BEAR Scotland – NE Unit
A9 Mound Sluices M & E Refurbishment

Feasibility Study

Prepared by Babtie Group on behalf of BEAR
for the Scottish Executive

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Executive Summary

BEAR Scotland have requested that Babtie Group prepare a report to on the feasibility, options and cost for the replacement of two winch mechanisms. Each of the winch mechanisms is located in a housing on opposite banks of the river for the opening of the sluice gates on the Mound Sluice Structure adjacent to the A9, approximately 40 miles North of Inverness. The report details the options available and includes Babtie's recommendations.

The study found that that the current mechanisms were in a dangerous state and required replacement. Two options of replacement have been recommended, hand operated winch and an electrically powered winch. Both options are viable and it would be dependent on the operator's preference to which option is installed. The Council's Conservation Architect had indicated that the options for refurbishment appeared suitable. However, planning permission would still be subject to production of a detailed proposal of work, and approval from Historic Scotland and the Council. This approval is required because of the historic nature of the structure.

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Appendix F - Chain Details

1. Introduction

1.1 The bridge spans the River Fleet and has six arches each with a pair of sluice gates (image 1 three arches looking north towards the North winch house). The winches used for the opening of the sluice gates are extremely old and worn. Their condition has resulted in safety implications in their operation and an operator has already been injured.

1.2 The object of this report is to assess the feasibility for the refurbishment of the winches enabling compliance with modern standards and with minimal impingement of the historic nature of the structure. The report will study a number of proposed solutions and then draw conclusions from the proposals based on cost and practicality.

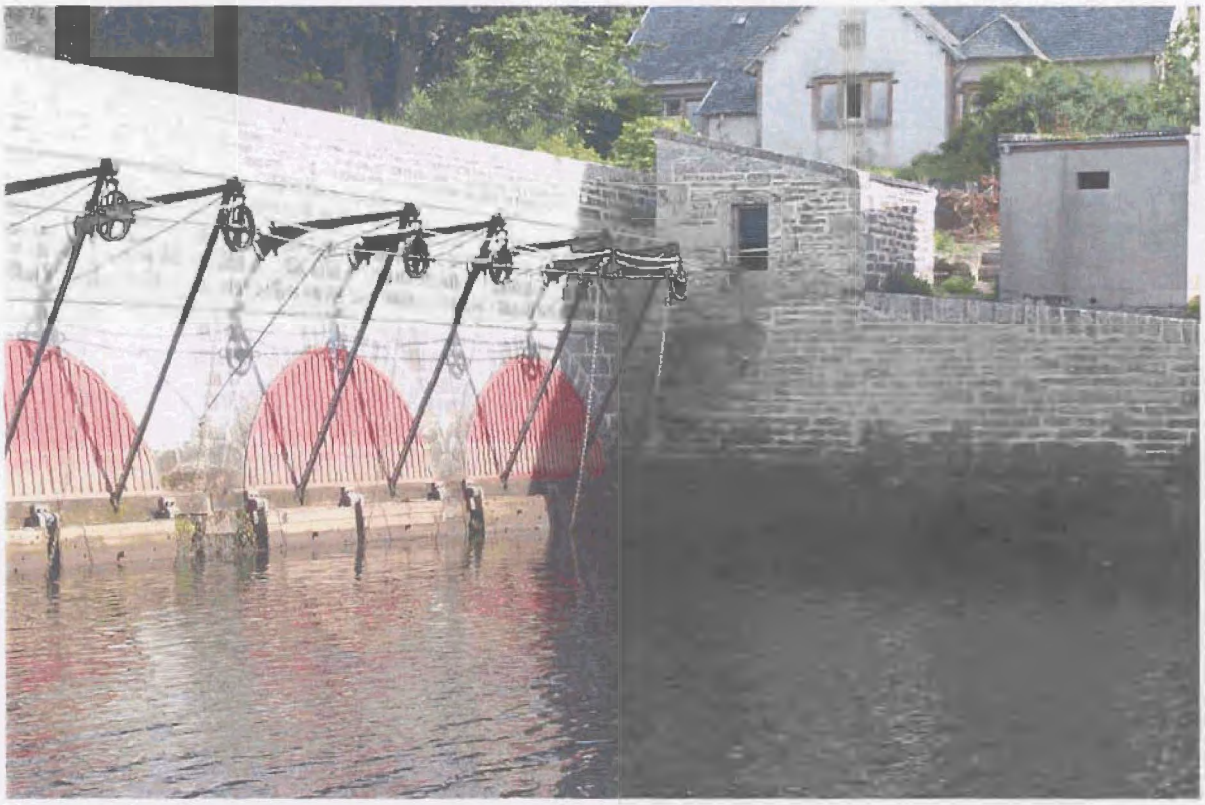

Image 1.

2. Description and Method of (Current) Operation

2.1 The structure was originally constructed in 1816 and consists of 6 Arches, within each arch is housed 2 gates. The gates basically act as flap valves preventing the River Fleet from flooding by the sea at high tide and allowing the river to flow to sea at low tide.

2.2 The operation of the gates is automatic, this action prevents the landside of the structure from flooding by the sea. However, during storm events the land side occasionally floods and, to assist with, the removal of the flood water during low tide the gates are manually winched open. The flooding is currently highlighted by local residents (mainly farmers). The residents contact the bridge operators who send out personnel to manually operate the winches. Level sensing has been considered to provide automated warning of flood conditions and is described in section 5.

2.3 The gates are operated manually, in pairs, by the winching of a chain. The gates are controlled per arch. There are two winch houses, one on each bank, where three chains used to open the gates are located. To open the gates the operator attaches one of the chains to the winch, winds the chain in until the pair of gates are open, locks off and removes the chain from the winch, attaches the next chain to the winch and repeats the process until the required number of gates are opened.

3. Review of Existing Equipment for Refurbishment

3.1 The use of chain and winch in the manner installed is now not common practice. The reasons behind this is the advancement of wire rope technology which became more widely used in the 1850s, wire rope is more readily wound, unpredictable loading that the chain links may be subjected to in its winding on to the winch and that the chain's integrity is link dependant. The barrel of the winch drum is very narrow in comparison to modern design winches.

3.2 The winch drums are worn from their long service also the ratchet mechanism and gear teeth have suffered similarly (Image 2 South Winch, Image 3 North winch). The ratchet has worn to such an extent that it now poses a serious safety issue as it has been reported to have failed and slid on a number of occasions. In the North winch house the ratchet has completely failed and is replaced by a wooden post jammed through the spokes of the wheel.

Image 2.

Image 3.

3.3 The arrangement for locking the chain off once the sluice gate is opened is in desperate need of refurbishment. In the South winch house, the cleats that the chains get jammed on are worn. The bar that the cleats latch on to has yielded and plastically deformed (can be seen in image 3). In the North winch house the latching mechanism appears to have sheared off and a dangerous make shift mechanism for holding the cleats been put in place.

3.4 The chain appears to be a galvanised low carbon steel type. The chain has no test certificates for load lifting and is not of the round link, high tensile type commonly used for load lifting. The chain that will travel around the new winch will require to conform to modern standards. It is further recommended that the entire chain system be brought into line with modern standards. The chain should be compliant with EN 818. The cost of the required lengths of chain are detailed later in the report (further technical details are contained in *Appendix F*)

3.5 Whilst not within this scope of work it is recommended that the existing chain holding structure be surveyed to assess its fitness for purpose. It was further noted during survey that the support furthest South was not attached to the bridge structure above the gate and was hanging free (Image 4).

3.6 During the site visit, it was noted that above the wheels on the North side a guide on each support keeps the chains away from the pulleys. This would be considered advantageous if also introduced onto the South side to prevent the chains fouling each other during operation, thus allowing improved operation from a safety perspective.

Image 4.

4 Refurbishment Options

4.1 Various options were considered with the emphasis on maintaining the external appearance of the structure as far as practicably possible. Access for installation of large items constructed off site could be via the roof of the winch houses. The roofs are of corrugated iron construction, have recently been replaced and would appear easy to remove and reinstall. The 5 most feasible options below are based on an advised estimate of a mass of 500Kg per gate, this mass estimate was obtained when the gates were removed during a recent refurbishment:

- *Horizontally mounted electric hoist (1 tonne)* ***(Option A)*** *Appendix A* - This option involves the removal of the original winch mechanism from the winch houses and its replacement with a chain hoist mounted horizontally on a frame. The hoist will be able to pull the sluice chain in for each pair of gates in two one metre pulls. The frame which the hoist is mounted too is capable of anchoring only one pair of gates at a time A separate anchor device is envisaged. The power supply would be buy SSE Plc and would enter a control panel. There would be hoist control panels located in each winch house with an interlock preventing simultaneous operation. The hoist would be controlled by a push button control for up and down.

- *Hand Winch (3 tonne) skid mounted* ***(Option B)*** *Appendix B* - This option involves the removal of the original winch mechanism from the winch houses and its replacement with a skid mounted hand winch. The handle of the winch would rotate in a parallel plain to the floor. The length of chain required to be wound around the winch drum would require replacement. The chain may be locked off by either an attachment to the skid or another separately mounted device.

- *Hand Winch (3 tonne) skid mounted* ***(Option C)*** *Appendix C* - This option involves the removal of the original winch mechanism from the winch houses and its replacement with a skid mounted hand winch. This winch would have a small length of wire rope to allow attachment to the chain. It would then allow the winching of the chain in a similar manner as the original mechanism. The length of chain to be wound around the winch drum would require replacement. The locking off of the chains would be in a similar manner to that of option B.

- *Electric Winch (1.3 tonne) skid mounted* ***(Option D)*** *Appendix D* - This option involves the removal of the original winch mechanism from the winch houses and its replacement with a skid mounted electrically powered winch. This would work in the same manner as Option B except it would be powered. The length of chain to be wound around the winch drum would require replacement This option is obviously dependent on the ability of gaining a suitable power supply for the winch which may be achieved via the national grid or by a local generator. The power supply would be buy SSE Plc and would enter a control panel. There would be hoist control panels located in each winch house with an interlock preventing simultaneous operation. The hoist would be controlled by a push button control for up and down.

- *Electric Chain Windlass (2.4 tonne) skid mounted* ***(Option E)*** *Appendix E* - This option involves the removal of the original winch mechanism from the winch houses and its replacement with a skid mounted electrically powered chain windlass. The chain windlass would work by pulling the chain through a grooved wheel. The chain would then be anchored off as per options B C & D. For this option a length of chain would require replacing to allow compliance with the windlass and a suitable power supply would be required. However, it is felt that only the length of chain being pulled would require replacement (i.e. 2-3 metres). The power supply would be buy SSE Plc and would enter a control panel. There would be hoist control panels located in each winch house with an interlock preventing simultaneous operation. The hoist would be controlled by a push button control for up and down.

5 Feasibility of Level Sensing Equipment and Automated Control

5.1 As part of the feasibility study the option of a completely automated control was looked at. It was felt that various safety-associated complications would have to be overcome to make this option feasible. The chains and pulleys would have to be enclosed in a protective guard, the winch would have to be electric and the gates would require to be operated at the same time. It was felt that this would not be feasible as the external façade of the bridge would require to be altered and the winch and chain arrangements would require upgrading resulting in greater costs This option would also bring reliability and maintenance issues into contention.

5.2 It was felt that some form of water level sensing would be a feasible and beneficial option. For the effective operation of the sluice gates the water height of the sea and fresh waters is required to be known. It was envisaged that this could be ascertained off site by telemetry and thus preventing the need for personnel to visually check the levels by attending site. This would prevent unnecessary visits to the mound sluice to assess conditions.

5.3 The most effective water level detection system would likely consist of two ultra sonic sensors located on hinged brackets (for ease of maintenance). One located outside the North winch house to one side of the window and the other beside the ladder on the fresh water side of the North bank. Both would wire back to the North side winch house to separate control boxes and then into a common telemetry box. The telemetry box may then be wired to a BT socket (taken from the local telephone network) The level sensing equipment will be able to indicate flood conditions to the operator and set of an alarm. The equipment would also allow the monitoring of the levels on dialling the telemetry box, (the telemetry will require a power supply, a battery run option may be possible).

6 Estimated Costings

6.1 The cost for the replacement of the entire chain, estimated at some 200metres has been included as its failue could result in operator injury. The material cost would be in the region of [redacted]) and connectors[redacted].

6.2 Costs of the various options (more detailed breakdown in appendices):

- **Option A:**

[redacted]

- **Option B:**

[redacted]

- **Option C:**

[redacted]

- **Option D:**

[redacted]

- **Option E:**

[redacted]

7. Conclusions and Recommendations

7.1 After consultation with the Council Conservation Architect, it was felt that an option that operated in a similar manner to the original would be more favourable.

7.2 For a manual option the most favourable design would be that of Option C.

7.3 For an electric option the most favourable design would be that of Option D.

7.4 Overall the manual Option C would be the recommended option. This is due to the ease of maintenance and reliability over that of the electrical options. It was further thought that the saline, coastal environment and the infrequency of use would be detrimental to the electric options. However, although Option B is less expensive and also manually operated its robustness and design life are thought to be limited in comparison to that of Option C. It is further recommended that the level sensing equipment be installed allowing prompt warning of flood conditions.

7.5 Notwithstanding the final option selection, it is recommended that the replacement is programmed at the earliest opportunity given the life-expired condition of the existing system.