5.1.5. In-situ Geotechnical Testing

Standard Penetration Tests (SPT's) were undertaken in the boreholes using either a split spoon sampler (SPT(S)) or a 60º solid cone (SPT(C)), depending upon the material being tested. The values of penetration resistance ('N' value) are presented in the borehole logs in Appendix 2 and summarised in Figure 1 (Appendix 1).

The relative density noted in the borehole logs are based on the field values of penetration resistance uncorrected for the effects of overburden pressure.

5.1.6. In-situ Photo Ionisation Detection Field Testing

Photo Ionisation Detection (PID) screening was undertaken on all samples from the borehole, Trial Pits and Infiltration Test Locations. All results were noted to be 0.0ppm. The results are presented in Appendix 2.

5.1.7. Ground Gas and Vapour Monitoring

A monitoring program involving the measurement of Ground Gas, Vapour (VOC) and groundwater levels has been undertaken by ERS Ltd. Six monitoring visits have been undertaken at the site by ERS Ltd. Tables 4 and 5 provide a summary of the monitoring visits undertaken.

Table 4: Summary of Monitorable Boreholes

	Phase 1A
Ground Gas and Vapour Monitoring Boreholes	WBH04 WBH05 WBH06 WBH07 WBH08 WBH09 WBH10 WBH11 WBH12 WBH14

Table 5: Summary of ERS Ground Gas/Vapour Monitoring Visits and Conditions of Monitoring

Visit	Date	Atmospheric Pressure (mb)	Weather Conditions
1	29/01/2013	972 – 981	Cloudy
2	12/02/2013	1000 – 1012	Clear and Sunny
3	26/02/2013	1022 – 1028	Cloudy with light snow
4	08/03/2013	988 – 996	Cloudy with light rain
5	26/03/2013	1008 - 1013	Cloudy with light snow
6	05/04/2013	1007 - 1011	Cloudy

6.0 Intrusive Investigation Works Undertaken (Phase II Investigation)

6.1. Intrusive Investigation

The intrusive investigation was undertaken by Fairhurst Engineers between the 14th September and 6th of October 2015.

A summary of the works undertaken is provided below. The Fairhurst Ground Investigation Factual Report is presented in Appendix 2.

An exploratory location plan is presented in (Drawing 72054/9027, Appendix 1).

6.1.1. Trial Pits

Forty-three trial pits (TP01-TP14, TP16-TP31, TP34-TP37, TP39-TP44 and TP46-TP48) were mechanically excavated to depths between 0.60mbgl and 3.20mbgl using a JCB 3CX wheeled excavator. Groundwater ingress was encountered in ten of the trial pit positions at depths ranging between 0.65mbgl and 2.80mbgl. Suspected rockhead was encountered in thirty-two trial pits at depths ranging between 0.60mbgl and 2.30mbgl. Exploratory trial pit logs are presented in Appendix 2.

6.1.2. Laboratory testing

In each of the trial pit positions, representative soil samples were taken at the approximate road formation depth to permit laboratory CBR, MCV and PSD analysis to be undertaken to allow the design of proposed roads in accordance with the Scots National Roads Development Guide (NRDG).

7.0 Summary of Investigation Findings (Phase I)

7.1. Ground Conditions

There are variable ground conditions across the site. The north and central section of the site is predominantly Topsoil underlain by Medium Dense SAND with bedrock at a relatively shallow depth. The southern section of the site is predominantly Topsoil underlain by Sandy Gravelly CLAY. A sporadic shallow strata of Loose and Medium Dense SAND (0.30-1.00m) was encountered in the southern section of the site immediately below the Topsoil and above the Clay.

A summary of the strata is presented in Table 6.

Engineering logs of the exploratory positions undertaken during the works are presented in the Contractors Factual Report (Appendix 2).

An exploratory location plan of the surveyed positions is presented in Appendix 1 Drawing 72054/9027).

Table 6: Summary of ground conditions

Strata	Typical Thickness (m)	Typical depth to base of deposit (mbgl)
Topsoil	0.20 – 0.65	0.20 – 0.65
Medium Dense Sand	0.10 – 2.80	0.40 – 3.10
Loose and Medium Dense Sand	0.30 – 2.05	0.60 – 2.35
Soft and Firm Clay	1.00 – 3.00	1.30 - 3.30
Bedrock	Not Proven	Not Proven

7.1.1. Topsoil

Topsoil was encountered in the all exploratory locations with the exception of TP21 which identified Made Ground (Other Made Ground was identified during the ground investigation i.e. TP78, TP85, TP86, TP87 and SA12 however these positions are outwith the Red Line Boundary). Topsoil was of relatively uniform thickness and encountered between ground level and up to 0.65mbgl. The Topsoil comprised slightly organic silty sandy TOPSOIL with roots and rootlets.

7.1.2. Granular Deposits & Weathered Granite

A majority of the site i.e. Northern and Central section is underlain by Medium Dense SAND. The Particle Size Distribution testing indicated that the granular deposits are relatively well-graded sands and gravels with a significant 'fines' content and is predominantly 'coarse' in nature. The deposits were noted to be variable in thickness with no obvious spatial pattern associated with their depth. The deposits were encountered to a maximum depth of 3.10mgbl and a maximum thickness of 2.80m. The deposits were generally underlain by obstructions, suspected to be boulders or Granite bedrock.

The Southern section of the site is predominantly underlain by CLAY. Localised areas of Loose and Medium dense SAND were identified across the south of the site in the area of the Pheppie Burn between the Topsoil and Clay Strata. The Particle Size Distribution testing indicated that these granular deposits are relatively well-graded sands and gravels with a significant '*fines*' content and are generally 'fine to medium' in nature. The Loose

and Medium Dense SAND deposits were encountered to a maximum depth of 2.35mbgl and a maximum thickness of 2.05m.

7.1.3. Cohesive Deposits

The Southern section of the site is comprised predominantly of Soft and Firm CLAY deposits underlying Topsoil and or the sporadic Loose and Medium Dense SAND. The Particle Size Distribution testing indicated that the cohesive deposits are relatively well-graded silts and clays with a significant granular content. The CLAY deposits were noted to be variable in thickness with no obvious spatial pattern associated with their depths. The deposits were encountered to a maximum depth of 3.30mbgl and a maximum thickness of 3.00m and are generally underlain by obstructions suspected to be boulders or Granite bedrock.

7.1.4. Possible Rockhead/Obstructions

Possible Rockhead Obstructions were noted during the intrusive investigation.
Based on description (provided by the contractor) they are associated with '*possible boulder or bedrock*', 'probable weathered bedrock' and '*Grey weathered GRANITE*'

The obstructions are detailed in full and presented in Table 6 (Appendix 6). From plotting depth of obstructions (at mAOD) it appears rockhead is dipping downwards to the south east of the site.

Possible bedrock was encountered at a relatively shallow depth over the northern and central section of the site. Possible Bedrock was encountered at minimum depth of 0.30mbgl in the area of the proposed borrow pit (QTP01 + QTP03) and also 0.38mbgl in the Northern section of 'SITE C' (TP38) located approximately in the centre of the overall Phase 1A Development site. (Rockhead was not proven by rotary drilling).

7.2. Stability

All trial pits remained stable during their excavation.

7.3. Groundwater

Groundwater strikes were noted in several locations during the excavation of the trial pits and boreholes. Groundwater has also been monitored on four occasions following completion of the field works. The results are summarised in Table 7.

Table 7: Groundwater Strike Levels During Ground Investigation

Location	Ground Level (mAOD)	Groundwater (mbgl)	Groundwater (mAOD)
TP01	86.90	0.900	86.00
TP02	86.23	3.200	83.03
TP03	86.98	0.700	86.28
TP10	79.73	1.500	78.23
TP13	78.90	2.300	76.60
TP19	81.00	0.400	80.60
TP22	105.13	2.200	102.93
TP28	96.39	1.500	94.89
TP32	96.55	1.000	95.55
TP33	99.70	1.700	98.00
TP48	98.71	0.380	98.33
TP59	90.01	1.700	88.31
TP68	64.11	2.200	61.91
TP71	72.83	2.000	70.83
WBH08	113.11	0.600	112.51
WBH11	81.83	0.800	81.03

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Table 8: Groundwater Monitoring Levels

Location	Ground Level (mAOD)	Groundwater Level Visit 1		Groundwater Level Visit 2		Groundwater Level Visit 3		Groundwater Level Visit 4		Groundwater Level Visit 5		Groundwater Level Visit 6	
		mbgl	mAOD	mbgl	mAOD	mbgl	mAOD	mbgl	mAOD	mbgl	mAOD	mbgl	mAOD
WBH04	89.46	0.67	88.79	0.31	89.15	0.80	88.66	0.71	88.75	0.40	89.06	0.40	89.06
WBH05	78.69	0.20	78.49	0.33	78.36	0.44	78.25	0.48	78.21	0.42	78.27	0.41	78.28
WBH06	86.71	0.00	86.71	0.00	86.71	0.35	86.36	1.33	85.38	0.67	86.04	1.10	85.61
WBH07	112.02	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-
WBH08	113.11	0.57	112.54	DRY	-	0.85	112.26	0.81	112.30	0.78	112.33	DRY	-
WBH09	113.52	0.45	113.07	1.04	112.48	DRY	-	1.00	112.52	1.40	112.12	DRY	-
WBH10	79.69	0.22	79.47	0.06	79.63	0.43	79.26	0.46	79.23	0.39	79.30	0.42	79.27
WBH11	81.83	0.98	80.85	0.82	81.01	0.82	81.01	0.82	81.01	0.81	81.02	0.87	80.96
WBH12	81.51	0.30	81.21	0.40	81.11	0.53	80.98	0.57	80.94	0.50	81.01	0.60	80.91
WBH13	105.30	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-
WBH14	97.39	0.76	96.63	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-
WBH15	99.71	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-	DRY	-

7.4. Visual-Olfactory Assessment/ Photo Ionisation Detector Field Results

No olfactory signs of contamination were encountered during the investigation. Made ground including Brick Fragments was identified in one trial pit (TP21).

7.5. Infiltration Testing

Thirteen infiltration tests were undertaken at the site (SA01-SA13). The results are summarised in Table 9. Infiltration Results are presented in Appendix 2.

Table 9: Infiltration Testing Results

ID	Run	Depth (mbgl)	Depth (mAOD)	Associated Strata	Infiltration Rate (m/hr)
SA01	1 of 3	1.10	102.96	Medium Dense SAND	0.036
SA01	2 of 3	1.10	102.96	Medium Dense SAND	0.028
SA01	3 of 3	1.10	102.96	Medium Dense SAND	0.029
SA02	1 of 2	1.50	98.82	Medium Dense SAND	0.003
SA02	2 of 2	1.32	99.00	Medium Dense SAND	0.004
SA03	1 of 2	1.00	99.47	Medium Dense SAND	0.001
SA03	2 of 2	1.00	99.47	Medium Dense SAND	0.004
SA04	1 of 1	1.10	97.78	Medium Dense SAND	0.000
SA05	1 of 1	1.30	93.89	Medium Dense SAND	0.000
SA06	1 of 1	1.60	86.98	Medium Dense SAND	0.000
SA07	1 of 1	1.50	82.80	Soft and Locally Firm CLAY	0.000
SA08	1 of 1	1.40	80.05	Soft and Locally Firm CLAY	0.000
SA09	1 of 3	1.20	91.78	Medium Dense SAND	0.103
SA09	2 of 3	1.05	91.93	Medium Dense SAND	0.106
SA09	3 of 3	1.05	91.93	Medium Dense SAND	0.107
SA10	1 of 1	1.00	96.44	Medium Dense SAND	0.001
SA11	1 of 1	1.20	95.30	Medium Dense SAND	0.000
SA12	1 of 1	1.20	79.55	Medium Dense SAND	0.002
SA13	1 of 4	1.20	80.70	Fine and Medium SAND	0.010
SA13	2 of 4	1.20	80.70	Fine and Medium SAND	0.007
SA13	3 of 4	1.20	80.70	Fine and Medium SAND	0.008
SA13	4 of 4	1.20	80.70	Fine and Medium SAND	0.007

8.0 Summary of Investigation Findings (Phase II)

8.1. Ground Conditions

Ground conditions over the site were found to be variable, however generally consist of grass or barley over Topsoil from surface between 0.25m and 0.50m thick, overlying natural superficial deposits and suspected rockhead. The natural deposits varied between predominantly granular and predominantly cohesive materials but in the majority of positions comprised silty clayey SAND with frequent cobbles and boulders. Layers of CLAY with frequent cobbles and boulders and pockets of clay within predominantly granular materials were also encountered in several of the pits.

A summary of the strata is presented in Table 10.

Engineering logs of the exploratory positions undertaken during the works are presented in the Fairhurst Factual Report (Appendix 2).

An exploratory location plan of the surveyed positions is presented in Drawing 72054/9027, Appendix 1.

Table 10: Summary of ground conditions

Strata	Typical Thickness (m)	Typical depth to base of deposit (mbgl)
Topsoil	0.20 – 0.50	0.20 – 0.50
Slightly silty, slightly gravelly Sand	0.20 - >2.95	0.50 - >3.20
Sandy, gravelly Clay	0.80 - >2.20	1.10 - >2.50
Grey weathered Granite	Not Proven	Not Proven
Suspected Rockhead	Not Proven	Not Proven

8.1.1. Topsoil

Topsoil was encountered in all of the exploratory locations with the exception of TP13 and TP14 where Hardcore was present from surface. Topsoil was of relatively uniform thickness and was encountered between ground level and up to 0.50mbgl. The Topsoil comprised slightly organic silty sandy TOPSOIL with roots and rootlets.

8.1.2. Granular Deposits & Weathered Granite

A majority of the positions were underlain by slightly silty slightly gravelly SAND. The Particle Size Distribution testing indicated that the granular deposits are relatively well-graded sands and gravels with a significant *'fines'* content and are predominantly *'coarse'* in nature. The deposits were noted to be variable in thickness with no obvious spatial pattern associated with their depth. The deposits were generally underlain by obstructions, suspected to be boulders or Granite bedrock.

8.1.3. Cohesive Deposits

In a number of positions (TP01, TP16, TP22, TP23 and TP43), superficial deposits were found to comprise soft sandy, gravelly CLAY. The Particle Size Distribution testing indicated that the cohesive deposits are relatively well-graded silts and clays with a significant granular

content. The CLAY deposits were noted to be variable in thickness with no obvious spatial pattern associated with their locations and depths.

8.1.4. Possible Rockhead/Obstructions

Possible Rockhead Obstructions were noted during the intrusive investigation. Based on description they are associated with '*possible boulder or bedrock*', '*probable weathered bedrock*' and '*Grey weathered GRANITE*'

A surfer plot showing the depth of obstructions encountered during both phases of investigation is presented in Drawing 72054/9030, Appendix 1.

8.2. Stability

The side walls of trial pits were noted to remain stable in the majority of positions, however a number exhibited side wall spalling due to the disturbance of large boulders.

8.3. Groundwater

Groundwater strikes were noted in several locations during the excavation of the trial pits and boreholes. A summary of groundwater strikes is presented in Table 11.

Table 11: Groundwater Strike Levels During Ground Investigation

Location	Ground Level (mAOD)	Groundwater Strike (mbgl)	Groundwater Level (mAOD)
TP02	108.85	1.90	106.95
TP22	100.79	2.50	98.29
TP23	99.50	1.80	97.70
TP25	98.11	1.00	97.11
TP28	100.49	1.60	98.89
TP28	100.49	1.90	98.59
TP34	97.92	0.65	97.27
TP37	94.73	1.60	93.13
TP46	93.64	1.00	92.64
TP46	93.64	2.30	91.34
TP47	92.72	1.80	90.02
TP47	92.72	2.80	89.92
TP48	91.48	1.10	90.40

9.0 Chemical Analysis and Site Monitoring

9.1. Summary of Environmental Testing Undertaken

The Fairhurst Geo-environmental Desk Study identified two potentially contaminative land uses onsite. The features which presented potentially significant onsite pollutant linkages are indicated on Drawing 72054-9027, Appendix 1, they include;

1. In-filled Dam (Made Ground) adjacent to Nether Cairnhill Farm.

Following the ground investigation the '*In-filled Dam*' was identified as a distinct offsite structure with the walls of the Dam on the far side of the fence line boundary and having no encroachment onto the development site.

2. Upper Cairnhill - Current and historic Fuel Tank
   The Steading - Potential heating Oil Tank present suspected Asbestos (cement bound roofing tile).

With reference to the contaminants of concern presented in the Fairhurst Phase 1A Desk Study Report (Appendix 2) and the findings during the ground investigation, selected representative soil samples were obtained during the ground investigation and submitted for chemical laboratory testing. The testing is summarised in Table 12 and 13 below and a Tier 1 Risk Assessment is presented in Table 17 and 18 (Appendix 4).

Chemical Testing anticipated to be required for made ground in TP01 - TP02 and WBH06, was not undertaken as the made ground deposits were not identified in this area.

Groundwater sampling and testing was not possible from WBH7 - 9 as these positions were '*dry*' on monitoring and did not allow samples to be obtained for analysis.

Table 12: Chemical Testing Rationale (Soils)

Source	Spatial Distribution	Medium	Testing		
			Exploratory Position		Tests
			No.	Depth range of samples tested (mbgl)	
Natural Deposits	75m offset herringbone grid	Soil	60	0.50 – 3.00	BRE Special Digest Suite
Natural Deposits	Targeted to location of water pipework trench	Soil	10	0.50 – 1.20	UKWIR Full Suite*
Natural Deposits	Targeted to location of water pipework trench	Soil	3	0.50 – 1.20	UKWIR Mandatory Suite
Onsite Fuel Tanks	Onsite fuel tanks/pipework associated with properties	Soil	3	0.50 – 1.50	TPH (screen) PAH (USEPA 16)
Made ground	Made Ground, Onsite fuel tanks/pipework associated with properties	Soil	1	0.00 – 1.00	Heavy Metals,TPH (screen), PAH (USEPA 16), VOC's/SVOC's, Asbestos, Phenols, SO_3/SO_4, pH

***UKWIR Full Suite**
Extended suite includes VOC Suite (with TIC), BTEX + MTBE, Extended SVOC Suite (with TIC), Phenols, Cresols and chlorinated phenols, Mineral Oils C11 – C20, Mineral Oils C21 – C40, Corrosive (Conductivity, Redox Potential and pH), Amines, Nitrobenzene, Ketones, Aldehydes

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Table 13: Chemical Testing Rationale (Water)

Source	Spatial Distribution	Medium	Testing		
			Exploratory Position		Tests
			No.	Depth range of samples tested (mbgl)	
Suspected In filled Dam*	WBH06	Water	1	0.00 – 2.50	Heavy Metals, Fuel Oils, PAH (USEPA 16), VOC's/SVOC's, Phenols, SO_3/SO_4, pH, Organic Content
Made Ground	WBH07-09 & T21	Water			Dry with no water to Sample

*The Dam which was suspected to be Onsite was confirmed to be Offsite during the Ground Investigation.

9.2. Summary of Ground Gas and Vapour Monitoring Results

Six Ground Gas and Vapour Monitoring visits have been undertaken by ERS Ltd as outlined in the CIRIA C665 Guidelines.

9.2.1. Monitoring Methodologies

To collect the data from site, a GFM Series Gas Analyser was used in combination with a Photo Ionisation Detector (Minirae 3000) to measure concentrations of ground gas and levels of volatile organic compounds (VOC's) respectively within the boreholes at the site.

Ground Gases were monitored in each borehole for ten minutes reaching steady state. The results are recorded every ten seconds during the first 60 seconds followed by recording the results every 30 seconds thereafter for a period of ten minutes. The Ground Gases monitored included Methane (CH_4), Carbon Dioxide (CO_2), Oxygen (O_2) and Hydrogen Sulphide (H_2S) in accordance with CIRIA C665 and BS 8485 Ground Gas Risk Assessment. A summary of the results undertaken to date is presented in Table 14.

Table 14: Summary of Gas Monitoring Results

ID	Strata [1]	Peak CH_4		Steady State CO_2		O_2	H_2S		Maximum Flow Rate (ltr/h)
		% min	% max	% min	% max	% min	min ppm	max ppm	
WBH04	C	0	0	0.0	1.6	16.6	0	0	0.3
WBH05	C	0	0	0.0	0.7	19.0	0	0	0.1
WBH06	C	0	0	0.0	1.7	16.4	0	0	0.3
WBH07	MS & WG	0	0	0.0	1.1	18.3	0	0	0.2
WBH08	MS	0	0	0.0	0.3	19.2	0	0	0.2
WBH09	MS & WG	0	0	0.0	1.6	17.3	0	0	0.0
WBH10	C	0	0	0.0	0.2	19.4	0	0	0.0
WBH11	C	0	0	0.0	1.0	18.6	0	0	0.2
WBH12	C	0	0	0.0	0.4	19.2	0	0	0.2
WBH14	MS	0	0	0.0	0.8	18.7	0	0	0.4

The full results of the monitoring visits are presented in Appendix 2.

[1] MS – Medium Dense Sand
C – Soft and Firm Clay
WG – Weathered Granite

Summary of Vapour Monitoring Results

Monitoring for Volatile Organic Compounds (VOC's) was undertaken as outlined in the CIRIA C665 Guidelines and CIRIA 682 (UK Practice to assessing risks from VOC's). The results are summarised in Table 15. The presence of VOC's was monitored for in the headspace of monitoring well locations.

Table 15: Summary of VOC Monitoring Results

Position	VOC Concentration (ppm)	
	Min	Max
WBH04	0.0	0.0
WBH05	0.0	0.0
WBH06	0.0	0.0
WBH07	0.0	0.0
WBH08	0.0	0.0
WBH09	0.0	0.0
WBH10	0.0	0.0
WBH11	0.0	0.0
WBH12	0.0	0.0
WBH14	0.0	0.0

The full results of the monitoring visits are presented in Appendix 2.