Report for Poynton Town Council

Proportionality and Practicability of Proposed Flood Alleviation Measures at Poynton Pool

by

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29 August 2023

1. Introduction

1.1 On 24 July 2023 Poynton Town Council instructed me to comment on aspects of proposed new flood control measures for Poynton Pool, in particular on the 'proportionality' and 'practicability' of the proposals and related issues.

1.2 The matter arises because the Pool, which is artificial and was constructed circa 1750, has been designated as a reservoir under The Reservoirs Act 1975 because of its volume, which in turn has triggered a hazard rating which concluded that overtopping followed by a dam breach event at the Pool posed a significant risk to a road (A523)[1] and human life. This led to a search for control measures. These involve substantial engineering works which would have a negative impact upon the established environment of the Pool. The Council, a local community group known as 'The Friends of Poynton Pool' and others, have queried the need for the works and the science behind the proposals. One response to these queries has been to imply that 'it's a matter of one's preference for saving either lives or trees.'

1.3 The historical record, so far as it is known, has identified no instances of over-topping during the known major flood events although it is surmised in the Jacobs report that 'there could have been minor overtopping which went unnoticed' (Jacobs, 2019).

1.4 Poynton has experienced actual flood events recently in 2016 and 2019. These events were not associated with the Pool. A monitoring station has been established on Poynton Brook by the Environment Agency (EA) to provide warnings.

1.5 In writing this report I clarify that I am not a flood engineer. I am a Professor of Risk Management at Middlesex University, Director of its Centre for Decision Analysis and Risk Management (DARM), and Director of Risk Assessment and Management Associates Ltd (RAMA). The current work is undertaken by RAMA. My experience includes research for national / international regulators of risk and spanning diverse fields ranging from nuclear and offshore safety to environmental protection and consumer safety. Recently, I was convenor of an international panel of scientists on behalf of the European Institute for Science, Media and Democracy (EISMD) which led to publication of 'Principles of risk management.'[2]

2. The fundamental approach to risk management v the Jacobs methodology

2.1 A key source of advice for UK public policy decision makers is HM Treasury's 'The Green Book'.[3] This has been available for over 30 years and is regularly updated. Its purpose is to act as a best practice guide with the aim of bringing consistency to decision making across government and the wider public sector, including decisions about risk and safety. Consistency is important because where there is inconsistency resources will not be allocated to provide best public value. The Green Book (p4, 2022) says that for consistency, departmental guidance *should be aligned with it*. It also points out that the approach it describes is *not a mechanical or deterministic decision-making device* (p3, 2022).

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[1] Recent opening of the Poynton relief road means that the London Rd is now classified as a B road
[2] https://www.eismd.eu/wp-content/uploads/2020/02/Capur-Statement-of-Principles.pdf
[3] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020

2.4 The approach set out in The Green Book requires an assessment of the costs, benefits and risks of alternative ways of meeting objectives. It is concerned with overall social welfare efficiency, and not just economic market efficiency. Likewise, social or public value includes all significant costs and benefits that affect the welfare and wellbeing of the population either nationally or, in the case of place-based decisions, locally. These might include environmental, cultural, health, justice etc. considerations, sometimes referred to as 'externalities.' They may apply to the natural environment via the concept of 'natural capital' which includes consideration of landscape, tranquillity, inland water bodies, wildlife and biodiversity and opportunities for recreation in urban areas and the associated physical health benefits. The Green Book describes approaches to valuing these non-traded goods.

2.5 If one compares the above Green Book approach to decision making with that of the Jacobs report there is a conspicuous divergence. The Jacobs approach, which appears to follow that described in the EA's SC090001/R2 (2013),[4] takes no account of collateral effects and unintended consequences of the proposed flood mitigation measures. Collateral effects would include ecosystem impacts, public health or heritage considerations. These are largely side-lined other than for brief acknowledgements of their existence (e.g., p44, Jacobs report 11 June 2021 where it is merely said that any remediation work should be detailed to minimise impact on the area). The Green Book, however, states that collateral effects and unintended consequences need to be thought about when developing and appraising options, i.e., not left until choices have been made such that only remedial patches can be applied. There is no attempt to incorporate these issues early on (even though these are what most commentators are concerned about) into the appraisal of the control options which is limited to consideration of discounted net costs of each scheme versus its hypothetical discounted lifesaving potential. The dangers of not including these factors from the beginning are several: a non-optimal solution may be chosen; there is no guarantee of the extent and form of the proffered remediation work; decisions might be resented.

2.6 Thus, while it might be argued that the Jacobs work follows established practice in flood risk management, the practice is not consistent with that in The Green Book, nor with modern understanding of how risks to the public should be managed.[5] The modern approach would be much more sensitive to such things as taking too narrow a view from the outset, meaningful communication (multi-way) between experts and all stakeholders from the outset, unintended consequences of control measures and uncertainty, all of which figure in the 2022 edition of The Green Book and in much earlier editions too. Similar issues about what is important in managing public risk have been brought up by the former Risk and Regulation Advisory Council 20 years ago,[6] and in countless other publications on risk management.

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[4] The EA's 2013 'Guide to risk assessment for reservoir safety management.'

[5] The Independent Reservoir Safety Review by David Balmforth (2021) notes (p100) that reservoir legislation has not kept pace with approaches to safety management in other sectors. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/985172/reservoir-safety-review-report.pdf

[6] https://webarchive.nationalarchives.gov.uk/ukgwa/20100104183913/http:/www.berr.gov.uk/deliverypartners/list/rrac/index.html

2.7 From the various notes and minutes of meetings which I have seen it appears that the justification for the exclusion of these factors[7] will be along the lines of the Jacobs approach being established practice in flood management. In my opinion, I would say that the established practice, which is embedded in a mechanical and formulaic approach, and which delegates decisions to engineering judgement, lags modern thinking on risk management and this is one reason why the current dispute has arisen. This is not to say that flood engineers do not have a valuable contribution to make. It is obvious that they do, but the issue is how that knowledge and expertise is introduced into the decision process and where authority lies.

2.8 To mention just one other publication on the management of risks to the public, EISMD's 'Principles of risk management' (2020), this summarises current thinking and I reproduce in Figure 1 below a list of their principles. It could be argued without great difficulty that all of Principles 1 to 5 have been violated by the Jacob's approach.

Figure 1: Principles of risk management (EISMD, 2020)

[7] The EA guidance does acknowledge impacts upon environment and cultural heritage, but only from the point of view that they might be affected by floods. The possibility that control options might have unintended consequences (which they almost always do) is not incorporated. It could be said that the guidance is valid in situations not giving rise to concern over collateral effects.

3. Reasonable practicability, ALARP and gross disproportion

3.1 These three concepts, which originated and are closely tied to occupational safety and health (OSH) law, are much in evidence in the Jacobs report. The concepts are also used in nuclear safety.[8] They can be found in the EA's guide to flood risk management (2013), having, it seems, been embraced.

3.2 I have discussed these terms, and their roots, in relation to the Jacobs calculations in Appendix A. In brief, the term 'practicability' is strongly linked with a 1949 legal case concerning the death of a coal miner in Wales. The Court of Appeal held that 'reasonably practicable' is a narrower term than 'physically possible' and implies a computation between quantum of risk on the one hand and the time, cost and trouble of safeguards on the other.[9] Thus, the notion of ALARP (as low as reasonably practicable) arises in that OSH law requires all practicable (or ALARP) measures, i.e., those for which the risk reduction afforded by some control measure outweighs the cost and trouble, to be implemented.

3.3 However, a complication arose in the OSH sphere, which is that the Court, in deciding the Edwards case, ruled that a control measure must be implemented as long as the costs are not grossly disproportionate to the risk. It has been suggested that the reason the judge did this was because in those days (the 1940s) human safety was grossly undervalued whereas nowadays the valuation is based on willingness to pay and consequently should not be upgraded by a gross disproportion factor (see Box 1 and discussion by Professor Andrew Evans of gross disproportion in the context of road and rail safety). The argument about the current legitimacy of gross disproportion in OSH has never been entirely settled in court and so simmers on, though only on the sidelines.

3.4 Were a gross disproportion factor to be used in OSH, there is a further obvious issue which is the magnitude of the factor. Few authorities have attempted to assign a numerical value to it, although John Locke, the first Director General of the HSE, suggested a range of from one to ten, the chosen value depending on circumstances, in particular, the level of individual risk being experienced.

3.5 So far as I am aware there is no law which requires the introduction of gross disproportion factors in flood risk management. Nonetheless, the Jacobs report introduces a very substantial factor (five) into its assessment of the proportionality of the various options. While, as with Professor Evans (Box 1), I accept the principle of linking the definition of what is reasonably practicable to the value of preventing a fatality, which is what Jacobs have done in their approach to the assessment of the proportionality of the various flood control options, I do not accept the introduction of the gross disproportion factor. Effectively, this discriminates against the cost of control and all the other unintended but real consequences of the various options, such as environmental damage, which I suspect would not be so weighted even if they had been included in the calculations of what was proportionate.

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[8] In the context of the disposal of nuclear waste it has long been recognised that solutions are not purely scientific – see the work of CoRWM.

[9] Edwards v National Coal Board [1949] 1 All ER 743 CA

The writer accepts the principle of linking the definition of what is reasonably practicable to the value of preventing fatalities (VPF) and injuries. In that case, a safety measure is regarded as reasonably practicable if its cost of preventing fatalities (CPF) is less than or equal to its VPF. That is broadly the definition adopted by the railways. However, in the case of roads it is clear from section 4.1 that there are many possible road safety measures for which the CPF is less than the VPF, but which are not implemented. It follows that either the ALARP principle is not applied to roads, or else that road authorities adopt a different definition of reasonable practicability.

On gross disproportion, the writer agrees with the Rail Safety and Standards Board in their discussion document Valuing Safety[7] that:

> "If we have correctly weighed the safety benefits | there can be no justification for demanding that duty-holders take action disproportionate to its benefits, and even less for the much-quoted requirement that it should be `grossly disproportionate'" (page 3).

It may be useful to observe that the valuations of preventing fatalities current at about the time of the Edwards v National Coal Board "gross disproportion" judgement in 1949 were very much lower in real terms than they are today. As shown in Table 1, the first roads VPF published for 1952 by Reynolds[8] was of £2,000—admittedly described as a minimum—which is equivalent to £37,500 at 2004 prices and 1/37th of the 2004 VPF. The amount of compensation paid to the widow of the miner in the Edwards v National Coal Board case after her successful appeal was £984 at 1948 prices, equivalent to £23,000 at 2004 prices. If the judgement is interpreted as requiring that safety managers spend much more than sums such as these on preventing fatalities, it is clear that subsequent generations are already implementing that requirement.

Box 1: Memorandum by Professor Andrew Evans to Select Committee on Economic Affairs (2006)

https://publications.parliament.uk/pa/ld200506/ldselect/ldeconaf/183/6021402.htm

3.6 According to the EA guidance, the purpose of gross disproportion factors is to "allow for the imprecision of estimates of costs and benefits and also to ensure that the duty holder robustly satisfies the ALARP principle" (EA p151). I understand this is the justification used by Jacobs. However, there is no evidence that this was ever the intention behind gross disproportion.

3.7 In public life, disproportion in decision making has created difficulties and anomalies. In the 2000s it was realised that safety requirements which impinged on the public were at times becoming unbalanced and were actually stopping people from doing useful and beneficial things. In 2006 the Government felt it necessary to pass The Compensation Act which says as follows:

"A court considering a claim in negligence or breach of statutory duty may, in determining whether the defendant should have taken particular steps to meet a standard of care (whether by taking precautions against a risk or otherwise), have regard to whether a requirement to take those steps might—

(a) prevent a desirable activity from being undertaken at all, to a particular extent or in a particular way, or

(b) discourage persons from undertaking functions in connection with a desirable activity."[10]

3.8 For similar reasons the Cameron government also found it necessary to initiate the Löfstedt inquiry into OSH.[11] Numerous public bodies were struggling against restrictions placed on public life by perceived OSH requirements and this led to the formation of groups such as the UK Play Safety Forum and the National Tree Safety Group which pressed for recognition of the benefits of risky things and risky activities. Ultimately this required a new approach to risk assessment, one which recognised that there was more often than not a trade-off between risk and benefit and that risk control alone was not the name of the game.

3.9 In 2023 the International Standards Organisation published ISO 4980 on what is called 'benefit risk assessment.' This was in the context of sport and recreation, but essentially continues the trend in public risk management away from non-compensatory decision making which focuses on one thing, e.g., risk reduction, towards compensatory decision making which weighs the positive and negative attributes of the considered alternatives and allows positive attributes to compensate for negative ones. The relevance here is that the Jacobs approach omits to consider the loss of the positive aspects of the Poynton Pool being essentially a non-compensatory approach.

4. Societal risk and FN curves

4.1 The Jacobs report introduces the concept of societal risk and FN diagrams. Societal risk is a term which usually refers to situations in which multiple lives are at risk of death. Multiple lives are generally taken to mean more than 10. The projected number of fatalities should the dam fail, according to the Jacobs report, is 1.04. On that basis societal risk is of marginal applicability. The Jacobs report nonetheless contains an FN diagram. FN diagrams are used to show the relationship between frequency of failures and number of persons killed.

4.2 Figure 2 shows an example FN plot from the EA guide. This has two sloping lines drawn on it which are used to denote three regions of risk: unacceptable, broadly acceptable and an in between region where it is usually taken that the risk is tolerable but any control measures which satisfy the ALARP cost-benefit test must be implemented.

4.3 The position and gradient of these lines is obviously important but there is no universal agreement on where they should lie. Various agencies have come up with propositions[12]. For example, the HSE has suggested in the nuclear context, and bearing in mind public aversion

[10] https://www.legislation.gov.uk/ukpga/2006/29/section/1

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/66790/lofstedt-report.pdf

[12] Ball and Floyd, report to HSE.

to nuclear accidents, that the upper line should pass through the (100, 10^{-4}) point, that is, the point at which the risk of an incident in which there are ≥100 fatalities has a likelihood of once per 10,000 years.[13] The gradient of the line is another issue. A gradient of -1 is roughly speaking risk neutral in that it does not apply extra weight to high fatality incidents. The upper line on Figure 2 fits the HSE criteria in that it passes through (100, 10^{-4}) and has a gradient of -1. The lower line mirrors the upper but is set at probabilities which are 100 times lower.

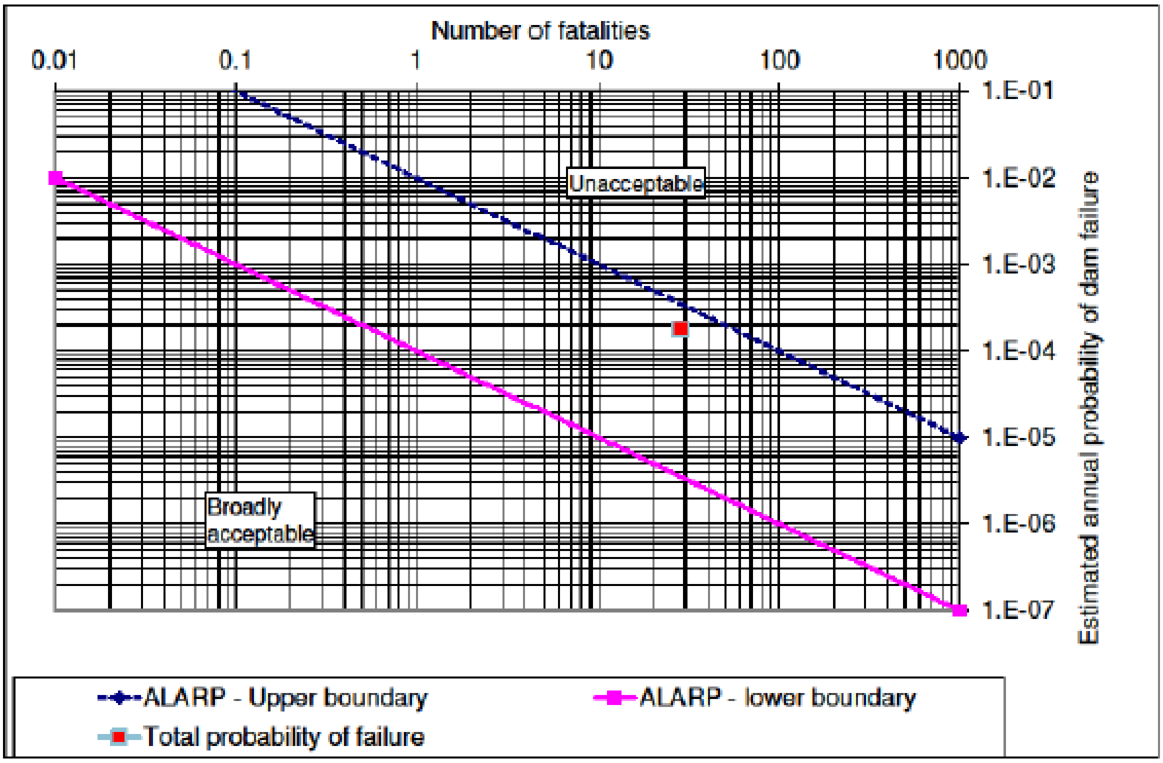

Figure 2: Example of FN plot (EA p146)

4.4 Figure 3 shows an FN plot as reported by Jacobs (p31). There are several points marked on it. The black triangle is the (1.04, 1/250) point based on the likelihood of dam failure of 1/250 per annum with 1.04 fatalities as reported by Jacobs. According to the Jacobs report this indicates that the current risk from the dam is unacceptable (because the point is above the upper dashed line). However, the line is not positioned according to the EA or HSE proposals and its origin is unknown. Were the HSE criteria for the position of the upper line used then the estimated current risk from the dam would be in the ALARP region.

4.5 Personally I don't think the discussion of societal risk in Jacobs or in this report is of much relevance as the dam does not threaten a catastrophe in which multiple lives would be lost. The matter needs only to be addressed because the proposition by Jacobs that the risk from the current dam is unacceptable generates an emotional argument.

4.6 It should also be recognised that FN lines and FN criteria are seldom strictly applied. Their main purpose is to provide information, not to regulate. In the case of Poynton Pool my

[13] A less stringent anchor point of (500, 2 x 10^{-4}) was referenced in a study of the societal risk posed by the Canvey Island petrochemical complex.

view is that considerations of acceptability or tolerability should be largely based on individual risk criteria and extended cost benefit analysis.

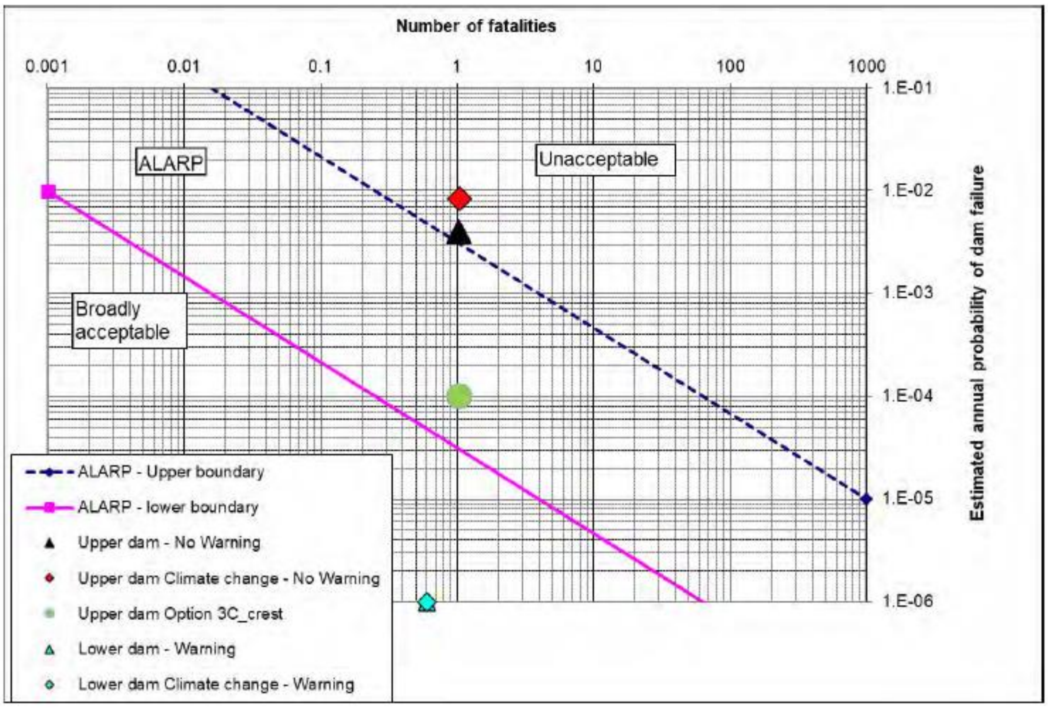

Fig 3: Jacobs FN plot (11/6/21, p31)

5. Risk estimates and uncertainty

5.1 The calculations in the Jacobs reports are lengthy and difficult to follow in places so I have investigated some in detail to comprehend the methodology and meaning of the numbers. In Appendix A of this report, I examine the analysis underlying the Jacobs data in their example provided in Appendix C (p52) of their 11/6/2021 report. I will now use the information from that exercise to examine Table 6.2 of that same report. Table 6.2 is a summary of the costs and benefits of the different options as estimated by Jacobs, and calculations of the cost to save a life (CSL) for each option.

5.2 Table 1 below is my truncated version of Jacobs' Table 6-2 with added explanations in the interests of clarity, and to enable a closer look at the issue of proportionality. The calculations are for options 2 to 3C Upper, excluding climate change (because of the uncertainty), and for dam failure with release of reservoir with no prior warning. I chose dam failure rather than flooding of the A523 (now a B road) as I thought it was likely the main public concern.

5.3 With reference to my Table 1, and for Option 2, the risk of dam failure per annum is said to be reduced from 1/250 to 1/6000. In column 3 I have calculated the change in annual risk provided by Option 2. Column 4 then calculates the 100-year risk reduction (the benefit of the measure) by the simple device of multiplying by 30 (not 100) as per the Jacobs report. Thirty is a discounted value which takes account of supposed consumer preferences (crudely, for cake today rather than tomorrow). This enables the value of averted property damage over this 100-year period to be estimated. The footnote to Table 6-2 says £5M of property is at risk, so in column 5 £5M is multiplied by the number in column 4 (the 100-year risk reduction factor) to estimate the saving through averted property damage (£0.575M), which is subtracted from the cost of the Option in column 1. This gives a net cost of Option 2 of £0.725M. The cost to save a life is then calculated by dividing £0.725M by the number of lives saved during the 100-year period. It is a quirk of the data that this can be done by dividing the number in column 6 by the number in column 4. This is because the base case loss of life in the Jacobs report is very close to unity, i.e., 1.04 (p29 of report), so the numbers in column 4 coincide almost exactly with the estimated loss of life over the 100 years.

	1	2	3	4	5	6	7
Option	Budget cost	Annual risk of dam failure	Change in annual risk by option	Change in 100-year risk at discounted rate (x30)	Property damage averted £M	Net cost of scheme £M	Cost to save a life
Existing situation		1/250					
2	£1.3M	1/6000	1/250 – 1/6,000 = 0.0038	0.115	£5m x 0.115 = £0.575M	£1.3M - £0.575M = £0.725M	£0.725M/0.115 = £6.3M
3A	£0.75M	1/500	1/250 – 1/500 = 0.002	0.060	£0.30M	£0.45M	£0.45M/0.060 = £7.5M
3B	£0.73M	1/1,000	0.003	0.090	£0.45M	£0.28M	£0.28M/0.09 = £3.1M
3C upper	£0.54M	1/10,000	1/250 – 1/10000 = 0.004	0.12	£0.60M	-£0.06M	-£0.06/0.12 = -£0.5M

Table 1: Cost and benefit calculations for options

5.4 In Table 1 I have repeated the calculations for Options 3A, 3B and 3C upper. Option 3C upper has been pinpointed by Jacobs as "worthwhile whilst the other options are marginally proportionate" (Executive summary). For 3C upper I have put some figures in red. This is to highlight that these numbers are negative. The reason is all about the estimated projected savings on property damage which comes to £0.60M over 100 years and is marginally greater than the projected preset-day cost of the scheme. If the Jacob's cost estimates are correct,[14] this would suggest 3C upper is a rational choice because the benefits of the scheme in the form of reduced property damage would exceed its costs, even were it to save no lives. The question of proportionality, which in these contexts is usually about life saving costs, is not

[14] In the Jacobs report of 15 October 2021 Option 3C with a footpath is costed as £1.34M suggesting much potential volatility in the proportionality assessments.

engaged and this is exemplified by the negative numbers for the cost of saving a life which have been generated. However, Table 1, its data and methodology, identifies and raises issues.

Data Accuracy and Implications

5.5 It can be seen in Table 1 that currently the annual risk of dam failure has been given as 1 in 250 which means that calculations indicate the dam will fail once in every 250 years. All the options then considered reduce the annual risk of failure by a factor of between 2 (Option 3A) and 40 (Option 3C upper). Column 3 of Table 1 shows, however, that the change in annual risk provided by each of the options falls within a narrow range of, essentially, 0.002 (Option 3A) to 0.004 (Options 2 and 3C upper). There is not a lot to choose between them in terms of risk reduction potential and given that there will be considerable uncertainty around the input data it may be that from a statistical perspective there is no difference.

5.6 It is notable that the Jacobs report contains no analysis of uncertainty. This is a serious deficiency given that there is likely considerable uncertainty around, e.g., the 1/250 base case risk estimate and the projected number of lives lost, both of which estimates will be reliant upon many assumptions. The CSL numbers in column 7, used to assess proportionality, are calculated from the quotient of two numbers of unknown certainty and should therefore be treated with considerable caution. In the case of the 1/250 risk, if this were in error by relatively small factors which, given the complexity of the calculations which must underlie them, could easily be in the range of 2, 3 or more, then the argument that 3C upper is proportionate is overturned.

5.7 The Jacobs report goes on to compare the CSL numbers with the going rate for CSL[15] multiplied by Jacobs' chosen Gross Disproportion Factor of 5. I have discussed the background to gross disproportion factors in Section 3 of this report. It is undeniable that the introduction of arbitrary factors into cost benefit distorts the analysis and discriminates against other attributes affected by the decision.

5.8 It might also be felt by residents that the individual risk posed by dam failure is not particularly high. Even with the estimate of 1 in 250 of dam failure and with the suggested consequence of about one fatality within a population of a certain size, the individual risk might well be quite small compared with other risks which people routinely face.

5.9 The local community is also much concerned about the environmental impact upon the lake and surrounding habitat. Trees which would likely be sacrificed have been valued at £3M (range £0.4M to £5.4M) (Morris, 2023). The Jacobs methodology notes but takes no account of environmental losses in its calculations. A compensatory decision process, which takes on board the wider impacts (positive and negative) of a scheme, would include such costs. Were the £3M added to the costs of 3C upper the Option would shift from proportionate to entirely disproportionate, and alternatives which are less destructive of the environment might appear more plausible.

6. Other issues

Historical experience

[15] The CSL figure of £1.7M used by Jacobs is in fact a 2010 figure whereas the 2020 figure is around 17% higher at £2M

6.1 The historical record, so far as known, has identified no instances of over-topping although, as noted earlier, it is surmised in the Jacobs report that ‘there could have been minor overtopping which went unnoticed’ (Jacobs, 2019). Jacobs also use this information to justify the 1/250 per annum estimate of the risk of dam failure. They say that this is consistent with the age of the reservoir of around 250 years with no reported failures.

6.2 This, however, is not a valid argument. If the annual likelihood of failure were 1/250, the likelihood of zero failures during the following 273 years is approximated by:

$$(249/250)^{273} = 0.33$$

6.3 In other words, if the annual risk of failure is 1/250, then the likelihood of no failure occurring during 273 years (the actual supposed age of the dam) is 33%. This does not provide evidence of consistency. It does hint that the risk might be lower than 1/250.

<u>Erodibility of existing bank</u>

6.4 One obvious requirement for a reliable estimate of the likelihood of dam failure is information on the erodibility of the embankment, but this has not been investigated. Jacobs suggest it is a ‘research exercise.’ While that may be so, without such information it cannot be possible to estimate the risk of failure with much reliability. The EA guidance (Figure 1.3, p4) (see below) identifies embankment foundations as one of three key elements in assessing the likelihood of failure.

Figure 1.3 Building blocks for assessment of likelihood of failure

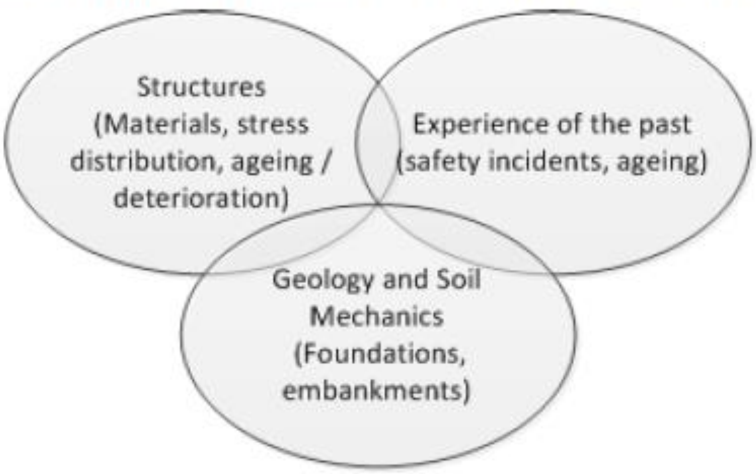

Figure 4: Dam failure assessment (EA, p4)

<u>Catchment behaviour</u>

6.5 Another important source of uncertainty is the behaviour of the catchment, including assumptions about its size, and the inflow and outflow characteristics of the Pool during storms. Much has been done in the way of computer modelling, but such models should be validated. It is suggested here that this might be approached by measuring the level of Poynton Pool and its inflows and outflows continuously over an extended period of time and the results correlated against weather patterns. Preferably this might be done over a period of a few years. This might seem long, but it is not considering the decade or so delay in making a decision, and the implications for the Pool and its environment. Even after a few years of monitoring it cannot be expected that data on extreme events would become available because of their rarity, however, some testing of the models and assumptions would be possible, an added benefit of which would be increased public confidence in the work.

Warning systems

6.6 The risk estimates assume that residents will have no warning of an extreme event. Is this realistic and if so could it be rectified? The Balmforth review (2021, p100) notes that warning protocols have been successfully implemented in other industries and at reservoirs in other parts of the world, and that they can make risks tolerable.

Tree removal

6.7 The impact of tree removal and vegetation change on the stability of the earth bank has not been considered in the Jacobs report.

Public consultation

6.8 The fact that a dispute has arisen is symptomatic of an approach with insufficient public consultation. Modern approaches to stakeholder (public) engagement would be integral to the process from the outset. The strong reliance upon engineering judgement and engineering procedures in the face of such a sensitive matter is inappropriate in the 21st C. Certainly engineering input, computer models and cost benefit should figure in the discourse but not to the exclusion of inputs from the local community.

6.9 Principle 8 (Figure 1) notes that participatory / deliberative approaches have potential both to promote sound risk management and legitimise decisions. These procedures fuse expert and lay knowledge and seek to accommodate all concerns. They have been used by, for example, the UK Committee on Radioactive Waste Management. Jacobs themselves suggest (p15) that an alternative approach would be to hold a workshop of key stakeholders to agree an event tree describing the failure process and probability of each step. Although participatory / deliberative processes require somewhat more, this appears to be a step towards them.

7. Conclusions and recommendations

7.1 Any suggestion that the debate over Poynton Pool is simply 'a matter of one's preference for saving either lives or trees' is inaccurate. The situation is more appropriately described as one of *uncertain benefits of flood control measures versus certain losses to an established environment*. Tradeoffs of this kind appear in virtually every public policy decision that is made and need to be carefully scrutinised, hence the utility of The Green Book and the methodologies it recommends.

7.2 The methodology used by Jacobs to assess the need for flood control and appraise options, which is based on 2013 EA recommendations, is not consistent with current or historic HM Treasury advice on public policy decision making. The approach taken is mechanical and deterministic and deviates on several counts from currently accepted principles of good risk management as set out in The Green Book and other sources.

7.3 The approach veers towards relegating impacts of remedial works on the environment and heritage to afterthoughts and inevitably creates public anxiety.

7.4 The proportionality assessment excludes consideration of externalities such as environmental impacts, public health, heritage, and amenity etc., all of which are of local concern.

7.5 The approach fails to give an account of uncertainty in its estimates. Consideration of uncertainties could have a major impact on determinations of proportionality.

7.6 The approach inserts a gross disproportion factor of five into its cost benefit calculations which distorts the findings.

7.7 The individual risk posed by the hazard of dam failure might be tolerable in exchange for the benefits of the existing Poynton Pool.

7.8 Given the situation and the already substantial delay, it is suggested that further work is necessary as proposed in para. 6.5 aimed at reducing uncertainty in the risk and consequence estimates before a decision is made. This would have the added benefit of improving understanding of the behaviour of the Poynton catchment which has already witnessed flood events in recent years unrelated to the Pool. Such work might include monitoring. The time could also be used to promote public engagement.

7.9 It is believed by the present author that the above is consistent with the conclusions of the Balmforth review which found that "The current system for managing reservoir safety has become over reliant on compliance at the expense of ensuring due diligence in managing safety. A different emphasis is now needed to adequately protect the public" (p80). Balmforth goes on to recommend more emphasis on monitoring and periodic inspection in order to achieve solutions which are reasonably practicable.

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APPENDIX A: The Approach Used to Assess Proportionality / Practicability

A.1 Appendix C (p52) of the 11/6/2021 report by Jacobs sets out the method used by them to address the issue of proportionality and practicability. The method described is quite widely used in decision making being based on cost-benefit analysis (CBA). For example, CBA is used by the National Institute for Health and Care Excellence (NICE) to decide upon which medicines and medical procedures are appropriate in the NHS. This is necessary because NHS resources are limited, and some health interventions are extremely costly. The Department for Transport also uses CBA to decide which road traffic safety interventions to support, as do other agencies.

A.2 The simple rule is that if you can quantify the expected benefits (B) of some intervention and also its costs (C), then it would be rational to proceed with the intervention if B is greater than C. Mathematically this can be written as:

$$\text{proceed if } B > C$$

A.3 However, interventions, for whatever purpose, often have unintended consequences, or consequences not related to the primary objective. These can be positive or negative and should also be factored into the above equation for decision making purposes. For example, drugs have side effects and Smart Motorways create new risks.

A.4 The way in which Jacobs have addressed the proportionality issue is first to calculate the 'implied value of a human life' for each control option. This is done by estimating the cost of the intervention and dividing by the number of lives it is projected to save (here the number of lives saved is the benefit, B). For example, if a new spillway were to cost £1M and it is thought that during the spillway's lifetime it would prevent 10 fatalities, then the implied value of preventing a fatality (VPF) by that means would be £1M+10, or £100,000.

A.5 Having made a calculation of this type, Jacobs then compare the implied VPF with the 'going rate'. The 'going rate' for the VPF used in the UK for road transport safety is currently around £2M.[16] This value originates from earlier academic research sponsored by the DfT into how much consumers were willing to pay to reduce traffic risks to themselves. The Health & Safety Executive adopted the same value for the assessment of workplace safety interventions, and this is from whence the term 'practicability' originates.

A.6 The term 'practicability' is most strongly linked with a 1949 legal case concerning the death of a coal miner in Wales. The Court of Appeal held that 'reasonably practicable' is a narrower term than 'physically possible' and implies a computation between quantum of risk on the one hand and the time, cost and trouble of safeguards on the other.[17] Thus, the use of CBA is supported even in situations where people are exposed to potentially fatal risks.

A.7 A further complication arises in the occupational safety sphere, which is that the Courts, in deciding the Edwards case, ruled that a control measure must be implemented if the costs are not grossly disproportionate to the risk. That could be written (mathematically):

[16] Jacobs use the 2010 value which is £1.7M.
[17] Edwards v National Coal Board [1949] 1 All ER 743 CA

Proceed if B (the risk reduction) x GDF > C

where GDF is the gross disproportion factor.

A.8 The use of GDF factors, other than unity, is not universal and there is some controversy around them. Further, few authorities have attempted to assign a numerical value to the GDF, although John Locke, the first Director General of the HSE, suggested a range of from one to ten, the chosen value depending on circumstances.

A.9 Returning to Appendix C, Jacobs say (p52) that "At its simplest where the CPF (Cost of Preventing a Fatality) is less than the "value of preventing a fatality" (VPF) then the candidate works would be *proportionate risk reduction measures*; whilst where CPF exceeds VPF then the cost is *disproportionate*." The CPF is then calculated from:

> CPF = (Cost of risk reduction measure minus the Present Value of property damage averted by the measure) divided by the Present value of the change in the number of lives lost as a result of the intervention

A.10 It is normal procedure to subtract avoided property damage costs from the cost of the measure as in the above formula. To calculate this term the procedure is to multiply the projected value of the property damage by the change in risk brought about by the intervention. The calculation in Appendix C uses as an example a present risk of 1/20,000 per annum and a risk after intervention of 1/200,000 per annum (ten times lower) and the property damage as £35M. Thus, the annual expected property damage diminishes from £35M/20,000 to £35M/200,000, i.e., from £1,750 to £175, the reduction being £1,575. Jacobs then multiply this by 30 to estimate the savings from property damage avoidance over the next 100 years. There are two assumptions here, namely, the intervention is good for 100 years and that the present value of recurring costs over 100 years is 30 times the annual value (this involves consideration of discount rates). If this is accepted, the accumulated saving is 30 x £1,575 = £ 47,250.

A.11 The net cost of the intervention is then the cost of the candidate works (given as £300,000 in Appendix C) minus £47,250, or £252,750.

A.12 Appendix C then assumes that 32 lives would be lost in an incident with a probability of 1/20,000 per annum without the intervention, reducing to 1 in 200,000 with the intervention. Thus, on an annual basis 0.0016 lives could be expected to be lost per year as things stand, and 0.00016 per year after the intervention. The lifesaving potential of the intervention is thus the difference between these numbers (0.00144 lives saved per year). Again, the calculation is done for 100 years with the discounted factor of 30 applied, leading to an equivalent lifesaving over the century of 0.0432 persons.

A.13 From this, the CSL (cost of saving a life for this intervention) is calculated as £252,750 divided by 0.0432 which equals £5.85M.

A.14 This CSL is clearly greater than the 'going rate' of £2M which would suggest that there are questions about its proportionality. However, Jacobs then introduce a GDF of 5 which reverses this position. This is done on the basis that "The purpose of a PF (Proportion Factor) "grossly" greater than unity is to allow for the imprecision of estimates of costs and benefits and also to ensure that the duty holder robustly satisfies the ALARP principle.” Jacobs go on to say that the public are not aware of the risk from dams and hence the risk is involuntary and therefore warrants a PF exceeding 5.