Response to planning consultation 23/4152M re The Dam Embankment of Poynton Pool, Poynton Park, London Road North, Poynton.

1. Background

1.1 The Town Council would refer the Case Officer and Strategic Planning Board (SPB) to our previous submission in response to this application uploaded on the 9th January 2024.

This submission deals with the reasons for deferral at the SPB and comments on the Planning Officer's report to the SPB which was not available at the time of Poynton Town Council's initial consultation response.

1.2 At a meeting on Wednesday 24th April 2025 the SPB resolved to defer planning application 23/4152M for the following reasons:

- *"To consider and update where necessary any inaccuracies in the submitted data to ensure modelling is accurate;*
- *To review the current condition and risks associated with the existing dam wall, and the impact caused by the removal of trees on the dam;*
- *Encourage engagement with third parties to consider/explain alternatives*
- *To instigate a further independent view, if necessary;*
- *To review the location of the proposed mitigation and consideration of any alternatives"*

1.3 At the request of the Local Planning Authority the Town Council was asked and provided a list of inaccuracies and omissions which we believed were important factors when determining the planning application

1.4 Below are the Town Council's remaining concerns relating to the current planning application. They have been set out in line with the reasons to defer the planning application as set out by the SPB.

2. To consider and update where necessary any inaccuracies in the submitted data to ensure modelling is accurate

2.1 Volume and depth of water

Following the SPB deferral the Environment Agency undertook a bathymetric and topographical survey of Poynton Pool.

The survey found that the volume of water was significantly reduced from 130,000m^3 to 75,600m^3 at Low Water Level and that at the dam's crest from the volume was reduced from 175,800m^3 to 96,680m^3.

Furthermore 40% of the volume of the pool is known to be silt. Paragraph 6.4 of the bathymetric survey clearly indicates that silt at the southern sector of the pool would not be expected to escape in a catastrophic breach scenario and that the aquatic vegetation would also make silt less liable to being scoured.

In response to the Town Council's submitted list of inaccurate data, the Applicant stated in relation to the volume of water *"If there is a very significant change, we will review the reservoir flood risk"* and *"… for the purposes of clarification, if there is a very significant change to reservoir volume, we will review the reservoir flood risk in a "wet day" scenario."*

This has not been done. The Town Council would argue that a reduction of 41.8% reduction in the volume of water (at Top Water Level) and a reduction of 45% volume of water at the dam's crest is significant. When taking into account the comments in relation to the silt it is now evident that the volume of water and silt that would escape from the pool as a consequence of a dam breach is significantly less than what was originally modelled.

We understand from the recent Section 10 report that *"… the most destructive phase of the breach is the initial flood wave that is more reliant on the depth of the reservoir as opposed to the volume"*. From the Bathymetric Survey we now know that the depth of the reservoir is a maximum of 2.8m (restricted to a very limited area that we assume to be the channel of the original watercourse) and a maximum of 1m in the southern section. The average depth of the pool is therefore just over 1.15m not the 2m depth that the flood maps have presumably used.

The Environment Agency flood inundation maps which have been used by the Applicant to calculate the consequences of a dam breach are based on inaccurate data not just in relation to volume but depth as well.

The bathymetric survey has provided the Applicant with accurate data relating to the Pool. The Environment Agency have spent a significant amount of taxpayers' money undertaking the survey which shows that the reservoir is considerably smaller and shallower than originally thought. Why then have Cheshire East Council not used the survey findings to review the modelling as they had undertaken to do?

The Applicant's Technical Memorandum dated the 20th March 2025 confirms that the difference in Peak Flow Breach resulting from the updated volume and depth of the reservoir is 19%.

	Parameter		Environment Agency FMSS	Binnies 2024 Table 6.21	Difference
			wet day		
			North dam		
1	dam crest level;	mAOD		91	
2	Top Water Level (twin weirs)	mAOD		90.66	
3	Lowest internal hard bed level (base of silt)	mAOD		87.84	
4	Lowest external ground level	mAOD		87.4	
5	Freeboard	m		0.34	
6	Water depth at breach	m	3.07	3.16	
7	surface areas			62,000	
8	Total volume of water at TWL	m3	130,000	75,600	
9	Total volume of water at dams crest		175,800	96,680	
Reservoir flood					
	Peak Breach discharge	m3/s	106	86	19%
Impact on people					
	maximum population at risk		3,549		
	likely loss of life		1.97		
	Property damage		79M		

The above table is set out in the technical memorandum and although the updated calculation is used it does not go on to show what difference this will make on the impact of a dam breach on people.

The Town Council would urge that the original RARS Tier 2 screening breach and consequence should be rerun. Section 4 of the original options report dealing with the consequences and existing risk of failure should be updated based on the accurate information that is now available.

2.2 <u>Catchment</u>

It is noted in the response to both the Town Council and Friends of Poynton Pool that the Applicant has stated in relation to the impact of disused coal mines on the catchment that *“In order to provide a fuller response evidence of where underground flow paths systems, relevant to extreme floods should be provided”*. This information has already been provided to the applicant. At a meeting on the 26th July 2023, information from a report from a previous planning application for open cast mining was shared with the Applicant which clearly states the extent to which much of the water from the catchment area drains away from Poynton Pool and into Norbury Brook. A copy of the extract of report can be found in Appendix A.

The information on coal mining is also readily available and even referenced in the Section 10 report. The extensive coal mining could account for the significant discrepancies. The model of the catchment which suggests that the dam will overtop in a 5% AEP when we have experience of such events and there has been no overtopping.

2.3 Risk of overtopping

Throughout the reports lodged in support of the planning application, various figures have been provided for overtopping. Section 1.1 of the Planning Statement states that the dam risks of overflow in flood event in excess of 1 in 50 chance per year.

However, paragraph 4.3.3 the same report states 2 *"As a result of the proposed development, the reservoir will be expected to overflow the western dam during the 0.1% AEP compared to the 5% AEP under the current scenario."* 5% AEP is a 1 in 20 chance per year. This is echoed by the other documents lodged with the planning application, including the Summary Options Report and Flood Risk Assessment.

The Poynton FRA Model Report references the Flood Study and states *"the assessment indicated that the existing historic reservoir does not satisfy the current safety design requirements, with the existing weir crest expected to experience significant overtopping from the 3.33% (AEP 1:30) year event"*. However, these figures do not accord with table 6.4 from the Flood Study 2019.

The Flood Study 2025 states "the 2% AEP (50 year) event has modelled still water that is just **24mm below** (our emphasis) the lowest point on the dam crest…overflow events of greater magnitude will cause overtopping of the dam." We can find no reference in the published Flood Study Report October 2023 to the dam having significant overtopping from a 3.33% (AEP 1:30) year event. It should also be noted that the baseline figures shown in table 5.1 of the Poynton FRA Model Report vary from the original figures provided in the study, no explanation has been given regarding the variance.

The Flood Study 13th October 2019 does quantify overtopping except in the 1 in 1,000 and 1 in 10,000 events.

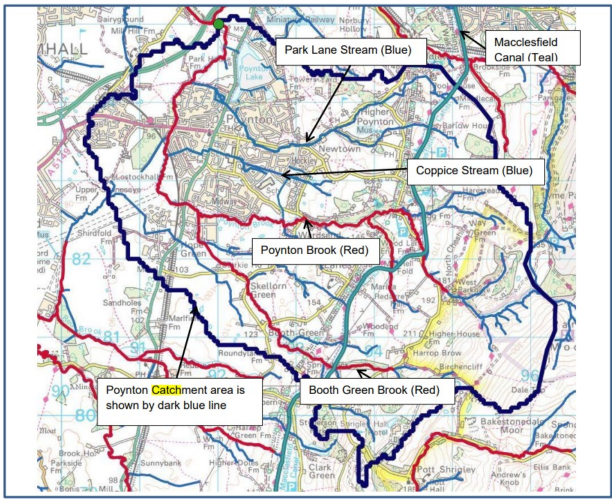
Historically there is no evidence showing that Poynton Pool has flooded in its 270+ year existence even during known local flood events (further information can be provided on the magnitude of these events and where flooding occurred in neighbouring areas if required by the Planning Authority). This is despite numerous floods of greater magnitude of 1 in 50 years.

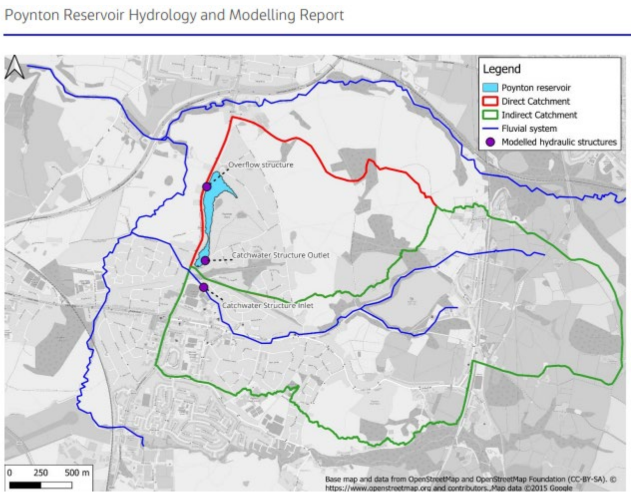
The applicant has not provided a substantive response only stating that previous flooding events were in a different catchment. They were not. The section 19 report[1] on Flooding in Poynton in 2019 identifies the Poynton Brook catchment (Figure 12) which clearly includes the pool and its entire direct and indirect catchment (see comparison with catchment taken

[1] For link to Section 19 report on 2019 flooding, see: https://www.cheshireeast.gov.uk/planning/flooding/floods-and-flood-risk/flood-investigations.aspx

from the October 2025 Hydrology and Modelling Report). No explanation has been provided as to the discrepancies in the various reports and why the model appears to be so at odds with the observed reality (see Town Council's first response to the planning application for further details on historical flooding).

Figure 12 Indicative hydrological catchment of Poynton Brook





2.4 Risk of dam failing

At the meeting on 24th April 2025, a member of the Strategic Planning Board asked the applicant to quantify the risk of the dam failing.

Likelihood of dam failure – This is not set out in any of the documents submitted. Information should be provided as to the current likelihood of the dam failing and what the reduction in that risk would be once the works are completed.

The Executive Summary of the Summary Options Report states that *"improvements are therefore needed to the dam to reduce the likelihood of it failing in an extreme weather event"* but this is not quantified within the documentation.

Impact of dam failure – The Summary Options Report states that *"in the event of failure of the dam and release of the reservoir around 3,500 people would be present in the area at risk of injury and death…and on average around two people would be killed"*.

However, this statement fails to make it clear that these figures are for dam failure on a wet day event. Jacobs' initial options report BRJ10627 – J470-DOC-001/004 notes that the *"the other important factor in evaluation of the potential impact of dam failure on a wet (relevant to spillway capacity) is the flood would be happening anyway even with no dam failure"*. It should be noted that the report in table 4.4 from the Initial Options Report (see below) shows that the failure of the dam alone (dry day) would result in an estimated 274 people in the population being impacted and likely loss of life is 0.12.

For the purposes of the economics ALARP assessment, the base case likely incremental loss of life provided by the Environment Agency, is adopted as 1.04. In practice in the event of dam failure the public downstream are likely to assign the overall impact of 1.97 lives as being the responsibility of the Undertaker. (Cheshire East council)

Table 4.4 Screening estimate of risk to life (wet day)

Source	Scenario	Number of houses at risk (Note 1)	Maximum/ Time averaged population at risk	Likely loss of life		Property damage £M	Source comment
				No warning	with warning		
Environment Agency 2016 dambreak	Dry day		274/ 184	0.12		6	
	Wet day		3538/ 2246	1.97		79	
	Incremental wet day		2031/ 1306	1.04		45	

The text included in the table confirms that the Environment Agency do not use the figure of an average of two people being killed which has been quoted widely through the lodged planning documents. The impact of dam failure is therefore inaccurate and should be amended.

3. To review the current condition and risks associated with the existing dam wall, and the impact caused by the removal of trees on the dam;

3.1 Ground Investigation

Following the Strategic Planning Board meeting the Town Council and Friends of Poynton Pool highlighted that there were a number of deficiencies in the knowledge around the existing dam wall. The need for investigation of the level of the geotechnical properties was initially raised in the original Flood Study Report (D01 C01) states "*The level of the embankment clay core is unknown. It is recommended that this should be established along with other geotechnical properties of the embankment, in order to quantify the risk of seepage through the dam*".

This was reiterated in Jacobs 2021 Initial Options Report which advised *"Once the preferred option has been chosen by CEC then the requirements for ground investigation can be carried out."*

In an email on the 11th November 2024, following a site inspection, the Applicant stated: *"The proposed GI works are still at the initial stages of the feasibility and investigating the options, ahead of finalising a full specification, as well* ***as understanding the timescales for undertaking this work****. It is understood that the current proposals under development, includes for standpipe piezometers with data loggers and online access, in line with your expectations."*

And *"This will also assist and inform the planned collaborative discussions to be arranged by the LPA in due course."*

However, as yet the ground investigation works have still not been undertaken. Six years have passed since the initial recommendation for site investigation.

As an absolute minimum, the structure of the dam should be established by site investigations. The Town Council is extremely concerned that to carry out any work without understanding the structure of the embankment could result in an increase rather than reduction in risk.

The level of clay in the dam and the geotechnical properties of the embankment is a key factor in assessing potential modes of failure for the dam. This is particularly important when the method of constructing the dam is unknown. No plans have survived from the original construction. We also note that calculations relating to the peak breach flows are very uncertain particularly when the erodibility of the dam is not known. In a meeting on the 26th February 2025, David Neave (the Inspecting Engineer) in response to an enquiry as to whether the make-up of the embankment was critical stated that it was for overtopping as an embankment will fail much more quickly if its' make-up is sand/gravel than a clay material.

It is notable that in the Planning Officer's report to the earlier SPB he stated that:

"The minimum requirement for regulating the crest to meet the Reservoirs Act 1975 are that it will:

- *Spread out overflow uniformly along the length of the crest and therefore be able to tolerate a larger overflow before a breach occurs*

- *Have the crest kerb in intimate contact with the clay embankment to prevent flow going under the kerb and removal of roots under the kerb which would provide a flowpath."*

As the level of clay in the embankment is unknown the latter might not be achievable.

<u>3.2 Removal of trees</u>

The Jacobs Arboricultural Assessment (AIA) identifies 86 individual trees, and 12 groups of trees present on the embankment. The AIA Technical Addendum states that 78 trees will be removed (32 individually classified trees and 47 trees removed as a group of trees) and that further trees whilst retained could be "pushed into a terminal decline". It should be noted that Friends of Poynton Pool dispute these figures and believe that over 200 trees will be removed as a consequence of the planning application.

Irrespective of the precise number, the planning application, this view seems to be supported by the recent section 12 inspection, which states

As part of the proposed works, the 400m section of over-topable embankment is to have most trees along its upstream face removed. It is advised that reeds be allowed to establish along this section to provide protection to the face of the dam.

will result in a significant loss of trees and at least an 80m stretch of the embankment where all trees have been removed.

The issue of root decay and potential seepage and internal erosion of the embankment has been repeatedly dismissed by the Applicant despite the overwhelming body of publications and reports that highlight the risk from removal of trees on earth embankment dams inter alia;

1. Poynton Pool Section 10 Report - David Neeve Arup
2. Chapter 8, Geotechnical Engineering of Dams 2nd Edition - Fell et Al
3. FEMA (2005b) Technical Manual for Dam Owners, Impacts of Plants on Earthen Dams
4. Trees of dams: Life Cycle Management - Dams and Reservoirs Vol.26 Issue 3
5. Vegetation and Embankment Dams - Hoskins and Rice -Water Resources and Reservoir Engineering 1992
6. https://www.gov.uk/guidance/reservoirs-how-to-manage-your-large-raised-reservoir (Diagram 6)

The Inspecting Engineer in his recent s10 report stated, *"Care is required when removing large trees from embankment dams as the increase in moisture content may cause instability of the embankment and may create leakage paths as the root system decays"*.

The planning statement in support of this application asserts that *"The existing trees along the dam embankment also pose dam resilience safety concerns, as tree roots can damage the embankment dam structure retaining the reservoir and increases the likelihood of structural failure of the dam, which therefore increase the risk of flooding downstream due to dam failure"*.

In correspondence between Friends of Poynton Pool and the Editor of 'Dams and Reservoirs' at the British Dam Society it was stated by the Editor "*The Reservoirs Act 1975, including clauses modified or added by the Flood and Water Management Act 2010, makes no mention of grass or trees, or indeed any other physical condition of a dam.*

It puts the onus for safety on a qualified civil engineer (the Inspecting Engineer) to identify any aspects that could put the dam or reservoir at risk. The Inspecting Engineer must then issue a report in which 'Matters in the Interests of Safety' are stated, which the undertaker (responsible for the safety of the reservoir) is then legally required to carry out.

The publication by the Institution of Civil Engineers that I believe you are referring to is Floods and Reservoir Safety – 4th Edition. Note that this is not a legal document – it simply gives guidance to reservoir engineers.

This document does indicate that trees on the downstream face of dam can cause changes in the flow pattern if the dam overtops, causing turbulence and erosion, but that is simply a reminder to reservoir engineers to consider the potential effects It certainly does not say that trees must be removed or that the only growth accepted is grass.

The many dams with trees growing on their embankments are typically at privately-owned reservoirs on estates, and I am not at liberty to release the names of these. However, during my 30 years as a Supervising Engineer I was appointed to a number of these, all of which were subject to Inspecting Engineers' reports at least once every ten years. As these were often by different Inspecting Engineers from year-to-year quite a number of engineers saw these trees, but not one of them felt that – on these particular dams – they posed a risk to the dam's safety."

Hoskins and Rice document the case study of Aldenham Reservoir in Hertfordshire, which has many similarities with Poynton Pool i.e. an earth embankment without clay core constructed in the eighteenth century to supply compensation water to the Grand Union Canal. In the early 1970s Reservoir Safety Works required the removal of all trees and undergrowth to upstream slope and crest raising to increase the freeboard. Slope instability and seepage occurred in 1975, 1982 and again in the late 1980s, requiring extension remedial works to stabilise the embankment. The authors conclude that the vegetation enhanced the embankment stability by reducing pore pressures and binding the superficial layers of the slope together (see report in Appendix B).

The FEMA guide is very clear on trees and advocates removal of all roots and reconstruction of the embankment following tree removal, if this were carried out at Poynton the pool would need to be drained down or a cofferdam installed whilst the embankment is rebuilt over the 2 number 40m lengths. This would significantly increase the cost of the proposed works of Jacobs' Option **4. Encourage engagement with third parties to consider/explain alternatives**

Following the deferral of the planning application by the SPB, the Town Council had hoped that there would be urgent and timely engagement and consultation with the Applicant, Town Council and Friends of Poynton Pool.

The Town Council contacted the Local Planning Authority early in May 2024 to set out what issues we thought the SPB wanted to address, and on the 14th of May 2024 we received an email from Debra Wrench stating that she would like to work with us collaboratively and advising us that the supervising engineer would be calling for a new S10 inspection. Progress was also made with a bathymetric survey being commissioned.

However, it was disappointing that the Applicant did not arrange a meeting with the Town Council or Friends of Poynton Pool until February 2025, 10 months after the planning application was deferred. Whilst the Town Council appreciates that arranging inspections and surveys can take time, we feel that an earlier meeting to discuss the alternative proposals would have been beneficial to all parties.

It is also disappointing that despite assurances that the ground investigation work was in hand in October 2024 only recently has the Applicant agreed to undertake investigations and the results will not be available until after the SPB meets.

5. To instigate a further independent view, if necessary

The Town Council would have liked to have seen David Neave appointed as the QCE on the project, which would have provided a degree of independence given that existing QCE works for Jacobs who proposed the initial scheme and designs.

6. To review the location of the proposed mitigation and consideration of any alternatives

No mitigation or alternatives have been suggested. The Town Council remains concerned that the CAVAT value of the trees is not being used to assess the cost of this scheme. The applicant has proposed mitigation at an offsite location with no public access at Walnut Tree Farm to compensate for the loss of trees within the woodland.

Policy ENV6 of the SADPD requires that where the loss of significant trees is unavoidable replacement planting of commensurate amenity value should be provided on site as part of a comprehensive landscape scheme, and where this is not practicable, contributions to off-site provision should be made, prioritised within the locality of the development.

The use of CAVAT is necessary in order to attach a monetary value to the trees as an asset and to compare with other capital costs of the development and assist with weighing up the planning balance. The Town Council has commissioned and submitted a monetary valuation of trees using the Helliwell, CAVAT and CTLA valuation systems, which found a mean value of £2,980,520.

However, given the reference to CAVAT in the Council's policy, it is worth specifically noting the CAVAT figure, which was very close to this mean figure at £3,081,070. CAVAT is used to help calculate necessary contributions towards off-site planting.

The CAVAT and BNG approaches are assessing different things using different metrics. BNG calculates biodiversity loss, and it is not exclusive to woodland, it can be applied to individual trees. CAVAT is calculated based on amenity and public benefit.

Method	**BNG**	**CAVAT**
Purpose	Measures ecological value and biodiversity impact	Measures amenity value and public benefit of trees
Attributes	Habitat quality, distinctiveness, and ecological function	Tree size, location, visibility, and public accessibility
Use in Planning at Cheshire East	Required under the Environment Act 2021 for most developments	Used to assess compensation or replacement value
Metric	Biodiversity units (based on habitat area, condition, etc.)	Monetary value (based on tree characteristics and context)

Method	BNG	CAVAT
Replacement/ compensation	Requires habitat creation/enhancement to achieve 10% net gain	May require financial compensation or planting of equivalent trees

7. Alternatives schemes assessment

7.1 Background

In his report to the Strategic Planning Board in April 2024, the case officer in summary stated that

"The proposal results in a significant loss of trees from the existing woodland which is prominent in views from London Road North and from within Poynton Park. The loss of these trees is significantly harmful to the amenity of local area and the non-designated heritage assets of Poynton Pool and Poynton Park. The replacement planting at Walnut Tree Farm over 2km away from the application site, and within Stockport Borough does little to mitigate for the amenity or historic value of the trees within Poynton. Whilst the new woodland planting would lead to a 10.27% net gain in biodiversity compared to the existing on-site habitat, there would still be significant harm to the LWS and localised harm to a number of species. It is also disappointing that mitigation is not provided for the slight increase in flood risk to the residential properties at 2-10 Anglesey Drive.

The volume and strength of local opposition to the proposals is acknowledged and completely understood. However, the identified harm is considered to be outweighed by the need for the proposal and the lack of any viable alternatives in this case."

At the centre of the Planning Officer's recommendation was that there were no viable alternatives to the current proposal.

Cheshire East Council has now confirmed that an alternative proposal does exist, and the Town Council and Friends of Poynton Pool would argue that the proposal is viable and proportionate.

The comparison table of existing options set out in the Supplement to Summary Options Report raises significant issues. When the original comparison table was included in the Initial Options Report it was caveated with *"The comparison is to some extent subjective, and selection of the preferred option has to be a client decision, based on various considerations and their relative weighting"*.

The table provides no descriptors to enable a weighted evaluation to be made. The key at the bottom of the table simply states Key (scale of 1 to 3): ✓ Beneficial, x Detrimental, - Neutral/No change

Setting aside cost which will be dealt with separately. Using a simple weighted evaluation of the CEC evaluation and based on the Planning Officer's Report, it becomes clear that a number of considerations have been incorrectly weighted in the Jacobs Option Summary

Key

X minimal alternation or harm	✓ minimal benefit or alteration
XX moderate alteration or harm	✓✓ moderate benefit or alteration
XXX major alteration or harm	✓✓✓ major benefit or alteration
No change	

7.2 Cheshire East preferred option

Onset of Flooding London Road North Currently ✓ should be no change - The report on the further investigation of Option 3c BRJ10627-J470-DOC-002 states "no change in risk of flooding London Road North"

Visual Impact Currently X but should be XX or XXX as the Planning Officer states, *"The associated removal of trees and the clearance of two 40m sections of woodland will, however, be unequivocally visually harmful from vantage points within and outside of the park."*

Heritage Currently X but should be XXX - *"The pool has a longstanding use as a valuable amenity for the local community. The opening up of two sections of the woodland to the main road leading into Poynton will have a significant impact upon the Pool and Park and their setting, by diluting the enclosed and intimate character along the western bank, which is considered to be harmful to these heritage assets identified in the PNP."*

Not all planning considerations have been included.

Landscape character – *"The landscape character of the area will be harmed by the proposed development, and as such the proposal is considered to be contrary to policies SE4 and SE2 of the CELPS, policies ENV3, and ENV5 of the SADPD, and policies EGB3 EGB7 and EGB8 of the PNP"*

Increased risk of flooding on Anglesey Drive – *"The proposed works are likely to increase these garden flood depths by up to 0.18m (0.14m existing flood depths compared to 0.32m proposed)".*

Loss of amenity – "*The loss of these trees is significantly harmful to the amenity of local area and the non-designated heritage assets of Poynton Pool and Poynton Park".*

	CEC preferred option Jacobs Assessed	CEC preferred option based on Planning Officer’s Comments /Applicants comments
CEC reputation flood risk management	✓	✓
Spillway capacity – dam failure	✓✓✓	✓✓✓
Onset of flooding London Road North	✓	✓ **(The report on the further investigation of Option 3c states**
Onset of damage of dam	✓✓	✓✓
Risk of future dam safety works	✓	✓
Fluvial Flood Risk	✓✓✓	
Heritage	**X**	**XX or XXX**
Visual Impact	**X**	**XXX**

7.3 Friends of Poynton Pool alternative scheme

Currently XXX but should be XX Friends of Poynton Pool would argue that their scheme is less impactful that removing the trees. The labyrinth weir will be buried in the embankment and submerged on the upstream face. Although the structure would be visible from London Road as a vertical wall 12m long and 1.5-2m above pavement level; it could be

clad with stone to minimise visual impact. The image below is of the spillway and wave wall at Tegg’s Nose Reservoir in Macclesfield Forest where a similar approach to cladding was used.

The Planning Case Officer is also referred to the successful scheme at Tredegar House in South Wales which is similar to Poynton Pool. The National Trust and Planning Authority adopted a scheme which did not involve the mass removal of trees and was sympathetic to the local landscape and the amenity value to the local community (see photograph below).

7.4 Costs

The costs provided by Cheshire East Council from the Independent Quantity Surveyors are currently disputed. The Town Council is not expert in this area but there did appear to be some discrepancies and omissions in the figures. We understand that Currie and Brown the Quantity Surveyors have been asked to review the costs further. No decision should be made until revised figures are received.

The Town Council also believes that the non-building work such as the ongoing maintenance costs and the amenity value of the trees should be included when assessing the different costs of the schemes. The community will lose a significant and valued community asset which is not compensated for by the biodiversity net gain planting on Walnut Tree Farm (outside Cheshire East), to which the public has no access.

8. Conclusion

The Town Council would urge the Planning Officer to consider the numerous errors, omissions and contradictions which continue in this application. Of most concern continues to be the unwillingness of the applicant to undertake a review of the consequences of a dam breach with modelling using the correct data and to carry out site investigation works before this application is returned to the SPB.

The application should also be deferred until the final costings from the Quantity Surveyor have been received and reviewed by all parties and full investigations have been completed into the structure and foundations of the earth dam.

Appendix A

Towers Road Open Cast Mining

10. WATER RESOURCES

10.1 Summary

10.1.1 The groundwater movement in the Towers Farm part of the Poynton Coalfield is largely controlled by the disused coal workings, shafts, adits and drainage levels from the deep mining in the area carried out from the 18th century up to 1935. The natural and artificial discharges flow into the surface water streams, principally the Norbury Brook.

10.1.2 During the excavation of the deeper part of the proposed open pit mine it will be necessary to pump groundwater to permit the work to continue. This pumping will alter the present water flow conditions. The overall impact on the flow in the Norbury Brook will be insignificant as following treatment the water will be discharged into the Norbury Brook.

10.1.3 When the workings reach a depth significantly lower than the bed of the Brook, it is thought possible that water may "leak" through exposed sandstones in the stream bed. Records show that some deep coal mining in the area caused water to flow into the workings from the Norbury Brook. Calculations show however, that the magnitude of this effect will be minimal and not greater than the normal variances likely in stream flow between Summer and Winter months.

10.1.4 There are few water abstractions in the area none of which are likely to have the quantity of water available for abstraction reduced by the proposed mining activities. A licensed abstraction from the Norbury Brook at Brookside Nurseries could be impacted if the water discharged into the Norbury Brook is not adequately settled. This discharge will need consent from the National Rivers Authority (NRA) who, it is expected will require the water to be of a high standard with settlement treatment available.

10.1.5 The water quality survey carried out as part of this study shows that the groundwater in the vicinity of the proposed mine and water seeps and discharges in the area contain little iron. Ferruginous waters are a common problem in coal field areas and potentially cause water quality problems in mining activities. The low iron content of local waters together with the predominance of sandstone over shale in the local geological sequence suggests that there will be no such difficulties in either the mining activities or once the site has been back-filled and restored.

10.2 Introduction

10.2.1 The hydrological and groundwater section of this Environmental Statement have been complied using information from a number of sources. These include geological maps published by the British Geological Survey, geological information obtained from boreholes drilled over the site by Coal Contractors Ltd, groundwater level measurements taken in these boreholes, abstraction and flow measurement information provided by the National Rivers Authority North West Region, effective rainfall information included in the First Periodical Survey of Water Resources published by the Mersey and Weaver River Authority and a walk-over and water sampling survey carried out as part of this study. The information on mining and mine drainage was obtained from a publication *Poynton, A Coalmining Village* by W.H. Shercliff, D.A. Kitching and J.M. Ryan together with old estate maps showing the property owned by Lord Vernon in 1857.

10.3 Hydrological and Drainage Characteristics

General

10.3.1 Surface topography is of land rising to the east reaching its summit near to the eastern boundary, just to the west of New House Farm. At this point, land is 162m AOD and falls away within the site to the north, south and west down to approx 90m AOD at Towers Farm. The majority of the site drains north to Norbury Brook, with a small area in the south-east draining to a pond to the south-west of the site and a further area along the western boundary of the site draining to Poynton Lake via a ditch in Serpentine Wood.

10.3.2 Many of the drainage features present within and just outside the site are associated with the old Park Pit Colliery and Poynton Park. There are a number of areas within the site which have been affected by historic mining activity, in particular in OS Nos 6951 and 4500. In addition, there are a number of wet areas within the site which are the result of surface water flows from the disused colliery.

Main Watercourses

10.3.3 The whole of the proposed site lies in the catchment of the Norbury Brook. This has its sources some 5 kilometres to the east, to the south of Disley. It is an upper part of the Micker Book system, a tributary of the River Tame.

10.3.4 The catchment area of the Norbury Brook above the A523 road bridge, near Towers Farm on the northern side of Poynton is some $10km^2$. The catchment lies on the slopes of the Pennines with the elevation of the higher part of the catchment divide being over 400m AOD. This compares with ground levels in the area of the proposed site which fall in the range of 90-160m AOD.

10.3.5 As a result of the differences in topography, the annual rainfall varies over the catchment from less than 1000mm to approaching 1200mm. The effective rainfall, that is the quantity of rainfall which is not lost by evaporation, is approximately 450mm in the area of the proposed mine.

10.3.6 In the vicinity of the site, the Norbury Brook runs along a narrow, deeply incised valley some 15m deep, which forms a local topographical feature known as Norbury Hollow. The break of slope at the top of the Norbury Hollow forms the northern boundary to both the site and the proposed open pit.

10.3.7 The area immediately to the south of the site lies in the catchment of the Poynton Brook which is a left hand tributary of the Norbury Brook with a confluence some 500m downstream of the A523 road bridge. A minor tributary of the Poynton Brook which drains this area, runs along an incised valley known as Potters Clough which lies some 500m to the south of the site boundary.

10.3.8 There is little available information on the flows of the Norbury Brook as the NRA does not have any flow measurement stations on this water course. Three current meter flow gauging's were made at the A523 road bridge during the dry summer of 1984 which showed the flow to lie in the range 2,500 - 3,000m^3/day. From these measurements it can be assumed that the minimum flow of the Norbury Brook in the vicinity of Towers Farm is likely to be in excess of 2,000m^3/day.

Site Drainage

10.3.9 In general terms, the site slopes steeply to the west and is partly drained by a system of stone-lined drains which follow the line of natural watercourses. These are now seen on the ground as low, linear depressions with occasional lengths of open channel or ditch. On large scale Ordnance Survey maps such features are indicated by 'issues' and 'sinks'.

10.3.10 These drainage systems are typical of many parts of the Pennines and many were constructed in the seventeenth century as part of land improvements. They usually take the form of a channel lined on each side by a low stone wall which is bridged by a flagstone. The culvert so formed is usually buried to provide continuous fields. Typically, some sections of the water courses are left as open channels or ditches to allow access for stock watering.

10.3.11 In addition, the drainage from the site is strongly influenced by the old mine workings which include shafts, adits and drainage soughs. This aspect of the site drainage is considered in the Hydrogeological Section below. The main constituents of the site drainage system are shown on Drawing No WR1. and the drainage catchments within the site on Drawing WR2.

10.3.12 The main culvert drain in the vicinity of the site appears to have its source in two small ponds which lie approximately 200 metres due south of the south eastern corner of the proposed site at an elevation of some 150m AOD at NGR SJ93958432. These ponds and a ditch running along the south eastern boundary of OS 6951 feed the larger of the ponds (OS 7236) in Princes Wood near the south western corner of the site.

10.3.13 From the ponds the drain continues to the west of the wood and a piped section connected to the ditch to the south-west of Park Pit Cottages. This ditch turns to the north following the boundary of the former Park Pit Colliery site.

10.3.14 To the south-east of Park Pit Plantation this ditch feeds a steel 225mm diameter pipe. This is laid in a shallow depression and continues towards Long Plantation, partly as an open channel. It is likely that surface water and the discharge from the 160mm pipe from the north-west boundary of the former colliery site discharge along this depression. The system discharges into the Norbury Brook at NGR SJ92878532.

10.3.15 From consideration of the topography this drain will receive run off from parts of the southern and western areas of the site, as well as some adjacent areas.

10.3.16 The ditch running north along the western boundary of the former colliery site receives a discharge from a pond (NGR SJ 93538474) adjacent to the Park Pit spoil heaps which is understood to receive an overflow from the Park Pit shafts. It is also thought to pick up the overflow from the spring to the south west of Park Pit Cottages.

10.3.17 A ditch along the boundary of OS Nos 4500 and 7500 flows west before connecting to a pipe which eventually discharges into Norbury Brook approximately 200 metres up stream of Long Plantation. The inlet to this pipe is almost completely silted up, but it is thought to be a 225mm dia pipe probably constructed of brick sides with stone flags on top. In addition, the depression in the land through which the ditch flows continues north-west to the site boundary before outfalling via a 150mm pipe approximately 60m NE of Long Plantation in OS 0119. This outfall caters for surface water run-off from the land immediately east of Long Plantation.

10.3.18 The ditch along part of the western boundary of OS 0003 picks up surface water run-off from part of field OS 0087 to the south before discharging into Norbury Wood.

10.3.19 The ditch along the east side of OS 7500 extends south (piped under farm track) along the northern and western boundaries of OS 0064 picking up surface water run-off from both fields. This ditch then extends off site through Norbury Wood, and under the road into Norbury Brook.

10.3.20 Approximately 15 ha in the south west corner of the study area falls towards a small ditch within Serpentine Wood. This ditch flows westwards before discharging into a small pond to the east of Towers Road. It is thought that this pond feeds a larger pond within the housing development to the west of Towers Road and this, in turn, discharges into Poynton Lake. Part of the upper section of ditch within Serpentine Wood has been infilled and that surface water draining to the north-east end of Serpentine Wood has been diverted to the ditch alongside Long Plantation via stone drain.

10.3.21 A minor ditch running east along the southern boundary of OS 0033 picks up run-off from the eastern half of this field. This discharges south across OS 2119 in a 100mm SGW pipe and under the road.

10.3.22 The remainder of OS 0033 drains across OS 0022 to an impounding pond along its southern boundary. This outfalls via a ditch to a further pond in Princes Wood and then is ditched westwards to a small lake to the north of Towers Yard Farm.

<u>Underdrainage</u>

10.3.23 No recent underdrainage has been installed within the site and it is understood that any systems present are likely to be at least 50 years old. Some localised patching up of existing drains has been undertaken by both occupiers and during the course of this work it is clear that some of the shallow mini valleys contain old stone drains. These are constructed of brick sides with flags or tiles across the top. This is most apparent running NW towards Serpentine Wood across OS Nos 3861, 1965, 0060 and 0006 running NNW through OS Nos 2300 and pt 7500 and running NW to the north-east of Long Plantation.

<u>Mine Workings</u>

10.3.24 Many of the existing drainage features in the centre of the site are associated with the disused colliery. As well as the discharges along its western boundary the colliery is said to have been supplied with water from the pond in Princes Wood (OS 7236). There is an old chamber alongside the pond which, at one time, could have housed the flow control gear and a cast iron pipe is believed to cross OS 6951 to supply water to the washery. The outfall ditch from this pond is eventually piped northwards to outfall into the ditch running along the western boundary of the colliery rather than follow its more natural route south-west towards Towers Yard Farm. It is considered that this was so that the colliery could intercept and make use of this water. As described at Section 10.3.23 above, the 2 ponds in the south east of Princes Wood are also connected with the disused colliery - it is understood that the lower pond provided water for the 'incline' engine which pulled the coal wagons along the mineral railway.

Other Ponds

10.3.25 The other ponds found within or in close proximity to the site include a small pond in Park Pit Plantation; a larger pond to the north of New House Farm, which apart from 3 No 75mm outfalls and 1 No 150mm SGW outfall is fed by surface run-off; a small pond in OS 6951 which is the result of localised subsidence and a pond to the west of Towers Farm which has a 300mm overflow pipe which crosses the site before discharging into Norbury Brook.

Water Supply

10.3.26 There are no field water troughs or mains water supply within the site. Farm stock drink from any of the many ponds that exist on site.

10.4 Hydrogeology

10.4.1 The geology of the proposed opencast coal mine has been described in detail in Section 2 of this document and comprises a typical Coal Measures sequence of mudstones (or shales), sandstones and coal seams. The Coal Measures rocks are generally overlain by glacial drift which consists of boulder clay over much of the site. However, there is a relatively small area of glacial sand and gravel with the main deposit being to the south of the Park Pit.

10.4.2 The strata are well understood from both the mapping by the British Geological Survey and the boreholes drilled by Coal Contractors Limited to evaluate the site. The sandstones are potential aquifers (or water bearing rocks) and are capable of both storing groundwater and allowing it to flow. The sandstones of the Coal Measures are often well cemented and much of the groundwater flow takes place via fissure systems and hence there is likely to be a variation across the site in the ability of the rocks to permit groundwater movement, with most of the flow occurring along the thicker sandstones. The sands and gravels in the drift deposits also form minor aquifers.

10.4.3 The mudstones are poorly permeable and do not permit groundwater flow. The coal seams also have a low permeability except where they have been worked where the voids created by coal digging dramatically increase the permeability.

10.4.4 The natural groundwater flow regime will consist of a series of aquifers of variable thickness which are separate except where faulting provides an interconnection. Groundwater will flow in these aquifers towards the natural discharge points which are controlled by the inter-relationship between the geological structure and the surface topography. In the area under consideration it can be expected that some of the groundwater will flow northwards along the strike of the rocks to discharge into the Norbury Brook and the rest will form springs and seepages down the hill side.

10.4.5 The glacial sands and gravels are permeable and will provide flow paths for some of the seepages from the consolidated aquifers. Groundwater also discharges from the sand and gravel deposits to form the base flow of the minor water courses in the area.

10.4.6 The effect of coal workings, including shafts, headings and roadways is to greatly enhance groundwater movement by providing extensive, large capacity flow paths which interconnect otherwise discrete aquifers. These workings also increase the volume of potential groundwater storage in both the aquifer and non-aquifer rocks. In 1883 the Park Pit (NGR SJ 93578472) workings were connected by a drainage adit to the Lady Pit which lies about 1.5 km to the south west at NGR SJ 93148346. The Lady Pit was used as a central pumping point for a number of the coal mines in this part of the Poynton Coalfield. It is likely therefore, that the Park Pit workings are connected with most of the other old workings which lie to the south. It is probable that many of the old workings have collapsed which will reduce the degree of interconnection while still permitting some flow.

10.4.7 The situation will be further complicated by the backfilling and capping of some shafts such as the Lady Pit. The fact that these old workings are interconnected is supported by a report that during a period when water was abstracted from the Park Pit shafts for coal washing during the late 1980's, the overflow from the Lower Vernon Pit was dried up, which lies some 600m to the south west at NGR SJ 93228422. The water contained in these abandoned workings will constitute the largest single groundwater body in the area of the site.

10.4.8 The various investigation boreholes which have been drilled across the site demonstrate that there are several separate aquifers and also provide some general indication of groundwater levels across the site. In addition, six boreholes have been drilled around the site specifically to provide groundwater level readings. All these data have been interpreted to provide a generalized groundwater level map (Drawing WR3).

10.4.9 These levels indicate that the groundwater in the northern part of the site is flowing in a northerly or north westerly direction towards the Norbury Brook. Part of this area is known to be drained by a drainage sough (or adit) which was constructed in the late 18th century. The sough discharges into the Norbury Brook at NGR SJ 93408546 and records show that it was some 340 m long, extending in an arc to a former shaft in Cawley Nursery near NGR SJ 93668517.

10.4.10 In the central and southern parts of the site groundwater levels also appear to be controlled by draining through the old mine workings. The overflow from Park Pit into the culverted drain system is likely to be attracting flows from the area to the east of Park Pit and the low groundwater levels towards the southern edge of the site suggest that flow is continuing to take place along the old Park Pit/Lady Pit drainage adit. The controlling effect of the overflows from old mine workings will produce a depressed water table over most of the site.

10.4.11 The permeable drift which occurs over part of the southern section of the site will also contain groundwater. It can be expected that this aquifer is perched and therefore will behave largely independently of the groundwater in the consolidated rocks. The best evidence for the perched nature of the drift aquifer is provided by a perennial spring at NGR SJ 93488457 which is used for the water supply to the Park Pit Cottages. It issues from a sand and gravel deposit at an elevation of some 124 m aOD whereas the groundwater levels in the Coal Measures in this location are more than 10 m lower than the spring level.

10.5 Water Quality

10.5.1 A series of water samples were taken for chemical analysis to determine the current water quality in the area. All samples were analyzed by the NAMAS accredited laboratories of Southern Science Ltd. Samples were taken from several boreholes drilled by Coal Contractors Ltd across the site, from the private water supply to Park Pit Cottages and in several water courses at the site. A sample was also taken from the old drainage sough discharge into Norbury Brook.

10.5.2 None of these samples showed iron concentrations in excess of 1 mg/l and were generally much lower. The discharge into the Norbury Brook for example, has an iron content of 0.11 mg/l. These results indicate that the local groundwater is typical of Coal Measures sandstones and that the mine drainage water discharging from the area to be mined under the present proposals has a low iron content.

10.5.3 It is common for the discharge from old mine workings to be ferruginous caused by the oxidation of iron pyrites on contact with air or oxygen rich groundwaters. The pyrites generally occurs in shale deposits within the Coal Measures sequence and is isolated from circulating oxygen rich waters by the low permeability of the shales. When the shales are exposed by coal mining the process begins causing the orange ochreous deposits often seen in coalfield water courses.

10.5.4 One explanation for the low iron content of the water discharging from the mine drainage sough is that all the iron has leached out during the long period of closure. Alternatively, it may indicate that there is little iron present in the geological deposits in the vicinity of the proposed mine. In view of the relatively high sandstone content in the local succession the later explanation is considered more likely.

10.5.5 Samples were also taken from a series of trial pits excavated along the boundary between the site and the former Park Pit landfill site to determine whether any leachate is flowing into the site. The water samples obtained from these trial pits showed a similar chemistry to the other water samples analysed from the area except for one sample taken from a trial pit located near the north western corner of the Park Pit spoil heap (NGR SJ 93328496). The water sample taken from this trial pit is typical of a coal spoil heap run-off.

10.6 Water Supplies

10.6.1 A search by the NRA of their abstraction licence records revealed only two sources within a distance of some 500 m from the proposed open pit mine. The details of these two abstractions are given in Table WR1 from which it can be seen that one is an abstraction from a well at Towers Farm and the second is an abstraction from the Norbury Brook at Brookside Nursery.

LOCATION	NATIONAL GRID REFERENCE	SOURCE OF SUPPLY	ANNUAL ABSTRACTION RATE
Towers Farm, Poynton	SJ 927851	Well	730,000 gallons ($3,319 m^3$)
Brookside Garden Centre, Poynton	SJ 925852	Norbury Brook	100,000 gallons ($454.5 m^3$)

TABLE WR1 - Licensed Abstractions

10.6.2 An examination of the published geological map for the area shows that Towers Farm lies on the down throw side of a major fault and that it is underlain by Collyhurst Sandstone of the Permian. The Towers Farm well is geologically isolated from the Lower Coal Measures which will be excavated during the open pit mining exercise and will be unaffected by the de-watering.

10.6.3 The total annual abstraction from the Norbury Brook is significantly less than the daily low flow rates as measured by the NRA during the dry summer of 1984. Consequently the anticipated impact of the de-watering pumping on the Norbury Brook will not prevent the abstraction from taking place. In any event, the flow of the Norbury Brook will be enhanced during the period of de-watering as the pumped water will be discharged into the stream.

10.6.4 The only private domestic water supply in the immediate vicinity of the site is at the Park Pit Cottages. This water source consists of a spring discharge into a collection chamber adjacent to a culverted drain which takes the spring overflow. The spring has been used as a water source for the past forty years during the occupancy of the present owner and is understood to have been the water source used since the cottages were first built.

10.6.5 The cottages are shown on a plan of the property owned by Lord Vernon in the Poynton area dated 1857, although the spring is not marked. However, the spring is indicated on an Ordnance Survey map on the 1:10,560 scale dated 1908. This evidence strongly indicates that the spring supply was used for many years during the period of active coal mining when de-watering was extensive. From the information provided by the maps published by the British Geological Survey it is apparent that the spring emerges from the base of sand and gravel deposit which lies to the south of the site. These drift deposits overlie Middle Coal Measures shales on the up-throw side of the Park Fault and form a perched aquifer which is isolated from the groundwater system in the Coal Measures aquifers. The difference in level between the spring discharge and local groundwater levels, as described in the previous section provides very strong evidence of this perching.

10.6.6 The flow of this spring has been estimated by field measurement as 1 l/min. It is claimed that the flow of this spring remains constant and on this basis extent of the catchment feeding the spring can be calculated as around 1,000 m^2 taking the effective rainfall as 450 mm/year. A catchment area of this magnitude would be expected to be located entirely on the western side of the Park Fault. The proposed open pit mining and associated de-watering will not affect the flow of this spring.

10.6.7 Under the provisions of the Water Resources Act 1991, riparian occupiers have a right to abstract water for stock watering from water courses contiguous with their land. Any riparian use of the Norbury Brook will be protected by the discharge of pumped water in the same way as the Brookside Nursery abstraction. There is a potential impact on the riparian abstractions from the minor water courses which flow across the Towers Farm part of the site. However, this potential impact will only last during the operation of the site when the land will be not used for grazing.

10.7 Landfill

10.7.1 The former spoil heaps at the Park and Lawrance Pits have undergone significant changes since the collieries were closed down in 1935. The spoil heaps were used first as a source of material for brick making which was followed by a period of coal washing and more latterly, the site was used as a landfill. It is understood that the waste materials included putrescible materials and therefore, there is some risk of localized pollution.

10.7.2 There are no signs of leachate flowing out of the landfill and no such material was noted in any of the trial pits excavated in the immediate vicinity of the landfill site. However, it is considered prudent for precautions to be taken during the open cast mining operation to monitor for polluted water from this source so that appropriate action can be taken should any leachate be detected. This action would include the construction of interceptor drains with the leachate collected in sealed tanks and taken off site for disposal through an approved route.

10.8 Potential Impact on Water Resources

Groundwater Conditions

10.8.1 The impact caused by the proposed open cast coal mining operation and associated de-watering will not be as extensive or as extreme as any impact which was caused by the former deep mining in the area. The proposals involve excavations to a maximum depth of 45m partly through water bearing rock. Consequently it will be necessary to de-water the excavation employing the usual water management methods.

10.8.2 As the proposed site is adjacent to old mine workings it will be necessary to partly de-water these workings and maintain a level equivalent to the base of the working pit. It is difficult to estimate the volume of water which will have to be pumped to lower the groundwater body in the old workings to the base of the proposed open pit. However, if it is assumed that the area of interconnected workings extends to some 4 km^2; that on average the amount that the water level has to be lowered is some 20 m; and that the average void space in the rocks which contains water is some 10%; then the volume of water is $4 \times 10^6 \times 20 \times 0.1 = 8 \times 10^6$ m^3. On the basis of the reliability of the assumptions used in the calculation it is considered that the volume of water which will need to be pumped from the workings is likely to lie in the range 5-12 million cubic metres.

10.8.3 The pumping rate to control the water level in the workings will be up to a maximum equal to the annual effective rainfall. The average annual effective rainfall is taken to be some 450 mm which over an area of some 4 km^2 will produce $4 \times 10^6 \times 0.45 = 1.8 \times 10^6$ m^3/year, or some 5,000 m^3/day. It is unlikely that all the effective rainfall on the area of the interconnected old mine workings will contribute to the flow into the open pit and a more likely average inflow rate will be some 1,000 m^3/day.

10.8.4 The available groundwater level records in the northern part of the site suggest that groundwater is currently flowing into the Norbury Brook from the site and hence contributes to the stream flows. The necessary de-watering during the mining operation will intercept the groundwater flowing to the Brook and gradually reduce the quantities reaching it. As the excavation is deepened below the level of the stream bed, there will be an increaing potential for water to flow from the Brook into the excavation via the intervening strata. An estimate of the likely quantities has been completed using extreme values for the parameters involved which suggests that the maximum rate will be 650 m^3/day with the likely value of less than half that figure.

10.8.5 Any environmental impact caused by a depletion of flows will be mitigated by the pumped water being discharged into the Norbury Brook after any necessary settlement.

Drainage

10.8.6 The major potential impacts of the proposed site on drainage can best be considered under the headings of - discharges into the site, discharges from the site, and site restoration.

Discharges into the Site

10.8.7 The main source of offsite water entering the site is the ditch which flows north along the western boundary of the disused colliery before entering a 225mm pipe in the south east corner of Park Pit Plantation. The pipe then crosses the site in a north westerly direction before discharging into a ditch along the western boundary of Long Plantation.

10.8.8 The pipe will require protection works to ensure that it is not damaged during site working and the ditch along the western boundary of Long Plantation will need to be protected to ensure that water arising on the site during working does not discharge directly into it.

Discharges from the Site

10.8.9 Discharges from the site working areas, including soil and overburden mounds, potentially will carry a silt burden or other suspended solids from the areas stripped of vegetation as wll as any other suspended materials from the site. Appropriate water treatment areas will be required to control these discharges.

10.9 Site Restoration

10.9.1 The general intention for working the opencast coal mine is for the excavation to be backfilled with overburden as the working face proceeds. A high proportion of this material will be made up by sandstone, which when placed in the excavation site will provide a porous medium which will ensure that the site is free draining. As a result the drainage from the site will continue to be controlled by the old mine drainage system in the area with discharges from the existing locations being ultimately restored. Once groundwater levels have recovered to their present levels there will be no further potential impact on water supplied. It is estimated that this recovery will be complete within one year of the cessation of pumping from the mine.

10.9.2 A further potential problem from the restored site is that the circulating oxygen rich waters may oxidize any iron pyrite in the fill material thereby causing orchreous discharges to occur. It is considered that this is unlikely for the reasons set out in the section on water quality. However, a monitoring programme will be instigated to monitor the rate of groundwater recovery in both the fill and adjacent areas, together with routine sampling of selected discahrge points to identify any potential problem of ochreous discharges. If such pollution occurs resulting from the mining activity remedial measures will be taken to treat the water to meet the requirements of the NRA.

10.9.3 At restoration the restored soil profile of topsoil and subsoil will initially be less permeable than in its undisturbed state. In addition, the site operations will have resulted in the removal or disruption of existing surface and underdrainage systems within the site working area. The installation of an appropriate drainage infrastructure should be a high priority of restoration, to prevent flooding within and through the installation of underdrainage, and the successful re-establishment of agricultural, golf course, woodland and conservation afteruses.

10.10 Mitigation Measures

General Requirements

10.10.1 The site working drainage proposals are shown on drawings DP 1 to 5 in Section 2 of this statement. Ditches will be provided around the site to collect all run-off water and groundwater pumped from the working void. These ditches will convey the water to the respective water treatment areas and ensure no discharge is made prior to treatment. The water treatment areas will be designed to a specification acceptable to the National Rivers Authority to ensure that the standards of a discharge consent can be met.

10.10.2 Lagoons in the south west corner of the site will be provided for water pumped from the Phase 1 excavations. These will be retained for as long as may be necessary during the restoration and aftercare periods.

10.10.3 For Phases 2, 3 and 4 all water will be treated at lagoons in the north west of the site. A separate system is proposed for the coal preparation area, the site offices and car park.

10.10.4 Protective toe ditches will be provided for all soil banks and overburden storage mounds to convey run-off water to the treatment areas and eliminate ponding at the bases of the banks and mounds.

10.10.5 The access road will be provided with side ditches and culverts where necessary. Culverts and ditches crossed by the access and haul roads will be adequately strengthened.

Offsite Water

10.10.6 The quantity of water which has to be treated within the site will be minimised be ensuring that clean water entering the site is protected from operational areas. It can thus be discharged from the site boundary without the need for further treatment.

10.10.7 The old cast iron pipe leading from the large pond on the northern boundary of Prices Wood to the disused colliery needs locating and blocking off at source prior to excavations commencing.

Northern Boundary

10.10.8 It is unlikely that dewatering operations for the Phase 3 excavations will have adverse effects on the woodlands at Norbury Hollow. Nevertheless it is proposed that the length of the drainage ditch along the northern boundary adjacent to the excavations will be deepened and used to store water.

Mine Water

10.10.9 It is estimated that between 5 and 12 million cubic metres of water may need to be drained from the old colliery workings to lower the water level to the base of the proposed excavations. This is not unusual at opencast sites and the company has recent experience of operating sites successfully with similar conditions.

10.10.10 It is not anticipated that this water will present serious difficulties at the Towers Farm site. However, should problems be experienced in coping satisfactorily with the ingress of water into the excavations, then consideration will be given to dewatering the old workings in advance of continuing excavations.

Norbury Hollow

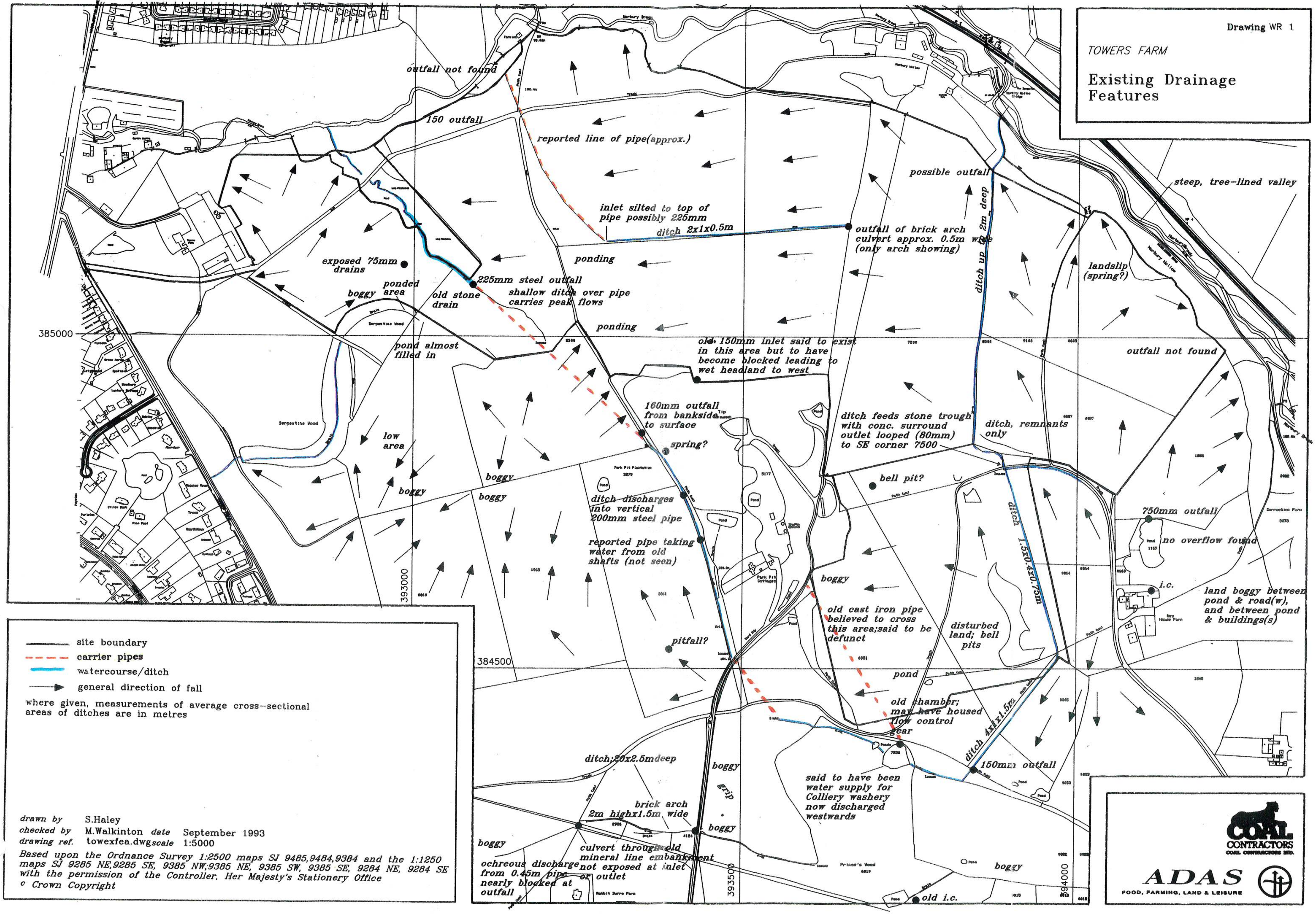
10.10.11 As the excavations within Phase 3 are deepened below the level of Norbury Hollow there will be an increasing potential for water to "leak" through the stream bed and the sandstone strata into the excavations. However only part of each cut within Phase 3 will be below the level of the stream and therefore any impact will be intermittent. Phase 3 is programmed over the winter and early spring months when higher natural stream flows will mean that any flow reduction will be of minimal significance.

10.10.12 The worse case estimate of the quantity of water from the stream is 650 m^3/day with a likely quantity estimated to be less than half that amount. These volumes are a small proportion of the stream flow. The potential erogation will be mitigated by the discharge of water from the site back into Norbury Brook.

Restoration Drainage

10.10.13 The lagoon in the north west corner of the site is to be retained to form a wildlife feature at restoration stage. This can be fed by the existing pipe/ditch from the disused coliery which will provide a constant source of water.

10.10.14 During the aftercare period a comprehensive underdrainage system and field water supply will be installed across all areas restored to agriculture. Any existing drainage problems, such as the ponding of surface water within the field alongside the northern boundary of the disused colliery can be picked up and improved permanently as part of the drainage works for the proposed golf course scheme.


Drawing WR 1
TOWERS FARM
Existing Drainage Features
outfall not found
150 outfall
reported line of pipe(approx.)
inlet silted to top of pipe possibly 225mm
ditch 2x1x0.5m
outfall of brick arch culvert approx. 0.5m wide (only arch showing)
possible outfall
ditch up to 2m deep
steep, tree-lined valley
landslip (spring?)
exposed 75mm drains
ponded area
boggy
225mm steel outfall
shallow ditch over pipe carries peak flows
old stone drain
ponding
pond almost filled in
old 150mm inlet said to exist in this area but to have become blocked leading to wet headland to west
outfall not found
160mm outfall from bankside to surface
spring?
ditch feeds stone trough with conc. surround outlet looped (80mm) to SE corner 7500
ditch, remnants only
low area
bell pit?
ditch discharges into vertical 200mm steel pipe
reported pipe taking water from old shafts (not seen)
ditch 1.5x0.4x0.75m
750mm outfall
no overflow found
i.c.
land boggy between pond & road(w), and between pond & buildings(s)
old cast iron pipe believed to cross this area;said to be defunct
disturbed land; bell pits
pitfall?
pond
old chamber; may have housed flow control gear
ditch 4x1x1.5m
150mm outfall
ditch;20x2.5mdeep
grip
brick arch 2m highx1.5m wide
said to have been water supply for Colliery washery now discharged westwards
culvert through old mineral line embankment not exposed at inlet or outlet
ochreous discharge from 0.45m pipe nearly blocked at outfall
old i.c.
385000
384500
393000
393500
394000
site boundary
carrier pipes
watercourse/ditch
general direction of fall
where given, measurements of average cross-sectional areas of ditches are in metres
drawn by S.Haley
checked by M.Walkinton date September 1993
drawing ref. towexfea.dwg scale 1:5000
Based upon the Ordnance Survey 1:2500 maps SJ 9485,9484,9384 and the 1:1250 maps SJ 9285 NE,9285 SE, 9385 NW,9385 NE, 9385 SW, 9385 SE, 9284 NE, 9284 SE with the permission of the Controller, Her Majesty's Stationery Office
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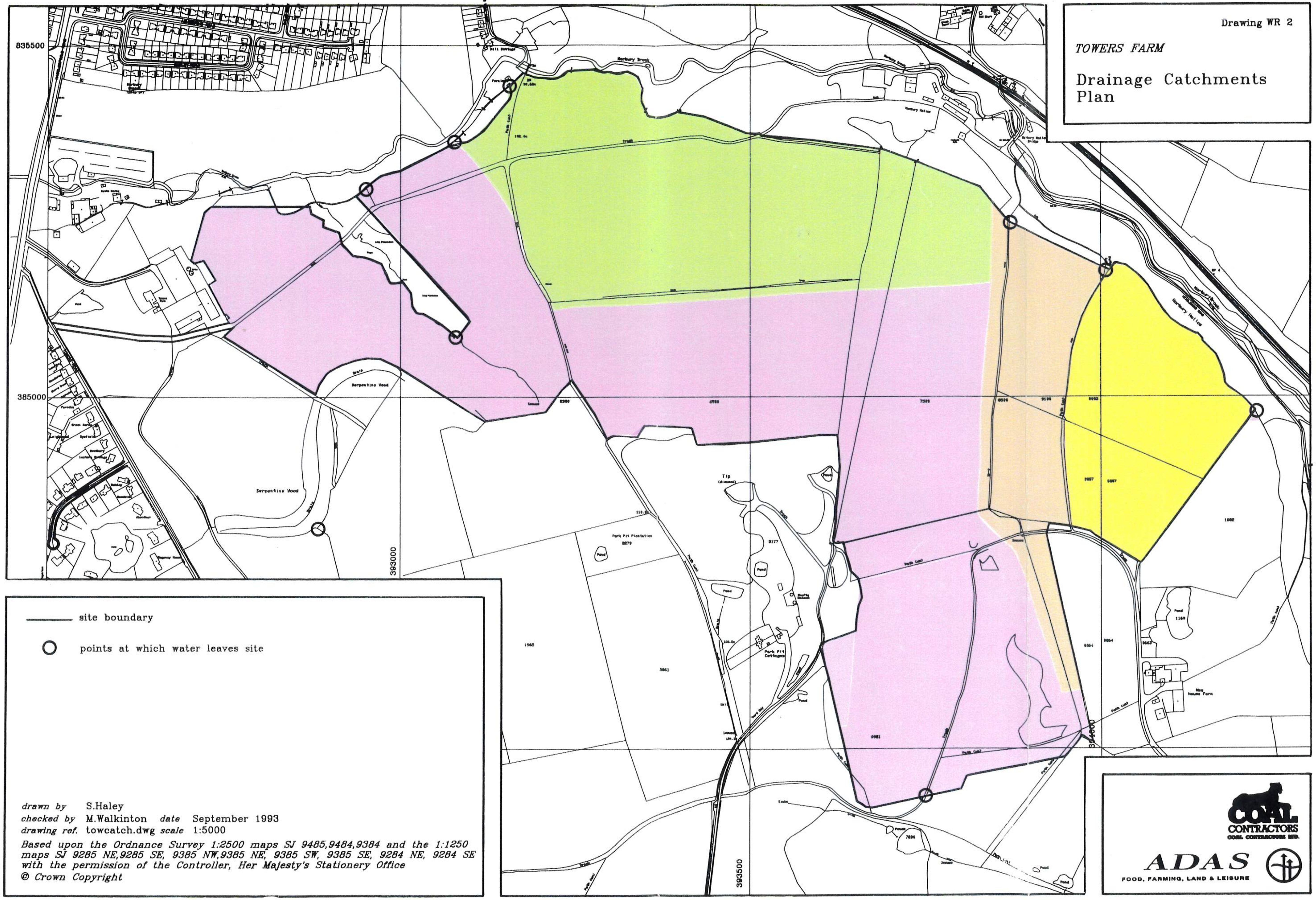
Drawing WR 2

TOWERS FARM

Drainage Catchments Plan



site boundary

points at which water leaves site

drawn by S.Haley
checked by M.Walkinton *date* September 1993
drawing ref. towcatch.dwg *scale* 1:5000

Based upon the Ordnance Survey 1:2500 maps SJ 9485,9484,9384 and the 1:1250 maps SJ 9285 NE,9285 SE, 9385 NW,9385 NE, 9385 SW, 9385 SE, 9284 NE, 9284 SE with the permission of the Controller, Her Majesty's Stationery Office

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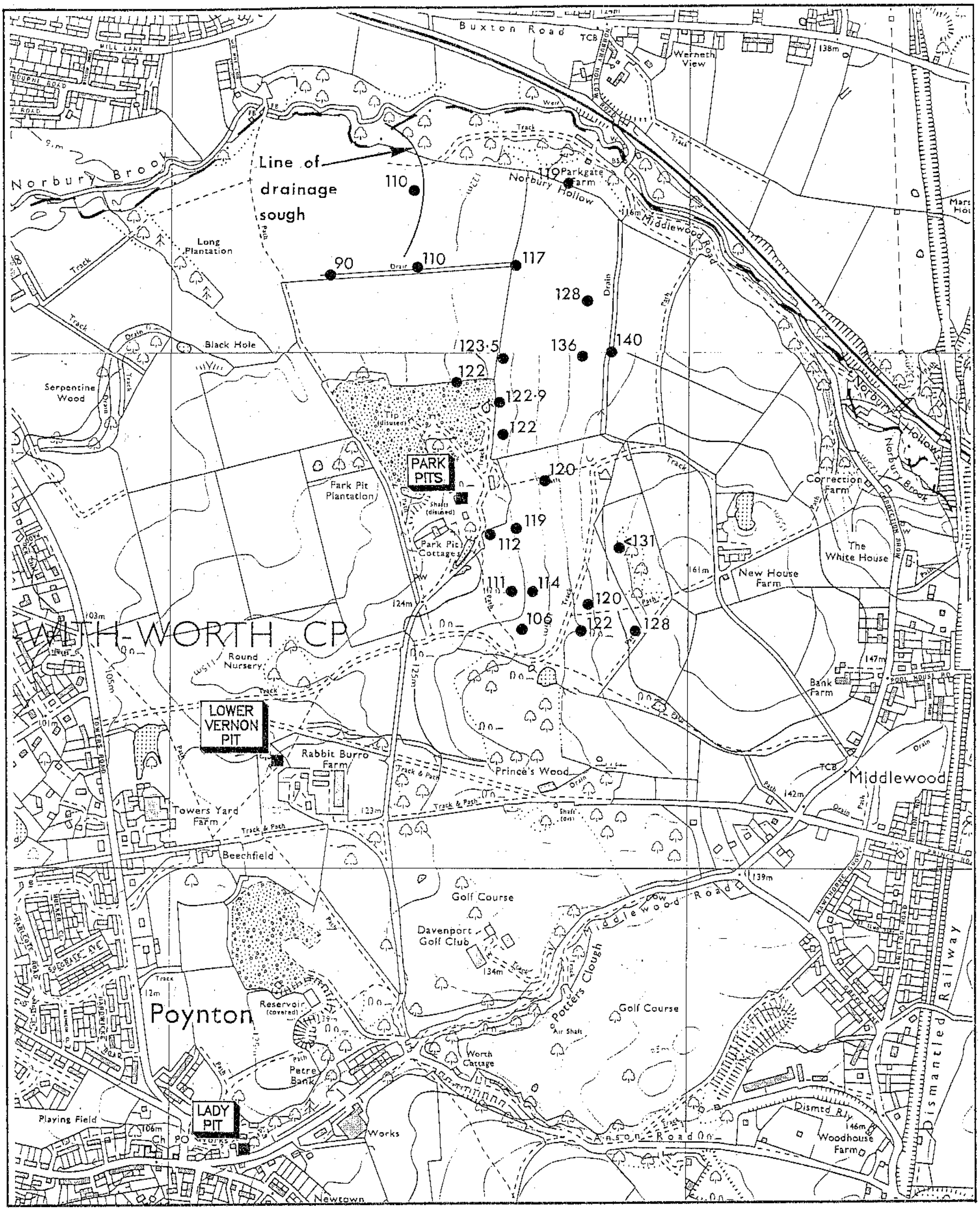

LEGEND

● 111 groundwater level in metres above OD

Note:
Groundwater readings have been taken at different times.

Map ref: SJ98NW, SJ98SW

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Site

TOWERS FARM

Title

GROUNDWATER LEVELS

SPOT READINGS BASED ON BOREHOLE RECORDS

Dwg.No. WR3	Scale 1:10,000	Date: Oct 1993

Appendix B

Vegetation and Embankments, Hoskins and Rice

Vegetation and embankment dams

C. G. HOSKINS, BSc(Eng), MICE, RKL Geotechnical, and
P. R. RICE, BSc, ARK Associates

SYNOPSIS. A substantial amount of information is available on the effects of vegetation on structures, but the consequences and benefits on embankment dams have received little attention to-date in papers and the technical press. Many engineers have actively discouraged the presence of all bar a grass cover on slopes, but recent events suggest that this approach may be misguided and larger trees and vegetation on certain parts of the embankment are not detrimental and may improve the safe functioning of a dam. Increasingly, environmental considerations require the planting or maintenance of a more substantial vegetation cover and thus there is likely to be an increasing move towards more vegetation in the future. A case history of dam instability following tree removal is given.

BACKGROUND AND CONTEXT

1. Many of the earliest dams that are still functioning today were planted deliberately with trees. In the 1700s Capability Brown, Humphrey Repton and others remodelled country estates and planted large numbers of trees with planting schemes that extended onto and over the embankment. Other dams on the lowland areas from that time onwards were also planted or allowed to develop a tree covering. Subsequently in the late 1700s and for the next two hundred years, substantial numbers of reservoirs have been built for water supply or augmentation purposes or as canal feeders. Water availability, amongst other facts, have resulted in many of these being sited in upland areas. The embankments were often steeper and of a greater height than those earlier and, with their location in less favourable areas for the subsequent development of a tree cover, their vegetation has been limited typically to grass plus sparse trees and shrubs where these could develop in the more sheltered positions. This allied with the increase in the number of dams in less hospitable locations, appears to have fuelled a general belief that extensive vegetation cover, particularly trees, is detrimental to the well-being of the embankment and, in many instances, any developing trees have been removed. This approach has continued to the present time and many instances

are known where tree cover that has been in place for many years or decades has been cut down at the request of an Inspecting Engineer. In some instances, this has led to consequent problems with the embankment and an example is given later in this paper.

2. The current trend towards an enhanced environmental awareness will necessitate a greater justification for the future removal of mature trees and the loss of the associated woodland habitat. The effects of the trees, whether detrimental or beneficial, must now be considered more fully before any action is taken and their removal shown to be necessary. The increasing use of existing reservoirs for amenity purposes is likely to continue and this will exert further pressure to retain and improve their wooded cover. Reservoir construction in the future is likely to include a significant number of reservoirs for amenity, landscaping and recreational purposes whose size would put them at the lower end or just beyond the scope of the Reservoirs Act 1975, and thus will necessitate a more balanced view.

EFFECTS OF VEGETATION ON EMBANKMENT DAMS

3. The major influences of vegetation on embankment dams are hydrological and mechanical. Whilst all vegetational features have an effect, to some extent, the root system is of particular relevance in dam engineering. They vary from very fine fibrous hair roots through to larger branched roots, frequently with a near vertical tap root. Occasionally near vertical sinker roots often link up the various root levels. Shallow roots form a near surface mat which extracts mineral nutrients from the enriched areas just below the litter layer. Deeper roots form the anchorage and provide the main water extraction facilities. The larger roots are perennial whereas many of the fine roots, whether for mineral or water extraction, are subject to seasonal dieback and regrowth. Much of the root system develops solely to extract water and thus the root pattern is largely dependent on the soil-moisture relationship for any given type. Well drained soils, particularly with a poor nutrient content, will lead to a sparse development of deep roots; wetter soils will necessitate a less extensive growth to obtain the same amount of water. A water table or a densely compacted soil or barrier at shallow depth will result in a more shallow lateral root spread covering a wider area. Much of the root system below a grass cover is within the uppermost 50mm and takes some years to develop. The roots tend to be highly branched and fibrous, but the parts of the root system which remain active in winter are greatly reduced. Most roots from other vegetation are found within a few hundred millimetres of the surface below herbaceous vegetation, but may typically extend to 3m depth below trees. Some roots may be found at greater depth, but these normally

form only a small proportion unless the water table is very low.

4. Two frequent misconceptions are often believed with regard to tree roots. The first is that the root spread is equal to the size of the crown, i.e. the branch spread, and the second is that tree roots are either shallow rooted or are essentially a tap root. Both are incorrect and the roots will develop as required to abstract sufficient water and ensure stability of the tree. Thus the lateral extent of tree roots can be considerable and can extend well beyond their crown area as the hair roots seek to extract water in unfavourable conditions. The extent of influence for various species has been investigated by several authors (eg Ward (Ref. 1), Driscoll (Ref. 2), Greenway (Ref. 3)), and the rank order of water demand tree species given. These have not been entirely consistent but some general comments can be made. The water loving species, willows, alders and poplars have particularly extensive root systems and a high water demand. These tend to be well known in this respect, but other trees can develop moderately deep roots to satisfy their water needs. Included in this list are oak, horse chestnut, hawthorn, rowan/service tree, cherries/plums and, in some instances, sycamores/maples.

5. The roots have a tensile strength which will vary considerably with species, age, size and time of year; a value of about 30 MN/m^2 has been quoted for the Pedunculate Oak. Following felling, the strength of the roots is slowly lost; falling to perhaps 50% after one year but retaining some strength for several years. Roots on a slope, particularly those of the larger shrubs and trees, tend to grow in an upslope direction to counteract gravity forces and thus tend to remain perpendicular to the ground slope. The application of forces to the roots causes them to thicken and thus the thickest roots will be on the upslope side of a tree, particularly those running obliquely to the slope and acting as anchors.

6. Roots have great difficulty in penetrating soils which have strengths greater than 2 MN/m^2 (ie weak rock), but a high bulk density can also limit penetration. Densities above which growth is restricted are approximately 1.4 t/m^3 for clay soils and 1.7 t/m^3 for sandy soils. Clay content also has a significant effect on root penetration and an increasing content tends to retard penetration. The structure, voids content and presence of organic matter and existing roots all tend to influence root penetration. Roots tend to follow the easiest route and thus backfilled trenches and holes offer least resistance to spreading; this has been confused in the past with roots seeking water from the pipe in the drain. Where a fracture does occur, the root will gain entry and spread along depending on the amount of flow.

Opening up of the fracture and increased root development is then likely. Certain trees are more prone to affecting drains and a summary by Cutler and Richardson (Ref. 4) suggests that cherries/plum trees, horse chestnut and sycamores/maples are more likely to affect drains in addition to willows and poplars. Root growth can be sufficient to affect adjacent structures and walls, but this is normally very localised and results from the development of large lateral roots immediately adjacent to the trunk.

7. The effect of vegetation results in an overall increase in the strength of a soil mass as a result of soil reinforcement by the roots and a soil moisture deficit by evapotranspiration. The latter is seasonally variable and thus soil moisture levels will build up in winter and may approach the field capacity. The soil moisture deficit implies suctions in the soil which can be considered as a reduction in pore pressure in a saturated soil. In a partially saturated soil, the effect of a soil suction can be more readily considered as an increase in cohesion. Soil suction increases as the size of voids and capillary channels decrease; its effects are therefore greater in fine grained soils. Methods of assessing the soil strength by allowing for the presence of an additional cohesion, c_r, due to the root reinforcement and a further cohesion, c_s, resulting from the soil suctions have been proposed (Walker and Fell (Ref. 5)). Where the permeability is low and the rate of replacement of water is not large, the development of soil suctions will result in a lowered water table. This can be considered directly as an appropriate way of allowing for the effect of vegetation on soil strength, in preference to adjusting the cohesion.

8. The principal benefits of established vegetation on embankment dams are improved slope stability, surface erosion control against flowing water or abrasion effects and, on the upstream slope in some instances, wave erosion control. Other lesser benefits, in some instances, may include noise attenuation, wind shelter and access barriers. The vegetation may also act as an indicator and show colour changes, more lush growth or changes in inclination which may be indicative of variation from the existing conditions.

9. Detailed methods for quantifying the effects of these benefits are given by Coppin and Richards (Ref. 6) but the most useful process is in controlling slope stability. The beneficial effect of vegetation develops over a long period and may compensate for a gradual loss of soil strength with time due to weathering. Thus there is a tendency for the effects to be underestimated. Often it is the sudden removal of vegetation which can best demonstrate its effectiveness as illustrated by the onset of slope instability after a wooded slope has been cleared. This will normally take the form of

shallow instability or steady creep, but sometimes deeper seated movement can occur. Failure does not normally occur immediately after felling but typically take a few years to occur as the stability gradually decreases as soil moisture deficits are lost and roots rot and lose strength. The most widespread form of failure in the British Isles is in over-consolidated clays where typically a shallow slip up to two metres deep develops. Whilst these typically occur on the relatively steep slopes adapted for motorway embankments, they have been noted on some dam slopes where these materials have been used. Tree and shrub roots extend down typically to two to three metres and thus there is scope for utilising vegetation to reduce the risk of future instability of these slopes.

10. Many shallow slope failures tend to occur during the early spring when the vegetation is only just beginning to start its regrowth and ground water levels are at their highest. Root die-back is also at a maximum at this time. Thus any stability analyses should consider conditions at this time rather than other times of the year when more favourable conditions are present.

11. The response to storm conditions of strong winds, heavy rain or snowfall is clearly dependent on the vegetation species and its shape and height above ground level, assuming the roots are adequate to maintain stability. This may involve severe stresses in the trunk and branches of trees and lead to damage and loss of moderate sized branches. In extreme conditions, toppling or snapping of the main trunk may occur as seen so vividly in south-eastern England after the October 1987 hurricane. The likelihood of toppling or major branch loss is clearly increased where the tree is already dead or generally unhealthy, badly out of balance or mishapened, or has a shallow root system. Experience from the hurricane suggests that sloping ground had little effect due to the increased root development and that toppling or snapping of the trunk was essentially dependent on the species. Most conifers and ash trees tended to snap several metres above the ground whilst most other broad leaved trees toppled. Oaks were not generally felled but, in the worst instances, tended to have all bar the major branches removed. It should not be forgotten, however, that oak trees may shed quite substantial branches in relatively small storms.

12. The potentially adverse effects of trees on embankment slopes which can arise through lack of management are summarised by Johnson et al (Ref. 7). These include uprooting of trees in storms which may disrupt surface protection layers leaving voids vulnerable to erosion, penetration of slope protection and membranes by root systems, concentration of erosion at the water line between trees and blanketting of the surface making surveillance less

effective. Trees on the upstream slope, the crest and uppermost levels of the dam are clearly the greatest potential threat. Roots, however, are unlikely to penetrate into the core unless they are particularly close or have a high water demand. Other authors, e.g. Cronin (Ref. 8), Merivale (Ref. 9) and Page (Ref. 10) warn against trees on dams or give examples where substantial root growth into the core has occurred. In all cases, however, unless the trees had been allowed to develop close to the core, only roots of alder and willow had penetrated into the core. Bishop (Ref. 11) also reported upon root entry into a puddle core and attributed the root growth to a long-term lowering of the water level. The roots in this case were reported to be herbaceous and primarily from docks. Thus potential problems should be minimised if trees and shrubs, and certain of the larger herbaceous plants, are not allowed to develop near the crest of the dam and the more extreme of the water loving species, namely willows, poplars and alders are excluded.

13. Where works on a well wooded embankment or tree removal are planned, it is essential that the effects of the vegetation are fully considered at any early stage. The type, size and general condition of each tree should be recorded together with the positions and details of any stumps. A series of exploratory holes sunk adjacent to and remote from the vegetation should give some visual indication of the effects of dessication. Samples should be recovered to assess the ratio of insitu moisture content to the Atterberg Limits and the degree of dessication assessed. Clearly the time of year must be considered. Roots should be recovered where possible and identified to assist in estimation of the root spread. Where no roots are encountered, this should also be recorded. Once the type and possible extent of the vegetation is more clearly known, the effects of removal can be considered. This must include not only an assessment of the long-term stability following removal, but the effects of removal on other trees and vegetation and the likely increase in runoff. Where excavation is planned adjacent to trees, care should be taken to minimise the effect on the tree, both from the excavation itself, from construction plant or by ill-considered stockpiling around the tree (Ref. 12).

14. Any investigations on dams where removal of vegetation in the past has led to problems should also seek to recover any roots. Several laboratories hold reference samples and most roots can be readily identified. Knowledge of the extent of past vegetation, which may become evident from the root spread, and the type may help assessment of the problem.

15. Vegetation, and particularly trees, will not always continue to perform their necessary function and may develop various weaknesses. The recognition of hazardous trees is an

important aspect of any visual inspection and any risks should be assessed. The Forestry Commission (Ref. 13) have published a useful guide for recognising hazards and recommended courses of actions. In certain instances, mature trees may have reached the end of their useful life and will require felling. Failure to fell mature trees when they cease to perform their intended function or become a hazard may be as serious as ill-considered removal. It should be noted that a felling license from the Forestry Commission is required and certain trees may be protected by a tree preservation order or a blanket protected woodland order. Where weaknesses are noted and felling is required, it is essential that the major roots adjacent to the trunk are removed and the hole backfilled with compacted material of similar type to the rest of the embankment. If the tree appears to be carrying out some beneficial function to the embankment, a suitable replacement should be planted which should be as large as possible to enable the effects of removal to be minimised.

16. Similarly, any trees which have toppled, heaving up a large disc of earth and larger roots, should be removed and the hole inspected. Loosening is possible down to two to three metres, depending on species, but the hole typically may be less than one metre deep. Where this is away from the crest and upper levels of the slope, the hole can be refilled with compacted material. Adjacent to the crest, all disturbed material should be removed to sound fill and the hole refilled; this may require temporary protective measures against inflow from the reservoir. Alternatively, if the damage is limited to certain areas or if the tree is unbalanced, selective pruning or pollarding on the appropriate species may be sufficient to ensure a healthy tree.

17. It should be noted that trees damaged or weakened by natural or man-made agencies do not die off immediately. They will tend to linger on with little new growth and be prone to increased pest and disease attack. Thus they will gradually weaken and die, typically four or five years after their real cause of decline.

18. Disease is often a secondary effect following physical damage, extreme climatic conditions, insect or animal attack, pollution or general poor health. Older trees and clumps of single species are more prone to attack, but most diseases and pests attack a specific species, i.e. Dutch Elm Disease. All trees have a natural span which may range from a few decades for birches to several centuries for the oaks and ultimately all trees must die. Toppling is associated with trees of all ages, but an older tree is more likely to be affected as are trees left adjacent to felled areas which may be subject to substantially changed wind loadings.

ALDENHAM RESERVOIR - REMOVAL OF TREES

19. Aldenham Reservoir was formed about 1795 to supply compensation water for mill owners in conjunction with the construction of the Grand Junction Canal. The embankment was built of random fill of London Clay and was raised soon after construction. Problems with stability occurred soon after construction and have continued intermittently to the present day. The present maximum height is 7.6m with a length of 399m. The slopes are variable with a typical slope of 1V:5H on the upper levels of the downstream slope and a variable steeper slope over the lower levels. Despite minor instability on the downstream face, a good covering of mature trees and undergrowth was known to be present by the beginning of this century.

20. Hertford County Council leased the reservoir in the early 1970s and carried out various remedial works following recommendations under the Reservoir (Safety Provisions) Act 1930. This included removal of all the trees and undergrowth over the upper levels of the upstream slope and marginal raising of the crest to increase the freeboard. Following drawdown of the reservoir for other remedial works in 1975, major slips occurred on both the upstream and downstream slopes. A ground investigation was carried out and the slipped area reinstated. Wet areas developed subsequently in the late 1970s and a series of shallow localised drainage trenches were installed. In 1982, signs of incipient instability were noted in the form of severe cracking and deformation of the crest track in the central length of the embankment. Investigation showed a shear surface was present at about one metre depth, and thus remedial works in the form of two metre drainage trenches at five metre spacing were installed and these successfully controlled the instability. Further cracking and deformation subsequently developed to both sides of the initial length in the late 1980's and thus the remedial works were extended to a total length of 75% of the embankment. To-date these have successfully controlled the instability and no further cracking or deformation has been evident.

21. Apart from one short section of embankment which was affected by both the 1975 and 1982 failures, the areas of instability have developed progressively along different lengths of the embankment. This suggests that some time dependent effect is reducing the stability of the downstream shoulder, and an increase in moisture content in a just stable slope appears to be the controlling mechanism in this instance.

22. Unfortunately, during both of the earlier investigations, little consideration was given as to the effect of the previous vegetation on the insitu moisture content and thus no special testing or studies were carried

out. Reconsideration of the index properties and insitu undrained strengths obtained from these investigations, however, suggests that the fill material had a high moisture content and low strength. Thus any previous moisture content deficits that would have been expected beneath the vegetation cover had been lost or substantially reduced by that time. Piezometers at shallow depths of one to three metres have also indicated some evidence of increased water levels and this would further support this idea. Unfortunately, the piezometers have been vandalised and no information is available since installation of adjacent deep drainage trenches.

23. Thus the downstream slope appears to have been only marginally stable, and ill considered removal of the vegetation, possibly assisted by the placement of fill to the crest, was sufficient to allow instability to develop. The vegetation appears to have a two-fold function in assisting stability; pore water pressures would have been reduced, whilst the roots would have helped to hold the superficial layers of the slope together.

CONCLUSIONS

24. The effects of vegetation must be considered as an integral part of the design of a new dam or a continuing facet of the operation and maintenance of existing structures. Some factors that affect the performance of the vegetation are within the control of the designer, whilst others such as climate are clearly not. Thus, early discussion with a landscape architect are essential to develop an acceptable planting proposal. Similarly, the operation and maintenance controls on a dam can affect the health and performance of existing vegetation.

25. Vegetation may amount to a way of adding an extra margin of confidence to stability and reduce the likelihood of future maintenance or remedial work. It may also help guard against long term changes or local variations in conditions on the embankment.

26. Certain species, namely willow, poplar and alder have a high water demand and a very extensive root system. Experience has shown that such species should be excluded on dams at all times. Other species, namely oak, horse chestnut, hawthorn, rowan/service tree, cherries/plums and in some instances, sycamores/maples, also have a moderate water demand and may develop a relatively extensive root system. Their use, together with most other trees, is not considered detrimental on dams, provided they are excluded from certain parts of the embankment. These include the crest and upstream slope, within a few metres of the crest on the downstream shoulder, a similar distance from any drains or ditches and, clearly, not on any auxiliary spillways or

immediately adjacent to structures. Where mature trees have developed on an existing dam, however, they should be retained and maintained in a healthy condition. Where they are too large, out of balance or unhealthy, selective lopping and pruning should be carried out as required, whilst dead trees should be removed.

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