Toddbrook Reservoir Incident.

16 February 2020

Proposed Modifications and Repairs.

Summary.

This paper provides proposals for all the necessary modifications and repairs to the Toddbrook Reservoir. They are described in some detail and are required due to the events of July- August 2019 in which the dam was seriously damaged. This was caused by the disastrous installation in 1971 of a concrete overflow structure on top of the earth dam. The 1971 installation entirely removed the original safety margin that protects the clay core and this allowed erosion channels to develop. Other modifications arise due to the cumulative neglect and lack of routine maintenance over many years of various reservoir control facilities which were also exposed during the crisis. Some original design defects must also be resolved. All this work has been included in the list. There is some net gain because some operations which are required to rectify the decay and neglect are also required by some of the proposed modifications

Two papers on this incident have been published previously (Ref 1, 2). The first describes the sequence of events that led to the damage to the dam and the second provides the analysis of the causes with evidence. Both papers have justified and outlined these modifications.

This third paper provides a constructive and prudent Modification Plan which deserves serious assessment on criteria of safety, feasibility and cost compared with any other modification ideas that may have evolved since last August. Any other plan must meet the same constraints:- Concrete removed from Dam, Dam inspected and repaired, Load must be reduced on old Dam, so max water level must be lowered, so Overflow channel must be revised. These proposed modifications are cost effective and use standard, effective civil engineering techniques. There are specialist Companies who are experienced in Reservoir Safety operations who would tender. I am concerned that without independent assessment the logic and merits of this modification plan could be just dismissed. At a recent meeting on (29th. Jan.) the CRT confirmed that:-

a) The Toddbrook Reservoir has *High Risk* status. (Reservoirs Act (*Ch. 23. Para 2C*))

b) All the concrete, ancient and modern, will be removed from the Dam.

c) The Reservoir will not be filled until the final modifications and repairs have been completed.

Contradictions.

If the dam cannot be repaired then no other repairs will be needed therefore work on the Dam must have the highest priority. Given that the state of the Dam can only be assessed after all the concrete is removed, we find it incomprehensible that the CRT are currently adding more costly concrete structures to the existing defective concrete spillway instead of removing it all.
There is apparently a strange “rule” which cannot be found in the Reservoir Act that is being used to justify the “Temporary Spillway” on a reservoir which has maximum emergency discharge options activated and which is not going to be filled (Ref.3). But this “rule” will have to be broken, just as it was 10 years ago when the valves were replaced. And it will remain broken in the future when the Dam is being investigated and repaired because the concrete spillway etc. will have to be removed for the investigation to happen. So it must be a very flexible and convenient “rule”. Current CRT actions are not logical, residents are deeply suspicious of this contradiction.

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1.0 Introduction.

This Plan addresses the defects already exposed and ensures that the reservoir will be able to pass the necessary Safety Audit before it becomes operational again. The CRT has now confirmed that Toddbrook is a reservoir designated with "High Risk" status. (Reservoirs Act (*Ch. 23. Para 2C*). The Earth Dam must therefore be isolated from the historic ill judged overflow facilities because this is the fundamental safety requirement that must be met before the re-instatement of the Toddbrook Reservoir. It is this non negotiable requirement that determines all the other modifications.

In view of the near disaster to Whaley Bridge in August 2019 that could have inundated and smashed the school, killed residents and destroyed their homes and businesses, the flawed concrete overflow arrangements over the crest of the earth dam must be abandoned and removed. This will allow the fundamental Principle of Earth Dam Safety to be re-established at Toddbrook after 50 years.

"***Flowing water must always be kept separate from the structure and especially the crest of an Earth Dam.***"

Once this principle is accepted the logic and justification for the proposed modifications and repairs described below becomes obvious.

2.0 Modification Plan.

Although some of these modifications are independent, all of them will be required to reduce the risk and meet Safety Approval for this High Risk Reservoir.

1) The downstream face of the earth dam must be exposed, inspected and repaired. All Concrete panels, walls, temporary stuff, 500 bags must be removed. The 150 ft. long crack in the Apron must be investigated and explained.
2) The maximum reservoir water level must be lowered.
3) The Convergence basin floor must be lowered in consequence.
4) The walls of the Bypass channel on the bend must be properly engineered, the flow must be managed.
5) Input Flow regulation and control of the Todd Brook at the weir must be implemented.
6) Directional merging of the Bypass flow with the River Goyt must be implemented.
7) The blocked canal feeder culvert must be investigated and made operational.
8) An Operational Procedure Manual must be produced for ToddBrook Reservoir.
   This must include a 6 month maintenance regime for valve operation and all channel clearance
9) Dangerous Electrical Cables to be inspected and one of them removed.

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3.0 Modifications and Repairs.

3.1 Toddbrook Dam.

All of the 170 concrete spillway panels and especially the side walls must be removed and discarded. All the 500 temporary bags and any unnecessary 'temporary walls' added recently must also go. This will allow the downstream face of the Dam to be properly inspected for hidden damage for the first time in 50 years. The dam structure can then be reinstated and restored to its single original function which is to support the vital clay core inside. The dam will no longer be endangered by the 1971 overflow facilities installed in error.

After a thorough inspection and repairs, structural earth and clay must be added appropriately to replace the many hundreds of cubic metres removed in 1971 and over 600 cu.m washed away in 2019. The Footway, which is an attractive feature and the Apron, can remain in place because the Apron will no longer be a threat to the safety of the Dam due to the lowering of the maximum water level described later.

Lowering the maximum level of the reservoir reinstates the 1840 Safety Margin on the Dam (see 1830 Design spec. page 14). The reservoir was designed to have a safety margin of 5ft (1.5m) of waterproof clay core above the Primary Cill. This was destroyed in 1971 by British Waterways for the installation of the disastrous concrete panel spillway. The new lower Cill will ensure that once again there is at least 1.5m of clay core above max water level across the whole dam. The water level will never again reach the underside of the Apron where the erosion channels have been formed during the last 50 years which nearly led to disaster for Whaley Bridge.

Loading and pressure on the old abused Dam will be reduced by lowering the maximum water level which will reduce the weight of impounded water by 218-220 thousand tonnes. The maximum storage capacity of the reservoir will be reduced by 15% - 16%. (Ref.4). This is a reservoir with High Risk status so the safety of and risk to the community and their buildings is paramount and supersedes any operational considerations like a modest loss of capacity occasionally. With 85 % capacity the CRT should be content to be in the "Reservoir Half Full" camp in this regard. For most of the year the water level is below the new Max level in any case.

3.2 New Lower Cill.

The maximum reservoir water level must be lowered by 1.5 m. by installation of a new lower Primary Cill in conjunction with work on the Convergence Basin. This is shown in diagrams CB1 and CB1.

The Toddbrook Reservoir overflow system has one inherently poor characteristic in the original design which rarely if ever occurs on typical Pennine Earth Dam Systems. The overflow discharge does not have a descending private channel for sole use. There is not even a short length before it connects into the Bypass channel. Currently the Reservoir overflow just drops over the Cill which only 0.2m above the Convergence Basin floor where it must immediately merge and compete with the Bypass flow

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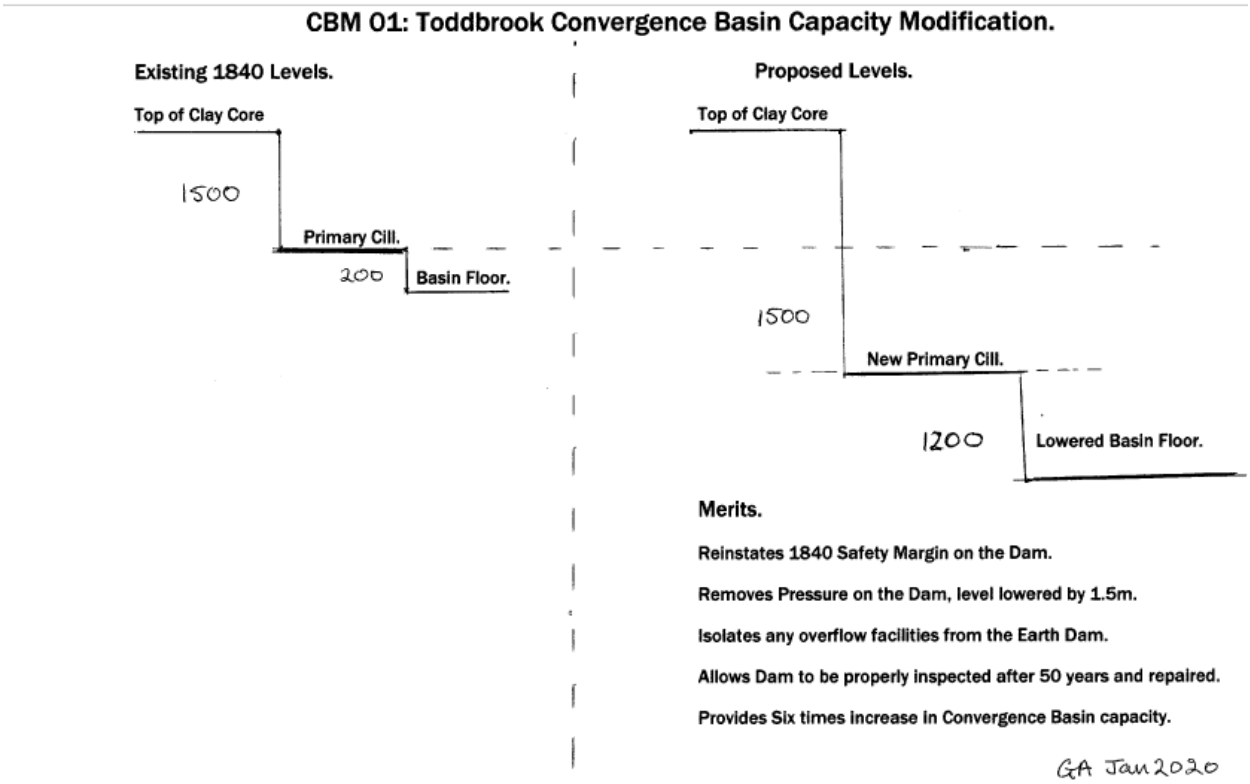
The Bypass level alone can easily rise to 0.2m due to its own volume and exacerbated by the poor flow design of the exit channel immediately downstream on the bend below the ex wardens house. So it is obvious that the Bypass flow not only easily blocks the reservoir overflow but the bypass flow can also force its way back into the Reservoir to replace any water that manages to get out ! This was what I saw on 1st. Aug 2019.

There is a very important benefit arising due to lowering the level. There has never been access for a vehicle to the weir path if the reservoir is nearly full. This means that men, materials and tools cannot get to the weir in an emergency as was the case last August. Fortunately on that occasion a Chinook helicopter did become available after a few days. I foresaw this safety defect three years ago and proposed a solution to the CRT which was not even considered.

Now it's even easier. With the increased margin due to the new lower level at the side of the reservoir there will enough space to make a short permanent hard core roadway onto the Weir Path so that vehicles can reach the weir quickly. In fact due to the empty reservoir this must have already happened and is currently in use by vehicles to manage the weir and Bypass channel.

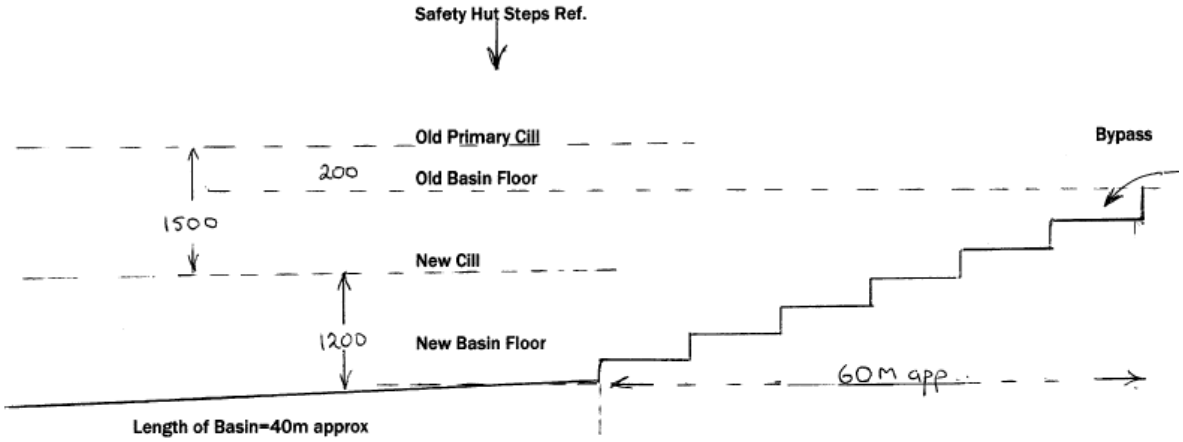


3.3 Convergence Basin Floor.

If the Cill is lowered then so must the Convergence Basin. The sloping Basin floor should be reconstructed approximately 1.0- 1.2 m below the new Cill to provide a much greater capacity for the reservoir overflow to converge with a simultaneous large flow in the Bypass Channel.

This modification provides a more than six times increase in Convergence Basin capacity. The deeper basin will solve the various problems of flow contention described above. Overflow from the reservoir will be able to drop 1.2 m into the Basin, Bypass water will not impede this outflow nor will the Bypass be able to flow back into the reservoir.

CBM 02: Toddbrook Bypass Level Change Modifications.



Bypass Channel Floor is lowered by 2.5 m

7 steps (or more?) probably better than a slope.

Channel Side walls renewed.

Reservoir Road supported

GA January 2020

3.4 Bypass channel flow arrangements on the Bend

The new taper of the Basin exit channel floor would feather into the existing channel floor downstream leading to the bend due to the progressively steeper gradient. The sidewalls of the bend should be streamlined and contoured in concrete to ensure a much more efficient flow to enable a more efficient drainage rate out of the new Convergence Basin. In addition the flow should be managed and directed by long alloy guide blades inserted into the Bypass floor approaching and in the bend. There is an excellent example of this flow steerage and control method using about 10 tailored blades installed for the same purpose on the Horse Coppice Reservoir Bypass bend in Lyme Park. The Bypass there has to execute a tighter steeper bend than at Toddbrook, which endorses the feasibility of my proposal.

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The Horse Coppice Reservoir Bypass Guide Blades. **Ten blades steer the flow to avoid damage and high loads on the LH wall, exactly as is required at the Toddbrook Bypass Bend.**

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The Horse Coppice Reservoir, Lyme Park …More details….

The blades are precisely placed at angles and in positions on the Bypass Floor. There are three active planes on some blades as seen here which modify the direction of flow in a progressive sequence. This scientific arrangement fully demonstrates an existing solution for the Toddbrook Bypass, it both endorses and vindicates the modification proposals for the Bypass channel described in this paper.

The sides of the Bypass channel and Convergence basin are currently just stones pitched into a wall of clay still in the state as built in 1831-40. Reservoir road did not exist then nor did any of the houses beyond Whaley Hall. There might have been a farm track which was surfaced and widened without waterside curbs about 100 years ago before heavy traffic occurred. Despite recent cosmetic tarmac patching, Reservoir Road shows instability and creep because the Bypass side wall cannot support the modern traffic loads. The state on the bend at the ex- warden's house has been an unstable mess for ages, probably since the damage in 1964 and it must be given serious attention now. The dangerous redundant live mains cable in a pipe must be removed. The proper shoring up of the road will involve renewal of about 100m of the Basin & Bypass channel wall regardless of my proposal to deepen the Basin which will require the same work in any case.

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This safe cost effective solution described in principle in this paper for managing high levels of flow in the Bypass has been carried out successfully on several other bypass channels by Askam Civil Engineering of Lancaster who specialise in this work. There is a local example of their Bypass modification at the Bollinhurst Reservoir above the Horse Coppice Reservoir (SJ 973,836) 4 miles away from Toddbrook, just SW of Disley. Although the proposed modification lowers the max reservoir level and deepens the Basin, it does not require the Bypass to be widened on the bend next to the ex wardens house, which will not be affected. It is illustrated in CBM 01 and CBM 02.

3.5 Flow Management at the Todd Brook Weir.

The CRT has outlined a necessary and suitable design for taking proper control of the inflow to the reservoir and the Bypass channel which has never existed previously. Three power operated sluice gates will control and block the main flow over the weir into the Reservoir, a fourth similar sluice gate will replace the ancient manually operated gate on the Bypass which was locked in a virtually shut state prior to Aug. 1st. In addition it will be necessary to repair and modify all the historic damage and derelict masonry above and below the weir as part of this safety modification (see photos in Ref 2).

3.6 Directional merging of the Bypass flow with the River Goyt.

The Bypass connection is currently at right angles to the River Goyt and should be altered so that it does not oppose and block the River's flow as it did on 30th July to 2nd August. With this direct angle the Bypass continued to fight the Goyt which backed up, as did the Bypass which flooded the Park. The backed up Goyt blocked the Randall Carr Brook (100m up river) which drains the Combes Reservoir. The wall of the main bend of the Randall Carr was damaged and it required extensive repair in Oct Nov 2019.

This is a serious requirement, obvious to anybody who saw the videos in which a huge wall of water from the Bypass *flowed on top* of the blocked Goyt and headed for the school, which is only 90m away. The Bypass channel (on the riverside after the Park Memorial Bridge) must be steered and guided to merge and flow in the same direction as the river flow. This modification would not disturb the Memorial Bridge.

This proposed arrangement is shown in CBM 03 and in a photograph showing the same directional convergence of the Mosel with the Rhine at Koblenz.

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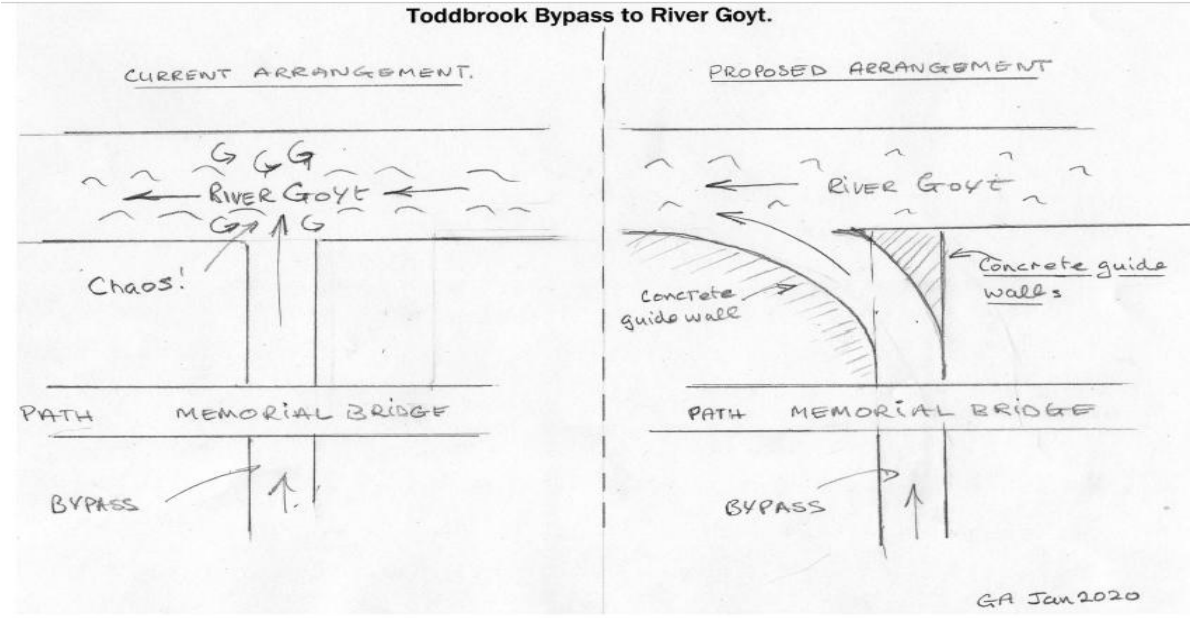
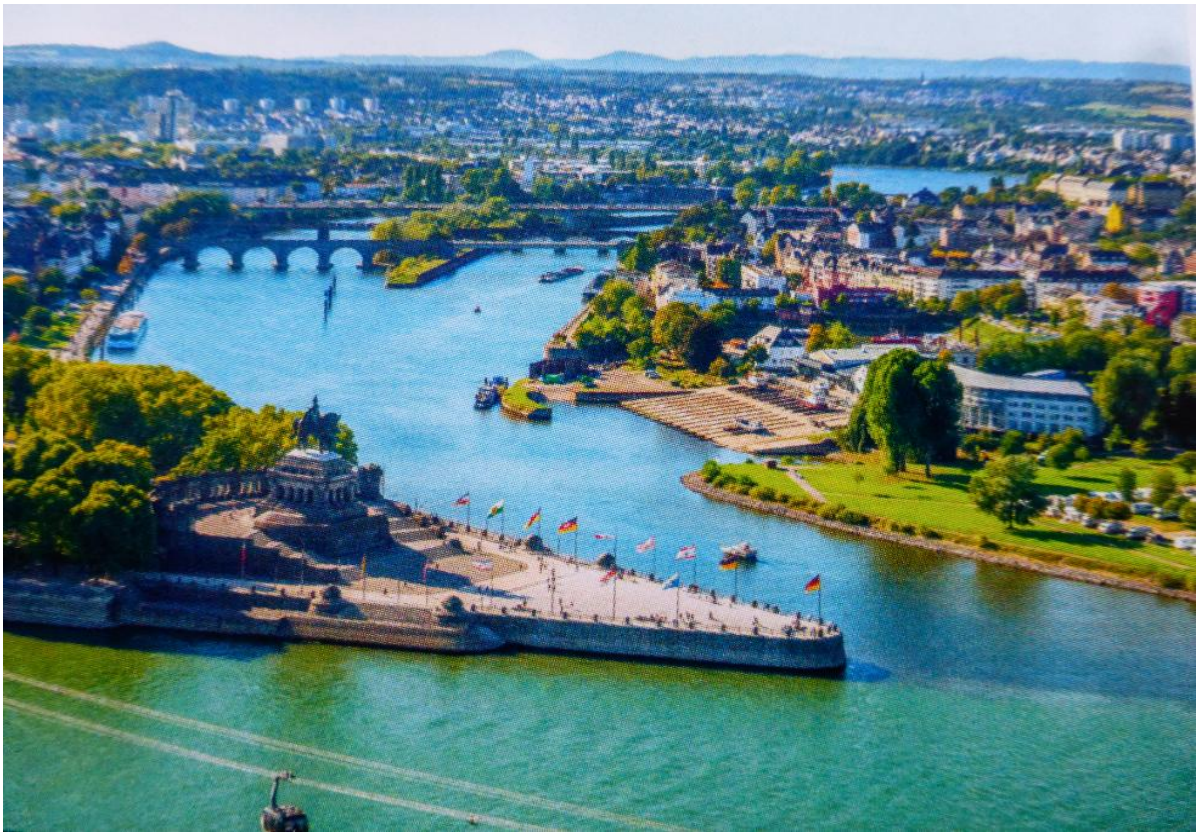


Below: 630 miles to the south, the Mosel merges with the Rhine at Koblenz.



Typical Example: The orderly flow convergence of the two great rivers is achieved by the guidance structure and the directionally curved river banks.

3.7 Blocked Canal Feeder Culvert.

An arrangement of open culverts downstream of the Dam allows both discharge valves to feed either the canal or the River Goyt *via the Bypass channel*. The culvert for the No.2 valve to the canal has been blocked for many years possibly in the vicinity of the former church near the Park entrance. The canal culverts are underground there and they merge into a single channel under Reservoir Road to go to the canal. The blocked channel could easily be re-connected under the Park Road to the working channel with a short length of new pipe work as the easier solution.

This is necessary because it is vitally important for safety to have all available discharge facilities operational for an emergency drawdown and to be able to dump the maximum into the canal rather than into the river.(Ref.5) When the Bypass is overloaded as it was last August the dump culverts were blocked by the huge very fast Bypass flow so the obvious solution is to send all the discharge water via existing feeder culverts to the canal where it has the opportunity if needed to overflow down into the Goyt without any contention.

3.8 Reservoir Operational Procedure Manual.

All potentially lethal and high energy systems must have rules and procedures for all events that threaten Public Safety. In many systems the detection of errors or overload can generate an automatic safety response but not here. Therefore a designated **High Risk** reservoir like Toddbrook must have an Operational Procedures Manual specific to Toddbrook, authorised and approved by the CRT Engineering Director, which describes all the procedures to be followed both for routine events and record keeping as well as inspections, anticipation of emergencies and the emergencies themselves. Of course the procedures must be written so that actions are taken to avoid an emergency, for example, opening both discharge valves when a given water level is reached.

This was not the case on Aug 1st at 10:00 am when serious Panic Mode was witnessed in those who were uncertain but were trying to do “something” but, alas, far too late. They cannot be held responsible without training and Approved Procedures.

3.8.1 Routine Exercising of Valves.

There is a legal requirement under the Reservoir Act 1975 on High Risk Reservoirs (which I have highlighted below) to record routine exercising of discharge valves exactly as described here. If it is carried out at Toddbrook (and the law demands that it must be) then such records would be in both of the 10 year Inspection Reports. However these documents were 100% redacted and published black, on grounds of "National Security". It is not credible that reporting the success of exercising a discharge valve 20 times in 10 years could possibly be a security matter. It does suggest that "National Security" is used as a convenient umbrella to cover up embarrassing findings on subjects that don't carry any security risks. We also wonder if either of the Inspections recognised the evidence of water erosion under the Apron. The 100% redaction of the Inspection Reports is a missed opportunity by the CRT to develop the trust of the Community.

Quotation below from Ref 5 *: SC130001 Volume 1….Environment Agency. Aug 2017.*

"**2.3 Routine exercising of facilities**

If not operated routinely there is a risk that valves and penstocks may become seized and therefore not be available in an emergency. Similarly, low-level outlets may become silted up with equal consequences. To mitigate these risks it is recommended that valves and gates on all drawdown facilities are regularly exercised. Many reservoir owners exercise the valves at 6-monthly intervals. For reservoirs registered under UK reservoir legislation, regular valve exercising is frequently a statutory direction by the inspecting engineer. It is good practice to maintain a record of valve operations along with a comment on the ease of operation and any issues found. **For reservoirs designated as 'high-risk' under the Reservoirs Act 1975 it is a legal requirement to record such details in Part 16 of the Prescribed Form of Record. Valves and gates should preferably be exercised over their full range of travel (i.e. fully opened and closed again).** If valves are only exercised over part of their range there is a risk they will not open beyond this range in an emergency. Other hazards associated with operating valves partially open are discussed in Section 2.1.2 (Low-level outlets). When exercising valves they should ideally be left open for a few minutes, until the discharge becomes clear, in order to flush any silt or debris through the outlet and thus ensure a good seal when the valve is closed again. However, it is acknowledged that in some cases fully opening a low-level outlet may cause localised flooding downstream or cause undesirable environmental impacts. These issues need to be managed as described in Sections 2.4 and 2.5 and should not generally be an excuse for not properly exercising drawdown facilities. However, this may be easier said than done in some situations, and where major issues prevent routine exercising of critical valves under full head then advice should be sought from an inspecting engineer"

3.9 Dangerous Electricity Supplies.

The photo below shows a potentially live cable P74, crossing the 3m Bypass without any proper support on the bend by the ex warden's house. It is part of the local grid and will have no local fuse or breaker. It is incredibly dangerous, less than 1m above the Bypass floor and would have been underwater on Aug 1st. I am certain that it is the power supply to the redundant flow chart recorder (fitted in the British Waterways era) which is located in the yard just over the wall behind the cable. The arched cabinet roof is visible from the road. This is not the supply for the ex-wardens house, which I believe is supplied by the more heavily insulated cable labelled P75 which crosses the Bypass clamped to a rotting beam under Footbridge No.1 nearby. P75 may also supply the sailing club ?

I strongly recommend that P74 should be electrically disconnected at source and removed by the Electricity North West for safety reasons and to allow the future work on the Bypass bend to be conducted unimpeded by such a dangerous element. At the same time the Authority should be asked to inspect the condition and safety of the P75 cable because FB No 1 is rotting away and was scheduled for replacement in October 2019 so the cable would have to be disturbed quite soon.

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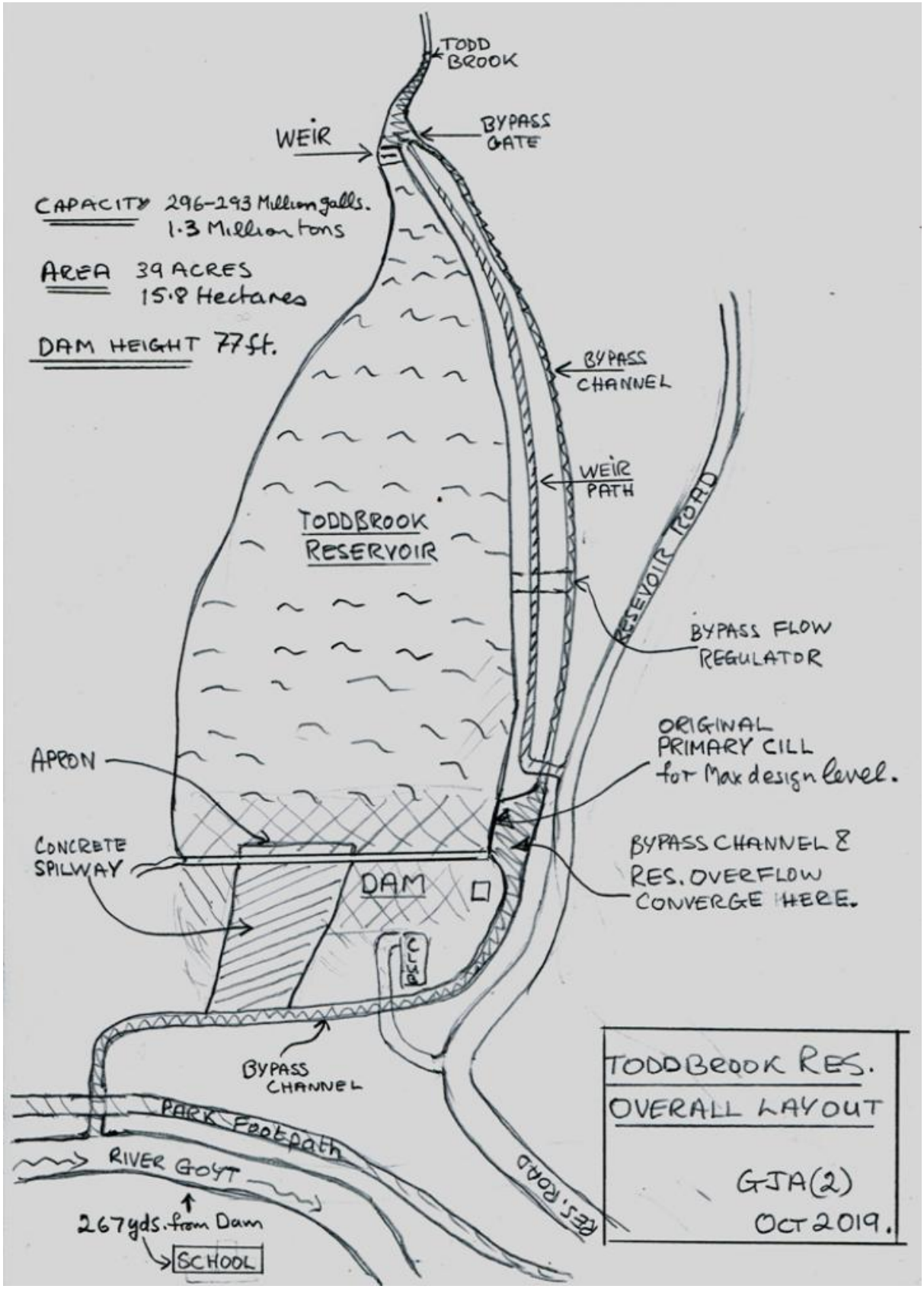

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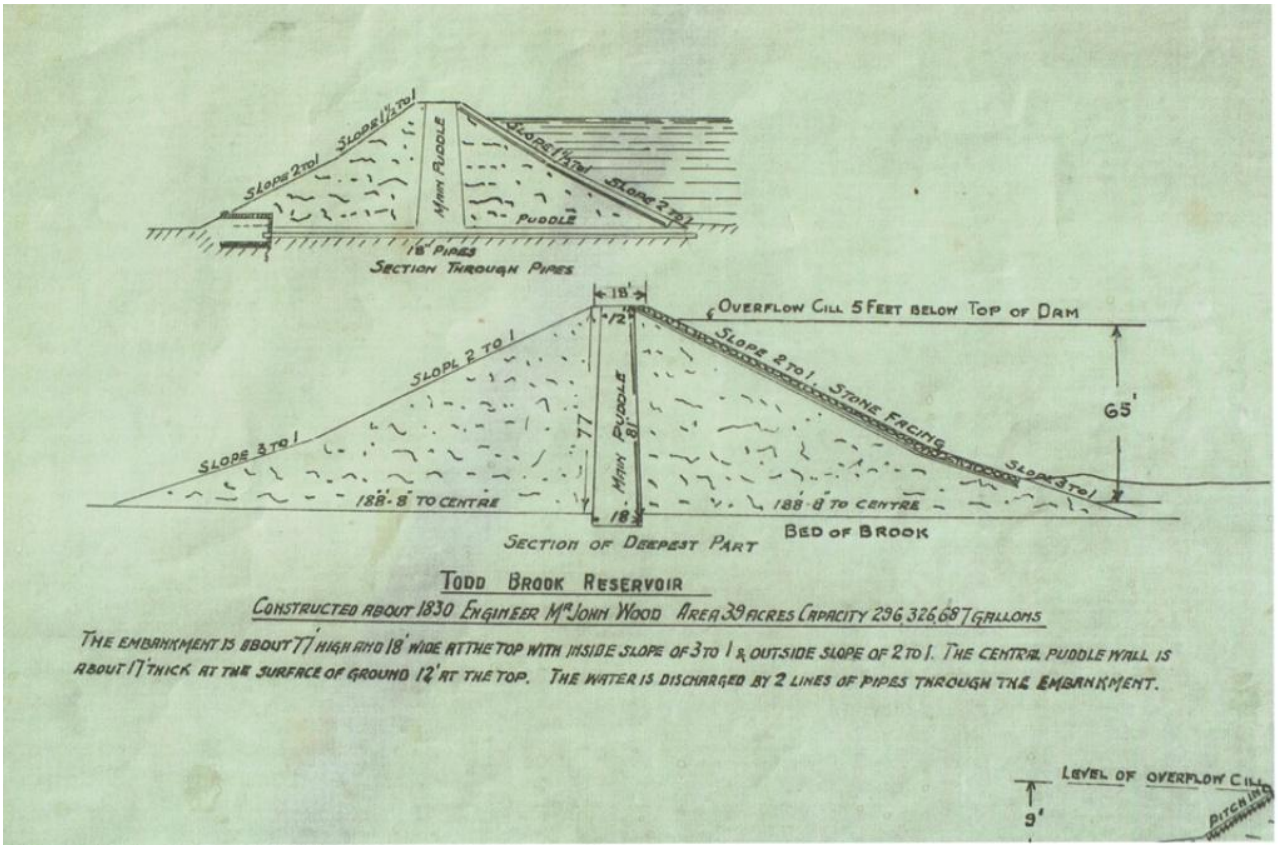

The Original Toddbrook Dam Design Specification 1830.

The CRT was apparently not aware of this document until just recently although it was included in my two previous reports. This is the key document that justifies which modifications must be carried out.

The note "**Overflow Cill 5 feet below Top of Dam**" on the RH side defines the 5 ft. (1.5m) safety margin for the Toddbrook Dam which was destroyed 48 years ago by British Waterways in 1971. This Safety Margin must now be reinstated right across the dam by lowering the maximum water level as I have described if the CRT want to achieve Safety Approval to operate this High Risk Reservoir above Whaley Bridge School and Town.

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Diagrams included for reference:-

Sketch: Toddbrook Reservoir Overall Layout (GA2.)

Original 1831 Dam Design Specification by J Wood.

References:

Ref 1: *Toddbrook Reservoir Dam Report Sept*. 2019. Aldred. G

Ref 2: *Toddbrook Damage Analysis 2.0* Dec. 2019. Aldred. G

Ref 3: *Response to Temporary Spillway Proposal.* Jan. 2020. Aldred.G

Ref 4: *Toddbrook Capacity Model, a function of Slope and Depth*. G A

Ref 5: *Guide to drawdown capacity for reservoir safety and emergency planning. SC130001 Volume 1….Environment Agency Aug 2017.*

Graham Aldred

February 16th. 2020