APPENDIX 2757/DAL/A3

Excerpt from BCL HIA / ROMP report, August 2013

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HV Bowen & Sons

Tan-y-Foel Quarry
Cefn Coch, Welshpool, Powys

Planning Application for a new quarry waste stone tip (partly retrospective), regularisation of use, quarry deepening and retention of existing permitted quarrying site for the purposes of the Environment Act 1995 Review (ROMPP)

Hydrogeological & Hydrological Impact Assessment

BCL Consultant Hydrogeologists Limited

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Hydrogeological & Hydrological Impact Assessment

6th August 2013

Report Prepared For:

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BCL CONSULTANT HYDROGEOLOGISTS LIMITED

EXPERIENCE & QUALIFICATIONS

BCL is an independent consultancy specialising in all aspects of hydrogeology and hydrology as they relate to minerals extraction, water supply and environmental issues.

Gavin Chaplin (the author of this report) holds a first degree [Geology] conferred by Keele University, 1990 and a Master of Science Degree [Groundwater Engineering], Newcastle University, 1993.

Staff of BCL have provided specialist services and advice to the extractive industry since 1990. During this time experience has been gained from involvement in the study of hydrogeological and hydrological systems in connection with planning matters at over 150 quarries throughout the United Kingdom and Ireland.

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EXECUTIVE SUMMARY

Author

BCL Consultant Hydrogeologists Limited (BCL) is an independent consultancy specialising in all aspects of hydrogeology and hydrology as they relate to minerals extraction, water supply and environmental issues. Gavin Chaplin (the author of this report) holds a first degree [Geology] conferred by Keele University, 1990 and a Master of Science Degree [Groundwater Engineering], Newcastle University, 1993. Staff of BCL have provided specialist services and advice to the extractive industry since 1990. During this time experience has been gained from involvement in the study of hydrogeological and hydrological systems in connection with planning matters at over 150 quarries throughout the United Kingdom and Ireland.

Introduction

BCL were commissioned by Quarryplan GB Limited (QPGBL) during October 2012 to undertake hydrogeological, hydrological and flood risk assessments of proposals for the future development (the Proposed Development) of HV Bowen & Sons' Tan-Y-Foel Quarry (the Site) near Cefn Coch, Powys. The proposals are to form the subject of a planning application (the Application) seeking approval for: i) the provision of new planning conditions as part of the Environment Act 1995 review process, ii) retention of the existing stocking area, ancillary development and associated concrete batching plant, iii) the deepening of the Quarry by one additional bench, iv) regularisation of the existing site boundary and v) extension of the existing peripheral Waste Stone Tip (part retrospective). Geological assessment has determined that working of the Proposed Development would release a total of 9.3 million tonnes (mt) of saleable reserves, sufficient for approximately 50 years working at a rate of 175,000 tonnes per year.

Baseline Conditions

The Site occupies an area of some 40 hectares (ha), comprising three principal quarrying areas (Quarries "A", B" and "C"), a mineral processing plant, site offices, a weighbridge, mineral stockpiling and water settlement areas, together with a Waste Stone Tip (located within the north-western Site area). Stockpiling of inert construction and demolition materials is also undertaken at the Site. The economic minerals extracted at the quarry are gritstones, belonging to the Silurian Penstrowed Grits Formation (PGF). The gritstones are interbedded with shales, siltstones and mudstones, which comprise some 20% to 30% of stone extracted at the quarry. These materials are not of saleable quality and are therefore discarded within the Waste Stone Tip situated upon the site's north-western boundary.

The Site is situated within an upland catchment of the eastward flowing Afon Rhiw which borders the southern boundary of the Site. this watercourse is augmented by two minor tributaries (the "Western" and "Eastern Rhiw Tributaries") that drain runoff from lands to the north of the current quarrying area. The Western Rhiw Tributary has its headwaters within moorland to the north of the Site, being carried within a cut ditch and also culverted via 300mm diameter concrete pipe for some 100 metres (m) beneath the Waste Stone Tip before discharging to the Afon Rhiw upon the Site's south-westernmost boundary. The Eastern Rhiw Tributary coalesces north of the Site, flow being made south-eastwards to discharge to the Afon Rhiw some 2.45 kilometres (km) to the east. The entire Site resides within Flood Risk Zone (FRZ) 1, implying a likelihood of flooding each year of 0.1% or less (*i.e.* > 1 in 1,000-year return period). Drainage from the quarrying areas is discharged to the Afon Rhiw under Environment Agency Consent. The consented discharge is made southwards under gravity from a shallow collector sump within Quarry A, via a sub-horizontal borehole passing immediately to the east of the Site offices, through settlement lagoons within the southern section of the Site and finally to the Afon Rhiw. This is periodically augmented by pumped discharge from a deeper sump contained within the lowest sinking of Quarry A. Estimates made for 2012 indicate an average daily discharge from the system of circa 540

cubic metres per day (m^3/d), comprising some $440m^3/d$ of groundwater and approximately $100m^3/d$ of rainfall ingress.

The PGF of the Site and surrounding area have limited groundwater storage and transmittal potential, being defined as a "Secondary Undifferentiated" aquifer by the EA (formerly termed either "minor aquifer" or "non-aquifer"). The local occurrence of the PGF is considered to operate as a series of semi-isolated aquifer blocks. Groundwater flow is anticipated to be concentrated within the sandier sequences of the formation, these being separated by lower permeability silty strata. Assessment concludes that the pre-quarrying level of groundwater within the PGF was some 370maOD and that quarry workings progressed beneath the watertable sometime during the mid 1970's. The floor of Quarry A has progressed to a depth of some 7m below the undisturbed groundwater level within the PGF, the deeper sump extending to some 16m below groundwater. There are no licensed groundwater abstractions within 4km of the Site although 7-no. unlicensed private groundwater dependant supplies have been elucidated within 650m.

Proposed Development

No processes or prescribed activities additional to those already undertaken at the Site are proposed as part of the Proposed Development. The deepest current floor level at the Site resides at some 363maOD. The Proposed Development involves deepening within Quarries A, B and C, over a series of 11m to 12m high benches, in a general north-westerly direction to a lowest level of 328maOD. Expansion of the Waste Stone Tip will be required to accommodate the significant quantities of non-saleable aggregate that will be produced. This necessitates extension of the existing culvert conveying a minor watercourse beneath the tip, from its current length of 100m to an extended length of some 290m. Current site drainage practices will be continued for the maintenance of safe and efficient working conditions. As the quarry deepens, the periodic pumping of groundwater and rainfall ingress presently undertaken from the deep sump of Quarry A will become a permanent requirement. At completion of quarrying, pumped discharge will cease. The quarry void will become inundated with a combination of groundwater and rainfall ingress to form a restoration lake that will be in continuity with groundwater.

Potential & Predicted Environmental Impacts

Assessment has examined the potential for the Proposed Development to cause both primary and secondary impacts upon the water environment. Potential primacy impacts that have been examined include:

i) impact upon Groundwater levels and flow

ii) direct derogation of surface water flows & waterbodies

iii) direct derogation of groundwater quality

iv) direct derogation of surface water quality

v) potential for quarry discharge to increase extant flood risk.

The assessment of potential secondary impacts has included:

i) indirect derogation of surface water flow rates and / or waterbodies resulting from drawdown of groundwater associated with the proposed dewatering operation

ii) impact upon volumes of groundwater and / or surface water available for existing and potential abstractions

iii) derogation of the quality of groundwater and / or surface water available to existing and potential abstractions,

iv) impact upon floral and / or faunal habitats as a result of flow / quality derogation within surface watercourses / wetland areas.

At full development, workings are anticipated to extend to a final depth of some 42m below the pre-quarrying level of groundwater. Calculation indicates a worst-case radius of influence upon groundwater levels of some 310m (the magnitude of groundwater lowering diminishing with increasing distance from the Site) and a pumping requirement in the order of 1,600m^3/d, equivalent to an instantaneous rate of 18.5 litres per second (l/s). The residual radius of influence upon groundwater following establishment of the restoration lake is anticipated to be negligible, being less than has already occurred at the Site to date. Assessment concludes that whilst groundwater levels and flow will be impacted by the Proposed Development, there will be no discernable impact upon the flow regime of the Afon Rhiw or the volumes of water available to existing or potential licensed abstraction (be they groundwater or surface water abstractions).

Working of the Proposed Development will not involve the removal of any reach of any (controlled) surface watercourse or waterbody (albeit that short sections of peripheral ditching will be removed by the proposed northwards extension of mineral extraction). The Proposed Development is considered not to pose a threat to either the flow volumes or water quality associated with surface watercourses or surface waterbodies. Therefore, there is considered to be no mechanism by which aquatic ecology may be adversely affected.

Under average conditions the rate of off-site discharge from the quarry will be matched by a broadly corresponding decrease in the rate of groundwater that naturally discharges to the Afon Rhiw (the dewatering activity serving to intercept, or "short-circuit", groundwater that would otherwise have drained to the watercourse). This "short-circuiting" will thus introduce no additional volumes into the local water environment and therefore will not place any additional stress upon the receiving watercourse. With respect to storm conditions, assessment of the proposed drainage system has demonstrated that the quarry design has ample scope to accommodate sufficient attenuation capacity for rainfall ingress during rainfall events up to, and including, a 1 in 100 year storm. The provision of attenuation storage within the quarrying areas will ensure that the peak rate of discharge to the Afon Rhiw will not be increased by the Proposed Development. Numerical modelling has been applied to examine the implications of extending the Waste Stone Tip culvert. Modelling indicates the proposed extension will have no adverse impact upon the existing drainage capacity of the culvert under average or storm flow conditions. Alternatives to the proposal to extend the Waste Stone Tip culvert have been reviewed. Review concludes that the extension proposals form the most practicable means of maintaining drainage within the Western Rhiw Tributary.

Mitigation of Impacts

In view of the close proximity of several existing unlicensed abstraction sources, it is recommended that a programme of programme of level monitoring allied to contingency mitigation be developed and implemented for these abstractions.

Measures have been formulated and advanced for the protection of groundwater and surface water quality which are considered to provide appropriate mitigation with respect to the potential for quality derogation of existing and potential abstraction sources.

Following review of alternatives to the proposal to extend the existing Waste Stone Tip culvert, it is considered prudent that the alternative, of re-aligning the tributary immediately upstream of the culvert intake, to take drainage southwards, via sub-horizontal borehole, into the quarrying area / completed

restoration, should be retained as a contingency measure to be applied in the event of a total failure of the existing / extended culvert.

To ensure that the tip's south-western slope is not destabilised by the generation of steep head gradients (high pore-water pressures) within and above the toe of the tip in the event of a (total) failure of the culvert, the tip extension should be founded upon free-draining granular materials.

Potential Residual Impacts

Groundwater levels will be permanently impacted by the Proposed Development, albeit to a lesser degree than has occurred to date. However, the magnitude and extent of this primary impact is small and is considered to carry insignificant potential to cause secondary impacts upon the water environment or existing abstractions. that will occur as a result of the Proposed Development. Beyond the permanent re-adjustment of groundwater levels, there are considered to be no other significant residual impacts associated with the working of the Proposed Development.

Conclusions

Assessment concludes that the proposals for continued working and restoration of Tan-Y-Foel Quarry, which include measures for the minimisation of impacts upon the water environment, have no associated hydrogeologically or hydrologically based concerns that would normally indicate that development should not proceed in the manner to be described by the Application.

1 INTRODUCTION

1.1 Background

1.1.1 HV Bowen & Sons (Quarry) Limited (HVBL), owners and operators of Tan-Y-Foel Quarry (the Quarry), near Welshpool, have commissioned the preparation of a Planning Application (the Application) seeking approval for:

i. the provision of new planning conditions as part of the Environment Act 1995 review.

ii. retention of the existing stocking area, ancillary development and associated concrete batching plant.

iii. the deepening of the Quarry by one additional bench.

iv. the regularisation of the existing site boundary.

v. extension of the existing peripheral Waste Stone Tip (part retrospective).

1.1.2 Detailed geological assessment has determined that the Quarry contains a total of 9.3 million tonnes (mt) of saleable reserves, sufficient for approximately 50 years working at a rate of 175,000 tonnes per year.

1.1.3 HBVL have appointed a specialist planning consultancy, Quarryplan GB Limited (QPGBL), to coordinate the Application and the preparation of associated supporting information.

1.1.4 BCL Consultant Hydrogeologists Limited (BCL; the authors of this report) have been commissioned by QPGBL to undertake an assessment of the potential hydrological and hydrogeological impacts associated with the planned future working of the Quarry (the Proposed Development).

1.1.5 This report presents the findings of hydrological and hydrogeological assessment undertaken in respect of the Proposed Development. The report has been prepared to inform consultations during the design, consultation and determination period for the Application.

1.2 Scope and Methodology of Assessment

1.2.1 Collection and interpretation of baseline data, together with a walk-over reconnaissance survey, have facilitated a conceptualised understanding of the nature

of, and interactions between, the groundwater and surface water systems operating within and around the Site.

1.2.2 The conceptual understanding has been employed to aid determination of the likely impacts of the Proposed Development upon the water environment.

1.2.3 Significant potential impacts identified during the course of investigations have been addressed by the review of existing mitigation measures and / or specification of additional measures as appropriate.

1.2.4 The scope of assessment has been informed by both mineral and local planning policies, which reinforce the need to pay due regard to the likely effect of development upon various aspects of the water environment.

1.2.5 The scope of Assessment has also been informed by a formal Scoping Opinion, adopted the Mineral Planning Authority (MPA: Powys County Council [PCC]) on 11th September 2012.

1.2.6 Where appropriate, the assessment methodology has been informed by prevailing guidance, most notably the recently adopted National Planning Policy Framework (NPPF: Department for Communities and Local Government [DCLG], March 2012), Technical Guidance to the National Planning Policy Framework[Ref.2] (tgNPPF: DCLG, March 2012), Development and Flood Risk: A Practice Guide Companion to PPS25[Ref.3], DCLG, February 2009 (referred to herein as PPS25pg and referenced in lieu of any published Practice Guide for the NPPF) and Environment Agency Science Report SC040020/SR1.

1.3 Data Sources

1.3.1 Site Specific Data Sources

1.3.1.1 Site specific data, including information relating to the design of operations and planning matters at the Site, includes the following:

i. "Tan-y-Foel Quarry, Cefn Coch, Welshpool, Powys, SY21 0AN. Town and Country Planning (Environmental Impact Assessment) Regulations 2011. Request for a Regulation 13 Scoping Opinion for an Environmental Impact Assessment to accompany a planning application for a new quarry waste tip (partly retrospective), regularisation of use, quarry deepening and retention of

existing permitted quarrying site for the purposes of the Environment Act 1995 review.", prepared by QPGBL on behalf of HVBL, June 2012.

ii. "Tan-y-Foel Quarry, Location Plan", Drawing No. M11.161.01, QPGBL for HVBL, June 2012.

iii. "Tan-y-Foel Quarry, Site Context Plan ", Drawing No. 00316/21, QPGBL for HVBL, Undated.

iv. "Tan-y-Foel Quarry, Ownership Plan ", Drawing No. 00316/22, QPGBL for HVBL, Undated.

v. "Tan-y-Foel Quarry, Site Summary Plan", Drawing No. 00316/23, QPGBL for HVBL, Undated.

vi. "Tan-y-Foel Quarry, Site Survey, January 2011", Drawing No. 00316/24, QPGBL for HVBL, Undated.

vii. Tan-y-Foel Quarry, Development Phases, 3-Dimentional Montage, (PDF 00316/24A), QPGBL for HVBL, 16th April 2012.

viii. "Tan-y-Foel Quarry, Phase 1 Extraction & Tipping", Drawing No. 00316/25, QPGBL for HVBL, Undated.

ix. "Tan-y-Foel Quarry, Phase 2 Extraction & Tipping", Drawing No. 00316/26, QPGBL for HVBL, Undated.

x. "Tan-y-Foel Quarry, Phase 3 Extraction & Tipping", Drawing No. 00316/27, QPGBL for HVBL, Undated.

xi. "Tan-y-Foel Quarry, Phase 4 Extraction & Tipping", Drawing No. 00316/28, QPGBL for HVBL, Undated.

xii. "Tan-y-Foel Quarry, Final Development", Drawing No. 00316/29, QPGBL for HVBL, Undated.

xiii. "Tan-y-Foel Quarry, Restoration Concept", Drawing No. 00316/30, QPGBL for HVBL, Undated.

xiv. "Tan-y-Foel Quarry, Llanllugan, Newtown, Boundary of Planning Permission Classified as an Active Phase 1 Site under Schedule 13 of the Environment Act 1995", Drawing No. M/B94/96/2, John German Chartered Surveyors for HVBL, September 1996.

xv. "Tan-y-Foel Quarry, Working Plan", Drawing No. M/B94/96/4, John German Chartered Surveyors for HVBL, December 1996.

xvi. Environment Agency response to a request for data concerning: rainfall, licensed abstractions, groundwater levels, groundwater quality , surface water levels, surface water flows, surface water quality, landfill sites, groundwater Source Protection Zones (SPZ's), extent of flooding, known or derived flooding elevations.

xvii. Powys County Council response to a request for data concerning unlicensed private water supplies and designated non-statutory sites of ecological importance.

xviii. "Initial Observations and Comments on the Geology and Mineral Resources of Tan Y Foel Quarry owned by H.V. Bowen and Sons Ltd", Paul Brewer Geological Services Limited for HVBL, 17th December 2010.

xix. "Tan-y-foel Quarry, Geotechnical Assessment", Key-GeoSolutions Limited for HVBL, September 2009.

1.3.2 Published Data Sources

1.3.2.1 Published documents and other sources of information, guidance and reference that have been examined include:

i. Ordnance Survey (OS): Topographic plans at scales of 1:50,000, 1:25,000, and 1:1,250 (digital, supplied by QPGBL).

ii. OS open-source digital data (Meridian 2 & Panorama data-sets).

iii. British Geological Survey (BGS): Published 1:50,000 scale solid and drift geological mapping, sheet-no's. 150,151,164,165.

iv. Environment Agency (EA): "Policy and Practice for the Protection of Groundwater", Catchment Abstraction Management Strategy (CAMS).

v. Environment Agency Science Report (SC040020/SR1): "Hydrogeological Impact Appraisal for Dewatering Abstractions". Water Resource Consultants for the Environment Agency, April 2007.

vi. Countryside Council for Wales (CCW): Spatial mapping & citation information for Designated Sites of ecological interest (Special Areas of Conservancy [SAC's] & Sites of Special Scientific Interest [SSSI's]).

vii. "Flood studies report, Volume II: Meteorological Studies.", National Environment Research Council, 1975.

viii. "Kinematic wave nomogram for times of concentration.", Ragan, R.M. & Duru, J.O. Journal of the Hydraulics Division, American Society of Civil Engineers, 1972.

ix. "Technical Management of Water in the Coal Mining Industry", NCB, 1982.

x. "The Flood Estimation Handbook CD-ROM No.3", Centre for Ecology & Hydrology, Wallingford, Oxon, UK, 2009.

xi. "Control of groundwater for temporary works", SH Somerville, 1986, Construction Industry Research and Information Association (CIRIA) report no. 113.

xii. "The Calculation of Actual Evaporation and Soil Moisture Deficit over Specified Catchment Areas", Grindley J, November 1969, Hydrological Memorandum 38, Meteorological Office, Bracknell, UK.

xiii. "Estimation of Open Water Evaporation, Guidance for Environment Agency Practitioners", R&D Handbook W6-043/HB, J W Finch and R L Hall, October 2001.

xiv. On-line Flood Mapping Service, Environment Agency, July 2012.

xv. "Groundwater Hydrology", D K Todd, 1980.

1.4 Report Structure

1.4.1 Baseline data concerning the topography, geology, hydrology and hydrogeology of the study area, which are drawn together to inform a conceptual understanding of the extant hydrogeological and hydrological regimes, are presented at *section 2*.

1.4.2 An account of the proposed future development of the Site, including description of intended working methods, depths, elevations and water management measures, both during operations and for the support of the proposed restoration, is given at *section 3*.

1.4.3 Assessment of the potential impacts of continued mineral extraction, and review of mitigation measures proposed to ameliorate significant such impacts, are made in *section 4*.

1.4.4 A summary of the findings of hydrogeological and hydrological assessment together with report conclusions and recommendations are given in *section 5*. Unless otherwise stated, all figures referred to by this report are included as *appendix 1*.

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2 THE SITE AND ITS ENVIRONS

2.1 Site Location

2.1.1 The Site is centred upon rural lands at National Grid Reference (NGR) $^{3}013$, $^{3}015$; approximately 3.8 kilometres (km) south-southwest of the hamlet of Cefn Coch, some 22km south-southwest of Welshpool, Powys.

2.1.2 The Site is bordered to the north by the 'C' class Llanfair Caereinion to Carno road, whilst the unclassified Adfa road runs through the southern section of the Site.

2.1.3 The Site location is shown at *figure 1.*

2.2 Site Operations

2.2.1 The Site occupies a total area of some 40 hectares (ha), comprising:

i. three principal quarrying areas (occupying some 18ha of the central area of the Site and referred to as "Quarries A, B & C").

ii. the Processing Plant area (some 1.1ha, situated within the central southern section of the quarried areas).

iii. the Office, Weighbridge, Stockpiling and Water Settlement areas (located upon 4.1 ha of land to the south of the Adfa road).

iv. the Waste Stone Tip (2.2ha within the north-western section of the Site).

v. the Proposed Quarrying Extension (10ha of agricultural lands to the north of the current quarried areas).

vi. the Proposed Waste Stone Tip Extension (4.9ha of agricultural lands to the north-west of the currently quarried areas).

2.2.2 The economic mineral extracted at the quarry is vertically bedded Silurian gritstone which is interbedded with shale, siltstones and mudstones. The gritstone produces a high quality construction aggregate which is used in the manufacture of asphalt, concrete and concrete blocks.

2.2.3 The quarry is worked in a conventional manner, utilising drilling and blasting techniques to extract mineral in a series of benches approximately 12 metres (m) in height. The as-blasted rock stone is loaded by hydraulic excavator into a dump truck

for transportation to the processing plant where it is crushed and screened into a series of sizes for stockpiling awaiting sale.

2.2.4 Quarries A and B are currently being worked in a north-easterly direction; in accordance with the geological strike. Quarry C is currently used for inert construction and demolition recycling and for stockpiling materials. Quarry C will also be quarried in the future, again, in a north-easterly direction, parallel to and adjacent to Quarry B.

2.2.5 Quarry A has been developed to a general floor level of some 363maOD. A small area of the quarry floor has been deepened to circa 354maOD to form a catchment sump. Quarry B has a slightly higher general floor level, averaging some 368maOD.

2.2.6 The shale that is interbedded with the gritstone is not suitable for use as a quality construction aggregate. A proportion of the shale bi-product is thus sold for bulk-fill material, although the majority disposed of within the Waste Stone Tip.

2.2.7 The amount of waste stone produced varies between 20% and 30% of total quarry production at the Site. On average some 150,000 tonnes of stone are exported from the Site annually, although recent sales have been almost 170,000 tonnes. This includes sales of waste stone for bulk fill, sales of which are not consistent.

2.2.8 In addition to the quarrying and aggregate recycling operations, there is also a concrete batching plant present at the Site. This plant uses single sizes of stone and fine stone wastes from the quarry to produce ready mixed concrete for the local building and construction markets.

2.2.9 Site layout and local topography are illustrated by a detailed survey plan included here at *figure 2* and pictorially by a 3-dimentional representation included at *figure 3*.

2.3 Topography and Land Use

2.3.1 The Site occupies a rural hillside location (Y Foel Hill) between elevations of 365 metres above Ordnance Datum (maOD) and 414maOD.

2.3.2 Lands surrounding the Site comprise open areas of rough grazing and improved pasture with isolated coniferous woodland blocks. Enclosed field patterns are more typical on lower lying ground within sheltered valleys.

2.3.3 Y Foel Hill comprises a compact ridge oriented generally from south-west to north-east. The summit of the hill is situated close to the northern limit of existing mineral extraction at some 414maOD.

2.3.4 Ground levels generally fall away from the Site in all directions, creating pronounced valleys to the south and south-west (320maOD at NGR $^{3}013$ $^{3}011$, adjacent the southern-most point of the Site and 365maOD adjacent the south-western boundary).

2.3.5 A shallower valley, oriented from north-east to south-west and falling locally south-westwards to some 375maOD, lies immediately to the north of the Site. This valley has been truncated by the Waste Stone Tip associated with quarrying operations at the Site. Prior to creation of the tip, the valley formed a continuous feature bordering the north and south-west of the Site. Beyond this valley, ground levels rise again, attaining a local summit of 413maOD at NGR $^{3}0174$, $^{3}0223$, some 400m to the north.

2.4 Designated Sites of Ecological & Geological Importance

2.4.1 Statutorily Protected Sites

2.4.1.1 Data obtained from CCW indicate that there are no Special Areas of Conservation (SAC) within a 6.5km radius of the Site.

2.4.1.2 The locations of local Sites of Special Scientific Interest (SSSI) are illustrated at *figure 4*. Outline details, taken from the CCW Citation Database, are given below at *table 1*. Full citations are included at *appendix 2*.

Table 1: Summary Details of SSSI local to the Site

SSSI	Distance & Direction from Site*	Type	Summary Description of Habitat and Ecology
Llyn Mawr	4.7km S	B	Moderately oligotraphic upland lake within a relatively unimproved catchment. The site is of considerable ornithological importance, being extensively used by waterfowl.
Llanllugan Mire	5.5km ENE	B	Undisturbed basin mire supporting a number of different wetland vegetation types and several uncommon species.
Bryn Coch	6.5km N	B	Comprises locally very scarce lowland fen and acid grassland containing an exceptional variety of vegetation types.
Gweunydd Dolwen	6.6km WNW	B	Acid and neutral dry grassland supporting the uncommon greater butterfly-orchid *Patanthera chlorantha*.
Great Wood, Gregynog	7.8SE	B	Wood-pasture / parkland habitat representing one of the finest surviving examples of the habitat in Wales. Supports epiphytic lichens and tree dwelling specialist invertebrates.

** - at shortest distance between void and SSSI; B – Biological; G - Geological*

2.4.2 Non-Statutorily Protected Sites

2.4.2.1 The Site does not contain any designated areas of non-statutory nature conservation.

2.4.2.2 The locations of local County Wildlife Sites and Wildlife Trust Nature Reserves are illustrated at *figure 5*, the closest to the Site being Llyn Hir, located some 3.9km to the north-northeast at its closest approach.

2.5 Landfill Sites

2.5.1 The EA have confirmed that there are no operational or known historic landfills within the Planning Permission boundary of the Site.

2.5.2 The locations of operational and known historical landfill local to the Site, as taken from the EA's Public Register, are illustrated at *figure 6* and summary details given below at *table 2*.

Table 2: Summary Details for Local Landfill

Site Name	NGRx	NGRy	Distance from Site (km)	Site Address	Status	WML / EP Ref.	Class	Operator
Four Crosses	30565	30817	7.5	Four Crosses, Llanerfyl	Closed	Not given	Int, Ind,Co, Ho, Sp	Not Recorded / Closed 1979
Neuadd	30873	30756	9.2	Neuadd, Llanfair Caereinion	Closed	Not given	Int, Ind,Co, Ho, Sp	Not Recorded / Closed 1972

Int: Inert; Ind: Industrial; Co: Commercial; Ho: Household; Sp: Special

2.6 Geology

2.6.1 The geology within and surrounding the Site has been characterised by reference to the following data sources:

i. BGS publications.

ii. Geological and geotechnical reports prepared in respect of Site operations.

2.6.1 Regional Geological Setting

2.6.1.1 The geology of the Site and its environs comprises superficial drift deposits overlying solid geological strata dominated by mudstones and sandstones.

2.6.1.2 The drift geology of the region comprises mainly glacial deposits, present as discontinuous cover above solid strata. In addition, thin ribbons of alluvium have been deposited by riverine processes and areas of high ground have some peat cover.

gritstones, greywackes and shales which have been subjected to low grade metamorphism.

2.6.2.2 The PGF has widespread presence at outcrop and at varying depth from surface across the region. The Site is situated towards the eastern-most extent of the PGF outcrop area, with the Penstrowed Grits Formation dipping steeply to the east and becoming overlain by the younger Nantglyn Flags Formation (NGF) at the Site's eastern extremity.

2.6.2.3 Although largely obscured by drift cover, the outcrop of the PGF on which the Site is located forms a series of adjacent north-east to south-east striking synclines and anticlines, forming a range of hills lineated generally from south-east to north-west. The distribution of these folding structures is notably offset in places by extensive faulting.

2.6.2.4 The PGF thins from north to south across the region, dependent upon the degree of uplift and erosion it has been subjected to. As a result, the PGF is generally thickest on the southern side of the Llanerfyl Fault (which trends generally from south-southwest to north-northeast and downthrows to the north, some 8.5km north-northeast of the Site), and thins to the south east. The PGF is thinner or absent to the north west of the fault due to uplift and erosion.

2.6.2.5 To the south, the Site is bordered by an east west trending fault. The Site is situated upon the downthrow side of this fault, making it likely that the PGF is thinner on the fault's southern side. This fault has also displaced the bedrock by ~800m to the east, such that the outcrop of the PGF is more distant on the southern side of the fault.

2.6.2.6 The east-west trending Guilsfield Fault borders the northern boundary of the Site, with the Site being situated upon the downthrow side of the fault. The vertical displacement caused by the fault has caused the older Nant-Ysgollon Mudstone Formation (NYMF) to be exposed in a small area to the immediate north of the fault. As a result of the northward dip of strata, the PGF once again conceals this formation a short distance to the north.

2.6.1.3 The youngest strata in the region are seen to outcrop in the east of the region, with older strata being uncovered in the west. This structure forms part of the Welsh Basin, which occupies much of mid Wales, extending from the Midlands Platform to the Irish Sea.

2.6.1.4 Local outcrop distribution is heavily influenced by the degree of uplift, extent of erosion and widespread faulting. Solid strata of the region comprises a heavily eroded series of mudstones and sandstones present within a series of generally north-easterly striking synclines and anticlines.

2.6.1.5 The distribution of geological units of the area is illustrated upon an extract from British Geological Survey (BGS) mapping, which is reproduced here as *figure 7a*. The general structural form is illustrated at *figure 7b*, which reproduces a representative cross section of the local geology from published BGS mapping.

2.6.1.6 The stratigraphic sequence of the region is represented at *table 3* below.

Table 3: Summary Stratigraphic Sequence

Age	Formation / Lithology	Description
Quaternary	Peat	Blanket and Basin Peat
	Alluvium	Sand, gravel, silt and clay
	Alluvial Fan Deposits	Sand and gravel, variably clayey
	Till	Gravelly clay
Silurian	Nantglyn Flags Formation	Dark Grey, thinly bedded mudstones with sandstone (up to 800m thick)
	Mottled Mudstone Member	Burrowed Mottled Mudstone, up to 20m thick, 400m above base of Nantglyn Flags Formation
	Gregynog Mudstone Member	Massive sandy and silty mudstones
	Penstrowed Grits Formation	Sandstone turbidites, high matrix sandstones and slumped sandstones (up to 25-400m thick)
	Nant-Ysgollon Mudstone Formation	Dark grey mudstone, 100 to 150m thick
	Dolgau Mudstones Formation	Pale grey, green and purple banded mudstone, up to 80m thick
	Laundry Mudstone Formation	Grey, shelly mudstone, 50-170m thick
Ordovician	Graig-Wen Sandstone Formation	Massive, fine grained sandstone, 15-20m thick
	Dolhir Formation	Mudstone and siltstone, over 400m thick seen

2.6.2 Solid Geology

Distribution and Structure

2.6.2.1 Published geological mapping shows the Site to be located on an exposed section of the Penstrowed Grits Formation (PGF). The Formation comprises sandstones,

gritstones, greywackes and shales which have been subjected to low grade metamorphism.

2.6.2.2 The PGF has widespread presence at outcrop and at varying depth from surface across the region. The Site is situated towards the eastern-most extent of the PGF outcrop area, with the Penstrowed Grits Formation dipping steeply to the east and becoming overlain by the younger Nantglyn Flags Formation (NGF) at the Site's eastern extremity.

2.6.2.3 Although largely obscured by drift cover, the outcrop of the PGF on which the Site is located forms a series of adjacent north-east to south-east striking synclines and anticlines, forming a range of hills lineated generally from south-east to north-west. The distribution of these folding structures is notably offset in places by extensive faulting.

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2.6.2.7 To the west of the Site, the PGF rises and thins, exposing the older geology of the NYMF and the Dolgau Mudstones Formation (DMF), approximately 2km distant from the Site.

Local Lithology & Occurrence

2.6.2.8 Geological reports prepared in respect of the quarrying operations describe the PGF of the Site as a mid grey fine / medium to medium grained sandstone containing interbedded shales, siltstones and mudstones.

2.6.2.9 Bedding at the Quarry is near vertical to sub-vertical, although some overturned strata are present along the margins of the south eastern face of Quarry A. Thus, the Quarry is being developed along the strike of the beds in a south-west to north-east direction.

2.6.2.10 Within the Site, thick beds (up to 3m) of sandstone dominate the base of the section, which is exposed in the north-west of the quarried area. Above this unit the section is dominated by a thin to thick-bedded interbedded sandstone / mudstone sequence. Here, the planar-bedded sandstones exhibit a typical thickness of some 0.3m, ranging up to 1.6m.

2.6.2.11 Individual sandstone beds possess sharp contact-bases with underlying mudstones, grading upwards from very coarse to fine grained, transitioning gradually into overlying mudstone / siltstone. The mudstone / siltstone beds are typically 0.1m to 0.3m thick, locally developing up to 2m to 3m.

2.6.3 Drift Geology

2.6.3.1 BGS mapping shows unworked sections of the Site to be located upon an exposed section of the PGF largely devoid of drift cover. However, a limited area of peat is shown to be present upon the Site's northern boundary, with an area of glacial till present at its north western extent.

2.6.3.2 Glacial till dominates the drift cover of the area, being present over large areas of the local undulating moorland. This cover surrounds the Site on all sides, becoming most extensive to the east and south.

2.6.3.3 To the north and west of the Site, outcrops of the PGF are exposed from beneath the Till on higher ground. These outcrops are associated with drift cover comprising blanket and basin peats.

2.6.3.4 To the north and south of the Site, alluvial fan deposits are present, being associated with the head-waters of local watercourses. these deposits comprise clayey sand and gravel. The lower reaches of these watercourses are associated with deposition of alluvium.

2.7 Hydrology

2.7.1 Metrological Data

2.7.1.1 The Standard Average Annual Rainfall (SAAR) in the standard period (1961 to 1990) as recorded by the Flood Estimation Handbook CD-ROM database No.3 is 1,404mm (SAAR4170: 1,415mm).

2.7.1.2 Long-term average (LTA) monthly rainfall data, taken from MAFF Technical Bulletin 34 (Area 49N), are given at *table 4* below.

Table 4: Area LTA monthly rainfall and potential transpiration (mm)

mm	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Average Rainfall	123	84	78	73	81	72	81	103	111	117	130	131	1,184
Potential Transpiration	0	5	28	48	74	83	84	66	40	19	4	1	452

2.7.1.3 The above data have been utilised to derive estimates for monthly effective rainfall for both vegetated surfaces and open water, using the methods of Grindley and EA R&D Handbook W6-043/HB. These estimates are presented below at *table 5*.

Table 5: Derivation of Effective Rainfall for Various Surfaces using the Grindley Water Budget Method

rc = 75 (permanent grassland); PE – Well Watered Short Grass

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	123	84	78	73	81	72	81	103	111	117	130	131	1,184
Pe	0	5	28	48	74	83	84	66	40	19	4	1	452
rf-Pe	123	79	50	25	7	-11	-3	37	71	98	126	130	732
dPsmd	0	0	0	0	0	11	3	-14	0	0	0	0	
dAsmd	0	0	0	0	0	11	3	-14	0	0	0	0	
Psmd	0	0	0	0	0	11	14	0	0	0	0	0	25
Asmd	0	0	0	0	0	11	14	0	0	0	0	0	25
Ae	0	5	28	48	74	83	84	66	40	19	4	1	452
ERF	123	79	50	25	7	0	0	23	71	98	126	130	**732**

rc = 200mm (woodland); PE – Woodland

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	123	84	78	73	81	72	81	103	111	117	130	131	1,184
Pe	0	5	28	48	74	83	84	66	40	19	4	1	452
rf-Pe	123	79	50	25	7	-11	-3	37	71	98	126	130	732
dPsmd	0	0	0	0	0	11	3	-14	0	0	0	0	
dAsmd	0	0	0	0	0	11	3	-14	0	0	0	0	
Psmd	0	0	0	0	0	11	14	0	0	0	0	0	25
Asmd	0	0	0	0	0	11	14	0	0	0	0	0	25
Ae	0	5	28	48	74	83	84	66	40	19	4	1	452
ERF	123	79	50	25	7	0	0	23	71	98	126	130	**732**

Open Water

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Correction Constants	1.4	1.1	0.9	1.0	0.9	1.0	1.2	1.4	1.5	2.0	2.3	2.0	
Ae	0.0	5.7	25.8	45.6	67.3	84.7	104.2	90.4	58.8	37.8	9.2	2.0	531.4
ERF	123.0	78.3	52.2	27.4	13.7	-12.7	-23.2	12.6	52.2	79.2	120.8	129.1	**652.6**

rc: Root Constant
rf: Rainfall
dAsmd: Change in Actual Soil Moisture Deficit
Asmd: Actual Soil Moisture Deficit
ERF: Effective Rainfall
Pe: Potential Evaporation
Psmd: Change in Potential Soil Moisture Deficit
Psmd: Potential Soil Moisture Deficit
Ae: Actual Evaporation
All units are millimetres

2.7.1.4 To supplement the above data, monthly rainfall totals for the area of the Site for the period January 2007 to December 2012 have been obtained from the EA Cefn Coch Main rain-gauge (No. 1338; NGR: ^{3}04137, ^{3}02562).

2.7.1.5 The Cefn Coch gauging station is situated some 2.6km north-east of the Site and resides at an altitude of some 315maOD. The supplied data indicates an annual average rainfall for the 5-year period (2007 to 2012) total of 1,184mm; (somewhat coincidentally) identical to the regional (MAFF) LTA values utilised to derive effective rainfall above.

2.7.1.6 Considerable variation is exhibited by the EA data, (*i.e.* 2008 and 2010 annual totals of 1409.8mm and 869mm respectively, representing some 119% and 73% of the established LTA rainfall for the area). Recent monthly variability from the LTA data

is illustrated at *table 6* below, which gives monthly rainfall totals for the period 2007 to 2012 compared with the established LTA.

Table 6: Monthly Rainfall Totals (2007 to 2012) v's LTA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
LTA Rainfall (mm)	123	84	78	73	81	72	81	103	111	117	130	131	1,184
2007 (mm)	202.6	131.4	81.6	9.4	96	165.4	192.2	29.6	87.4	44.2	66.8	188.2	1,294.8
% of LTA	*165%*	*156%*	*105%*	*13%*	*119%*	*230%*	*237%*	*29%*	*79%*	*38%*	*51%*	*144%*	*109%*
2008 (mm)	215.6	69.6	146.8	73.2	40.6	84	145.6	115.8	146.4	184.6	96	91.6	1,409.8
% of LTA	*175%*	*83%*	*188%*	*100%*	*50%*	*117%*	*180%*	*112%*	*132%*	*158%*	*74%*	*70%*	*119%*
2009 (mm)	113.2	22	79.2	60	87.4	101.8	161.4	55	43.6	95	295.4	102.2	1,216.2
% of LTA	*92%*	*26%*	*102%*	*82%*	*108%*	*141%*	*199%*	*53%*	*39%*	*81%*	*227%*	*78%*	*103%*
2010 (mm)	78.8	55.8	57.6	39.2	44.6	44.6	115	72.2	113.2	92	104.8	51.2	869
% of LTA	*64%*	*66%*	*74%*	*54%*	*55%*	*62%*	*142%*	*70%*	*102%*	*79%*	*81%*	*39%*	*73%*
2011 (mm)	128.6	116.6	16	14.4	83.4	106.4	81.2	41.4	85.4	79.6	76.8	248.6	1,108.6
% of LTA	*105%*	*139%*	*21%*	*20%*	*103%*	*148%*	*100%*	*40%*	*77%*	*68%*	*59%*	*190%*	*94%*
2012 (mm)	158.8	53.2	20.4	153	54.8	179.6	132	68.6	113.8	126.6	109.2	40	1,210
% of LTA	*129%*	*63%*	*26%*	*210%*	*68%*	*249%*	*163%*	*67%*	*103%*	*108%*	*84%*	*31%*	*102%*

2.7.2 Surface Watercourses & Waterbodies

Regional

2.7.2.1 The entirety of the Site is located within an upland catchment of the eastward flowing Afon Rhiw. The Afon Rhiw is a tributary of the River Severn, which it meets at Berriew some 20.5km east of the Site.

2.7.2.2 The principal surface watercourses and waterbodies of the area are illustrated at *figure 8*.

Local

2.7.2.3 The main channel of the Afon Rhiw flows generally from north-west to south-east, and, at its closest approach, borders the southern boundary of the Site.

2.7.2.4 Two minor tributaries of the Afon Rhiw drain the Site area; these being referred to here as the "Western Rhiw Tributary" and "Eastern Rhiw Tributary". The watercourses local to the Site are illustrated upon *figure 9*.

2.7.2.5 The Western Rhiw Tributary has its headwaters within open moorland immediately to the north of the shallow valley situated north of the existing quarrying areas.

2.7.2.6 Below its headwaters, the Western Rhiw Tributary flows generally south-westwards within a cut ditch upon the base of the shallow valley north of the Site, toward a

culvert (a 300mm diameter concrete pipe) which extends for some 100m beneath the Waste Stone Tip.

2.7.2.7 The Western Rhiw Tributary emerges upon the south-western boundary of the Waste Stone Tip, from where it is ditched in its course towards a highway culvert beneath the Adfa road; discharging to the Afon Rhiw at the Site's south-westernmost boundary.

2.7.2.8 Assessment of detailed topographic surveying indicates that the total surface catchment area draining to the Western Rhiw Tributary extends to cover some 11.24ha.

2.7.2.9 The Eastern Rhiw Tributary coalesces from diffuse drainage within the eastern section of the shallow valley to the north of the current quarrying areas. Flow is made south-eastwards, discharging to the Afon Rhiw near Belan Ddu at NGR: ^{3}0412, ^{3}0141, some 2.45km east of the Site.

2.7.3 Site Drainage

2.7.3.1 Discussions with Site management indicate that since the mid 1970's, off-site drainage has been perpetual. The hill-side setting of the Site has negated the need for pumped discharge, drainage having been made under gravity for the vast majority of this time.

2.7.3.2 More recently, with the development and expansion of the 363maOD floor level within Quarry A, (and consequent lowering of the quarry floor beneath ground level upon the southern perimeter of the sinking) gravity discharge has been maintained by the drilling of a sub-horizontal borehole upon the Site's southern margin (draining from a shallow collector sump contained upon the southern boundary of the sinking).

2.7.3.3 The sinking of a deep sump (to circa 354maOD; see *figure 9*) within Quarry A during 2011 has necessitated periodic pumped discharge. Water pumped from the deep sump is discharged to the shallow collector sump, then draining from Site via the sub-horizontal borehole under gravity.

2.7.3.4 Drainage via the sub-horizontal borehole from the quarrying areas is discharged, via a series of settlement lagoons located within the southern section of the Site to the Afon Rhiw under EA Consent No. S/01/55291/T.

Water Balance

2.7.3.5 Pumping from the deep sump is undertaken using a diesel powered 100mm-diameter rotary impellor suction-pump. Within the current discharge configuration, the pump is capable of discharging some 25 litres per second (l/s).

2.7.3.6 Discussions with Site management indicate that during 2012, maintenance of a controlled and suppressed water level within the sump (estimated to approximate to circa 354maOD) required periodic pumping equating to some 6 hours per day during quarry operational hours.

2.7.3.7 From knowledge of pump running hours and performance, it is estimated that the averaged pumping rate made from Quarry A Sump during 2012 was some 540 cubic metres per day (m^3/d), equating to an average instantaneous discharge rate of some 6.25 litres per second (l/s).

2.7.3.8 Examination of rainfall data presented previously (*table 6)* indicates that local rainfall during 2012 was only marginally elevated above the LTA for the area. Thus, it is likely that that the pumping requirements experienced during 2012 are representative of the typical annual requirements at the Site (at least with respect to workings to some 354maOD; the estimated basal level of the deep sump).

2.7.3.9 Assuming the deep sump within Quarry A is fed by both rainfall runoff and groundwater, and that all runoff from the Quarry A were captured by the deep sump collector, calculation indicates that the proportion of pumping undertaken during 2012 that may be attributable to groundwater inflow to the sump is some 75% to 80% of the estimated average discharge rate (*i.e.* a groundwater component of circa $440m^3/d$ and a rainfall component of some $100m^3/d$).

2.7.4 Flooding

2.7.4.1 The entire Site resides within Flood Risk Zone (FRZ) 1 as defined by the EA and as illustrated at *figure 10*. FRZ 1 status implies a likelihood of flooding each year (from rivers or the sea) of 0.1% or less (*i.e.* > 1 in 1,000-year return period).

2.7.4.2 The closest areas mapped by the EA to be at risk of flooding are associated with the Afon Rhiw, some 500m south of the Site.

2.8 Hydrogeology

2.8.1 Aquifer Characteristics

2.8.1.1 The ancient sandstones and associated siltstones of the PGF forming the economic mineral of the Site (and comprising the bedrock of its surrounding area) typically possess extremely limited primary porosity and modest to negligible intergranular permeability.

2.8.1.2 The PGF is defined as a "Secondary Undifferentiated" aquifer by the EA's aquifer classification scheme. This classification, which was formerly termed either "minor aquifer" or "non-aquifer", characterises predominantly lower permeability rocks, capable of storing and yielding only limited amounts of groundwater

2.8.1.3 The EA's aquifer definition is essentially economic; the extremely low permeability (transmittal properties) and primary porosity (storage capacity within the matrix of the rock mass) typical of such rocks imply that any groundwater present will generally be available only in extremely limited quantities and with negligible ability for movement.

2.8.1.4 The poor aquifer properties of the PGF would generally prohibit its economic exploitation as a water resource for anything other than small-scale private abstractions.

2.8.1.5 Notwithstanding the foregoing, groundwater may be expected to be present within the strata, but generally in limited quantities and of limited interconnection. The dominant groundwater flow mechanism is likely to be fissure / fracture flow (*i.e.*

groundwater movement is made through open and interconnected cavities, such as fractures and joints).

2.8.2 Piezometery

Present Day

2.8.2.1 Study, including enquiries made with the EA, has not elucidated any historical groundwater level data for the strata of the Site or its immediate surroundings.

2.8.2.2 In order to provide some information upon groundwater levels at the Site a programme of weekly measurements of groundwater level within both a water supply well and a sump located within the quarried areas, and a domestic well serving a nearby property (Rhyd-y-Biswal) was commenced during January 2013.

2.8.2.3 Groundwater level measurements have been made using a conventional dip-meter from a fixed datum. The initial set of three observation points were augmented in early February 2013 by the installation of a pair of purpose drilled groundwater level measurement piezometers, installed within the northern sections of Quarry A and Quarry B.

2.8.2.4 The locations of the groundwater observation points are illustrated at *figure 11*. The collected data is included here at *appendix 3*.

2.8.2.5 Groundwater levels recorded at the 5-no. observation points are generally within 1.5m of ground surface. Although time-series data is limited, a modest range of fluctuation has been recorded to date, with a maximum at any one observation point of 1.28m.

2.8.2.6 Preliminary evaluation of the collected groundwater level data, ignoring the potential effects of structure, bedding and lithological variation, indicates that groundwater flow is focussed upon and made radially towards the shallow collector sump within Quarry A (the deep sump not having been pumped for any significant duration during the monitoring period). The prevailing groundwater gradient appears to steepen upon its approach to the shallow collector sump. Interpolated groundwater contours are illustrated here at *figure 11*.

Historical

2.8.2.7 The apparent focussing of groundwater flow upon the shallow sump suggests that the gravity drainage system is exerting an influence upon local groundwater levels. This factor, taken together with i) the perpetual nature of off-site discharge (*section 2.7.3*), ii) the coincidence between levels within the shallow sump and those interpolated for groundwater and, iii) the extended periods of pumping required to maintain depressed levels within the deep sump, strongly indicates that workings within Quarry A have progressed to a depth of circa 7m below undisturbed groundwater level, whilst the deeper sump extends to around 16m below undisturbed groundwater level within the PGF.

2.8.2.8 It is considered probable that, prior to the penetration of the watertable at circa 370maOD during the mid 1970's, the undisturbed local groundwater flow direction was made obliquely towards to Afon Rhiw (*i.e.* from west-northwest to east-southeast).

2.8.2.9 When considering the potential effects of structure, bedding and lithological variation upon groundwater level distribution, it is noteworthy that the data indicates groundwater levels measured within Quarry B to reside some 5m above those measured within Quarry A.

2.8.2.10 The observation points from which groundwater level measurements were made within Quarries A and B are only some 135m apart. The relatively high head gradient suggested by the data is indicative of strata possessing modest hydraulic conductivity; and possibly reflects the "compartmentalising" effect caused by of vertically bedded strata containing numerous low permeability siltstone / shale / mudstone horizons.

2.8.2.11 The local section of the PGF is thus considered to operate as a series of semi-isolated aquifer blocks comprising the sandier sequences of the formation, these being separated by lower permeability argillaceous strata.

2.8.2.12 On the basis of the currently available data, it is impossible to determine the degree of prevailing separation between any such "aquifer blocks". However, it considered very likely that groundwater flow will be focussed primarily along the strike of the

strata, thus adopting a preferential south-west to north-east and north-east to south-west flow direction (*i.e.* toward the shallow collector sump of Quarry A rather than the more simple interpretation of data involving radial flow, as presented previously).

2.8.2.13 Whilst some flow is likely to be made across the bedding of the strata (*i.e.* from north-west to south-east and south-east to north-west), the volume of groundwater transmitted in this direction is considered likely to be markedly lower than that made along the strike of the strata.

2.8.2.14 As described, it is considered that groundwater movement is likely to be relatively elevated along the strike of the strata. However, the total rate of flux is anticipated to remain small; the low hydraulic conductivity of the material being capable of sustaining steep hydraulic gradients.

2.8.2.15 Further evidence for the presence of relatively high hydraulic head gradients comes from data collected from a piezometer installed upon the 372maOD bench of Quarry A (groundwater observation point no. 4; *figure 11*). Groundwater levels recorded within this piezometer reside some 7m above the floor of the adjacent quarry sinking, the south-east to north-west oriented face of which is situated only some 21m from the piezometer location.

2.8.3 Abstractions

2.8.3.1 Information upon licensed and unlicensed (deregulated) groundwater abstractions has been obtained from the EA and PCC respectively.

Licensed Abstractions

2.8.3.2 The EA have confirmed that there are no licensed groundwater abstractions within 4km of the Site.

Unlicensed (deregulated) Abstractions

2.8.3.3 PCC have provided information relating to unlicensed (deregulated) private water supplies within the area of the Site. The locations of these supplies are illustrated at *figure 12* and a schedule of abstractions given at *appendix 4*.

2.8.3.4 Information for unlicensed abstractions within 2km of the Site are summarised below at *table 7*.

Table 7: Unlicensed (deregulated) Abstractions Local to the Site

Site Name	NGRx	NGRy	Distance from Closest Sections of Current / Proposed Quarrying (m)	Type	Map Code *(figure 12)*
Tan y Foel Quarry	301350	301320	125	N/R	25
Fuches Goch	301153	301201	190	Well	24
Rhyd y Biswal	300922	301386	215	Spring	23
Gwaun y Maglau	301786	301981	245	Well	29
The Barn Waenyfigyn	301819	301266	330	N/R	30
Y Ty Waenyfigyn	301824	301260	340	Well	31
Groesafon	301842	300870	650	Well	32
Dolgwynfelin	302289	300695	950	Spring	35

2.8.4 Source Protection Zones

2.8.4.1 By virtue of the poor aquifer characteristics of the surrounding strata, the Site resides outwith any groundwater Source Protection Zone (SPZ) as delineated and managed by the EA.

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3 THE PROPOSED DEVELOPMENT

3.1 Quarrying & Restoration Operations

3.1.1 Excluding the sump recently cut into the floor of Quarry A, the deepest current floor level at the Site resides at some 363maOD.

3.1.2 The Proposed Development will involve the progressive development within Quarries A, B and C, over a series of 11m to 12m high benches, in a general north-westerly direction and downwards to a lowest level of 328maOD.

3.1.3 The existing planning permission authorises extraction to a final floor level of 339maOD. The Proposed Development therefore seeks additional extraction of one further bench in the quarry floor to produce the planned floor level of 328maOD.

3.1.4 The Proposed Development includes for the extraction of the major shale horizons currently separating each of the three quarrying for use in restoration of the Site.

3.1.5 There are no proposals to alter the method of working or the rate of extraction at the Site. The processing plant would remain in its current location and no new machinery, beyond that which is currently permitted and employed within the existing operations, is proposed as part of the Proposed Development.

3.1.6 The Proposed Development of the Site is shown upon a series of phasing plans included here as *figures 13a & 13b* and may be summarised as follows:

- ***Phase 1***: Quarries A and B worked down to 363maOD and the Waste Stone Tip being extended in a westerly direction. This Phase would release 0.6mt of saleable stone which would be worked over 3.5 years.
- ***Phase 2***: Quarries A and B worked down to 340maOD, to be undertaken along with removal of shales from the spine separating the two sinkings and continued infilling of tip extension and removal and realignment of the south-easternmost tip.
- ***Phase 3***: Quarry A developed down to 328maOD, to achieve the full depth of proposed workings. The Waste Stone Tip to be completed and restored. Phases 2 and 3 would release some 1.5mt of saleable stone, to be worked over approximately 8 years.
- ***Phase 4***: Extension of the quarry northwards to the full extent of the existing planning boundary, being worked down to 368maOD. With the Waste Stone Tip now restored, non-saleable aggregate would be used to infill Quarry A and

part of Quarry B This Phase would release some 4.3mt of saleable stone which would be worked over 24 years.

- ***Phase 5***: Part of the northern extension to the quarry to be worked down to 328maOD. Waste stone to be tipped into Quarry C and this area restored. Restoration is completed in Quarries A and B. This Phase would release some 2.9mt of saleable stone to be worked over 16 years.

- **Final Restoration Concept**: The proposed restoration includes profiled tips which have been grassed, tree planting, a lake and exposed geological faces and features.

3.2 Water Management

3.2.1 Within Quarrying Areas

Current

3.2.1.1 As described (*section 2.7.3*), drainage of both rainfall and groundwater ingress is currently made under gravity to the Afon Rhiw via a series of settlement lagoons located within the southern section of the Site.

3.2.1.2 The recent sinking of a deep sump to a level of circa 354maOD within Quarry A has necessitated periodic pumped discharge from the Site. This pumped discharge is made via the pre-existing routing and settlement ponds serving the gravity discharge system.

Proposed

3.2.1.3 As with existing workings, operation of the Proposed Development will involve the creation of sump(s) to be formed within the base of the extraction area(s) for the collection of groundwater and rainfall ingress.

3.2.1.4 It is assumed that the current system for pumped discharge of groundwater and surface water ingress will simply be extended to cater for the enlarged quarry. Discharge will continue to be made to the Afon Rhiw via the existing settlement lagoon system located within the southern area of the Site.

3.2.1.5 Groundwater ingress rates associated with pumped dewatering at full extent of the Proposed Development (extraction to 328maOD within Quarry A), have been estimated using methodologies described by Todd and by CIRIA113.

3.2.1.6 Calculation has been performed using literature derived input variables considered appropriate for the strata of the Site; constrained by the water-balance derived estimates of present day groundwater inflow described above.

3.2.1.7 Full details of calculations, including idealised schematic drawdown profiles, are provided at *appendix 5*. A summary of the results of analysis is given below at *table 8*.

Table 8: Predicted Groundwater Ingress Rates at full extent of Proposed Development

Hydraulic Conductivity (m/d)	Calculated Estimate of Groundwater Ingress		Off-Site Discharge Rate (including evacuation of rainfall ingress)	
	m^3/d	l/s*	m^3/d	l/s*
Hydraulic conductivity = 0.508m/d	1,479	17	1,581	18.3
** - assuming 24hr/d/& 365d/a pumping*				

3.2.1.8 Calculation indicates that the total pumping capacity required to dewater the full extent of proposed workings will likely be of the order of 1,600m^3/d (equivalent to an instantaneous rate of 18.5l/s; each rounded-up from calculated values of 1,581m^3/d and 18.3l/s).

3.2.1.9 The discharge rate estimated by calculation accords with experience gained from similar operations elsewhere within the UK, and also compares well with the averaged estimates of current discharge.

3.2.2 Upon Peripheral Lands

Current

3.2.2.1 Other than the establishment of settlement lagoons within the southern section of the Site (for treatment of runoff collecting within and channelled from the quarrying areas), historic / current interaction between Site operations and drainage of lands peripheral to the quarrying areas is limited to the historical culverting of the Western Rhiw Tributary beneath the Waste Stone Tip (*figure 9*).

3.2.2.2 The culverting works, which were undertaken to facilitate formation of the tip across the shallow valley within the north-western area of the Site, are understood to have been undertaken in the early 1990's.

Proposed

3.2.2.3 The water management measures upon lands peripheral to the quarried areas that are required to facilitate the Proposed Development are outlined below.

- The proposed enlargement of the Waste Stone Tip (see *figure 13a*) necessitates the existing 300mm diameter culvert carrying the Western Rhiw Tributary beneath the existing tip to be extended by some 190m.
- Minor re-alignment of the ditch containing the Western Rhiw Tributary within the shallow valley immediately to the north of the extended quarry area.
- Removal of some 350m of existing ditch feeding the headwaters of the Eastern Rhiw Tributary within the shallow valley to the north of the extended quarry area (as a result of the planned northwards expansion of mineral extraction).
- Minor re-alignment of the central ditch feeding the Eastern Rhiw Tributary within the shallow valley immediately to the north of the extended quarry area.
- Contingency for enlargement of existing settlement lagoon system located within the southern Site area.

3.2.3 At Restoration

3.2.3.1 At completion of mineral extraction and restoration, pumped discharge of groundwater and rainfall ingress will cease and all production infrastructure will be removed.

3.2.3.2 Following the cessation of dewatering, the quarry void will become inundated with a combination of groundwater and rainfall water ingress.

3.2.3.3 The concept restoration plan for the Site illustrates a final lake level of circa 368maOD.

3.2.3.4 If required, control of restoration lake levels could be ensured by installation of an overflow splay, discharging to a drainage channel / culvert, to flow southwards, thus connecting with the existing discharge route to the Afon Rhiw.

4 IMPACT ASSESSMENT & MITIGATION MEASURES

4.1 Background

4.1.1 Baseline assessment has facilitated the conceptualisation of the extant groundwater and surface water regimes operating within and around the Site. In turn, this understanding has been utilised to inform assessment of the impacts that are potentially posed by the planned workings upon the water environment.

4.1.2 The process of the design of the Proposed Development has been undertaken with cognisance of the need to minimise impact upon the water environment. Where appropriate, the iterative nature of the EIA process, has allowed for the incorporation of mitigation measures into the design and / or operation of the planned workings. Such elements include, inter-alia, the proposed water management measures.

4.1.3 Where impact assessment has determined it necessary, operational procedures for the minimisation of the risk of impact and / or surveillance monitoring measures are proposed.

4.2 Generic Primary Potential Impacts

4.2.1 As is typical of the majority of quarrying operations of this type and scale, working and subsequent restoration of the Site in the planned manner has the *potential* to impact upon the water environment in the following primary ways:

i. Potential for impact upon Groundwater levels and flow.
ii. Potential for direct derogation of surface water flows & waterbodies.
iii. Potential for direct derogation of groundwater quality.
iv. Potential for direct derogation of surface water quality.
v. Potential for quarry discharge to increase extant flood risk.

4.3 Generic Secondary Potential Impacts

4.3.1 The potential primary impacts outlined above may lead, in-turn, to secondary impacts upon:

i. Potential for indirect derogation of surface water flow rates and / or waterbodies resulting from drawdown of groundwater associated with the proposed dewatering operation.

ii. Potential for impact upon volume of groundwater and / or surface water available for existing and potential abstractions.

iii. Potential for impact upon the quality of groundwater and / or surface water available to existing and potential abstractions.

iv. Potential impact upon floral and / or faunal habitats as a result of flow / quality derogation within surface watercourses / wetland areas.

4.4 Assessment of Potential Primary Impacts

4.4.1 The potential primary impacts upon the water environment associated with the Proposed Development are discussed individually below.

4.4.1 Potential for Impact upon Groundwater Levels and Flow

During Quarrying Operations

4.4.1.1 As discussed previously at *section 3*, the Proposed Development involves enlargement and deepening of the present series of quarry floors to a lowest level of 328maOD. On the basis of the available information, (continued) dewatering of the PGF strata will be required to provide safe and efficient working conditions.

4.4.1.2 Pre-quarrying groundwater levels have been estimated to be circa 370maOD (*section 2.8.2*). On this basis, at full extent of working, the Proposed Development will result in a total groundwater drawdown of some 42m. Groundwater inflow and a lowering of the watertable around the excavations would therefore occur at increased rates and scale than presently prevail.

4.4.1.3 The magnitude of influence upon groundwater levels will diminish with increasing distance from the excavations. The low permeability of the PGF and "compartmentalised" nature of groundwater flow (*section 2.8.2*) will serve to significantly limit the radius of influence of dewatering, creating an extremely steep "cone of depression" centring upon the lowest sections of the quarry floor.

4.4.1.4 Calculations have been performed, using industry standard procedures, to provide estimates of the likely radius of influence upon local groundwater levels.

4.4.1.5 The radius of influence describes the maximum distance from the Proposed Development at which a lowering of groundwater levels may be discerned. Values of

hydraulic conductivity used within the estimation procedure have been taken from standard hydrogeological texts and constrained by water-balance derived estimates of present day groundwater inflow described above (*section 2.7.3*).

4.4.1.6 Calculation has assumed workings at their full proposed lateral extent and at the full design depth of dewatering (some 42m) and therefore represent a worst-case assessment.

4.4.1.7 Calculation indicates a representative radius of influence upon the watertable of some 310m. Full details of calculations are presented at *appendix 5*. The results of calculation are summarised below at *table 9*.

Table 9: Distance-Drawdown associated with Dewatering at full extent of Proposed Workings

	Anticipated drawdown of groundwater from pre-development levels (m)						
	Distance from Quarry Face (m)						
	5	*10*	*40*	*80*	*180*	*250*	*310*
Hydraulic conductivity: 0.508m/d	37.3	35	21.1	14	5.9	2.3	0

4.4.1.8 It should be noted that the adopted analysis method was devised for study and interpretation of intergranular flow systems.

4.4.1.9 Application of the calculation procedure here is reliant upon the generalising assumption that the joint and fracture system of the rock mass may, en-mass, be thought to operate analogously to an intergranular system.

4.4.1.10 The necessary adoption simplifying assumptions within calculation dictates that the analysis results should be taken only as indicative of the likely general hydraulic response to the dewatering operation.

4.4.1.11 It considered that the estimates should be taken as worst-case portrayals of the likely field-situation for the following reasons:

i. the limitations inherent to predictive calculation as described above.

ii. the "compartmentalised" nature of the aquifer (which will serve to limit drawdown across the bedding of strata).

iii. the lack of accounting, within calculation, for loss of hydraulic head due to turbulent flow occurring within a few metres of the seepage face (which will further serve to limit the propagation of groundwater drawdown).

4.4.1.12 The potential for groundwater lowering associated with the proposed dewatering to cause secondary impacts upon the water environment is discussed below at *section 4.5*.

Consideration of Requirement for Planning Controls

4.4.1.13 Whilst groundwater levels are anticipated to be lowered local to the Site during quarrying operations, this is not a matter *per-se* that would generally require or benefit from planning controls.

Following Completion of Quarrying Operations

4.4.1.14 During workings, groundwater will be pumped from the Site, forming a "cone of depression" upon the watertable that will centre upon the pumped sump.

4.4.1.15 At completion of mineral extraction, all quarry plant will be removed and the restoration completed as proposed. Dewatering will be terminated, and the void resulting from quarrying will be allowed to flood with a combination of groundwater and rainfall ingress to create a groundwater lake.

4.4.1.16 The proposed restoration design illustrates an anticipated final lake level of circa 368maOD, being comfortably be accommodated within the perimeter of undisturbed rock forming the restored bowl of the Proposed Development.

4.4.1.17 If required, the proposed restoration design lends itself to the inclusion of a spillway at the 368maOD to 369maOD level in the south-western area of the proposed extension.

4.4.1.18 Off-site discharge made from the restoration lake (via spillway) may be routed, under gravity, through the existing final settlement ponds to enter the Afon Rhiw via the current off-site discharge path.

4.4.1.19 Following restoration, a new groundwater equilibrium will be established, with the level of the groundwater lake being either the amalgam of groundwater levels that prevailed across its area prior to quarrying or at a level limited by the proposed spillway.

4.4.1.20 In view of the scale of development, topographic setting and local meteorological characteristics, evaporative losses from the groundwater lake are anticipated to be negligible.

4.4.1.21 The design area of the proposed restoration lake is some 4.31ha. Computing this area with the previously estimated (*table 5*) rates of effective rainfall for open water areas resolves an increase in average daily evaporative losses for the area of the proposed lake of some 9.4m^3.

4.4.1.22 The anticipated rate of evaporative loss from the restoration lake is equivalent to less than 0.11l/s. Although not a licensable activity, this rate is significantly below the threshold above which licences are generally required (*i.e.* 20m^3/d).

4.4.1.23 The potential for groundwater lowering associated with the proposed restoration lake to cause secondary impacts upon the water environment is discussed below at *section 4.5*.

Consideration of Requirement for Planning Controls

4.4.1.24 In summary, it is considered that there will be no long-term significant impacts upon groundwater levels following attainment of equilibrium pond levels.

4.4.1.25 The depth and radial extent of influence upon the watertable following restoration will be less than has already occurred to date. Furthermore, the impact upon groundwater levels anticipated following completion of quarrying operations is not a matter *per-se* that would generally require or benefit from planning controls.

4.4.1.26 In view of the foregoing factors, planning controls or further mitigation measures are considered unnecessary in this regard. However, PCC MPA may consider it appropriate to request, via formal planning obligation, the supply of further details regarding the contingency provision of an engineered overflow spillway for the regulation and drainage of final restoration lake levels.

4.4.2 Potential for Direct Derogation of Surface Water Flows & Waterbodies

4.4.2.1 The proposed areal enlargement of extraction is negligible when compared with the scale of catchments serving individual watercourses draining the Site area.

4.4.2.2 Working of the Proposed Development will not result in the removal of any reach of any (controlled) surface watercourse or waterbody, albeit that short sections of peripheral ditching will be removed by the proposed northwards extension of mineral extraction.

Consideration of Requirement for Planning Controls

4.4.2.3 In view of the foregoing factors, direct derogation of surface water flow or waterbodies as a result of the Proposed Development is not anticipated. Planning controls or further mitigation measures are thus considered unnecessary with regard to these matters.

4.4.3 Potential for Direct Derogation of Groundwater Quality

4.4.3.1 Potential exists for groundwater quality to be derogated as a result of spillages of potential contaminants (oils, lubricants and solvents) within the proposed working areas and reduction in natural attenuation capacity due to the removal of a section of the unsaturated zone. These matters are discussed separately below.

Accidental Spillages / Long-term Leakage

4.4.3.2 It is important to recognise that the likelihood or consequences of accidental spillage or long-term leakage of potential groundwater contaminants during working of the Proposed Development are no greater than currently prevail at the Site, or, indeed, numerous similar operations sited throughout the region.

4.4.3.3 Quarrying is a historical activity at the Site; the Proposed Development will be carried out in an equivalent manner, and within the same hydrostratigraphic environment, as the historical operations. Therefore, neither the potential scale, nor likelihood of occurrence, of a derogation of groundwater quality will significantly increase as a result of continued workings.

4.4.3.4 Notwithstanding the foregoing, in recognition of the potential for this impact to occur, measures to minimise the risks for contamination of groundwaters during working of the Proposed Development have been formulated. These measures, which comply with EA guidelines (the Oil Care Code), are advanced below.

i. Fuel-oil powered mobile plant shall be restricted to that necessary to undertake mineral extraction, remedial measures and subsequent restoration of the Site.

ii. A code of practice shall be developed for the refuelling and maintenance of machinery. Such work is to be carried out only by trained personnel and takes place within a surfaced area equipped with fluid interceptors.

iii. Any oil storage tanks to be located within the proposed extension should be sited upon impermeable bases enclosed by oil-tight walls. The enclosure should remain at a volume of at least 110% of the capacity of the oil tank and maintained free of accumulations of rainwater.

iv. All fill and draw pipes emanating from oil storage tanks should be provided with locking mechanisms and be contained within the impermeable enclosure.

v. No refuelling or maintenance should be carried out in areas of mineral working.

vi. Operators should check their vehicles on a daily basis before starting work to confirm the absence of leakages. A reporting system should be implemented to ensure that repairs are undertaken to that vehicle before it enters the working area.

vii. Sufficient oil sorbant material (*3M Oil-Sorb* or similar) should be available on Site to cope with a loss equal to the total fluid content of the largest item of plant. Following the use of such oil sorbant material, any contaminated materials should be disposed of from Site in accordance with current waste disposal legislation.

viii. Hydraulic & fuel oil lines on all plant operated within the extraction areas shall be renewed at the manufacturers recommended service intervals to minimise the potential for contamination following failure of hoses or lines.

Consideration of Requirement for Planning Controls

4.4.3.5 Compliance with existing guidance and legislation concerning fluids handling is generally considered appropriate mitigation for the protection of groundwater quality from the potential for accidental spillages / long-term leakage. Therefore, the imposition of additional planning controls is not considered necessary in this regard.

Reduction of Attenuation within the Unsaturated Zone

4.4.3.6 The unsaturated zone controls the rate at which rainfall recharge contributes to groundwater. Natural attenuating processes within the unsaturated zone can reduce potential contaminant concentrations prior to entry to the watertable.

4.4.3.7 Within fractured and jointed strata such as the PGF of the Site, the importance of the unsaturated zone for attenuation is lessened by the relatively rapid transit times

afforded by the fracture system of the rock. Furthermore, the volume of unsaturated zone that will be removed as a result of the Proposed Development is extremely limited in relation to the overall outcrop area of the strata. Thus, in terms of the overall groundwater catchment, the rate of groundwater recharge from rainfall will not be discernibly changed by the Proposed Development.

Consideration of Requirement for Planning Controls

4.4.3.8 In view of the foregoing, it is considered that the Proposed Development will not significantly impact upon the current attenuating capacity offered by the unsaturated zone, and thus that mitigation measures / planning controls are unnecessary in respect of this potential impact.

4.4.4 Potential for Direct Derogation of Surface Water Quality

4.4.4.1 Potential exists for derogation of surface water quality from:

i. accidental spillage / long-term leakage of potentially contaminating substances associated with the quarrying operation (fuels, lubricants and solvents) within the working area of the Proposed Development.

ii. mobilisation of suspended solids.

4.4.4.2 The potential routes of entry for contaminants to enter the surface water system include:

i. gravity / pumped discharge from the Site to the Afon Rhiw

ii. natural groundwater discharge under gravity to the Afon Rhiw to the south of the Site.

4.4.4.3 It is considered that the measures proposed above for the protection of groundwater quality from the risk of accidental spillages of fuels, lubricants and solvents (*section 4.4.3*) will provide appropriate protection from the potential impact upon the Afon Rhiw from either direct overland discharge or from the Site and / or baseflow input from groundwaters flowing beneath / adjacent the Site.

4.4.4.4 As at present, suspended solids loadings within discharge to the Afon Rhiw will be removed from the final discharge by treatment within the existing settlement lagoons located within the southern section of the Site.

4.4.4.5 Due to the mechanical filtering inherent to groundwater flow, significant loadings of suspended solids are not anticipated within diffuse groundwater discharge to surface watercourses.

Consideration of Requirement for Planning Controls

4.4.4.6 In view of the foregoing, further mitigation measures / planning controls are considered unnecessary in respect of the potential for derogation of surface water quality.

4.4.5 Potential for Quarry Discharge to Increase Extant Flood Risk

4.4.5.1 As with the current operations, the working of the Proposed Development will require off-site discharge of groundwater and surface water to be made, via the existing settlement system, to the Afon Rhiw to the south of the Site.

4.4.5.2 Due to the proposed enlargement and deepening of the quarry, the rate of off-site discharge will increase. Thus the *potential* exists for the Proposed Development to increase the extant risk of flooding within the Afon Rhiw downstream of the Site.

4.4.5.3 The impact of the Proposed Development upon existing flooding risk is discussed below. Assessment has been undertaken for both average and storm conditions.

Average Conditions

4.4.5.4 Estimates have been made of the average discharge rate required to maintain dry working conditions at maximum extent of the Proposed Development (*table 8*).

4.4.5.5 Calculation indicates a likely daily average discharge requirement of circa 1,600m^3 (18.5l/s). Whilst this is a relatively modest rate, it does represent an increase of some 12.25l/s over the current discharge.

4.4.5.6 Under average conditions the increased rate of quarry discharge will be matched by a broadly corresponding decrease in the rate of groundwater that naturally discharges to the Afon Rhiw (the dewatering activity serving to intercept, or "short-circuit", groundwater that would otherwise have drained to the watercourse).

4.4.5.7 Under average conditions, the "short-circuiting" of the existing system will introduce no additional volumes into the local water environment and thus will not place any additional stress upon the receiving watercourse.

Storm Conditions

4.4.5.8 An assessment has been made of the implications for off-site discharge and quarry operations of the increased ingress of rainfall under storm conditions. The procedure adopted for assessment is described by National Coal Board document: "Technical Management of Water in the Coal Mining Industry".

4.4.5.9 The assessment procedure comprises a combination of recommendations made within the Flood Studies Report and research performed by Ragan & Duru and has been widely applied to inform design of water management systems within the quarrying industry.

4.4.5.10 The assessment procedure recognises that provision of settlement capacity sufficient for peak flow (storm) events is seldom practical or economic; the area required for settlement of runoff during storm conditions often far exceeding that which is available. This is addressed by determination of the appropriate storm attenuation volume (or "storm balancing" volume).

4.4.5.11 The principle of storm attenuation is thus one of containment of peak discharges upon site for discharge at a controlled rate following abatement of storm conditions.

4.4.5.12 Enumeration has been undertaken assuming a 1 in 100 year storm event and performed for Phases 1 through to 3 collectively and Phase 4 individually. An outline of the assessment procedure is given below.

i. Assessment of physical characteristics of the catchment and calculation of the Time of Concentration attributable to it.

ii. Calculation of the Peak Flow Rate from the catchment.

iii. The assumption that off-site discharge will continue to be made at circa 18.5l/s (*i.e.* no more that the average rate determined by calculation [*table 8*]).

iv. Calculation of the required Attenuation Storage, using site-specific depth-duration-frequency rainfall statistics taken from the Flood Estimation Handbook CD-ROM No.3.

Phases 1 through to 3

4.4.5.13 Details of the numerical assessment undertaken to determine the required storm attenuation for Phases 1 through to 3 of the Proposed Development are tabulated at *appendix 6*; the results of which are summarised below.

i.	Design Storm Return Period:	100 years.
ii.	Peak flow rate during design storm:	1,789l/s.
i.	Maximum off-site discharge rate[1]:	18.5l/s.
ii.	Required storm attenuation volume:	7,188m^3.

4.4.5.14 Thus, adopting the Design Storm (*i.e.* 1 in 100 year return period), and assuming discharge at some 18.5l/s, an attenuation volume of some 7,188m^3 will be required.

4.4.5.15 It is assumed that the required attenuation capacity will be provided in the form of freeboard within the basal sump of the quarry. Assuming sump of dimensions 30m x 25m, a free-board depth of some 9.6m would be required to provide the required storage.

Phase 4

4.4.5.16 As with Phases 1 through to 3, details of the numerical assessment undertaken to determine the required storm balancing storage for Phase 4 are tabulated at *appendix 6*; the results of which are summarised below.

i.	Design Storm Return Period:	100 years.
ii.	Peak flow rate during design storm:	2,568/s.
iii.	Maximum off-site discharge rate:	18.5l/s.
iv.	Required storm attenuation volume:	15,646m^3.

4.4.5.17 Adopting a 1 in 100 year return period storm, and assuming discharge at some 18.5l/s, an attenuation volume of some 15,646m^3 will be required.

[1] To ensure adequate settlement – set at the anticipated average off-site discharge rate, quarry management having reported no systematic problems with the quality of discharge achieved historically at the Site

4.4.5.18 Assuming the required attenuation capacity will be provided within a basal sump of dimensions 45m x 35m, then a free-board depth of some 10m would be required.

Discharge of Attenuated Storm Water

4.4.5.19 Off-site discharge of the stored volume would be made in the usual manner using the pumped discharge system at a controlled rate following abatement of storm conditions.

Concluding Commentary

4.4.5.20 Numerical assessment of the proposed drainage system, made using industry standard procedures, has demonstrated that the proposed quarry design has ample scope to accommodate sufficient attenuation capacity for rainfall ingress during rainfall events up to, and including, a 1 in 100 year storm.

4.4.5.21 The sensitivity of flooding risk within the Afon Rhiw to the anticipated discharge rate of 18.5l/s under storm conditions is unknown. However, any potential risk may be satisfactorily ameliorated by attenuation of storm runoff within the quarry and / or management of the dewatering system to curtail or suspend off-site pumping when the watercourse is in spate.

Consideration of Requirement for Planning Controls

4.4.5.22 In view of the foregoing, further mitigation measures / planning controls are considered unnecessary with respect to the potential for quarry discharge to impact upon extant downstream flood risk.

4.4.6 Implications for Flooding associated with the Proposed Extension of the existing Waste Stone Tip Culvert

4.4.6.1 As described (*section 3.2.2)*, enlargement of the Waste Stone Tip (*figure 13a*) will require the existing 300mm diameter culvert carrying flow beneath the tip to be extended by some 190m. The implications for extant flood risk of this proposal are discussed and evaluated below.

Culvert Performance under Average Rainfall Conditions

4.4.6.2 The catchment area draining to the existing culvert inlet is modest, measuring some 11.24ha.

4.4.6.3 Computing a simple Catchment Area x Standard Average Annual Rainfall calculation resolves an average instantaneous runoff feeding the culvert of some 4.1l/s (equating to 354.3m^3/d, and of the order of flow estimation made during field survey undertaken November 2012).

4.4.6.4 Applying the standard Hazen-Williams formula, indicates the theoretical carrying capacity of the existing culvert to be some 98l/s (assuming a roughness coefficient appropriate for concrete and an existing surveyed fall of 1m over 100m).

4.4.6.5 The results of calculation accord with site experience, that the existing culvert configuration has ample capacity to convey rainfall runoff under average conditions.

4.4.6.6 Application of the Hazen-Williams formula assuming extension of the culvert by 190m as proposed, yields a theoretical carrying capacity of some 116l/s (again assuming a roughness coefficient appropriate for concrete and design a fall of 4m over 290m).

4.4.6.7 Calculation indicates that the present configuration is capable of conveying some 24 times more than the average runoff generated by the catchment. The proposed configuration, involving extension of the culvert by 190m, would be capable of carrying over 28 times the average catchment runoff.

Culvert Performance under Storm Conditions

4.4.6.8 A spreadsheet based numerical model has been developed to examine the performance of the culvert, in its existing and proposed configurations, under 1 in 100-year return storm conditions. The model resolves the following:

- Determination over a series of discrete time-steps of the rainfall runoff generated by the catchment that drains to the culvert (*i.e.* the "runoff hydrograph" for the culvert intake). This is calculated using the "NCB Procedure" (which is based upon the Flood Studies Report Rational Procedure), and adopting catchment characteristics taken from topographic

mapping, industry standard nomograms describing runoff coefficients for various surface types and rainfall intensity data taken from the Flood Estimation Handbook CD-ROM No.3.

- Calculation of the carrying capacity of the culvert (Hazen-Williams formula).
- Calculation of the volume of water retained (ponded) upstream of the culvert (the runoff generated during early stages of the design storm being far in excess of the capacity of the culvert; in either its present or proposed configurations), using the same time-stepping scheme as used to determine the runoff hydrograph.
- Calculation of the volume of seepage through the base of the tip that may be anticipated as a result of the retention of a head of water at the culvert inlet (calculated using Darcy's Law and an assumed value of hydraulic conductivity for the unconsolidated material comprising the tip), again, using the same time-stepping scheme as used to determine the runoff hydrograph.
- Calculation of the area and depth of ponding arising from the holding-back of rainfall runoff generated in excess of the carrying capacity of the culvert (based upon the geometry of the land surrounding the culvert inlet, as established from detailed topographic survey), using the same time-stepping scheme as used to determine the runoff hydrograph.

Current Culvert Configuration

4.4.6.9 The model indicates that under 1:100-year return storm conditions the present culvert configuration would have insufficient capacity to convey storm runoff.

4.4.6.10 The model indicates that the volumes of rainfall runoff generated in excess of the carrying capacity of the culvert would lead to the backing-up, at the culvert intake, of a maximum of approximately 3,322m^3 of impeded runoff with an associated maximum ponding depth of some 2.84m.

4.4.6.11 The model indicates that peak retention would occur some 210 minutes following commencement of the design storm, inundating an area of some 1,942m^2 and requiring a further 17.75 hours to drain-down.

Proposed Culvert Configuration

4.4.6.12 Modelling analysis carried out for the proposed culvert extension suggests a peak retained volume at the culvert intake under design storm conditions of some 3,122m^{3,} with an associated maximum ponding depth of some 2.77m.

4.4.6.13 The model indicates that peak retention would occur some 165 minutes after commencement of the design storm, inundating an area of approximately 1,880m^2 and requiring a further 14.5 hours to drain-down.

Implications of Inundation at Culvert Intake during Peak Storm Events

4.4.6.14 The results of the numerical modelling exercise are described in full at *appendix 7*, which also shows the areas of predicted inundation at the culvert intake for present and proposed configurations under 1:100-year return period storm conditions.

4.4.6.15 The results of modelling indicate that the proposed extension of the culvert would, by virtue of the greater fall associated with the proposal, marginally decrease the periodicity and magnitude of backing-up of runoff around the intake.

4.4.6.16 For either the current or proposed culvert configurations, the modelled depth, residence-time and area of anticipated inundation (as illustrated at *figures A7.1* and *A7.2*) are considered to be insignificant given the agricultural use of the land.

4.4.6.17 The "backing-up" of storm runoff at the culvert intake, as predicted by the model, is considered to be of benefit to downstream flood risk, as the finite capacity of the culvert intake effectively lends additional attenuation capacity, albeit marginal, to the local fluvial system.

Sustainability of Culvert

4.4.6.18 The numerical model described above has also been applied to determine the retention volumes, heads, inundation area and residence times associated with a major degradation of culvert carrying capacity (*i.e.* due to blockage or collapse) coinciding with a 1 in 100-year storm.

4.4.6.19 Assuming the carrying capacity of the culvert were reduced to 5% of design flow (*i.e.* 4.9l/s and 5.8l/s for the current and proposed culvert configurations respectively), the model predicts maximum retained volumes of some 8,529m^3 /

8,225m^3 at a ponded depth of 4.15m / 4.09m after 105.25 hours (4-days : 9.25 hours) / 92.25 (3-days : 20.25 hours) hours and a further time to total drainage after attainment of these peaks of some 28-days / 24-days.

4.4.6.20 The areas of inundation predicted by the model to be associated with these scenarios are 3,393m^2 and 3,314m^2 for the current and proposed culvert configurations respectively (*figures A7.3* and *A7.4*, *Appendix 7*).

Consideration of Alternatives

4.4.6.21 Potential alternatives to the proposal to extend the Waste Stone Tip culvert have been considered, including;

- *Re-alignment of the Western Rhiw Tributary upstream of the culvert intake to divert flow around the northern head of the Waste Stone Tip.* This option would not be effective. This is because the prevailing topography would require the diversion to be affected a considerable distance upstream of the culvert intake, leaving some 90% of the catchment to drain to the culvert.

- *Re-alignment of the Western Rhiw Tributary immediately upstream of the culvert intake, to drain southwards, via sub-horizontal borehole, into the completed restoration.* Whilst this option would give opportunity of capturing almost all runoff currently draining to the existing culvert, it would require, by means of angled borehole, the installation of a culvert-like structure, and therefore has no meaningful advantage over the current proposals. However, of this option should be retained as a contingency measure, to be applied in the event of a total failure of the existing / proposed Waste Stone Tip culvert. Drainage of the Western Rhiw Tributary made into the restored Site in this manner would eventually discharge into the Afon Rhiw as part of the contingency drainage proposals made in respect of the final restoration of the Site (*section 3.2.3*).

- *Excavation and removal of tip material to re-instate the historical open channel ditch carrying the Western Rhiw Tributary.* Given the lack of significant impact associated with either the existing or proposed culvert configurations (as demonstrated by numerical modelling), the benefits that

would be gained by excavation of the tip and re-instatement of the historical channel are considered unjustifiable, either economically or in terms of the considerable expenditure of natural energy resources associated with this option.

Concluding Commentary

4.4.6.22 Numerical modelling has been applied to examine the implications of proposals to extend the existing Waste Stone Tip culvert have indicated that such an extension will have no adverse impact upon the existing drainage capacity of the culvert under average or storm flow conditions.

4.4.6.23 Neither the depth, extent or residence time of ponding at the culvert intake associated with temporary retention (attenuation) of 1:100-year storm flows predicted by the model are considered to be significant given the agricultural setting of the area.

4.4.6.24 It should be noted that modelling has been performed assuming present-day catchment characteristics. This lends a conservative approach to prediction, as the significant ameliorating effect of catchment reduction that will be affected by the quarry extension have been ignored.

4.4.6.25 The proposed northward extension to the existing quarry will reduce the catchment area draining to the Waste Stone Tip culvert inlet by 2.7ha. This represents to almost 25% of the entire catchment currently draining to the culvert.

4.4.6.26 Re-running the numerical model to account for the reduction in catchment area that will be affected by the quarry extension indicates that for the extended culvert configuration, residence times for ponding at the intake reduce from the previously predicted 14.5 hours to 10.25 hours. The predicted area of inundation is reduced from 1,880m^2 to 1,562m^2 and the ponded depth reduced from 2.77m to 2.38m.

4.4.6.27 The results of numerical analysis undertaken in respect of the current and proposed configurations of the Waste Stone Tip culvert are summarised below at *table 10*.

Table 10: Waste Stone Tip Culvert: Summary Results of Hydrometric Modelling					
		Assuming Operation at Design Efficiency		Assuming Operation at Diminished Efficiency (5%)	
Rainfall Conditions		Current Configuration	Proposed Configuration	Current Configuration	Proposed Configuration
Average		24 x Required Capacity	27 x Required Capacity	1.2 x Required Capacity	1.41 x Required Capacity
1:100-yr Storm	Ponded Depth (m)	2.84	2.77	4.15	4.09
	Ponding Volume (m^3)	3,332	3,122	8,529	8,225
	Ponding Area (m^2)	1,942	1,880	3,393	3,314
	Time to Peak Retention	210 mins	165 mins	4-days:9.25hrs	3-days:20.25hrs
	Time to Drain	17.75 hours	14.5 hours	28-days	24-days

Consideration of Requirement for Planning Controls

4.4.6.28 In view of the foregoing and the potential for blockage / failure of both the existing and proposed configurations of the Waste Stone Tip culvert, PCC MPA may wish to give consideration to additional planning controls to ensure that the tip extension be founded upon granular free-draining material. This will ensure that the tip's south-western slope is not destabilised by the generation of steep head gradients (high pore-water pressures) within and above the toe of the tip.

4.5 Assessment of Potential Secondary Impacts

4.5.1 The potential for primary impacts upon the water environment associated with the Proposed Development to cause secondary effects upon groundwater and / or surface water dependant features are discussed individually below.

4.5.1 Potential for Indirect Derogation of Surface Water Flow Rates and / or Waterbodies resulting from Drawdown of Groundwater

4.5.1.1 The lowering of groundwater levels associated with the planned dewatering of the Proposed Development, and, to a lesser extent, the long-term re-adjustment of the local groundwater gradient following establishment of the restoration lake, have the *potential* to affect natural discharge of groundwater to either local watercourses and / or surface waterbodies.

During Quarrying Operations

4.5.1.2 Estimates of the likely radius of influence upon groundwater associated with dewatering of the quarry have been made previously (*table 9*). Of the surface watercourses and waterbodies identified by survey, only the Afon Rhiw to the south

of the Site is considered to both be in continuity with groundwater and within the anticipated zone of groundwater lowering.

4.5.1.3 The dewatering operation is likely to intercept a proportion of groundwater presently discharging under gravity as seepage to the Afon Rhiw. However, all groundwater and rainfall ingress to the quarry will be discharged to the watercourse, effectively short-circuiting the pre-existing flow system. Therefore, there will be no significant alteration to the extant average rate of groundwater input to the watercourse.

4.5.1.4 The foregoing factors, together with the relatively minor component of overall flow within the watercourse that is sourced from the adjacent section of PGF, dictate that although groundwater levels and flow will be impacted by the proposed dewatering operation, there will be no discernable impact upon the flow regime of the Afon Rhiw.

Consideration of Requirement for Planning Controls

4.5.1.5 In view of the above, significant indirect derogation of surface water flow or waterbodies resulting from the working of the Proposed Development is not anticipated. Planning controls or further mitigation measures are thus considered unnecessary.

Following Completion of Quarrying Operations

4.5.1.6 At completion of mineral extraction, dewatering will be terminated, and the quarry void allowed to flood with a combination of groundwater and rainfall ingress, to create a groundwater lake.

4.5.1.7 As described (*section 4.4.1*), the long-term impact upon local groundwater levels following quarry restoration is anticipated to be small. This factor, coupled with the absence of watercourses or waterbodies within the anticipated equilibrium radius of influence, dictates that there are likely to be no effects upon such features associated with longer-term groundwater level adjustment.

Consideration of Requirement for Planning Controls

4.5.1.8 In view of the above, significant indirect derogation of surface water flow or waterbodies following restoration of the Proposed Development is not anticipated. Planning controls or further mitigation measures are thus considered unnecessary.

4.5.2 Potential for Impact upon Volume of Groundwater and / or Surface Water available for Existing and / or Potential Abstractions

During Quarrying Operations

4.5.2.1 The water management measures associated with the Proposed Development, including the planned dewatering, are all non-consumptive processes. Therefore the will be no impact upon the volumes of water potentially available to for new abstractions (albeit that the temporary lowering of groundwater associated with the operational phase of the Proposed Development may require deeper drilling than might otherwise be the case, for example, should a new and very local supply source be required).

4.5.2.2 The results of assessment into the effect of quarry dewatering upon extant groundwater levels (*table 9*) have been used to inform evaluation of the likely impact of quarrying upon existing groundwater and / or surface water sourced abstractions.

4.5.2.3 The EA have confirmed an absence of any licensed abstractions within 4km of the Site. There is therefore no potential for the Proposed Development to impact upon licensed abstraction.

4.5.2.4 Information from PCC indicates the following unlicensed abstractions within the calculated radius of influence of dewatering (Tan-Y-Foel quarry abstractions omitted).

Table 11: Unlicensed Abstractions Within Calculated Radius of Influence upon Groundwater

Site Name	NGRx	NGRy	Distance from Closest Sections of Current / Proposed Quarrying (m)	Type	Map Code *(figure 12)*
Fuches Goch	301153	301201	190	Well	24
Rhyd y Biswal	300922	301386	215	Spring	23
Gwaun y Maglau	301786	301981	245	Well	29
The Barn Waenyfigyn	301819	301266	330	N/R	30
Y Ty Waenyfigyn	301824	301260	340	Well	31

Consideration of Requirement for Planning Controls

4.5.2.5 As described (*section 4.4.1*), the calculated radius of influence upon groundwater levels is interpreted to be a worst-case estimate of likely field conditions. However, in view of the close proximity of several existing unlicensed sources to the Proposed Development, it is considered prudent to initiate a programme of level monitoring for these abstractions, to be operated concurrent with mineral extraction. Such a programme would typically be regarded as an appropriate matter for enforcement via planning controls, either by way of planning condition, or Section 106 Agreement.

Following Completion of Quarrying Operations

4.5.2.6 As described (*section 4.4.1*), the scale of long-term impact upon groundwater levels following completion of quarrying operations is anticipated to be small. The extent to which such lowering will propagate from the restoration lake is limited, such that all existing abstractions lie outside the anticipated equilibrium radius of influence upon the watertable.

Consideration of Requirement for Planning Controls

4.5.2.7 In view of the above, planning controls or further mitigation measures are considered unnecessary with regard to the potential for post-restoration impact upon potential or extant groundwater and / or surface water sources.

4.5.3 Potential for Impact upon Quality of Groundwater and / or Surface Water Available to Existing and Potential Abstractions

4.5.3.1 The factors and measures described previously (*sections 4.4.3* and *4.4.4*) are considered to provide appropriate mitigation with respect to the protection of groundwater and surface water quality available to existing and potential abstraction sources.

Consideration of Requirement for Planning Controls

4.5.3.2 In view of the above, further mitigation measures or planning controls are considered unnecessary in respect of the potential for impact upon the quality of exploitable groundwater and / or surface water resources.

4.5.4 Potential for Impact upon Aquatic Ecology / Designated Sites of Ecological Interest

4.5.4.1 As the Proposed Development has been judged to pose no significant threat to either the volumes or quality of surface water flow or surface waterbodies, there is considered to be no mechanism by which aquatic ecology may be adversely affected.

Consideration of Requirement for Planning Controls

4.5.4.2 In view of the foregoing, specific mitigation measures and / or planning controls are considered unnecessary in this regard.

5 SUMMARY & CONCLUSIONS

5.1 The potential for continued working and restoration of HV Bowen & Sons' Tan-Y-Foel Quarry (the Site) to impact upon the water environment has been assessed as part of proposals for the regularisation, lateral extension and deepening of existing operations (the Proposed Development). The Proposed Development is to be the subject of a Planning Application (the Application), which will also seek approval for the provision of new planning conditions for the governance of operations at the Site in accordance with the Review of Old Mineral Planning Permissions procedure (ROMPP; Environment Act 1995).

5.2 Quarrying operations are already undertaken at the Site. The Proposed Development represents a spatial and temporal extension of current working methods, summarised as follows:

i. retention of the existing stocking area, ancillary development and associated concrete batching plant.

ii. the deepening of the Quarry by one additional bench.

iii. the regularisation of the existing site boundary.

iv. extension of the existing peripheral Waste Stone Tip (part retrospective).

5.3 The Site is centred upon NGR $^{3}013$, $^{3}015$; some 3.8km south-southwest of the hamlet of Cefn Coch, 22km south-southwest of Welshpool, Powys. The Site occupies an area of approximately 40 hectares (ha), comprising three principal quarrying areas (Quarries "A", B" and "C"), mineral processing plant. offices, weighbridge, mineral stockpiling and water settlement areas, together with a Waste Stone Tip which is located within the north-western area of the Site. Quarries A and B are worked in a north-easterly direction; in accordance with the geological strike of the strata. Recycling and stockpiling of inert construction and demolition materials is undertaken within Quarry C. The economic mineral extracted at the quarry is gritstone. belonging to the Silurian Penstrowed Grits Formation (PGF). The economic mineral is interbedded with shale, siltstones and mudstones. These materials, which comprise some 20% to 30% of stone extracted at the quarry, are not of saleable quality and are therefore discarded within the Waste Stone Tip.

5.1.1.1 The Site is situated within an upland catchment of the eastward flowing Afon Rhiw, a tributary of the River Severn. The Afon Rhiw flows from north-west to south-east, bordering the southern boundary of the Site. Two minor tributaries of the main watercourse drain the Site area (the "Western" and "Eastern Rhiw Tributaries"). The Western Rhiw Tributary has its headwaters within open moorland to the north of the Site. The watercourse is carried within a cut ditch and culverted via 300mm concrete pipe for some 100m beneath the Waste Stone Tip, emerging to a ditched channel which conveys flow to the Afon Rhiw upon the Site's south-westernmost boundary. The Eastern Rhiw Tributary coalesces from diffuse drainage to the north of the Site, flow being made south-eastwards to discharge to the Afon Rhiw some 2.45km to the east. The entire Site resides within Flood Risk Zone (FRZ) 1, implying a likelihood of flooding each year of 0.1% or less (*i.e.* > 1 in 1,000-year return period).

5.4 Quarry drainage is discharged to the Afon Rhiw under EA Consent No. S/01/55291/T. The discharge is made southwards under gravity from a shallow collector sump within Quarry A, via a sub-horizontal borehole to the east of the Site offices, through settlement lagoons within the southern section of the Site. This drainage is periodically augmented by pumped discharge from a deeper sump contained within the lowest sinking of Quarry A. Water balance estimates made for 2012 indicate an average daily discharge of circa 540m^3/d, comprising some 440m^3/d of groundwater and approximately 100m^3/d of rainfall ingress.

5.5 The PGF of the Site and surrounding area possess extremely limited primary porosity and modest to negligible intergranular permeability and are defined as a "Secondary Undifferentiated" aquifer by the EA (formerly termed either "minor aquifer" or "non-aquifer", characterising lower permeability rocks, capable of storing and yielding only limited amounts of groundwater). The PGF is considered to operate as a series of semi-isolated aquifer blocks. Groundwater flow is anticipated to be concentrated within the sandier sequences of the formation, these being separated by lower permeability argillaceous strata. Assessment (which has included the drilling of two dedicated groundwater observation boreholes and initiation of a programme of groundwater monitoring at several local observation points) has concluded that the pre-quarrying level of groundwater within the PGF was some 370maOD, workings having penetrated the watertable during the mid 1970's. The general floor of Quarry

A has progressed to a depth of some 7m below this level, the deeper sump extending to some 16m below undisturbed groundwater level within the PGF. There are no licensed groundwater abstractions (or Source Protection Zones) within 4km of the Site. Seven unlicensed private groundwater dependant supplies have been elucidated within 650m.

5.6 The deepest current floor level at the Site resides at some 363maOD. The Proposed Development involves deepening within Quarries A, B and C, over a series of 11m to 12m high benches, in a general north-westerly direction to a lowest level of 328maOD. As at present, future working will involve the use of conventional drilling and blasting techniques. Expansion of the Waste Stone Tip is required to accommodate the significant quantities of non-saleable aggregate that will be produced. This will require extension of the pre-existing culvert, from its current length of 100m to an extended length of some 290m. The current mode of site drainage will be continued to maintain safe and efficient working conditions. During the operational phase of the Proposed Development, and as workings deepen, the periodic pumping of groundwater and rainfall ingress presently undertaken from the deeper sump of Quarry A will become a permanent requirement. At completion of quarrying, pumped discharge will cease and the quarry void will become inundated with a combination of groundwater and rainfall ingress to form a restoration lake that will be in continuity with groundwater contained within the surrounding PGF. No processes or prescribed activities additional to those already undertaken at the Site are proposed as part of the Proposed Development.

5.7 Impact assessment has examined the following primary impacts (and, in addition, several associated secondary impacts):

i. Potential for impact upon Groundwater levels and flow.
ii. Potential for direct derogation of surface water flows & waterbodies.
iii. Potential for direct derogation of groundwater quality.
iv. Potential for direct derogation of surface water quality.
v. Potential for quarry discharge to increase extant flood risk.

5.8 Assessment has involved hydrometric evaluation of several aspects of the Proposed Development, including:

i. Calculated estimation of the likely average off-site discharge rate that will be associated with expansion and deepening of the quarrying areas.

ii. Calculated estimates of the likely radius of influence upon groundwater associated with the proposed deepening and expansion of the quarried areas.

iii. Evaluation of the requirements for attenuation storage to minimise of off-site flooding risk (in view of the likelihood of increasing groundwater ingress as quarrying deepens).

iv. Evaluation of the implications of the proposed extension of the Waste Stone Tip culvert.

5.9 Assessment concludes that the planned workings will, as at present, continue to progress deeper beneath the watertable contained within the PGF. At full quarry development, workings are anticipated to extend to a final depth of some 42m below the pre-quarrying level of groundwater. Calculation indicates a worst-case radius of influence upon groundwater levels of some 310m, the magnitude of groundwater lowering diminishing with increasing distance from the Site. Calculation indicates a dewatering pumping requirement at full extent of proposed workings in the order of 1,600m^3/d (equivalent to an instantaneous rate of 18.5l/s, representing an increase of some 12.25l/s over the existing estimated average rate of 6.5l/s [based upon water balance estimates carried out upon data from 2012]). At completion of quarrying, dewatering will be terminated and groundwater levels allowed to return to a level approximating to pre-quarrying levels. The radius of influence upon groundwater following establishment of restoration equilibrium levels is anticipated to be small. Calculation indicates that evaporative losses from the restoration lake will be minimal (and, although not a licensable activity, well below the current "licensing threshold" of 20m^3/d). Secondary impacts of groundwater lowering, upon existing or potential groundwater supported sources or ecological features, are not anticipated.

5.10 Measures for the protection of both groundwater and surface water quality have been advanced. Where appropriate, the efficacy of these measures have been evaluated using industry standard procedure. The results of assessment indicates exceedance of accepted standards which gives confidence in the likely performance of the proposed systems.

5.11 The potential for increasing extant downstream flood risk associated with the requirements for off-site discharge has been examined. Assessment, which has

involved hydrometric evaluation of both average and 1:100-year storm conditions, concludes that provision of attenuation storage ("balancing storage") within the quarry areas will provide appropriate and satisfactory mitigation in this regard. The requisite volumes of attenuation storage have been calculated and presented.

5.12 The implications for extant flood risk of the proposals to extend the existing culvert beneath the Waste Stone Tip have been examined in detail. This has included examination of the performance of both the existing and proposed culvert configurations under average and 1:100-year storm conditions. Numerical evaluation has been extended to examine the consequences of significantly diminished carrying capacity in the event of collapse or blockage of the culvert. Alternatives to the proposed culvert extension have also been considered and their efficacy assessed. Numerical modelling indicates that the proposed culvert extension will have no adverse impact upon the existing drainage capacity of the system under either average or storm flow conditions. In addition, neither the depth, extent nor residence time of ponding at the culvert intake predicted by modelling of 1:100-year storm conditions are considered of significance given the agricultural setting of the area.

5.13 In view of the findings of this Assessment, there are considered to be no over-riding hydrogeologically or hydrologically based reasons why the planned development should not proceed in the manner described by the Application. This conclusion is made on the basis that any permission, if granted, should be conditioned by implementation and adherence to any relevant recommendations advanced within this report and other such conditions that may be reasonably imposed by the Planning Authority.

Consideration of Requirements for Planning Controls: Summary

5.14 In accordance with the requirements of the Environment act 1995 (the ROMPP element of the Application) and on the basis of the findings of impact assessment, consideration has been given to the provision of planning controls for the appropriate regulation of the Proposed Development for protection of the water environment, as summarised below:

i. PCC MPA may consider it appropriate to request, via formal planning obligation, the supply of further details regarding the contingency provision of

an engineered overflow spillway for the regulation and drainage of final restoration lake levels.

ii. Provision of further details describing the foundation and sub-drainage of the proposed Waste Stone Tip extension (given the potential for blockage / failure of both the existing and proposed configurations of the Waste Stone Tip culvert). It is recommended that the tip extension be founded upon granular free-draining material. This will ensure that the tip's south-western slope is not destabilised by the generation of steep head gradients (high pore-water pressures) within and above the toe of the tip.

iii. Provision of a scheme of monitoring, allied to contingency mitigation, for the protection of existing groundwater sources within the vicinity of the Site (as described at *table 11*).

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6th August 2013

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HV Bowen & Sons

Tan-y-Foel Quarry
Cefn Coch, Welshpool, Powys

Planning Application for a new quarry waste stone tip (partly retrospective), regularisation of use, quarry deepening and retention of existing permitted quarrying site for the purposes of the Environment Act 1995 Review (ROMPP)

Hydrogeological & Hydrological Impact Assessment

Appendices

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Hydrogeological & Hydrological Impact Assessment

Appendix 1: Figures

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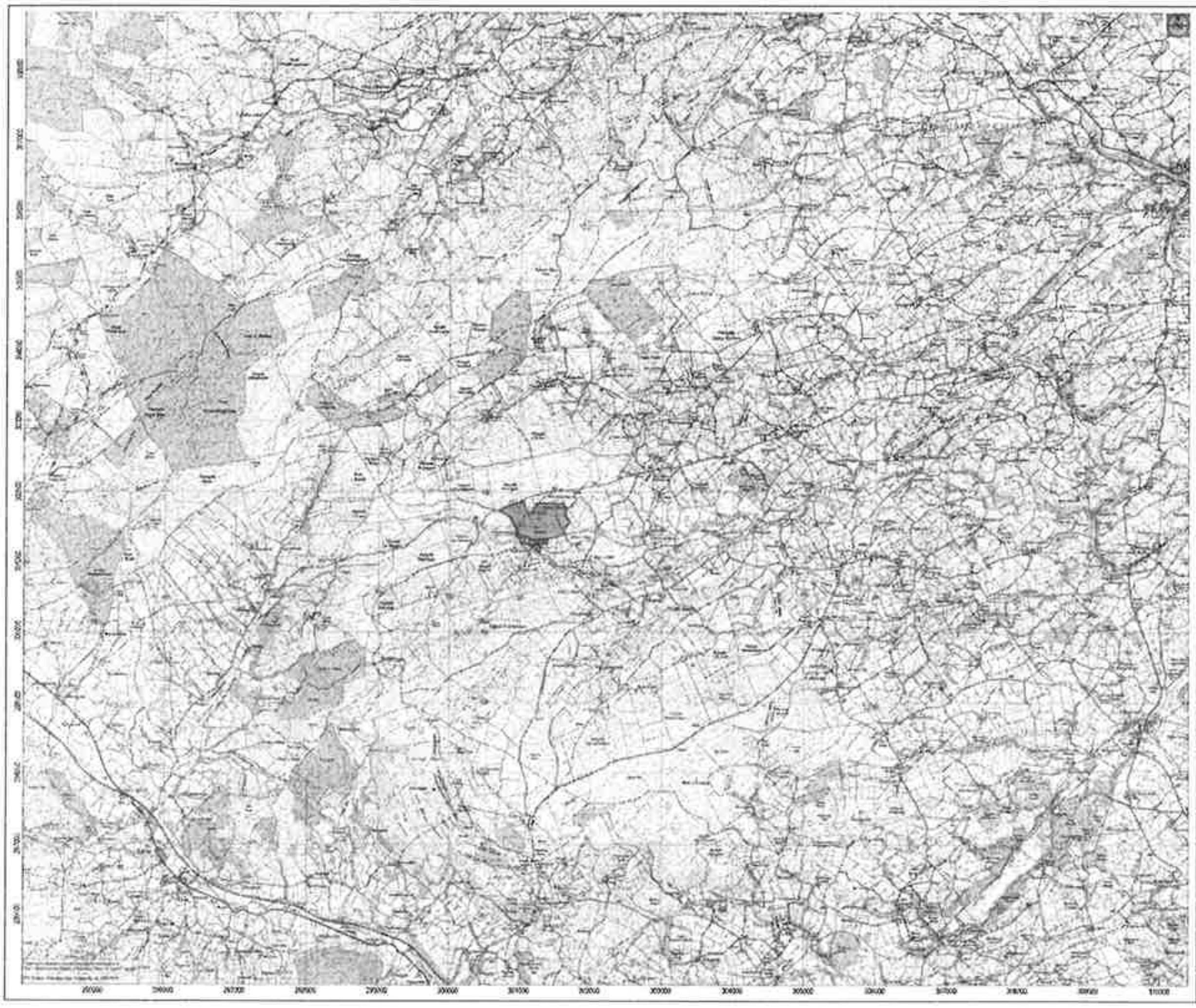

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Hydrogeological & Hydrological Impact Assessment

Site Location

Drawn By:	GC	Scale:	1:50,000
Date:	06/08/13	Figure No.	1