



FLOOD RISK AND DRAINAGE ASSESSMENT

Cleator Mill, Proposed Residential Development, Flood Risk Assessment.

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CONFIDENTIALITY STATEMENT

This report is addressed to and may be relied upon by the following:

Gleeson Regeneration Ltd
Rural Enterprise Centre
Redhills
Penrith
Cumbria
CA11 0DT

This report has been prepared for the sole use and reliance of the above-named parties. This report shall not be relied upon or transferred to any other parties without the express written authorisation of RWO Associates Limited. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party.

DOCUMENT HISTORY

VERSION	PURPOSE/DESCRIPTION	DATE
1	Draft Issue – for client comment	04.11.2020
2	Amended following Environment Agency comments	12.07.2021
3	Amended following addition flood modelling, LLFA & EA comments.	31.08.2022
4	Updated to suit the revised layout and unnamed watercourse flood modelling.	21.06.2023
5	Site developable area amended and risk assessed for new area.	28.11.2023
6	Modelling revised to consider both unnamed watercourse and River Ehen combined.	09.11.2024

1.0 EXECUTIVE SUMMARY

This assessment has looked at the implications of the proposed Residential developments in relation to flood risk.

The proposed development site is shown as being in Flood Zone 1. 2 & 3a on the Environment Agency flood maps. When reviewing the defended flood modelling undertaken by the Environment Agency the site is afforded protection for all events up to and including the 1:200 year return period.

The flow rates and water levels for varying events have been considered including the upper central and higher and flow rates are comparable to the 1:1000 year return period, giving a clear indication of potential water levels on the site when looking at the modelled results.

It is proposed to only develop the site outside of the 1:1000yr modelled flood level. The Rivier Ehen and Unnamed Watercourse have been modelled as per the request of the Environment Agency, with the modelling confirming the area of site which is not impacted by flood waters and therefore classified as Flood Zone 1.

The Environment Agency surface water flood maps have been reviewed against the topography with flows shown coming over the site in a low-risk event. When reviewing the contours and local topography we believe that surface water flows would follow the road, given the kerb phase and raised levels to the site on the boundary as opposed to run straight across the site. As such surface water overland flow can be managed with the route maintained around the perimeter of the development site. This is further confirmed by the overland flows from the unnamed watercourse and the route that these flows can be seen following.

Safe access and egress have been established via the new proposed access road onto the A5086. The overland flood flow routes do not impede the proposed access/egress for the development's new entrance.

The Environment Agency does not provide a Flood Warning Service for Cleator. It is noted that the site is covered by the River Ehen, Calder, Irt and Esk Flood Alert areas, it would therefore be recommended this be included within the homeowner's packs.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment required to ensure the River Ehen water quality remains protected.

Any potential impact of the development can be adequately addressed by good drainage design.

2.0 INTRODUCTION

RWO Associates Ltd (RWO) has been instructed by Gleeson Regeneration to prepare a Flood Risk Assessment to support a planning application for a proposed residential development at Cleator in Cumbria.

This assessment is reviewing the available information which includes;

- The Strategic Flood Risk Assessment.
- Environment Agency Flood Maps, including flood modelling information (River Ehen 2015 model, released in 2016)
- AEG4648_CA23_Cleator Moor_O3_TN (Flood modelling of the River Ehen and unnamed watercourse).

This site is covered by a Strategic Flood Risk Assessment (by Jacobs dated 2007 and published on the local authority website [Strategic Flood Risk Assessment | Copeland Borough Council](#)) commissioned by Copeland Borough Council. This, more detailed, site-specific Flood Risk Assessment supplements the findings of the Strategic Flood Risk Assessment. It is also covered by the more recent Draft Copeland Borough Council, Level 1 SFRA. For clarity and reference purposes, this report has utilised the latest Draft SFRA dated 2018 to ensure the latest SFRA maps are utilised and considered as part of this FRA.

AEGAEA has been utilised to undertake a Breach Analysis of the existing flood defences located on the North and Eastern boundaries, along with flood modelling of the unnamed watercourse, as requested by the Environment Agency.

The site is currently Greenfield, and the client wishes to create residential development; location plans are included in Appendix A.

This report will review the risks associated with the River Ehen, the unnamed watercourse and other published risks. With the River Ehen and unnamed watercourse having been modelled as per the Environment Agency request. Recommendations as to the developable area and any mitigation requirements will also be made.

3.0 THE SITE

The proposed development site is located to the east of Cleator, about 300m to the south of Cleator Moor and immediately to the west of the Lake District National Park; Figure 1 below shows the site location.



Figure 1 – Site Location (Redline indicates approximate extents)

The River Ehen forms the eastern and southern boundary, with residential dwellings located to the west and north. To the immediate south of the proposed development site is the former Kangol factory, with the building varying in age between the early 19th Century and the 1960s. The original building was a linen mill in the 19th Century. The eastern portion of the site historically had a derelict factory located on it, which has since been demolished and it currently utilised as a Park & Ride. The A5086 is on the north-western boundary of the proposed development site.

4.0 PROPOSED DEVELOPMENT

It is proposed to consider the site for residential development and consider the number of dwellings that can be safely accommodated without increasing flood risk to others or creating a risk for the proposed development. Based upon the available information the extent of land ownership is located in Flood Zone 1, 2 & 3a, it is noted that the latest Environment Agency flood maps for planning identify the development site has flood defences located to the northeast and east. An extract of the strategic flood map can be seen below in Figure 2 (area identified as E8) with the full map included in Appendix B.

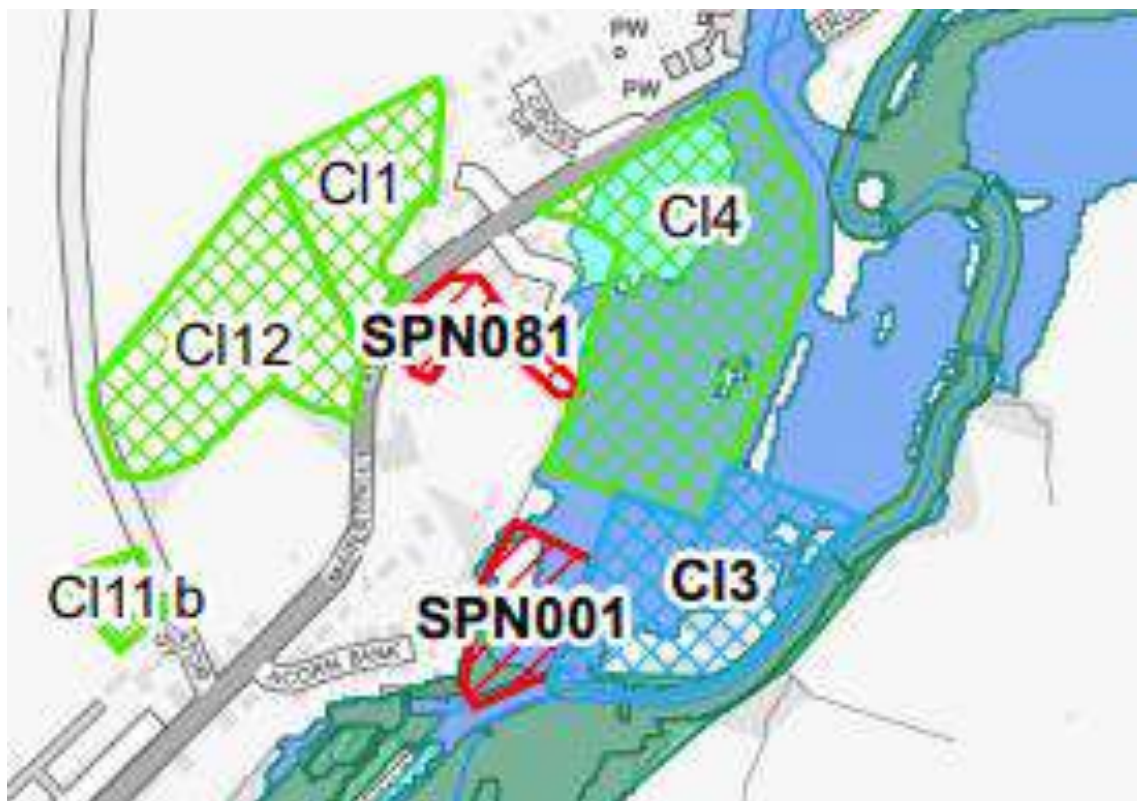


Figure 2 – Draft Copeland SFRA 2018 Extract

As the development site is shown as being located in Flood Zone 1, 2 and 3a with an annual probability of flooding of greater than 1:1000 year, between 1:100 and 1:1000 years and 1:100 years (>1%) , it will therefore be subject to the sequential and exception test in accordance with NPPF Technical Guidance should any development fall within flood zone 3a.

A topographical survey is included in Appendix C, along with site sections through the flood defences with the various flood levels indicated as taken from the Environment Agency Model.

5.0 FLOOD RISK

River Ehen

The site is located adjacent to the River Ehen, to the west, within flood zone 3a and 2 as identified by the Copeland Strategic Flood Risk Assessment, map included in Appendix B. Modelled flood levels have been reviewed based upon the Environment Agency hydraulic modelling with further breach analysis undertaken by AEGAEA on behalf of the developer, it is noted that the required climate change allowance has been amended since the agreement with the Environment Agency, therefore

this has been reviewed separately as an extension to the breach analysis. AEGAEA has utilised the Environment Agency model from 2016, further details noted within the AEGAEA report are included in Appendix E. The unnamed watercourse to the northeast has also been modelled by AEGAEA and this has been included in Appendix E, as a joint assessment of the River Ehen and the unnamed watercourse have been utilised. The Environment Agency modelled flood levels are included below in Table 1.

Cross Section reference	10 Year	25 Year	50 Year	75 Year	100 Year	100+CC Year	200 Year	1000 Year
1896	63.74	63.852	63.898	63.941	63.972	64.029	64.7	64.939
1726	62.013	62.223	62.32	62.42	62.472	62.692	63.383	63.685
1806	63.052	63.284	63.418	63.553	63.621	63.823	63.779	64.135
1606	60.846	61.066	61.219	61.368	61.427	61.658	61.61	62.193
1502	60.275	60.504	60.626	60.744	60.808	61.001	60.953	61.398
1406	59.892	60.118	60.224	60.379	60.451	60.559	60.56	61.039
1299	59.379	59.549	59.64	59.733	59.775	59.912	60.56	61.039
1206	58.826	58.938	58.992	59.044	59.056	59.075	59.071	59.234

Table 1 – Modelled Flood Levels (defended)

Figure 3 below shows the positions of the modelled node cross sections referenced above;

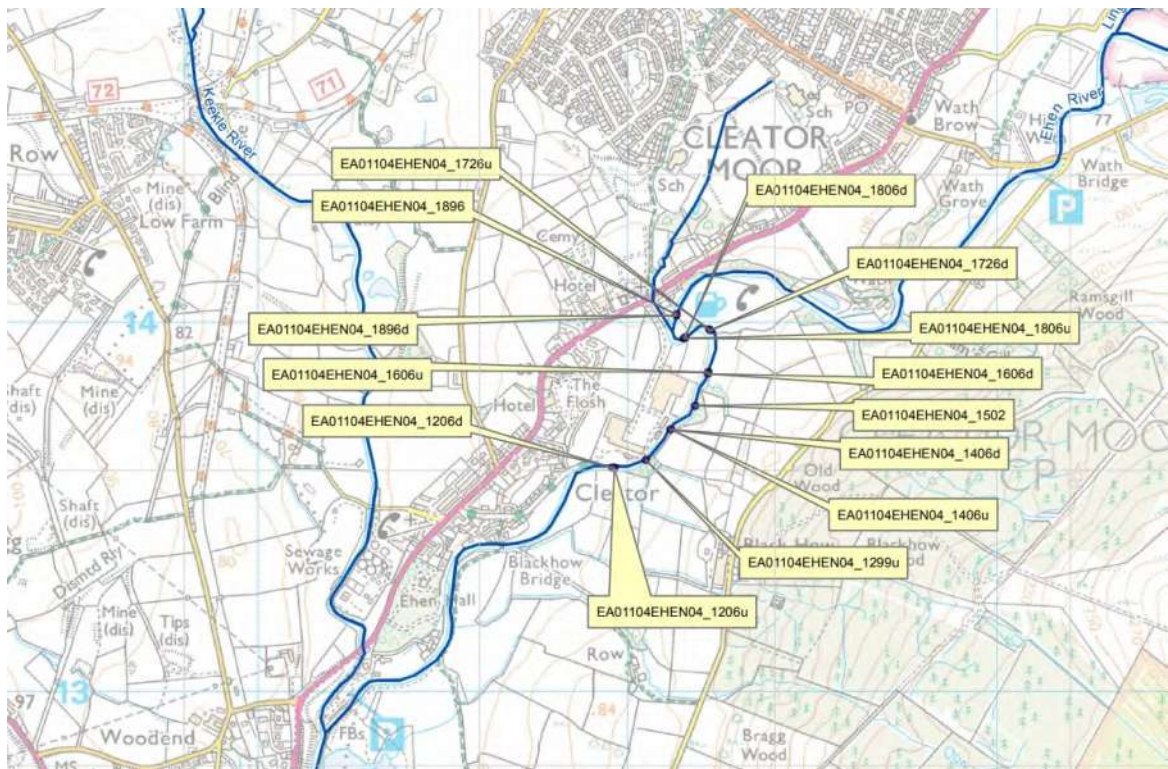


Figure 3 – Modelled Node Locations



Photo 1 – Hard flood defences between 1896 & 1726

The proposed development has engineered hard flood defences to the northeastern extent, downstream of the hard defences, soft earth defences exist continuing north to the extents of the Kangol Factory/premises. These defences afford the site a level of protection to the 1:200-year modelled return period, which is confirmed by the Environment Agency River Ehen model from 2016. The location of the modelled reference points has been cross-referenced against a topographical survey undertaken; this is included in Appendix C; which includes sections showing the flood levels against the existing ground levels. Given the reliance of flood defences RAB Consultants were appointed to update the previous condition survey undertaken, A copy of the report is included in Appendix D.

The survey identifies various works which need undertaken immediately and within 1 year, it is recommended these works are carried out prior to works commencing, the total estimate value is £25,300 for the works as identified in the RAB report (RAB; 2869). It is then recommended that a condition survey be completed every 5 years as part of the management company's duties and the results are shared with the Environment Agency to ensure the flood defences are maintained and any further defects are rectified as part of the Environment Agencies' powers, should the Environment Agency deem that improvement/maintenance works necessary. At the most vulnerable point, on the northern boundary with the River Ehen hard defences are located on the right boundary located between modelled node points 1896 and 1726, as can be seen in Figure 3. The Environment Agency data shows these hard defences are at a 1:200-year standard. Based upon their model and information supplied as part of Product 4. These conditions are generally identified as being condition grade 2, which is a Good state of repair, except for some minor vegetation which is noted as condition grade 3. The vegetation should be dealt with and made good to ensure the asset is in all condition grade 2. The only flood defences graded Poor, condition 4, are located off-site southwest along Kiln Brow and do not impact the proposed development. The flood defences impacting the development site are graded mainly condition 3 and some condition 2, good to fair. As

such none of, the flood defences are graded as poor within the latest condition survey undertaken and included in Appendix D.

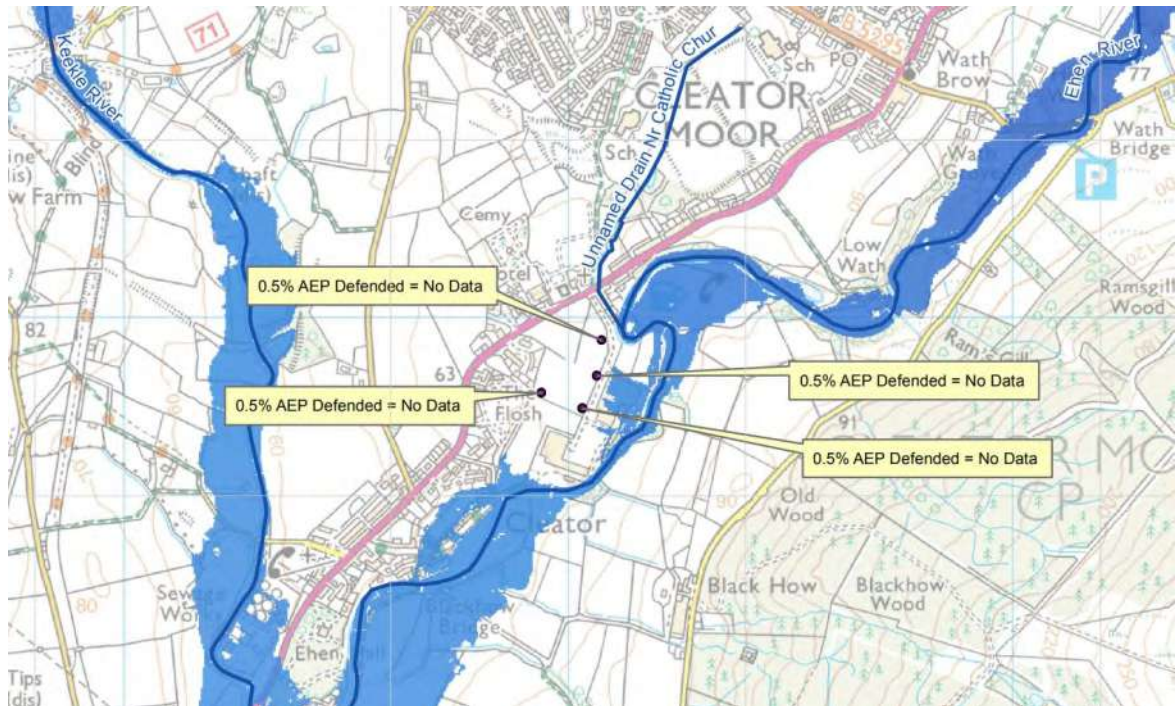


Figure 4 – Extract of Product 4 1:200 Year return period flooding, Defended Scenario

The above extract demonstrates that the site does not flood in the defended scenario when considering the 1 in 200 year turn period from the Environment Agencies modelled flood data. A full suite of Product 4 flood maps is included in Appendix F.

Flood water is shown as breaching the site on the 1 in the 1000 year return period, in the defended scenario impacting approximately 50% of the site as can be seen in the below extract;

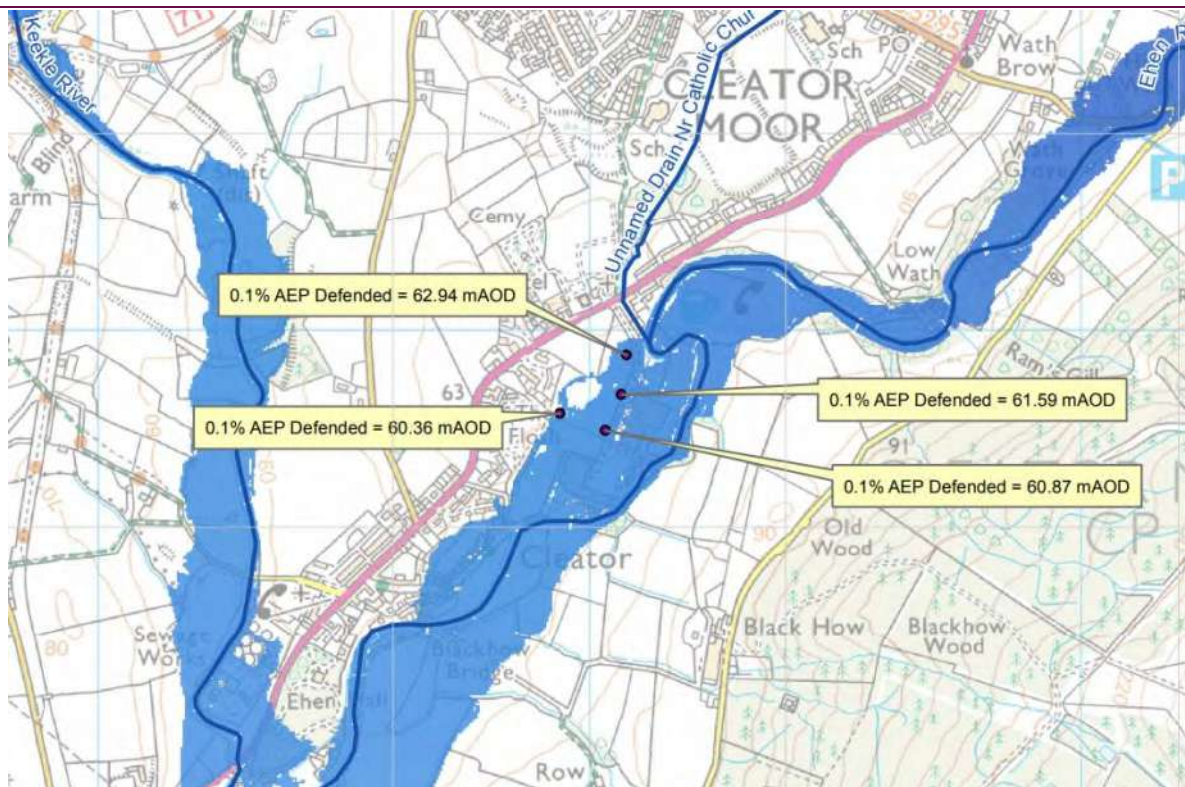


Figure 5 – Extract of Product 4 1:1000 Year return period flooding. Defended Scenario

Based upon the defended scenario the site is afforded protection to an equivalent standard as being located Flood Zone 2.

To assess the flood risk associated with the proposed development site climate change needs assessing under the Environment Agency guidance for Southwest Lakes Management Catchment with a 30% central allowance requiring consideration.

The flood modelling undertaken by AEGAEA includes the relevant climate change requirements of 30%, giving the modelling by AEGAEA a more accurate position than that of the Environment Agency Flood Maps.

Flood History

The fact flood defences have been formed along the boundary with the River Ehen suggests a historic flooding problem. It is understood the flood defences in their current form were constructed in 1978 by English Industrial Estates.

It is noted that the Copeland SFRA states there was some flooding from the River Ehen that caused damage to the factory in the autumn of 2000. A previously prepared FRA noted that the site warden had been interviewed and could not recall any flooding in his 15 years, this was in March 2010. As such if any flooding did occur or to what extent it is unknown. It was noted during our site walkover that outfalls to the River Ehen did not have tidal flaps/non-return valves installed and as such, it may have been possible for waters to back up the onsite drainage system causing localised flooding.

Having reviewed available data and previously prepared reports it is understood during the extensive flooding in Cumbria during 2008 & 2009 this site was not affected.

Critically, when reviewing the Environment Agency's historic flood maps there are no recorded events on the site.

Flood Defence Overtopping

Flood defences afford the site protection from the risk of flooding, as identified in Appendix D, with a condition survey undertaken by Rab Consultants in 2022. The hard flood defences are substantial and appear to be in an operational condition which is confirmed by the independent condition survey, with the hard defences being given a grade of 3 which is defined as being Fair. The soft defences and the riverbank have also been assessed as part of the condition survey, which are also given a grade of 3, confirming they are in Fair condition.

A condition survey undertaken by RAB Consultants, is included in Appendix D.

Based on the condition of the flood defences the overtopping scenario is considered within the River Ehen 2016 flood model with no flooding identifiable for the development site prior to the 0.1% AEP / 1000yr return period.

The RAB Consultants condition survey identifies various works which need undertaken immediately and within 1 year, it is recommended these works are carried out prior to works commencing, the total estimate value is £25,300 for the works as identified in the RAB report (RAB; 2869). It is then recommended that a condition survey be completed every 5 years as part of the management company's duties and the results are shared with the Environment Agency to ensure the flood defences are maintained and any further defects are rectified as part of the Environment Agencies' powers, should the Environment Agency deem that improvement/maintenance works necessary.

The original agreed scope with the Environment Agency did not require overtopping to be considered in relation to FD2320.

Unnamed Watercourse to Northeast

The watercourse to the North East of the development site has been modelled by AEGAEA with the results included in Appendix F. The undamed watercourse does result in overland flows entering the site North West extent with the remainder of the flows being conveyed along the existing road to the east of the development site.

As such it is critical that the development on the boundary extents does not lower level FFL's should be a minimum of 300mm above existing where practicable.

Surface Water Flooding

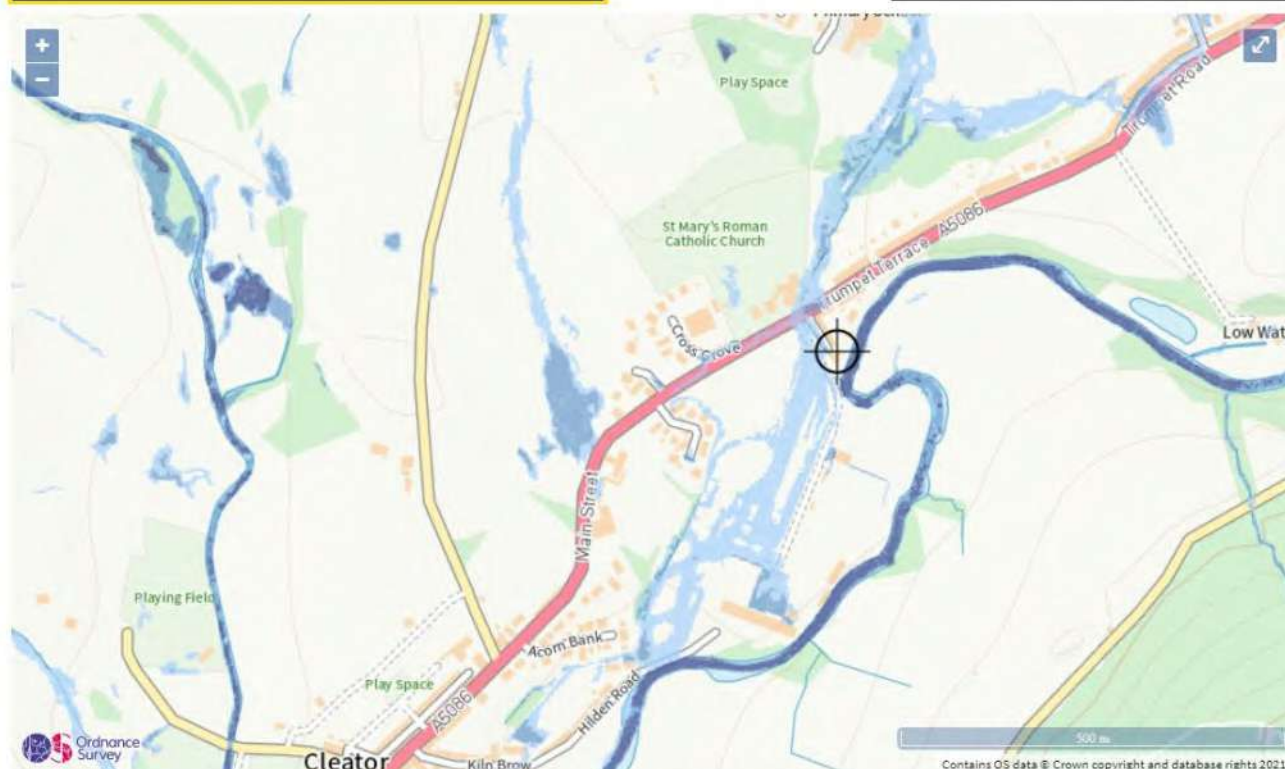
The surface water flood map available on the Environment Agency website (see Figure 7) indicated that part of the site is at risk of flooding due to surface water. The proposed residential development is at low risk of flows being conveyed across the site as identified by the Environment Agencies' own flood maps.

Flood risk

Low risk: depth

Location

Enter a place or postcode



Surface water flood risk: water depth in a low risk scenario

Flood depth (millimetres)

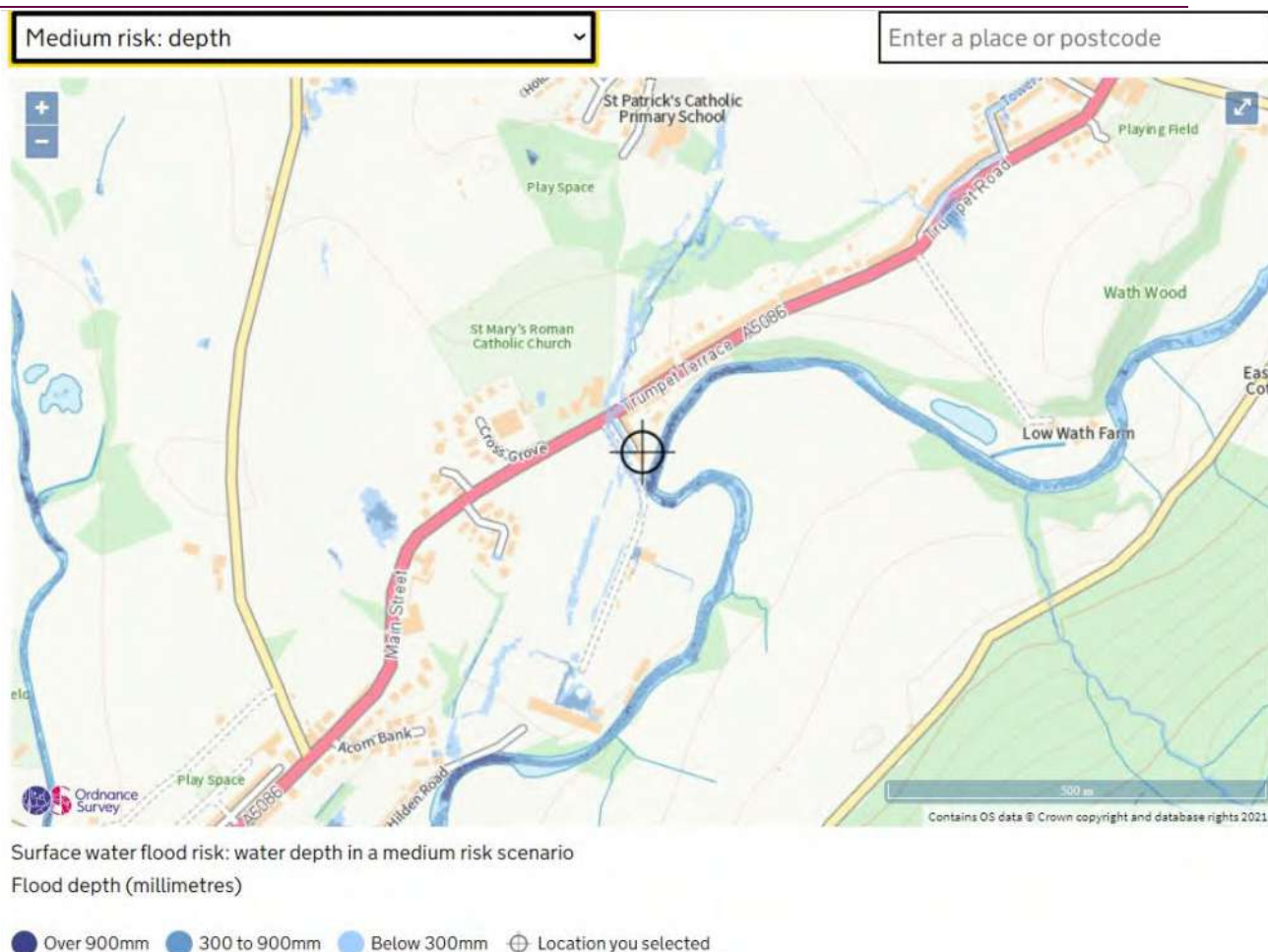
Over 900mm 300 to 900mm Below 300mm Location you selected

Extract 3 – Environment Agency Low-Risk Surface Water flood maps (17.07.2021)

The flow route itself is somewhat questionable given the topography given the kerb face along the road is circa 100mm and the route of flows appears to follow a raised mound as can be seen in picture 2 below;

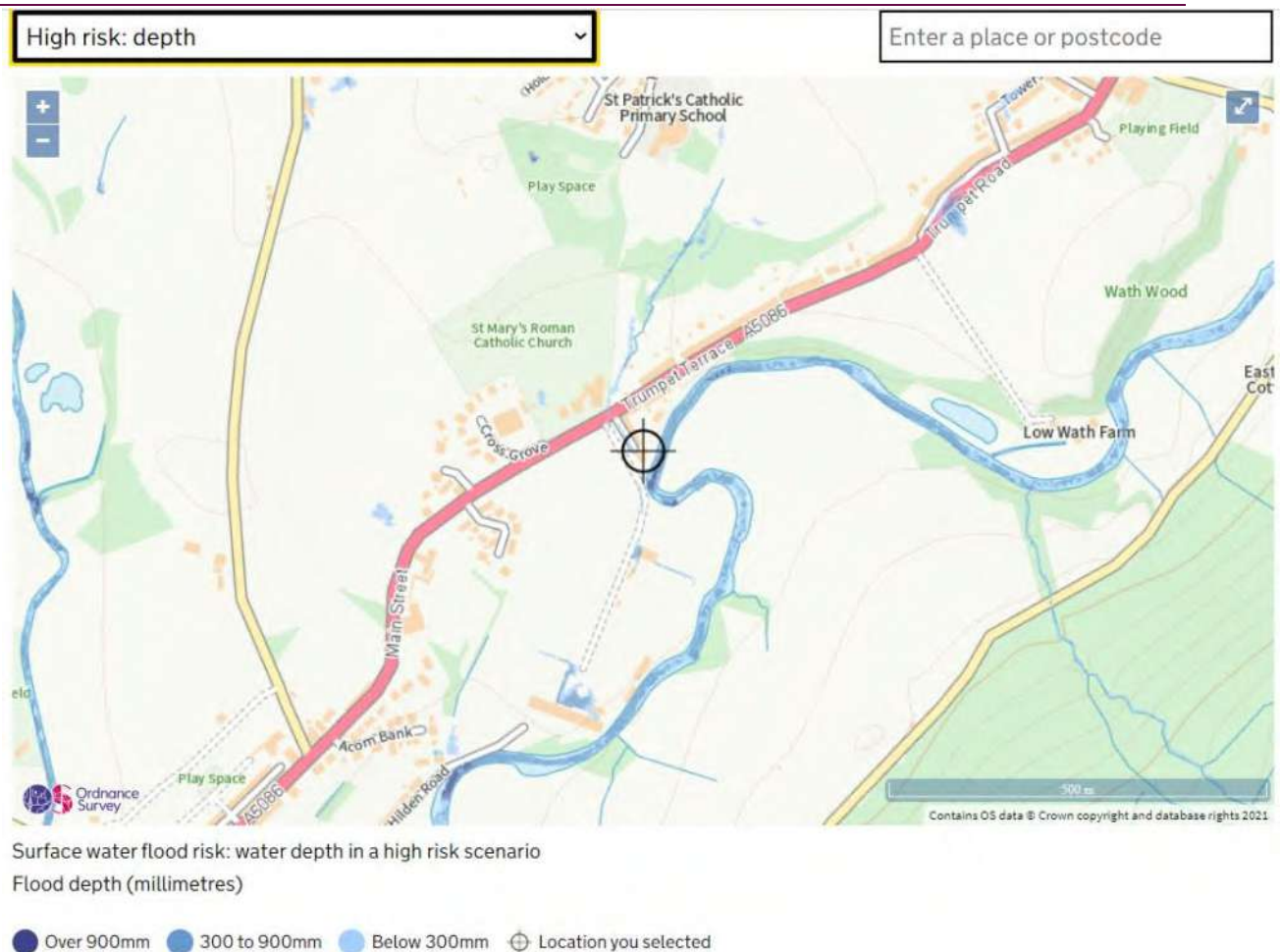


Photo 2 – Raised mound and kerbs along overland flood route



Extract 4 – Environment Agency Medium-Risk Surface Water flood maps (17.07.2021)

The Environment Agency medium flood risk maps demonstrate that no flows are being conveyed over the site and that water appears to be ponding in localised areas.



Extract 5 – Environment Agency High-Risk Surface Water flood maps (17.07.2021)

Extract 5 above highlights that the site is not at a high risk of surface water flooding.

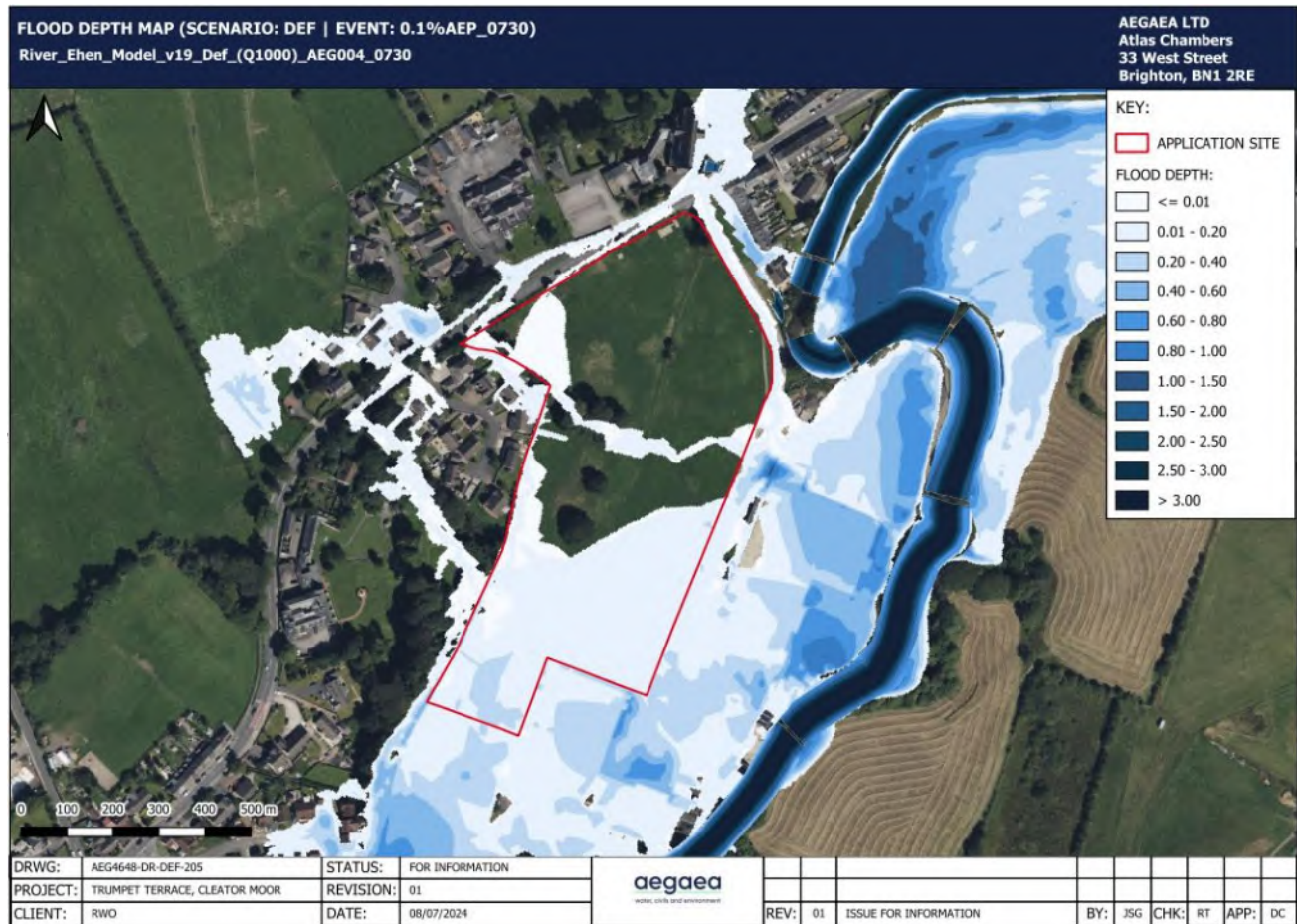
Taking into consideration the modelling of the overland flows from the unnamed watercourse it is considered the surface water flooding would follow the same route with some flows entering the site at the north west extent and the remainder following existing road patterns.

Based on the Environment Agency surface water flood map surface water runoff enters the River Ehen to the South. South-East of the development site. Ground levels should be maintained to ensure this flood route can be utilised in the event of a surface water flooding incident.

6.0 RECOMMENDED DEVELOPMENT AREA

To afford the development of a level of protection against future flooding, it is recommended that dwellings be located only on the land outside of the 0.1% AEP for flooding from the River Ehen and unnamed watercourse. In addition, dwellings should be located at or above existing ground levels to ensure the risk of flooding is not increased.

The proposed area of development has been reviewed for both defended and undefended scenarios, to ensure both are outside of the area at risk of flooding. Given the modelled scenarios identify an area of land outside of the risk of flooding of the 0.1% AEP / 1000yr return period this places a parcel of the land within flood zone 1 and therefore suitable of residential development.



Modelled 0.1% flood return period from River Ehen and Unnamed Watercourse

The area not shown as being flood is proposed to be utilised of the residential development. Placing all proposed dwellings in Flood Zone 1.

7.0 SAFE ACCESS AND EGRESS

As the proposed development site will be serviced by new access onto the A5086 located to the west of the development site, safe access and egress will always be achievable. In the event of a breach occurring in the northern flood defences, the extents of flooding do not impact upon the proposed access.

It is noted that the Environment Agency does not provide a Flood Warning service for the Cleator community. However, taking into consideration the access/egress location and the proposed FFL's, the risk of access/egress being unachievable is deemed low.

The surface water management plan associated with this development site has been considered utilising the following documentation;

- Building Regulations Part H,
- Sewers for Adoption,
- CIRIA C697

8.0 GROUND CONDITIONS

Elliot Environmental have undertaken the Site Investigation associated with the site with Geo-Environmental Engineering undertaking further soil infiltration tests following BRE365. Elliot Environmental reported ground conditions to have Sand and Gravel, which prompted the further investigation works undertaken by Geo Environment Engineering.

Geo-Environmental Engineering received instruction to undertake six soil infiltration tests across the site following BRE365. Figure 2 below shows the locations of the soil infiltration test results.



Figure 2 – Soil Infiltration Test Locations

SA01 recorded Topsoil from 0.00 – 0.40m with Sand & Gravel recorded from 0.40 – 2.00m, soil infiltration test results for this location have been calculated as 6.04665^5 m/s.

SA02 recorded Topsoil from 0.00 – 0.30m, Sand from 0.30 – 0.70m and 0.70 – 2.00m Sand & Gravel, soil infiltration test results for this location have been calculated as 4.97347^5 m/s.

SA03 recorded Topsoil from 0.00 – 0.20m with Sand recorded from 0.20 – 0.80m and Sand & Gravel from 0.80 – 2.00m, soil infiltration test results for this location have been calculated as 2.39464⁻⁵ m/s.

SA04 recorded Topsoil from 0.00 – 0.30m with Sand & Gravel recorded from 0.30 – 1.50m, soil infiltration test results for this location have been calculated as 2.27591⁻⁵ m/s.

SA05 recorded Topsoil from 0.00 – 0.35m with Sand recorded from 0.35 – 0.60m and Sand & Gravel from 0.60 – 2.00m, soil infiltration test results for this location have been calculated as 2.24551⁻⁵ m/s.

SA06 recorded Topsoil from 0.00 – 0.50m with Sand & Gravel recorded from 0.50 – 0.90m and Sand & Gravel from 0.90 – 1.50m, soil infiltration test results for this location have been calculated as 4.22297⁻⁵ m/s.

All of the recorded soil infiltration rates are well within the acceptable rates and as such the site will be suitable to utilise infiltration. Based upon this in accordance with Building Regulations and the CIRIA SuDS train, surface water should discharge into suitably designed soil infiltration drainage systems.

Geo-Environmental Engineering report is included in Appendix J.

9.0 RECEIVING WATERS

The nearest watercourse is the River Ehen, which generally flows in a south-westerly direction. The Ehen is located on the immediate eastern and southern boundaries of the proposed development site. It has been reported that the water quality within the River Ehen is Quality A in the past.

There is also a small issue located in the western boundary, which discharges into the River Ehen. A further small watercourse is shown flowing southwest before sinking or being culverted approximately 75m from the northern end of the site.

The critical issue relating to the surface water run-off from the proposed development site relates to the River Ehen which is classified as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). It is understood that a direct discharge to the River Ehen has been deemed as unacceptable, based upon this it is proposed to utilise infiltration to dispose of surface water as stated in section 8.0 of this report.

10.0 SURFACE WATER MANAGEMENT PLAN

The surface water management plan associated with this development site has been considered utilising the following documentation;

- Building Regulations Part H,
- Sewers for Adoption,
- CIRIA C697

Soil Infiltration

Section 4.0 Ground Conditions, includes a summary of the soil infiltration test results which have been undertaken by Geo-Environmental Engineering in accordance with BRE 365. A total of six tests have been undertaken, a summary of the results is below in table 1.

Soil Infiltration Test	Results
SA01	6.04665 ^s m/s
SA02	4.97347 ^s m/s
SA03	2.39464 ^s m/s
SA04	2.27591 ^s m/s
SA05	2.24551 ^s m/s
SA06	4.22297 ^s m/s

Table 1 – Soil Infiltration Test Results

The above summary of soil infiltration test results demonstrates that soil infiltration can be utilised across the proposed development site.

Based upon the soil infiltration test results the use of soakaways to accommodate the surface water runoff is deemed as viable. It is recommended that further water monitoring be undertaken to ascertain the water level across the proposed development.

11.0 CONCLUSIONS

This assessment has looked at the implications of the proposed Residential developments in relation to flood risk.

The proposed development site is shown as being in Flood Zone 1.2 & 3a on the Environment Agency flood maps. When reviewing the defended flood modelling undertaken by the Environment Agency the site is afforded protection for all events up to and including the 1:200 year return period.

The flow rates and water levels for varying events have been considered including the upper central and higher and flow rates are comparable to the 1:1000 year return period, giving a clear indication of potential water levels on the site when looking at the modelled results.

It is proposed to only develop the site outside of the 1:1000yr modelled flood level. The Rivier Ehen and Unnamed Watercourse have been modelled as per the request of the Environment Agency, with the modelling confirming the area of site which is not impacted by flood waters and therefore classified as Flood Zone 1.

The Environment Agency surface water flood maps have been reviewed against the topography with flows shown coming over the site in a low-risk event. When reviewing the contours and local topography we believe that surface water flows would follow the road, given the kerb phase and raised levels to the site on the boundary as opposed to run straight across the site. As such surface water overland flow can be managed with the route maintained around the perimeter of the development site. This is further confirmed by the overland flows from the unnamed watercourse and the route that these flows can be seen following.

Safe access and egress have been established via the new proposed access road onto the A5086. The overland flood flow routes do not impede the proposed access/egress for the development's new entrance.

The Environment Agency does not provide a Flood Warning Service for Cleator. It is noted that the site is covered by the River Ehen, Calder, Irt and Esk Flood Alert areas, it would therefore be recommended this be included within the homeowner's packs.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment required to ensure the River Ehen water quality remains protected.

Any potential impact of the development can be adequately addressed by good drainage design.



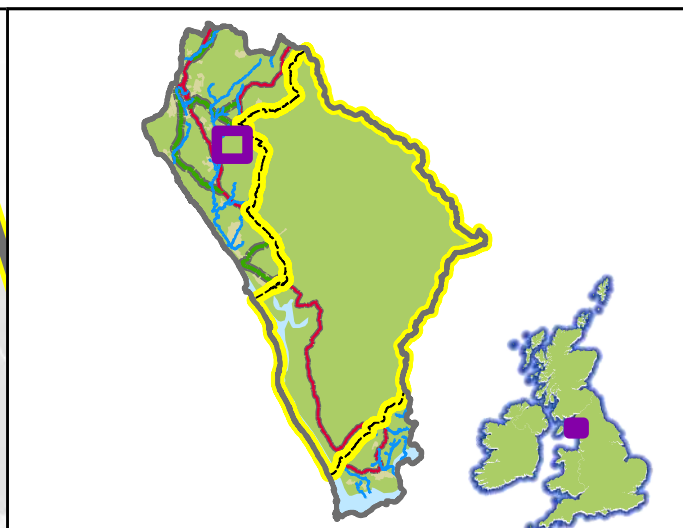
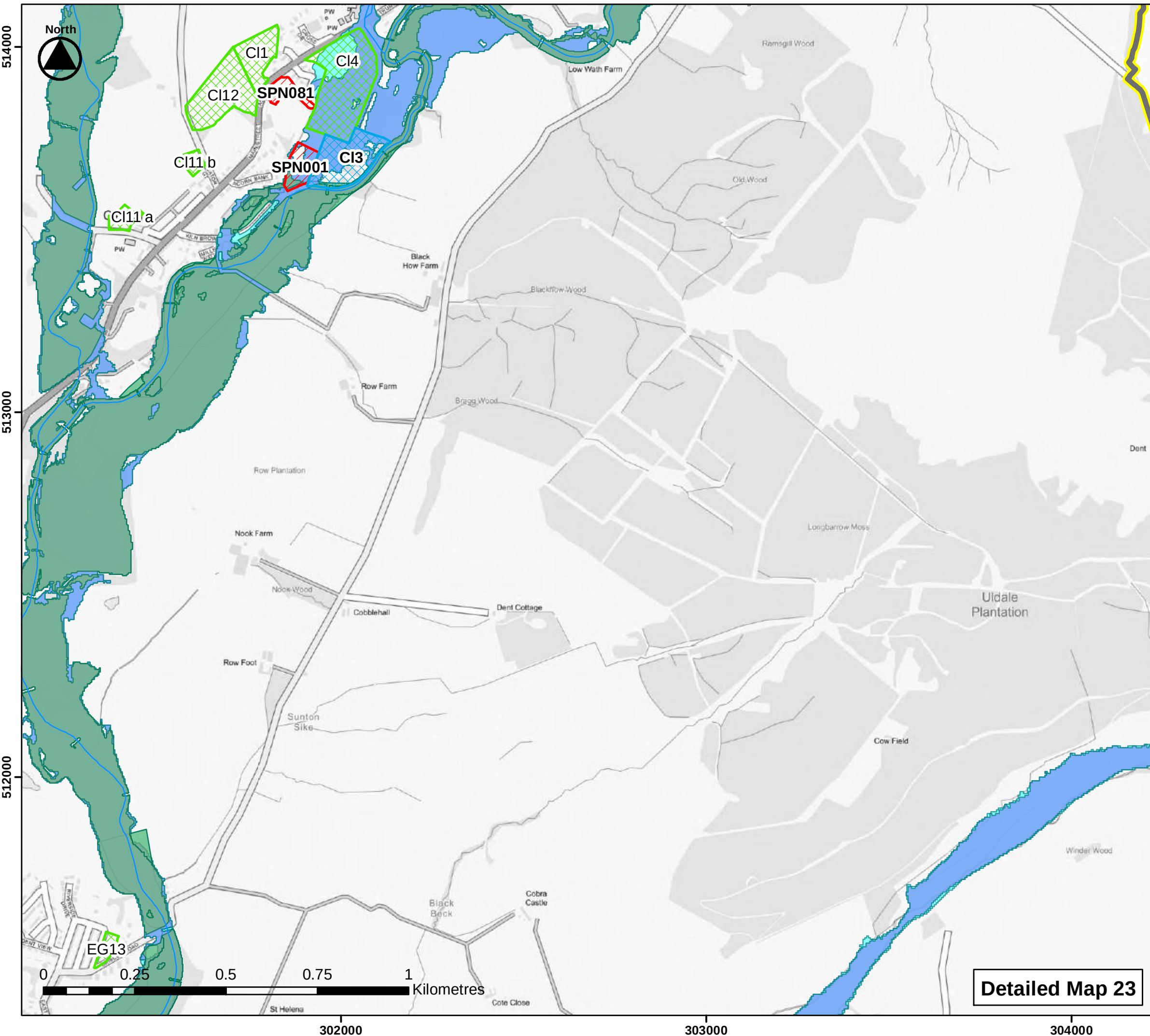
Ross Oakley
For and behalf of RWO Associates Limited
November 2024

Appendix A Site Location Plan



Location Map	
Site	Cleator Mill - Residential
Client	Gleeson Regeneration
Job Number	19002
Scale	NTS

Appendix B Strategic Flood Map



LEVEL 1
STRATEGIC FLOOD RISK ASSESSMENT
For
COPELAND BOROUGH COUNCIL

Please select a data type from the dropdown menu below that you wish to view:

- CBC boundary
 - Detailed River Network
 - LDNP boundary
 - Other LPA boundary
- Potential Development Sites**
- Employment Allocations
 - Employment Opportunity
 - Possible Housing Allocations
 - Possible Opportunity Sites
- New Sites Submitted 2**
- Residential
 - Employment
 - Mixed Use
 - Community Garden

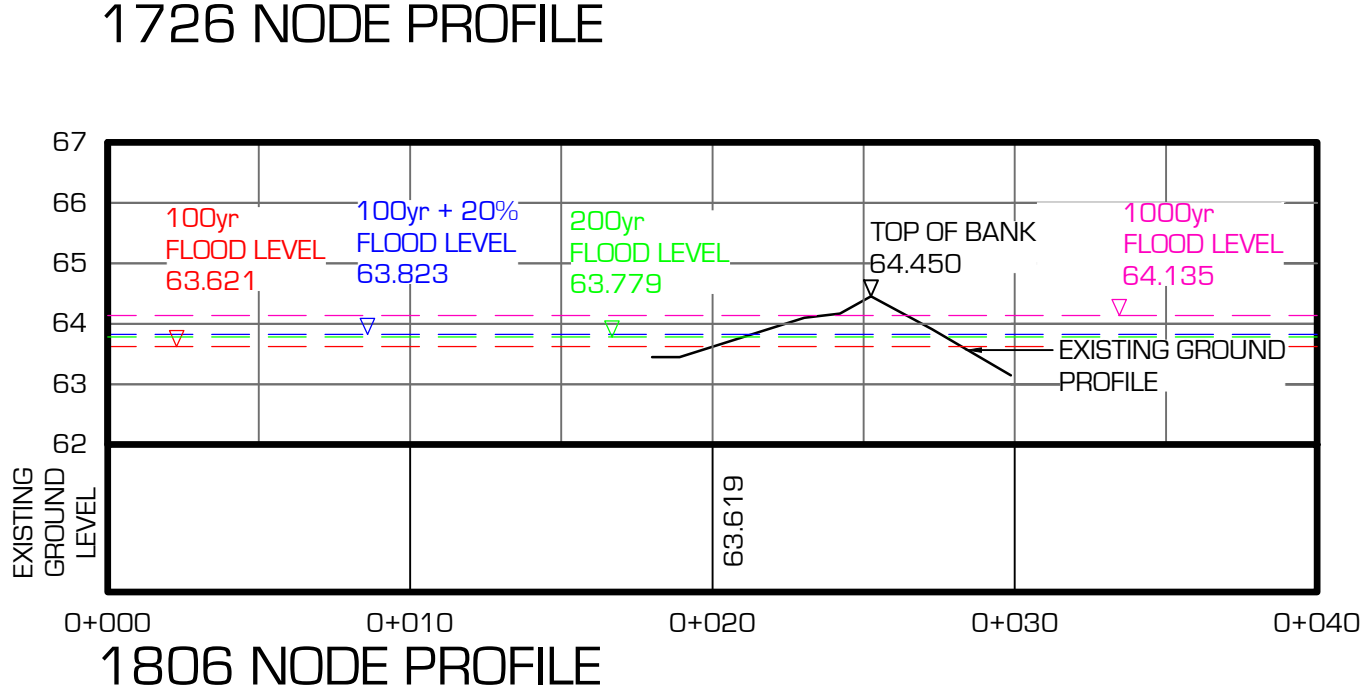
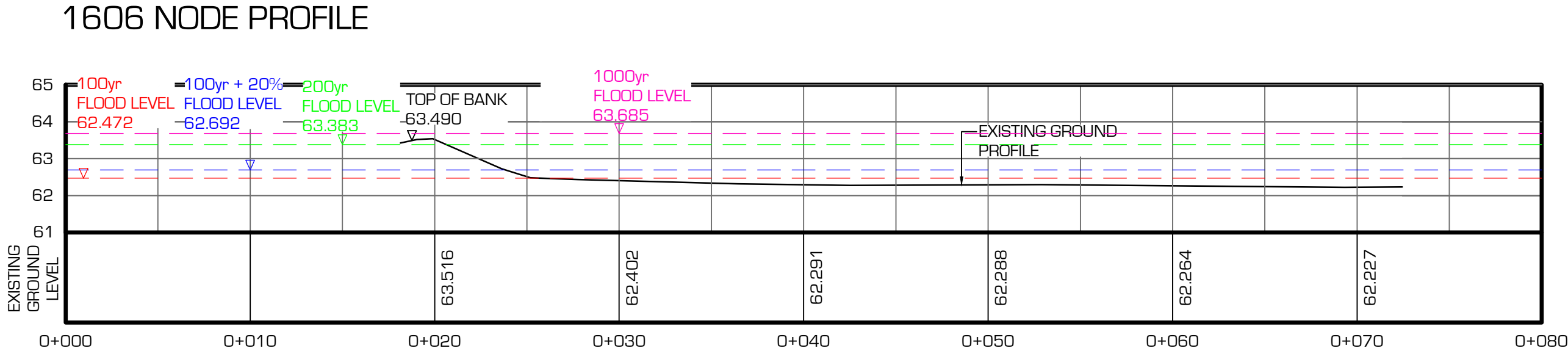
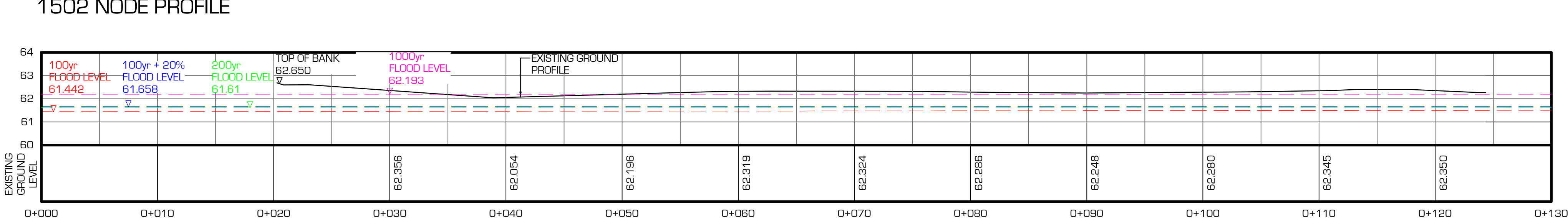
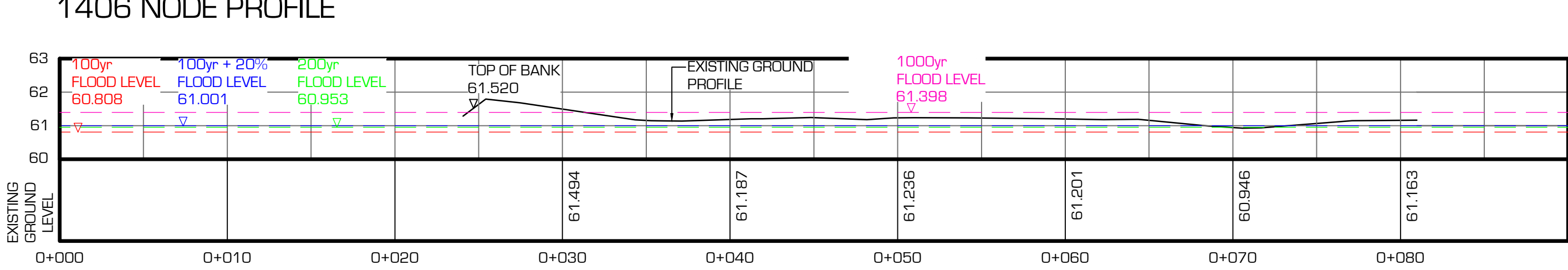
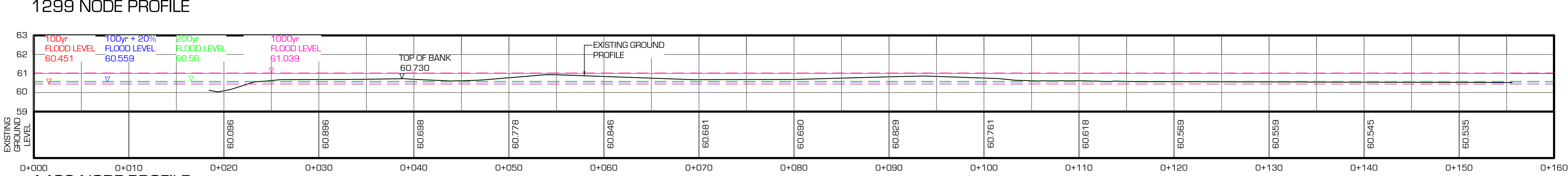
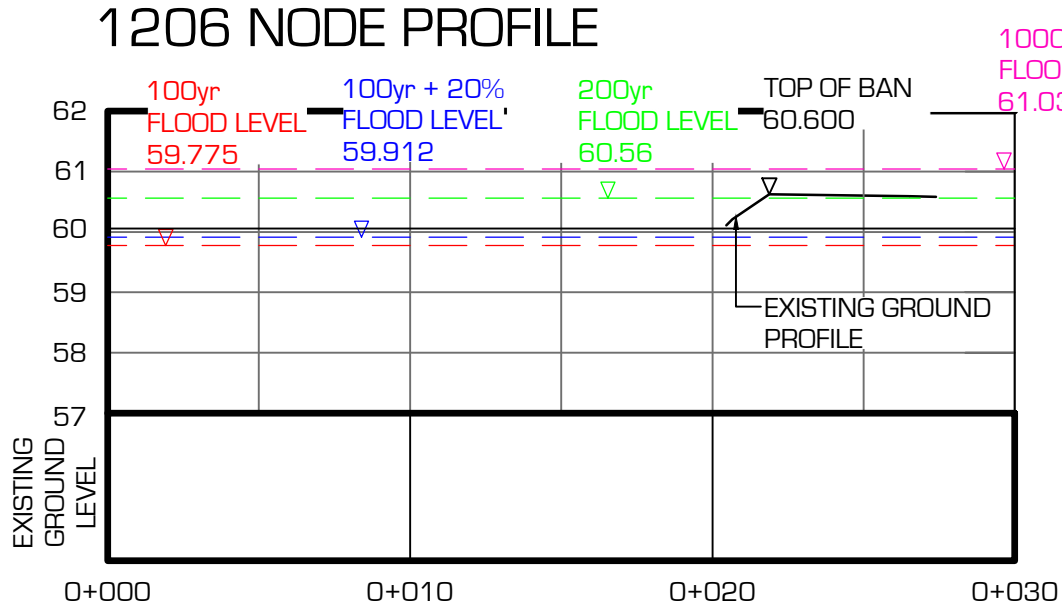
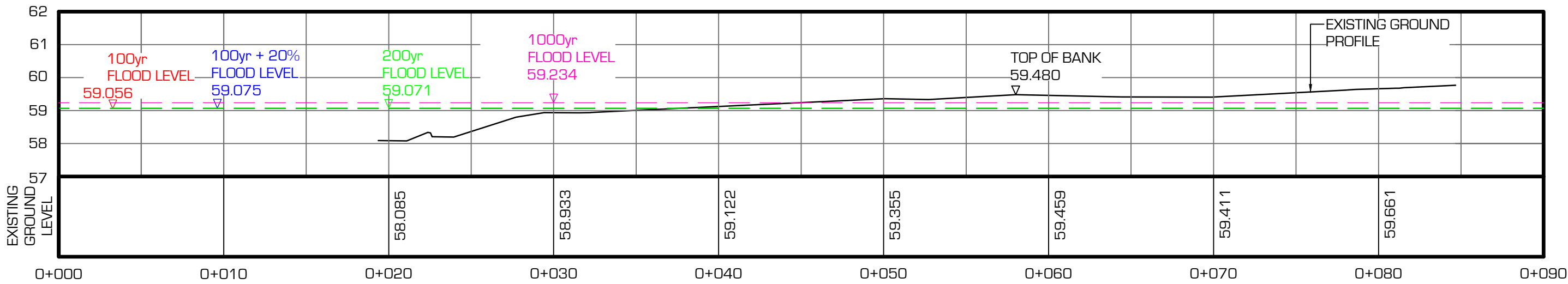
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

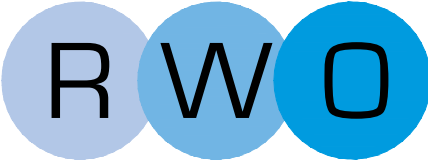
Show Site
Reference Labels



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Appendix C Topographical Survey and Site Sections



06.05.2021	AMENDED TO SUIT COMMENTS	NN	2
06.05.2021	AMENDED TO SUIT COMMENTS	NN	1
Date	Revisions	Drawn	Rev.
Dwg Status PRELIMINARY			
 RWO ASSOCIATES CONSULTING ENGINEERS RWO Associates LTD 6A Union Quay North Shields Tyne & Wear NE30 1HJ www.rwoassociatesuk.com			
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Title SECTIONS THROUGH NODES			
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Appendix D Flood Defence Survey



Cleator Flood Asset Condition Assessment

23 MAR 2022
Version 1.0
RAB: 2869



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Revision History

Version	Date	Amendments	Issued to
1.0	23/03/2022		Ross Oakley



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1.0 Introduction

Cleator, Cumbria is in the Borough of Copeland in the Northwest of England. The River Ehen is within the catchment of Copeland's Wild Rivers and runs from Ennerdale Water to Sellafield where it enters the Irish Sea. The watercourse passes through Cleator, where there are numerous flood defences and structures around the watercourse including embankments, outfalls, walls, natural high ground and engineered high ground.

Approximately 1km of the River Ehen flood assets were inspected to assess their condition, defects and required maintenance. This report contains details of the findings of these inspections including estimated costs for the preservation of the assets.

2.0 Method

The condition grading and descriptions given below are the standards adopted by the Environment Agency. The five condition grades range from 'very good' to 'very poor', and the descriptions reflect condition according to flood defence performance.

Grade	Rating	Description
1	Very Good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce the overall performance of the asset
3	Fair	Defects that could reduce performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed
5	Very Poor	Severe defects resulting in complete performance failure

The inspection was carried out and recorded in accordance with the Condition Assessment Manual (March 2012) and Version 4 of the Asset Template and Weighting Guidance on 28 January 2022 by Environment Agency accredited Flood Asset Inspectors.

Visual inspection is the simplest form of non-destructive testing, as it does not require any specialist equipment. It is a widely used technique for monitoring assets and their surroundings. However, as only the surface of a structure is visible, this method can only assess the surface details and condition of an asset; changes to interior structure and condition are not easily identifiable until they lead to changes to the surface of the asset. Assessment of an asset's surroundings remains a key indicator to the asset's performance and integrity.

The recommendations arising from the visual inspection include remedial works to address visible defects and bring each element of the asset back to at least "fair" condition, but also actions to overcome access constraints and/or the need for other tests or investigations to assess an assets performance and integrity.



3.0 Flood Assets and Condition Assessment

Figure 1 and Table 1 provide a summary of the location, type and condition grade of flood assets identified and inspected on 28 January 2022.

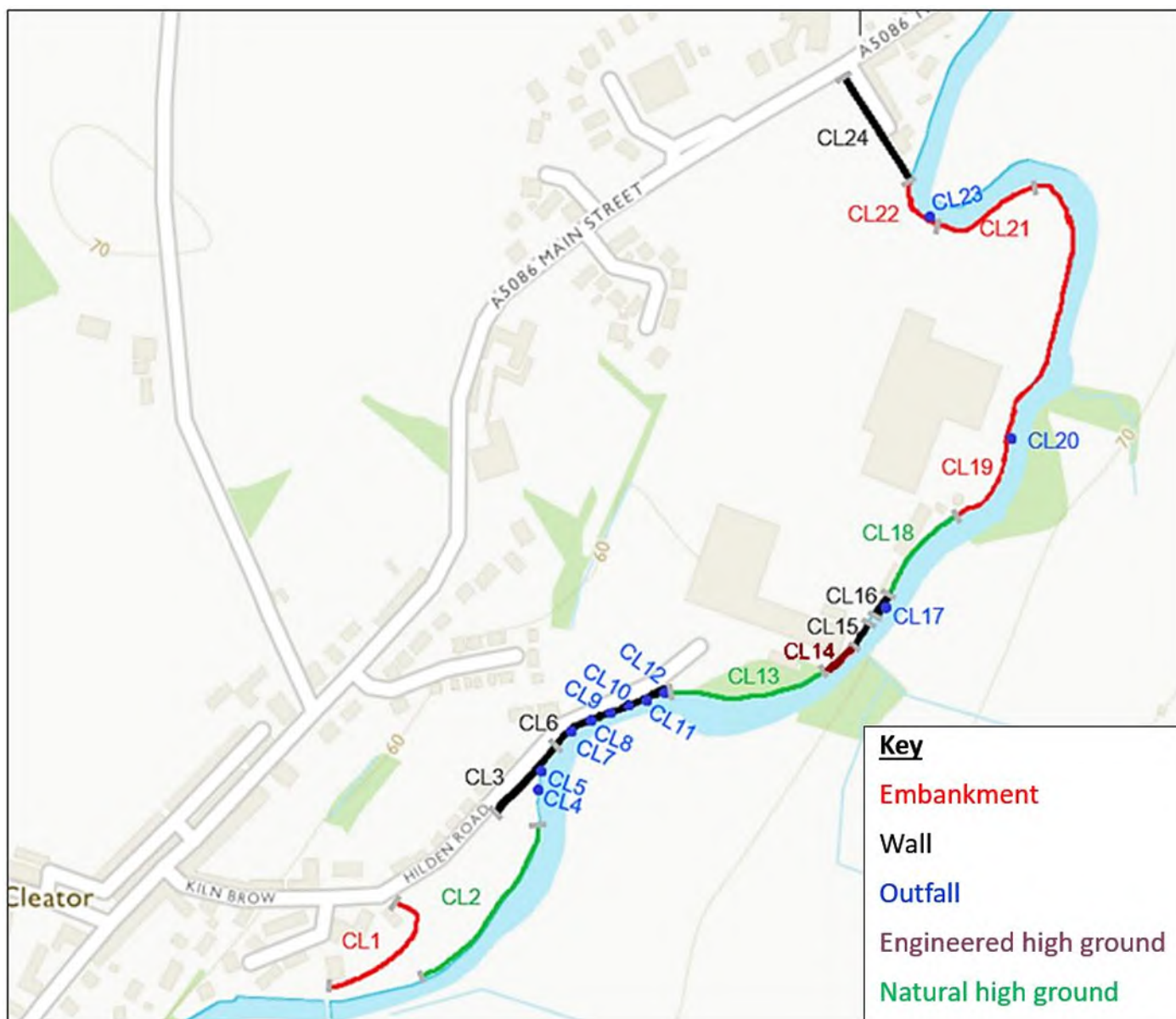




TABLE 1: FLOOD ASSET CONDITION SUMMARY.

Asset ID	Asset type/sub-type	Description	Grade
CL1	Defence - Embankment	Embankment running in front of houses below Hilden Road and Kiln Brow	4
CL2	Defence – Natural High Ground	Natural high ground located below Hilden Road before wall	3
CL3	Defence – Wall	Stone wall on Hilden Road with berm	4
CL4	Structure – Outfall	Outfall located on River Ehen	3
CL5	Structure – Outfall	Outfall located on River Ehen	3
CL6	Defence – Wall	Stone wall on Hilden Road	4
CL7	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
C8	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
CL9	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
CL10	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
CL11	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
CL12	Structure – Outfall	One of six identical outfalls located within wall on Hilden Road	2
CL13	Defence – Natural High Ground	Natural high ground located below Mill Street	3
CL14	Defence – Engineered High Ground	Engineered high ground in front of old mill	3
CL15	Defence – Wall	Stone wall in front of old mill	3
CL16	Defence – Wall	Brick wall with brick channel side located on River Ehen	3
CL17	Defence – Natural High Ground	Natural high ground located on River Ehen	3
CL18	Defence – Embankment	Earth embankment located on River Ehen	3
CL19	Structure – Outfall	Drainage pipe located on River Ehen	3
CL20	Structure – Outfall	Outfall located on River Ehen	3
CL21	Defence - Embankment	Earth embankment with gabions and sheet piling on River Ehen	3



Asset ID	Asset type/sub-type	Description	Grade
CL22	Defence - Embankment	Earth embankment with stone and sheet piling on River Ehen	3
CL23	Structure – Outfall	Outfall located on River Ehen	3
CL24	Defence - Wall	Wall located off Main Street	3

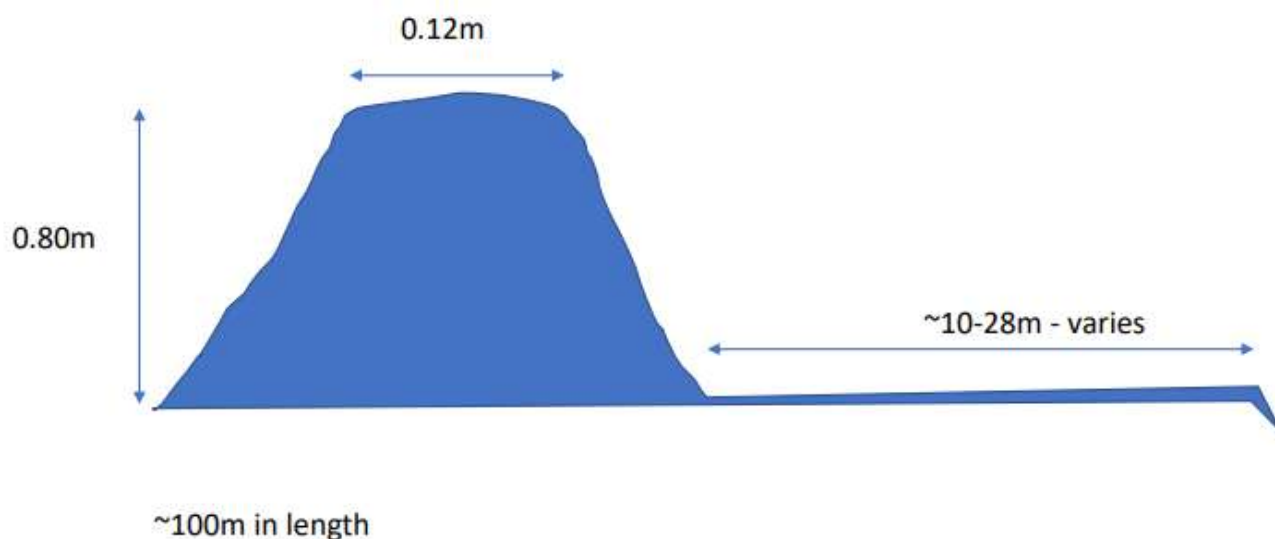


4.0 Findings and Recommendations

The following is a summary of the findings and recommendations to bring all asset elements to at least “fair” condition, grade 3.

CL1 – Embankment

Small earth embankment protecting residential properties behind.



Comments

Variant weighting used for crest as <4m wide. Drainage pipe running through entire width of embankment, low spots, some animal holes and rutting on crest, landward face and exposed face have some holes and uneven slopes but are well vegetated. Undermining, minor erosion and light foreign objects present on channel side but currently stable.

Grade = 4, Poor

Years	Recommendations	Cumulative Cost (£)
Immediate	Install none return valve to drainage pipe	£400.00
1	- Inspect embankment annually and infill any identified low spots on crest with topsoil and lay down grass seed - Manage vegetation to avoid undesirable vegetation growth and maintain grass growth - Consider pest control	£600.00
5	- Continue to inspect the embankment yearly to keep track of and identify potential issues - Continue vegetation management to prevent the growth of undesirable vegetation on embankment	£3,500.00



	• Infill identified low spots on crest with topsoil and lay down grass seed • Monitor condition of landward toe to ensure vehicle use does not damage asset – infill low spots and lay down grass seed in areas of vegetation loss	
10	• Continue yearly inspections and vegetation management • If extensive damage has been incurred to the embankment, reprofile the bank and lay down grass seed	£12,500.00
15	• Continue yearly inspections and vegetation management • If extensive damage has been incurred to the embankment, reprofile the bank and lay down grass seed	£16,600.00



CL2 – Natural High Ground

Natural high ground located in a grass field in front of residential properties with a width of 21-48m between the channel side and road.



4.1.1 Comments

Significant undermining, erosion and presence of light foreign objects on channel side. High ground in good condition.

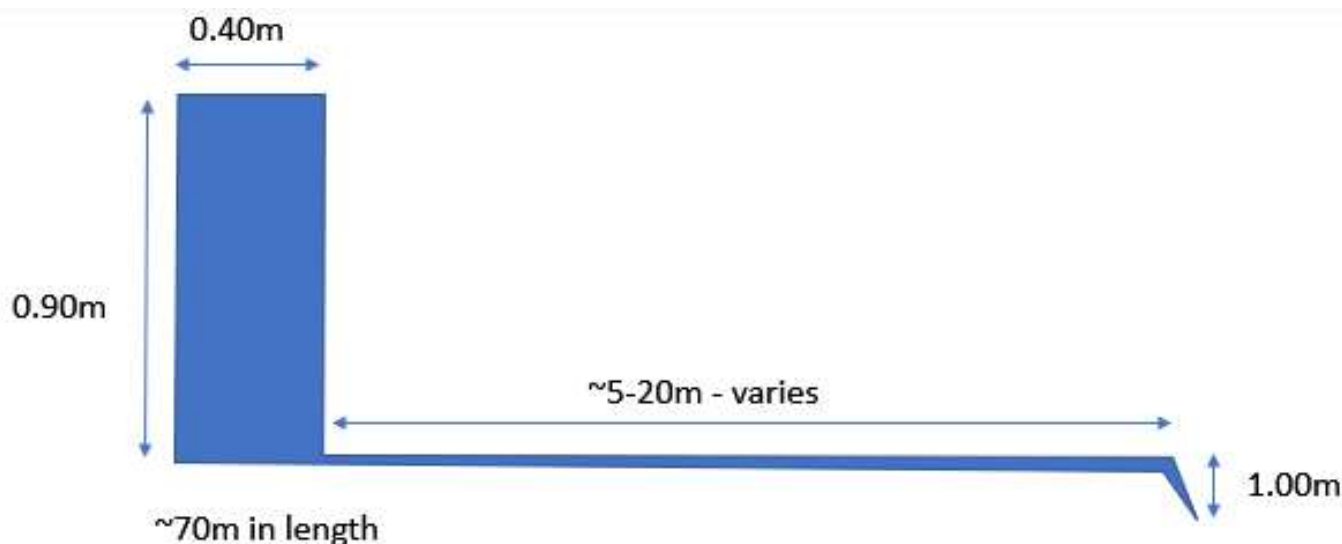
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct visual asset inspections annually, monitor erosion, maintain grass on high ground and ensure vegetation is kept stable and not blocking channel	£600.00
5	- Continue to inspect the high ground yearly to keep track of and identify potential issues - Continue with vegetation management and remove unstable trees	£3,100.00
10	- Continue yearly inspections and vegetation management - If considerable amounts of erosion are being incurred to the channel side, install coir erosion protection matting	£13,200.00
15	- Continue yearly inspections and vegetation management - If extensive erosion has been incurred to the channel side, consider reprofiling bank and installing rock armour	£21,500.00



CL3 – Wall

Stone wall next to road protecting residential properties but not designed as a flood wall.



4.1.2 Comments

Variant weightings used for both faces as no revetments. Significant mortar loss to crest, holes through wall, bulging of wall where light foreign objects are growing in front on wall, distorting its shape and some erosion to channel side.

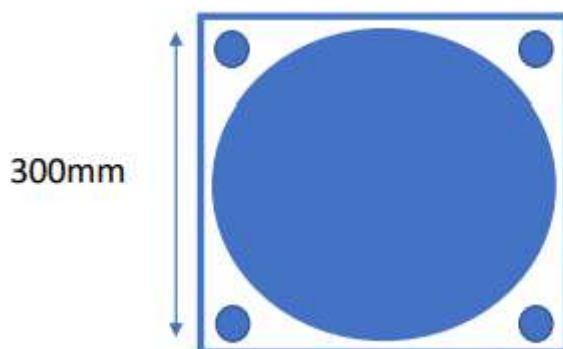
Grade = 4, Poor

Years	Recommendations	Cumulative Cost (£)
Immediate	Rebuild wall and remove trees in front of wall	£1,900.00
1	- Conduct visual asset inspections annually - Carry out minor repairs to bricks and mortar and maintain grass on berm	£200.00
5	- Continue to inspect the wall yearly to keep track of and identify potential issues - Carry out small repairs to brickwork and management of surrounding vegetation	£1,000.00
10	- Carry out repointing of wall - Continue with annual visual asset inspections and management of surrounding vegetation	£2,100.00
15	- If there has been any serious structural damage to the wall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage - If extensive erosion has been incurred to the channel side, consider reprofiling bank and installing rock armour	£10,100.00



CL4 – Outfall

300mm diameter flapped outfall with concrete apron located on channel side in front of wall. Owner and operator unknown.



4.1.3 Comments

Vegetation around headwall. Unable to see through pipe and no CCTV footage available.

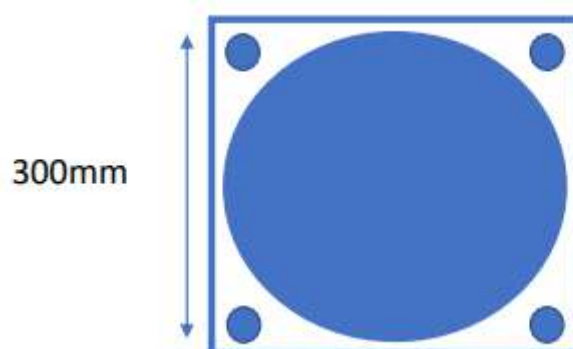
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue to inspect the outfall yearly, including CCTV inspections of the pipe every 5 years - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue yearly inspections of outfall including CCTV inspections of pipe every 5 years - Continue with vegetation management - Carry out small repairs to brick and mortar loss	£6,900.00
15	- Continue yearly inspections of outfall and manage vegetation growth - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ relevant operative to repair damage	£17,400.00



CL5 – Outfall

300mm diameter flapped outfall with no apron located on channel side in front of wall. Owner and operator unknown.



4.1.4 Comments

Outfall in good condition, very minor corrosion present on frame and flap valve. Unable to see through pipe and no CCTV footage available.

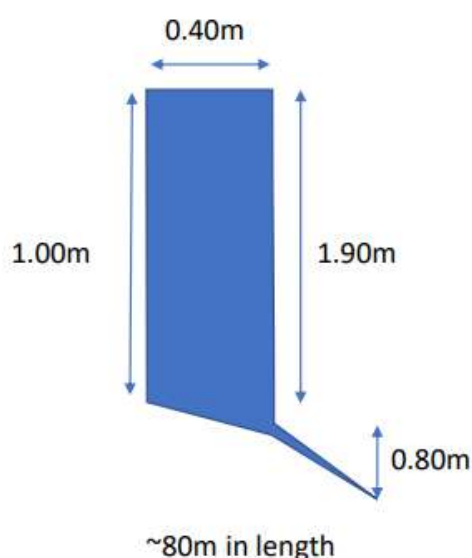
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue to inspect the outfall yearly, including CCTV inspections of the pipe every 5 years - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue yearly inspections of the outfall including CCTV inspections of the pipe every 5 years - Continue with vegetation management	£6,900.00
15	- Continue yearly inspections of the outfall and manage vegetation growth - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£17,400.00



CL6 – Wall

Stone wall with 6 highway outfalls in wall connecting to previous wall, also not a flood wall.



4.1.5 Comments

Heavy foreign objects growing towards channel on berm and channel side and undermining on channel side causing channel side to be unstable. Ivy growth on wall, heavy foreign objects growing close to wall causing bulging to wall and capping stones lost from crest halfway across wall.

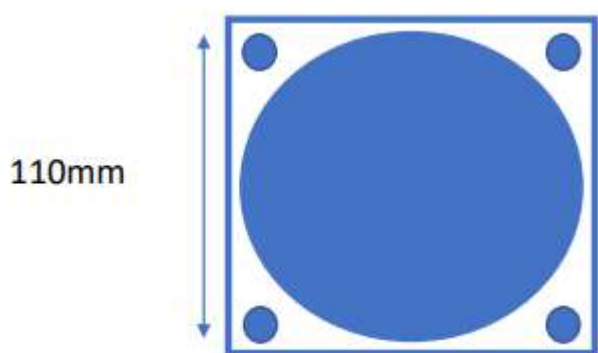
Grade = 4, Poor

Years	Recommendations	Cumulative Cost (£)
Immediate	Rebuild wall, remove unstable trees, and remove trees next to wall	£5,000.00
1	- Conduct visual asset inspections annually - Maintain surrounding vegetation to avoid wall incurring structural damage	£200.00
5	- Continue to inspect the wall yearly to keep track of and identify potential issues - Small repairs to brickwork and management of surrounding vegetation	£1,000.00
10	Carry out repointing of wall and continue with small repairs to brickwork and management of surrounding vegetation	£2,100.00
15	- If there has been any serious structural damage to the wall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage - If extensive erosion has been incurred to the channel side, consider reprofiling bank and installing rock armour	£11,000



CL7 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.6 Comments

No signs of corrosion to flap valve or frame, pipe has minor leaf debris but no blockages or damage. Downstream headwall has some cracks, vegetation growth and mortar loss.

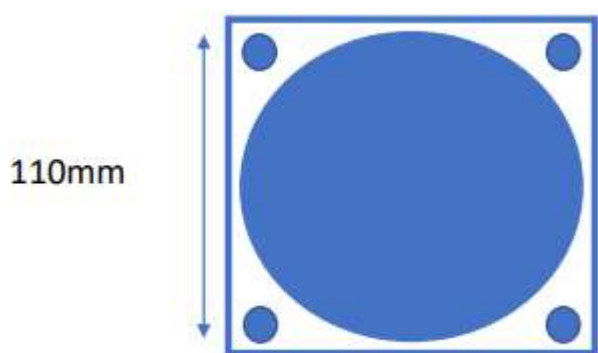
Grade = 2, Good

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL8 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.7 Comments

No signs of corrosion to flap valve or frame, pipe has minor leaf debris but no blockages or damage. Minor crack to downstream headwall, vegetation growth and mortar loss.

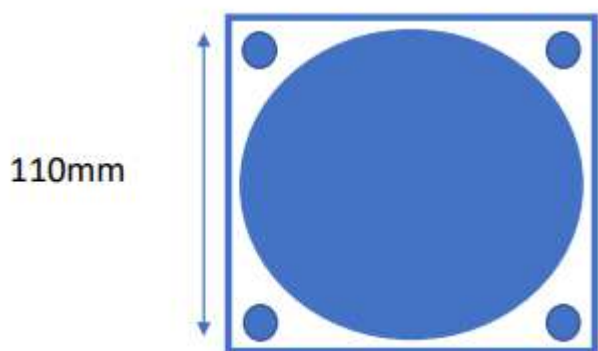
Grade = 2, Good

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL9 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.8 Comments

No corrosion to flap valve or frame. Cracks and mortar loss on headwall. Pipe has minor leaf debris but no blockages or damage.

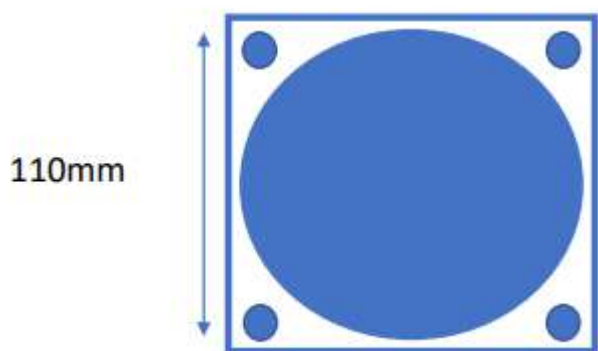
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL10 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.9 Comments

Ivy growth around frame and headwall. No corrosion to flap valve. Minor cracks and vegetation growth on headwall. Pipe has minor leaf debris but no blockages or damage.

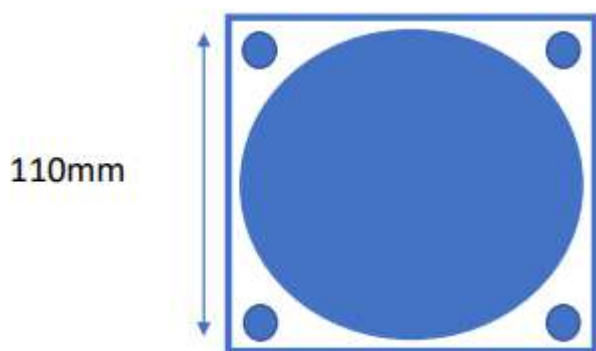
Grade = 2, Good

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL11 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.10 Comments

Ivy growth around frame and headwall. No corrosion to flap valve. Minor cracks and vegetation growth on headwall. Pipe has vegetation debris but no blockages or damage.

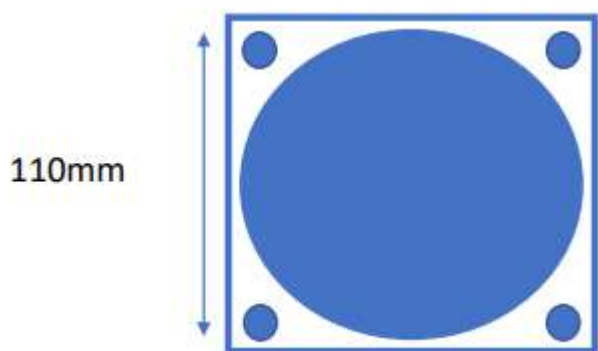
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL12 – Outfall

110mm diameter flapped highway outfall located within stone wall.



4.1.11 Comments

No corrosion to flap valve or frame. Minor cracks, mortar loss and minor vegetation growth on headwall. Pipe has minor leaf debris but no blockages or damage.

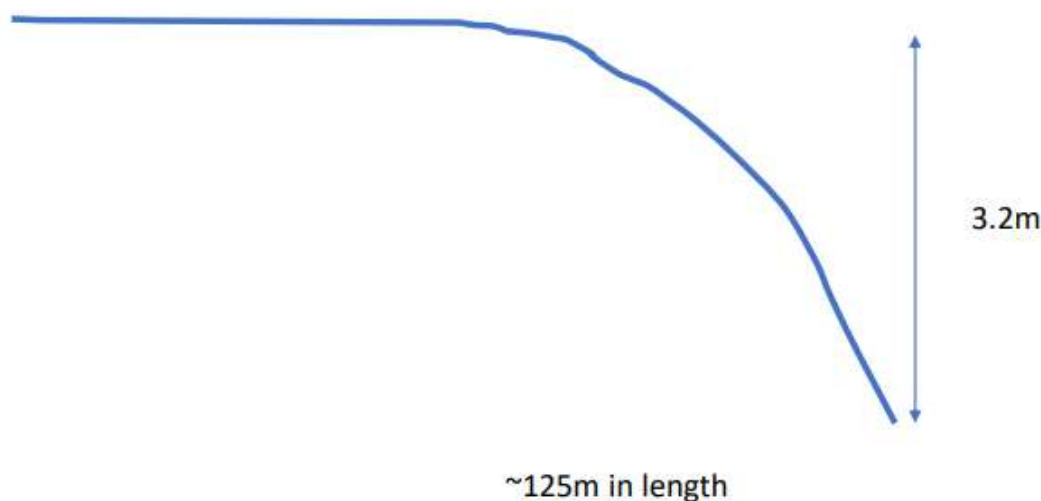
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct annual visual asset inspections and maintain surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue with annual inspections of the outfall - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall	£3,500.00
10	- Continue with annual inspections of the outfall - Continue with vegetation management - Conduct small brick and mortar repairs on headwall	£6,900.00
15	- Continue with annual inspections of the outfall and vegetation management - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£14,800.00



CL13 – Natural High Ground

Stretch of natural high ground with vegetation and trees.



4.1.12 Comments

Significant undermining, erosion, and presence of light foreign objects on channel side. High ground in good condition.

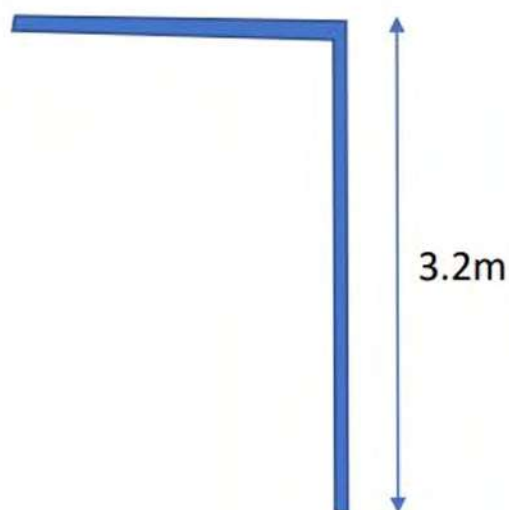
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct visual asset inspections annually, monitor erosion and ensure vegetation is kept stable and not blocking channel	£700.00
5	- Continue to inspect high ground yearly to keep track of and identify potential issues - Continue with vegetation management and remove unstable trees	£5,500.00
10	- Continue yearly inspections and vegetation management - If considerable amounts of erosion are being incurred to the channel side, install erosion protection matting	£17,900.00
15	- Continue yearly inspections and vegetation management - If extensive erosion has been incurred to the channel side, consider reprofiling bank and installing further erosion protection measures such as rock armour	£34,200.00



CL14 – Engineered High Ground

Masonry retaining wall at edge of road with metal fencing above.



~20m in length

4.1.13 Comments

Light foreign objects and ivy growing in front of and on top of channel side wall. High ground is road in good condition. Heavy foreign object upstream with roots growing into channel side brickwork.

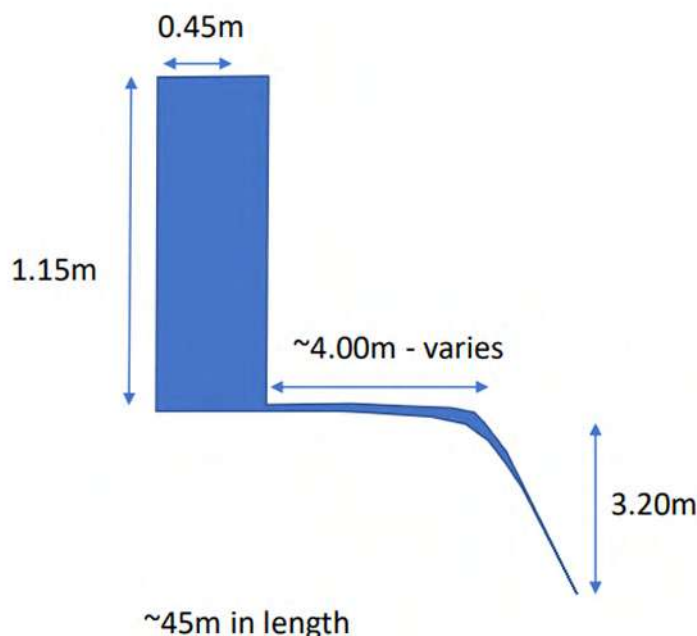
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	Conduct visual asset inspections annually and cut back surrounding vegetation to avoid damaging asset	£600.00
5	- Continue with annual visual asset inspections and vegetation management - Conduct small brick and mortar repairs	£1,100.00
10	- Continue with annual visual asset inspections and vegetation management - Consider repointing brickwork	£2,200.00
15	- Continue with annual visual asset inspections and vegetation management - If there has been any serious structural damage to the engineered high ground such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£12,000.00



CL15 – Wall

Masonry wall with capping stones with berm and channel side heavily vegetated with tree growth through wall.



4.1.14 Comments

Several heavy foreign objects on berm and channel side. Severe mortar loss in landward face, exposed face difficult to inspect but wall covered in ivy and some tree roots and growing through it. Crest is uneven where ivy has grown around it.

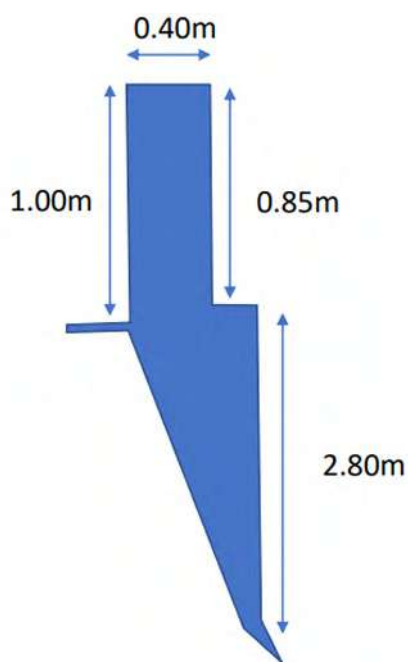
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Conduct visual asset inspections annually - Maintain surrounding vegetation including ivy removal to avoid wall incurring structural damage	£200.00
5	- Continue to inspect the wall yearly to keep track of and identify potential issues - Small repairs to brickwork and management of surrounding vegetation	£1,200.00
10	Carry out repointing of wall and continue with small repairs to brickwork and management of surrounding vegetation	£2,400.00
15	If there has been any serious structural damage to the wall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£7,700.00



CL16 – Wall

Brick wall with concrete landward face connecting to channel side brick retaining wall.



~30m in length

4.1.15 Comments

Extensive ivy growth, channel side wall is walling down with severe brick loss and root penetration. Heavy foreign objects growing on channel side causing brick displacement and loss. Crest is uneven due to brick loss but landward face is made from concrete slabs in good condition.

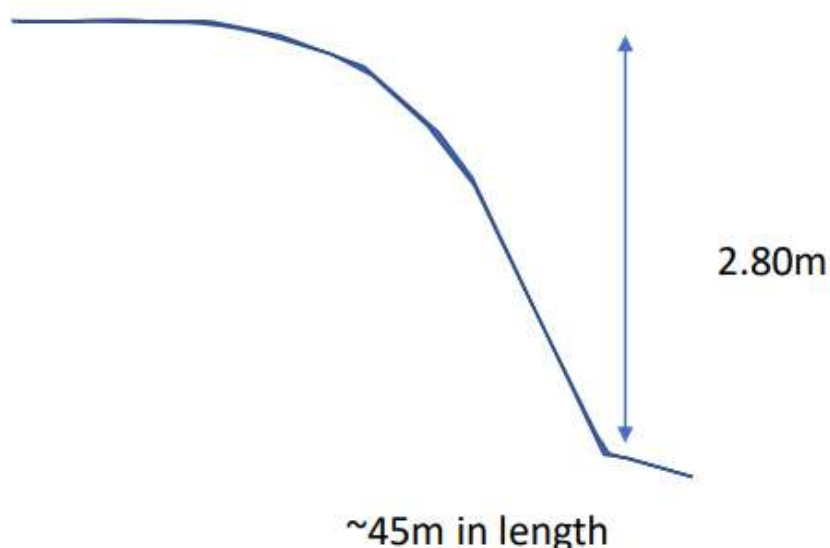
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Conduct visual asset inspections annually - Maintain surrounding vegetation to avoid wall incurring structural damage	£200.00
5	- Continue to inspect the wall yearly to keep track of and identify potential issues - Small repairs to brickwork and management of surrounding vegetation	£1,200.00
10	Carry out repointing of wall and continue with small repairs to brickwork and management of surrounding vegetation	£4,800.00
15	If there has been any serious structural damage to the wall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£8,200.00



CL17 – Natural High Ground

Natural high ground heavily vegetated with tree growth with brick building directly behind.



4.1.16 Comments

Heavy foreign objects on channel side leaning towards channel. Building <3m from channel on high ground.

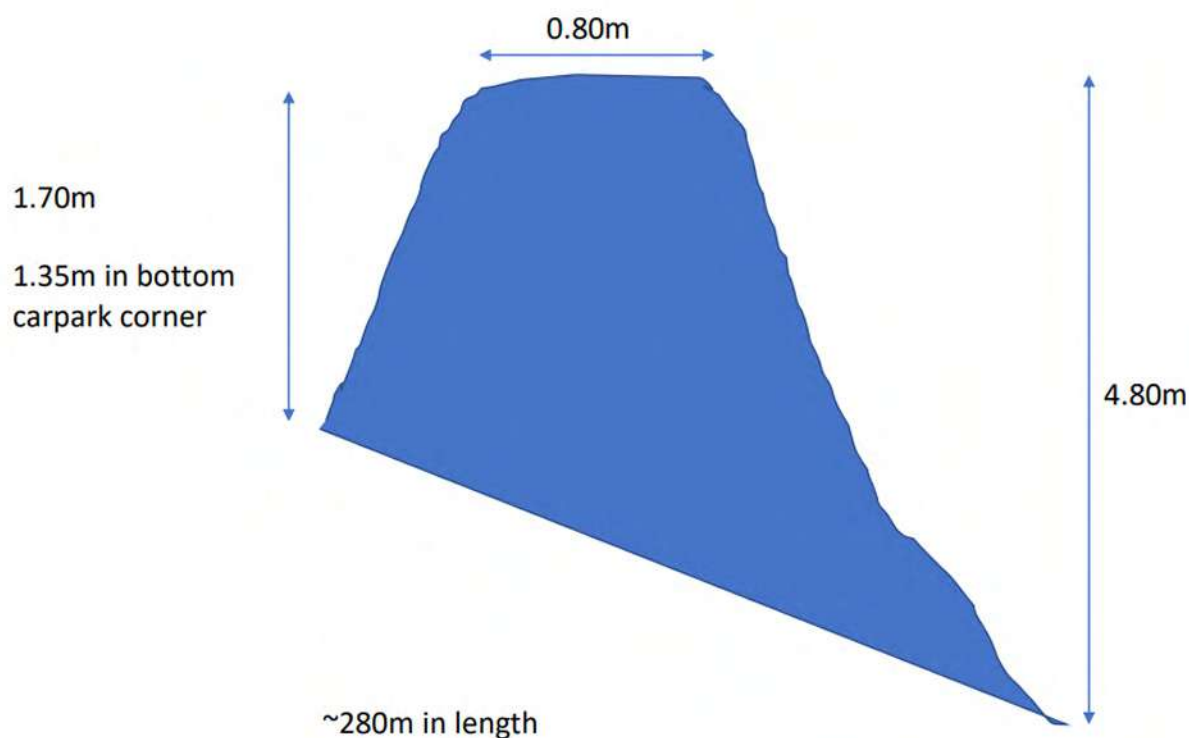
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Remove unstable trees - Conduct visual asset inspections annually, monitor erosion and movement which could affect nearby building - Ensure vegetation is kept stable and not blocking channel	£200.00
5	- Continue to inspect high ground yearly to keep track of and identify potential issues - Continue with vegetation management and remove unstable trees	£1,200.00
10	- Continue yearly inspections and vegetation management - If considerable amounts of erosion are being incurred to the channel side, install coir erosion protection matting	£4,800.00
15	- Continue yearly inspections and vegetation management - If extensive erosion has been incurred to the channel side, consider reprofiling bank and installing further erosion protection measures such as rock armour	£8,200.00



CL18 – Embankment

Earth embankment with unknown construction materials and unstable tree-ridden channel side, reducing stability of embankment. Unlikely to have clay core and may be comprised of waste material.



4.1.17 Comments

Low points and rutting in crest but well vegetated. Variant used for exposed face due to steepness. Exposed and landward faces have isolated bare patches. Telegraph pole behind embankment but embankment build around it. Severe undermining of channel side around heavy foreign objects with extensive root exposure.

Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Consider installing erosion protection to channel side such as rock armour - Inspect embankment annually and infill any identified low spots on crest with topsoil and lay down grass seed - Manage vegetation to avoid undesirable vegetation growth	£7,200.00
5	Continue to inspect the embankment yearly to keep track of, identify potential issues and monitor stability of telegraph pole within embankment	£33,400.00

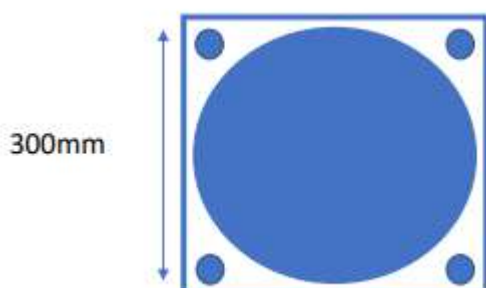


	- Continue vegetation management to prevent the growth of undesirable vegetation on embankment - Infill identified low spots on crest with topsoil and lay down grass seed	
10	- Continue yearly inspections and vegetation management - Infill any identified low spots on crest with topsoil and lay down grass seed - If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed	£90,100.00
15	- Continue yearly inspections and vegetation management - Infill any identified low spots on crest with topsoil and lay down grass seed - If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed - Consider employing engineer to assess asset condition in detail to identify potential structural issues with embankment, employ relevant operative to repair damage	£166,600.00



CL19 – Outfall

300mm outfall on channel side of embankment with damaged concrete headwall.



4.1.18 Comments

Drainage pipe halfway between wall and building on high ground. Unable to see through pipe and no CCTV footage available. Vegetation around headwall and at base of pipe.

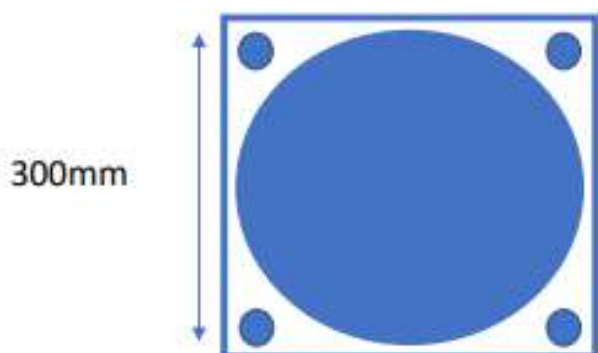
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Investigate stability of headwall, rebuild if necessary - Conduct CCTV inspection of pipe to assess condition - Conduct annual visual asset inspections and provide ongoing management of surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue to inspect the outfall yearly, including CCTV inspections of the pipe every 5 years - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall - Carry out small repairs to any brick and mortar loss on headwall	£3,500.00
10	- Continue yearly inspections of outfall including CCTV inspections of pipe every 5 years - Continue with vegetation management - Carry out small repairs to any brick and mortar loss on headwall	£6,900.00
15	- Continue yearly inspections of outfall and manage vegetation growth - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ relevant operative to repair damage	£17,400.00



CL20 – Outfall

150mm clay drainage pipe located on channel side of embankment surrounded by rocks providing unstable headwall.



4.1.19 Comments

Downstream headwall in pieces. Unable to see through pipe and no CCTV footage available.

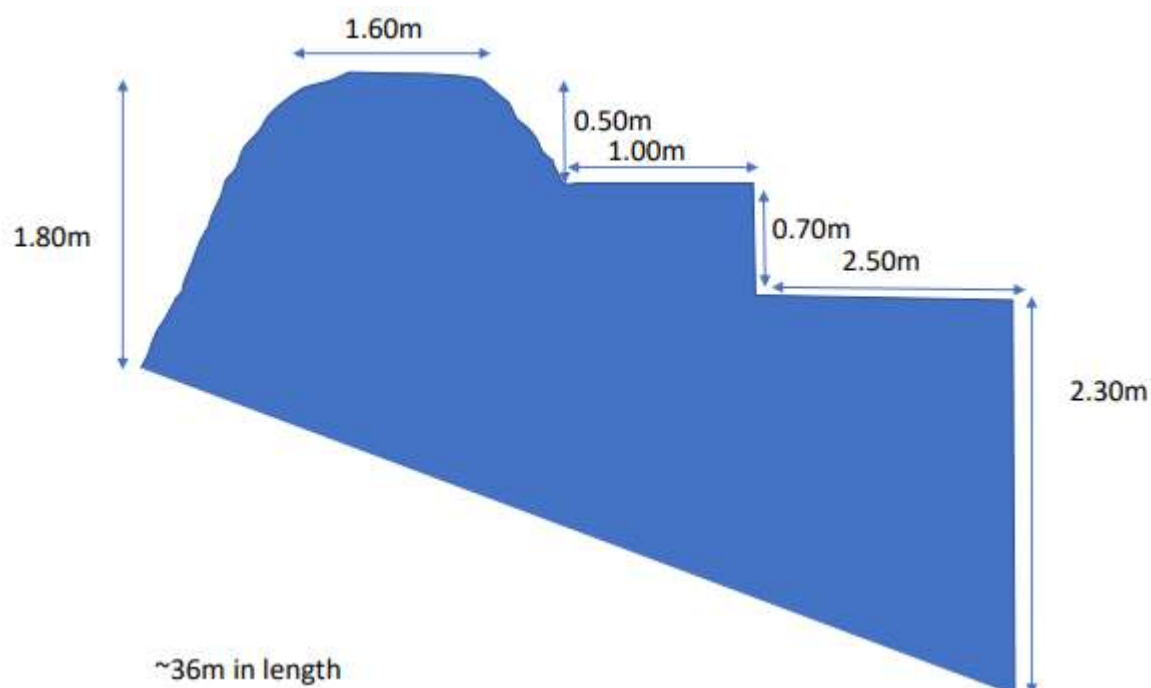
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Rebuild headwall - Conduct CCTV inspection of pipe to assess condition - Conduct annual visual asset inspections and provide ongoing management of surrounding vegetation to avoid damage incurring to outfall	£600.00
5	- Continue to inspect the outfall yearly, including CCTV inspections of the pipe every 5 years - Monitor and remove moss growth and vegetation growth on headwall to reduce damage to the headwall - Carry out small repairs to any brick and mortar loss on headwall	£3,500.00
10	- Continue yearly inspections of outfall including CCTV inspections of pipe every 5 years - Continue with vegetation management - Carry out small repairs to any brick and mortar loss on headwall	£6,900.00
15	- Continue yearly inspections of outfall and manage vegetation growth - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ relevant operative to repair damage	£17,400.00



CL21 – Embankment

Earth embankment with gabion basket and sheet piling exposed faces and concrete berm.



4.1.20 Comments

Berm 2 and channel side in good condition with minor cosmetic defects to sheet piles. Vegetation growth through gabion baskets with a few broken wires but no gabion displacement. Uneven ground on exposed face 1 and landward face but well vegetated. Rutting and low spots in isolated places on crest. Variants used on crest as less than 4m wide and landward face due to steepness.

Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Repair gabion baskets and remove vegetation growing through - Inspect embankment annually and infill any identified low spots on crest with topsoil and lay down grass seed - Manage vegetation to avoid undesirable vegetation growth	£200.00
5	- Continue to inspect embankment yearly to keep track of, identify potential issues - Continue vegetation management to prevent growth of undesirable vegetation on embankment - Infill identified low spots on crest with topsoil and lay down grass seed	£1,100.00
10	Continue yearly inspections and vegetation management	£2,500.00

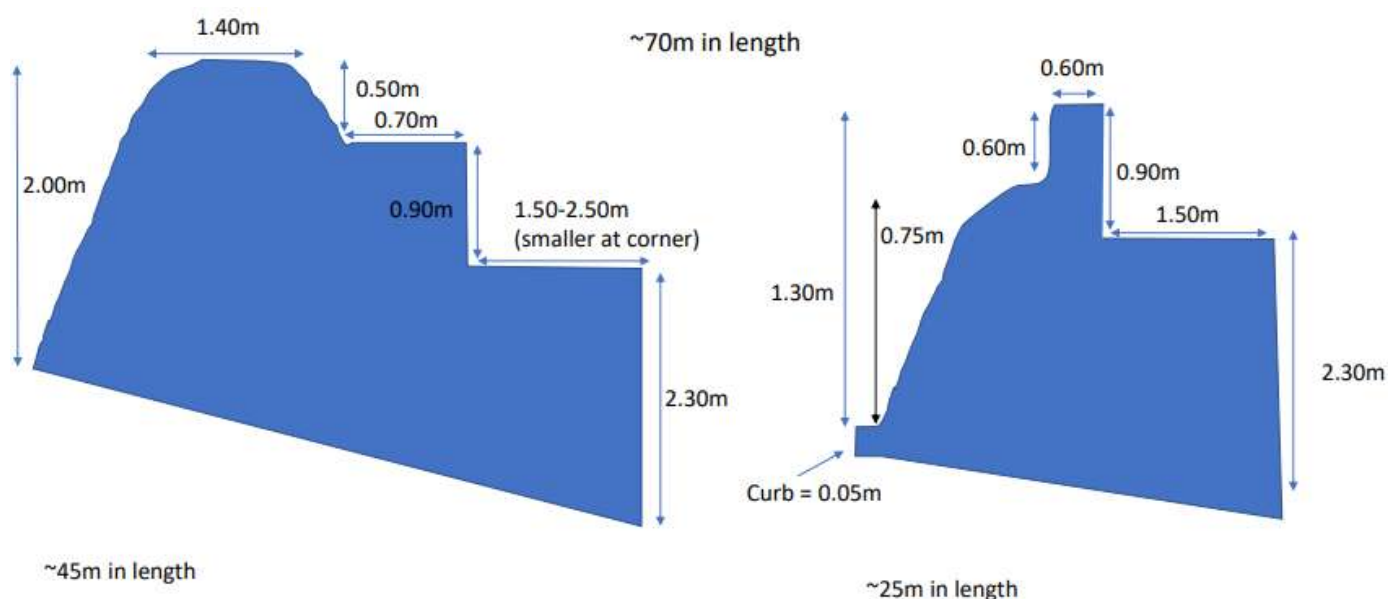


	• If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed • Repaint sheet piling • Repair any damage to gabion baskets	
15	• Continue yearly inspections and vegetation management • If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed • Repair any damage to concrete apron and gabion baskets • Consider employing engineer to assess asset condition in detail to identify potential structural issues with embankment, employ relevant operative to repair damage	£9,600.00



CL22 – Embankment

Earth embankment with stone wall and sheet piling exposed faces and concrete berm. Crest height and embankment width reduce as earth landward face diminishes and crest changes to stone crest.



4.1.21 Comments

Minor vegetation growth within berm 1 and exposed face 2 with minor mortar loss. Uneven crest with some low spots but well vegetated. Berm 2 and channel side in good condition with minor cosmetic defects to sheet piling. Landward face and exposed face 1 are well vegetated but uneven. Landward face 2 around corner and has minor vegetation growing through stone and minor mortar loss.

Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Inspect embankment annually and infill any identified low spots on crest with topsoil and lay down grass seed - Repair mortar loss and remove vegetation growing through - Manage vegetation to avoid undesirable vegetation growth	£200.00
5	- Continue to inspect embankment yearly to keep track of, identify potential issues - Continue vegetation management to prevent the growth of undesirable vegetation on embankment - Conduct small repairs on brick and mortar loss - Infill identified low spots on crest with topsoil and lay down grass seed	£1,600.00
10	Continue yearly inspections and vegetation management	£3,400.00

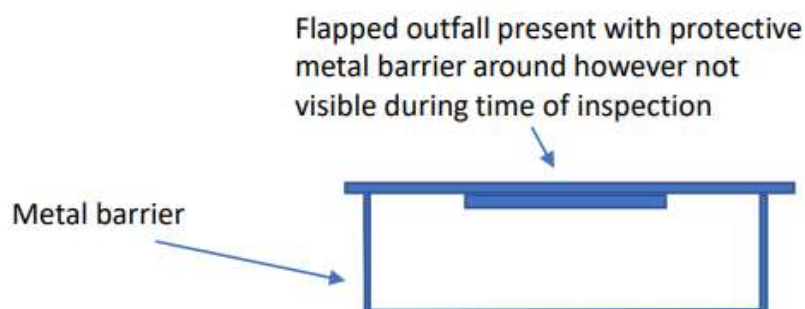


	• If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed • Continue with small repairs of brick and mortar loss • Repaint sheet piling • If extensive damage has been incurred to wall, rebuild wall	
15	• Continue yearly inspections and vegetation management • If extensive damage has been incurred to embankment, reprofile bank and lay down grass seed • Repair any damage to concrete apron and wall • Consider employing engineer to assess asset condition in detail to identify potential structural issues with embankment, employ relevant operative to repair damage	£9,600.00



CL23 – Outfall

Flapped outfall with unknown diameter located behind metal barrier which obstructs view of outfall.



4.1.22 Comments

Minor corrosion to barrier. Unable to see headwall and pipe due to high water level and barrier around.

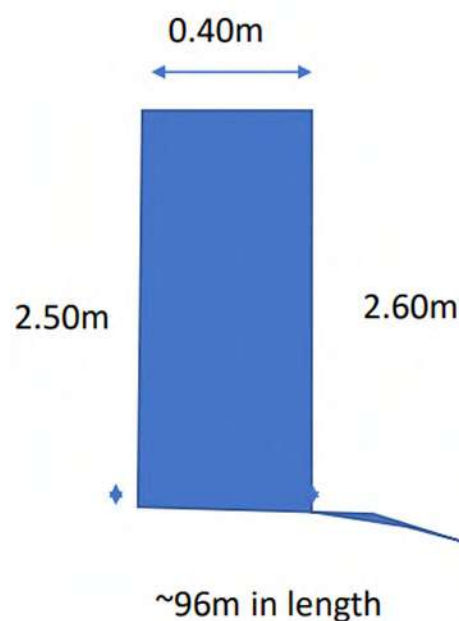
Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Investigate dimensions and condition of outfall - Carry out CCTV inspection to assess pipe condition - Conduct annual visual asset inspections to assess the condition of the asset	£600.00
5	- Continue to inspect outfall yearly, including CCTV inspections of pipe every 5 years - Monitor stability of metal barrier and replace if necessary	£3,500.00
10	- Continue yearly inspections of the outfall - Manage any vegetation growth which could damage asset	£6,900.00
15	- Continue yearly inspections of the outfall and manage vegetation growth - If there has been any serious structural damage to the outfall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£23,700.00



CL24 – Wall

High stone wall with capping stones located off right bank and going away from main channel towards village.



4.1.23 Comments

Minor vegetation growth through crest. Minor mortar loss on exposed face and a couple of holes on both faces, not whole way though. Few bricks missing for drainage

Grade = 3, Fair

Years	Recommendations	Cumulative Cost (£)
1	- Repair holes in wall and remove vegetation - Conduct visual asset inspections annually - Maintain surrounding vegetation to avoid wall incurring structural damage	£200.00
5	- Continue to inspect the wall yearly to keep track of and identify potential issues - Conduct small repairs to brick and mortar loss and manage surrounding vegetation	£1,100.00
10	Carry out repointing of wall and continue with small repairs to brickwork and management of surrounding vegetation	£2,200.00
15	If there has been any serious structural damage to the wall over time such as cracking or movement, employ an engineer to investigate. If investigations have found structural damage, employ the relevant operative to repair the damage	£9,200.00



5.0 Summary Costs of Repair and Maintenance

TABLE 2: TOTAL COST

Asset	Immediate	1 Year	5 Years	10 Years	15 Years
CL1	£400.00	£600.00	£3,500.00	£12,500.00	£16,600.00
CL2		£600.00	£3,100.00	£13,200.00	£21,500.00
CL3	£1,900.00	£200.00	£1,000.00	£2,100.00	£10,100.00
CL4		£600.00	£3,500.00	£6,900.00	£17,400.00
CL5		£600.00	£3,500.00	£6,900.00	£17,400.00
CL6	£5,000.00	£200.00	£1,000.00	£2,100.00	£11,000.00
CL7		£600.00	£3,500.00	£6,900.00	£14,800.00
CL8		£600.00	£3,500.00	£6,900.00	£14,800.00
CL9		£600.00	£3,500.00	£6,900.00	£14,800.00
CL10		£600.00	£3,500.00	£6,900.00	£14,800.00
CL11		£600.00	£3,500.00	£6,900.00	£14,800.00
CL12		£600.00	£3,500.00	£6,900.00	£14,800.00
CL13		£700.00	£5,500.00	£17,900.00	£34,200.00
CL14		£600.00	£1,100.00	£2,200.00	£12,000.00
CL15		£200.00	£1,200.00	£2,400.00	£7,700.00
CL16		£200.00	£1,000.00	£2,000.00	£5,900.00
CL17		£200.00	£1,200.00	£4,800.00	£8,200.00
CL18		£7,200.00	£33,400.00	£90,100.00	£166,600.00
CL19		£600.00	£3,500.00	£6,900.00	£17,400.00
CL20		£600.00	£3,500.00	£6,900.00	£17,400.00
CL21		£200.00	£1,100.00	£2,500.00	£9,600.00
CL22		£200.00	£1,600.00	£3,400.00	£9,600.00
CL23		£600.00	£3,500.00	£6,900.00	£23,700.00
CL24		£200.00	£1,100.00	£2,200.00	£9,200.00
Total	£7,300.00	£18,000.00	£94,000.00	£233,700.00	£504,300.00



6.0 Summary

Overall, three of the flood assets are in poor condition, two are walls which will require reconstruction, and the first of the embankments requires the installation of a none return valve to retain its flood defence function. There are six outfalls in good condition and the remaining fourteen flood assets are in fair condition. All assets are no longer inspected by the Environment Agency and have a limited flood protection function, the capacity of the channel itself and the lower land on the opposite bank provides some protection to the site.

The associated costs from immediate action to 15 years ahead involve visual asset inspections which will allow the condition of each asset to be assessed in order to ensure the assets remain in good working order. Vegetation management is also a very consistent cost for almost all assets since root penetration and undesirable vegetation can destabilise assets which could cause them to fail. Mortar repair is a minor but regular maintenance requirement for all defences and structures containing brickwork to ensure internal degradation to brick structures is reduced.

Larger costs which may be required after a longer period of time include the replacement of sheet piling, bank reprofiling and repointing of walls. These costs would be necessary to ensure the assets remain stable.

The recommendations made in Section 4 emphasise monitoring and management to maintain assets to allow them to reach or maintain a condition grade of 3 - 'Fair'. Monitoring and management makes up most of the 5 and 10 year costings outlined in Table 2, including yearly inspections, vegetation management, and minor repair work where required.

For the 15-year period, more intrusive, structural recommendations have been made to maintain assets to achieve condition grade 3 - 'Fair'. These recommendations make assumptions that the assets will degrade over time, and that erosion of the channel side will continue. Investigations by engineers will be required to determine any further work required at the time.



Appendix A: Asset inspection logs

Asset inspection logs including photos are available to download as PDF documents.



**RESILIENCE
& FLOOD RISK**

Cleator Flood Asset Condition Assessment Report

23 MAR 2022

Version 1.0

Asset ID	CL1	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Embankment				
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Earth				9	3
2	Landward Face	Earth				7	3
3	Exposed Face	Earth				7	3
4	Channel Side	Earth				5	3
5	Berm	Earth				5	2
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Variant weighting used for crest as <4m wide. Drainage pipe running through entire width of embankment, low spots, some animal holes and rutting on crest, Landward face and exposed face have some holes and uneven slopes but are well vegetated. Undermining, minor erosion and light foreign objects present on channel side but currently stable.						
Recommendations	Infill low spots on crest, remove drainage pipe from embankment and consider pest control.						



Asset ID		Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Channel	Asset Type - Subtype		Natural High Ground			
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition	CL2	Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	High ground	Earth				2	2
2	Channel Side	Earth				5	3
3							
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Significant undermining, erosion and presence of light foreign objects on channel side. High ground in good condition.						
Recommendations	Monitor erosion, consider installing erosion protection layer to channel side.						



Asset ID	CL3	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Wall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Stone				7	3
2	Landward Face	Stone				9	4
3	Exposed Face	Stone				9	4
4	Channel Side	Earth				5	3
5	Berm	Earth				5	2
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override	4		
Override Reason	Critical element has lower grading						
Comments	Variant weightings used for both faces as no revetments. Significant mortar loss to crest, holes through wall, bulging of wall where light foreign objects are growing in front on wall, distorting its shape and minor erosion to channel side.						
Recommendations	Rebuild wall and remove trees in front of wall.						



Asset ID	CL4	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	2
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	3
4	Apron	Concrete				5	2
5	Downstream headwall	Stone and concrete				8	3
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override	3		
Override Reason	Critical element has lower grading						
Comments	Vegetation around headwall. Unable to see through pipe and no CCTV footage available.						
Recommendations	Conduct a CCTV survey to inspect pipe and remove vegetation around headwall.						



Asset ID	CL5	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	2
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	3
4	Downstream headwall	Stone and concrete				8	2
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override	3		
Override Reason	Critical element has lower grading						
Comments	Outfall in good condition, very minor corrosion present on frame and flap valve. Unable to see through pipe and no CCTV footage available.						
Recommendations	Conduct a CCTV survey to inspect pipe.						



Asset ID	CL6	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Wall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Stone				7	4
2	Landward Face	Stone				9	4
3	Exposed Face	Stone				9	4
4	Channel Side	Earth				5	3
5	Berm	Earth				5	3
6							
7							
8							
9							
10							
11							
Calculated	4	Worst		Override			
Override Reason							
Comments	Heavy foreign objects growing towards channel on berm and channel side and undermining on channel side causing channel side to be unstable. Ivy growth on wall, heavy foreign objects growing close to wall causing bulging to wall and capping stones lost from crest halfway across wall.						
Recommendations	Rebuild wall, remove unstable trees and remove trees next to wall.						



Asset ID	CL7	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	2
2	Flap valve	Metal				9	2
3	Pipe	Unknown				9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	No signs of corrosion to flap valve or frame, pipe has minor leaf debris but no blockages or damage. Downstream headwall has some cracks, vegetation growth and mortar loss.						
Recommendations	Continue with ongoing vegetation maintenance.						



Asset ID	CL8	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	2
2	Flap valve	Metal				9	2
3	Pipe	Unknown				9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	No signs of corrosion to flap valve or frame, pipe has minor leaf debris but no blockages or damage. Minor crack to downstream headwall, vegetation growth and mortar loss.						
Recommendations	Continue with ongoing vegetation maintenance.						



Asset ID	CL9	Frequency		 RESILIENCE & FLOOD RISK			
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	3
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	No corrosion to flap valve or frame. Cracks and mortar loss on headwall. Pipe has minor leaf debris but no blockages or damage.						
Recommendations	Remove vegetation and continue with vegetation maintenance.						



Asset ID	CL10	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	3
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	Ivy growth around frame and headwall. No corrosion to flap valve. Cracks and vegetation growth on headwall. Pipe has minor leaf debris but no blockages or damage.						
Recommendations	Remove vegetation and continue with vegetation maintenance.						



Asset ID	CL11	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	3
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	Ivy growth around frame and headwall. No corrosion to flap valve. Minor cracks and vegetation growth on headwall. Pipe has vegetation debris but no blockages or damage.						
Recommendations	Remove vegetation and continue with vegetation maintenance.						



Asset ID	CL12	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Frame	Metal				7	3
2	Flap valve	Metal				9	2
3	Pipe	Unknown			X	9	2
4	Downstream headwall	Stone and concrete				8	3
5							
6							
7							
8							
9							
10							
11							
Calculated	2	Worst		Override			
Override Reason							
Comments	No corrosion to flap valve or frame. Minor cracks, mortar loss and minor vegetation growth on headwall. Pipe has minor leaf debris but no blockages or damage.						
Recommendations	Remove vegetation and continue with vegetation maintenance.						



Asset ID	CL13	Frequency						
Latest Assessment Date	28/01/2022	Due Date						
Asset Inspector	Alexandra Mackaness							
Asset Name	Channel	Asset Type - Subtype		Natural High Ground				
Asset Location	Cleator							
Description	Near to Millers Walk, Cleator							
Current Asset Condition		Target condition	3					
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition	
1	High ground	Tarmac				2	2	
2	Channel Side	Earth				5	3	
3								
4								
5								
6								
7								
8								
9								
10								
11								
Calculated	3	Worst		Override				
Override Reason								
Comments	Significant undermining, erosion and presence of light foreign objects on channel side. High ground in good condition.							
Recommendations	Monitor erosion, consider installing erosion protection layer to channel side.							



Asset ID	CL14	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Channel	Asset Type - Subtype	Natural High Ground				
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	High ground	Tarmac				2	2
2	Channel Side	Earth				5	3
3							
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Light foreign objects and ivy growing in front of and on top of channel side wall. High ground is road in good condition. Heavy foreign object upstream with roots growing into channel side brickwork.						
Recommendations	Remove trees on top of and in front of channel side brickwork. Remove ivy.						



Asset ID	CL15	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Wall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Stone				7	3
2	Landward Face	Stone				9	3
3	Exposed Face	Stone				9	3
4	Channel Side	Earth				5	3
5	Berm	Earth				5	3
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Several heavy foreign objects on berm and channel side. Severe mortar loss in landward face, exposed face difficult to inspect but wall covered in ivy and some tree roots and growing through it. Crest is uneven where ivy has grown around it.						
Recommendations	Rebuild wall, remove ivy and remove trees growing into wall.						



Asset ID	CL16	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Wall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Stone				7	4
2	Landward Face	Stone				9	2
3	Exposed Face	Stone				9	3
4	Channel Side	Earth				5	4
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Extensive ivy growth, channel side wall is walling down with severe brick loss and root penetration. Heavy foreign objects growing on channel side causing brick displacement and loss. Crest is uneven due to brick loss but landward face is made from concrete slabs in good condition.						
Recommendations	Rebuild wall and remove heavy foreign objects.						



Asset ID	CL17	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Channel	Asset Type - Subtype	Natural High Ground				
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition	3	Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	High ground	Tarmac				2	2
2	Channel Side	Earth				5	3
3							
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Heavy foreign objects on channel side leaning towards channel. Building <3m from channel on high ground.						
Recommendations	Continue with vegetation maintenance and monitor tree growth.						



Asset ID	CL18	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Embankment				
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition	4	Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Earth				9	3
2	Landward Face	Earth				9	3
3	Exposed Face	Earth				9	3
4	Channel Side	Earth				7	4
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Low points and rutting in crest but well vegetated. Variant used for exposed face due to steepness. Exposed and landward faces have isolated bare patches. Telegraph pole behind embankment but embankment build around it. Severe undermining of channel side around heavy foreign objects with extensive root exposure.						
Recommendations	Remove unstable trees on channel side, infill low spots on crest and seed bare patches.						



Asset ID	CL19	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Pipe	Unknown			X	9	3
2	Apron	Concrete				5	3
3	Downstream headwall	Stone and concrete				8	3
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Drainage pipe halfway between wall and building on high ground. Unable to see through pipe and no CCTV footage available. Vegetation around headwall and at base of pipe.						
Recommendations	Remove vegetation and provide ongoing vegetation maintenance. Conduct CCTV inspection of pipe.						



Asset ID	CL20	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Structure	Asset Type - Subtype	Outfall				
Asset Location	Cleator						
Description	Hilden Road, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Pipe	Unknown			X	9	3
2	Downstream headwall	Stone and concrete				8	4
3							
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Downstream headwall in pieces. Unable to see through pipe and no CCTV footage available.						
Recommendations	Rebuild headwall and conduct CCTV inspection of pipe.						



Asset ID	CL21	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Embankment				
Asset Location	Cleator						
Description	Near to Millers Walk, Cleator						
Current Asset Condition	3	Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Earth				9	3
2	Landward Face	Earth				7	2
3	Exposed Face 1	Earth				7	2
4	Berm 1	Gabions				5	3
5	Exposed Face 2	Gabions				7	3
6	Berm 2	Concrete				5	2
7	Channel Side	Sheet piling				5	2
8							
9							
10							
11							
Calculated	2	Worst		Override	3		
Override Reason	Critical element has worse condition grade						
Comments	Berm 2 and channel side in good condition with minor cosmetic defects to sheet piles. Vegetation growth through gabion baskets with a few broken wires but no gabion displacement. Uneven ground on exposed face 1 and landward face but well vegetated. Rutting and low spots in isolated places on crest. Variants used on crest as less than 4m wide and landward face due to steepness.						
Recommendations	Remove vegetation in gabions and repair wires. Infill low spots on crest.						



Asset ID	CL22	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
							
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Embankment				
Asset Location	Cleator						
Description	Between Mill Street and Brookside, Cleator						
Current Asset Condition	3	Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Earth				9	3
2	Landward Face	Earth				7	2
3	Exposed Face 1	Earth				7	2
4	Berm 1	Stone				5	3
5	Exposed Face 2	Stone				7	2
6	Berm 2	Concrete				5	2
7	Channel Side	Sheet piling				5	2
8	Landward face 2	Stone				7	2
9							
10							
11							
Calculated	2	Worst		Override	3		
Override Reason	Critical element has worse condition grade						
Comments	Minor vegetation growth within berm 1 and exposed face 2 with minor mortar loss. Uneven crest with some low spots but well vegetated. Berm 2 and channel side in good condition with minor cosmetic defects to sheet piling. Landward face and exposed face 1 are well vegetated but uneven. Landward face 2 around corner and has minor vegetation growing through stone and minor mortar loss.						
Recommendations	Monitor vegetation growth in wall and infill low spots in crest.						



Asset ID	CL23	Frequency						
Latest Assessment Date	28/01/2022	Due Date						
								
Asset Inspector	Alexandra Mackaness							
Asset Name	Structure	Asset Type - Subtype						Outfall
Asset Location	Cleator							
Description	Between Mill Street and Brookside, Cleator							
Current Asset Condition		Target condition	3					
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition	
1	Downstream headwall	Stone and concrete			X	8	3	
2	Pipe	Unknown			X	9	3	
3	Barrier	Metal				2	3	
4								
5								
6								
7								
8								
9								
10								
11								
Calculated	3	Worst		Override				
Override Reason								
Comments	Minor corrosion to barrier. Unable to see headwall and pipe due to high water level and barrier around.							
Recommendations	Conduct CCTV inspection for pipe and headwall.							



Asset ID	CL24	Frequency					
Latest Assessment Date	28/01/2022	Due Date					
Asset Inspector	Alexandra Mackaness						
Asset Name	Defence	Asset Type - Subtype	Wall				
Asset Location	Cleator						
Description	Brookside, Cleator						
Current Asset Condition		Target condition	3				
Element Sequence	Element Type	Material	Photo ref	Notes	ENI	Weighting	Condition
1	Crest	Stone				7	3
2	Landward Face	Stone				9	3
3	Exposed Face	Stone				9	3
4							
5							
6							
7							
8							
9							
10							
11							
Calculated	3	Worst		Override			
Override Reason							
Comments	Minor vegetation growth through crest. Minor mortar loss on exposed face and a couple of holes on both faces, not whole way though. Few bricks missing for drainage.						
Recommendations	Repair holes in wall and remove vegetation.						



Appendix E Watercourse Model



Hydraulic Model Technical Note

AE4648_CA23_Cleator Moor_03_TN

Land at Trumpet Terrace, Black How
Cleator Moor
CA23 3DX

UK Experts in Flood Modelling, Flood Risk
Assessments, and Surface Water Drainage Strategies

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1. Introduction

- 1.1. Aegaea have been commissioned by RWO Associates Ltd to undertake a hydraulic modelling exercise of River Ehen at Cleator Moor. The aim of the modelling is to identify the fluvial flood risk pertaining to the Application Site highlighted in drawing ref. AEG4648-DR-GEN-101 (Appendix A).
- 1.2. This report includes an overview of the hydraulic modelling methodology, as well as a summary of the hydrological assessment, modelling results and sensitivity testing.
- 1.3. Following previous hydraulic modelling exercises undertaken by third parties, one of the key aims of this study is to assess the impact of the kerb line that surrounds the perimeter of the Application Site, and is deemed to have a significant effect in diverting shallow flood depths in the vicinity of the Application Site.
- 1.4. The hydraulic modelling exercise is informed by the Environment Agency's hydraulic model developed under the 'Ehen 2015 and Cleator Moor 2009 study', hereafter referred as the EA's original hydraulic model.

Site Overview

- 1.5. The Application Site is a greenfield plot of land located to the south of Trumpet Terrace – as shown in drawing ref. AEG4648-DR-GEN-101 in **Appendix A**.
- 1.6. The site consists of greenfield land, and it is surrounded by an urbanised area to the west, by an access road leading to Kangol Park and Ride to the east, by Mill St to the south and by Trumpet Terrace to the north.
- 1.7. River Ehen flows north to south, as close as 10m to the east of the site. An unnamed tributary flows north to south, adjoining River Ehen at the confluence near the site. The unnamed tributary is culverted under Trumpet Terrace, prior to adjoining River Ehen.
- 1.8. The unnamed tributary is one of the key concerns in terms of flood risk to the site; and was studied by third parties as part of previous flood risk assessments.

- 1.9. The Application Site is known to be protected by flood defences along the right bank of River Ehen. The flood defence in the vicinity of the Application Site is known to be a concrete wall, which is incorporated in the EA's original hydraulic model.

2. Available Data

EA's Flood Map for Planning

- 2.1. An extract from the EA's risk of flooding from rivers and the sea (Flood Zone 2 and Flood Zone 3) is included in drawing ref. AEG4648-DR-GEN-102, in **Appendix A**. This extract does not include the effect of flood defences that are known to exist along the right bank of River Ehen.
- 2.2. Further site-specific hydraulic modelling is required to assess flood risk to the site and the effect of the flood defences and micro topographic features in the area.

EA's Fluvial Detailed Hydraulic Model

- 2.3. The Environment Agency was contacted and the 'Ehen 2015 and Cleator Moor 2009 study' was provided.
- 2.4. The EA's original hydraulic model is a ISIS-TUFLOW 1D-2D hydraulic model that modelled River Ehen between Ennerdale Water Lake and the estuary near Sellafield. Whilst River Ehen and River Keekle are part of the 1D ISIS domain, and some of the tributary watercourses (e.g. Nor Beck) are only included in the ETRY 1D domain. The unnamed tributary that flows underneath Trumpet Terrace is not included in the ISIS 1D domain in the EA's original model.
- 2.5. The hydraulic model developed under the current study will make use of the EA's original hydraulic model, developed under the 'Ehen 2015 and Cleator Moor 2009' study, which will be trimmed to the area of the study and will include site-specific information, including topographic survey of the sit. The unnamed tributary of River Ehen will also be added to the 1D domain of Flood Modeller Pro (former ISIS)

EA's Risk of Flooding from Surface Water Mapping

- 2.6. The EA's Long-Term Flood Risk Map can be used to provide indication of the risk of flooding from surface water runoff (RoFSW). An extract from the EA's *wms* datasets is included in AEG4648-DR-GEN-103, in **Appendix A**.
- 2.7. The Application Site appears to be affected by surface water flood extents for flood events greater than the 1%AEP. The flood routes affecting the Application Site appear to triggered by

the lack of capacity (or absence) in the culverted section of the unnamed tributary, that flows underneath Trumpet Terrace.

Terrain Data

- 2.8. Under this study, the 2D TUFLOW model was informed by the publicly available EA's LiDAR DTM dataset, with a 1m horizontal resolution. An extract of the EA's LiDAR dataset and 1m-spaced contours in the area of study is shown in AEG4648-DR-GEN-104, in **Appendix A**.
- 2.9. The 2D TUFLOW domain was also informed by a site-specific topographic survey within the Application Site and in its immediate vicinity. The topographic survey was converted into a 3D Digital Elevation Model and included in TUFLOW.
- 2.10. The topographic survey and respective 3D DEM is of particular importance due to the presence of a kerb line alongside the road that surrounds the Application Site. According to previous studies, the flood depths in the vicinity of the Application Site are known to be relatively shallow, meaning that standard kerb heights may have a significant impact on local flood patterns.

Survey Data

- 2.11. The unnamed watercourse that adjoins River Ehen immediately to the north of the Application Site was surveyed by third parties, and various cross-sections of the bed and key 1D features were provided in DAT format.
- 2.12. The survey included various cross-sections of the unnamed watercourse, as well as dedicated sections of the culvert underneath Trumpet Terrace, which ultimately outflows into River Ehen.
- 2.13. The original bed survey was not made available at the date this report was written and therefore this element was not verified or checked.

Roughness Data

- 2.14. The roughness data adopted in the 1D and 2D domains of the model was informed by the original EA's 'Ehen 2015 and Cleator Moor 2009 study'.

2.15. The list of Manning's coefficients is included in Table 1.

Table 1: List of Manning's roughness coefficients adopted in the hydraulic modelling exercise.

Land use description	Manning's roughness, n (-)
General Floodplain	0.060
Buildings (Porous approach)	0.050
Roads, Tracks and Paths	0.022
Inland Water	0.030
Railway	0.045
Gardens / Mixed	0.075
Woodland / Scrub	0.100
Manmade Surfaces	0.025
Stability Patch	0.250
Greenfield	0.040

3. Hydrological Assessment

Catchment Delineation

- 3.1. A hydrological assessment has been undertaken according to current EA guidelines to determine peak flows and design hydrographs to use as boundaries to the hydraulic model for the 5%AEP, 3.3%AEP, 1%AEP and 0.1%AEP. The Flood Estimation Report (LIT 65087) detailing the hydrological analysis is provided in **Appendix B** of this report.
- 3.2. A lumped estimation point has been identified for the River Ehen at the d/s extent of the hydraulic model (RE01). The catchment at RE01 has been divided into sub-catchments, according to the purposes of the hydraulic modelling and the scale of the area of interest.
- 3.3. Design hydrographs are required for the River Ehen at the u/s extent of the hydraulic model and for the unnamed tributary joining the River Ehen at the northern boundary of the site. Therefore, the locations identified as RE02 and UT01 on the River Ehen and unnamed tributary (u/s of their confluence) have been selected in order to delineate the sub-catchments appropriate to the purposes of the hydrological analysis.
- 3.4. The selected Hydrological Estimation Points (HEPs) and catchments as defined on the FEH Web Service¹ are shown in drawing ref. AEG4648-DR-GEN-106 in **Appendix A**. It should be noted that the contribution of the intervening area between the u/s estimation points (RE02 and UT01) and the d/s estimation point (RE01) has been accounted for through a lateral inflow to the hydraulic model.
- 3.5. It should also be noted that the catchment to UT01 has been modified on the basis of terrain analysis using LiDAR DTM data and inline with previous hydrological studies² undertaken on this catchment.
- 3.6. A selection of catchment descriptors for the River Ehen at RE01 and RE02 and for the unnamed tributary at UT01 is provided in Table 2. URBEXT2024 for the catchments at RE01 and RE02 is

¹ <https://fehweb.ceh.ac.uk/Map>

² FEH calculation record, by JBA (ref. 2013s7682)

the default URBEXT2000 value updated to present day according to the national average Urban Expansion Factor (UEF). URBEXT2024 at UT01 has been estimated according to WINFAP procedures from the fraction of urbanised catchment area (URBAN), according to FEH guidelines³.

Table 2 Selection of catchment descriptors for the River Ehen and unnamed tributary

HEP	Area (km2)	BFIHOST19	FARL	SAAR	URBEXT2024
RE01	77.161	0.461	0.84	2082	0.0052
RE02	75.560	0.456	0.833	2123	0.0020
UT02	0.681	0.531	0.998	1250	0.462

Estimation of design peak flows and hydrographs

- 3.7. Both the Statistical method and ReFH2 rainfall-runoff approach have been applied to derive and compare peak flow estimates at RE01 and UT01. In addition, the AMAX record at NRFA gauge 74003 (Ehen at Bleach Green) has been considered for comparison of peak flow estimates obtained by applying the standard approaches. The gauge is located on the River Ehen d/s of the Ennerdale Water reservoir and accounts for a catchment area of 44.587km².
- 3.8. QMED estimates at RE01 and RE02 obtained by scaling QMED at 74003 by the ratio of ungauged and gauged catchment areas are more conservative than the Statistical estimates. The scaled estimates have been selected as final because it has been considered that they incorporate information available for a gauged catchment hydrologically similar to the ungauged sites and the standard Statistical method to estimate QMED from catchment descriptors cannot be considered reliable due to low FARL at RE01 and RE02, according to FEH guidelines³.

- 3.9. QMED at UT01 has been estimated from catchment descriptors and adjusted by donor transfer from the closest suitable donor and for urbanisation, in accordance to FEH guidelines³ and following the methodology implemented in WINFAP5.
- 3.10. Growth factors have been derived from Statistical pooled analysis at RE01 and applied at all estimation points. This is appropriate to the scale of the study and helps promoting spatial consistency, in line with FEH guidelines³. The GL distribution has been selected to derive the growth curve, which has been adjusted for urbanisation in WINFAP5.
- 3.11. Lumped ReFH2 models have been built at RE01 and UT01 in order to derive peak flow estimates to compare with estimates from Statistical analysis at the same locations.
- 3.12. Hydrograph shapes derived from ReFH2 have been applied to generate design hydrographs for use as boundaries in the hydraulic model. For this purpose, two storms have been selected for testing in the hydraulic modelling, namely a 7.5hr winter storm (consistent with the lumped model built at RE01) and a 2.18hr summer storm (consistent with the urban catchment local to the site of interest at UT01)
- 3.13. Peak flows for all required events are detailed in Table 3. Peak flow estimates are provided at all HEPs and for the intervening area RE_i (0.919km²) between the d/s catchment at RE01 and the u/s catchments at RE02 and UT01. It should be noted that peak flow estimates for the intervening area have been obtained from estimates at RE01 scaled by the ratio of catchment areas. Both the Central and Higher Central climate change allowances have been applied to the 1%AEP peak flow estimate in order to assess the impact of climate change on flood risk, albeit only the central allowance was adopted in this study. Climate change allowances are for the South West Lakes Management Catchment and have been estimated as being equal to 30% and 39%, respectively, according to current guidance⁴.

³ Environment Agency. Flood Estimation Guidelines LIT11832. Published 23/12/2022

⁴ Environment Agency. Flood risk assessments: climate change allowances. Last Updated May 2022

Table 3 Final peak flow estimates at selected HEPs and for the intervening area RE_i

HEP	50% AEP	5% AEP	3.33% AEP	1% AEP	0.1%AEP	1% AEP + 30%
RE01	58.960	103.534	112.614	144.217	232.362	187.482
RE02	57.737	101.387	110.278	141.225	227.542	183.593
UT02	1.075	1.888	2.053	2.629	4.237	3.418
RE_i	0.703	1.234	1.342	1.719	2.769	2.234

4. Hydraulic Model Build

Scope of Modelling

- 4.1. This section summarises the baseline hydraulic model construction for the River Ehen at Cleator Moor.
- 4.2. The hydraulic model developed in this study uses the EA's original hydraulic model developed under the 'Ehen 2015 and Cleator Moor 2009' study. The EA's ISIS-TUFLOW 1D-2D hydraulic model was trimmed to the area of interest, near Cleator Moor and includes the unnamed tributary.
- 4.3. The model was simulated using Flood Modeller version 7.0 and TUFLOW HPC solver (version 2023-03-AA-iSP-w64).
- 4.4. All results presented in this section refer to the defended scenario, unless otherwise stated.

1D Domain

- 4.5. The River Ehen cross-sections were extracted directly from the EA's original hydraulic model, with panel markers added as required.
- 4.6. The cross-sections of the unnamed tributary were surveyed and provided by the Client in DAT format, from historical hydraulic modelling undertaken for the Application Site. The survey was not analysed as part of this hydraulic modelling exercise.
- 4.7. The hydraulic structures included within the model are summarised in Table 1.

Table 1: Hydraulic Structures

Watercourse	River Ehen
Node Label(s)	BR_EH4_0806u

Unit Type	Bridge - USBPR
Invert Level (m AOD)	54.206
Dimensions (m)	13.384m width and 3.364m high
Comments	Bridge incorporated in the EA's hydraulic model
Watercourse	Unnamed tributary
Node Label	TTD_Cul3 – TTD_Cul4
Unit Type	Conduit Circular
Invert Level (m AOD)	USIL 66.420 DSIL 64.330
Dimensions (mm)	Ø675
Comments	Includes trash screen at inlet
Comments	Culvert DAT file provided by third-parties.
Watercourse	Unnamed tributary
Node Label	TTD_Cul5 – TTD_Cul6
Unit Type	Conduit Circular
Invert Level (m AOD)	USIL 64.230 DSIL 61.350

Dimensions (mm)	Ø825
Comments	No trash screen included. Culvert DAT file provided by third-parties.

2D Domain

- 4.8. The EA's TUFLOW 2D domain was used as the basis of this hydraulic model, albeit the latest EA's 2022 National LiDAR Programme LiDAR Digital Terrain Model was adopted as part of this study.
- 4.9. At the transition between the 1D and 2D domains, the EA's model includes 2D_zsh lines to reinforce banks thus ensuring a correct 'spill' onto the floodplain.
- 4.10. The triangulated topographical data was used within TUFLOW to overwrite the LiDAR data where survey data was available.
- 4.11. A 4m grid resolution applied to the model and Sub grid Sampling (SGS) was used down to a depth of 1m. On top of this, a 500mm-resolution quadtree layer was used to represent the area surrounding the kerb line around the perimeter of the Application Site.
- 4.12. The buildings were modelled via the 'stubby buildings' approach, where building footprints are raised by 300mm. This approach is a departure from the original EA's hydraulic model, which used 2d_fcsh shapes to add a flow constriction within the footprint of buildings. 2d_fcsh shapes are not compatible with TUFLOW HPC at the time this study was undertaken.
- 4.13. As discussed in 2.14 the hydraulic model in this study adopts the roughness values found in the original EA's model.
- 4.14. In line with the original EA's approach, the model assumes floodplain soils are saturated during flood events and disregards any potential infiltration of soils.

Boundary Conditions

- 4.15. A 'Flow-Time' boundary was applied directly to the upstream section of River Ehen (fluvial flow estimated at RE02) and at the upstream section of the Unnamed Tributary (fluvial flow estimated at UT01), as lumped flows.

- 4.16. A lateral inflow boundary has also been applied in the stretch of river between the confluence of both water courses and the downstream section of the hydraulic model (i.e. RE_i).
- 4.17. Automated 'Head-Flow' (HQ) boundaries have been applied at the edges of the 2D domain where there is the potential for flow to glass wall.
- 4.18. A normal depth boundary applied to downstream end of 1D domain, this boundary is located approximately 450m downstream of the Application Site.
- 4.19. The hydraulic model schematic is presented in drawing ref. AEG4648-DR-GEN-105, in **Appendix A**.

Design Events

- 4.20. The model was simulated against the following key design flood events:
- 5%AEP (20-year return period)
 - 3.3%AEP (30-year return period)
 - 1%AEP (100-year return period)
 - 1%AEP30CC (100-year return period plus 30% allowance for climate change)
 - 0.1%AEP (1000-year return period)

5. Model Results

Defended Scenario

- 5.1. The results of the hydraulic modelling exercise hereafter shown refer to the defended scenario, unless otherwise specifically stated.
- 5.2. The flood depth maps for the 5%AEP, 3.3%AEP, 1%AEP, 1%AEP30CC and 0.1%AEP are included in drawings ref. AEG4648-DR-DEF-201 to AEG4648-DR-DEF-205, in **Appendix C**. Flood depths were found to be relatively shallow i.e. generally below 200mm for the 1%AEP30CC.
- 5.3. The results show the Application Site to be affected by flood events as low as the 5%AEP, with the southern part being the most affected part of the site.
- 5.4. The hydrological assessment stipulates that the critical storm duration is the 7h30m for River Ehen and its tributary. However, the unnamed tributary was also assessed for the 02h18m storm duration, which was found to lead to less severe flood extents in relation to the 7h30m duration. The comparison between the 07h30m and the 02h18m storm durations is shown in AEG4648-DR-DEF-206, in **Appendix C**.

Flood Mechanism

- 5.5. The local flood mechanism for the 3.3%AEP and 1%AEP30CC is presented in drawings ref. AEG4648-DR-DEF-207 and AEG4648-DR-DEF-208, in **Appendix C**. The velocity vector grid shows significant exceedance flow routes triggered at the inlet of the culverted section of the unnamed tributary under Trumpet Terrace.
- 5.6. The southern part of the site is severely affected by the exceedance flow routes that appear to travel from the unnamed access road onto the Application Site.
- 5.7. The northern part of the site is also affected by an exceedance flow routes originated by the lack of capacity in the culverted section of the unnamed ordinary watercourse.
- 5.8. Albeit the kerb line around the perimeter of the Application Site was reinforced with a 2d_zsh layer, it is worth noting that part of the exceedance flow routes may travel onto the site due to an inconsistency between the LiDAR DTM dataset and the 3D topographic model, which puts parts

of the road at the same level (or lower) than the Application Site, without creating a vertical upstand. This item is discussed in further detail in sections 6.1 and 6.2.

6. Model Sensitivity

Roads lowered by 125mm

- 6.1. As previously discussed, there is an inconsistency between the LiDAR DTM and the topographic survey, with some of the kerb levels recorded in the 3D topographic model found to be levelled with adjacent roads. This was partly expected as these are two distinct datasets with different resolutions, accuracy and processing methodologies.
- 6.2. To measure the potential impact of kerbs on local flood patterns, roads were lowered by 125mm. This sensitivity test is included in drawing ref. AEG4648-DR-DEF-301, in **Appendix D**. The results show a some degree of improvement in the southern part of the Application Site, where some parts of the kerb were found to be levelled with the adjacent road. However, this part of the Application Site is still considerably impacted by flows.
- 6.3. It is worth noting that lowering roads by 125mm is not a standard approach in fluvial flood modelling, as it can create artificial storage where it does not represent reality. Therefore kerb lines were applied directly from the topographical survey provided.

Testing Manning's Roughness

- 6.4. To account for uncertainty of the roughness in the floodplain, a sensitivity run was undertaken by varying the Manning's roughness by up to 20% above and below the standard assumed values. The 1D Manning's roughness in the channel itself was kept unchanged as the Application Site lies on the flood plain i.e. fully embedded in the 2D domain.
- 6.5. The difference maps between standard and deviated Manning's roughness are shown in drawings ref. AEG4648-DR-DEF-305 and AEG4648-DR-DEF-306, in **Appendix D**. The maps show significant changes within and in the vicinity of the Application Site i.e. flood depths varying as much as +/- 25mm within the site; and parts of the central part of the Application Site becoming flooded for a 20% reduction in Manning's roughness in the 1%AEP30CC flood event.
- 6.6. However, given the Manning's roughness were also adopted in the original EA's model and there are no significant changes in local land uses, no further changes are proposed to this assessment.

Testing 1D inflows

- 6.7. The inflows to the 1D domain (FMP) were also tested by varying the respective values by $\pm 20\%$. The sensitivity test are shown in drawing ref. AEG4648-DR-DEF-302, in **Appendix D**.
- 6.8. As expected, a 20% variation in inflows leads to a significant change in flood extents, with flood extents in the southern part of the Application Site being significantly reduced for a reduction in inflows. The increase in inflows also leads to significant changes in terms of flood extents, with the central part of the Application Site becoming affected the 1%AEP30CC flood events.

Downstream Boundary Slope

- 6.9. The slope of the automatic HQ boundary was tested by varying the slope by $\pm 20\%$ for the 1%AEP30CC flood event, given the assumption underlying this boundary parameter.
- 6.10. The difference maps shown in drawings ref. AEG4648-DR-DEF-302 and AEG4648-DR-DEF-303 (**Appendix D**) , show a negligible difference in the vicinity of the Application Site, with no variations within the Application Site. The only noticeable variation is within 50m from the downstream 2d_code boundary, where depths can vary as much as 50mm from standard values.

7. Model Stability & Limitations

Simulation Parameters

- 7.1. The double precision 1D engine of Flood Modeller Pro (FMP) was used in all simulations.
- 7.2. TUFLOW (2D) version 2023-03-AA-iSP-w64 Heavily Parallelised Compute (HPC) was used in all simulations.
- 7.3. A timestep of 2.5s was used in the FMP (1D domain), whilst TUFLOW HPC uses an adaptive timestep based on stability criteria. All remaining parameters were retained as default.

FMP Model Stability (1D Domain)

- 7.4. The stability of the 1D domain was inspected by analysing the mass balance error outputs, which were found to start at values near 20% at the beginning of the simulation for the 1%AEP30CC, rapidly decreasing to values in the range between 2% to 3%.
- 7.5. In terms of non-convergences, the 1D engine recorded a total of 4 no. non-convergence throughout the simulation of the 1%AEP30CC flood event, when inflows diverge/converge with outflows i.e. when the 2D domain (floodplain) is activated or deactivated. From this point, the non-convergence clear for the remaining simulation of the 1%AEP30CC storm event.
- 7.6. The non-convergence and mass balance error recorded are not deemed to have a significant impact on modelling outputs.

TUFLOW Model Stability (2D Domain)

- 7.7. No negative depths were reported in the 2D domain for the 1%AEP30CC defended simulation.
- 7.8. No repeated timesteps were reported in the HPC (2D) domain for the 1%AEP30CC defended simulations.
- 7.9. Mass error was reported as 0.00% for the 1%AEP30CC defended event, which is considered to be an indicator of a stable model.
- 7.10. For a HPC model to be considered stable, three parameters should be maintained: Nu (Courant number relates to velocity relative to the cell size), Nc (Celerity Control number relates to water depth relative to cell size) and Nd (Diffusion control relates diffusion of momentum relating to

the sub grid viscosity). Generally, for a stable model these values should be: $Nu < 1$, $Nc < 1$ and $Nd < 0.3$.

Table 4: HPC solver stability outputs

	Maximum allowance indicating a healthy model performance	Max Model outputs - 1 in 100yr 30%CC return period	Average Model outputs - 100yr 30%CC year return period
Nu (Courant number)	1	0.504	0.392
Nc (Celerity Control number)	1	0.902	0.484
Nd (Diffusion control number)	0.3	0.281	0.259

7.11. Based on the values in Table 4, the stability criteria were found to be well within an acceptable range, which indicates an healthy 2D domain.

7.12. TUFLOW HPC uses adaptive time stepping to maintain stability, a good indication of model health is the number of repeated timesteps. For the 1%AEP30CC defended scenario, no repeated timesteps were recorded which is indicative of healthy model performance. Therefore, the overall model is considered stable.

Limitations

7.13. The modelling exercise has made best use of the available data at the time of construction and simulation.

7.14. The floodplain topography is derived from LiDAR which has limited accuracy (+/- 150mm). This is considered to be sufficient for the purpose of this exercise.

7.15. This model was used to assess the flood extents within the Application Site, after the inclusion of a standard kerb along the road that surrounds the perimeter of the Application Site. It is worth noting that there was a compatibility issue between the LiDAR DTM and the topographic 3D model, which puts some parts of the top of the kerb levelled with adjacent roads. This issues is likely to lead to additional flows into the Application Site. Despite of this inconsistency, this

approach is perceived to be more conservative than other approaches e.g. lowering roads by 125mm, which may add additional storage volume within roads when it does not correspond to reality.

7.16. Unique TUFLOW checks and warnings generated during the 1%AEP30CC flood event in Table 4.

Table 4: TUFLOW checks and warnings for the 1%AEP30CC defended scenario

Check/ Warning	TUFLOW ID	Description	Number of occurrences	Comments
Check	3505	SGS TIN outside model domain	292	2d_zsh polygons outside model domain are ignored. No effect in simulations.
Check	3548	Setting SGS Sample Distance to minimum grid zpt resolution of 1	1	Standard message. No impact on model.
Warning	2073	Object ignore. Only points, lines polylines & region centres used GIS Object = Null shape	4	GIS incorrectly created null shapes whilst splitting polygons to prevent closed features. No effect on simulations as 2d_zsh effect checked.
Warning	3526	SGS Sample Distance command is ignored in SGS Approach == Method C.	2	Standard message. No impact on model.

8. Conclusions

- 8.1. A good hydraulic representation of the fluvial flooding mechanisms and magnitude within the study area has been established via the construction of a linked 1D-2D hydraulic model and a hydrological assessment.
- 8.2. This hydraulic modelling exercise used the Environment Agency's detailed hydraulic model for the area, developed under the 'Ehen 2015 and Cleator Moor 2009 study'.
- 8.3. Overall, the modelling exercise show significant parts of the site to be affected by fluvial flooding from the unnamed tributary of river Ehen for flood events as low as the 5%AEP. The flood mechanism shows that the culverted section of the unnamed tributary cannot convey the design flows and prompts exceedance flow routes that ultimately affect the Application Site, largely within the southern part.
- 8.4. There might be scope to provide flood alleviation measure in the southern parts of the site, whilst enabling development to go ahead in the northern part of the Application Site and providing benefit for the wider community. With the new guidance on Sequential Test, this may be acceptable but early engagement with the LPA and EA is recommended prior to any detailed study of mitigation measures. Connecting any mitigations measures and flood compensation areas to River Ehen might however reveal a challenge that will need to be overcome.
- 8.5. Sensitivity testing showed the model to be particularly sensitive to roughness coefficients, albeit the values were kept unchanged as per the EA's original hydraulic model. Due to the inconsistency between the LiDAR DTM and the topographic 3D model, roads were also lowered by 125mm to assess the impact of kerbs on flood routes. The later approach showed a reasonable reduction in flood extents in the southern part of the Application Site.

Appendix A - General Drawings

TRUMPET TERRACE, CLEATOR MOOR

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE

☐ APPLICATION SITE

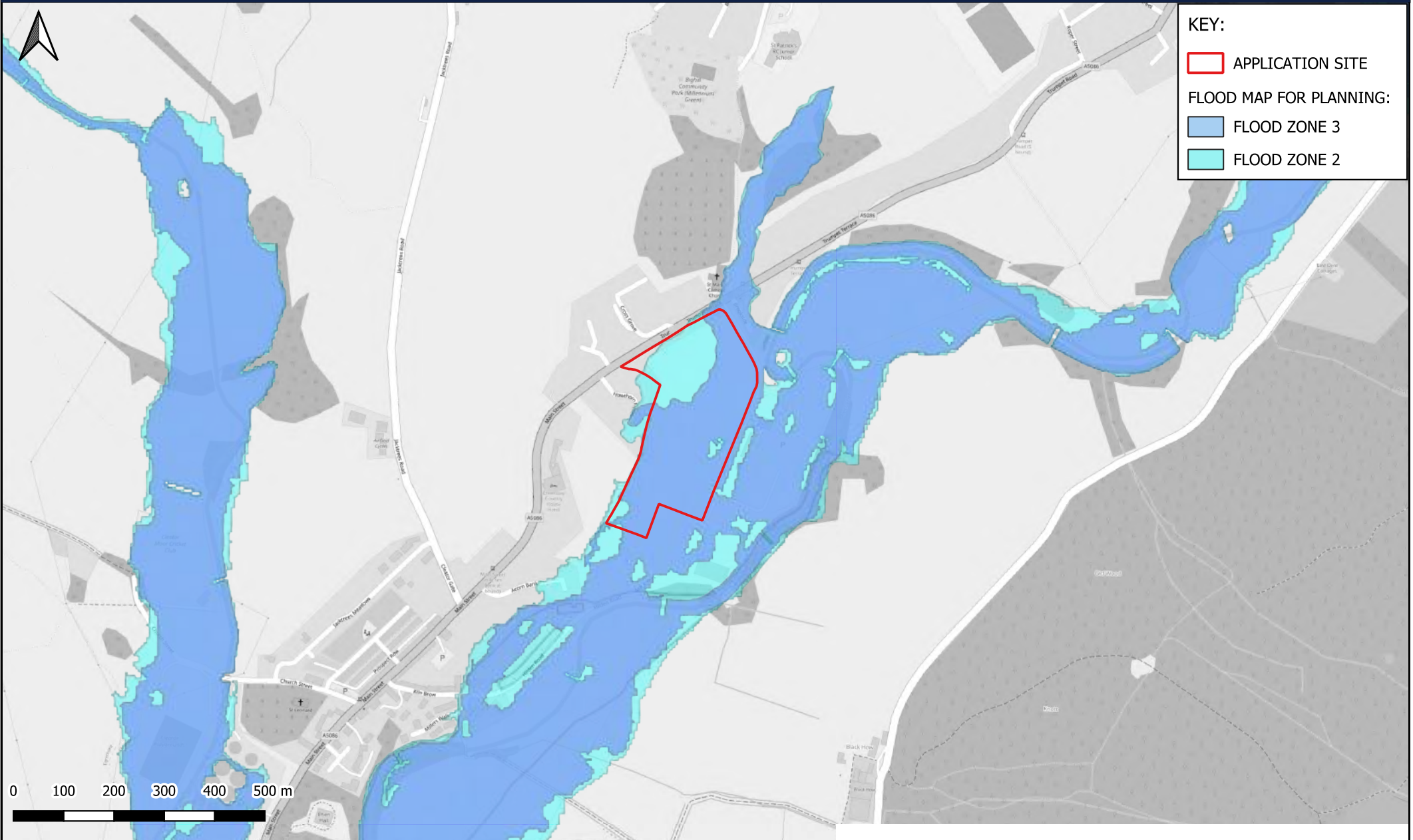


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PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01													
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC			

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

RISK OF FLOODING FROM RIVERS AND THE SEA ENVIRONMENT AGENCY'S WMS DATASET

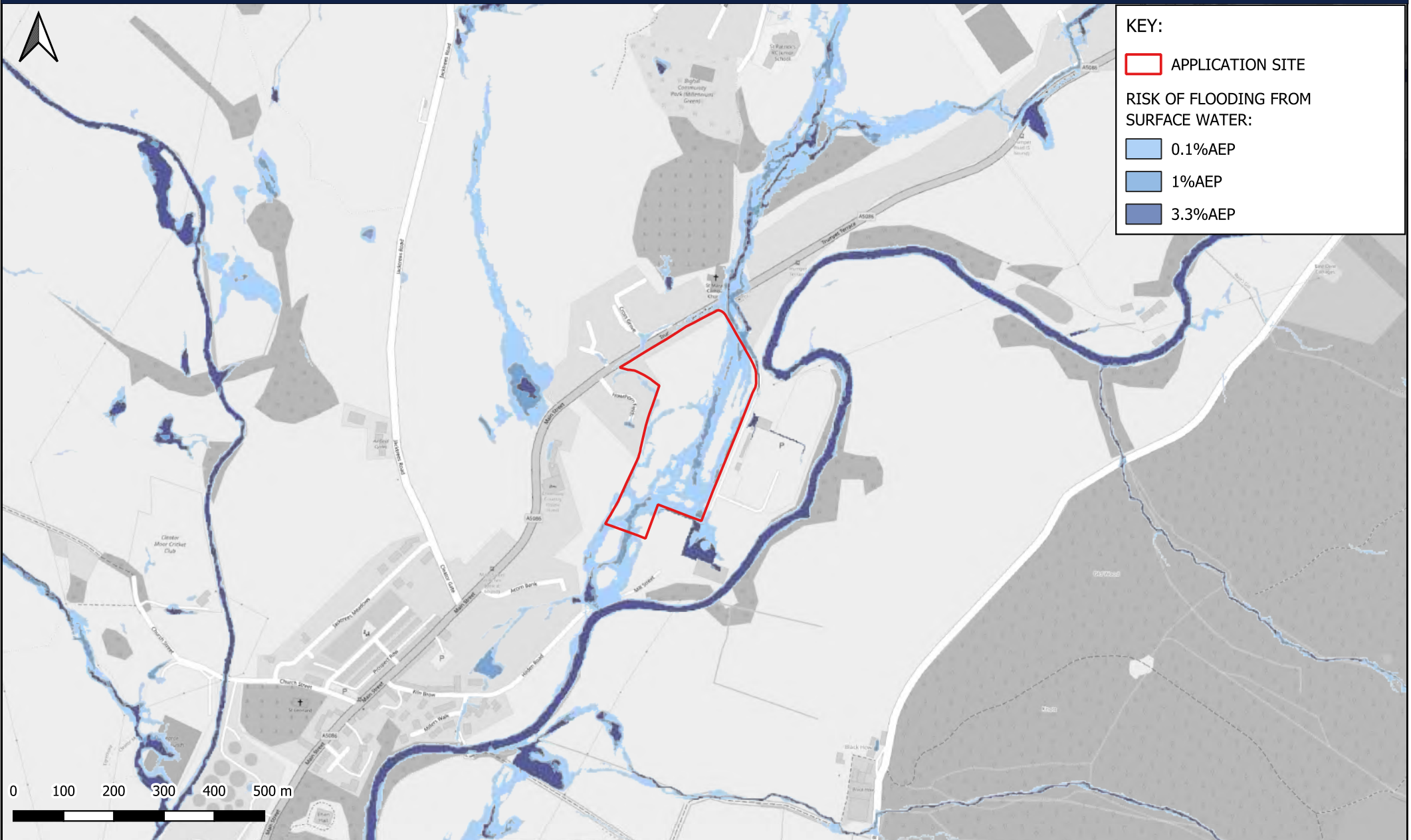
AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



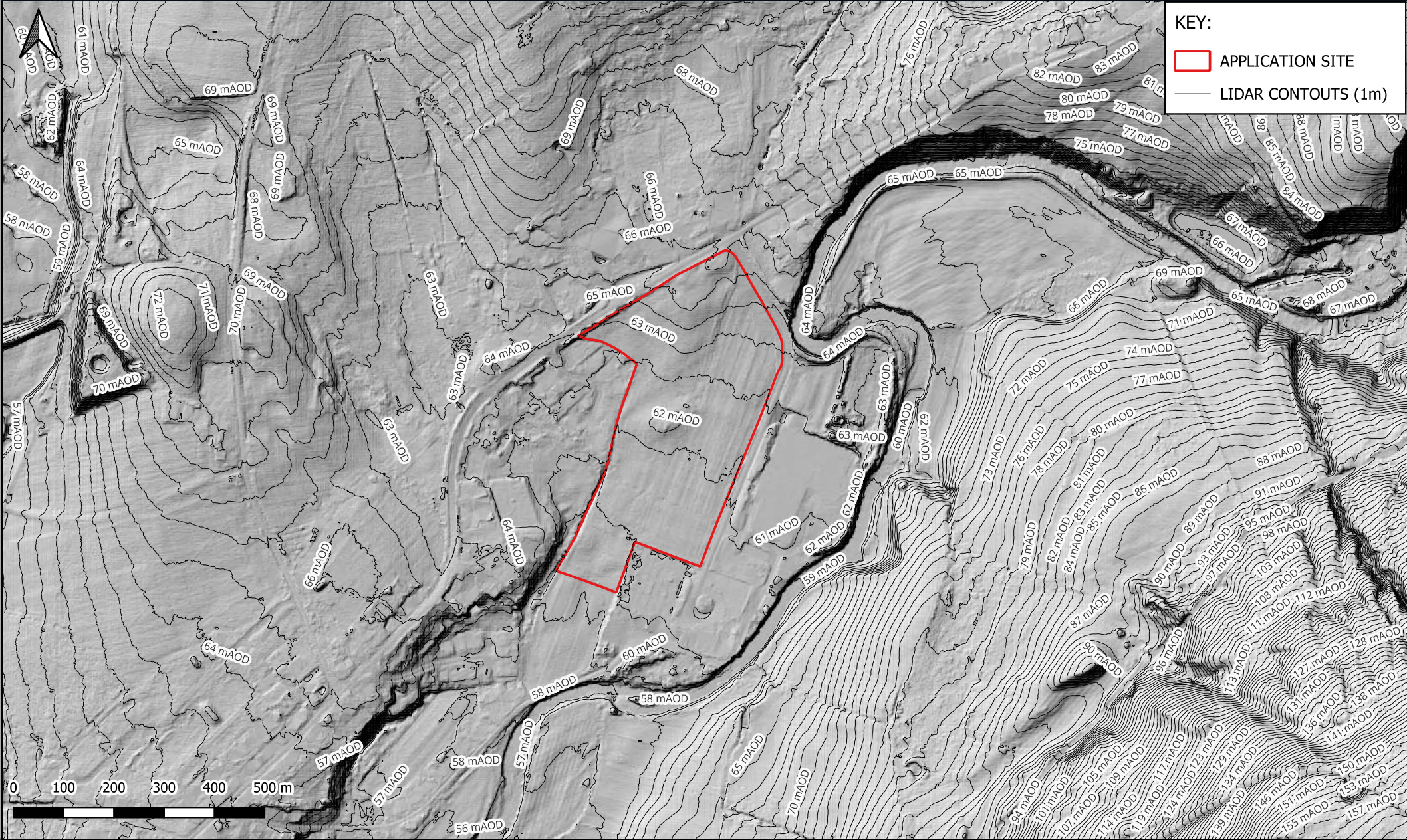
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CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC			

RISK OF FLOODING FROM SURFACE WATER ENVIRONEMNT AGENCY'S WMS DATASET

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Brighton, BN1 2RE



DRWG:	AEG4648-DR-GEN-103	STATUS:	FOR INFORMATION													
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01													
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC			



DRWG:	AEG4648-DR-GEN-104	STATUS:	FOR INFORMATION	 water, civils and environment										
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

HYDRAULIC MODEL SCHEMATIC
1D AND 2D DOMAINS

AEGAEA LTD
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33 West Street
Brighton, BN1 2RE



KEY:

- APPLICATION SITE
- 2D DOMAIN CODE (2d_bc)
- AUTOMATIC HQ BOUNDARY (2d_bc)
- URBAN AREAS (2d_mat)
- ROADS (2d_mat)
- GARDENS (2d_mat)
- BUILDINGS (2d_zsh)

1D DOMAIN BOUNDARIES (POINT):

- BED SLOPE
- QT
- 1D DOMAIN LATERAL INFLOWS

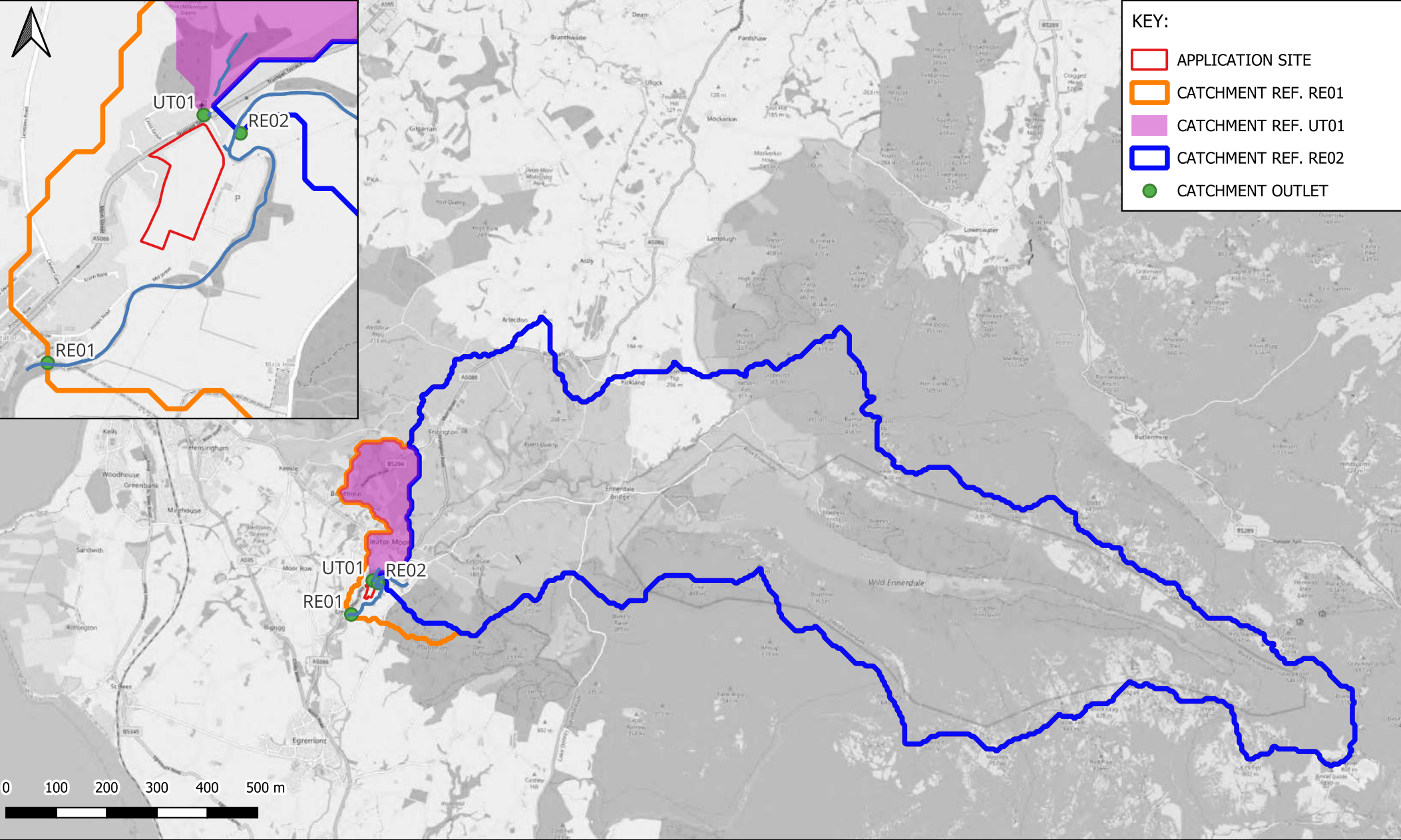
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PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01
CLIENT:	RWO	DATE:	08/07/2024



REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC
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HYDROLOGY
WATER CATCHMENTS

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Brighton, BN1 2RE



KEY:

- APPLICATION SITE
- CATCHMENT REF. RE01
- CATCHMENT REF. UT01
- CATCHMENT REF. RE02
- CATCHMENT OUTLET

DRWG:	AEG4648-DR-GEN-106	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP: DC

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Appendix B - Hydrology Report

Flood Estimation Report

Template: LIT 65087

Published: 29/12/2022

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Approval

Revision stage	Analyst:	Approved by:	Amendments	Date
Method statement	Sara Liguori			01/07/2024
Calculations - Revision 1				
Calculations - Revision 2				

Abbreviations

Abbreviation	Short for
AEP	annual exceedance probability
AMAX	Annual Maximum
AREA	Catchment area (km ²)
BFI	Base Flow Index
BFIHOST19	Base Flow Index derived using the HOST soil classification, revised in 2019
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
GEV	Generalised Extreme Value
GLO	Generalised Logistic
HOST	Hydrology of Soil Types
IF	Impervious Fraction
IRF	Impervious Runoff Factor
LF	Low flow statistics (flow duration curve)
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
ReFH2	Revitalised Flood Hydrograph 2 method
SAAR	Standard Average Annual Rainfall (mm)
Tp	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP	Windows Frequency Analysis Package (software that can be used for FEH statistical method)

1. Summary of assessment

1.1 Summary

Catchment location:

River Ehen and unnamed tributary at a development site at Cleator Moor, CA23 3DX.

Purpose of study and complexity:

Routine hydrological study of the River Ehen and unnamed tributary at the development site. The purpose of the hydrological assessment is to generate design inflows for use as boundaries in 1D/2D hydraulic modelling.

Key catchment features:

The River Ehen catchment is classified as rural/slightly urbanised and characterised by a low FARL. The unnamed tributary catchment is classified as small and very heavily urbanised.

Flooding mechanisms:

Fluvial

Gauged / ungauged:

The River Ehen catchment is gauged upstream of the site.

Final choice of method:

QMED estimates at selected estimation nodes on the River Ehen are from QMED estimated from AMAX record at upstream gauge (NRFA 74003) scaled by their respective catchment areas. QMED for the unnamed tributary is estimated from catchment descriptors and adjusted by donor transfer and for urbanisation. Final peak flows at lower AEPs are from Statistical growth factors applied to the selected final QMED estimates. ReFH2 hydrograph shapes have been applied to derive design hydrographs.

Key limitations / uncertainties in results:

The hydrological response of the catchment is affected by the presence of the reservoir and this might require further investigation of the critical storm duration at the site of interest.

1.2 Flood frequencies

- The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period.
- Return periods are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. However, AEP can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval.
- Results tables in this document contain both return period and AEP titles; both rows can be retained, or the relevant row can be retained and the other removed, depending on the requirement of the study.
- The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.013	0.01	0.005	0.001
Return period (yrs)	2	5	10	20	30	50	75	100	200	1,000

2. Method Statement

2.1 Requirements for flood estimates

Overview and Project Scope:

This document outlines the hydrological assessment undertaken to derive design hydrographs for use as boundaries to a 1D/2D hydraulic model of the River Ehen and one unnamed tributary joining the Ehen just upstream of a development site on Trumpet Terrace, Cleator Moor (CA23 3DX). Hydraulic modelling is being undertaken to assess flood risk to the site. Design hydrographs are required for the following %AEPs: 50, 5, 3.33, 1, 0.1. In addition, the impact of climate change on flood risk will be evaluated by applying both the Central and the Higher Central climate change allowances to the 1%AEP peak estimate. The hydrological study can be classified as routine.

2.2 The Catchment

Maps:

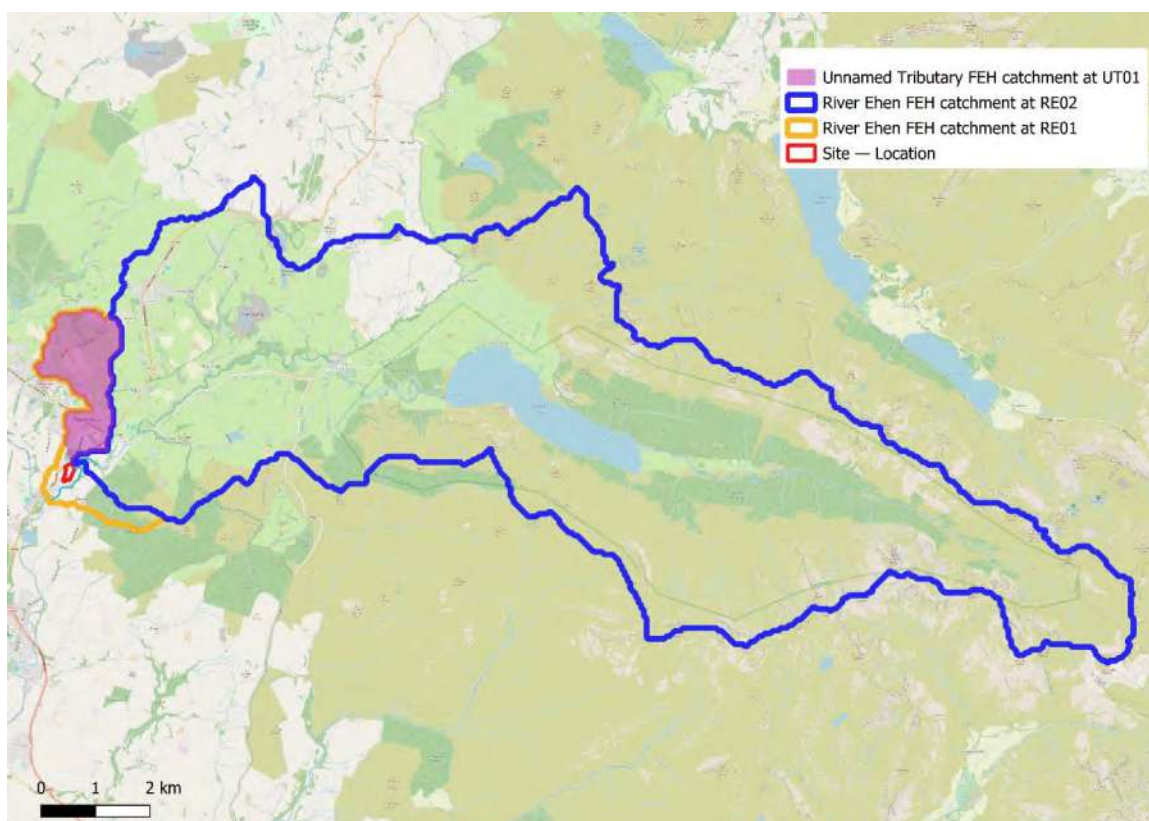


Figure 1 FEH catchments of the River Ehen and unnamed tributary at the selected Hydrological Estimation Points (HEPs)

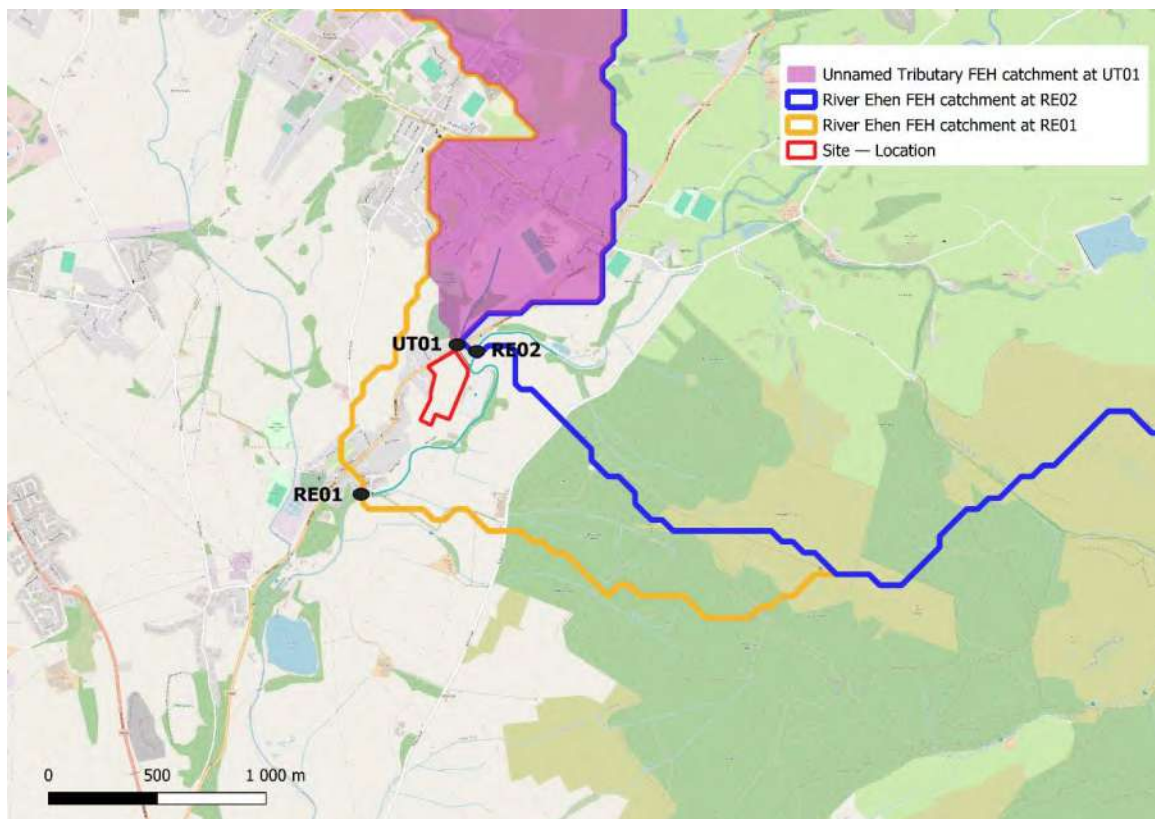


Figure 2 Detail of FEH catchments at the selected HEPs u/s (RE02 and UT01) and d/s (RE01) of the site. The intervening area d/s of RE02 and UT01 is accounted for by means of a lateral distributed inflow.

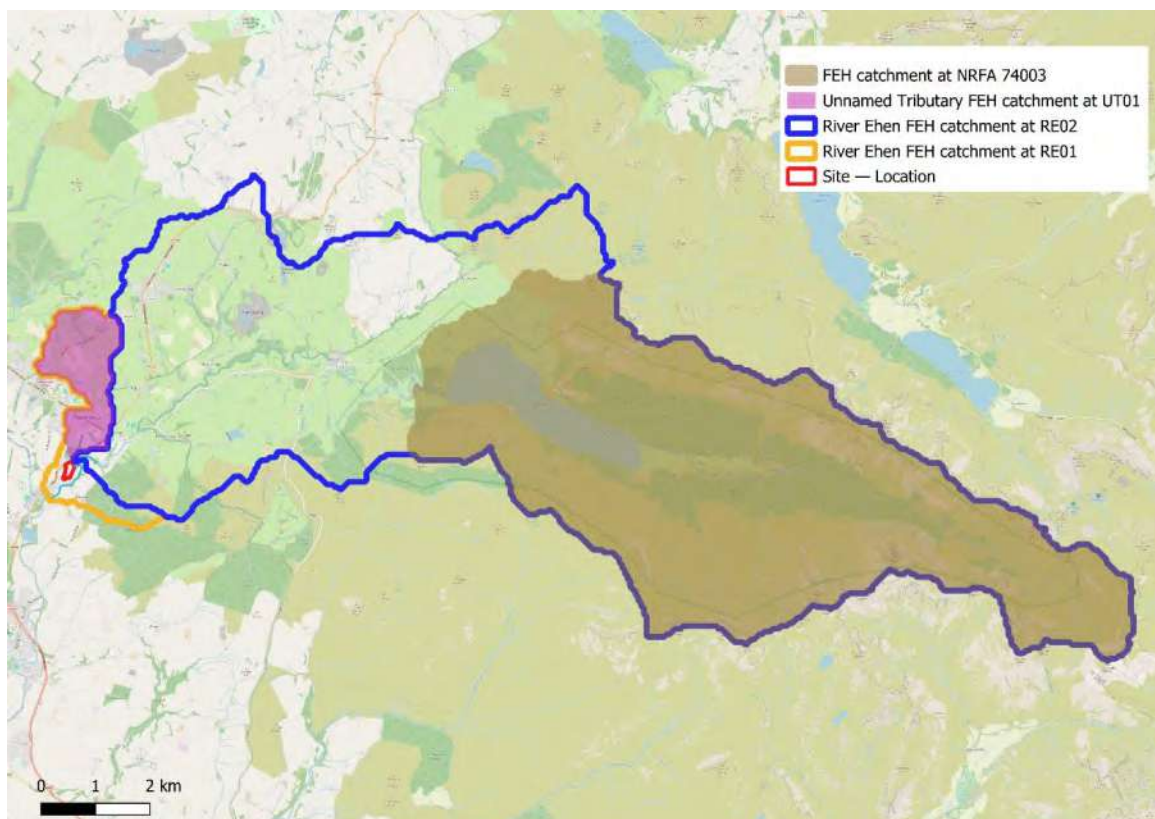


Figure 3 FEH catchments at the selected HEPs and FEH catchment at NRFA gauge 74003 assessed for the purposes of the hydrological analysis.

Catchment Description:

The River Ehen source is at the west end of Ennerdale Water, which is fed by the River Liza. The Ehen runs west through Ennerdale Bridge and past Cleator Moor and Cleator. It then flows southwards through Egremont and runs parallel to the Irish Sea where it eventually flows at Sellafield. The site of interest is located south of Cleator Moor and the unnamed tributary joins the River Ehen from the North just at the northern boundary of the site (see Figure 2).

2.3 Hydrometric Data

Source of flood peak data:

NRFA v12.1, released November 2023, contains data up to the end of September 2022.

Gauging stations (flow and level):

Watercourse	Station name	Gauging authority number	NRFA number	Catchment area (km ²)	Type (rated / ultrasonic / level...)	Start of record and end if station closed
River Ehen	Bleach Green		74003	44.587	Compound Crump Weir	1973-present

Data available at each flow gauging station:

Station name	Data source	Data type	Start and end of flood peak record	Update for this study?	OK for QMED?	OK for pooling?	Data quality check needed?	Station and flow data quality summary
River Ehen	NRFA	AMAX	1976-2022	No	Yes	No	Outside scope	Gaugings are a good fit to rating up to QMED. The station gauges the outflow from Ennerdale Water, but is much more responsive than other lake outflows in the area. Station is not suitable for pooling

Station name	Data source	Data type	Start and end of flood peak record	Update for this study?	OK for QMED?	OK for pooling?	Data quality check needed?	Station and flow data quality summary
								because there is uncertainty in top end of rating due to significant ungauged bypass flow.

Updates or revisions to flood peak data:

Outside scope

Data quality checks carried out:

NA

Rating Equations:

Station name	Type of rating e.g., theoretical, empirical; degree of extrapolation	Rating review needed?	Comments and link to any rating reviews
NA	NA	Outside scope	NA

Rating reviews:

NA

Other data available and how it has been obtained:

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings	NA	NA	NA	NA
Historical flood data	NA	NA	NA	NA
Flow or river level data for events	NA	NA	NA	NA
Rainfall data for events	NA	NA	NA	NA

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Potential evaporation data	NA	NA	NA	NA
Results from previous studies	Yes	Report	EA	Jacobs, 2009. North Area ex-Critical Ordinary Watercourses Flood Risk Mapping Hydraulic Modelling and Hydrology Report – Phase 2 Report Ref. B1042900/F001 and Appendix C
Other data or information	NA	No	NA	NA

Conclusions of hydrometric data review:

Station name	Rating suitability	Suitability for flood estimation calculations	Non-stationary analysis requirements
NA	NA	NA	NA

2.4 Hydrological understanding of the catchment

Plots of flood peak data and interpretation:

Figure 4 shows the AMAX series at NRFA 74003 which is located upstream of the site of interest. The data series shows a tendency to the occurrence of higher annual maxima after the year 2008.

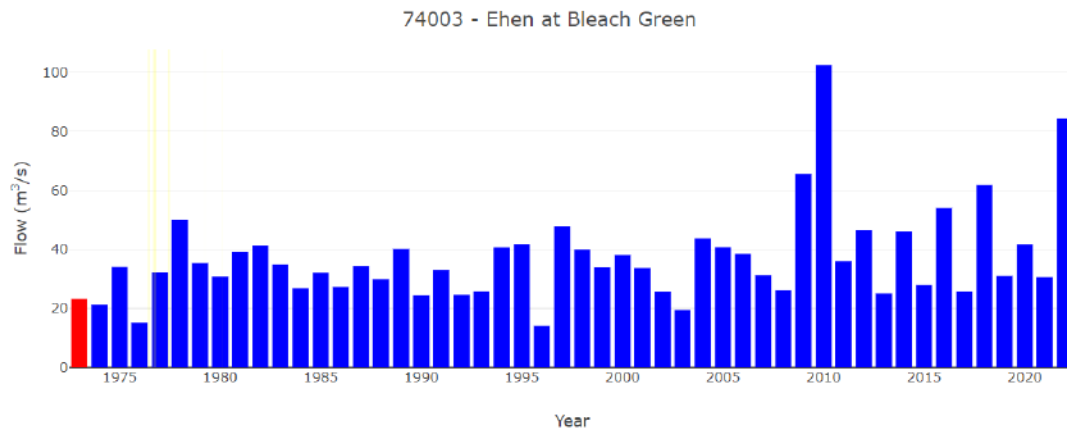


Figure 4 AMAX series at NRFA 74003

Plots of flow data and interpretation:

NA

Plots of stage data and interpretation:

NA

Conceptual model:

The site of interest is located just south of Cleator Moor, with its northern boundary being adjacent to the confluence of an unnamed tributary from the North with the River Ehen. Flood defences are located along the River Ehen banks upstream and downstream of the site. However, fluvial flooding from the unnamed tributary might potentially affect the site on its northern boundary.

Unusual catchment features:

The River Ehen catchment is classified as rural/slightly urbanised and characterised by a low FARL due to the presence of Ennerdale Water. The unnamed tributary catchment is classified as small and very heavily urbanised.

2.5 Initial choice of approach

Are FEH methods appropriate?

Standard FEH methods are appropriate. However, FEH guidelines¹ suggest caution to routinely apply standard methods due to low FARL. The FEH statistical method accounts for the attenuation from lakes and reservoir through the catchment descriptor FARL, which impacts on QMED and guides the selection of pooling groups. Estimates might be made more reliable by flood peak data available downstream of the reservoir and close the site of interest. FEH

guidelines¹ state that *You should not rely on the QMED equation when FARL is below around 0.9 due to impounding reservoirs unless they are kept permanently full and thus act like natural lakes (FEH Volume 3 Section 13.7.4).* With respect to rainfall-runoff approaches, the guidelines indicate that, *when using catchment descriptors alone, be aware that the ReFH/ReFH2 method does not account for the influence of lakes and reservoirs.* Hydrograph shapes should be estimated from observed data where possible. It is also important to notice that the design storm duration should account for the flood hydrograph delay associated with the reservoir.

Initial choice of method(s) and reasons:

Both the Statistical method and the ReFH2 rainfall-runoff approach will be applied to derive and compare peak flow estimates at the d/s extent of the hydraulic model (RE01 in Figure 2) and on the unnamed tributary at its confluence with the River Ehen (UT01 in Figure 2). The HEPs have been selected due to the requirements of the hydraulic modelling and the extents of the area of interest. In addition, the AMAX record at NRFA 74003 (Ehen at Bleach Green) will be considered for comparison of peak flow estimates obtained by applying the standard approaches on the River Ehen. The assessment of data records for consideration of observed hydrograph shapes, if available, is outside the scope of this study.

How will hydrograph shapes be derived if needed?

Hydrograph shapes are derived from ReFH2.

Will the catchment be split into sub-catchments? If so, how?

The catchment at RE01 will be split into two sub-catchments, namely the River Ehen and the unnamed tributary upstream of the site (RE02 and UT01, respectively, in Figure 2). Design hydrographs estimated at these locations will be applied as u/s lumped inflows. The contribution of the intervening area between the confluence and d/s extent of the hydraulic model (RE01) is also accounted for through a distributed inflow. Design peak estimates will be derived at RE02, UT01 and for the intervening area (hereafter referred to as RE_i). Design hydrographs at all HEPs and for the intervening area will be derived by applying a ReFH2 hydrograph shape to the selected peak flow estimates.

Software to be used:

WINFAP5

ReFH2.4

3. Locations where flood estimates are required

3.1 Summary of subject sites

Site code	Type of estimate: lumped (L) or sub-catchment (S)	Water-course	Site name / description	Easting	Northing	AREA on FEH Web Service (km ²)	Revised AREA (if altered) (km ²)
RE01	L	River Ehen	River Ehen at d/s hydraulic model extent	301650	513400	79.413	77.161
RE02	S	River Ehen	River Ehen at confluence with unnamed tributary (just u/s of site)	302150	514050	75.608	75.560
UT01	S	Unnamed tributary	Unnamed tributary at confluence with River Ehen (just u/s of site)	302050	514100	2.6025	0.681
RE_i		River Ehen	Intervening area between the u/s catchments at RE02 and UT01 and the d/s catchment at RE01				0.919

3.2 Catchment Descriptors

Final catchment descriptors at each subject site:

Site code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2024	FPEXT
RE01	0.84	0.71	0.461	14.21	228.8	2082	0.0052	0.052
RE02	0.833	0.71	0.456	13.55	237.1	2123	0.0020	0.0496
UT01	0.998	0.71	0.531	0.804	37.4	1250	0.462	0.0759

Catchment boundary checks and revisions:

FEH catchment boundaries were checked against DTM data and catchment boundaries at UT01 revised accordingly.

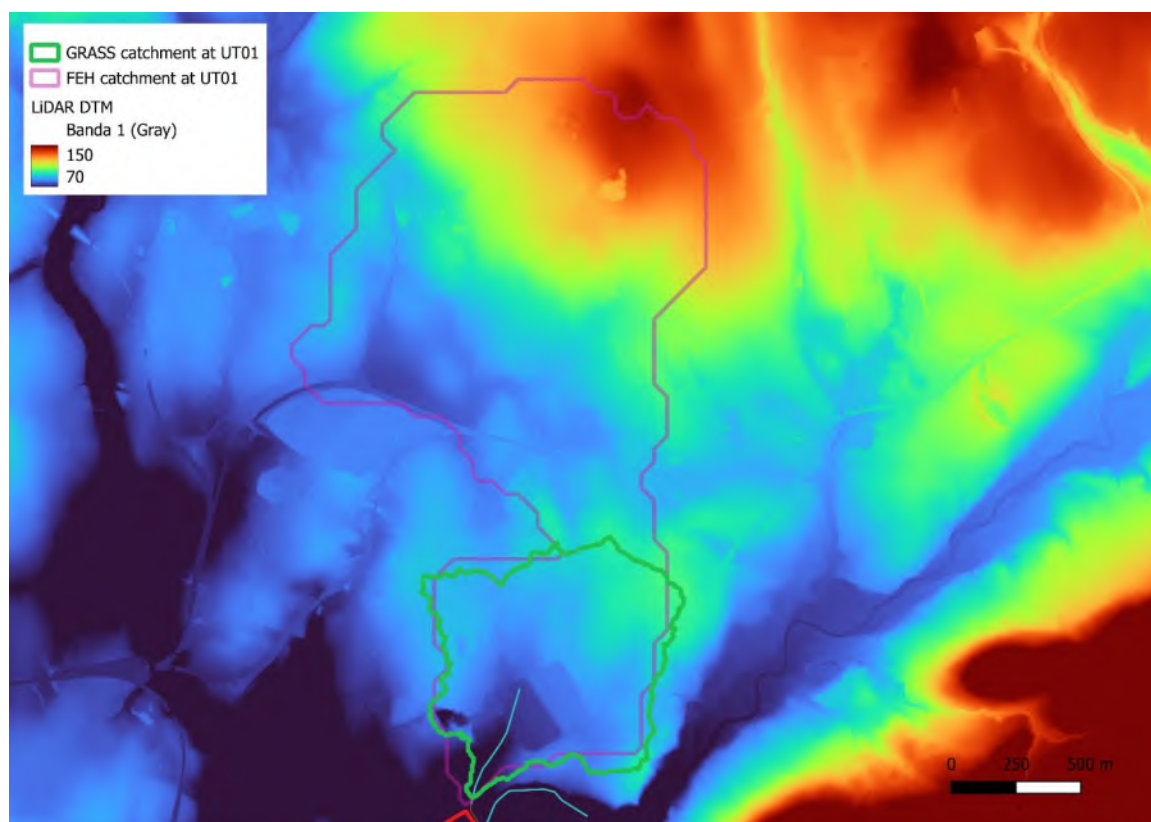


Figure 5 Updated catchment boundaries at UT01 from LiDAR DTM data compared with original FEH catchment.

URBEXT source and method for updating:

URBEXT2000 has been updated to 2024 using the national average UEF (Urban Expansion Factor)¹ at RE01 and RE02. URBEXT2024 at UT01 has been estimated according to WINFAP procedures as $URBEXT = 0.638 \times URBAN$, with URBAN being the fraction of the catchment area shown as urbanised on an OS 1:50 000 map (Section 2.3 FEH guidelines¹).

BFIHOST source, checks and updates:

Soil maps show the area being characterized by slowly permeable but base-rich loamy and clayey soils. Geology maps show soils lying on limestone with subordinate sandstone and argillaceous rocks. Therefore, BFIHOST19 values have been found to be appropriate.

Checks and revisions to other catchment descriptors:

FARL values were checked against OS mapping and found to be consistent. At UT01 catchment area has been revised according to DTM data analysis and DPLBAR has been revised for the updated catchment area according to FEH Volume 5 Section 7.2.4. DPSBAR and LDP have been updated for consistency with previous study³. Catchment area at RE01 and RE02 has been revised according to updated catchment area at UT01. However, it should be noted that flow estimates at both locations have been derived for the original FEH catchment area due to changes being extremely small relative to the original FEH catchment size. The remaining catchment descriptors were not subject to any revision. It should also be noted that catchment descriptors for the intervening area RE_i are not provided in the table above because peak flow estimates for RE_i have been obtained from estimates at RE01 scaled down by the ratio of catchment areas (further details in Chapter 9).

¹ Environment Agency. Flood Estimation Guidelines LIT11832. Published 23/12/2022

4. Stationary statistical methods

4.1 Method overview

What is the purpose of applying these methods?

To derive peak flows at RE01, RE02, and UT01.

What methods will be used to estimate QMED and growth curves?

Site code	Methods used for QMED	Methods used for growth curves
RE01	Catchment descriptors adjusted by donor transfer and for urbanisation. It should be noted that QMED estimated from statistical analysis is going to be compared with QMED from AMAX records at u/s gauge 74003 (details in 4.2) scaled by the ratio of catchment areas. The comparative analysis of QMED estimates is covered in Chapter 9.	Pooling at ungauged site with standard method applied in guiding the selection of default pooling group. It should be noted that the enhanced single site analysis at 74003 has not been considered due to the gauge being unsuitable for pooling.
RE02	Catchment descriptors adjusted by donor transfer and for urbanisation. Similarly to RE01, QMED estimated from statistical analysis is going to be compared with QMED from AMAX records at u/s gauge 74003 (details in 4.2) scaled by the ratio of catchment areas. The comparative analysis of QMED estimates is covered in Chapter 9.	Growth factors from pooled analysis at RE01 applied at RE02
UT01	Catchment descriptors adjusted by donor transfer and for urbanisation	Growth factors from pooled analysis at RE01 applied at UT01 Pooling at ungauged site with small catchments

Site code	Methods used for QMED	Methods used for growth curves
		method guiding the selection of pooling group.

4.2 Estimating QMED

QMED at gauged subject sites:

Site code	Method (AM/ POT/LF)	Initial QMED (m ³ /s)	Number of water years of data used	Adjustment for climatic variation?	Final QMED (m ³ /s)
74003	AM	34.07	49	No	34.07

Methods: AM – Annual maxima; POT – Peaks over threshold; LF – Low flow (flow duration curve) statistics.

QMED at ungauged subject sites:

Site code	Method (CD/DT/BCW)	Initial QMED (rural) from CDs (m ³ /s)	Donors used (NRFA numbers)	Donor distances from subject centroid (km)	Individual donor weights	Combined and weighted donor adjustment factor	Urban adjustment factor	Final QMED (m ³ /s)
RE01	DT	36.270	74005	3.39	0.536	1.325	1.006	48.323
			74003	3.83	0.513			
			75004	8.38	0.399			
			74002	9.76	0.383			
			75018	13.8	0.35			
RE02	DT	34.808	74003	3.43	0.534	1.342	1.002	46.810
			74005	3.80	0.514			
			75004	8.11	0.402			
			74002	9.46	0.386			
			75018	13.50	0.352			
UT01	DT	1.746	74005	4.86	0.47	1.152	1.119	2.252

Methods: CD - Catchment descriptors alone; DT - catchment descriptors with donor transfer; BCW - catchment descriptors with bankfull channel width.

Urban adjustment of QMED:

Urban adjustment carried out according to WINFAP5. URBAN calculated on URBEXT2024 (i.e. URBEXT2000 updated to 2024).

Search for donor sites:

For sites RE01 and RE02 there are 6 potentially suitable donors within 15km from subject sites, namely NRFA gauges 74005, 74003, 74006, 75004, 74002, and 75018. According to information available through the NRFA, all of these gauges can be considered reliable QMED donors, with the exception of NRFA 74006 (Calder@Calder Hall) which is gauged to within 1% of QMED. However, for this gauge the NRFA highlights that QMED is probably slightly overestimated, due to the weir becoming at least partially drowned at QMED. The site has, therefore, been discarded as donor for both RE01 and RE02. It should be noted that QMED at 75018 has not been adjusted for climatic variation, despite its record being less than 14 years. The gauge is the furthest from both subject sites, with individual donor weights being equal to 0.35 and 0.352, and the climatic adjustment at 75018 is expected to have an insignificant impact on final QMED estimates at both RE01 and RE02.

UT01 is classified as small catchment. According to current FEH guidelines¹, a single donor is appropriate for the adjustment of QMED by donor transfer on small catchments. The closest potential suitable donor to the subject site is NRFA 74005 and has been selected as donor.

Donor sites chosen and QMED adjustment factors:

NRFA no.	Method (AM/POT/LF)	Adjustment for climatic variation?	QMED from flow data (m ³ /s)	De-urbanised QMED from flow data (m ³ /s) (A)	QMED from catchment descriptors (m ³ /s) (B)	Adjustment ratio (A/B)
74005	AM	No	72.685	71.716	53.016	1.353
74003	AM	No	34.07	34.07	17.34	1.965
75004	AM	No	53.33	53.312	49.217	1.083
74002	AM	No	22.23	22.228	22.589	0.984
75018	AM	No	210.898	209.997	238.041	0.882

Methods: AM – Annual maxima; POT – Peaks over threshold; LF – Low flow (flow duration curve) statistics.

4.3 Estimating growth curves

Derivation of growth curves at subject sites:

Site code	Method (SS, P, ESS, H.)	If P or ESS, name of pooling group	Distribution used and reason for choice	Any urban or non-flood years adjustments	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period
RE01	P	P	GL, best fit	Urban	Location 1 Scale 0.183 Shape - 0.218	2.446
UT01	P	P	GL, best fit	Urban	Location 1 Scale 0.151 Shape - 0.333	2.645

Methods: SS - Single Site; P - Pooled; ESS - Enhanced Single Site; H - Historical. Pooled and ESS growth curves were derived using the procedures from Science Report SC050050 (2008). Urban adjustments are carried out using the method of Kjeldsen (2010).

Flood frequency curve plots:

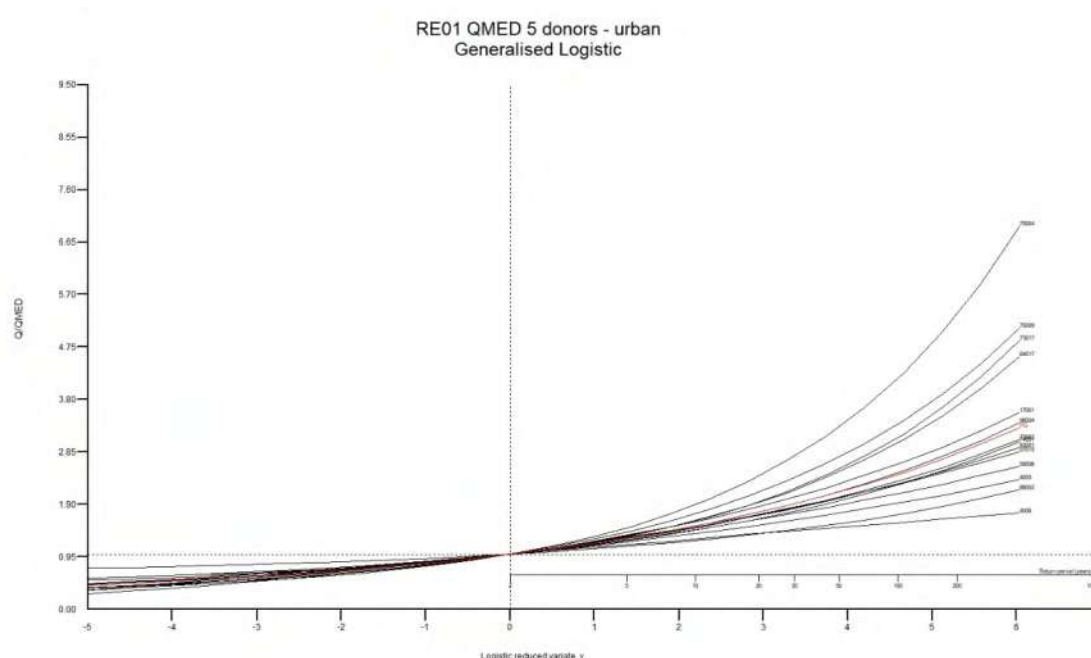


Figure 6 RE01 Pooling Group growth curves

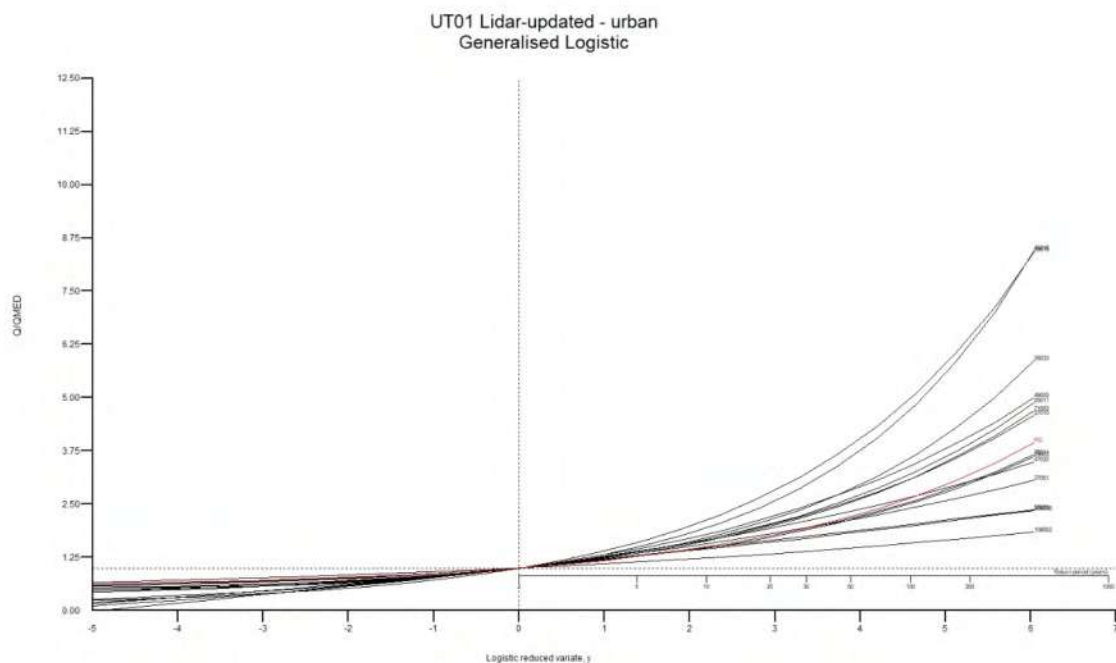


Figure 7 UT01 Pooling Group growth curves

Derivation of pooling groups:

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (ESS)	URBEXT2000 threshold applied to pooling group selection?	L-moments deurbanised (including subject site for ESS)?	Small catchment pooling procedure applied?
RE01	RE01	No	0.03	Yes	No
UT01	UT01	No	0.03	Yes	Yes

Methods: Unless otherwise stated, pooling groups were derived using the procedures from Science Report SC050050 (2008). The small catchment pooling procedure is given in the report on Phase 2 of project SC090031 (2021) and implemented in WINFAP v5.

Pooling group composition:

Name of group	Changes made to default pooling group, with reasons	Weighted average L-moments
RE01	The default pooling group was assessed on the basis of the distribution of L-moments within the pooling group as well as some of the characteristics of the sites. Site 4006 was investigated but retained in the pooling group, while site 83002 was removed due to its short record and high discordancy within the pooling group. The resulting pooling group includes 530 years of flood data. The group is still possibly heterogeneous. However, further review is	L-CV 0.186 L-SKEW 0.217

Name of group	Changes made to default pooling group, with reasons	Weighted average L-moments
	not expected to produce an improvement on the output statistical peak estimates.	
UT01	The distribution of L-moments within the default pooling group was assessed and no changes were made.	L-CV 0.219 L-SKEW 0.248

4.4 Final choice of QMED and growth curves

Method choice and reasons:

Site code	Final choice of QMED and reasons	Final choice of flood growth curve method and reasons
RE01	QMED from catchment descriptors adjusted by donor transfer from 5 sites and for urbanisation. All selected sites are suitable according to NRFA and are located within short distance from the subject site.	GL distribution (best fit) with urban adjustment
RE02	QMED from catchment descriptors adjusted by donor transfer from 5 sites and for urbanisation. All selected sites are suitable according to NRFA and are located within short distance from the subject site.	Growth factors estimated at RE01. Appropriate to the scale of the study.
UT01	QMED from catchment descriptors adjusted by donor transfer from 1 site and for urbanisation. This is appropriate given the size of the catchment and is in line with current guidelines ¹ .	Final growth factors estimated at RE01. The PG at UT01 generated by implementing the <i>small catchments</i> method was assessed for comparison with PG RE01 and produced slightly but consistently larger growth factors at all %AEPs. However, the standard PG at RE01 was selected to provide final growth factors at UT01. This is appropriate to the scale of the study and helps promoting spatial consistency, in line with FEH guidelines ¹ (Section 4.2

Site code	Final choice of QMED and reasons	Final choice of flood growth curve method and reasons
		<i>Estimating growth curves using pooling groups)</i>

Final flood estimates from stationary statistical methods:

Site code	2 50%	20 5%	30 3.3%	100 1%	1000 0.1%
RE01	48.323	84.855	92.297	118.198	190.441
RE02	46.81	82.198	89.407	114.497	184.478
UT01	1.075	1.888	2.053	2.629	4.237

Flood peak in m³/s for the return periods in years or AEP (%) events.

7. Revitalised flood hydrograph 2 (ReFH2) method

7.1 Method Overview

What is the purpose of applying this method?

To derive and compare peak flow estimates at RE01 and UT01. To derive hydrograph shapes suitable to be applied to derive design hydrographs.

Rural and urban catchment sub-divisions:

Sub-divisions calculated within ReFH2.4 according to standard procedures. Paved areas have been calculated using standard equations from URBEXT2000 updated to 2024. No transfer of water via sewers across the topographic catchment boundary has been allowed.

Version of ReFH2 applied:

2.4

7.2 Model Parameters

Summary of model parameters:

Site code	Method	Tp (hours) rural	Cmax (mm)	BL (hours)	Area modelled as urban (km2)	TP urban scaling factor	IF	IRF	DS
RE01	CD	2.308	343.44	42.22	0.6222	0.75	0.4	0.7	0.5
RE02	CD	2.22	339.89	41.578	0.2251	0.75	0.4	0.7	0.5
UT01	CD	1	379.071	23.606	0.4930	0.75	0.4	0.7	0.5

Methods: OPT: Optimisation from event analysis, BR: Baseflow recession fitting, LAG: TP from lag analysis, CD: Catchment descriptors, DT: Data transfer, CAL: model calibration.

Analysis undertaken to derive model parameters:

Parameters from catchment descriptors

7.3 Model inputs for design events

Design events for lumped catchments:

Site code	Rainfall DDF model	Urban or rural	Highly permeable?	Season of design event	Storm duration (hrs)	Initial soil moisture Cini	Initial baseflow BFO
RE01	DDF22	Rural	No	Winter	7.5	85.143	7.354
UT01	DDF22	Urban	No	Summer	2.18	61.238	0.021

Design events for sub-catchments and intervening areas:

Site code(s)	Rainfall DDF model	Season of design event	Storm duration (hrs)	Storm area for ARF	Areal reduction factor ARF	Reason for selecting storm
RE02	DDF22	Winter	7.5	79.413	0.917	Appropriate to the scale of the study. This is the larger River Ehen catchment wide storm and it has been considered in order to assess its impact on flood risk local to the site
	DDF22	Summer	2.18	0.681	0.975	Storm representative of the quick response of the urban area close to the site of interest. It has been selected as it might potentially be the most impactful on

Site code(s)	Rainfall DDF model	Season of design event	Storm duration (hrs)	Storm area for ARF	Areal reduction factor ARF	Reason for selecting storm
						flood risk local to the site.
UT01	DDF22	Winter	7.5	79.413	0.917	Same as above
	DDF22	Summer	2.18	0.681	0.975	Same as above

Storm duration testing:

Both the winter 7.5 hr and the summer 2.18 hr storms have been assessed in the hydraulic modelling in order to determine and compare their impact at the site of interest. The above storm durations are the ReFH2 recommended at RE01 and UT01, respectively. However, it should be noted that a check has been undertaken in ReFH2 in order to determine the storm duration that produced the highest peak at UT01. Changes in storm duration produced minimal changes in the estimated peaks, and, therefore, the recommended storm duration has been retained in the study.

7.4 Final choice of ReFH2 flow estimates

Method choice and reasons:

Site code	Final choice of design inputs and model parameters
RE01	Model parameters from catchment descriptors; Storm durations selected for the distributed modelling are the recommended at RE01 (winter storm profile) and UT01 (summer storm profile).
RE02	Same as at RE01
UT01	Same as at RE01

Final flood estimates from ReFH2 method:

Site code	2 50%	20 5%	30 3.3%	100 1%	1000 0.1%
RE01	67.832	107.856	115.877	148.673	261.783
UT01	0.750	1.320	1.430	1.820	3.420

Flood peak in m³/s for the return periods in years or AEP (%) events.

9. Discussion and summary of results

9.1 Comparison of results from different methods

Site code	<i>Ratio of ReFH2 to stationary statistical peak, 50% AEP</i>	<i>Ratio of ReFH2 to stationary statistical peak, 1% AEP</i>	<i>Ratio of ReFH2 to stationary statistical peak, 0.1% AEP</i>	<i>Ratio of scaled QMED from AMAX at 74003 to stationary statistical peak</i>
RE01	1.118	1.002	1.095	1.256
RE02				1.234
UT01	0.698	0.692	0.807	

9.2 Final choice of method

Choice of method and reasons:

Final QMED estimates at RE01 and RE02 is QMED from AMAX records at 74003 scaled by the ratio of catchment areas (with the ratios of catchment areas being 1.78 at RE01 and 1.69 at RE02, respectively). The selection of this method to provide final QMED estimates is motivated by the following:

- The standard Statistical method to estimate QMED from catchment descriptors is not reliable due to low FARL, according to FEH guidelines¹;
- The selected method makes use of available flow data through the AMAX records at the gauged site, which is highly hydrologically similar to the ungauged subject site.

QMED at UT01 has been estimated from catchment descriptors and adjusted by donor transfer from 1 gauge and for urbanisation, in accordance to guidelines.

Peak flows at lower %AEPs have been estimated by multiplying the final QMED values by the growth factors estimated from pooled statistical analysis at RE01. The GL distribution has been selected for this purpose and the growth curve has been adjusted for urbanisation. Hydrograph shapes derived from ReFH2 have been applied to generate design hydrographs. For this purpose, two design storms have been selected for testing in distributed modelling, and these are specified as:

- 7.5hr winter storm (consistent with the lumped model built at RE01)
- 2.18hr summer storm (consistent with the urban catchment local to the site of interest at UT01)

It should be noted that design hydrographs for the intervening area RE_i have been derived from design hydrographs at RE01 scaled by the ratio of catchment areas.

How will the 0.1% AEP flows be estimated?

RE01 and RE02: FEH Statistical growth factor applied to scaled QMED from 74003 AMAX. UT01: FEH Statistical estimate.

How will the flows be applied to a hydraulic model?

Hydrographs estimated at RE01 and UT01 are applied as u/s lumped inflows. Hydrographs for the intervening area RE_i is applied as later inflow.

9.3 Final results

Site code	2 50%	20 5%	30 3.3%	100 1%	1000 0.1%
RE01	58.960	103.534	112.614	144.217	232.362
RE02	57.737	101.387	110.278	141.225	227.542
UT01	1.075	1.888	2.053	2.629	4.237
RE_i	0.703	1.234	1.342	1.719	2.769

Flood peak in m³/s for the return periods in years or AEP (%) events.

Design storms applied in the hydraulic model:

Site code(s)	Season of design event	Storm duration (hrs)	Storm area for ARF (km ²)	Return period(s)	Reason for selecting storm
RE01	Winter	7.5	79.413	20,30, 100, 1000	Appropriate to the scale of study and to the assessment of flood risk at the site of interest
UT01	Summer	2.18	0.681	20,30, 100, 1000	Appropriate to the scale of study and to the assessment of

Site code(s)	Season of design event	Storm duration (hrs)	Storm area for ARF (km ²)	Return period(s)	Reason for selecting storm
					flood risk at the site of interest

Climate change allowances:

Central and higher central allowances for the South West Lakes Management Catchment, estimated according to current guidance² as being equal to 30% and 39%, respectively.

9.4 Checks

Growth factor checks:

Site code	1% AEP growth factor	0.1% AEP / 1% AEP ratio
RE01	2.446	1.611

Specific discharge:

Site code	2 50%	20 5%	30 3.3%	100 1%	1000 0.1%
RE01	7.641	13.418	14.595	18.690	30.114
RE02	7.641	13.418	14.595	18.690	30.114
UT01	15.786	27.720	30.151	38.612	62.211
RE_i	7.641	13.418	14.595	18.690	30.114

Flood peak in l/s/ha for the return periods in years or AEP (%) events.

Spatial consistency of results:

Peak estimates at RE01 are smaller than the sum of u/s peak estimates (including RE_i)

² Environment Agency. Flood risk assessments: climate change allowances. Last Updated May 2022

Return periods for notable historic floods:

NA

Compatibility with longer-term flood history:

NA

Comparisons with previous studies:

Appendix C of the Jacobs 2009 report³ provides estimates for the unnamed tributary. Estimates are based on the reduced catchment area (2.61 km² to 0.7km²). Estimates (table below) are consistently lower than in the current study, with QMED being substantially lower (0.64m³/s vs 1.075m³/s). The difference could be due to the updates to data (catchment descriptors, AMAX for selected donors) and methods (QMED equations, donor adjustment process) occurred since the time the Jacobs study was completed.

Modified Catchment			
			Pooled Peak Flows (m ³ /s)
Flood Return period in years	Annual Exceedance Probability (AEP)	Growth factors	Hydrograph A
2	50.0%	1	0.64
5	20.0%	1.351	0.87
10	10.0%	1.604	1.03
25	4.0%	1.966	1.26
50	2.0%	2.274	1.46
100	1.0%	2.622	1.68
200	0.5%	3.015	1.94
500	0.2%	3.619	2.32
1000	0.1%	4.12	2.65

Table C.2 – Peak flow estimates from Pooling Group Analysis

Checks on hydraulic model results:

Not carried out at this stage

³ Jacobs, 2009. North Area ex-Critical Ordinary Watercourses Flood Risk Mapping Hydraulic Modelling and Hydrology Report – Phase 2 Report Ref. B1042900/F001

9.5 Assumptions, limitations, and uncertainty

Assumptions (specific to this study):

- The hydrological response of the catchment at the site of interest is affected by the presence of the Ennerdale Water and can be represented with reasonable accuracy through records at the upstream NRFA gauge 74003 due to the similar catchment characteristics at gauged and ungauged sites.
- The most suitable potential donor at UT01 is representative of flows at the site despite difference in catchment size between gauged and subject sites.
- ReFH2 recommended storm duration at RE01 is representative of critical storm duration for the wider catchment at the site, despite the presence of the reservoir.

Limitations:

- FEH Statistical applied for generating growth factors for all events down to the 0.1%AEP.
- QMED adjustment factor from the most suitable available donor at UT01 might not be representative of ungauged site due to the difference in catchment size.
- ReFH2 from catchment descriptors at RE01 used to identify storm for testing in distributed modelling, in the absence of detailed information concerning the reservoir.

Site code	50% AEP Lower 95%	50% AEP Upper 95%	5% AEP Lower 95%	5% AEP Upper 95%	1% AEP Lower 95%	1% AEP Upper 95%	0.1% AEP Lower 95%	0.1% AEP Upper 95%
RE01	24.272	153.523	38.360	293.029	50.465	431.919	71.743	915.921
RE02	29.465	113.815	50.725	203.916	69.244	289.696	104.736	491.804
UT01	0.430	2.698	0.680	5.210	0.894	7.731	1.229	14.616

Upper and lower 95% confidence bounds for the flood peak in m³/s for the AEP (%) events. Please note, the above values are calculated for the results of the Statistical method, which do not match the final estimates at RE01 and RE02. Furthermore, the uncertainty bounds are calculated for 6 donors at RE01 and RE02 and 1 at UT01.

Suitability of results for future studies:

Results are suitable to the assessment of flood risk local to the area of study.

Recommendations for future work:

Investigating the impact of reservoir on critical storm duration in the area of interest.

10. Appendix

10.1 Digital files

Input data:

CEH web .xml and .shp files at NGR:

301650_513400 (RE01)

302150_514050 (RE02)

302050_514100 (UT01)

Project or calculation files:

RE01.wxml

RE02_QMED.wxml

UT01_LiDAR_updated.wxml

Output data:

Design_Qt_SD7hr30min_v01.xlsx

Design_Qt_SD2hr18min_v01.xlsx

10.2 Other Supporting Information

Table 1 Final pooling group at RE01

Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
75004 (Cocker @ Southwaite Bridge)	0.546	55	53.33	0.282	0.282	0.369	0.369	1.617
84017 (Black Cart Water @ Milliken Park)	0.578	38	34.646	0.203	0.205	0.328	0.324	0.719
4006 (Bran @ Dosmucheran)	0.584	32	84.353	0.127	0.127	-0.007	-0.007	1.724
57015 (Taff @ Merthyr Tydfil)	0.591	44	92.955	0.196	0.198	0.135	0.133	1.253
73002 (Crake @ Low Nibthwaite)	0.711	51	21.058	0.175	0.175	0.205	0.205	0.028
73017 (Kent @ Bowston)	0.725	23	67.089	0.202	0.202	0.355	0.355	0.82
96004 (Strathmore @ Allnabad)	0.808	19	198.528	0.183	0.183	0.234	0.234	0.814
4005 (Meig @ Glenmeanie)	0.812	37	101.633	0.146	0.146	0.132	0.132	0.335

17001 (Carron @ Headswood)	0.854	34	77.743	0.211	0.213	0.211	0.208	0.629
86002 (Eachaig @ Eckford)	0.872	19	80.978	0.092	0.092	0.237	0.237	2.492
93001 (Carron @ New Kelso)	0.906	27	181.095	0.182	0.182	0.172	0.172	1.351
58006 (Mellte @ Pontneddfechan)	0.935	51	89.148	0.175	0.175	0.125	0.124	0.977
74001 (Duddon @ Duddon Hall)	0.939	55	122.247	0.155	0.155	0.242	0.242	0.4
75009 (Greta @ Low Briery)	0.969	45	110.942	0.243	0.243	0.306	0.306	0.841
Rejected Stations								
83002 (Garnock @ Dalry)	0.828	6	66.332	0.099	0.101	0.207	0.203	

Table 2 Pooling group at UT01

Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
76011 (Coal Burn @ Coalburn)	0.787	45	1.84	0.171	0.171	0.292	0.292	0.498
45816 (Haddeo @ Upton)	1.824	29	3.248	0.289	0.29	0.432	0.431	0.974
28033 (Dove @ Hollinsclough)	1.952	47	4.15	0.231	0.231	0.381	0.381	0.556
27051 (Crimple @ Burn Bridge)	2.247	50	4.641	0.218	0.218	0.133	0.133	0.383
25011 (Langdon Beck @ Langdon)	2.364	36	15.878	0.223	0.223	0.321	0.32	0.433
47022 (Tory Brook @ Newnham Park)	2.382	27	6.176	0.246	0.248	0.151	0.149	0.613
71003 (Croasdale Beck @ Croasdale Flume)	2.475	37	10.9	0.212	0.212	0.323	0.323	0.235
27073 (Brompton Beck @ Snainton Ings)	2.512	42	0.816	0.212	0.213	0.02	0.018	1.375
25003 (Trout Beck @ Moor House)	2.535	49	15.12	0.165	0.165	0.298	0.298	0.656
106002 (Laxdale @ Laxdale)	2.553	15	17.224	0.093	0.093	0.131	0.131	1.69
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.554	12	4.924	0.266	0.267	0.268	0.267	2.637
206006 (Annalong @ Recorder)	2.574	48	15.33	0.189	0.189	0.052	0.052	1.877
27010 (Hodge Beck @ Bransdale Weir)	2.712	41	9.42	0.224	0.224	0.293	0.293	0.105
25019 (Leven @ Easby)	2.717	44	5.384	0.34	0.341	0.367	0.366	1.97

Appendix C - Modelling Outputs for Defended scenario

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 5%AEP_0730)

River_Ehen_Model_v19_Def_(Q0020)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-201	STATUS:	FOR INFORMATION
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01
CLIENT:	RWO	DATE:	08/07/2024



REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC
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FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 3.3%AEP_0730)

River_Ehen_Model_v19_Def_(Q0030)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-202	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 1.0%AEP_0730)

River_Ehen_Model_v19_Def_(Q100)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



KEY:

APPLICATION SITE

FLOOD DEPTH:

- <= 0.01
- 0.01 - 0.20
- 0.20 - 0.40
- 0.40 - 0.60
- 0.60 - 0.80
- 0.80 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

DRWG:	AEG4648-DR-DEF-203	STATUS:	FOR INFORMATION	 water, civils and environment										
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 1.0%AEP30CC_0730)

River_Ehen_Model_v19_Def_(Q100CC30)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-204	STATUS:	FOR INFORMATION	 water, civils and environment										
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 0.1%AEP_0730)

River_Ehen_Model_v19_Def_(Q1000)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-205	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 1.0%AEP30CC_0218 vs 1.0%AEP30CC_0730

River_Ehen_Model_v19_Def_(Q100CC30)_AEG004_0218 & 0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



KEY:

APPLICATION SITE

FLOOD EXTENTS:

1.0%AEP30CC_0730

1.0%AEP30CC_0218

DRWG:	AEG4648-DR-DEF-206	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

River_Ehen_Model_v19_Def_(Q0030)_AEG004_0730

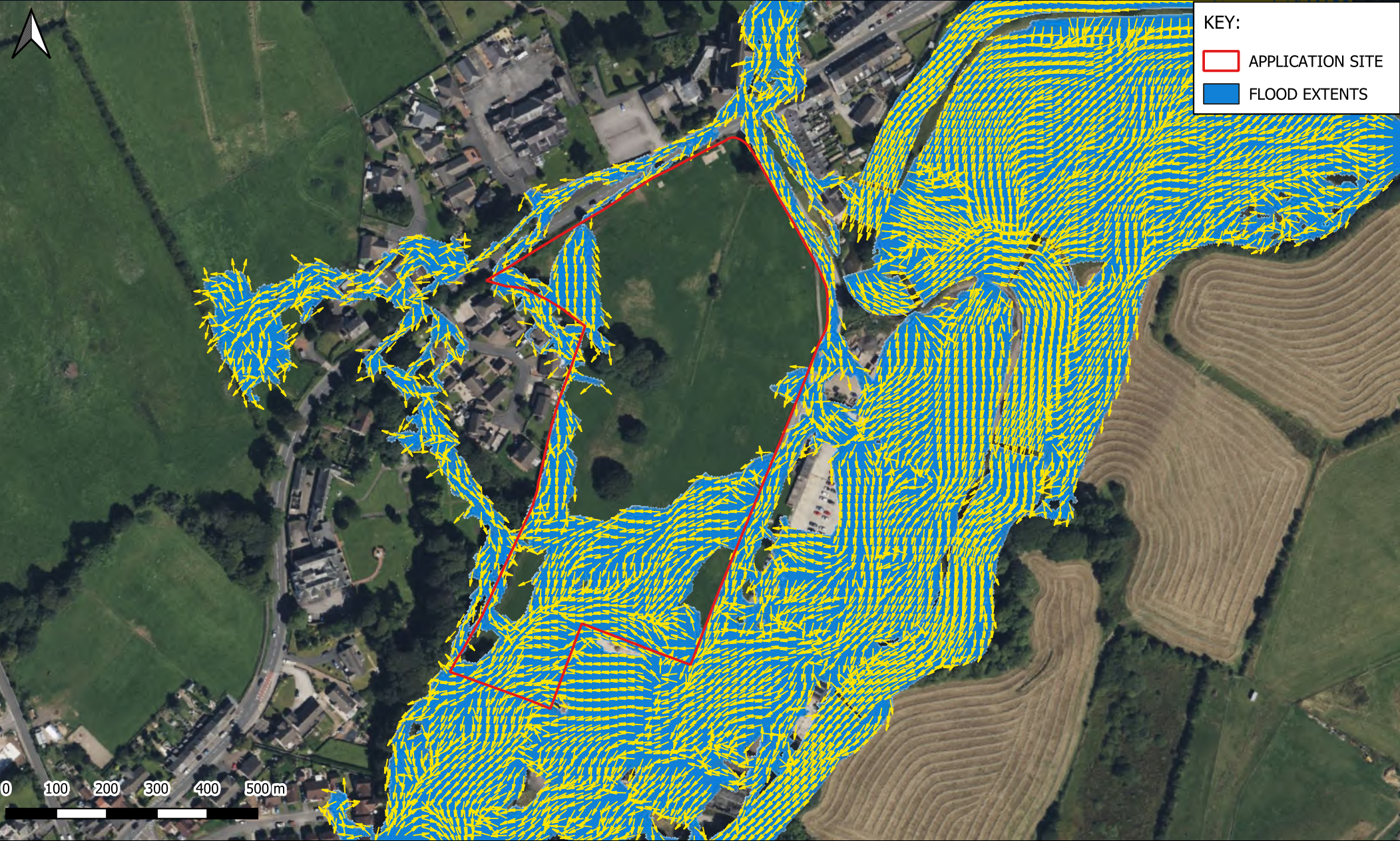
KEY:

 FLOOD EXTENTS

FLOOD MECHANISM MAP (SCENARIO: DEF | EVENT: 1.0% AEPCC30_0730)

River_Ehen_Model_v19_Def_(Q100CC30)_AEG004_0730

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



KEY:

APPLICATION SITE

FLOOD EXTENTS

DRWG:	AEG4648-DR-DEF-208	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

Appendix C - Modelling Outputs for Sensitivity Testing

FLOOD DEPTH MAP (SCENARIO: DEF | EVENT: 1.0%AEP30CC_0730)

River_Ehen_Model_v19_Def_(Q100CC30)_AEG009_0730 vs AEG004_0730 (ROADS LOWERED BY 125mm)

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



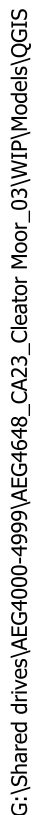
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PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS



DRWG:	AEG4648-DR-DEF-302	STATUS:	FOR INFORMATION	aegaea water, civils and environment										
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS



DRWG:	AEG4648-DR-DEF-303	STATUS:	FOR INFORMATION														
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01														
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION	BY:	JSG	CHK:	RT	APP:	DC				

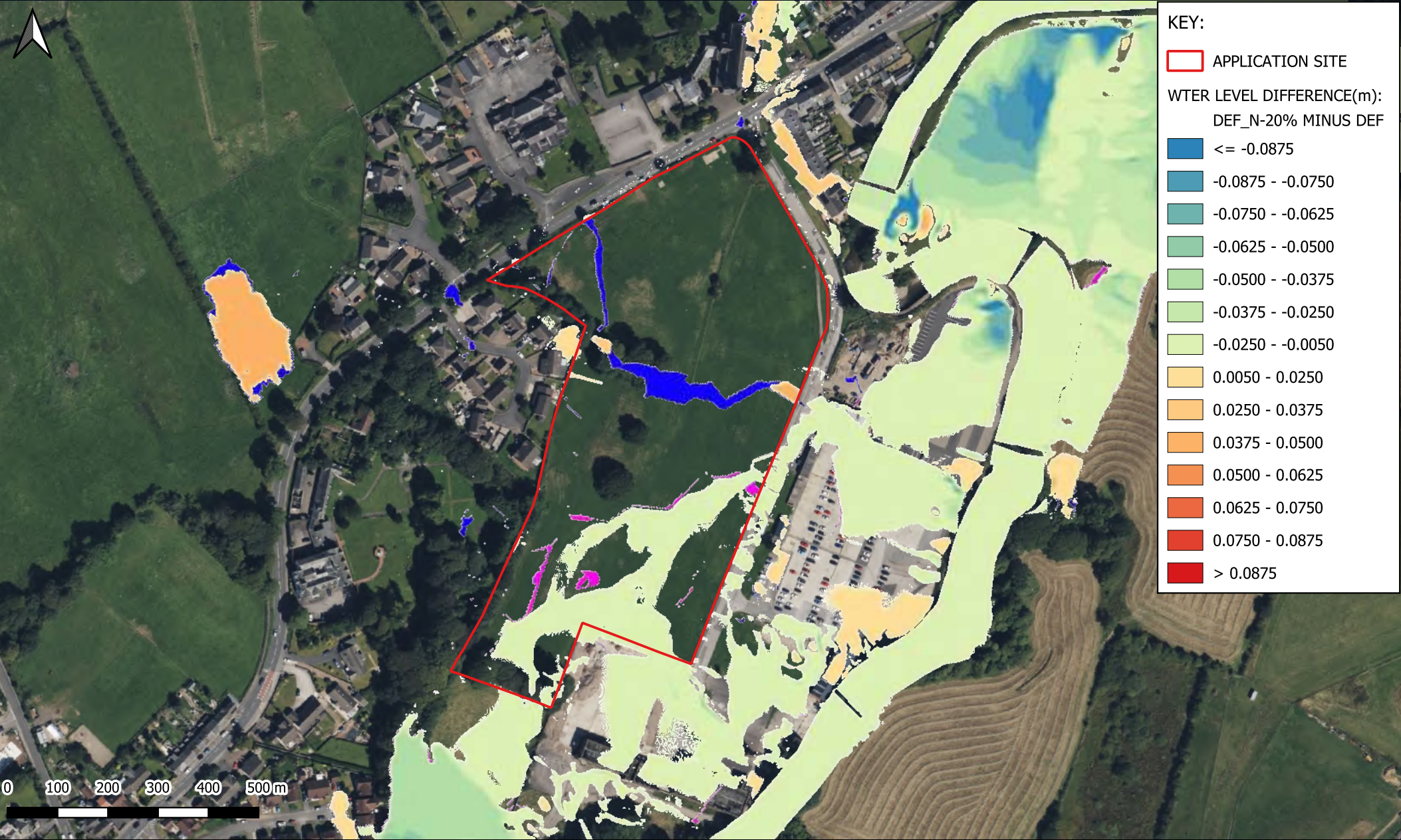


DRWG:	AEG4648-DR-DEF-304	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

FLOOD DEPTH MAP (SCENARIOS: DEF & DEF_NMINUS20% | EVENT: 1.0%AEP30CC_0730)

River_Ehen_Model_v19_Def_(Q100CC30)_AEG004_0730_Nminus20% MINUS DEF

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-305	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

FLOOD DEPTH MAP (SCENARIOS: DEF & DEF_Nplus20% | EVENT: 1.0%AEP30CC_0730)

River_Ehen_Model_v19_Def_(Q100CC30)_AEG004_0730_Nplus20% MINUS DEF

AEGAEA LTD
Atlas Chambers
33 West Street
Brighton, BN1 2RE



DRWG:	AEG4648-DR-DEF-306	STATUS:	FOR INFORMATION											
PROJECT:	TRUMPET TERRACE, CLEATOR MOOR	REVISION:	01											
CLIENT:	RWO	DATE:	08/07/2024		REV:	01	ISSUE FOR INFORMATION			BY:	JSG	CHK:	RT	APP:

G:\Shared drives\AEG4000-4999\AEG4648_CA23_Cleator Moor_03\WIP\Models\QGIS

Appendix F Environment Agency Flood Data

Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

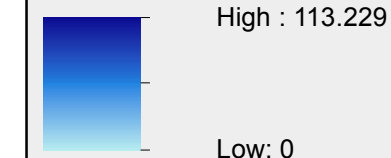
NGR: 301,733 514,107

Key

 Main River

1 in 30 Undefended Scenario

mAOD

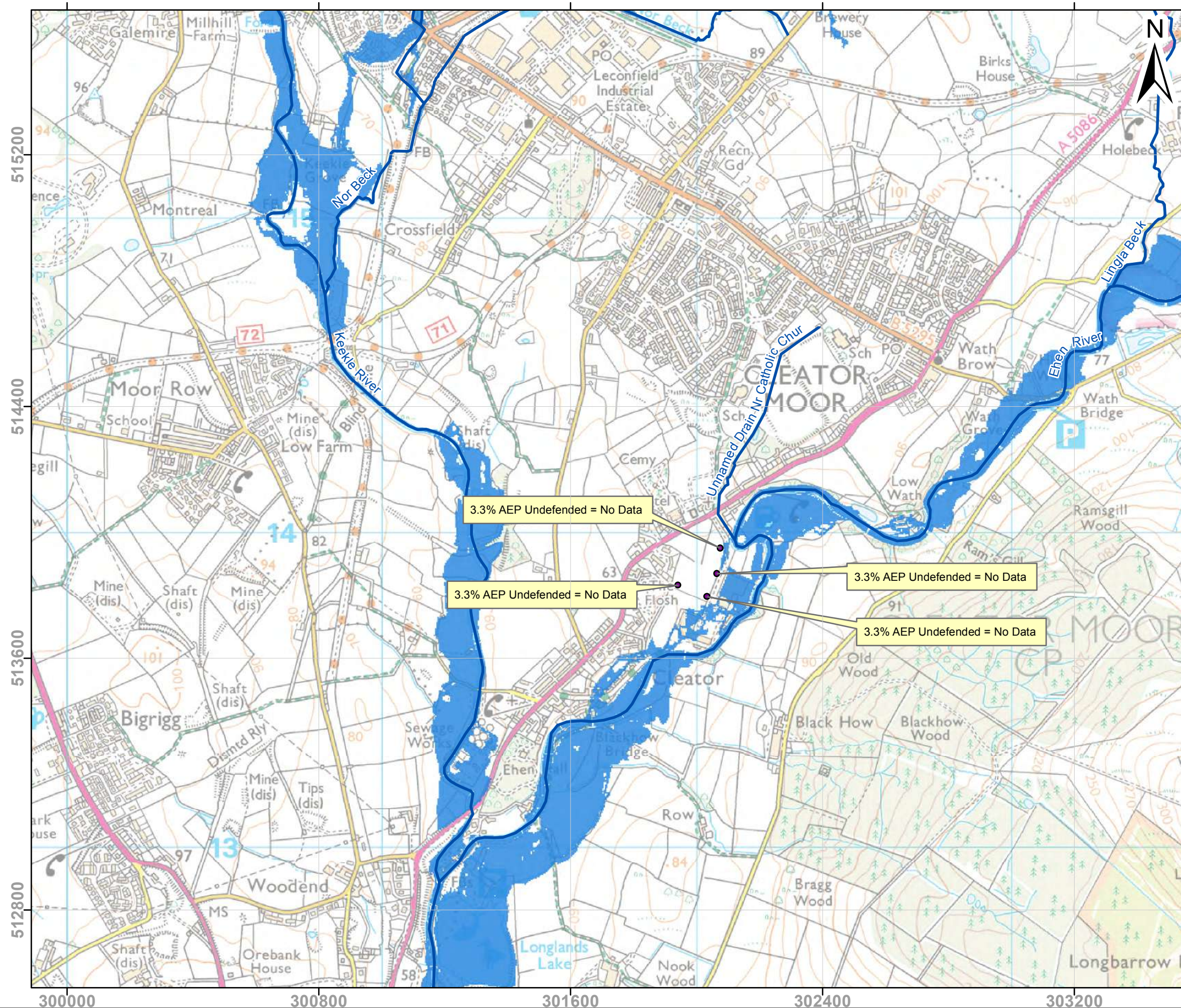


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

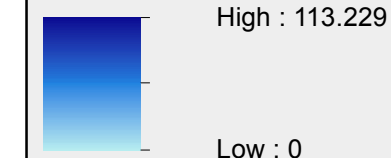
NGR: 301,733 514,107

Key

 Main River

1 in 30 Defended Scenario

mAOD

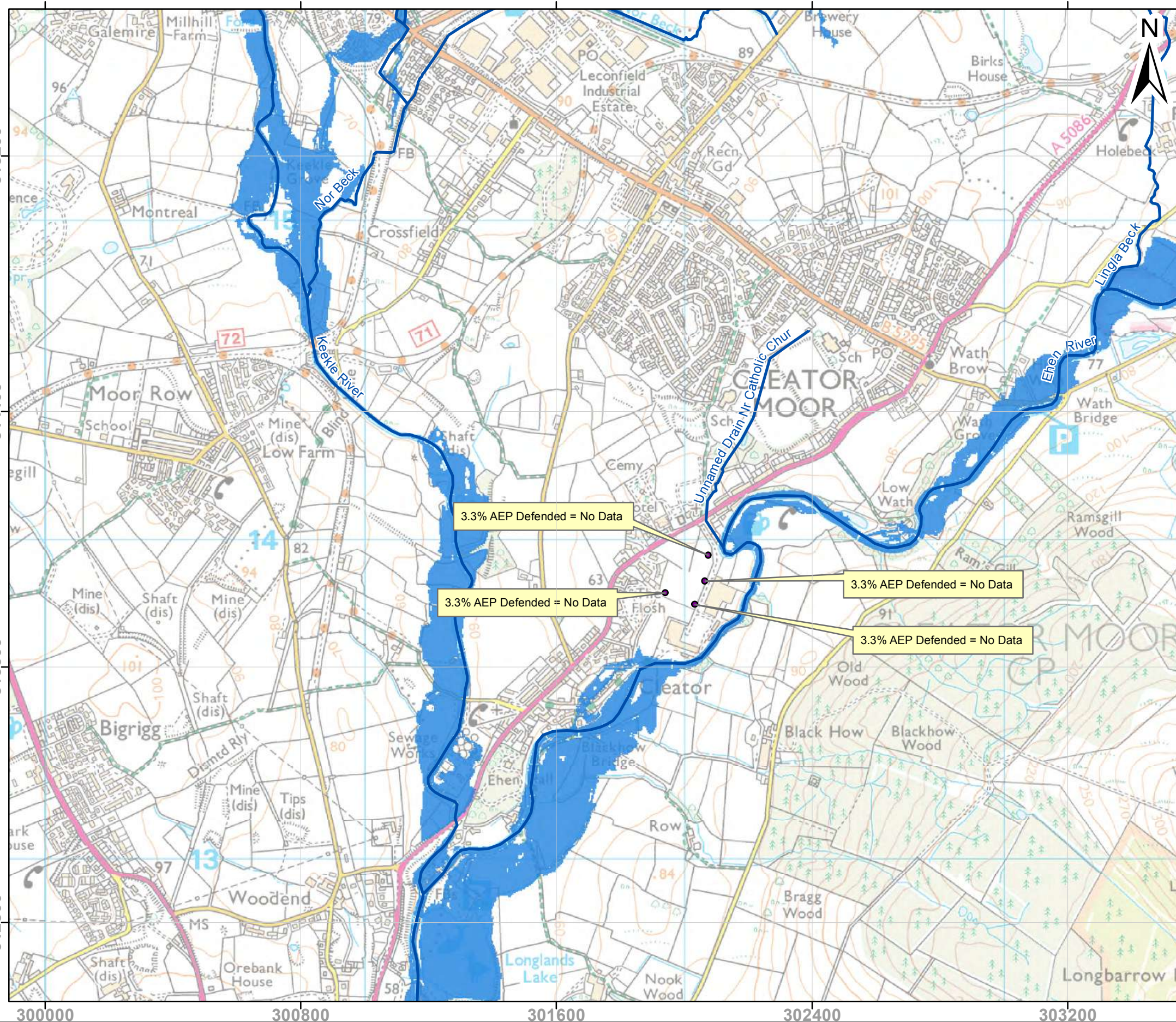


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

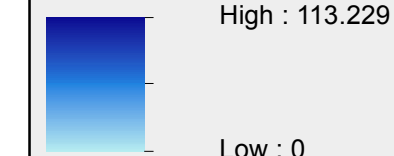
NGR: 301,526 513,720

Key

 Main River

1 in 50 Undefended Scenario

mAOD

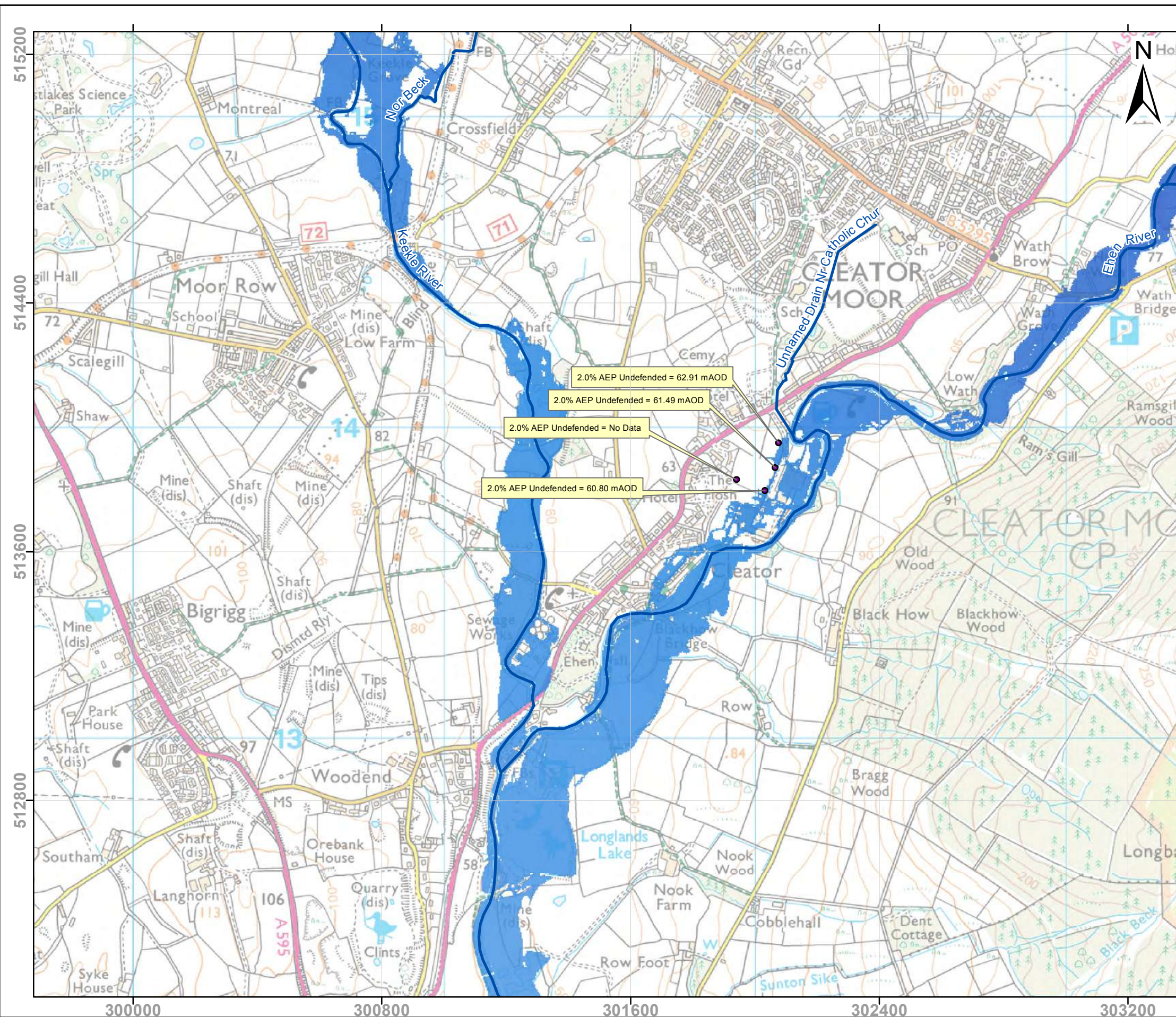


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

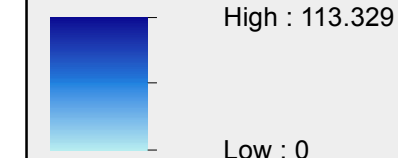
NGR: 301,720 514,026

Key

 Main River

1 in 50 Defended Scenario

mAOD

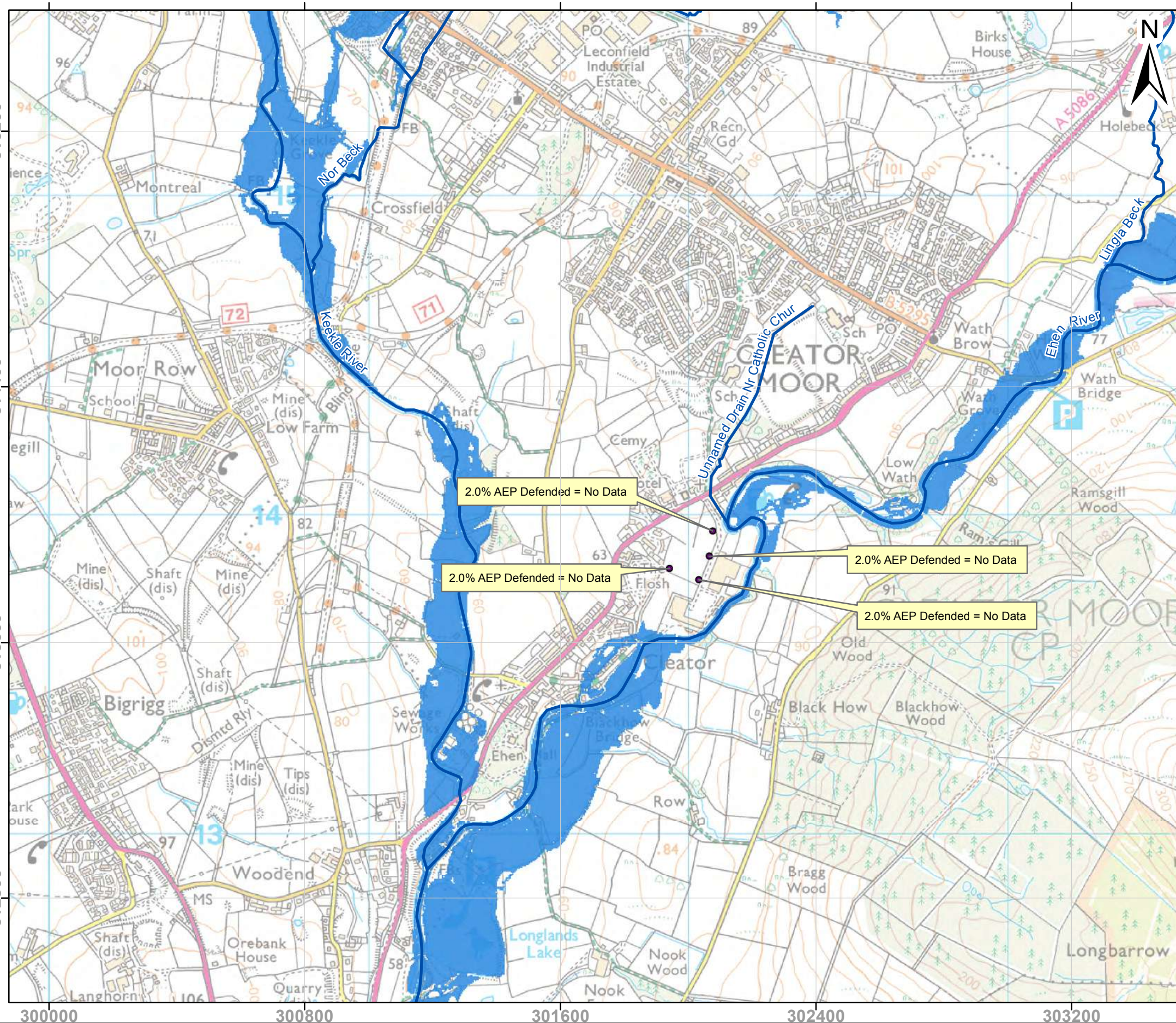


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

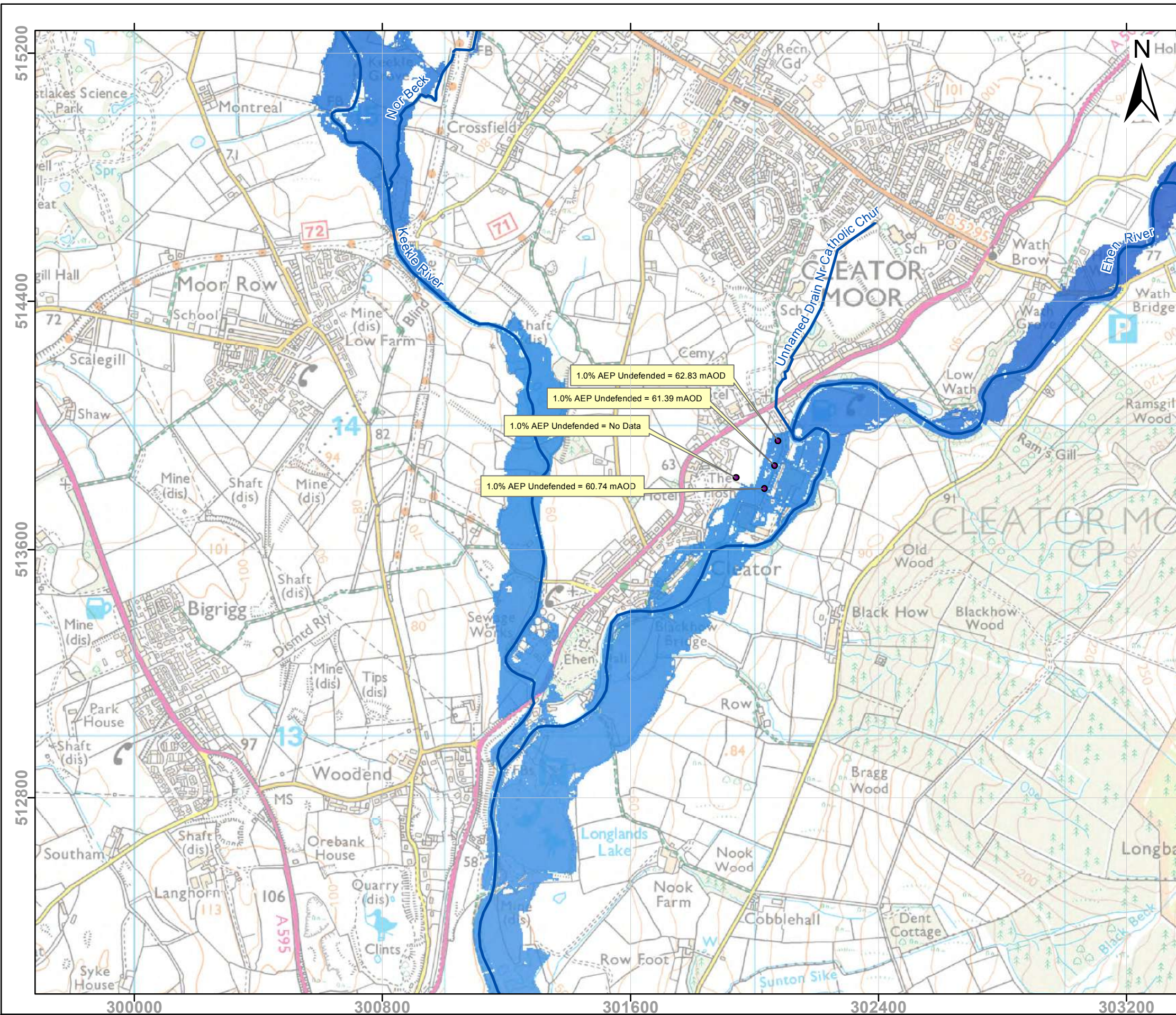
ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

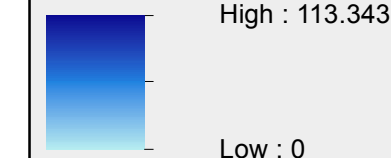
NGR: 301,526 513,720

Key

Main River

1 in 100 Undefended Scenario

mAOd



Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

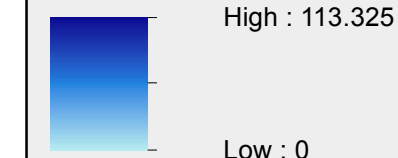
NGR: 301,720 514,026

Key

 Main River

1 in 100 Defended Scenario

mAOD

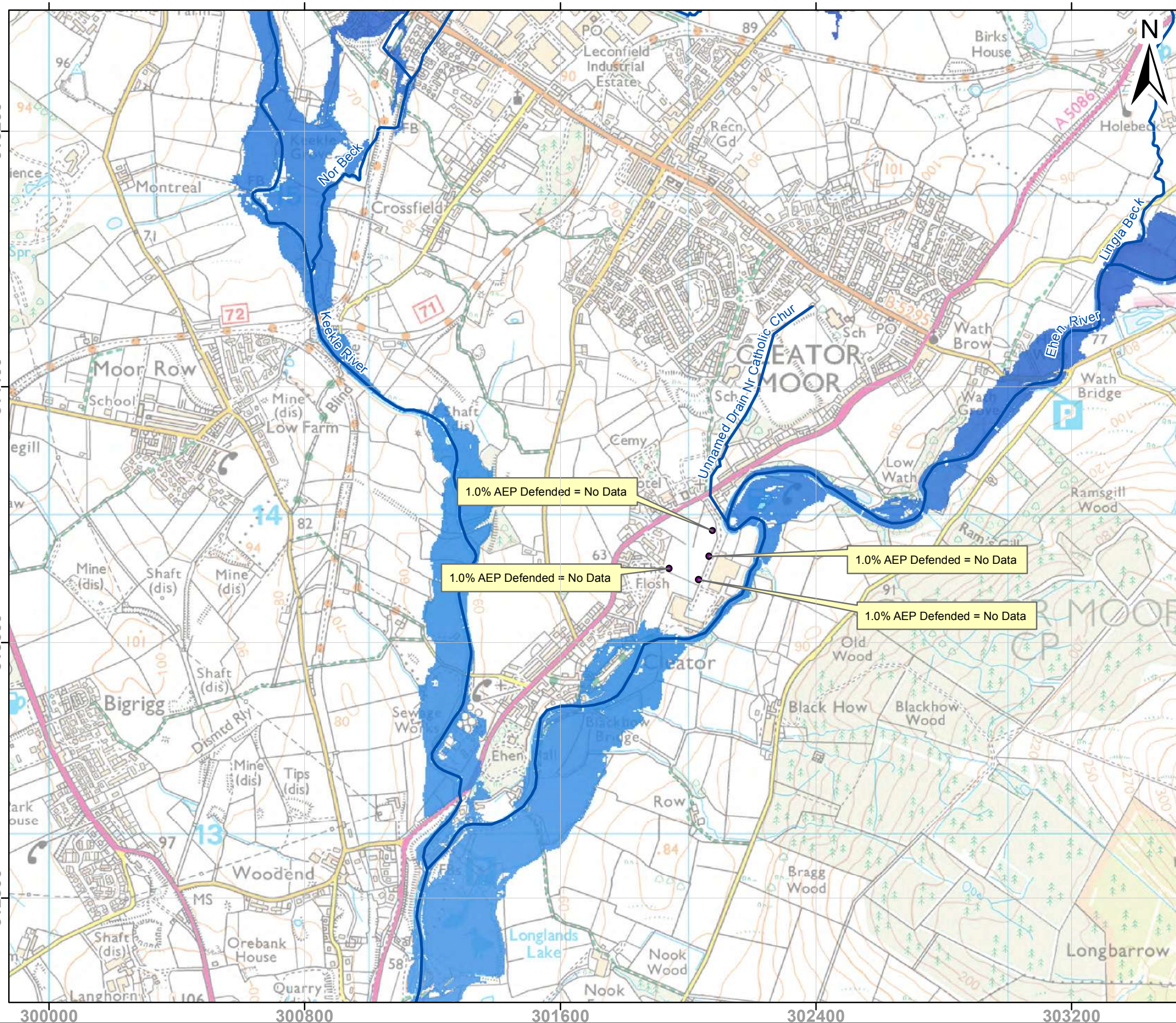


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

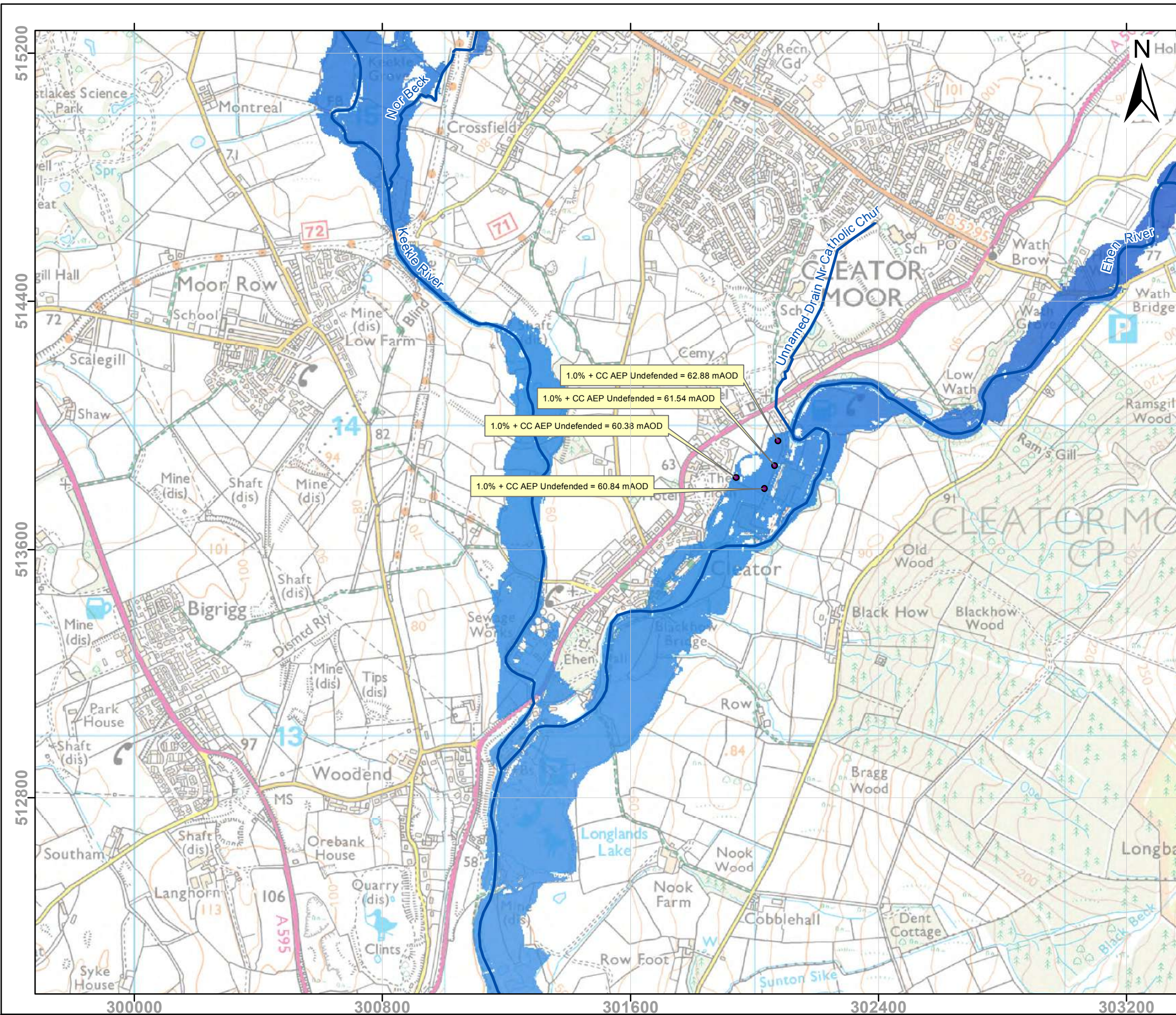
ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

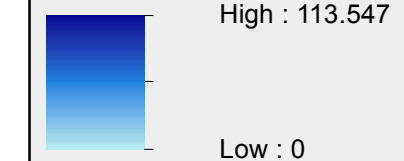
NGR: 301,526 513,720

Key

Main River

1 in 100 + CC Undefended

mAOD



Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

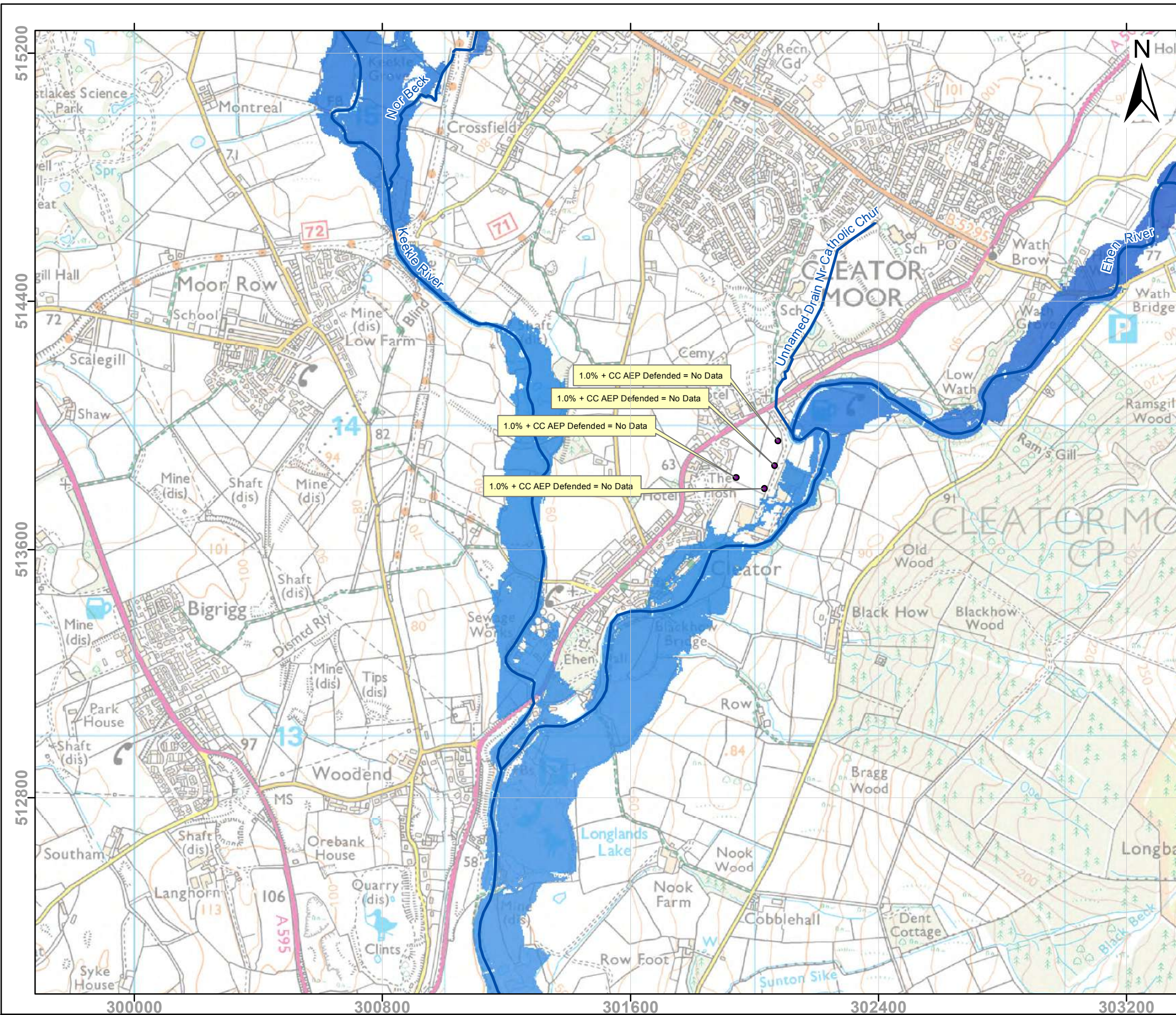
ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

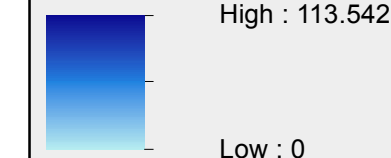
NGR: 301,526 513,720

Key

Main River

1 in 100 + CC Defended Scenario

mAOD



Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

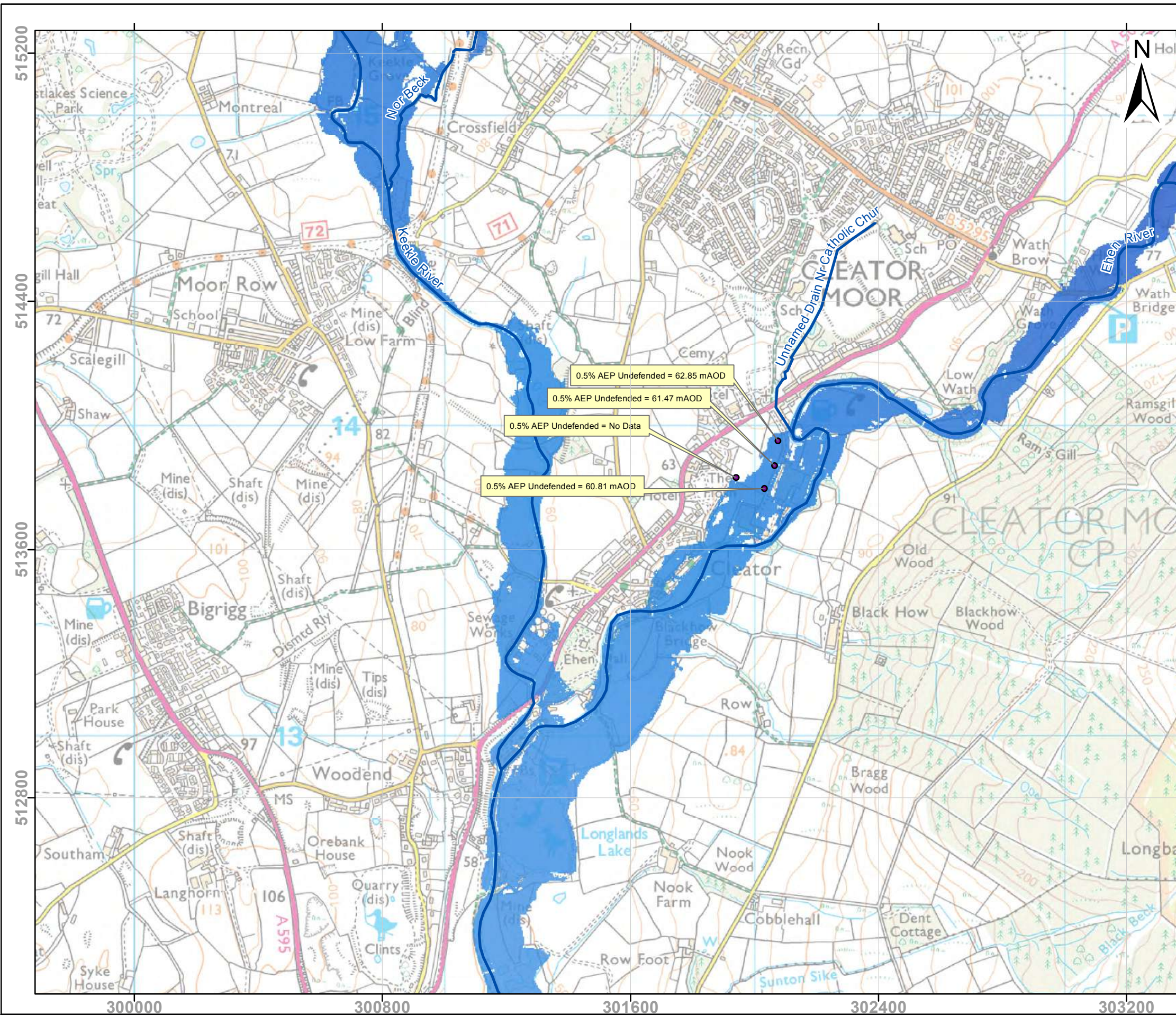
ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

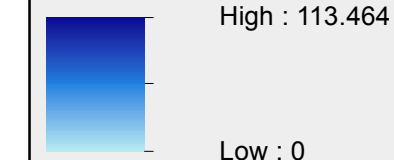
NGR: 301,526 513,720

Key

Main River

1 in 200 Undefended Scenario

mAOB



Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

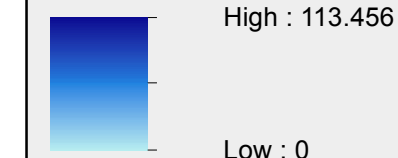
NGR: 301,720 514,026

Key

 Main River

1 in 200 Defended Scenario

mAOD

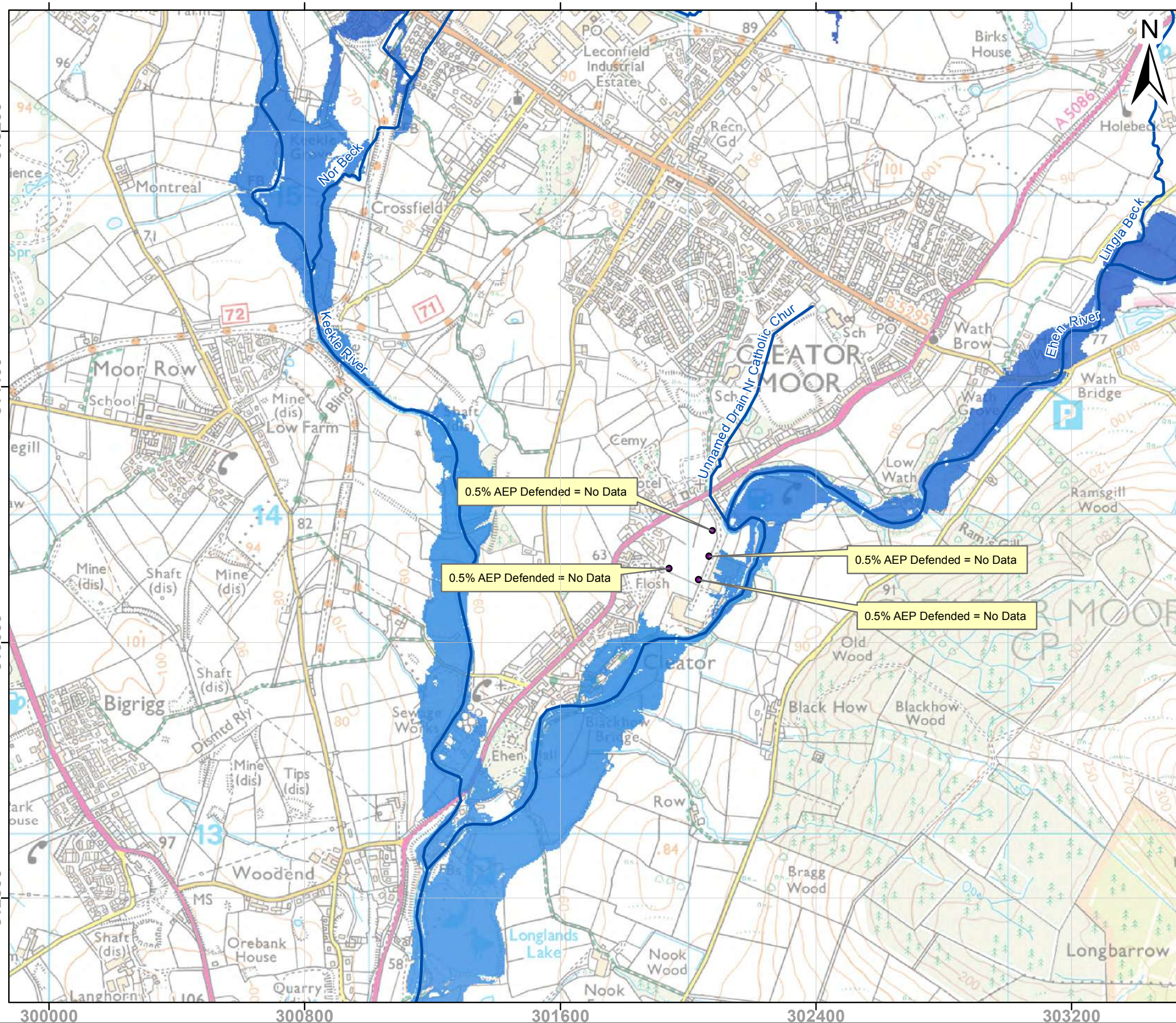


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

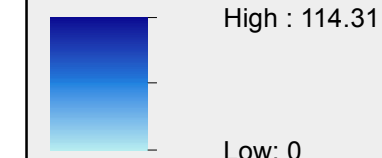
NGR: 301,720 514,026

Key

 Main River

1 in 1000 Undefended Scenario

mAOD

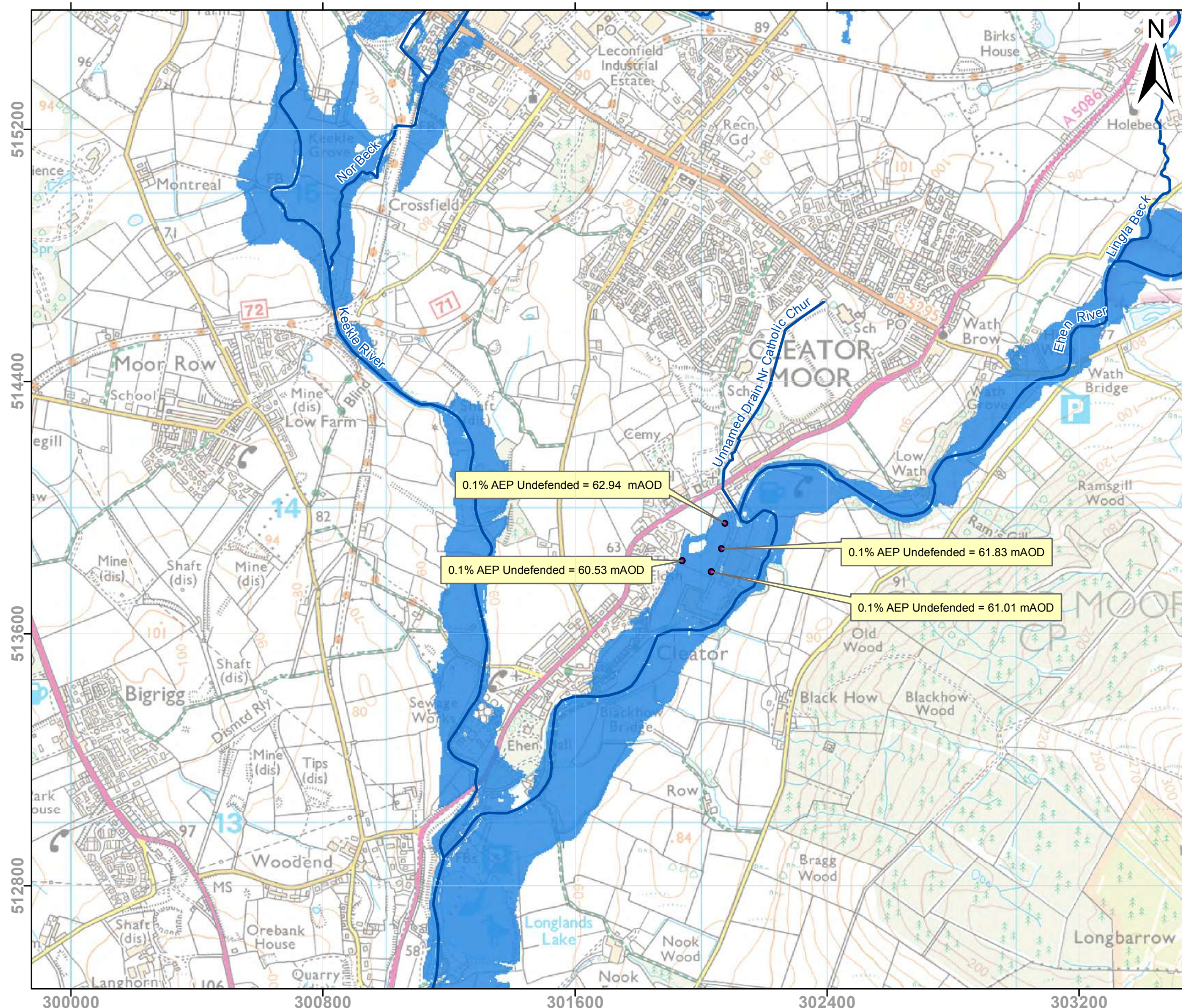


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

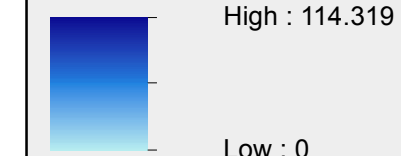
NGR: 301,720 514,026

Key

 Main River

1 in 1000 Defended Scenario

mAOD

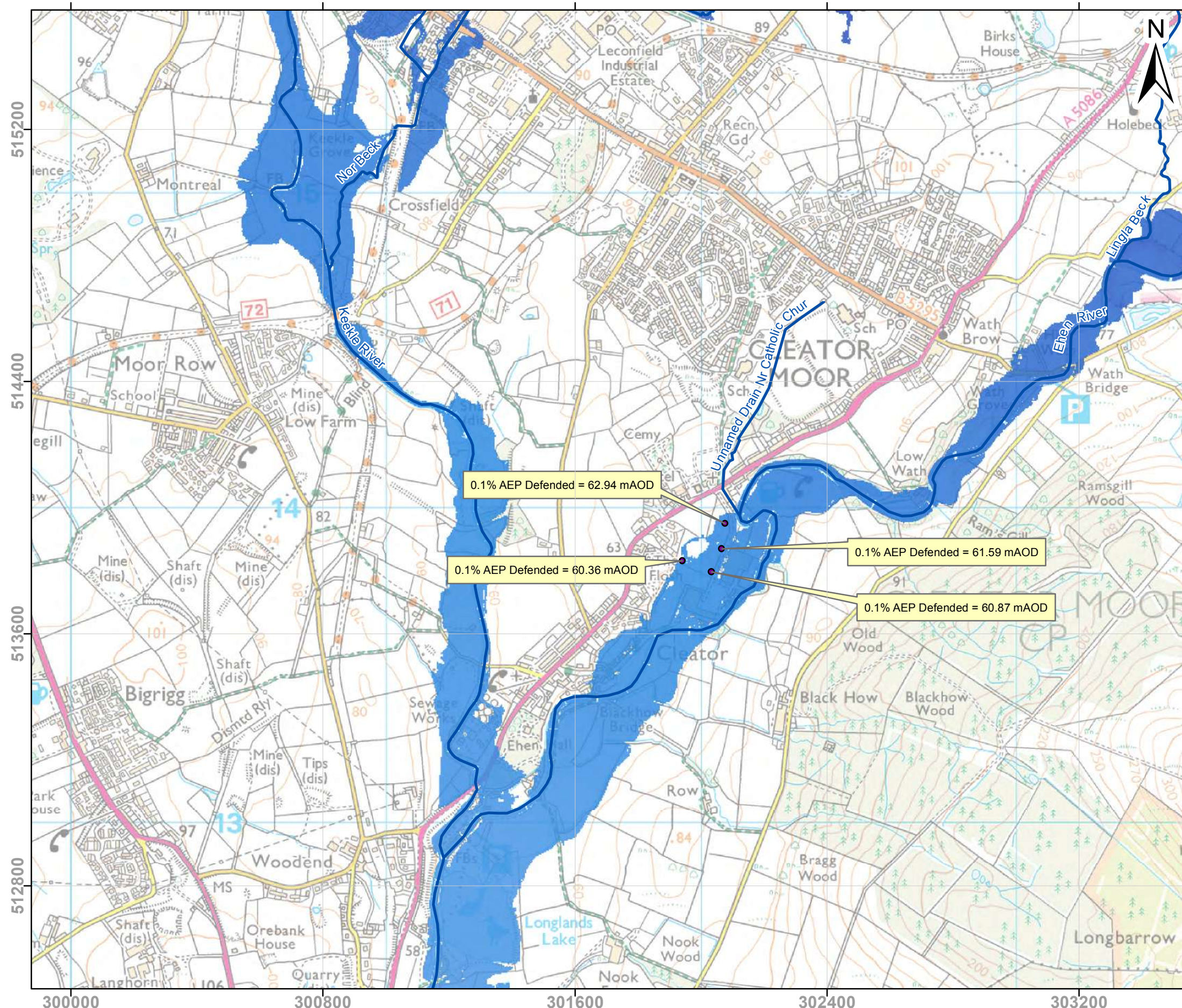


Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Node Point Location Map: Cleator Mills, Cleator, CA23 3DU

Produced: 10 July 2019

Our Ref: CL132929

NGR: 301,720 514,026

Key

• Modelled Node Point

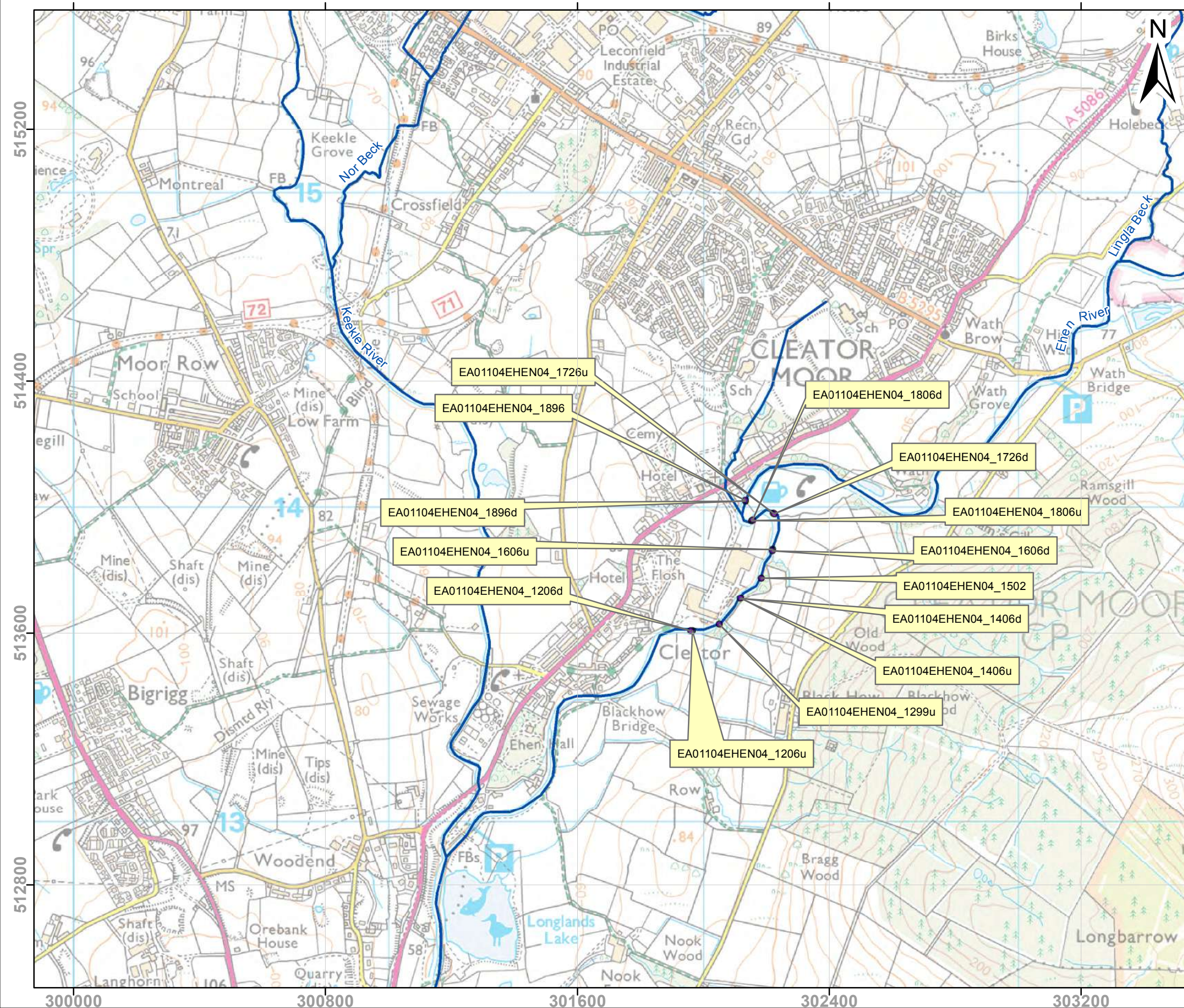
~ Main River

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Node Point ID	Model Flood group	Return Period(Yrs)	Water Level (maod	Flow (cumecs)
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	10	62.013	85.003
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	25	62.223	101.675
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	50	62.32	111.803
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	75	62.42	122.091
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	100	62.472	127.207
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	100+CC	62.692	143.88
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	200	63.383	140.216
EA01104EHEN4_1726d	EA1104FRMEHEN2015_def	1000	63.685	173.534
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	10	62.772	67.006
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	25	62.972	101.675
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	50	63.086	111.803
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	75	63.198	122.091
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	100	63.251	127.207
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	100+CC	63.419	143.88
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	200	63.779	92.749
EA01104EHEN4_1726u	EA1104FRMEHEN2015_def	1000	64.135	100.247
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	10	63.052	77.551
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	25	63.284	86.275
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	50	63.418	89.701
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	75	63.553	91.197
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	100	63.621	91.358
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	100+CC	63.823	93.242
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	200	63.779	92.749
EA01104EHEN4_1806d	EA1104FRMEHEN2015_def	1000	64.135	100.247
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	10	63.948	76.434
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	25	64.086	85.916
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	50	64.146	90.072

EA01104EHEN4_1896	EA1104FRMEHEN2015_def	75	64.194	92.974
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	100	64.223	94.056
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	100+CC	64.291	98.815
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	200	64.015	100.488
EA01104EHEN4_1896	EA1104FRMEHEN2015_def	1000	64.152	116.027
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	10	63.74	77.543
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	25	63.852	87.567
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	50	63.898	92.126
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	75	63.941	95.293
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	100	63.972	96.513
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	100+CC	64.029	101.484
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	200	64.7	120.715
EA01104EHEN4_1896d	EA1104FRMEHEN2015_def	1000	64.939	147.259
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	10	63.052	77.551
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	25	63.284	86.275
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	50	63.418	89.701
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	75	63.553	91.197
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	100	63.621	91.358
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	100+CC	63.823	93.242
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	200	64.276	97.704
EA01104EHEN4_1806u	EA1104FRMEHEN2015_def	1000	63.754	86.424
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	10	61.545	85.032
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	25	61.765	101.24
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	50	61.882	111.013
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	75	61.994	121.169
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	100	62.052	126.737
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	100+CC	62.231	145.965
EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	200	62.192	141.565

EA01104EHEN4_1606u	EA1104FRMEHEN2015_def	1000	62.545	185.438
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	10	60.834	85.032
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	25	61.064	101.24
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	50	61.208	111.013
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	75	61.354	121.169
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	100	61.427	126.737
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	100+CC	61.666	145.965
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	200	61.61	129.311
EA01104EHEN4_1606d	EA1104FRMEHEN2015_def	1000	62.193	165.107
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	10	60.275	85.057
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	25	60.504	101.728
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	50	60.626	111.889
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	75	60.744	122.965
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	100	60.808	129.137
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	100+CC	61.001	151.25
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	200	60.953	146.021
EA01104EHEN4_1502	EA1104FRMEHEN2015_def	1000	61.398	198.323
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	10	59.892	85.08
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	25	60.118	101.697
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	50	60.224	111.657
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	75	60.379	122.255
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	100	60.451	128.097
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	100+CC	60.559	149.927
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	200	60.56	144.657
EA01104EHEN4_1406d	EA1104FRMEHEN2015_def	1000	61.039	202.596
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	10	59.892	85.08
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	25	60.118	101.697
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	50	60.244	111.657

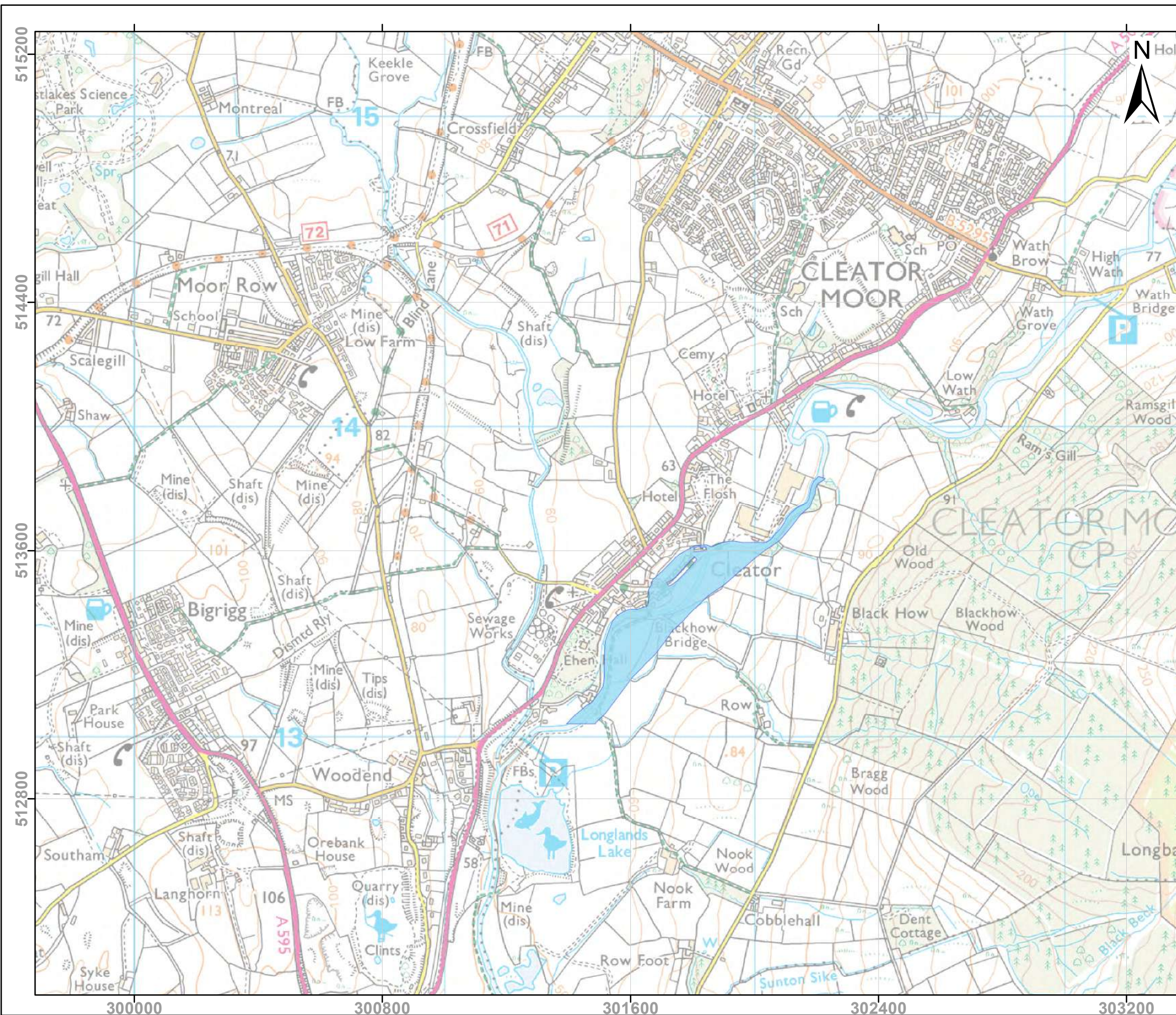
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	75	60.379	122.255
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	100	60.451	128.097
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	100+CC	60.599	149.927
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	200	60.953	146.021
EA01104EHEN4_1406u	EA1104FRMEHEN2015_def	1000	61.398	198.323
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	10	59.379	85.106
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	25	59.549	101.801
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	50	59.64	111.974
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	75	59.733	123.071
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	100	59.775	129.253
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	100+CC	59.912	152.206
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	200	60.56	144.657
EA01104EHEN4_1299u	EA1104FRMEHEN2015_def	1000	61.039	202.596
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	10	58.826	85.128
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	25	58.938	101.546
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	50	58.992	111.299
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	75	59.044	121.701
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	100	59.056	127.645
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	100+CC	59.075	150.014
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	200	59.88	146.482
EA01104EHEN4_1206u	EA1104FRMEHEN2015_def	1000	60.205	210.945
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	10	58.826	85.128
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	25	58.938	101.546
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	50	58.992	111.299
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	75	59.044	121.701
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	100	59.056	127.645
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	100+CC	59.075	150.014
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	200	59.071	144.439
EA01104EHEN4_1206d	EA1104FRMEHEN2015_def	1000	59.234	203.897

Node Point ID	Model Flood group	Return Period(Yrs)	Water Level (maod)	Flow (cumecs)
EA01104EHEN4_1726d	EA1104FRMEHEN2015	10	62.024	85.635
EA01104EHEN4_1726d	EA1104FRMEHEN2015	25	62.203	98.295
EA01104EHEN4_1726d	EA1104FRMEHEN2015	50	62.29	104.334
EA01104EHEN4_1726d	EA1104FRMEHEN2015	75	62.392	109.629
EA01104EHEN4_1726d	EA1104FRMEHEN2015	100	62.443	112.064
EA01104EHEN4_1726d	EA1104FRMEHEN2015	100+CC	62.208	119.508
EA01104EHEN4_1726d	EA1104FRMEHEN2015	200	62.241	140.216
EA01104EHEN4_1726d	EA1104FRMEHEN2015	1000	63.035	135.814
EA01104EHEN4_1726u	EA1104FRMEHEN2015	10	62.78	85.635
EA01104EHEN4_1726u	EA1104FRMEHEN2015	25	62.933	98.295
EA01104EHEN4_1726u	EA1104FRMEHEN2015	50	63.003	104.334
EA01104EHEN4_1726u	EA1104FRMEHEN2015	75	63.062	109.629
EA01104EHEN4_1726u	EA1104FRMEHEN2015	100	63.089	112.064
EA01104EHEN4_1726u	EA1104FRMEHEN2015	100+CC	63.17	119.508
EA01104EHEN4_1726u	EA1104FRMEHEN2015	200	63.383	118.004
EA01104EHEN4_1726u	EA1104FRMEHEN2015	1000	63.339	135.814
EA01104EHEN4_1806d	EA1104FRMEHEN2015	10	63.097	67.006
EA01104EHEN4_1806d	EA1104FRMEHEN2015	25	63.284	69.381
EA01104EHEN4_1806d	EA1104FRMEHEN2015	50	63.367	71.016
EA01104EHEN4_1806d	EA1104FRMEHEN2015	75	63.438	72.753
EA01104EHEN4_1806d	EA1104FRMEHEN2015	100	63.469	73.652
EA01104EHEN4_1806d	EA1104FRMEHEN2015	100+CC	63.563	76.122
EA01104EHEN4_1806d	EA1104FRMEHEN2015	200	63.544	75.778
EA01104EHEN4_1806d	EA1104FRMEHEN2015	1000	63.754	86.424
EA01104EHEN4_1896	EA1104FRMEHEN2015	10	63.778	64.737
EA01104EHEN4_1896	EA1104FRMEHEN2015	25	63.844	66.953
EA01104EHEN4_1896	EA1104FRMEHEN2015	50	63.887	68.838

EA01104EHEN4_1896	EA1104FRMEHEN2015	75	63.929	71.243
EA01104EHEN4_1896	EA1104FRMEHEN2015	100	63.949	72.743
EA01104EHEN4_1896	EA1104FRMEHEN2015	100+CC	64.016	78.371
EA01104EHEN4_1896	EA1104FRMEHEN2015	200	64.002	77.1
EA01104EHEN4_1896	EA1104FRMEHEN2015	1000	64.458	112.23
EA01104EHEN4_1896d	EA1104FRMEHEN2015	10	63.601	65.878
EA01104EHEN4_1896d	EA1104FRMEHEN2015	25	63.667	68.625
EA01104EHEN4_1896d	EA1104FRMEHEN2015	50	63.707	70.898
EA01104EHEN4_1896d	EA1104FRMEHEN2015	75	63.743	73.527
EA01104EHEN4_1896d	EA1104FRMEHEN2015	100	63.758	75.168
EA01104EHEN4_1896d	EA1104FRMEHEN2015	100+CC	63.805	81.063
EA01104EHEN4_1896d	EA1104FRMEHEN2015	200	63.794	79.925
EA01104EHEN4_1896d	EA1104FRMEHEN2015	1000	63.925	97.461
EA01104EHEN4_1806u	EA1104FRMEHEN2015	10	63.097	67.006
EA01104EHEN4_1806u	EA1104FRMEHEN2015	25	63.284	69.381
EA01104EHEN4_1806u	EA1104FRMEHEN2015	50	63.367	71.016
EA01104EHEN4_1806u	EA1104FRMEHEN2015	75	63.438	72.753
EA01104EHEN4_1806u	EA1104FRMEHEN2015	100	63.469	73.652
EA01104EHEN4_1806u	EA1104FRMEHEN2015	100+CC	63.563	76.122
EA01104EHEN4_1806u	EA1104FRMEHEN2015	200	63.544	75.778
EA01104EHEN4_1806u	EA1104FRMEHEN2015	1000	63.754	86.424
EA01104EHEN4_1606u	EA1104FRMEHEN2015	10	61.556	85.791
EA01104EHEN4_1606u	EA1104FRMEHEN2015	25	61.738	99.175
EA01104EHEN4_1606u	EA1104FRMEHEN2015	50	61.834	106.938
EA01104EHEN4_1606u	EA1104FRMEHEN2015	75	61.928	115.064
EA01104EHEN4_1606u	EA1104FRMEHEN2015	100	61.974	119.209
EA01104EHEN4_1606u	EA1104FRMEHEN2015	100+CC	62.107	132.378
EA01104EHEN4_1606u	EA1104FRMEHEN2015	200	62.077	129.311

EA01104EHEN4_1606u	EA1104FRMEHEN2015	1000	62.468	165.107
EA01104EHEN4_1606d	EA1104FRMEHEN2015	10	60.846	85.791
EA01104EHEN4_1606d	EA1104FRMEHEN2015	25	61.066	99.175
EA01104EHEN4_1606d	EA1104FRMEHEN2015	50	61.219	106.938
EA01104EHEN4_1606d	EA1104FRMEHEN2015	75	61.368	115.064
EA01104EHEN4_1606d	EA1104FRMEHEN2015	100	61.442	119.209
EA01104EHEN4_1606d	EA1104FRMEHEN2015	100+CC	61.658	132.378
EA01104EHEN4_1606d	EA1104FRMEHEN2015	200	61.61	141.565
EA01104EHEN4_1606d	EA1104FRMEHEN2015	1000	62.193	165.107
EA01104EHEN4_1502	EA1104FRMEHEN2015	10	60.291	85.849
EA01104EHEN4_1502	EA1104FRMEHEN2015	25	60.51	100.509
EA01104EHEN4_1502	EA1104FRMEHEN2015	50	60.632	109.947
EA01104EHEN4_1502	EA1104FRMEHEN2015	75	60.75	120.011
EA01104EHEN4_1502	EA1104FRMEHEN2015	100	60.814	125.364
EA01104EHEN4_1502	EA1104FRMEHEN2015	100+CC	60.984	143.259
EA01104EHEN4_1502	EA1104FRMEHEN2015	200	60.947	139.137
EA01104EHEN4_1502	EA1104FRMEHEN2015	1000	61.321	193.319
EA01104EHEN4_1406d	EA1104FRMEHEN2015	10	59.906	86.039
EA01104EHEN4_1406d	EA1104FRMEHEN2015	25	60.115	101.387
EA01104EHEN4_1406d	EA1104FRMEHEN2015	50	60.238	110.983
EA01104EHEN4_1406d	EA1104FRMEHEN2015	75	60.397	121.057
EA01104EHEN4_1406d	EA1104FRMEHEN2015	100	60.435	126.415
EA01104EHEN4_1406d	EA1104FRMEHEN2015	100+CC	60.562	144.742
EA01104EHEN4_1406d	EA1104FRMEHEN2015	200	60.549	140.363
EA01104EHEN4_1406d	EA1104FRMEHEN2015	1000	61.039	194.063
EA01104EHEN4_1406u	EA1104FRMEHEN2015	10	59.09	86.039
EA01104EHEN4_1406u	EA1104FRMEHEN2015	25	60.115	101.387
EA01104EHEN4_1406u	EA1104FRMEHEN2015	50	60.238	110.983

EA01104EHEN4_1406u	EA1104FRMEHEN2015	75	60.367	121.057
EA01104EHEN4_1406u	EA1104FRMEHEN2015	100	60.435	126.415
EA01104EHEN4_1406u	EA1104FRMEHEN2015	100+CC	60.562	144.742
EA01104EHEN4_1406u	EA1104FRMEHEN2015	200	60.549	140.363
EA01104EHEN4_1406u	EA1104FRMEHEN2015	1000	60.998	194.063
EA01104EHEN4_1299u	EA1104FRMEHEN2015	10	59.39	86.067
EA01104EHEN4_1299u	EA1104FRMEHEN2015	25	59.547	101.558
EA01104EHEN4_1299u	EA1104FRMEHEN2015	50	59.634	111.404
EA01104EHEN4_1299u	EA1104FRMEHEN2015	75	59.725	121.991
EA01104EHEN4_1299u	EA1104FRMEHEN2015	100	59.767	127.705
EA01104EHEN4_1299u	EA1104FRMEHEN2015	100+CC	59.881	1146.854
EA01104EHEN4_1299u	EA1104FRMEHEN2015	200	59.854	142.423
EA01104EHEN4_1299u	EA1104FRMEHEN2015	1000	60.162	201.548
EA01104EHEN4_1206u	EA1104FRMEHEN2015	10	58.833	86.088
EA01104EHEN4_1206u	EA1104FRMEHEN2015	25	58.937	101.308
EA01104EHEN4_1206u	EA1104FRMEHEN2015	50	58.989	110.761
EA01104EHEN4_1206u	EA1104FRMEHEN2015	75	59.039	120.695
EA01104EHEN4_1206u	EA1104FRMEHEN2015	100	59.059	126.069
EA01104EHEN4_1206u	EA1104FRMEHEN2015	100+CC	59.088	144.551
EA01104EHEN4_1206u	EA1104FRMEHEN2015	200	59.08	140.338
EA01104EHEN4_1206u	EA1104FRMEHEN2015	1000	59.218	195.285
EA01104EHEN4_1206d	EA1104FRMEHEN2015	10	58.833	86.088
EA01104EHEN4_1206d	EA1104FRMEHEN2015	25	58.937	101.308
EA01104EHEN4_1206d	EA1104FRMEHEN2015	50	58.989	110.761
EA01104EHEN4_1206d	EA1104FRMEHEN2015	75	59.039	120.695
EA01104EHEN4_1206d	EA1104FRMEHEN2015	100	59.059	126.069
EA01104EHEN4_1206d	EA1104FRMEHEN2015	100+CC	59.088	144.551
EA01104EHEN4_1206d	EA1104FRMEHEN2015	200	59.08	140.338
EA01104EHEN4_1206d	EA1104FRMEHEN2015	1000	59.218	195.285



Historic Flood Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

NGR: 301,526 513,720

Key



November 2009 Recorded Flood
Outline

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

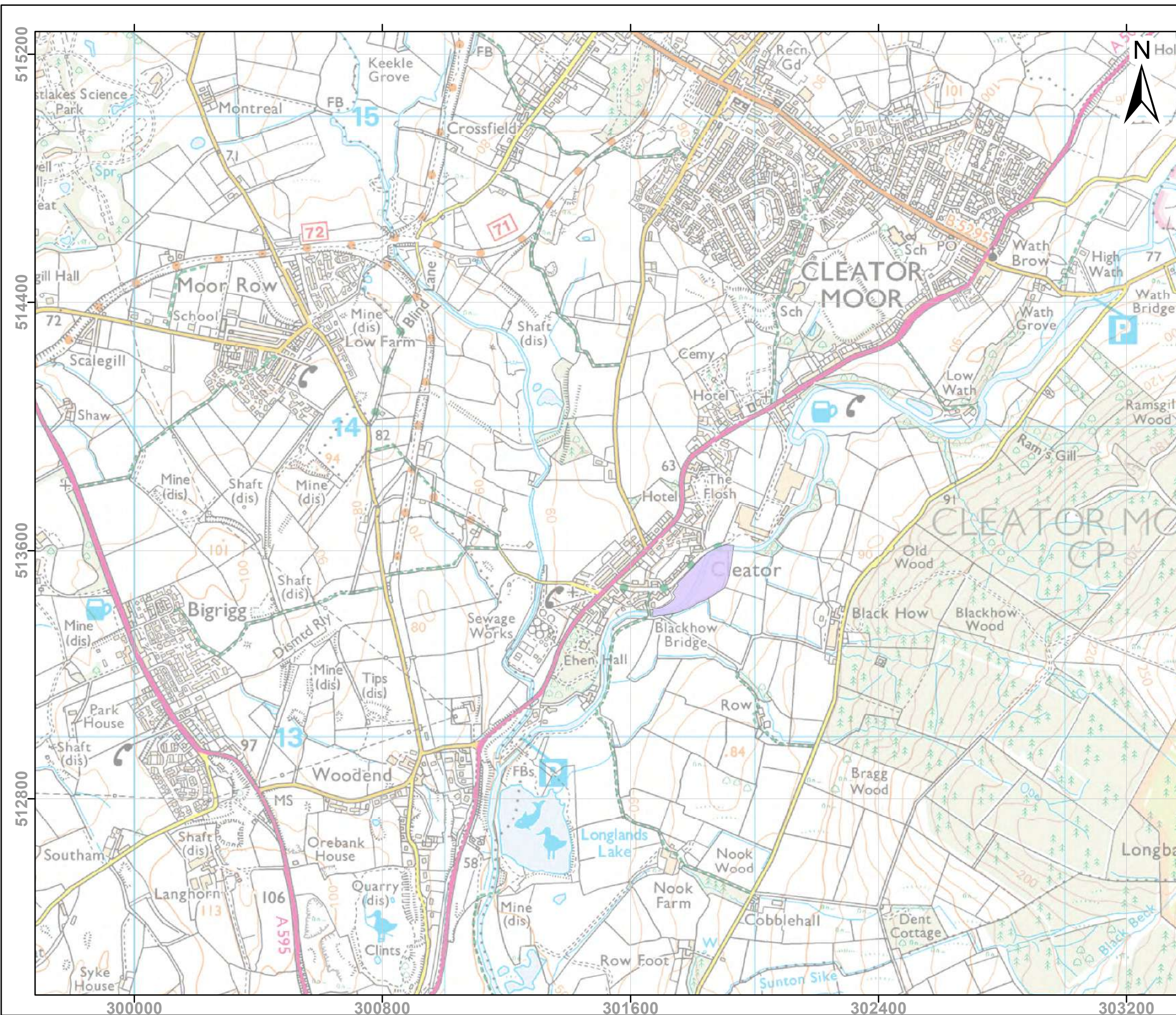
ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk



Historic Flood Map: Cleator Mills, Cleator, CA23 3DU

Produced: 09 July 2019

Our Ref: CL132929

NGR: 301,526 513,720

Key



October 2017 Recorded Flood
Outline

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

ABDs (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Appendix G Topographical Survey



KEY

LINETYPES

- VERGE
- FENCE - CHAIN LINK
- FENCE - METAL
- FENCE - WOODEN
- FENCE - POST & RAIL
- WALL
- BARRIER
- CHANNEL LINE

CONCRETE EDGE

- FOOTPATH
- TRACK
- BUILDING
- TREE
- GATE
- SURVEY STATION
- EAVES

UTILITY KEY

LINE TYPES		
BT BELOW GROUND	WATER ABOVE GROUND	WATER BELOW GROUND
BT ABOVE GROUND	WATER ABOVE GROUND	WATER ABOVE GROUND
BT ASSUMED ROUTE	WATER ASSUMED ROUTE	WATER ASSUMED ROUTE
CATV BELOW GROUND	UNKNOWN BELOW GROUND	UNKNOWN BELOW GROUND
CATV ABOVE GROUND	UNKNOWN ABOVE GROUND	UNKNOWN ABOVE GROUND
CATV ASSUMED ROUTE	UNKNOWN ABOVE GROUND	UNKNOWN ABOVE GROUND
COMB BELOW GROUND	COMBINED WATER SEWER	COMBINED WATER SEWER
COMB ABOVE GROUND	COMBINED WATER SEWER	COMBINED WATER SEWER
COMB ASSUMED ROUTE	COMBINED WATER SEWER ROUTE	COMBINED WATER SEWER ROUTE
FOG BELOW GROUND	FOG WATER BELOW	FOG WATER BELOW
FOG ABOVE GROUND	FOG WATER ABOVE	FOG WATER ABOVE
FOG ASSUMED ROUTE	FOG WATER ASSUMED ROUTE	FOG WATER ASSUMED ROUTE
ELECTRIC BELOW GROUND	ELECTRIC BELOW GROUND	ELECTRIC BELOW GROUND
ELECTRIC ABOVE GROUND	ELECTRIC ABOVE GROUND	ELECTRIC ABOVE GROUND
ELECTRIC ASSUMED ROUTE	ELECTRIC ASSUMED ROUTE	ELECTRIC ASSUMED ROUTE

[illegible]

DISCLAIMER
Unless otherwise stated, all services shown on this plot have been surveyed using approved detectors and the connections between manholes, if not traced, are assumed to be direct.

No guarantee can be given that all services have been shown.
In ideal conditions this device is recommended for the continuous and reliable operation in a 24/7/365 environment.

Utilities traced using GPR techniques show depths approximately from ground level to the top of the utility. Utilities traced using Electromagnetic techniques provide an estimated depth which is measured from ground level to the centre of the utility. Drainage and water mains within 100m (330ft) of the ground surface are detectable. All information is stored on a hard disk.

Where services are shown as 'Taken From Records' on the drawing we are not liable for any loss that may arise due to a lack of accuracy in that guided information.

Reference should be made to the methodology used on site as detailed within the latest version of SiteScan Procedures for Utility Inspection Surveys.

SiteScan recommend that all excavations are to be carried out in accordance with HSG 47 (Avoiding Danger from Underground Services).

Plan accuracies of the order of + or - 150mm may be achieved but this figure will depend on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.

Existing record information showing underground services is often incomplete and of doubtful accuracy. It should be regarded only as an indication and cannot be guaranteed.

NOTES

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REV	AMENDMENT	DRAWN	CHECKED
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SITESCAN

Vita House, Fish Quay, North Shields, Tyne & Wear, NE30 1JA
www.sitescanltd.com info@sitescanltd.com
Tel: 0191 2572911

RWO

CLIENT

KANGOL FACTORY
CLEATER

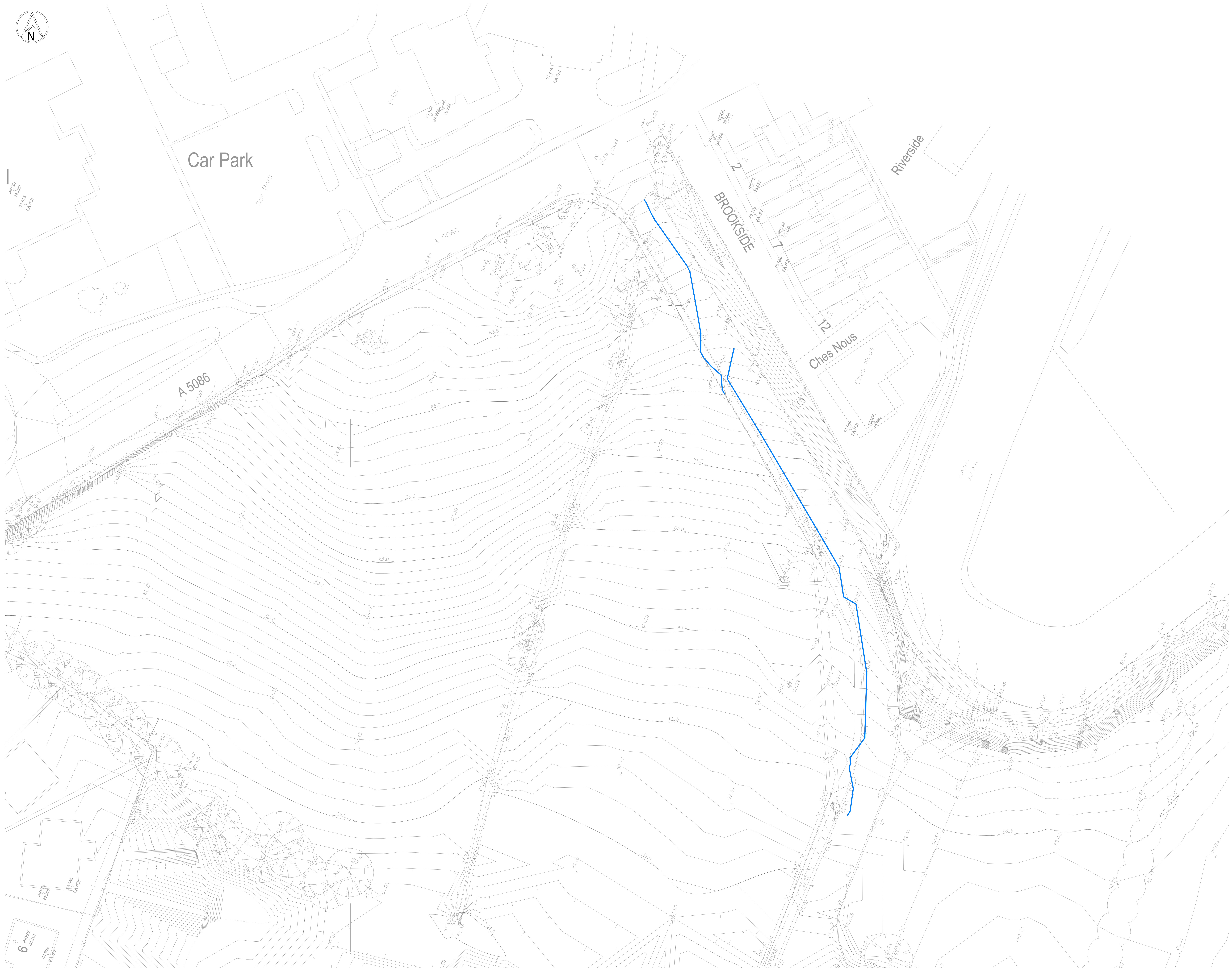
PROJECT TITLE

DRAINAGE SURVEY

ADDRESS AND CITY

NTS		JUN 2013			
SCALE P. 20		DATE		ORIENTATION	
JRD		JRD		NC	
SURVEYED BY		DRAWN BY		APPROVED	
CLE/RWO/DRAIN				1 of 1	A
PROJECT NO.				SHEET NO.	REV.

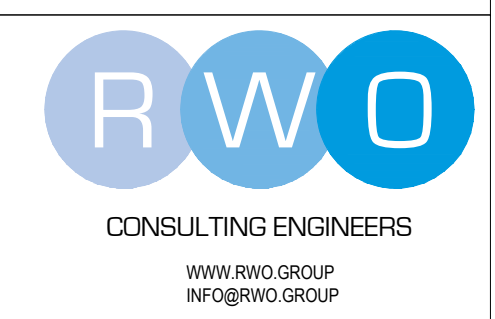
Appendix H Overland Flow Route



KEY

→ OVERLAND FLOW ROUTE

Date	Revisions	Drawn	Checked	Rev
INFORMATION				
NORTH EAST 0191 256642				
YORKSHIRE 0113 335 3500				
Client GLEESON HOMES				
Project CLEATOR MILLS				
Title OVERLAND FLOW ROUTE PLAN				
DO NOT SCALE	Scale @ A3: 1:200	Drawn: AGM	Checked:	Date: 12.07.2021
Job No: 19002	Drawn No: SK003	Rev:		



Appendix I Soil Infiltration Test Results

FAO Ross Oakley
RWO Associates Ltd
6A
Union Quay
North Shields
NE30 1HJ

****Sent by Email****

21st October 2013

Dear Ross,

Re: Land at Cleator Mills – Soakaway Test Letter Report

Please find attached to this letter the following information:

- Exploratory Hole Location Plan (TP01 to TP06)
- Trial Pit Logs
- Soakaway Test Workbook Extracts (SA01 to SA06 inclusive)

From the trial pit logs it can be seen that the ground conditions typically comprised grass and topsoil over sand and gravel with many cobbles and boulders to the terminal depths of the trial pits between c.1.50m and c.2.00m below current ground levels. No water ingress was noted within the trial pits, although the sand and gravel materials were generally unstable with the materials posing a risk of sidewall collapse.

As requested in-situ soakaway tests were undertaken at the six trial pit locations at depths varying between c.0.50m and c.2.00m below ground levels. All the trial pits successfully drained completely within 2 hours of commencing the tests.

I trust the above and attached is to your satisfaction and if you have any questions or then please call or email.

Yours Faithfully



.....
Curtis R. Evans *B.Sc (Hons) FGS*

Director

For and On Behalf Of Geo Environmental Engineering Ltd

Visit our *NEW* Website: www.geoenvironmentalengineering.com Email: info@geoenvironmentalengineering.com

Tel: 08456 768 895, Mob: 07883 440 186

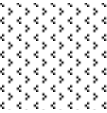
“Without Site Investigation Ground is a Hazard”

Site Investigation Steering Group (SISG), 1993

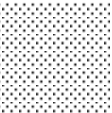
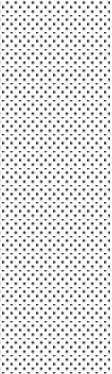
GEO2013-776: Exploratory Hole Location Plan (Approximate Locations – Not to Scale)



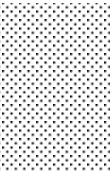
GEO2013-776: TP01

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.40	TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets.		
0.40	2.00	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		0.50m Soakaway Test (results on SA01)
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.1.50m Soakaway test completed from c.0.50m to c.1.50m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

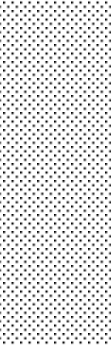
GEO2013-776: TP02

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.30	TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets.		
0.30	0.70	Red brown slightly gravelly SAND.		
0.70	2.00	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		1.00m Soakaway Test (results on SA02)
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.1.50m Soakaway test completed from c.1.00m to c.2.00m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

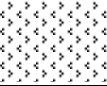
GEO2013-776: TP03

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets.		
0.20	0.80	Red brown slightly gravelly SAND.		
0.80	2.00	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		1.00m Soakaway Test (results on SA03)
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.0.80m Soakaway test completed from c.1.00m to c.2.00m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

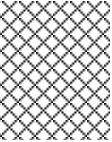
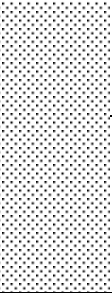
GEO2013-776: TP04

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.30	TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets.		
0.30	1.50	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		0.50m Soakaway Test (results on SA04)
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.1.00m Soakaway test completed from c.0.50m to c.1.50m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

GEO2013-776: TP05

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.35	TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets.		
0.35	0.60	Red brown slightly gravelly SAND.		
0.60	2.00	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		1.00m Soakaway Test (results on SA05)
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.1.50m Soakaway test completed from c.1.00m to c.2.00m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

GEO2013-776: TP06

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.50	MADE GROUND: TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets and rare brick pieces.		
0.50	0.90	Red brown slightly gravelly SAND.		0.50m Soakaway Test (results on SA06)
0.90	1.50	Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout.		
		End of trial pit Trial pit remained dry on completion Trial pit noted as unstable below c.1.00m Soakaway test completed from c.0.50m to c.1.50m		
Site: Land at Cleator Mills Client Reference: N/A Engineer: CE Plant: JCB3CX		Log Notes: Spt = Standard Penetration test (blows per 300mm n300) HSV = Hand Shear Vane (result in kN/m ²) CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage) LP = Limited Penetration (HSV/CBR) NP = No penetration (HSV/CBR) B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub		

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
DATE	21-Oct-13	CHECKED BY	CRE/GE
		REV	P1

REF										OUTPUT									
Calculation of soil infiltration rate in accordance with BRE Digest 365																			
Length of trial pit				=	L_{TP}		=	3.000 m											
Width of trial pit				=	W_{TP}		=	0.450 m											
Effective Depth				=	D_{TP}		=	1.500 m (measured below incoming invert)											
75% Effective Depth of trial pit				=	D_{75}		=	(D_{TP} x 0.75)		=	1.125 m								
50% Effective Depth of trial pit				=	D_{50}		=	(D_{TP} x 0.50)		=	0.750 m								
25% Effective Depth of trial pit				=	D_{25}		=	(D_{TP} x 0.25)		=	0.375 m								
Pit Voids				=	PV		=	100 %		(For open pits, PV = 100%. For stone filled pits, PV = 30%)									
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth																			
Test No 1		time to fall from 75% to 25% eff depth						=	T_1		=	40.0 mins							
Test No 2		time to fall from 75% to 25% eff depth						=	T_2		=	mins							
Test No 3		time to fall from 75% to 25% eff depth						=	T_3		=	mins							
TAKE THE LONGEST OF THE 3 TESTS ABOVE								=	T_L		=	40.0 mins							
Volume of water escaping during this test between D_{75} and D_{25}																			
				=	V_{TP75_25}		=	(L_{TP} x W_{TP} x (D_{75} - D_{25}) x PV)		=	1.013 cu m.								
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.																			
ie		A_{P50} = (Wet Base Area + 50% of Wet Sides Area)																	
		A_{P50} = (L_{TP} x W_{TP}) + ($2L_{TP}$ + $2W_{TP}$) x D_{50}																	
		A_{P50} = 1.350 + 5.175																	
		A_{P50} = 6.525 sq m																	
Soil Infiltration Rate				=	f		=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$		m/s									
Soil Infiltration Rate = f = 6.46552E-05 m/s																			
Notes: Pit drained completely within 40 minutes.																			

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
DATE	21-Oct-13	CHECKED BY	CRE/GE
		REV	P1

REF											OUTPUT
Calculation of soil infiltration rate in accordance with BRE Digest 365											
Length of trial pit	=	L_{TP}	=	2.000	m						
Width of trial pit	=	W_{TP}	=	0.450	m						
Effective Depth	=	D_{TP}	=	2.000	m	(measured below incoming invert)					
75% Effective Depth of trial pit	=	D_{75}	=	($D_{TP} \times 0.75$)	=	1.500	m				
50% Effective Depth of trial pit	=	D_{50}	=	($D_{TP} \times 0.50$)	=	1.000	m				
25% Effective Depth of trial pit	=	D_{25}	=	($D_{TP} \times 0.25$)	=	0.500	m				
Pit Voids	=	PV	=	100	%	(For open pits, PV = 100%. For stone filled pits, PV = 30%)					
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth											
Test No 1	time to fall from 75% to 25% eff depth	=	T_1	=	52.0	mins					
Test No 2	time to fall from 75% to 25% eff depth	=	T_2	=		mins					
Test No 3	time to fall from 75% to 25% eff depth	=	T_3	=		mins					
TAKE THE LONGEST OF THE 3 TESTS ABOVE			=	T_L	=	52.0	mins				
Volume of water escaping during this test between D_{75} and D_{25}											
	=	V_{TP75_25}	=	($L_{TP} \times W_{TP} \times (D_{75} - D_{25}) \times PV$)	=	0.900	cu m.				
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.											
ie	A_{P50}	=	(Wet Base Area + 50% of Wet Sides Area)								
	A_{P50}	=	($L_{TP} \times W_{TP}$)	+	($2L_{TP} + 2W_{TP}$)	$\times D_{50}$					
	A_{P50}	=	0.900	+	4.900						
			A_{P50}	=	5.800	sq m					
Soil Infiltration Rate	=	f	=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$	m/s						
Soil Infiltration Rate = f = 4.97347E-05 m/s											
Notes: Pit drained completely within 52 minutes.											

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
SHEET No	SA 03	CHECKED BY	CRE/GE
DATE	21-Oct-13	REV	P1

REF										OUTPUT										
Calculation of soil infiltration rate in accordance with BRE Digest 365																				
Length of trial pit		=	L_{TP}		=	2.500		m												
Width of trial pit		=	W_{TP}		=	0.500		m												
Effective Depth		=	D_{TP}		=	2.000		m		(measured below incoming invert)										
75% Effective Depth of trial pit		=	D_{75}		=	($D_{TP} \times 0.75$)		=	1.500		m									
50% Effective Depth of trial pit		=	D_{50}		=	($D_{TP} \times 0.50$)		=	1.000		m									
25% Effective Depth of trial pit		=	D_{25}		=	($D_{TP} \times 0.25$)		=	0.500		m									
Pit Voids		=	PV		=	100		%		(For open pits, PV = 100%. For stone filled pits, PV = 30%)										
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth																				
Test No 1		time to fall from 75% to 25% eff depth			=	T_1		=	120.0		mins									
Test No 2		time to fall from 75% to 25% eff depth			=	T_2		=			mins									
Test No 3		time to fall from 75% to 25% eff depth			=	T_3		=			mins									
TAKE THE LONGEST OF THE 3 TESTS ABOVE					=	T_L		=	120.0		mins									
Volume of water escaping during this test between D_{75} and D_{25}																				
					=	V_{TP75_25}		=	($L_{TP} \times W_{TP} \times (D_{75} - D_{25}) \times PV$)		=	1.250		cu m.						
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.																				
ie		A_{P50}		=	(Wet Base Area + 50% of Wet Sides Area)															
		A_{P50}		=	($L_{TP} \times W_{TP}$)		+	($2L_{TP} + 2W_{TP}$)		$\times D_{50}$										
		A_{P50}		=	1.250		+	6.000												
				A_{P50}		=	7.250		sq m											
Soil Infiltration Rate		=	f		=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$		m/s												
Soil Infiltration Rate = f = 2.39464E-05 m/s																				
Notes: Pit drained completely within 120 minutes.																				

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
DATE	21-Oct-13	CHECKED BY	CRE/GE
		REV	P1

REF											OUTPUT
Calculation of soil infiltration rate in accordance with BRE Digest 365											
Length of trial pit	=	L_{TP}	=	2.600	m						
Width of trial pit	=	W_{TP}	=	0.500	m						
Effective Depth	=	D_{TP}	=	1.500	m	(measured below incoming invert)					
75% Effective Depth of trial pit	=	D_{75}	=	($D_{TP} \times 0.75$)	=	1.125	m				
50% Effective Depth of trial pit	=	D_{50}	=	($D_{TP} \times 0.50$)	=	0.750	m				
25% Effective Depth of trial pit	=	D_{25}	=	($D_{TP} \times 0.25$)	=	0.375	m				
Pit Voids	=	PV	=	100	%	(For open pits, PV = 100%. For stone filled pits, PV = 30%)					
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth											
Test No 1	time to fall from 75% to 25% eff depth	=	T_1	=	120.0	mins					
Test No 2	time to fall from 75% to 25% eff depth	=	T_2	=		mins					
Test No 3	time to fall from 75% to 25% eff depth	=	T_3	=		mins					
TAKE THE LONGEST OF THE 3 TESTS ABOVE			=	T_L	=	120.0	mins				
Volume of water escaping during this test between D_{75} and D_{25}											
	=	V_{TP75_25}	=	($L_{TP} \times W_{TP} \times (D_{75} - D_{25}) \times PV$)	=	0.975	cu m.				
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.											
ie	A_{P50}	=	(Wet Base Area + 50% of Wet Sides Area)								
	A_{P50}	=	($L_{TP} \times W_{TP}$)	+	($2L_{TP} + 2W_{TP}$)	$\times D_{50}$					
	A_{P50}	=	1.300	+	4.650						
			A_{P50}	=	5.950	sq m					
Soil Infiltration Rate	=	f	=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$	m/s						
Soil Infiltration Rate = f = 2.27591E-05 m/s											
Notes: Pit drained completely within 120 minutes.											

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
DATE	21-Oct-13	CHECKED BY	CRE/GE
		REV	P1

REF										OUTPUT										
Calculation of soil infiltration rate in accordance with BRE Digest 365																				
Length of trial pit				=	L_{TP}		=	2.700 m												
Width of trial pit				=	W_{TP}		=	0.450 m												
Effective Depth				=	D_{TP}		=	2.000 m		(measured below incoming invert)										
75% Effective Depth of trial pit				=	D_{75}		=	($D_{TP} \times 0.75$)		=	1.500 m									
50% Effective Depth of trial pit				=	D_{50}		=	($D_{TP} \times 0.50$)		=	1.000 m									
25% Effective Depth of trial pit				=	D_{25}		=	($D_{TP} \times 0.25$)		=	0.500 m									
Pit Voids				=	PV		=	100 %		(For open pits, PV = 100%. For stone filled pits, PV = 30%)										
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth																				
Test No 1		time to fall from 75% to 25% eff depth						=	T_1		=	120.0 mins								
Test No 2		time to fall from 75% to 25% eff depth						=	T_2		=	mins								
Test No 3		time to fall from 75% to 25% eff depth						=	T_3		=	mins								
TAKE THE LONGEST OF THE 3 TESTS ABOVE								=	T_L		=	120.0 mins								
Volume of water escaping during this test between D_{75} and D_{25}																				
				=	V_{TP75_25}		=	($L_{TP} \times W_{TP} \times (D_{75} - D_{25}) \times PV$)		=	1.215 cu m.									
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.																				
ie		A_{P50}		=	(Wet Base Area + 50% of Wet Sides Area)															
		A_{P50}		=	($L_{TP} \times W_{TP}$)		+	($2L_{TP} + 2W_{TP}$) $\times D_{50}$												
		A_{P50}		=	1.215		+	6.300												
				A_{P50}		=	7.515		sq m											
Soil Infiltration Rate				=	f		=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$		m/s										
Soil Infiltration Rate = f = 2.24551E-05 m/s																				
Notes: Pit drained completely within 120 minutes.																				

CALCULATIONS/SKETCHES

PROJECT GEO2013-776 Land at Cleator Mills			
JOB No	2013-776	PREPARED BY	CRE
SHEET No	SA 06	CHECKED BY	CRE/GE
DATE	21-Oct-13	REV	P1

REF											OUTPUT
Calculation of soil infiltration rate in accordance with BRE Digest 365											
Length of trial pit	=	L_{TP}	=	2.500	m						
Width of trial pit	=	W_{TP}	=	0.450	m						
Effective Depth	=	D_{TP}	=	1.500	m	(measured below incoming invert)					
75% Effective Depth of trial pit	=	D_{75}	=	($D_{TP} \times 0.75$)	=	1.125	m				
50% Effective Depth of trial pit	=	D_{50}	=	($D_{TP} \times 0.50$)	=	0.750	m				
25% Effective Depth of trial pit	=	D_{25}	=	($D_{TP} \times 0.25$)	=	0.375	m				
Pit Voids	=	PV	=	100	%	(For open pits, PV = 100%. For stone filled pits, PV = 30%)					
Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth											
Test No 1	time to fall from 75% to 25% eff depth	=	T_1	=	60.0	mins					
Test No 2	time to fall from 75% to 25% eff depth	=	T_2	=		mins					
Test No 3	time to fall from 75% to 25% eff depth	=	T_3	=		mins					
TAKE THE LONGEST OF THE 3 TESTS ABOVE			=	T_L	=	60.0	mins				
Volume of water escaping during this test between D_{75} and D_{25}											
		=	V_{TP75_25}	=	($L_{TP} \times W_{TP} \times (D_{75} - D_{25}) \times PV$)	=	0.844	cu m.			
The mean surface area through which the above volume escapes, is the <i>wetted area</i> . Only 50% of the effective depth is allowed in the calculation.											
ie	A_{P50}	=	(Wet Base Area + 50% of Wet Sides Area)								
	A_{P50}	=	($L_{TP} \times W_{TP}$)	+	($2L_{TP} + 2W_{TP}$)	$\times D_{50}$					
	A_{P50}	=	1.125	+	4.425						
			A_{P50}	=	5.550	sq m					
Soil Infiltration Rate	=	f	=	$\frac{V_{TP75_25}}{A_{P50} \times 60 \times T_L}$	m/s						
Soil Infiltration Rate = f = 4.22297E-05 m/s											
Notes: Pit drained completely within 60 minutes.											



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