Analysis of the Damage to the Toddbrook Dam.

Summary.

This document complements my previous analysis "*Toddbrook Reservoir Dam Report " Sept. 2019* which showed that the reservoir was allowed to overfill without any emergency discharge actions for several days prior to Aug 1st . This brought the defective concrete spillway into use for the first time in its 48 year life. The ill considered installation of the Spillway in 1971 had destroyed the clay core safety margin of the dam. We examine the sequence of damage to the dam as revealed both by my own photographs and those available on the internet.

They show that the dam was seriously damaged because, initially, one panel was pushed upwards by water pressing underneath the spillway delivered in various water erosion channels under the Apron. Such channels in earth dams have caused the majority of dam failures because the impounded water under pressure exploits any 'through-dam' weaknesses that have not been excluded by careful design. In 1831 the Toddbrook design was careful and safe, but in 1971 British Waterways modified the dam with the Spillway which removed the safety margin of the dam and consequently provided an enormous area for water erosion channels to develop. In addition the spillway deliberately invited water to flow over the top of an earth dam which is a cardinal error in earth dam design.

Photographs often capture details that the photographer did not see at the time which is particularly true for videos made by drone based cameras. Some of the publically available images have been examined carefully and some important issues which fundamentally affect future actions at the dam have been revealed.

A drone video has revealed that the Apron has a continuous structural crack 150 ft. long across 75% of its width. The cause of this crack and the potentially profound structural implications for the dam itself must be independently investigated. This alone should at least delay if not forbid the reinstatement of the concrete spillway.

The defective secondary spillway will only operate when the water is at least 15in. above the Primary Cill. The level on 11:00 on 1 Aug. was at least 2ft. above the Primary Cill. There would have been at least 100,000 tons of extra water over-loading the dam for at least 36 hours. This additional load on the dam (and spillway) had never happened before so it must be considered when explaining the 150ft. long crack.

Since the incident on 1 Aug various work has been carried out. This has been both cosmetic (mowing the dam, weeding the spillway) and functional –belated maintenance on the congested convergence basin and the virtually blocked Bypass channel entrance. The removal of mud banks, debris, stones and weeds which drastically impede the flow would have helped in the desperate effort to drain the reservoir but it would not have prevented the ingress of water under the spillway which lifted the panels and caused serious damage to the earth dam.

The neglected state of both these safety control systems impeded the emergency discharge actions taken after the incident. This evidence for obvious lack of routine maintenance of the reservoir system for more than 20 years should have been an obvious finding in the Toddbrook Reservoir Inspection Report (Nov 2018). The report was so embarrassing that it was totally redacted and yet published with over 100 sheets blacked out when publication was forced under an FOI request in October.

Analysis of the Damage to the Toddbrook Dam.

There is a concern that the Head of the Incident Enquiry, Prof. David Balmforth was only appointed in mid October after a lot of tidying up and 'fault investigation' had already occurred so the Enquiry may not have seen the Reservoir System in prime failure mode and in its neglected pre-incident state. This document has been submitted to Prof. David Balmforth.

A copy of the original Dam Specification (1831) by Engineer John Wood and sketches of the overall reservoir system and the details of the concrete spillway installation are added. These will compliment the previous document Ref1)

I would like to acknowledge the use of images produced and uploaded to the internet by others. Several were anonymous, a 'Foxes Afloat' video revealed the Long Crack in the Apron. This is a very important image which otherwise we would never have seen. About half of the photos are my own. Three people collaborated with 'Foxes' but may have uploaded their own material as well, Les Chesley, David Jones, Steve Phillips. If there are others then I thank them too, my use is non commercial, it is simply to describe the details of this dangerous incident by use of generously available images.

Graham Aldred B Sc.(Eng) 15 Dec 2019

Contents.

References. Ref1: "*Toddbrook Reservoir Dam Report " Sept. 2019. Aldred G.*

Introduction.

Photo 1 (above). The footway has 9 support legs (one hidden by the bush) plus 2 supporting abutments therefore there are 10 gaps under the footbridge. For this survey these gaps will be called Gaps 1-10 numbered from the left in this picture. The damage occurred in the middle of the dam on the spillway below Gap1.

Photo 2 (above). A variety of weeds and shrubs have always flourished in the unsealed margins of the 170 panels of the Spillway and Apron, therefore the roots can easily find water underneath the panels. Mosses and lichens grow well on the decaying rough concrete surface.

When the spillway was constructed large stones, some visible here, (also photo 17a) were deliberately embedded in the wet concrete of the panels. It is assumed that their purpose was to disturb the flow down the spillway before it entered the Bypass channel below. The intention was to create turbulence and redistribute the forward energy of the flow so the water would be slower and be less able to jump over the Bypass channel (see Photo 8).

Photos 3 & 4. The Apron viewed from the reservoir side showing the considerable weed growth along the long junction between the mid and outer panels across the Apron. There are water erosion channels that pass underneath the Apron because water has been seen driven right through by waves (Ref1). The luxuriant weed growth did provide a good indicator for the location of the erosion channels where the roots can access water but unfortunately all weeds that provide these clues have now been removed from both the Apron and the Spillway.

Photo 4. Zooming in on the well nourished flora. The Secondary Cill is the raised concrete curb in front of the footway legs. This Cill is supposed to be 12-15in. above the original primary Cill. So the reservoir has to be over filled above its design limit with at least 50,000 tons of water before the secondary Cill will operate. (The rate is 50,000 tons per foot.) This obviously overloads the dam.

The First Test of the 1971 Spillway.

Photo 5 (above). Photo taken before the panels were lifted by water from underneath, (probably Wed. 31 July). Many people and their children came to experience the excitement of the power and noise of this unique waterfall. The dark lines in the water are heads of weeds amazingly able to disturb such a powerful water flow. All the other raised 'mounds' are possibly caused by the implanted stones. The weeds and stones may have been successful in creating useful directional chaos to absorb energy but now the CRT has removed most of them.

Photo 6 (above). The foot of the spillway before the panels were lifted and smashed. The Bypass channel in the foreground is hardly distinguishable. Water has overflowed onto the unprotected earth dam at the side wall on the LHS which for some unknown reason is lower than the RHS wall.

Photo 7 (above). The RH side of the photo shows the congestion and back up caused by the Bypass water hitting the River Goyt at right angles, in virtual opposition to its flow. This actually caused the Goyt to back up which then caused the nearby Randal Carr Brook to back up which drains the Coombs Res. Considerable damage occurred to the Randal Carr. The Bypass channel junction with the river should be re-engineered to remove this contention so that the Bypass and the Goyt converge and merge in the **same** direction.

Photo 8 (above). At the LHS the flow jumps across the bypass channel and takes a short cut under the trees, across the playground and footpath to reach the Goyt. This is caused by the flawed design of the spillway, which is narrower at the bottom and offset from the top. Photos 7&15 show that the LHS side wall changes direction considerably to try to steer the flow but water cannot be compressed and the contention shown here is the result.

The Spillway Panels Under-mined, Collapsed and Broken.

Photo 9 (above): Spillway below Gaps 1 & 2. It was probably taken late on 1 Aug., after 36 hours of the massive flow. Here the water is still over flowing, the first panels have snapped and collapsed into the deep hole caused initially by water flowing underneath the Apron.

Photo 10 (above) : As in Photo 9 but taken from the footway looking down, showing the big empty cavity underneath adjacent spillway panels to the right where more of the clay core has been excavated which will lead to the further collapse seen in photo 11.

Photo 11(above) : More panels have dropped and the appalling inadequate footings of the side walls are exposed.

Photo 12 (above): The Gap 2 spillway panels have now both snapped in half and fallen into the empty void. Thin sheets of concrete without metal reinforcement and weakened by minimal water in the concrete mixture when cast are especially brittle and can easily be snapped.

The upper spillway panels seem to have snapped in half along approximately the same line. Perhaps an inherent weakness already existed due to the 'turbulence' stones inserted in straight lines across the panels which will assist snapping along the same (dotted) line. Or perhaps their top half was supported whilst the clay beneath the bottom half was washed away. The immense weight and pressure of water would subsequently load the unsupported panels and snap them along the line of greatest weakness.

The concrete of the spillway panels is of poor uncontrolled variable quality , they are too thin for their large area, have limited tensile strength and are not reinforced.

The collapse of over 9 spillway panels into a deep cavity indicates the extent of the huge loss of clay & earth core underneath.

Note the steep angle of the side wall trying to steer the flow which causes the chaos shown in Photos 7 & 8.

Side Wall Undermined.

Photo 13 (above). A early picture taken not long after the flow has stopped. There is a significant large cavity under the RH spillway panel where the wall footing was undermined.

Photo 14 (above).

It is probable that the abutment wall footings at the top of the dam have always provided the major weakness for water erosion channels to develop. This is the region of maximum pressure on the dam, where the spillway panels have always been wet and where water was seen by me bursting through the panel gaps, pulsed by waves on the reservoir hitting the underside of the

apron. The footing for the abutment wall requires a trench which crosses the whole dam section much deeper than the Apron and Spillway and therefore provides a direct route for a water erosion channel to follow. In addition this deeper trench is more frequently below the water level.

Concern for this particular vulnerability of the dam might explain why two pressure sensors were fitted just at the other side of the wall about 1 m apart. The two white stubs in the grass at the top of the wall in both Photos 13&14 are the pressure sensors.

Photo 15 (above): This important photo provides the evidence of the undermining of the side wall at the top and the reason for the big cavity shown in Photo 13 on the other side of the wall. Videos on 31 July showed a spectacular tall fountain about 25 ft. high bursting out at the earth side of the wall at the top where the bags have filled the slot now.

Obviously the footings of that wall are ineffective and vulnerable. They provide another serious indication that the concrete overflow structure was an ill judged mistake fraught with numerous flaws which could not be demonstrated because the operation of the spillway could never be tested.

The wall is supposed to contain the flow and protect the rest of the vulnerable earth dam but it failed. There is an overwhelmingly strong case to disable and remove the spillway as described in much detail in Ref 1.

The deep trail of stones and clay in the foreground on the grass has come under the wall from the core of the dam.

.

Photo 16 (above): The Bag Drop is complete. The volume of missing clay under Gaps 1&2 has been replaced by about 500 one tonne bags of stones and aggregate. If the volume of each bag is only 1 cu.m, the dam would have lost at least 500-600 cu.m of clay core and earth embankment material. These figures of considerable depletion contradict official claims that the clay core has 'not been damaged'.

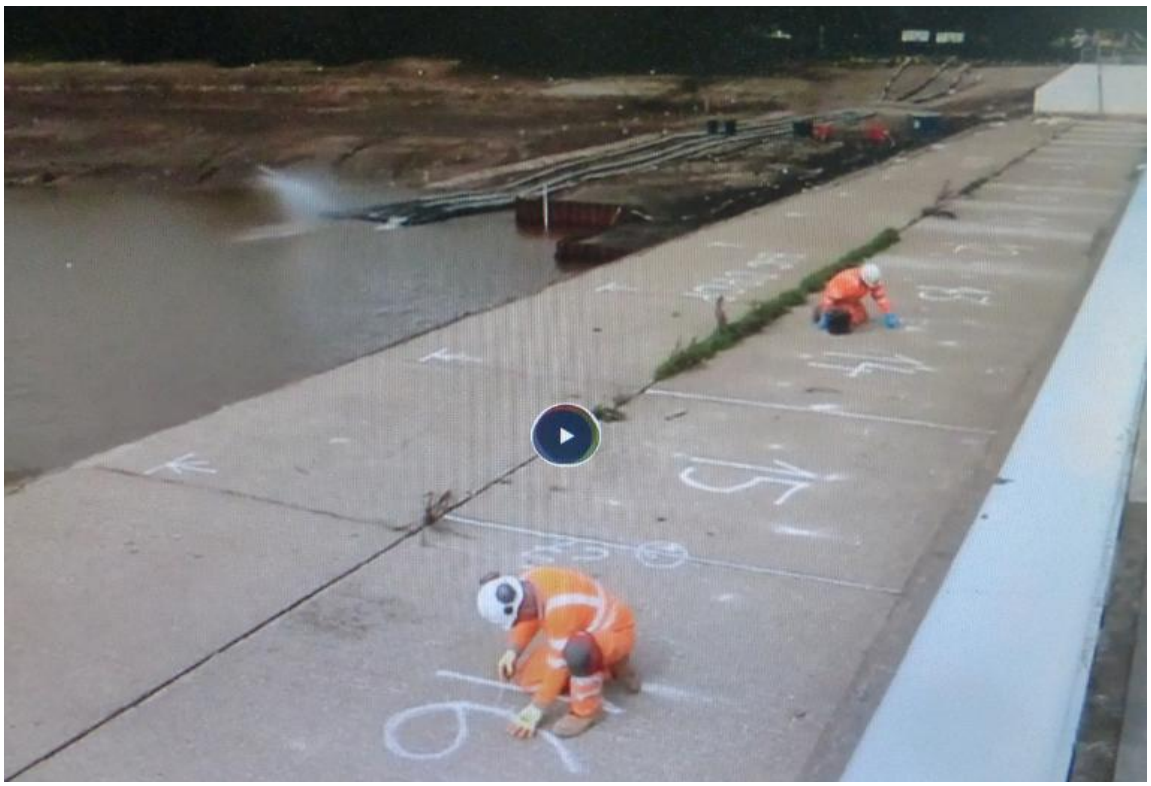
In addition the extent of other water erosion cavities under all the other panels of the Apron and Spillway which were not lifted by the flood is completely unknown because no forensic examination has taken place.

Photo 17 above & 17a. Some of the clay core on the foot of the spillway, the rest went into the Bypass and then on to the River Goyt.

Photo 17a

The Apron

Photo 18 (above). *Grouting the Apron ?* All the middle Apron panels have been given numbers. There are 2 Apron panels spanning each Gap, (*except that Gap 1 has 3 apron panels*).



Photos 19 (above). The men appear to be filling small holes with grout but only in the mid apron panels. These may be inspection holes drilled deliberately in the hope that a camera would reveal an erosion channel if the hole happened to have been drilled in a

'lucky' place. They are also grouting some of the inter-panel gaps, but only the mid panels

These actions and subsequent removal of every weed in the spillway and apron strongly suggest that the CRT is confident that the Report from the current Enquiry will exonerate the design and construction of the Concrete Spillway structure. These actions indicate that the CRT believe that the concrete structure will stay in place and be kept potentially operational despite all the known inherent defects and despite the fact that there has been no extensive forensic search for erosion channels under the Apron. It is very curious that this cosmetic work and other functional much neglected maintenance can be carried out before the Independent Assessment of the cause of damage has been reported to the Secretary of State and made public.

The Long Crack in the Apron.

Photo 20 (above). Whilst reviewing the images and videos on the internet. I found this image quite by chance in some background footage on a drone video made by Foxes Afloat . It shows that there is a continuous crack which extends across several Apron panels. By counting back from the far wall Gap 3 is located in the immediate foreground of photo 20. The group of white sandbags is at the start of Gap 4 (covering up some of the crack). The regular raised slabs of concrete along the RH edge of the photo are the footbridge post footings which stand on the apron and define each gap. The blue handrail is just visible above.

Careful study of Photo 20 (and other video footage) shows that the crack extends into the distance to half way across Gap 8. It is very probable that the crack originated in Gap 1 when the major spillway damage occurred although there is no picture to confirm this.

The conclusion is that there is a long virtually continuous crack in the concrete panels which extends right across the Apron from Gap 1 to half way across Gap 8. This means that 75% of the Apron has been severely damaged by considerable forces which must be explained and reconciled with any future functional use of the ill considered concrete spillway. Given that the footway is 200 ft. long then this crack will be about 150 ft. long.

The crack is continuous across adjacent panel boundaries (Photo 20&21) and it always passes in front of the Footway Legs. These are important facts. The path is independent of individual panels, but is defined by something which all panels have in common, like perhaps a long empty void under the Apron allowing them to snap when loaded ?

Photo 21 (above). Close up of the crack crossing Gap 3. Blue stripes at right angles to the crack and across panel boundaries on the spillway indicate a recent CRT investigation perhaps with expansion gauge pieces to check for relative movement. This crack was not there before the incident because it would certainly be visible to anybody who paused virtually anywhere on the footway. Later images show that this crack in the Apron has been filled with white grout !

Photo 22 (above). Photos 22 & 23 are an attempt to demonstrate the length of the crack. To the right of the photo, Apron panel 16 is the first of the pair in Gap 8. Above panel 16 on the far side of the footbridge there is a smudgy white line on the far apron panel. This is the far end of the crack. This winding smudgy line can be followed to the left across the picture, note that it always passes on the far side of the support legs. This is the track of the crack.

Photo 23 (above). This the same photo with different contrast and brightness which may help to show the line of the crack as an indistinct winding white smudge on the far side of the footbridge. The reason for the whiteness is because there has been an attempt to fill it with white grout and this has been smudged onto the adjacent concrete.

A continuous coherent crack 150ft long on the multi panel Apron indicates a serious structural loading which must be analysed and explained. This crack must not be covered up as if it was just a cosmetic blemish.

Conclusions

Unfortunately this study has had to be carried out using only the available images and without any access to the dam itself with opportunities to investigate and measure. Nevertheless it has exposed more functional weaknesses of the untested structure.

There is a continuous structural crack 150 ft. long across 75% of its width of the Apron. The forces that caused this crack and the structural implications for the dam itself must be investigated and explained. This alone should forbid the reinstatement of the concrete spillway.

The location of the initial failure at Gap1 corroborates the strong evidence for pre-existing water erosion channels underneath the Apron, the top two spillway panels and side wall in Gap1. The photos show that the side wall and its footing provides a major opportunity for water erosion channels to develop across the top of the dam following the wall or its footings 3-4ft below the Apron.

The abutment walls of the Apron would have required a deep trench for footings taking away even more of the clay core than the apron did, well below original safety margin of 5ft. This means that any developing erosion channels in this trench would be more frequently under water because the reservoir level is much more frequently lower than the Apron. So these channels would have developed quicker and grown during the last 50 years than those just immediately under the Apron.

It is clear that the construction of this overflow structure on top of the existing earth dam has hugely increased the vulnerability of the dam to water erosion channels by creating many surfaces between clay core and concrete which did not exist before and yet must always remain watertight. But these interfaces cannot be sealed, tested or inspected periodically. The Spillway structure is therefore an ill judged engineering modification which has created serious safety problems for which there is no solution other than to remove it.

It is only necessary to deduce why the first panel was lifted and damaged, because once the core of the dam and the underside of the spillway are exposed to the enormous power of the flowing water then the progression of further considerable damage is inevitable. The further damage and potential broaching can only then be prevented by maximum discharge actions.

Initially the first spillway panel could only have been lifted and then snapped by an imbalance of forces acting on it which would require either (or both) of:-

a) A strong upwards force applied underneath the panel caused by massive static water pressure delivered by a rogue channel through the dam from the overfilled reservoir.
b) Or partial excavation of the bed of earth and clay that supports the panel. This would require a powerful jet of running water which would therefore require an exit path. The exit path was very probably the erosion channel under the side wall (and subsequent tall fountain) discussed in photos 14 & 15. Once part of its base has gone, a brittle spillway panel is unsupported, large forces on it will become unbalanced, it will snap and be pushed aside.

Then the sequence of further damage and erosion will accelerate radically according to the energy of the flow, the arbitrary relative weaknesses of the structure and its design. The exact sequence may not be very important, but considerable damage will definitely occur as panels are smashed and more clay and earth becomes exposed and rapidly eroded.

The Case against the Spillway.

This survey of photographs has shown that this secondary spillway even if 'repaired' it cannot be trusted to function safely at any time.

The Apron has a continuous structural crack 150 ft. long across 75% of its width. This alone should prevent the reinstatement of the concrete spillway. The cause of this crack and the potentially profound structural implications for the dam itself must be investigated and explained.

There are no possible actions for the existing spillway except complete removal. The safest and cheaper solution for continued functional use of the reservoir is to:-

a) Install height gauges so that reservoir levels and discharges can be managed safely most especially the water level at the Primary Cill.
b) And, deepen the convergence basin and the last 100m. of Bypass channel to accommodate both the overflow from the reservoir and the Bypass flow (ref1).

It is vital for the safety of Whaley Bridge and especially the school to return to careful engineering practice in which the Earth Dam must always be protected and isolated from any flowing water.

There are apparently no other earth/clay dams in the UK which have been modified with such a dangerous arrangement.

Completely removing the original safety margin to install the spillway has guaranteed that water erosion channels will always develop under the Apron and side walls. There is no way initially or periodically to test the waterproof integrity of the Apron & Spillway.

This is a fundamental design problem. It could be solved by lowering the primary Cill to lower the maximum level of the reservoir which would ensure that waves don't ever lap under the Apron. But this would require the convergence basin to be deepened (Ref 1) which would mean that the concrete spillway was redundant ! That is the safest solution

The photos show that the side walls are incapable of managing high volume flow rates. They have been angled and narrowed at the bottom, water just jumps over them and destroys the earth embankments at each side, which is what the walls are supposed to protect. In addition they have shallow and undermined defective footings which are a haven for erosion channels.

There are so many fundamental defects which could not be resolved even if the spillway was entirely replaced and reconstructed to current Civil Engineering Standards .

The only safe and less costly solution is to:-

a) Remove the entire concrete Apron, Spillway, Side Walls. Then replace lost Dam material.
b) Modify the Bypass channel and Convergence basin by deepening and contouring, which is a standard civil engineering solution for increasing the Bypass capacity used on other reservoirs.
c) Lower the Primary Cill to lower the maximum reservoir level by perhaps 2m.

Graham Aldred 15 Dec 2019

The Convergence Basin Clearance.

Photo 1: The Bypass Channel approaching the Convergence Basin. This channel should be wide and straight. Never maintained for over 20 years, it has been allowed to contract to half its constructed width by mud banks and weed growth. The safety of the Reservoir depends fundamentally on the flow rates that the Bypass channel system can achieve. This was the state when the dam was damaged.

Photo 2: Pumping out the reservoir, showing a pile of weeds and mud obstructions which had to be removed initially from the Basin by the Emergency Team improve the flow when desperately trying to empty the reservoir.

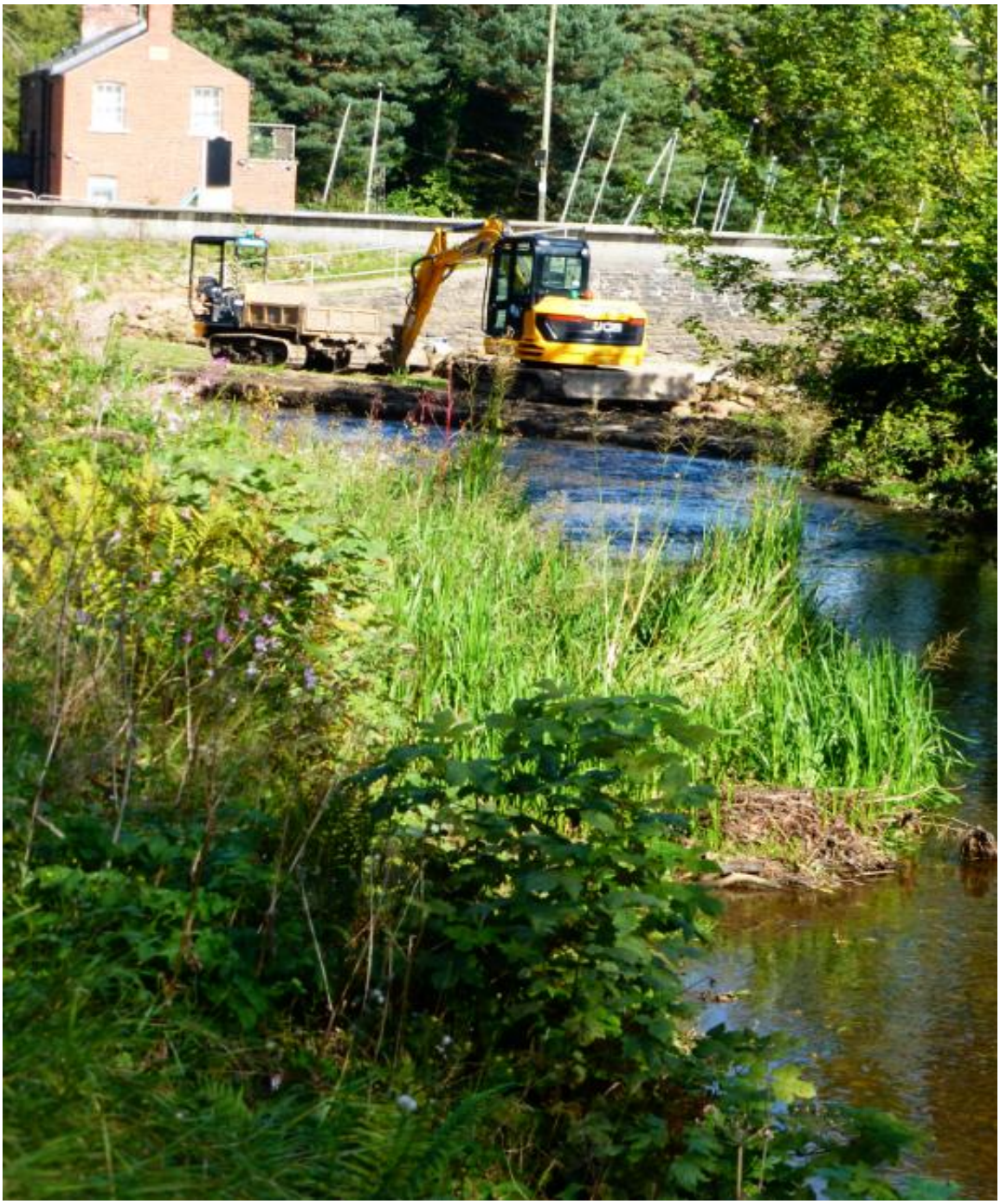


Photo 3 : A typical mud bank and weed obstruction in the Bypass..

Photo 4 : Some of the many tonnes of mud ,weeds and stones that were dug out and removed from the Basin and last 100 m of Bypass channel several weeks after the incident. All this material unnecessarily occupied precious volume in the convergence basin during the flood and impeded the flow as the reservoir tried to drain over the primary Cill. The pile of mud is a measure of the consequences of not doing any routine maintenance to the Basin for over 20 years.

Photo 4: This is the Bypass channel that appears in Photo 1 but seen now (Nov.) after being properly and thoroughly cleared of all the mud banks, weeds and vegetation. It is more than double the width with nothing to choke or obstruct the flow. The Bypass now looks like the functional canal that it was engineered to be 180 years ago.

It is an indictment of the CRT that it took the near destruction of Whaley Bridge and many possible deaths for simple proper routine maintenance to be carried out. We can be certain that this has only happened because there was a crisis on the dam.

Photo 5: The 'Convergence Basin' now belatedly cleared of all obstructions (Nov). This is where Bypass water and Reservoir overflow water have to converge so maximum capacity here is crucial. There was massive congestion this year during the incident caused by allowing the reservoir to overfill and the loss of capacity caused by numerous mud banks and weeds.

But clearing out the Basin and Bypass is not enough, it will not alone guarantee future safety unless there is a resident reservoir keeper or a reliable hi tech alarm system to initiate full discharge actions to prevent overfilling. If this Basin was deepened here there would be no requirement for the dangerous and ineffective concrete spillway over the top of the earth dam to be repaired or replaced. (Ref1)

The Weir and the Bypass Gate.

Photo 1: Taken 8 Aug after no rain for a week and the reservoir had been virtually drained showing the Bypass Gate had been raised for max flow to the Bypass Channel. I saw that this gate was virtually shut (6in.) and locked on 1 Aug. after the damage had started. Therefore most of the Todd brook had flowed into the reservoir and overfilled it for the last week of July.

The large mud bank is the foreground has blocked the direct entrance under the gate for over 25 years. The water has to meander round and enter from the side as in the photo. The Gate was only fully opened after the panels were smashed on 1 Aug. Later the passage in the foreground was dug through the mud bank to get maximum water moving directly towards the Bypass, exploiting the power of the then fast flowing Brook. See photo 2 (below).

Photo 2: Looking up stream from above the Bypass gate. This shows the same huge mud bank in front of the bypass gate with the trench cut through it. The emergency team had to dig out this passage through the mud bank to cause direct flow during the crisis when trying to stop the reservoir from continuing to fill. This is just another illustration of the systemic neglect of the vital reservoir controls at Toddbrook.

As of end Nov. all the mud banks, shingle and weeds in this photo have now been removed completely, months after the incident. But it was too late, once every 25 years is not acceptable. Reservoirs that can destroy a village school in 30 seconds should have to have an annual critical operational safety test against a schedule, just like an MOT.

Photo 3: This neglected and curious mess is in fact the entrance to the weir to fill the reservoir. The throat of the weir has been blocked with Gabions under the sheet but the layers of broken concrete in front are always there, just part of this poor neglected old weir. In this photo all the water of the Todd Brook is going into the Bypass by the side route to the left, the direct flow into the bypass is still obstructed by the mud banks in photos 1&2 . There is not enough water to even cover the broken concrete which indicates how these irregular concrete lumps normally regulate and impede the input to the reservoir.

Photo 4 : The upstream view of the Weir and Bypass Gate illustrates the whole arrangement at the weir, the obstruction of the mud bank, also showing the Bypass channel running towards the Convergence Basin (a mile away) by the footpath (top Right) .

Photo 5: The downstream view of the weir itself after the incident in Aug 2019 showing the accumulation of 180 years of damage and neglect.

Photo 6: This was the state of the bottom of the weir in July 2017 showing failed historic attempts to prevent the undermining and destabilising the weir base by crude concrete infill repairs superimposed on each other. By Aug 2019 these repairs have already failed, previously attacked and broken by the power of successive floods, as photo 7 shows.

Photo 7: The foot of the weir, Aug 8 2019, after this year's flood. The damaged concrete of the crude repair in photo 6 has been washed away. The side wall at the LHS has been broken down by this year's flood that actually came round the back of the weir and pushed the side wall forward into the river. This side wall has no mortar, it's just a dry stone construction, utterly inappropriate as a side wall to guide the huge flow out of the weir.

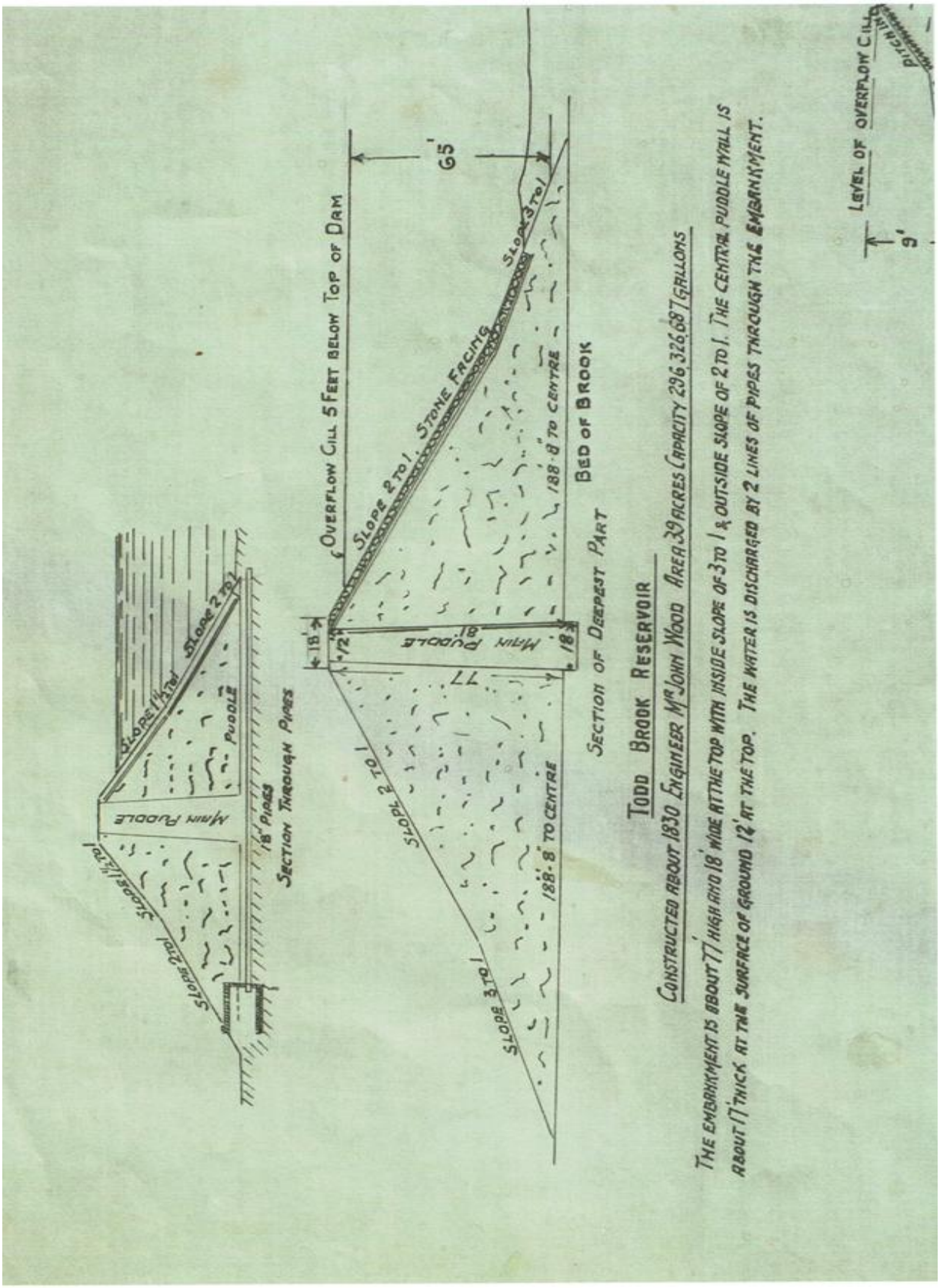
Comment on the Weir and Bypass Gate.

These photos show that the weir and the Bypass gate require extensive and major engineering redesign and repair. The weir provides the fundamental safety control for this reservoir. It has the only facilities to control the filling of the Reservoir.

In the recent emergency a multi million pound helicopter was required to make several flights to bring materials to block the weir. There is no access for vehicles to the weir, a major deficiency I foresaw three years ago and emphasised to the CRT (Ref1). No usable controls have been designed to close this weir. In the first 180 years the intelligent and alert actions of the reservoir keeper were sufficient.

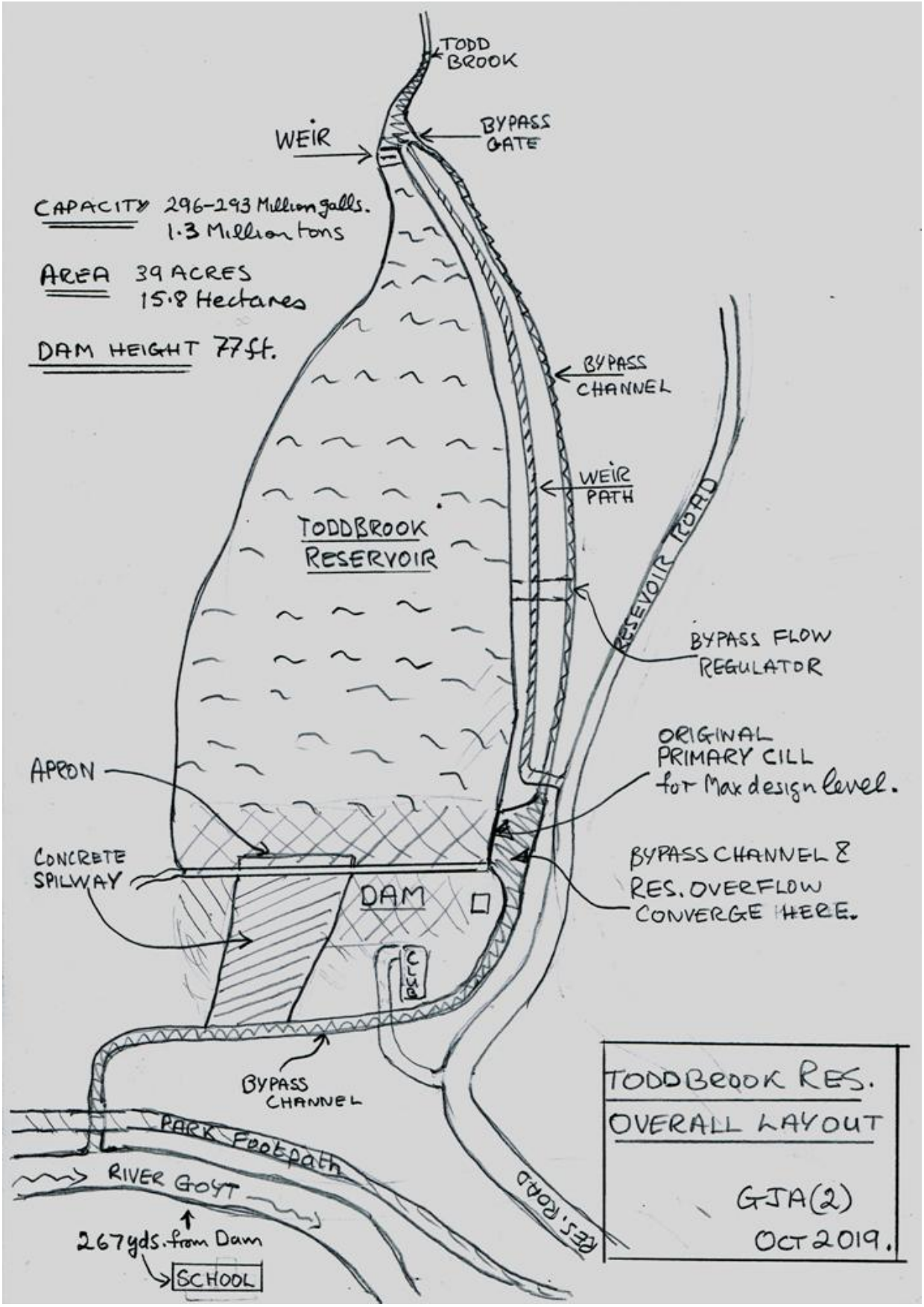
This state of neglect is unacceptable and cannot be justified in the 21st C for a Reservoir with a self activating dam-destroying spillway, which impounds more than 1.3 million tons of water about 290 yards away from the vulnerable village school and a small town.

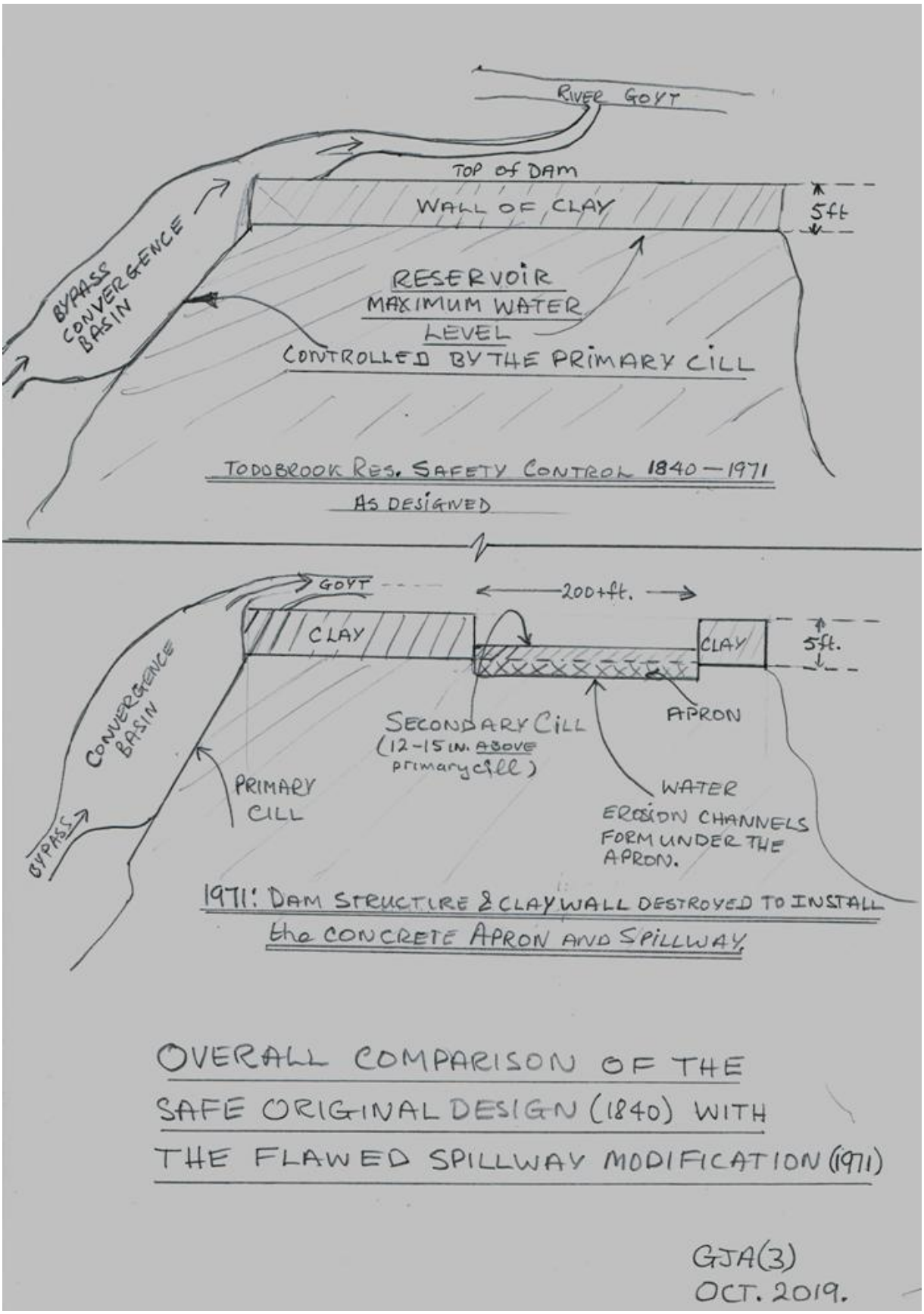
Graham Aldred B.Sc (Eng.) 17 December 2019

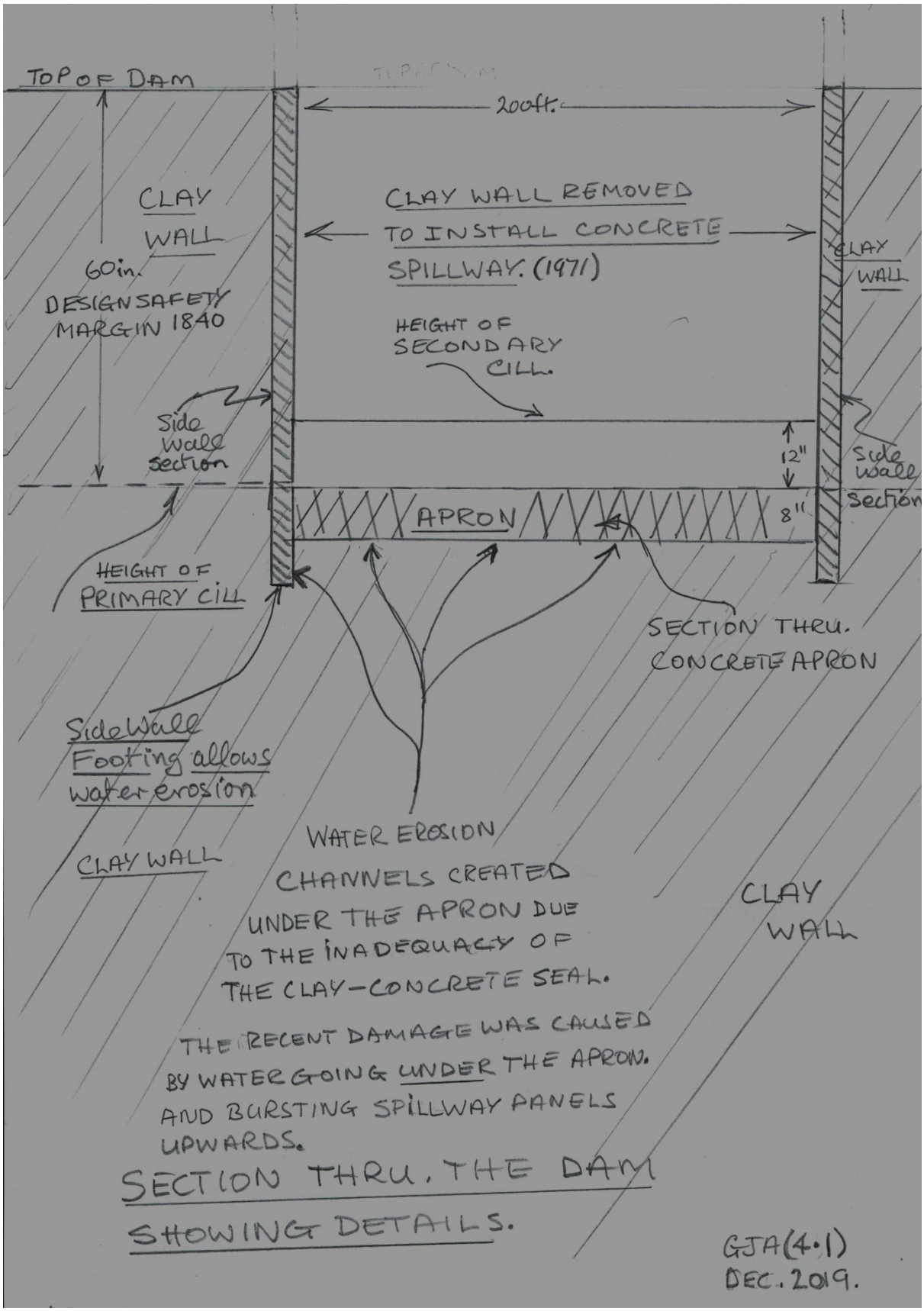


The Original 1831 specification of the Dam.

Note the vital Safety Specification about." ***Overflow Cill 5 feet below Top of Dam.***" This safety margin was destroyed by British Waterways in 1971 by construction of the concrete Spillway.


TODD BROOK
WEIR
BYPASS GATE
CAPACITY 296-293 Million galls.
1.3 Million tons
AREA 39 ACRES
15.8 Hectares
DAM HEIGHT 77ft.
BYPASS CHANNEL
WEIR PATH
TODDBROOK RESERVOIR
RESEVOIR ROAD
BYPASS FLOW REGULATOR
ORIGINAL PRIMARY CILL for Max design level.
APRON
CONCRETE SPILWAY
DAM
BYPASS CHANNEL & RES. OVERFLOW CONVERGE HERE.
CLAY
BYPASS CHANNEL
PARK Footpath
RIVER GOYT
267yds. from Dam
SCHOOL
RES. ROAD
TODDBROOK RES.
OVERALL LAYOUT
GJA(2)
OCT 2019.


RIVER GOYT
TOP of DAM
WALL OF CLAY
5ft
BYPASS CONVERGENCE BASIN
RESERVOIR MAXIMUM WATER LEVEL CONTROLLED BY THE PRIMARY CILL
TODDBROOK RES. SAFETY CONTROL 1840—1971
AS DESIGNED
GOYT
200+ft.
CLAY
CLAY
5ft.
CONVERGENCE BASIN
SECONDARY CILL (12-15 IN. ABOVE primary cill)
APRON
PRIMARY CILL
WATER EROSION CHANNELS FORM UNDER THE APRON.
BYPASS
1971: DAM STRUCTURE & CLAY WALL DESTROYED TO INSTALL the CONCRETE APRON AND SPILLWAY.
OVERALL COMPARISON OF THE SAFE ORIGINAL DESIGN (1840) WITH THE FLAWED SPILLWAY MODIFICATION (1971)
GJA(3)
OCT. 2019.


TOP OF DAM
200ft.
CLAY WALL
60in.
DESIGN SAFETY MARGIN 1840
CLAY WALL REMOVED TO INSTALL CONCRETE SPILLWAY. (1971)
HEIGHT OF SECONDARY CILL.
CLAY WALL
Side Wall Section
12"
Side wall Section
APRON
8"
HEIGHT OF PRIMARY CILL
SECTION THRU. CONCRETE APRON
Side Wall Footing allows water erosion
CLAY WALL
WATER EROSION CHANNELS CREATED UNDER THE APRON DUE TO THE INADEQUACY OF THE CLAY-CONCRETE SEAL.
CLAY WALL
THE RECENT DAMAGE WAS CAUSED BY WATER GOING UNDER THE APRON. AND BURSTING SPILLWAY PANELS UPWARDS.
SECTION THRU. THE DAM SHOWING DETAILS.
GJA(4.1) DEC. 2019.

The Dam Specification and Drawings (above).

The first drawing provides the evidence for the "5 ft. Safety Margin". This key specification is defined on the original Dam design (1831) by the Engineer Mr.John Wood. My sketches expose in detail how the installation of the concrete spillway not only destroyed this fundamental margin of safety and then allowed water erosion channels to develop but also invited water to flow over an earth and clay dam on an inferior structure that is not waterproof.

The last sketch (GJA 4.1) illustrates the serious consequences of the abutment walls and their footings on the top of the dam, which I have only just recently appreciated. They provide a direct deep route across the top of dam for water erosion to develop. I suspect that if there was a thorough investigation this is where the major cause would be found.

These sketches are really intended to complement my previous document "*Toddbrook Reservoir Dam Report " Sept. 2019* but they were not complete at the time of issue. I hope that they will be of use now.

::****************:::

Quotations from "Lessons from Historical Dam Incidents. 2011" Defra. Charles, Tedd, Warren.

An excellent analysis of all dam failures in the last 200 years.

"Near misses' are incidents which have not caused casualties or property damage, but which might have done had there been no human intervention; typically a near miss incident requires emergency action such as **rapid reservoir drawdown**, the implication being that without such emergency action a breach would be likely"

.....So the Toddbrook Dam Incident was a 'Near Miss'........

"An uncontrolled release of reservoir water is generally associated with a breach of the dam and evidence of the cause of failure is likely to be destroyed in the failure. With a near miss the **evidence still exists and can be fully investigated**."

....and the Evidence of the Cause is still there.......but may not have been investigated.....

 graham@sheardhall.co.uk