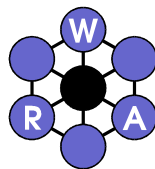


Andrew Aird
Groundwork and Leisure Services Ltd

Penley Mill Lake, Wetland and Wildflower Meadow near Wrexham, Wales Flood Consequence Assessment

**Final Report
November 2021**



**Water Resource
Associates**

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Cover photographs: Emral Brook and floodplain, ornamental pond, exposure of glacio-fluvial sand, breakthrough drainage line.

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Summary

Introduction

Planning Application and Hydrographic Location

This flood consequence assessment supports planning application P/2021/0107, validated on 9-March-2021 for construction of a new lake, wetland and wildflower meadow in the floodplain south of Penley Mill, Lion Lane, Penley, Wrexham, LL13 0LY. Natural Resources Wales commented on the proposals in two letters dated 10-March-2021, and 3-September-2021.

The project area is located in the catchment of the Emral Brook which has a catchment of 64.5 km² at Worthenbury where it joins a similar size stream called the Wych Brook, to flow into the River Dee 8 km east of Wrexham.

Proposed Landscape Features

The project involves construction of a new lake in the Emral Brook floodplain, occupying 8,439 m² at top water level [38 m OD], formed by excavation of alluvial deposits down to a maximum depth of 3 m. The spoil will be deposited as low mounds with micro-relief and surface area of 8,400 m² in the southern part of the floodplain, outside the maximum flood extents of Emral Brook. The grassland and marsh floodplain cover an area of 53,224 m².

The floodplain is delimited along the eastern side by an old mill race which is no longer in use, and this intercepts local runoff from a small catchment of 0.19 km² which will supplement water in the lake, otherwise fed by groundwater and inundation from Emral Brook when the stream is in flood.

FCA Focus

The project will enhance the landscape and biodiversity of the area, and is therefore unlike development of land for buildings and infrastructure, which tend to be the focus of many FCAs. The lake itself will lower floodplain level and increase flood storage, thereby reducing downstream flooding; this is another positive element of the project. Consequently, the main focus of the FCA will be to demonstrate that any increase in ground level which results from the re-distribution of soil arising from the excavation lies outside the area of predicted maximum flooding.

Flood Hydrology

Emral Brook FEH Characteristics

The Emral Brook catchment has an area of 15.37 km² at the Lion Lane confluence and is rural except for the village of Welshampton which lies in the headwaters. After Penley Mill, Emral Brook continues to flow north for 10.9 km where it joins the Wych Brook to form Worthenbury Brook, a tributary of the River Dee. At the Dee confluence, the catchment area is 153 km².

The Emral Brook valley has a well-developed corridor of alluvium, which is sandier upstream of the proposed Penley Mill lake due to glacio-fluvial deposits, and more clay-dominant downstream due to extensive boulder clay.

Peak Flood Discharge

Catchment mean annual rainfall is 743 mm for the period 1941-70, and 694 mm for 1961-2010.

WINFAP-5 software was used to estimate peak flood discharge in the Emral Brook, which indicates that the T1000 flood is 12.4 to 12.5 m³/s, while more-frequently-occurring floods of T75 and T200 are 6.8 and 8.6 m³/s.

Flood Levels

Flood extents shown on the NRW flood maps were digitally sampled and mapped to the LiDAR DTM using GIS so that the flood outlines could be overlaid on the limits of the proposed lake and spoil mound. This was done for the 200-year [T200] and 1000-year [T1000] extents, giving flood levels of 38.45 and 38.6 m OD at the northern end of the lake. The levels were then compared with FEH predictions of peak stream discharge converted into water levels using LiDAR DTM cross-sections and the Manning equation. This showed that flood flows expand across the floodplain, encroaching on the proposed lake area, and outflow converges through a constriction of the floodplain downstream.

The T1000 cross-section and Manning estimate using floodplain gradient of 0.0041 and roughness coefficient of 0.087 gave peak flow of 12.53 m³/s, which compared well with the FEH estimate of 12.46 m³/s. The T75 cross-section using stream gradient of 0.0052 and roughness coefficient of 0.050 produced a peak flood estimate of 6.82 m³/s, [compared with the FEH estimate of 6.86 m³/s]. This has been mapped in the lake area from a flood level of 38.46 m OD in the lake south to 38.38 m OD in the lake NW corner. The importance of doing this was to determine to what extent more frequently-occurring floods will affect the proposed lake.



Local Runoff

The mill race bund and ditch are historical features not operational since 1954, but the bund still has sufficient definition to intercept, divert and focus local overland flow, during intense rainfall from the 0.19 km² catchment.

Historically, water flowed down the millrace into an elongated pond, with an overflow discharging back into the Emral Brook via a deep ditch just north of the proposed lake. An ornamental pond has been built on the north side of this old channel, and there is a prominent spring in the old overflow channel some 8 m back from the stream margin, which discharged of the order of 2-3 l/s at the time of survey. It is likely that the spring is fed by infiltration through the pond bottom and local groundwater, confirming the movement of groundwater underneath the clay alluvium.

An important feature of the millrace bund is the existence of breakthrough drainage points which are aligned across the floodplain and feed areas of marshy grassland. These linear features are mainly present to the south of the proposed lake and cross the area of proposed spoil disposal to form the wildflower meadow. Their importance is impact on runoff and feed into the marshy areas where water ponds on the clay surface of the floodplain.

Lake and Floodplain Characteristics

Geology and Soils

Penley Mill is characterised by extensive deposits of till and glacio-fluvial deposits overlying Wilmslow Sandstone. In the area of the proposed lake, there are significant outcrops of glacio-fluvial sand and gravel, which were quarried in the land due west of Old Hall. In the Emral Brook valley, clay and silt alluvial deposits overlie the glacial deposits and sandstone. The higher ground in the area is generally covered in diamicton deposits with large boulders and rock fragments in a clay matrix. There is a large number of ponds on this clay surface.

At depth, the solid geology dips eastwards into the Shropshire syncline with a roughly north-south strike-line, and the Wilmslow Sandstone underlying Penley Mill gives way to the conglomeratic sandstone of the basal part of the Helsby Formation, eastwards, between the project site hillside and Penley village.

Soils reflect the geology to a large extent. Over the glacial till, and alluvial deposits downstream of the proposed Penley Mill lake, the ground is dominated by slowly permeable, seasonally wet, slightly acid but base-rich loamy and clayey soils. These areas typically have seasonally wet pastures with woodlands, and generate overland flow draining to the stream network. In contrast, the glacio-fluvial sand and gravels develop free-draining, slightly acid, loamy soils, characterised by neutral and acid pastures with deciduous woodland or bracken and gorse on higher ground, supporting mixed arable farming and grassland. This soil allows infiltration and recharge of groundwater, which may then feed the base of the proposed lake.

Impact of Geology on Lake Performance

Excavation is likely to intercept the underlying glacio-fluvial sand and gravel containing groundwater, in addition to minor seepages in silty sand lenses in the clay alluvium. These deposits were confirmed in hillside exposures to the east of the proposed lake area. A borehole drilled in April 1980 at Penley Mill [SJ43NW10] for BGS Industrial Minerals Assessment Unit to a depth of 16.5 m, found 3.4 m of alluvium overlying glacio-fluvial sand and gravel.

Although most of the lake excavation will occur in alluvial silt and clay, it is likely that groundwater will be encountered in the bottom 0.5 m or so of the deeper part of the lake, which will require dewatering during construction. Rainwater and runoff infiltrating on the slopes to the east, will feed groundwater circulation under the lake, and if a connection is made by excavation into the glacio-fluvial sand, this will help maintain water in the lake and keep the water sweet.

Dug-wells in the vicinity are no longer useful for groundwater observation.

Impact of Lake on Floodwater Movement

Floodwater will leave the Emral Brook congested with trees and flow parallel to the channel in the nearest floodplain separated by natural levees. This strip will expand as the flood becomes larger and partially overlaps the proposed lake. The lake will overflow at the north-west corner, where floodwater converges and flow velocity will accelerate.

There will be a significant gain in floodplain storage, as maximum predicted flood extents only overlap the western side of the lake. An estimate of this gain in floodplain storage at T1000 flood level is 5900 m³. This will result in lower predicted flood levels downstream, as new storage in the lake attenuates discharge passing along the floodplain corridor.



Proposed Wildflower Meadow

Material excavated from the proposed lake area will be used to create higher ground [mound] in the southern part of the floodplain and planted with wildflowers. The southern tip of the proposed mound impinges on the T1000 flood extent, so the shape of the mound has been redesigned slightly, moving it away from the lower-lying ground floodplain.

The original mound did not take into consideration the existing terrain or routes of overland flow. It was also found that the proposed mound would have an average thickness of 3 m based on the volume of arisings from the lake excavation and footprint of 5402 m² shown in the CBA drawings. Based on lake volume of 16274 m³ and 1:3 slopes, the central height would be excessive to achieve the calculated spoil volume.

The proposed mound has therefore been reduced in elevation and broken up into at least three segments to maintain overland flow routes and achieve the correct volume. There are a number of break-through drainage points along the old mill race, where overland flow runs off the hillside, collects in the remains of the bunded ditch and then continues across the floodplain.

The mound segments would be moulded into the side of the existing slope up to the millrace bund, maintaining existing gradients of 1:7 to 1:13, down-hill from the old millrace.

Pluvial Flooding

The risk of pluvial flooding is shown on NRW mapping, and this information was reviewed in the light of field reconnaissance and topographic data.

Sheet flow running off the steep hillsides adjacent to the area of proposed lake and spoil mound, will tend to accumulate in the old mill race, which has no outlet. However, past erosion of the containment bund will allow breakthrough of the ponding and overflow on to the adjacent floodplain, following lineaments across the field into marshy areas.

The main process of note will be runoff from the mangel wurzel fields in the prominent eastern valley, which will both enter the old mill race and overflow into the proposed lake. It is likely that the old mill race further south will also trap overland flow, where the infiltration capacity of the sandy soils is exceeded, and overflow along the drainage lines.

Conclusions

There will be an estimated gain in T1000 floodplain storage of 5900 m³, thereby reducing downstream flooding.

The Emral Brook catchment area is 15.37 km² at the Lion Lane confluence, with predicted T200 and T1000 flood peaks of 8.6 and 12.5 m³/s, and flood levels of 38.4, 38.6 m OD at the northern end of the lake. Floodwater will partially overlap the proposed lake, and overflow at the northwest corner, with convergence and increase in flow velocity.

Abandoned since 1954, the mill race bund and ditch have sufficient definition to intercept, divert and focus local runoff. The bund has drainage breakthrough points which feed areas of marshy grassland, following lineaments to the south of the proposed lake across the area of proposed wildflower meadows into marshy areas.

Glacio-fluvial deposits exposed on the hillside eastwards, and underlying the alluvium will potentially feed the base of the proposed lake. Spring in the old millpond overflow ditch is fed by local groundwater.

Excavation will intercept underlying glacio-fluvial sand and gravel containing groundwater, in addition to minor seepages in silty sand lenses in the clay alluvium.

The southern tip of the proposed mound impinges on the T1000 flood extent, so the shape of the mound has been redesigned, moving it away from the lower-lying ground, lowering elevation and dividing into segments to maintain overland flow routes and achieve the correct volume.

The mound segments would be moulded into the side of the existing slope up to the millrace bund, maintaining existing gradients of 1:7 to 1:13, down-hill from the old millrace.

The proposed access track should be relocated to follow the edge of the floodplain, thereby avoiding the area at the NW corner of the lake where flood velocities will be higher and avoiding the need to bridge or culvert the spring which appears in the old overflow ditch.



Glossary of Units, Terms and Abbreviations

m	metres
mm	millimetres
m ³ /s	cubic metres per second
l/s	litres per second
m ²	square metres
m ³	cubic metres
km ²	square kilometres
ML	mega-litres
Ha	hectare
mm/min	millimetres per minute
m/s, secs	metres per second, seconds
m/hr	metres per hour
m/d	metres per day
m OD	metres above Ordnance Datum
m bgl	metres below ground level
Min	minimum
Max	maximum
T	Return Period in years [eg T200 is 200-year]
LiDAR	Laser imaging, detection, and ranging
DSM	Digital surface model
DTM	Digital terrain model
FRA	Flood risk assessment
ReFH2.3	Revitalised
BFIHOST19	Baseflow Index, Hydrology of soil types
SAAR	Standard Annual Average rainfall
CC	Climate change
GEV	General Extreme value
GL	Generalised Logistic
KAP3	Kappa 3
QMED	Median peak flow that has a return period of approximately 2 years
FEH	Flood estimation handbook
BGS	British Geological Survey
NRW	Natural Resources Wales
OS	Ordnance Survey
CBA	Chris Burnett Associates
Soilscape	Soil landscapes of England and Wales [Cranfield Soil and AgriFood Institute]



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1 Introduction

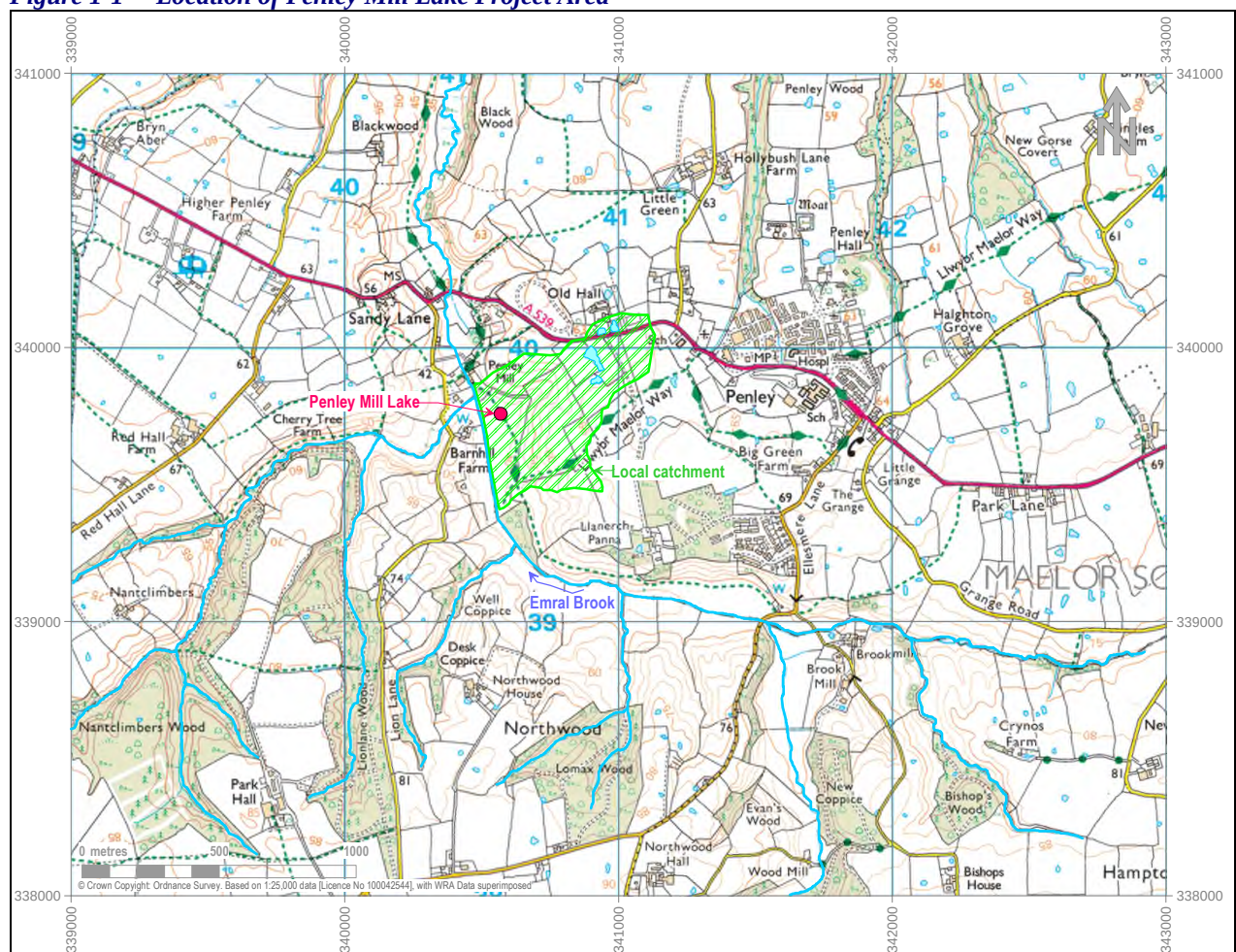
1-1 Planning Application

This report has been produced for Andrew Aird of Groundwork and Leisure Services Ltd and provides a flood consequence assessment [FCA] for construction of a new lake, wetland and wildflower meadow in the floodplain south of Penley Mill, Lion Lane, Penley, Wrexham, LL13 0LY.

The planning application, P/2021/0107, was validated on 9th March 2021, and Natural Resources Wales [NRW] commented on the proposals in two letters dated 10th March 2021, and 3rd September 2021. This FCA addresses the concerns raised by NRW with respect to flood risk, transcribed in [Appendix A](#).

The proposed project area is located in the catchment of the Emral Brook which has a catchment of 64.5 km² at Worthenbury where it joins a similar size stream called the Wych Brook. Roughly 2 km upstream of Worthenbury, the Emral Brook splits into two roughly equal sub-catchments of 28.7 km² [Emral Brook] and 28.3 km² [Cumbers Brook]. The location of the project area is shown in [Figure 1-1](#).

Figure 1-1 Location of Penley Mill Lake Project Area



1-2 Proposed New Physical Features

The project consists of the construction of a new lake in the floodplain adjacent to a winding reach of Emral Brook and immediately upstream of a tributary coming from Nantclimbers Wood. The lake will be formed by excavation of soil down to a maximum depth of 3 m bgl. The soil arising from the excavation will be deposited as a low mound with micro-relief and surface area of 5,402 m² at the southern end of the floodplain, outside the maximum flood extents of Emral Brook. The floodplain field where work will be carried out

[project site] covers an area of 53,224 m² of which the lake will occupy 8,439 m² with a volume of 0.012 Mm³ at top water level [38 m OD].

Runoff from the local catchment of 0.14 km² will be used to supplement water in the lake, as well as groundwater and inundation from Emral Brook when the stream is in flood. Following discussion between the client and NRW, planned outlets from the lake were removed from the design. However, it is the opinion of the consultant that protection of the north-west lake margin should be included where outflow occurs, otherwise erosion is likely to occur on the downstream end of the lake, when floodwater or local inflow increases the hydraulic gradient from one end to the other of the lake.

The old mill race passes along the eastern side of the floodplain, but it is no longer in use.

1-3 Scope of Work

The assessment identifies risk and consequence of flooding that may occur in the project area and which may affect both the locality and other areas downstream, to show that they can be managed to an acceptable level. This includes an analysis of the lake and floodplain, and areas of increased ground elevation resulting from re-moulding of the land surface to form a wildflower meadow.

This FCA is proportionate to the scale of the lake and meadow proposals.

The proposed formation of a new lake and wildflower meadow to enhance the landscape and biodiversity of the area is in itself an environmentally positive project, and therefore unlike development of land for buildings and infrastructure, which tend to be the focus of many FCAs. The lake itself will lower floodplain level and increase flood storage, thereby reducing downstream flooding; this is another positive element of the project. Consequently, the main focus of the FCA will be to demonstrate that any increase in ground level which results from the re-distribution of soil arising from the excavation lies outside the area of predicted maximum flooding.

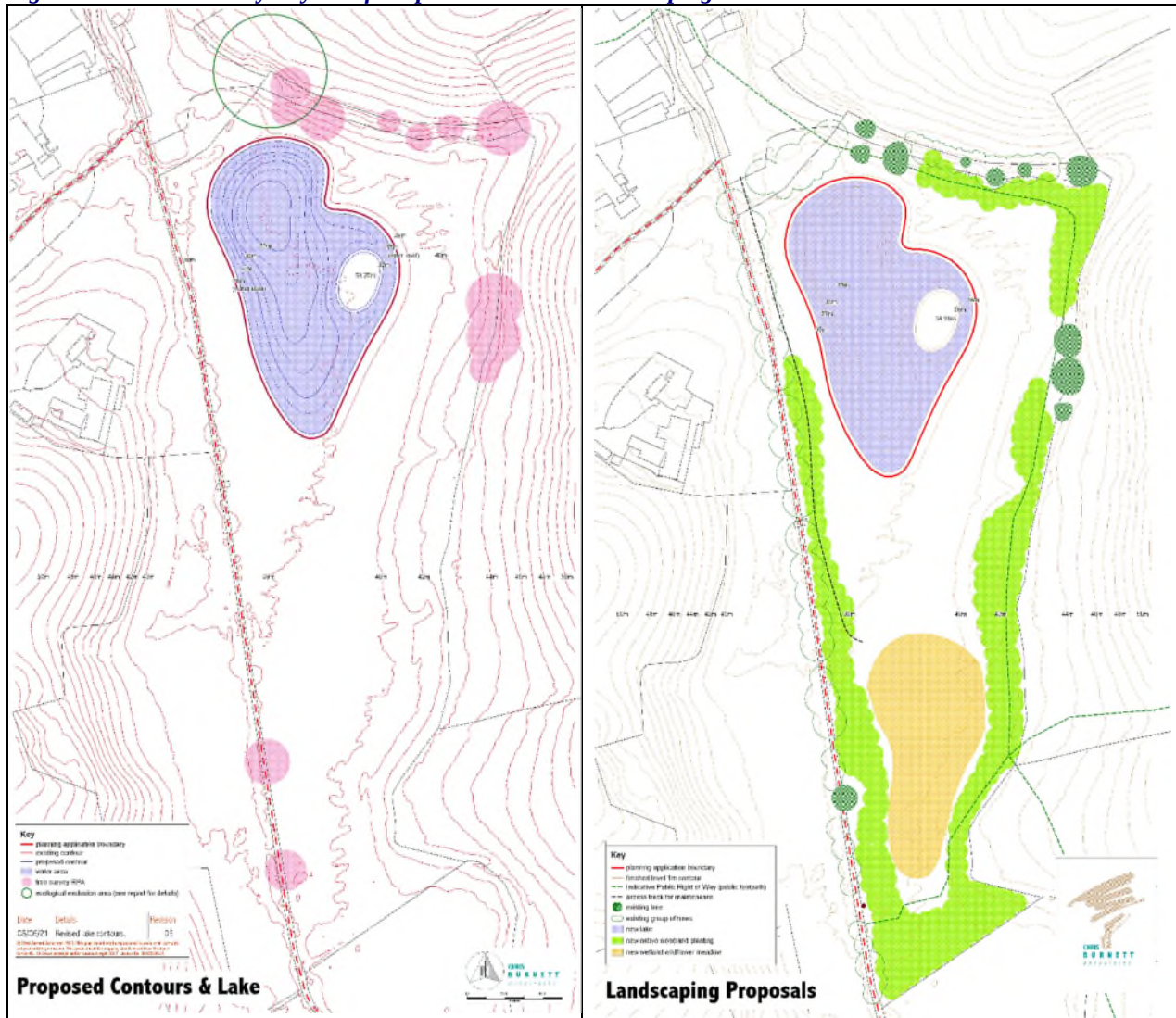
The assessment includes fluvial and pluvial flooding, as well as an analysis of local groundwater.

1-4 Landscape Design

Outline design of the lake and associated meadow was completed by Chris Burnett Associates in Jan-2021, and revised in Jun-2021. Those details are shown in [Figure 1-2](#).

These plans show the position of the proposed lake in the northern sector of the field, and the distribution of excavated material in the southern sector of the floodplain. These outlines have been used in the remainder of this report.

The landscape plan shows an access track between the stream and lake through ground which is currently very boggy.

Figure 1-2 Preliminary Layout of Proposed Lake and Landscaping Scheme

Extracts from Chris Burnett Assoc Drawings: PMLW20.05 rev-05, 8-Jun-2021; PMLW20.07 rev-03, 8-Jun-2021

2 Flood Hydrology

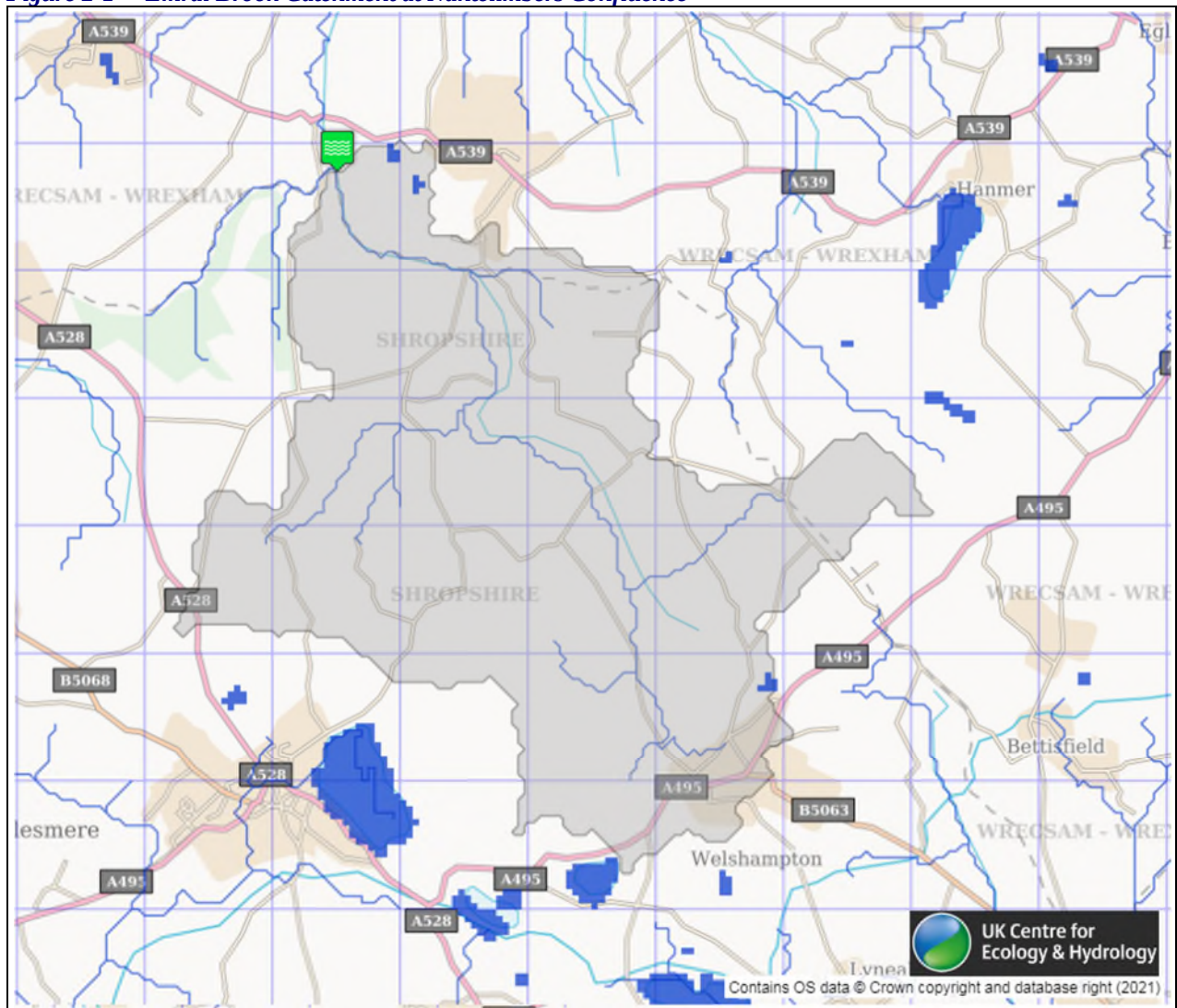
2-1 Emral Brook Catchment

2-1-1 FEH Catchment Characteristics

The project floodplain lies adjacent to Emral Brook, just upstream of its confluence with a tributary from Nantclimbers Wood, at which point it drains an area of 15.37 km², as shown in Figure 2-1. The catchment is essentially rural except for the village of Welshampton which sits on the headwaters. After Penley Mill, Emral Brook continues to flow north for 10.9 km where it joins the Wych Brook to form Worthenbury Brook, a tributary of the River Dee, some 8 km east of Wrexham. At the Dee confluence, Worthenbury Brook has a catchment area of 153 km² [FEH data].

The Emral Brook catchment area was defined using the FEH web-service and FEH data are summarised in Appendix B.

Figure 2-1 Emral Brook Catchment at Nantclimbers Confluence



FEH web-service.

The Emral Brook valley has a well-developed corridor of alluvium, which is sandier upstream of the proposed Penley Mill lake, and more clay-dominant downstream, primarily resulting from the distribution of glacio-fluvial deposits and boulder clay.

2-1-2 Rainfall and Catchment Descriptors

The rainfall characteristics of the catchment were derived using FEH, which shows a mean annual rainfall [SAAR] of 694 mm for the period, 1961-2010, which has decreased from 743 mm for the period, 1941-70.

The FEH catchment descriptors are summarised in [Appendix B-1](#).

2-1-3 Peak Flood Discharge

WINFAP-5 software was used to estimate peak flood discharge in the Emral Brook for a range of return periods at the Penley Mill Nantclimmers confluence. The simulation is based on use of the FEH catchment descriptors and application of the Pooled & QMED statistical method. This included options for FEH Enhanced Single Site (ESS) analysis.

The results are included in [Appendix B-2](#), and summarised in [Table 2-1](#). This indicates that the T1000 flood is of the order of 12.39 to 12.46 m³/s., while more-frequently-occurring floods which would be used to delineate the functional floodplain are of the order of 5.5 to 6.9 m³/s.

Table 2-1 FEH Peak Flood Discharge Estimates for a Range of Frequencies

Return period [T] years	Rural			Urban		
	GL (m ³ /s)	GEV (m ³ /s)	KAP3 (m ³ /s)	GL (m ³ /s)	GEV (m ³ /s)	KAP3 (m ³ /s)
T 30	5.457	5.529	5.507	5.481	5.553	5.531
T 75	6.828	6.657	6.779	6.859	6.688	6.810
T 200	8.596	7.925	8.321	8.638	7.966	8.362
T 1000	12.388	10.164	11.349	12.456	10.224	11.414

2-1-4 Flood Levels

Estimated flood levels in the floodplain where the proposed lake would be constructed, have been assessed using a combination of methods.

The proposed project does not involve construction of buildings or other forms of urban or agricultural development which would require precise elevation values of peak floodwater across the site to establish floor levels and impact of structures: the need for detailed hydraulic modelling has therefore been discounted.

Firstly, the flood extents shown on the NRW flood maps were digitally sampled and then mapped to the LiDAR DTM using a GIS-linked algorithm, so that the flood outlines could be overlaid on the limits of the proposed lake and mound of arisings. This was done for the 200-year [T200] and 1000-year [T1000] extents as shown in [Figure 2-2](#). This procedure resulted in estimated T200 and T1000 flood levels of 38.45 and 38.6 m OD at the northern end of the lake. These flood levels increase respectively to 38.6 and 38.8 m OD at the southern end of the lake. The levels were then compared with FEH predictions of peak stream discharge derived using FEH rainfall and catchment characteristics for Emral Brook, converted into water levels using LiDAR DTM cross-sections and the Manning equation.

It can be seen that Emral Brook passes through a relatively incised reach upstream of the old mill diversion weir, and downstream flood flows expand across the floodplain, notably encroaching on the proposed lake area. Another important point is the constriction of the floodplain about 30 m downstream of the proposed lake, where the flood corridor averaging 50-60 m wide is reduced to a width of 26 m. Velocities will therefore increase at the outlet from the lake and adjacent floodplain. More detailed flood and lake mapping is provided in [Appendix B](#).

The Manning equation was used to derive the peak flood estimates summarised in [Table 2-2](#) where a roughness coefficient varying from 0.060 to 0.080 calibrates well with the FEH estimates, while varying stream and floodplain gradient to simulate hydraulic gradient. The T1000 wetted perimeter produced a peak flood estimate of 12.53 m³/s, which compares reasonably with the 12.46 m³/s estimate from the FEH statistical analysis, using floodplain gradient of 0.0041 and roughness coefficient of 0.087. The T75 section produced a peak flood estimate of 6.82 m³/s, [compared with the FEH estimate of 6.86 m³/s] estimate using stream gradient of 0.0052 and roughness coefficient of 0.050, which would usually be used to define the

extent of functional floodplain. This has been mapped in the lake area from a flood level of 38.46 m OD in the lake south to 38.38 m OD in the lake NW corner. The importance of doing this was to determine to what extent more frequently-occurring floods will affect the proposed lake, described in [Section 3-6](#).

Figure 2-2 Emral Brook Flood Extents at Penley Mill

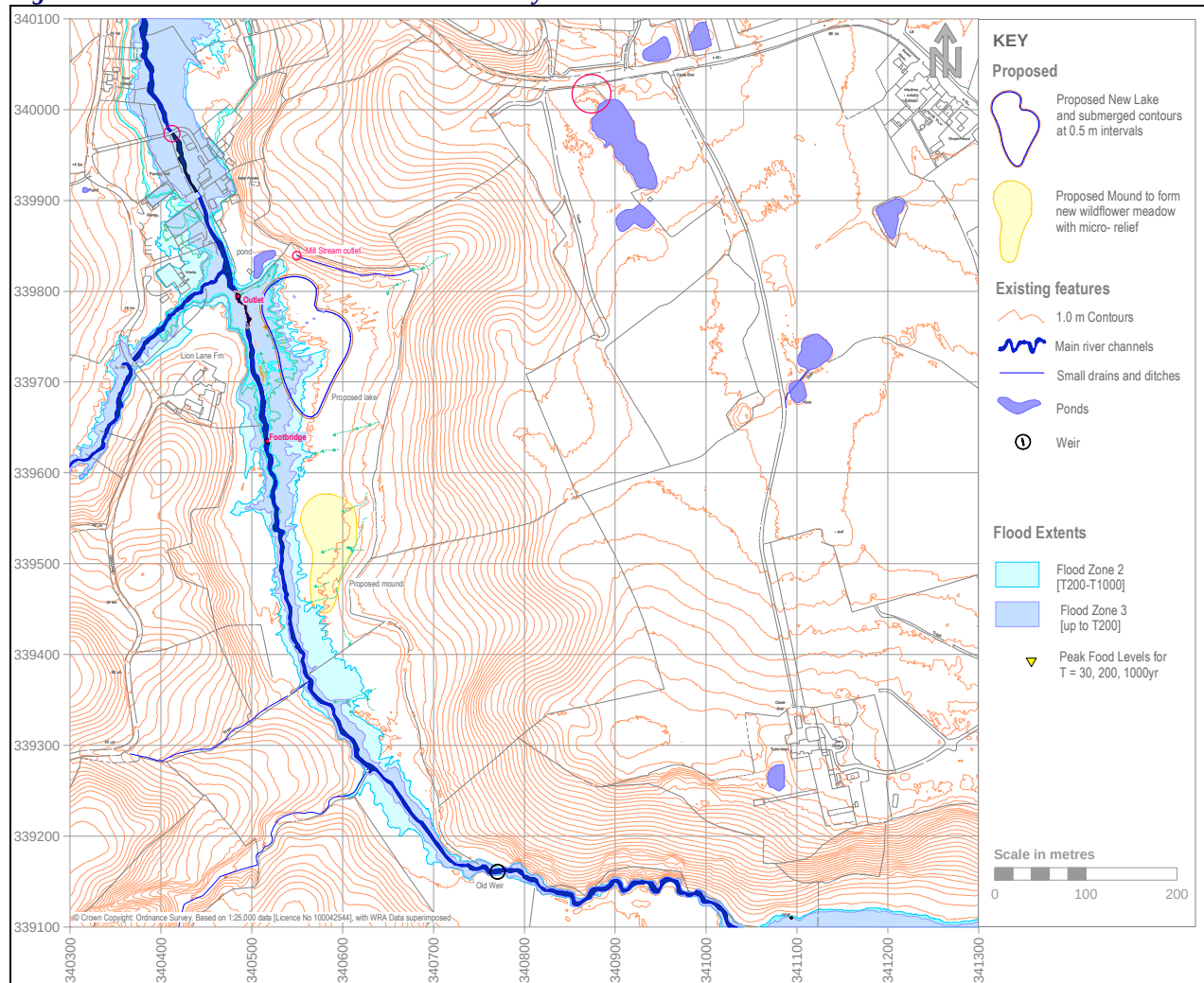


Table 2-2 Peak Flow Estimates using Manning Equation

Flood Level	XS No	Gradient	Area m ²	Wetted perimeter	Hydraulic radius	Roughness coefficient	Velocity m/s	Discharge m ³ /s	FEH Peak flow
m OD		i	A	P	A/P	n	V	Q	m ³ /s
lake mid-way using floodplain gradient									
38.46	xs3-75	0.00410	14.5703	49.7216	0.2930	0.060	0.47	6.86	6.86
38.53	xs3-200	0.00410	18.0089	50.5349	0.3564	0.067	0.48	8.65	8.64
38.70	xs3-1000	0.00410	27.1873	54.8434	0.4957	0.087	0.46	12.53	12.456
lake north using variable gradient									
38.38	xs1-T75	0.0052	11.5977	45.8706	0.2528	0.050	0.58	6.69	6.86
38.45	xs-T200	0.0034	14.6573	46.9088	0.3125	0.046	0.58	8.56	8.64
38.60	xs1-T1000	0.0034	21.9555	51.3196	0.4278	0.060	0.55	12.11	12.456
lake mid-way using mean stream-bed gradient									
38.46	xs3-75	0.0034	14.5703	49.7216	0.2930	0.068	0.47	6.82	6.86
38.53	xs3-200	0.0034	18.0089	50.5349	0.3564	0.061	0.48	8.65	8.64
38.70	xs3-1000	0.0034	27.1873	54.8434	0.4957	0.080	0.46	12.41	12.456

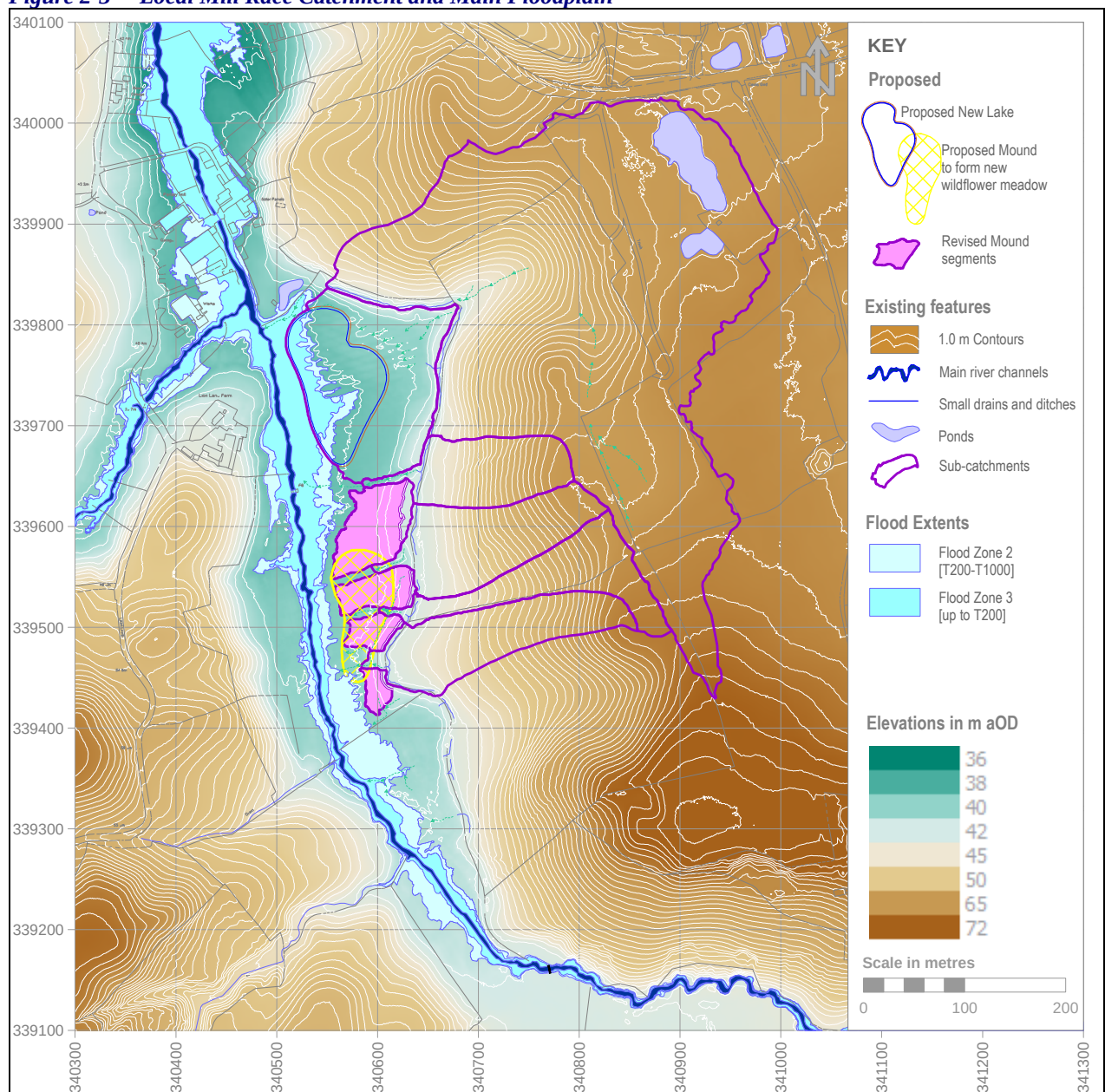
2-2 Local Runoff captured behind the Millrace Bund

The mill stream is a defunct physical feature of the landscape, but the bund still has sufficient definition to divert and focus local overland flow, when it occurs. The neighbouring fields uphill are cropped with mangel wurzel, as well as the floodplain south of Llanerch Panna. The old diversion weir was removed at some time after 1954, but the channel becomes much narrower at the old weir site.

The local runoff sub-catchments feeding into the old mill stream channel has been based on LiDAR and reconnaissance, and shown in [Figure 2-3](#).

Water from the old diversion weir some 810 m upstream of the mill, followed a bunded channel along the line of the contour, falling from an approximate elevation of 45 m OD at the offtake down to 42 m OD at the mill. Most of this old channel [now a dry ditch for most of the time, choked with vegetation] lies on the opposite side of the boundary fence, while the bund is well within the client's property. Historically, water flowed down the millrace into an elongated pond bunded at considerable height above the mill. This pond had an overflow which discharged into a channel just north of the proposed lake. The channel is now a large damp ditch choked with vegetation, which descends to the Emral Brook.

Figure 2-3 Local Mill Race Catchment and Main Floodplain

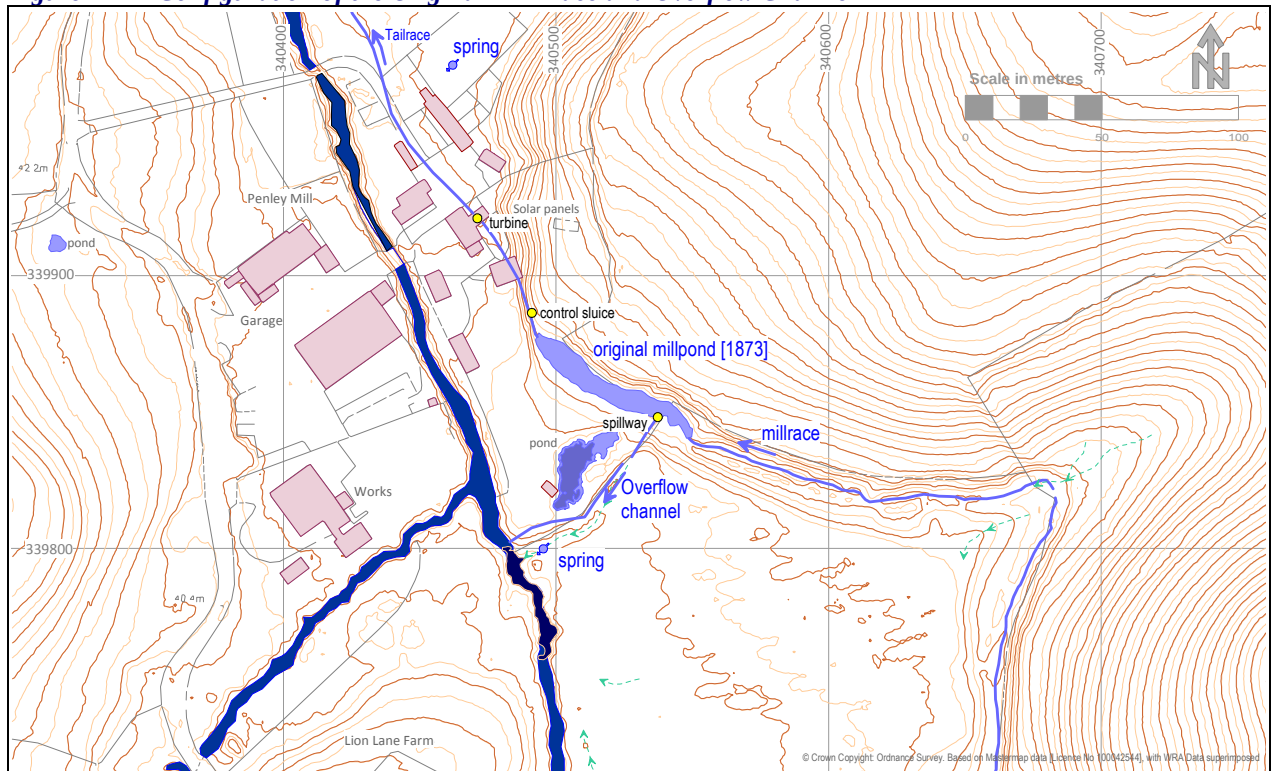


A new ornamental pond has been built on the north side of this old overflow channel, but does not seem to be connected. However, there is a prominent spring in the old overflow channel some 8 m back from the stream margin, which discharged of the order of 2-3 l/s at the time of survey [19 November].

This spring appears at an elevation of 37.4 m OD, over 2 m below adjacent ground level of 39.6 m OD. With the pond water level at 39.3 m OD and no visible outlet, it is likely that the spring is fed by infiltration through the pond bottom and local groundwater.

This provides further confirmation of the movement of groundwater underneath the clay alluvium, which will be discussed later. The historical and existing features are shown in [Figure 2-4](#), based on 1873 OS mapping.

Figure 2-4 Configuration of the Original Mill Race and Overflow Channel

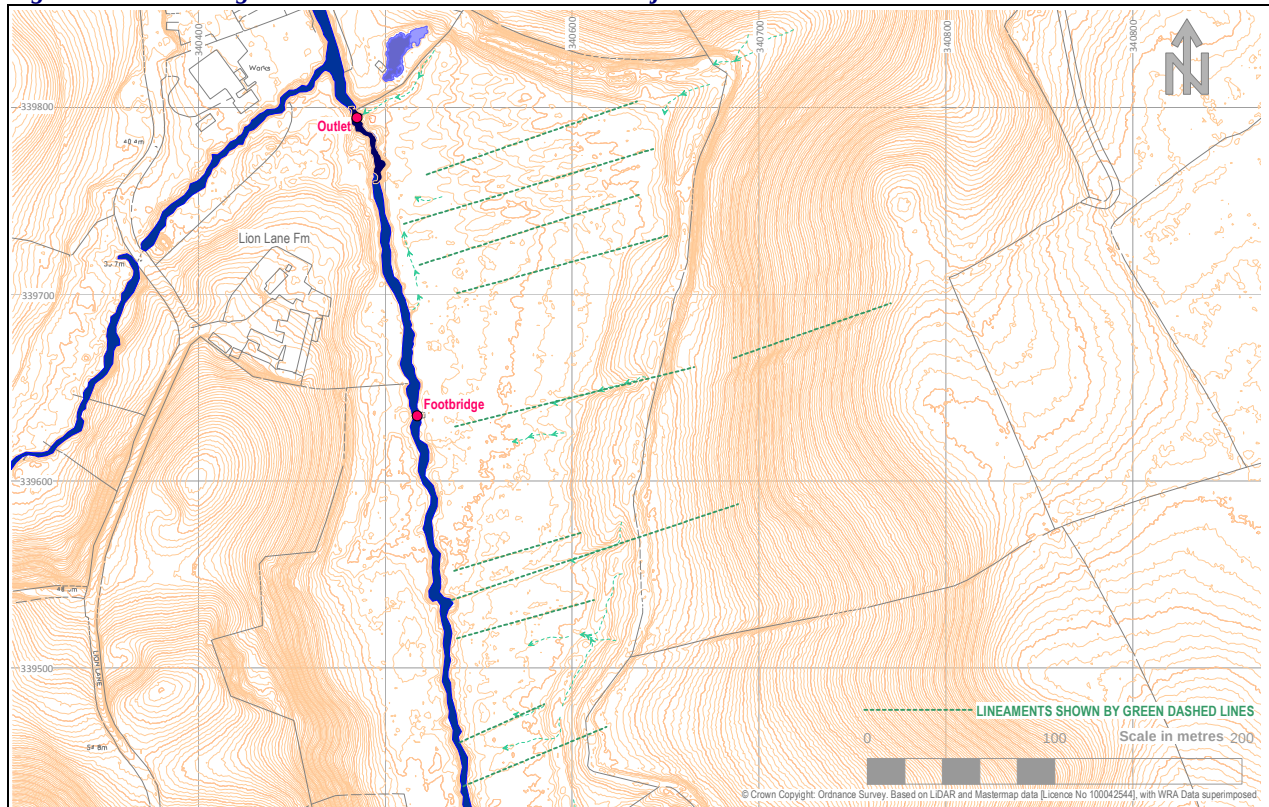


An important feature of the millrace bund and local runoff is the existence of breakthrough points in the earth embankment which are aligned across the floodplain and appear to feed areas of marshy grassland. These drainage features are only present to the south of the proposed lake and cross the area of proposed spoil disposal to form the wildflower meadow. It will be important to maintain these features during mound construction, and have been referenced as micro-relief.

Although the drainage breakthroughs are present south of the proposed lake, these drainage lines follow a series of lineaments which are present across the whole floodplain orientated North 75° East. There appears to be no geological explanation for these features so they may reflect historical practices in this field. They are shown in [Figure 2-5](#) and their main importance is impact on runoff and feed into the marshy areas where water ponds on the clay surface of the floodplain.

The various sub-catchment areas all add up to a contributing area of 0.19 km² as follows:

• Millrace - breakthrough drainage line 1	10030 m ²	0.0100 km ²
• Millrace - breakthrough drainage line 2	13336	0.0133
• Millrace - breakthrough drainage line 3	10638	0.0106
• Millrace - breakthrough drainage line 4	13033	0.0130
• Proposed lake catchment upstream of millrace	120256	0.1203
• Lake residual area downstream of millrace	22284	0.0223

Figure 2-5 Drainage Control and Lineaments in the Project Area

3 Lake and Floodplain Characteristics

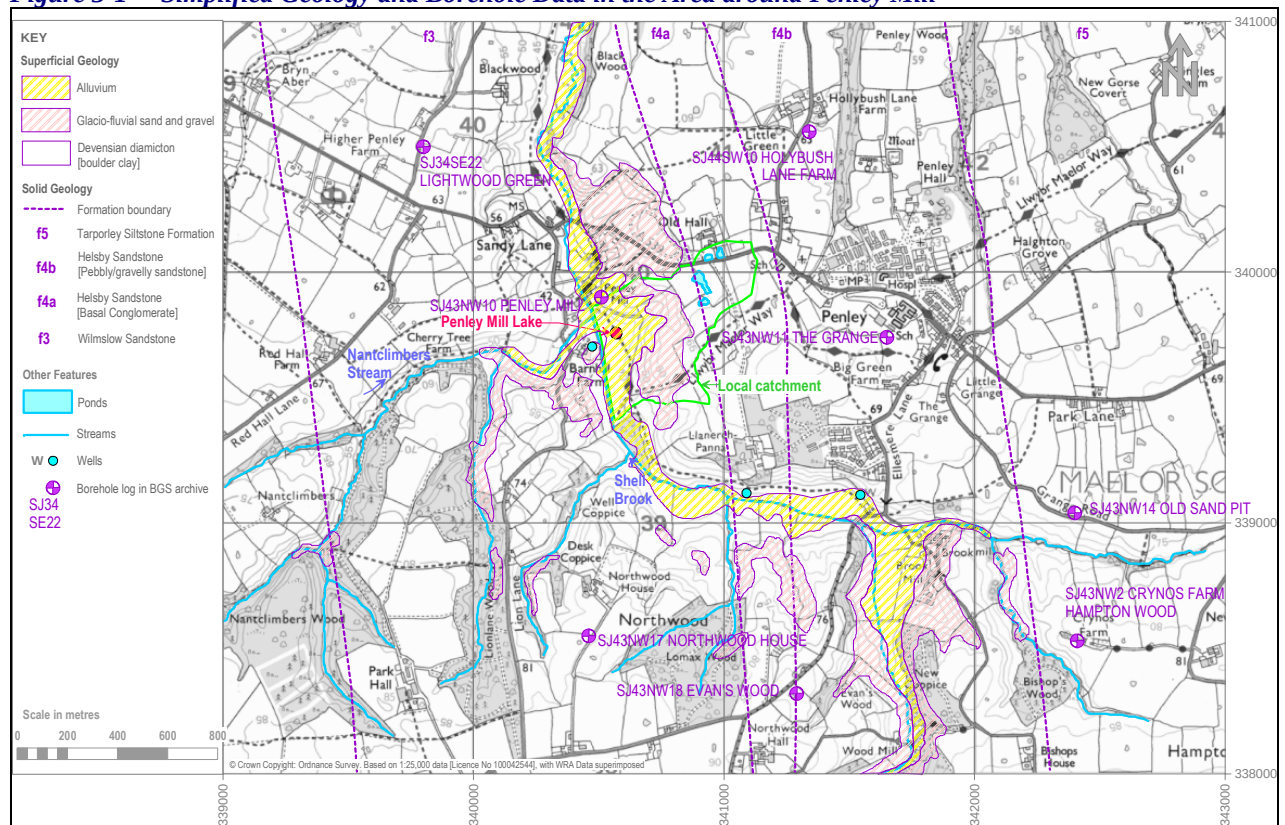
3-1 Geology

The Penley Mill area is characterised by extensive sheets of glacial and glacio-fluvial deposits overlying the Wilmslow Sandstone Formation [Triassic], which is classified as a principal aquifer. In the Emral Brook valley bottom, alluvial deposits consisting of clay, silt, sand and gravel, overlie the glacial deposits, and at Penley Mill, significant outcrops of Devensian glacio-fluvial deposits are found, which are much more permeable, consisting of sand and gravel, and these deposits have been quarried in the land due west of Old Hall. The old sand pit has since been reinstated and now has an ovoid-shaped “gallop” track. This formation has important considerations for the hydrology of the proposed lake.

The higher ground in the area is generally covered in Devensian diamicton deposits consisting of large boulders and rock fragments in a clay matrix. There is a large number of ponds on this clay surface.

At depth, the solid geology is dipping eastwards into the Shropshire syncline with a roughly north-south strike-line, and the Wilmslow Sandstone underlying Penley Mill gives way to the conglomeratic sandstone of the basal part of the Helsby Formation, eastwards, between the project site hillside and Penley village. The local geology and borehole data sites are shown in Figure 3-1.

Figure 3-1 Simplified Geology and Borehole Data in the Area around Penley Mill



3-2 Soils

Soils reflect the geology to a large extent. Over the glacial till, and alluvial deposits downstream of the proposed Penley Mill lake, the ground is dominated by slowly permeable, seasonally wet, slightly acid but base-rich loamy and clayey soils [Soilscape 18]. These areas typically have seasonally wet pastures with woodlands, and generate overland flow draining to the stream network.

In contrast, the glacio-fluvial sand and gravels develop free-draining, slightly acid, loamy soils, characterised by neutral and acid pastures with deciduous woodland or bracken and gorse on higher ground [Soilscape 6].