Murgatroyd Pump Shaft

Discussion of Observations from FLODIM Sonar Survey

Purpose of Report

The report was carried out by Flodim, on behalf of Robertson Geologging to assess the condition of the pump shaft at the Murgatroyd Pumping Station.

The purpose of the survey was to permit Middlewich Heritage Trust to assess the condition of the shaft, in order to give an indication of possible remedial works which may be required as part of the restoration project.

Date of Visit

The visit took place on 8th March 2017

Flodim Reference

Report No 17-3022

Test Procedure

A pilot probe, measuring depth, inclination and temperature, was lowered into the shaft.

The survey datum was set at the level of the pump plinths within the pumphouse. (Fig 2)

The probe was then slowly lowered until the tension came off the lifting cable. At this point, the probe inclination suddenly increased to 5^0, indicating that the probe was resting on the bottom, or some large obstruction. The depth was measured as 61.2 m below datum.

The pilot probe was then withdrawn, and replaced by another probe, containing a sonar sensor which could take horizontal and angled measurements to the shaft walls. This probe also included a compass, allowing the shaft sections to be correctly oriented relative to the building above.

III. LIST OF ACQUIRED MEASUREMENTS

- 55 oriented circular horizontal sections from 60.0 m to 4.0 m deep, with a 1 m step.
- 2 down-tilted oriented circular sections from 58.0 m deep, in order to characterize the cavity floor.
  Tilts from -80° to -70° (10° step) with respect to the horizontal.
- 8 up-tilted oriented circular sections from 4.0 m deep, in order to characterize the cavity roof.
  Tilts from 10° to 80° (10° step) with respect to the horizontal.
- 1 complementary measurement to determine the cavity floor depth.

Figure 1 – List of measurements (extracted from Flodim Report)

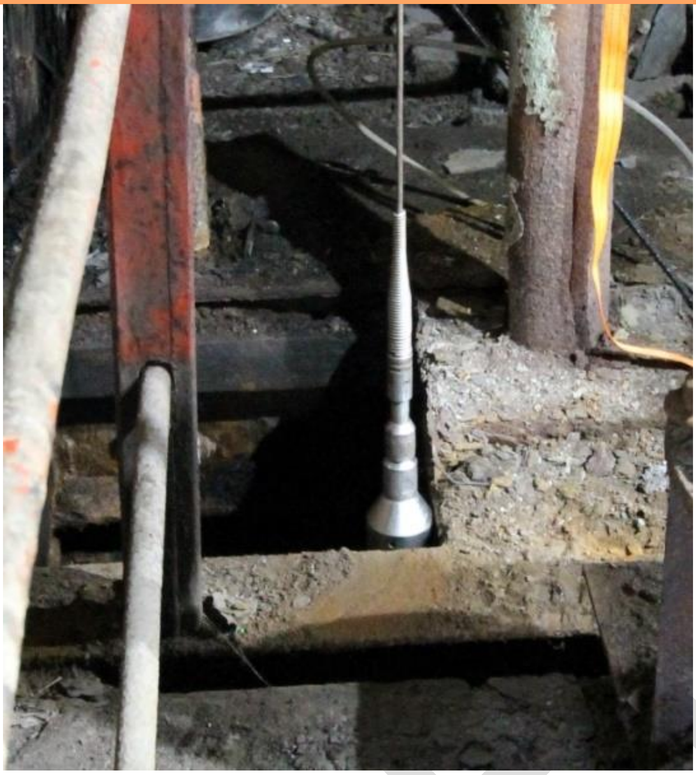


Figure 2 – Survey Datum (Probe datum is widest point of shoulder)

Access to the shaft was limited to a small inspection hatch between the two main pump support steels, North of Pump No3 and East of the Submersible pump.

The exact location of the probe is indicated on the Plan view (Figure 3).

Shaft sections derived from by the survey are centred on the probe.

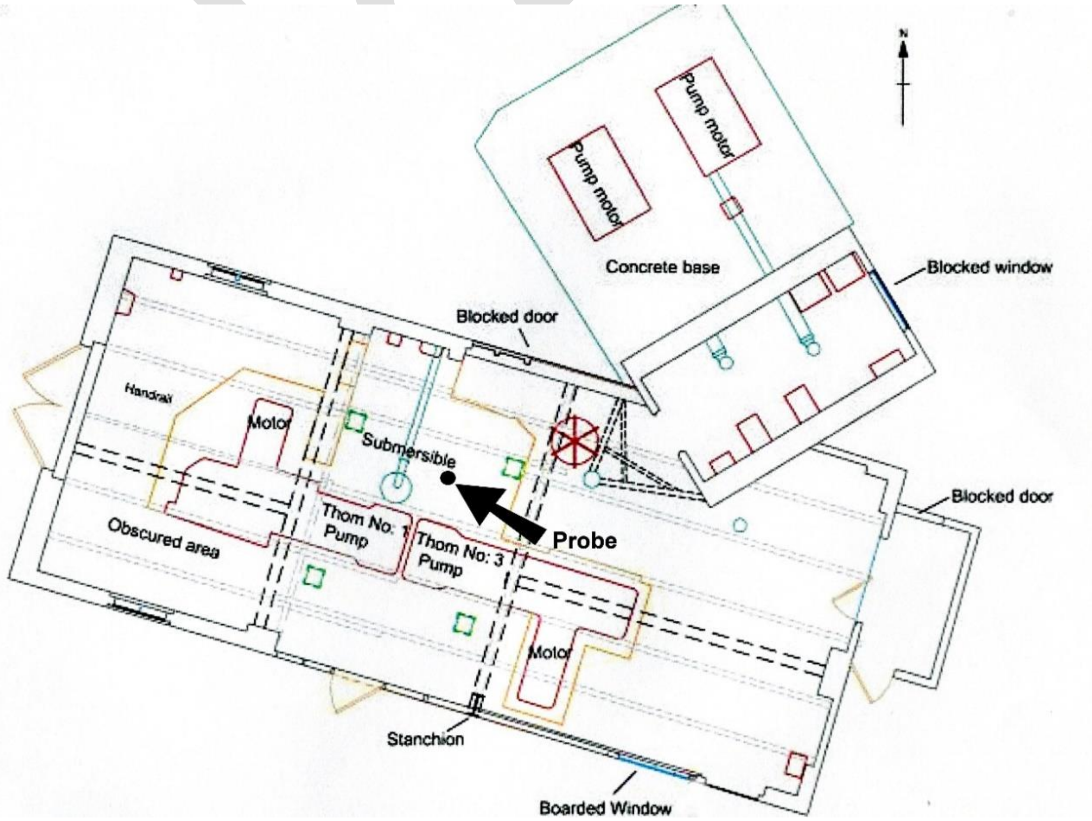


Figure 3– Plan View of Pump House, showing location of survey probe

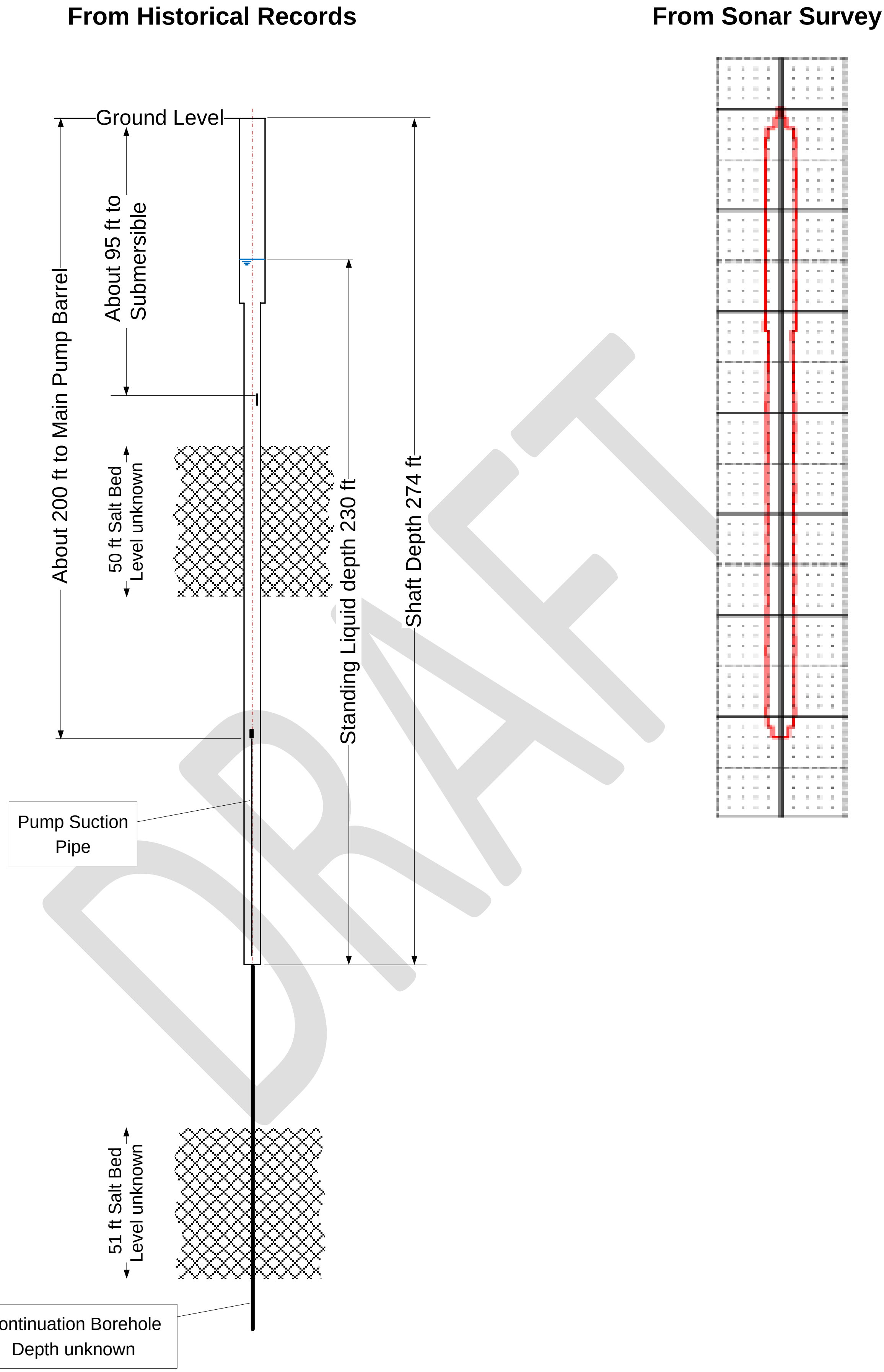


Figure 4 – Section of shaft comparing historical records with survey

Explanation of Diagrams

The ultrasonic probe emits an horizontal pulse of energy in a narrow beam. This pulse will be reflected from any hard surface, and the time taken for the pulse to return is measured. If the speed of sound in the relevant liquid (in our case, brine) is known, and the time of travel is known, the distance to the reflective surface can be calculated.

The equipment used rotates the beam horizontally, emitting pulses at 5^0 intervals. When the resulting distances are plotted on a circular chart, a cross section of the shaft can be obtained.

A typical plot is shown in Figure 5

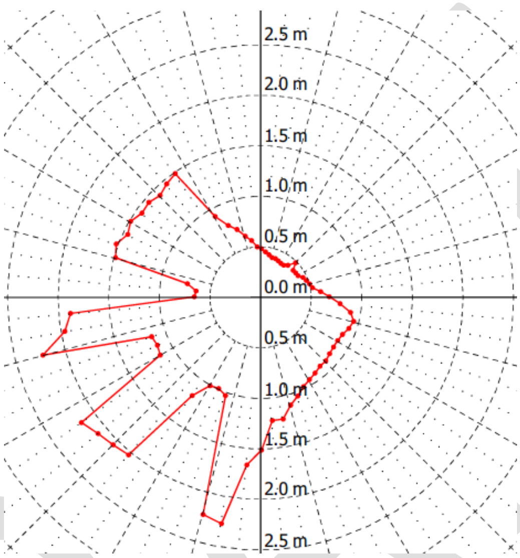


Figure 5 – Typical horizontal section

The probe is located at the zero point in the centre of the chart. North is at the top.

Each red dot represents a single distance reading. This reveals a square shaft aligned, roughly, NE – SW.

The three indents are the pump delivery pipes running vertically up the shaft. Clearly, if the sonar signal is reflected by the pipe, it is prevented from reaching the shaft wall behind the pipe. This causes a series of acoustic “shadows” behind the pipes, where no detail can be detected.

To get an overall picture of the shaft, all the survey results were plotted on to a single diagram (Figure 6).

This reveals the following:

- The upper and lower shafts are both rectangular, as expected, but the lower shaft is offset so that there is no step in the NE wall. It can be seen from the individual sections, that the transition takes place at around 21m depth
- Either the NE wall was not so well finished as the other three, or there has been some spalling on the NE wall. The other three walls appear to be fairly uniform, with little irregularity. This suggests that the shaft is stable.

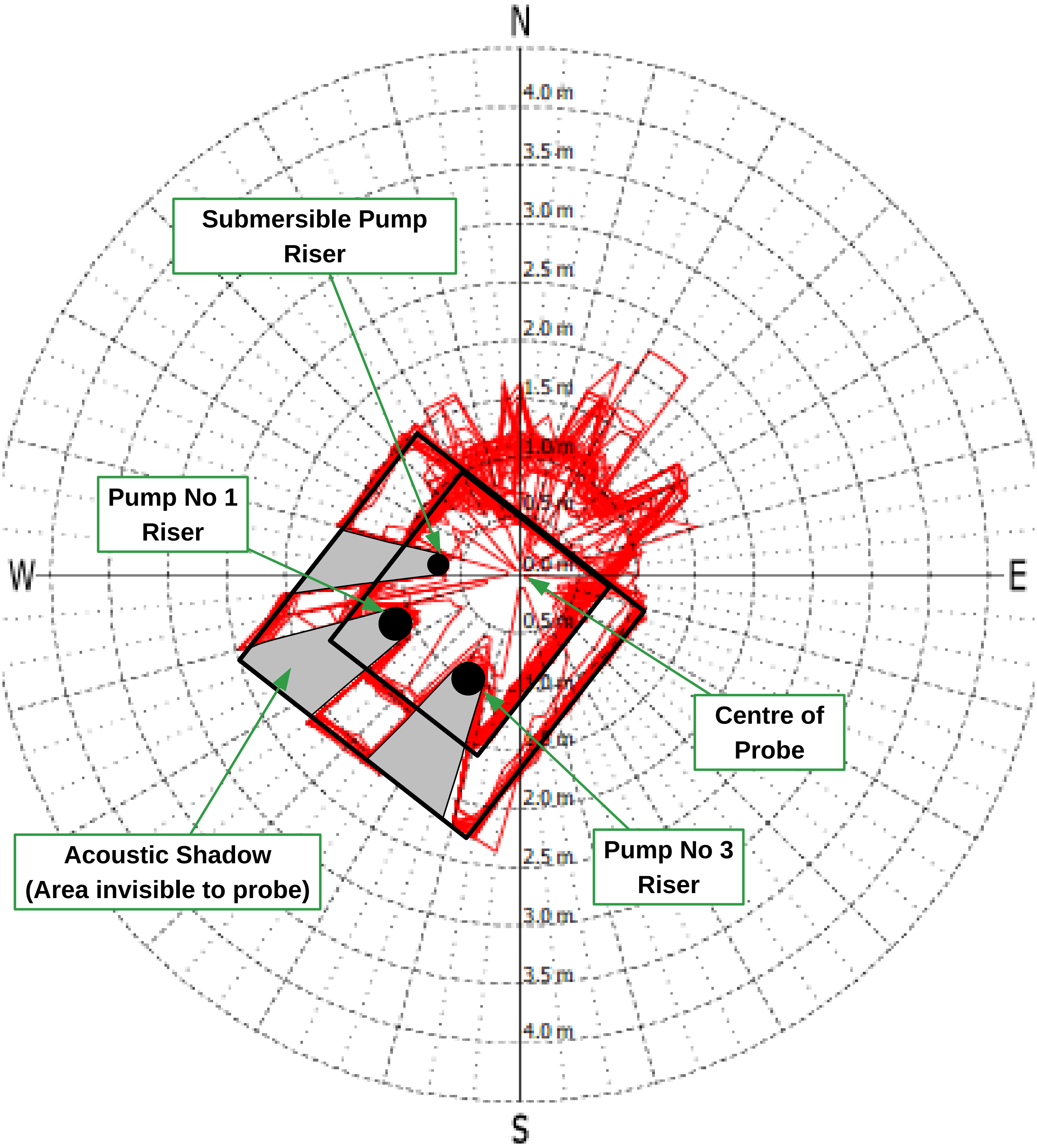


Figure 6 – Summary trace showing shaft and pipes

Comments on the survey observations

- From Figure 4, it can be seen that the shaft should be much deeper than the survey suggests. An examination of the individual sections also reveals some anomalies.
- The change of section occurs between 21 & 22m. This agrees reasonably with the stated depth of "about 60 ft."
- The Submersible Pump Riser disappears from the trace at about 25m, and is not seen again. This corresponds reasonably well with the expected depth of "about 95 ft."

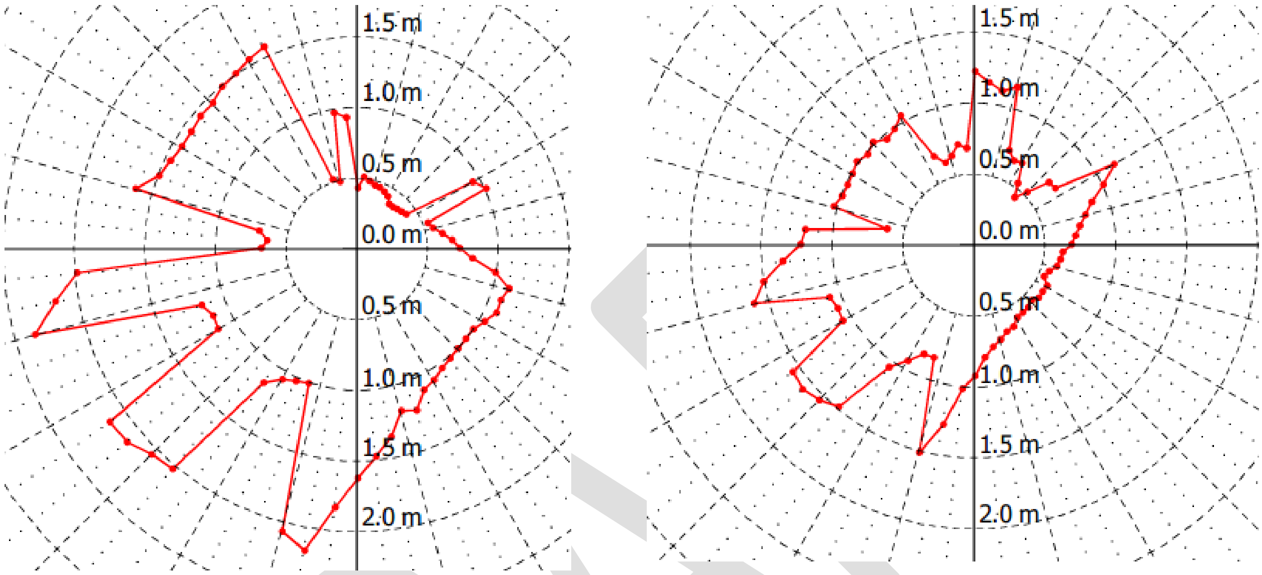


Figure 7 – Upper (Large) shaft @ 20m level & Lower (small) shaft @ 22m level

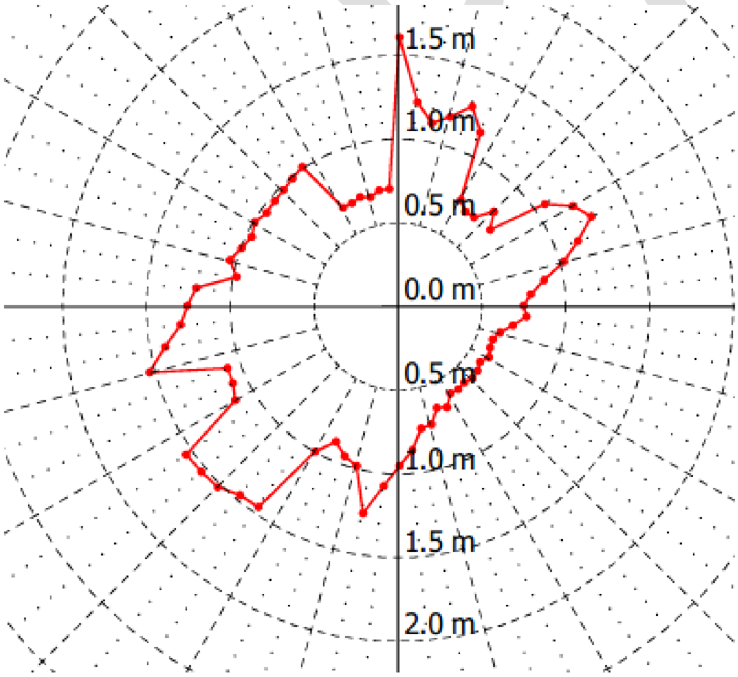
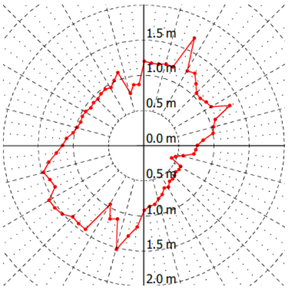
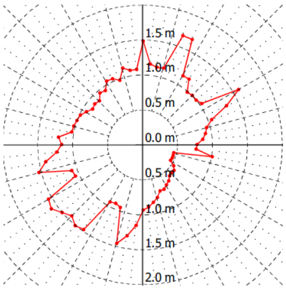


Figure 8 – 25m Level – Submersible riser now absent

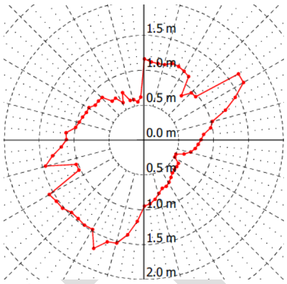
- However, at 28m level, the No1 Pump Riser also disappears from the trace, reappears in a reduced form at 30m, is absent 38 & 39m, present, in reduced form 40 – 48m and is then present intermittently to 60m
- No3 pump riser disappears at 35m, reappearing at 38m, is absent from 44m, reappearing at 60m
- The trace at 61m level is very confused, and it was not possible to get the probe beyond this depth.



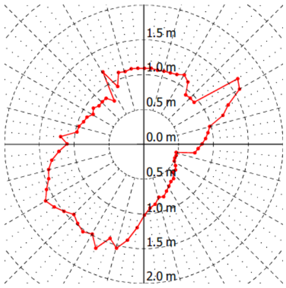
28 metres



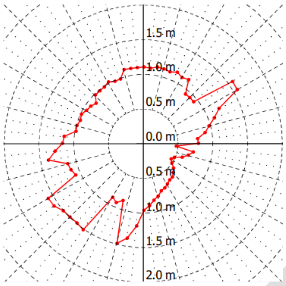
30 metres



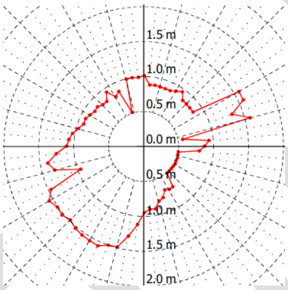
35 metres



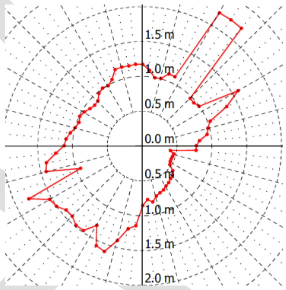
37 metres



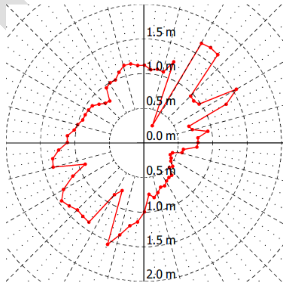
40 metres



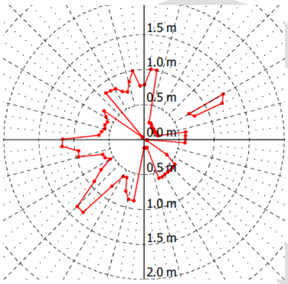
48 metres



59 metres



60 metres



61 metres

Figure 9 – Selected sections at various levels

Discussion

The sonar beam has a solid angle of divergence of about 2.5^{o}. This means that, at the typical measuring distance of 1.0 – 1.5 m, in the lower shaft, it will be 45 – 50 mm dia.

The angular distance between readings is 5^{o}, i.e. the beam moves 90 -100 mm between readings so, for a 250 mm dia riser, it is likely that the probe will hit it two or three times on each sweep. This is confirmed by the scans from the 25m level, showing three hits and four hits respectively on the two riser pipes.

However, for a 40mm dia pump rod the probe will have only a 1 in 4 chance of detecting it. Signals such as this can be seen at the 48m and 59m levels.

It seems possible that the two riser pipes have broken off at a depth of about 32m. It is not known how far from the bottom the suction pipes ended, but dropping a string of cast iron pipe even a modest distance would cause the lower end to shatter.

It is possible that the two pump rods survived because the buckets are a sliding fit in the barrels. Once the buckets were free of the working barrels, there would be no residual load on the rods. However, the scans are unlikely to detect them because of the factors discussed above.

The NE shaft wall is irregular, and shows a significant loss of material between 28m and 48m depth. This may be due to solution of the salt bed but, if it were, the solution would be expected to occur in all directions. However, the other three walls show very little irregularity.

Alternatively, part of the shaft wall may have broken away. The resultant rock fall could easily have caused the damage to the riser pipes.

As far as the project is concerned:

- It would be prudent to lift the submersible pump, in case that is also dislodged by another fall.
- It is most unlikely that we can retrieve a whole John Thom pump, because the working barrel is probably tangled in the debris in the bottom part of the shaft.
- Because of this debris, it is most unlikely that we can retrieve any artefacts from the shaft or adit.
- It is very likely that the pump buckets are free, so that it will be simple to put a pump in motion without any risk of seizure, or having to dispose of pumped brine.
- If the buckets are not free, we can cut the pump rod, near the surface, confident that this will not cause significant further damage to the pumps or shaft.