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As the responsible project manager, how would you approach the process of introducing a specified new piece of equipment (such as a survey unit or microscope) for use by your team, and what measures you would take to ensure that it was being used correctly and safely (documentation, training, and monitoring)?

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1. Background

As the responsible project manager for the geoarchaeology section of a consortium of three national commercial units¹, bidding on the 2030 HS4 project to link London to Plymouth via Bristol and Exeter, the remit is to plan a borehole Survey to build up modelling data for Phase 3 of the project, the HS4 rail link between Bristol to Exeter. The primary consideration is what type of borehole equipment we need to use in the project to achieve the maximum amount of quality geotechnical data within the designated schedule, the recruitment and training requirements to use the coring equipment, review of health and safety requirements, implementation of the project, monitoring of the project team, and ongoing maintenance, calibration requirements of the equipment.

¹ Wessex Archaeology, Headland Archaeology and Museum of London Archaeology (MOLA).

2. Schedule

The proposed Phase 3 link is to run 126 kilometres between Bristol and Exeter near the M5 corridor. As current Borehole data is inconsistent (British Geological Survey, 2023), we propose obtaining new borehole samples using cable percussion rig technology at approximately 100-meter intervals. Therefore, we must core approximately 1260 new borehole samples to supplement existing British Geological Survey (BGS) data sets to build a representative deposit model of Phase 3 - HS4. Following current Historic England guidance (Historic England, 2023), the samples must have sufficient depth to record deep stratigraphy to the bedrock. In shallow substrates the MOLA project team will also develop a targeted strategy of test pitting.

Wessex Archaeology is conducting geophysical surveys using Ground Penetrating Radar (GPR) ahead of the Phase 3 borehole survey. It is anticipated that by triangulating the GPR data, original BGS data and mapping data sources in the Archaeological Data Service (Archaeological Data Service, 2023) and Historical Environmental Record (Heritage Gateway, 2023), a detailed sampling strategy for the boreholes can be utilised in line with objectives in specific regional and thematic research frameworks (Research Frameworks Org, 2023).

The commencement date for gathering the borehole data is the 1st of February, 2030. A field team of six trained geoarchaeologists across the consortium working in pairs with three compression cable rigs should be able to obtain, process and upload to the RockWorks database model approximately 8.5 borehole datasets per day. This equates to a duration of 147 working days or 7 Months of work in the field.

Action	Start date	End Date	Result
Desk Based Assessment (DBA) using BGS, ADS and HER data sets to formulate sampling strategy on proposed HS3-Phase 3	01/10/2029	15/11/2029	Focused strategy to inform Geophysics data collection
Wessex Archaeology Geophysics unit, data collection using GPR on results of DBA	01/11/2029	15/01/2030	New Geophysics data sets on targeted areas
WSI - Written Scheme of investigation/ Review, of sampling strategy based on data sets	16/01/2030	16/01/2030	Tripart meeting of consortium stakeholders to update the WSI and finalise schedule of field team.
Commencement of borehole survey and test pitting at Bristol Parkway.	01/02/2030	30/08/2030	Completion of borehole survey and test pitting at Exeter St David's.

Table 1.1: Proposed initial outline schedule for data collection and field work.

3. Equipment

Various types of rigs produced by different rig manufacturers could be used to complete the survey work for the deposit modelling. The specified equipment must balance cost, efficiency, ease of use, and practicality to reach the objectives outlined in the above schedule. Cable percussion drilling is an industry-standard used for borehole surveys in the UK. The technology can be used on both consolidated and unconsolidated substrate formations, is relatively easy to transport, has the option to drill deep and is comparatively time effective to alternative manual drilling options.

In terms of practicality and reliability, it would be beneficial to hire three cable percussion rigs that have been operated and manufactured extensively in the UK for survey work. For this reason, DANDO geotechnical cable percussion drilling rigs offer the best option. Specifically, the DANDO 3000 Rig, from Drilling Rig Hire UK (Rig Hire UK, 2023). Note, to reduce pollution and improve the overall environmental impact of the project, it has been decided that water lubricant will be used instead of drilling additives such as foams, hydratable clays, or polymers.

Action	Start date	End Date	Result
Equipment Supplied for Safe Operational Use of Equipment from Drilling Rig Hire UK:	25/01/2030	06/09/2030	3 x DANDO 3000 Cable Percussion Rigs
			3 X Plant Trailers
			3 x Off Road Vehicles with Toe Bars.
			3 X Diesel Generators and fuel
			Sinker bar, shell, clay cutter, clack valve, swivel rod, stubber, cross chisel, and casings.
			Automatic drop hammer bar, boring bar, sample barrel, adaptor, cone, and shoe.
			U4, U100s and UT100s sampling equipment.
			Spill Kits
			Ground guards
			Water bowser
Additional Equipment to Purchase for Safe Operational use of Equipment:	15/01/2029	-	Full PPE for six members of field Staff. And first aid kits
			Heras fencing/barriers for public
			C.A.T Scanners x 3
			Manual Digging Tools
			6 X Full body harness and lanyards.
			Mobile Welfare Unit with cooking and toilet facilities.
			Hazard signs for public

Table 1.2: Proposed equipment needed to operate 3 x DANDO 3000 cable rigs safely between 25/01/2030 to 06/09/2030.

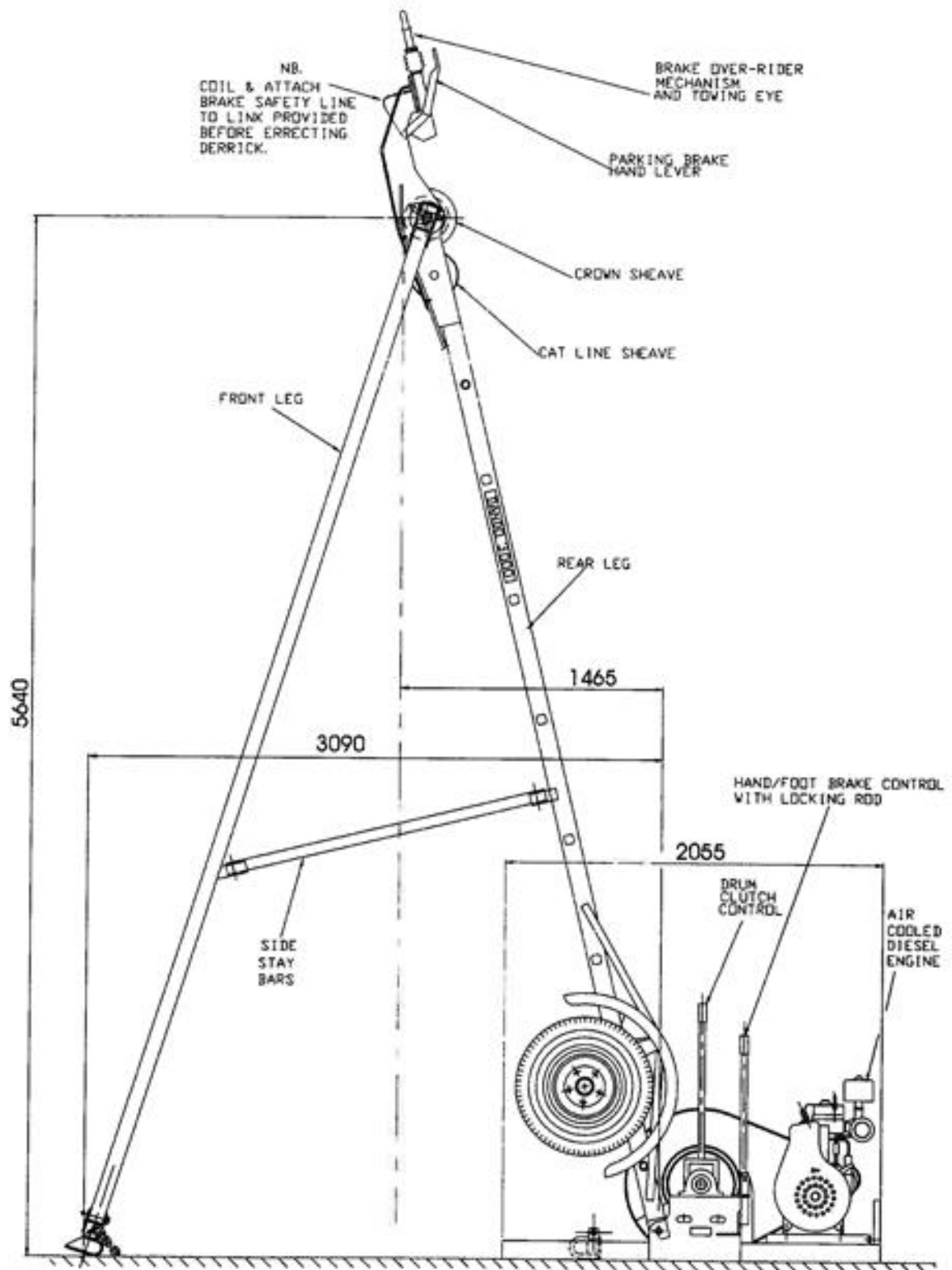


Figure 1.1 Schematic side view of Dando 3000 Rig.

4. Recruitment and Training

The structure of the field team will be three senior geoarchaeologists, who will also be drill supervisors for each compression cable rig, and three junior or trainee geoarchaeologists who will be drill operatives for each rig. The British Drilling Association (BDA) recommends that at least two people operate each drill (BDA, 2016). The drill supervisors should have at least two years of experience using cable compression rigs. Each of the three consortium members can supply a senior geoarchaeologist with the relevant experience to use the equipment, but each of the consortium members will need to recruit a junior team member for the operative role.

The BDA offers an 18-month National Vocational Qualification (NVQ) in Land Drilling, which is a mixture of twenty days of classroom-based learning and the remainder on the job training (BDA, 2023). This would be a good opportunity to train and update employee skills and knowledge, while also working with the BDA to customise a learning program that is specific to the needs of UK geoarchaeology. Rather than a generic program of learning, provided by a third party NVQ trainer and geared towards the requirements of the engineering sector.

Specific training will be needed on the use of the DANDO 3000 cable percussion rigs, therefore Borehole Solutions LTD, has agreed to provide two days on-site training for the DANDO 3000 and will also offer ongoing support and advise when required (BoreHole Solutions, 2023).

Senior Geoarchaeologist – Drill Supervisor		Junior Geoarchaeologist – Drill Operative	
Two + Years Compression Cable Drilling Experience in geoarchaeology practice.	Yes	Two + Years Percussion Cable Drilling Experience in geoarchaeology practice.	No – but desirable to have background knowledge of geoarchaeology / quaternary science.
BDA 18-month National Vocational Qualification (NVQ) in Land Drilling.	N/A	The BDA 18-month National Vocational Qualification (NVQ) in Land Drilling.	Starts 05/01/2030 Milton Keynes, UK.
Borehole Solutions Ltd. Two-day onsite training and support package for DANDO 3000 Rig.	27/01/2030 – 28/01/2030	Borehole Solutions Ltd. Two-day onsite Training and support package for DANDO 3000 Rig.	27/01/2030 – 28/01/2030
UK Driving License	Pre-contract check- over 21 years of age.	UK Driving License	Pre-contract check - over 21 years of age.
C.A.T Cable Avoidance Tool and Signal Genny - Training.	Half day Refresher Course – MOLA Bristol 26/01/2030	C.A.T Cable Avoidance Tool - Training.	One day course – MOLA Bristol 26/01/2030
Emergency First Aid at work course.	St Johns Ambulance – Medic course one day Bristol 25/01/2030	Emergency First Aid at work Course	St Johns Ambulance – Medic course one day Bristol 25/01/2030
Valid CSCS cable percussion operative blue card - ID.	Should state: Lead Driller on reverse of card.	Valid CSCS cable percussion operative red card - ID.	Registered on commencement of NVQ and should state: Support Operative on reverse of card.

Table 1.3 Equipment training requirements and skill checks for borehole team.

5. Health and Safety Legislation, Regulations, Guidance, Relevant to the DANDO 3000

The operation of large mobile mechanical pieces of equipment requires a significant amount of safety planning. As an extensive and ongoing national infrastructure project and recruiting personnel from three separate organisations, it is incumbent under the Health and Safety Act 1974 to ensure all employees and employers are equally aware and understand the requirements for safe and professional practice. Between the 6th and 7th of January 2030, the team will meet at the BDA HQ: 55 Crown St, Brentwood CM14 4BD, for an induction/review program. Note: the trainees on the NVQ program will cover this curriculum as a study component; attendance is therefore not compulsory for junior team members.

Legislation and Regulations		Guidance (HSE)
The Health and Safety at Work Act 1974 Overview of the law as it relates to employers and employee.	Key Points: Source: (British Safety Council, 2023) 1.Adequate training of staff to ensure health and safety procedures are understood and adhered to. 2.Adequate welfare provisions for staff at work 3.A safe working environment that is properly maintained and where operations within it are conducted safely. 4.Suitable provision of relevant information, instruction, and supervision	HSG151 Protecting the public 2014. HSG168 Fire Safety in Construction, 2010
Control of Pollution Act 1989 and Environmental Protection Act 1990	The use of spill kits and drill lubrication chemicals	EH44 Dust in the Workplace, 2013
Supply of Machinery Regulations 2011	Manufactures safety requirements and documentation for use of DANDO 3000. Detailing correct assembly.	
Construction (Design and Management) Regulations 2015	Requirement to plan for risks (assessment below), and schedule key personal into workflow.	L153 Managing Health and Safety in Construction.
Provision and Use of Work Equipment Regulations 1998 (PUWER)	Key Regulation concerning the safe operation of drilling equipment – maintenance, daily checks, emergency stops, correct guarding.	HSG47 Avoiding Dangers from underground Services 2014 GS6 Avoiding Danger from Overhead Power Cables
Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)	Key Regulation ensuring lifting of drills planed and managed in a safe way and inspected for safety.	
Personal Protective Regulations 2002	(PPE) Requirements based in Risk Assessment	L25 Personal Protective Equipment at Work, 2015

Control of Substances Hazardous to Health (COSHH)	Chemicals used in drilling process, materials in equipment and hazards from ground containments.	
Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	Emergency procedures, reporting and actions required when an occurrence has been triggered.	
Control of Noise at Work Regulations 2005	Maximum levels and duration of noise exposure during operation of DANDO 3000	
Health and Safety (First Aid) Regulations 2013	Assessment of First Aid needs on site during operations.	L74 Health and Safety (First Aid)
Work at Height Regulations 2007	Dependent on locations of boreholes and use of platforms.	
Waste Management Regulations 2006	Recycling and disposal of waste products on site, should be in specific site induction.	
Manual Handling Operations Regulations 1992	Correct handling of drills and prevention of Work-Related Upper Limb Disorders (WRULD)- when possible use of mechanical equipment should be used. Electric winches.	

Table 1.4 BDA Requirements for safe cable percussion drilling in the UK (BDA, 2016) – Note: source is 2016 and will need to be reviewed by BDA to make sure this is up to date with 2020 V2 of the manual. Health and Safety Executive (HSE, 2023).

6. Risk Assessment for Safe Operation of DANDO 3000

The conditions of each site will determine additional risk factors.

Identified Risk	Risk Level*	Actions to Reduce Risk	Reduced Risk Level*	People at Risk
Underground Services – gas, water, and electricity when drilling.	H	- C.A.T Survey to be conducted before excavation of boreholes. - Gas detection equipment/alarms to be used during excavation. - Access to suitable water pump equipment as area / conditions dictate.	L	- Drilling Team - Site Operatives - General Public
Rotating Parts and guarding	H	- POWER regulations and checks to ensure moving machinery protected from hazards such as entanglement. - Emergency stop terminals on all mechanical equipment.	L	Drilling Team
Movement of Drilling Rig on public highways.	M	- Use red sidelights, stoplights, reflective triangles, illuminated number plate, white reflectors, reverse lights, orange side markers and signage warning plates for long vehicle. - Keep to speed limits for towing vehicles.	L	- Drilling Team - General Public
Movement of Drilling Rig on Site	M	- Plan ahead for risks of overhead structures and cables. - Plan safe route to borehole location allow room to move and turn trailer. - Maintain eye contact/communication with site staff and use banksman where possible. - LOLER lifting regulations for equipment and manufacturers guidance. - Safety Hazzas fencing erected around boreholes.	L	- Drilling Team - Site Operatives - General Public
Unexploded Ordinance	L	In locations such as MOD airfields it maybe necessary to use a magnetometer in the borehole, to detect potential bomb risks.	L	- Drilling Team - Site Operatives
Fire Preventions	H	- Flammable fuels to be stored on site in the designated no smoking zone. - No smoking in vicinity of the drill, no flammable fuels pored into borehole. - Sufficient time be allowed for plant to cool down when refilling.	L	- Drilling Team - Site Operatives

		- Spill kits to be used immediately on fuel spillages and clothes and PPE contaminated are to be disposed immediately. - Fire extinguishers adequate size and type should be in near location to the rig.		
Asbestos and contaminates	H	- All landfill sites should be categorised as substantial risk for asbestos. PPE precautions must be assessed individually and if required, then measures need to be individually risk assessed with the health and safety manager. - All material brought to the surface must be treated as a potential contaminant – use of polythene sheeting should be used as a temporary measure, until material can be disposed of following the sites waste management/environmental policy.	L	Drilling Team – Site Staff
Working at Height	H	- Avoid working at height. - If unavoidable, only use mechanical means, such as a cherry picker and safety harness. – contact management team to arrange.	L	Drilling Team
COSHH - Used in Drilling: Fuel, Battery Acid, Lubrication, Aerosols, Paint, Hydraulic Fluids and Hand Cleaners.	H	- Evaluate risks that can be avoided/not avoided. - Provide safe system of use and provide PPE.	L	Drilling Team
Noise	H	Percussion drills are high risk prolonged noise exposure. High quality ear protection must be always worn, and regular intervals/breaks taken from noise exposure.	L	Drilling Team – Site staff
Personal on-Site Safety: Head, Eyes, Skin, Respiratory, Feet protection and visibility.	H	Mandatory: hard hats, hi viz overalls, safety boots, gloves, and access to first aid kit. - Assessed: safety eyewear, disposable PPE and fitted face masks/respirators.	L	Drilling Team
Vibration – Clutch Break Handles and Percussive Hand tools	H	- Limit Duration of continuous work - Provide protective equipment for hands	L	Drilling Team
Manual Handling and Work-Related Upper Limb Disorders (WRULDS).	H	- Drilling involves significant amount of repetition movement of upper body. - All operations should be assessed, and physical work is shared equally across team with regular breaks. - PPE and Training provided for effective manual handling requirements of equipment.	L	Drilling Team

Table 1.5: Risk Assessment Dando 3000.

*L = Low Risk, M = Medium Risk and H = High Risk

7. Daily Implementation Workflow and Associated British Standards

Basic Workflow	British Standards
Arrange and plan access to the site for borehole survey and distribute map to team members.	
Locate site management team for specific induction.	
Confirm the location of the boreholes and agree safe access route across site for vehicles and equipment.	
Confirm Site Specific Risk Assessments (fire procedure /flooding/Gas) and produce valid CSCS cards.	BS EN 50054 Electrical equipment for detection of combustible gas.
Confirm potential contaminated land risks.	
Confirm Specific PPE requirements for location.	BS EN 365: 2004 PPE Prevention of falls from height. BS EN352-1:2002, BS EN352-3:2002, BS EN352-4:2002, Hearing Protection.
Confirm with management team buried services completed.	PAS 128, Specification for underground utility detection. 2014
Confirm RIDDOR and COSHH procedures .	
Confirm pollution risks and waste management procedures.	
Confirm welfare and toilet facilities are accessible for team.	
Obtain a valid permit to dig	
Position Hazzas fencing around borehole.	
Manually dig initial pits to required depth for drill.	
Follow LOLER procedures and unload/erect equipment per manufactures instructions.	BS EN ISO 16228-1 & 2: 2014 Safety of mobile drill rigs.
Follow PUWER procedures and inspect equipment for safe use.	BS ISO 4309: 2010 Cranes, wire ropes, maintenance, and inspection. BS EN ISO 2015 Safety and machinery, emergency stops.
Install casing and casing head in inspection pit.	BS 5930:2015 Code of practice for ground investigations.
Insert boring tool inside casing and attach to casing head.	
Use winch and lift tool and casing, place into the ground.	
Release winch brake to drop tool to base of the borehole.	
Use the winch so tools penetrate the ground.	
Remove tool from borehole and clean.	
Bag and contain	
Reinsert tool and repeat until sample/test depth.	
Use SPT or UT100 for core samples.	BS EN 224751, 2 and 3 Geotechnical investigation and testing – sampling methods
Record samples on context documentation and take photographic records. Upload data to RockWorks® database.	BS 8574: 2014 Code of practice for management of geotechnical data.

Forward samples to environmental team (procedure to be agreed).	
Backfill Borehole	
Remove cable tool casing in lengths with a winch.	
Lower rig (LOLER)	BS EN ISO 16228-1 & 2: 2014 Safety of mobile drill rigs.
Load equipment onto truck and secure.	
Reinstate area and confirm borehole is safe to site supervisors' requirements.	
Exit Site and sign out.	

Table 1.6: Workflow was adapted from Triton Knoll borehole survey with a cable percussion rig for an onshore windfarm cable route, 2016/17 (Triton Knoll, 2023). British Standards institute (BSI, 2023).

8. Project Monitoring

Internal:

- Review of assessments from training days by Borehole Solutions Ltd, early January 2030, and identifying additional requirements for training and supervision on the equipment.
- Review of trainee progress on NVQ program from competency criteria and supervisor feedback.
- Weekly interval review of borehole data across the three drill teams to ensure that modelling data is consistent and accurate.
- Continual Professional Development (CPD) and Appraisal. Three monthly meetings between team members and line management to assess how employees are progressing in the project and identify any additional training requirements or problems.
- Intermittent site visits from the project management team and health & safety team to ensure procedures are followed regarding daily checks of the rig and lifting equipment.

External:

- BDA audit cards (CCCS) Skills Certification Scheme – a requirement for all team members.
- BDA Audits are conducted on-site to check the following:
 - Rig has a certificate of examination. Every 12 months.
 - Lifting equipment has a certificate of examination. Every six months.
 - Construction Phase plan on-site.
 - Welfare Facilities on site.
 - RAMS up to date.
 - COSHH assessments complete.
 - Risk Assessment for working at height completed.
 - PPE issued and used correctly.
 - First Aid and RIDDOR procedures in place.
 - Emergency stops working correctly, and spill kits/fire extinguishers are available.
 - Guarding in place.
 - Electric winches working.

9. Ongoing Calibration and Checks

Drill Team:

- Daily rig check sheet complete (Appendix 1).
- Supervisors' percussion rig inspection sheet completed weekly, and then sent back to head office for project managers attention (Appendix 2).

Health and Safety Team:

- Ensure calibration of the C.A.T tool is up to date and working correctly.
- Monthly check of fire extinguishers, spill kits and the first Aid Kit are all in date and well stocked.
- Ensure PPE is available to team members and assess requirements for each location.
- Ensure hand digging tools are safe to use and supplied.
- Ensure adequate welfare and toileting facilities are accessible to project field team.

Project Manager:

- Ensure good daily communication with team supervisors with regards to specific problems and additional equipment and resources which might be required for continuous operation of DANDO 3000.
- Contact Rig Rental company to ensure that all equipment is serviced every two months during the project.
- Monthly review with internal stakeholders in the consortium, to update progress, review continuous risk management and financial requirements of project.

10. Project Closure

MOLA has agreed to archive the project datasets and project archive onto the Archaeological Data Service (ADS) in a reusable file format. Keywords regarding the drilling equipment used and methodology will be included in the metadata so that the project will be discoverable and accessible for future geoarchaeologists that need to plan borehole survey data to build representative models. The borehole data sets will also be forwarded to the British Geological Survey (BGS) and the Local authority, Historical Environmental Records (HERs) teams. Going forward, the immediate use of the borehole data will be used to design further archaeological interventions along the planned HS4 Phase 3 for the 2030-2031 project.

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Appendices:

Appendix 1: Example Daily Inspection Sheet.

EXAMPLE DAILY INSPECTION SHEET

ASSOCIATION

		Date of report	
		Location of inspection	
		Rig Unique number	
		Rig Manufacturer	
Main components	NAD (No Apparent Defect)	Comments	
Is the winch guarded in line with PUWER			
Is the engine guarded in line with PUWER			
Chain or belt guard guarded in line with PUWER			
Engine is free from leaks			
Engine mountings secure and complete			
Operation of emergency stop			
Exhaust system secure and complete			
Winch general condition			
Gearbox security and condition			
A frame free from cracks and bends			
Front legs free from cracks and bends			
Base plate free from cracks and bends			
Side stays and cross bar fitted correctly and secured			
Side stays free from crack and bends			
Crown wheel Pulley block attaching point			
Condition of the main crown wheel			
Crown wheel rope retainers and loops			
Winch operates correctly			
Winch Foot brake works efficiently			
Winch Hand brake works efficiently			
Foot brake anti slip condition			
Condition of wire rope			
Type of wire rope			
Wire Rope Grips (state number)			
Rope termination condition			

EXAMPLE DAILY INSPECTION SHEET

Transport		
Road wheels braking condition		
Road wheel hand brake condition		
Road wheel tyre condition		
Mud guards secure and complete		
Rig lighting correct and complete		
Rig raising winch (if fitted)		
Condition of winch rope		
Is the winch guarded in line with PUWER		
Condition of pulley wheels		
Security of winch to main frame		
Condition of remote control		
Overall comments		
Signature of person marking this report		Date

Source: BDA (BDA, 2023).

Appendix 2: Example Drill Supervisor Inspection Sheet.

CABLE PERCUSSION RIG INSPECTION SHEET FOR SUPERVISORS



Cable Percussion Rig Inspection Sheet

Project			
Rig Type		Rig ID	
Engineer		Date	
ITEM	CHECK		
Health and Safety	SAFE	CONCERN	UNSAFE
Does the drilling operation look safe			
What Safety Signage is in place			
Where is the First Aid Kit located			
Where is the Fire Extinguisher located			
Is all PPE & RPE available (Spares available)			
Is any specialist PPE / RPE required during drilling			
Operational Rig Safety - General	SAFE	CONCERN	UNSAFE
When was the rig last serviced (POWER)			
Is the rig in good working order			
When was the rig last thoroughly inspected (LOLER)			
Does the rig have a valid LOLER certificate			
Are Emergency Stops clearly marked and working			
Are harness points located on the mast			
Is a climbing harness available & emergency plan in place			
Is the rig set up on flat ground or suitable timbers			
Is there any visible damage to Electrical Wiring			
Are both side stays secured in place with bolts and nuts/pins			
Is the cross bar secured in place with bolts and nuts/pins			
Does the rig have a suitable Samson Bar			
Can the rig be raised without assistance			
Is the rope jump bar in place to the crown sheave			
Is the Winch Wire in good condition			
Is the secondary Winch Wire in good condition			
Are the Winch Wires correctly terminated			
Is a LOLER certificate available for all lifting equipment			
Is the exhaust venting away from the driller			
Operational Rig Safety - Guarding	SAFE	CONCERN	UNSAFE
Is a fixed guard covering the winch drum			
Is a fixed guard in place over the chain and sprocket			
Is a fixed guard in place over the capstan wheel			
Is a fixed guard over the clutch / crank spindle			
Environmental	SAFE	CONCERN	UNSAFE
Does the rig have any engine / hydraulic oil leaks			
Is a spill kit available			
Is there any other means to contain leakage i.e. drip tray			
Additional Observations, Comments and Actions		Checked By	
			PASS
			FAIL

Source: BDA (BDA, 2023).

