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Godre'r Graig Quarry Spoil Tip, Godre'r Graig
Drainage Strategy Assessment

Report Reference: ESP.7234e.08.3972

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Godre'r Graig Quarry Spoil Tip, Godre'r Graig Drainage Strategy Assessment

Prepared for:
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Report Reference: **ESP.7234e.08.3972**

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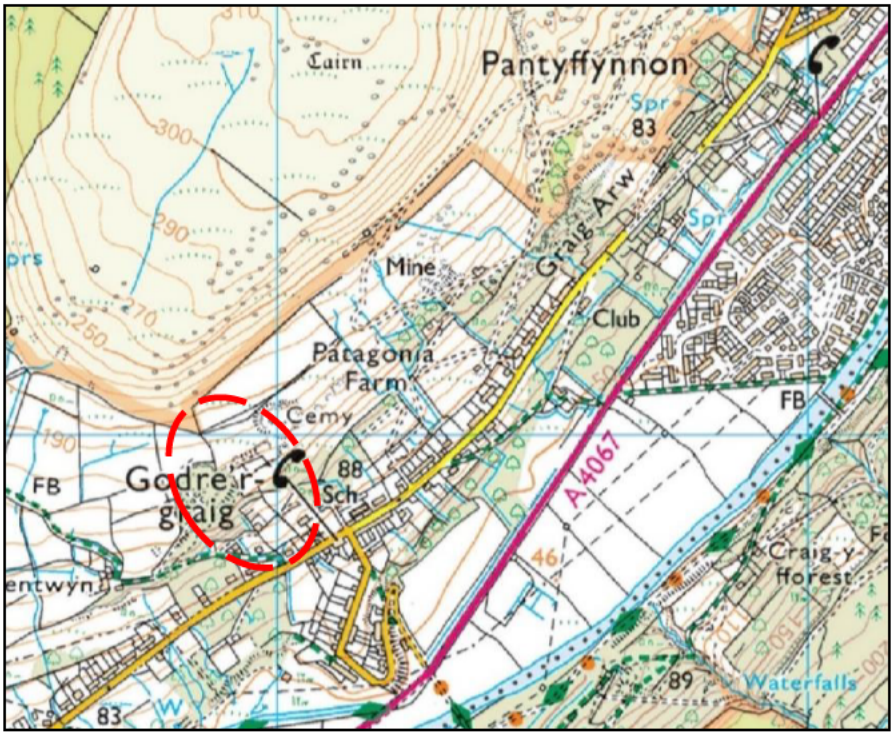
Contents

1 Introduction

1.1 Background

Neath Port Talbot County Borough Council (NPTCBC), hereafter known as the Client, have instructed Earth Science Partnership Ltd (ESP), Consulting Engineers, Geologists and Environmental Scientists, to undertake a drainage design for betterment of a Spoil Tip on the slopes above Godre'r Graig Primary School (the School) in the Tawe Valley. The site location is shown on Insert 1 below.

The general location of the school and tip are shown in Insert 1 below.



Insert 1: School and surrounding area with tip above shown by red circle. 1:10,000 (Ordnance Survey License No.: AL100015788).

ESP have undertaken previous assessments for the area that included consideration of risks to the primary school users and separately, village residents. The details of the previous reports are provided below:

Godre'r Graig School

- Preliminary Landslide Hazard and Risk Assessment – ESP.7234e.3221 Rev 1 (August 2019);
- Preliminary Investigation and Additional Assessment – ESP.7234e.02.3302 Rev 2 (February 2020);
- Tip Remediation assessment – ESP.7234e.04.3564 Rev 4 (September 2021); and,
- Initial Hydrology Assessment – ESP.7234e.06.3800 (October 2022).

Wider Godre'r Graig Village

- Preliminary Landslide Hazard and Risk Assessment - ESP.7372e.3337 Rev 2 (June 2020)

Executive summaries for the above assessments have also been produced and issued to avoid repetition. Salient information from the previous assessments is summarised in Section 2.0, the previous reports should be referenced in full alongside this assessment.

The previous assessments and remedial options appraisals have identified that the implementation of drainage system and improvements to existing drainage in the area, is a feasible solution for betterment to increase the stability of the tip.

1.2 Objective and Scope of Works

The works brief comprised assessment and design of drainage to enable a reduction in infiltration/saturation and improve the hydrology of the quarry spoil tip.

The proposed works are considered 'betterment' and won't necessarily improve the stability or factors of safety within the quarry spoil tip/hillslope. It will help to address/control the obvious inputs of water that are typical of poor practice (e.g. AGS 2007).

The scope of works for the Hydrology Assessment and Drainage Design was mutually developed with the Client and ESP within an agreed budget, and comprised:

- Repeat site visit with our partner civil engineers and for spot surveying;
- Catchment assessment/analysis;
- Defining how the upslope drainage interfaces with the existing drainage network at/downslope of the school;
- Typical detail drawings and figures for the hydrology improvements;
- Reporting and recommendations.

The contract was awarded on the basis of a competitive tender quotation. The terms of reference for the assessment are as laid down in the Earth Science Partnership proposal of 5th June 2023 (email).

The investigation and assessment was undertaken in September to November 2023

1.3 Report Format

This report includes a summary of the previous investigation and assessments in Section 2.0. Details of the updated hydrological setting and drainage assessment are provided in Section 3 and 4. Discussion on the drainage betterment options is provided in Section 5.0, with conclusions and recommendations providing in Section 6.0. This report is issued in a digital format only.

1.4 Limitations of Report

This report represents the findings of the brief as detailed in Section 1.1. It should be appreciated that only a limited intrusive investigation has been undertaken to date. Should an alternative current land use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals or land uses. Where preventative, ameliorative or remediation works are required, professional judgement will be used to make recommendations that satisfy the site-specific requirements in accordance with good practice guidance.

Consultation with regulatory authorities will be required with respect to proposed works as there may be overriding regional or policy requirements which demand additional work to be undertaken. It should be noted that both regulations and their interpretation by statutory authorities are continually changing.

This report represents the findings and opinions of experienced geo-environmental and geotechnical specialists. Earth Science Partnership does not provide legal advice and the advice of lawyers may also be required.

As discussed in Section 1.1, this report encompasses the study area previously referred to as 'Site 2' (ESP, Aug 2019) comprising the Quarry Spoil Tip upslope from Godre'r Graig Primary School, the quarry above and the immediate surrounding vicinity.

Given the nature of the site, a number of limitations were imposed on the assessment. Limited access to the site was primarily due to constraints posed by dense vegetation and steeply sloping ground. Due to private land ownership, access to the site was restricted.

Whilst the previous assessment was undertaken during the autumn months, with higher rainfall. The site visits relating to this assessment were primarily undertaken during dryer summer months and as such, this may have missed some seasonal variations in the groundwater regime, or perhaps seasonal movement of the tip has not been identified. The monitoring should be continued, and the assessment should be updated accordingly.

It should be noted, that we have not considered Sustainable Drainage Systems (SuDS) as part of this assessment and we understand it is not required for the proposed development.

2 Initial Hydrology Assessment Summary

As discussed in Section 1.2, previous desk based assessments and intrusive site investigations have been carried out at the site. A summary of the ground conditions, hydrological and hydrogeological setting is provided in the ESP report (ESP. 7234e.06.3800), which should be referred to alongside this report.

2.1 Site Summary

The study area comprises the quarry spoil tip/heap associated with an old quarry on the lower slopes of Mynydd Allt-y-grug. The slopes underlying layered bedrock of the Llynfi Beds comprising sandstone and mudstone has results in a gently stepped topography which has since been anthropogenically modified and over-steepened as a result of quarry spoil tipping (Quarry Spoil Tip).

2.2 Hydrogeological and Hydrological Setting Summary

A review of the historical maps was undertaken as part of the previous assessment, which indicated a series of springs that emanate in the hillside above the tip. They all flow downhill, toward the east or southeast. No water features or areas of wet ground were identified within the boundaries of the Quarry Spoil Tip. The previous water features identified are shown on Figure 1.

The presence of several streams, and areas of standing water, or waterlogged ground at the base of the tip suggest that there is a body of water in the Quarry Spoil Tip . Previous observations have indicated water flow to be constant, suggesting a groundwater source rather than a response to rain/infiltration alone. It is considered that groundwater in the tip is hydraulically linked to groundwater in the hillside.

As part of the previous assessment, field mapping was undertaken by ESP on two occasions with the primary aim to identify the current hydrological status at the site including a review of surface water features and formal/informal drainage systems directly interacting with the Quarry Spoil Tip and immediate surrounding area. The results of the mapping were presented as a schedule of surface water features as detailed in the ESP report ref. 7234e.06.3800 (ESP, 2022). The table has been updated following additional visits and is presented in Section 3.1.

2.2.1 Additional Observations

In addition to the schedule of features identified during the site inspection, the following site observations were made and are considered pertinent to the assessment.

- Generally, surface water flow was observed to be higher during the second visit and following a period of heavier rainfall;
- Waterlogged ground and rushes were regularly observed along the base of the Quarry Spoil Tip . The base of the Quarry Spoil Tip is generally observed by a significant break in slope.
- The majority of the lower field and the access track, was observed to be waterlogged during both visits.

- Anecdotal information provided by a private land owner indicated that during periods of high rainfall, the upper extents of feature S3 (Ch. 140 – 165) would experience higher flow rates and would generally be more visible at ground surface.
- The upper extents of feature S2 and a source have not been clearly identified during the site mapping undertaken to date. This may be due to the source being covered/masked by the Quarry Spoil.
- Anecdotal evidence suggested the presence of large water tanks relating to feature S2. No evidence of these tanks has been observed during previous assessments, or this updated assessment. A review of private drainage plans indicate the presence of two Inlet Bays, at the north east and middle, northern extent of the School.

3 Updated Hydrological Assessment

3.1 Updated Schedule of Surface Water Features

The previous schedule of surface water features (ESP, 2022) has been updated with site observations identified during the recent mapping undertaken in July 2023 during dryer ground conditions, the updated results are presented below as Table 1.

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Table 1: Updated Schedule of surface water features

ESP Reference	Type	Feature Start	Feature End	Chainage (Ch.)	Approximate Width	Approximate Depth	Status	Flow Rate Comments			Additional Observations
								V1	V2	V3 (July 2023)	
S2	Watercourse	Unknown	Culverted	0-15	450mm	Underground	Culverted Stream – Underground pipe (400mm). with gravel surround.	Steady, low flow at pipe end (Ch.0).	Steady, low to moderate flow at pipe end (Ch.0).	Very low flow at end pipe.	Identified on historic and recent OS mapping.
				15 – 25	400mm	300mm	Incised channel. Gutter pipe and blue pipe leading to bathtub holding water.	Steady low flow.	Steady, low to moderate flow.	Very low flow.	Rushes and waterlogged ground observed in wider area.
				25 – 35	n/a	n/a	Waterlogged ground surface. No obvious channel. 250mm underground pipe observed at ch.25 (partially blocked).	No obvious surface water flow.	Steady low surface water.	Very low flow.	Rushes and waterlogged ground observed in wider area.
				35 – 40	n/a	n/a	No obvious channel. Surface water emanating from vegetated fence line.	Steady, low surface water flow.	Steady, low surface water flow.	Very low flow.	Rushes and waterlogged ground observed in wider area.
				40 – 55	n/a	n/a	Unknown, not identified due to dense vegetation.[4]	-	-		-
				55 – 95 (approx.)	n/a	n/a	Not identified during visit 1. Visit 2 located stream emanating from two pipes at ch. 95.	-	Steady low to moderate flow at pipe end (Ch.95).	Very low to low water flow.	S2 feature beyond 45m chainage previously identified (ESP, 2020). Area immediately north noted as waterlogged with some surface water flow.
S3	Watercourse	Waterfall	Culverted (3 pipes)	0 – 15	3000mm	Underground	Culverted Stream – Underground pipe (300mm). with gravel surround	Very low flow observed from pipe end (Ch.0).	Steady moderate flow observed from pipe end (Ch.0).	No water flow observed.	Identified on recent OS mapping.
				15 – 45	500mm	400 – 500mm	Well defined incised channel. Vegetation debris (leaf, branches) partially obstructing flow. At ch.45 – channel splits (S3_A)	Steady, low flow.	Steady, low to moderate flow.	Very low flow observed at ch. 15. No access upstream.	Stream channel present within large 'v' shaped ground feature.
				45 – 65	400 – 600mm	400 – 500mm	Well defined incised, stepped channel. Vegetation debris (leaf, branches) partially obstructing flow. At ch.65 – channel splits (S3_D)	Steady, low flow.	Steady, low to moderate flow.	No access upstream.	
				65 – 120	300 – 600mm	400 – 500mm	Well defined incised, stepped channel. Leaf/vegetation debris partially obstructing flow. Channel significantly meanders, not traced fully in this section due to heavy vegetation.	Steady, low flow.	Steady, low flow.	No access upstream.	
				120 – 140	700 – 1000mm	500mm	Well defined incised, stepped channel. Very steeply sloping ground. Leaf/vegetation debris obstructing flow.	Very low, intermittent flow.	Steady, low flow.	No access upstream.	
				140 – 165	400 – 500mm	300mm	Less defined, slightly incised channel. Feature observed to spring/sink regularly.	Very low, intermittent flow.	Intermittent, low flow.	No access upstream.	-
				165 – 220	n/a	n/a	Not observed.	n/a	n/a	No access upstream.	Feature S3 believed to be present below ground level.
				220 - 240	300mm	300mm	Defined, shallow channel. Clean. Water source identified as a waterfall from cliff face beyond accessible area. Stream observed to sink into ground at ch. 220.	Steady, low to moderate flow.	Steady, moderate flow.	No water flow observed.	As identified during previous investigation.

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S3 A	Tributary	Spring	Joins S3	0 – 20	300 – 400mm	500mm	Well defined channel with gravel/cobble base.	Very low, intermittent flow.	Steady, low flow.	No access upstream.	Waterlogged ground conditions and rushes noted in area north of S3_A.
				20 - 45	300 – 600mm	200 – 400mm	Well defined, moderately incised channel, stepped base with leaf/vegetation debris. Spring observed at ch.45.	Very low, intermittent flow	Steady, low flow.	No access upstream.	Waterlogged ground conditions and rushes noted in area north of S3_B.
S3 B	Channel	Spring	Joins S3A	0 – 15	300 – 500mm	100mm	Well defined, moderately incised channel, stepped base with leaf/vegetation debris.	Dry, no water flow observed.	Dry, no water flow observed.	No access upstream.	Feature previously identified (ESP, 2020) and observed as emanating from an area of ponded water.
S3 C	Tributary	n/a	n/a	n/a	200mm	100mm	Poorly defined channel with leaf/vegetation debris.	Dry, no water flow observed.	Dry, no water flow observed.	No access upstream.	Feature previously identified (ESP, 2020) to have flowing water.
S3 D	Tributary		Joins S3	0 – 25	300 – 600mm	100mm	Moderately defined channel, wide and shallow with leaf/vegetation debris.	Dry, no water flow observed.	n/a	No access upstream.	Feature previously identified (ESP, 2020) and observed as emanating from an area of ponded water.

4 Updated Drainage Assessment

As discussed in Section 3.1, a site visit was undertaken on 7th July 2023 with the primary aim to assess the existing site drainage and outfalls previously identified by ESP and produce a hydrological catchment assessment.

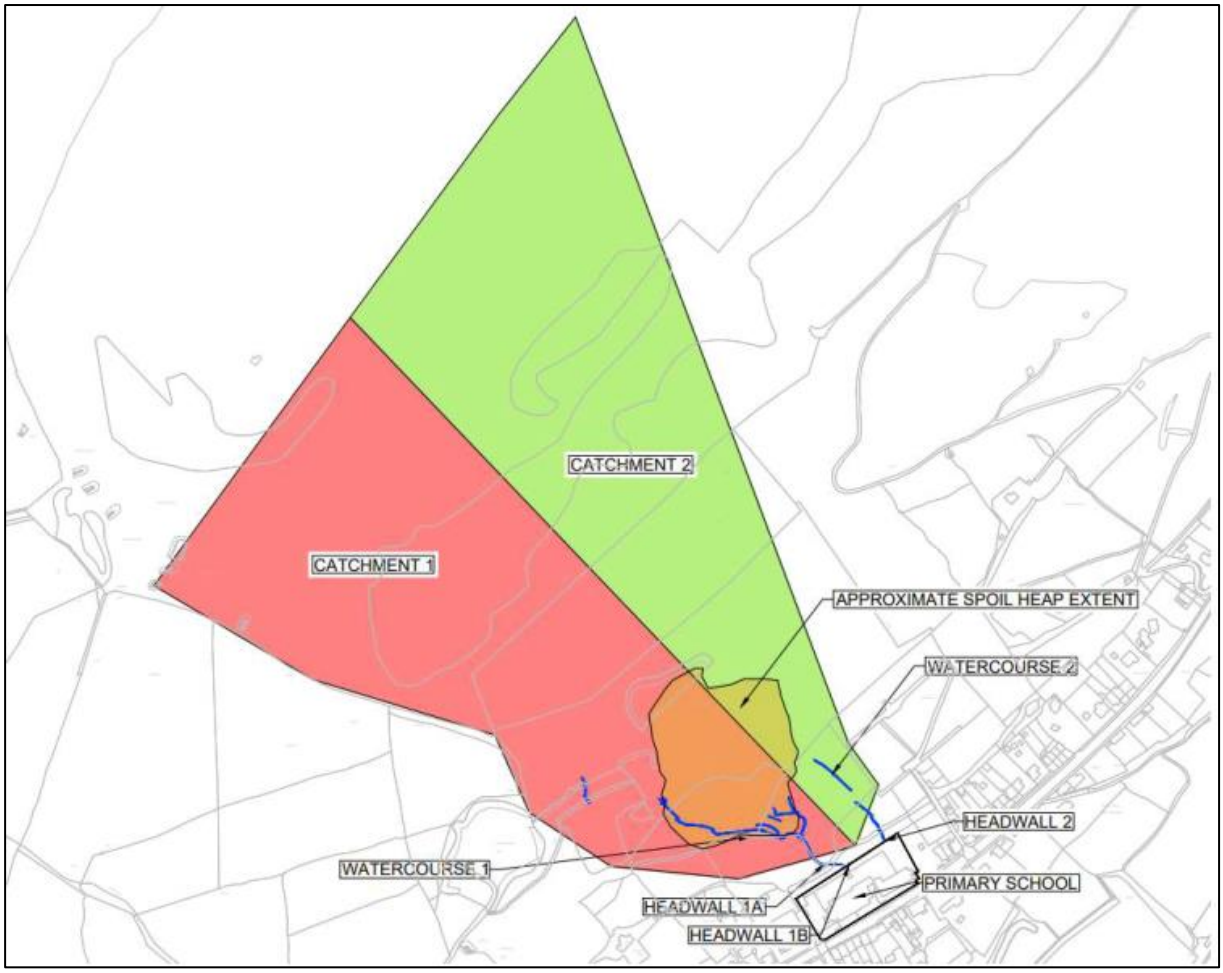
The visit was undertaken during a dry and hot period and it should be noted that no vegetation clearance was undertaken prior to the survey and as such, large areas of the site were inaccessible due to dense vegetation.

4.1 Catchment Analysis

Surveying of the water features S2 and S3 identified two catchment areas.

S3 (Watercourse 1 in Insert 2) travels in a south-eastern direction traversing step gradients along natural topography and the Spoil Tip whilst picking up smaller ditches/gulley's before out falling at Headwall 1A and Headwall 1B, serving Catchment 1.

S2 (Watercourse 2 in Insert 2) situated east of the Spoil Tip, travels south to outfall via underground culverts at Headwall 2, serving Catchment 2.



Insert 2: *Catchment Plan of Watercourse 1 (water feature S3) and Watercourse 2 (water feature S2) which outfall at the rear of the school.*

The catchments are situated upon two distinctive areas on soilscape maps, referencing the Canfield Soil and AgriFood Institute (CSAI) (supported by DEFRA). The upper area of Catchments 1 and 2 has very acid loamy upland soils with a wet peaty surface. The lower area has freely draining acid loamy soils over rock. It should be noted that the mapping is not likely to identify the spoil tip in the area.

4.2 Catchment Flooding

In order to support drainage design, the anticipated median annual flood has been calculated for the two catchment areas.

Using the Flood Estimation Handbook (1999), statistical equation the median annual flood (Qmed return period 1:2 years) can be predicted as detailed in Table 4 below.

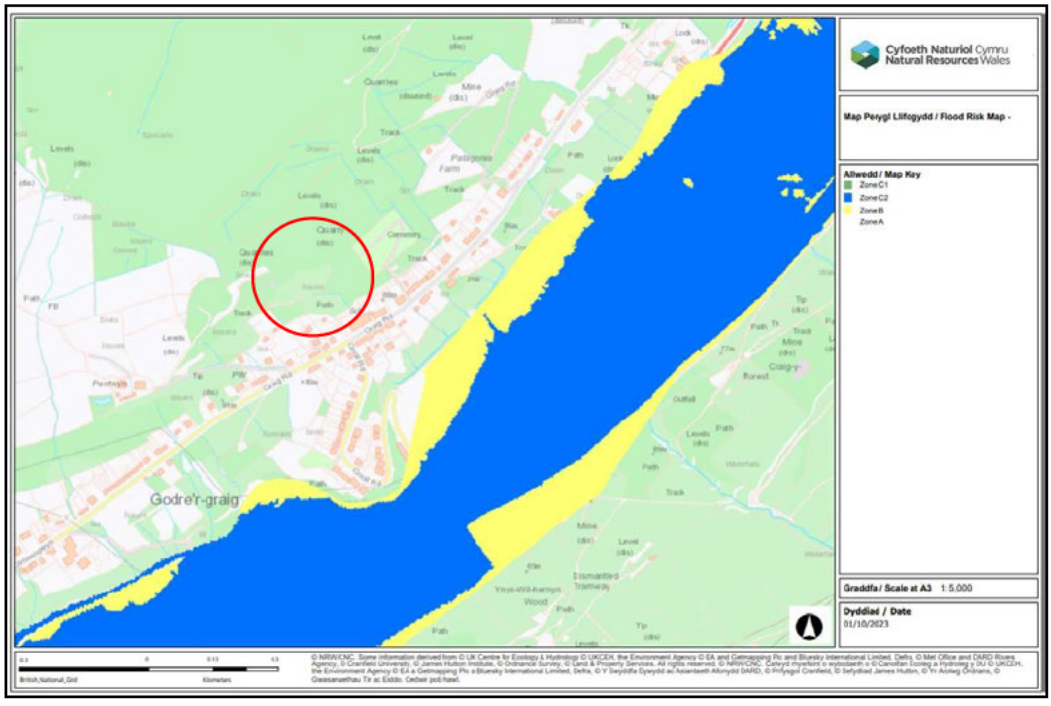
Table 2: Median annual flood predictions.

Catchment Area	Median annual flood (Qmed)
Upper area of catchments 1 & 2	14.86 l/s/Ha
Lower area of catchments 1 & 2	1.87 l/s/Ha
Combined total	**16.73 l/s/Ha**

Based on the analysis of the contouring of both the upper areas, the approximate contributing catchment of surface runoff that is likely attributed to each watercourse can be estimated, which is as follows:

- S3 serves Catchment 1 at approx.. 10.45 Ha, therefore 10.45 * 16.73 = **173.83 l/s**
- S2 serves catchment 2 at approx.. 10.11 Ha, therefore 10.11 * 16.73 = **169.14 l/s**

The Natural Resources Wales (NRW) TAN 15 Development Advie Maps (DAM) for the area identifies that these watercourses do not become main rivers. The lower levels of the valley reside within Flood Zones C2 and Zone B whilst the areas in the immediate vicinity of the Spoil Tip are unaffected, as displayed in Insert 3.



Insert 3: Natural Resources Wales (NRW) TAN 15 Development Advie Maps (DAM).

4.3 Existing Drainage

The existing drainage information relating to the school and adjacent land have been provided by the Client and are displayed as Appendix B. These illustrate that the two headwalls behind the school consist of 1no 375mm pipe serving Watercourse 1, and 1no. 300mm pipe serving Watercourse 2.

The drawings indicate that the drainage system continues under the school, Graig Road and adjacent dwellings, before discharging into unclassified ditches within the forested areas and lower farmlands. These two surface water pipes also collect drainage serving the school yard.

4.4 Drainage Design Requirements

Using the data calculated in the Section 4.2, and guidance outlined within The Tables of the Hydraulic Design of Pipes and Sewers (HR Wallingford, 2006), it can be determined that in order to accommodate the anticipate surface water runoff calculated above, as a minimum, the following drainage would be required;

- a 300mm diameter pipe would need to be laid at 1:40 grade to communicate such flows, or alternatively larger pipes would achieve this flows at flatter gradients.

At this time there are no reported flooding issues at the headwall and school; the pipe gradients are likely steeper than 1:40 and therefore are likely to accommodate the above flows on relatively small pipework. Further surveys should be undertaken to determine the downstream culvert sizes and gradients and the condition of the existing drainage system.

5 Discussion of Betterment Options

5.1 Introduction

The previous assessments undertaken by ESP (See Section 1.1) identified a potential risk posed by the Quarry Spoil Tip, namely to the school that was located downhill of the tip.

Previous monitoring of the Quarry Spoil Tip has indicted clear ground movement towards the school. The information from the inclinometers suggest that the Quarry Spoil Tip is moving and may be **Actively Unstable, i.e., destabilising forces are producing continuous or intermittent movements.** See Section 6.0 for further discussion.

Remediation solutions such as the removal of the Quarry Spoil material and hard engineering solutions, were considered to be not feasible for the project.

Previous preliminary stability modelling (ESP, 2020) has shown that the stability increases if there is less water within the tip material. Site drainage offers a single solution but would need to be designed to ensure control of surface water and groundwater as discussed in the sections below.

Our brief was to recommend options for betterment of the tip drainage and an assessment on the current drainage. It was not to design a drainage scheme that would effectively stabilise, drain the tip or result in defined increases in stability factors of safety.

5.2 Betterment Options

5.2.1 Primary Aim of Betterment

As discussed in Section 1.2, the objective of this assessment is to inform betterment options e.g. design of surface water drainage systems, with the aim of betterment of water flow within the Spoil Tip. The betterment options adopted could reduce the amount of water flowing into the Quarry Spoil Tip and to reduce areas of ponding and saturated ground., e.g. by providing preferential flow routes away from and around the tip and improving subsoil drainage.

5.2.2 Overview

The findings to date have identified a complex network of surface water features which are considered to directly interact with the Quarry Spoil Tip. The approaches adopted for betterment of the overall drainage will be depend on the area of the site as discussed further in the sections below.

We generally consider that a combination of existing channel improvement and the formation of a surface water interception drainage system at the base of the Quarry Spoil Tip will provide betterment to the slope/tip drainage.

An ESP watching brief will be required for the betterment works.

5.2.3 Existing Watercourse Improvement

It is recommended that existing vegetation is cleared along known watercourses and in areas where it is assumed that watercourses are present. Clearance and improved access would enable survey to identify the condition, undulation, banks, cascades that may need to be improved.

Confirmation of the watercourse S3 route is recommended, this may involve stream tracing using dilution gauging. Whilst dye tracing could be utilised, it can be diluted as it flows down the watercourse and therefore provide unclear results. Dilution gauging, using a flowmeter and rhodamine/salt solution, may be a better solution to trace the watercourse downstream.

It may be that some sections of the watercourses are in good condition and surface flows communicate without issue, but it is likely that some areas would require repair where soft spots have formed, vegetation has been undermined, and banks have eroded or are not present.

It is possible that some area of watercourses could benefit being formalised. The use of concrete canvassing may provide a suitable lining for the watercourses which would assist in protecting banks, inhibiting infiltration, and combined with cascade can slow the water down in step areas.

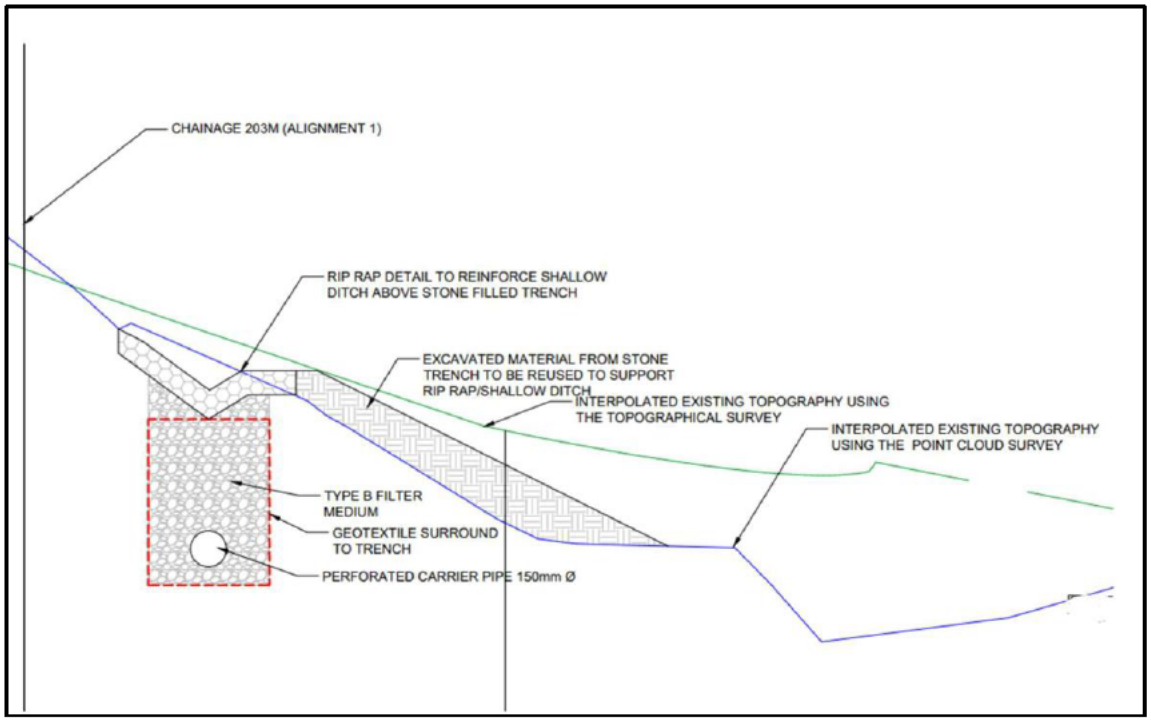
Should further survey work confirm the flow path of the waterfall in the north western extent, and infiltration is to be reduced, the use of a Geosynthetic Clay Liner (GLC) at the bottom of the waterfall with a combination of rip rap would allow water to pool, and a new ditch leading to the existing watercourses could be formed.

Care should be taken during any vegetation clearance with only limited vegetation, primarily fallen branches/plant debris removed where possible. Excess removal of vegetation could impact slope stability and is generally considered as poor hillside construction practice. In addition, changes to the profile of the slope should be kept to a minimum as part of any construction works. Examples of poor and good hillside construction practices (AGS, 2007) are displayed in Appendix A. If required, a suitably qualitied engineer should be consulted.

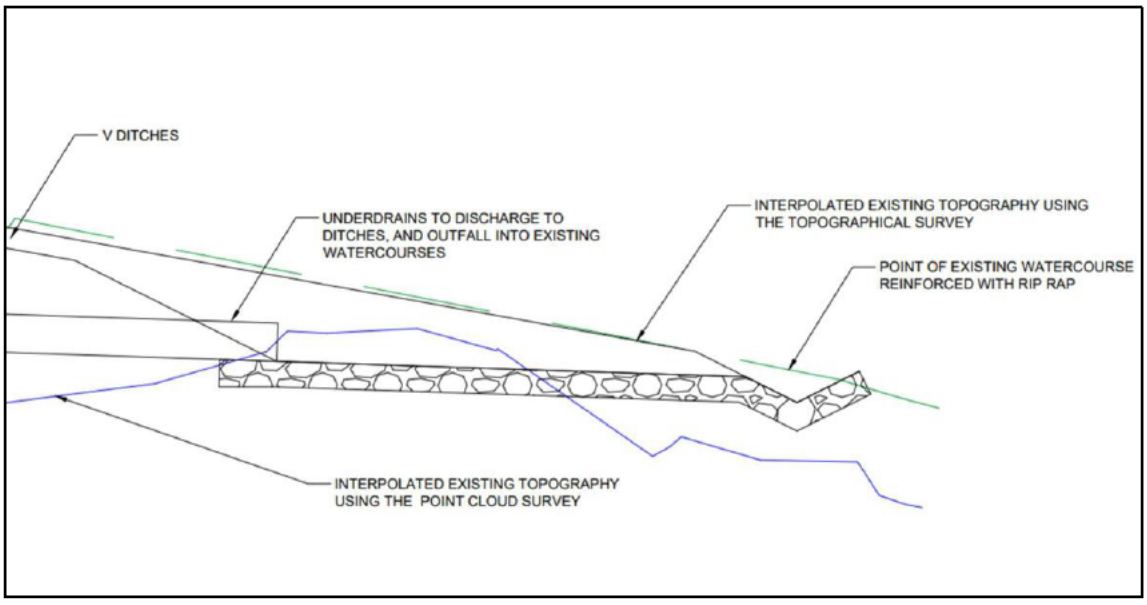
5.2.4 Formal Drainage Options

The construction of formal drainage features in the form of ditches could intercept runoff at the surface that has yet to reach watercourses, and then formally direct to the nearest watercourse. The ditches could be combined as dispersal trenches with underdrains which would act as a barrier and intercept shallow runoff that has infiltrated prior to reaching the ditches.

As the topography is steep, these dispersal pipes could also discharge into the existing watercourses, where a rip rap is provided to boost the integrity of the watercourse at branch connections, typical arrangements can be seen below in Inserts 4 & 5. Examples of where drainage options could be adopted are presented as Figure 2.



***Insert 4**: Typical Dispersal Ditch*



***Insert 5**: Dispersal Ditch outfall into existing watercourses.*

5.3 Additional Considerations

Access will need to be improved so that tracked vehicles can access the tip to install the drainage improvements. This process will allow access to areas not previously possible by vehicles, plant and machinery. Once complete it would be useful to install a greater density of boreholes to facilitate groundwater and ground movement monitoring. The boreholes will also help assess if the drainage betterment works have been successful.

If previously unidentified water features are identified during the works, a specialist should be consulted for further advice. ESP can provide support in this regard if required.

Depending upon the temporary works and access some reprofiling, along with netting and ground anchors could be installed.

Whilst the access is made, it would be useful to collect more samples with an improved spatial coverage for geotechnical testing to increase resolution on material parameters, or to at least understand the wider variability of the tip so that the slope stability modelling can be confirmed.

Whilst the above will provide betterment, it still may not result in a slope that would be classified as 'stable' in accordance with modern practice.

6 Updated Coal Tip Assessment

6.1 Updated Risk Category

The Welsh Government (WG) has committed to bringing forward legislation to deal with the legacy of mining and to provide improved management for coal tip safety. As part of working guidance amendments, disuses coal tips have been given interim risk categories (WG, 2023).

The Godre'r Graig Quarry Spoil Tip was recently classified as '***Category D:*** *A tip with the potential to impact public safety, to be inspected at least twice a year.'*

7 Conclusions and Recommendations

In summary the recommended improvements would comprise the following:

- Determine the exact extent of the watercourses, for instance tracing the existing site by dilution gauging. This could help confirm where water may be lost/gained on the site and determine sources.
- Formalising the flows from the waterfall area and directing to existing watercourses.
- Clearance of debris and vegetation in the route of the watercourses to ensure effective conveyance of flows. Dispersal ditches could be located at the toe of the tip extent, this will help capture runoff at surface level, and shallow ground water at source and directed to nearest watercourses.
- Where erosion has occurred, these areas could be repaired and watercourse slopes rectified.
- Depending on condition and gradient, methods such concrete canvass could be utilised to minimise infiltration and improve conveyance.
- ESP watching brief of betterment works.

The following works are recommended to support detailed drainage design:

- Drainage survey from the two culverts that pass under the primary school. Whilst the route and outfall are not critical it would be useful to understand its conditions, current capacity, gradients and any potential issues further downstream. This would also assist with the future aspirations of the school site.
- The survey should also encompass the schools existing drainage as its likely to communicate to these culverts and this may need to be reviewed with the development/demolition of the schools and end user of the site.
- An inspection should be undertaken following completion of the betterment works outlined above to review existing drainage function and capacity if water flow is increased as a result of the works.
- Regular e.g. twice yearly, inspection of the drainage systems to ensure water flow is as intended and if required, undertake clearance and repair works. Inspections should be undertaken by a suitably qualified professional.

8 References

AUSRALIAN GEOMECHANICS SOCIETY. 2007. Commentary on Practice Note Guidelines for Landslide Risk Management. Journal and News of the Australian Geomechanics Society. Vol.41 No.1 March 2007. (AGS, 2007c)

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