

AtkinsRéalis



WALTERS

**Ground Treatment
(Including Void
Stabilisation) Design
Input Statement
(Washery Only)**

Walters Group

23 May 2024

GCRE001-AWJV-EW-XX-RP-GE-00015

GLOBAL CENTRE OF RAIL EXCELLENCE (GCRE)

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1. Introduction

1.1 Overview

AtkinsRéalis UK Limited (AtkinsRéalis) are engaged as design partner to Walters Group (Walters) for the design of earthworks and assessment of mining risk for the proposed Global Centre of Rail Excellence (GCRE) project. The GCRE project comprises a high-speed rail loop (Main site), a new stabling depot (the Washery) and connecting track (Delta Junction), as shown in Figure 1-1.

The proposed scheme lies within the former Nant Helen opencast colliery, a site that is also known to be underlain by historical coal workings.

1.2 Objectives

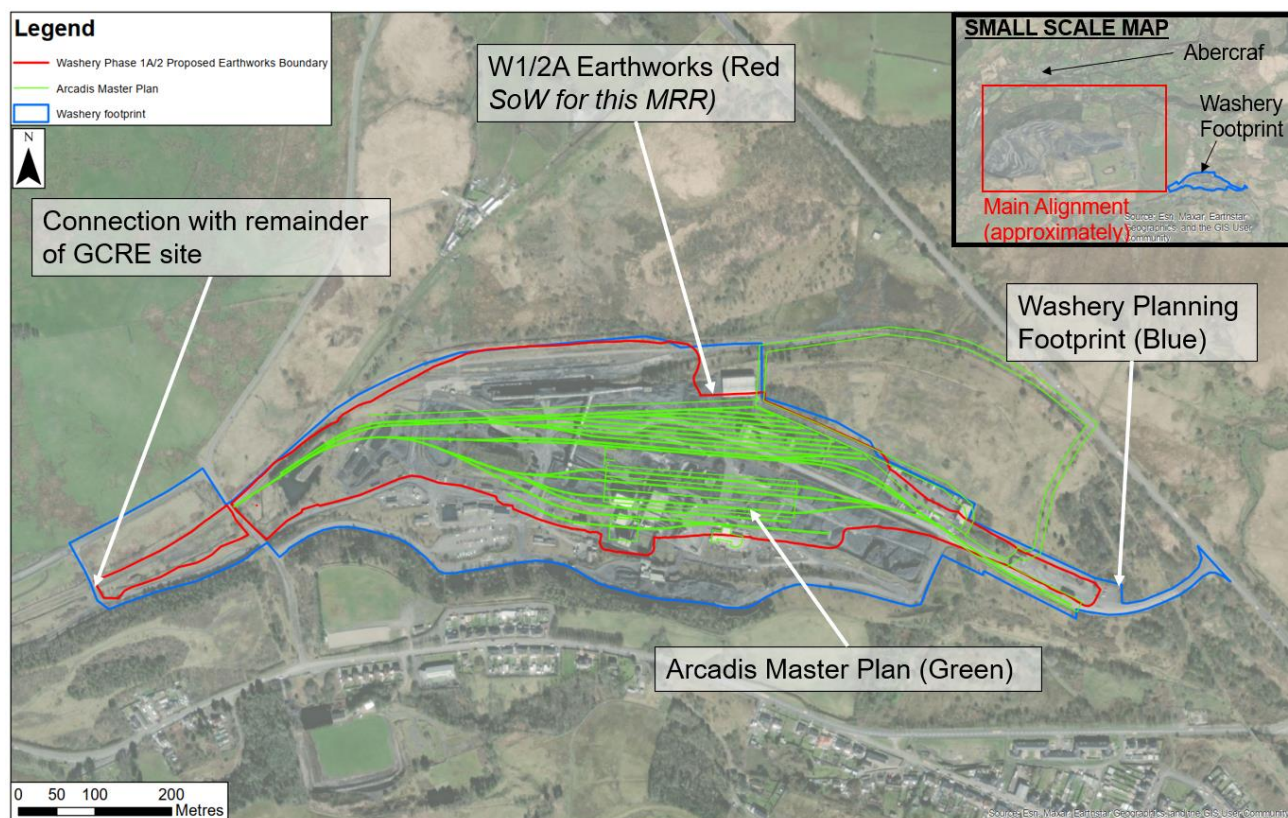
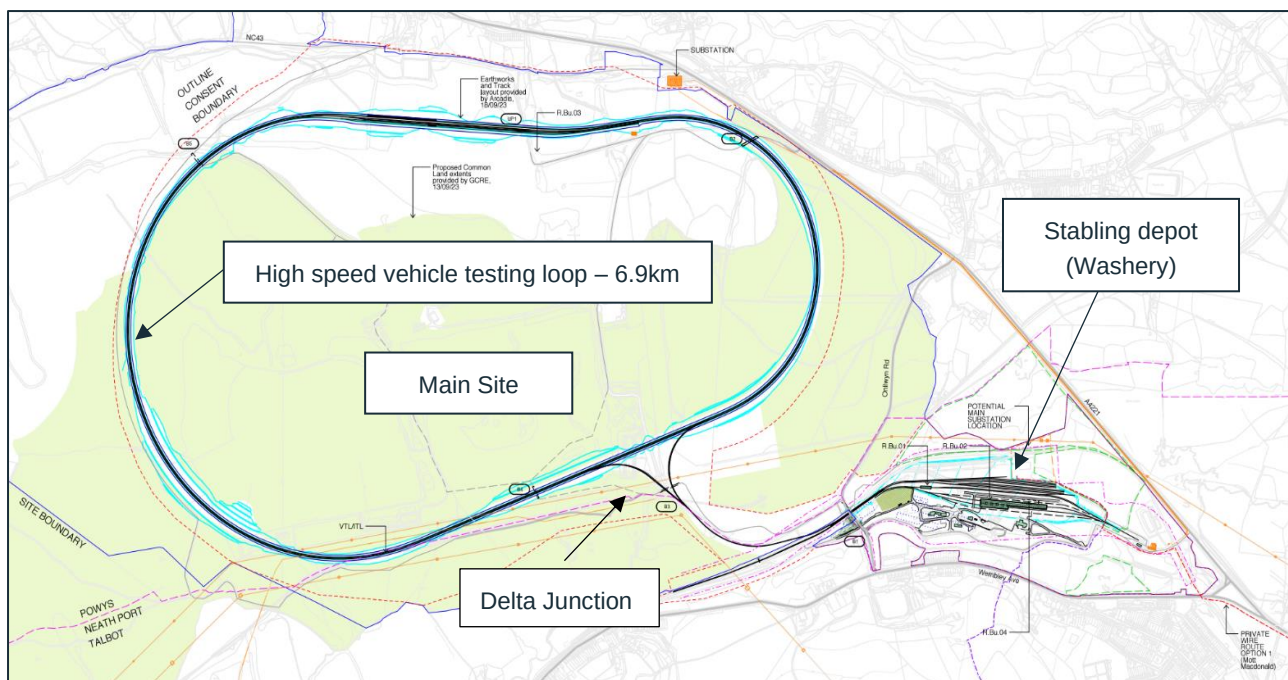
This Design Input Statement (DIS) addendum has been prepared for the updated Washery design. It is understood that the high-speed rail loop design will be updated at a later date and so consideration of the Main site and Delta Junction is excluded from this document.

This DIS been prepared following an outline assessment of mine workings treatment necessary to address the risk of potential subsidence to the proposed works from abandoned mine workings and mine entries. This DIS considers only the latest Washery earthworks footprint (see red line on Figure 1-2). The Arcadis Master Plan layout falls within the earthwork boundary but is not within the scope of AtkinsRéalis and Walters work, this document is also not applicable for the Washery planning boundary or the wider Washery area.

The objectives of this DIS are to:

- Define the risk to the site from underground mine workings and mine entries, as determined in the Mining Risk Review (MRR) (Document No. GCRE001-AWJV-00-XX-RP-GE-00003), appended to the AtkinsRéalis Ground Investigation Report (GIR) (Document No. GCRE001-AWJV-00-XX-RP-GE-00002). An additional bespoke Washery MRR has also been prepared (Document No. GCRE001-AWJV-EW-XX-DR-GE-04008).
- Outline the optioneering process used to assess the mine remediation options for the site.
- Present the design of remediation measures required.
- Define the next steps and highlight additional information required to support design.





1.3 Overview of Remediation Requirements

Section 5.1 of the Employer's Requirements [1] states the following requirements regarding the treatment of mine workings below earthworks:

"It will be necessary to either 'dig out' or undertake drill and grout treatment of any areas of shallow mine workings where these are present below the 'earthworks formation' and where these have less than 15-20m of rock cover present over historical mine workings. It is envisaged that such treatment would only be required outside the areas of historical opencast backfill, where superficial cover above rockhead is less than 20-25m, albeit details of this will need to be discussed and agreed with the Coal Authority as part of a Permit to treat application."

In considering the above, the mine working remediation design has been undertaken using currently available ground investigation (GI) data as well as information and mining records provided by the Coal Authority and Celtic Energy. A review of the findings from the available Preliminary GI and mining records is included in the Site Wide MRR (Document No. GCRE001-AWJV-00-XX-RP-GE-00003) and bespoke Washery MRR (Document No. GCRE001-AWJV-EW-XX-DR-GE-04008).

In reviewing the available data, AtkinsRéalis identified a stability risk areas across the Washery and a requirement for further GI to inform:

- The presence and/or extent of abandoned mine workings.
- The nature and thickness of rock and overburden strata present.
- Confirm the presence and/or extent of suspected mine entries identified posing a risk to the scheme.

In agreement with the Employer, GCRE Ltd. additional GI was completed in Phases (Stage 1 and 2), with both stages complete by late 2023, to supplement preliminary GI undertaken by Arup 2022.

The Stage 1 GI focused on the 'Washery 1A' which, at the time, was the proposed layout for the initial construction phase of the Washery. A summary of the findings of the Additional Stage 1 GI pertinent to this design process is provided in Annex A. The Stage 1 GI was designed with reference to the Washery 1A footprint available at the time and it is recognised that further GI is required to investigate mine entries, see Sections 3.3.2 and 4

The Stage 2 GI focused on certain areas of the high-speed loop (Main site) and investigation of mine entries in the Washery, at the direction of GCRE Ltd. this GI has not been assessed in depth and no GIR has been produced. However, during compilation of the bespoke Washery MRR the key findings in relation to the Washery were reviewed and are as follows:

- Adit 284210-035 was further investigated to delineate it further south-east. The investigation encountered additional 1.3 to 1.5 m wide voiding at 10 to 10.2 m bgl, with 4.2 to 5.5 m of bedrock cover (S2-BH262.7, S2-BH262.8, S2-BH262.9 and S2-BH262.11).
- Adit 285210-001 was investigated where it trends beneath the Washery. The investigation found 1.5 to 2.5 m wide voids at 21 to 22 m bgl, with 13.5 to 16 m of bedrock cover (S2-BH264.5 & S2-BH264.7-13). The voiding was constrained on the north-west side but not constrained on the remaining sides (south-west, north-east and south-east) as such it is not confirm if this is in fact the adit or may be unknown workings.
- Adit 285210-026 was investigated where it trends beneath the Washery. The investigation found 1.5 m wide voids at 12 m bgl, with 4.5 m of bedrock cover (S2-BH263.2 & S2-BH263.26-29).
- All other rotary-cored boreholes encountered only intact coals.



It is understood that changes to the earthwork footprint are an ongoing part of the design development of the scheme, the remediation design and approach should be revisited prior to site works to confirm compatibility with the latest earthwork design.

The remediation design and approach should also be reviewed in light of observation of treatment works, if any, once they have commenced.

2. Remediation Design Documents

This DIS should be read in conjunction with the following drawing included in Appendix B:

- Mining Remediation Plan and Profile (Drawing No. GCRE001-AWJV-EW-XX-DR-GE-04009)

3. Worked Seams

3.1 Overview

Historical records examined during the production of AtkinsRéalis Site Wide MRR and Washery MRR indicate that three coal seams have been worked in the vicinity of the Washery, see Figure 3-1. These workings are:

- Peacock seam in the north;
- Bluers seam in the south; and
- Brass seam also in the south of the site.

Mine abandonment plans suggest that the stoop and room method (alternatively known as room and pillar) of mineral extraction was predominantly used.

Following abandonment, old workings of this type were often left as open voids or partially backfilled resulting in the potential for collapse due to the deterioration of supporting pillars, working floors and roofs. Following the collapse, voids can potentially migrate to the ground surface resulting in subsidence and the formation of crown holes.

Numerous coal outcrops are present in the vicinity of the Washery, as shown on Figure 3-1, unmapped workings, presumed to be of these outcropping seams, were encountered during GI. See also Section 1.3 and Appendix A.

The working of seams is recorded as being facilitated through a combination of adits and shafts which exist in areas of reported shallow workings. Following abandonment, poorly backfilled or capped shafts or adits have the potential to collapse impacting on surface features. Refer to Section 4 for further discussion on mine entries.



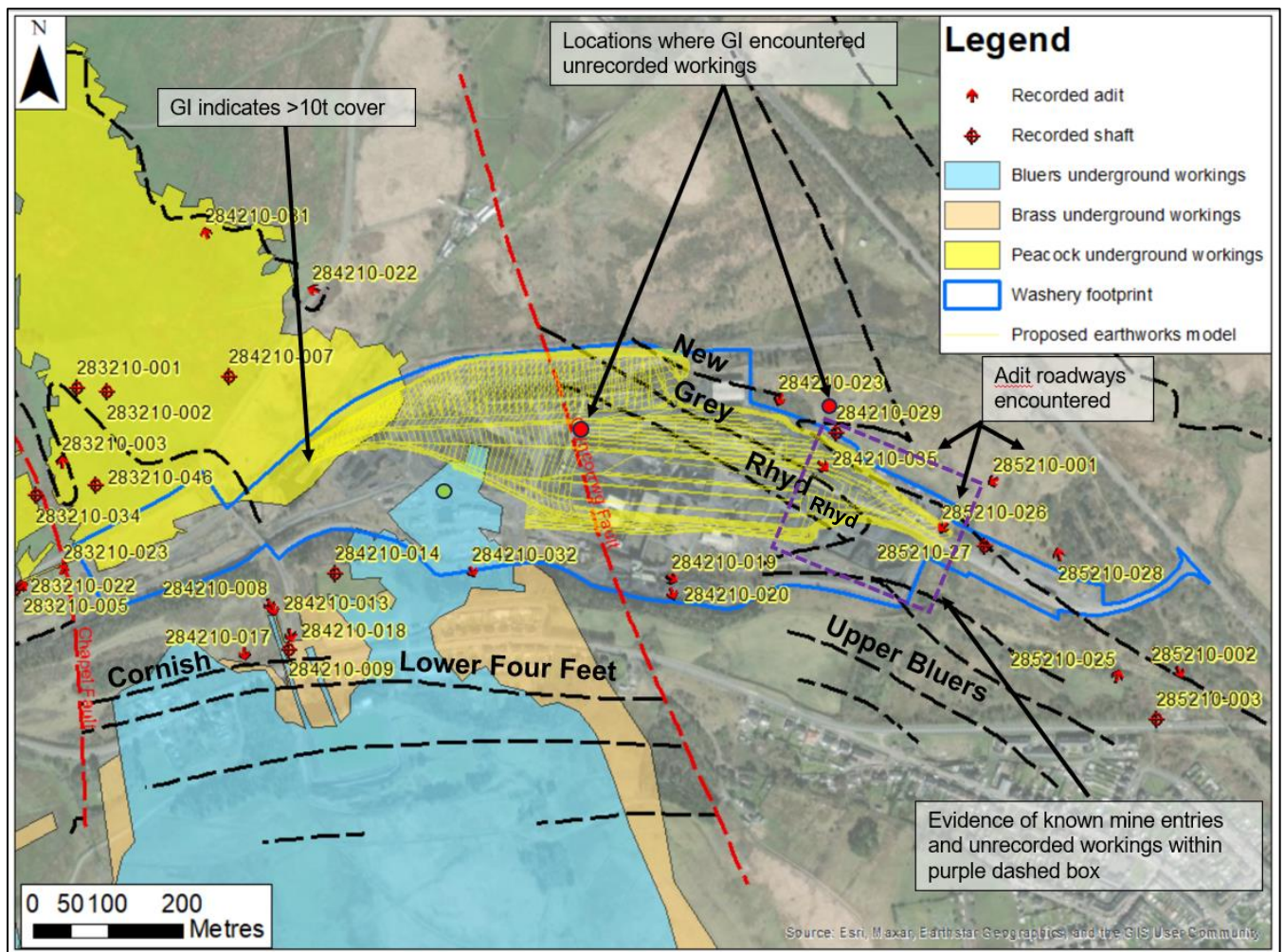


Figure 3-1 - Worked seams in the vicinity of the Washery and other mining features including unmapped workings encounter during ground investigation.

3.2 Subsidence & Collapse

Settlements resulting from the collapse of shallow stoop and room workings are unpredictable. For this reason, the generally accepted approach, and the initial approach taken for the GCRE project to comply with Employer's Requirements, is to mitigate the risk rather than attempting to predict the likely magnitude of settlements and hence determine if mitigation is required.

During the development of the preliminary remediation design, it became apparent that such an approach, comprising bulk infill stabilisation would likely require significant quantities of grout to facilitate treatment across the full site. Discussions with GCRE Ltd. identified that the costs in such an approach would likely render the project financially unviable.

Consequently, a risk-based approach, considering the potential impact of subsidence on the proposed asset has been developed with GCRE Ltd. For the Washery this approach comprises: react and treat approach to coal mining-related subsidence. It is noted that this approach represents a deviation from the Employer's Requirements, as discussed and confirmed with GCRE Ltd.

A meeting held between GCRE Ltd., Arup and AtkinsRéalis on 9 February 2023, confirmed the following:

- No treatment is proposed for the recorded Peacock workings in the west of the Washery, which were proved during the Stage 1 GI to have sufficient cover to prevent void migration to the surface.
- Mine voids encountered during the Stage 1 GI in the east of the Washery do not pose a significant risk to the proposed Washery layout given the low sensitivity of proposed assets in this area.
- The exception being the substation, proposed at the time, which was considered to be a more sensitive asset. Two additional boreholes were drilled at the location (as was) of this structure, no evidence of workings was encountered.
- Use of geotextile in low-speed track sections of the scheme (including The Washery) does not present an advantage to the project given the low sensitivity of overlying assets and train movements and the requirement to treat any collapses regardless of whether geotextile is installed or not.
- Therefore, for the Washery, GCRE Ltd. opted for the use of a 'react and treat' approach, without application of geotextile as a temporary mitigation measure. GCRE Ltd. stated that it accepts residual risks as detailed in Sections 3.4 and 4.3.

This approach was reconfirmed in a meeting with GCRE Ltd., Arup and AtkinsRéalis on 26 April 2024 with the following caveats due to changes in the Washery footprint:

- Additional mine entries, not previously investigated, pose risk to the revised Washery earthworks layout and will require further investigation.
- Buildings, proposed within the Arcadis Master Plan for the Washery, are more sensitive receptors than the track and earthworks and the evaluation of the mining risk to these proposed assets is likely to indicate that further investigation and treatment is required. It is noted that these buildings do not sit within the AtkinsRéalis and Walters scope, it is understood that the building design and location is still to be determined.
- Known (Bluers Seam) and unknown mine workings may be further investigated prior to construction on a case-by-case basis with reference to the proposed overlying structures and their sensitivity. For example, additional investigation may be undertaken beneath buildings in the Washery considered to be sensitive to mining related subsidence.

It is noted that the site area of the entire GCRE project (including the Washery) is substantially covered with backfill, placed in stockpiles and infilling of opencast workings, which is known to be undergoing active subsidence. The magnitude of settlement associated with these actions is assessed and discussed separately in Section 7 of the AtkinsRéalis Geotechnical Design Report (GCRE001-AWJV-EW-XX-RP-GE-00011).

3.3 Mitigation Approach (Option 2a)

3.3.1 General

A simplified workflow for the mitigation of the underground mine workings is detailed in Appendix C (Drawing No. GCRE001-AWJV-XX-XX-DR-GE-00022).

3.3.2 Washery

Considering the low-speed nature of the Washery, the project has opted to deviate from the Employer's Requirements for "drill and grout treatment of any areas of shallow mine workings where these are present below the 'earthworks formation'" [1]. Instead, the project will adopt a 'react and treat' approach for mine workings across the Washery.



Known/suspected shallow workings extend beneath the Washery, bedrock cover is not expected to be sufficient to mitigate against void migration in the event of working collapse. Geotextile was considered as a temporary support measure to be employed over known/suspected mine workings in these areas. Geotextile can provide temporary support to the track in the event of mine working collapse below and void migration/subsidence at surface allowing for full remediation of any voids by other methods (i.e. drill and grout).

Following the findings of the Additional Stage 1 GI and after discussions during the meeting of 9 February 2023, the use of geotextile as a temporary support measure will not be adopted with the project accepting the residual risks (see Section 3.4 and 4.3).

Details on the residual risks associated with the abovementioned conclusions are provided in Section 3.4.

3.4 Residual Risk

There are recorded and unrecorded shallow mine workings (encountered during investigations) within the 10t influence zone, as defined by CIRIA C758D [2], beneath the Washery which may be open and untreated. There is potential for such abandoned workings to collapse and subsequent void migration to surface leading to surface subsidence/voiding and damage to structures or injury.

GCRE Ltd. has been made aware of this residual risk during previous reporting and meetings. A reactive approach will be adopted to treat any collapse after the event.

The following further/future mitigation of residual risks is proposed:

- Known (Bluers Seam) and potential for unknown mine workings may be further investigated prior to construction on a case-by-case basis with reference to the proposed overlying structures and their sensitivity.
- Excavation of cuttings in the Washery may provide further information on the presence or absence of mine entries and workings beneath the Washery, the Contractor should adopt a safe method of working cognisant of the residual risks.

The requirement for remediation should be revisited as investigation and construction proceed.

4. Mine Entries

4.1 Mine Shafts

Shafts were formed during the extraction of coal in the area to provide access and/or ventilation to the underlying coal seams. These were often not sufficiently backfilled following closure and therefore pose a risk of sudden or gradual collapse causing subsidence or crown holes to form at the surface.

Known shafts in the vicinity of the Washery and the status of their investigation are listed in Table 4-1 and shown in Figure 3-1.

Collapse zones for known shafts were calculated using the methodology defined in CIRIA C758D [2], whereby the radius of the collapse zones for a given shaft is a function of shaft dimensions, overburden thickness and friction angle. The location of shafts has not been proven by investigation, however, possible offset in location has been factored into the calculation of collapse zones using Coal Authority guidance covering expected departure distance from true location [2]. Further details and assumptions are provided in the Coal Mining Risk Review document



(GCRE001-AWJV-00-XX-RP-GE-00003), included in Appendix C of the AtkinsRéalis GIR (GCRE001-AWJV-00-XX-RP-GE-00002).

Probe holing following the standard arrangement shown in CIRIA C758D [2] has been employed to determine the location of shafts, some shafts still require investigation to confirm their location (see Table 4-1).

Where existing treatment of shafts is found to be insufficient or treatment is absent, shafts shall be treated using a reinforced concrete slab founded at bedrock. Capping slabs are expected to have a minimum dimension of twice the proved mine shaft diameter (including any lining) and a minimum thickness of 450 mm. However, details of capping requirements shall be finalised once location, dimensions and depth to rock head are confirmed for each shaft by investigation.

Shaft 285210-027 was not previously within impacting distance of the previous Washery layout but now lies within close proximity and is to be investigated.

The Additional Stage 1 GI did not encounter evidence for shaft 284210-029, as such this shaft is not proposed for treatment (see Annex A). However, this shaft may require treatment if it is encountered elsewhere on site. Further details of the residual risks associated with this shaft are provided in Section 4.3 below.

Table 4-1 - Reported mine shafts in the vicinity of the Washery

Mine Entry ID	Easting (m)	Northing (m)	Depth (m bgl)	Shaft diameter (m)	Treatment Records	GCRE Project Status / Action
284210-029	284934	210611	10	2.5	No records of treatment.	Investigated but no evidence of shaft. No further investigation proposed.
285210-027	285133	210459	-	2.5	No records of treatment	To be investigated

4.2 Adits

A number of known mine adits are expected within the footprint of the Washery, others are expected beyond the alignment with roadways mapped to extend under the proposed alignment. In both cases, adits and roadways pose a stability risk to the proposed scheme.

Known adits and the status of their investigation are detailed in Table 4-2 and shown in Figure 3-1. Adit 285210-025 did not impact previous iterations of the Washery layout so has not yet been investigated. Adits 284210-009 and 284210-020 fall within the wider Washery planning boundary (out of scope for this report) but in an area not currently marked for development, these adits are projected to head away from the Washery and are not considered to pose risk to the current earthworks layout.

Based on the findings of the Additional Stage 1 and Stage 2 GI, and discussions with GCRE Ltd., (see outlined in Annex A), adits within the Washery may be treated with reference to the sensitivity of proposed overlying assets.

Details and drawings of adit backfilling requirements are to be produced once the location and dimensions are confirmed by the investigation. The installed remediation shall allow the adit to drain in the event of changing water conditions.



Details on the residual risks associated with the aforementioned conclusions are provided in Section 4.3.

Table 4-2 - Reported mine adits in the vicinity of the Washery.

Mine Entry ID	Easting (m)	Northing (m)	Azimuth (degrees)	GCRE Project Status / Action
284210-023	284859	210653	200	Investigated but no evidence of adit. No further investigation proposed.
284210-035	284917	210565	131	Investigated and partially delineated.
285210-001	285145	210544	239	Investigated and partially delineated
285210-026	285077	210482	225	Investigated and partially delineated. Further investigation proposed.
285210-025	285309	210284	014	Not yet investigated, to be investigated if required.

4.3 Residual Risk

To date, a total of one shaft and four adits have been investigated as part of the Additional Stage 1 and Stage 2 GI within the Washery area.

Adits 284210-035, 285210-001 and 285210-026 were encountered and are proposed for further investigation and treatment at a later date if the final earthworks footprint and sensitivity of assets requires, see Table 4-2. Similarly 285210-025 (previously outside the Washery boundary) may be investigated depending on the sensitivity of assets above.

During construction of the Washery the Contractor should ensure that the known adits are not tracked over or loaded above current conditions. The Contractor should develop a safe method of working taking cognisance of this residual risk – it is suggested that the area is demarcated and barriered off to prevent access.

No evidence was found for the other adit (284210-023), nor the shaft (284210-029) mapped within the Washery. Failure to locate a mine entry suggests either:

- The true location of the mine entry is different to the recorded location of the mine entry; or
- The mine entry is not present, potentially due to having been incorrectly recorded on the mine abandonment plan, misidentified during the Coal Authority review process or subsequently removed or collapsed.

If the former is true, the mine entry may be present in a different and unknown location within the Washery footprint. There remains a residual risk of collapse of the mine shaft or adit during construction or operation damaging surface structures or causing injury.

Considering the lack of further information or site observations to direct further investigation and given the limited sensitive assets/low speed nature of the Washery no further investigation is proposed. The Contractor should develop a safe method of working cognisance of this residual risk.



5. Unknown Mine Workings and Entries

There remains a residual risk of unknown shallow mine workings and entries being present on site, it is considered likely that unknown features are present. The Coal Mining Risk Review (GCRE001-AWJV-00-XX-RP-GE-00003), included in the AtkinsRéalis GIR (GCRE001-AWJV-00-XX-RP-GE-00002) identified crown holes in historical aerial imagery indicative of unmapped bell pits. Additionally, several mine abandonment plans indicate old workings and adits with no level or condition information.

Shallow unknown mine workings and entries are considered more likely to occur under the eastern part of the Washery where they have already been encountered during the Stage 1 and Stage 2 investigations, see the bespoke Washery MRA (Document No. GCRE001-AWJV-EW-XX-DR-GE-04008). This is an area where coal outcrops and known shallow workings occur and are also outside the areas of major Nant Helen open casting.

The Contractor should develop a safe method of working cognisant of this residual risk being vigilant for any signs of surface instability, mine entries and uncovering unknown workings.

6. Proposed Ground Investigation

Within the Washery additional investigation of mine shafts is proposed.

Further investigation may be scoped with reference to the overlying structures where there are deemed to be sensitive to any mining related instability (i.e. buildings).

7. Mine Gas

Mine gas monitoring has been undertaken across the site as part of the Preliminary GI, Stage 1 GI and Stage 2 GI. Details on the scope and findings of the mine gas monitoring can be found in the 1A/2A Geo-Environmental Interpretive Report (GCRE001-AWJV-00-XX-RP-CLAH-00004).

A summary of the conclusions and recommendations from the 1A/2A Geo-Environmental Interpretive Report are presented below. Full details and rationale on the mine gas risks and recommendations are detailed in the 1A/2A Geo-Environmental Interpretive Report.

7.1 Conclusions

- Due to the type, depth and age of coal mine workings on-site, nature of the development (absence of enclosed spaces where gas risk may occur) and site circumstances (water levels, geology and cover soils) it is considered that within the site, a low risk from coal mine gas is present where confined spaces will not be present.
- A moderate risk is considered to be presented to any structures that have enclosed spaces such as the UKRRIN building and future structures such as train maintenance depot, electricity substation, maintenance sheds and Innovation Hub and Characterisation Situation 3 (CS3) is considered to be present.
- There is a potential for unacceptable risks to off-site receptors and on-site buildings to occur during the remediation of mine workings. Grouting works have the potential to displace gases and groundwater that may then migrate and present a risk if not managed by appropriate working methodologies and risk assessment of the remediation works. No grouting works are currently proposed in the Washery area.



- It should be noted that carbon monoxide exceeds its STEL in S1-BH05, while depleted oxygen levels are also present which would pose a risk of asphyxiation if present within confined spaces or on-site buildings. It is considered that gas protection installed to protect against coal mine gas risk will mitigate this potential risk.

7.2 Recommendations

Detailed design of ground gas protection measures within the site should be completed in accordance with CIRIA C80 and CL:AIRE's Good practice in assessing mine gas emissions

- Shaft locations are confirmed by GI, treated and/or buildings are not constructed within 50 m of any shaft locations. Building design is not within AtkinsRéalis scope however based on the provided layouts no buildings appear to be within 50m of mapped mine shaft locations, the 50m exclusion zone is to be defined once shaft locations are confirmed.
- If piled foundation solutions are being considered, additional risk assessment will be required to assess the risks to future properties as the piling may result in direct pathways being created.
- Appropriate health and safety measures should be implemented during any on-site works and a safe system of work must always be implemented to address risks of asphyxiation from elevated methane, carbon dioxide or reduced oxygen concentrations if entry to a confined space is required and unavoidable. Guidance issued by the HSE for working in confined spaces should be followed.
- Groundwater samples should be tested for dissolved methane, further GI completed, and the gas risk re-assessed if buildings from Stage 2 and 3 works are planned in these locations.
- Once all monitoring works are complete, all boreholes and wells must be decommissioned through backfilling and sealed in a manner that prevents them from acting as migration pathways for mine gas. Decommissioning on monitoring wells should be completed in line with the EA's Good practice in the decommissioning of redundant boreholes and wells.
- Where remediation of mine workings is proposed an assessment of the acute risks associated with the remediation measures e.g. grouting of workings and potential for displacement of mine gas will be required (no grouting works are currently proposed in the Washery area).
- Further gas monitoring is recommended to reduce uncertainty and conservatism in the coal mine gas risk assessment with respect to buildings in the south of the site.

It is considered that Mine gas, if present any impact is unlikely to impact on the design and operation of earthworks that forms AtkinsRéalis' scope. The remediation design should be revisited once further gas monitoring has been completed.

8. Mine Water

The AtkinsRéalis GIR (GCRE001-AWJV-00-XX-RP-GE-00002) notes that it is currently assumed that groundwater levels are relatively static at approximately 200m AOD, well below the level of workings to be treated. Therefore, it has been assumed that all workings are currently dry.

However, it is noted that perched water is present on site (encountered in previous investigations) and may be in connectivity with shallow workings. Drilling of S1-BH107 and S1-BH114 in the Additional Stage 1 GI encountered artesian conditions possibly linked to flooded known workings in the Peacock seam in the west of the Washery, workings encountered in the east of the Washery were found to be dry. As treatment is no longer proposed in either area there is no impact on design, nor will there be impact from the remediation on current hydrogeological conditions.



As the hydrogeological regime is not fully quantified the impact, if any, of the remediation design on the hydrogeological regime has not been quantified, barring the above in the area of the Washery.

Should groundwater rebound and flood workings this could induce instability and collapse of the previously dry workings leading to further void propagation to the surface. The areas proposed for treatment are unlikely to be affected, however, unknown workings that are untreated may be impacted.

The 1A/2A Geo-Environmental Interpretive Report contains further details on the hydrogeological regime. Coal mine water can pose a variety of hazards, including environmental, health, and safety hazards. The main hazards are as follows:

1. **Environmental hazards:** Acid mine drainage (AMD) is the release of acidic water from coal mines, which can cause environmental damage by contaminating local water sources. AMD occurs when water flows through sulphur-bearing rocks, such as coal, and reacts with the sulphur to form sulfuric acid. This acidic water can leach heavy metals and other contaminants from the surrounding rock, making it unsuitable for human consumption or agricultural use and impact on water quality.
2. **Flooding hazards:** Coal mine water can also cause rapid flooding, which can result in disruptions to construction and operation.
3. **Explosion and fire hazards:** Methane gas when combined with water, can create explosive conditions. If water comes into contact with electrical equipment, it can create a fire hazard.
4. **Health hazards:** Coal mine water can contain harmful substances, including heavy metals, arsenic, and other toxins, which can pose human health risks.
5. **Stability hazards:** Rapid draining or inundation of water can result in collapse of the workings and/or shaft.

The remediation design should be revisited once the hydrogeological regime has been further developed.

9. Monitoring

The GCRE project will be in intermittent use by trains for the purposes of testing. It is understood that prior to each test a survey of the track will be undertaken to assess conditions and monitor for any changes in levels. It is recommended that a visual inspection for voids and crown holes is also undertaken.

Where evidence of voids, subsidence or other collapse is identified, train tests shall be suspended until remediation has been completed.

Gas monitoring shall be conducted during the construction phase and during drilling exercises to ensure the safety of site operatives (e.g., during drill and grout operations, ground investigations, etc.). Temporary and/or permanent enclosed structures on site also require gas monitoring.

10. Assumptions

The following assumptions have been made:

- The remediation proposals presented herein will be reviewed prior to construction against the latest earthworks footprint and as the works progress.
- It is understood that further GI shall be undertaken ahead of construction, as detailed in the sections above.
- The remediation design must be revisited against the developing understanding of the mine gas and hydrogeological regime.



- The remediation plan will require the consent of the Coal Authority and the issuing of a Coal Authority permit to be obtained prior to works. It is assumed that no explosive gas will be encountered in or above the mine workings. Appropriate mitigation measures shall be followed on-site to reduce this risk.
- When assessing the risk posed by workings across the site, seam thickness has been assumed to be worst case 2 m based on a typical roadway height.
- It is assumed that a monitoring and operation plan will be developed to mitigate the risk across the site, particularly with respect to the areas of 'react and treat' in the Washery.

11. References

- [1] GCRE Co. Ltd, "GCRE Earthworks – Volume 2 (C) GCRE Employers Requirements Document, REF GER01".
- [2] CIRIA, "Abandoned mine workings manual, C758D," London, 2019.



APPENDICES

Appendix A. Stage 1 Ground Investigation

A.1 Overview of Ground Investigations

At the time of writing, three phases of GI have been completed across the site, as detailed in Table A-1. A summary of the findings of the Preliminary GI is provided in the AtkinsRéalis Mining Risk Review document (Document No. GCRE001-AWJV-00-XX-RP-GE-00003). This section is intended as a high-level summary of findings of the Additional Stage 1 GI pertinent to the mining-related activities. A full review of the completed GI is provided in the AtkinsRéalis Stage 1 GIR for the Additional Stage 1 GI.

Table A-1 - Summary of GI phases at the GCRE site.

Phase	Approximate GI Dates	Parties Involved	General Purpose
Preliminary GI	November 2021 to January 2022.	Specified by Arup. Performed by Quantum Geotechnical Limited.	High-level GI across the Main Alignment, Delta Junction and Washery.
Additional Stage 1 GI	November 2022 to January 2023.	Specified by AtkinsRéalis. Performed by Jackson Geo.	Focused on the Washery 1A, including rotary cored boreholes to investigate mining activities across the area of the Washery 1A and further rotary probing at the locations of three conjectured mine entries in the east of the Washery 1A.
Additional Stage 2 GI	<i>February to May 2023</i>	Specified by AtkinsRéalis. No GIR produced	Proposed to focus on the Main Alignment. Includes the additional investigations targeted in the proposed substation and at selected recorded adits along the Delta Junction approach.

A.2 Additional Stage 1 Ground Investigation – Summary of Findings

The key findings from the Additional Stage 1 GI (Washery 1A only) are as follows:

- Adit roadway from mine entry 284210-035 located at approximately 10 m bgl outside of the Washery 1A boundary heading south-east away from the site (Figure A-1).
- Open workings interpreted to be in the New Seam located at approximately 15-20 m bgl overlapping with the eastern boundary of the Washery 1A boundary interpreted to be open to the south and east. Insufficient rock cover is present to prevent void migration in the event of collapse.
- Peacock underground workings mapped to underlie the 1A boundary in the west were encountered at approximately 15-20 m. Sufficient rock cover is present to prevent void migration in the event of collapse (Figure A-1).
- All other rotary cored boreholes encountered only intact coals.



- Mine entries 284210-023 (adit) and 284210-029 (shaft) were not encountered during rotary probing.

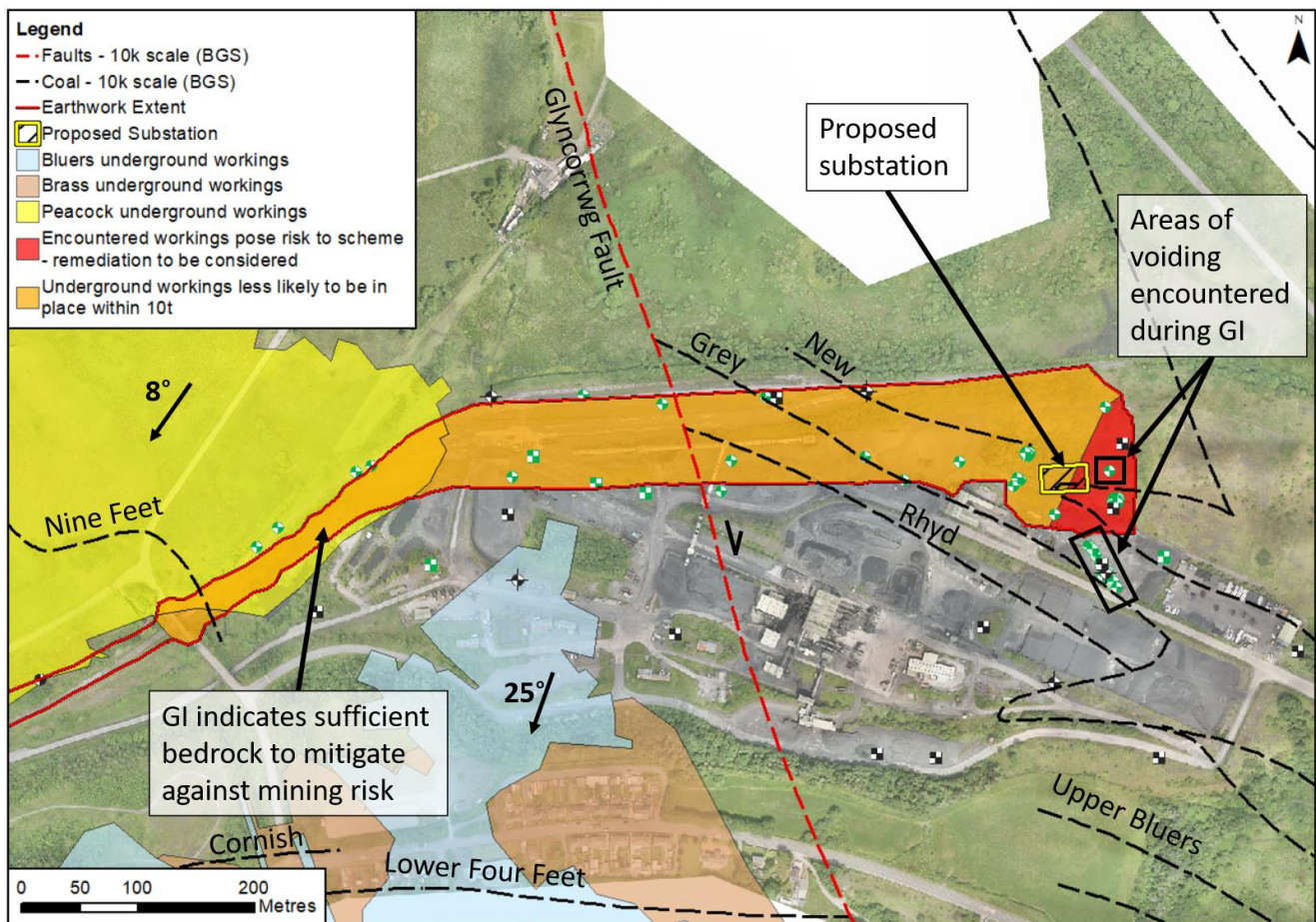


Figure A-1 - Recorded and potential unrecorded workings in and around the Washery 1A Area (Washery 1A layout has now been superseded).

N.B: Red area in east is defined by the likely extents of voiding as recorded during the Preliminary GI and Additional Stage 1 GI.

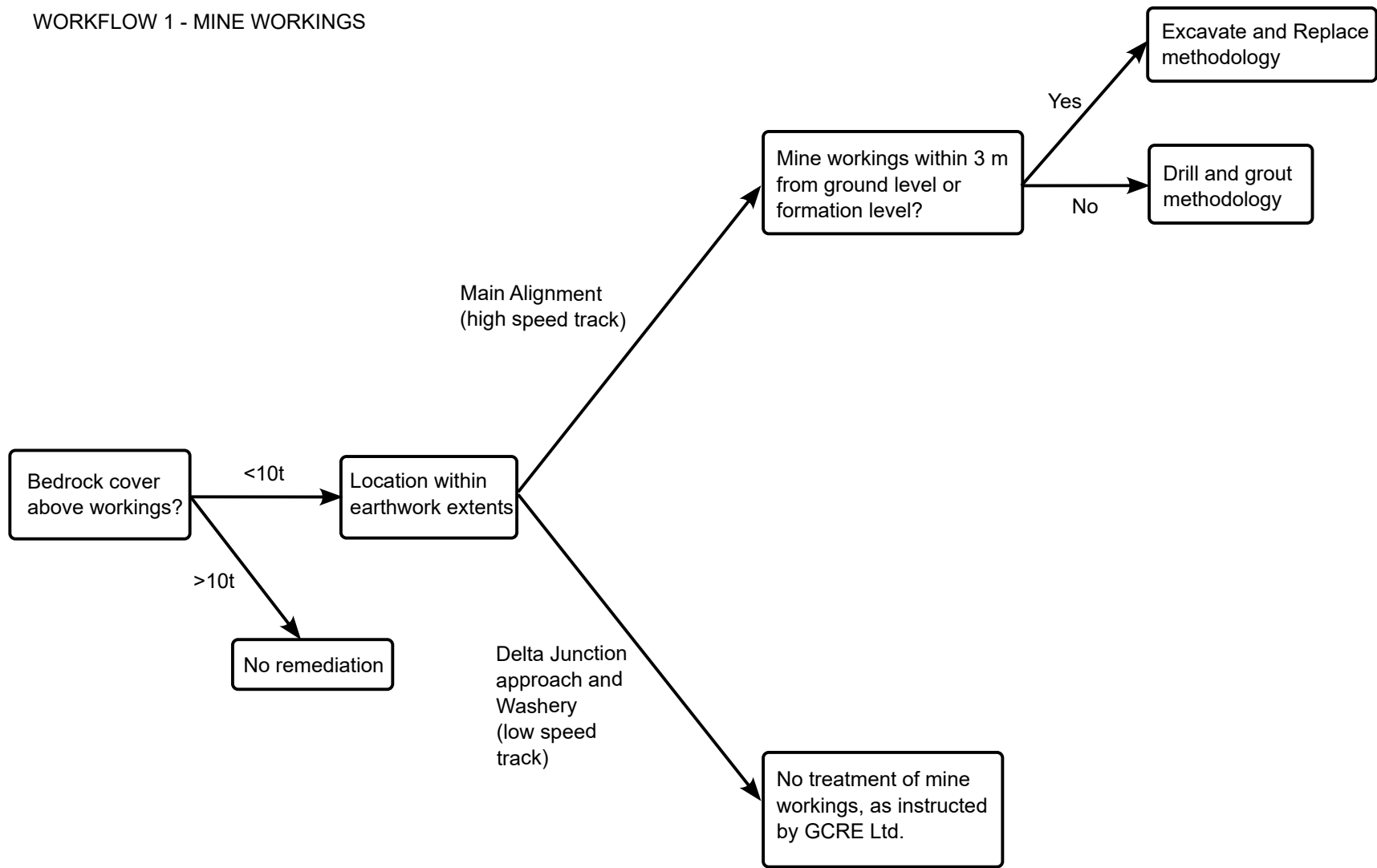
Appendix B. Drawing



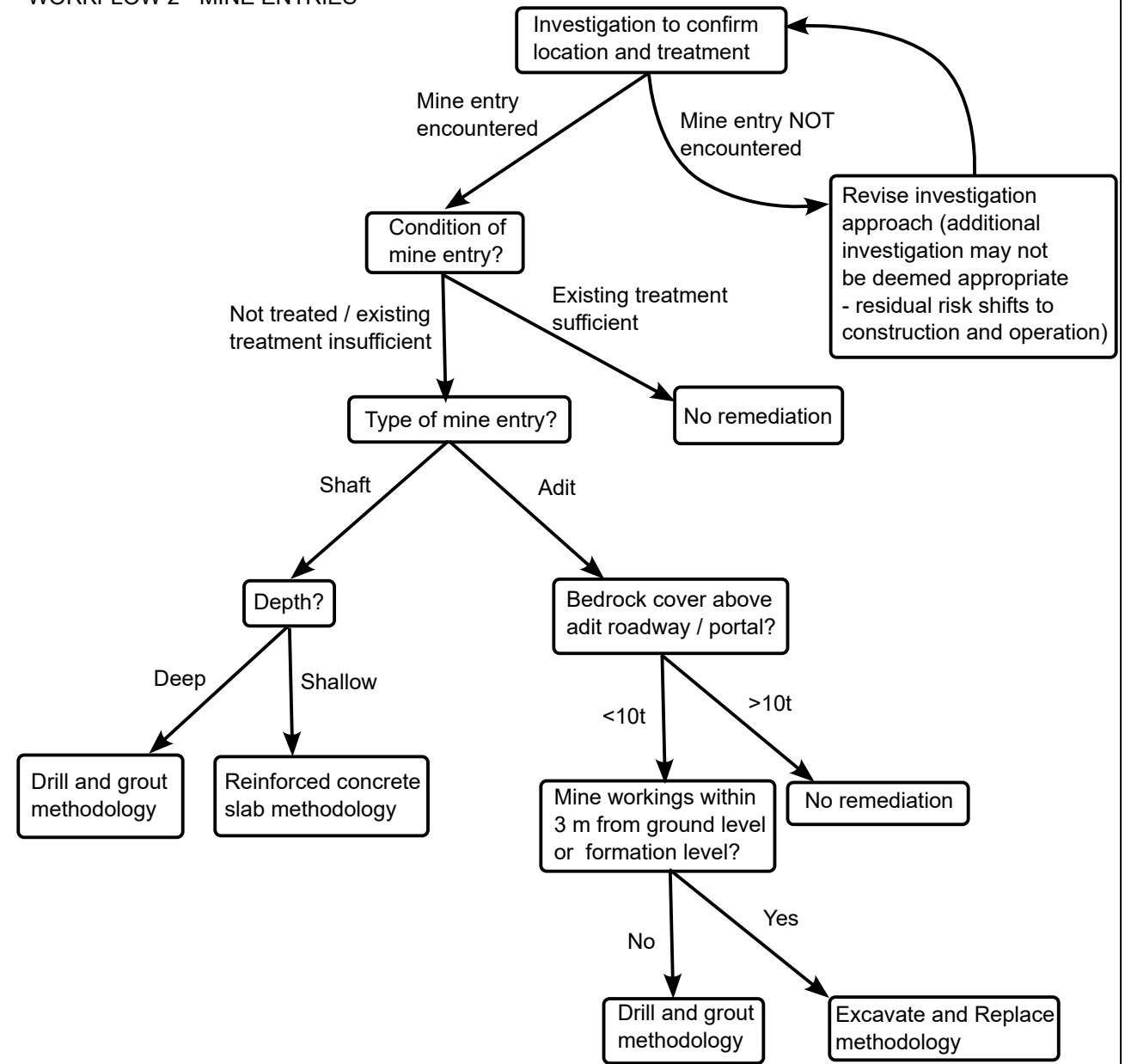
Appendix C. Mining Remediation Workflows



WORKFLOW 1 - MINE WORKINGS



WORKFLOW 2 - MINE ENTRIES



NOTES

1. This drawing and its contents have been prepared and are intended solely as information for GCRE Co. Ltd and use in relation to the Atkins GDR for the earthworks design and associated Ground Treatment Design Input Statement. Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this drawing and/or its contents.
2. This drawing provides a simplification of the mining remediation design outlined in the Atkins GDR for the earthworks design and, therefore, shall be read in connection with the contents of the Atkins GDR for the earthworks design.
3. '10t' corresponds to the industry rule of thumb of ten times the worked seam thickness outlined in CIRIA C758D.

3	DRAFT FOR ISSUE	HW	13/03/2023	-		
2	DRAFT FOR ISSUE	HW	21/02/2023	PA		
1	DRAFT FOR ISSUE	HW	02/09/2022	PA	KP	
VER	DESCRIPTION	BY	DATE	CHK'D	REV'D	AUTH
CLIENT: GCRE Co Ltd						
PROJECT: Global Centre of Rail Excellence						
TITLE: Mining Remediation Workflow						
SCALE: N/A		ORIGINATOR: HW	CHECKED: -	REVIEWED: -	AUTHORISED:	
SIZE: A3		DATE: 13/03/2023	DATE: -	DATE: -	DATE:	
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