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Remediation Strategy and Verification Plan



Desk Studies | Risk Assessments | Site Investigations | Geotechnical | Contamination Investigations | Remediation Design and Validation

Site: Glossop Brook Road

Client: Glanville Consultants Limited

Report Date: 20th March 2023

Project Reference: JN1575

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SUMMARY

The site at Glossop Brook Rd, in Glossop, Derbyshire extends to 0.4ha and comprises a disused pub and car park.

It is proposed to redevelop the site with a new McDonalds Restaurant with an associated car parking area, 'drive-thru' and areas of hard and soft landscaping.

A desk study was carried out and indicates that the site was largely undeveloped for most of its history, located within an industrial area, although some buildings were present in the south-east corner from the earliest mapping until around 1980. A gasometer was shown off-site, close to these buildings, until the late 19th Century. Some land raising appears to have occurred on site, possibly at the time that the scrapyard was constructed, on or immediately adjacent to site, in 1980. The Wrens Nest pub on site dates from the early 2000's. Off-site, the adjacent land with gasometer, the scrapyard and similar land raising exercises were considered the most significant off-site potential sources of contamination.

The site has been the subject of two phases of intrusive investigation (internal & external), comprising windowless & window sampling as well as shell & auger boreholes.

Relevant Pollutant Linkages were only identified for minor concentrations of heavy metals, various organic contaminants and asbestos. Most of the minor risks, however, are to the new service pipes and the site workers, rather than the customers or restaurant staff.

Recommendations are made for a provision of clean cover in soft landscaped areas, and implementation of a discovery strategy, subject to the approval of the regulatory authorities. Upgraded utility pipes are also likely to be required, due to some of the minor concentrations of organic compounds recorded, subject to the comments of the providers.

A Verification Plan and Discovery Strategy are included. The monitoring wells should be decommissioned in line with industry guidance.

The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based upon them. Their validity should be confirmed at the time of site development.

This report has been prepared for the sole internal use and reliance of Glanville Group. This report shall not be relied upon or transferred to any other parties without the express written authorization of Southern Testing Laboratories Limited. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The findings and opinions conveyed via this report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing Laboratories Ltd believes are reliable. Nevertheless, Southern Testing Laboratories Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Dr Joe Kelly		Chris Nolan BSC MSc FGS
(Countersigned)		(Signed)

For and on behalf of Southern Testing Laboratories Limited STL: JN1575

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A INTRODUCTION

1 Authority

Our authority for carrying out this work was assigned by Hylton George of Glanville Group Ltd.

2 Location

The site is located 700m to the west of Glossop train station in Derbyshire, adjacent Wrens Nest Retail Park and a short way south of Glossop AFC football ground. The approximate National Grid Reference of the site is SK 02800 94229. The site location is indicated on Figure 1 within Appendix A.

3 Proposed Construction

It is proposed to construct a new single-storey McDonald's restaurant, with associated soft landscaping, drive-thru and car parking, as per the AEW Architects schematic dated 16/11/2020.

For the purposes of the contamination risk assessment, the proposed development land use is classified as Commercial, CLEA Model Ref [1] / C4SL Report Ref [2].

The gas sensitivity of the proposed development is therefore rated as low CIRIA C665 Ref [3].

4 Scope

This report presents our Remediation Options Appraisal, Remediation Strategy, and Verification Plan for the proposed remedial works at the site.

As with any site there may be differences in soil conditions between exploratory hole positions and this method statement relies of the Phase I and II findings by others.

The findings and opinions conveyed via this report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing Laboratories Limited believes are reliable. Nevertheless, Southern Testing Laboratories Limited cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

This report has been prepared for the sole internal use and reliance of Glanville Group. This report shall not be relied upon or transferred to any other parties without the express written authorization of Southern Testing Laboratories Limited. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The recommendations contained in this report may not be appropriate to alternative development schemes.

The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based upon them. Their validity should be confirmed at the time of site development.

B BACKGROUND INFORMATION

5 Site Investigation Works

The site has been the subject of a Phase I and II investigation.

Date	Author	Title/ Ref No.	Subject
October 2021	ST Consult	Desk Study – JN1575.	Desk Study.
Feb2022	ST Consult	Phase II Site Investigation & Risk Assessment Report – JN1575.	Intrusive Investigation.

These reports provided reasonable coverage. The information derived from these reports is discussed below. The reader is referred to the original reports for supporting detail.

6 Site Investigation Summary

6.1 Desk Study (October 2021)

A desk study was carried out [1] and indicates that the site was largely undeveloped for most of its history, located within an industrial area, although some buildings were present in the south-east corner from the earliest mapping until around 1980. A gasometer was shown off-site, close to these buildings, until the late 19th Century. Some land raising appears to have occurred on site, possibly at the time that a scrapyard was constructed, on or immediately adjacent to site, in 1980. The Wrens Nest pub on site dates from the early 2000's.

Geological records indicate the site to be underlain by Alluvium, over Till, over Marsden Formation sandstones & mudstones. The superficial deposits and Bedrock are all Secondary Aquifers. The site is not located in a SPZ.

An Unexploded Ordnance (UXO) risk assessment was carried out by a specialist contractor as a precaution – the site was reported as low risk.

The pub construction, demolition in the south-east corner, land raising and possible scrapyard on site, represent potential sources of contamination. The adjacent land with gasometer, scrapyard and similar land raising, are considered the most significant off-site potential sources of contamination.

A Phase II intrusive investigation was recommended to assess the contamination risk.

6.2 Phase II Ground Investigation (Feb 2022)

Two phases of intrusive investigation were carried out – initially external and then internal [2]. This comprised a series of 11 No. window/windowless sampler holes and 2 No. cable percussion boreholes.

There were areas of the site that were inaccessible during the fieldwork phases in association with on-site infrastructure, service easements and the heavily forested retained margin. The same ground conditions should not be assumed in these areas.

The soils encountered comprised several metres of clay and gravel based Made Ground (3.0-5.6m), over soft becoming firm laminated clays (-6.0/8.9m). These are underlain by waterlogged gravels of 1-3m thickness. From 10m+ the above alluvial sequence is underlain by a firm to stiff gravelly clay Till.

There was evidence of low level soil contamination, including asbestos, relative to the commercial use proposed, with some impact of the perched water in the bank (although not the groundwater at depth or the perched water beneath the main site). No gas risk has been identified by the monitoring undertaken. A bulk earth removal will be carried out on the eastern boundary to facilitate the construction of the drive thru. This will remove at least some of the impacted soil (as noted in WLS6, 7 and 8). Some basic remediation measures are recommended for any new soft landscaped areas and new service pipes.

7 Relevant Pollutant Linkages

The site investigations and risk assessment identified the following Relevant Pollutant Linkages for the site:

Contaminant / Source	Pathways	Receptor
Metals in Made Ground (Lead, Copper and Zinc)	Soil/dust dermal exposure Soil/dust ingestion/inhalation Direct contact	Construction workers Construction Workers Structures/services
PAH's in Made Ground	Soil/dust dermal exposure Soil/dust ingestion/inhalation Direct contact	Construction workers Construction Workers Structures/services
Petroleum hydrocarbons in Made Ground	Direct contact	Structures/services
Asbestos in Made Ground	Soil/dust dermal exposure Soil/dust ingestion/inhalation	Construction Workers/end users Construction Workers/end users
SVOC's (other than PAH's)	Soil/dust dermal exposure Soil/dust ingestion/inhalation Direct contact	Construction workers Construction Workers Structures/services

C REMEDIAL OBJECTIVES AND OPTIONS

8 Remedial Objectives

On the basis of the investigation carried out to date, and the site proposals, the remediation objectives are as follows:

- Reduce any minor risk to the new service pipes from slightly elevated concentrations of metals and organics within the site made ground.
- Provide measures to mitigate the exposure risk to site operatives from the minor heavy metal, PAH, asbestos and various SVOCs.
- Provide measures to mitigate exposure risk to the customers and restaurant staff through clean landscaping (from the minor asbestos impact recorded).

9 Options Appraisal

Each of the below occurrences are within the eastern margin of the site and will be significantly mitigated during the site redevelopment as bulk soil removal is intended as the retaining wall is 'pushed back'.

9.1 PAH and other SVOC compounds in the Made Ground

In light of the minor organic impact reported (which is not a risk to human health given the proposed end-use), the new service pipe providers will likely insist on the use of Protecta-Line pipes or similar. This should be confirmed with the suppliers. This is the only viable and sustainable option to mitigate the risk to the new service pipes, as opposed to removing all the Made Ground from site.

As for the site workers to mitigate the minor risk to them, they should all wear appropriate PPE as well as using the welfare facilities appropriately.

9.2 Heavy metals in the Made Ground

These values are below the guideline values for the for the end user exposure risk, but may represent a slight risk to site workers and new water service pipes for the site. As such site workers should don appropriate personal protective equipment (PPE) as well as use of welfare facilities. As for the risk to water pipes Protecta-line pipes or similar should be installed to mitigate the slight risk the heavy metals pose. These are the only viable and sustainable remediation options, as discussed above.

9.3 Asbestos in the Made Ground

The analysis reviewed above has found limited and localised asbestos. Specific remedial measures are not considered necessary in this regard at this stage, although the occurrence should be emphasised within the development watching brief and there is a potential risk to customers and restaurant staff where soft landscaping is located. The contractors should also be provided with a copy of this report for their own health and safety assessment, in terms of working practices and PPE.

The only way to almost completely mitigate this minor risk, to the customers and restaurant staff, as discussed above, would be to remove all the Made Ground, which is unsustainable and unnecessary. Given the nature of the contamination, providing clean cover in the soft landscaped areas, along with a discovery strategy, will mitigate any minor risk in these more sensitive areas.

9.4 Petroleum Hydrocarbons in the Made Ground

The concentrations of petroleum hydrocarbons recorded in the made ground represent a minor risk to new service pipes, not the contractors, customers or restaurant staff. The only viable mitigation measure is the use of Protecta-Line pipes or similar.

Again, this is the only viable and sustainable option to mitigate the risk to the new service pipes, as opposed to removing all the Made Ground from site.

The organic contamination measured on site, in general, is minor and in-situ or ex-treatment methods are also not viable.

D REMEDIATION STRATEGY

11 Remediation Method

As discussed, some basic remediation is required. As some planting and landscaping is proposed, there will be a requirement to import some certified clean topsoil and possibly subsoil, depending on the depth needed.

Location	Details
Soft landscaped areas and areas of planting	To provide a growing medium over the made ground, and mitigate the very minor contamination risk identified, a minimum of 300mm certified clean topsoil is recommended, mainly to provide a growing medium, placed above an alert membrane to separate the imported soil from the underlying Made Ground. Some removal of the made ground may be required depending upon finished levels. Please note, the depth quoted above is considered a minimum. The landscaping contractor may wish for a greater depth of topsoil in some areas depending on the specific planting. This should be confirmed with the specialist contractor.
New Service Pipes	Protecta-Line or similar, subject to review by the providers.
Monitoring Wells	The 4 monitoring wells will be decommissioned in line with industry guidance.

12 Assessment Criteria

The following assessment criteria values will be used in the verification process:

Any imported soils shall be free from deleterious materials, weeds and contamination. The material to be used will comply with the appropriate BS Specifications for Topsoil (BS 3882:2015) and, if relevant, Subsoil (BS 8601:2013), and the analysis shall also comply with the values given for a Residential with Homegrown Produce consumption, as a precaution to ensure a good source, in the table in Appendix B. These values are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based on them. Their validity should be confirmed at the time of site development.

E VERIFICATION PLAN

13 Data Collection

Location	Data	Responsibility
Soft Landscaped/ Planting Areas	*Reducing levels (if required) and laying membrane* *Post placement check of thickness* *Post placement soil samples* *Consignment Notes*	*Main Contractor* *Southern Testing* *Southern Testing* *Groundworker*
Service Pipes	*Upgraded service pipes (to be confirmed with the supplier). Protecta-Line or similar. Pictures taken during installation as proof.*	*Consultant engineer/ Groundworker*
Decommissioning Monitoring Wells	The monitoring wells on site, BH 1, WS2, 5 and 7, will be decommissioned in line with industry/regulatory guidance (See below and Appendix D)	*Groundworker*

14 Analytical Framework

For any additional analysis (addressing unforeseen ground conditions, for example, or for confirming the quality of imported topsoil) and where there are sufficient samples, a statistical analysis will be carried out to determine the UCL for the sample population, which will be compared with the assessment criteria given in Appendix B, for a residential development in the case of imported topsoil.

A minimum of three samples of imported topsoil will be analysed to support the certificates provided.

15 Reporting and Lines of Evidence for Inclusion

At the end of the remediation, a verification report will be produced by ST Consult. The remediation and validation process at McDonald's sites is well established. The contractor is provided with a copy of the Phase II report, and this validation report, so is aware of the data that is required. Discussions will also be held with the groundworker to confirm this.

For the soft landscaped areas photographic evidence is provided of the alert membrane beneath the imported topsoil.

Photographs showing the full depth of topsoil will be provided by Southern Testing for inclusion in the report, along with data for the topsoil, both certification by the supplier (which is reviewed prior to import) and independent testing following sampling from the validation visit.

Photographs of the Protecta-Line pipes, in service trenches, are taken by the groundworker for inclusion in the report.

There are 4 monitoring wells on site, as shown on Figure 2 in Appendix A (BH1, WS 2, 5 and 7). These need to be decommissioned in line with guidance as outlined the EA document appended (Good Practice for decommissioning redundant boreholes and wells – see Appendix C). The proposal is to backfill these with low permeability material (cement, concrete or bentonite grout). A concrete cap of suitable strength, with a diameter at least one metre greater than the width of the backfilled borehole (see Fig. 1 of the appended document), should then be installed

16 Discovery Strategy

As with any site, areas of contamination not identified during site investigation works may come to light in the course of redevelopment. Accordingly, a discovery strategy will be adopted to ensure that any hitherto unknown contamination is identified and dealt with in an appropriate manner, as follows:

- A close watch will be maintained during all demolition and excavation works.
- In the event that unexpected or malodorous soils or liquids are encountered, excavation work shall cease in the affected area.
- The affected area shall be made safe and fenced off to prevent unauthorised access.
- The Site Manager shall notify *Southern Testing Laboratories* of the discovery, who will attend site to inspect the suspect materials, provide advice and take samples as necessary. Within *ST Consult,* Joe Kelly shall be the first point of contact.
- The Site Manager shall notify High Peak Borough Council, of the discovery, depending where the contamination is identified. Within the council, the contaminated and officer shall be the first point of contact. This will be confirmed in due course.

Any suspect excavated soil will be stockpiled separately on polythene sheeting, covered, and tested before being removed.

17 General Guidance

In general terms, the workforce and general public should be protected from contact with contaminated material. There is a range of relevant documents published by the Health and Safety Executive, and organisations such as CIRIA, and the BRE.

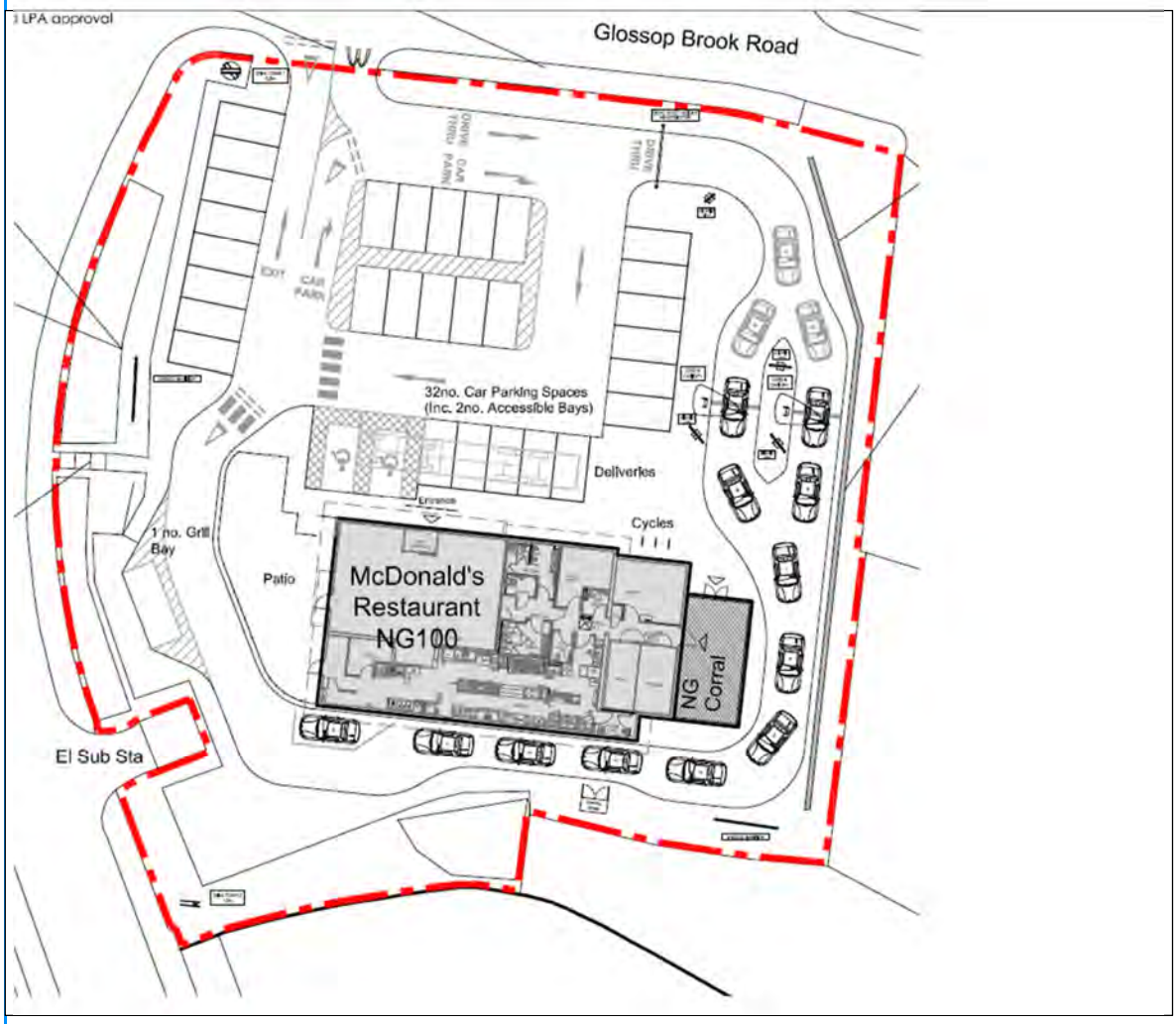
Some soils will require removal from site and disposal to suitably licensed landfills. Different guidelines and charges will apply to different waste classifications. As waste producers, the Developer holds responsibilities under the various governing regulations, including:-

- Ensuring that waste is characterised in accordance with current Technical Guidance.
- Ensuring that waste is disposed of at a facility appropriately licensed to receive the waste as classified.
- Keeping accurate records of all waste classification, transfer and a disposal log including information such as:
    - Date, Waste Classification, Carrier's Registration Number, Transfer Note Number, Ultimate Destination.
- Submitting full copies of those records for inclusion in validation/closure reports.

Maintaining those records for potential future regulatory inspection.

APPENDIX A

Site Plan



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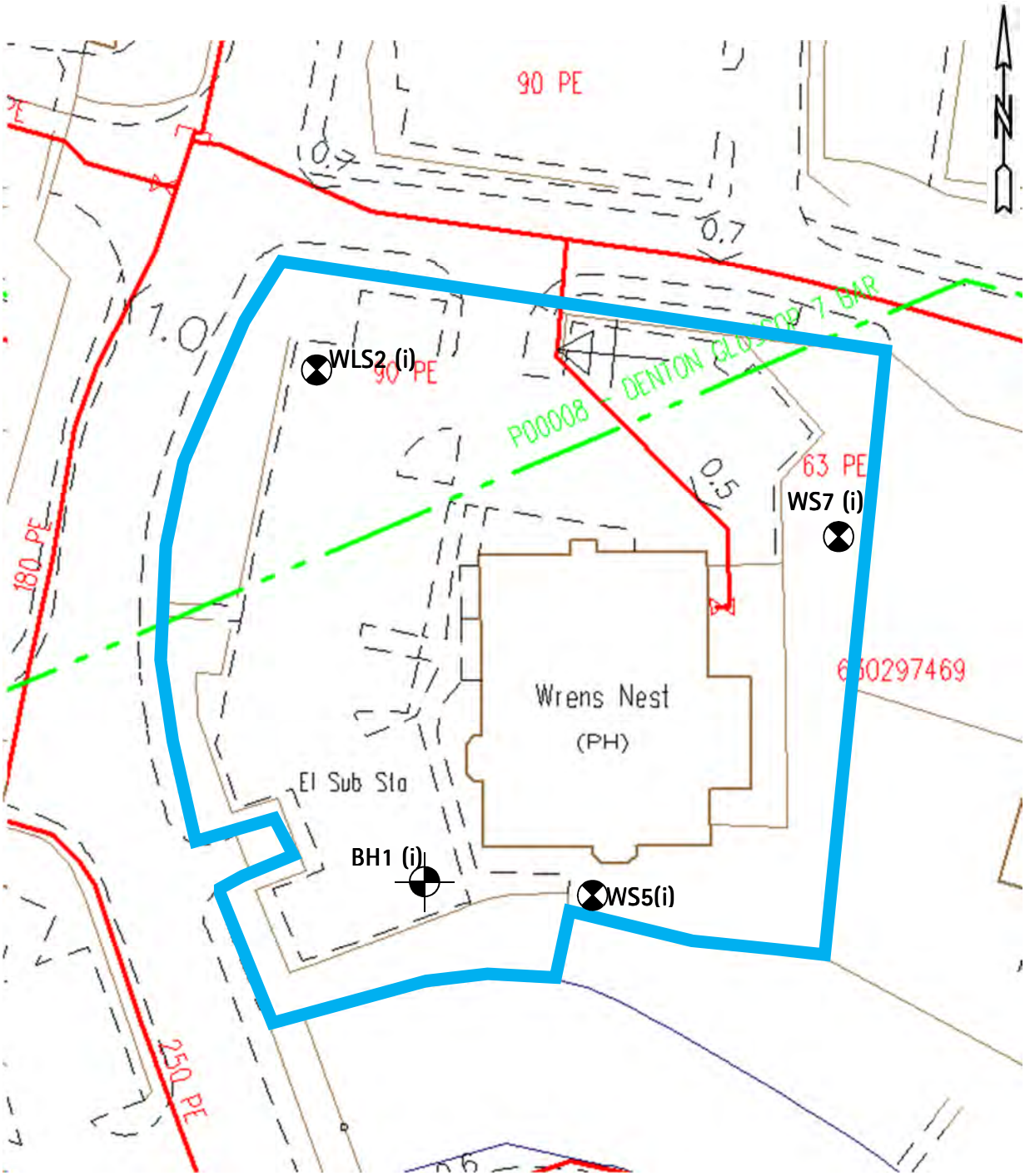
Site:	Glossop Brook Rd, Glossop	Project ID	JN1575
Figure 1	Site Location	Date:	



NB: Positions of exploratory holes / test positions are only indicative

Site:	Glossop Brook Rd, Glossop	Project ID	JN1575
Figure 2	Monitoring well installations	Date:	11-13 Oct 21

APPENDIX B

Verification Criteria

Contaminant Screening Values for Imported Soils

Contaminant	Units	Proposed Land Use					
		Residential with homegrown produce consumption	Residential without homegrown produce consumption	Open Space* (Residential)	Open Space* (Park)	Allotments	Commercial / Industrial
Arsenic (As) [2]	mg/kg	37	40	79	170	43	640
Cadmium (Cd) [2]	mg/kg	11	85	120	555	1.9	190
Trivalent Chromium (CrIII) [2]	mg/kg	910	910	1,500	33,000	18,000	8600
Hexavalent Chromium (CrVI) [2]	mg/kg	6	6	7.7	220	1.8	33
Lead (Pb) [3]	mg/kg	200	310	630	1300	80	2330
Mercury (Hg) [1,2,7]	mg/kg	7.6-11	9.2-15	40	68-71	6.0	29-320
Selenium (Se) [2]	mg/kg	250	430	1,100	1,800	88	12,000
Nickel (Ni) [1,4]	mg/kg	pH<6.0 60 pH 6.0-7.0 75 pH>7.0 110					
Copper (Cu) [1,4]	mg/kg	pH<6.0 100 pH 6.0-7.0 135 pH>7.0 200					
Zinc (Zn) [1,4]	mg/kg	pH<6.0 200 pH 6.0-7.0 200 pH>7.0 300					
Phenol [1,2]	mg/kg	120-380	440-1200	440-1300	440-1300	23-83	440-1300
Benzo[a]pyrene [1,5]	mg/kg	1.7-2.4	2.6	4.9	10	0.67-2.7	36
Naphthalene [1,2]	mg/kg	2.3-13	2.3-13	77-430^{+}	77-430^{+}	4.1-24	77-430^{+}
Total Cyanide (CN) [6]	mg/kg	/	/			/	/
Free Cyanide [6]	mg/kg	/	/			/	/
Complex Cyanides [6]	mg/kg	/	/			/	/
Thiocyanate [6]	mg/kg	/	/			/	/

Notes:

* Open Space levels calculated on the basis of the exposure modelling developed in the C4SL research.

+ Screening values constrained to saturation limit. Higher values may be acceptable on a site specific basis.

[1] Where ranges of values are given for organic contaminants, the screening value is dependent on the Soil Organic Matter. Where ranges are given for inorganic contaminants, the screening value is dependent on the pH.

[2] LQM/CIEH S4UL (2014). Copyright Land Quality Management Ltd reproduced with permission; Publication Number S4UL 3116. All rights reserved.

[3] C4SL (DEFRA 2014).

[4] Copper Zinc and Nickel may have phototoxic effects at the GAC or SGV concentrations and alternative criteria are given for importation of Topsoil or other soils for cultivation, based on BS3882:2015 (Topsoil) and BS8601:2013 (Subsoil).

[5] Based on the Surrogate Marker approach and modelled using the modified exposure parameters of C4SL but retaining 'minimal risk' HCV.

[6] Usually Non-Detect concentrations. Screening criteria to be derived on a site specific basis if test results indicate.

[7] SGV/GAC for Methyl Mercury, higher concentrations may be tolerable if inorganic mercury is the only species present. Lower concentrations apply for elemental mercury.

These screening values are valid at the time of writing but may be subject to change. Their validity should be confirmed at the time of site development.

APPENDIX C

Well Decommissioning Guidance

Good practice for decommissioning redundant boreholes and wells

October 2012

What's the purpose of this guidance?

Redundant boreholes and wells must be dealt with appropriately to make them safe and secure, and also to ensure they don't cause groundwater pollution or loss of water supplies. This guidance focuses on groundwater protection aspects but there are many other important factors owners and developers need to consider when designing and carrying out decommissioning works. These will be site specific, depending on the situation and intended afteruse. For example, boreholes near landfills or other sources of soil gas may require an opening to the air to prevent the build-up of noxious, explosive or flammable gas. Therefore, you should seek expert site-specific advice.

Legal framework

The Environment Agency (EA) has a duty to promote the sustainable use of water and to ensure it is protected from pollution. The Environmental Permitting (England and Wales) Regulations 2010 require the EA to take all necessary measures to prevent input of so called hazardous substances (for example pesticides) and limit the input of other non-hazardous pollutants (such as nitrate) into groundwater*, including for example contaminated run-off directly entering groundwater via an uncapped borehole.

**Groundwater is defined as water that is below the surface of the ground in the saturated zone and is in direct contact with the ground or subsoil.*

Why is it important to decommission properly?

Boreholes and wells are constructed for a variety of purposes including water supply, de-watering excavations, collecting geological information, investigating or sampling soils and groundwater and, increasingly, for ground source heating and cooling and geothermal (non-carbon) energy production. Many old water wells and boreholes are redundant as most properties are now connected to a mains water supply.

Improperly abandoned boreholes and wells can provide preferential pathways for groundwater or contaminant movement. This may result in the contamination of groundwater, the mixing of groundwaters of variable quality from different aquifers, or contribute to the loss of aquifer yield and water pressure (referred to as the potentiometric or piezometric head) as groundwater flows out of the system. This can threaten the availability and quality of groundwater resources for other users and potentially have an impacts on wetlands. Abandoned boreholes and wells can also present a physical hazard to people and property.

Artesian boreholes (where groundwater at depth in a 'confined aquifer' is at sufficient pressure to cause water to discharge either at the ground surface or into another overlying aquifer without any pumping) can be particularly problematic. They require special attention to prevent uncontrolled discharge of groundwater or cross-contamination of different aquifer units.

Therefore, site owners need to ensure that redundant boreholes and wells are made both safe and structurally stable, and also backfilled or sealed to prevent groundwater pollution and flow of water

between different aquifer units. This is particularly important where other potable groundwater supplies are at risk.

However, in certain circumstances they may be adapted for use as a groundwater monitoring facility. **You must not use wells or boreholes as soakaways for foul or surface water drainage** because they provide a direct discharge route into groundwater and, as such, pose a risk of groundwater pollution.
This is prohibited by the Environmental Permitting (England & Wales) Regulations 2010.

Firstly, what are the construction details?

When considering how best to backfill and seal a borehole or well, or whether it could be adapted for monitoring purposes – you should first obtain information on the geological strata encountered by the borehole and how it was constructed (including depth, diameter and casing details). These can usually be obtained from site records or the original driller's log; the British Geological Survey holds the national water well archive and other borehole databases.

Is the site suitable for groundwater monitoring?

There are many good reasons for collecting groundwater samples or measuring groundwater levels; the information can, for example, help to validate the success of any remedial works being undertaken on a contaminated land site. Therefore, before decommissioning a borehole you should consider whether you wish to retain it as a monitoring facility. If it is to fulfil part of a planning condition or other legal monitoring requirement you may wish to discuss the details of how you do this with the Environment Agency.

If not, it is still worth contacting us via our National Customer Contact Centre (NCCC) to check whether we would be interested in incorporating it into our strategic groundwater level or quality monitoring networks.

If the borehole is not going to be converted then it should be abandoned using the guidelines below and the British Geological Survey should be informed.

Decommissioning

Each situation is different in terms of its location, geological setting, borehole construction, dimensions, hazards and, very importantly, intended site afteruse. Therefore the most appropriate abandonment procedure will vary from site to site. It is strongly recommended that you engage the services of a proficient well contractor with a good knowledge of the local geology and well abandonment procedures. For large boreholes and wells you may need to seek engineering advice. (**Note that structural aspects are outside the scope of this guidance.**)

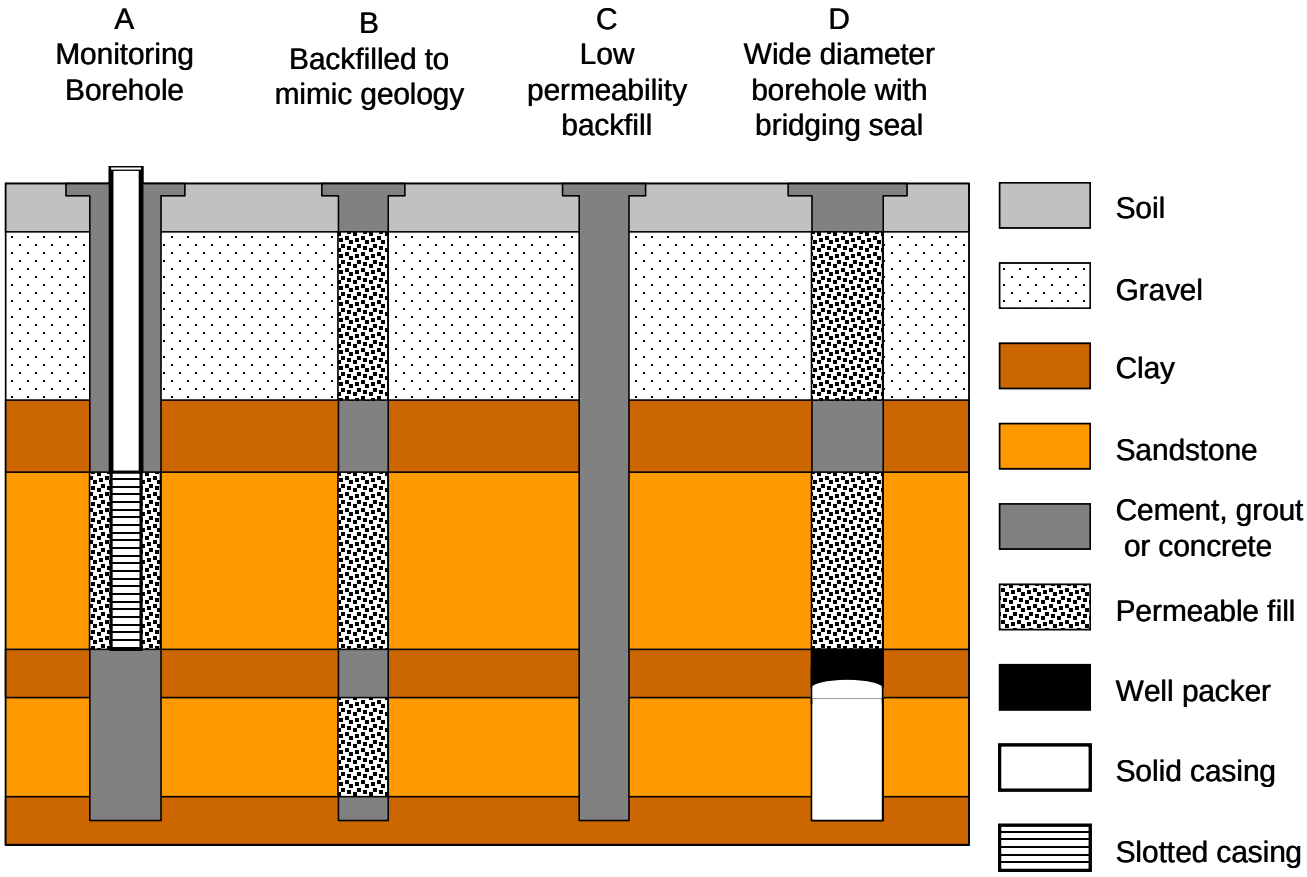


Figure 1: Schematic options (B–D) for decommissioning wells and boreholes

Step 1 - Defining the objectives

When planning the decommissioning works, in addition to any site specific afteruse considerations, the method should address the following objectives:

- Remove the hazard of an open hole (safety issues).
- Prevent the borehole acting as a conduit for contamination of groundwater.
- Prevent the mixing of contaminated and uncontaminated groundwater from different aquifers.
- Prevent the flow of groundwater from one geological horizon to another.
- Prevent the wastage of groundwater from the overflow of artesian boreholes.

Step 2 - Removing headworks and casing

It is crucial to ensure that the borehole or well is free from all obstructions that may interfere with the sealing of the hole. In particular, the pump and pipework should be removed, together with any other infrastructure (dip tubes etc).

The condition of any borehole casing and grout must be examined to ascertain whether its retention in the hole would prejudice any of the objectives of the abandonment. For many holes, examination of the casing from the ground surface will be adequate. However, deep boreholes may require the use of closed-circuit television (CCTV) to examine the casing at depth.

Where the casing has corroded or broken, or the grouting has failed, depending on the setting it may be necessary to remove those materials to prevent any flow of groundwater around the outside of the borehole. However, this is not without its own risks since removal of the well casing can result in collapse of the borehole walls (particularly in unconsolidated materials) and possible subsidence at ground level. If the well casing needs to be removed, a specialist well contractor can advise on appropriate techniques and associated risks.

Step 3 - Backfilling

General considerations

For most purposes the ground should be restored as closely as possible to its pre-drilled condition. The borehole or well should be backfilled with clean (washed), uncontaminated materials so that the permeability of the selected materials are similar to the properties of the geological strata against which they are placed. The backfilled borehole will then mimic the surrounding natural strata and groundwater flow and quality will be protected.

Restoration will require a variety of materials to be used so that permeable aggregates (for example pea gravel and sand) are positioned adjacent to aquifer horizons, whilst low permeability materials (usually clay, bentonite cement grout, or concrete) are positioned adjacent to low permeability horizons (see Fig. 1(B)). Alternatively, the entire borehole or well can be backfilled with low permeability

materials that will prevent significant vertical or horizontal movement of groundwater through or along the borehole (see Fig. 1(C)).

The backfill materials must be clean, inert and non-polluting. Suitable materials include pea gravel, sand, shingle, concrete, bentonite, cement grout and uncontaminated rock. There are also a range of recycled products, like crushed glass, on the market that are designed for use in boreholes

IMPORTANT - Never use backfill materials that can cause pollution.

You should also consider the geochemical environment into which these materials will be placed, as the behaviour of materials may change under different environmental conditions (for example, iron-rich sands may contaminate the aquifer; phenol contamination may prevent bentonite grouts curing).

Aggregates (pea gravel, shingle, sand etc) should be selected such that they have a grain size that allows easy delivery into the borehole and should be introduced in a controlled manner to ensure that accidental 'bridging' does not occur within the borehole. Concrete and grouts that are introduced in a liquid form should be introduced through an appropriate delivery pipe (e.g. tremie pipe), to ensure that voids do not form. **Note**: It is good practice to monitor the volume of backfill material that is being emplaced, compared to that calculated at the design stage, to check if bridging within the borehole, or loss to the formation is occurring.

Boreholes that penetrate highly fissured aquifers, such as some limestones and gypsum bearing units, present additional problems. Liquid grouts (particularly those injected under pressure), or fine-grained aggregates (e.g. sand) may be transported out of the borehole into the body of the aquifer through fissures. Careful monitoring of the process is required if these techniques are used, and in these cases it may be more appropriate to use coarser aggregates such as gravel as a backfill.

Deep and large diameter boreholes/wells

When dealing with very deep or large diameter boreholes and wells (note, this does not apply to mine shafts), the volume of the hole may be considerable. In such circumstances it may be appropriate to adopt an alternative approach to completely backfilling the void, as long as this will not prejudice any of the design objectives.

Provided that the long-term structural stability of the borehole can be demonstrated, it may be possible to place a permanent bridging seal within the borehole and then to infill above this level using the approach summarised above (see Fig. 1(D)). The bridging seal should ideally be positioned below the lowest aquifer horizon. However, where this is not possible, it is important that the open borehole beneath the bridging seal penetrates no more than a single aquifer unit, thereby preventing the flow of groundwater between different aquifers.

The material commonly used as a bridging seal is cement, although a combination of a mechanical plug (packer) and cement can be used. Cement seals must be allowed to set (cure) in place before backfilling is continued and completed.

Again, this is a specialist area of work that requires high standards of design and workmanship to ensure an effective permanent seal is achieved.

Artesian boreholes

For artesian boreholes, the decommissioning process should aim to confine the groundwater to the aquifer from which it came – in order to prevent loss of confining pressure and the loss of water resources to the surface or other formations.

The first step is to control the artesian flow. There are a number of ways to accomplish this depending, in part, on the water pressure in the confined aquifer and the depth to which the water level must be lowered. These include:

- Pumping the borehole to produce the necessary drawdown.
- Pumping nearby boreholes.
- Extending the casing above ground level beyond the elevation to which water will rise in the borehole. (the potentiometric or piezometric surface).
- Introducing dense, non-polluting fluids into the borehole.
- Introducing a pre-cast plug at an appropriate level within the hole.
- Using an inflatable packer and pressure grouting the void space below it.

In aquifers that have large seasonal fluctuations in water level, decommissioning artesian boreholes is likely to be easiest in late summer, when groundwater levels and artesian flows are at their lowest.

The importance of the potential pathways in and around the casing should also be considered.

Decommissioning artesian boreholes is a specialist job and requires expert advice.

Step 4 - Sealing the top of the borehole

The backfilled borehole/well should be completed with an impermeable plug and cap to prevent entry of potentially contaminated surface run-off or other liquids. The top two metres should be filled with cement, concrete or bentonite grout. A concrete cap of suitable strength, with a diameter at least one metre greater than the width of the backfilled borehole (see Fig. 2), should then be installed. The exact finished depth of this cap will depend on the setting and planned afteruse of the site. It should be at least 2 metres below plough depth in agricultural areas and at least 1 metre below formation level for sites proposed for redevelopment. Never build structures directly onto well caps or linings.

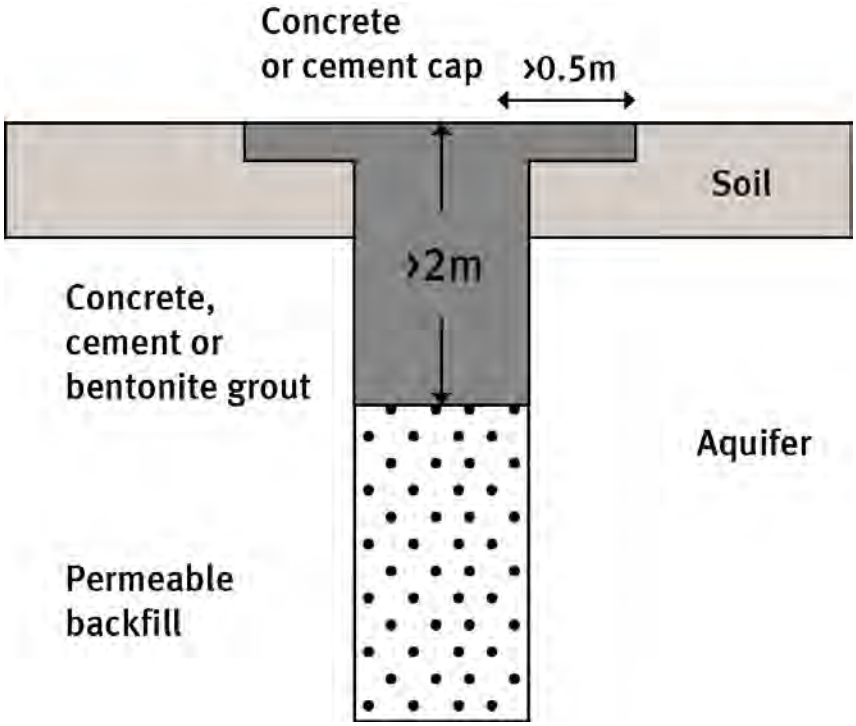


Figure 2: Schematic diagram for borehole seal and cap

Step 5 - Recording details and informing others

You should keep an accurate record of the abandonment details for future reference, including:

- The reasons for abandonment (for example water quality problems).
- Measurement of groundwater level prior to backfilling.
- The depth and position of each layer of backfilling and sealing materials.
- The type and quantity of backfilling and sealing materials used.
- Any changes made to the borehole/well during the abandonment (for example casing removal).
- Any problems encountered during the abandonment procedure.

The location of abandoned borehole and wells should be clearly marked on site records This is essential where any part of the well has not been filled.

It is also very good practice to mark or deeply inscribe well caps with the word "WELL". Even if done crudely it can avoid considerable risk, delay or uncertainty in the event of the structure being discovered during excavation by others in the future, who may not otherwise know what the feature is.

Always notify the Environment Agency and British Geological Survey of the abandoned well location and structure.

Conversion to soakaways

Wells and boreholes should not be converted to soakaways, as these allow the direct discharge of pollutants into groundwater without any potential for attenuation, and will often result in groundwater pollution. The direct discharge of hazardous substances to groundwater, via a borehole, is effectively prohibited by the Environmental Permitting (England & Wales) Regulations 2010, and the pollution risk from any direct discharge of non-hazardous pollutants, such as sewage effluent, is so great as to make it highly unlikely to be acceptable.

Further advice and guidance

It is recommended that the advice of a specialist well contractor should always be sought, Details can be obtained from:

- **The British Drilling Association**. Wayside, London End, Upper Boddington, Daventry, Northamptonshire, NN11 6DP. Tel: 01327 264 622, email: office@britishdrillingassociation.co.uk

The Environment Agency cannot provide an advisory service on decommissioning individual boreholes and wells but your local Groundwater & Contaminated Land team may have some generic advice to help you; and would appreciate a copy of your abandonment details. They can be contacted via our National Customer Contact Centre (NCCC)

- **Environment Agency NCCC** Tel: 03708 506 506

The British Geological Survey are the national custodian of water well records in addition to other borehole records and geological information. They may have a record of the borehole or well you are dealing with, and will be interested in the abandonment details

- **British Geological Survey. National Geosciences Data Centre (NGDC)**, Keyworth, Nottingham, NG12 5GG. Tel: 0115 936 3143.

Useful references

- Environment Agency GP3 (Groundwater Protection Principles and Practice) http://www.environment-agency.gov.uk/research/library/publications/40741.aspx
- American Society for Test and Materials (ASTM) D5299 - 99(2005) Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
- Driscoll, F.G., 1986. Groundwater and Wells. Second Edition, Johnson Division.

Note: *This guidance supersedes the document ' Good practice for decommissioning redundant boreholes and wells' produced by our former National Groundwater and Contaminated Land Centre*

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