Carlyon Bay Environmental Statement (2011)

Chapter K

Geology & Ground Conditions

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K1.0 Introduction

Scope

K1.1 This chapter comprises a number of separate but inter-related assessments including consideration of solid geology, soils and ground conditions, past mining, land contamination, slope stability and RIGS. The chapter has been prepared by MLM.

K1.2 The assessment presented in this Chapter considers the geology and ground conditions in the scoping report as follows:-

1 Solid Geology

2 RIGS

3 Soils and ground conditions

4 Mining

5 Contamination

6 Radon

7 Slope stability

K1.3 This chapter draws on information contained in various reports undertaken for the site which are listed in section K10.0. A Preliminary Contamination Assessment report is contained at Appendix K1 and a Contaminated Land report incorporating data from all intrusive investigations at the site is contained in Appendix K2.

Structure

K1.4 The remaining sections of this Chapter are structured as follows:

- Section 2: Policy Context
- Section 3: Assessment methodology – an overview of the methods and tools used to undertake the assessment
- Section 4: Baseline Conditions – consideration is given to both the natural baseline and also to the extant permission
- Section 5: Potential effects – consideration of the effect of the proposals on the geology and ground conditions as defined above. Both effects during construction and after completion are considered.
- Section 6: Mitigation measures – where necessary measures that may be put in place to mitigate impacts
- Section 7: Residual effects – identification of any effects on the geology and ground conditions that remain after mitigation measures are in place
- Section 8: Summary and Conclusions
- Section 9: Abbreviations

- Section 10: References

K2.0 Policy Context

K2.1 The following policy documents have been reviewed in the context of this chapter:-

1 Planning Policy Statement 9: Biodiversity and Geological Conservation (PPS9) (August 2005) and the consultation paper on a new Planning Policy Statement: Planning for a Natural and Healthy Environment (March 2010)

2 Planning Policy Statement 23: Planning and Pollution Control (November 2004) - Annex 2 Development on Land affected by Contamination.

3 Saved policies of the Restormel Local Plan (saved September 2007) and particularly:-

i Policies 23 and SA6 – Earth Science Sites

ii Policies 39 and 40 – Derelict, Contaminated and Unstable Land

4 Cornwall Core Strategy Topic Based Papers (draft June 2010) – see Biodiversity and Geodiversity: Soil Air and Water Quality

5 Planning Policy Guidance 14 Development on Unstable Land (April 1990) - Annex 1: Landslides and Planning

K2.2 The key issues associated with these documents that have informed this chapter are:-

1 Ensuring sustainability and enhancement of geological resources as part of the development – PPS9

2 Prevention of harm to geological conservation interest through development – PPS9

3 Ensuring likely significant environmental effects from Land Contamination as a result of development are understood and can be mitigated PPS23.

4 Reducing contamination and dereliction - RLP

5 Safeguarding geological value - RLP

6 Development will not be threatened by landslides or cause instability and any remedial works do not lead to significant adverse effects – PPG14.

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K3.0 Assessment Methodology & Significance Criteria

Assessment Methodology

K3.1 The baseline data upon which the range of inter-related assessments presented in this chapter are based, was compiled by a combination of on site reconnaissance, and a desk based review of aerial photographs, maps, plans and other available data, including various British Geological Survey memoirs and publications. The most relevant sources were of the reports listed at Section K10.0 of this chapter and which provide details of the site investigation and sampling techniques undertaken, together with soil and rock profiles, descriptions and results of analysis.

K3.2 A more detailed consideration of the elements of study undertaken is set out below: -

Solid Geology, Soils & Ground Conditions

K3.3 The assessment considers the effect if any of the development on geology and ground conditions and also the effect of geology and ground conditions on the development. It has been based on a desk study.

K3.4 A generic quantitative risk assessment (GQRA) of potential soil contamination has been undertaken. GQRA involves a comparison of chemical laboratory results to generic assessment criteria (GAC) that are considered appropriate and relevant to the context of the site. The purpose of the GRQA is to identify potential sources of contamination for further evaluation.

K3.5 For human health risk assessment of future site users, MLM has used the soil guideline values (SGVs) derived using the Contaminated Land Exposure Assessment (CLEA) technical guidance. MLM has used the SGVs published on the Environment Agency website at the time of assessment. These are for arsenic, cadmium, mercury, nickel, selenium, BTEX compounds and phenols. The new SGV's do not differentiate between 'with' and 'without' plant uptake.

K3.6 For those potential contaminants where there is an absence of published SGVs, MLM have used GAC jointly published by LQM and the Chartered Institute of Environmental Health (CIEH) (LQM & CIEH 2009). Currently these are for total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAH) and the common metals copper and zinc.

K3.7 For cyanide, which is commonly included for testing of contaminated land samples, there is currently no accepted SGV/GAC. In the absence of alternative guidance for cyanide, MLM has used a Dutch Invention Value of 50mg kg^{-1} (VROM 2000) for use as a screening value.

K3.8 Risks to water supply pipes have been assessed using guidance published by Water Regulation Advisory Service (WRAS 2002). The guidance provides

threshold concentrations above which organic compounds can permeate water supply pipes, impact on their construction and posing a risk to water consumers.

K3.9 Potential risks to plant life, such as for proposed landscaping, are assessed through BS3882:2007 (BSI 2007a). This standard sets out the threshold values in soil above which phytotoxic effects can occur from the metals copper, nickel and zinc.

RIGS

K3.10 The assessment considers the effect of development and construction on the RIGS, particularly in relation to construction activity and slope stabilisation works, either damaging, obscuring or restricting access to these features. Plans showing the location and extent of the two RIGS (located to the east and to the west of Carlyon Bay) relating to the site are appended to Chapter E: Biodiversity.

Mining

K3.11 The assessment considers the impact of historical mining activity on the development in terms of potential for collapse and damage to structures.

Contamination and Radon

K3.12 The assessment considers the effect of construction and development in increasing the potential for release or migration of compounds that would otherwise not be released and assesses the health and safety impact of contamination and radon in respect of the development.

Slope Stability

K3.13 The assessment considers the impact of construction and development increasing potential for slope instability and cliff failures through vibration, it also assesses the impacts, in terms of health and safety, of these on development.

Significance Criteria

K3.14 There are three stages required to enable the significance of impacts to be identified as follows:-

1 Identification of the baseline conditions and the sensitivity and importance of the receptors.

2 Identification of the magnitude of change (impacts) upon the receptor.

3 Identification of the impact significance, which is the product of a combination of the above two variables.

K3.15 The process for combining the sensitivity of the receptor with the magnitude of change (to evaluate the level of impact) results in the following criteria for measuring impact adversely or positively:-

1 Substantial beneficial

2 Moderate beneficial

3 Minor beneficial

4 Neutral/Negligible

5 Minor adverse

6 Moderate adverse

7 Substantial adverse

Note:

- Substantial - considerable effect by nature of extent, duration or magnitude or of more than local significance.
- Moderate – limited effect considered to be significant
- Minor – Slight very short time timeframe or highly localised

K3.16 The significance criteria for each individual component of ground conditions that are addressed in this chapter are as follows:-

Geology, Soils & Ground Conditions

K3.17 There are no specific significance criteria for geology soils and ground conditions over and above the individual components discussed in sections K3.18 to K3.21.

RIGS

K3.18 A substantial effect on the RIGS would primarily comprise circumstances leading to the loss of the features or irreversible damage.

Mining

K3.19 The degree of significance of effect arising from mining instability has been assessed in terms of risk to human health and safety in comparison with current baseline conditions.

Contamination and Radon

K3.20 The assessment considered the risk to human health in comparison with current baseline conditions having regard to nationally adopted contaminated land guideline values and radon levels considered protective of human health for specific exposure scenarios.

K3.21 With respect to the environment and particularly water quality significance criteria, exceedance of Environmental Quality Standards has been considered where these are at a level which adversely impacts on water quality. These are

Environmental Quality Standards (EQS) for List 1 and List 2 dangerous substances (EC 1976).

Slope Stability

K3.22 The degree of significance of effect has been assessed in terms of potential risk to human health in comparison with existing baseline conditions of slope instability.

Consultation

K3.23 In response to the request for Cornwall Council to form an EIA scoping opinion, comments were received from a range of consultees including officers of Cornwall Council, the Cornwall RIGS Group and the Environment Agency. These comments have been taken into account in carrying out the assessment. Ongoing discussions with Cornwall Council and the Cornwall RIGS Group has taken place during development of the proposals for Carlyon Bay.

K4.0 Baseline Conditions

Solid Geology

K4.1 Geological maps of the site (BGS Sheet 347), site observations and site investigations indicate that the solid geology of the area comprises rocks of the Bovisand Formation (Meadfoot Group) from the Lower Devonian period; consisting of dark grey slates, phyllites and meta-siltstones. The geology of the development site is presented in Figure K1 at Appendix K3.

Regionally Important Geological Sites (RIGS)

K4.2 RIGS occur at either end of the proposed development site (see Figure K2 at Appendix K3 and Chapter E). The RIGS (or County Geology Sites) designation is a non-statutory designation and does not imply any rights of access or management commitment.

K4.3 The two RIGS sites are located as follows:-

1 *Carlyon Bay East*, *Grid ref. SX06752* – The East end of Carlyon Bay, which includes the eastern end of Polgaver Beach and Fishing Point, comprises rocks of the Bovisand Formation. The lithologies are unusual in that they contain substantial volcaniclastic material, and the area is also noted for the outcrop of a dolerite sill, a recumbent fold, and raised beach material capped by Head.

2 *Carlyon Bay West, Grid ref. SX055520* – This RIGS site encompasses the far West end of Crinnis Beach from just above MHWM to MLWM as well as the outcrop at Crinnis Island. On the cliff, the RIGS commences and extends westwards some 100-200m southwest of the southernmost extremities of the proposed sea wall. Again the rocks are part of the Bovisand Formation and contain fossils and volcaniclastic material. In addition, east-west trending copper/lead veins cut the rocks and, as at the east end of the bay, a small patch of raised beach is exposed at Crinnis Island.

K4.4 The RIGS primarily relate to the rocks forming the cliff line above the beach and to localised areas of raised beach capping the rock.

K4.5 Of the two RIGS, the westerly is the most significant in that it extends for some 200m along the shoreline and includes the small rock outcrop known as Crinnis Island (i.e. forms part of the intertidal beach area of Crinnis Beach). Under the current situation Crinnis Island is exposed to the natural elements, resulting in significant ongoing levels of weathering and erosion.

Soils & Ground Conditions

K4.6 The investigations and studies undertaken by MLM and others as referenced in K10.0 indicate that the soil below the cliffs was recently formed (within the last 100-200 years) as a result of deposition by streams and rivers of waste sediment derived from the china clay and lead/copper workings inland of the

site. These sediments comprise primarily quartz and mica forming sand and gravel sized material, finer material has probably been brought in by tidal action. Below the waste sediment, natural beach/marine sediments and bedrock are encountered at variable depth. In addition to the quartz and mica sand and gravel, there is slope derived material in the form of clay, gravel and boulders at surface and within the soil at depth.

K4.7 Ground conditions at Crinnis have been found to generally comprise 3.0-8.5m of loose to medium dense, generally coarse sand and gravel (made ground) with some obstructions, overlying a generally thin natural beach deposit (0.3-4.9m thick). Bedrock comprising phyllite/slate was encountered at 3.7-10.8m depth.

K4.8 Ground conditions at Shorthorn have been found to generally comprise between 0.7 and 7.4m of made ground of similar consistency to Crinnis, again with a thin layer of natural beach material beneath (1.0-3.6m thick). Bedrock comprising phyllite/slate was present at 5.0-5.3m below ground level in the areas investigated. Although no extensive investigation of bedrock profile has been undertaken at Polgaver, sediment thickness is anticipated to broadly resemble that at Shorthorn.

K4.9 The Made Ground, although extensively comprising a coarse sand and gravel, also includes distinctive areas primarily within zones immediately below the cliff line or in areas thought to have been subjected to mining activity that contain soft to stiff clay and shale gravel and cobbles. This comprises weathered and worked materials from the cliffline.

K4.10 A localised area of clayey silt is also present around the promontory between Crinnis and Shorthorn, possibly reflecting the former course of the river in this area.

K4.11 Soil above the cliffline is primarily Head Deposit generally thin in nature. There are also localised areas at Crinnis Island and at the eastern end of Polgaver of raised beach deposits both of which are RIGS. Mantling the cliffs in areas of weathering/erosion and slope failure is a generally coarse angular gravel cobbles and boulders which in places forms a scree deposit on shallower slopes and toward the toes of the cliffs. In some of the more recent and un-vegetated areas there is continuous spalling and ongoing movement.

K4.12 Soils over the entire site consist of skeletal sandy soils of recent origin, generally infertile and affected by the marine conditions. Greater soil development, with increased organic matter content, is evident in the well vegetated areas, generally in the upper areas of the site.

K4.13 Soil conditions are presented in Figure K1 at Appendix K1 and MLM's report '*Environmental Geoenvironmental Assessment'* (2003) provides the most up to date and comprehensive information on ground conditions.

Mining

K4.14 As identified above, the rocks of the area contain mineralised fissures which were exploited primarily for copper as early as the 17th Century. Figures K3 and K4 provide further details of the features reviewed below.

K4.15 Crinnis lies within the later Wheal Pembroke mining sett, with the West Crinnis or Wheal Regent sett to the ENE and with the less important Great Crinnis and Carlyon Consolidated mines to the WSW. These mines were mainly copper producers from the early 17th Century. The last operations ceased a little after the mid-19th Century and were part of a larger grouping of mines under the name of South Par Mine.

K4.16 Prior to the larger setts named above, smaller setts were present including Great Crinnis to the North West, Little Crinnis to the west and South Crinnis appearing to form the cliff and beach area.

K4.17 Several mineralised veins or 'lodes' and possible mineralised crosscourses are present in the general and immediate vicinity of the site, and which have been worked at an early period.

K4.18 As far as can be ascertained, the only original record of the lodes and some of the workings in the immediate and closely surrounding area relate to an early group of mines, including Great Crinnis, Little Crinnis and South Crinnis and to part of Wheal Pembroke. Crinnis and surrounding cliff edges appears to form the area of South Crinnis.

K4.19 In the west part of Crinnis Island, the Lode is poorly recorded but there is indication of it at adit level to trend WNW-ESE and passing through Crinnis Island (the rock outcrop now at the edge of the beach and just above the Mean High Water line). An adit is also recorded in the cliff, to the WSW of the existing car park.

K4.20 A shaft is recorded from old plans from 1908 in the cliff to the west of the existing car park, and it is also shown on the surface mine plans as Island Shaft. A recorded well (a possible mine shaft) to the WNW of the shaft may also access this lode.

K4.21 A later plan of Great Crinnis and Carlyon Consolidated, the main workings of which lie to the WSW of the composite plan area, records the Crinnis Silver Course as trending SSW – NNE and as lying in the west part of the site. It may be a similar structure as is recorded to the NNE of the plan area as Crinnis Load.

K4.22 To the NNE of Island Lode and a little inland is New Lode, trending WNW-ESE. Again poorly recorded, it may relate to two poorly defined lodes recorded in the cliff face. A later Ordnance Survey plan depicts an 'issues' and pond close to the west of the car park and which may possibly indicate an adit portal or other working in the cliff face and which may be related to the two unnamed lodes or to New Lode.

K4.23 To the NNE of New Lode is South Lode, trending WNW-ESE and which intersects the nearly NWSE trending North Lode. A third unnamed lode appears to be recorded between these.

K4.24 These lodes are poorly recorded and difficult to define as to the exact position. The very approximately defined shafts, including that on the cliff edge, appear to access these lodes. The 2nd edition Ordnance Survey plan (circa 1908) depicts two adits in the nearby cliff base, the westerly being depicted as an 'issue' on the later plan. These adit portals probably access these lodes.

K4.25 A steeply easterly dipping crosscourse, recorded on the Wheal Pembroke mine plans and trending NNW-SSE, intersects the cliff a little to the east of the North Lode adit portal. An unnamed and rather tentative WNW-ESE trending lode passes a little to the NNE of the east section of the cliff.

K4.26 In summary, there are at least 4 adit portals and two shafts within or just above the cliff line at Crinnis.

K4.27 Waste associated with mineworks is locally present above and at the foot of the cliffline in the western area of Crinnis with a large area of waste above the cliff on the promontory between Crinnis and Shorthorn.

K4.28 The location of the features discussed above is presented in Figure K3 at Appendix K3.

K4.29 At Shorthorn and Polgaver, the main mineralised veins or 'lodes' and workings of Wheal Pembroke lie to the north of the area. The nearest lodes for the closely parallel Barrett's Lode and Pembroke Lode trench roughly WNW-ESE, dip towards the north and pass approximately 150 metres to the NNE of the cliff line of the east part of the site.

K4.30 The only recorded mine workings or related features within Polgaver and Shorthorn are as described below.

K4.31 Roughly at the centre of Shorthorn, and on the edge of the cliff, a mine shaft is recorded by the Ordnance Survey. A 19th century surface mining plan of the area also records an isolated shaft but which is shown to lie a little to the east. The early plan also shows a crosscut tunnel, below sea level, as passing from the shaft towards the SSW, most probably to intersect a projection of the WNW-ESE trending lode from the west. This shaft appears to be an isolated exploratory shaft.

K4.32 A little to the west of these shafts, a drainage tunnel, known as the Wheal Merthyn Tye Adit, is marked by a line of shafts and has its outlet or portal at the foot of the cliffs (approximately 490 metres to the WSW of Merthyn Farm). A more recently driven water tunnel, known as the 'Crinnis Tunnel', passes close to and parallel with the Wheal Merthyn Tye Adit tunnel, with a newer portal close to the older one. It should be noted that these tunnels, whilst possibly intersecting mine tunnels along the lodes to the north, are not strictly typical adits, but are drainage tunnels driven from the valley to the northwest in

order to carry river, mine and leat water. These tunnels are under the control of South West Water.

K4.33 The early Geological Survey (circa 1908) records a WNW-ESE trending lode as passing into the west part of the beach area, but no details or original source confirmation is known. Two faults are also recorded at and close to the east of the east end of the beach.

K4.34 The 'streamworks' depicted on the 1st edition Ordnance Survey plan (circa 1880) most probably relates to processing of the once highly tin slime lade water from the Wheal Merthyn Tye Adit discharge.

K4.35 Within Polgaver, on the eastern cliff, two poorly recorded unnamed lodes are shown at an undefined elevation. There are no records to indicate these lodes have been worked within the beach section, or whether they are visible in the cliff line

K4.36 An old quarry is recorded at the top of the cliff line, on the western side of Polgaver. The extent and depth of the quarry, nature of any quarry infill or stability of the quarry faces is not known.

K4.37 Figure K4 at Appendix K3 presents the findings of the historical plans for the area to the west of Crinnis (Little Crinnis) beyond the headland. It shows that workings did extend under the beach areas and out below sea level in the area west and southwest of Crinnis, but none extend into the development area of the site or the beach.

K4.38 In summary, mining features are evident above the cliffline and adit portals are evident at the toe of the cliffs, there is no obvious evidence either historic or through site investigation that workings extend below the site.

Contamination

K4.39 An assessment of soil and groundwater contamination has been undertaken via desk based studies of previous investigations. The key documents for reference are those numbered 18 and 19 in the list at section K10.0 and which are reproduced at Appendices K1 and K2. The assessment is a summary of previous investigations and studies undertaken in a piecemeal fashion over the period 2003 and 2010. with data reviewed and re-assessed against current (2010) guidelines and criteria. Levels of compounds present in soil, soil leachate and groundwater have been assessed against standard guideline values for the proposed end use and against criteria for assessing impact to controlled waters.

K4.40 The assessment has identified the following: -

1 The current beach material has been formed from waste materials from the local china clay industry.

2 The only significant historical development to have occurred at the site was the construction of the now derelict leisure facilities. Associated with the proposed residential and leisure development, steel sheet pile and rock

revetment sea defences and a perimeter access road have been constructed.

3 The superficial deposits and underlying bedrock mudstones, siltstone and sandstone of the Meadfoot group are classed as a Secondary A aquifer by the Environment Agency.

4 A below ground chamber containing a below ground fuel tank is located adjacent to the Coliseum building.

5 Asbestos containing materials may remain present in the partially demolished buildings on site.

6 The site is in an area where new dwellings require radon protection.

7 Japanese Knotweed is present on site and on surrounding cliff tops. This is currently being treated and will continue to be treated on site.

K4.41 The conceptual site model indicate there are sources of potential contamination at the site which pose a 'Moderate' risk to (i) water supply consumers from historic mining activities, fuel tanks and compounds in made ground, (ii) Future site occupants from gas, (iii) Construction / maintenance workers from historic contamination from soil contamination, (iv) surface and groundwater from historic soil contamination.

Risks to Human Health

K4.42 The scheme has been considered for residential land use for the purpose of human health risk assessment. To consider the impact on human health from soil contaminants, a GQRA has been undertaken and is presented below.

1 Other than arsenic, all the determinants were recorded at levels below their respective SGVs.

2 Concentrations of arsenic were recorded in 13 no. Made Ground samples at Crinnis and Shorthorn at levels above the SGV for residential land use (between 38 and 120mg kg^{-1}). While above the SGV, these values are typical of natural arsenic concentrations in the UK and particularly in Cornwall, where it is present across the county in mineral deposits. According to the EA's UK Soil and Herbage Pollutant Survey, arsenic levels in rural soil in England range from 1.37 to 143 mg kg^{-1}. Arsenic levels in samples recovered from Polgaver were below the SGV.

3 Speciated PAH results obtained from the site have been used to calculate the average percentage for each PAH determinant. The resulting factors have been used to calculate the typical concentrations of each PAH determinant in total PAH results. None of the compounds were recorded above the PAH SGVs.

Risks to Water Supply

K4.43 A total of 2 No. samples of Made Ground were analysed for the organic substances listed by WRAS guidance. Concentrations of TPH and PAH did not exceed guidelines for organic compounds listed in the guidance.

Risks to Plant Life

K4.44 A total of 18 No. samples of Made Ground were analysed for the potentially phytotoxic metal compounds listed in BS3882:2007. A single sample of copper was recorded above the GAC of 200mg kg^{-1}, with a value of 940mg kg^{-1} in a sample recovered from BH1 (2002) at a depth of 3.0m.

Nature and Distribution of Soil Contamination

K4.45 Made Ground across Crinnis and Shorthorn contain arsenic above SGV for residential land use, but within the typical range for arsenic concentrations in rural soils. Made Ground at Polgaver are free from compounds above the relevant SGV. A single sample of Made Ground soil from a depth of 3.0m bgl in BH1 contained copper at a concentration which could in theory impact upon plant growth. However the depth at which this has been recorded is such that there is a sufficient covering of soils to protect future plant growth, and no further action is required.

Assessment of Soil Leachate Data

K4.46 Potential risks to controlled waters have been assessed generically by considering the results of testing for soil leachability. In assessing the levels of compounds in groundwater beneath the site, the results of analyses have been compared to Environmental Quality Standards (EQS) for List 1 and List 2 dangerous substances (EC 1976).

K4.47 There is no EQS for total petroleum hydrocarbons and reference is made to an EQS of 30µg l^{-1} for benzene as an acceptable alternative. In the absence of guidance for phenol, MLME has used a Dutch Invention Value of 2000mg kg^{-1} (VROM 2000) for use as a screening value. As the site is a beach, the EQS for a coastal/marine environment have been used.

Leachability

K4.48 Table K4.1 lists the results of soil leachate tests exceeding the adopted EQS.

Table K4.1 Comparison of Leachate Test Results to EQS

Contaminant	EQS	Min.	Max.	Location Exceeding (Location, depth, conc.)
Copper	5	<10	36	BH1, 1.0, 32 BH3, 4.0, 36
Zinc	40	<10	50	BH1, 1.0, 44 BH3, 4.0, 50

Note: All units µg l^{-1}

Nature and Distribution of Soil Leachate Contamination

K4.49 Soil leachate from Made Ground in BH1 at 1.0m bgl and BH3 at 4.0m bgl in the Crinnis Beach area contains slightly elevated concentrations of copper and zinc above EQS. The levels of copper and zinc in soil leachate are comparable to the slightly elevated concentrations of zinc and copper recorded in soil samples recovered from similar locations.

Contaminated Land Risk Assessment

K4.50 The assessment of risk from contamination follows the source-pathway-target approach. If one of these three elements is absent it is considered that there is no risk of harm. If, however, there is considered to be a linkage between source and receptor then a risk-based approach is used to assess the significance or impact of the potential SPR-linkage.

- **Source** – Contamination that has the potential to impact on human health or the environment.
- **Pathway** – The route by which a receptor may come into contact with the source.
- **Receptor** – Receptors are typically humans or the environment (e.g. water resources) that could be affected by contamination.

K4.51 Risks are defined as the likelihood of an event occurring combined with the magnitude of the consequence of that event occurring.

Conceptual Site Model

K4.52 The potential risks posed to human health and the environment by contamination at this site have been evaluated using a quantitative risk assessment which incorporates the 'source-pathway-receptor' identification and assessment methodology in accordance with CLR11.

K4.53 The risk assessment process involves the identification of source based on desk study and site investigation findings together with identification of the exposure pathway and sensitive receptor. The potential risks to the receptor (and its relative sensitivity) are then assessed by considering the potential

effect of the source on the receptor as well as the likelihood of a pathway linking the two.

Potential Contamination Sources

K4.54 Potential sources of contamination have been identified by the GQRA presented in the preceding sections of the report as follows:-

- S1 - Arsenic in Made Ground exceed GAC for human health at Crinnis Beach and Shorthorn Beach
- S2 - Copper and zinc in leachate exceed EQS

K4.55 Gas monitoring has not been undertaken as part of this assessment and therefore the potential impact of ground gas contamination has not been included in this report.

Receptors

K4.56 The identified sources of contamination can, subject to the existence of a plausible pathway, impact on the following receptors:

- R1 - Site users (residents and visitors)
- R2 - Site workers during construction and services maintenance
- R3 - Plant life in garden and landscape areas
- R4 - Surface water in Atlantic Ocean
- R5 - Groundwater beneath the site

Plausible Exposure Pathways

K4.57 The investigation has identified the following pathways that could provide a linkage between the sources and receptors identified above:

- P1 - Direct contact with contaminated soil. There is the potential for exposure to soil in future areas of proposed gardens and landscaping areas of the development.
- P2 - Uptake by plants. Plants grown in surface soils could come into direct contact with phytotoxic metal compounds.
- P3 - Leaching down to groundwater.
- P4 - Groundwater movement off site. Groundwater is present in deposits of sand and gravel beneath the site and flows generally from northwest to southeast towards the Atlantic Ocean.
- P5 - Surface runoff. During construction, exposed soil could generate sediment-laden runoff and contain elevated metal compounds. These could enter the Atlantic Ocean.

K4.58 The assessment indicates that with the exception of the compounds detailed below, no other compounds are present at levels which offer any risks to future development or to the general environment.

K4.59 Arsenic is present in the soil at Crinnis and Shorthorn at levels which exceed guideline values for a residential end use but are within the typical range for arsenic concentrations in rural soils. Copper and zinc are present locally in leachate derived from soil that locally that exceed Environmental Quality Standards for coastal/marine waters.

Radon

K4.60 Radon is a colourless, odourless radioactive gas formed by the radioactive decay of the small amounts of natural uranium that occur naturally in rocks and soil.

K4.61 In the southwest of England, radon is particularly prevalent and associated with the igneous rocks that underlie Cornwall and Devon. The area of the proposed development falls within an area where generally greater than 30% of homes have radon above the Action Level as defined in Health Protection Agency Document HPA-RPD-033. The site has, however, no greater level of naturally occurring radon than anywhere else within the immediate St Austell area.

Slope Stability

K4.62 The site comprises Crinnis, Shorthorn and Polgaver beach areas, all characterised by variable height cliff above the site and with distinct promontories between each beach area.

K4.63 The cliffs comprise rock with a thin superficial soil cover, above and in some localities mantling the slopes. Both have been subjected to weathering and erosion and there is ongoing failure and collapse influenced primarily by the rock structure and locally by previous mining activities. The rocks comprise mudstones and silstones which were subjected to regional metamorphism to produce the slates, phyllites and meta mudstones that can be observed in the cliffs.

K4.64 Locally there is an area of intrusive diabase that is exposed in the cliff in the western area of Crinnis and a similar localised area of intrusive dolerite in the middle of the cliff line at Polgaver.

K4.65 The rocks are characterised by various joints and fractures together with a number of faults. The cleavage dips broadly south-eastwards and this, together with the discontinuities makes the rocks susceptible to spalling and collapse.

K4.66 Rockhead extends from the toe of the cliff deepening below the beach area and varies at beach level, typically from ground level to 10.8m bgl or minus 5m OD in the intertidal zone. Crinnis Island at the western end of Crinnis beach stands as a distinct area of rockhead exposed above the beach in the intertidal zone.

K4.67 The rocks are characterised by steeply dipping mineralised fissures or lodes which have been subjected to mining activity. Locally the lodes are believed to extend below the beaches, but with no evidence of mining activity below the beaches.

K4.68 In some areas along the cliff weathering and erosion has resulted in continuous spalling of the rock and soil such that the shallower slopes are mantled with an angular scree of coarse soils. The cliff line profile and the solid geology exposed continues to change as a result of ongoing natural weathering and erosion and slope failure.

K4.69 An area of cliff along the access road to the beach has been previously stabilised with netting rock bolts and retaining walls to prevent rockfall and slope failure impacting the access road. This has proved successful.

Summary

K4.70 The current baseline conditions with respect to the RIGS and the cliffs is that they are subject to natural erosion, weathering and ongoing instability. Surveys and assessments undertaken by MLM over a period of 3-7 years indicate that failure of cliffs and erosion are ongoing although it is difficult to fully quantify the magnitude or timeframe over which failure could occur.

K4.71 Past mining features are primarily located above the cliffline and outside the area of the development and have been partly or completely obscured by vegetation, and subsequent development over a number of centuries. There is no evidence of mining activity beneath the proposed development or beach areas.

K4.72 Naturally occurring radon and naturally occurring compounds in soil and rock are ubiquitous throughout the region. Levels of radon and naturally occurring compounds (including arsenic) are no higher within the development area than anywhere else in the general St Austell area, although arsenic is present at levels which exceed UK guideline level in relation to human health.

K4.73 Presence of Underground Storage Tanks (USTs) in chamber adjacent to existing buildings offer risks in relation to hydrocarbons that require investigation after demolition.

K5.0 Potential Effects

Introduction

K5.1 The proposed development has the potential to impact on the following receptors:-

1 The RIGS through inducing instability obscuring the features and potential ultimate loss of the features

2 Past mining features (where these exist)– obscuring, damaging or resulting in collapse on and off site.

3 Contaminants including Radon through aiding migration or release

4 Rock slope profile inducing instability and collapse

K5.2 The Development itself could also be impacted by all the above with the exception of the RIGS.

K5.3 For consideration of the effect of the proposals on the heritage of past mining, refer to Chapter M: Heritage.

K5.4 The stability of rock slopes, erosion and weathering as it relates to RIGS and the impact of rock slope instability on the development are considered in this section. Further consideration of the RIGS is provided in Chapter E: Biodiversity.

K5.5 Contamination and radon (where this is either naturally occurring or industrially related) are both considered in this section.

During Construction

RIGS

K5.6 There are various aspects of the construction process that could impact on the RIGS comprising physical excavation; stabilisation work on the cliffs; piling and construction activity for the sea wall; and development induced vibration together with direct vehicle movement inducing vibration (see also Chapter I: Noise & Vibration).

K5.7 Stabilisation work on the cliffs are necessary to protect the development and are included as part of the scheme under consideration. Any impact would be most likely through inducing instability and collapse and thereby resulting in possible loss of the features (e.g. the raised beach) or through obscuring the features.

K5.8 The Carlyon West RIGS includes Crinnis Island and the area of cliffs which commences some 100-200m beyond the southernmost extremity of the proposed seawall.

K5.9 Sea wall construction will take place inshore of Crinnis Island and this area of the RIGS will therefore not be directly affected by construction

processes. Vibration from piling plant will be at such a distance from the Island that any vibration induced loosening or failure of the rocks or soil on the Island will be of minor short term adverse impact.

K5.10 There is some potential risk of construction plant colliding with the Island, although this would be managed via good construction practices and health and safety measures. Impact during construction is considered to be minor adverse short-term and localised.

K5.11 For the cliffline, the sea wall and building construction, (particularly any piling or ground improvement in close proximity to existing unstable and largely unvegetated sections of cliff) has potential to aid instability through vibration inducing failure or weakening of the rock. However the RIGS on the cliff are at such a distance from the proposed construction that impact is unlikely.

K5.12 Current instability and potential future instability impacting construction workers through rock falls and slope failure is a health and safety risk. Measures such as rock stabilisation or removal of loose/unstable areas will be undertaken (and as identified above are included as part of the current proposals). These will have a direct impact on the cliffline and potentially locally on the RIGS by obscuring features.

K5.13 Any stabilisation has the potential to help preserve any geological features. This is considered to be a long term minor benefit.

K5.14 The overall impact from construction activity is neutral.

Past Mining Features

K5.15 There is no evidence to suggest mining has taken place below the site or beach. Construction of the sea wall will be at some distance from identified mining features which are located above or at the foot of the cliff and will have no adverse/neutral impact on the features. This conclusion is based on the findings of intrusive investigations and extensive detailed studies of past mining

K5.16 Development related construction, although in closer proximity to these features, will also be primarily at site level. Localised service provision and possible sandy river outlet works could impact on specific mining features through assisting in destabilisation or blocking/removal of drainage adits. However, these are already well recorded and construction work will be designed and managed to reduce any potential impact. Construction will have negligible impact on past mining.

K5.17 There is no previous or current direct evidence of mining instability although the potential for mining instability aiding slope failure does exist and has therefore been assessed. Construction work on the access road and cliffs is at minor adverse risk from mining instability impact.

Contaminants and Radon

K5.18 Naturally occurring compounds (including arsenic) in soil and in rock are currently subject to natural movement of surface water and groundwater at the site. This does result in leaching of compounds and migration in solution into groundwater and sea water but this does not adversely impact on water quality or exceed environmental quality standards. Construction activity (primarily excavation, dredging and piling) is a short-term transitory nature and will have minimal impact on this naturally occurring process. The levels of compounds are such that any change to the natural processes through construction would be difficult to quantify and apportion to construction activity and any potential for movement is in any case very small.

K5.19 No adverse impact on water quality from contaminants during construction will take place and the overall impact is considered to be neutral.

K5.20 The level, type and form of compounds present at the site offers negligible risk to construction workers or to the general public and is no different to the risks from these compounds anywhere else in this part of Cornwall or currently on the site.

Rock Slope Stability

K5.21 The cliffs along sections of Crinnis, Shorthorn and Polgaver are naturally unstable with ongoing failure evident. There is potential for increased short-term instability locally due primarily to construction induced vibration although natural failure could also occur and will be the primary mechanism for instability. Construction will have an initial short-term minor adverse impact on stability but the measures required to stabilise the cliffs for health and safety reasons will have a substantial long term benefit to stability.

K5.22 Construction activity is at risk from cliff line instability and measures will be implemented during construction to stabilise the higher risk areas. This may involve stabilisation work on the cliffs or temporary protection measures. Full details are not known at this stage. There are moderate adverse risks to construction from cliff instability without stabilisation taking place.

Comparison with the Extant Scheme

K5.23 The extant scheme would be constructed over part of the Crinnis West RIGS. The proposed development does not cover the RIGS and this is therefore a benefit compared to the extant scheme as construction activity will not be required in the vicinity of the RIGS.

After Completion

RIGS

K5.24 The RIGS are not affected by the works following completion and as such the impact is neutral.

Past Mining Features

K5.25 As there are no past mining features identified below the site, following completion of the scheme there will be no activities or processes associated with development which could affect any features. The effect is therefore neutral. Flows of water from adits and their impact on mineworkings off site are beyond the scope of this assessment and are considered further in Chapter D: Water Environment.

K5.26 As there has been no known mining below the development site or beach and as there is no evidence of instability in the cliff line associated with past mining there is negligible risk to the development from past mining.

Contaminants

K5.27 No adverse impact in respect of ground contamination from the development is anticipated as the scheme will not add to existing contamination or create pathways for existing compounds to migrate into groundwater surface water or the sea. Reduced rainwater infiltration through the soils due to presence of hardstanding will reduce potential for migration of naturally occurring compounds. In this respect there are minor benefits arising from the development.

Rock Slope Stability

K5.28 No adverse effect on the stability of the cliffs or rock slopes is anticipated following completion of the scheme. Development will facilitate stabilisation of parts of the existing cliffs that are in an unstable and dangerous condition allowing safer access and use of the beach area. Stabilisation will also assist in retaining the coastal path. Development can be considered to have a significant long-term benefit in facilitating stabilisation.

Comparison with Extant

K5.29 The extant scheme would have been constructed over part of the Crinnis West RIGS. The proposed development does not cover the RIGS and this is therefore a significant benefit compared to the extant scheme.

K5.30 The proposed development covers a smaller area compared to the extant scheme and therefore will be minor beneficial with regards to contamination and radon.

K5.31 Both developments involve construction close to the cliff but with the proposed development this will comprise a drainage ditch at the rear of the site on Shorthorn compared to an access road in the extant scheme. The proposed scheme is therefore slightly beneficial compared to the extant scheme.

Other Effects

Potential Impacts on Construction Works

K5.32 There is no previous or current direct evidence for mining instability although potential for mining instability aiding slope failure does exist. Construction work on the access road and cliffs is at minor adverse risk from mining instability effects where these exist.

K5.33 There are no mineworkings below the site that could impact any construction activity. Risks to construction are negligible.

K5.34 The risks from naturally occurring compounds to construction workers or the general public during the construction period are negligible, would be very short-term in duration and would not increase as a result of construction activity.

K5.35 Instability of the cliffs gives rise to the need for stabilisation works and mitigation during construction for health and safety reasons. There are moderate adverse risks from unstable cliffs on construction without mitigation.

Potential Impacts on Development

K5.36 Arsenic compounds in soil and naturally occurring Radon do give rise to the potential for minor adverse long-term effects to site occupiers which will require mitigation to reduce impact to acceptable levels of risk.

K5.37 There are no mineworkings below the site which could adversely impact on development.

K5.38 Unstable slopes do offer risks to the development which are adversely significant locally and mitigation in the form of stabilisation and management will be required for health and safety reasons. These works are included as part of the development proposals where necessary.

Summary of Effects

K5.39 Minor adverse short term localised impact to the RIGS due to cliff stabilisation works necessary to reduce health and safety risks during construction and development has been identified. The RIGS may in part be obscured by stabilisation work. Following completion of the scheme, the stabilisation work can be considered to have a minor long-term benefit through stabilisation of the cliffs limiting failure and through permitting safe access to the RIGS.

K5.40 There is no evidence of mining activity below the site and impacts from development or to development are therefore assessed to be neutral.

K5.41 Mining did take place at the foot of and above the cliffs and there is the potential for a minor adverse risk to construction through localised increased potential for instability.

K5.42 Naturally occurring arsenic compounds and radon are present at levels where there is the potential for minor adverse long-term effects on development that will require mitigation.

K5.43 Construction and development are unlikely to give rise to adverse effects on contamination or radon but development has a minor long-term beneficial effect in terms of reducing potential for ongoing migration of naturally occurring compounds.

K5.44 Construction and development are likely to give rise to a significant long-term benefit locally to the cliffs. Stabilisation will reduce ongoing naturally occurring failure, help protect the coastal path, allow access to the RIGS and reduce health and safety risk to beach and site users.

K5.45 Construction and development are at risk from cliff instability where impact is likely to be moderately adverse.

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Table K5.1 Summary of Impacts

Origin	Area Affected	Contaminants	Pathway	Receptor	Likelihood	Potential Magnitude	Overall Risk	Notes
Made Ground	Crinnis and Shorthorn	Arsenic	Direct contact	Site users (residential)	Possible	Moderate	Moderate	Where present, Buildings and hardstanding will act as a barrier between contaminants and site users. However, in garden areas, site users could come into contact with contaminated soils. Gardens and landscaped areas should be capped with clean imported material. Where development removes the Made Ground, capping will not be required.
			Direct contact	Construction staff	Possible	Moderate	Moderate	Construction and maintenance staff working in soils could come into contact with contaminated soils. Site staff should wear appropriate PPE.
Made Ground	Crinnis	Leachable copper and zinc	Migration	Atlantic Ocean	Likely	Mild	Low	The concentrations of copper and zinc in leachate from Made Ground are only marginally above guideline values. Seawater will not be significantly impacted by the levels of leachable metals recorded due to the size and volume of the receptor.

Origin	Area Affected	Contaminants	Pathway	Receptor	Likelihood	Potential Magnitude	Overall Risk	Notes
			Migration	Groundwater	Likely	Mild	Low	Groundwater is likely to be in hydraulic continuity with seawater and therefore likely to be of similar chemical composition. Therefore, any impact is likely to be negligible.
Natural strata	Crinnis, Shorthorn and Polgaver	Radon	Migration	Site users in new dwellings	Likely	Severe	High	Greater than 30% of homes in area are affected by radon. Note: No development proposed on Polgaver
USTs	Crinnis	Hydrocarbons	Contact	Water supply & consumers	Possible	Moderate	Moderate	Services could be impacted by hydrocarbon in soil.
			Direct Contact	Construction Maintenance workers	Possible	Moderate	Moderate	Site workers are likely to come into contact with soils
			Leaching	Groundwater (Secondary A aquifer)	Possible	Moderate	Moderate	No evidence of leaks / spills. Tanks to be decommissioned in appropriate manner
			Groundwater movement	Secondary A aquifer and Marine Waters and ecology	Possible	Moderate	Moderate	No evidence of leaks / spills. Tanks to be decommissioned in appropriate manner
			Surface runoff	Surface water (Stream and marine waters) and	Possible	Moderate	Moderate	No evidence of leaks / spills. Tanks to be decommissioned in appropriate manner

Origin	Area Affected	Contaminants	Pathway	Receptor	Likelihood	Potential Magnitude	Overall Risk	Notes
				ecology				
		Gas/vapour	Migration in permeable soil and inhalation	New construction	Possible	Moderate	Moderate	No evidence of leaks / spills. Tanks to be decommissioned in appropriate manner. Local risk.

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K6.0 Mitigation Measures

Introduction

K6.1 Any mitigation will only be required where construction or the development has a greater adverse impact on the receptor than current baseline conditions or where mitigation has a substantial benefit such that it is likely to give rise to enhancement to the scheme.

K6.2 Mitigation measures required to manage the risks from baseline conditions on construction activity or development are also identified in this section.

During Construction

K6.3 Construction activity will be undertaken in accordance with existing regulatory requirements, good practice and to site specific requirements including:

1 Site Specific Code of Construction Practice

2 Environmental Management Plan

3 Environmental Liaison

K6.4 This will mitigate the risks from vibration potentially increasing instability of slopes in the area of the RIGS and reduce any adverse impact to acceptable levels without recourse to additional specific measures.

K6.5 No specific mitigation to address impact of construction on past mining is required. No specific mitigation to address impact on contamination or radon is required.

K6.6 Mitigation including stabilisation work required for health and safety reasons and installed during construction will have an adverse long-term minor and localised impact on the RIGS.

After Completion

K6.7 No specific mitigation measures are required for the RIGS.

K6.8 Stabilisation work necessary to reduce health and safety risks will have a long-term minor benefit in stabilising unstable areas of the RIGS and allowing safe access. Stabilisation work which takes account of the sensitivity and importance of the RIGS will be undertaken to minimise adverse impact.

K6.9 No specific mitigation for contamination or radon is required in relation to groundwater or other environmental receptors, although development hardstanding and drainage will reduce rainwater infiltration into the soils reducing potential for leaching out of compounds into solution. Development has a minor positive impact.

K6.10 Continued drainage from any adits or other mineworkings is essential to ensure there is no impact on stability of workings within the planning application area or more importantly in the past mining areas to the north. These mitigation measures are discussed in Chapter D: Water Resources.

Other Mitigation

Mitigation to Reduce Risk to Construction

K6.11 Construction activity is at risk from unstable cliffs. Measures to reduce these risks to acceptable levels will be required for specific areas of the site and for specific construction activity.

K6.12 As well as working practices and health and safety procedures, either temporary or more permanent, rock and soil stabilisation will be required.

Mitigation to Reduce Risks to Development

K6.13 Buildings and infrastructure, together with site occupiers and site users are at risk from unstable cliffs. A combination of stabilisation works and risk management will be implemented to mitigate these risks.

K6.14 Radon which is naturally occuring will require specific measures for all ground floor buildings that will be occupied or where man entry is possible. Radon protection measures will be required, which may include installation of a radon membrane and underfloor sumps or other methods as agreed with the Approved Building Control Inspector.

K6.15 Naturally occurring arsenic in sediments will require mitigation in any gardens. This will take the form of clean imported capping material below any growing media to provide a barrier between site users and the underlying soils. No mitigation is required for any buildings, roads, hardstanding or for general site users.

K7.0 Residual Effects

Introduction

K7.1 This section identifies any effects remaining after implementation of the mitigation measures in the previous section.

During Construction

K7.2 No residual negative effects are likely following implementation of the mitigation measures.

After Development

K7.3 No residual negative effects have been identified following implementation of the mitigation measures. The proposed cliff stabilisation works will have a positive impact on cliff stability, on the retention of the footpaths at cliff level and in protecting site users from rockfalls.

K7.4 After development, there will be a positive residual effect in providing improved access to the RIGS.

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K8.0 Summary and Conclusions

K8.1 The Carlyon Bay site is characterised by steep and, in places, unstable cliffs with beach deposits derived from historical mining and china clay workings inland of the site.

K8.2 The rocks contain naturally occurring Radon and the soil contains certain metal compounds including arsenic, all of which are common to this area of Cornwall.

K8.3 Geological and geomorphological features in the western half of Crinnis beach are Regionally Important Geological Sites (RIGS).

K8.4 Historical mining for metals took place throughout the area and this included workings via shafts and adits above and on the cliff line at Crinnis and Shorthorn. There is no evidence for mineworkings below the beach level.

K8.5 The assessment has identified potential impacts to various geological features/processes although none are considered to be significant and are themselves more of a risk to development.

K8.6 The RIGS will not be impacted adversely by development and the development may encourage access to and interest in these features aiding their protection. Stabilisation works required on the cliff will assist in stabilising these features but may also in part obscure them. Impact is not, however, considered to be significant.

K8.7 There will be no adverse impact from the development on Radon and contamination but these offer risks to development that will require mitigation.

K8.8 Construction activity may in the short term have an adverse affect locally on slope stability which will require mitigation via stabilisation but long term stabilisation required to protect the development will reduce cliff erosion and failure and help maintain the coastal path and permit greater public access to the area.

K8.9 Mining is not present below the beach and development will have no adverse effect on mining features.

K8.10 There are no significant adverse impacts from construction or development. Mitigation proposed is primarily to reduce impact from the naturally occurring compounds and unstable slopes on development.

K8.11 Post mitigation there are no adverse residual effects.

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K9.0

Abbreviations

1 PPS – Planning Policy Statement
2 RIGS – Regionally Important Geological Site
3 EQS - Environmental Quality Standards
4 BGS – British Geological Society
5 GQRA - generic quantitative risk assessment
6 GAC - generic assessment criteria
7 SGV - soil guideline values
8 CLEA - Contaminated Land Exposure Assessment
9 BTEX - benzene, toluene, ethylbenzene and xylenes
10 LQM – land quality management
11 CIEH - Chartered Institute of Environmental Health
12 TPH - total petroleum hydrocarbons
13 PAH - polyaromatic hydrocarbons
14 WRAS - Water Regulation Advisory Service
15 BSI – British Standards Institution
16 SPR – 'source-pathway-receptor'
17 HPA – Health Protection Agency
18 PPE – personal protective equipment

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K10.0

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2 Planning Policy Statement 23: Planning and Pollution Control. Annex 2 Development on Land affected by Contamination.

3 Saved policies of the Restormel Local Plan (saved September 2007)

4 Cornwall Core Strategy Topic Based Papers (draft June 2010) – see Biodiversity and Geodiversity: Soil Air and Water Quality

5 Planning Policy Guidance 14 Development on Unstable Land Annex 1: Landslides and Planning

6 Report on Site Investigation at Carlyon Bay, St Austell, Structural Soils Ltd, June 1990. Crinnis only. 16 exploratory holes or pits

7 Preliminary Geoenvironmental Assessment Report, MLM Environmental, 2003. Crinnis and Shorthorn. 28 exploratory holes or pits

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9 Geological Appraisal Crinnis Bay, St Austell, John Grimes Partnership 96/1551. 1996. Desk Based only

10 Appraisal of Land Stability for Proposed Redevelopment of Land at Carlyon Bay, John Grimes Partnership. 2971. July 2000. Crinnis only. Desk Based only

11 Basic Contamination Investigation Polgaver ref. MLM Environmental 722145 July 2010 – Intrusive Investigation only comprising eight trial pits and soil sample analysis.

12 Historic Mining Assessment Polgaver ref. MLM Environmental 722145 July 2010 – Desk Based only

13 Slope and Past Mining Assessment. Crinnis Beach Non intrusive survey. MLM Environmental 720447/R3/F

14 Geotechnical Assessment Sea Wall Crinnis and Shorthorn Beaches. MLM Environmental 720447/R6/F. 23 exploratory holes and geophystical surveys

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24 Contaminated Land report. MLM Environmental. 722145/R5. October 2010

25 UK Soil and Herbage Pollutant Survey, Report Number 7, Environment Agency (Science Project No. SC000027). June 2007