

Breydon Water Navigation Works
Report by the River Engineer

Summary: This report provides an overview of works undertaken on Breydon Water over the past year. The report covers work on navigation marking and layby mooring facilities, management of hazards, dredging. This report also includes consideration of the immediate and long term management requirements of Turntide Jetty with recommendations made.

Members' views are sought on the suggested measures for the maintenance of Turn Tide Jetty as set out in Section 3.4 and the appended condition survey report.

1 Introduction

- 1.1 The Authority has committed significant resource over the past year to management and improvements to navigation through Breydon Water. This report covers the associated design and construction work undertaken with a particular focus on navigational structures installed or requiring maintenance.

2 Navigation Works

2.1 Channel markers

- 2.1.1 Upstream of Breydon Bridge the navigation channel through Breydon Water is marked by 93 numbered marker posts and four steel mooring posts. The numbered marker posts are timber piles and a number of these which were recently installed by the Port are softwood (Corsican Pine or Douglas Fir).
- 2.1.2 In the last year the Construction and Maintenance team has had to replace seven of the timber markers due to very poor condition, breakage or where they have been found to simply be missing. In all cases where the original post has been present to remove, significant rot and attack by gribble worm has been observed below the mean water level.



Photo 1: Broken navigation marker with significant gribble worm attack.

- 2.1.3 Gribble worm is common in marine estuaries and Breydon Water is no exception. These small crustaceans bore into the timber and therefore exacerbate the progression of rot. Gribble worm will bore into any timber but softwood is particularly vulnerable.
- 2.1.4 The majority of replacement markers installed over the last year have been hardwood (greenheart), which has a good resistance to both biological attack and rot. However, as the issue has become clearer officers will consider using steel tubes in future replacements. Steel tubes also deteriorate due to corrosion, however, with a good paint system and wall thickness; they should offer good durability. The table below provides some estimated life costs for different piles in Breydon Water. This shows that steel tubes are a viable alternative to hardwood and certainly provide better value than softwood even without taking into account the cost of more frequent mobilisation.

Pile Type	Typical cost per pile	Estimated Life (years)	Pile cost over serviceable life (£/yr)
Softwood (Douglas Fir)	£200	10	20
Softwood (Pitch pine)	£270	15	18
Hardwood (Greenheart)	£500	40	13
Steel tube	£670	50	13

Table 1: Estimated whole life pile costs

- 2.1.5 Replacing degraded markers is expected to be an ongoing requirement. Mobilisation to work on Breydon Water is significant. Even with a pontoon mounted crane in the area, working with the weather and tides is time

consuming. Therefore the team will endeavour to work efficiently by replacing several markers at a time where temporary marking with buoys is acceptable.

2.2 Layby pontoons

- 2.2.1 During early summer the Construction team installed a floating pontoon between Breydon Bridge and Bure Mouth. This facility provides a waiting berth for vessels which have arrived at Bure Mouth before the tide conditions will allow a passage through the bridges, and is for a maximum of two hours mooring only. A number of quotations were sought, resulting in the supply of pontoons from Varis Engineering based in Scotland. During installation the Authority was able to make good use of Fendercare Marine Lifting Services for the storage and mobilisation of the materials and equipment.
- 2.2.2 Due to potential site conditions, the pontoons are a heavier duty design than typical marina pontoons. At 20m long and 3m wide they offer a stable layby facility for two typical vessels.



Photo 2: New Layby mooring pontoon

- 2.2.3 Since installation Trinity House, during a routine inspection, requested that the pontoons be lit with appropriate navigation lights.

2.3 De-masting dolphins

- 2.3.1 During the summer new de-masting dolphins have been constructed upstream of Breydon Bridge. The dolphin structures have been installed in response to a demand for improved de-masting facilities and issues that had been raised with regard to the safe use of the existing mooring posts (or 'bottle dolphins').

- 2.3.2 Following detailed consultation with Natural England and the RSPB an agreement was reached to allow the installation of a new dolphin on either side of the channel, however with the starboard hand dolphin located further slightly upstream to avoid potential disturbance to an important high tide feeding area and roost.
- 2.3.3 Installation has been hampered by poor weather conditions, however the two dolphins upstream of Breydon Bridge are almost complete. Once these are complete the installation of a further two dolphins at Bure Mouth will be programmed. These dolphins will replace two of the three existing dolphins that are presently in very poor condition.



Photo 3: New de-masting dolphin during construction

3 Turntide Jetty

- 3.1 Following a hydromorphological study of Breydon Water (which included modelling the function of Turntide Jetty), a condition survey of Turntide Jetty has been undertaken. Taking advantage of a low spring tide, the survey included close inspection of typical elements and a walkover of the entire visible structure.
- 3.2 A full report on the condition survey has been written and this is included in Appendix 1 for reference. However as a brief overview; the Jetty was seen to be in a general poor condition with a particular issue at the upstream end of the River Yare face where the piling is progressively collapsing riverward into the channel.

- 3.3 The hydromorphological study suggested that the Jetty does provide a beneficial function with regard to training water flows along the main channel. The study however suggests that the Jetty would continue to be effective without the existing narrow downstream extent (coloured blue in the figure below).

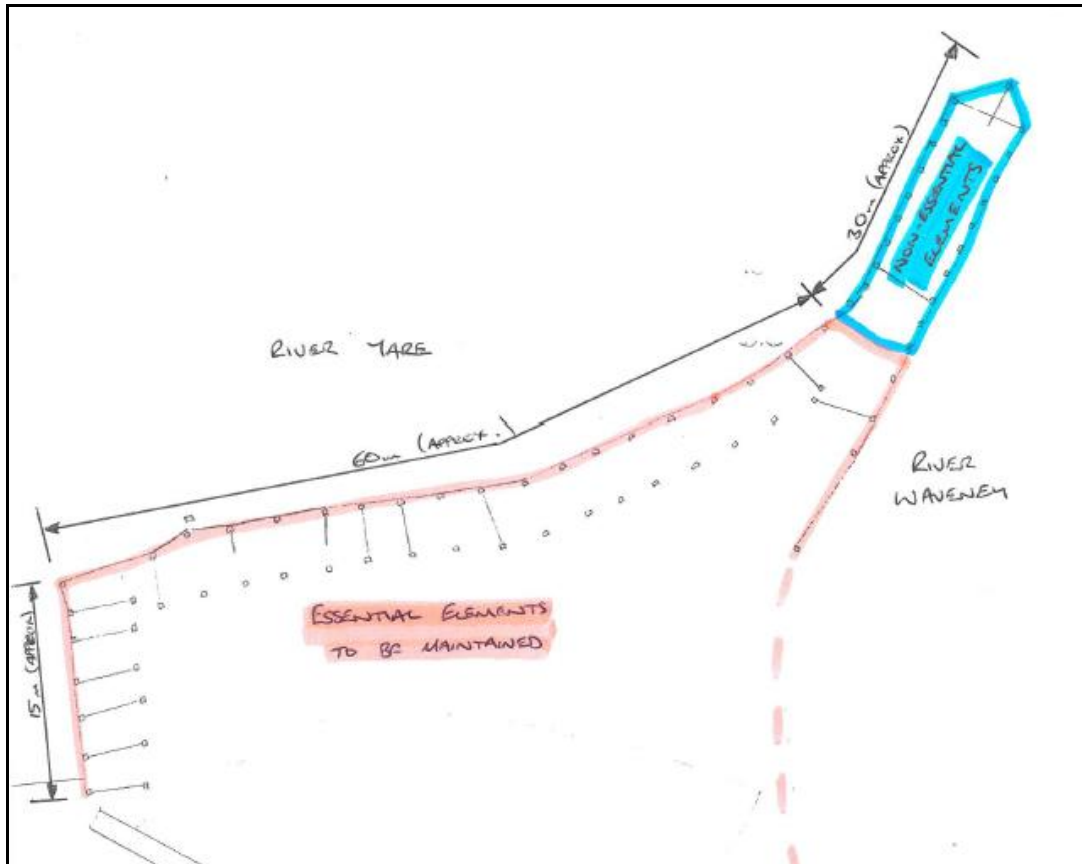


Figure 1: Turntide Jetty showing essential and non-essential parts

- 3.4 Therefore the recommendations of the report are to:
- (i) improve navigation marking over the whole structure
 - to be completed before April 2014 (included in budgeted programme)
 - estimated cost is £2,500 (local contractor)
 - (ii) install additional steel wire ties to the narrow downstream extent to minimise any movement of elements into the channel
 - to be completed before April 2014 (included in budgeted programme)
 - estimated cost is £2,500 (local contractor)
 - (iii) reconstruct the essential parts of the structure by re-piling either as a single operation or phased, as outlined in the following options.

Option 1	Re-pile the essential part of the structure in one operation within 2014/15 <ul style="list-style-type: none"> • Estimated total cost £250,000 • Saving on mobilisation costs • Requires contribution from the MMR budget in place of one 24hr mooring re-piling project with a significant contribution from the reserves.
Option 2	Re-pile the essential part of the structure in one operation, but programme the work to take place starting March 2015 with the work extending over two financial years. <ul style="list-style-type: none"> • Estimated total cost £250,000 • Saving on mobilisation costs • Requires expenditure from the Mooring Maintenance budget (MMR) over two years in place of two 24hr mooring re-piling projects with potentially a minor contribution from reserves.
Option 3	Re-pile the essential part of the structure in three phases <ul style="list-style-type: none"> • Estimated total cost £270,000 • Requires expenditure from the MMR budget over three years (potentially in place of three 24hr mooring re-piling projects) with some contribution from reserves expected in year one.

Table 2: Re-piling options with likely budget implications

3.5 The estimated costs given above are effectively concept costs. These have been based on a piling cost of £2000 per linear metre with some additional allowance for site conditions and difficult access to the structure. If the re-piling options are considered appropriate, further investigation and preliminary designs will be undertaken by officers to establish and report on more accurate cost estimates.

3.6 At this stage it has been assumed that the work will be undertaken by specialist contractors. Some saving could be afforded through the use of in-house plant and labour, however undertaking this work in-house would reduce the operational capacity for programmed dredging and maintenance work and specialist piling contractors are expected to be better equipped to undertake this work.

4 Dickey Works

4.1 The hydromorphological study of Breydon Water also modelled the function of the Dickey Works, which is a former jetty structure close to the NRA jetty. The study concluded that the existing superstructure remains had little effect on the local hydraulic flows.

- 4.2 A low tide survey of the Dickey Works was therefore undertaken in September to gather any available information on the location and current condition of visible remains.



Photo 4: Dickey Works at low tide

- 4.3 Even on a low spring tide little of the remaining structure of the Dickey Works is visible and therefore the extent of the survey was limited. To draw firm conclusions it may be necessary to undertake a sonar survey beneath the waterline. This will provide better detail on the extent of the remaining structure and navigation hazard posed.
- 4.4 At present the structural remains are marked, but removal is considered appropriate. A trial will be undertaken to pull some of the piles to establish the feasibility of mechanical removal and confirm the extent other services such as divers will be required.

5 Removal of Hazards

- 5.1 Throughout Breydon Water and the River Bure channel there are a variety of known submerged hazards. Most of these are outside of the channel and either sunken vessels or remains of old piling. However there were remains of timber piled structures at Bure Mouth which were very close to the channel.



Photo 5: Piling remains now removed from Bure Mouth

- 5.2 During the summer the Authority took the opportunity to use a local contractor to remove these piles, whilst the Construction and Maintenance team mobilised to remove a degraded dolphin structure from the River Bure just upstream of Acle New Road Bridge.

6 Dredging

- 6.1 In response to local reports, the Construction team programmed dredging of a shallow area immediately upstream of Breydon Bridge. The shoal is localised to an area upstream of the port hand navigable span of the bridge.
- 6.2 With a low volume required to be removed, officers were able to gain permission from Natural England to side-cast the material to the adjacent shoreline. Following a notice to Mariners, the dredging was programmed to take place in late September 2013. However, the work has had to be postponed due to a run of poor weather with strong winds and impact on other projects.

Background papers: None

Author: Tom Hunter
Date of report: 26 November 2013

Broads Plan Objectives: NA4

Appendices: APPENDIX 1 – Turntide Jetty, Structural Condition Survey & Recommendations

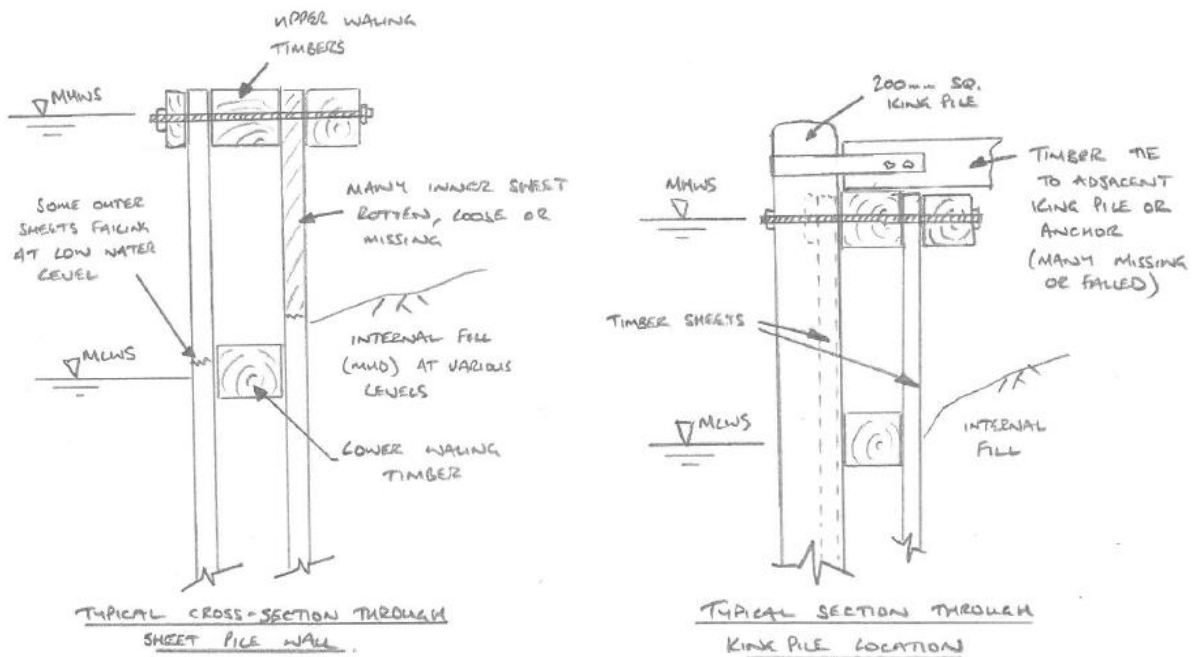
TURNTIDE JETTY STRUCTURAL CONDITION SURVEY AND RECOMMENDATIONS

This report outlines the current condition of Turntide Jetty and outlines some preliminary recommendations for immediate work to safely mark the existing structure and also longer-term construction works to maintain the essential parts of the structure in a safe and functional manner.

1.0 CURRENT CONDITION

A visual survey of Turntide Jetty was undertaken in September 2013, taking advantage of a low spring tide. The survey included close inspection of typical elements and a walkover of the entire visible structure.

Essentially the structure is an anchored timber sheet piled structure. The structure relies on cantilever strong points provided by 200mm square timber king and anchor piles. Typical cross-sections are shown below.



Much of the structure remains in place and therefore continues to function as a training structure to the hydraulic flows. However, with the exception of the return at the west end, the general condition of the structure is poor. Many elements, particularly on the erosive River Yare side, have failed or are failing. This is leading to localised loss of fill and progressive collapse of the sheet piled frontage.

The figure on the proceeding page shows a plan of the structure with more detailed notes on its condition.



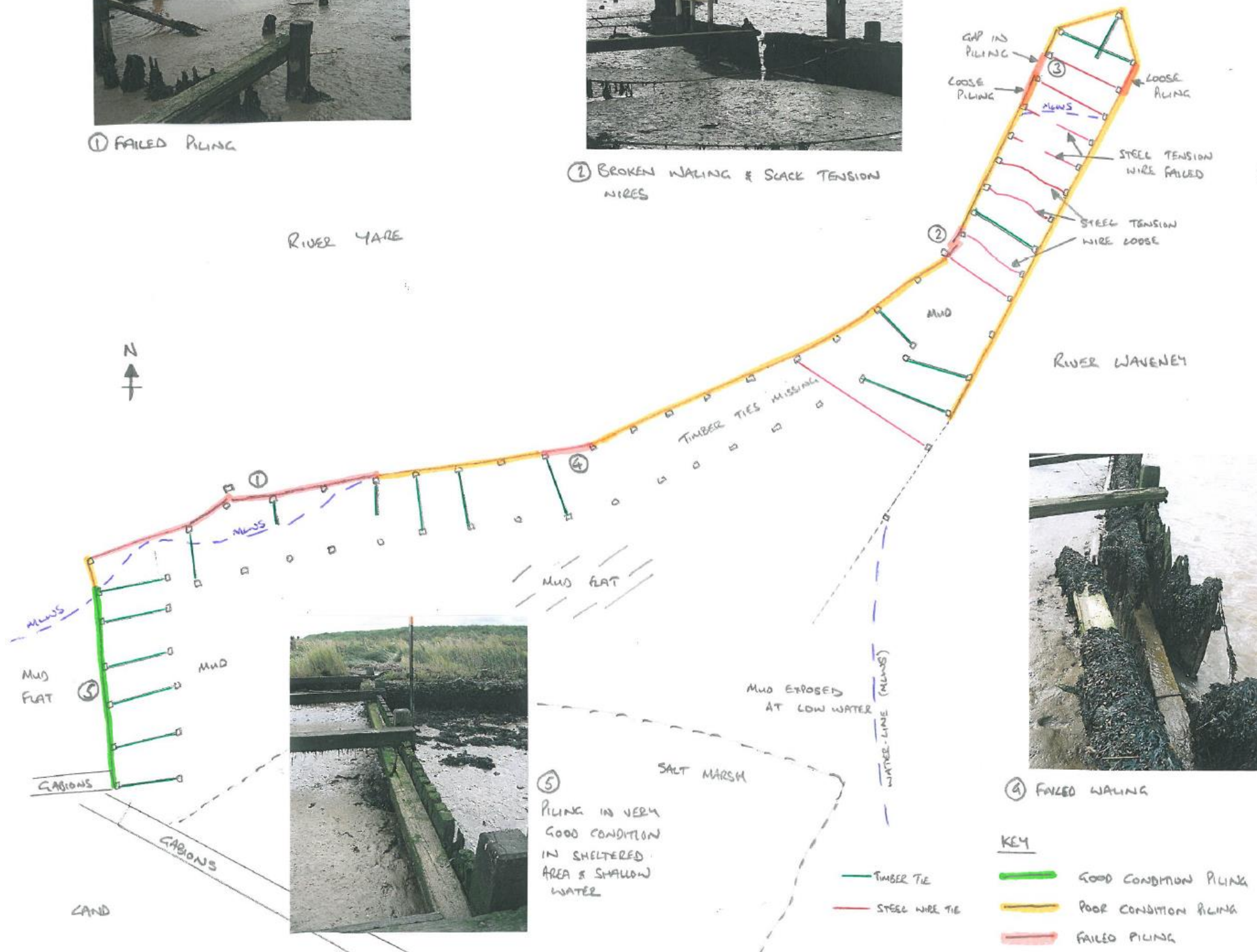
① FAILED PILING



② BROKEN WALING & SLACK TENSION WIRES



③ TENSION WIRE STILL EFFECTIVE (ADJACENT TO MISSING PILING)





④ FAILED WALING

⑤ PILING IN VERY GOOD CONDITION IN SHELTERED AREA & SHALLOW WATER

TURNTIDE JETTY
GENERAL CONDITION SEPTEMBER 2013
BROADS AUTHORITY
T. HUNTER OCT. 2013
DRAWING: TTS/2013/002
NOT TO SCALE

As shown in the above figure, the run of piling at the downstream end of the River Yare section is the most vulnerable part and in the poorest condition. It was clear from the survey that the piling is now progressively failing. Historical aerial photographs show that this has significantly deteriorated over the last six years, as shown in the timeline of photographs below.

1999 The piling along the Yare face is intact and remains reasonably straight with all anchor ties visible.	
2004 The piling remains intact with all ties visible but piling is starting to bow riverward.	
2006 Similar to 2004 the piling is intact, but it is beginning to bow and one of the ties is no longer visible (assumed to have failed at the connection and sunken into the silt).	

<p>2010</p> <p>Bowing is becoming more apparent but the sheet piling remains largely intact.</p>	
<p>2013</p> <p>As per the survey the piling has now failed and some of the sheet piles are now collapsing riverward.</p>	

Now that the structure has failed and the sheet piling is no longer continuous, the structure along this face is likely to fail progressively due to ongoing deterioration of the timber and washout of material in front of the anchor piles. Therefore following the survey it has become clear that work will be required to ensure the essential part of the structure remains functional and does not present an unacceptable hazard to navigation. The recommended measures are set out in the next section.

2.0 RECOMMENDATIONS

The hydromorphological study suggests that the jetty structure does act to control flows and there are no recent reports of shoaling; therefore it is considered an effective training structure. The study however suggests that the full extent of the structure is not essential and that removal or loss of the narrow offshore extent ('pier section') could be afforded without detrimental effect.

Therefore the recommendations outlined in this section are intended to keep only the essential part of the structure functional with a minimum of work to other parts to prevent a hazard developing.

2.1 Work to essential parts of the Jetty – Re-piling

Timescale for undertaking the work: Within 3 years

There is a requirement to undertake structural work to maintain the function of the jetty long term. Any significant capital or resource commitment should be limited to the essential landward part of the structure, as shown in the figure below.

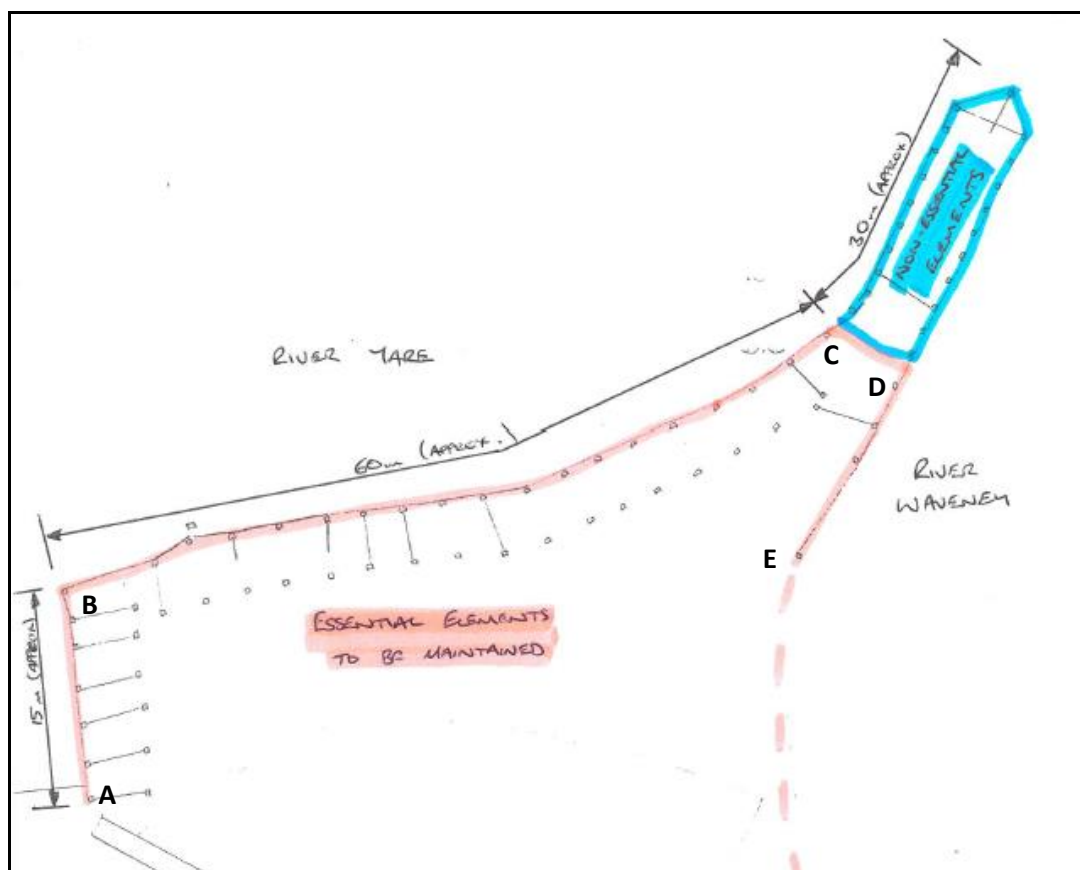


Figure: Layout of the structure showing essential elements

Due to the condition of much of the timber an attempt to repair the structure is not likely to be cost effective. Therefore reconstruction of the essential part of the jetty will be required for which there are several options including piled construction (i.e. steel or timber sheet piling) or a gravity structure (i.e. rock, gabion, concrete, geotube or even large sunken

vessels). The following table outlines considerations given to the feasibility of each type of structure.

Rock armour structure	<p>Imported rock could be used to form a long lasting functional training structure in place of the jetty. However this is not a recommended form of structure for the following reasons:</p> <ul style="list-style-type: none"> • Rock fill will generally require sides sloped at a gradient of 1:3 or less. Considering the depth of the bed of the River Yare the structure would require a large foot print. • Mislaid rocks or slippage could cause a significant navigation hazard. • Rock is a heavy bulky material so the cost of transport and associated plant to handle and place the rock would be very significant. • A rock structure would provide an ideal habitat for the 'killer shrimp' and could therefore encourage its ongoing spread.
Geotube structure	<p>Recent work at Salhouse Broad shows that geotubes can be used to form an effective gravity retaining structure on soft ground. However geotubes require a large footprint on level ground. Without very significant ground work in a difficult environment, retaining geotubes in the required location next to the deep River Yare channel would be virtually impossible.</p> <p>Therefore a geotube structure is not considered appropriate.</p>
Sunken vessels	<p>Similar to geotubes, sinking and retaining a redundant vessel alongside the deep River Yare channel would be difficult without significant groundwork or piling. Also where hard surfaces are situated alongside soft material, strong currents will cause scour; therefore over time scour would likely destabilise a sunken vessel at this location and therefore this solution is not considered appropriate.</p>
Concrete caisson structure	<p>Concrete caissons are another form of large gravity structure which would require significant ground work (levelling) to provide a stable structure long term. The risks of scour and settlement destabilising this kind structure make this solution undesirable.</p>
Piled structure	<p>It is suggested that reconstruction be undertaken using anchored sheet piling for the following reasons:</p> <ul style="list-style-type: none"> • The existing jetty structure has proved a piled design to be effective for a significant period of time. • Re-piling could be done in front of the existing structure. Therefore the training function of the Jetty could be largely maintained throughout the work. • A sheet piled structure could be constructed with minimal disruption to navigation

It is recommended that the most effective method of reconstruction will be using anchored steel sheet piling. Sheet piling could be constructed in phases with priority given to the most vulnerable sections. Using the letters shown on the above figure the order of priority for re-piling the essential part of the structure is as shown in the table below.

Indicative costs are also given in the table below. These are based on current costs for an in-house design and the use of specialist external contractors for construction. In house design would make use of knowledge of the existing structure and other similar piled structures around the Broads. Alternatively a ground investigation could be undertaken and specialist consultants employed to provide a fully calculated structural design. This would provide greater assurance of structural performance, however modelling the poor soil properties in calculation could well lead to a higher construction standard and cost than typical Broads structures.

The costs shown are based on an estimate of £2000 per linear metre (in each case including mobilisation, ancillary costs etc.) with some additional contingency for difficult site conditions and requirement to work around the existing structure.

Priority 1	B-C	Approximate Length 60m Cost estimate £150,000
Priority 2	C-D	Approximate length 7m Cost estimate £30,000 <i>(higher cost per metre due to difficult access to pile face)</i>
Priority 3	A-B	Approximate length 15m Cost estimate £35,000
Priority 4	D-E	Approximate length 20m Cost estimate £50,000

If budget allows savings in mobilisation could be gained by tackling the whole structure in one phase. If this is not possible then phasing the work is an option with attention given to temporarily integrating new and existing elements.

2.2 Work to the non-essential parts of the Jetty – Steel cable ties

Timescale for undertaking the work: Within 1 year

It is apparent that within that last 10-20 years at least eight steel wire cables have been installed on the pier section in place of the original timber ties. The majority of these steel cables have failed or become loose due to slipping of friction grips.



Photo: Steel wire tie (temporary strengthening)

Replacing five of these wire ties is only a temporary measure. However it is a relatively easy measure that will help reduce the risk of outward collapse of the piling as it fails, and therefore reduce the risk of significant navigation hazard. It is recommended that this measure is taken within 1 to 2 years, before much more significant movement occurs.

Wire ties should be installed between any available and sound anchors and king piles. On installation the wires should be brought just to tension to reduce further movement. Wire should not be used to attempt to pull in the existing piling.

Installing the steel wire ties should enable the structure to remain in-situ for a greater length of time as it deteriorates. However there is likely to come a time where the structure will need to be removed.

2.3 Work to the all parts of the Jetty – Navigation Marking

Timescale for undertaking the work: Immediate

Within the last 10 years the Port of Great Yarmouth installed regular timber up-stand markers which were simply screwed or bolted to the structure. These were painted in a high visibility orange colour. Most of these remain in place but they are small and the paint is now degrading.



Photo: River Waveney side piling showing current orange markers

It is recommended that an immediate measure to improve navigational safety, these markers should be replaced with larger (100mm square) timber markers. These markers should be:

- i. Fixed to the structure at regular intervals not exceeding 5.0m
- ii. Painted yellow, or other appropriate colour to be advised by the Head of Ranger Services
- iii. Extend 2.0m above the top of the existing jetty sheet piling