14. HYDROLOGY, HYDROGEOLOGY, FLOOD RISK AND DRAINAGE

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Introduction

Background

14.1 Trefil Quarry is located about 4 km to the northwest of Tredegar, and about 300 m north of Trefil village, in Gwent. The quarry has been used for limestone extraction since the 19th century until quarry operations ceased in the mid-1950s. The quarry was reopened in 1994 by Gryphonn and currently covers an area of 29.5 ha.

14.2 Gryphonn Quarries Ltd ("Gryphonn") is submitting a planning application to extend the existing Trefil limestone quarry to include a northern extension area. The extension area, henceforth titled the "Extension Area", is shown in **Figure 14.1** and covers an area of 22.7 ha which will provide approximately 5 million tonnes of saleable limestone reserves. In addition to this, a section 73 application is being submitted for the currently approved quarry area (henceforth titled the Existing Quarry) to allow for the filling of the existing void with site derived material until 2044. The combined Extension Area and Existing Quarry combined is termed "the Site" in this assessment.

14.3 The reserves within the Existing Quarry are approaching exhaustion. In 2006, Gryphonn submitted a planning application to revise conditions 1, 2, 17, and 22 of the extant planning permissions for the Site (Planning Application 94/0369 – extant planning application). The revision to Condition 2 was to allow the quarry to be deepened from its currently consented minimum level of 439 mAOD to the base of the Dowlais Limestone at approximately 412 mAOD. The application to deepen the Existing Quarry was submitted in 2008 and supported by a Hydrogeological Impact Assessment (ESI, 2008).

14.4 To ensure the continuity of working at the Site and to provide the required reserves identified by the Blaenau Gwent County Borough Council Local Development Plan (LDP), an extension to the quarry is necessary. The LDP identifies 38 hectares of land adjacent to Trefil Quarry as a Preferred Area which contains approximately 15 million tons of saleable limestone and sandstone reserves. The Extension Area is situated within this designated Preferred Area.

14.5 A requirement of the planning application is that it should be supported by a comprehensive Hydrogeological Impact Assessment (HIA) and Flood Consequence Assessment (FCA) for the proposed development. This Chapter comprises the HIA and summarises the findings of the FCA which is included in full in **Appendix 14.2** (Stantec, 2021).

Scope of work

14.6 Gryphonn instructed Stantec UK (formerly ESI) in 2017 to undertake an HIA in support of the Planning Application for the proposed Extension Area at the Site. This Chapter includes the HIA and focusses on the impacts of mineral extraction and restoration at the Site on hydrogeology, flood risk and drainage and has been written in line with the guidance and policy summarised within the Legislative and Planning Policy Context section of this Chapter.

14.7 The scope of work undertaken for this HIA includes the following:

- Review of the baseline hydrogeology for the Site and surrounding area;
- identification of receptors and assessment of potential impacts;
- recommendations for appropriate monitoring and mitigation measures; and
- preparation of an HIA for the proposed development (this Chapter).

- Stantec has also undertaken a Flood Consequence Assessment (FCA), which is the subject of a separate report (Stantec, 2021, see **Appendix 14.2**). The findings of the FCA report have been brought through and summarised in this Chapter.

Chapter outline

14.8 This Chapter includes the following:

- an identification of the study area;
- a summary of the legislation, planning policies and guidance followed;
- an outline of the methodology used to assess the impacts and collect the data;
- a review of the relevant baseline conditions and conceptual model for the Site;
- an assessment of the potential impacts of the quarry development;
- recommendations for appropriate monitoring and mitigation measures;
- a review of the residual effects following mitigation measures;
- a summary of the in-combination and cumulative effects and
- a summary of the results and key conclusions.

Data source

14.9 The information and assessments in this Chapter are predominantly based on secondary data analysis associated with both the Site itself and the surrounding land area. The main sources of data are summarised below:

- Proposed development plans provided by Gryphonn (**Appendix 2.1**);
- proposed restoration plan provided by Viridian Landscape (**Appendix 5.2**);
- geological data from on-site monitoring well drilling;
- water levels, rainfall, and pumping rates collected by Gryphonn staff;
- previous reports for the Site by ESI (2018);
- British Geological Survey (BGS) mapping;
- Ordnance Survey mapping;
- water feature survey undertaken by Stantec in May 2017;
- site visits undertaken by Stantec on 27th September 2019, 02nd October and 15th October 2019; and
- data from Natural Resource Wales (NRW) including water quality, rainfall, historic landfill data, LiDAR data, abstraction licences and discharge consents.

Proposed development

14.10 The Proposed Development Chapter of the Environmental Statement contains full details of the proposed development during the operation and restoration stages.

14.11 Rock will be excavated from the Extension Area in a series of three phases from south to north. The minimum elevation within the extension area will be 467 mAOD (in the southern part) and no dewatering below the water table will be required (Boyer, 2021) hence no drawdown in groundwater levels are expected from the Proposed Development.

14.12 Ground elevations in the excavation area will slope back towards the Existing Quarry. Runoff will be directed back towards the Existing Quarry void via a system of defined channels which will keep the Site runoff separated, as far as possible, from vehicle trafficking, in order to minimise the generation of suspended sediment and will enter the current water management scheme (see Site water management plan section).

14.13 The duration of the operational phase of the development is expected to be approximately 27 years (comprising three phases). Extracted material will be processed at the current, on-site processing plant. Unsalable material ('out-of-specification' limestone, together with Twrch Sandstone overburden and smaller quantities of superficial sediment, comprising glacial till, peat and doline infill sediments) will be deposited in the Existing Quarry void.

14.14 Some restoration will be progressively undertaken as the working of the Extension Area progresses. This will involve infilling of the Existing Quarry void with unwanted material (predominantly 'out-of-specification' limestone with Twrch Sandstone overburden as outlined above). The Extension Area will not be restored to existing ground elevations as this will have the benefit of providing access to any exposed karstic features within the limestone and expanding the habitat available for roosting bats (see Geodiversity Chapter of the Environmental Statement).

14.15 Following the Site restoration, some surface water bodies (small, ephemeral pools) will be present across the Site (in the Existing Quarry Area), providing habitat improvements as well as small areas of water storage capacity. The Site will be permitted to regenerate naturally to upland scrub cover.

14.16 A large valley is included in the final design, located between the fill material in the Existing Quarry void and the limestone face along the north-eastern extent. This has been designed to receive runoff from the Existing Quarry, including the northern side of the infill. Runoff from this feature will be confluent with that draining southward from the Extension Area and allow infiltration to ground as discussed in the FCA (**Appendix 14.2**).

Scoping opinion

14.17 A Scoping Report was issued in July 2016 by Blaenau Gwent County Borough Council (see **Appendix 14.3**).

14.18 The sections relevant to hydrology and hydrogeology have been reiterated below:

"It is advised the EIA considers the following:

- *A Hydrogeological Risk Assessment (HRA) which should include assessment of changes to recharge via removal of the unsaturated zone and demonstrate that the activity will not significantly affect controlled waters, third party abstractions or significantly affect surface water or groundwater regimes;*
- *A Flood Risk Assessment (FRA) which must consider the frequency of flooding in this catchment and any changes over time in relation to change made in the local drainage system and downstream capacity of the River Sirhowy;*
- *A Water Management Plan for surface and groundwater encompassing the quarry including the extension together with the catchment area impacted upon by the quarry both upstream and downstream and which includes measures to mitigate potential impacts of*

the proposed extension which have been identified in the FRA, hydrological risk assessment and mass balance calculations including the management measures and associated physical infrastructure proposed and the measures and controls proposed. These should be set out systematically for each stage of working and restoration including during the preparatory, operational and post operational stages of the development; and

The ES should include:

- *A detailed plan and description of the current drainage regime (the baseline) including existing streams, pipes and watercourses entering and leaving the site; internal pumping regimes and volumes, associated control mechanisms and protocols (including the overflows originally installed on streams north of the quarry to direct some flood waters into the quarry's low spot), together with existing discharge consents;*
- *Modelling of current hydrological systems including re-checking the surface and groundwater baseline and modelling given the presence of sink holes;*
- *An assessment of whether water storage within the quarry currently contributes to flood attenuation in the event of heavy rain;*
- *Assessment of all hydrological changes likely to arise from the quarry extension including the siting of screening bunds and overburden tips during site operation as well as the potential hydrological effects which might occur to water following restoration;*
- *Appropriate modelling and assessment to demonstrate the effectiveness and appropriateness of the proposed measures and the alternative options considered and to demonstrate compliance with relevant legislation and guidance and should also provide for the future proofing, taking into account climate change and other factors and future maintenance, monitoring and upkeep of all associated infrastructure;*
- *Mitigation measures including SUDs, options for water management and opportunities for the proposed scheme to contribute to the alleviation of existing water management issues in the catchment which should also be assessed for their likely impacts on sensitive receptors in terms of landscape impact and biodiversity in the relevant ES chapter;*
- *An assessment of the restoration proposal which determines as accurately as possible the likely water level and seasonal fluctuations in the quarry once pumping has ceased; and the length of time needed for water levels to rise to this level; and*
- *The assessment should also evaluate the surface water, groundwater and flood risk implications on the surrounding area of the modelled increase in water levels in the quarry post"*

Study Area

14.19 Trefil Quarry is located about 4 km to the northwest of Tredegar, and about 300 m north of Trefil village, in Gwent (**Figure 14.1 within Volume 2 Technical Appendices**). It is centred on an approximate national grid reference of 312000, 213500.

14.20 The Extension Area is located immediately north-northeast of the Existing Quarry and is centred on an approximate national grid reference of 312150, 214150 (**Figure 14.1**).

14.21 The surrounding landscape consists of rolling moorland, with the Site located on the eastern slope of the steep-sided Trefil Valley. Much of the surrounding area is used for rough grazing. The hills on each side of the valley fall steeply from about 550 mAOD to about 410 mAOD at the Trefil Stream to the west of the Quarry. The land also falls to the south.

14.22 The ground levels within the Existing Quarry generally range from about 413 mAOD (base of the quarry void) to about 510 mAOD along the north-eastern ridge. The most recent survey was undertaken in August 2020 (**Appendix 14.6**).

14.23 The ground levels across the Extension Area ranges between approximately 495 mAOD in the south-eastern corner and approximately 540 mAOD in the north-eastern corner based on a review of LiDAR data as shown on **Figure 14.2.** A description of how the Site currently drains is included in Section 2.4 of the FCA (**Appendix 14.2**).

14.24 Within the valley, the Trefil stream flows to the south-southeast, towards the River Sirhowy and Shon Sheffrey spring and reservoir (at about 365 mAOD) as shown in **Figure 14.2**.

14.25 Further details on the site setting are provided in the Site and Surroundings Chapter of the ES and within the Baseline Conditions section of this Chapter.

Legislative and Planning Policy Context

National Planning Policy Context

14.26 The primary tool of planning policy which has been consulted during this study and written in line with is the Planning Policy Wales 11 (PPW) guidance (Welsh Government, 2021). In particular, section 6.6 of the document which outlines the water and flood risk.

14.27 The assessment conforms to the requirements of government guidance and position statements for protection of groundwater with regards to the technical approach to ensure the protection of groundwater in the vicinity of the Site. NRW have adopted the Environment Agency's approach to protecting groundwater (Environment Agency, 2017).

Methodology

Assessment methodology

14.28 The impact assessment methodology applied is set out in **Appendix 14.4**, and each of the identified receptors has been assigned a value from low to high and, along with the magnitude of effect at each receptor, an associated impact of the proposed development has been deduced. Where the significance of impact is more than minor, the impact is considered significant and possible mitigation measures have been proposed. The guidance outlined in Thompson et al. (2008) has been referred to during the assessment process to understand the potential effects associated with quarrying.

Water feature survey methodology

14.29 A water feature survey was undertaken in May 2017 by Stantec to identify and survey water features within a 2 km radius of the Site. The following methodology was used:

- Visit surface water abstractions and discharges identified from an NRW data request.

- Identify and visit observation boreholes currently monitored by Gryphonn identified from conversations with Gryphonn (Ken Williams).
- Identify and visit impoundments, ponds, streams and springs identified from 1:25,000 scale Ordnance Survey (OS) mapping.
- Identify and visit dolines within Mynydd Llangynidr SSSI.

14.30 Locations identified are displayed on **Figure 14.8** with details of each provided in **Error! Reference source not found.**, including a brief description of each feature. Photographs taken during this survey and during subsequent visits are included in **Appendix 14.5.**

Baseline Conditions

Geology

14.31 Full details of the geology can be found in the Geodiversity Chapter of the Environmental Statement, but a summary of the key pieces of information relevant to hydrogeology are presented here.

Regional geology

14.32 The bedrock and superficial geology of the region is displayed in **Figure 14.3** and **14.4**. The geological sequence is taken from the 1:50,000 scale geological map for Abergavenny Solid and Drift Edition (Sheet 232, BGS, 1990) and summarised in Error! Reference source not found.**.** Approximate thicknesses are taken from a borehole location about 500 m to the south of the quarry (Trefil BH 1 - see **Figure 14.5** for location - from Welsh Water Authority (WWA), (1980)).

Table 14.1 Summary of regional geological succession (WWA, 1980)

Age	Unit	Approximate thickness (m)	Description
Carboniferous	Twrch Sandstone Formation	20	Quartz conglomerates, quartzitic sandstones and occasional siltstones
	Dowlais Limestone	90	Dark grey bituminous limestone, occasional beds of oolite, isolated beds of sandstone in lower section and extensive dolomitization in upper section
	Llanelly Formation	9.5	Variable thin sandstones, limestones, and clay locally
	Abercriban Oolite Subgroup	25	Massive oolitic limestone with bands of fine grained crystalline dolomite
	Cwmyniscoy Mudstone (Lower Limestone Shale Group)[1]	35	Interbedded grey mudstones and thin- to medium-bedded skeletal packstones

14.33 The Site is located on the northern edge of the South Wales syncline and is largely underlain by Carboniferous (Dowlais) Limestone. The strata dip towards the south at an angle of between 3°

[1] The Cwmyniscoy Mudstone effectively forms the base of the formations of interest for this study.

and 6° with Upper Carboniferous Twrch Sandstone Formation deposits cropping out to the south as a result (lying unconformably on the Lower Carboniferous deposits). Devonian Old Red Sandstone deposits crop out to the north.

14.34 A number of normal faults trending NNW/SSE are present in the area. These are shown in **Figure 14.3**.

14.35 Based on the available data, geological cross sections through the study area have been prepared and are presented in **Figure 14.14** and **Figure 14.15**.

Local geology

14.36 Information on local geology is available from a number of boreholes as shown in **Figure 14**.5. Borehole logs are presented in **Appendix 14.1**. The relevant boreholes are described as follows:

- WWA (1982) report on two boreholes (Trefil BH1 and BH2) drilled to the south of the Site in September/October 1981 as part of an exploratory drilling programme to determine potential groundwater resources in the vicinity.
- Two boreholes were drilled in March 2004 within the Existing Quarry for mineral assessment purposes (Hole 1 and Hole 2). These were drilled in the quarry floor in the vicinity of the quarry sump in the northeast of the quarry at measured ground levels of between 441.8 and 440.5 mAOD but their exact locations are not known.
- Three monitoring boreholes were drilled in May 2007 (BH1/07, BH2/07, and BH3/07). These boreholes were installed with piezometers for groundwater level monitoring.
- Two boreholes were drilled in October 2014 (BH3 and BH4) in the Extension Area. These boreholes were installed with piezometers for groundwater level monitoring.

14.37 A summary of all available boreholes in the vicinity of the Site is given in **Error! Reference source not found.** with further description of the geology encountered provided in the text below.

Table 14.2 Available borehole information in site vicinity

Borehole name	Easting	Northing	Ground level (mAOD)	Top of casing (mAOD)	Borehole Depth (m)	Elevation of base (mAOD)	Piezometer base depth (m)
Trefil BH1	312340	212600	≅ 410	-	141	≅ 269	141
Trefil BH2	312110	212090	≅ 393	-	187	≅ 206	187
Hole 1	On quarry floor adjacent to sump		441.8	-	36	405.8	Not installed
Hole 2	On quarry floor adjacent to sump		440.5	-	36	404.5	Not installed
BH1/07	311943	213708	442.23	442.69	30.5	411.73	30.5
BH2/07	311838	213555	452.35	452.75	16.5	435.85	16.5
BH3/07	311966	213230	453.03	453.5	32.5	432.43	20.5
BH3	312315	214274	517.06	-	90	427.06	90
BH4	311927	214542	533.76	-	90	443.76	90

Hole 1 and 2 at base of quarry (2003)

14.38 In Hole 1 and 2 on the quarry floor adjacent to sump, the contact between the Dowlais Limestone and underlying Llanelly Formation was proved at 414.8 and 412.5 mAOD respectively, proving thicknesses of 27 and 28 m of Dowlais Limestone (Ramsey, 2003a). The Abercriban Oolite Subgroup was encountered beneath the Dowlais Limestone, but the base of this unit was not proven.

14.39 Ramsey (2003a and 2004) reported that:

- the Dowlais Limestone beneath the Site consists of good quality limestone generally described as a dark limestone containing quartz sand with the lower 4 m consisting of a calcareous sandstone with interbedded mudstones.
- The Llanelly Formation is approximately 12 m in thickness beneath the Site and consists of a succession of limestone and calcareous sandstones and clays. An upper 6 m thickness of a hard green clay was found at Hole 1 and 2.
- The Abercriban Oolite Subgroup (approximately 27 m) is a good quality limestone.

Monitoring well installation (2007)

14.40 Three monitoring boreholes were drilled and installed in May 2007. Their locations are shown in **Figure 14.5** with borehole logs given in **Appendix 14.1**.

14.41 The boreholes were completed with a 5 m slotted section placed at the base of the borehole.

14.42 BH1 was drilled to the top of the clay layer at the top of the Llanelly Formation and installed within the Dowlais Limestone. BH2 and BH3 were drilled and installed within the Dowlais Limestone.

Monitoring well installation (2014)

14.43 Two monitoring boreholes were drilled and installed in October 2014 in close proximity to the eastern (BH3) and western (BH4) boundaries of the Extension Area. Their locations are shown in **Figure 14.5** with borehole logs given in **Appendix 14.1**. Both boreholes were drilled to a depth of 90 m and are installed within the Dowlais Limestone however returns during drilling were sparse due to the soft nature of the limestone. Multiple voids were encountered during drilling at the Site which are likely karstic features.

14.44 The boreholes were completed with screens set at 62 – 90 m in BH3 and 40 – 90 m in BH4.

Other information

14.45 WWA (1979) reports that the Carboniferous Limestone and overlying Twrch Sandstone Formation outcrop display considerable evidence of karstification in the area, with swallow and sinkholes, collapsed dolines and other solution subsidence features being well developed. A large number of these features can be seen on the hills to the north of the Quarry. These features are also detailed in Ford (1989).

14.46 During the site visit on 11 July 2007, it was noted that there appeared to be a significant number of clay infilled palaeokarst features in the upper benches of the quarry. However, the frequency of these features and degree of fissuring of the limestone reduced with depth.

Infilled ground/landfilling

14.47 Details of existing and historical landfills within 4 km of the Quarry have been obtained from NRW and are shown in **Figure 14.6**. There are no active landfills within this radius. **Error! Reference source not found.** summarises the four historical landfills within this boundary.

Table 14.3 Historical landfills within the Site vicinity

Landfill Name	Distance from Site	Operator	Type of waste(s) accepted
Pentwyn Farm	170 m south	Mr R S Thomas	Inert
West Hill Tip	3.4 km south	Tredegar Urban District Council	Commercial
West Hill. Also known as Bryn Bach Park	3.9 km south	Blaenau Gwent Borough Council	Inert, industrial, commercial, household, special
Sirhowy	3.9 km southeast	Unknown	Household

Hydrogeology

14.48 **Error! Reference source not found.** is taken from WWA (1980) and summarises the regional hydrogeology of the main formations in the area. Hydrogeological information is also presented in **Figure 14.12**.

Table 14.4 Lithology hydrogeological significance

Unit	Hydrogeological significance
Twrch Sandstone Formation (Basal Grit)	Secondary (fracture) permeability. Direct recharge through fractures and via sinkholes extending to the underlying Dowlais Limestone. Potentially in hydraulic continuity with the Dowlais Limestone.
Dowlais Limestone	Aquifer. High permeability in upper levels. Decreased permeability towards base.
Llanelly Formation	Generally low permeability. Impermeable where upper member present as clay.
Abercriban Oolite Subgroup	Moderate secondary (fracture) permeability.
Cwmyniscoy Mudstone (Lower Limestone Shale Group)	Impermeable. Forms base of aquifer.

Groundwater classification and systems

14.49 The Carboniferous Limestone is classified as a Principal Aquifer and hence is of high vulnerability. Principal Aquifers are layers of rock or drift deposits that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. Mostly, Principal Aquifers were previously designated as major aquifers.

14.50 The surrounding sandstone formations are classified as Secondary A aquifers and these are permeable layers capable of supporting water supplies at a local rather than strategic scale and can be an important source of base flow to rivers. Typically, these aquifers were formerly classed as minor aquifers.

Groundwater levels and flow

Site visits

14.51 Stantec staff visited the site on 27th September 2019, 2nd October 2019, and 15th October 2019. The purpose of the visits was to collect information on groundwater within the Extension Area boreholes.

14.52 A water level data logger was installed in the hole at this time to record the groundwater response and provide high frequency water level data between 2nd October 2019 and 15th October 2019 (date of the logger removal).

Groundwater levels

14.53 Groundwater levels are available for on-site boreholes BH1/07, BH2/07 and BH3/07 (within the Existing Quarry), BH3 and BH4 (within the Extension Area) and off-site boreholes Trefil 1 and Trefil 2 (see **Figure 14.5**). Statistics for each borehole are summarised in and are discussed below and **Figure 14.12** displays average groundwater levels at all on-site and off-site boreholes. The hydrogeological conceptual model section is discussed below and brings together the groundwater levels for the area.

Table 14.5 Groundwater level statistics

Borehole Name	Data Period	Frequency	Datum (mAOD)	Data period	Statistics (mAOD)			Total range (m)
					Min	Arithmetic Mean	Max	
BH1/07	Sep 07 – Dec 20	Weekly to monthly	442.691	Full record	426.90	433.48	436.95	10.05
BH2/07	Sep 07 - Dec 20	Weekly to monthly	452.753	Full record	435.99	438.21	442.40	6.41
BH3/07	Sep 07 – Dec 20	Weekly to monthly	453.499	Full record	432.08	433.50	436.31	4.23

Borehole Name	Data Period	Frequency	Datum (mAOD)	Data period	Statistics (mAOD)			Total range (m)
					Min	Arithmetic Mean	Max	
BH3	Nov 14 - Dec 20	Weekly to monthly	533.76	Gap: Dec 15 – July 19	451.66	451.84	452.36	0.70
BH4	Nov 14 - Dec 20	Weekly to monthly	517.06	Gap: Dec 15 – July 19	457.62	466.35	467.31	9.69
Trefil 1	July 09 - Dec 20	Monthly	427.06	Full record	374.81	376.46	380.11	5.30
Trefil 2	July 09 - Dec 20	Monthly	393.31	Full record	367.86	369.09	372.70	4.84

*Note: The data for BH2/07 prior to 25th June 2007 are not included in the statistics as this data appears to be anomalous (see **Figure 14.7**), this also applies to the data collected in October 2014.*

Existing Quarry

14.54 The sump at the base of the Existing Quarry is at an elevation of about 412.9 mAOD as shown on the recent 2020 site survey (**Appendix 14.6**). The sump is pumped when water levels in the base of the quarry need to be lowered to allow mineral extraction and the pump is operated manually. This will continue in the existing void as it is filled, however, once filling is complete above the water table then pumping will stop. The water within the sump currently constitutes both surface water runoff from within the Site and groundwater. However, once it is filled above the water table then it will not exist.

14.55 Boreholes BH1/07, BH2/07 and BH3/07 were installed in May 2007 and were screened across the Dowlais Limestone, with groundwater levels recorded every few days for approximately the first year before switching to weekly visits. The following points were noted during the construction of these boreholes:

- Borehole 1/07 was drilled close to the quarry sump to the base of Dowlais Limestone. Groundwater was encountered from a shallow depth during drilling.
- Groundwater was also encountered in borehole 2/07 from a shallow depth during drilling.
- No water strike was noted during drilling of borehole 3/07. However, water entered the borehole after installation.

14.56 A groundwater hydrograph for these boreholes is shown in **Figure 14.7**.

14.57 The cumulative departure from mean rainfall[2] for both Rhymney and Trefil rain gauges (see hydrology rainfall section) are also shown to illustrate trends in rainfall and highlight correlations with groundwater levels. The period during which groundwater levels have been monitored on-Site

[2] A falling trend of cumulative departure from mean rainfall indicates below average rainfall and a rising trend above average rainfall

includes both very wet and dry periods. Rainfall levels in May and July 2007 were the highest on record in South Wales and therefore the groundwater levels recorded in the summer of 2007 may not have fallen to typical summer levels. This does not have any significance for any interpretations made within this Chapter.

14.58 In general, the three hydrographs follow each other fairly closely, suggesting that they are monitoring groundwater levels in a single groundwater body. Groundwater levels in BH1/07 saw a gradual decline (with an overall fall in level of c. 4 m) between December 2014 and August 2015 during which time the base of the quarry was deepened to working level 5 with a minimum elevation of 420 mAOD (**Appendix 14.6**). Since this time the BH1/07 groundwater levels appear to have been stable (at around 429 mAOD). No such water level impacts have been evident in other borehole datasets, suggesting that this is a localised effect of the base of the Existing Quarry being below the water table. Groundwater levels in BH2/07 and BH3/07 have remained relatively stable across the monitoring record[3]. The drop in groundwater levels at BH1/07 also appears to correlate with a reduction in the cumulative departure from mean (CDM) rainfall that has occurred since January 2015. A reduction in the amplitude of variation in all three boreholes is recorded and this is likely due to a reduced monitoring frequency from weekly to monthly from mid-2015.

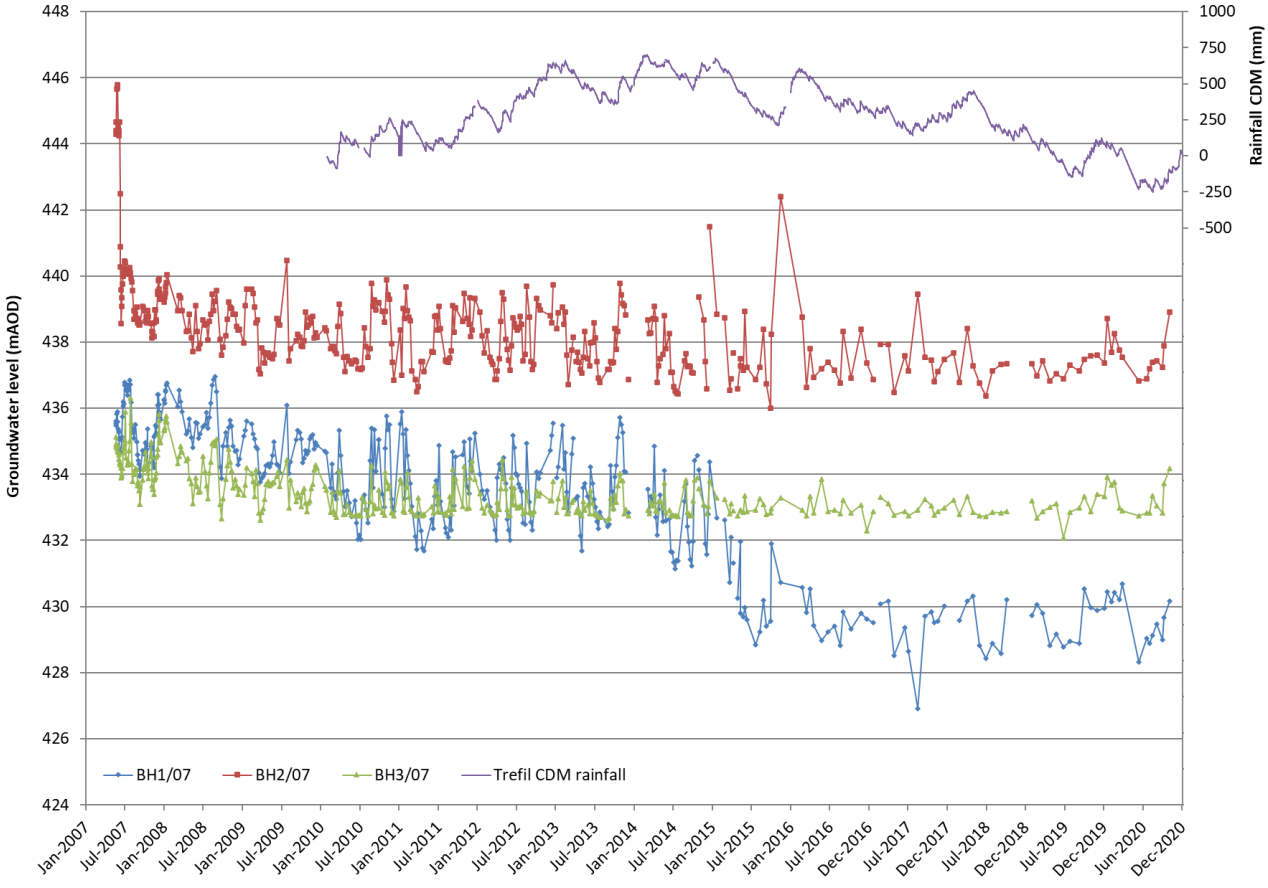

Figure 14.7 Groundwater levels for on-site boreholes

Extension Area

[3] The only exceptions are selected groundwater level data obtained for BH2 in October 2014 which are likely to be erroneous.

14.59 Boreholes BH3 and BH4 were installed in 2014 and are screened across the Dowlais Limestone. Groundwater levels in the Extension Area are higher in the northwest (BH4) than the southeast (BH3) (see **Figure 14.8**). Levels at BH3 were level during monitoring in 2014-15 at around 451 – 452 mAOD. Since monitoring recommenced at BH3 in July 2019 there has been little to no variation in levels which is uncommon in limestone and it is likely that the measurements are for standing water in the base of the borehole. It was attempted to pump out the standing water, but this failed due to low permeability sediment blocking the Waterra tubing. However, this borehole was confirmed as being dry during Stantec visits in September and October 2019 and due to the similar readings pre-2016 this could imply the borehole was previously dry then as well.

14.60 Levels at BH4 were initially around 467 mAOD after being drilled. However, when monitoring recommenced in 2019 levels had dropped by around 10 m to 457 mAOD. It is unclear as to why this has occurred with no noticeable events happening between these dates that could have caused the difference.

14.61 Pumping and recovery tests were performed at both locations during a site visit in September 2019 to ascertain whether the water observed in the wells was standing water (water unconnected from the aquifer) or groundwater (local water table). BH3 was recorded as dry during the tests which may suggest water initially observed in the well in 2014 was standing water which subsequently drained away. The high-resolution logger data collected from BH4 showed a recovery following pumping and responses to rainfall events indicating that the water observed at BH4 was not standing water. **Figure 14.10** shows the logger data plotted with daily rainfall totals recorded at Penderyn (located 16 km to the west and with a longer available timeseries).

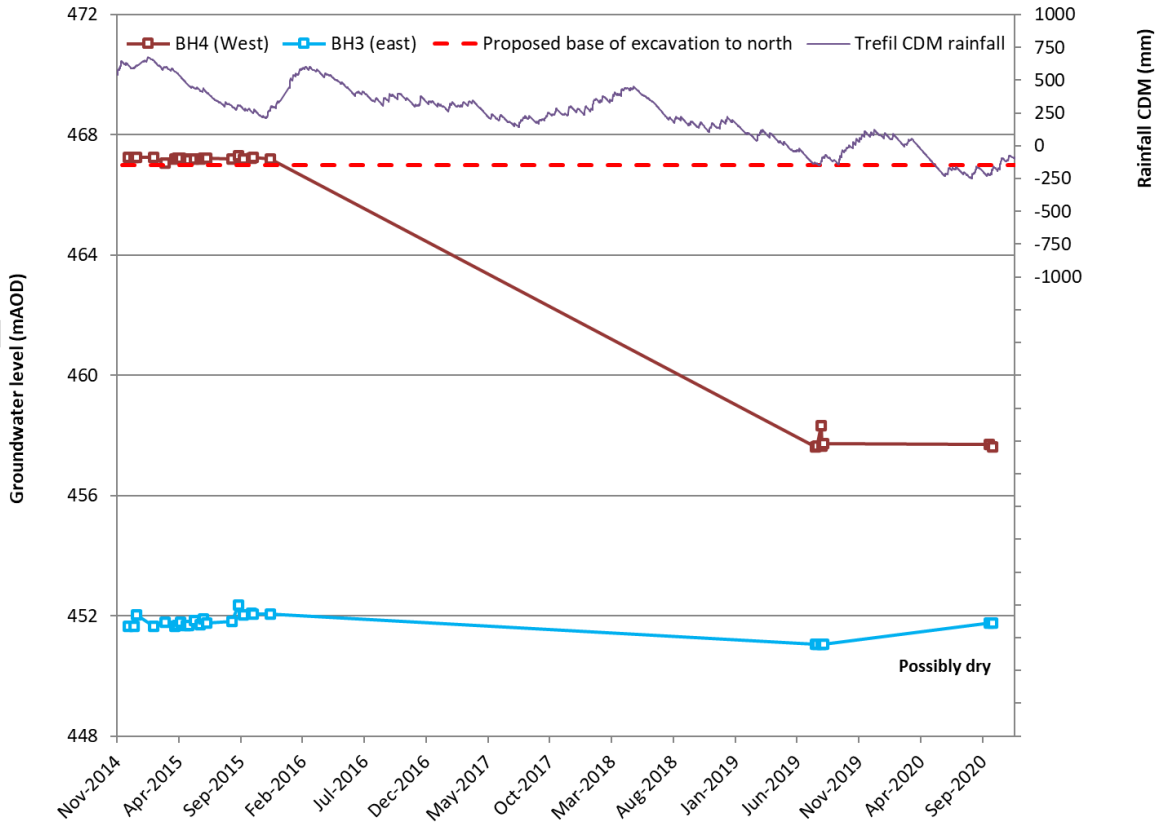

Figure 14.8 Long term groundwater levels for boreholes in northern extension

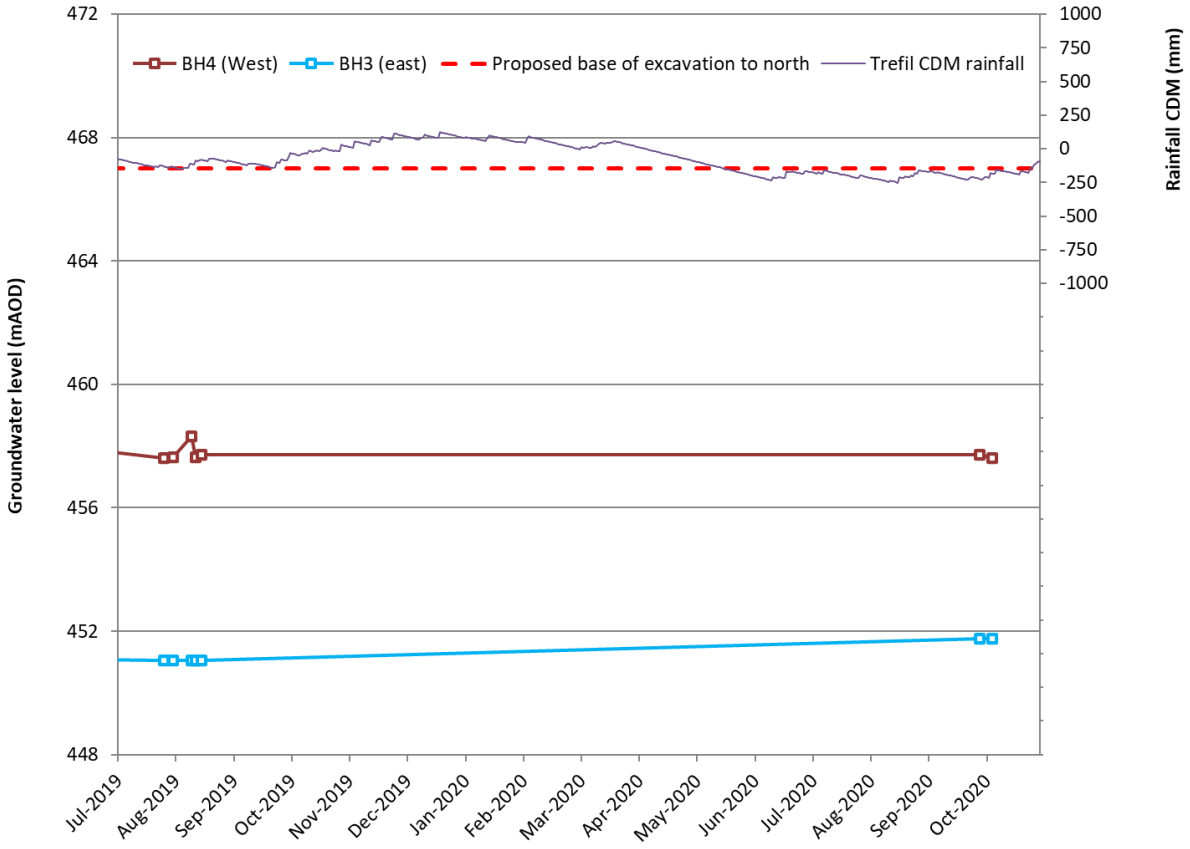

Figure 14.9 *Groundwater levels for boreholes in northern extension in 2019 and 2020*

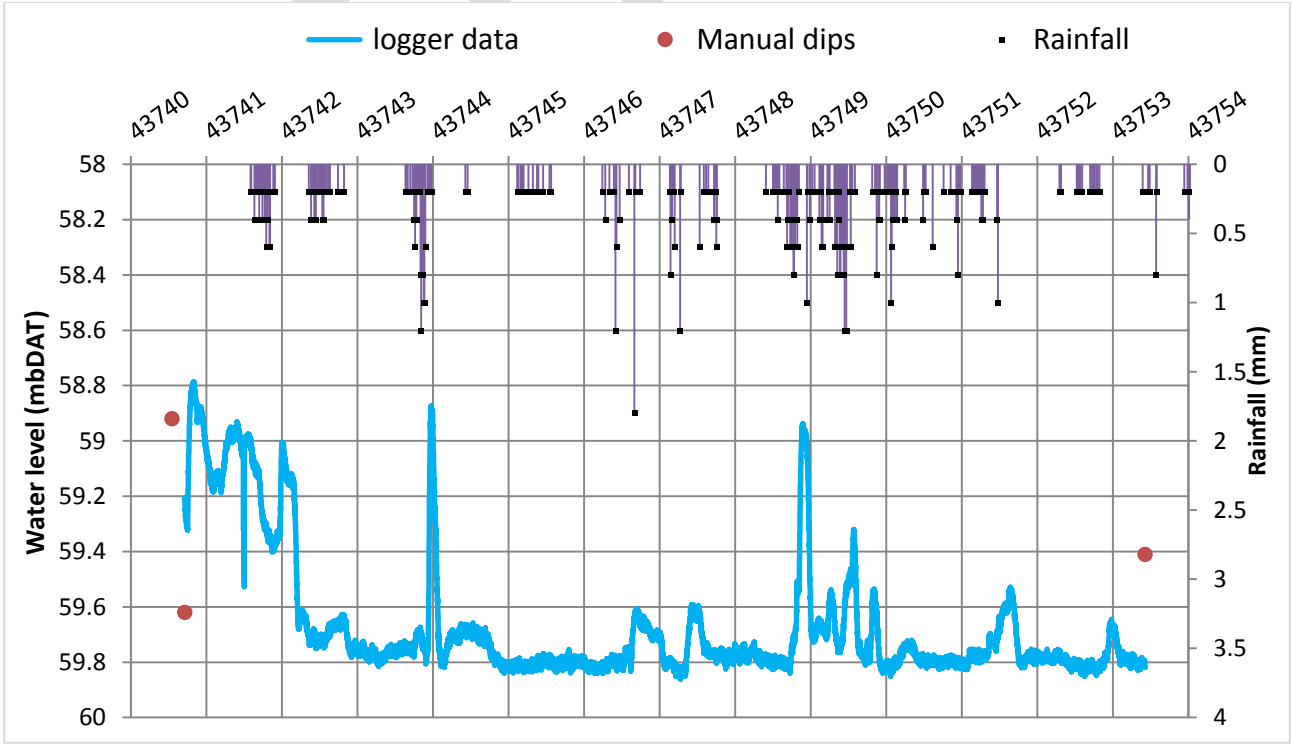

Figure 14.10 *Groundwater logger data recorded at BH4 with Penderyn rainfall data*

14.62 From the data provided above, it is unlikely that groundwater levels will exceed those recorded in BH4 and hence the planned design has been amended to not dip below the water table with a proposed excavation depth of 467 mAOD.

External locations

14.63 Trefil Boreholes 1 and 2 were completed in September and October 1981 respectively.

14.64 Trefil Borehole 1 had a rest water level of 52.8 m below ground level (mbgl) after drilling was completed in 1981. This equates to about 357 mAOD based on an estimate of ground level of 410 mAOD reported in the borehole log (neither borehole has been surveyed). However, the Ordnance Survey map suggests the ground level is about 430 mAOD at this location, which would imply a rest water level after drilling of about 377 mAOD. This latter estimate is considered to be more realistic given the estimated level of the Shon Sheffrey Spring downgradient of the Site at 365 mAOD. Trefil Borehole 2 encountered a water strike at 26 mbgl with a rest water level of 24.87 mbgl and this equates to about 368 mAOD based on an estimate of ground level of 393 mAOD reported in the borehole log.

14.65 Manual data are available since 2010 for Trefil 1 and 2009 for Trefil 2 and these are displayed in **Figure 14.11**. Levels recorded at these two boreholes in Trefil village are around 60 m below those recorded at the Existing Quarry. With a distance of c. 800 m between BH3/07 and Trefil Borehole 1, this yields a hydraulic gradient to the south from the Existing Quarry of 0.071. The groundwater level variability observed at these locations is around 2.5 m which is comparable (perhaps slightly smaller) to those seen at the Existing Quarry boreholes.

14.66 The Nant Trefil which is located to the west of the Site and flows in a southerly direction, has an elevation of around 410 mAOD in the vicinity of the quarry (i.e. significantly below groundwater levels recorded in the on-site boreholes despite a horizontal separation of only a few hundred metres (implied hydraulic gradient of 0.06)). There are two intermittent ponds along the course of the stream and the watercourse itself dries up in summer to the south of Trefil (potentially ephemeral), which suggests a good connection with a highly permeable underlying aquifer (see more discussion of this in the hydrogeology conceptual model section).

14.67 The Shon Sheffrey Spring emerges at about 365 mAOD (Simpson & Partners, 1995) to the south of the quarry (70 m fall in groundwater levels over 1500 m – hydraulic gradient of 0.047). It consists of two separate springs which discharge into a common collection area and subsequently over a weir into Shon Sheffrey Reservoir (Simpson & Partners, 1995). The reservoir is fed by the Afon Sirhywi which flows in a southerly direction towards the Severn Estuary. The surface water catchment draining to the reservoir comprises an area of around 8 km^2 and a larger groundwater catchment of around 11.5 km^2 (estimate) due to secondary fractures along faults (Simpson & Partners, 1995). Rapid recharge occurs due to absent to thinly developed soils and also through sinkholes and collapsed dolines in the area. Almost all effective precipitation recharges the aquifer.

14.68 The groundwater levels recorded in the external boreholes suggest a fairly shallow hydraulic gradient (0.005) between these and Shon Sheffrey Spring. However, neither external borehole has been surveyed, as outlined above, and so the groundwater levels used in the hydraulic gradient calculation should be used with caution.

14.69 WWA (1980) reports that an intermittent spring at Rhymney Bridge, about 4 km to the southwest of the Existing Quarry, acts as an overflow system from the Shon Sheffrey spring groundwater catchment.

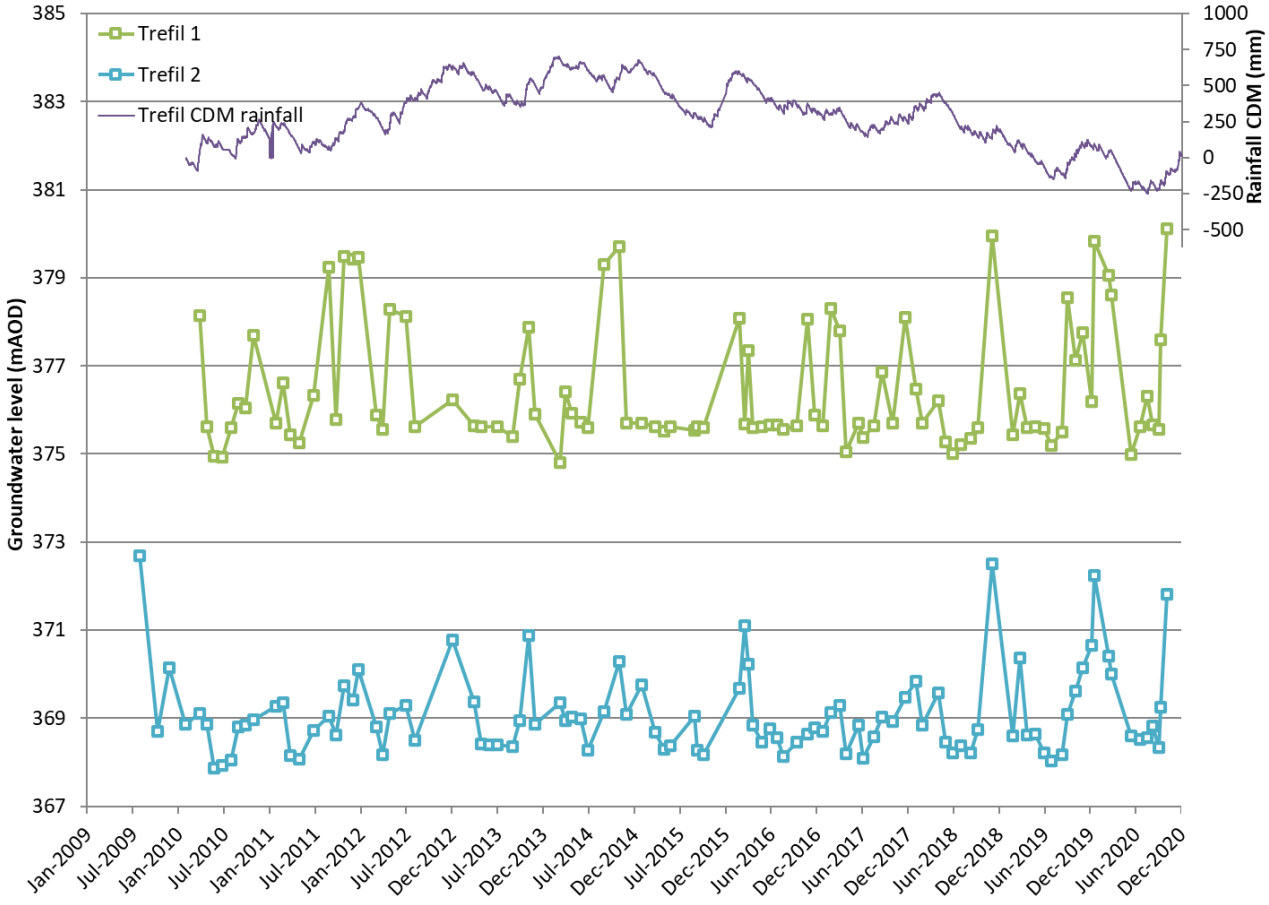

Figure 14.11 Groundwater levels for external (Trefil) boreholes

Other site groundwater level information

14.70 Ramsey (2004) interprets the main regional groundwater table in the Carboniferous Limestone in the vicinity of the Site to occur in the Abercriban Oolite Subgroup below the Llanelly Formation. The Llanelly Formation lies beneath the Dowlais Limestone that is generally being screened in the on-site boreholes recording groundwater level data and is the formation being excavated at the Site.

14.71 In Hole 2, drilled at the base of the quarry in 2003 as detailed in the local geology section, the borehole was dry to about 30 mbgl, when a water strike was noted near the top of the Llanelly Formation following which water levels rose rapidly to about 440 mAOD. Flow ceased when the Abercriban Oolite Subgroup beneath the Llanelly Formation was encountered. This supports the view that the piezometric level in the underlying Abercriban Oolite Subgroup is lower than the groundwater level in the Dowlais Limestone (as observed in the quarry sump) and that the vertical groundwater head gradient between these formations is controlled by the 6 m of clay at the top of the Llanelly Formation which locally restricts vertical groundwater movement.

Groundwater flow

Unsaturated zone

14.72 ESI (2008) noted that small volumes of flow intermittently issue from fissures in the north eastern quarry face (adjacent to where the Extension Area is to be situated). It was concluded that these represent intermittent flow along bedding planes/conduits in the unsaturated zone during and after periods of rainfall. This is consistent with the conceptual model described in the hydrogeology conceptual model section.

Tracer tests

14.73 WWA (1980) reports on a number of tracer tests undertaken in 1980 using dyed Lycopodium spores. The spores were injected in sinkholes within the Twrch Sandstone Formation at localities believed to be on the flow lines to Shon Sheffrey spring. Proven connections to Shon Sheffrey spring are shown in **Figure 14.12**. Water tables were high at the time, with connections established in 1-3 days. It was reported that a travel time of 48 hrs from one of these injection points, 2000 m from the spring, was encountered (this represents and average velocity of 1 km/d).

14.74 Ford (1989) suggests that the fault on which Shon Sheffrey lies may capture water from within the surrounding valley area.

14.75 Based on the WWA (1980) tracer work, a groundwater catchment for Shon Sheffrey Springs of 12 km^2 was defined which was later supported by Simpson & Partners (1995) and is shown in **Figure 14.12**. However, the SPZ shown on **Figure 14.12** is larger than the catchment area as it merges with those related to the Rhymney Bridge and Ffynnon Gisfaen catchments immediately to the west and east of Shon Sheffrey catchment respectively at around 2 km from the Site to the catchment edge. The limestone outcrop in this catchment area is 3.9 km^2 and so the catchments also include the wider sandstone / Twrch Sandstone Formation.

14.76 Wimpey Environmental Limited (1994c) reported that dye tracing performed from the quarry in December 2003 showed that a stream entering a sink on the floor of Trefil Quarry reappeared in the Nant Trefil. No other details were available.

14.77 Gunn (2012) identified cave systems to the east of the Site, underlying the Mynydd Llangynidr; the closest lies 830 m to the northeast (Ogof Fawr) as shown on **Figure 14.14** along with the location of the nearest dolines to the Site identified during the study (more dolines are present in the area as shown on the satellite imagery of the map). Gunn (2012) reported that two sinks just to the east of the Site (around doline points 76 – 82 on **Figure 14.14**) drain south to Shon Sheffrey, however, as also shown on **Figure 14.14**, further dolines to the northeast of the Site (close to Ogof Cynnes) were traced to the east (including Agen Allwedd) suggesting an underground watershed beneath Mynydd Llangynidr with separate groundwater flow directions to the south and to the east. The exact location of this watershed is unclear and so the boundary between groundwater flow to the south and to the east is also unclear. During drilling of the new boreholes in the Extension Area, voids were encountered, suggesting that cave systems may be present under the Site; however, the extent of these is unknown. More detail on the karstic features in the area can be found in the Geodiversity Chapter of the Environmental Statement.

Groundwater flow patterns

14.78 A summary of hydrogeological information is included in **Figure 14.12**. This includes a summary of average groundwater levels recorded at both on-site and off-site boreholes.

14.79 The tracer tests suggest that Shon Sheffrey is the main discharge point for the Carboniferous Limestone in this area. The tracer tests show that groundwater flows towards the spring from both the north and northwest (**Figure 14.12**) although the actual flow paths cannot be directly determined from these results.

14.80 A very flat hydraulic gradient occurs between the external Trefil boreholes and the spring which suggests that the aquifer is highly permeable in this area. The location of the Shon Sheffrey spring along this fault zone is also an indication of enhanced transmissivity along the fault which allows flow through the overlying Twrch Sandstone Formation[4].

14.81 Groundwater levels appear to be higher to the north of Trefil village (supporting baseflow in the upper reaches of the Nant Trefil throughout the year) and higher still at the Site. The relatively steep hydraulic gradients implied by these groundwater levels are considered to be due to lower transmissivity in the former case and steep vertical hydraulic gradients in the latter case (see discussion about the role of the Llanelly Formation above).

Aquifer properties

14.82 **Error! Reference source not found.** is taken from WWA (1980) and summarises the regional hydrogeology of the main formations in the area.

Table 14.6 Lithology hydrogeological significance

Unit	Hydrogeological significance
Twrch Sandstone Formation	Secondary (fracture) permeability. Direct recharge through fractures and via sinkholes extending to the underlying Dowlais Limestone. Potentially in hydraulic continuity with the Dowlais Limestone.
Dowlais Limestone	Aquifer. High permeability in upper levels. Decreased hydraulic conductivity towards base.
Llanelly Formation	Generally low permeability. Impermeable where upper member present as clay.
Abercriban Oolite Subgroup	Moderate secondary (fracture) permeability.
Cwmyniscoy Mudstone (Lower Limestone Shale Group)	Impermeable. Forms base of aquifer.

[4] Note that, while faults may act as zones of enhanced transmissivity, they can also form barriers to flow.

Twrch Sandstone Formation

14.83 BGS (1986) reports that, in the Twrch Sandstone Formation, groundwater movement occurs predominantly through secondary discontinuities of high permeability, with yields previously recorded from boreholes generally ranging from 10-12 l/s.

14.84 Water runs off the Twrch Sandstone Formation becoming slightly acidic in the process and then to recharge around the outcrop boundary of the sandstone where it meets the limestone. The acidic nature of runoff results in dissolution and enhanced recharge features adjacent to the geological boundary.

14.85 Jones *et al*. (2000) reports that leakage of groundwater from the Twrch Sandstone Formation to the underlying main limestone is considered to be facilitated by collapsed sinks in the areas where these occur. The sinkholes represent areas of percolation into the limestone, in which flow may subsequently be of diffuse or conduit type, according to the extent of fissure opening by solutional processes.

14.86 Jones *et al*. (2000) considers that the Basal Grit is generally in hydraulic continuity with the Carboniferous Limestone.

Carboniferous Limestone

14.87 The Carboniferous Limestone consists of the Dowlais Limestone, Llanelly Formation, and the Abercriban Oolite Subgroup. It is classified as a major aquifer (a highly permeable and productive formation able to support large abstractions for public supply). Shon Sheffrey spring Source Protection Zone (SPZ) is located within the Carboniferous Limestone.

14.88 Little relevant information is available on aquifer properties of the Carboniferous Limestone in this area. The Carboniferous Limestone aquifer is considered to be most permeable at or above the zone of water table fluctuation (WWA, 1979). Below this level, fissure and secondary permeability development are markedly reduced.

14.89 WWA (1979) reports that at Rhymney Bridge, about 4 km to the southwest of the quarry, the aquifer is confined and has a transmissivity of 10-20 m^2/d and storage coefficient of $4x10^{-4}$ to $9x10^{-4}$ (obtained from pumping tests). This suggests poor solution development of fractures at depth. WWA (1979) considers a specific yield of 0.5% to be appropriate in the unconfined parts of the aquifer.

14.90 WWA (1982) indicates that at Trefil Borehole 1 (**Figure 14.5**), during water level monitoring, a 130 mm rainfall event in the area resulted in a rise in groundwater level of 9 m suggesting a specific yield of about 1%. Despite the area showing evidence of significant subsurface dissolution of the limestone, a pumping test on the borehole gave poor results with an estimated long term yield of only 2 l/s with transmissivity calculated to be only 10 m^2/d, possibly as a result of fractures being filled with sediment from the Twrch Sandstone Formation (WWA, 1982). This is supported by observations during the site visit, as mentioned in the local geology section, that clay infilled palaeokarst features were present.

14.91 Trefil Borehole 2, about 500 m to the southwest of the Existing Quarry, also provided a low estimate of transmissivity of 35 m^2/d based on testing. It was concluded that the fractures are mainly developed above the water table and provide conduits for rapid throughflow to springs and

resurgences but do not provide a water bearing system at depth suitable for exploitation by boreholes (WWA, 1982).

14.92 WWA (1980) report the Dowlais Limestone has a very low primary permeability with most groundwater movement a result of secondary permeability. Hyder (2005) reports that the upper 40 m of the Dowlais Limestone is extensively dolomitized/brecciated and this has led to enhanced permeability in this zone.

14.93 The Llanelly Formation is approximately 12 m in thickness beneath the Site and consists of a succession of limestone and calcareous sandstones and clays. An upper 6 m clay unit is present which may inhibit vertical groundwater flow in this area. Below this is the Abercriban Oolite Subgroup which is a more permeable formation.

Lower Limestone Shale

14.94 The Lower Limestone Shale is considered to be impermeable and forms the base of aquifer with the Cwmyniscoy Mudstone being the main unit within the group (WWA, 1980).

Hydrology

Rainfall

14.95 Rainfall data have been provided by NRW for a rain gauge located at Rhymney about 3 km to the southwest of the Site from 1961 to 2020; monthly rainfall data are available between January 1961 and July 2000 then daily rainfall data thereafter. Daily rainfall data are also available for a rainfall gauge located at the existing quarry site from 2010 to 2020.

14.96 Details of both rainfall gauges are presented in **Error! Reference source not found.**. The reason for the discrepancy between mean annual rainfall values is unclear although it is relatively small. The Centre for Ecology and Hydrology's Flood Estimation Handbook (Centre of Ecology and Hydrology, 2021) provides a Standard Average Annual Rainfall of 1,701 mm for the Site, which would suggest the data collected at the quarry are an underestimate of the true value.

Table 14.7 Rain gauge details

Name	Easting	Northing	Approximate elevation (mAOD)	Period of available record	Mean rainfall (mm/a)
Rhymney	310480	209910	330*	July 1961 – December 2020	1,405**
Trefil	-	-	-	February 2010 – December 2020	1,282

**value taken from https://gridreferencefinder.com/*

***incomplete years (1965-1970, 2001-2002, 2009-2013 and 2019) not included*

14.97 Long term monthly average data are included in **Error! Reference source not found.**. Monthly rainfall for 2000 – 2020 is shown in **Figure 14.13** along with the cumulative departure from mean (CDM) for the same period.

14.98 The CDM data indicate long term trends in rainfall and show an increase from 2006 to 2014 followed by a decline from 2015 onwards.

Table 14.8 Monthly Rhymney rainfall data

Month	Long term monthly average (mm)	
	Rhymney (1961-2020)	Trefil (2010-2020)
January	151	144
February	121	85
March	126	102
April	72	67
May	94	71
June	82	95
July	114	61
August	128	131
September	107	99
October	188	158
November	184	153
December	199	94

Effective precipitation and recharge

14.99 WWA (1979) reports that average effective rainfall (total rainfall minus actual evapotranspiration) in the region was computed by the Meteorological Office as 1,125 mm/a for the period 1968 to 1978.

14.100 Simpson & Partners (1995) reports that the average effective precipitation is 748 mm/a (from MORECS square 146).

14.101 Simpson & Partners (1995) reports that rapid recharge occurs due to absent or thin soils with recharge also occurring through sinkholes and collapsed dolines in limestone areas. The fissured nature of the limestone suggests that little runoff occurs with almost all of effective rainfall recharging. The Grit supports typical moorland vegetation which can support a substantial thickness of peat which may hold a significant volume of water which is slowly released. Stream flows over the Twrch Sandstone Formation are generally small.

Surface water features

14.102 Surface water features in the vicinity of the Site are shown in **Figure 14.2** and, in more detail, on **Figure 14.8**. The Site lies on a plateau with topography sloping to the south and west.

14.103 The Nant Trefil is the main surface water feature in the vicinity of the Site. It rises about 1 km to the northwest of the Site at an elevation of about 460 mAOD and flows towards the southeast through the Trefil Valley. The Site is near the head of the catchment, with the overall area of the catchment in the vicinity of the quarry being only about 329 ha. The feature is a relatively small, shallow stream in this area. A small but distinct spring rises in the middle of the valley floor near the Duke's Table (NGR 31097 21412) as shown on **Figure 14.2** and contributes a significant proportion of the flow to the upper reaches of the stream. This spring is located close to the

outcrop of the base of the Abercriban Oolite Subgroup where it overlies the Cwmyniscoy Mudstone.

14.104 There are some small seeps rising from spoil heaps that form the eastern side of the valley to the south of this point. The Existing Quarry discharges treated water (i.e. a combination of natural runoff and dewatered water) to the Nant Trefil adjacent to the quarry boundary under the conditions of a discharge permit (**Appendix 14.7b**). The discharge location is shown on **Figure 14.2** and runs steeply down the hillside and under the road at approximately (NGR 3118 2133). The stream is at an elevation of about 410 mAOD to the immediate west of the quarry.

14.105 Two intermittent pools exist along the Nant Trefil to the north of and within Trefil village (Upper and Lower Pool respectively on **Figure 14.2**). The Nant Trefil flows into the Upper Pool from which there is little or no surface water outflow during most of the year. This is likely to be because the pool intercepts the Nant Trefil flow and sinks into the ground where it recharges to the Shon Sheffrey as it is within the Shon Sheffrey catchment zone. It is possible there is a sink in the lower pool as well because on the occasions when there is flow from the upper pool an outflow is not always observed from the lower pool. Both ephemeral pools are flooded sink holes thought to be in continuity with groundwater. These are flooded depressions formed when underlying karstic cavities collapse. The Lower Pool is located in the village to the west of Trefil Road. The Nant Trefil appears to be dry through much of the summer along the reach from Trefil village to Shon Sheffrey.

14.106 The Ordnance Survey map shows the Nant Trefil to join the Sirhowy River (Afon Sirhywi) about 450 m to the northwest of Shon Sheffrey reservoir. The Sirhowy River rises on Twrch Sandstone Formation strata and flows into the reservoir. It has a number of spring fed tributaries and appears to be perennial, in contrast to the Nant Trefil.

14.107 Shon Sheffrey spring also provides flow to the reservoir which is a public water supply operated by Welsh Water/Dwr Cymru). This spring issues at an elevation of about 365 mAOD (Simpson & Partners, 1995). The Shon Sheffrey Spring is located adjacent to the Pen-y-Fan fault trace and therefore may be associated with the fault.

14.108 There are some springs noted on the escarpment to the north of the Site (**Figure 14.2**). However, examination of the geological map indicates that none of these rises from the main limestone formations and as such they are not considered further in this assessment.

14.109 To the east of the Site a number of springs, mainly within the Twrch Sandstone Formation, flow to the southeast before joining the Nant Milgarw which flows towards the southwest where it joins the Sirhowy River south of Shon Sheffrey reservoir. These water features were examined by Stantec during a water features survey undertaken in April 2017. The results of which are presented in **Error! Reference source not found.** and each location is shown in **Figure 14.8**.

Table 14.9 Trefil Quarry Extension Area water feature survey

ID	Name	X	Y	Description (correct as of time of visit – 03/05/2017)
1	Sinkhole	312145	214573	Large sinkhole, typical of those found east of the site. c.25 m diameter. Very small inflow into sinkhole, flow appears to be from its own discrete catchment area.
2	Llyn y Garn Faw N	312632	214992	Northernmost of two small lakes. c.10 m diameter and c.0.4 m depth, no obvious inflow.
3	Llyn y Garn Faw S	312661	214921	Southern lake, dry silty lake bed at time of visit. Small channel connects this area to the Northern lake. At the Southernmost point of the lake there is evidence of a small muddy sink which was not flowing, no other outflows were seen from this lake.
4	Shake hole	312762	214672	Very large shake hole, c.30 m diameter. Damp base but no inflows. Also, no evidence of stream marked on OS map that flows past here. Small pools of water 0.5 m diameter dotted around this locality.
5	Stream source	312809	214510	First sign of stream marked on OS map supposedly flowing from Llyn y Garn. Possible spring but no actual flow here, just ponded water. Upstream obscured by thick vegetation. Change in elevation, vegetation and scree slop marking a possible lithological boundary NE and E of this locality.
6	Pool	312676	213947	Pool marked on OS map, c.15 m diameter. Currently dry and silted. Pipe debris within pond, possible evidence of defunct drain? No inflows observed.
7	Artificial Pool	312409	213811	Pool, c.7 m diameter. Artificially dammed. Currently 2 m below level of outflow and estimated at 0.5 m deep at the centre.
8	Sinkhole	312851	213556	Big sinkhole with a relatively large but dry inflow channel compared to other stream channel sizes in the local vicinity. This inflow forks off from the main stream running next to the sinkhole acting like an overflow channel. Nearby, at the confluence of three streams there is still no flowing water, just stagnant ponded water.
9	Springs	313050	213503	Multiple springs, marked on OS map as a single issue. 3 separate damp areas form a single channel. Horizon of springs is below the same ridgeline extended from point 5.

ID	Name	X	Y	Description (correct as of time of visit – 03/05/2017)
10	Nant Milgatw Waterfall	313520	212648	Flow estimated 4-8 l/s. Very peaty water. Massive limestone overlaying shaley horizons.
11	Stream	313366	212510	Runs N and almost parallel to Nant Milgatw. <2 l/s very low flow.
12	Spring	312954	212306	Spring N of disused railway line. Flow <1 l/s. Marshy bog.

Surface water flow and levels

14.110 Stage data have been collected by NRW from 2001 to 2017 for a constant stage gauge located on the Sirhowy River (Nant y Bwch) at grid reference 313165, 211480 (Gauge AS1 on **Figure 14.2**). The data shows an average stage of 0.18 m with a range of 1.29 m and similar fluctuations across this time period from approximately 0.1 m to 0.6 m. Flow rates at this location are not available as a ratings curve for this data is not available from which to derive flow conditions.

14.111 Reservoir water level data at Shon Sheffrey reservoir are available between January 2014 and December 2019. However, the reservoir is of a small size compared to the catchment area and there is uncertainty around abstraction rates from the reservoir for water treatment works. The data are recorded in metres below Top of Water Level (mbTWL) and generally vary between 0 and 6 mbTWL. Assuming an elevation of 365 mAOD for Shon Sheffrey as mentioned in the groundwater levels and flow section this would display an elevation range of 359 – 365 mAOD. The average and 95th percentile annual water elevation has slightly increased from 2014 to 2018 and this is consistent with a decrease in pumping at the Site across the same years. However, it could also be due to weather conditions.

Site drainage and water management

14.112 The Extension Area is a greenfield site with no formal surface water management system. Runoff from this area drains mostly to the Nant Trefil (partially via the existing quarry's water management system) but also the Nant Milgatw to a lesser degree. Surface water catchments and indicative runoff directions in the area are displayed in Stantec (2021).

14.113 The water management system at the Existing Quarry is shown in the FCA, as presented in **Appendix 14.2** and is summarised here. Runoff is permitted to collect in the sump of the active void. Water is pumped from the sump to the processing plant area. From here, water can flow under gravity through some water treatment features (the enhanced lagoon and settling pond) to the discharge point on the Nant Trefil. Diversion controls are in place to divert flow back to the sump should water quality indicate a sub-standard water quality for off-site discharge.

14.114 Water is discharged from the Site to the Nant Trefil to the west of the Site (see **Figure 14.**2 for location) under the conditions of a discharge permit (see **Appendix 14.7b**). The discharge permit specifies that the total suspended solids shall not exceed 100 mg/l, the concentration of total oil and grease shall not exceed 10 mg/l and the maximum volume of discharge shall be dependent on rainfall. The water management system includes oil interceptors and regular observations are recorded on the presence/absence of any elevated turbidity/oil etc.

Site water management plan

14.115 The WMP for the existing quarry was presented by ESI (**Appendix 14.7a**) following the completion of the original HIA (ESI, 2008) and specified requirements for three key activities:

- Monitoring
- Mitigation measures
- Annual review

14.116 The monitoring regime comprises the following data collection activities in order to quantify the level of impact at key sites and, to ensure that the system is continuing to behave as predicted on the basis of the current conceptual model, a monitoring system has been implemented:

- Groundwater levels in the three boreholes on site (BH1/07, 2/07, and 3/07) are measured.
- Groundwater levels in Trefil Boreholes 1 and 2 are monitored.
- The rate of quarry pumping from the sump is monitored by means of an in-line flow meter.
- The suspended solids/turbidity of the quarry discharge is measured by the quarry operator together with a note of the weather conditions at the time.
- Rainfall data are monitored by means of a site rain gauge.
- The site drainage system is inspected to ensure that the oil booms are in place and that there is no visible oil downstream of the booms.

14.117 The above data collection has been presented in annual monitoring reports since the completion of the WMP. The WMP is currently under review in conjunction with the production of this Impact Assessment.

14.118 The mitigation measures outlined in the original WMP were designed to comply with the requirements of the discharge permit issued by the Environment Agency for the site (reference: AN0258201) and to cope with the predicted increase in dewatering rates. These mitigation measures were designed to effectively control any risks of impacts on surface water and groundwater quality. Measures included in the WMP comprise:

- Installation of settlement ponds
- A new bunded fuel-tank installed, relocated on-site to avoid run-off and potential contamination
- Adapting the emergency procedures regarding fuel spills
- Flocculants are intended to be introduced shortly on Site to enhance settlement in the event that suspended solid measurements exceed the discharge consent limit.
- Weekly inspection and documentation of working areas to look for the presence of void (which might indicate preferential pathways)
- A diversion scheme to divert water flow back into the sump is under construction.

Surface water and groundwater quality

Surface water quality

14.119 ESI (2008) reported on Electrical Conductivity (EC) data collected at Shon Sheffrey as well as suspended solids and hydrocarbon data for the quarry discharge.

<u>Electrical Conductivity</u>

14.120 The 2008 report showed that the discharge from the quarry had a lower EC than that recorded along Nant Trefil. It was subsequently concluded that the Carboniferous limestone groundwater discharging to the watercourse at various points typically had an EC of 300 µS/cm (recorded during a Site visit in June 2011 as detailed in ESI (2008)) whereas the quarry discharge was diluted with surface water runoff resulting in the lower EC value.

14.121 The Sirhowy River was shown to have a markedly lower EC than the Nant Trefil, consistent with this stream being derived from rainfall runoff from the Twrch Sandstone Formation rather than the Carboniferous Limestone (as mentioned in the surface water features section).

14.122 WWA (1980) reported the EC of Shon Sheffrey as varying between 80 µS/cm in winter and 280 µS/cm in summer.

Suspended Solids and Hydrocarbons

14.123 Suspended solids data were provided by the Environment Agency for the quarry discharge for the period 2002 and 2007. The data show periodic exceedance of the discharge limit of 100 mg/l. Nant Trefil quality data from 1997 directly upstream and downstream of the site discharge point shows a possible slight increase in suspended solids downstream. The stream dries up almost immediately downstream of the quarry discharge point in most conditions which will limit the periods of suspended solids impact downstream.

14.124 The number of suspended solids limit exceedances and maximum recorded value in the quarry discharge for each year are presented in **Error! Reference source not found.** for the last 10 years. The exceedances of the 100 mg/l threshold and higher readings have always occurred following storms and heavy showers the previous evening.

Table 14.10 Suspended solids exceedances compared to 100 mg/l limit

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of exceedances	1	0	1	3	1	2	0	0	1	0
Maximum value (mg/l)	125.8	99	622	103.3	252	233.73	99.07	99.14	100.22	98.34

14.125 Only one suspended solids data point was available for Shon Sheffrey spring (22 March 2007). This gave a result below detection limit. However, WWA (1982) reports that sand derived from the Twrch Sandstone Formation reaches Shon Sheffrey Spring after heavy rainfall. If the sand is reaching the spring via a groundwater route, then this could only occur as a result of rapid flow through relatively large conduits within the limestone.

14.126 During the 27 years that the quarry has been operated by its current owners there have been no known reports of any contamination from hydrocarbons in any of the local watercourses. This suggests that the current precautionary measures (Site water management plan section) are effective at protecting the local water environment from accidental spillages from operating heavy plant in the area.

14.127 Impacts from suspended solids and hydrocarbons are further discussed within the Impact Assessment and Significance of Effects Section.

Groundwater quality

14.128 BGS (1986) reports that groundwater quality in the Carboniferous Limestone is usually good under low flow conditions, with total hardness of 250-300 mg/l (mainly carbonate) and chloride

concentrations less than 30 mg/l. Groundwater can become turbid and polluted after heavy rainfall, with the quality reflecting that of the infiltrate. Under these circumstances, total hardness can be as low as 150 mg/l with high concentrations of suspended solids, organic matter, bacteria, and nitrates. Note that these are general characteristics of the Carboniferous Limestone, and are not necessarily reflective of the local conditions at the Site.

14.129 WWA (1980) reports that the chemical characteristics of Shon Sheffrey Spring indicate that the water is derived from a combination of stored groundwater (diffuse flow) and rapidly moving conduit flow, which supports a two layered aquifer concept (**Error! Reference source not found.** however the data period for these results is unknown). It was reported that:

- During periods of low rainfall, high concentrations of calcium and bicarbonate and moderate to low electrical conductivity (EC) readings were encountered due to discharge of a larger percentage of water with a longer residence time within the limestone.
- During higher rainfall, these values were lower due to a larger component of rapidly moving conduit flow.

Table 14.11 Chemical composition of Shon Sheffrey Spring (WWA, 1980)

Determinand	Minimum	Mean	Maximum
Sodium (mg/l)	3.3	4.4	5.9
Potassium (mg/l)	0.27	0.69	2.6
Calcium (mg/l)	9.9	30.8	55.2
Magnesium (mg/l)	0.5	2.9	7.7
Bicarbonate (mg/l)	36.8	92.1	142.7
Nitrate (mg/l)	1.33	1.97	2.66
Chloride (mg/l)	4.1	6.0	9.0
Sulphate	3.9	10.5	13.8
Electrical Conductivity (uS/cm)	80	170	250
pH	7.1	7.7	8.3

14.130 No information is available on groundwater chemistry within the Existing Quarry.

14.131 WWA (1982) reports that analysis from Trefil Borehole 1 showed a similar ionic content to Shon Sheffrey spring in September 1979, suggesting a connection of the groundwater within this borehole with the spring. It was also noted that sand was present in the borehole which was derived from the Twrch Sandstone Formation and as mentioned above sand also reaches Shon Sheffrey Spring after heavy rainfall which would suggest that the borehole is intercepting relatively large conduits within the limestone.

Potential Receptors

Surface water features

14.132 Apart from Shon Sheffrey Spring, the only other surface water feature considered to be potentially vulnerable to the Extension Area is the Nant Trefil and this is taken forward as a potential receptor.

14.133 The potential receptors are displayed on **Figure 14.18**.

Licenced water abstractions and discharges

Shon Sheffrey spring public water supply

14.134 Shon Sheffrey Spring is a licensed public water supply operated by Welsh Water/Dwr Cymru. The Site is located about 1.3 km to the north of this spring which feeds Shon Sheffrey reservoir. Welsh Water/Dwr Cymru has confirmed that it is the reservoir itself (rather than the spring) which is the official abstraction point.

14.135 The Site is located within the Shon Sheffrey total catchment source protection zone (see **Figure 14.12**). Due to the fissured nature of the aquifer, it is difficult to determine travel times and thus only a "total catchment" exists for this source rather than a Zone I, II, III as is usual (Environment Agency letter as shown in **Appendix 14.8**).

14.136 Hyder Consulting (2005) reports that Shon Sheffrey reservoir and treatment works were constructed in 1930. The reservoir provides storage for use in low flow periods and has a capacity to support the Nantybwch Water Treatment Works for 17 days. All flow from the Shon Sheffrey spring enters the reservoir.

14.137 Simpson & Partners (1995) reports that:

- Shon Sheffrey spring consists of two separate springs which discharge from the Carboniferous Limestone via the Twrch Sandstone Formation to a common collection area and subsequently over a weir into Shon Sheffrey reservoir, which is operated by Welsh Water.
- The abstraction licence has an annual limit of 10,148 Ml/a (equivalent to 28 Ml/d, 320 l/s).
- Rough grazing and stock occur on the catchment.
- The spring is associated with a fault zone which runs down Trefil Valley.
- The upper levels of the Dowlais Limestone are the most permeable and where the major perennial (a stream or river that flows all year round) springs occur.

14.138 During the 2017 water features survey, a series of stone chambers linked by a large diameter pipe were noted at intervals along the length of the Nant Trefil from the Upper Pool through to the southern part of Trefil village. The purpose of these chambers and their connection to the spring or reservoir could not be determined on-site or from subsequent discussions with Welsh Water/Dwr Cymru staff. However, it seems very likely that these are some form of collecting chamber system that was designed to enhance/protect flows to the spring/reservoir.

14.139 Due to the location of the quarry within the SPZ and the dependence of the spring supply on good quality groundwater from the Carboniferous Limestone, this site is taken forward to the impact assessment stage as a potential receptor (A1 Impacts on neighbouring abstractions section).

Other licenced water abstractions

14.140 Apart from Shon Sheffrey Spring, data received from NRW reported two surface water abstraction licences within 2 km of the Site. These are both located at the Shon Sheffrey reservoir and are effectively considered to be part of the same receptor for impact assessment purposes.

14.141 The NRW public register showed two further abstractions 3 km southeast of the Site for Enviro Wales Ltd and Yuasa Battery UK Ltd at Rassau Industrial Estate, however it is not confirmed whether these are surface water or groundwater abstractions.

14.142 There are no other licensed abstractions in the vicinity of the Site.

Groundwater

14.143 Groundwater within the Carboniferous Limestone aquifer is a receptor to be considered by the impact assessment.

Private water supplies

14.144 A query to Blaenau Gwent County Borough Council regarding private water supplies was made in November 2007. The Environmental Health Department indicated that there is one private water supply in the vicinity of the Site at Dros-y-Lynn, about 1.3 km to the south of the quarry and 400 m to the northwest of Shon Sheffrey reservoir. It was reported that this supply is from a spring and is treated as a precaution for suspended solids and bacteria. This is at an elevation of about 370 or 380 mAOD.

14.145 This spring is considered to be sourced from the Twrch Sandstone Formation which could be in hydraulic continuity with the underlying Carboniferous Limestone and is therefore considered to be potentially vulnerable to dewatering activities at the Site. However, no issues have been reported from this supply during current dewatering activities at the Existing Quarry.

14.146 There are no other known abstractions in the vicinity of the quarry.

Designated environmental sites

14.147 The Extension Area is located in the Mynydd Llangynidr Site of Special Scientific Interest (SSSI). The SSSI was designated in on 23 August 2012 and, as a result, was not considered as part of the 2008 HIA for the deepening of the Existing Quarry (ESI, 2008).

14.148 As explained more fully in the Geodiversity Chapter, the SSSI was designated due to its karstic geomorphology, particularly the doline field. The karstic features, including the dolines, are due to the dissolution of limestone by percolating groundwater. However, there is currently no evidence to suggest that the dolines are linked to any active cave systems as outlined in the cave systems section (paragraphs 11.45 to 11.48) within the Geodiversity Chapter. As such, the designation is not considered groundwater dependant.

14.149 Mynydd Llangatwg SSSI lies adjacent to Mynydd Llangynidr to the east, 5 km to the east of the Site, and is designated for its active cave systems which are likely linked to groundwater movement. As mentioned above, there is likely to be a groundwater catchment divide further east of the Site within the Mynydd Llangynidr (between the Site and Mynydd Llangatwg SSSI) based on tracer test results and therefore there will be minimal potential impacts on the Mynydd Llangatwg

SSSI which is supported in the Geodiversity Chapter and hence has not been considered further in this assessment.

14.150 The only other designated site located within 3 km of the Site is the Cwar yr Ystrad a Cwar Blaen Dyffryn SSSI located approximately 2 km northwest of the Site. This is upgradient of the Site and is designated due to its geological exposures within the disused quarries and therefore not considered groundwater dependant and is not considered further in this assessment.

14.151 There are no Special Areas of Conservation or nature reserves within 3 km of the Site. The Brecon Beacons National Park is located approximately 100 m to the north of the Site.

14.152 Bryn Back Country Park located about 2 km to the south of the Site contains a man-made lake at about 390 mAOD. This is above expected groundwater levels in the area and is not considered to be hydraulically connected with the Site. It is therefore not considered further in this assessment.

14.153 There are no other designated sites in the vicinity of the Site.

Hydrogeological conceptual model

14.154 **Figure 14.**15 shows a conceptual hydrogeological cross section running west to east through the Site perpendicular to the groundwater flow direction and **Figure 14.16** shows a cross section running north to south through the Site. These lines are displayed on **Figure 14.3**. These cross sections are based on available borehole logs, groundwater levels and the conceptual understanding developed for the area. This section summarises the hydrogeological conceptual model for the Site.

14.155 Superficial deposits are sparse in the vicinity of the Site with a very small outcrop of peat in the north and till in the east. Elsewhere, they are mostly comprised of glacial till and head – clay, silt, sand and gravel. The bedrock geological sequence at the Site features Twrch Sandstone comprised of cemented sandstone and conglomerate overlying a sequence of Carboniferous Limestone of the Pembroke Limestone Group. The Cwmyniscoy Mudstone Formation forms the base of this sequence. This sequence is described in more detail in the geology section. WWA (1979) reports that the Carboniferous Limestone and overlying Twrch Sandstone Formation outcrop display considerable evidence of karstification in the area, with swallow and sinkholes, collapsed dolines and other solution subsidence features being well developed. A large number of these features can be seen on the hills to the north of the Site and clay infilled palaeokarst features are also observed in the upper benches of the Existing Quarry. However, the frequency of these features and degree of fissuring of the limestone is generally considered to reduce with depth.

14.156 The Nant Trefil is the closest watercourse to the Site, being situated 400 m west at an elevation of around 410 mAOD at its closest approach. However, the Shon Sheffrey spring is the main discharge point for the Carboniferous Limestone which emerges at about 365 mAOD (Simpson & Partners, 1995) to the south of the Site. Surface watercourses tend to be mostly over areas of Twrch Sandstone or where the limestone is overlain by superficial deposits.

14.157 The Twrch Sandstone Formation is not thought to be saturated at the Site and groundwater flow is predominantly through secondary discontinuities. This unit recharges the underlying Carboniferous Limestone, hence they may be in hydraulic continuity with each other, through collapsed sinkholes where flow may then be of diffuse or conduit type, according to the extent of fissure opening by solutional processes (Jones *et al*., 1997).

14.158 The limestone has a low transmissivity, yield and primary permeability, with most groundwater flow dependent on secondary features, i.e. faults, karstic features and conduits. These are mostly developed above the water table, with the upper section of the Dowlais Limestone being extensively dolomitised/brecciated, hence the enhanced permeability and the conduits providing rapid through-flow to springs and resurgences but not to depth. The Llanelly Formation upper clay unit may constrain vertical groundwater flow in this area.

14.159 There could be some discharge from the limestone aquifer to surface water features including the Nant Trefil where the watercourse directly overlies the limestone aquifer. Wimpey Environmental Limited (1994c) reported that dye tracing performed from the quarry in December 2003 showed that a stream entering a sink on the floor of Trefil Quarry reappeared in the Nant Trefil.

14.160 The regional groundwater table is within the Abercriban Oolite Subgroup beneath the Llanelly Formation. However, the Dowlais Limestone is another aquifer with a groundwater table within it (this has been referred to as the water table in the report) and the vertically downwards hydraulic gradient between the two water tables is dependent on the Llanelly Formation.

14.161 Based on groundwater levels, groundwater flow appears to be flowing southwards, with the highest levels at the Site. Hence, flow may be along bedding planes with the limestone strata dipping 3 - 6^{o} to the south.

14.162 From the regional setting, it would be anticipated that the hydraulic gradient across the Existing Quarry would be toward the main discharge points (the Nant Trefil and Shon Sheffrey spring) to the south and/or west. This is generally observed across all boreholes with only BH2 in the Existing Quarry displaying a different pattern. In fact, groundwater levels are highest in BH2 and lower in BH1 and BH3. This could be due to BH1 being the deepest borehole and the lower water level may reflect a downwards vertical hydraulic gradient or it could be due to the water table being locally lowered around BH1 (which is located near the current sump) by dewatering activities on the Site which haven't transmitted as far as BH2 and BH3. However, this is not consistent with the previous position of the quarry sump level at 439 mAOD, which was above the level in BH1 even though water levels in the Existing Quarry (c. 433 – 438 mAOD) are now currently above the base of the excavation (412.9 mAOD) and could have been affected by quarrying activities.

14.163 Tracer tests show connections between the sinkholes to the east of the Site and the Shon Sheffrey spring, with the spring being the main discharge point from the Carboniferous Limestone. Groundwater flow has been proven to flow to the spring from both the north and northwest. A high transmissivity zone is thought to be related to the faulting along Trefil valley also with the Shon Sheffrey spring being located along this fault zone allowing flow through the overlying Twrch Sandstone Formation[5]. Sinks within the SSSI have been traced further east to the Ffynnon Gisfaen and Agen Allwedd cave system. Therefore, groundwater flow will vary spatially dependent on the density of the fractures and karst formation.

14.164 Simpson & Partners (1995) reports that rapid recharge occurs due to absent or thin soils, with recharge also occurring through sinkholes and collapsed dolines in areas underlain by Twrch Sandstone Formation which represent preferential recharge pathways to the limestone aquifer. The fissured nature of the limestone suggests that little runoff occurs, with almost all effective rainfall recharging, hence contributing to aquifer recharge.

[5] Note that, while faults may act as zones of enhanced transmissivity, they can also form barriers to flow.

14.165 The Site is located within the Shon Sheffrey total catchment source protection zone which is a licensed public water supply operated by Welsh Water/Dwr Cymru. Mynydd Llangynidr SSSI is the closest designated site, immediately adjacent to the Site, but is not considered groundwater dependant as it is designated for its karstic geomorphology, including the dolines which have formed on the Twrch Sandstone to the east and north of the Site.

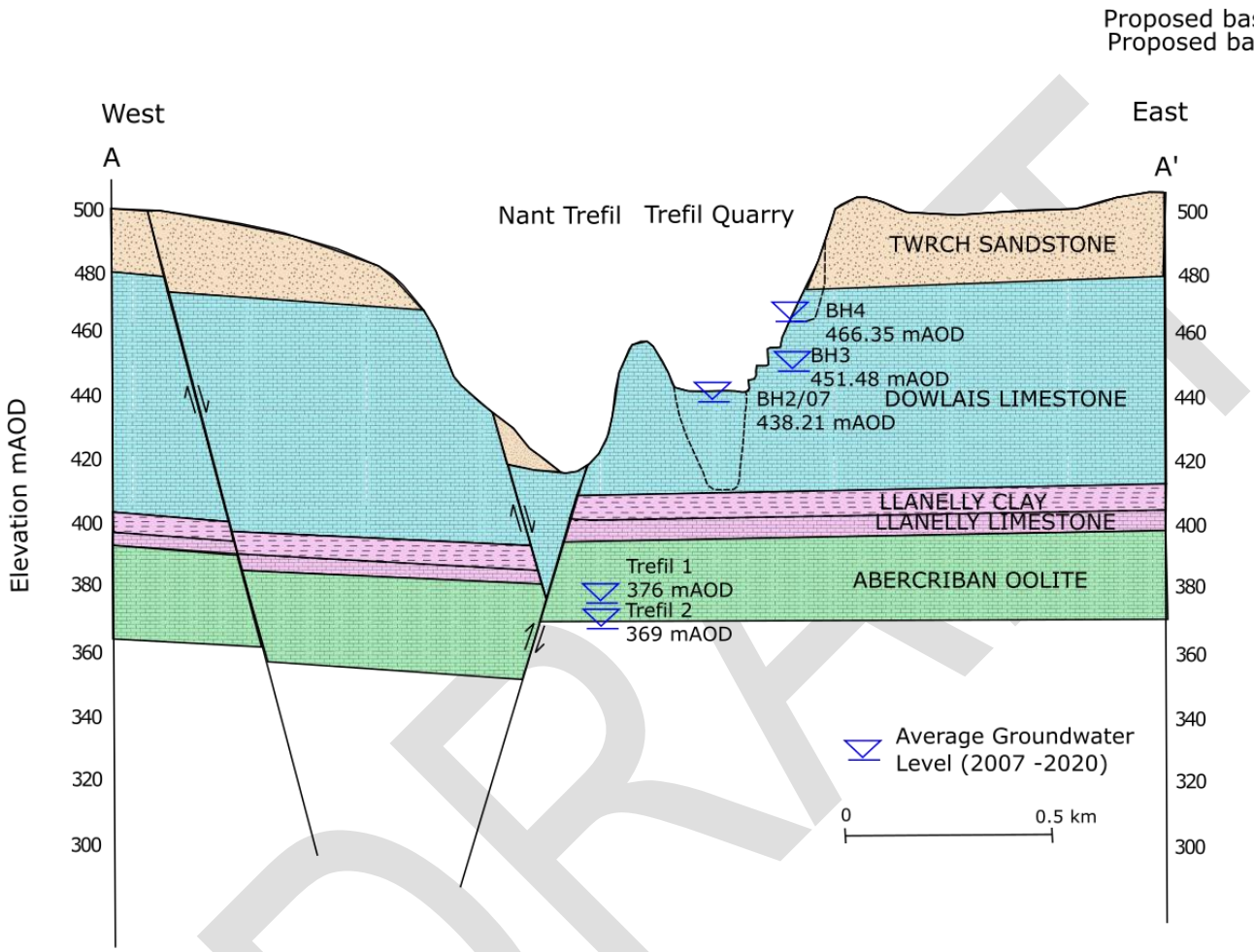

Figure 14.15 Conceptual hydrogeological cross-section through the Site (W - E)

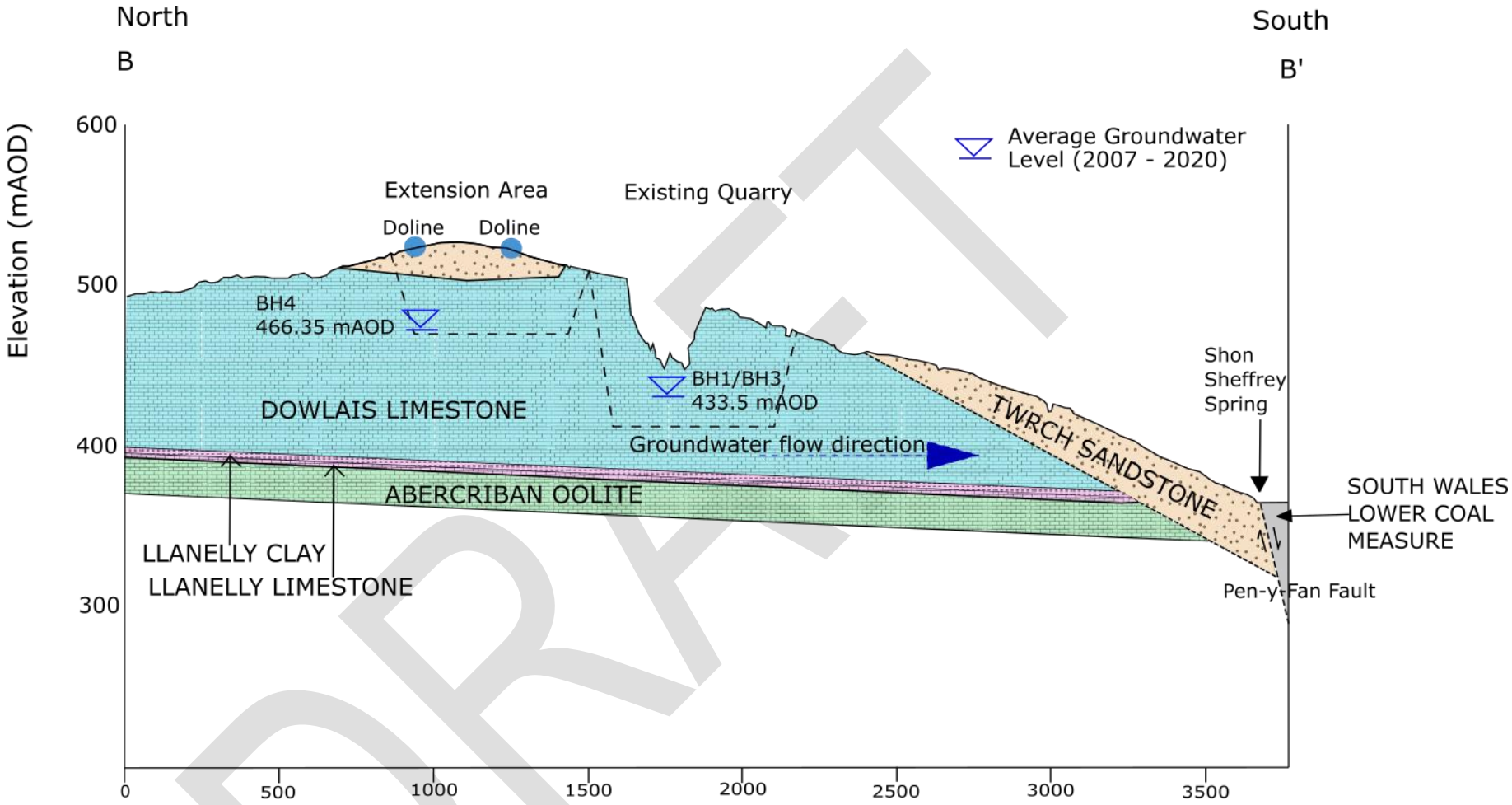

Figure 14.16 Conceptual hydrogeological cross-section through the site (N – S)

Impact Assessment and Significance of Effects

Estimate of water inflows to the Excavation

14.166 The principal impacts associated with quarries on hydrology and hydrogeology are related to dewatering of groundwater (while working below the water table) and/or changes in surface water catchment morphology. In this setting, consideration of groundwater flows within the unsaturated zone is required, as quarrying will be above the water table and, as outlined in Thompson et al. (2008), changes to recharge via removal of the unsaturated zone should be considered. The following subsections provide estimates of water inflow to the Extension Area specifically. These estimates feed into the following impact assessment sections.

Rainfall and runoff inflow

14.167 Rainfall and runoff inflows have been calculated based on the proposed plan that the ground surface in the Extension Area will slope back towards the Existing Quarry. Runoff will be directed back towards the main quarry void and enter the current water management scheme. Details of the drainage scheme during the operational and post-restoration phases are provided in the drainage strategy (**Appendix 14.2**).

14.168 The rate of rainfall falling on and running off the Extension Area, Existing Quarry and the Site (both combined) has been calculated by multiplying the area of each section by the mean annual rainfall from the hydrology rainfall section. Note that this is a long-term average; the rate of rainfall inflow during individual storm events will exceed this amount. This estimation is conservative because it assumes 100% runoff; losses due to interception and evapotranspiration have not been accounted for. Additionally, some run-off will infiltrate into the ground prior to reaching the quarry void, and this loss of water has not been accounted for here.

Groundwater inflows

14.169 During the operational stage of the Extension Area, it is not proposed to work below the water table so groundwater dewatering will not be necessary. The base of the excavation is proposed to be worked to 467 mAOD and currently groundwater levels in the east of the Site are below 452 mAOD and in the west around 457 mAOD; hence, the base will be well above the current water table. Groundwater levels in the groundwater levels and flow section show that the greatest historical water level in the west of the Site (recorded several years ago and since then c. 10 m lower) is approximately equal to the proposed excavation depth.

14.170 There is the potential for intercepted karstic flow to inflow to the excavation through karstic features, e.g. a conduit, prior to it reaching the water table if such features are intercepted. The exact location of all karstic features is not known and they may be present above the water table (in the unsaturated zone) and hence intercepted. These may act as pathways for groundwater to enter the Site periodically (typically after periods of prolonged or heavy rainfall). The likelihood of encountering such features and the degree to which they might be expected to flow is extremely difficult to predict with any certainty.

14.171 It is likely that karst features are present within the excavation given the presence of dolines at the surface and voids encountered during the drilling of Extension Area boreholes. The exact extent of the catchment area of the unsaturated zone upgradient of the Extension Area is very difficult to

delineate with any certainty. Likewise, is the current destination of unsaturated zone flow passing through the area, with some likely flowing west and discharging to the Nant Trefil, some known to be entering the northern face of the existing quarry, and some perhaps flowing in a south-easterly direction towards Shon Sheffrey Reservoir as proved by tracer tests. However, overall groundwater is unlikely to travel eastwards from the Site as the groundwater catchment does not extend across to the Mynydd Llangatwg with a groundwater catchment divide beneath Mynydd Llangynidr.

14.172 An approximation of the groundwater catchment area has been made in **Figure 14.17** based upon the known dip in the bedrock strata, doline patterns, and topography. Based on this it is estimated that the total groundwater catchment area of the Extension Area is 48.4 ha, with an estimated 27 ha currently flowing to the Nant Trefil, 2.3 ha currently discharging to the existing quarry and the remaining 19.1 ha discharging to the southeast (most likely discharging to the Shon Sheffrey spring given the proximity of proven connections via tracer test).

Total inflows

14.173 Once operations at the Existing Quarry have finished, no dewatering below the water table will be carried out at the Site. Analysis has been undertaken to determine the position of the water table in the Extension Area so that quarry workings will be kept above it so as not to draw in groundwater. The Extension Area lies within a proportion of the surface water and groundwater catchment area of the Existing Quarry and would increase these by 68%.

14.174 Total inflow of intercepted karstic flow across the Extension Area, Existing Quarry and both combined (the Site) have been calculated in **Error! Reference source not found.** using the surface water catchment area and SAAR value of 1,701 mm (1.701 m/year). The same calculation for the groundwater catchment area of the Extension Area (484,000 m^2) results in an inflow of 2,256 m^3/d and therefore the amount of inflow will slightly increase in the Extension Area by around 1,310 m^3/d. However, this is a conservative approach and does not consider losses to interception and evapotranspiration.

Table 14.12 Total inflows based on surface water catchment areas

Location	Area (m^2)	Rainfall (m/year)	Total (m^3/day)
Whole Site	481,200	1.701	2,242
Extension Area	203,000	1.701	946
Existing Quarry	295,000	1.701	1,375

General impacts of the proposed development

14.175 The array of potential impacts from quarrying activities associated with limestone extraction and subsequent quarry void restoration is well understood (Thompson et al, 2008). A well-designed quarry and standard mitigation measures can minimise many of these potential impacts. **Error! Reference source not found.** lists potential impacts and the typical mitigation measures applied.

14.176 In the following sections the potential for the general hydrogeological impacts listed in **Error! Reference source not found.** to apply to the receptors identified in the potential receptors section

is discussed for both the operational and restoration phases of the proposed quarry extension. “Construction phase” impacts are considered to be included in the operational phase for this assessment. Any mitigation measures are then detailed within the Additional Mitigation Section.

Table 14.13 Potential impacts of quarry developments (not site specific)

No.	Type of Impact	Typical Mitigation Measures
A	Impacts from quarry operation on water levels and flows	
A1	Impacts on water levels in nearby abstractions	Avoid working nearby, wet working, cut off walls, recharge trenches, discharge of compensation flows to drains
A2	Impacts on habitats sensitive to shallow groundwater levels	
A3	Impacts on water levels in any nearby ponds and lakes in connection with the aquifer	
A4	Impacts on baseflows in drains and watercourses sourced from limestone aquifer	
A5	Impacts on neighbouring buildings and infrastructure caused by drawdown related settlement	
B	Impacts from quarry operation on water quality	
B1	Impacts on groundwater and surface water quality from standard plant operation	Settlement lagoons, standard planning conditions regarding bunding of fuel tanks, appropriate spill response procedures etc.
C	Impacts from discharge of water	
C1	Impacts on receiving drain water quality	Water treatment features and discharge consent. Cover by drainage/water management strategy.
C2	Impacts on receiving drain water flows	Water treatment features and discharge consent. Cover by drainage/water management strategy.
C3	Diversion of baseflow from one catchment to another	Relocation of discharge point, discharge of compensation flows to drains
D	Impacts from restoration	
D1	Long-term impact on groundwater levels and baseflow (can be either increased or decreased depending on restoration scheme)	Appropriate design of restoration, particularly the materials used to restore slopes and the level and location of the overflow point

No.	Type of Impact	Typical Mitigation Measures
D2	Additional loss of water from open water evaporation	Reduce areas of open water in restoration concept
D3	Faster runoff and increased flood risk	SuDS-style overflow channels to minimise peak flows

Impacts from Operational Phase

14.177 While the base of the quarry void in the Existing Quarry is below the ambient groundwater elevation (estimated to be c. 435 mAOD – 440 mAOD based on historical ground water level data), pumping is likely to be required on occasion to facilitate dry working conditions for the filling operations. The degree to which this will be required is unclear at the present time, but the volumes are unlikely to be any greater than historical rates/volumes given that the void will become progressively shallower. During the operational stage of the Extension Area, it is not proposed to work below the water table so groundwater dewatering will not be required. Therefore, the receptors could only be impacted by a reduction in recharge to the limestone. A reduction in recharge could be caused by the quarrying of limestone leading to the removal of karstic dissolution features, e.g. dolines, located within the unsaturated zone.

14.178 As the Site is worked, water will likely runoff and enter the Site. This water would then either recharge the aquifer or runoff to the quarry sump before being discharged to the Nant Trefil. However, the Site and surrounding area is within the same catchment (Shon Sheffrey catchment) and so any intercepted recharge by the quarry will still reach the reservoir but via the Nant Trefil as opposed to through the karstic features.

A1 Impacts on neighbouring abstractions

14.179 The main abstractions in the area relate to the Shon Sheffrey spring and reservoir which are located 1.3 km south of the Quarry (two abstractions as noted in the licenced water abstractions and discharges section). These abstractions could be impacted by a reduction in flow reaching the spring as the Site lies within the Shon Sheffrey catchment zone. Tracer tests have confirmed that nearby dolines, to the east and west of the Site, are in hydraulic connectivity with the Shon Sheffrey spring. If dolines feeding the spring are removed through quarrying activities, some of the recharge to the spring will be intercepted, thereby reducing flows to the spring. However, Welsh Water confirmed that the Shon Sheffrey abstraction point is the reservoir, not the springs, and therefore, because the quarry discharge goes to the Nant Trefil which discharges to the reservoir, there should be no net change in water input to the reservoir. This abstraction is considered to be a high status receptor but a low degree of effect is predicted resulting in a **Moderate** degree of impact. The mitigation measures are outlined in the proposed mitigation measures section.

14.180 All other known abstractions lie at greater distances from the Site and it is highly unlikely that there will be any noticeable effect at these locations; consequently, the degree of effect and hence degree of impact will be **Negligible**.

A2 Impacts on sensitive sites

14.181 If a sensitive site (for example, SSSI) is considered as a receptor then they are classified as highly sensitive receptors. The Extension Area is situated in the Mynydd Llangynidr SSSI. However, the SSSI status of the Site relates to the karstic geomorphology (dolines and caves) and as such is not considered groundwater dependent. There is no pumping associated with quarrying in the Extension Area and any associated with the Existing Quarry would have no impact on the status of the SSSI and hence the impact is considered **Negligible**.

A3 Impacts on waterbodies in connection with the aquifer

14.182 Waterbodies in connection with the aquifer are classified as medium sensitivity receptors. There are a number of surface water features located in the vicinity of the Site as discussed in the surface water features section, however none of these features lies within the Site. The two intermittent pools to the west of the Site are fed by the Nant Trefil and are thought to be in hydraulic continuity with the groundwater below. However, as dewatering is not occurring at the Site the baseflow in the Nant Trefil should not be affected and hence neither should the supply to the pools. Therefore, the impact is considered negligible.

A4 Impacts on baseflow in watercourses

14.183 The Nant Trefil is the closest watercourse to the Site and lies approximately 100 m to the west of the Site at its closest approach. This is considered to be a medium value receptor. There is the potential that baseflow in the surrounding watercourses could be decreased as a result of recharge interception by the Extension Area. However, there will be no net loss in the catchment area of the Shon Sheffrey as the water intercepted from the karstic systems to the east will be directed through the water management system and later discharged to the Nant Trefil before reaching Shon Sheffrey. Discharging of the additional intercepted groundwater from the Extension Area to Nant Trefil may increase surface flows however the flood risk from this has been assessed in the FCA (Stantec, 2021). The effect is considered to be low on neighbouring watercourses and hence a minor degree of impact.

A5 Risk of ground settlement

14.184 Dolines are subsidence features and any potential change to the groundwater regime could result in further settlement of the collapsed material within these features. However, the risk of ground settlement would be such that it is largely confined to the existing dolines and would be consistent with normal conditions in such areas. The limestone is a strong rock and is effectively incompressible. Weathered sections of the unit closer to the surface will be weaker and more compressible however, this compressibility and therefore the risk of settlement will still be small.

B1 Impacts on water quality from plant operation

14.185 Water quality could be affected by chemical spillages or mobilisation of suspended solids. Spills at the Site could feasibly occur from the accidental loss of fluids from mobile or fixed plant equipment. The limestone aquifer is utilised for licenced water supply abstractions and has been assigned as a high value receptor.

14.186 Given that mitigation measures are already in place at the Existing Quarry, these will also be applied at the Site, the degree of effect on the limestone aquifer system from a chemical spill is

considered to be negligible, meaning that the degree of impact is also expected to be negligible. Further mitigation measures, in addition to those already in place at the Existing Quarry, are therefore not required. Runoff will be controlled by directing it into defined channels which separate the water from areas of vehicle trafficking to help minimise the generation / mobilisation of fines. Current measures already account for suspended solids with a settlement pond which allows the solids to separate out before the water is discharged from the Site plus weekly monitoring of suspended solids.

C1 Impacts on receiving watercourse quality

14.187 Runoff from the Extension Area will flow southwards into the Existing Quarry void and will be dealt with in accordance with the existing water management system for Existing Quarry. Discharges from the Existing Quarry to Nant Trefil will be in accordance with the existing discharge licence. Therefore, the degrees of effect and impact will be negligible.

14.188 Shon Sheffrey spring is to some extent 'shielded' from the Extension Area by the Existing Quarry which is immediately down hydraulic gradient, and this should reduce the risk of encountering fissures that are directly connected to the spring and thus of potentially contaminating the spring with turbid water. Therefore, the degrees of effect and impact will be negligible.

C2 Impacts on receiving watercourse flows

14.189 There is to be no water discharge from the Site as a whole above greenfield runoff rates, and all excess runoff will be attenuated within the boundaries of the Site and will initially flow to the existing quarry void, and then to the Valley Feature as detailed in the FCA (Stantec, 2021) once filling begins, before infiltrating to ground via the sandy fill material and the in-situ bedrock. Some runoff which currently makes its way directly to the Nant Trefil could be intercepted and directed through the site water management system instead. Mitigation measures including SuDS, options for water management, and opportunities for the proposed scheme to contribute to the alleviation of existing water management issues in the catchment are assessed in the accompanying FCA (Stantec, 2021).

C3 Diversion of baseflow from one catchment to another

14.190 There will be no dewatering within the Site and there will be no diversion of baseflow between catchments.

Impacts from Restoration

14.191 Some restoration will be progressively undertaken during working of the Extension Area. This will involve infilling of the Existing Quarry void with unsalable material ((‘out-of-specification’ limestone, together with Twrch Sandstone overburden and smaller quantities of superficial sediment). The Proposed Development Chapter of the Environmental Statement contains full details of the proposed development during the operation and restoration stages.

D1 Long-term impact on groundwater levels and baseflow

14.192 Once quarrying operations cease and the pumps are switched off in the Existing Quarry, groundwater levels in the areas adjoining the Site (e.g., BH1/07 as displayed in the groundwater levels and flow section) are expected to recover to be similar to pre-development natural levels, but

this is not expected to present a flood risk to the nearby receptors for the reasons set out in the FCA (Stantec, 2021). There may be some influence on recharge rates that currently occur via the dolines that will be removed by quarrying; however, the drainage strategy (Stantec, 2021) includes for a large proportion of site runoff to infiltrate to ground via the Valley Feature which will offset any reduction. As dewatering is not proposed in the Extension Area, there will be no additional effects on groundwater levels.

14.193 Post restoration, the Existing Quarry void will have been partially filled in with unsalable material (((‘out-of-specification’ limestone, together with Twrch Sandstone overburden and smaller quantities of superficial sediment), except for the Valley Feature. As highlighted in the FCA (Stantec, 2021), once the land in this area protrudes above the surrounding ground surface, water will shed radially from the fill landform. Runoff from the eastern half of the filled area and from the extension area will enter the Valley Feature between the existing limestone face and the deposited, sandy fill material. The Valley Feature will act as an infiltration feature to encourage groundwater recharge in this area and hence no long term impacts to groundwater levels and baseflow should be expected. Runoff from the western part of the filled area will be conveyed by the retained water management features.

D2 Additional loss of water from open water evaporation

14.194 Only small open water restoration features will remain at the Site which may be ephemeral. Open water evaporation would cause losses to groundwater which could affect the availability of water in the catchment. Losses to groundwater could affect baseflows in neighbouring watercourses and discharges to local groundwater discharge points (Nant Trefil). However, the proposed areas of open water and hence the rate of evapotranspiration is very small in comparison to the total catchments of the neighbouring watercourses. Consequently, the impact and effect are considered to be negligible.

D3 Faster runoff and increased flood risk

14.195 Runoff from the Site will increase due to climate change as short-duration, high-intensity rainfall and long-duration rainfall events will become more frequent. Runoff from much of the Site will be attenuated in the Valley Feature and infiltrate to ground as per the SuDS strategy in **Appendix 14.2**. As a result, the net change will be a decrease in offsite runoff rates and volumes relative to the greenfield scenario, see **Appendix 14.2**.

Summary

14.196 **Error! Reference source not found.** summarises the impacts on neighbouring receptors for the operational phase of the proposed development and the likely significance of effects. Further mitigation and monitoring measures are described below where this is considered necessary.

14.197 **Error! Reference source not found.** provides a summary of impacts from the restoration of the proposed development on the water environment.

Table 14.14 Summary of impacts from working the Site – operational phase

No.	Type of Impact	Receptor	Receptor Value	Degree of Effect	Degree of Impact pre mitigation	Mitigation Required	Residual Effect
A	**Impacts on water quantity**						
A1	Neighbouring abstractions	Shon Sheffrey licenced abstractions	High	Low	Moderate	Yes	Negligible
		Private water supplies (both groundwater and surface water dependent)	Low	Negligible	Negligible	No	Negligible
A2	Impacts on sensitive sites	Mynydd Llangynidr SSSI	High	Negligible	Negligible	No	Negligible
A3	Impacts on waterbodies	Pools along Nant Trefil	Medium	Negligible	Negligible	No	Negligible
A4	Impacts on watercourses	Nant Trefil / surrounding watercourses	Medium	Low	Moderate	Yes	Negligible
B	**Water quality impacts**						
B1	Spillage of fuels and mobilisation of suspended solids.	Limestone aquifer	High	Negligible	Negligible	No	Negligible
		Twrch Sandstone	Medium	Negligible	Negligible	No	Negligible
C	**Impacts from discharge of water**						
No.	Type of Impact	Receptor	Receptor Value	Degree of Effect	Degree of Impact pre mitigation	Mitigation Required	Degree of Impact post mitigation
C1	Impacts on receiving watercourse water quality	Nant Trefil	Medium	Negligible	Negligible	No	Negligible

C2*	Impacts on receiving watercourse flows	Nant Trefil	Medium	Negligible	Negligible	No	Negligible
C3	Diversion of baseflow between catchments	Nant Trefil	Medium	Negligible	Negligible	No	Negligible

** = See FCA (**Appendix 14.2**) for more detail*

Table 14.15 Summary of impacts from working the Site - restoration phase

No.	Type of Impact	Receptor	Receptor value	Magnitude of Impact	Significance of Effect	Mitigation Required
D1	Long term impact on groundwater levels	Groundwater	High	Negligible	Negligible	No
D2	Additional loss of water from open water evaporation	Nant Trefil	Medium	Negligible	Negligible	No
		Groundwater	High	Negligible	Negligible	No
D3*	Faster runoff and increase in flood risk	Buildings & infrastructure	High	Negligible	Negligible	No

** = See FCA (**Appendix 14.2**) for more detail*

Additional Mitigation

Proposed mitigation measures

14.198 Additional mitigation measures are identified to reduce or remedy environmental impacts. Two strands of mitigation measures will be considered at this stage of the process - standard and actionable.

14.199 Even though recharge to the Shon Sheffrey spring is expected to be impacted via interception of flow through subsurface drainage pathways, the water will be discharged to the Nant Trefil which eventually discharges into the Shon Sheffrey reservoir, meaning the recharge will still reach the reservoir, just via a different route. However, it has been noted that the Nant Trefil appears to be dry through much of the summer along the reach from Trefil village to Shon Sheffrey. Little flow is monitored leaving the Upper Pool on the Nant Trefil downstream of the discharge point and so it is considered likely that surface water sinks back into the aquifer at the pool. Because this feature is within the Shon Sheffrey catchment zone it should still reach the reservoir in groundwater/subsurface drainage. Discharge of quarry water to the Nant Trefil should therefore act as effective mitigation for any potential loss of water currently reaching the spring but which would be intercepted by the Extension Area in future.

14.200 Potential water quality impacts will be addressed by standard planning conditions applied to the planning permission. A spill is considered unlikely however, were this to occur, it would be retained within the active quarry void for a sufficient length of time to allow it to be collected using oil absorbent materials, with standard operational procedures. Contaminated material would then be disposed of in accordance with current best industry practices. Discharge from the quarry void would cease during this time.

14.201 Facilities for the storage of soils, fuels or chemicals will be sited on an impervious base and surrounded by impervious bund walls. These will be sited within the Existing Quarry in accordance with best practice and existing planning conditions. The volume of the bunded compound will be greater than the tank capacity. Filling points, vents, gauges and sight glasses will be located within the bund walls. The bund drainage system will be sealed with no discharge to any watercourse, land, or underground strata permitted. Associated pipework will be located above ground and protected so as to prevent accidental damage. All filling points and tank overflow pipe outlets will discharge downwards into the bund.

14.202 Drainage systems at the Site will be regularly inspected to ensure that visible oil and hydrocarbons are not present. The drainage strategy in **Appendix 14.2** outlines the plan for reducing impacts to water quality. An environmental management system will be established to ensure that all procedures follow best practice.

14.203 Suspended solid concentrations in the water may become elevated due to the movement of mobile plant equipment or mobilisation of sediment in runoff, however this will be controlled by the in-built mitigation measure of directing runoff to a system of defined channels which will keep the site runoff separated, as far as possible, from vehicle trafficking. Any discharge off site will be controlled by the terms of the existing discharge permit. Suspended solids will be given ample time to settle out of suspension prior to discharge to Nant Trefil. It is recommended that the suspended solids concentration is continued to be monitored regularly to allow compliance and the limit on the permit remains at 100 mg/l which is currently in place at the Site.

14.204 Flood risk and drainage mitigation measures are presented separately by Stantec in the accompanying FCA (Stantec, 2021).

Proposed monitoring

14.205 Based on the findings of this Chapter, most notably that working will be above the water table, it is not considered necessary for any changes to the existing water monitoring regime at Trefil Quarry and hence year-round monitoring of water levels within the Existing Quarry and Extension Area will continue.

Residual Effects

14.206 None of the impacts relating to hydrology and hydrogeology are considered to be "significant" following due consideration of the proposed mitigation measures that have been included in the design. Therefore, there will be negligible residual effects on the Shon Sheffrey licenced abstraction and Nant Trefil / surrounding watercourses after the mitigation measures are implemented as the degree of impact will be reduced.

In Combinational and Cumulative Effects

14.207 This section considers the impact of the proposed development in conjunction with other, nearby activities and effects noted in other sections of the Environmental Statement.

In-combination effects

14.208 In-combination effects look at the combined action of a number of different environmental-topic-specific effects upon a single receptor or resource. The receptors considered in this report are:

- Shon Sheffrey spring public water supply.
- Nant Trefil watercourse.
- Groundwater within the Carboniferous Limestone aquifer.

14.209 There may be in-combination effects with the Geodiversity and Ecology Chapters of the Environmental Statement. In-combination effects with the Geodiversity Chapter will be due to the removal of the adjacent Mynydd Llangynidr SSSI in the Extension Area which is designated due to the dolines and karstic features. In-combination effects with the Ecology Chapter will be due to the bats in the Valley Feature and possible aquatic ecology in the receiving water course. However, as outlined above mitigation measures have been provided so that the effects should be negligible.

Cumulative effects

14.210 Cumulative effects look at the combined action of a number of developments, cumulatively with the development being assessed on a single receptor.

14.211 The following developments have been considered for potential cumulative effects:

- An application to renew the outline planning permission for the Circuit of Wales,
- Wind turbine proposals located within Rassau Industrial Estate whereby planning permission has been granted for a single turbine at Unit 18 (C/2018/0293) and another is about to be granted at Unit 19 (C/2020/0301), and
- Ciner glass bottle plant at Rassau Industrial Estate (no application submitted to date).

14.212 The locations of these developments are approximately 3 km to the south-east (down-gradient) of the Site at Rassau Industrial Estate and none of these developments are groundwater dependent and therefore the cumulative effect of these in addition to the Site on hydrology and hydrogeology issues in the surrounding area is negligible.

Conclusions

14.213 Gryphonn is proposing to extend limestone extraction to the north of the existing Trefil Quarry and to allow for the filling of the existing void with site derived material until 2044. The Extension Area is to be worked to a level of not less than 467 mAOD and the excavations will not require groundwater dewatering.

14.214 Stantec has reviewed the potential hydrogeological and hydrological impacts of the development at the Site and subsequent restoration. Potential impacts to neighbouring abstractions, surface water bodies, water quality and sensitive sites have been assessed. The most proximal receptors include a licenced DCWW surface water abstraction (named Shon Sheffrey spring although the abstraction point is Shon Sheffrey reservoir), the Nant Trefil, Mynydd Llangynidr SSSI and the limestone aquifer.

14.215 Residual effects from the proposed development are expected to be negligible following mitigation and, hence, not significant. Recharge to Shon Sheffrey spring could be intercepted by the extension of the quarry through removal of dissolution features resulting in reduced spring flow. However, the intercepted water will be discharged to Nant Trefil which converges with the Sirhowy River to the south of Trefil and flows to Shon Sheffrey reservoir. The discharge will effectively mitigate this impact and there will be no net loss of water to the abstraction.

References

BGS, 1986. Hydrogeological Map of South Wales. 1:125,000.

BGS, 1990. Geological Survey of England and Wales 1:50,000 geological map series. Abergavenny (Solid & Drift). Sheet number 232.

Environment Agency, 2017. Groundwater protection: Collection. UK: Environment Agency. Retrieved 01 07, 2021, from https://www.gov.uk/government/collections/groundwater-protection

ESI Ltd, 2008. Trefil Quarry: Hydrogeological Impact Assessment. Report reference: 6878R1rev1, June 2008

Centre of Ecology and Hydrology, 2021. Flood Estimation Handbook (FEH) website.

Ford, T.D. (Ed), 1989. Limestones and Caves of Wales. Cambridge, Cambridge University Press.

Gunn, J, 2012. Assessment of Mynydd Llangynidr as a Potential Site of Special Scientific interest.

Hyder Consulting Ltd, 2005. Proposed deepening of Trefil Quarry: Hydrogeological and Hydrological Assessment.

Jones H.K., Morris B.L., Cheney C.S., Brewerton L.J., Merrin P.D., Lewis M.A., MacDonald A.M. Coleby, L.M., Talbot, J.C., McKenzie, A.A., Bird, M.J., Cunningham, J. & Robinson V.K., 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey Hydrogeology Group Technical Report WD/00/4, Environment Agency R&D Publication 68.

Ramsey, Dr. A.T.S., 2003a. An assessment of the limestone reserves, North Trefil Quarry. Department of Earth Sciences Cardiff University.

Ramsey, Dr. A.T.S., 2004. The Dowlais Limestone, Trefil Quarry: Assessment of limestone thickness and quality. Department of Earth Sciences Cardiff University.

Simpson & Partners, 1995. Shon Shreffrey National Rivers Authority Welsh region groundwater protection zones data collection and presentation.

Stantec UK Ltd, 2021. Flood Consequence Assessment Trefil Quarry – northern extension. Report reference 6878R9.

Thompson, A.; Howarth, C.L.; Goodwin, A.; Buckley, C; and Harris, K, 2008. *Good Practice Guidance on Controlling the Effects of Surface Mineral Working on the Water Environment*. Report to the Department of Communities and Local Government, and the Mineral Industry Research Organisation. Capita Symonds Ltd, East Grinstead. (207 pp plus Appendices)

Welsh Government, 2021. Planning Policy Wales, Edition 11. https://gov.wales/sites/default/files/publications/2021-02/planning-policy-wales-edition-11_0.pdf

Welsh Water Authority, 1979. South East Wales Groundwater Study – Interim Report (by Howard Humphreys and Partners)

Welsh Water Authority, 1980. South East Wales Groundwater Study – Reconnaissance Report (by Howard Humphreys and Partners)

Welsh Water Authority, 1982. South East Wales Groundwater Study – Results of Exploratory Drilling Report (by Howard Humphreys and Partners)

Wimpey Environmental Limited, 1994c. Assessment of potential hydrogeological impact of quarry on Shon Sheffrey reservoir, Trefil Quarry. (Reference S/29471/3).