



CHALK MINE STABILISATION PROJECT HIGHBARNES, HEMEL HEMPSTEAD

Treatment Area 5: 14, 16, 18, 20, 22 & 24 Highbarnes

Report Number: 0013-UA000857-TR-01-TAR-0005

OCTOBER 2015



Incorporating

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1 INTRODUCTION

Dacorum Borough Council (DBC) has commissioned Arcadis Consulting (UK) Ltd (Arcadis) (formerly Hyder Consulting (UK) Limited) to oversee the treatment and validation of abandoned chalk mines identified beneath residential areas in the Nash Mills area of Hemel Hempstead, Hertfordshire. The mine workings identified at the site have been assessed to comprise a single level of chalk mine galleries in the vicinity of Highbarns, Pond Road and East Green road junction. The mine treatment has been funded under the Land Stabilisation Programme (LSP), administered by the Homes and Communities Agency (HCA).

The background to the scheme, interpretation of the mine, and treatment works are set out in the overarching treatment report (Arcadis, 2015). This report forms an addendum to the above report and should be read in conjunction with it.

The objective of this report is to set out the works that were undertaken to treat the mines and provide the results of post mine treatment validation probing. The properties discussed in this report are as follows:

- Nos 14, 16, 18, 20, 22 & 24 Highbarns.

The broader site location, treatment areas and interpreted extent of mine workings within the Derelict Land Clearance Order site boundary are shown in the overarching Treatment Report (Arcadis, 2015), Appendix A.

This Treatment area, validation probes and extent of grouting work specific to this treatment area are shown on drawings TA0005-01 and 02 in Appendix A.

Factual information relating to the investigative probes, validation probes and extent of grouting work are contained in the BAM Ritchies' Sectional Validation Report for Nos. 14 - 24 Highbarns Road, (BAM, 2015).

2 SUBSURFACE INVESTIGATIONS

The subsurface investigations at these properties were undertaken in response to historical subsidence events across the site.

The pre-contract investigations were undertaken by Soil Engineering Ltd in 2012 and included investigative dynamic probes and dynamic windowless sampled boreholes. A review of historical information, the natural topography and the geotechnical investigations were used to identify zones of probable mining related disturbed ground.

Following and during each stage of the treatment works, validation dynamic probing was undertaken to establish the effectiveness of the mine treatment.

The scope of the validation dynamic probing completed during and following the treatment works for 14, 16, 18, 20, 22 & 24 Highbarns are summarised in Table 1 below.

Table 1: Summary of Validation Investigations

Type of Investigations	Number
Total No. of External Validation Dynamic Probes (VP)	83
Total No. of Internal Validation Dynamic Probes (VP)	3

The results of the validation dynamic probes undertaken during and after treatment works are presented in the relevant sectional factual report VR005 for this treatment area (BAM Ritchies, 2015). For the purposes of this report, additional dynamic probes

undertaken concurrently with the grouting works in order to further investigate the extent of mine workings are designated validation probes.

Findings of the pre-contract design phase ground investigation undertaken by Soil Engineering and subsequent interpretations are contained in the Interpretive Ground Investigation Report for the site (Hyder, 2012a).

3 MINE TREATMENT

Mine treatment works have been undertaken in accordance with the Hyder Specification for site works (Hyder, 2012b). The techniques of mine treatment adopted at the site consisted of bulk infilling of open voids and compaction grouting of collapsed ground.

A summary of the treatment works are set out in Table 2 below.

Table 2: Summary of Treatment Works

Property	Location	Type of Hole	Number of Holes	Range of Grout volumes ¹ (m ³)	Total Grout volume ¹ (m ³)
No. 14 Highbarns (Total Grout Holes = 13, Total Grout Volume = 350.31m ³)	Beneath the property	Inclined compaction grout holes	1	4.546 (CGI659)	4.55
	Rear garden	Inclined compaction grout holes	2	8.004 (CGI658) to 78.500 (CGI650)	86.50
	Rear garden	Vertical compaction grout holes	10	3.937 (CGV654) to 98.845 (CGV542).	259.26
No. 16 Highbarns	Rear garden	Vertical compaction grout holes	6	1.610 (CGV531) to 11.078 (CGV535)	41.32
No. 18 Highbarns	Rear garden	Vertical compaction grout holes	9	2.638 (CGV527) to 8.011 (CGV525)	29.98
No. 20 Highbarns	Rear garden	Vertical and inclined compaction grout holes	11	2.030 (CGI647) to 47.162 (CGV520)	201.6
No. 22 Highbarns	Rear garden	Vertical and inclined compaction grout holes	8	1.919 (CGV510) to 81.798 (CGV514)	170.39
	Front garden	Vertical compaction grout holes	2	3.405 (CGV110) to 77.503 (CGV109)	80.91
	Rear garden	Vertical compaction grout holes	16	1.940 (CGV508) to 20.607 (CGV507)	117.16
No. 24 Highbarns (Total Grout Holes = 24, Total Grout Volume = 216.95m ³)	Beneath the property	Inclined compaction grout holes	6	0.937 (CGI33) to 5.735 (CGI31)	18.88

Notes:

The above extract is based on data from BAM Ritchies' Sectional Validation Report for Nos. 14, 16, 18, 20, 22 & 24 Highbarns (BAM, 2015). The factual report should be referenced for further details of treatment works including the volumes of grout injected and injection pressures per grout hole.

The treatment was undertaken in a phased approach with several stages of grouting and validation dynamic probe testing. Additional stages of grouting and validation testing were completed where validation testing raised doubts as to the extent of the grout penetration beneath properties or where additional mining related disturbed ground was identified.

4 VALIDATION

Validation of the treatment works has been based upon a combination of factors including a comparison of pre-treatment investigations, validation probing and grout volumes recorded during treatment. The number of grout holes, their location and the phasing of the grouting was adjusted as the work proceeded in order to accommodate the findings of the treatment works. Experience gained from other chalk mine projects has identified that dynamic probe blow counts of less than 3 per 100mm penetration is indicative of the presence of mine workings. Consequently, treatment was only considered complete where validation probes proved blow counts greater than 3 per 100mm penetration at the level of the suspected mine as interpreted from the pre-contract investigations.

A detailed scope of validation procedures adopted during the treatment works is presented in the Highbarns Chalk mine Stabilisation Treatment Report (Arcadis, 2015).

Specific observations for each property are set out in the subsequent sections.

4.1 No. 14 Highbarns

Treatment works at No. 14 Highbarns were initially concentrated along the anticipated mine gallery along the back garden of the property interpreted from the pre-treatment investigation. Drilling works at location CGV539 identified a void at depths between 14.6m and 19.0m confirming the expected mine depth along the back garden. Several high grout takes at CGV539 (77.2m³) and CGV542 (98.8m³) along the back garden indicated generally open mine workings with subsequent high grout takes at CGV540 (18.0m³) and CGV541 (23.8m³) further suggesting a possible increase in mine extents than previously anticipated.

A collapse occurred along the front garden of No. 1 Meadow Road while treatment works were on-going at Nos. 14-24 Highbarns. Due to the proximity of this unexpected collapse to the treatment areas, a row of dynamic probing (VP687-VP696) was carried out to investigate the possibility of a mine gallery connection between the mine passage at the rear of No. 14 Highbarns and the mine complex at the junction of Highbarns and Meadow Road. Validation probe VP688, located close to the property, uncovered evidence of mined ground at depths between 14.1m and 17.1m bgl, which was consistent with the previous voids uncovered. A review of the data indicated an additional mine gallery extending under the property. The subsequent treatment works carried confirmed the need for treatment, particularly at CGI650 (78.5m³) and CGI658 (8.0m³).

Validation dynamic probing was carried out following the treatment works with two additional dynamic probes (VP658 and VP659) added to the original scope to further validate ground conditions around holes with high grout volumes. Validation probes carried out showed competent ground conditions at the anticipated mine depths. Validation probes carried out along the back garden to validate the area of previously unknown treatment (VP754-VP759) also recorded competent ground conditions following treatment outside the original mine extents.

4.2 No. 16 Highbarns

The grouting works at No 16 Highbarns, designed to treat the anticipated mine gallery along the rear of the property, indicated a general decrease in grout volumes suggestive of collapsed mine workings. Access restrictions to the back garden meant that several grout holes had to be inclined from the adjoining properties. A review of the relevant grouting records revealed that grout volumes at CGV535 (11.1m³), CGV530 (9.4m³) and CGV525 (8.0m³) were seen to be reflective of general ground conditions in the area. A reduction in grout volumes was generally observed with successive grouting holes as the work proceeded.

Validation dynamic probing was carried out in a number of phases as the work proceeded. Validation dynamic probing along the original mine layout and later at the additional mine layout (originating at No. 14 Highbarns) further towards the property both showed a general level of improvement of the ground conditions indicative of mine treatment.

4.3 No. 18 Highbarns

During the course of treatment works for the mine along the rear of No. 18 Highbarns, grout volumes were seen to decrease to nominal levels indicative of consolidation of generally collapsed mine workings. When reviewed in conjunction with the adjacent property at No. 16 Highbarns, a marked decrease in volume could be observed, confirming the presence of the single mine gallery as established by pre-treatment investigations.

Validation dynamic probing (VP287a-VP291a) carried out along the mine gallery following the completion of treatment works did not record conditions that would suggest residual untreated mine ground.

4.4 No. 20 Highbarns

Due to restrictions in gaining access to the back of the dwelling, this property was grouted using inclined compaction grout holes drilled from the adjacent properties, particularly No. 18 Highbarns. A noticeable increase in grout volumes was observed, with CGV517 (29.8m³), CGV520 (47.2m³) and CGV522 (29.8m³) all inclined from the adjacent property. A reduction in grout volumes was generally observed with successive grouting holes reducing to expected average volumes (CGV519-2.2m³).

Validation dynamic probing was carried out following completion of the design grout works. However, validation probes VP285a and VP286a uncovered evidence of weak ground close to ground level. A further three validation dynamic probes were carried out, with VP655 – VP657 confirming this was not an isolated ground feature. An additional two grout holes were undertaken from No. 18 Highbarns, with CGV644 (2.7m³) and CGI647 (2.03m³) aimed to treat any remaining mining-related disturbed ground closer to ground level. Further validation probing was carried out to confirm that no residual weakness remained following treatment (VP750) as well as to ensure that no additional mine workings extended towards the main property (VP903 – VP904). These validation dynamic probes did not reveal evidence of mined ground.

4.5 No. 22 Highbarns

Treatment works at No. 22 Highbarns were focused on stabilizing the anticipated mine gallery extending along the back garden. CGV511 (55.7m³) and CGV514 (81.8m³) located along the centre of the expected mine passage confirmed the anticipated mine layout. The high grout volumes suggested treatment of the junction with an east / west trending passageway in the area. Further grout volumes along the back garden were seen to reduce with successive grout holes. A further two inclined grout holes were aimed beneath a detached shed located in the back garden.

The original scope of treatment works was increased due to the volumes of grout injected and the larger than expected mine junction in the back garden. Additional grout holes (CGI662-CGI664) were carried out from the nearby East Green garages to ensure treatment at the mine junction. The high grout takes at CGI663 (38.6m³) and CGI664 (24.9m³) confirmed the need for this further treatment around the mine junction.

4.6 No. 24 Highbarns

A review of the pre-treatment ground investigation suggested the presence of mine workings along the back and side garden of the property before extending to public open space adjacent to the east of the property.

Two particularly high grout takes at CGV507 (20.6m³) and CGV509 (15.5m³) were anticipated due to their position close to known open void locations as well as being in close proximity to an anticipated mine junction. Validation probes carried out along the back garden following treatment generally proved that the treatment had improved the relative density of the ground.

Grouting volumes along the side of No. 24 Highbarns were generally recorded as nominal but validation probing, carried out in the area following treatment, uncovered evidence of untreated ground at VP612 particularly at depths between 16m and 18m bgl. An additional validation dynamic probe, VP651, did not confirm this and it is thought that the results indicate only localized weak ground.

Grout hole CGV109 forming part of the scope of works treating the main mine complex at the junction of Highbarns, Pond Road and East Green and located along the front of No. 24 Highbarns had a particularly high grout volume (77.5m³). This was interpreted as indicative of possible further mine workings extending towards the property from the main mine complex. Several rows of dynamic probes were carried out along the front of the property (Phase I works: VP441-445, VP886-887; Phase II works: VPM105-108, VPM149-153) to investigate whether this was a further mine passage extending towards No. 24 Highbarns. The presence of voids in VPM150 confirmed the need for additional treatment along the front of the property. An additional phase of grouting works (CG25, CG27, CG29-CG36) was carried out from an area of public open ground with an initial grout volume observed in CG25 of 14.22m³. Thereafter, successive treatment holes reported a general reduction in grout volumes to generally nominal levels.

5 CONCLUSIONS

Grouting has been completed under 14, 16, 18, 20, 22 and 24 Highbarns to stabilise mining related disturbed ground due to former chalk mining. From the investigations and treatment work undertaken and the subsequent validation testing it can be reasonably concluded that;

- based upon the evidence, all mined ground encountered has been treated and that compaction and consolidation of void | collapsed voids has taken place;
- as a result of the above assessment, the risk of settlement from chalk mine workings within the treatment area has reduced to an acceptably low level following treatment;
- there is no evidence of any adverse impacts on groundwater quality beneath the site as a consequence of the work;
- there is no evidence of any significant movement or other adverse effects on buildings or infrastructure during the works; and
- the risks from further untreated workings in the treatment area is considered to be no higher than elsewhere in Hemel Hempstead.

The grouting work undertaken has only targeted the treatment of mined ground for the current site use and building layout. It is still the responsibility of the land owner to seek appropriate design advice prior to future development.

Dacorum Borough Council Building Control should be informed if any evidence of mine workings (such as shafts, voids or collapsed ground) is found during any future works undertaken as part of redevelopment.

6 REFERENCES

1. Arcadis Consulting (UK) Limited (2015), Chalk Mine Stabilisation Project, Highbarns, Hemel Hempstead, Treatment Report, No 0013-UA000857-TR-01, October 2015.
2. BAM Ritchies (2015), *Highbarns Sectional Validation Reports ref. BBK704U, VR-001 to 012*. March 2015.
3. Hyder Consulting (UK) Limited (2012a), *Highbarns Chalk Mines Project, Interpretive Ground Investigation Report*, No 0010-UA000857-GDR-01, September 2012.
4. Hyder Consulting (UK) Limited (2012b), Highbarns, Hemel Hempstead, Chalk Mine Stabilisation Project, Specification for Site Works, No 0007-UA000857-GDR-01, September 2012.

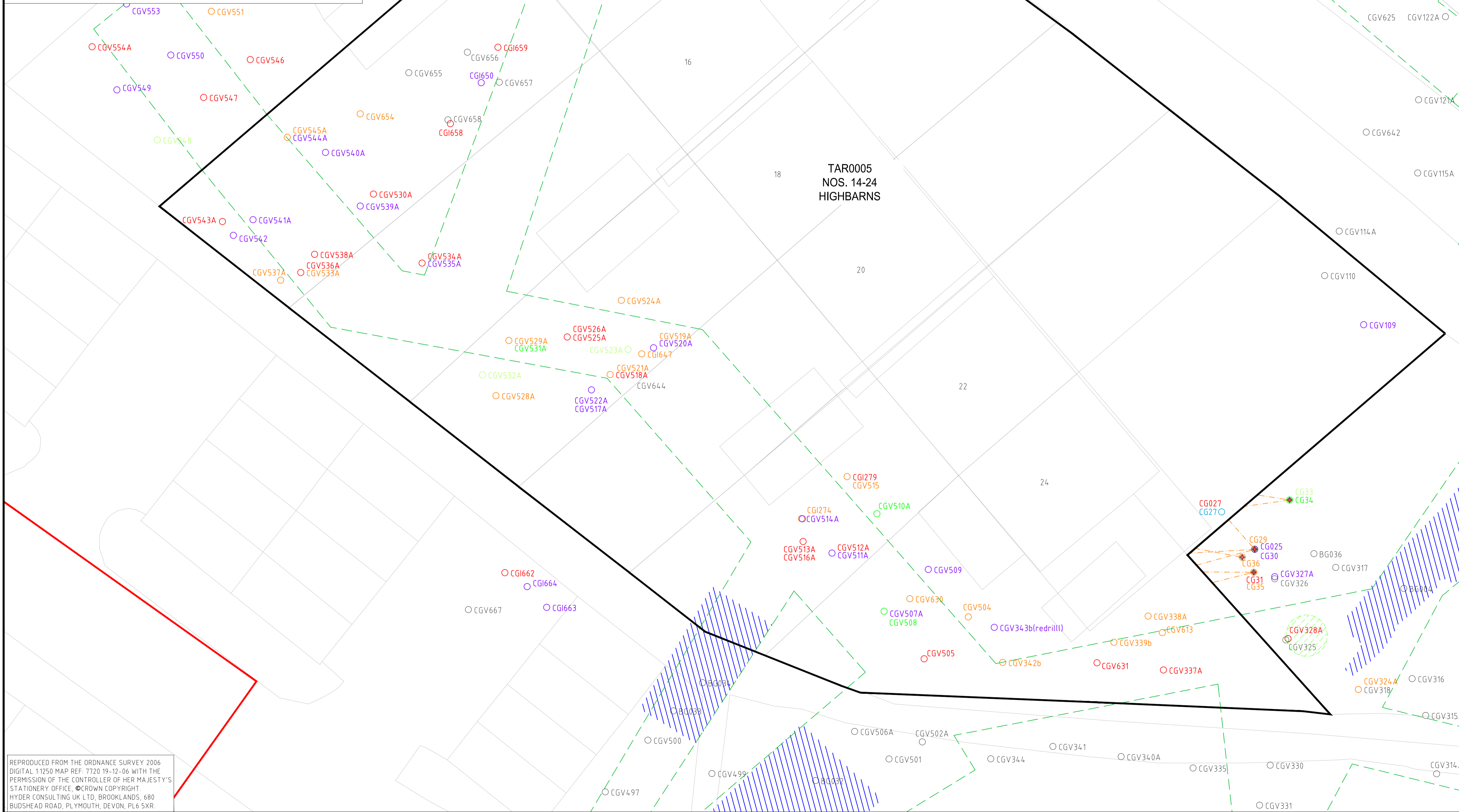
APPENDIX A

**Drawing TA05-01 – Treatment Area Plan for TAR0005
with Grout Holes**

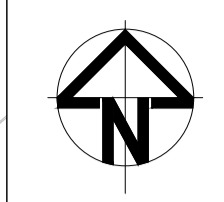
**Drawing TA05-02 – Treatment Area Plan for TAR0005
with Validation Probes**



SITE MAP
NTS



TREATMENT AREA PLAN
SCALE 1:100



- NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
 2. ALL LEVELS IN METRES UNLESS NOTED OTHERWISE.
 3. VALIDATION AND GROUTING DATA BASED ON BAM RITCHIES' SECTIONAL VALIDATION REPORT (IBK706E VR0001 TO VR00012) AND DATED APRIL 2015.
 4. VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 ARE BASED ON PETER BRETT ASSOCIATES (2008), INTERPRETATIVE GEOTECHNICAL REPORT - PHASE 1, NO 2024.7/004.3/INT01/REV2, JULY 2008.
 5. VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2012 ARE BASED ON INSPECTAHIRE (2012), CALS AND CCTV INSPECTION OF VOIDS REPORT NO 6658, ISSUE 02, AUGUST 2012.

LEGEND	
PATTERN	DETAIL
	TREATMENT AREA BOUNDARY
	DERELICT LAND CLEARANCE ORDER BOUNDARY
	INTERPRETED MINE EXTENTS FOLLOWING TREATMENT
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2012 (SEE NOTE 5)
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 (SEE NOTE 4)
	INTERPRETED SHAFT LOCATION FOLLOWING TREATMENT
	CGV138 / CGM138 COMPACTION VERTICAL GROUT HOLES
	CGI138 / CGM138 COMPACTION INCLINED GROUT HOLES (ORIENTATION INDICATED BY DASHED LINE WHERE INFORMATION PROVIDED IN FACTUAL REPORT (SEE NOTE 3))
	CGI38 COMPACTION GROUT HOLES (INCLINED OR VERTICAL (SEE NOTE 3))
	BGM138 / BGM138 BULK GROUT INFILL HOLES (SEE NOTE 3)

GROUTING LEGEND	
PATTERN	DETAIL
	CGV138 / CGI108 COMPACTION GROUT HOLES (10.0-1.0m³)
	CGV138 / CGI108 COMPACTION GROUT HOLES (11.0-2.0m³)
	CGV138 / CGI108 COMPACTION GROUT HOLES (2.0-5.0m³)
	CGV138 / CGI108 COMPACTION GROUT HOLES (5.0-10.0m³)
	CGV138 / CGI108 COMPACTION GROUT HOLES (>10.0m³)

Rev	Date	Auth	Description	Ckd	Apprd
A01	15.10.15	AB	FIRST ISSUE	AH	RB



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Drawing status: PRELIMINARY

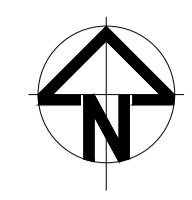
Drawing title: TREATMENT AREA PLAN FOR TAR0005 WITH GROUT HOLES

Drawn by: D.MORE	Date: 15.10.15	Author: A.BLAKE	Date: 15.10.15
Checker: A.HOPE	Date: 15.10.15	Approver: R.BARSBY	Date: 15.10.15
Scale: AS SHOWN ON DRAWING	Sheet No.: 01	Drawing No.: TA0005-01	Revision: A01

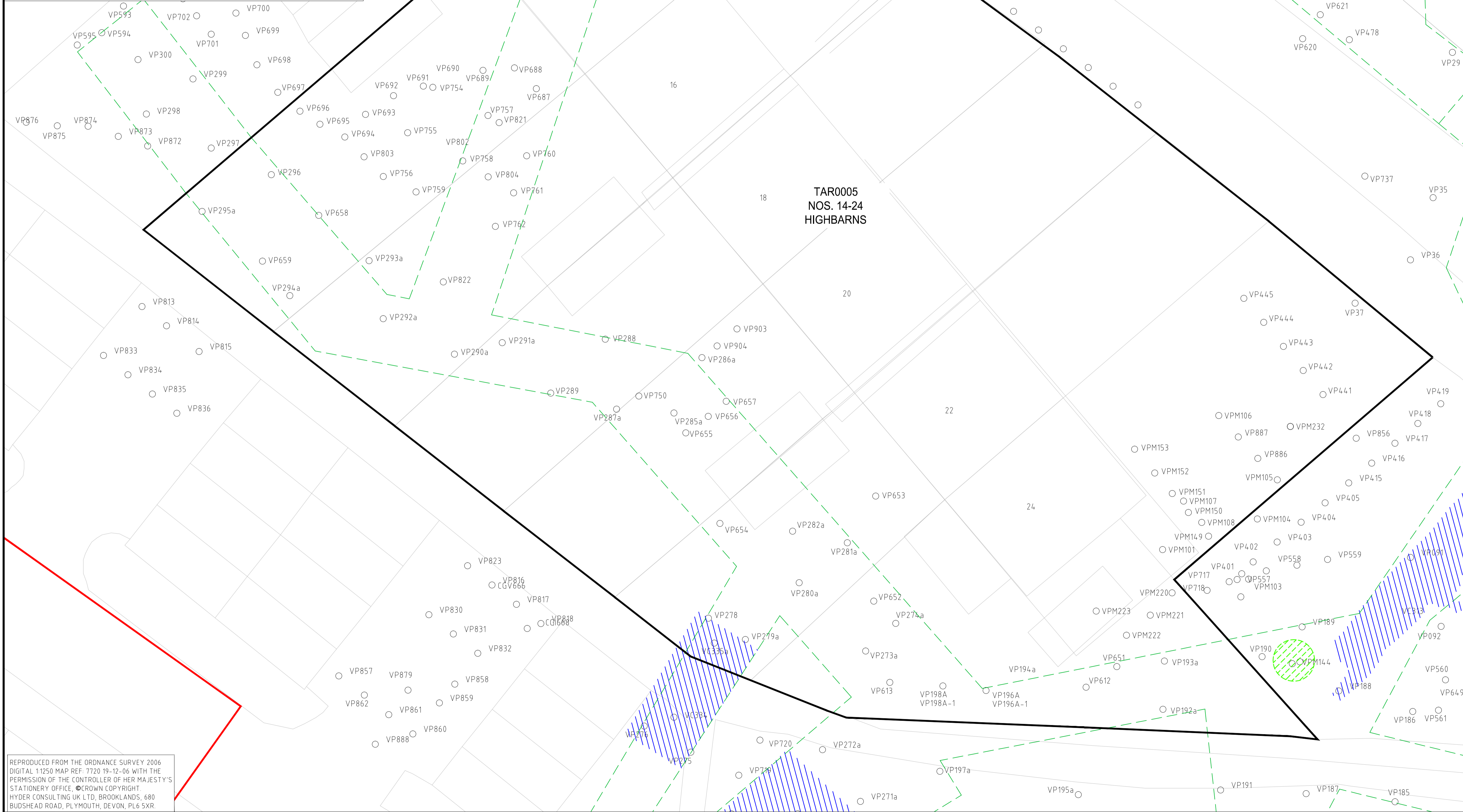
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SITE MAP
NTS

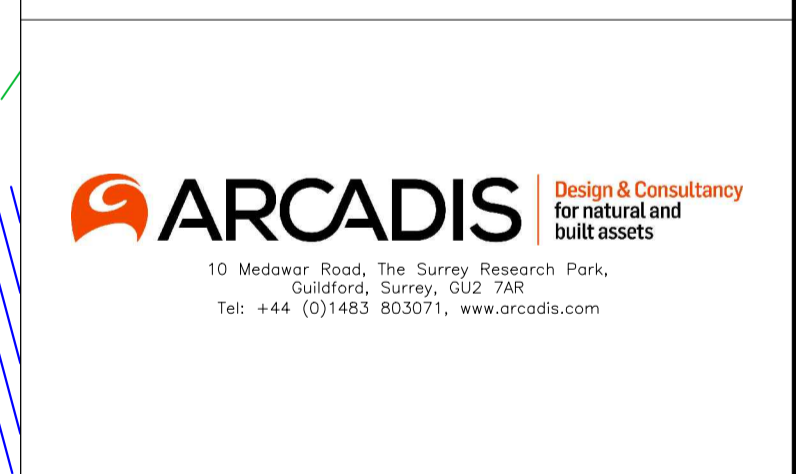


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LEGEND	
PATTERN	DETAIL
	TREATMENT AREA BOUNDARY
	DERELICT LAND CLEARANCE ORDER BOUNDARY
	INTERPRETED MINE EXTENTS FOLLOWING TREATMENT
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2012 (SEE NOTE 5)
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 (SEE NOTE 4)
	INTERPRETED SHAFT LOCATION FOLLOWING TREATMENT
	VP249/VPM249/ DPM249/VP249
	VALIDATION DYNAMIC PROBES

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Drawn by: D.MORE	Date: 15.10.15	Author: A.BLAKE	Date: 15.10.15
Checker: A.HOPE	Date: 15.10.15	Approver: R.BARSBY	Date: 15.10.15

Scale: AS SHOWN ON DRAWING	Sheet No.: 01
Drawing No: TA0005-02	Revision: A01

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TREATMENT AREA PLAN
SCALE 1:100

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