APPENDIX 1*: Dukesfield Leat Excavation 2014*, by Pete Lee

Dukesfield Leat Excavation 2014

Pete Lee

The two main sections in this document record some notes of the excavations in the leat at the Dukesfield Lead Smelting Mill: firstly during May 2014; and secondly in July 2014. Before May, the hearthstone-lined leat had been cleared out by earlier digs.

To help the orientation of the explanations, the leat will be assumed to be running *west* (from the dam and weirs upstream in Devil's Water) to *east* (towards the Arches), so facing *north* from the leat is looking down over the bank towards Devil's Water.

May 2014 Excavations

Excavations in May were in two main areas:

1. In the leat itself, at the west end of the cleared section of the leat, and at the east end just before the leat enters the culvert.
2. On the north-facing bank of the leat, where it was assumed the launder(s) must have been taken off to feed the Mill.

1. Leat Excavations

1.1 At the west end of the cleared section of the leat, excavations uncovered a slot between the hearth stones lining the leat floor, running north into the bank, and south to the edge of the lining hearth stones, labelled 1 in Figure 1.

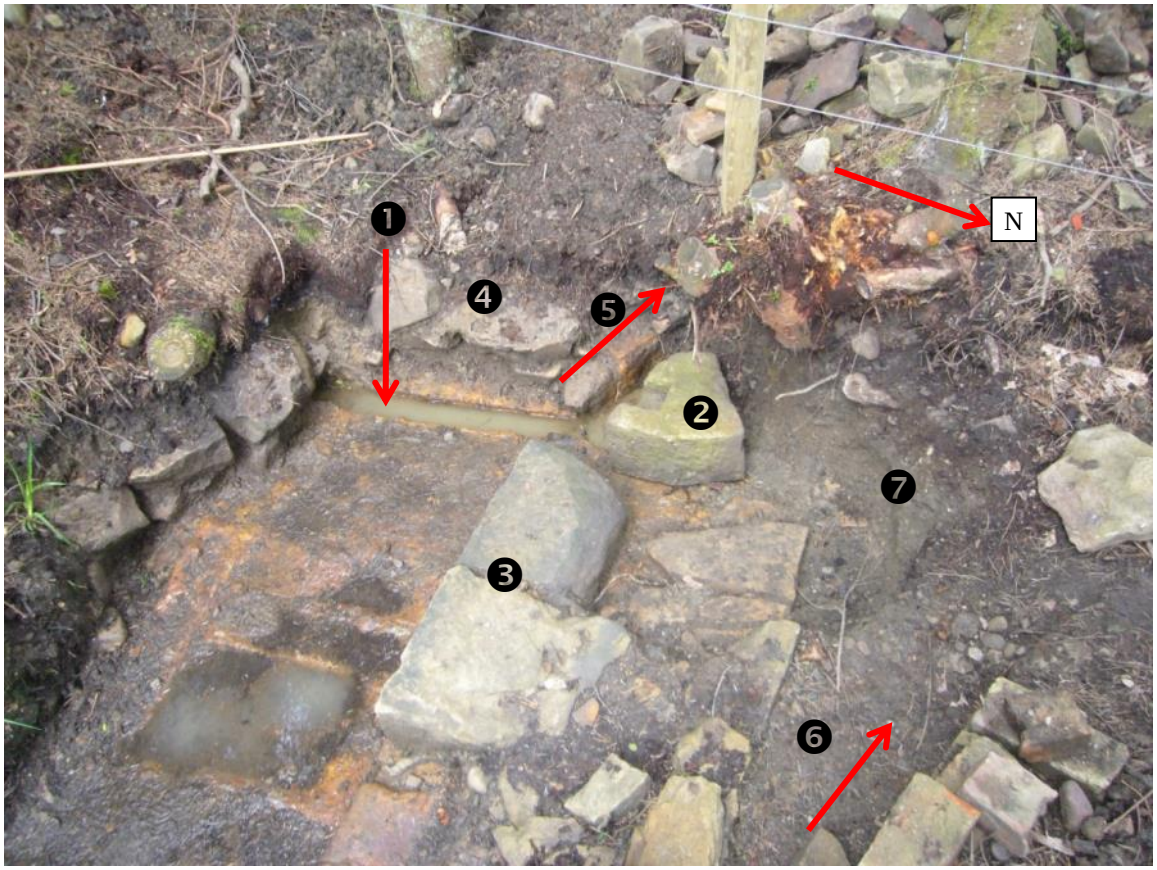

Figure 1. West End Of Leat

1.2 This slot was approximately the same width as the one found in earlier excavations at the east end of the leat near the culvert, which was assumed to be for a sluice gate. Was this another sluice gate?

1.3 The leat appeared to have been blocked off by the stones labelled 4 in Figure 1. Maybe this was done when the Mill was closed down in 1834/6.

1.4 At the north end of the slot a new "reused" hearthstone was uncovered (5 in Figure 1). This was running off at an angle to the leat, under the fence post and trees and stumps, as can be seen in Figure 1. Earlier excavations had uncovered a poorly-constructed single-course brick wall (6 in Figure 1). Is this wall oriented at the same angle as hearthstone 5? Was this an exit from the leat to the middle of the three launders shown on the 1802 map?

1.5 The stone labelled 2 in Figure 1 is not in-situ. This stone was found somewhere in this area of the leat during earlier excavations. The slot in the stone does appear to be the same width as that between the hearthstones, but the stone did not fit into the gap at the end of the two large stones on the north side of the leat (3 in Figure 1). However, stone 2 appears to have been dressed (on the vertical face below the 2 label in Figure 1). It could have been a re-use of a previously dressed piece of stone of course. It is difficult to envisage how that dressed face might have formed part of an external wall in the situation shown in Figure 1. Otherwise, maybe stone 2 formed part of the waterway exit from the leat, with water flowing along this dressed face and with a sluice gate preventing water from flowing west? This would seem strange if the main water supply was to the west from Devil's Water, but might make sense if there was a significant flow of water down the already uncovered stone chute on the south bank of the leat, near the culvert, from a diverted Hall Burn, so that the sluice gate across the face of the culvert together with one at the west end could have given a flow of water out of what might have been the middle launder shown on the 1802 map.

1.6 Excavations at point 7 in Figure 1 revealed flat stones (exit floor?). These stones did appear to end approximately where the 7 label is situated, although more extensive excavations were not undertaken.

1.7 Could the 2 large stones labelled 3 in Figure 1 have been inserted in what was a launder exit, when a launder here was closed down? Maybe the slotted stone 2 also?

1.8 Further excavations in the areas labelled 5, 6 and 7 in Figure 1 would be interesting, to see if the launder shown on the 1802 map could be accurately positioned.

1.9 Excavations at the east end of the leat concentreated on trying to find a possible exit to feed the launder showing on the 1802 map as heading towards the smelt mill. (I think that Richard took a picture of this site before excavations started.)

1.10 The slot (1 in Figure 2) had been uncovered previously, together with timber remnants in the slot.

1.11 A half of an old hearthstone was in-situ approximately in the position identified by 2 in Figure 2. This was removed.

1.12 The fill materials in this area seemed to be of three distinct types:

A. To the left of label 2 in Figure 2 was what seemed to be compacted clay, very hard to dig out, up to the old hearthstone (3 in Figure 2, also visible in Figure 3(b)) running north into the bank and up to stone 4 in Figure 2 in between the hearth stones on the north edge of the leat. This stone looked like it was blocking a possible exitway from the leat. Were the clay and stone 4 there to provide a permanent sealing off of this exitway?

B. Material in the area of label 5 in Figure 2, and to the right of label 2 (and in the water-filled hole) was of a much more sandy consistency, with few stones, and was easy to dig. This material headed north under the surface cobbles (6 in Figure 2), but was not explored further than shown in Figure 2 due to the possibility of collapse. It should be noted that the flat vertical face to the left of label 5 in Figure 2 seemed to appear as a feature.

C. There was wooden shuttering on the east side (7 in Figure 2) which extended horizontally into the bank, but was not excavated further into that bank.

Figure 2. East End of Leat

1.13 Later in the dig, a trial hole was dug in the sand underneath label 2 in Figure 2. This hole is shown in Figure 3.

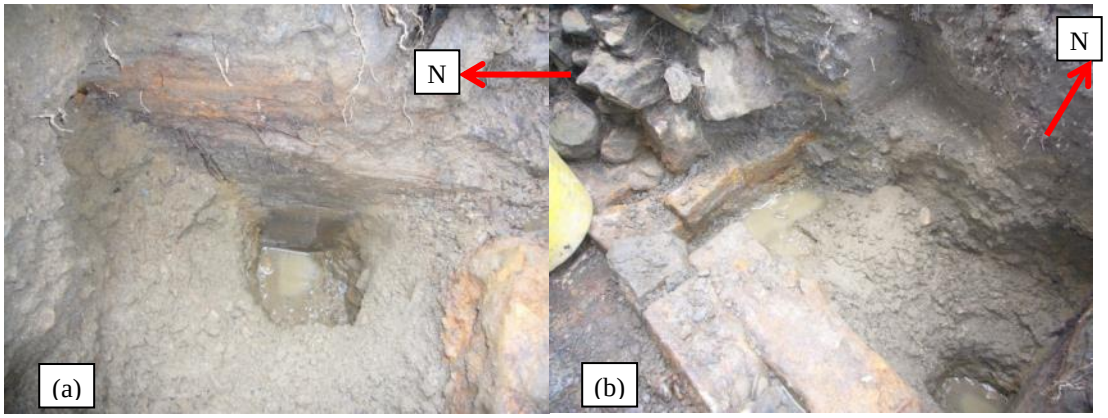

Figure 3. East End of Leat (a) Wooden Shuttering on East Side, and (b) Hearthstone on West

1.14 The material dug through was primarily sand, with very few stones.

1.15 The wooden shuttering extended down, and no obvious "floor" was uncovered, although there may be one further down. The sandy nature of the fill together with the amount of moisture present prevented further vertical excavation. At a depth of approximately 30cm from the floor level of the leat (from memory), a horizontal edge to the wooden boards was uncovered – roughly at the bottom of the hole shown in Figure 2.

1.16 Further excavation in this area would be interesting. The sandy surface uncovered so far couldn't have been in a water exit to a launder, as it would have been washed away. No evidence of a more substantial floor has yet been uncovered. Is there a floor at a deeper depth? If so, maybe the level of the leat was originally much lower than that shown by the hearthstones. Could a first version of the leat, being fed by the older dam on Devil's Water (downstream from the dam/weir by the footbridge),

have been at a lower level, and a subsequent renovation of the leat (when the newer dam/weir was introduced) took place, which included raising the level near the culvert (through the use of the hearthstones) and the sealing off of an original launder exit for the smelt mill? If so, is there a newer launder exit somewhere in this area?

1.17 The possibility of the leat having been renovated (and its banks heightened) is returned to below, in Section 2.19.

2. Leat Bank Excavations

2.1. To try to determine where the exit from the leat to the launder feeding the smelt mill was situated, a 2m x 1m trench was opened on the north bank of the leat, to the north of the cobbled surface (6 in Figure 2).

2.2. The trench is shown in Figure 4. Here the left-hand side of the trench had been taken back to chase what looked like a wall feature extending in line with a tree root (1 in Figure 2).

Figure 4. Trench on Top Of Leat Bank

2.3. Once the top peat/soil surface had been removed, I think the next layer was of a mortar/sand consistency, although this is from memory. (Note to trainee archaeologist Pete: take more notes and pictures!) Figure 5 shows the top layers in the early excavation of the leat bank (see below) which is thought to be similar to that found in the trench.

Figure 5. Top Layers

2.4. The stone-based surface shown in Figure 4 was soon reached. As can be seen in the figure, there were layers of large stones, often with a quite flat upward-facing surface. They gave an appearance of having been placed in situ (rather than being random demolition/fill rubble). There appeared to be many small voids under each layer, also shown in Figure 6 (after further excavations from Figure 4).

Figure 6. Trench on Leat Bank After Further Excavation

2.5. The bottom face of many of the flat stones was black; it was noticed that the stones immersed in the Hall Burn were also showed a similar colouring. Were the stones showing in this trench in a flow of water at some time (although no obvious channel was emerging)? Figure 7 shows a typical underside of a lifted stone, with the sandy colour where this stone was resting on one below. Often, as also shown in Figure 7, there were pebbles stained black under the stone, often "cleaner" than shown in that picture. Some of the rain showers (and un-expert excavation!) had led to sand (and mortar?) being washed in over the surfaces being exposed, particularly in Figure 6 and Figure 7.

Figure 7. Underside of Trench Stone

2.6. The uncovered stones gave the impression that they had been in a flow of water, in a waterway comprising lots of little channels formed by voids between the larger stones (in carefully placed layers). It is difficult to make any sense of such a waterway. The flow of water would not be great (designed to provide a gentle flow of water?), and the level of these stones was much higher than that of the bottom of the leat. However, the stones certainly didn't give an impression of being random in-fill.

2.7. The north-facing vertical section of the trench under label 2 in Figure 4 showed the continuation of the layers of large flat stones, with the characteristics discussed in 2.4 and 2.5 above. It was felt that more might be learned by digging away the bank to the north of the trench, again to try to uncover exits for the launder.

2.8. Figure 8 shows a first stage of the bank excavation, looking south up from the bank, and the edge of the trench discussed above can be seen, marked with labels 1 and 2. Label 3 marks the approximate position (on the top of the leat) of the edge of the wooden shuttering in the leat.

2.9. At this early stage, three areas of stonework, which were thought to be distinct, were apparent, as shown in Figure 8:

A. In the area labelled 4, the stones were more irregular and possibly mortared into place. They gave an impression of forming a rough arch shape (the arch approximately indicated by the dotted red line in Figure 8), although not a normal self-supporting arch which you would get with a tunnel below.

B. In the area labelled 5, the stones seemed more rectangular in shape with flat upper and lower surfaces, and tightly packed, with small voids, but without any mortar, and with the black colouring characteristics descrived in 2.5 above. These characteristics are particularly visible in the vertical section; the horizontal section at the bottom of the photograph is obscured with excavation debris.

C. In the area labelled 6, a stone structure was emerging with the obvious line on the right-hand side

Figure 8. Leat Bank Top and Initial Bank Excavation

2.10. The results of further excavation towards the bottom of Figure 8 and in the area labelled 5, are shown in Figure 9. This shows the emerging stone wall on the right-hand side, the possible arch, and the in-fill between these two features. Is that really an arch, or is it the result of a collapsed vertical wall? The author has little archaeological experience, but it did look like an arch structure more than a collapse (but not a self-supporting arch, as mentioned previously); the stones in-filling between the arch and the wall didn't appear to be collapsed rubble material. In particular, the stones in this in-fill (in the middle metre of the measuring pole) had the characteristics mentioned earlier in sections 2.4 - 2.6, namely of being packed in very tightly, but very cleanly, with no mortar and with lots of little voids. Figure 10 is after further excavation of this in-fill, showing these characteristics more clearly. Figure 11 is a close-up of some of the stones in this in-fill, showing their clean but blackened appearance, with the pointed stone in the foreground being one of the stones on the wall at the right-hand side of the excavation (just above the measuring pole in Figure 9).

Figure 9. Further Leat Bank Excavation

Figure 10. Further Detail of In-Fill

Figure 11. Close-up of In-fill Stones

2.11. Did this "arch" and the stone wall mark the boundaries of a water channel that was in-filled with carefully positioned (and non-mortared) stones, to support the arch and a top surface, yet to give a channel, albeit with the peculiar characteristics noted in 2.6 above? It should be noted that the in-fill stones did build upwards to support the "arch" (so the arch wasn't a structural arch). Note also that the stones in the wall did jut into this possible channel, and formed part of the structure, and had mortar in places. When the in-fill stones were removed, some of these stones in the wall were unstable and had to be removed.

2.12. At this point it was agreed that the material in between the leat trench and bank excavations should be removed. Figure 12 and Figure 13 show a first view after this material was removed.

Figure 12. Bank Excavation Joined to Leat Trench, From Below

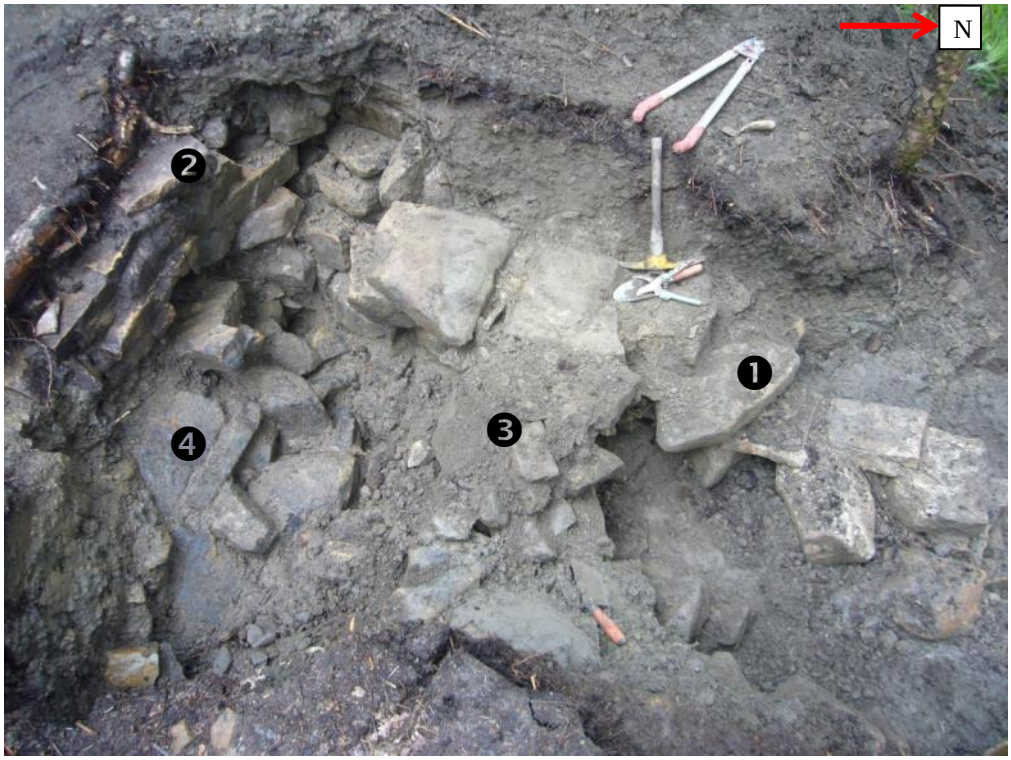

Figure 13. Bank Excavation Joined to Leat Trench, From Above

2.13. Figure 12 and Figure 13 can be related to the earlier bank excavation photographs by the stone labelled 1 (for example, this stone is just above the measuring pole on the wall in Figure 9). The feature labelled 2 is the south edge of the leat trench (labelled 1 in Figure 4). The feature labelled 3 possibly shows how stones at the top of the "arch" were mortared into place.

2.14. Note the feature labelled 4 in Figure 12 and Figure 13. This feature will be discussed below as a possible revetment, and shown in close-up in Figure 14, but here it may be noted that the "arch" and material are on top of this revetment, so were possibly a later feature in the leat/launder development.

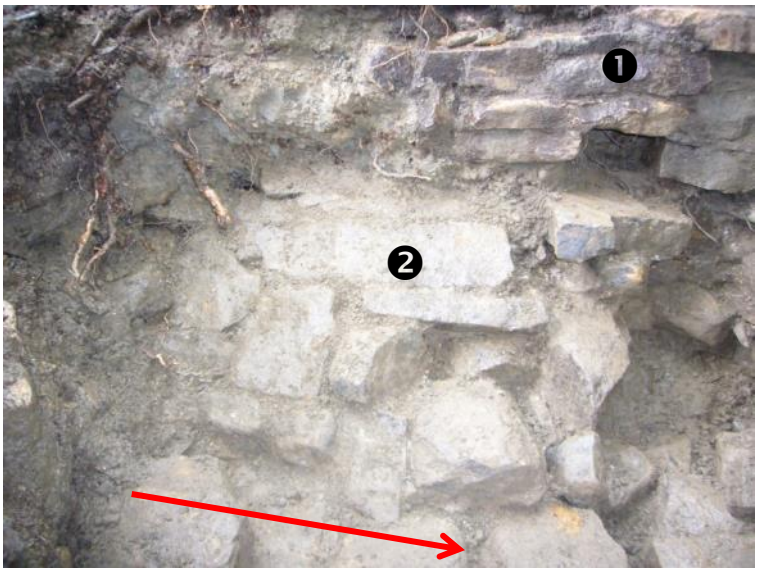

Figure 14. Possible Revetment in Leat Bank

2.15. Figure 14 is a close-up of this revetment feature, in a somewhat uncleaned-up state. Feature 1 is the original south side of the trench, just below the surface. The stones under the red line look to form a footing for this sloping revetment (this is more clearly shown in Figure 15 below.) It is thought that the stones in feature 1 are the same material as those in the revetment itself (labelled 2), although it

would be good to check up on this. Perhaps the revetment is part of the first development of the leat, and the stones were removed and repositioned (labelled 1) as part of a later re-development? This will be discussed further below.

Figure 15. Revetment and Footing Stones?

2.16. After further excavation, shown in Figure 16, the stone wall appears more prominently with random rubble in-filled on the right-hand side. This in-fill certainly looked quite random as compared with the more regular appearance of that between the arch and the wall. Cleared rubble revealed a cobbled-like surface (labelled 1).

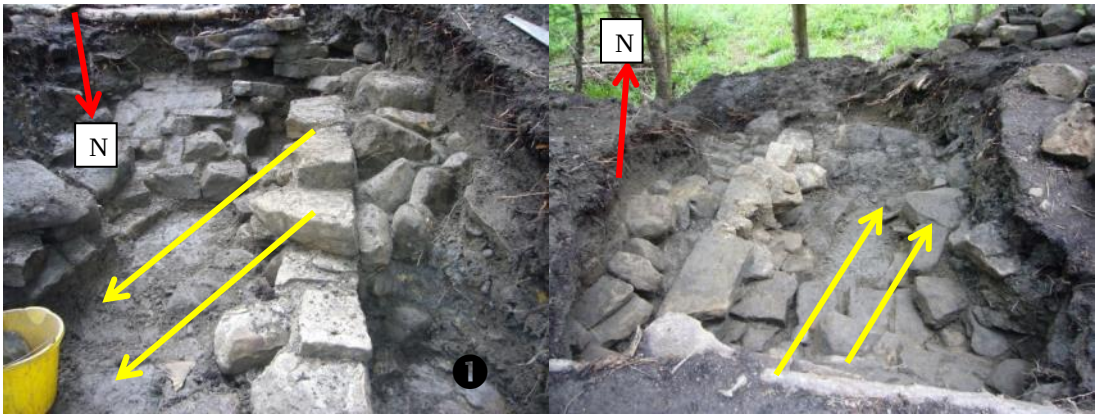

Figure 16. Further Leat Bank Excavation, From Bottom (left) and Top (right)

2.17. Stones in the floor gave an appearance of forming edges marked by the yellow lines in Figure 16. Do the two yellow lines mark the edges of an early water channel that pre-dated the stone wall? Their direction seems in-line with where an exit from the leat (associated with the wooden shuttering discussed in Section 1) might originally have been. It would be interesting to check alignments and levels to see if this "theory" might hold.

2.18. Figure 17 shows the bank after its final May excavation. There are more questions than answers left about the leat and launders.

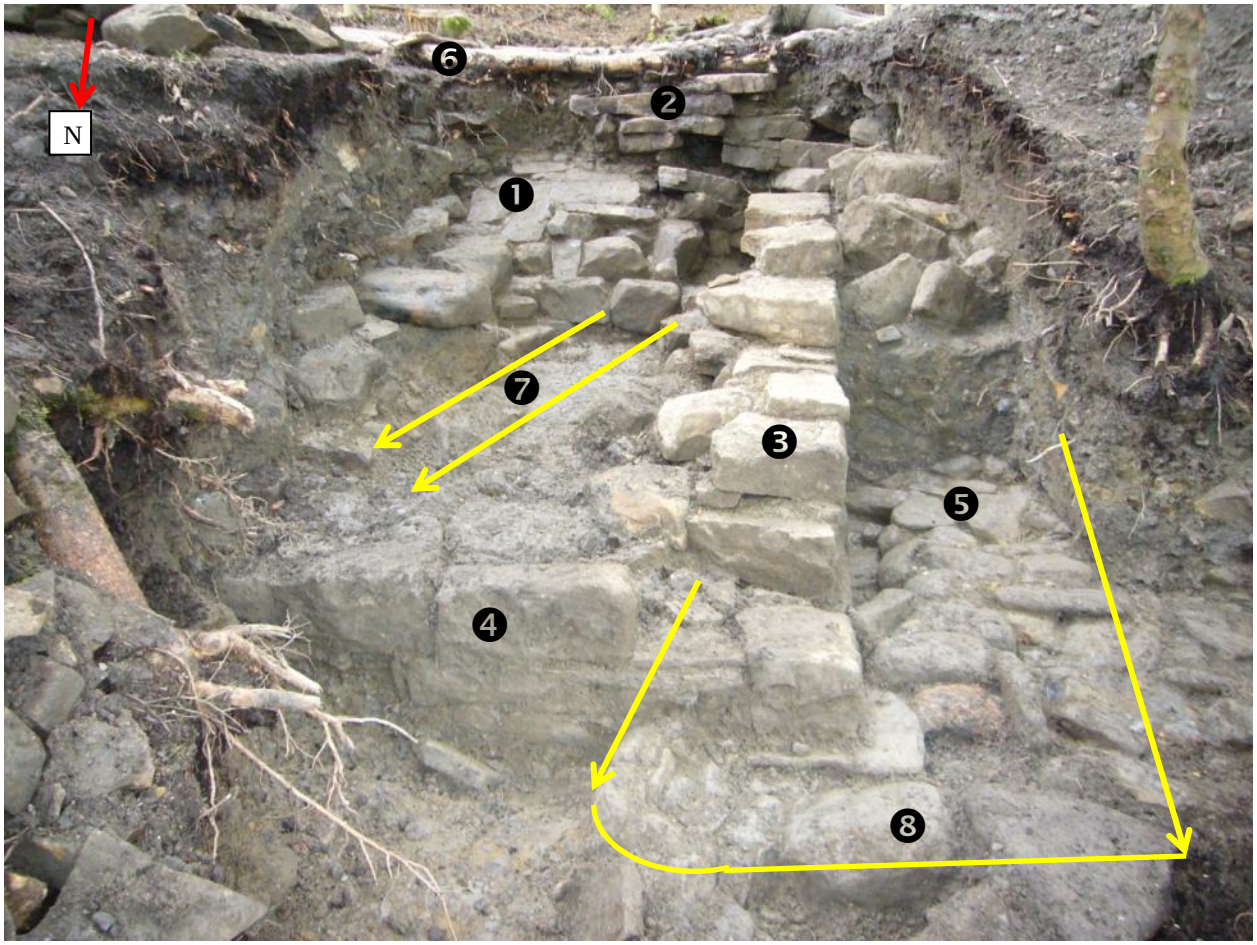

Figure 17. Leat Bank After Final Excavations

2.19. Was the revetment (labelled 1 in Figure 17) part of the first development of a leat, with a bank height (and leat floor level) lower than that visible today. The possibility of there being an earlier lower leat level was discussed in Section 1.16. Was the original leat top approximately where the top of the '1' label is, at the top of the revetment feature, with the leat being redeveloped at a later date to provide additional capacity (with the new dam and weir on Devil's Water upstream of the first dam)? Did that re-development add height to the original leat bank (on top of the revetment), seal off an original low launder exit (somewhere to the right and under label 2), and re-use stones (see 2 in Figure 17) from the revetment to build a new launder exit (see Section 2.15)? Further excavation under the feature labelled 2 in Figure 17 might provide some answers (or pose more questions!).

2.20. Could this so-called revetment have been the floor of a water exit (or overflow)? It seems too high to have been associated with such a function with the leat. If the culvert was contemporary, that surely would act as an overflow channel.

2.21. A number of possibilities for water channels exist:

A. Was there an early water channel, as marked by the yellow lines labelled 7 in Figure 17 (and also seen in Figure 16)? The alignment with a possible leat water exit below 2 in Figure 17 seems approximately correct. Did water flow over the revetment into this channel? The stones visible at the base of the revetment might have been disturbed by a subsequent redevelopment of the leat and water exits? Might this have been an open channel?

B. Was this open channel subsequently covered by the now-removed "arch" (to the left of the yellow lines labelled 7) and wall 3, to form a covered water channel (discussed in Sections 2.10 and 2.11 earlier)?

C. A feature that was belatedly noted is highlighted by the yellow lines labelled 8 in Figure 17. The left-side of the cobbled surface curves upwards, possibly forming one outer edge of a water channel? Was this the floor of the original water channel, subsequently built upon by the stone walls?

D. Was there a water channel to the right of label 3 in Figure 17 (subsequently backfilled with rubble), with the cobbled floor shown in Figure 17 (labelled 5), or was the cobbled floor part of an earlier launder and was left as a working surface? Preliminary excavations to the right of Figure 17 didn't uncover any matching wall that could have formed a channel.

2.22. The stone wall labelled 3 meets with another substantial wall (4) at a right angle. This all is presumably the latest development. Was this the base of a substantial pier that was used for a launder? Why was this wall built with a dressed face, unless it was exposed when the mill was in operation and was covered in at a later stage?

2.23. Not clear in Figure 17, but by label 6 there might be a feature running approximately north-east (heading towards the smelt mill). This feature looks like its aligment is in line with a "green finger" of land protruding from the leat bank in a north-easterly direction, heading directly for the corner of the exposed wheel pit. Is there something to uncover in these areas?

2.24. Further excavations in the leat bank area could obviously try to answer some of these questions. Removing the cobbled surface at the top of the leat bank and excavating down to meet the current excavation shown in Figure 17 (behind 2 and 6) might identify the leat exits. Further excavations to the west would determine whether there was a water channel to the right of the wall. Excavations to the east to find the end of the wall labelled 4 in Figure 17 could help to identify what this structure is.

This concludes the notes from the May 2014 dig.

July 2014 Excavations

This section of the document records my notes of the excavations in the leat area at the Dukesfield Lead Smelting Mill during July 2014, and concludes with some possible scenarios for the developments of the Dukesfield Mill water supply. Excavations were primarily undertaken by the author, Pete J, Joyce, Greg, James, Colin, and Laureen, as well as Marc and Richard.

As before, to help the orientation of the explanations, the leat will be assumed to be running *west* (from the dam and weirs upstream in Devil's Water) to *east* (towards the Arches), so facing *north* from the leat is looking down over the bank towards Devil's Water. Note that Section numbers and figure numbers from here restart from 1. and hence references to sections/figures refer to parts of the document from here onwards, unless otherwise noted. Some of the numeric labels on the figures are referred to in from later parts of the document rather than near to where the figure occurs.

Excavations were in two areas:

1. In the area parallel to the leat, running west/east, eventually uncovering what will be termed the mill pond; and
2. On the north-facing bank, at the east (culvert) end, where it is assumed water feeds to the mill's waterwheel exited.

1. Mill Pond Excavations

1.1. Excavations started in July on the north bank at the culvert end, removing the cobbled surface at the top of the leat bank (see feature labelled 6 in Figure 2 in the May 2014 Leat Excavation Document) and some tree roots, to meet the May excavation shown in Figure 17 (behind labels 2 and 6) in that earlier document. A new area of vertical timber shuttering was uncovered, running parallel to the leat (i.e. east/west), indicated as feature 1 in Figure 1.

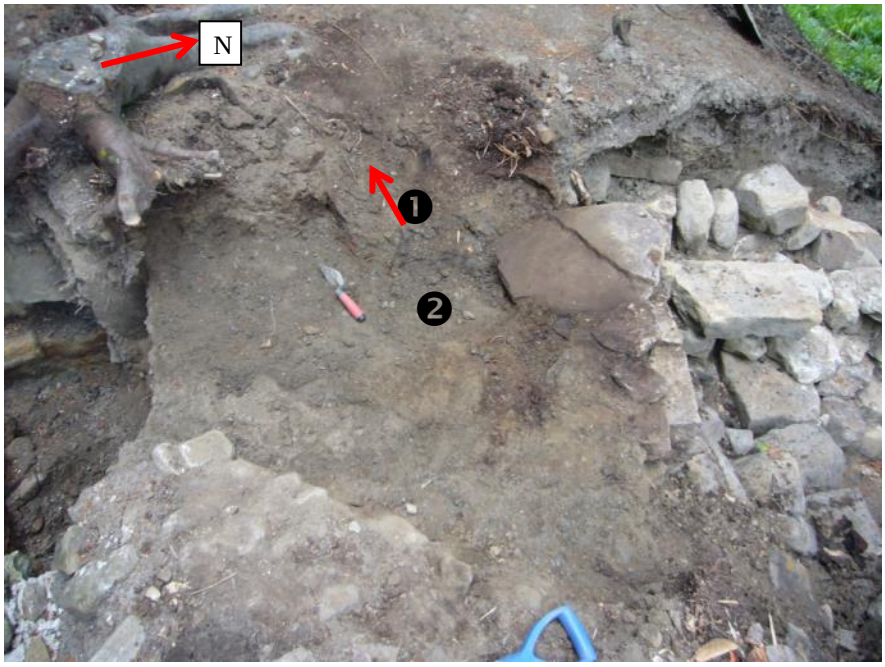

Figure 1. New Vertical Wood Shuttering

1.2. Further excavation in the area labelled 2 in Figure 1 revealed more of this wooden shuttering, shown in Figure 2. A vertical wooden post together with evidence of vertical ironwork is also shown in Figure 2. The ironwork may be in the bag of finds, although it had no distinctive shape or features.

Figure 2. Shuttering and Vertical Post

1.3. The vertical wooden shuttering continued westward under the tree stump. The top of a diagonal piece of timber was uncovered in the area where a launder exit is predicted, heading from this new shuttering to that uncovered earlier (see 1.12 (C) and feature 7 in Figure 2, in the May 2014 document). This is shown in Figure 3 and Figure 4.

Figure 3. Diagonal Timber (behind blue spade handle)

Figure 4. Close-up of Diagonal Timber

1.4. Removal of the tree stump shown at the top of Figure 3 allowed the vertical east/west wooden shuttering to be chased along and excavated. This work in progress is shown in Figure 5. The feature being uncovered will be referred to as "the mill pond" (rather than "mill race", since this feature may have acted partly as a reservoir for feeding the mill's water wheel).

Figure 5. Uncovering the Mill Pond North of the Leat

1.5. The random nature of the the stones facing into the leat (1 in Figure 5), which had been uncovered as part of the earlier leat excavation, was originally puzzling. However, it became clear that the stones facing the leat were the rear of a stone wall, the faced side of which formed the inside face of the mill

pond, with the timber shuttering forming the other side. A section of the typical material filling the mill pond is shown in Figure 6. This comprised a top layer of natural material (0.2M deep, already removed), followed by a light gray clay layer (labelled 1 in Figure 6), and then very sandy material containing small pebbles (labelled 2 in the figure). Although the right-hand photograph in Figure 6 appears to show a cobbled floor, this is believed to be a consequence of the excavation rather than a feature, since the sandy material and wooden shuttering continued below that level for approximately 0.5M where a compacted clay layer was uncovered. This is discussed further subsequently.

Figure 6. Section across Mill Pond

1.6. Excavating the mill pond westward revealed that the wooden shuttering continued right up to, and under, the wire fence marking the current boundary of the site, shown in Figure 7, with a close-up picture of the disappearing shuttering on the right. The top of the shuttering that would have been level with that discovered to the east had disappeared with only the lower level remaining, as shown in Figure 8. All the timber shuttering was in poor condition, with only a thin layer remaining that was infiltrated with small tree roots. Behind the timber framing appeared to be a layer of clay, presumably helping to form a watertight barrier (but also impervious to tree roots).

Figure 7. West End of Mill Pond Excavation (close-up on rhs)

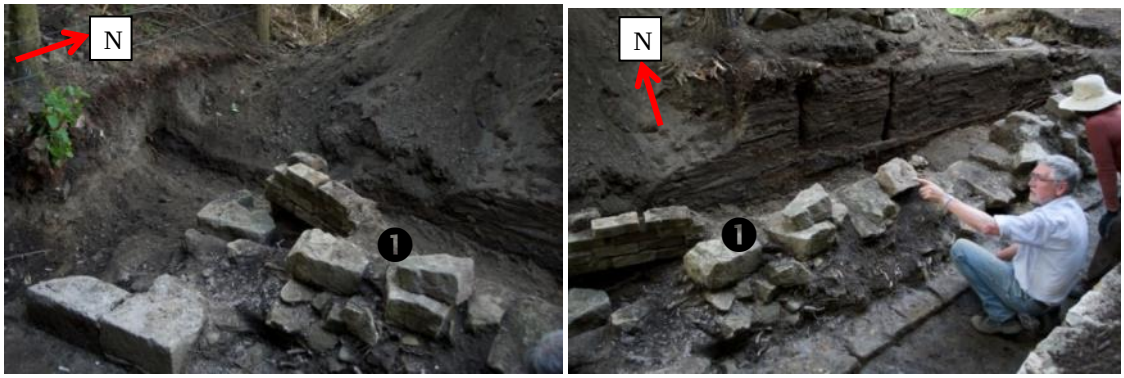

Figure 8. Shuttering Top Disappears

1.7. The flimsy single-course brickwork uncovered in earlier digs at the west end, and labelled 1 in Figure 8, was removed, as was the block of clay (labelled 2 in the earlier Figure 5) at the east end, to enable the sandy layer in the mill pond to be completely removed. Even then, the bottom of the wooden shuttering hadn't been uncovered, so three trial holes were excavated. These had to be dug through hard, gray, compacted clay. The final state of the clearing of the mill pond is shown in Figure 9, with the trial holes labelled 1 – 3. Also in this figure, the position of a number of vertical slots in the wooden shuttering can be seen, labelled 4 – 6.

Figure 9. Cleared Millpond In July 2014

1.8. The trial hole labelled 1 in Figure 9 is at the culvert end of the leat, directly opposite the cobbled chute exposed on the hill on the south bank. Excavating part of the very hard clay floor revealed the bottom of the wooden shuttering, possibly coming down onto a cobbled surface; see Figure 10.

Figure 10. Bottom of Shuttering, Culvert End of Mill Pond

1.9. Holes labelled 2 and 3 in Figure 9 are shown in detail in Figure 11 on the left- and right-hand respectively. The thicker horizontal timber board that is seen in Figure 10 also appears in the detail of hole 2.

Figure 11. Bottom of Shuttering

1.10. Detail of the three horizontal slots seen in Figure 9, labelled 4 – 6, are shown in Figure 12. Were these just part of the construction of the shuttering, or did they have another purpose? A possible answer will be discussed in Section 3.

Figure 12. Slots in Shuttering

1.11. A previous examination of the random stones facing the leat had revealed a possible mini-arch, in the position labelled 3 in Figure 5, where the stones appeared to have been more carefully positioned than in other places. This is shown in detail in Figure 13, before the excavations on the left, and during the excavation on the right. The rear of this area, from the mill pond side, is shown in Figure 14. A possible function for this feature will be discussed in Section 3.

Figure 13. Mini-Arch Facing Leat

Figure 14. Behind Mini-Arch, Mill Pond Side

2. Leat Bank Excavations

2.1. The starting point for the July excavations is shown in Figure 15, on the left-hand side. A more detailed picture of the top area after some excavations is shown on the right-hand side. A possible water exit is clearly visible, with a horizontal stone labelled 3 forming a protruding floor. The stones surrounding this hole were of the same material as those in the sloting revetment to the left, and it is suggested that these stones were originally part of the sloping revetment and removed and reused in a subsequent development of the area. This idea will be explored further in Section 3.

Figure 15. Top of Bank With Possible Water Exit Hole

2.2. The rear of the area in Figure 15 is shown in Figure 16. It can be seen that the level of the hole is approximately the same as the top of the diagonal timber that was discussed earlier in Section 1.3. The small amount of timber that was the vertical post had fallen out after the further excavation, but its position can clearly be seen (labelled 1 in Figure 16).

Figure 16. Possible Launder Exit From Leat Area Side

2.3. The bank on the right-hand side when looking towards Devil's Water was cleared further to uncover the stone feature, running approximately north-east that the May excavations had found. To the unexperienced eye, this stone feature appears to integrate with the sloping revetment wall (see Figure 17), and did not appear to extend any further down the bank. The large tree stump hindered further investigation.

Figure 17. Stone Feature At Top of Bank

2.4. Further clearing of the right-hand bank side (looking towards Devil's Water) revealed more of the large stones (labelled 1 in Figure 18), with a layer of gray clay-like material on top, but no obvious additional features.

Figure 18. Excavation on Right-hand Side of Bank

2.5. At the base of the excavated bank, further clearing of the substantial stone wall (labelled 2 in Figure 15 and in Figure 18) running west/east under the large tree exposed more of the structure of that wall. The tree and its roots prevented finding an answer to whether the end of the wall had been uncovered (see Figure 19).

Figure 19. Stone Wall at Base of Bank

2.6. Excavation down the side of the stone wall labelled 1 in Figure 15 revealed an interesting set of substantial stone steps meeting the previously uncovered cobbled surface, and looking contemporary with that surface (Figure 20). The dressed stone face of this wall was originally puzzing, and it was thought that it perhaps was the inside of a water channel. However, the uncovering of the steps now

suggests that wall's face was dressed because of the steps. The May excavations had suggested the stone walls were a later development than the cobbled surface, so that development presumably kept the steps as a feature. Looking at the left-hand picture of the steps in Figure 20, do they appear to be curving to the right-hand side towards the top?

Figure 20. Stone Steps in Bank

2.7. Figure 21 shows the top of the bank after further excavations down to the protuding stone labelled 3 in Figure 15. Clay is again prominent in the bank (labelled 1) and above the stones labelled 2, as if sealing those areas and making them watertight. The area around and under 2 appears to consist of large stones with many voids around them, rather than random in-fill, a characteristic of the area under the bank when first excavated (described in the May 2014 report) , although there was not time to investigate this further. At the time of this photograph, the steps described above had not been uncovered.

Figure 21. Excavations at Top Of Leat Bank

2.8. Excavations at the top of the bank continued down to the level which was the top of the sloping revetment, including removal of the protruding stone mentioned in Section 2.9 above. This work uncovered the top of yet another piece of timber, running west/east across the top of the revetment,

and indicated by the yellow arrow in the view from above in Figure 22. A more detailed picture of the ends of this timber are shown in Figure 23, the left-hand one in particular does look like a slot structure.

Figure 22. Timber Across Top of Sloping Revetment

Figure 23. Detail of Ends of Timber on Revetment Top

2.9. A trial hole was dug to expose more of the timber, as seen in Figure 24. A brick can clearly be seen, possibly part of in-fill when some feature here was decomissioned, but time prevented further excavation, and the hole was filled in to preserve the feature.

Figure 24. Detail of Timber Across Revetment Top

2.10. A view of the bank excavation at the end of the July dig is given in Figure 25, from the top standing on the east side and looking down.

Figure 25. Bank after July Dig

3. Water Supply at Dukesfield: A Possible Scenario

A possible scenario for the developments of the water supply at Dukesfield is given below. All subsequent sentences should be prefaced by "Possibly ..."!

The first use of water at Dukesfield might have involved the use of the Hall Burn and a waterwheel facing north/south. No evidence of this has been sought or uncovered, and the developments described below, and the building of the arches, probably removed any traces of that earliest development.

The first development on the undeveloped hillside facing Devil's Water was of the Mill Pond, as it was called above. This supplied a launder and an overshot waterwheel, the pit for which can be seen at the north foot of the Arches. A major re-development subsequently occurred when the Mill's output was increased significantly, when the Mill Pond was closed down and filled in, and the leat and the dams and weirs on Devil's Water were built. This re-development had been completed by 1802 (as shown on the 1802 map, see Figure 36 below). It is believed that this re-development supplied a different waterwheel to the west of the one by the arches, in the flat area of ground to the west of the Dukesfield Hall track. No excavation of this area has been undertaken to identify this other wheelpit. However, sightings from the possible launder exits from the leat, to be discussed below, seem to support this realignment of the launder and possibility of the undiscovered wheelpit.

3.1. Mill Pond Development

The Mill Pond was dug into the bank, with a faced stone retaining wall on the upper (south) bank side, and the timber shuttering on the north (Devil's Water) side. The spoil from this digging was thrown down the bank, resulting in the "widening" of the bank as it descends down towards the track. This widening has been somewhat obscured by the spoil from the May and July digs, but an indication of the widening from the original hillside slope is provided by the area immediately to the west of the currently fenced area which has not been disturbed. That area is shown in Figure 26 and Figure 27. Given that the wooden shuttering of the Mill Pond was found to be extending westward into this uninvestigated area, and given the size of the flat area of the banking in this area (see Figure 26), there is a strong possibility that further extensions of the already uncovered Mill Pond could be found in that area.

Figure 26. Undisturbed Bank to West From The Top

Figure 27. Bank From Below, Excavated Area on Left of Fence

The water supply to the Mill Pond was primarily from the Hall Burn, which was probably diverted completely to feed the Mill Pond via the cobbled chute near the later-developed culvert. There are a number of stone structures on the Hall Burn up the hill towards Dukesfield Hall that support this possibility, and further investigations there could reveal the feed into the Mill Pond below. The stone chute entered the East end of the Mill Pond, with vertical timber shuttering along that east side built into the bank. Remains of this shuttering have been uncovered. The feature labelled 2 in Figure 16 shows this vertical shuttering close to where the launder exit is assumed to be. Figure 28 below shows the line of the shuttering in front of the culvert (built later) and the end of the cobbled chute (labelled 1), perhaps also indicating that the slot was retained as a sluice gate in the re-development. Figure 29shows a close up of the shuttering (after the culvert walls had been rebuilt), but comparing that picture with Figure 28 suggests the timber pre-dates the culvert and leat development. The excavation in the floor of the east end of the Mill Pond, as shown in Figure 10, has exposed what looks like cobbles and hence the possible end of the cobbled shute, which the leat development has cut across.

Figure 28. Line of Mill Pond Shuttering

Figure 29. Line of Shuttering At East End of Mill Pond

A further possible water feed into the Mill Pond was provided via the "mini-arch" that was described earlier in Section 1.11 and shown in Figure 13. The subsequent leat development has destroyed any evidence of the entrance from the mini-arch into the Mill Pond (blocked off with clay – see Figure 14) and any evidence of a water feed into this mini-arch, but there may well be other feeds as yet uncovered on the hillside to the west of the cobbled chute.

The slots discovered in the west/east timber shuttering in the Milll Pond (features labelled 4, 5 and 6 in **Figure 9**) are not uniformly distributed which might suggest a function other than supporting the shuttering. Could some or all of these slots have been associated with sluice gates controlling the water in the Mill Pond? Slots 5 and 6 (and see the right-hand picture in Figure 13) could have held a sluice gate controlling the water entering from the mini-arch, controlling its flow to the west or east. Could the stone steps provide access for the workers to those sluice gates?

The exit from the Mill Pond to a launder has yet to be properly uncovered. However, there are strong indications of its position. Figure 30 shows the sloping revetment and the possible exit hole to the right, marked in yellow, while Figure 31 shows the view from the top and the possible water channel that aligns with that exit, again

marked in yellow. Manual viewing of the direction of this channel shows alignment with the wheelpit at the foot of the Arches. The exit, having been blocked up by the later development, is not cleanly delineated

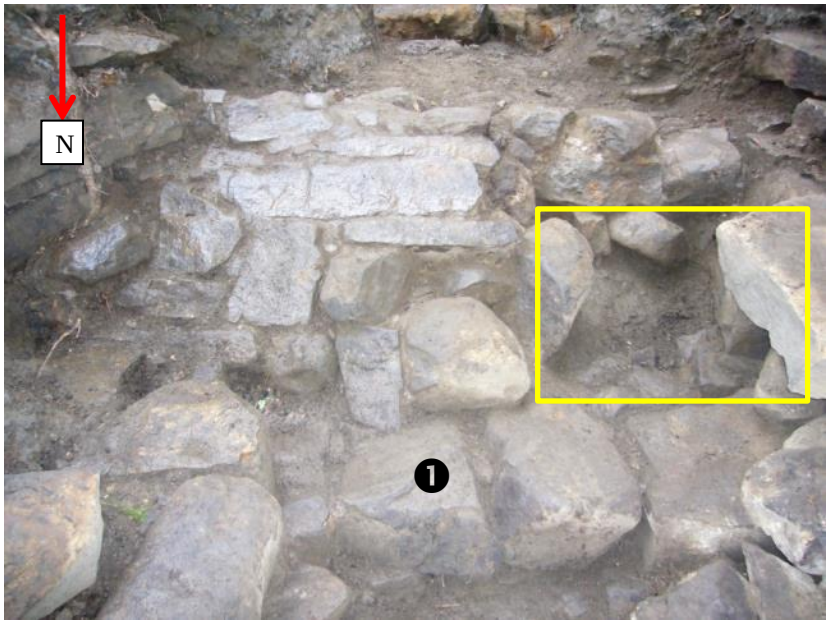

Figure 30. Exit From Mill Pond to Launder

Figure 31. Water Channel From Mill Pond

Figure 32 shows the alignment of the stone chute (1) and the possible water exit point (outlined in yellow).

Figure 32. Cobbled Water Chute and Possible Water Exit Point

A launder could have taken the water from the Mill Pond exit by the horizontal stones that seem to form the base of the sloping revetment (labelled 1 in Figure 30 and Figure 31 above), with an open channel then acting as a drain for leaks. Alternatively, the launder could have started further down the bank where the cobbled surface seems to end, under the stone wall which is assumed to be part of the later development (see Figure 19). This alternative seems less likely as it would result in a loss of height and hence water power,

In this scenario it would seem clear that the sloping revetment is then actually an overflow exit for the Mill Pond, draining into the channel and down the bank.

The timber discovered running across the top of the revetment (see section 2.8 and Figure 22 - Figure 24) could be the remains of a sluice gate controlling this Mill Pond exit, left in place in the later re-development to seal the exit. Further excavations of this timber seem highly desirable.

The exit on the Mill Pond side has yet to be uncovered. Looking at Figure 10, the exit could well be behind the thick board labelled 1, with that board having been added when the Mill Pond was decommissioned following the leat development. It would be interesting to see whether any "level" information captured by the archaeologists shows that the bottom of this board and the suggested Mill Pond exit on the bank are in horizontal alignment.

3.2. Leat Development

It is known that the smelting capacity of Dukesfield Mill was increased substantially around 1750, so that period would be an appropriate point at which the water power to the Mill had to be increased. Hence, a re-development of the Mill Pond discussed in Section 3.1 took place.

It is suggested that the leat was built as part of this re-development, being dug into the bank to the south of the Mill Pond's retaining wall. The leat was initially fed from the old dam and weir on Devil's Water about ¼ of a mile up from the Mill site, and subsequently with a leat extension to the dam and weir further up-stream. The culvert was built to act as an overflow water route. These developments provided an extra supply of water. The supply of water from the Hall Burn may have continued to be used, unless developments to the East of the Arches required all of the Hall Burn's supply.

The Mill Pond was lined with clay at the bottom, and possibly with the horizontal thicker boards that were found (see Section 1.9), filled with the sand and pebble material, and capped with a clay-like layer. Could the sandy fill – see **Figure 6** - discovered in the Mill Pond be natural material from the excavation of the Leat?

At the culvert end, old hearth stones were laid across the Mill Pond as foundations (see features labelled 1 in Figure 33), and a clay wall (2 in Figure 33) built on top of this, with its inner face (3) angled towards the exit at the top of the bank (4). There was possibly some wooden shuttering across between 3 and 4 to form the west side of the water exit. See Figure 9 also.

Figure 33. Features of Leat Development

The old Mill Pond water exit on the Mill Pond side was blocked with the board and clay (see Figure 10), as mentioned at the end of Section 3.1. The floor level around this exit was then increased up to the level of the leat bottom (see left-hand photograph in Figure 29), with the diagonal piece of wood helping to raise the floor level between the leat side and the exit through the bank towards Devil's Water. See Section 2.2 and Figure 16.

The Mill Pond exit on the bank size was filled in with clay and stones, and the sloping revetment partly dismantled to provide some flat stones that were used to build up the height of the wall above this revetment, and to form a water exit from the leat. This exit hole is shown on the left in Figure 34 (repeated from Figure 15), together with an earlier picture on the right from the top taken in May (from approximately where the person in the left is standing) of a trench excavated down to the top of this feature. The stone labelled 1 in each picture is believed to be the same stone. Also, see Sections 2.1 and 2.2, and Figure 15 and Figure 16. The increased height of the water exit would provide additional power to the Mill's machines, and possibly powered a waterwheel to the west of that below the Arches. This will be discussed further below.

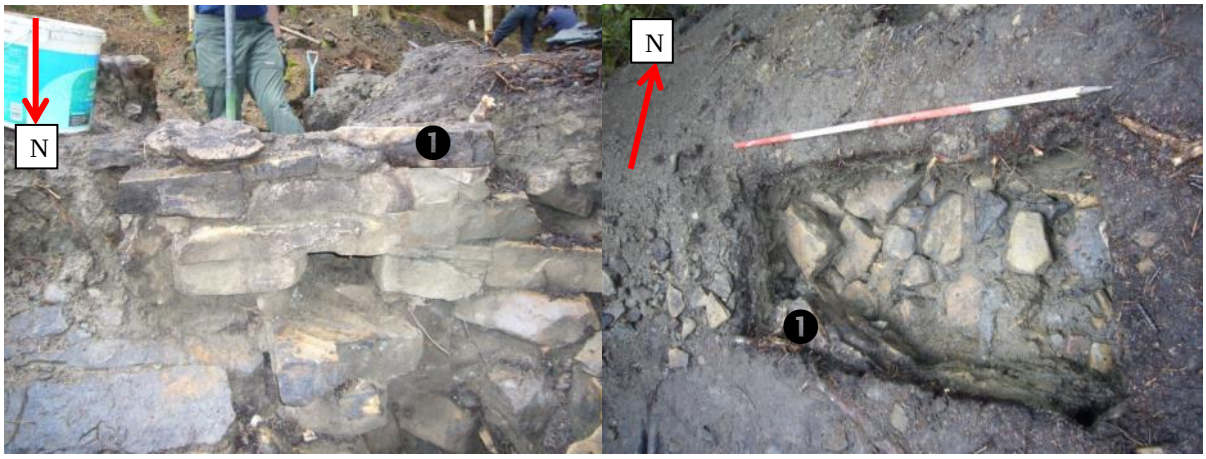

Figure 34. Leat Exit

It is presumed that the substantial stone walls labelled 1 and 2 in Figure 15 were built as part of this re-development, as they are, in parts, on top of earlier stonework/cobbles. What was the purpose of these walls? Given their engineering, it could be assumed that they were built to carry something substantial, such as a wooden launder attached to the exit from the leat shown in Figure 15 and Figure 34. A launder there would provide additional height to the water carried to the Mill compared to a launder taken from the bottom of the stone walls.

A launder at the bottom would have required water to flow in some form of channel to the left of stone wall 1 in Figure 15. The possibility of a water channel there was investigated in the May document, with some features suggesting the flow of water (blackened stones, stones laid without mortar to form voids). However, experts who visited the site didn't think that was a possibility, as water flows to feed machinery usually needed a smooth pathway. Perhaps the stones found between the stone wall and the bank on the east side were in-fill used when the leat was decommissioned, However, some of the features uncovered in May suggested that stones were more carefully positioned than might have been the case for a "demolition job". (Please see the May section above for more details.)

The May excavation suggested that this area of the bank was constructed as a sort of internally-supported archway, from the east bank onto the stone wall. A chronological sequence of photographs (Figure 35) from May illustrate what was uncovered. The stone labelled 1 is believed to be common across all of the shots (and is also visible in Figure 15, just above the 1 label in the left-hand photograph).

Figure 35. Excavation Sequence in Bank

Photographs in Figure 35 shows the stone wall and "internally-supported arch" (illustrated by the yellow line, just above the horizontal measuring pole). A capping layer of light gray clay is also visible just below the brown

layer of natural material. Was this all part of the construction, or part of the decommissioning? As mentioned in the May section, the in-fill stones seemed to have been carefully positioned, without mortar, and integrated into the construction of the wall (e.g. stones jutting from the wall were supported by stones inside), so the possibility of this being part of a decommissioning seems unlikely. If it was part of the construction that clay layer would presumably form a resonably watertight seal, so if a wooden launder was above it, leaks from the launder wouldn't soak away into that area. However, it would provide a surface upon which the workers could walk to access the area (e.g. to any sluice gates). Moreover, the area would act as a drain for any leakage from the old Mill Pond exit, and perhaps that was its only function.

So, the hypothesis is that the leat development constructed the substantial stone walls to act as a pier for a new wooden launder, and the area on the east bank was carefully filled with large stones, positioned to ensure that small voids remained and could act as a drain. A final layer of stones (the internally-supported arch) was then covered by a layer of clay-like material, to form a working surface.

Visual sightings of the direction of the pier and its launder suggests it was oriented in a slightly different direction from the earlier launder discussed in Section 3.1. As was noted, the earlier launder headed towards the wheelpit at the bottom of the Arches. The later launder is oriented to the west of that, and would appear to align with the end of an extended smelt mill as shown on the 1802 map (Figure 36).

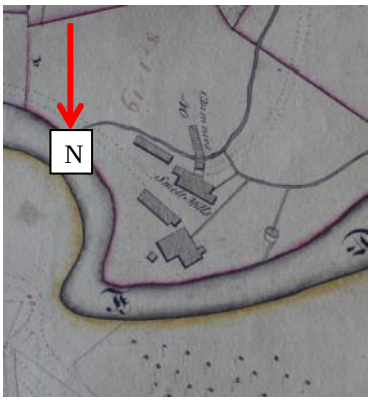

Figure 36. Buildings From 1802 Map

It is suggested that a new wheelpit (as yet undiscovered) was constructed, and an overshot waterwheel (possibly the wheel repositioned from the bottom of the Arches) was used to power the machinery, with new hearths in an extended mill and the old hearths at the foot of the Arches. Some evidence uncovered suggested that the new wheel was oriented north/south, with a shaft taken over to the old hearths – the evidence is a solid and substantial "pillar" built in the area at the foot of the arches (which could have carried the shaft and its bearings), together with a possible iron-lined channel aligning with this pillar and extending under the track that leads up to Dukesfield Hall.

The developments described in Section 3.1, and those in Section 3.2, are outlined on an aerial photograph of the site that was taken by www.flynorth.tv after the backfill and consolidation of the overall site had been completed. Figure 37 shows the water power that involved the Mill Pond and the wheelpit at the bottom of the Arches, while that in Figure 38 shows what is thought to be the later redevelopments.

The flat area to the west of the Dukesfield Hall track, where the extended smelt mill and as-yet undiscovered wheel pit could be situated, would be a great place for further excavations to help unpik more of the story behind the Dukesfield Mill water power provisions.

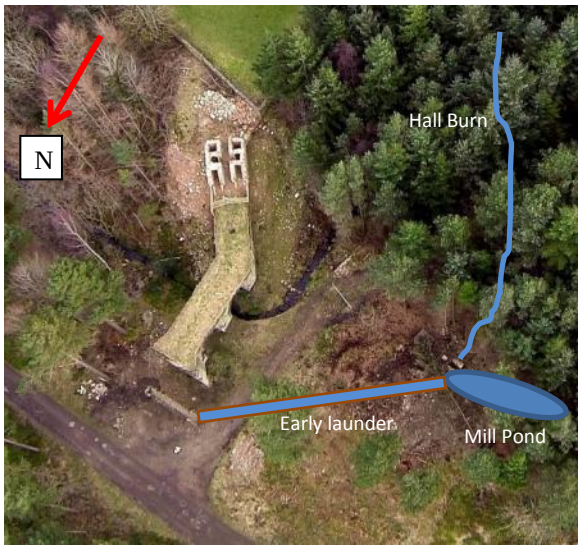

Figure 37. Initial Water Power

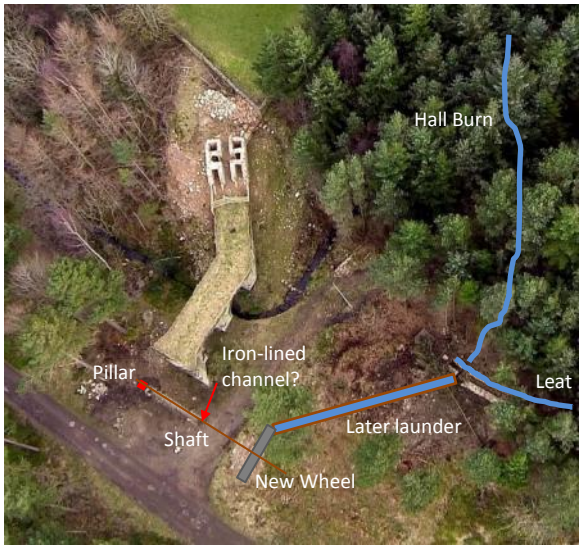

Figure 38. Later Water Power