

# Ffos-y-Fran

Merthyr Tydfil

## Hydraulic Modelling Summary Note

December 2024

| Scheme Information    |                                                                                                                                                                                                                                                    |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scheme:               | Ffos-y-Fran, Merthyr Tydfil                                                                                                                                                                                                                        |
| Report Title:         | Hydraulic Modelling Report                                                                                                                                                                                                                         |
| Client:               | Merthyr (South Wales) Ltd                                                                                                                                                                                                                          |
| Instruction:          | The instruction to undertake this modelling was received from Keith Bamsey of Merthyr (South Wales) Ltd                                                                                                                                            |
| File Ref:             | 15840-Hydraulic Modelling Summary Note-01                                                                                                                                                                                                          |
| Supporting Documents: | This Hydraulic Modelling Report should be read in conjunction with the associated FCA written by Waterco, December 2024 (15840 -FCA & Drainage Strategy-01) and the Water Framework Directive (WFD) assessment, December 2024 (15840-WFD-02.docx). |

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This report will remain valid for a period of twelve months (from the date of last issue) after which the source data should be reviewed in order to reassess the findings and conclusions on the basis of latest available information.

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## Glossary and Modelling Short Codes

**Table 1: Glossary of Technical Terms**

| Term / Acronym       | Definition                                                                                                                                                                     |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1D (model)           | One dimensional – A type of model typically built using watercourse cross-section survey data to represent the watercourse and adjacent floodplain                             |
| 2D (model)           | Two dimensional – A type of hydraulic model typically built using LiDAR and site-specific topographic data to represent the wider floodplain                                   |
| 1D-2D (model)        | A combination of 1D and 2D modelling (i.e. typically a representation of the watercourse and floodplain respectively)                                                          |
| AEP                  | Annual Exceedance Probability – the probability that a storm event will occur in any given year                                                                                |
| Defra                | Department for Environment, Food and Rural Affairs                                                                                                                             |
| DfI                  | Department for Infrastructure – one of nine departments in Northern Ireland responsible for regional strategic planning and development policy                                 |
| EA                   | Environment Agency – non-departmental public body responsible for the protection and enhancement of the environment in England                                                 |
| ESTRY                | Industry standard flood modelling software (1D engine built into TUFLOW)                                                                                                       |
| FCA                  | Flood Consequence Assessment                                                                                                                                                   |
| FRA                  | Flood Risk Assessment                                                                                                                                                          |
| FFL                  | Finished Floor Level                                                                                                                                                           |
| Flood risk           | The product of the frequency or likelihood of a flood event and the consequences (such as loss, damage, harm, distress and disruption)                                         |
| FMP                  | Flood Modeller Pro – industry standard flood modelling software                                                                                                                |
| HMR                  | Hydraulic Modelling Report                                                                                                                                                     |
| IDB                  | Internal Drainage Board                                                                                                                                                        |
| LA                   | Local authority                                                                                                                                                                |
| LiDAR                | Light Detection and Ranging (i.e. Ground elevation data)                                                                                                                       |
| LLFA                 | Lead Local Flood Authority                                                                                                                                                     |
| Main river           | A watercourse on which the relevant regulatory body (e.g. EA/NRW/SEPA/DfI) has permissive powers, but not a duty, to carry out maintenance, improvement, or construction work. |
| MIKE (11/21/FLOOD)   | Industry standard flood modelling software                                                                                                                                     |
| NGR                  | National Grid Reference                                                                                                                                                        |
| NRW                  | Natural Resources Wales – Welsh Government sponsored body responsible for managing the environment and natural resources of Wales                                              |
| Ordinary watercourse | A river, stream, ditch, cut, sluice, dyke or non-public sewer that is not a designated main river, and for which the LA has flood risk management responsibilities and powers. |

| Term / Acronym | Definition                                                                                                                                          |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| SEPA           | Scottish Environment Protection Agency – non-departmental public body responsible for the protection and enhancement of the environment in Scotland |
| TN             | Technical Note                                                                                                                                      |
| TUFLOW         | Industry standard flood modelling software                                                                                                          |

Short codes are used in the naming and referencing of model files, events and scenarios to ensure a consistent, high-quality naming convention is followed and to simplify communication of model results.

**Table 2: Modelling Short Codes**

| Model Short Code | Definition                                                                                                                                                                                        |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ABC              | Model identifier                                                                                                                                                                                  |
| BL[x]-[y]        | A y% blockage at location x<br>(e.g. BL1-67 – 67% blockage at location “1”)                                                                                                                       |
| BR[x]-[y]        | A y metre wide breach scenario at location x<br>(e.g. BR2-50 – 50m wide breach at location “2”)                                                                                                   |
| CC               | Climate change                                                                                                                                                                                    |
| DEV              | Post-development site layout                                                                                                                                                                      |
| EXG              | Existing (pre-development) site layout                                                                                                                                                            |
| MIT              | Flood mitigation option                                                                                                                                                                           |
| NC               | “Normal conditions”<br>A model setup representative of present channel and floodplain conditions throughout the study area – no additional structure blockages, defence breaches or pump failures |
| OPT              | Development option                                                                                                                                                                                |
| Q[x]             | 1 / x % AEP fluvial event                                                                                                                                                                         |
| R[x]             | 1 / x % AEP pluvial event                                                                                                                                                                         |
| ST[x]            | Sensitivity test x<br>(e.g. ST1 – channel and floodplain roughness +20%)                                                                                                                          |
| T[x]             | 1 / x % AEP tidal event                                                                                                                                                                           |

## Introduction

Waterco has been commissioned to undertake a hydraulic modelling study on behalf of Merthyr (South Wales) Ltd in respect of the proposed restoration of the former open cast mine at Ffos-y-Fran, Merthyr Tydfil, South Wales, CF48 4AH. A location plan and aerial plan of the site are included in Appendix A.

Merthyr (South Wales) Ltd are seeking the approval of the final restoration proposals of the former open cast mine with the appropriate authorities, including NRW. The most recent correspondence with NRW (Appendix B) outlines the requirement of the understanding of the potential impact of the restoration proposals may have on surrounding watercourses. Therefore, the main objective of this hydraulic modelling study is to quantify the surface water flow routes through the existing mine site that have the potential to discharge into the surrounding watercourses including the Goat Mill to the northwest, Cwm Nant-y-Coed to the west and Nant-Cwm-Blacs to the southwest. The change to the surface water flow routes (if any) as a result of the restoration proposals will also be quantified.

Additionally, the objective considers the potential impact of the proposed works on the level of the void during extreme rainfall events and during a high ground water event. The scope of works excludes the assessment of the ground water regime within the void, which will be considered by others. To enable this, a 2D<sup>1</sup> rainfall on grid model has been constructed. This report summarises the hydraulic modelling works completed.

## Site Description and Proposed Development

The key features of the final restoration have been outlined by the client and are as follows:

*‘Minimise bulk earthworks by retaining the existing groundwater lake that has formed naturally in the main void following cessation of coal extraction and when the de-watering of the main void was no longer required. The sides of the main void will be re-profiled and using existing spoil material and material from the overburden mound OB1. The height of OB1 would be reduced and re-profiled as a sinuous undulating ridge and areas of open rock face and scree retained for biodiversity and visual amenity. Existing ponds and water bodies, such important relics of the previous industrial extractive industries will be retained and enhanced for nature conservation and preserved as heritage assets. The bank to the west of the quarry void will be reprofiled and the remainder of the land will return to its former use as rough grazing pasture. The existing haul road routes would be retained as narrow plateaus and grassed tracks for future access and public amenity’.*

A proposed restoration plan is included in Appendix C and a full description of the restoration proposals is detailed in the associated FRA (15840-WFD-02.docx).

**Table 3: Site Overview**

| Site Overview                   |                                                                                                                                                |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Site Address                    | Ffos-y-Fran, Merthyr Tydfil, CF48 3AH                                                                                                          |
| NGR (located at centre of site) | 307420, 206984                                                                                                                                 |
| Topographic Survey              | A topographical survey of the site was undertaken by Richard Moorehead & Laing in November 2023 and is provided in Appendix D for information. |
| Current Site Use                | Former open cast mine                                                                                                                          |
| Regulatory body                 | LLFA & NRW                                                                                                                                     |

## Hydraulic Model Build

The information provided in this section details the modelling works carried out as part of this scheme. The model log<sup>2</sup> provided with the model files should be consulted if further details are required. An explanation of the file, event and scenario naming convention used is provided in the model log.

**Table 4: General model overview**

| General Model Overview                        |                                                                                                                                 |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>Brief Summary:</b>                         | A new 2D pluvial hydraulic model of the study area has been developed using the topographic survey data provided by the client. |
| <b>Model Type:</b>                            | 2D                                                                                                                              |
| <b>Software Builds:</b>                       | TUFLOW 2023-03-AF HPC<br>Double Precision<br>(Latest build available at the start of the project)                               |
| <b>Simulation Type:</b>                       | Pluvial                                                                                                                         |
| <b>Waterco Model Reference &amp; Version:</b> | 15840-29166-005                                                                                                                 |

<sup>2</sup> Doc ref: 15840-29166-Model\_Log.xlsx

## Data Sources

Table 5 details the data sources used within the model build process and are included in Appendix D.

**Table 5: Data sources**

| Data Source                            | Doc Ref                        | Provider                  | Date/Age                | Comments                                       |
|----------------------------------------|--------------------------------|---------------------------|-------------------------|------------------------------------------------|
| <b>Topographic Data</b>                |                                |                           |                         |                                                |
| Topographic survey                     | 3274-RML-M3_SurfaceNov2023.dwg | Richard Moorehead & Laing | November 2023           | Full coverage of site. Provided in Appendix D. |
| Restoration Plan                       | 3274-RML-M3_FinalJul2024.dwg   | Richard Moorehead & Laing | July 2024               | Full coverage of site. Provided in Appendix D. |
| NRW LiDAR DTM (1m)                     | -                              | NRW                       | Accessed Date July 2024 | Full coverage of site                          |
| <b>Other Data</b>                      |                                |                           |                         |                                                |
| Groundwater Regime & Borehole records. | Ffos_y_Fran.pptx               | Richard Moorehead & Laing | February 2024           | Full coverage of site. Provided in Appendix D. |

## Hydrology

To fully investigate the surface water flood risk during the existing (EXG) scenario, a range of rainfall events have been simulated; namely the 3.33% (R30), 1% (R100) and 0.1% (R1000) AEP events. The impact of future climate change (CC) has also been investigated during the 1% and 0.1% AEP events by increasing rainfall by 40% (R100CC40 and Q1000CC40, respectively).

Design hyetographs based on a recommended 3hr storm duration are required as input to the hydraulic model. To provide the required rainfall hyetographs the ReFH2 method has been undertaken.

The subject catchment is 2.13km<sup>2</sup> and not available on the FEH website, therefore a nearby catchment was used (NGR 308000, 206250) as a proxy catchment to obtain the catchment descriptors. The FEH catchment area was updated to the subject catchment area using a watershed analysis in GIS software, this was carried out on the 1m LiDAR and compared with the topographic survey. There were negligible differences between the two datasets and therefore the 1m LiDAR was used. A comparison of the FEH boundary and the adopted subject catchment area has been included in Appendix E.

The remaining catchment descriptors for the subject site have been checked and where necessary, updated in accordance with the FEH Handbook and Flood Estimation Guidelines. These catchment descriptors include DPLBAR, DPSBAR & FARL. All other catchment descriptors have been adopted from the proxy catchment. The original and updated catchment descriptors are detailed in Table 6 below.

**Table 6: Summary of Catchment Descriptors**

| Catchment                 | AREA | BFIHOST | BFIHOST 19 | DPLBAR | DPSBAR | FARL | PROP WET | SAAR | SPRHOST | URBEXT 1990 | URBEXT 2000 |
|---------------------------|------|---------|------------|--------|--------|------|----------|------|---------|-------------|-------------|
| Original (FEH)            | 0.68 | 0.29    | 0.30       | 0.70   | 58.50  | 0.79 | 0.54     | 1493 | 49.86   | 0           | 0           |
| Updated Subject Catchment | 2.13 | 0.29    | 0.30       | 1.32   | 198.70 | 1    | 0.54     | 1493 | 4986    | 0           | 0           |

The net rainfall (hyetographs) have been calculated using the ReFH2 calculation method. The net rainfall is used as this will account for the losses through infiltration in the catchment, not accounted for in the hydraulic model. The peak net rainfall results are summarised in Table 7. The full ReFH2 reports are included in Appendix F.

**Table 7: Peak Net Rainfall**

| Return Period (AEP) | Peak Net Rainfall (mm) |
|---------------------|------------------------|
| 3.33%               | 2.38                   |
| 1%                  | 2.97                   |
| 1% +40% CC          | 4.16                   |
| 0.1%                | 4.33                   |
| 0.1% + 40% CC       | 6.07                   |

## 2D Model Information

Table 8 summarises the detail of the 2D model, including the various parameters within the model.

**Table 8: 2D Model Information**

| 2D Model Information                                      |                                                                                                                                                                                         |                 |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>Number of Domains and Extent:</b>                      | 1 domain. The model extent is shown in Appendix G.                                                                                                                                      |                 |
| <b>DTM Data Sources:</b>                                  | The 2D TUFLOW model has been constructed using the topographic survey of the site (3274-RML-M3_SurfaceNov2023.dwg) and NRW 1m LiDAR DTM where there are gaps in the topographic survey. |                 |
| <b>2D Cell Size:</b>                                      | 2m – this resolution is adequate to represent the flow paths on site and within the wider floodplain whilst maintaining a reasonable run time                                           |                 |
| <b>Roughness Approach and Values (s/m<sup>1/3</sup>):</b> | Manning's n based on Chow (1959) and Aerial Imagery.                                                                                                                                    |                 |
|                                                           | <b>Mannings 'n' value</b>                                                                                                                                                               | <b>Material</b> |
|                                                           | 0.030                                                                                                                                                                                   | Inland Water    |
|                                                           | 0.035                                                                                                                                                                                   | Grassland       |
|                                                           | 0.04                                                                                                                                                                                    | Coal Mine       |

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Boundary Conditions:</b>     | <p>Rainfall applied to the 2D domain. Rainfall runoff method ReFH2 (version 2.3) has been used to provide design hyetographs for input into the hydraulic model. The net rainfall hyetographs, which include the losses through infiltration, have been applied directly to the 2D domain using a TUFLOW '2d_rf' rainfall polygon.</p> <p>2D Head-Discharge (HQ) boundary conditions have been applied at the model extent where water was initially shown to glasswall. The HQ boundary slope has been estimated based on local ground slope.</p> |
| <b>Post-Development Layout:</b> | An alternative 2D post development (DEV) DTM has been created using the restoration proposal (3274-RML-M3_FinalJul2024.dwg).                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Timestep:</b>                | TUFLOW HPC uses an adaptive timestep.<br>Initial timestep set to 1s                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Initial Conditions:</b>      | Using the groundwater information (Ffos_y_Fran.pptx ), the initial water levels within the void have been set to 284m AOD during the normal condition events and 311m AOD during the high ground water (HGW) scenario.                                                                                                                                                                                                                                                                                                                             |
| <b>Non-Default Parameters:</b>  | Cell Wet/Dry Depth = 0.2mm (as recommended for rainfall modelling)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Further Comments:</b>        | See assumptions and notes tab in the model log.<br>(Doc Ref: 15840-29166-Model_Log.xlsx)                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## Model Simulation Setup

The list of simulations modelled for this study are detailed in this section.

Primary simulations have been modelled for a range of pluvial design events for the existing site scenario.

**Table 9: Primary simulations under normal conditions (NC)**

| Pluvial Design Event (AEP) | Climate Change Allowance | Site Layout                                 |
|----------------------------|--------------------------|---------------------------------------------|
| 3.33%                      | -                        | Existing (EXG) / Proposed Development (DEV) |
| 1%                         | -                        |                                             |
| 1%                         | +40%                     |                                             |
| 0.1%                       | -                        |                                             |
| 0.1%                       | +40%                     |                                             |

## High Ground Water Simulations

A high ground water simulation has been assessed with respect to the 1% AEP +40% CC pluvial events, for both the EXG and DEV site layout scenarios. Details of the simulation can be found in Table 10 below.

**Table 10: High Groundwater simulation details**

| High Ground Water<br>(Model Short Code) | Considerations                                    | Level<br>(mAOD) | Fluvial Event<br>(AEP) | Site Layout  |
|-----------------------------------------|---------------------------------------------------|-----------------|------------------------|--------------|
| HGW                                     | 2D IWL applied at highest<br>groundwater recorded | 311             | 1% + 40% CC            | EXG &<br>DEV |

## Model Limitations

This section presents the steps taken throughout the modelling process to reduce uncertainty and improve confidence in the model outputs. Efforts have been made to assess and reduce the levels of uncertainty at each stage of the modelling process. The most appropriate available information has been used to construct the model to represent flooding mechanisms. The assumptions made are generally conservative for modelled water levels at the proposed scheme location and are therefore appropriate for the assessment of flood risk.

In the absence of available calibration data, sensitivity testing of three identified sources of uncertainty has been carried out along with model validation against a known flood event (if available) and a review of the model's performance rating. Table 11 lists and ranks identified sources of uncertainty and the assumptions made as part of the model build process.

### Limitations and Assumptions

**Table 11: Sources of uncertainty and assumptions**

| Rank | Source                   | Selected method                                                           | Assumptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|--------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Friction parameters      | Manning's n roughness coefficient based on available guidance (Chow 1959) | Structure and floodplain roughness have been assigned using the best available information (aerial photographs). The roughness values may vary over the year and the sensitivity tests have been carried out to quantify the impact.                                                                                                                                                                                                                                                                                                                          |
| 2    | Boundary conditions      | 2D HQ Boundary                                                            | The HQ boundary slope has been estimated from topographic survey levels. Sensitivity testing of the specified slope value has been carried out to assess any potential impact to the site.                                                                                                                                                                                                                                                                                                                                                                    |
| 3    | Rainfall hyetographs     | ReFH approach                                                             | Pluvial flows only, have been considered. See hydrology section above for more detail. Sensitivity tests have been carried out to quantify the impact.                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4    | Topography               | DTM, survey data and proposed scenario.                                   | <p>The topographic survey and the latest available 1m resolution LiDAR data has been used to represent the topography of the site in its existing form.</p> <p>The proposed restoration has been applied using a TIN of the proposed elevations. It must be noted there are differences between the TIN of the existing topography and the TIN of the proposed topography in areas where no ground alterations are proposed. Therefore, there are some anomalous results shown as a consequence of the differences in the TINs which form the model DTMs.</p> |
| 5    | Grid size                | 2m cell size                                                              | This is suitable to represent most of the floodplain features across the model extents to an appropriate level of detail.                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 6    | Ground water interaction | Static initial water levels                                               | Modelling of the dynamic Ground water levels in the void has not been considered as this was excluded from the scope. Ground water has been considered within the modelling by adding a 2D static initial water                                                                                                                                                                                                                                                                                                                                               |

| Rank | Source                      | Selected method                               | Assumptions                                                                                                                    |
|------|-----------------------------|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
|      |                             |                                               | level for the entire simulation based on borehole records (Ffos_y_Fran.pptx). The adopted approach is a conservative estimate. |
| 7    | Change in climate condition | Predictions of anticipated change to rainfall | Climate change events selected based on NPPF.                                                                                  |

### Sensitivity Tests

Sensitivity testing of four sources of uncertainty has been carried out. A total of seven sensitivity tests have been carried out (ST1-7) with respect to the 1% AEP + 40% CC pluvial event. Details of these sensitivity tests can be found in Table 12.

**Table 12: Sensitivity test details**

| Sensitivity Test Short Code | Varied Parameter          | Adjustment | Fluvial Event(s) (AEP) | Site Layout |
|-----------------------------|---------------------------|------------|------------------------|-------------|
| ST1                         | Roughness coefficients    | +20%       | 1% +40% CC             | EXG         |
| ST2                         | Roughness coefficients    | -20%       | 1% +40% CC             | EXG         |
| ST3                         | Downstream boundary slope | +20%       | 1% +40% CC             | EXG         |
| ST4                         | Downstream boundary slope | -20%       | 1% +40% CC             | EXG         |
| ST5                         | Rainfall Intensity        | +20%       | 1% +40%CC              | EXG         |
| ST6                         | Rainfall Intensity        | -20%       | 1% +40% CC             | EXG         |
| ST7                         | HPC Control Number Factor | -0.2       | 1% +40% CC             | EXG         |

The results of sensitivity tests ST1 and ST2 show that a significant variation (+/-20%) in the Manning's 'n' coefficients used within the floodplain does not increase/decrease the flood depths on site by more than 100mm. Changes to the flood extent across the site during this event are negligible.

The results of sensitivity tests ST3 and ST4 show that significantly varying the slope value used at the downstream boundary by +/-200mm does not have any effect on the flooding at the site, any minor variations are local to the boundary only. The assessment of flood risk at the site remains unaffected.

The results of sensitivity tests ST5 and ST6 show that significantly varying the rainfall by +/-20% respectively causes an increase/decrease in flood extents throughout the model as can be expected. The results of the sensitivity testing undertaken show that the maximum flood depths on site for the 1% AEP +40% CC pluvial event varies by generally +/-30mm which is deemed negligible. Where floodwaters collect in ponds on site, flood depths are shown to increase/decrease by up to 600mm.

The result of ST7 show that varying the control number factor by -0.2 does not affect the assessment of flood risk to the site.

### Model Validation

Comparison of model results against historical data was not possible as there are no available maps, flood

extents or gauge data of past historical flooding at the site. Increased significance has therefore been placed on sensitivity testing to understand confidence in the model outputs.

### Model Performance

Run performance has been monitored throughout the model build process and then during each simulation carried out, to ensure a suitable model convergence was achieved.

### 2D Stability

A review of the 2D log files shows that there are no comments, warnings or errors warranting attention during the NC simulations, additionally there are no repeated timesteps recorded.

During the HGW simulations there are records of 1 repeated timestep and TUFLOW NAN Warnings, these occur at the start of the simulation, and occur within the void, likely due to the significant change in ground elevations and deep water levels within the void. The assessment of flood risk to the site is not impacted.

TUFLOW HPC is a mass conserving scheme, as such all simulations are reporting 0.00% mass error.

## Model Results

This section of the report discusses the results obtained from the hydraulic model simulations for the existing and proposed development scenarios.

Maximum flood depth, velocity and hazard mapping has been provided for each primary simulation in Appendix H. Flood hazard ratings have been calculated in accordance with DEFRA document 'FD2320: Flood Risks to People' and EA guidance document 'Supplementary Note on Flood Hazard Ratings and Thresholds'.

The potential impact of the proposed development on flood risk elsewhere has been quantified by comparing the equivalent EXG and DEV simulation results. To provide a detailed assessment of the relative changes in flood depths throughout the site, a series of maximum flood depth difference maps have been created and are included in Appendix G.

### Existing Model Results

During the normal condition (NC) scenario, where the model has been set up with an initial water level of 284m AOD in the void, the results show that the rainfall follows the drainage network on site and flows to the low points and discharges into the watercourses.

During the high groundwater (HGW) simulation the water level in the void has been set to 311m AOD initially. The 1% AEP plus CC event results show that the maximum water level in the void reaches 311.2m AOD. The lowest elevation along the boundary of the void is 340m AOD, leaving a freeboard of over 28m during the HGW simulation.

### Proposed Restoration Model

The results of the proposed restoration (DEV) model show that flow mechanisms are similar to that of the existing results. The maximum depths difference maps show that the proposed development has negligible impact on offsite flood risk.

The model results show that where there are proposed cut and fill areas the results are showing the increase/decrease to flood depths on site. Whilst there are increase/decreases to maximum flood depths

shown across the wider site, this can be associated to the differences in the triangulation of the two DTMs provided (3274-RML-M3\_SurfaceNov2023.dwg & 3274-RML-M3\_FinalJul2024.dwg). This change in maximum flood depths is not significant and does not create any new overland flow routes which would discharge surface water flows off site.

During the proposed (DEV) HGW simulation the maximum level in the void reaches 311.3mAOD during the 1% AEP plus CC event. The lowest elevation along the boundary of the void is 340m AOD, leaving a freeboard of over 28m during the HGW simulation.

## Conclusions

This hydraulic modelling study has utilised the available information to assess the flood mechanisms within the existing and as a result of the proposed restoration works for the Ffos-y-Fran mine.

The modelling has considered the change in flood mechanisms including potential impact to surrounding watercourses.

Additionally, the modelling considers the potential impact of pluvial design events over a short-term period to the water level in the void, during both a normal condition and high ground water simulation in the void.

The modelling results indicate that there is a negligible impact on flows to the watercourses surrounding the site, as a result of the proposed restoration. Where there are proposed cut and fill areas the results are showing the increase/decrease to flood depths on site. Whilst there are increase/decreases to maximum flood depths shown across the wider site, this can be associated to the differences in the triangulation of the two DTMs provided. This change in maximum flood depths is not significant and does not create any new overland flow routes which would discharge surface water flows off site.

The results have also included that there is sufficient freeboard within the void during extreme rainfall events, including when a high groundwater is considered.

## Recommendations

This hydraulic model is considered suitable to support the application for the proposed restoration works at the Ffos-y-Fran mine, for the short-term pluvial storm events, considering a static ground water level. We recommend that detailed groundwater modelling is carried out as part of the application.

This report should be read in conjunction with the associated the FCA and WFD being prepared by Waterco and the works carried out by the client for the proposed restoration to the Ffos-y-Fran mine.