“An attempt at sealing natural water-holes or ‘swallows’ in the River Alyn”

The team of Halkyn miners employed to carry out the River Alyn work in the 1930s
Although this photograph does not form part of the 1938 report, the negative is affixed to it, placed there by Peter Wild at the time he deposited the document with Flintshire Records Office

Notes

Water from the River Alyn sinks into countless ‘swallows’ along the course of the Alyn gorge, between the hamlets of Loggerheads and Rhydymwyn. This water then follows an underground route into the Milwr Tunnel, where at times of heavy rain, lead mining operations were adversely affected. This reprint describes the extensive work carried out by Halkyn District United Mines in the 1930s identifying and sealing the many swallows. Despite this, new swallows soon appeared and the work in general had little, if any, long term effect.

The report is complete, although parts have been re-typed and several images re-drawn for clarity. The original is held by Flintshire Record Office, Hawarden, reference: ***D/DM/872/7****. It was rescued by the late Peter Wild in the 1970s whilst working as photographer for Courtaulds, Greenfield (shareholders in HDUM), who were clearing out old papers. Mine explorers were first given the opportunity of taking copies, then Peter lodged the document with the Records Office.*

Although the report is detailed, the gauging data contained can only be regarded as a record of conditions at the time. For example:

- *Although the text refers to the losses between Footbridge and Leaning tree, the gauging data makes no mention of these. Presumably the report was compiled after the work on the area was carried out, and the sealing at that time was successful. Today however, the area once again, accounts for significant losses.*
- *Inlets between weirs 8 and 9 are shown as adding an average of 669 gallons a minute to the river, presumably from the “Hawarden Waterworks springs” fed by Ogof Hen Ffynnonnau. No springs today appear in this area except under flood conditions.*
- *Negligible loss is shown between weirs 4 and 6. This includes the Devils’ Gorge area, which today accounts for significant losses*

Reprint compiled 2020 by C. Ebbs

D/DM/872/7

REPORT

ON

ATTEMPTS TO SEAL RIVER ALYN 'SWALLOWS'

February 10th 1938.

HALKYN DISTRICT UNITED MINES LIMITED

10th February, 1938

An attempt at sealing natural water-holes or 'swallows' in the River Alyn

Reporting to the Mold Mines as long ago as June 1824, John Taylor remarked that the diversion of water from the River Alyn into the leat did not lessen the water in the mines, so that it was even then realised that there was probably some connection between the leakage from this river and underground waters. The connection was definitely confirmed by tests carried out early in this century, and on several occasions comparitively recently.

The probability is that fissures crossing the leat connected with those fissures which are now known to communicate with our workings, and, in any case, the artificial channel was not of sufficient capacity to deal with the whole flow of the river in times of flood.

Many methods of overcoming the evil have been suggested from time to time e.g.

a) Canalising certain sections of the river

b) Re-opening and enlarging the leat

c) Piping the flow over bad stretches

d) Tunnelling from the Loggerheads through the hill to below Gwernymynydd and so completely cut out the Loggerheads-Rhydymwyn section of the river

none of which was proceeded with owing to cost.

The difficulty was aggravated in 1901 when the 1875 tunnel drained the Llynypandy lode, since which date the river has been absolutely dry at Rhydymwyn for several months in each year.

Several of the principal 'swallows' have been known for many years, and others were discovered in 1931 when the river was low, by diverting it past each leakage until the water disappeared again, diverting it once more etc. etc. until the water was made to flow about ¾ mile beyond the point at which it disappeared normally.

Weirs were erected at various points along the river and on its tributaries in the autumn of 1931 and weekly gaugings have been taken since that time. They have shown losses which vary up to over 6,000 gpm depending on the state of the river.

In 1935 an examination was made of the dam erected by the old men through a stope a short distance to the west of Mountain Shaft on Lode 576. The inspection was made in time of flood, when the dam was found to have been breached at the top and to be overflowing and leaking badly. The overflow was stopped, but it was not found possible to seal the leakages. The building up of the dam, however, caused excess water, in times of flood, to return to the river.

Dye tests have since shown that the water disappearing in the 'swallows' finds its way to the dam, and thence to the workings on Lode 576 .
(Appendix A).

The whole of the feed issuing at the western end of the workings on this lode, however, does not emanate from the river, as is proved by the fact that in September last, when the total average flow at Maeshafn, which is above all known leakages, was 824 gpm, the feed entering the mine South of Lode 621 was 1700 gpm, or more than twice the volume which disappeared from the river.
A probable explanation of this is given in Appendix 'B'.

Several methods of establishing the connection between surface and underground waters have been tried, e.g. puddled clay, sawdust, aniline dye, potassium permanganate and fluorescein.

Aniline dye was discarded as not being sufficiently permanent, permanganate because it was found that the grip water and silt, when treated chemically, gave a permanganate discolouration due to their manganese contents (Appendix 'C').
Fluorescein was looked on askance on account of its cost, until a cheap supply was discovered from I.C.I., and this, which gave a distinct colouration when diluted to the extent of 1 part in 4,000,000 has been used in all recent experiments.

A definate link has been established on more than one occasion between the water disappearing at Glan Alyn and also at Tan-y-graig with Lodes 576 and 596, a feature worthy of note being that the time lag between Glan Alyn and Lode 576 as about 20 hours (Appendix 'A'), whereas that between Tan-y-graig and the same point underground was ten hours only. The respective distances are approximately 1.72 miles and 1.55 miles, so that a reduction in distance of 10% leads to a reduction in time lag of 50%, pointing to the fact that the connection from Tan-y-graig is much more free and direct than that from Glan Alyn.

During the summer of 1936 a considerable amount of work was done between the Loggerheads and Pont Newydd, which consisted in cutting four new channels (photos 1 & 2) to divert the stream away from known bad sections, building a concrete wall to segregate the flow from leakages at Glan Alyn (photo 3) and exposing fissures and filling them either with concrete or bags of earth. During the ensuing winter floods, it was found, however, that little or no good had been done, and that conditions underground were not improved. This was due to leakages in the diversions and under the concrete fillings, and to the fact that there were many hidden 'swallows' which had not been exposed for filling.

During the floods of last spring an attempt was made to improve matters by depositing in the river bed, at various points from loggerheads to Rhydymwyn, upwards of 5,000 cubic yards of ashes,
in the hope that these would be sucked into the 'swallows' and so seal them. This again had little or no effect.

These floods showed that the diversions were not of sufficient capacity to deal with the maximum flow, and as water had overflowed the concrete wall at Glan Alyn and some of the dams at the ends of the diversions had either been overflowed or given way, a section of the wall was increased in height, and the dams built up and strengthened. It is worthy of note that in enlarging the diversions, new leakages were exposed, showing the futility of attempting to cure the evil by this method.

The use of ashes for sealing leaks in launders and reservoirs is a well known remedy, and it can be demonstrated that it is very efficacious in the former case so long as the launder is not disturbed. It was therefore decided to test this method in the river by deliberately re-opening a leak which had been sealed during the summer of 1936, and experimenting upon it. It was found that ashes containing clinkers and large pieces were useless, but that if the fines through a ¼ inch screen were used, good results could be obtained, and these were further improved by the addition of slimes, in the proportion of approximately two of ashes to one of slimes. It was further found that slow feeding of the mixture was far more efficient than feeding it rapidly, the presumption being that, in the former case, it was carried further down the fissure and had time to build up and consolidate.

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PHOTOGRAPH NO. 1.

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PHOTOGRAPH NO. 2

Mine captain, Jack Francis

No. 2 Weir in Abereilun Diversion, looking downstream .

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PHOTOGRAPH NO. 3

No. 1 weir at Glan Alun, showing concrete wall on right, and old mill foundations in right background. Dam at downstream end of diversion in distance. Swallows filled in foreground, and area below weir pitched.

The section of the river in which leakages are known or suspected to occur extends from Loggerheads to Rhydymwyn (plan 1), a distance of approximately 4½ miles, measured along the river bed, but there appear to be comparatively long stretches included in this section in which there are no leakages. The worst known sections are Big Tree and Leaning Tree area (plan 2), Glan Alyn area (plan 3), Tan-y-graig area (plan 4) whilst other losses occur in the Maes-y-groes area, above Pont Newydd Bridge, at Llyn-y-pandy lode and above Rhydymwyn Foundry (Bryncelyn Lode). In the aggregate, these leaking sections amount to not more than about one mile in length.

Although there are numberless leakages in the river bed, the water which has been proved to enter the mine from this source does so from three or four points only, showing that somewhere between the points of leakages and the workings the network of surface fissures must converge into a few major ones, connected to a great extent with lode 576.

Applying this theory during last summer, it was decided to open the major known fissures in some of the worst sections of the river, in the hope that the water would carry the mixture of ashes and slimes throught the complicated surface network of fissures and deposit it in the main channels below, and so seal the feeds into the mine.

In order to show the results of the work a number of temporary weirs were erected, built of earth-filled bags and planks (diagram 1), at various points along the river, viz:-

	Glan yr afon	(damaged)
	Footbridge	(damaged)
	Big Tree	(damaged)
No. 1	Glan Alyn (photo 3)	
No. 2	Abereilun, in second diversion (photos 1 & 2)	
No. 3	Tan-y-graig (photo 4)	
No. 4	Tan lan	
No. 5	Pensarn	(now dismantled)
No. 6	Maes-y-groes	
No. 7	Bluff	
No. 8	Pont Newydd	
No. 9	Llyn-y-pandy	
No. 10	Nant Alyn	(damaged)

Two small weirs were also erected in the tail race from the Loggerheads Mill, which showed a loss up to 300 gpm between them. Their sites are shown on Plan 1.

When the work was carried out the river was very low, so that leaks which were large during times of flood, were not active in the circumstances pertaining, and in order to simulate flood conditions, and so bring to light leakages on the banks, eight temporary earth and stone dams were built between Footbridge and No. 4 weirs, and these answered their purposes fairly well, showing up certain losses which were not evident during times of drought, and in other case showing that there were no losses other than those which were known.

In order to give details of the work carried out during the summer and autumn of 1937, the river may be divided conveniently into three sections, viz: Footbridge to Leaning Tree, Glan Alun area and Tan-y-graig area, and details of the work accomplished in each section, not necessarily in chronological order, are given below.

Reference to the banks are given looking upstream.

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PHOTOGRAPH NO. 4

No. 3 Weir at downstream end of Tan-y-graig Area.
Note wall on far side of bank of river.

Footbridge to Leaning Tree Area (Plan 2)

The 'swallow' which had previously been filled, and which was re-opened for experimental purposes, was situated on the left bank at 'A' about 40 feet below Leaning Tree. This was capable of taking a feed of approximately 150 gpm. The 'swallow' was dammed off from the stream and connected to it by means of a launder, the feed being regulated as required. About a barrowful of unscreened ashes was then fed into the launder and carried into the excavation. The water soon backed up, but it was found that little or no good had been done.

The 'swallow' was again cleaned out to a greater depth, but this time was fed with the fines through a quarter inch screen. About five times the quantity of ashes used in the first experiment was fed in before the water backed up, and the leakage appeared to be sealed for a few days, after which a slight leak developed. The 'swallow' was opened a third time and fed with a mixture of two of ashes to one of slime, when the leakage was stopped. About 15 cu. yards of ashes and slimes were required to seal this 'swallow'.

In all 'swallows' which were filled subsequently a similar mixture of ashes and slimes was used.

Three major 'swallows' were opened in this area, two of them (B and C) (photos 5,6 & 7) close together at the leat wall, on the left bank 160 feet below Footbridge weir, and they absorbed at times nearly 3,000 gpm, and one on the right bank at 'F' a short distance above the stepping stones, through which as much as 1,000 gpm disappeared. These were all successfully sealed by diverting the stream into them through a 20 inch pipe, out of which a section was cut, and through which the mixture of ashes and slimes was fed. The two upper 'swallows' absorbed about 71 cu. yards of mixture, and the lower one 15 cu. yards.

One disturbing feature was that two smaller 'swallows' were not affected by the sealing, and had to be filled separately. This points to the probability that these smaller leakages joined the main leaks beyond the point to which the ashes had penetrated, and similar experiences were met with in other instances.

The two weirs in this section showed a leakage of up to 50 gpm between them, excluding the leakages down the major 'swallows', and considerable time was spent trying to trace this. Finally, by dividing the bed into small sub-sections by means of temporary dams, it was found that the loss was confined to a comparatively small area immediately above Big Tree weir and near the concrete shelf made in 1936 alonside the Big Tree. Furthermore, it was discovered that there were numerous small leaks under the shelf, in the river bed, and through the retaining wall on the left bank. These were all dealt with in the usual manner, and leaks which were found at Big Tree and in the field on the right bank, which were active in times of flood only, were also treated with about 31 cu. yards of mixture.

After the river had risen, two bank 'swallows' (G & H) were discovered in the right bank a short distance above Leaning Tree. These were also filled with about 12 cu. yards of mixture but conditions were such that it was not possible to open them down to the solid rock.

Despite the large amount of work done in this area gaugings show that there is still a loss of about 350 gpm between Footbridge and Big Tree weirs, and it probably occurs in bed leaks which are always most difficult to identify, and all efforts to find them have been unsuccessful.

The major 'swallows' were kept open until the last so that the river could be diverted down them at will, and so give dry conditions for other work in this section and further downstream.

Approximately 147 cu. yards of ashes and slimes were used in this area.

A retaining wall was built for about 100 feet along the right bank opposite to Leaning Tree, and all important fillings were pitched with large stones in order to prevent any scouring action.

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PHOTOGRAPH NO. 5

Leat Wall 'swallow' "B" showing water pouring down 'swallow' before filling.

PHOTOGRAPH NO. 6.

Leat Wall 'swallow' "B". Note 20 inch pipe delivering water and man filling mixture through hole cut out of pipe.

Glan Alun Area (Plan 3)

This has long been known to be one of the worst areas; as much as 8,000 gpm has been seen to disappear near the old mill on the right bank (photo 3) and there were numerous other leakages in the bed, and in the limestone outcrop on the left bank, past which the stream was diverted in 1936.

The first work here was to make a breach through the concrete wall, and fit this with a sluice, so that the river could be diverted at will into the 'swallows' on the south side of the wall, or turned down its natural course. This ensured dry conditions for carrying out work below this point under normal river flow, and answered its purpose admirably.

The first 'swallow' opened was on the left bank, opposite the concrete wall at 'A' (see plan). This was sunk to a depth of 16 feet when several horizontal fissures were exposed. It was capable of taking over 1,600 gpm and dye tests proved it was connected with the largest of the known 'swallows' on the south side of the concrete wall. The 'swallow' was fed with minus ¼ inch ashes to the top of the excavation but it was found that a leak of over 150 gpm still occurred. It was again cleaned out and fed with a 2/1 mixture of ashes and slimes, which proved highly successful, and reduced the capacity of the large 'swallow' referred to to 800 gpm.

The permanancy of the sealing was tested by allowing the river to run over the filling, when it was obvious that another leakage had opened up in the bed at 'B'. This was exposed by sinking through badly shattered limestone on three sides, the fourth side being a large fissure filled with clay. The fissures were more or less horizontal, and as no vertical one was found at a depth of 18.5 feet, the stream was turned into the excavation which was rapidly filled up to the level of the fissures, through which the whole flow disappeared.
The 'swallow' was filled in the usual way and a complete seal made. The two 'swallows' absorbed about 143 cu. yards of mixture.

There are still considerable leakages, and it was obvious that the principal channel through which they occurred, had not yet been found. One of the 'swallows' on the south side of the concrete wall was, therefore, excavated at 'C' and a fissure running parallel to the wall was found at a depth of 8 feet, which proved to be capable of taking a small flow only. Further sinking proved no important fissure, and the pit was abandoned in favour of a trench 'D', nearer the wall. Water caused trouble in sinking this, but the diversion of the river down 'swallows' in the Big Tree area led to dry conditions and work continued without any trouble under this head. The same horizontal fissure which had been exposed in the first pit was found in the trench, in which it showed a marked tendency to run under the wall and towards the river bed. Water was then turned down the river from the 'swallows' in the Big Tree area, when a dimunition was noticed in the Glan Alun diversion. Fluorescein was used in the diversion and the colouration was found in both the pit and the trench.

At a depth of about 8 feet in this trench a peculiar bronze ring was found, which the authorities at the British Museum stated was probably a piece of horse harness of ancient British date. This is now lodged at the Museum.

Inasmuch as the flow from the trench was towards the bed of the river, the next pit 'E' was sunk in the bed some 20 feet below No. 1 weir. This was timbered and sunk to a depth of 22 feet, at which the same feed was encountered, coming in through shattered limestone. Two new feeds were also found at this depth which fluorescein showed were not connected with the trench to the south of the wall, but that they came from the bed of the diversion.

A second pit 'F' was sunk slightly downstream from the last, when it was found that all feeds had converged and flowed towards the left bank.

The third pit ‘G’ on plan, was sunk downstream and nearer the left bank in order to intercept the feeds which were running horizontally. This at a depth of 22 feet had not got into touch with the water, so a drift (photo 8) was commenced under the left bank, and this in 10 feet broke into a small cavern, through which all feeds appeared to pass. The drift was continued for a total length of 69 feet along the watercourse, which ran more or less horizontally and was at times of small capacity, and as there were no signs of any fissure dipping vertically, the drift was stopped, and arrangements made to fill it with ashes and slimes.

A point of interest was that, in several of the small fissures met with, there were traces of ashes which proved penetration during previous experiments.

In order to ensure that the mixture of ashes and slimes was delivered into the drift, a breach was made in No. 1 weir, and a 12 inch pipe built in. The pipe line was continued to the drift, and had incorporated in it a tee piece through which the mixture was filled. At first it appeared that the fissures were not capable of taking much water, but in the level rising to the roof of the drift, they absorbed the maximum flow through the 12 inch pipe line with a head of 2.5 feet. When the mixture had risen to the roof of the drift and the water was overflowing downstream, the inflow was stopped, and it was noticed that the level fell to 18 inches from the top of the pit, at which it remained constant. The phenomenon had been experienced previously and it had been found that it was caused by high level ‘swallows’, probably running more or less horizontally. The pit was, therefore, filled with the mixture until the level of the leakage was reached, and above that level the filling was kept agitated by means of a rake, thus ensuring that the finer particles would be carried forward into the fissure. This method successfully sealed the leakage.

The stream was then turned over the pit, and on diverting it again by opening the sluice, it was found that there were serious leakages between the timbers supporting the pit, and the alluvium through which it had been started. The majority of the timber was then removed and the pit re-fed with ashes and slime, which stopped all visible leakages; 170 cu. yards of mixture was used in this pit.

Two or three small ‘swallows’ later developed between No. 1 weir (photo 3) and the pit and these were stopped in the usual way.

The area was pitched with large stones over a length of 70 feet from the weir, and the river turned over the pitched area for 24 hours. On stopping the flow, a further bed leak was discovered 10 feet below the weir, and on removing the pitching a cavity approximately 3 feet deep by 2 feet square was discovered. This was also sealed and when the water was turned down the river bed once more, no leakages could be discovered.

The ‘swallow’ in the trench behind the concrete wall was also filled with 40 cu. yards of mixtures.

An important ‘swallow’ at the weir measuring post was excavated to a depth of 7 feet and was found to be capable of taking a feed in excess of 500 gpm. It was anticipated that the sealing would have the effect of stopping this, but this was not the case, and dye tests failed to show its connection with any of them.

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PHOTOGRAPH NO. 8

Men in drift from pit 'G' at Glan Alun.

The ‘swallow’ was dammed off from the stream and a connection made to it by means of a section of 20 inch pipe, out of which a section 18 inches X 10 inches had been cut, and through which the mixture was fed. This method of feeding through the pipe was used in several cases, and it has the following advantages:

a) The flow can be diverted directly into the excavation without cascading down the sides and carrying gravel etc. with it.

b) A grid fixed over the end of the pipe prevents the entrance of leaves etc. into the fissure, and this was particularly important as the work was done in the autumn.

c) By using a plate over the end of the pipe the flow can be regulated.

This ‘swallow’ required far more mixture to fill it than was anticipated, and about 105 cu. yards was used, showing that the penetration must have been very considerable.

As there was a certain amount of visible leakage through the banks of the diversion, and as considerable underflows were also suspected, three ‘swallows’ were opened in the old river bed, one of which was proved to be capable of allowing 1,000 gpm to leak through it.

In excavating for strengthening the dam at the downstream end of the diversion a leakage of over 400 gpm was found, and this and other ‘swallows’ in the bed were all satisfactorily sealed by the use of about 115 cu. yards of mixture.

Lastly, the dam referred to, through which the loss had been serious, was built up and the leakage is now not more than 5 to 10 gpm.

In all, about 589 cu. yards of mixture were used in this area.

Tan-y-graig Area (Plan 4)

From the point of view of leakage, this area is amongst the worst stretches along the whole course of the river and, as already remarked, water dyed here discoloured the water in lode 576 in about 10 hours.

Two important leakages were cleaned down to bedrock at ‘A’ and ‘B’ below the point at which the Abereilun Brook joins the main stream, one in the river bed and one on the right bank, the latter being capable of taking several thousand gallons per minute. The bed ‘swallow’ at ‘A’ appeared to be honeycombed under concrete which had been laid in 1936, and the fissure in ‘B’ radiated in all directions over about 270°. The complicated system of fissures in these ‘swallows’ is shown in photograph No.9.

These two ‘swallows’ were amongst the earliest treated, and were first filled with unscreened ashes. These, at the outset, appeared to have reduced the leakages to small dimensions, and there was a small overflow over No.3 weir (photo No.4) for a short time. This soon ceased, when it was noticed that there was a seepage through the fillings, and that a new and larger ‘swallow’ had opened in the bed above them at ‘C’ and finally the leakage was traced to ‘D’.

‘A’ and ‘B’ were again cleaned out and a pit sunk at ‘D’. The fissure was followed vertically through gravel and shattered limestone to a depth of nearly 20 feet, and plumbed for a further 19 feet, at which depth it appeared to turn off.

The water shortage had now become so acute that no flow could be obtained at Tan-y-graig, so attention was diverted to ‘swallows’ upstream in the Glan Alun and Big Tree Areas.

It was not until the end of October that there was sufficient flow in the river to allow of any further sealing being done in this area.

The temporary dams had brought to light two left bank ‘swallows’ at ‘E’ and ‘F’ from 100 feet to 150 feet above the Aber Eilun confluence. The track from Tan-y-graig field was extended to these, and they were sealed with 126 cu. yards of mixture.

Before filling the main fissures in this area, two dams were built across the river in the positions shown by dotted lines on plan. Two 20 inch pipe lines were incorporated in the upper dam, one leading direct into the ‘swallow’ to be filled and the other through the lower dam, in order to act as a by-pass (photo No.10) should the volume of water become too great to be absorbed by the ‘swallow’. It was thus possible to regulate the feed of water, and to isolate the ‘swallows’ from it should occasion arise. The 20 inch pipeline was carried to the top of the centre of the excavation, thence through a wooden box and to the bottom through 12 inch pipes, which ensured that all ashes and slimes fed through the opening in the pipe were delivered to the bottom of the fissure. The method proved very successful.

The first ‘swallow’ dealt with was at ‘D’. The water was turned through the pipes and so regulated that the maximum churning effect occurred in the box without overflow. The mixture was then added, and the excavation filled until it began to build up in the pit, when the flow was stopped by turning it into the by-pass. The lowermost length of 12 inch pipe was removed, the same procedure being repeated as it became necessary to remove the remaining lengths. The ‘swallow’ was eventually sealed, and the portion of the mixture which overflowed under the concrete shelf sealed the ‘swallow’ at ‘C’. The filling of these two ‘swallows’ used about 200 cu. yards of mixture.

On the assumption that all the leakages in this area were connected with that at ‘D’, which appeared to be the principal one, it was hoped that the sealing of it would also affect the very large ‘swallow’ in the right bank at ‘B’, but this unfortunately was found not to be the case, and the fissures at ‘B’ were still easily capable of passing several thousand gallons per minute, and at the time were absorbing the whole capacity of a 20 inch pipe working under a head of about 9 inches.

The pipeline was continued to ‘B’, and the ‘swallow’ at this point was not sealed until about 300 cu. yards of mixture had been fed into it. This again points to great penetration, as the actual excavation made was not more than about 8 cu/ yards.

A small cavity, which had been covered by a thin crust of alluvium opened up accidentally in the sealed area, and although large quantities of water had evidently passed through it at one time, it was found that it was now incapable of permitting any flow.

Finally, the area between the two dams was flooded, after which the water was turned through the by-pass, and as no leakage could be detected, it was considered that the area had been dealt with satisfactorily, and the dams were removed.

The whole area (photo No.10) approximately 110 feet by 28 feet was then pitched with large stones to prevent erosion of the filling, a strong dry wall, pointed at the upstream end, being built into the right bank, and the left bank graded and pitched.

As the temporary dams had server their purpose and might cause flooding, they were removed.

Work Downstream from Tan-y-graig

A ‘swallow’ on the right bank below Tan Lan was filled with bags and the filling in the ‘swallow’ on the left bank, a short distance below the Hawarden Waterworks Springs, was repaired. One or two small holes, which had been made in the bed of the river on the approximate line of lode 576 were filled in, and this concluded the work for the time being.

PHOTOGRAPH NO. 9

View downwards to show complicated system of fissures in 'swallow' "B" at Tan-y-graig.

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PHOTOGRAPH NO. 10

Cleaning up Tan-y-graig Area after sealing 'swallows'. By-pass pipe shown on right and No. 3 weir in distance. Note track from ashes dump on right and retaining wall on left.

CONCLUSIONS

Appendix ‘F’ This shows the details of weir gaugings and a graph summarising the leakages between the temporary weirs that were erected along the river during last summer to divide it into smaller sections than hitherto.

Although the gaugings give anomalous results in some cases, the readings of these weirs, together with those of the permanent ones give a much closer idea as to where the leakages in the mine workings are occurring, and from these it appears that the greatest losses are between weirs Nos. 1 to 6, and especially between Nos. 1 and 2 and Nos. 3 and 4. The other most serious loss is between No 9 weir and the Foundry, which is probably fairly equally divided between weirs 9 to 10 and 10 to Foundry, which stretches embrace respectively the Llynypandy and Bryncelyn Lodes. That being so, it would seem that any further work done should be concentrated in those sections of the river bed.

We consider that it has been proved that individual ‘swallows’ can be sealed by ash – slime mixture, and it is indicated that there is such a vast number of ‘swallows’ along the river bed that any further effort should be concentrated on stretches where greatest leakages are shown.

There have been no serious floods since operations were suspended and it it too early as yet to form an opinion as to the efficacy of the work carried out in 1937 (Appendix ‘D’).

Daily gaugings are being taken along the whole course of the river from Maeshafn to Rhydymwyn, the maximum of which has, so far, shown that about 45,000 gpm at Maeshafn plus over 9,000 gpm joining the stream below that point, a total of 54,000 gpm. This volume, which is much above the average annual flow, has caused no inconvenience underground, and it certainly would have done so a year ago, but how much of the improvement in underground conditions is due to work done on the river, and how much to the dredging and enlargement of the grip it is at present impossible to say.

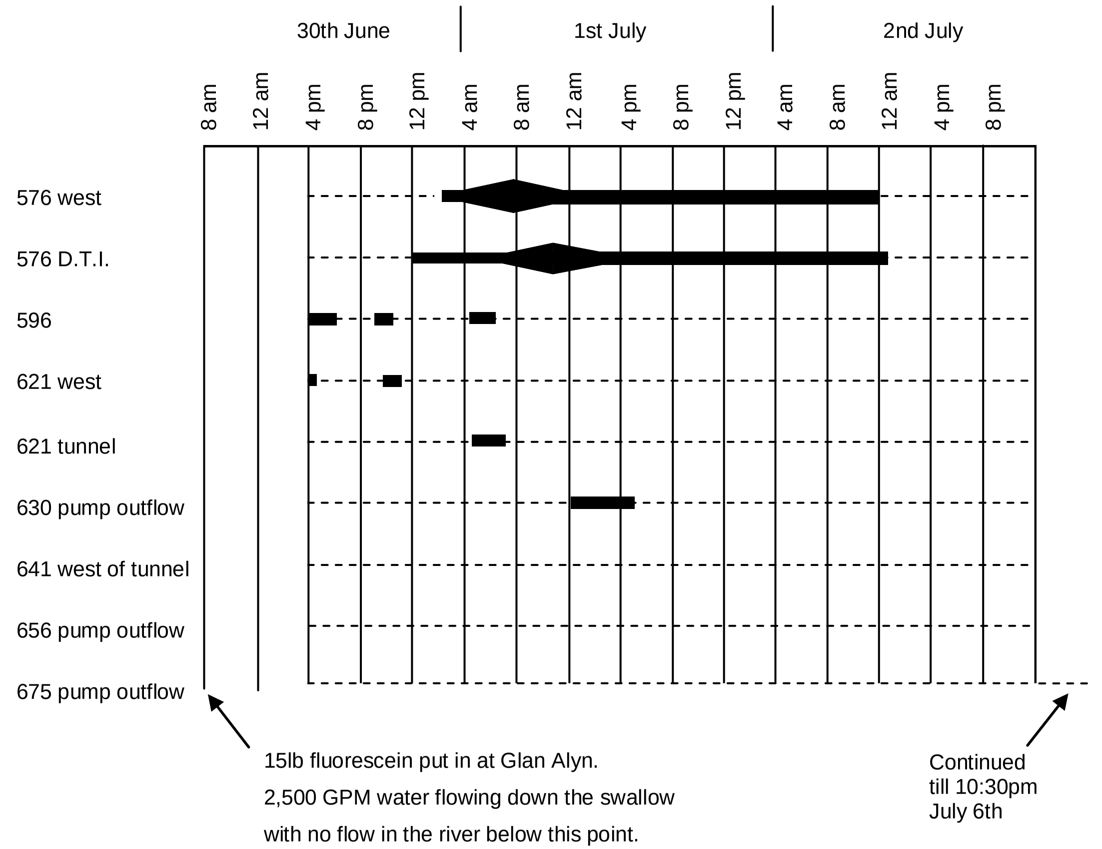
These daily gaugings, however, show serious losses in areas which have already been dealt with, though, despite intensive research, no leakages are visible in them. The total leakage to the Foundry in this abnormally dry winter is still about 5,000 gpm.

Another disappointment has been to find that practically each individual leakage had to be treated, as it was found that penetration of the mixture was not sufficient to reach the ‘mother’ fissure, as cut by the underground workings, into which all of a network of surface leakages must converge.
A further disquieting feature has been the opening up of new ‘swallows’ in the neighbourhood of several of those sealed.

JLF/PAB
19/3/38

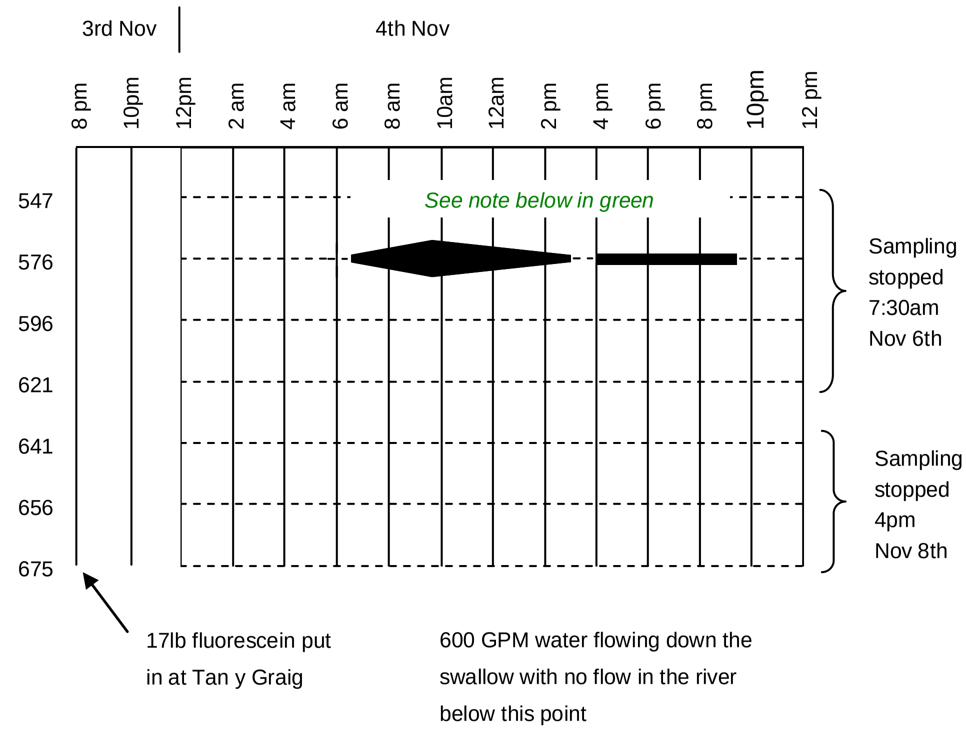
Glan Alyn Area dye test 30th June 1937

Record of underground samples



Tan y Graig Area dye test 3rd November 1937

Record of underground samples



NB The original report shows discolouration occurring at Lode 547 and not 576, but the text makes this clear that this was an error. It has therefore been corrected to Lode 576 (C.E.)

Broken horizontal lines indicate period of sampling

Shaded areas indicate period when sampling coloured

Tan-y-Bryn.
15-8-37.

APPENDIX "B"

RIVER ALYN AND SURFACE DRAINAGE CONTROL

In examining the aspects of this problem, in regard to the volume and origin of the various sources of water entering the mine workings, it may safely be assumed that there are two main factors, viz:-

(1) The River Alyn and its tributaries.

(2) Other subsidiary feeders.

The first sketch shows a section of the River Alyn under normal and flood conditions in a comparatively low graded portion of the river, in which impervious clay may reasonably form the bed of the river.

In normal periods of rainfall, when the level of the river is low, the feed of water draining into the mine workings at this point may be accounted for as follows :

(a) Very little from the River
and
(b) A proportionately large volume from

surface fissures, other than those draining into the river, which latter are comparatively few in number, and form a small proportion of those leaking over the whole area occupied by the Company.

In flood periods The volume of water draining into the mine becomes :

(a) A very much larger amount from the River Alyn.
and
(b) An increased amount from surface leakages other than those connected with the river, the two factors together making the underground drainage problem very acute.

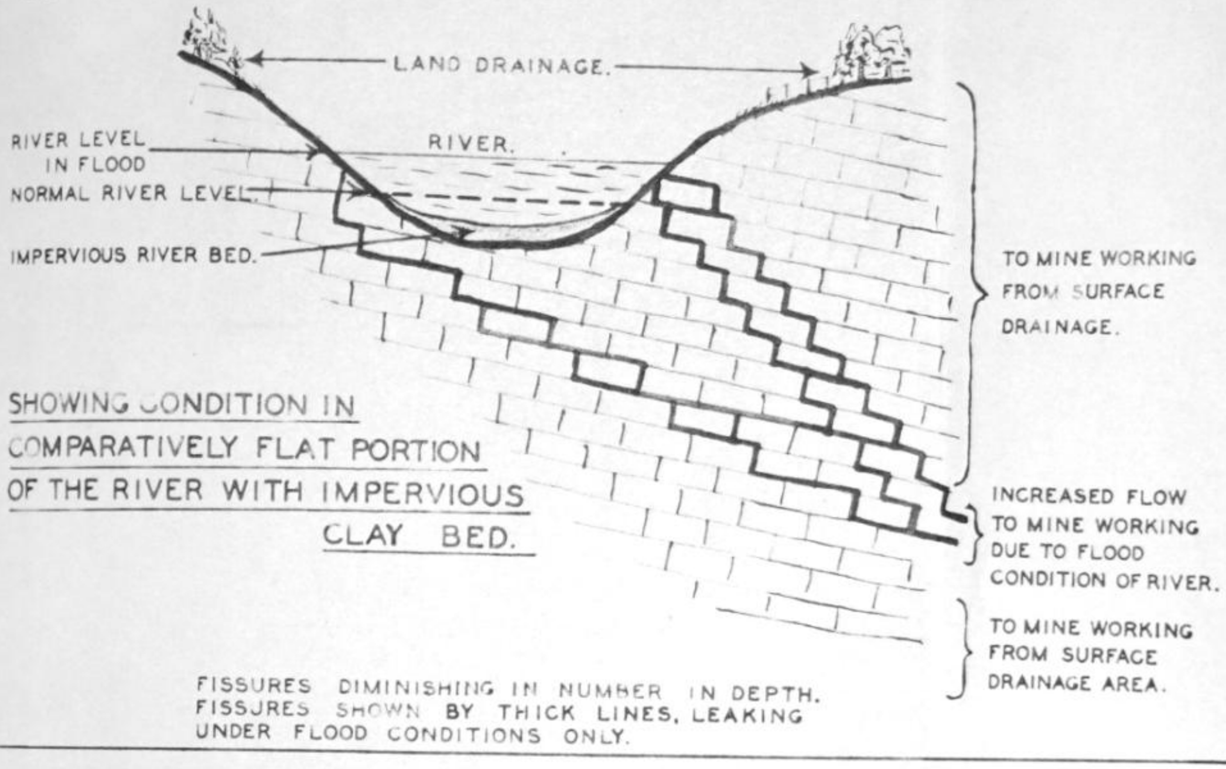
The second sketch represents a section of the river in a more steeply graded part, where the large volume of water leaking into the mine under normal conditions is greatly increased in floods. This, of course, is coupled with a proportionate increase from the leakages mentioned in (b) above.

Another difficulty in this problem may possibly be due to inaccurate conclusions as to the amount of water following the river Alyn water course, as it is not improbable that a greater body of water may be flowing than is supposed, as is illustrated in the third section across the river Alyn, in a part of the stream, passing over a highly porous and broken stretch of the river bed.

IDEAL CROSS-SECTION ON RIVER.

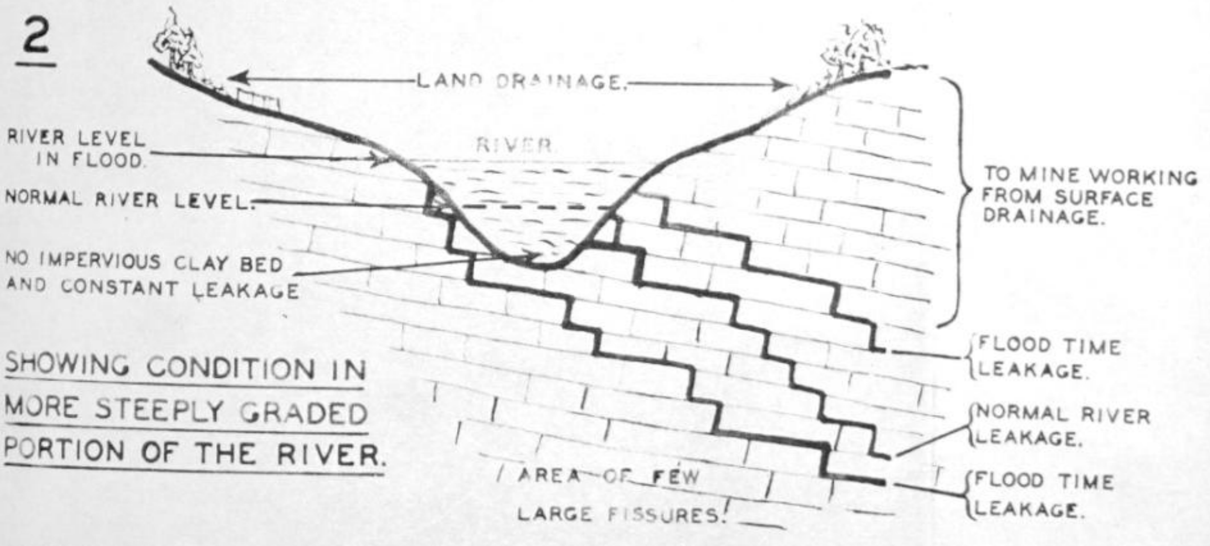
APPENDIX "B"

1



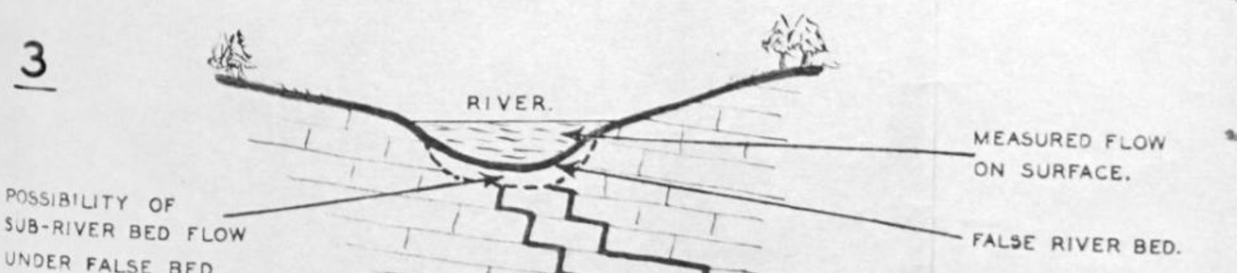
SHOWING CONDITION IN COMPARATIVELY FLAT PORTION OF THE RIVER WITH IMPERVIOUS CLAY BED.

2



SHOWING CONDITION IN MORE STEEPLY GRADED PORTION OF THE RIVER.

3



SHOWING POSSIBILITY OF UNMEASURED SUB-RIVER FLOW.

HALKYN DISTRICT UNITED MINES LIMITED

April 20th, 1937.

APPENDIX "C"

The Manager.

UNDERGROUND WATER

Following our discussion of yesterday on the subject of obtaining a cheap and satisfactory method for determining the point in the river bed at which the bulk of the water enters the mine, I have had some tests run in the lab. using Potassium Permanganate as an indicator.

These tests have given very interesting results and I believe the method is well worth a trial.

The tests showed that one cwt. of the salt will impart a deep tint to more than 3,000,000 gallons of water.

A litre of tap water was taken and $KmnO_4$ solution equal to 0.0036 grammes $KmnO_4$ was added to it. The resultant mixture was bright pink in colour. A quantity of ground limestone was added to the solution and the whole agitated with compressed air.

After a short time the solution was decolourised. A portion of the liquor containing suspended limestone was taken and treated with H_2SO_4 and $(NH_4)_2S_2O_8$ (Ammon Per.Sulph.) and the colour was immediately restored.

Samples of filtered liquor and supernatant liquor after settling failed to respond to the above treatment, showing that the manganese is precipitated and settles with the mud, or more probably the finely divided precipitate is adsorbed by the fine particles of limestone.

In taking the samples of the water entering the mine, care would have to be taken to collect as much as possible of the suspended matter, such as mud and fine clay entering with it.

The fact that the manganese becomes concentrated in the solids was proved by treating some of the residue from the above test after filtration. A deep pink colour resulted.

Potassium Permanganate is a fairly expensive salt and costs approx. £4 per cwt. It is believed, however, that Sodium Permanganate would work equally well and should not cost much more than a quarter the price of the former salt. It is, moreover, much more soluble than the Potassium Permanganate, being listed as very soluble in both hot and cold water. In practice it might be advisable to anchor a sack of the salt in the bed of the river to avoid too rapid solution and consequent loss of material. Messrs. I.C.I. have been asked by phone to quote for Soda, Permang: in cwt. lots and to send a small sample by first post.

(Sgd.) A.P. NEWALL.

HALKYN DISTRICT UNITED MINES, LIMITED

May 5th, 1937

APPENDIX "C"

The General Manager.

UNDERGROUND WATER

Test carried out in tunnel grip using Potassium Permanganate as dyeing agent.

The object of this test, which was run between 10.20 a.m. and 2.30 p.m., May 5th, was to see :

(a) If Potassium Permanganate could be visually detected in the grip water at a point a considerable distance from the place of admission.

(b) If the colour could be restored or intensified chemically in the samples taken.

The results showed that :

(a) The colour was still quite pronounced after 3½ hours contact with the grip water, during which time it flowed a total distance of approximately 3.5 miles down the grip.

(b) That the colour of the samples could be intensified and fixed chemically by treatment with Ammonium Persulphate to form Permanganic acid.

Details of Test

A total weight of 20 pounds of $KMnO_4$ was dissolved in cold water and added to the grip at Lode 576 beyond Nant Alyn crosscourse. The material was dissolved and added to the grip in the following manner : the solid $KMnO_4$ was put into a 40 gallon drum filled with water and stirred thoroughly. Every half minute a bucket-full of the solution was dipped from the drum and poured into the grip. This was replaced by a bucket-full of fresh grip water and stirring continued for a further half minute and so on.

The addition started at 10.20 a.m. and was complete at 10.41 a.m., the 20 pounds thus being added over a period of approximately 20 minutes. The samples were taken at the bottom of Penybryn shaft a distance of 3.5 miles from the point of admission.

The grip water flowing past the shaft was sampled continuously, two composite samples covering 15 minutes each being kept for the first half hour and thereafter samples covering periods of 10 minutes.

APPENDIX "C"

Sampling started at 10.15 a.m. The first indication of colour in the water at Penybryn was at approximately 1.45 p.m. or 3½ hours after the first addition was made. On its way down the main tunnel the permanganate could be observed as a deeply dyed stretch of water, several hundreds of feet in length. This coloured stretch took approximately 25 minutes to pass the sampling point.

Of the 25 samples taken, only three, that is, those taken between 1.45 p.m. and 2.15 p.m. showed any sign of coloration. The samples taken immediately before the colour appeared and immediately after it disappeared were tested for manganese and found to be free. The colour of the three visibly dyed samples was intensified by adding to 50 cc. of the sample, 15 cc. strong sulphuric acid and (after heating) 2 cc. N/10 $AgNO_3$ solution and 2 grammes of ammonium persulphate. The silver chloride, was, in each case, removed by filtration. The relative strengths of colouration in the three samples were readily detected by comparison in Nessler tubes.

Calculated loss of Reagent during Test

In order to check, roughly, the percentage of the total weight of $KMnO_4$ remaining in the water when it reached Penybryn, a composite sample was made by taking equal parts of each of the three samples taken during the period over which manganese was found in the water. The colour was restored and intensified chemically and the quantity of permanganate estimated colourimetrically by comparison with standard solutions produced by mixing known volumes of standard permanganate solution with grip water.

It was found in this way that the average potassium permanganate content of the water passing the sampling point in approximately 25 minutes was 0.000025 pounds per gallon. Measurements, taken by the Survey department showed that approximately 19,500 gallons per minute were passing, or equivalent to 487,500 gallons in 25 minutes.
This volume of water contained, therefore :

487,500 X 0.000025
or 12.2 pounds of $KMnO_4$

Therefore, of the 20 pounds added to the grip, 12.2 pounds or approximately 61% still remained after 3.5 hours contact with the water and at a distance of some 3.5 miles from the point of admission.

The results of this test indicate that potassium permanganate may prove to be a satisfactory reagent to use in tracing the course of the underground water. It is suggested, as a further step in the investigation, that a quantity of $KMnO_4$ solution be introduced at Mountain Shaft and efforts made to detect its presence in the water entering the underground workings at Llynypandy. A test along these lines is to be carried out on May 7th.

(Sgd) A. P. NEWALL.

HALKYN DISTRICT UNITED MINES LIMITED

May 19th, 1937

APPENDIX "C"

UNDERGROUND WATER

Test carried out introducing Pot. Permanganate at Mountain Shaft. Samples taken at Llynypandy lode (underground).

Object of test

To find to what extent it is possible to detect the presence of Potassium Permanganate in water after passing through underground leakways. The test was carried out between 11 a.m. and 1.30 p.m. on May 7th.

Results of Test

It was found that the water issuing from the large feed point at Llynypandy face was deeply coloured with permanganate as the result of introducing 15 pounds of potassium permanganate into Mountain Shaft. The colouration was visible in the water at Llynypandy approximately one and a half hours after it was introduced at Mountain Shaft, a distance of 400 yards away (actually 1300 ft. horizontally and 200 ft. vertically). Chemical treatment of the water resulted in intensifying and fixing the colour as in the previous tests with potassium permanganate.

Details of Test

A total weight of 15 pounds of $KMnO_4$ crystals was dissolved in 50 gallons of water and the whole volume of solution poured down Mountain Shaft at 11 a.m. After pouring the solution into the shaft it was followed by a quantity of fresh water from a ½" pipe running for forty minutes to wash any of the solution from the walls of the shaft.

The shaft is 260 feet deep and the feed which crosses the bottom of it contributes approximately 150 gallons of water per minute to the mine. The dilution, is therefore, considerable as some 5,000 gallons per minute enters at Llynypandy.

Samples were taken at two different points, namely the Face of D.T.1 where the smaller feed enters the drift and also at the large feed which enters near the face of the drift, or the N. side of D.T.7, 40' in from X.cut. The samples were taken continuously and bottled at intervals of fifteen minutes, starting at 11.45 a.m. Between 12.30 and 12.45 p.m. the water issuing from the large feed hole at the face was observed to be pink in colour. The colour persisted until the water joined the tunnel water in the main tunnel grip. Subsequent chemical treatment of the samples showed that the effect of the addition of permanganate was first observable at 12.30 p.m. Throughout the test no colouration was observed in the water issuing from the small feed point. Chemical treatment also failed to reveal the presence of manganese in the water, though a quantity of settled sediment collected while the samples were being taken showed the presence of a considerable

APPENDIX "C"

quantity of manganese after treatment. As the rocks naturally contain traces of manganese a further sample of sediment will be obtained from the same point under normal conditions to find out if the colouration was due to naturally occurring manganese or to the precipitation of the added potassium permanganate.

Conclusions

The results of these tests seem to be sufficiently conclusive to warrant a trial of the method in the river Alyn. Arrangements are being made to run such a test as soon as possible.

(Sgd) A.P. NEWALL

NOTE:

The blank run as indicated above gave a colouration similar to that obtained during the test on the feed from the face of D.T.1. The sediment was obtained in both cases by running part of the feed through a ½" pipe into a bucket (19.5.37)

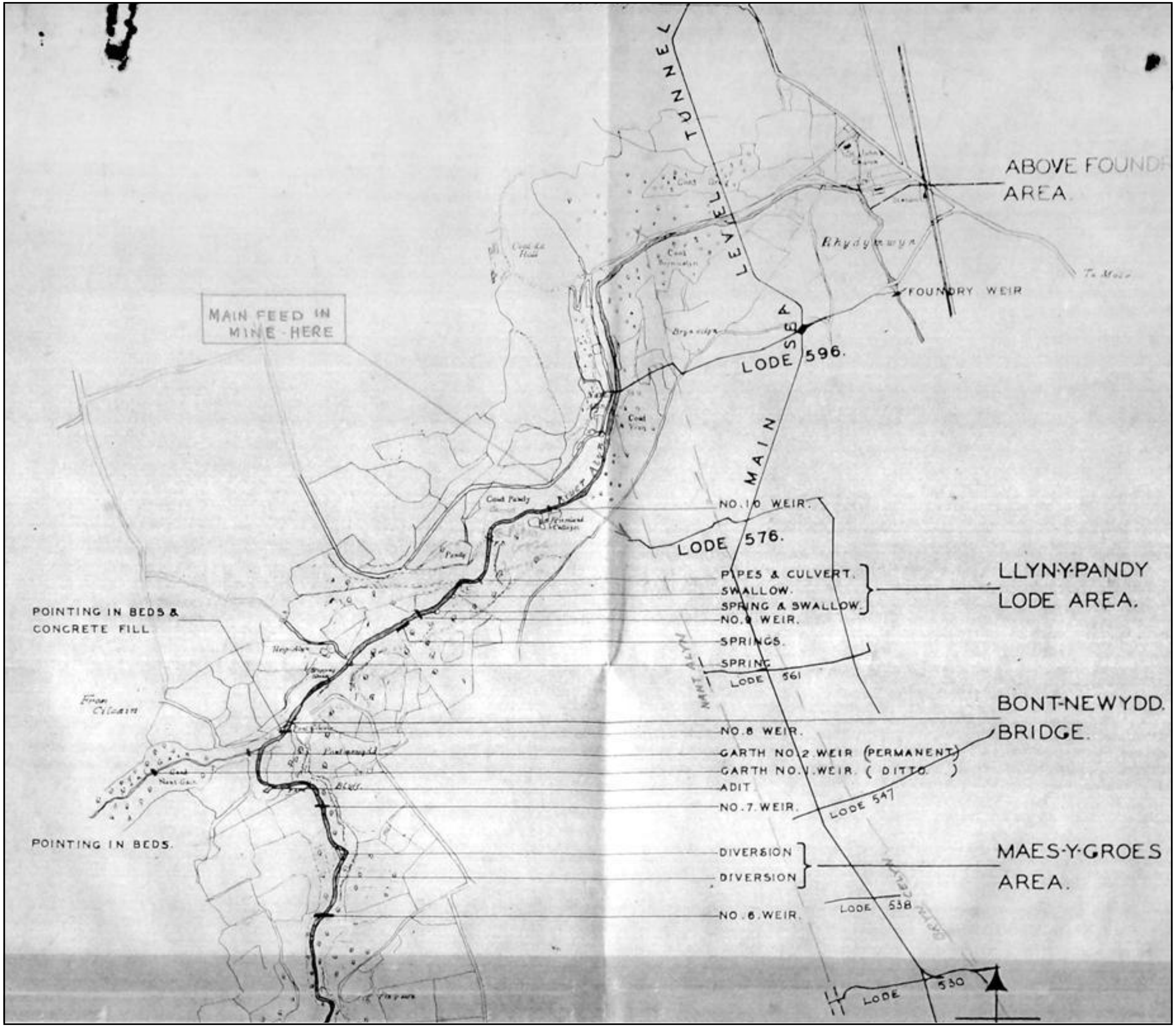
This seems to eliminate $KMnO_4$ as a useful dye, as the more difficult tests would in all probability take so long that the colour would be destroyed, and if it could be got back from any muddy water nothing conclusive would be obtained. One would never get any colour back from the filtrate, as the Manganese is precipitated on decolourisation.

(Sgd) J.D.W.

Plan 1a

Plan showing
location of work on the
River Alyn

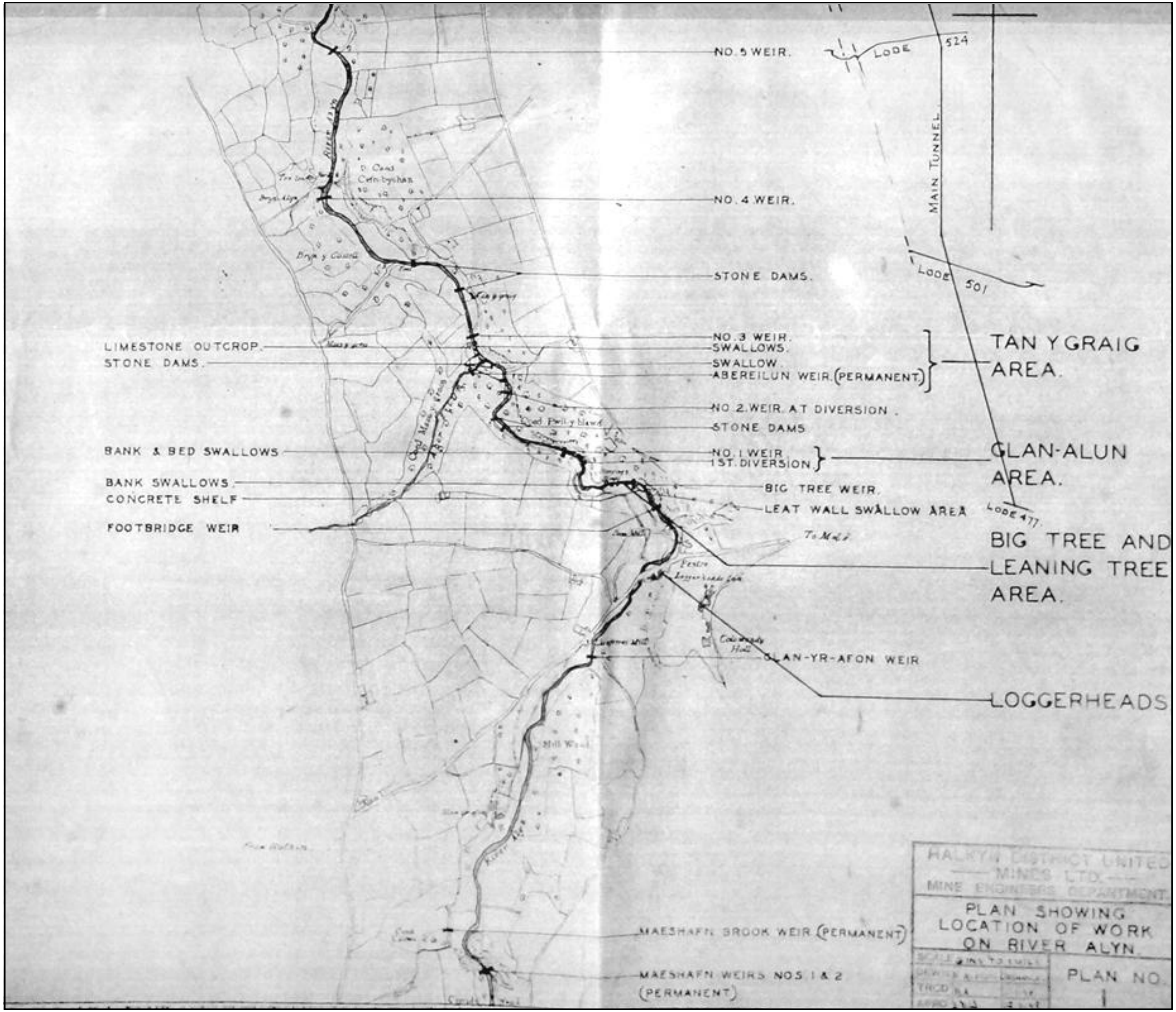
Northern section

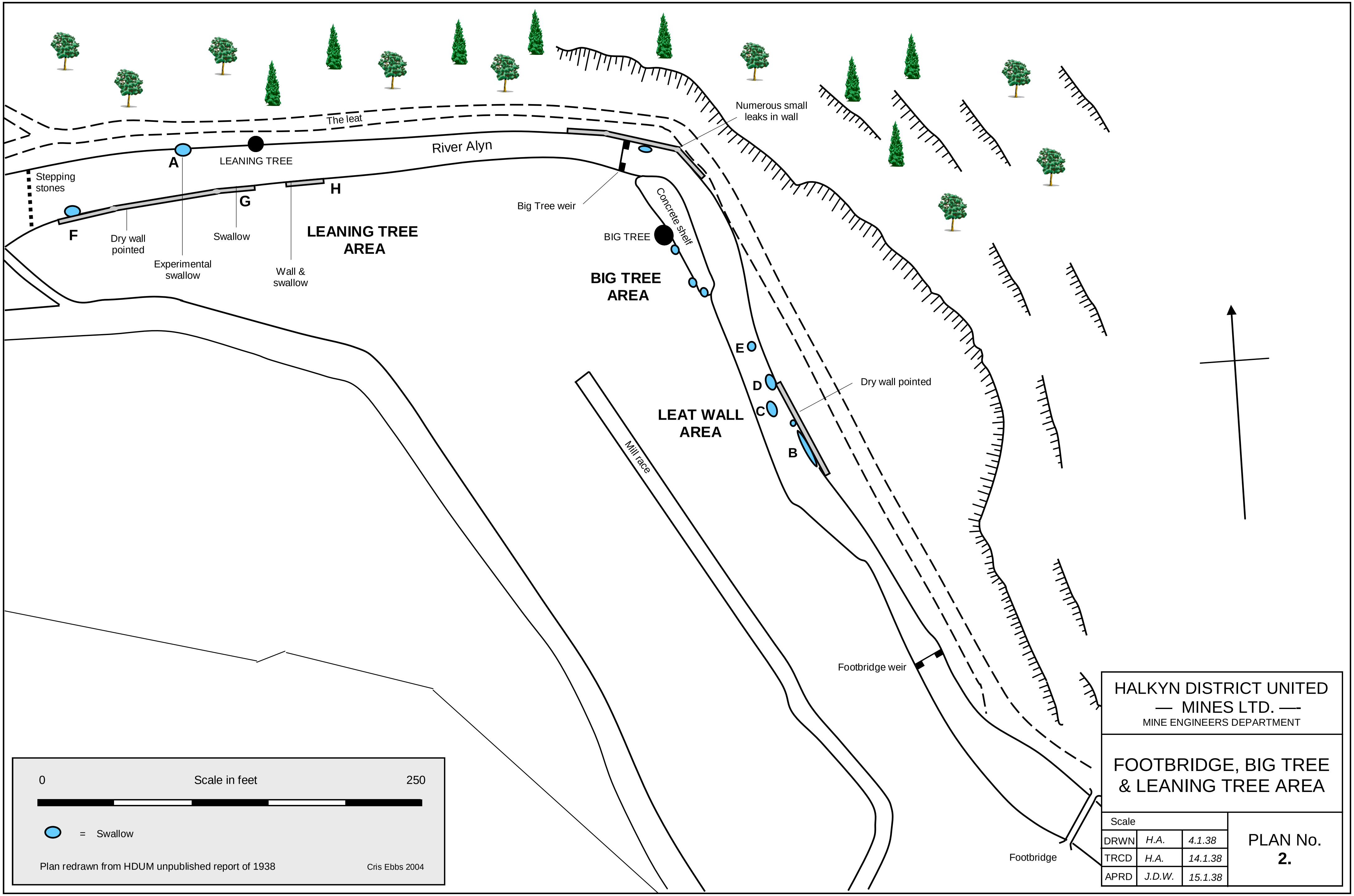


Plan 1b

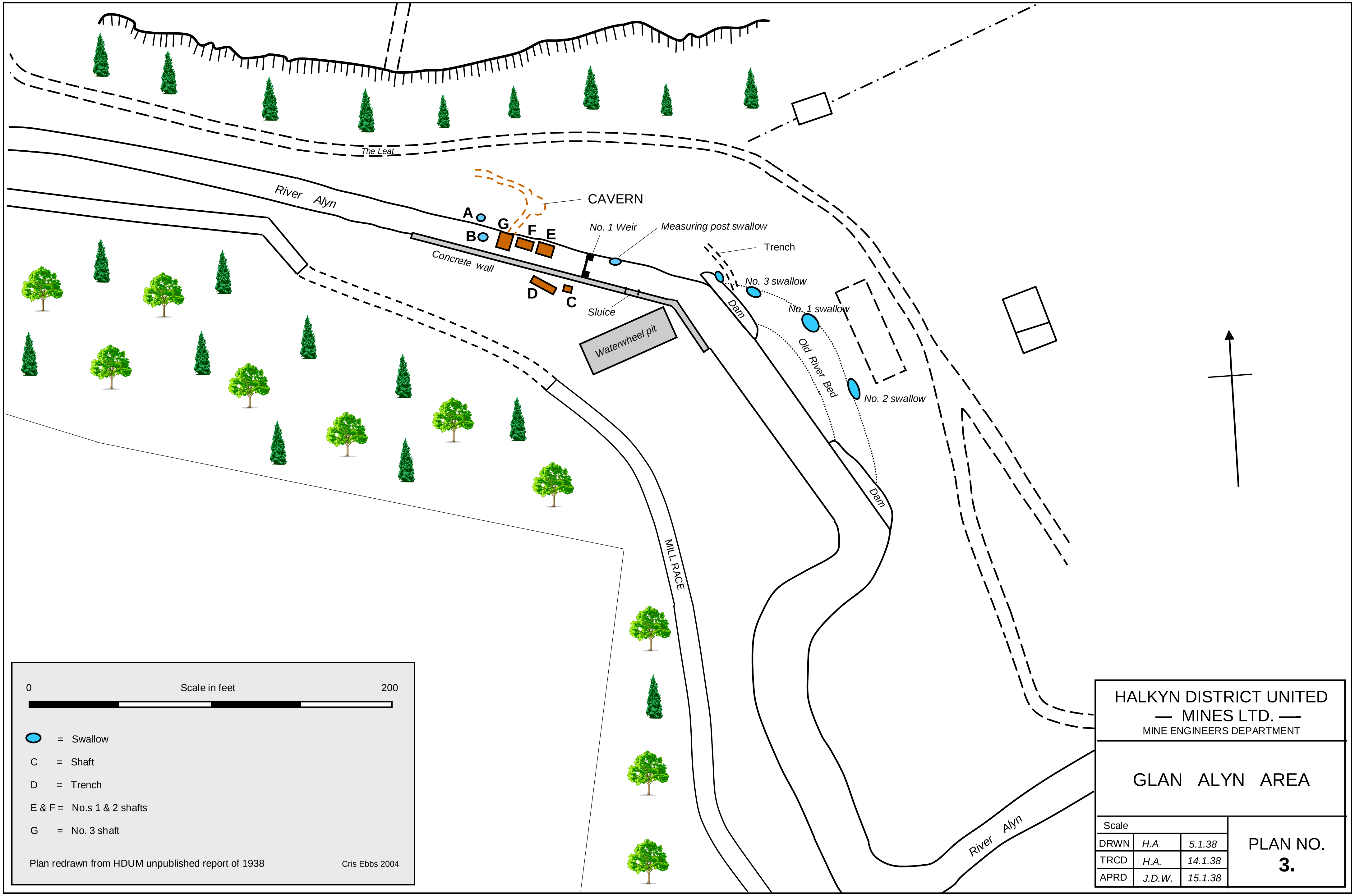
Plan showing location of work on the River Alyn

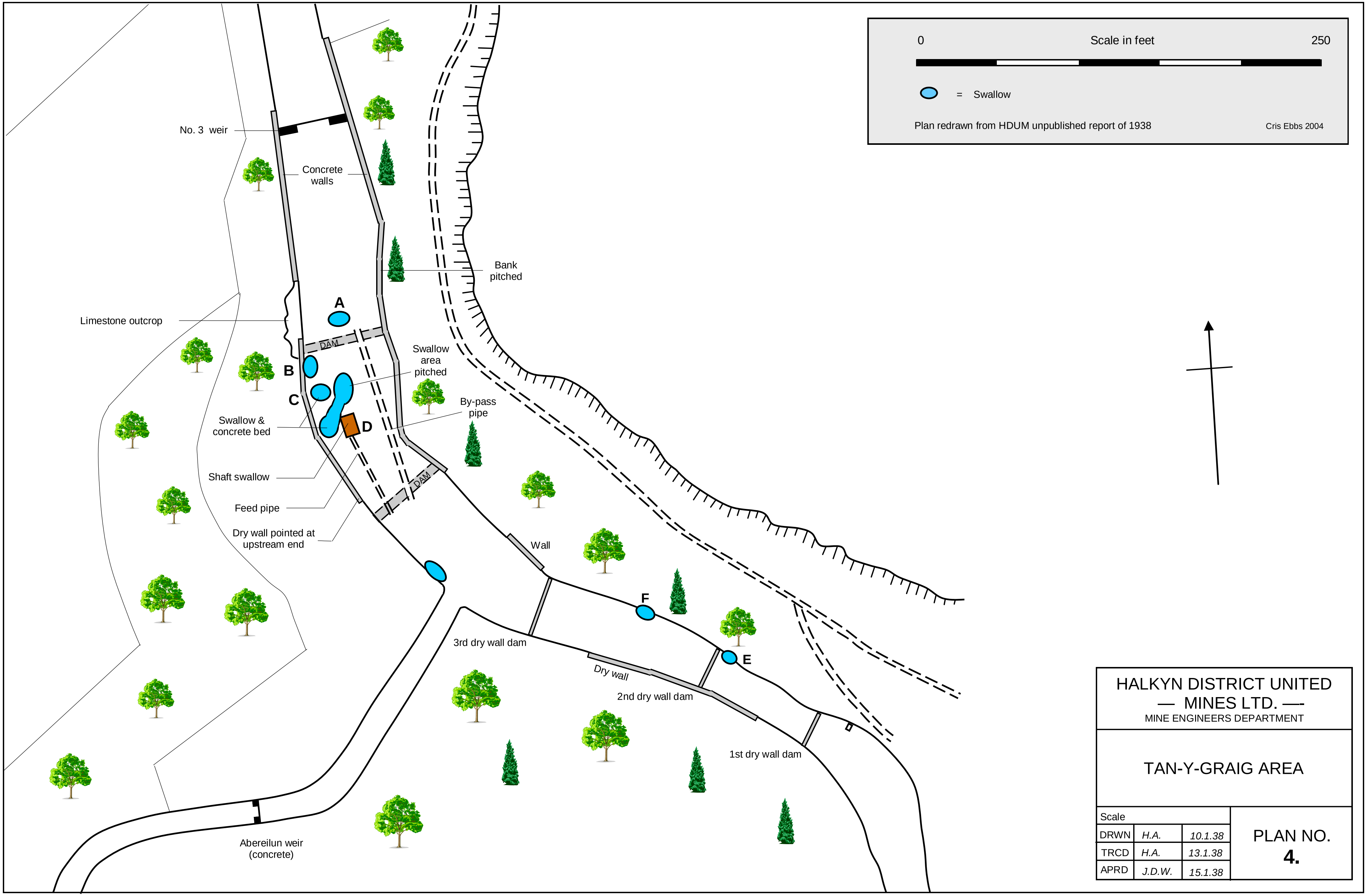
Southern section





HALKYN DISTRICT UNITED
— MINES LTD. —
MINE ENGINEERS DEPARTMENT
FOOTBRIDGE, BIG TREE & LEANING TREE AREA
Scale
DRWN H.A. 4.1.38
TRCD H.A. 14.1.38
APRD J.D.W. 15.1.38
PLAN No. 2.
The leat
River Alyn
Numerous small leaks in wall
Stepping stones
A
LEANING TREE
F
Dry wall pointed
Experimental swallow
G
Swallow
H
Wall & swallow
LEANING TREE AREA
Big Tree weir
BIG TREE
Concrete shelf
BIG TREE AREA
E
D
C
B
Dry wall pointed
LEAT WALL AREA
Mill race
Footbridge weir
Footbridge
0
Scale in feet
250
= Swallow
Plan redrawn from HDUM unpublished report of 1938
Cris Ebbs 2004


The Leat
River Alyn
CAVERN
A
B
G
F
E
D
C
No. 1 Weir
Measuring post swallow
Trench
No. 3 swallow
No. 1 swallow
No. 2 swallow
Old River Bed
Dam
Dam
Concrete wall
Sluice
Waterwheel pit
MILL RACE
River Alyn
0
Scale in feet
200
= Swallow
C = Shaft
D = Trench
E & F = No.s 1 & 2 shafts
G = No. 3 shaft
Plan redrawn from HDUM unpublished report of 1938
Cris Ebbs 2004
HALKYN DISTRICT UNITED
— MINES LTD. —
MINE ENGINEERS DEPARTMENT
GLAN ALYN AREA
Scale
DRWN H.A 5.1.38
TRCD H.A. 14.1.38
APRD J.D.W. 15.1.38
PLAN NO.
3.



0
Scale in feet
250
= Swallow
Plan redrawn from HDUM unpublished report of 1938
Cris Ebbs 2004
No. 3 weir
Concrete walls
Bank pitched
Limestone outcrop
A
DAM
B
C
D
Swallow area pitched
By-pass pipe
Swallow & concrete bed
Shaft swallow
Feed pipe
DAM
Dry wall pointed at upstream end
Wall
F
E
3rd dry wall dam
Dry wall
2nd dry wall dam
1st dry wall dam
Abereilun weir (concrete)
HALKYN DISTRICT UNITED
— MINES LTD. —
MINE ENGINEERS DEPARTMENT
TAN-Y-GRAIG AREA
Scale
DRWN H.A. 10.1.38
TRCD H.A. 13.1.38
APRD J.D.W. 15.1.38
PLAN NO.
4.

CHART SHOWING WATER FLOWING IN RIVER ALYN AND THAT FLOWING IN THE TUNNEL.

RIVER FLOW AT MAESHAFN, TUNNEL FLOW AT LODE 656.

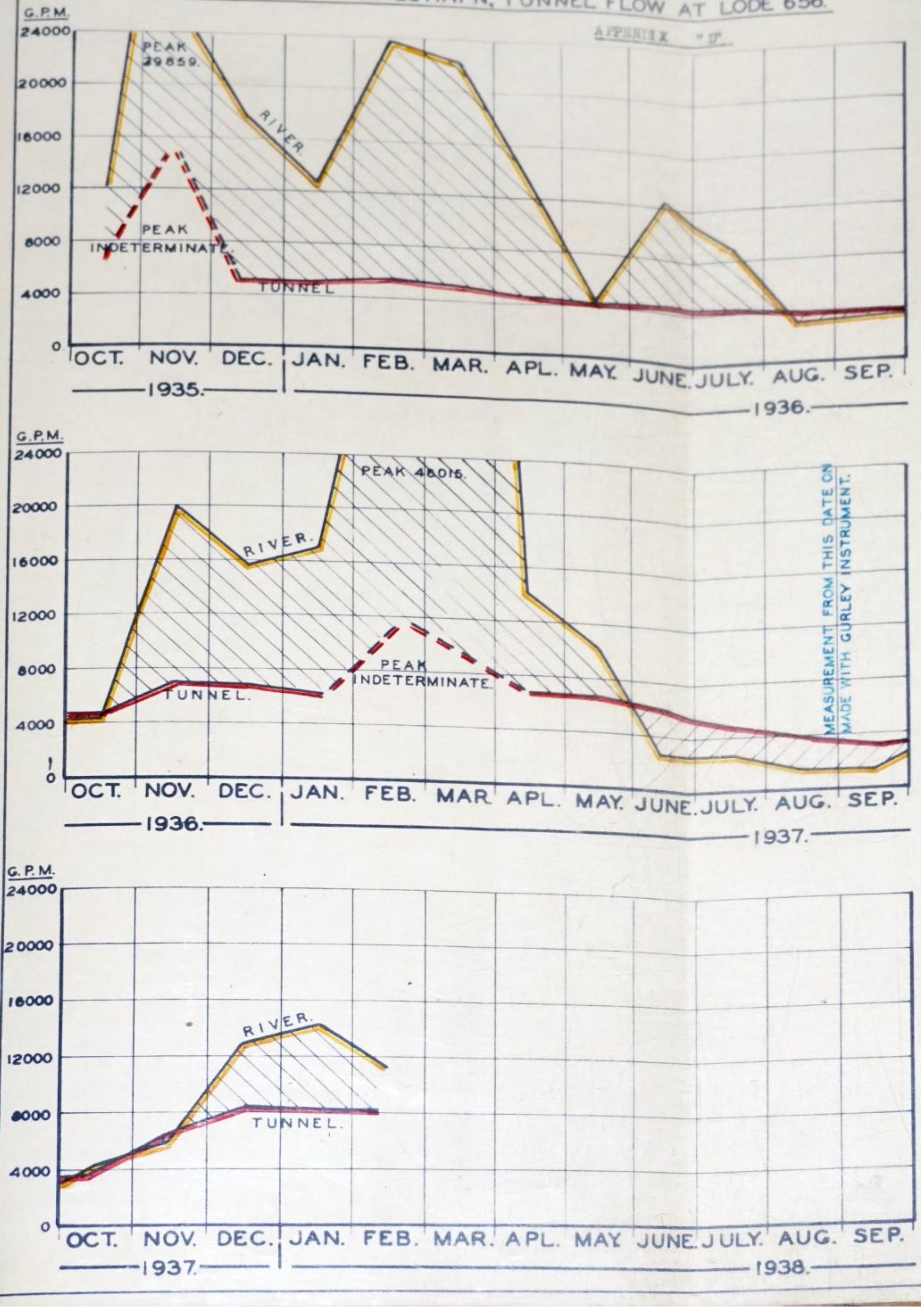
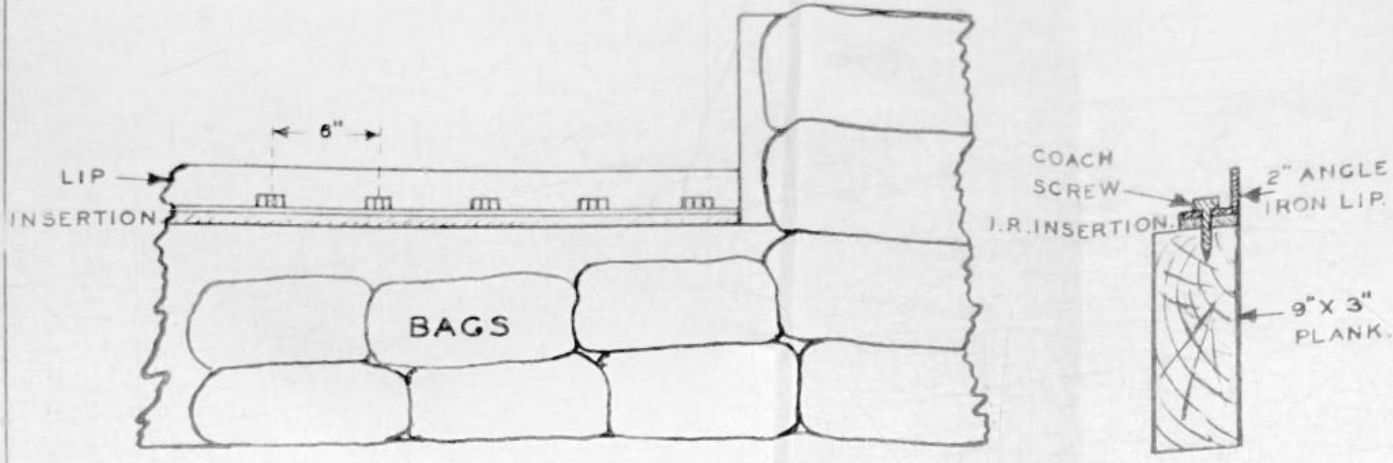
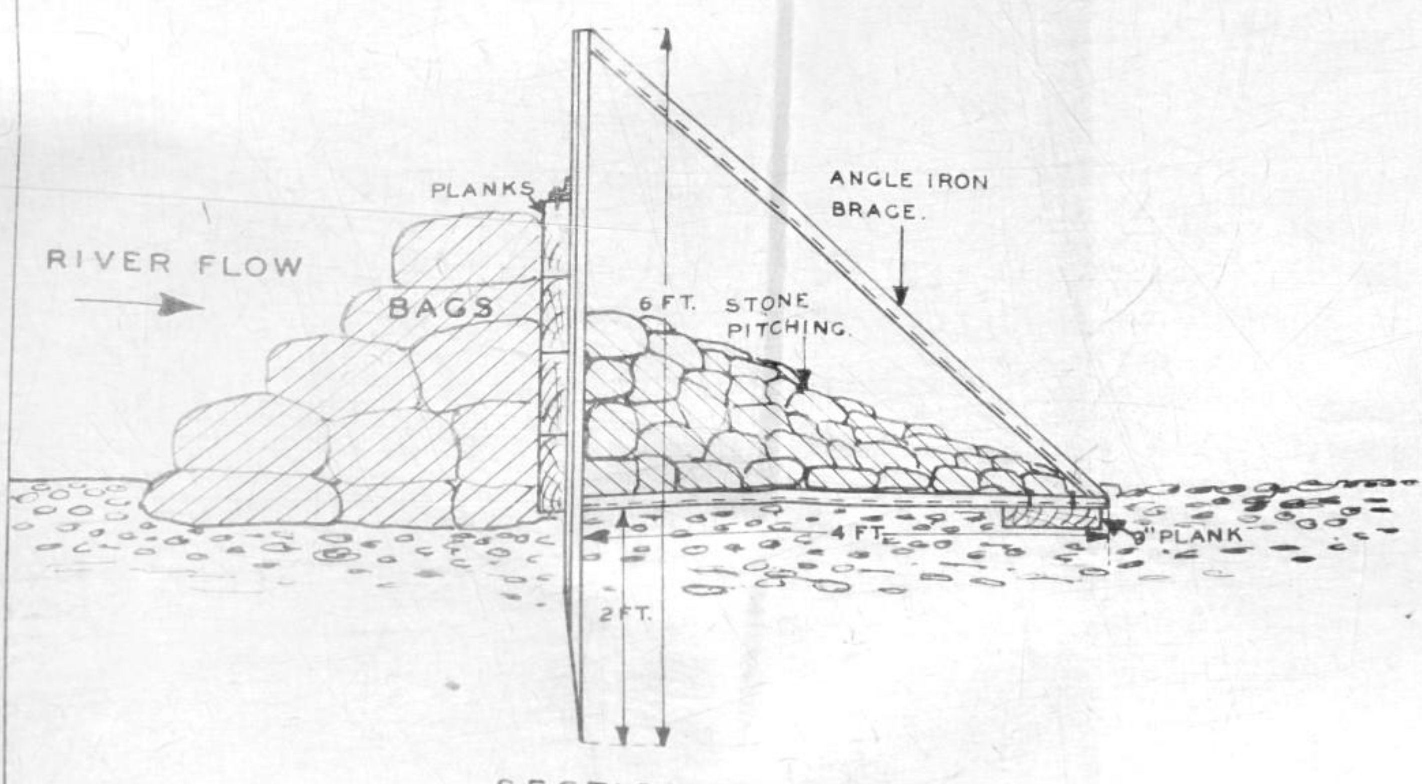


DIAGRAM NO. 1

METHOD OF ATTACHING LIP TO PLANKS AND PART OF FRONT VIEW OF WEIR.





SECTION.

HALKYN DISTRICT UNITED MINES LTD.
MINE ENGINEERS DEPARTMENT.

STANDARD TEMPORARY WEIR.

DRWN		
TRCD	[illegible]	1.2.38
APRD	[illegible]	4.2.38

COPY.

APPENDIX "F"

October 13th, 1931.

Sir Cecil L. Budd, K.B.E.,
Chairman,
Halkyn District United Mines Limited,
London.

Dear Sir,

NOTES ON WATER PROBLEM

I have pleasure in submitting the following preliminary survey of the water problem in our Area, and in doing so will attempt to review all the data so far gleaned :-

The position is complicated by the well known fact that there are serious leakages from the River Alyn into the Mines, and that this river, which rises near Llandegla, brings into our Area, from a tract of 9 square miles South of the Llanarmon District, a large volume of water which otherwise would not have to be taken into account, and also that some of its tributaries feed it with water which falls on the Silurian rocks of the Moel Fammau Range. It will be realised, therefore, that in attempting to compute the probable volume of water underground, the survey must cover a much wider field that than embraced by our Mining rights.

Having dealt with the possibility of water entering our Area from the South and West, the question arises as to whether any may be expected to come from the North and East.

With regard to the North. Taking into consideration the fact that the outflows from the Holway and other Adits have not been affected by tunnelling operations, and that the portion of the Milwr Tunnel owned by the Holywell-Halkyn Mining and Tunnel Co. serves as an intercepting channel for any flows from this direction, it appears reasonable to assume that little, if any, of the water we are considering finds its way in from the North. The feed of about 5000 gallons per minute at the Pant Lode is admittedly difficult to deal with, but inasmuch as the tapping of the Wern feed did not affect it to the extent of more than 1000 to 1500 gallons per minute, I assume that the remainder has no connection with the Halkyn Area.

The eastern margin of our Sett is covered by the shales of the Lower Coal Measures, which, being impervious, should not admit of any serious percolation, and their drainage is largely towards the River Dee and tributaries of the Alyn which join that River to the East of the outcrop of limestone. Water from the East may therefore be discounted, except from the comparatively small area of Holywell shales, lying wholly within our Sett, which drain into the Rhydymwyn Valley.

APPENDIX "B"

RAINFALL

No consideration of this question is possible without a study of rainfall statistics, and the following data are available for stations in or near our Area :

Station.	Height above O.D. Feet	Average Annual Rainfall Inches	Maximum Annual Rainfall recorded. Inches
Halkyn, ¼ mile N. of Penybryn	875	31.20	38.92
Cilcen Hall, 1¾ miles S.W. of Penybryn	785	29.70	40.36
Hawarden Waterworks, Cilcen, 1½ miles W. of our Area, or 2½ miles N.W. of Loggerheads.	680	29.27	38.93
Soughton Hall, Northop, 1 mile E. of our Area	418	32.10	41.39

The average annual rainfall at these stations works out at 30.57 inches, but to allow for the higher ground in the Llanarmon District and in the neighbourhood of Llandegla, for which no particulars are available, I propose to work on an average annual figure of 32 inches, which is probably not too high.

The average maximum rainfall in the area covered is 39.9 inches, or say, 40 inches per annum, not more than 25% greater than the normal.

The Meteorological Office has stated that it is common to assume that 14 inches of rainfall per annum is evaporated, and applying the rule in our case, we get 18 inches to account for, either underground or carried off the Area by the Alyn and the small consumption of about 600 gallons per minute of the Mold and Hawarden Waterworks.

AREAS

The area of the gathering ground of the Alyn and its tributaries from Llandegla to Rhydymwyn is 35.22 square miles, and the extent of our mining and drainage sett is 25.27 square miles, of which, 4.21 square miles is not included in the gathering ground of the Alyn, so that the maximum area we have to consider is 35.22 plus 4.21, or 39.43 square miles.

APPENDIX "E"

COMPUTATION OF PROBABLE VOLUME

One inch of rainfall per annum is equivalent to 14,520,000 gallons of water per square mile, or 27.6 gallons a minute (Appendix 1). It follows, therefore, that 18 inches over an area of 39.43 square miles amount to 19,589 gallons per minute, which should be found in the Alyn at Rhydymwyn, plus Waterworks' consumption, and in our Tunnels.

The rainfall at Cilcen Hall (Appendix 2) from January to September this year, for particulars of which I am indebted to Mr. W.B. Yates, has averaged 3.3 inches per month, which is at the rate of 39.6 inches per annum, an excess of about 25% over the normal, so that during this year, we have to account for 19,589 plus 25%, or 24,486 gallons per minute from the Area.

Whilst the methods so far available for gauging are rough, and the period over which they have been taken is not sufficiently long to obtain anything approaching an accurate average, particularly in the case of the Alyn, where gaugings were not taken at regular intervals, and not at all in August and September, during each of which months over 6" of rain fell, I nevertheless venture on the following computation from such data as are available.

	Gallons per Minute	
SURFACE		
Flowing in the Alyn at Rhydymwyn	9317	
Flowing in Fechlas which joins Alyn below point at which gaugings were taken... say	700	
Piped off Area for Waterworks	600	10,617
UNDERGROUND		
New Tunnel: Passing Penybryn Shaft since intersection of feed at 8238 feet, and neglecting all feeds in Milwr Section	10,000	
Outflow from 1875 Tunnel	4,118	14,118
		24,735

The figures for Underground may be taken as reasonably accurate, but the average for the Alyn is very unsatisfactory, as it has been computed from four gaugings in dry weather in June, July & October, plus one estimate of 30,000 gallons per minute during a period of floods early in June.

APPENDIX ...1

One inch of rainfall per year

over 1 square mile = $\frac{1}{12}$ X 5280 X 5280 X 6.25

= 14,520,000 gallons per annum

= $\frac{14,520,000}{365 \times 24 \times 60}$ gallons per minute

= 27.6 gallons per minute

18 inches of rainfall per annum over an area of

3943 square miles = 18 X 27.6 X 39.43

= 19,589 gallons per minute.

APPENDIX 2

RAINFALL AT CILCEN HALL

1 9 3 1

	Inches
January	2.43
February	2.43
March	1.01
April	2.40
May	2.67
June	4.205
July	1.735
August	6.72
September	6.135
	29.735

Average per Month 3.3 inches, or at the rate of

39.6 inches per annum.

A P P E N D I X "F"

RIVER ALYN . DAILY GAUGINGS AT WEIRS IN GALLONS PER MINUTE

(Columns marked X are estimates only)

Date 1937	Total Maeshafn Weirs	No.1	No.2	Aber-eilun Brook	No. 3	Cilcain road X	No.4	Tan lan spring X	No.6	No.7	Garth Brook No.1	No.8	H.s.s. Springs X	No.9	No.10	Coed du. X	Foundry	Total loss to Foundry	REMARKS
Dec.16	14,846	15,461	14,805	700	15,461	80	13,997	40	13,997	12,894	984	14,317	850	16,664	14,479	-	12,468	5,032	
" 17	13,936	14,161	13,209	627	13,524	90	12,427	70	12,734	11,665	984	13,051	800	14,977	13,051	50	9,711	6,846	
" 18	11,976	12,849	12,117	562	12,274	70	11,369	55	11,369	10,195	855	11,219	850	13,346	11,518	50	9,393	5,020	
" 20	10,976	11,518	10,626	422	10,773	70	9,754	60	9,476	8,644	612	9,476	800	11,190	9,618	50	8,100	4,890	
" 21	10,591	11,072	9,907	422	10,195	70	9,198	50	9,198	8,101	731	9,062	800	10,814	9,198	50	7,800	4,914	
" 22	26,432	28,998	26,118	3,559	29,269	200	24,021	150	25,883	25,521	6,326	31,269	1000	38,097	26,753	70	29,382	8,355	Discarded in Avges
" 23	24,775	24,769	21,021	3,807	23,247	150	20,291	150	21,021	21,021	5,590	23,247	1000	27,450	21,021	50	25,632	9,890	Weirs overflowi
" 24	18,976	20,654	20,368	2,155	23,753	100	19,165	100	20,868	19,665	4,434	22,791	1000	26,973	21,368	60	19,911	6,914	-do-
" 26	13,694	15,298	14,161	1,183	14,805	60	13,367	50	13,524	12,584	1,892	14,479	850	16,242	14,642	50	12,468	5,311	
" 28	10,768	11,219	10,337	700	11,072	60	9,754	40	9,754	8,783	1,269	10,195	800	11,753	10,626	40	8,757	4,920	
" 29	10,205	10,484	9,618	627	9,907	50	8,920	25	8,783	7,969	855	9,062	700	10,243	9,062	40	7,800	4,702	
" 30	9,549	9,618	8,505	562	9,062	40	8,101	25	7,969	7,177	612	7,833	700	9,000	7,969	40	7,182	4,346	
" 31	9,010	8,644	7,434	364	7,969	30	7,434	20	7,177	6,421	731	7,051	700	8,315	6,925	40	5,757	5,138	
1938																			
Jan. 1	8,112	8,227	7,051	364	7,177	10	6,421	10	6,179	4,998	612	6,179	600	7,140	6,179	40	4,686	5,062	
" 3	7,217	7,051	5,938	312	5,938	0	5,229	0	4,998	4,331	398	4,777	600	5,730	4,777	40	3,432	5,135	
" 4	7,018	6,925	5,938	261	5,820	0	5,113	0	4,777	4,116	215	4,331	500	5,287	4,116	40	2,982	5,052	
" 5	6,683	6,421	5,229	261	5,229	0	4,547	0	4,118	3,491	139	3,491	500	4,426	3,491	40	2,325	5,298	
" 6	6,883	6,673	5,701	261	5,701	10	4,998	0	4,547	3,906	139	4,011	500	4,853	3,906	40	2,550	5,283	
" 7	7,217	7,177	5,938	261	6,059	20	5,229	0	4,998	4,331	215	4,547	600	5,287	4,547	50	3,675	4,688	Weirs Nos. 2,
" 8	7,417	7,051	5,938	261	5,820	20	5,113	0	4,777	4,116	215	4,116	600	5,137	4,116	40	2,982	5,571	3,4 and 10
" 10	7,520	7,177	6,059	209	5,938	20	5,229	0	4,888	4,331	109	4,436	500	5,287	4,226	40	2,982	5,416	damaged
" 11	8,112	7,969	6,673	261	6,799	40	6,059	0	5,701	4,998	75	5,575	600	6,644	5,460	50	4,182	4,956	Jan.16th.
" 12	9,902	13,209	11,665	364	12,584	40	11,665	0	11,818	10,773	398	12,117	700	13,539	11,965	50	9,711	1,744	
" 13	13,524	13,839	12,584	364	12,584	50	11,369	0	11,518	10,484	612	11,369	700	12,946	11,518	50	9,711	5,589	
" 14	12,623	12,894	11,665	364	11,965	50	10,626	0	10,773	9,907	731	10,773	700	12,349	11,072	40	9,393	5,115	
" 15	23,968	29,769	26,491	3,290	25,753	100	23,791	30	23,791	23,791	3,574	27,747	850	31,450	27,747	100	23,832	8,080	Discarded in
"																			Averages
" 17	44,898	41,140		4,315		150		80	35,880	30,769	3,574	37,880	1000	39,597		100	24,350	19,767	Weirs overflowing
" 18	32,021	30,247		3,807		100		60	25,291	25,291	3,172	27,021	1000	31,454		80	28,461	11,779	-do-
" 19	25,444	30,247		3,807		100		60	26,253	24,291	2,784	26,753	800	32,450		70	23,832	9,233	-do-
" 20	20,975	27,105		3,807		70		40	21,477	21,477	2,418	23,368	800	28,006		60	18,675	9,495	-do-
" 21	18,499	23,868		3,062		50		30	21,477	19,790	2,059	22,868	600	23,164		50	16,239	8,111	Discarded in Averages
" 22	15,266	17,117		2,574		50		20	15,279	14,161	731	15,630	500	16,664		40	13,593	5,588	Weirs overflowing
" 24	12,697	13,839		1,943		30		10	11,369	10,195	349	10,773	400	11,753		30	9,075	6,384	
" 25	11,789	12,894		1,943		30		10	10,484	9,476	398	10,337	400	11,384		30	8,436	6,164	
" 26	11,149	11,665		1,548		20		0	9,342	8,783	398	9,342	400	10,243		30	8,100	5,445	
" 27	10,932	11,369		1,548		20		0	9,062	8,227	398	9,062	400	9,893		30	7,800	5,528	
" 28	11,602	12,894		1,453		20		0	10,484	9,342	398	9,062	400	11,190		40	9,075	4,838	
" 29	13,026	13,839		1,651		20		0	11,369	10,195	398	10,920	400	12,150		30	9,393	6,112	
" 31	22,820	25,291		3,062		50		20	21,477	21,477	612	23,368	500	25,506		40	18,675	8,429	Discarded in averages
Feb.1	21,219	20,291		3,062		50		20	19,790	20,477	1,123	27,572	500	24,060		40	18,675	7,339	Weirs overflowing
" 2	18,178	19,477		2,821		40		10	17,292	16,624	1,054	19,477	500	19,196		40	15,468	7,175	-do-
" 3	16,157	15,624		2,574		30		10	15,642	14,317	984	16,792	400	17,310		40	13,593	6,602	
" 4	14,638	14,805		2,374		30		10	13,524	12,584	919	14,317	400	15,180		40	12,132	6,279	
" 5	13,122	13,524		2,265		20		10	12,274	11,072	666	12,894	400	13,740		40	10,725	5,798	
" 7	11,376	11,665		2,033		15		10	9,754	8,920	398	10,195	400	10,477		30	8,436	5,826	
" 8	10,587	10,773		1,828		15		0	8,783	8,101	398	9,342	300	10,073		30	7,800	5,358	
" 9	10,089	10,195		1,631		15		0	8,366	7,570	398	8,505	400	10,447		30	7,182	5,381	
" 10	10,029	9,907		1,631		15		0	7,833	7,177	398	8,366	300	8,827		30	6,900	5,503	

APPENDIX "F" Cont'd. DAILY GAUGINGS.

Date 1938	Total Maeshafn weirs.	No.1	No.2.	Aber-eilun Brook	No.3	Cilcain road X	No.4	Tal las Spng	No.6	No.7	Garth Brook No.1	No.8	H.W.W. Springs X	No.9	No.10	Coed du X	Foundry	Total loss to Foundry	REMARKS
Feb.11	9,454	9,342		1,528		10		0	7,177	6,547	349	7,434	300	7,800		30	6,036	5,635	
" 12	8,927	8,505		700		10		0	6,673	6,059	398	7,177	300	7,636		30	5,211	5,154	
" 14	7,760	7,702		422		0		0	5,701	5,229	215	5,938	300	6,187		20	4,425	4,292	
" 15	7,516	7,177		312		0		0	5,229	5,229	0	5,229	250	5,580		20	3,918	4,180	
" 16	7,013	6,673		210		0		0	4,651	4,226	500	5,229	250	5,287		20	3,432	4,561	
" 17	6,560	6,421		0		0		0	4,547	4,011	0	4,331	250	4,710		20	2,757	4,073	
" 18	6,346	5,938		122		0		0	4,116	3,806	75	4,116	200	4,290		20	2,550	4,213	
" 19	6,346	5,820		0		0		0	3,906	3,491	139	4,011	200	4,154		20	2,325	4,380	
" 21	5,636	5,229		0		0		0	3,297	2,719	0	3,098	200	3,374		20	1,389	4,467	
" 22	5,636	5,229		0		0		0	3,197	2,719	0	2,908	200	3,240		20	1,389	4,467	
" 23	5,636	5,113		0		0		0	2,908	2,541	75	2,814	200	3,120		20	1,389	4,542	
" 24	5,276	4,547		0		0		0	3,003	2,719	0	2,719	200	2,873		20	1,389	4,107	
" 25	5,276	4,777		0		0		0	2,908	2,184	0	2,362	200	2,527		20	882	4,614	
" 26	4,659	3,491		0		0		0	2,011	1,769	0	1,533 ø	200	1,874		20	486	4,193	ø plus 200 g.p.m. when H.W.W. pump working.
" 28	6,278	5,701		210		10		0	3,491	2,908	0	3,098 ø	250	3,374		20	1,389	5,379	
Mar. 1	5,783	5,575		0		0		0	3,197	2,719	0	2,908 ø	200	3,120		20	1,389	4,414	
" 2	5,636	5,229		0		0		0	2,541	2,011	0	2,184 ø	200	2,414		20	750	4,906	
" 3	5,005	4,547		0		0		0	2,541	2,011	0	2,184 ø	200	2,303		10	750	4,265	
" 4	4,972	4,331		0		0		0	2,362	1,848	0	1,848 ø	200	2,190		10	486	4,496	
" 5	4,800	4,331		0		0		0	2,268	1,690	0	1,690 ø	200	1,874		10	486	4,324	
" 7	4,626	4,331		0		0		0	1,848	1,381	0	1,381 ø	200	1,567		10	261	4,375	
" 8	4,342	3,701		0		0		0	1,848	1,381	0	1,459	200	1,874		10	168	4,384	
" 9	4,342	3,806		0		0		0	1,769	1,381	0	1,239 ø	200	2,303		10	0	4,352	
" 10	4,342	3,491		0		0		0	1,533	1,097	0	1,097 ø	200	1,373	409	10	0	4,352	Weir No.10 repaired March 10th.
" 11	4,182	3,701		0		0		0	1,239	835	0	714 ø	150	1,020	508	10	0	3,942	
	9,899	10,224	9,141	441	9,393	40	8,451	20	8,322	7,373	608	8,249	680	9,598	8,294	44	6,729	5,006	Averages to Jan.14 up to which all weirs were working
	8,698	8,709		627		20		8	6,755	6,011	361	6,668	423	7,498	7,641	31	5,166	4,957	Means of 60 readings disregarding those when weirs were overflowing

DIFFERENCES BETWEEN WEIRS

Maeshafn to No. 1	No. 1 to No. 2	No. 2 to No. 3	No. 3 to No. 4	No. 4 to No. 6	No. 1 to No. 6	No 6 to No 7	No. 7 to No. 8	No. 8 to No. 9	No. 9 to No.10	No.10 to Foundry	No. 9 to Foundry	Total loss to Foundry.	
+ 325	-1,083	-189	-982	-149	-2,403	-99	+ 268	+ 669	-1,304	-1,609	-2,913	-5,006	Mean of 22 readings to Jan. 14 disregarding those when weirs were overflowing.
+ 20					-2,609	-744	+ 333	+ 407			-2,363	-4,957	Grand mean of 60 readings from Dec.16th to March 11th, 1938, disregarding those when weirs were overflowing.

CHART SHOWING DIFFERENCES IN WEIR GAUGINGS ON THE RIVER.