Session 7

CASE STUDIES OF DESIGN AND CONSTRUCTION

Ageing Service Reservoirs - an increasing burden or scope for innovation? - I Hope

Butterley Spillway Improvement Works - R Woods

Design and Construction of Mitford Flood Storage Reservoir - J Penman

Asset or liability: stabilising an historic dam - M Cooper and N Walding

Discussion

AGEING SERVICE RESERVOIRS

An increasing burden or scope for innovation?

Ian Hope BSc MA CEng FICE
Dams and Reservoirs Manager, Severn Trent Water

SEVERN TRENT

INTRODUCTION

SR Purpose:
To retain a bulk volume of food grade water for human consumption

SERVICE RESERVOIR CONSTRUCTION TYPES

Construction Type	National Proportion in 1988	STW SR assets as of 2015
Brickwork	19%	1%
Mass concrete	21%	8%
Reinforced concrete	57%	83%
Post-tensioned concrete	2%	1%
Others	1%	7%

No current statistics nationally, indicative of legacy

This is being addressed by the current UKWIR project

UKWIR RESEARCH PROJECT – SERVICE RESERVOIR ASSET MANAGEMENT TOOLKIT

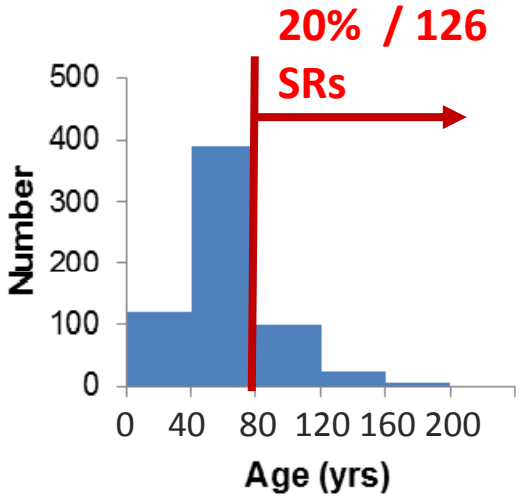
- Identify and share best practice for whole life-cycle management of service reservoirs and water towers
- Provide water companies with guidance and a toolkit for making operation, maintenance and investment decisions
- Produce a spreadsheet tool to facilitate navigating the guidance

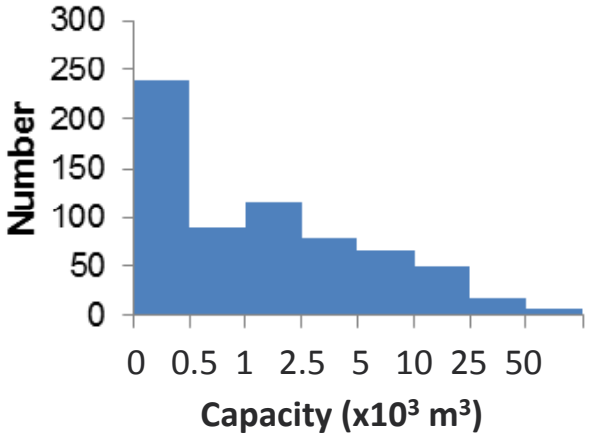
Contact Tim Hill for more details (tim.hill@mottmac.com)

MOTT MACDONALD

UKWIR

STOCK OF STW'S SERVICE RESERVOIR ASSETS





Built	Name	Type
1839	Hewletts No. 2	Brick
1849	Birches Head No. 1	Concrete
1970	Conwyn	GRP
1983	Cemmaes Rd	Metal

LEGISLATION AND GOVERNANCE FOR SR'S

Criteria	Legislation / Process	Regulator / Overseeing Body
Water quality	Water Act 1945 / WHO	Drinking Water Inspectorate
Safety	Health and Safety at Work etc. Act 1974	HSE
Security / resilience	Protection of National Infrastructure	CPNI / Defra
Protection against flooding	Reservoirs Act 1975	Environment Agency (England) NRW (Wales)
Emergency response to flooding	Civil Contingencies Act 2004	Local Resilience Forum
Funding	Asset Management Plans	Ofwat (economic regulator)
Customer Service	Continuity of supply	Ofwat (economic regulator)

- For an owner there are competing drivers beyond the Reservoirs Act 1975

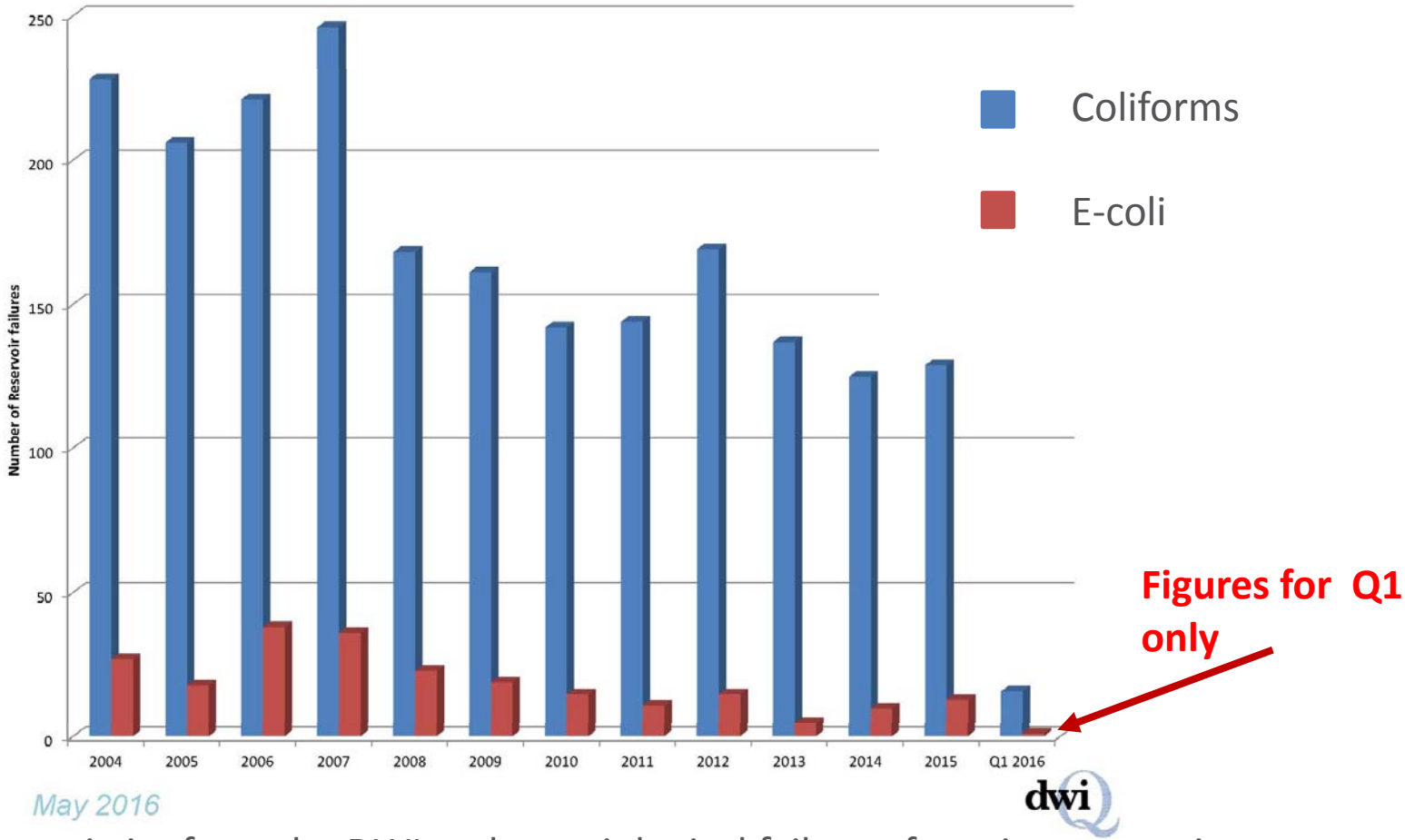
PART HEIGHT DIVISION WALLS – A CHALLENGE TO OPERATIONAL FLEXIBILITY

- Two examples of reservoirs with part height division walls which limit operating capacity to 25%:

Strelley SR

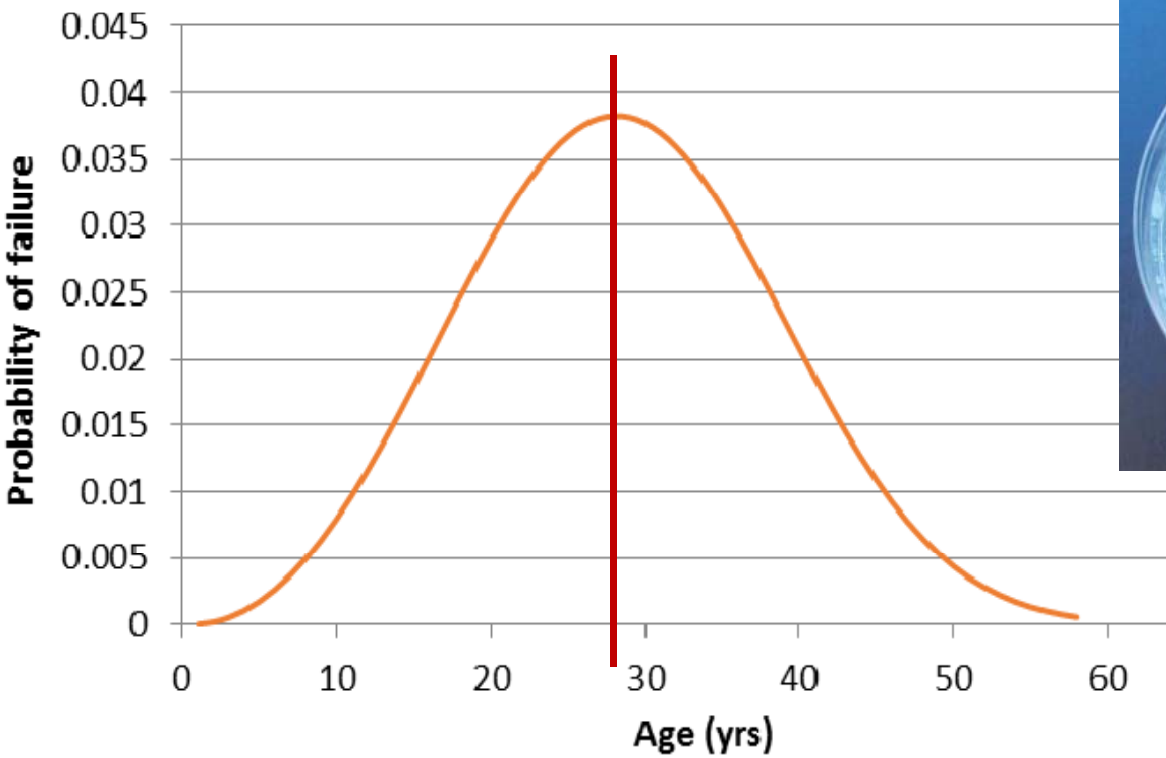
Erdington SR

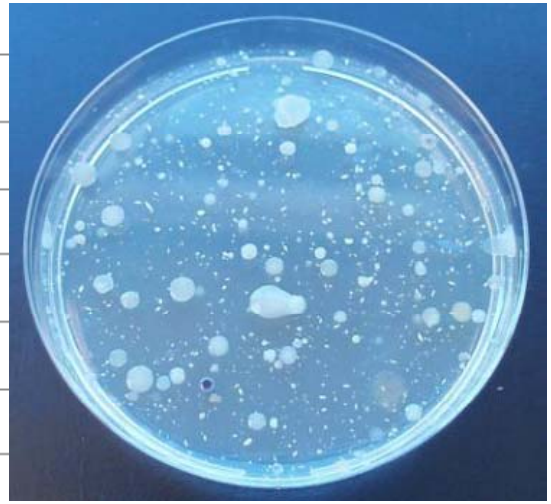
RESERVOIR BACTERIOLOGICAL FAILURE RATES

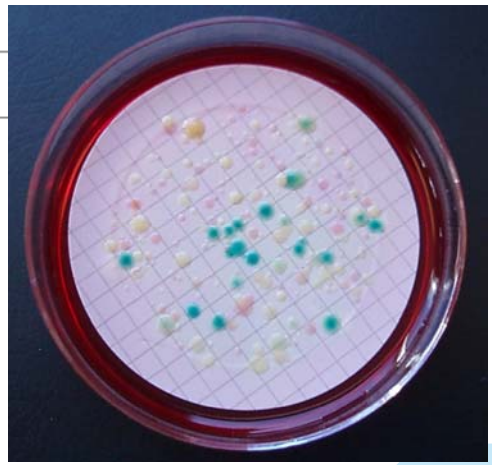


Recent statistics from the DWI on bacteriological failure of service reservoirs for England and Wales.

RESERVOIR BACTERIOLOGICAL FAILURE RATES







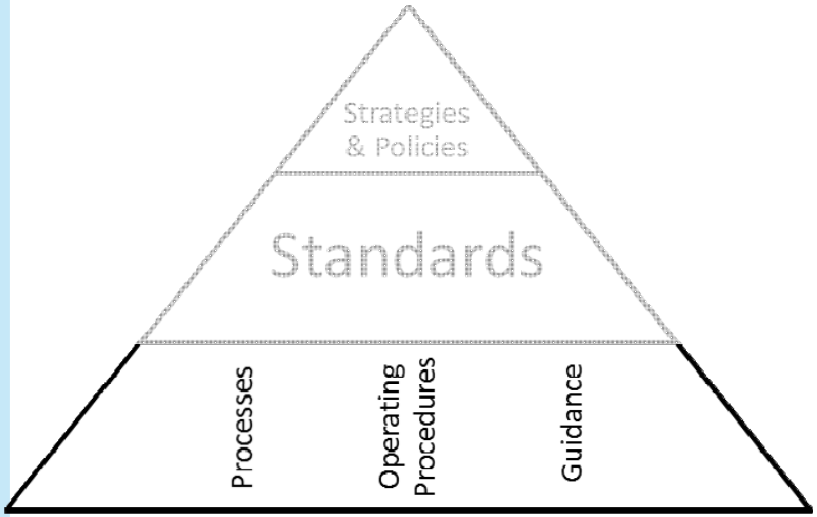
Average bacteriological failure rate is
28 years after construction

SERVICE RESERVOIRS AND THE RESERVOIRS ACT 1975

Emerging skills shortage?: Significant increase in regulated reservoirs

Country	SRs in Act (above 25,000m³)	SRs between 10 – 25,000m³	% increase	Total
England	153	360	235	513
Scotland	23	50	217	73
Wales	5	43	860	48
N. Ireland	10	30	300	40
Total	**191**	**483**	**253**	**674**

IMPLEMENTATION OF OPERATIONAL STRATEGY

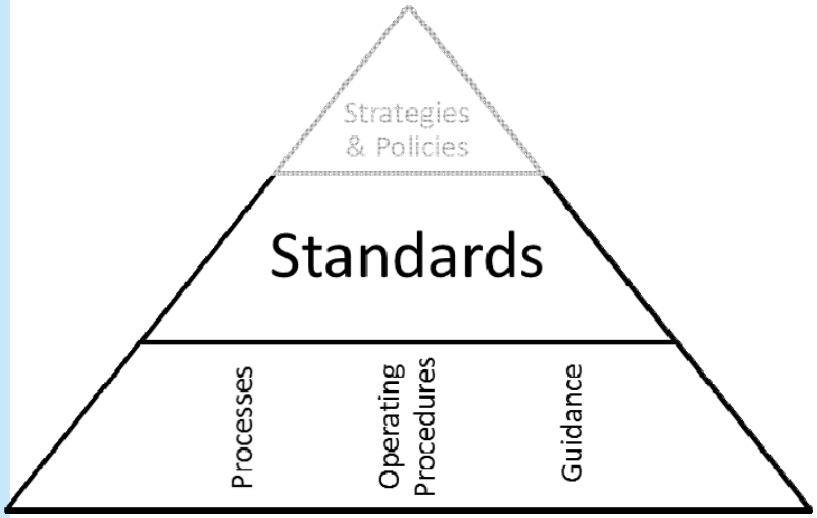


STW's strategic approach

Tier	Reservoir Team Input
Strategies and Policies	Compliance with Act Strategic direction Report to Board
Standards	SR inspection procedures for operators. Defined support. Asset records and reports.
Operating Procedures	Assessed surveillance training plus manuals
Processes	Inspection and re-training tasks
Guidance	New Inspection records, advice on repairs

Reservoir team's input

IMPLEMENTATION OF OPERATIONAL STRATEGY



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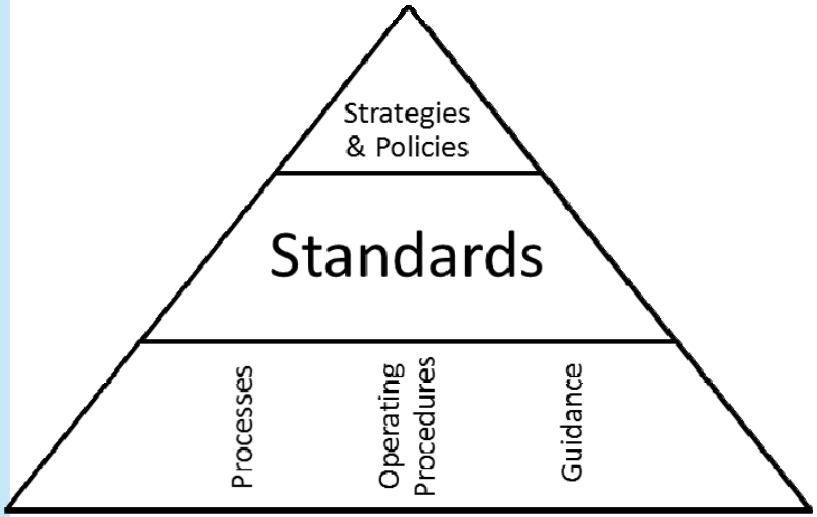

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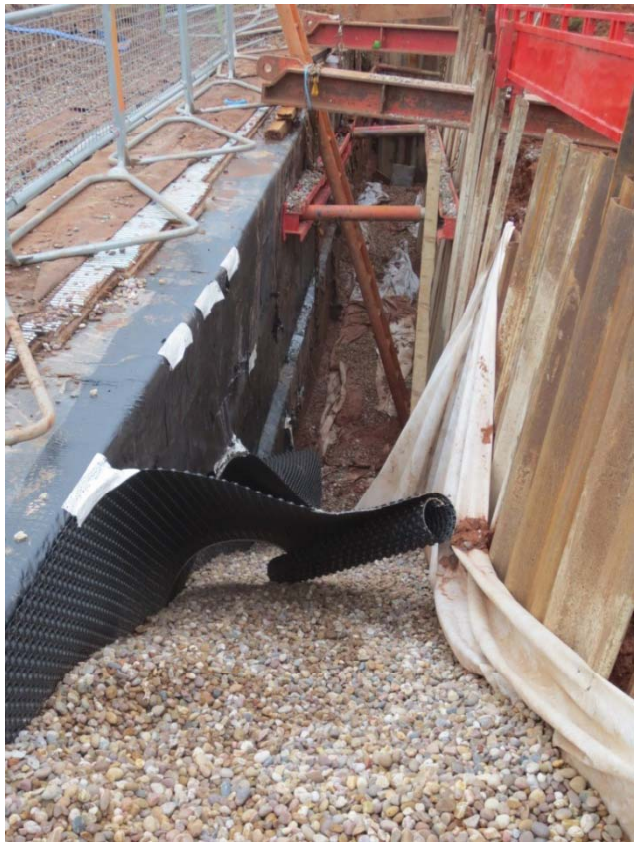
Reservoir team's input

REDUCING EXTERNAL HYDROSTATIC PRESSURE ON OLDER SR'S

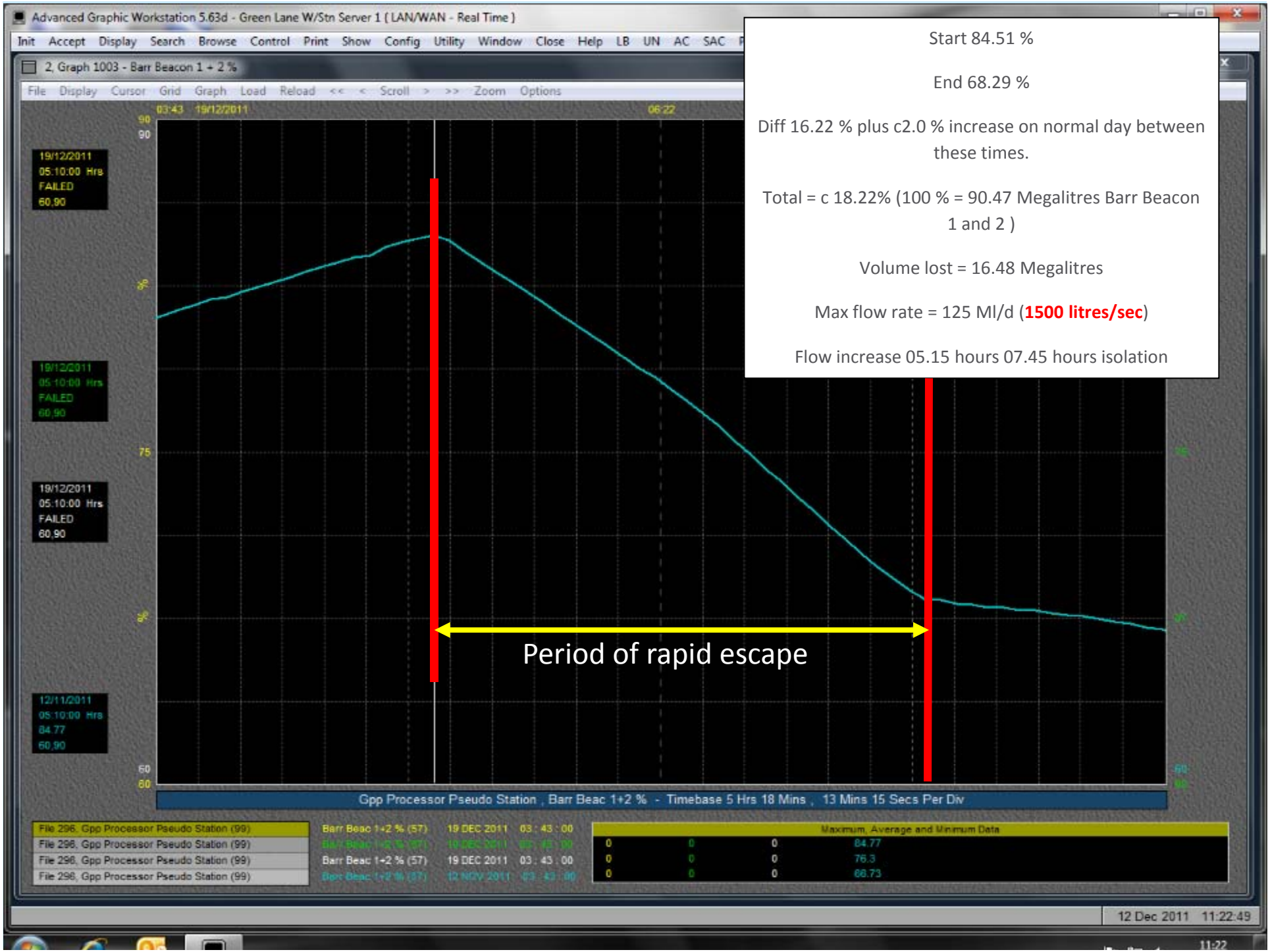


Frankley Treated Water Reservoir 2014

Installation of wall drainage and membrane at Frankley PWR1 – Cost ~£0.5M

CASE STUDY: BARR BEACON SR

- South Staffordshire Water – 2011



Start 84.51 %

End 68.29 %

Diff 16.22 % plus c2.0 % increase on normal day between these times.

Total = c 18.22% (100 % = 90.47 Megalitres Barr Beacon 1 and 2)

Volume lost = 16.48 Megalitres

Max flow rate = 125 Ml/d (**1500 litres/sec**)

Flow increase 05.15 hours 07.45 hours isolation

BARR BEACON SR

Cause of flooding - 18” diameter main leading from SR had burst

THE DEVASTATING POWER OF WATER

- Considerable damage following mains failure
- Despite extensive damage and disruption South Staffs Water banked social capital in the community by their response

SOURCES OF BACTERIOLOGICAL FAILURE

A vertical expansion joint with rear guard water stop

- 1. Movement during construction
- 2. Very poor detailing - wrong application of rear guard waterstop

CONTRACTOR SELF ASSURANCE?

- Backfilling on a new SR without drainage membrane, contrary to specification, allowing a positive water table with a potential for ingress.

FAILURE OF SCHOOLS IN EDINBURGH

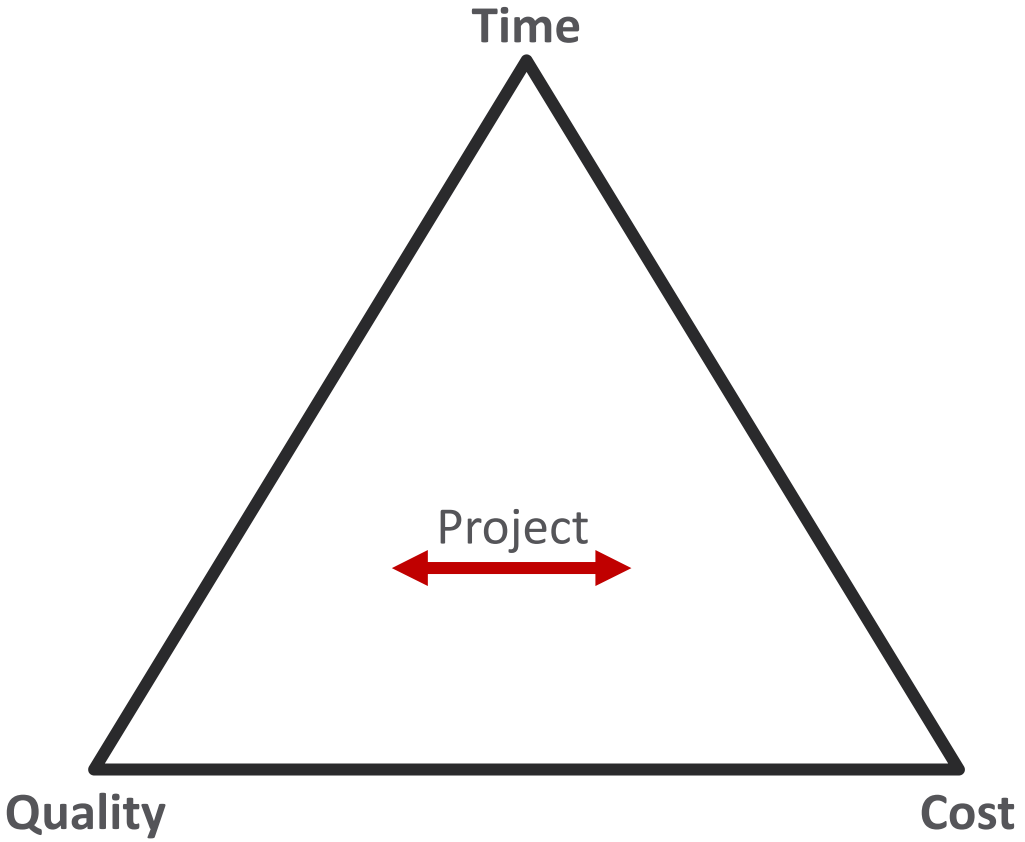
“Edinburgh’s 17 closed PFI schools may have to be rebuilt”

Simple omission of tie bars that arguably a Clerk of Works would have detected.

WILLMOTT DIXON

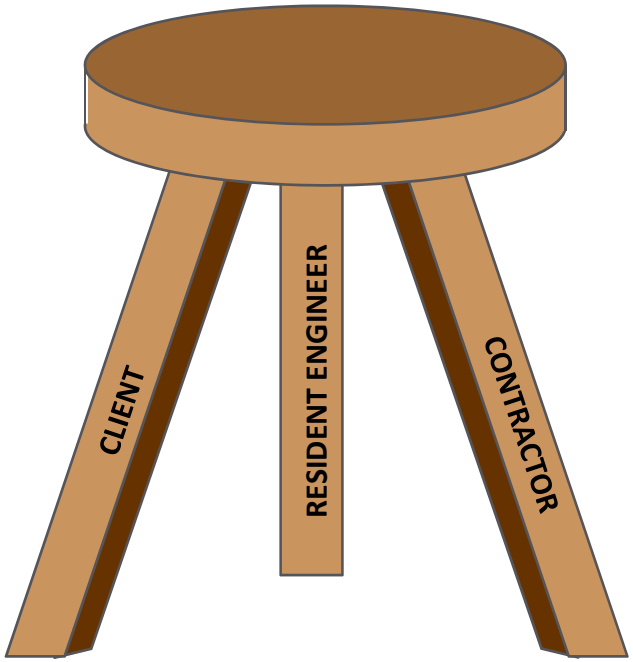
"Very few sites are making a mistake that has not been made before elsewhere in the company"

THE DILEMMA OF ANY PROJECT



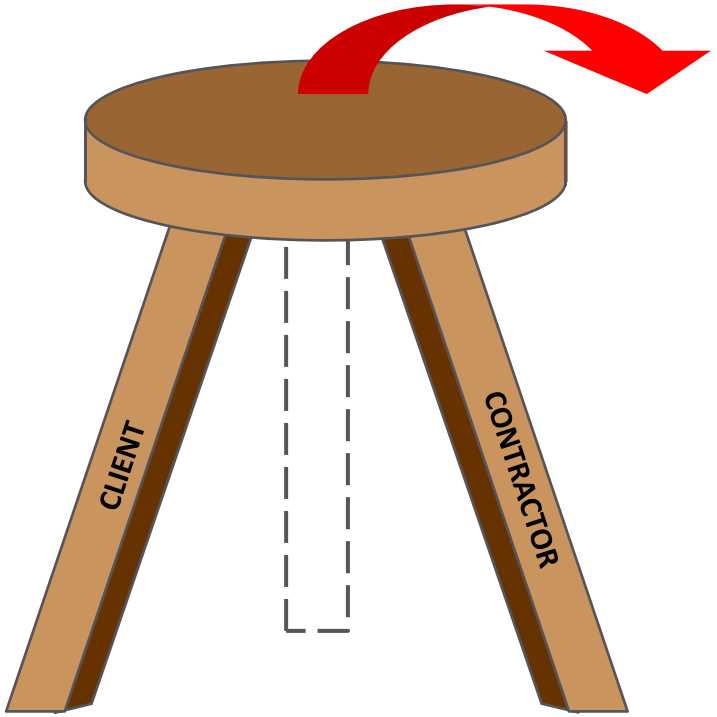
- However is too much emphasis being placed on cost and time at the expense of quality?

THREE LEGGED STOOL ANALOGY – PEOPLE/ROLES



Traditional contract

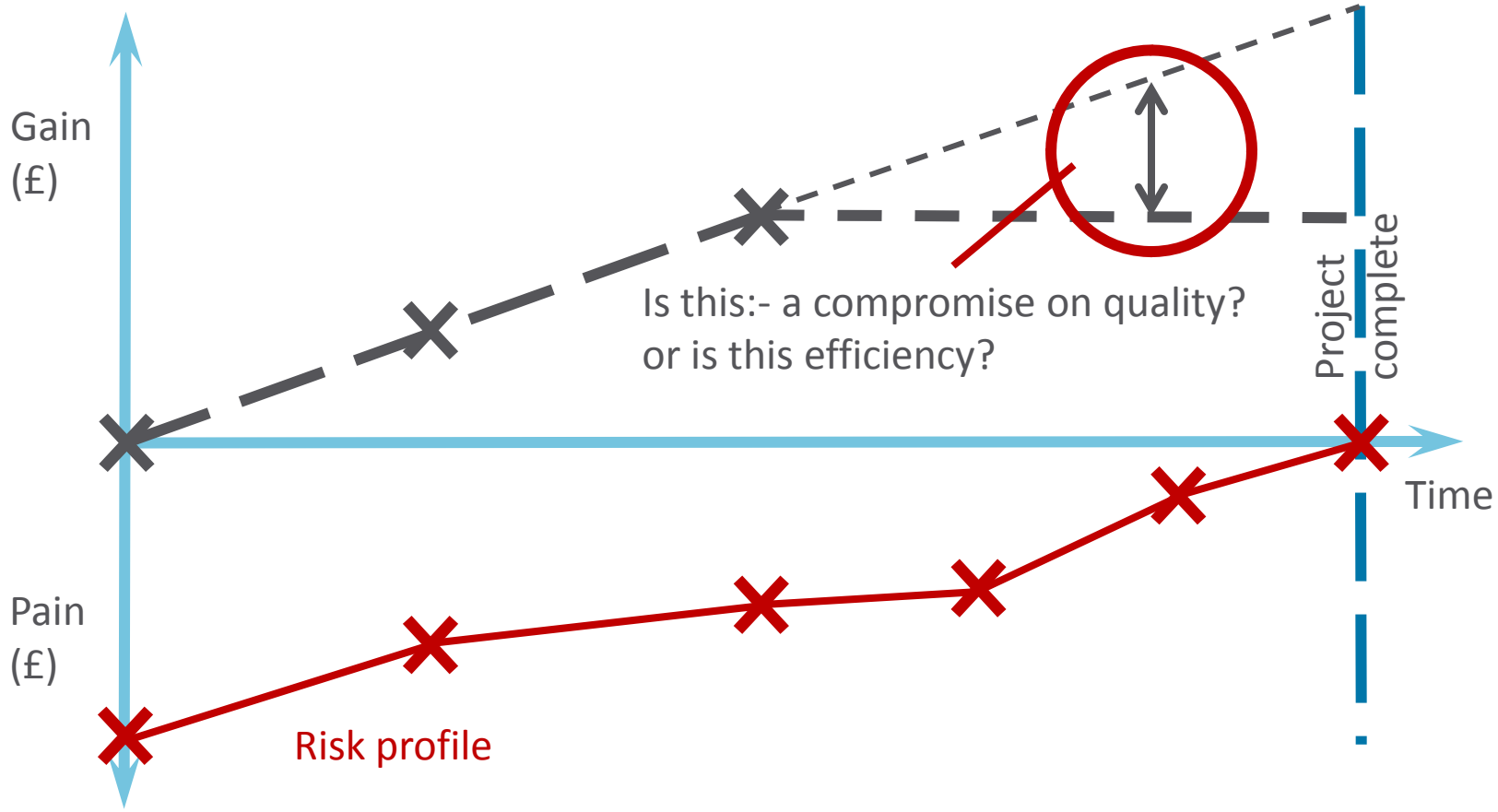
Potential to fall over!



IMBALANCE!

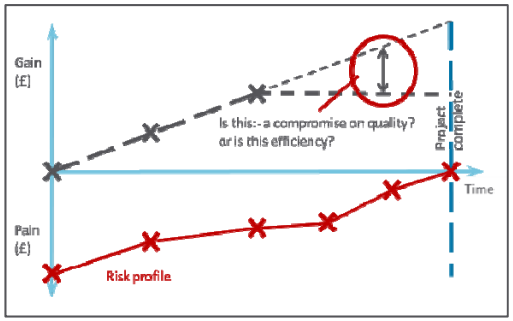
Partnering contract

COMPETING PRIORITIES



Typical project

COMPETING PRIORITIES



Gain
(£)

Project
complete

Savings?

Is this:- a compromise on quality?
or is this efficiency?

HIDING POOR WORKMANSHIP – WATER BAR

If not picked up, would this have been hidden by the next concrete pour?

Properly restrained prior to concrete pour?

AMBERGATE RESERVOIR – CONVENTIONAL CONSTRUCTION

- Ambergate No. 1 under construction using conventional methods
- Ambergate No. 2 will occupy the existing Ambergate reservoirs location employing DfMA techniques

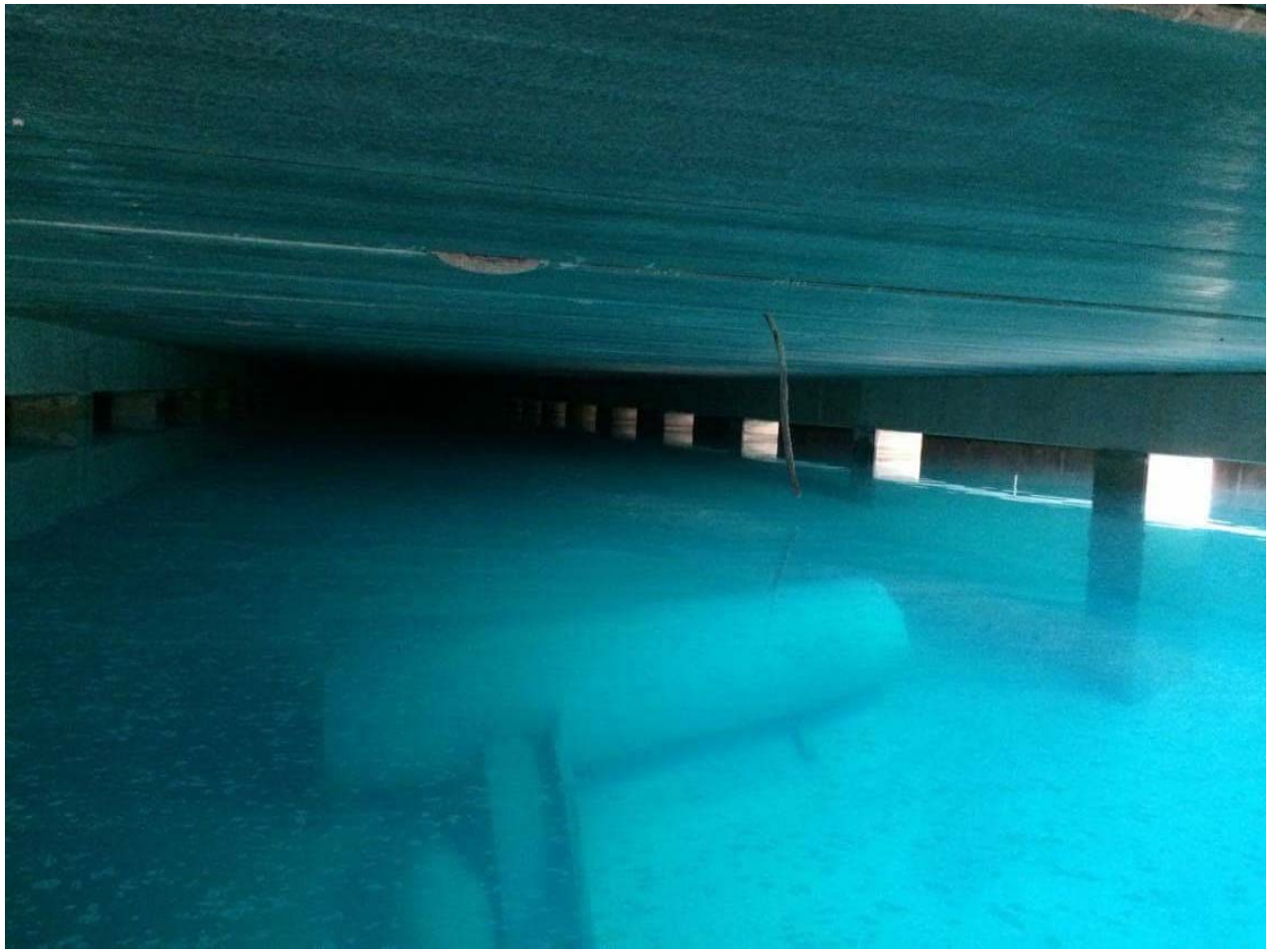
NEW AMBERGATE RESERVOIR

New Ambergate reservoir prior to water test

NEW AMBERGATE RESERVOIR

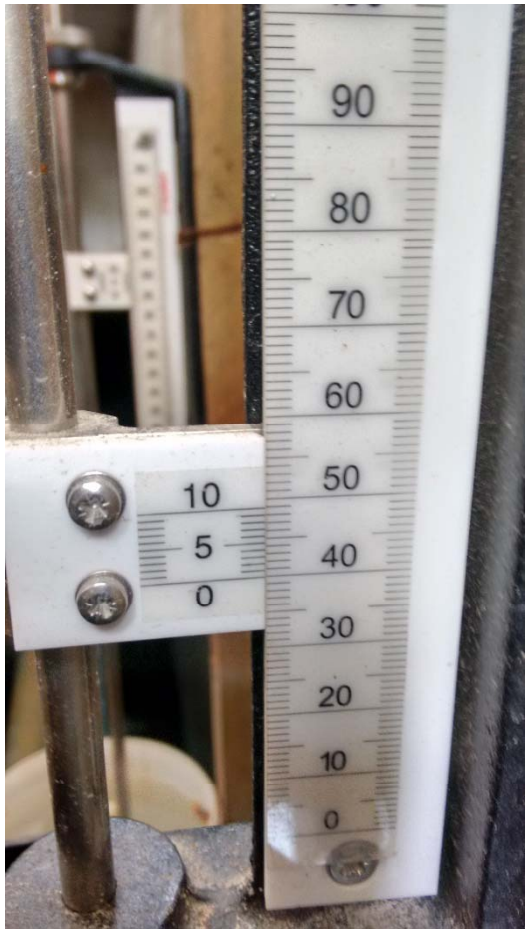
Reservoir prior to water test

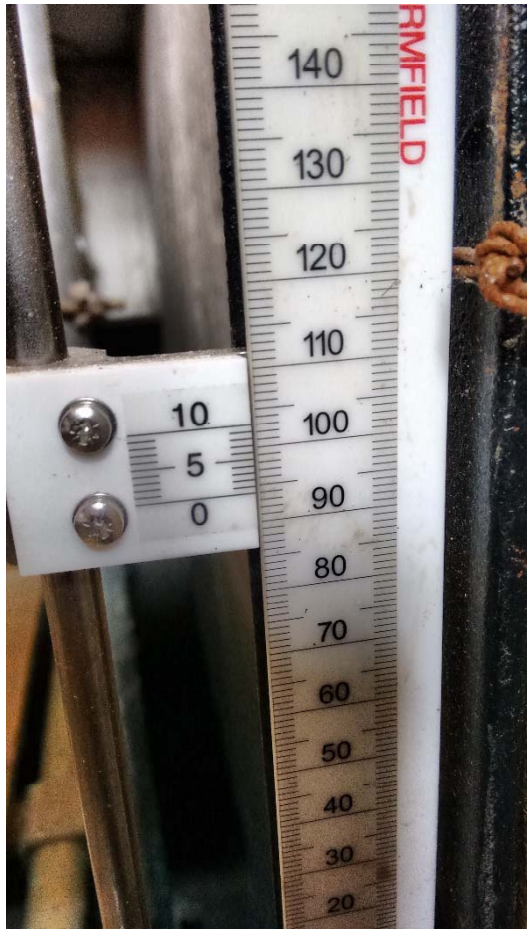
NEW AMBERGATE RESERVOIR – CESWI WATER TEST



Reservoir under water test

NEW AMBERGATE RESERVOIR – CESWI WATER TEST



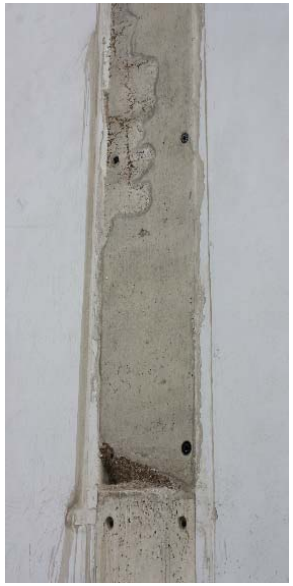


Vernier hook gauge used for accurately determining drop in level

USE PRE-CAST CONCRETE UNITS - 2015

Embracing factory construction -

- Hydrophilic water stop which swells following contact with water
- Significantly more joints – more potential failure points.

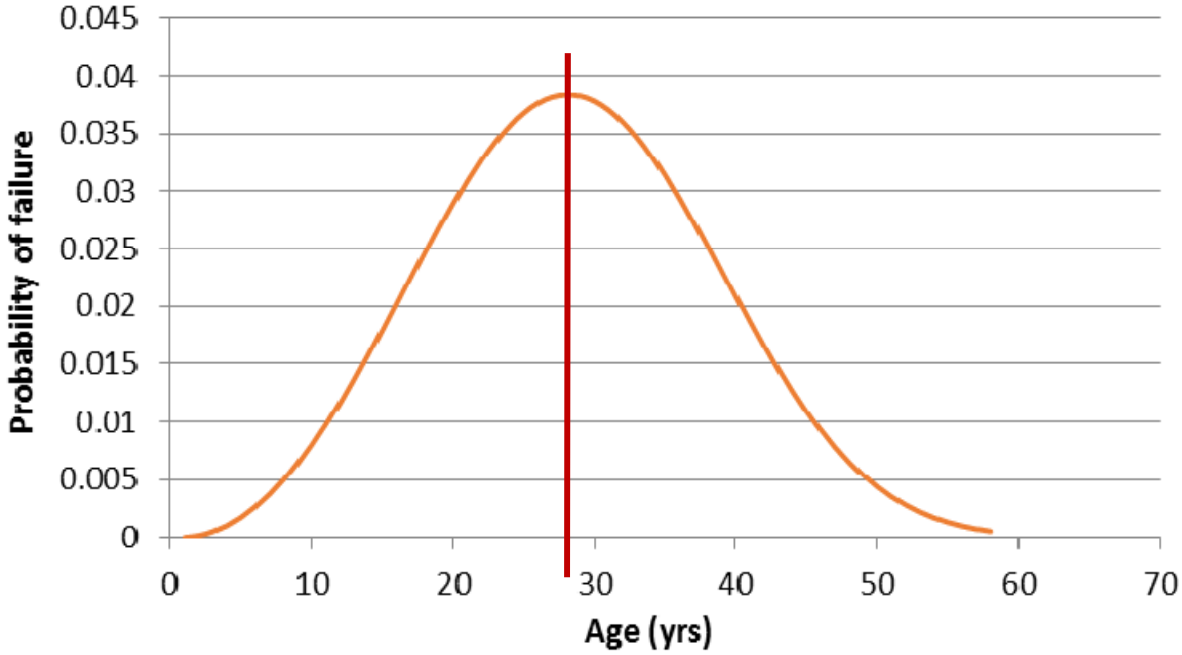


Grafham treated water reservoir

LACK OF ATTENTION TO DETAIL - 2016

- The water stop on the kicker has been damaged to allow access.

HERE GOES FOR A ROCKY RIDE!



"If you always do what you've always done you will always get what you've already got"

HERE GOES FOR A ROCKY RIDE!

We need to challenge convention

Why backfill against walls?

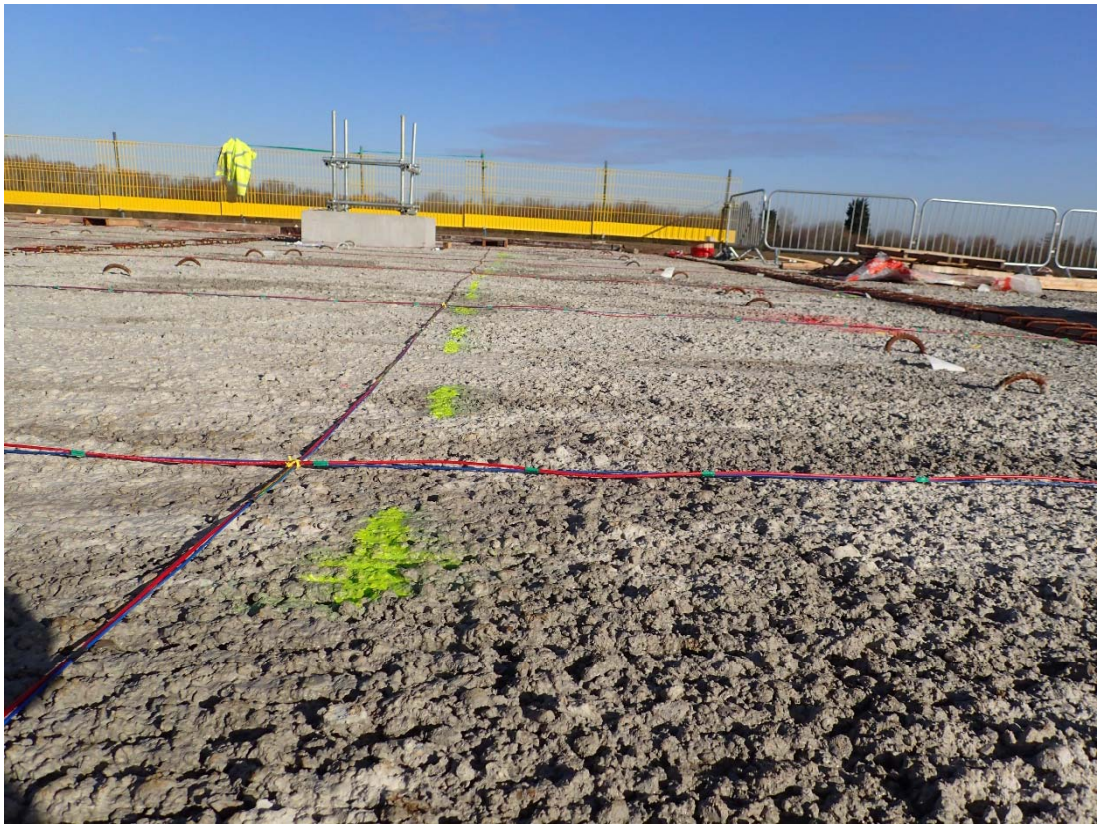
Why not put solar panels on roofs?

Be more engaged with site activities

EMPLOYING NEW TECHNOLOGY: FIBRE OPTIC MONITORING

- Fibre optic cables can detect changes in strain and temperature, indicating deformation or leakage respectively

- This allows both:
  - Construction monitoring
  - Operational integrity monitoring



AVOID BACKFILLING AGAINST WALLS AT ALL

For continued confidence in service reservoir integrity:

- Why backfill against reservoir walls?
- Why not use surplus spoil for landscaping away from the reservoir?

Unnecessary risk – Barby SR

Final finish – Ambergate SR

CONCLUSIONS

Crucially, we need to maintain the ability to provide continuous supply of water to our customers

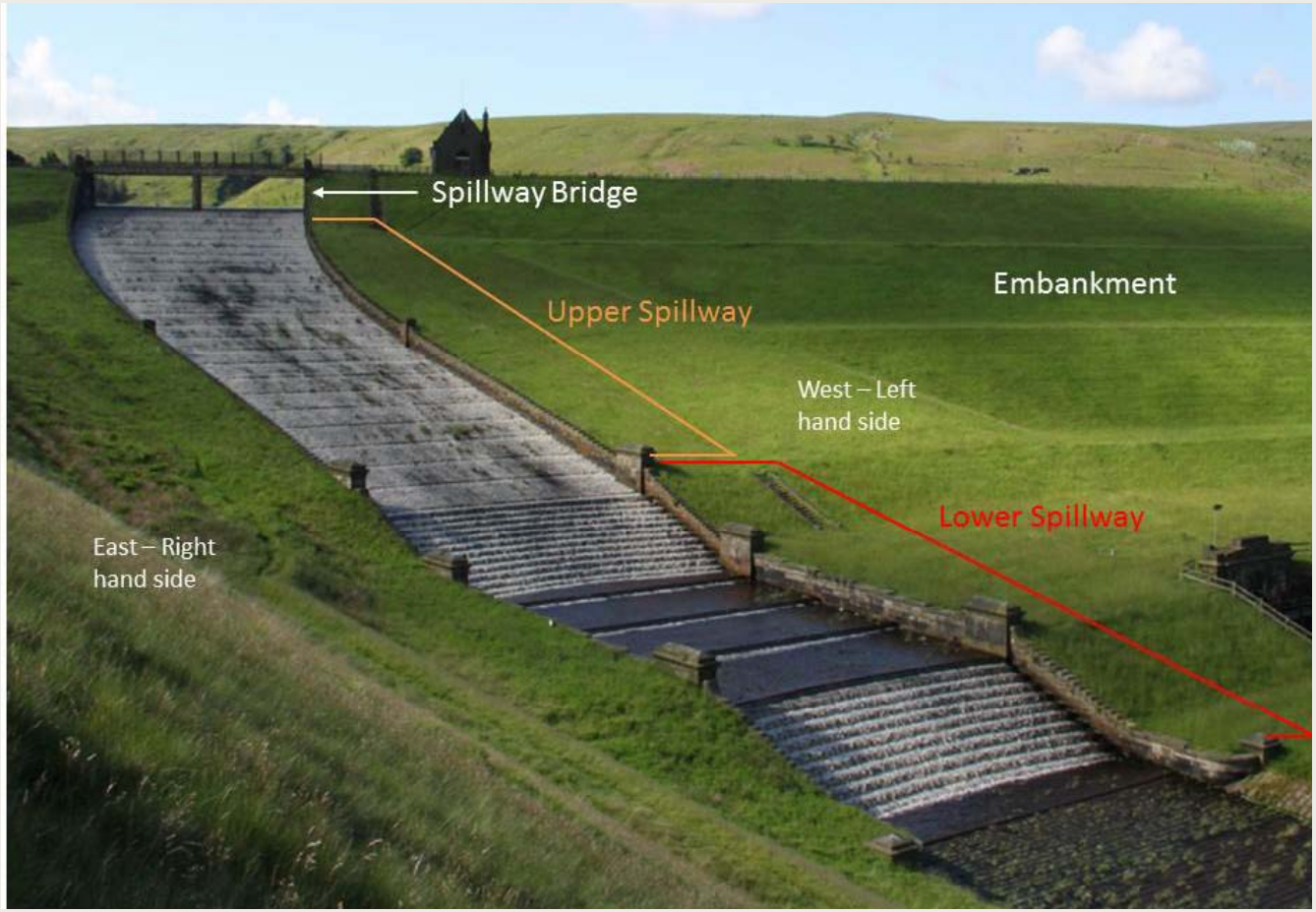
- New builds and repair works require our oversight
- We need to influence future investment needs
- We need to invest in order to address emerging skills shortage


THANK YOU!
Ageing Service Reservoirs – an increasing burden or scope for innovation?
SEVERN
TRENT

Butterley Spillway Improvement Works

Grade II Listed Structure

Rebecca Woods



Project
Butterley Spillway

Client
Yorkshire Water

Location
Marsden, West Yorkshire

Constructed
1906

Dam Height
34.0m

Dam Length
230m

Reservoir Volume
1,773,000m^3

MOTT MACDONALD

Failure

TIMELINE

2002

Investigation


1.Outerwall overtopping


2. Plumes at pillars

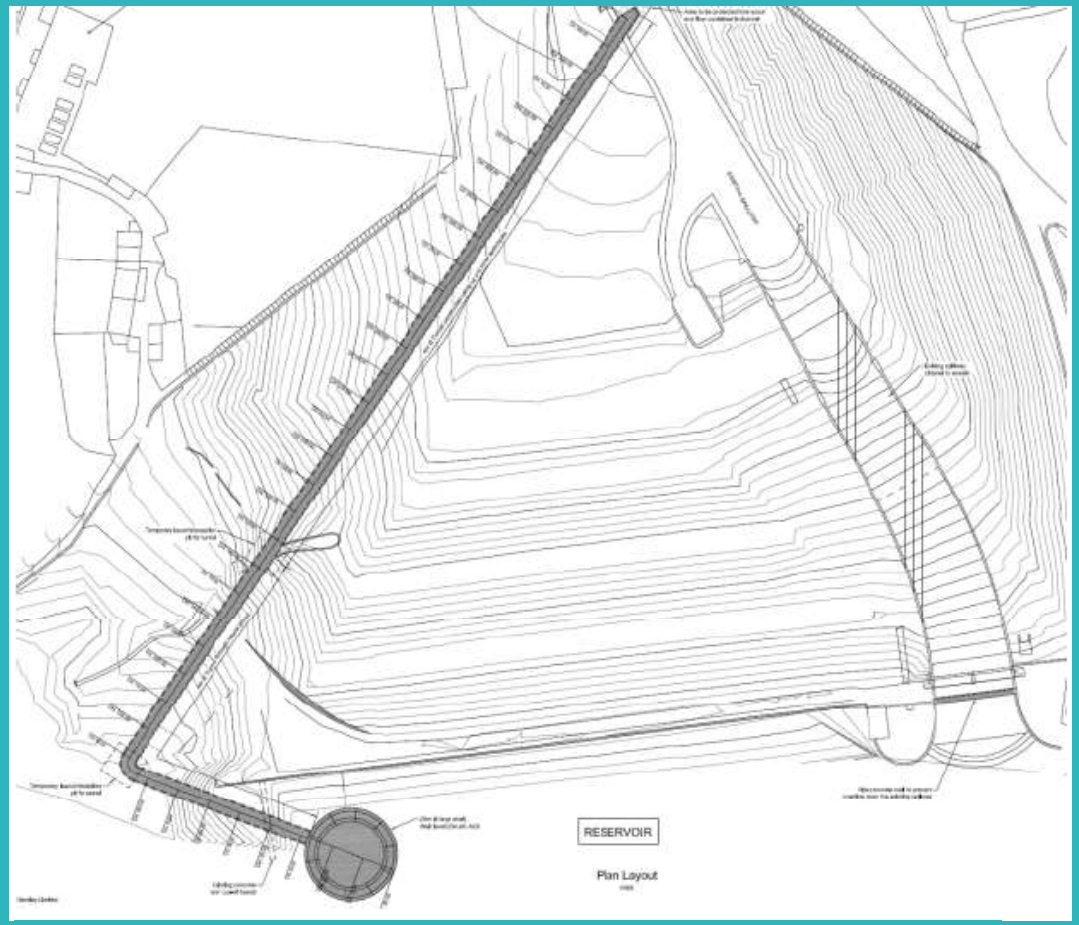

3. Flow separation at cascades


4. Large cross wave

TIMELINE

2009

Optioneering



Drop shaft & tunnel - LHS

Side weir & channel

Over embankment spillway

2012

Planning & Listed Building

MOTT MACDONALD

SAVE BUTTERLEY SPILLWAY

YorkshireWater

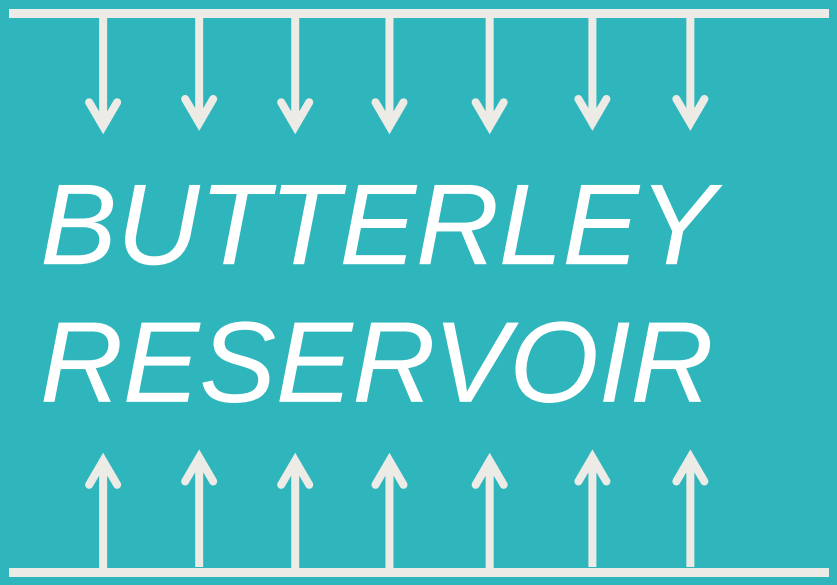
ENGLISH HERITAGE

NATURAL ENGLAND

MMB
Mott MacDonald Bentley

Kirklees COUNCIL

Planning (Listed Building and Conservation Areas) Act 1990

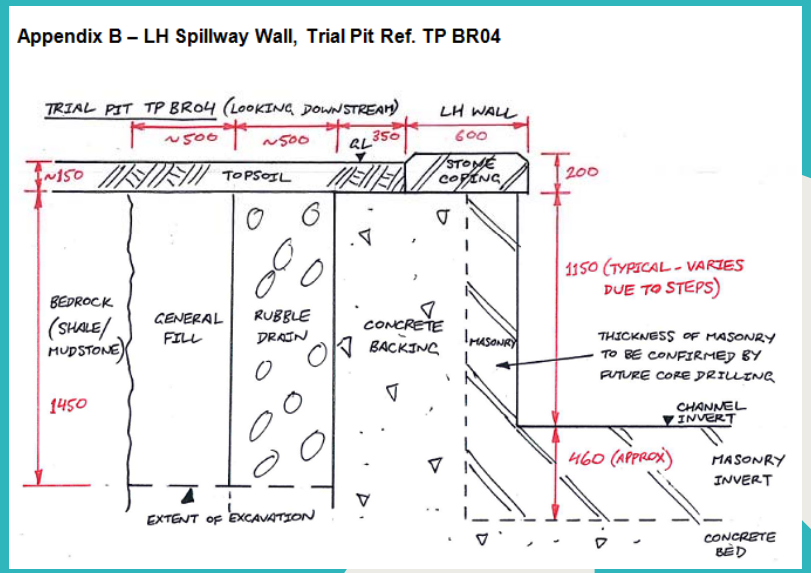


BUTTERLEY RESERVOIR

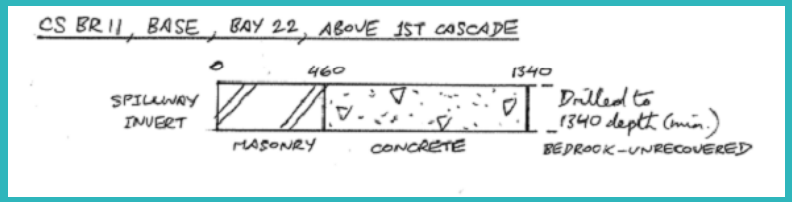
The Reservoir Act 1975

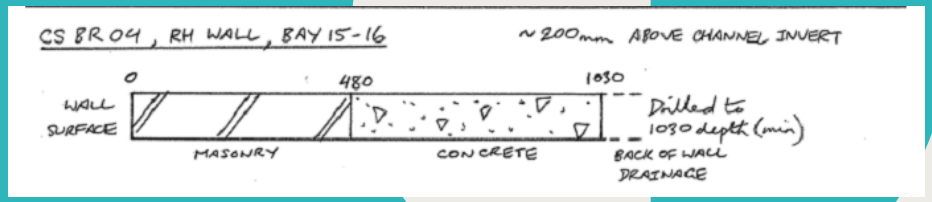
Second Investigation

1. Deconstruction of spillway wall



3. Trial pits



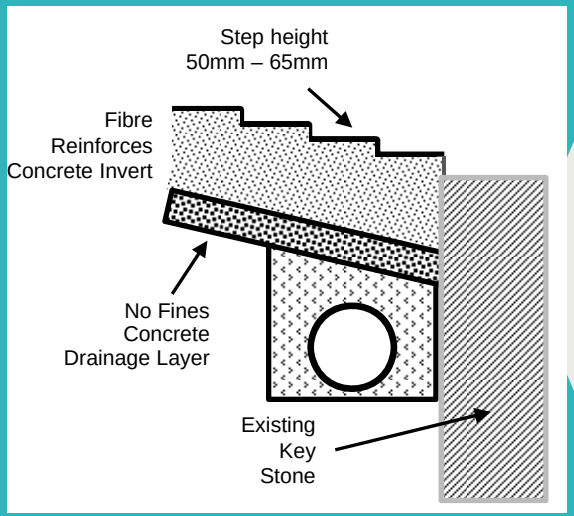


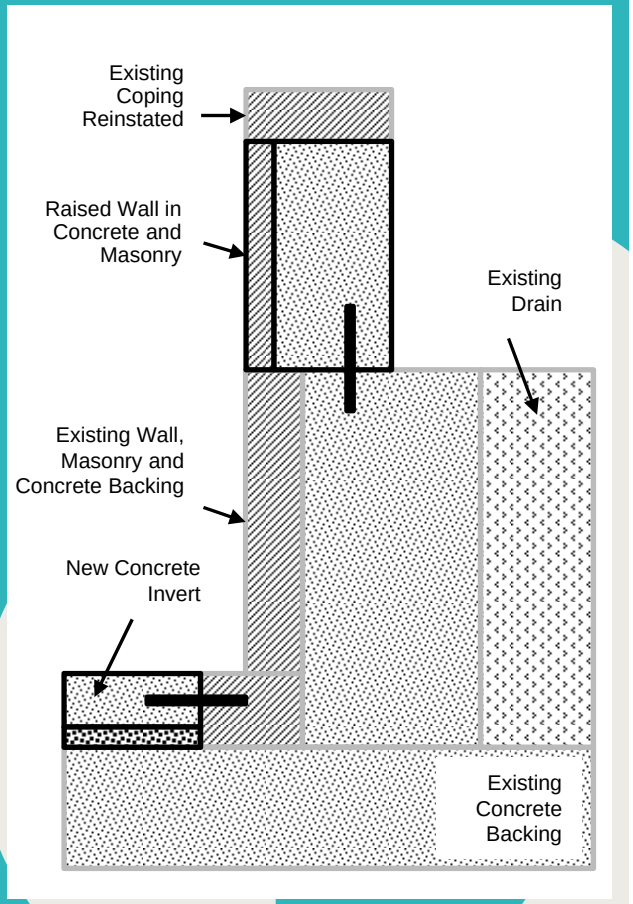
2. Wall and invert cores

TIMELINE

2014

Upper Spillway

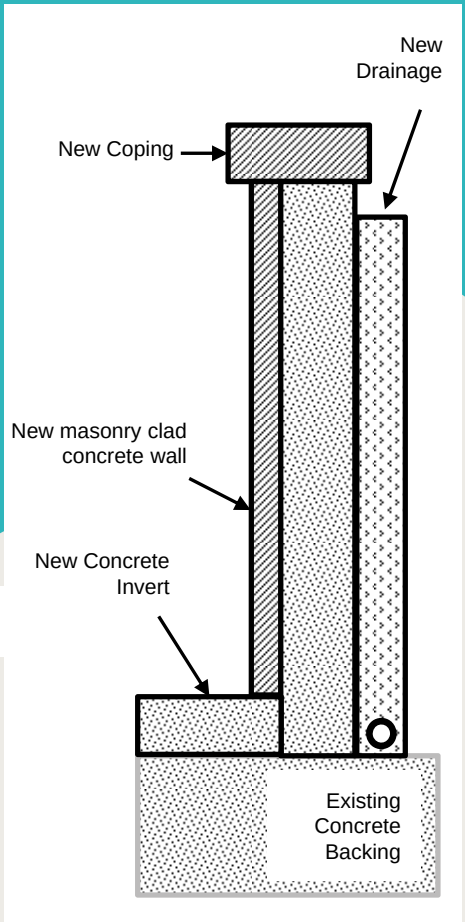


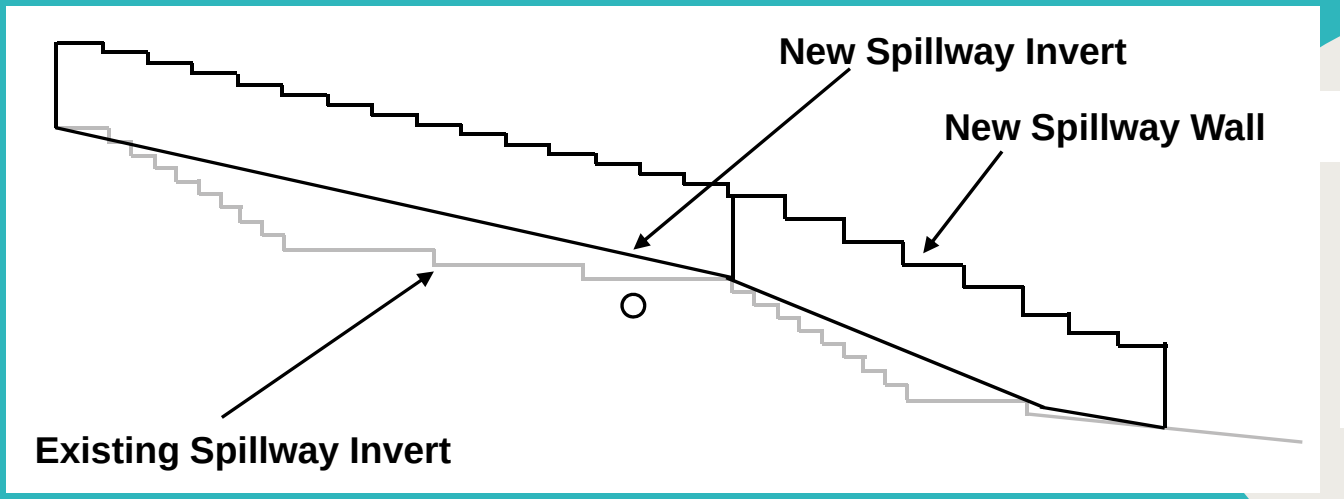


TIMELINE

2014

Lower Spillway





The Solution

Existing Spillway

Improved Spillway - Complete

Site Developments

TIMELINE

2016

Thank you

Design and Construction of Mitford Flood Storage Reservoir

James Penman, Mott MacDonald (formerlyCH2M)

Anthony Myatt, Environment Agency

Andrew Carr, CH2M

Sarah Coverdale, CH2M

Dorian Latham, JBA (formerly CH2M)

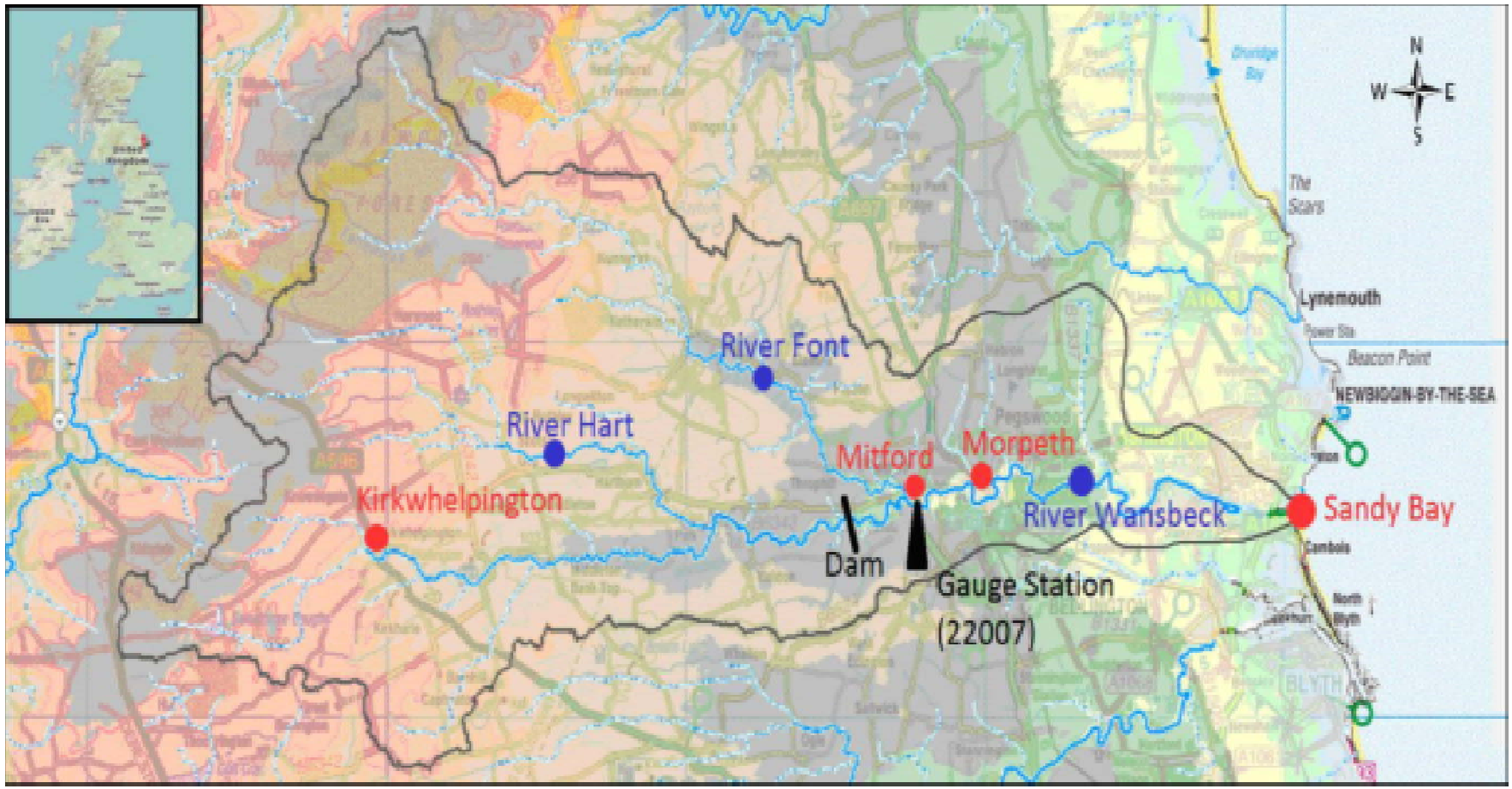
Iain Edmonds, CH2M

Background

21 flood events in Morpeth in last 175 years
Hydrological studies in 2005
September 2008 Flood

- 1000 Properties affected
- 400 people evacuated
- Estimated return period of 137 years

Project Location



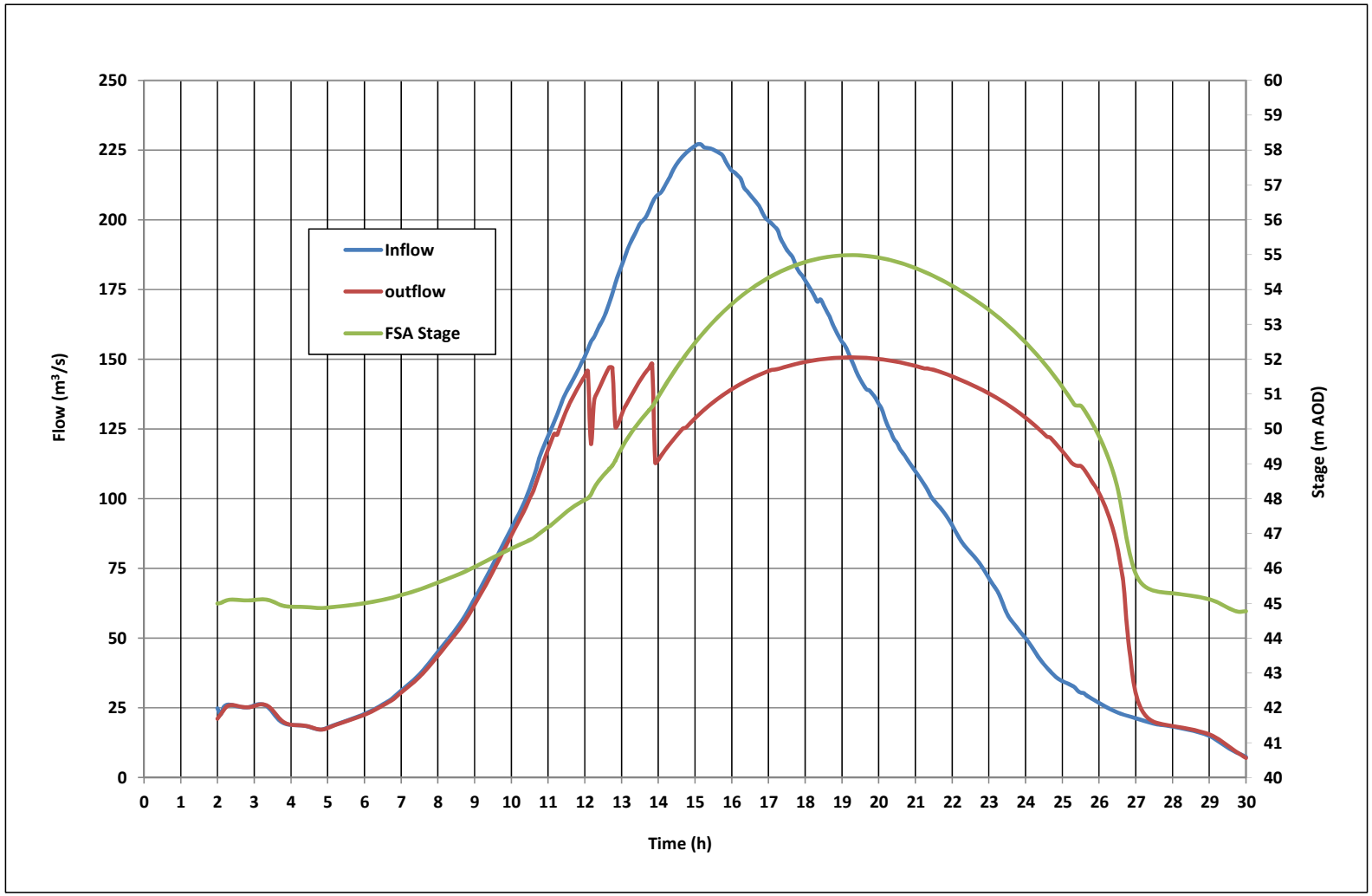
Morpeth Flood Alleviation Scheme

- Designed for 137 year return period event
- Town defences raised to establish a consistent level of protection
- Upstream flood storage reservoir

Conceptual design of flood storage reservoir

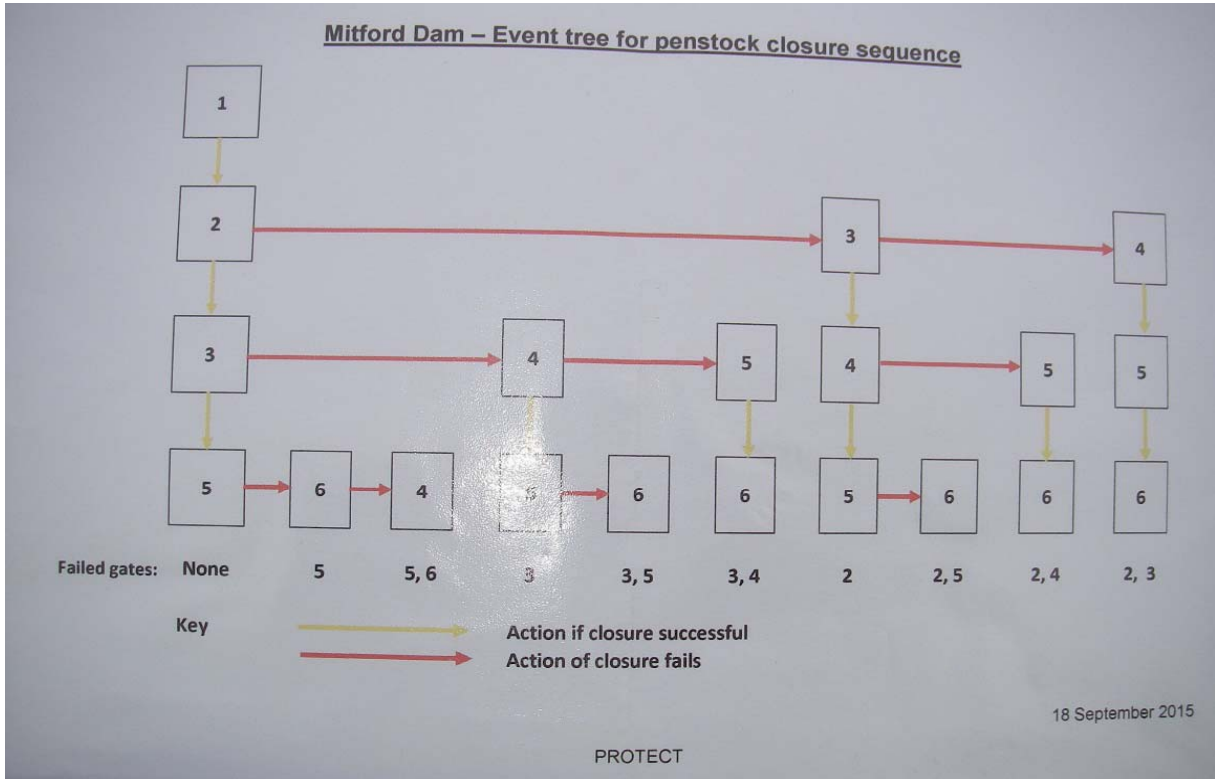
- Maximum pass forward flow of 150 m^3/s
- Category A dam designed to safely pass PMF
- 5 No culverts controlled by penstocks
- 2 penstocks to remain open in design flood, 3 penstocks to close
- Flow control options:
  - All gates close simultaneously triggered by reservoir level
  - Gates close one by one triggered by reservoir level
  - Gates close incrementally to deliver constant pass forward flow
  - Gates close incrementally based on downstream gauging (below Font confluence)

Adopted mode of operation



Gate control

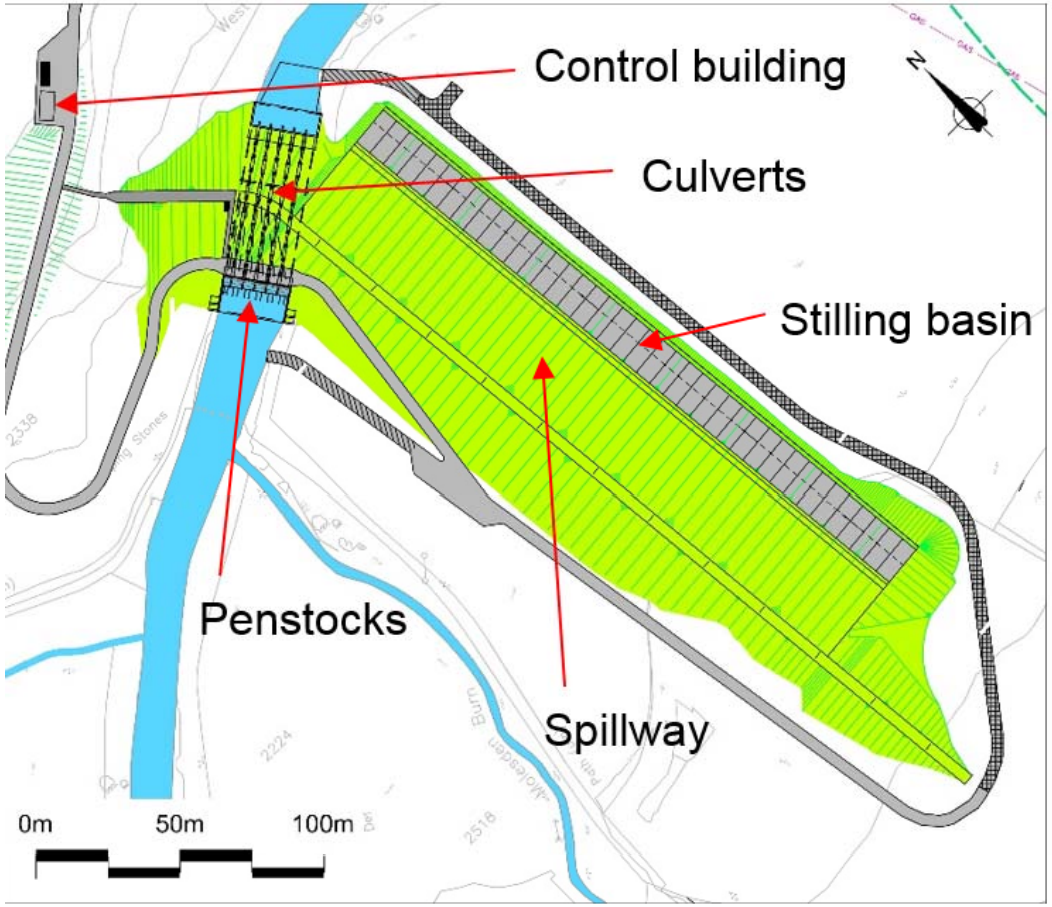
- Hydraulic actuators on all gates
- Permanent electricity supply with back up generator
- Gate closure sequence programmed to vary if gate is inoperable



Gate closure level (mAOD)	
1	44.5
2	48.0
3	48.8
4	50.3

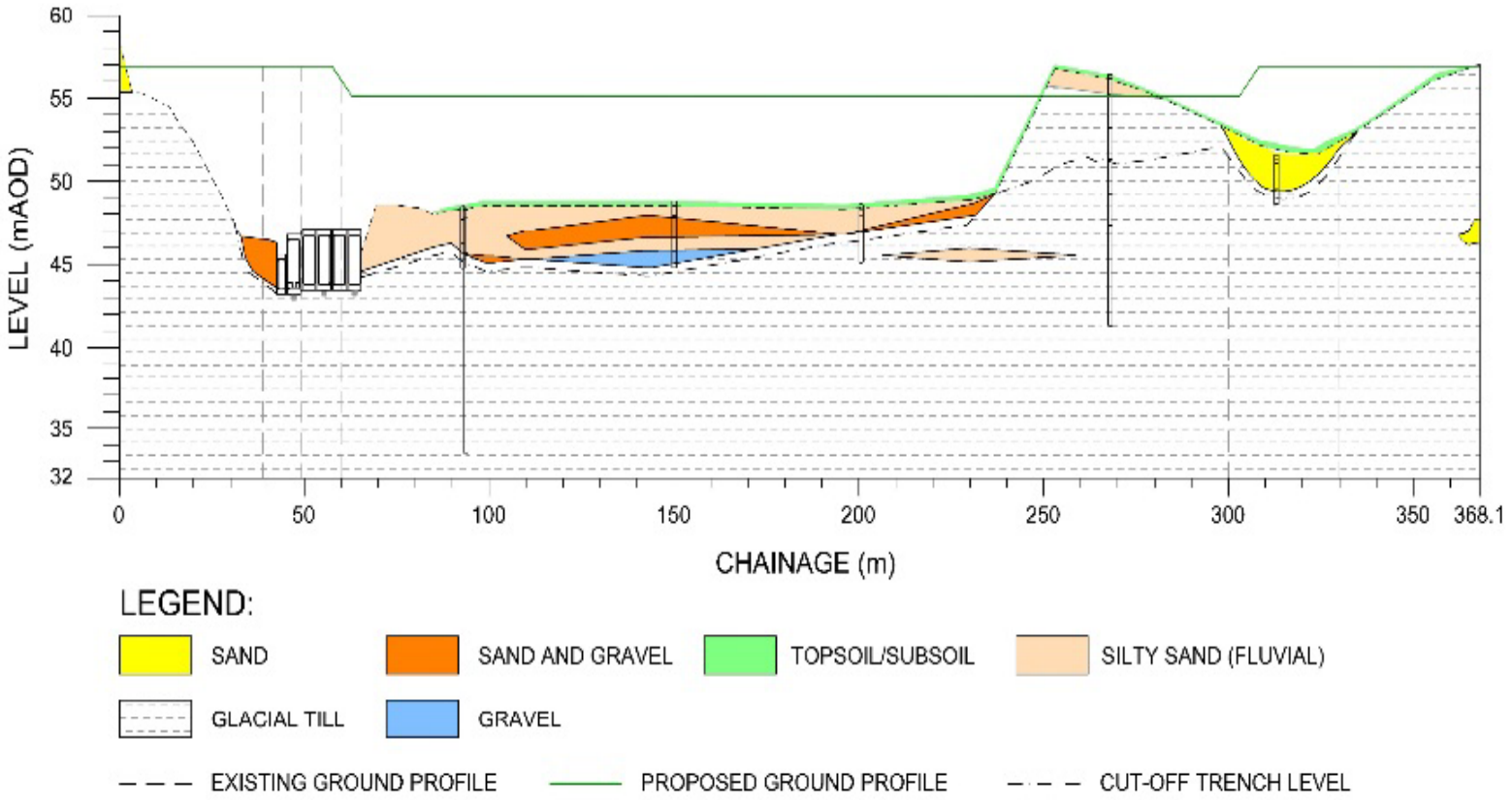
Culvert invert	43.7
Spillway crest	55.1

Scheme Layout



- 370m long embankment
- Homogeneous earthfill
- Max height 14m
- 1v:4h side slopes
- Res volume 1.4Mm^3
- 5nr 3m x 3m culverts
- 1 nr 1.8m x 1.8m culvert
- Pass forward flow 150m^3/s
- Spillway length 240m
- PMF outflow 932m^3/s

Geology


60
55
50
45
40
35
32
LEVEL (mAOD)
0
50
100
150
200
250
300
350
368.1
CHAINAGE (m)
LEGEND:
SAND
SAND AND GRAVEL
TOPSOIL/SUBSOIL
SILTY SAND (FLUVIAL)
GLACIAL TILL
GRAVEL
EXISTING GROUND PROFILE
PROPOSED GROUND PROFILE
CUT-OFF TRENCH LEVEL

Culvert construction Method

- River diverted to temporary channel
- Precast culverts constructed online
- River diverted through culverts and embankment completed

Spillway

- Max velocity approx 9m/s
- Dycell cable tied blocks
- Reinforced concrete stilling basin

Environmental Aspects

- Important river for native white clawed crayfish
- Geomorphological characteristics to be retained
- Impact on upstream movements to be minimized
- Crayfish culvert closes when flow exceeds $30m^3/s$
- Offset baffles provided to manage velocities

Completed Scheme - overview

Completed Scheme - culverts

First Operation – January 2016

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Morpeth flood gate closed as roads flood

5 January 2016 | Tyne & Wear

Flood defences were installed after the River Wansbeck in Morpeth flooded in 2008 and 2012

A barrier installed in a Northumberland town after previous flooding has been reclosed ahead of expected heavy rain.

Top Stories

Security Council condemns N Korea launch

The UN Security Council strongly condemns North Korea's launch range rocket, saying it will s sanctions resolution.

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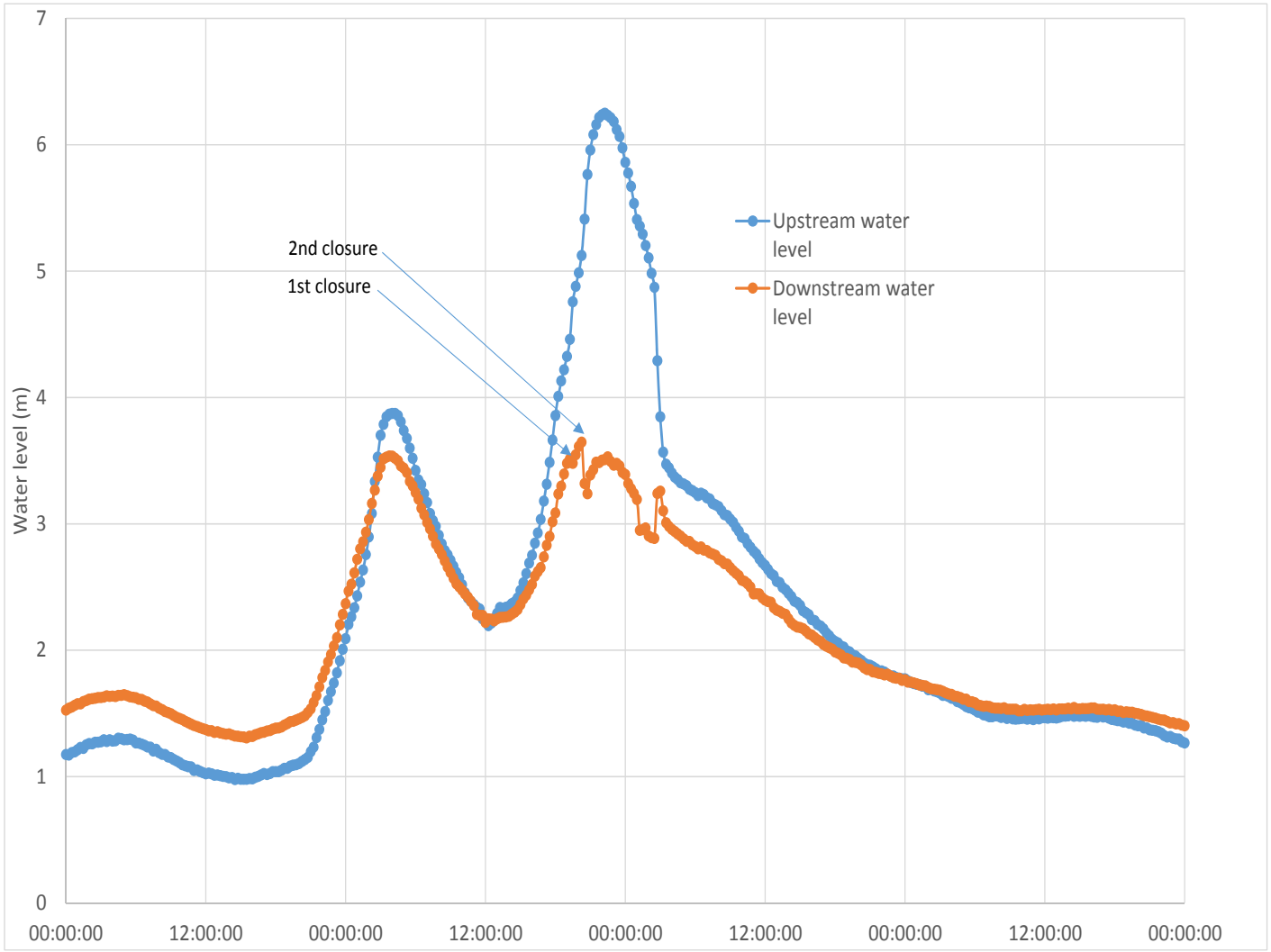
Success

Water levels in Dec 2015 flood event

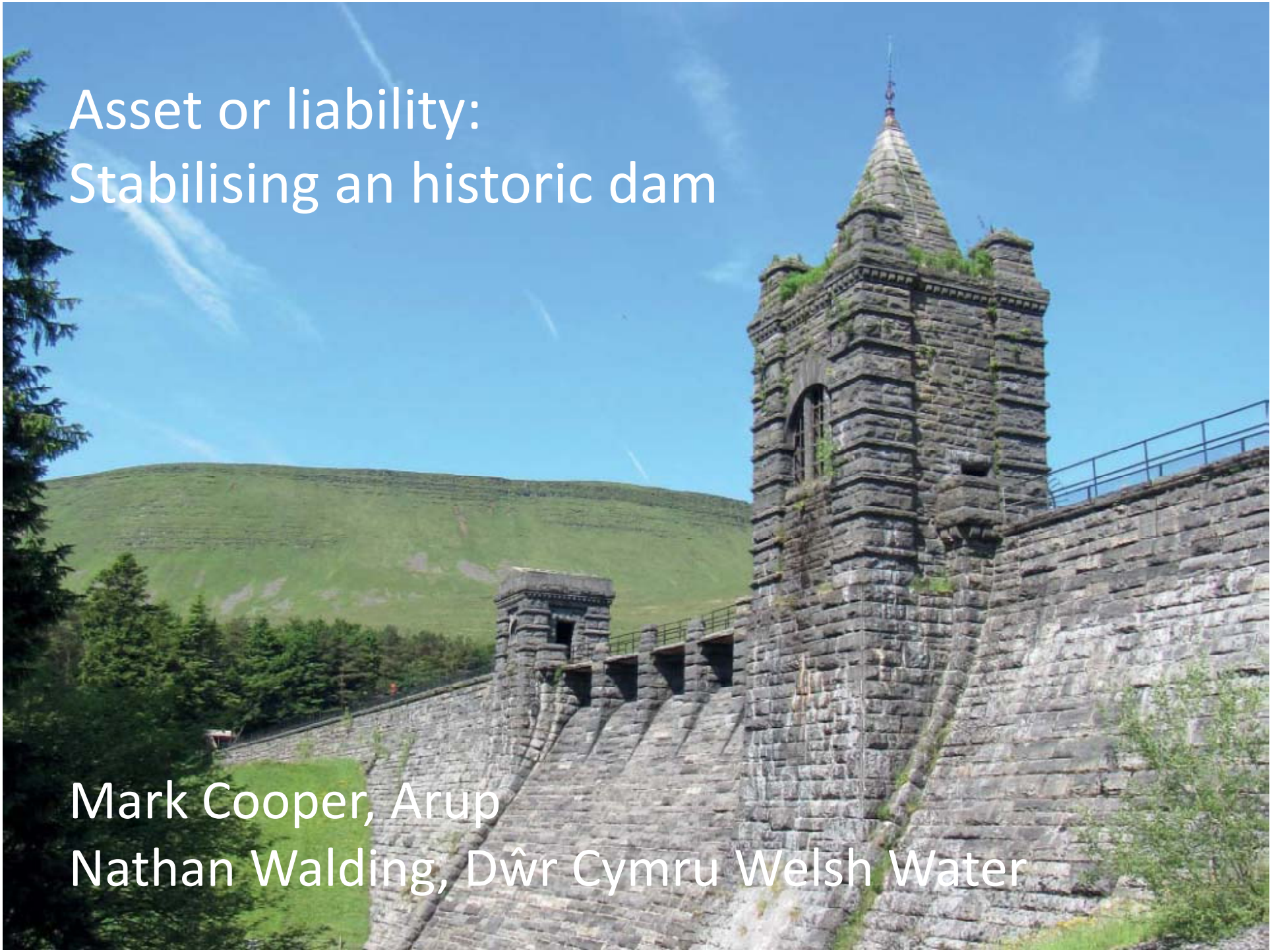


Trash removal

Summary

- Scheme constructed over a two year period (2013 to 2015)
- Morpeth protected from the 1 in 137 year flood event
- Flooding prevented in Jan 2016
- Satisfactory performance to date

Thank You


Asset or liability:
Stabilising an historic dam
Mark Cooper, Arup
Nathan Walding, Dŵr Cymru Welsh Water

Location

Dŵr Cymru Welsh Water

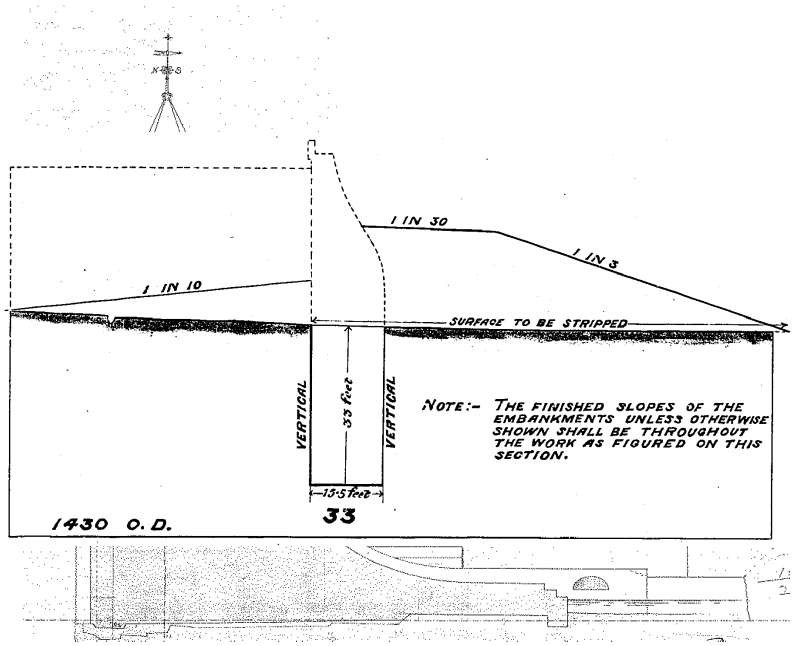
ARUP

Upper Neuadd dam

- First in a series of three reservoirs in cascade, lying upstream of Lower Neuadd and Pontsticill Reservoir
- Construction completed in 1902 for supply to Merthyr Tydfil Waterworks
- Grade II* listed building *"for its special interest as an architecturally-designed dam of spectacularly massive construction and definite character"*

Form of dam

- Masonry flanking embankment dam with cyclopean concrete infill
- Central mass gravity spillway section
- Narrower flanking sections relying on downstream embankments for stability
- A history of issues with seepage and movement, and concerns about stability



Measures to be taken in the interests of safety

The 2013 Section 10 report recommended measures to be taken in the interests of safety under Section 10(6) of the Act.

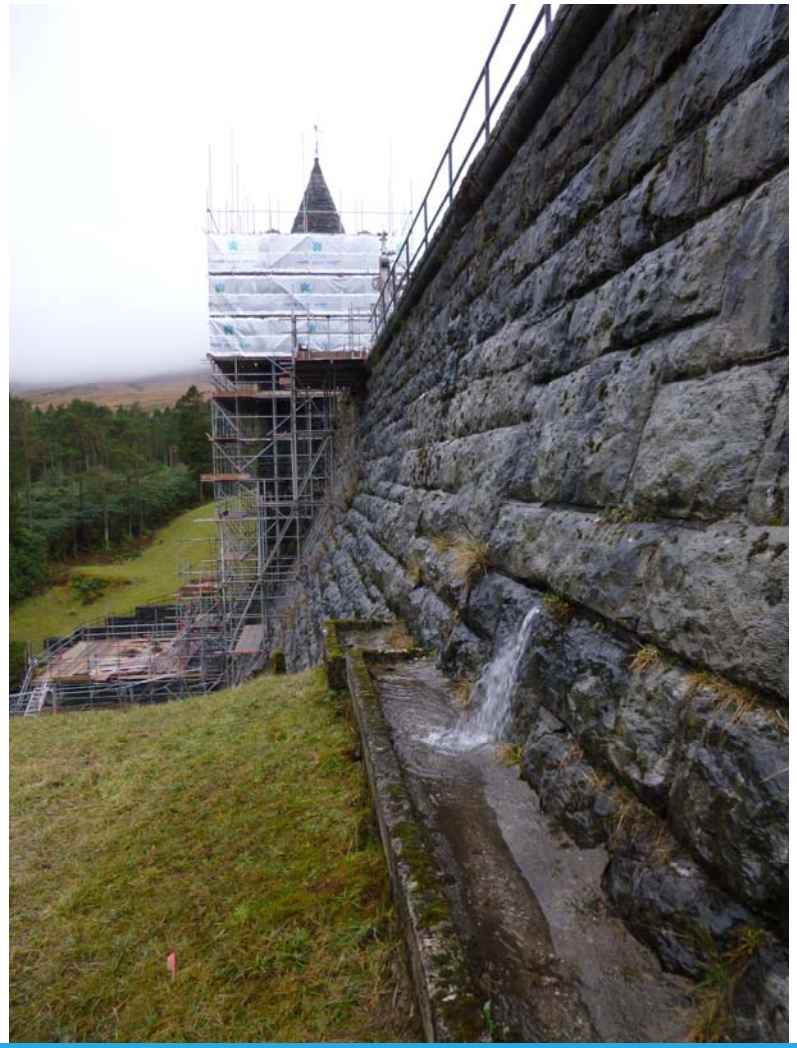
Either:

1 (a) Measures to limit the loading on the dam, by preventing the flood level in the reservoir during the passage of a PMF rising above a level that is 1m below the present spillway crest; or

1 (b) Measures to ensure the long-term stability of the entire dam when the reservoir is filled either to the present spillway crest level (or to a slightly lowered spillway crest level) including during the passage of the PMF.

Either of the above measures to be enacted by December 2015 (the enforcement date).

Site inspections



Dam leakage

Ground investigation objectives

- Confirm geometry of the dam and construction details at interfaces
- Identify primary seepage routes
- Identify geotechnical properties
- Provide additional instrumentation

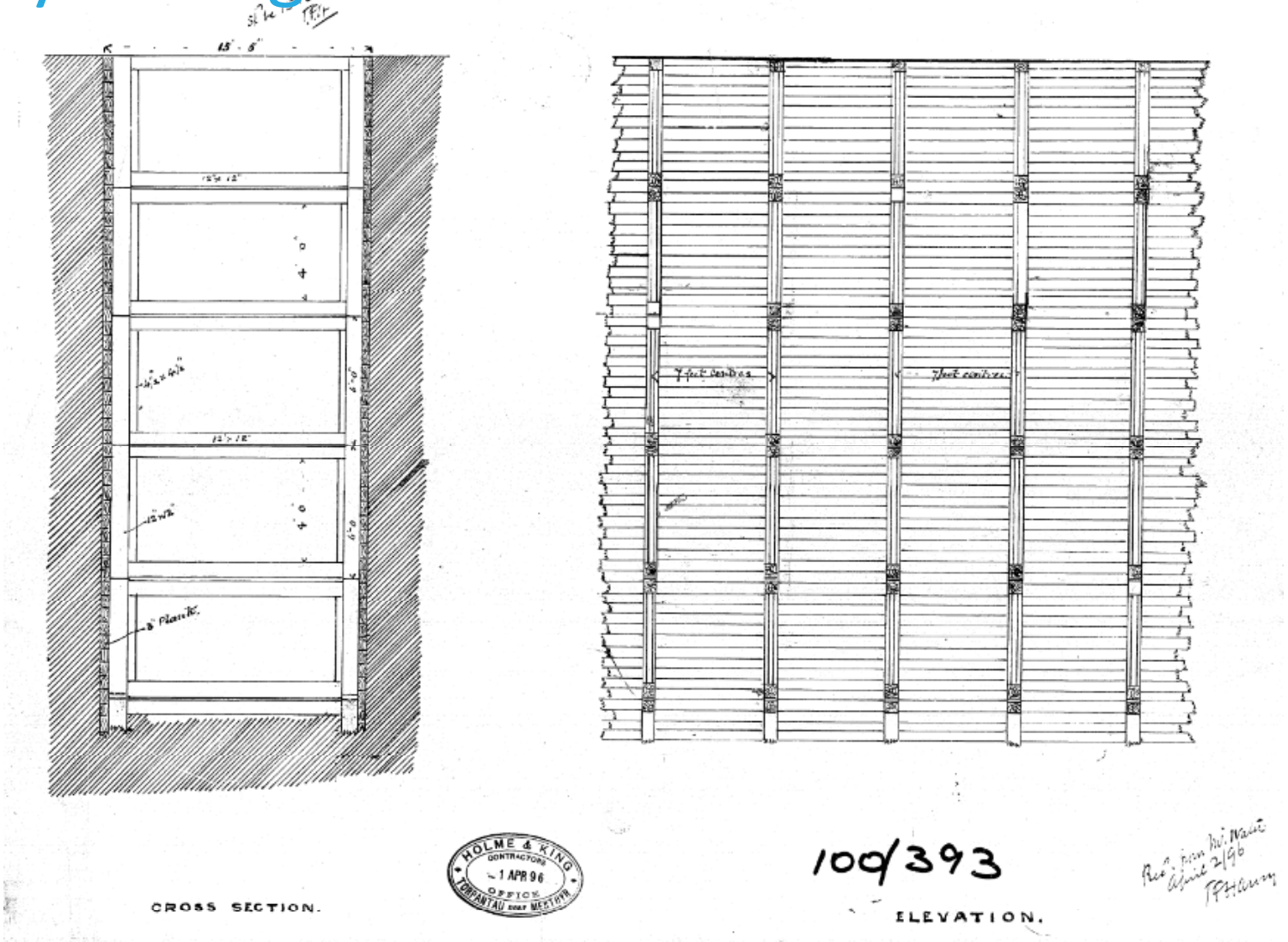
Key findings – dam construction

- Dam founded on competent bedrock
- Concrete cut off proven
- Geometry as per 1890s drawings
- Fractured concrete encountered throughout the dam
- Concrete eroded by flow of water

Key findings – concrete cut-off

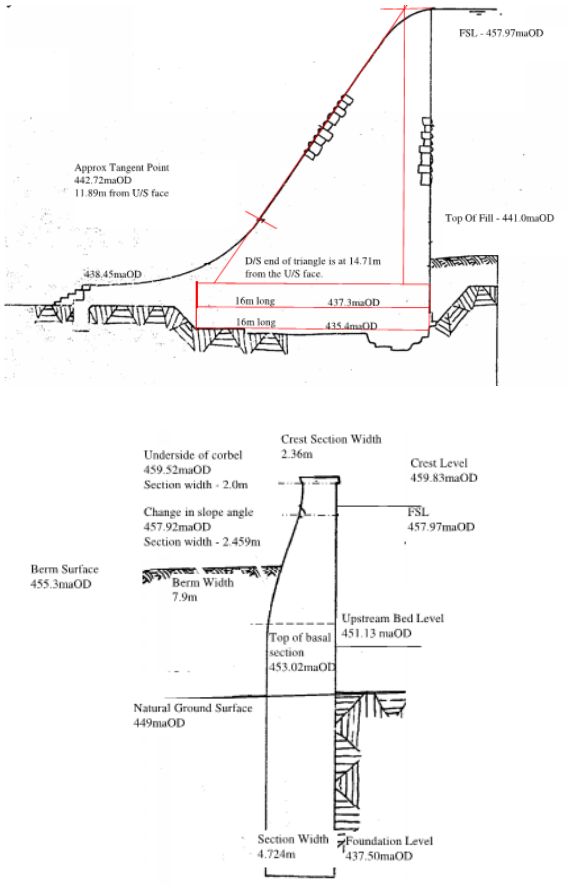
- Temporary timber shoring remains in place around cut-off
- Timber on the downstream, passive side has rotted
- Layout of timber shoring is typically as per 1890s temporary works drawings

Key findings – concrete cut-off



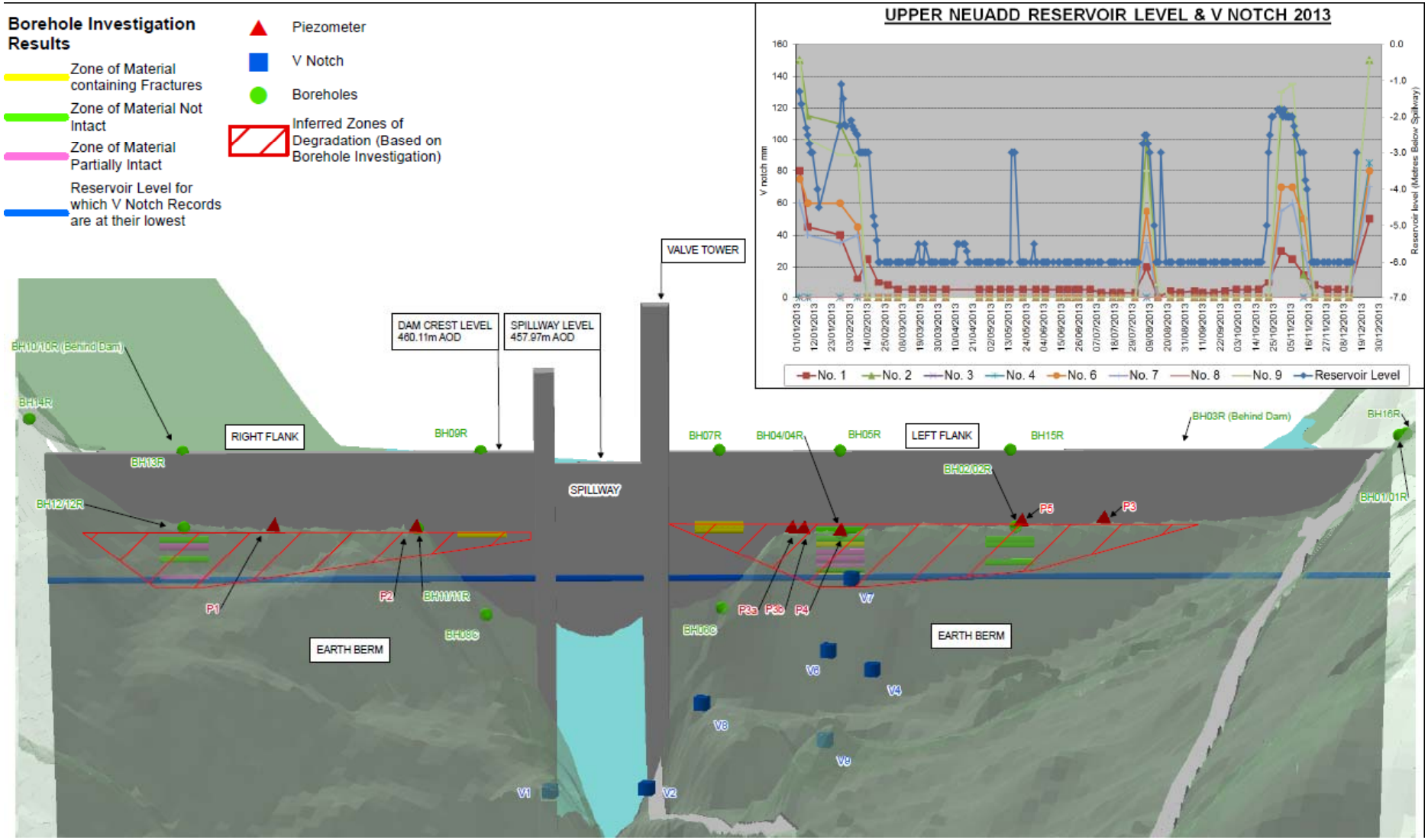
Summary of analysis

- Critical sections identified for assessment; also to correlate with SI cores and monitoring instrumentation locations.
- Parameters from the SI confirmed non-overflow (flanking) section stable against sliding, but inadequate for overturning.
- Storm event in January 2014 caused reservoir to fill and overflow the spillway, but the dam remained stable.
- Back analysis concluded that dam would have to strain under hydrostatic loading to generate the required earth pressure from the downstream berms for stability.
- Concluded that repeated deflections during storm events had exceeded the tensile capacity of the upstream face and led to the observed cracking and leakage.
- Level at which leakage flows increase correlates with the position of the degraded matrix in the SI cores and also the position where the greatest tension develops in the upstream face.
- Presence of timber formwork on downstream face results in excessive movement to generate passive resistance for stability.



Analysis sections

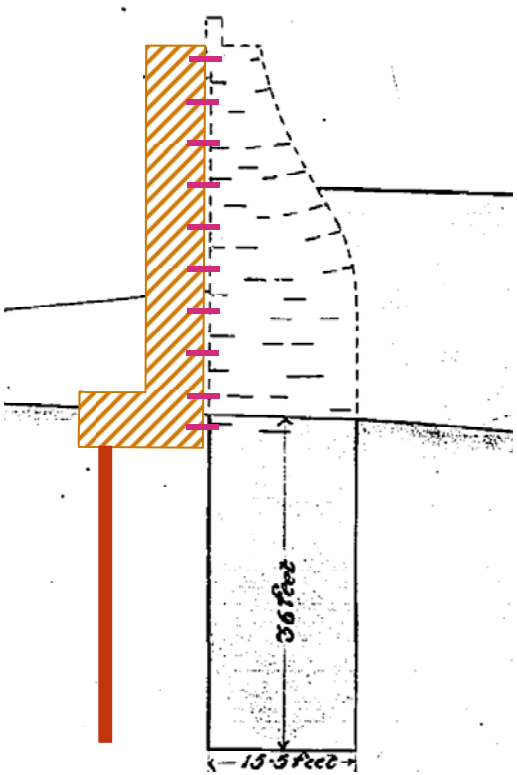
Summary of analysis

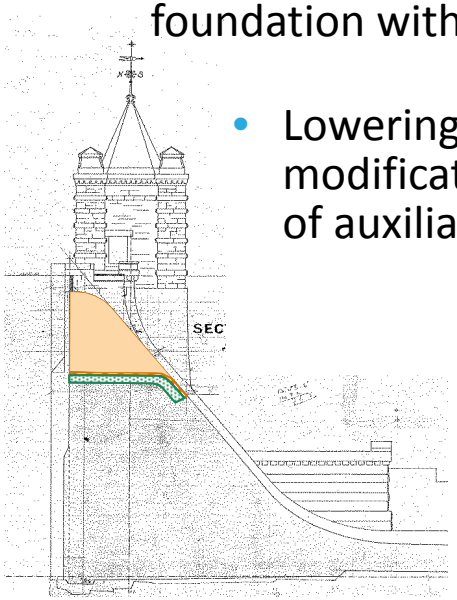


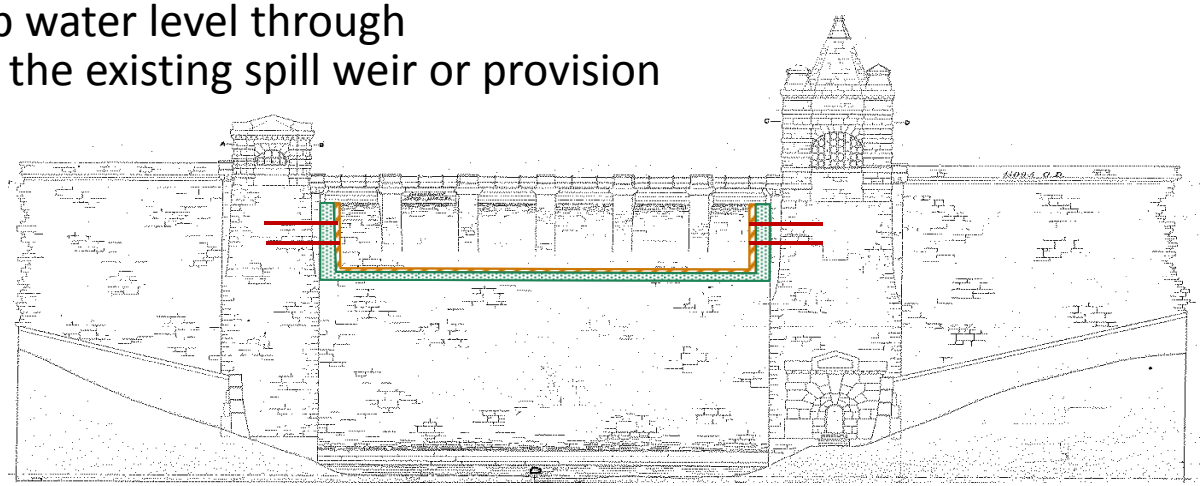
Remedial options

Options to maximise operational water level and solve stability and leakage issues:

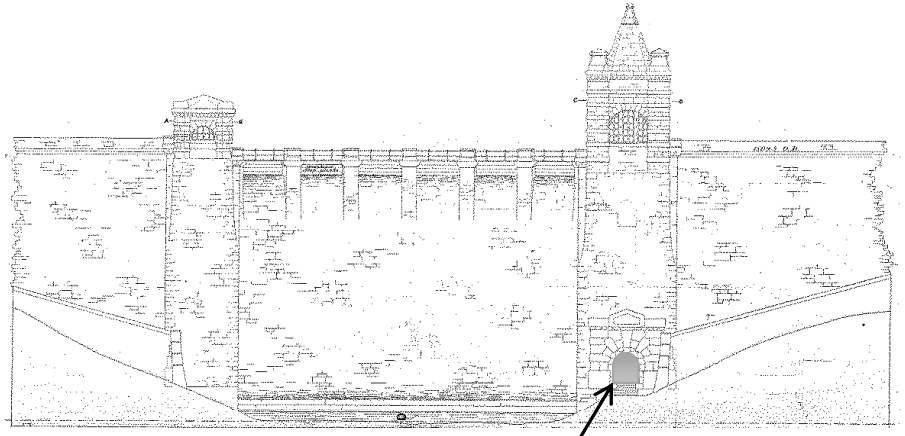
- Construction of a reinforced concrete wall on the upstream face of the dam
- Vertical anchors with an upstream liner, or with grouting of the dam
- Downstream buttresses built from the original dam foundation with an upstream liner
- Lowering the top water level through modifications to the existing spill weir or provision of auxiliary weir



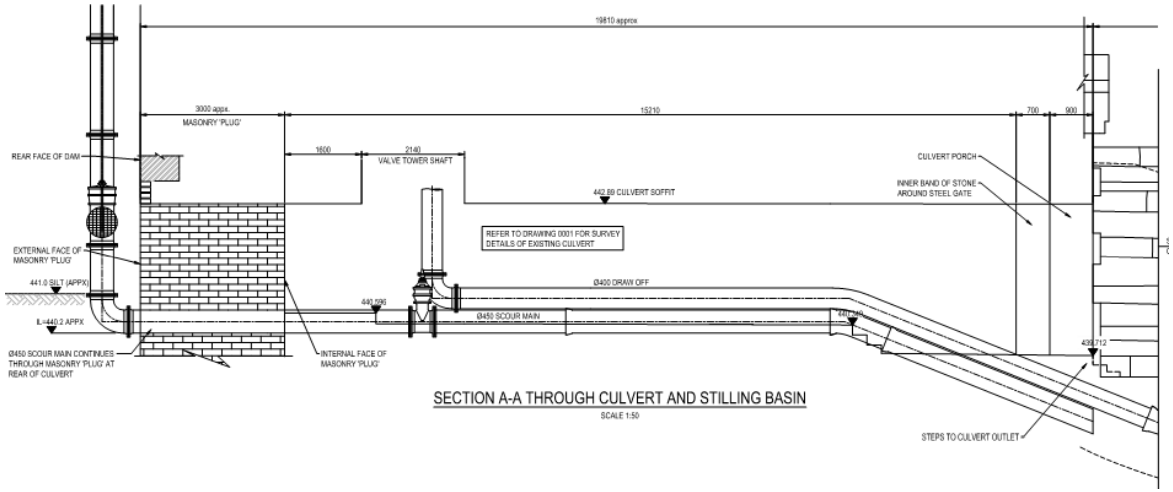




Preferred option – removing plug in the outlet tunnel

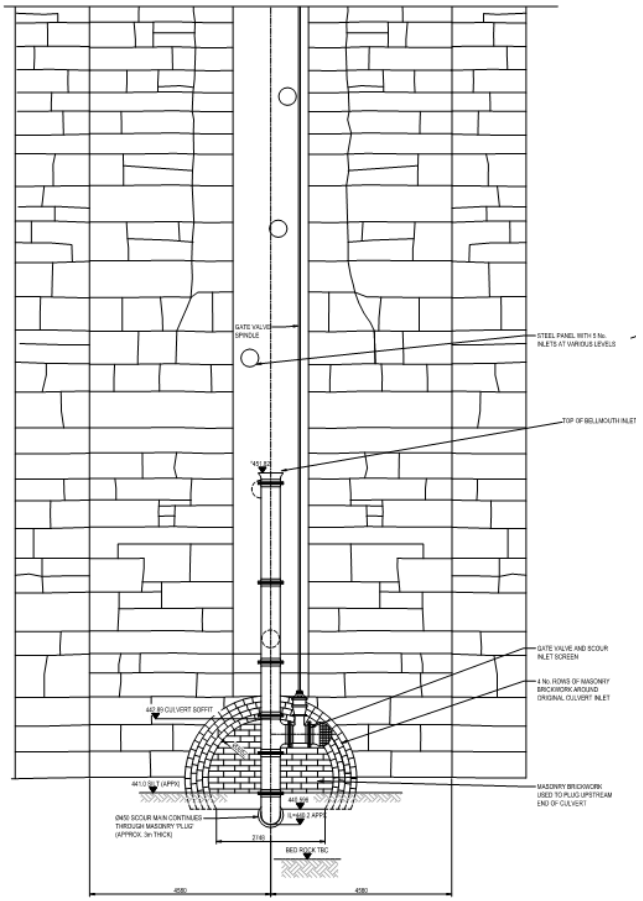


Removal of upstream masonry plug and lining of the tunnel. Modifications to the tunnel entrance and scour protection downstream.



SECTION A-A THROUGH CULVERT AND STILLING BASIN

SCALE 1:50



ELEVATION ON CULVERT INLET

SCALE 1:50

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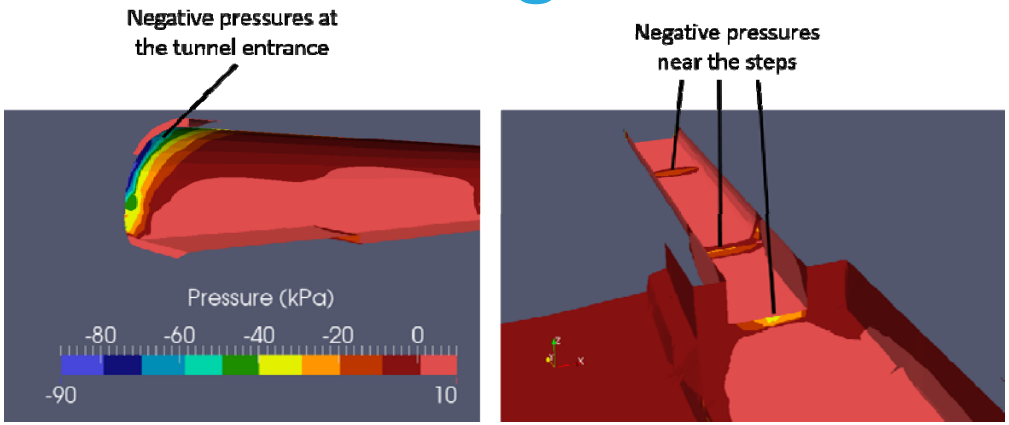
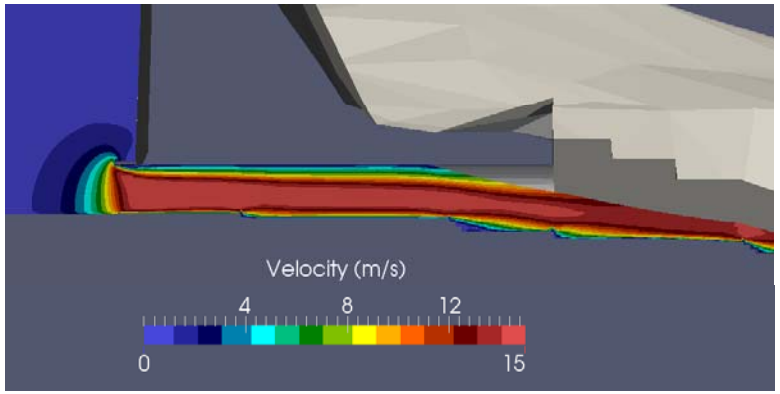
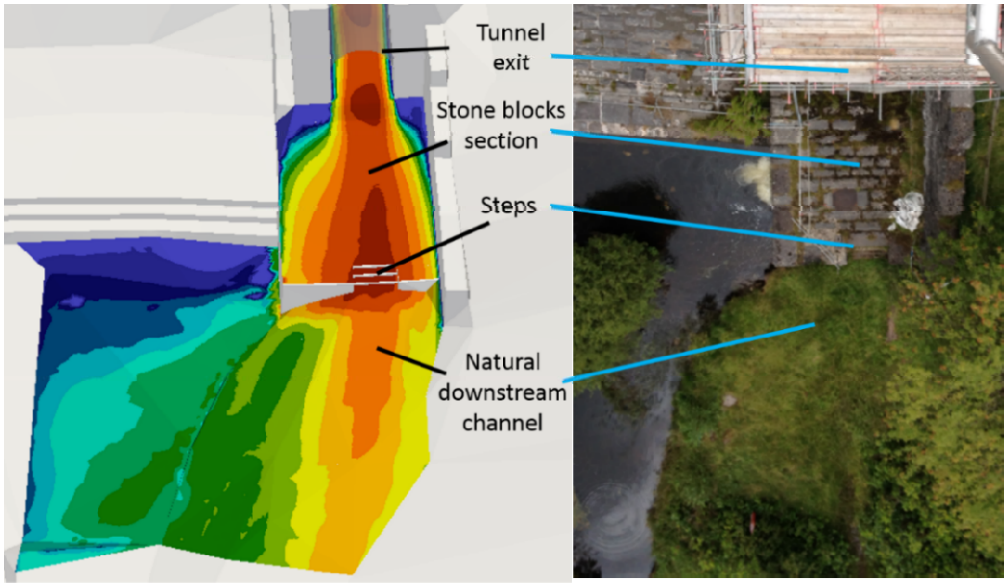
Flood routing and CFD modelling

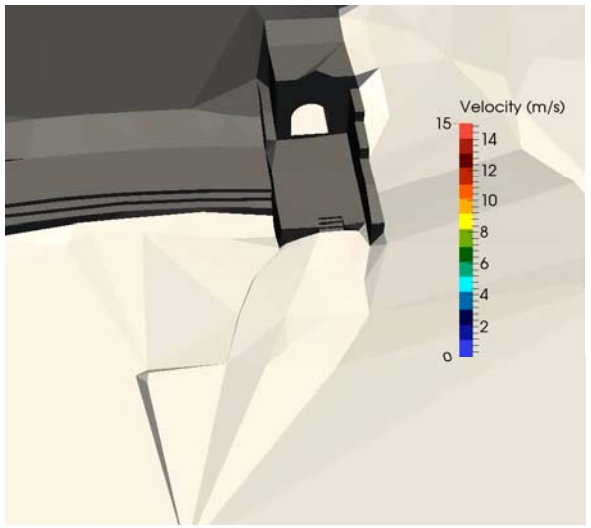


Negative pressure zones



Flow velocity through outlet culvert





Variation of maximum flow velocity at outlet and above channel bed

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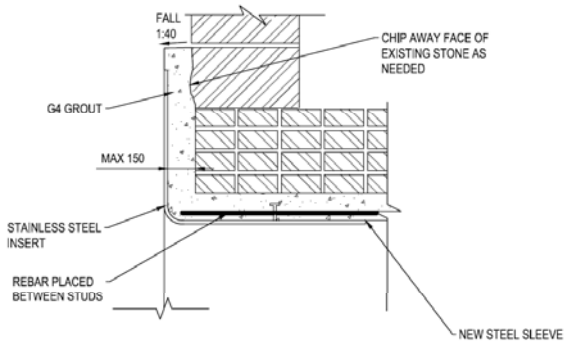
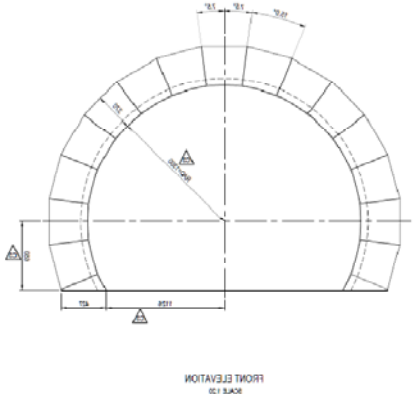
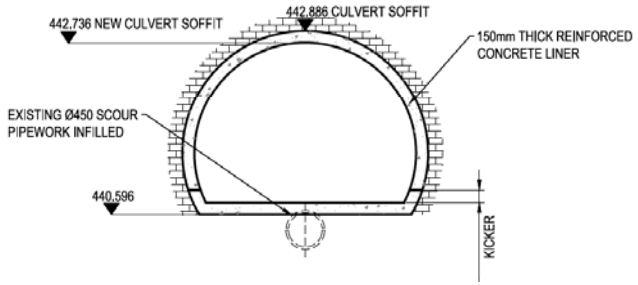
Detailed design – negative pressures

- Concern over negative pressures at tunnel entrance and existing steps
- Concern over the ability of the existing masonry lining to resist suction pressures
- Mitigated through provision of new 150mm thick reinforced concrete liner
- Concrete liner designed to act integrally with a new stainless steel insert at tunnel entrance to overlap existing bands of masonry



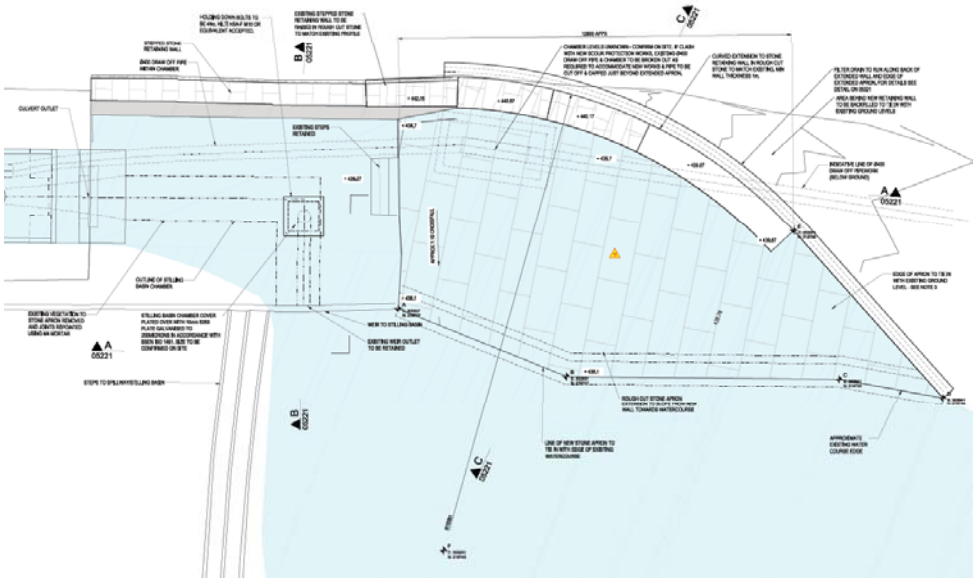




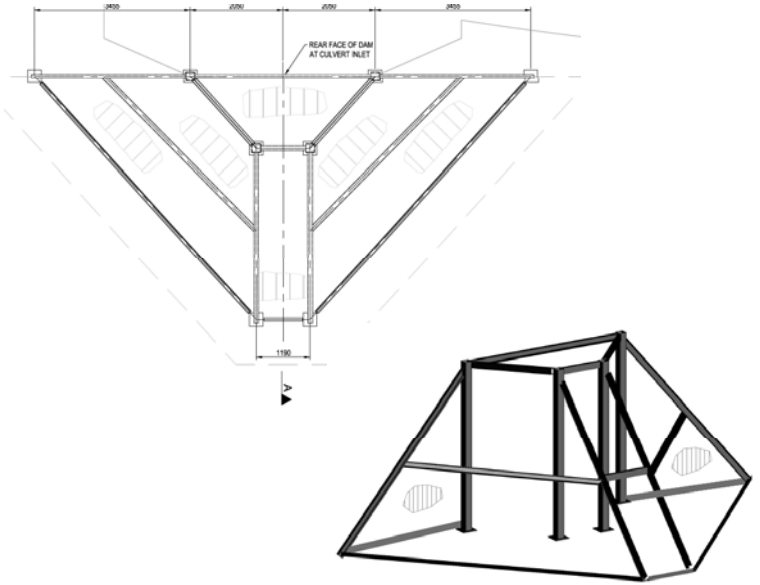
Stainless steel insert and concrete lining

Detailed design – risk of blockage and scour

- Risk of blockage in outlet tunnel mitigated through provision of an inlet screen
- Pull out load tests undertaken on existing stone apron at outlet tunnel to confirm ability to resist suction pressures
- Risk of scour to downstream berms & river channel mitigated through provision of new stone apron and deflector wall to direct flows into the existing stilling basin
- New stone apron and defector wall stone clad to match existing in accordance with Listed Building Consent requirements



New scour apron and deflector wall



Inlet screen

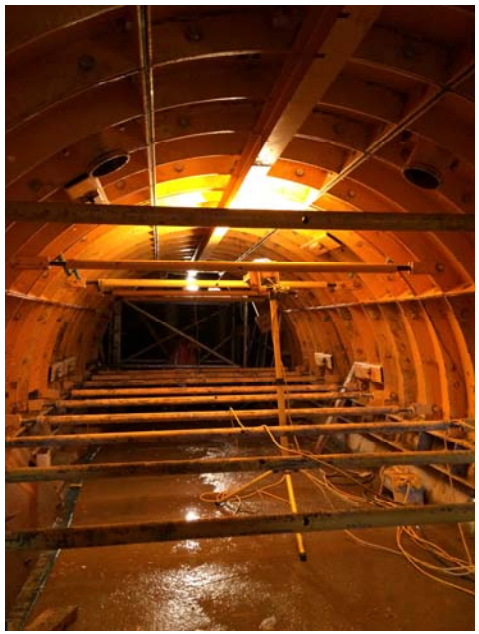
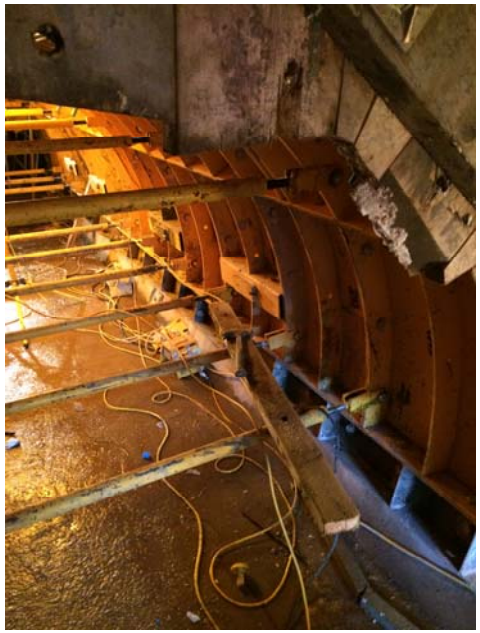
Construction

- Principal Contractor – Skanska; Main works package awarded to Joseph Gallagher Ltd (JGL)
- Main construction considerations:
  - Construction of concrete lining – compaction
  - Removal of existing masonry plug
  - Management of flows to complete works on upstream face of dam - drawdown
  - Unknown quantity of silt against upstream face of dam and suitable formation for inlet screen

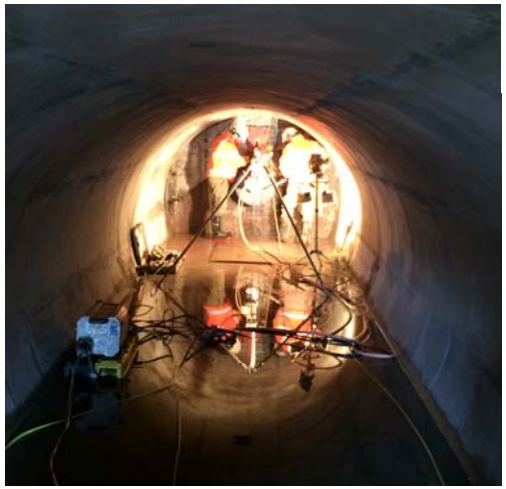
Reservoir basin – silt

Masonry plug

Construction




Management of the asset and its future

- Upper Neuadd previously supplied water to the Neuadd water treatment works in Pontsticill.
- More recently used in cascade with Lower Neuadd and Pontsticill reservoirs to supply Pontsticill water treatment works.
- Full reinstatement to original top water level was not progressed following review of the catchment yield, present and future demands and costs.
- Recent work undertaken to meet the requirements of the last statutory inspection, which required the dam to be safe under PMF loading.
- Calculations based on site investigations proved that the dam is safe under resultant water levels in a PMF event.
- Supervision of the reservoir is continued under the Act until a long-term solution is implemented.

Outlet culvert in operation

Dŵr Cymru Welsh Water

ARUP

Session Chairman: Jon Green
Technical Reporter: Bryn Philpott

Ageing Service Reservoirs – an increasing burden or scope for innovation (Hope, p427 of the Proceedings)

Question: Chris Peck (Independent Consultant)
You posed the question why is it necessary to backfill with soil around the side walls of service reservoir structure? For some sites this may be possible, but for others it may lead to problems in obtaining planning permission. This was the case on a reservoir I designed several years back in North West London at Dollis Hill. There we had to surround the concrete structure with grass covered sloping soil banks, but wall drains were also installed to minimise any ingress of rainwater falling on the slopes.

Response: Ian Hope (Severn Trent Water)
I'd like to challenge that approach. When you consider the initial short term economies of project promotion it may be regarded that this is a cheaper and easier option but I really think we need to be far more robust at the planning stage. There could have been more options that you could have pursued, perhaps using gabion blocks away from the reservoir wall to retain surplus soil. The challenge we are confronted with, on older reservoirs when we conduct internal inspections, following reported bacteriological ingress, where there is backfill to the external walls, it is often very challenging to determine where ingress is coming from. If you have got an elevated groundwater table outside of the reservoir it is clearly compounding our problems and increasing risk. As water companies we are driven towards TOTEX i.e. the whole life costings of our solutions. I believe that we should exert more challenge and robustness up front to save us from future problems.

Question: Tim Blower (Mott MacDonald)
Are there security implications to leaving service reservoir walls exposed?

Response: Ian Hope (Severn Trent Water)
First and foremost, security of all of our infrastructure is a key issue. We are advised on security by CPNI, through DEFRA on standards we should work to. We have a very comprehensive programme of investment through the SEMD programme. That programme involves risk assessment of every structure that provides public water supply and a comprehensive assessment is made of every element of the security of the site. For a service reservoir, for instance, it will start at the site boundary, standards of fencing and access points around the perimeter.

Water space access covers have to be to a specified standard. An interesting issue for us as engineers is the need for ventilation of the structure to deal with diurnal evacuation of water; this can conflict with the need to secure the structure, where the aim is to seal these as far as possible.

To summarise, all the infrastructure we use is designed with security parameters in mind. Having said that we should as owners always be vigilant on the site itself as to points of ingress into the structure but also of degradation of the asset. The integrity of all of our reservoirs is comprehensively approached in terms of security.

Question: Drummond Modley (Wessex Water)
A question concerning workmanship and durability of new service reservoirs. After constructing about twelve large service reservoirs across the West Country in the last two years for our new supply grid, we have chosen to build everything using *in situ* wall construction, with precast roof and columns. I note that Severn Trent have used precast wall segments for quite large reservoirs and wondered what you saw as the asset life of the structures as a result of using that construction technique.

Response: Ian Hope, (Severn Trent Water)
I totally agree with your point about the robustness of approach with regards to adopting the *in situ* wall solution. The new reservoir at Ambergate is in fact constructed using *in situ* walls and precast column and roof units where applicable. The photos shown in the presentation were for a reservoir at Grafham Water, which was an Anglian Water project. Severn Trent has a programme to replace a further six reservoirs; on two of these we are considering using precast wall construction. We have challenged the designers in terms of quality of approach - in particular I am concerned over the hydrophilic strip to establish a watertight seal. The two issues there are first of all the life of the joint material, that I have been assured is in excess of 80 years; the other is whether fluctuations in water level would allow the hydrophilic strip to dry out and potentially permit ingress in from outside. I have also challenged the need to backfill against reservoir walls to ensure that we get to a workable solution to prevent ingress into the reservoir. In terms of an overall asset life from the economic view point, we would be looking at 60 years but would hope for longer.

Comment: Drummond Modley (Wessex Water)
We would use 60 years for *in situ* construction but it is quite a challenge. If you use precast construction you can save up to 50% of the time on site which represents big savings on prelims and overheads etc. and therefore improve the margin of profitability for the contractors and undertakers. However as asset owners this is only any good if you actually achieve a 60 years asset life using such methods.

Response: Ian Hope (Severn Trent Water)
If I could just add one further point: that of the use of fibre optics i.e. the wrapping of the structure at critical points with fibre optic cables. This provides the potential opportunity to highlight the location of any ingress and be able to deal with it promptly.

Question: Stewart Tennant (GHD)
What ideas does Ian have to resolve the issue of the lack of construction supervision and self-certification?

Response: Ian Hope (Severn Trent Water)
I agree that it is a challenge. First and foremost we are in the process of renewing our contract for service reservoir refurbishment. We are looking to work with two suppliers who have been notified that there will be periodic checks by an independent engineer and that they should accommodate that within their remedial works process. In addition, my team have been trained up to inspect these specialist structures. They now have the skills to check for issues such as poor over-banding and we have also bought a Schmidt hammer so as to get a better understanding of the condition of the assets. The larger question involves our Asset Creation department, who let a huge amounts of work and I am addressing this through the internal audit route. In addition my team do get involved in an informal manner when they visit our reservoir sites where they undertake some checks during the construction process. I do think this is an emerging issue and one that we need to confront as an industry.

Butterley Spillway Improvement Works (Woods & Morrison, p347 of the Proceedings)

Question: Jim Claydon (Independent Consultant)
I congratulate those involved with the Butterley scheme on managing to get the scheme to site. The detailing is very good and I have been a supporter of the scheme locally.

There were other events causing damage to the invert, I am aware of at least two repairs before 2002. I am convinced that the spillway was inadequate hydraulically and defective structurally.

I was responsible for the new two span footbridge over the spillway which was done before the structure was listed in 1986. Perhaps that was fortunate as you might have been faced with a listed twelve span bridge on the line of the weir.

Please can you clarify the inconsistency between the 2015 guide to the Reservoirs Act, which states: 'Where planning permission or listed building consent is required…….such permission or consent must be given.' Whereas in the paper it states: '…..It appeared that Planning (Listed and Conservation Areas) Act 1990 was overruling the Reservoirs Act 1975. What is the latest situation?

Response: Rebecca Woods (Mott MacDonald Bentley)
One doesn't really outweigh the other in terms of planning and indeed listed building consent, which makes it slightly more complicated. The only real option we felt we had as a wider team was to keep pursuing the planning permission. We put forward improvements as best we could so we could come to an agreement. I wonder whether Andy Hughes would like to chip in from his experiences, but from my knowledge we had to get planning permission – it is as simple as that.

Comment: Andy Hughes (Atkins)
Thanks Jim for the question. I'll tell you more of this conflict in legislation in the context of the Hampstead Heath scheme when I talk in October in the civils. Lord Justice Lang has clarified the situation for us, but that's a heavy card to play. For local authorities whether it be the City of London or Yorkshire Water they sit in an environment where they have local stake holders and they have to take those people with them. Part of that process is listed building consent or planning permission issues, this is a National Park. It might be for badgers, bees and trees and all the other elements that conflict and can get in the way of doing the work. So I think any large organisation will always try and mitigate those concerns. At Hampstead Heath there was a very protracted and expensive process of consultation and one which led it to be challenged. A judicial review was called which has clarified the situation.

Butterley was itself a long and protracted exercise and the planning application itself went to open forum. I was six hours in a witness box trying to promote that scheme and it was taken to appeal through legal challenge and that cost Yorkshire Water a lot of time and money all within the legal framework of the timescales that is always ticking away with matters 'in the interests of safety'. So in essence there is always now, it appears through Lord Justice Lang's ruling that we could play the heavy card and say no matter what conflicting legislation exists, reservoir safety will predominate. However a company who has stakeholders and has to work and live and maintain its reputation within its own working environment will always have to consider those other things and go along with them as far as possible. The lesson is its going to cost you time and money.

Question: Paul Monaghan (City of London)
Designers and owners should not consider legislation as 'conflicting' or 'hierarchical', but complementary and good design should prevail for all elements. This seems to have been achieved at Butterley but I wonder how well informed the planning authority was with regards to reservoir safety requirements.

Response: Rebecca Woods (Mott MacDonald Bentley)
With regards to education, the conservation planner that I have been dealing with, who has been on the project throughout, was very helpful. He was very aware of where we started and what we were trying to get to as reservoir engineers and that the work is essential. Unfortunately his hands were rather tied and as a conservation officer he was required to give certain aspects equal weighting. Education was not a problem he was always very pragmatic and understood what we were trying to achieve. Perhaps Andy would like to respond?

Comment: Andy Hughes (Atkins)
Taking Paul's issue, the word 'conflict' I am using in a soft context in as much as these other elements of legislation, which I accept are complementary, all exist at the same time. These actually can stop us doing things so cause us severe problems. I don't believe that the design would have been any different as a result of looking at those potential conflicts. We came up with the scheme which was the best solution for the job. The objectors who oppose the scheme end up with very fixed ideas they will simply dig their heels in and say that this scheme should not progress. They disregard the consequences to the people downstream, and the evidence that is put before them and have very entrenched views that one then has to try and change and that often means recourse to law or a planning enquiry.

That is a question of education i.e. in terms of showing them what the consequences of not doing the work is, and we as engineers are duty bound to find the best solution. Some other elements of legislation mean we have to clad reinforce concrete and we have had lots of problems in the last few months with this where masonry has become detached and this was born in mind at Butterley. I think we have to look at this in the whole, there are aspects of legislation you feel you could reason with quite happily and you could get an engineered solution out of it. There others that stop what we are trying to do and in those cases other people have to mediate.

Design and Construction of Mitford Flood Storage Reservoir (Penman *et al,* p413 of the Proceedings)

Question: Peter Down (Mott MacDonald)
It is noted that there are trash screens upstream of the outlet controls at both Upper Mitford FSR and Upper Neuadd reservoir. These can give rise to problems and risk of blockage as water levels rise and fall and raises issues as to how they are cleaned. These were seen to have been realised at Mitford.

The presentation indicated access for clearance could only be gained from within the reservoir. Was any consideration given during design as regards clearance from above?

Response: James Penman (Mott MacDonald formerly of CH2M)
At Mitford the intent was such that all the small debris would go through and there would not be a blockage on the screens. Now as you saw on the photo we did get some but it did not prevent the reservoir from drawing down. There was not a problem cleaning it afterwards as access could be made from the river bed upstream of the screens and a telehandler was able to come in and remove the blockage.

The tops of the culverts were approximately seven metres below the crest of the dam and so to provide any means of clearance from above, when the reservoir was full, would have been a major increase in the complexity and it was not something we felt was merited.

Question: Alan Warren (Mott MacDonald)
I just would like to say that there is a new guide for the design, operation and maintenance of Flood storage reservoirs which should be published before the end of the year and will be presented to the BDS early next year. My question is for James, relating to the spillway at Mitford.

I note you have opted to put some sacrificial fill over the revetment to make it nice and green. There has been at least one incident in recent years where a moderate flood caused sacrificial fill to be washed downstream and concerned residents clearly thought the dam was about to fail. This caused a certain amount consternation even though it did not affect reservoir safety. I wonder whether that was thought through, i.e. the risks of losing the fill and the aspects of siltation downstream.

Response: James Penman (Mott MacDonald formerly of CH2M)
The simple answer is that it was considered with the Environment Agency to be acceptable. It is something that would happen in the extreme event i.e. greater than the 1 in 137 year flood - probably even greater than that before it starts to erode.

Question: John Ackers (Black and Veatch Ltd)
The issue of sacrificial topsoil and seed arose when we designed the enlargement of Bruton flood storage reservoir (Somerset), which included the installation of a wedge-block emergency spillway. Some of the internal consultees within the Environment Agency, which was the client, were particularly concerned about what they saw as the stark appearance of the precast blocks in the new spillway, looking for either a "softer" solution (which was not practicable at the head and velocities involved) or some means of disguising the blocks.

However, when we approached the planning authority to discuss the issue, they had no objection to the exposed precast blocks, considering the functional appearance to be entirely appropriate. If you look carefully when travelling on the Reading to Taunton railway line, you may see the FSR on the south side of the line just east of Bruton station.

Response: James Penman (Mott MacDonald formerly of CH2M)
I totally agree you on that and with Alan Warren regarding the material that could be washed off. The trouble in this case was that to secure the land, the EA had to satisfy of one of the key stakeholders who required that the downstream face was grassed in order to enhance its appearance.

Asset or liability: stabilising an historic dam (Cooper *et al,* p445 of the Proceedings)

Question: Peter D. Down (Mott MacDonald)
The presentation for Upper Neuadd did not indicate how the screens were to be accessed and cleaned. What arrangements have been provided?

Response: Nathan Walding (Welsh Water)
At Upper Neuadd the trash screens were designed in accordance with Environment Agency guidance and looking at the characteristics of the reservoir basin, which is not heavily vegetated at all, there were a few trees further up the catchment which could potentially wash down. We have gone for very wide spacing screens. We did consider trying to pull trees off from the top of dam but we had to get down there during construction so we built a haul road into the basin. There is a percentage blinding allowance on the screens so when the flood subsides then we can get into the basin with a small JOB and pull the material off, which was the intention.

Question: John Ackers (Black and Veatch Ltd)
Firstly, I was the inspecting engineer who made the Section 10(6) measures that were addressed by the works described in the paper, so I was pleased to learn that my recommendations were not too prescriptive to prevent the adoption of the solution described, which was not one of the options that I had in mind at the time.

Secondly, I wonder whether the residual storage capacity (below the invert level of the tunnel entrance) is now below the threshold for the Reservoirs Act 1975 to apply. If it is below the threshold, why has the reservoir not been discontinued or even abandoned, as the wording of the Act for the latter is that "the reservoir is incapable of filling accidentally or naturally…or is only capable of doing so to an extent that does not constitute a risk".

Response: Mark Cooper (Arup)
The reservoir has not been discontinued or abandoned**.** Welsh Water plans to continue with their current monitoring regime and inspections, with a view to the potential for stabilising and re-impounding the dam in the longer-term, so discontinuance or abandonment does not really impact in that way.

Response: Nathan Walding (Welsh Water)
In a PMF event it will impound greater than 10,000m³. The level it could rise to is 4.3m below the overflow level in the PMF and the dam is still stable. Welsh Water did not want to go down the abandonment route in case they wanted to return it to service in future so the works were designed to be easily reversible. It would simply be a matter of plugging the culvert.

Response: Peter Kelham (Arup)
John is perfectly right in his question. I have had numerous discussions with Welsh Water and the regulator NRW on this. Effectively there is no storage now, it is down more or less at original stream level so it could be abandoned, but it would still need the same level of supervision and inspection. Therefore the status of the reservoir makes little difference really, and although I have been pondering this with the owner and Enforcement Authority there is no clear consensus.