boulders immediately downstream of weir)



Photograph No10 – Middle Section general view downstream of weir - loose boulders and cobbles. Water in foreground is largely river infiltration through weir. There is a substantial tree trunk downstream of weir, washed over the weir in heavy flow conditions)

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Photograph No11 – Middle Section- general view of weir downstream face (looking towards right hand bank) Concrete apron damaged with dislodged boulders at downstream face



Photograph No12 – View looking upstream

Scour of downstream slope undercutting concrete apron, note running water through structure near ranging rod) weir height is approximately1.4m at this position)



Photograph No13– Middle section view looking towards right hand bank- large boulders immediately downstream



Photograph No14– Drop Weir Section view downstream of weir- boulders scattered on riverbed- some partially dressed masonry visible in foreground (remnants of previous weir construction possibly at location of drop weir)



Photograph No15 – Drop Weir Section- General View – 14.7m long straight drop weir section



Photograph No16 – Drop Weir Section -general view along crest of straight drop weir



Photograph No17 – East section concrete crest (vertical core hole drilled during 2014 investigation in foreground)



Photograph No18 - East Section general view - concrete apron slab between drop weir and bypass channel



Photograph No19 – East Section general view looking upstream concrete apron slab between drop weir and bypass channel



Photograph No20 – By-pass channel inlet



Photograph No21 – By-pass channel Note- fish pass steps and fin walls



Photograph No22 – By-pass channel – concrete fin division walls & bank edge conditions



Photograph No23 – By-pass channel (fish pass) downstream at entry into the main watercourse Note: scouring/undercutting beneath concrete apron and masonry side wall

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