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# 026893 EGS Eden Geothermal

## Ground Conditions & Hydrogeology Impact Assessment

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# 1 Introduction

EGS Energy Limited in conjunction with the Eden Project are proposing to build the UK's first geothermal power plant generating both heat and electricity at The Eden Project, St Austell, Cornwall.

This report addresses the potential impacts the project may have relating to ground conditions at the site and surrounding area. The assessment describes (i) the potential and known sources of contamination within and around the site, (ii) those aspects of the proposed development that could affect, or be affected by soil and water contamination or the physical ground conditions, and (iii) associated potential impacts, mitigation measures and residual impacts (following mitigation).


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# 2 Assessment Methodology and Criteria

## 2.1 Legislation and Policy Framework

Land contamination is regulated under several regimes, including environmental protection, pollution prevention and control, waste management, planning and development control, and health and safety legislation. A brief account of these regimes is provided below.

**Environmental Protection Act and Statutory Guidance**

UK legislation on contaminated land is contained in Part IIA of the Environmental Protection Act (EPA) 1990. This legislation endorses the principle of a 'suitable for use' approach to contaminated land, where remedial action is only required if there are unacceptable risks (or potentially unacceptable risks) to health or the environment, taking into account the current or intended uses of the site and its environmental setting. The Statutory Guidance contained in the Department of Environment Food and Rural Affairs (DEFRA) Circular 01/2006[1] describes a risk assessment methodology in terms of 'significant pollutants' and 'significant pollutant linkages' within a source-pathway-receptor conceptual model of a site. The model comprises:

- The principal pollutant hazards associated with the site (the sources);
- The principal receptor(s) at risk from the identified hazards, for example, people, environmental assets, surface or groundwater; and
- The existence, or absence, of plausible pathways which may exist between the identified hazards and receptor(s).

The legislation places a responsibility on the local authority, or the Environment Agency for 'Special Sites', to determine whether any sites in its area should be "determined" as Contaminated Land (as defined in the legislation).For land to be determined as Contaminated Land and thereby require remedial action, all three elements (source-pathway-receptor) of a significant pollutant linkage must be present.

The local authority has to consider whether:

- Significant harm is being caused; or
- There is a possibility of significant harm being caused; or

[1] DEFRA (2006). Circular 01/2006 Environmental Protection Act 1990: Part 2A Contaminated Land.


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- Pollution of controlled waters is being, or is likely to be, caused (local planning authorities will rely to a substantial extent on the advice of the Environment Agency in relation to issues relating to the pollution of controlled waters).

**Water Resources Act 1991/Water Act 2003**

The Water Resources Act 1991 protects the quality of ground and surface water collectively defined as 'controlled waters'. The Act makes it an offence to cause or knowingly permit poisonous, noxious or polluting matter to enter controlled waters. In such cases, the land owner is committing an offence if the pollution of controlled waters is not prevented once the site has been identified as being a source of contamination.

The Water Act 2003 amends the Water Resources Act 1991 to improve long-term water resource management, specifically with regards to the regulation of water abstraction and impoundment. The Act is being implemented in phases, some changes being introduced in April 2004, with most expected to be in force by the end of 2009.

**Groundwater (England and Wales) Regulations 2009**

The Regulations place a duty on the Environment Agency to protect groundwater, in effect by prohibiting discharges of hazardous substances to groundwater, and preventing pollution of groundwater by non-hazardous substances. The regulations require a permit for any input of hazardous substances to groundwater.

**Environmental Permitting Regulations (England and Wales) 2007**

The Environmental Permitting Regulations introduce a single environmental permitting and compliance regime to apply in England and Wales. This regime streamlines and combines Waste Management Licensing Regulations 1994 (as amended) and The Control of Pollution (Amendment) Act 1989 to create a single environmental permit with a common approach to permit applications, maintenance, surrender and enforcement.

**Hazardous Waste Regulations 2005**

Depending on its characteristics and the requirements for treatment or disposal, contaminated soil may be classified as hazardous, non-hazardous or inert waste. The relevance and need to consider the Regulations will depend on the composition and characteristics of waste soil generated at the site. The Hazardous Waste Regulations 2005 and the closely related List of Waste Regulations 2005 implement the provisions of the European Hazardous Waste Directive (91/689/EC) into England and


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Wales. The regulations set out procedures to be followed when disposing of, carrying and receiving hazardous waste.

**List of Waste Regulations, 2005**

The List of Waste Regulations 2005 determines the process for classifying a waste as hazardous or non-hazardous and provides details on thresholds for certain hazardous properties.

**The Duty of Care Regulations 1991**

The Duty of Care Regulations 1991 relate to the requirements on waste producers to prevent the escape of waste, environmental pollution or harm to human health during the transfer, treatment or disposal of waste. The producer has a responsibility to ensure that if the waste is transferred, it goes only to an: "…authorised person or to a person authorised for transport purposes" and a transfer note is also transferred to the new holder.

**National Planning Policy**

PPS23[2] advises that regional planning bodies and local planning authorities should adopt a strategic approach to integrate land use planning processes with plans and strategies for the control, mitigation and removal of pollution, as far as it is practicably possible. PPS23 aims to ensure the sustainable use of land, encouraging the reuse of previously utilised land. Consequently, opportunities should be taken wherever possible to assist and encourage the remediation of contaminated land programmed for reuse. Any potentially polluting activities should be sited, planned and subject to planning conditions, such that their adverse impacts are minimised to within acceptable limits.

PPS23 states that:

"Any consideration of the quality of land, air or water and potential impacts arising from development, possibly leading to impacts on health, is capable of being a material planning consideration, in so far as it arises or may arise from or may affect any land use…"

It goes on to state that:

"…as a minimum, after carrying out the development and commencement of its use, the land should not be capable of being determined as contaminated under Part IIA of the EPA 1990."

[2] ODPM. (2004). Planning Policy Statement 23 (PPS23): Planning and Pollution Control.


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**Local Policy and Guidance**

As the Cornwall Council Core Strategy is not anticipated to be published until June 2011 interim planning policy falls under the 'saved' policies of previously adopted Local Plans. In this instance the 'saved' policies of the Restormal Borough Council Local Plan and the Cornwall Structure Plan are still applicable.

**Restormal Borough Council Local Plan 2001-2011**

Policies 39 and 40 of Restormal Borough Council's Local Plan relate directly to derelict, contaminated and unstable land.

Policy 39 states that 'development proposals, on sites of actual or potential contamination, will not be permitted unless from the carrying out of a detailed site survey and analysis to determine the amount of hazardous substances present in the soil, and the underlying geology of both the application site and the immediate area surrounding, appropriate precautions, either to remove the contaminating substances or render them harmless to peoples health and safety and the environment, can be satisfactorily implemented'.

Policy 40 states that 'Development proposals on land which has been identified as unstable, or is considered to be potentially unstable, will not be permitted unless it can be shown, from a detailed stability report describing and analysing the issues relevant to ground instability, that remedial action, where appropriate, can be satisfactorily implemented'.

**Cornwall Structure Plan 2004**

Policy 3 of the Cornwall Structure Plan emphasises the need for development to avoid, directly or indirectly, the risk of significant levels of pollution or contamination to air, land, soil or water. The Policy states that '*Where development may affect an area of contamination or unstable land, a full analysis of the site and an assessment of the direct or indirect risks associated with the proposal should be carried out'*.

## 2.2 Scope of Assessment

This assessment summarises all the historical information available on the site to date, detailing the potential contaminants that may be present on site as a result of previous and current land uses. The potential impacts and effects during the construction phase of works and the site operation (based on the current proposed land use) are identified and assessed.

The assessment aims to:

- Identify existing baseline conditions;
- Identify potential impacts from construction and occupation;


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- Assess the significance of identified impacts; and
- Identify the need for specific mitigation measures.

### 2.3 Assessment Methodology

The significance of the hazards posed by potential sources of contamination both on and off site has been assessed by the following methodology:

- Desk based study[3]: (included as Appendix A) this includes a review of all available relevant environmental information on the site and surrounding areas (including previous site investigation data where available) and a detailed assessment of all historical information relating to the site and surrounding areas. The purpose of this assessment was to identify the existing sources of potential contamination as a result of historical and current land uses; the geological and hydrological conditions of the site and the residual risk associated with the redevelopment of the site.
- Site investigation[3] (included as Appendix A) review of site investigation data undertaken between the 15th and 30th March 2010.

An initial conceptual ground model has been developed through the desk based study and recent site investigation information (Appendix A). The work has been carried out with reference to and in general accordance with relevant BS5930[4] and BS10175[5] and the Environment Agency / DEFRA Model Procedures[6]. The information derived from these studies has also enabled an initial assessment of geotechnical factors relevant to the development and a Generic Quantitative Risk Assessment with respect to ground contamination[3].

### 2.4 Assessment Criteria

The methodology for impact prediction and mitigation is based on assessing both the magnitude of the changes expected and the sensitivity of the receptors.

#### 2.4.1 Impact Magnitude

Criteria for assessing the significance of potential human and environmental impacts have been based on a qualitative assessment of the magnitude of the effect, or how far the effect deviates from the baseline condition, and the receptor sensitivity. The qualitative criteria used to assess how far an

[3] Buro Happold, July 2010. EGS Eden Geothermal Geonvironmental Interpretative Report.
[4] British Standards Institute, (BSI) (1999). BS5930, The Code of Practice for Site Investigations.
[5] British Standards Institute (BSI) (2001). BS10175, Investigation of potentially contaminated sites, Code of Practice.


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impact effect deviates from the baseline condition, i.e. the magnitude of change, are described in Table 1 below.

[6] DEFRA/Environment Agency. (2004). Model Procedures for the Management of Land Contamination (CLR11).


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**Table 1: Criteria for assessing magnitude of change**

| Magnitude of change | Criteria |
|---|---|
| Large | Construction phase: Construction activities result in a major pollution release[1] or create a pollutant linkage with a substantial pollutant source.<br>Operational phase: The development introduces a new large-scale source of potential contamination or pollutant linkage. |
| Medium | Construction phase: Construction activities result in a moderate pollution release[2] or create a pollutant linkage with moderate pollutant source.<br>Operational phase: The development introduces a new relatively small scale source of potential contamination or pollutant linkage. |
| Small | Construction phase: Construction activities result in a minor pollution release[3] or create a pollutant linkage with a minor pollutant source.<br>Operational phase: The development introduces a new minor source of potential contamination or pollutant linkage.<br>Temporary pathway or receptor is introduced during construction only to create pollution linkage. |
| No Change | No foreseeable measurable change |

Notes

1. A major pollution release corresponds to a Category 1 pollution incident, which is defined by the Environment Agency as having persistent and extensive effects on water, land and air quality, major damage to all ecosystems, closure of a potable abstraction, major impact on land property, major impact on amenity value, major damage to agriculture and/ or commerce and serious impact upon man.

2. A moderate pollution release corresponds to a Category 2 pollution incident, which is defined by the Environment Agency as having a significant effect on water, land and air quality, significant damage to all ecosystems, non-routine notification of abstractors, significant impact on land property, reduction in amenity value, significant damage to agriculture and/ or commerce and impact on man.

3. A minor pollution release corresponds to a Category 3 pollution incident, which is defined by the Environment Agency as having a minimal effect on water, land and air quality, minor damage to local ecosystems, marginal effect on amenity value and minimal impact to agriculture and/ or commerce.

Full definitions can be found on http://www.environment-agency.gov.uk/research/library/data/99892.aspx

### 2.4.2 Receptor Sensitivity

Receptor sensitivity is defined in Table 2. For direct impacts to surface water, refer to FRA/drainage report.


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**Table 2: Criteria for assessing receptor sensitivity**

| Sensitivity | Receptor |
|---|---|
| High | People occupying land to be used; for residential purposes with domestic gardens, for allotments to grow crops for human consumption, or upon which animals are reared for human consumption.<br>Principal Aquifer or aquifer used for public water supply, water body of a high quality, or of a highly sensitive aquatic ecosystem.<br>Nationally designated/protected area e.g. SSSI, SPA, NNR, cSAC. |
| Medium | People occupying land to be used; for residential purposes without gardens, or for areas of public open space<br>Secondary A Aquifer, water body of medium quality, moderately sensitive aquatic ecosystem not used for large scale human consumption, can be used for industrial purposes. Often important for local recreational properties.<br>Regionally designated habitats or local amenity areas such as Sites of Nature Conservation Importance/Interest (SNCI) and local nature reserves, parks, playing fields. |
| Low | People occupying land for industrial/commercial end uses.<br>Construction/maintenance workers (assuming appropriate PPE is used)<br>Secondary B and C Aquifers, non potable water sources, water body of poor quality, low recreational qualities, and low ecological content. Non-designated areas such as open spaces/land etc. |

### 2.4.3 Significance Evaluation

The assessments of magnitude of change and sensitivity of the receptor have been used to qualitatively assess the impact significance of the project. Impacts have the potential to be either adverse or beneficial. For example, the project may remove a source of contamination or it may break a pathway that currently links a source to a receptor.

An adverse or a beneficial impact in respect of ground contamination relies on a source, pathway and receptor to be present. The significance of the impact depends on the value of the resource, the


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sensitivity of the receptor and the ways in which the proposed development can provide a pathway to the receptor. The significance of an impact partly depends on the timescales involved, i.e. short-term (less than three years duration), medium-term (between three and ten years duration) or long term (in excess of ten years duration) and the extent of the area affected.

The assessment of potential and residual impacts has therefore used the following scale of significance discussed in Table 3 and outlined below. It should be noted however, that the assessment of risk in accordance with the contaminated land regime and associated legislation takes precedence over the methodology set out below.

**Table 3: Assessment Criteria for Impact Significance**

| **Receptor Sensitivity** | **Magnitude of Change** | | | |
|---|---|---|---|---|
| | **Large** | **Medium** | **Small** | **No Change** |
| **High** | Major | Major | Moderate | Negligible |
| **Medium** | Major | Moderate | Minor | Negligible |
| **Low** | Moderate | Minor | Minor | Negligible |

**Major adverse**: Potentially major effect upon human health. Severe temporary or permanent reduction in the quality of a potable groundwater or surface water resource of local, regional or national importance. Permanent or severe temporary detrimental impact on animal or plant populations.

**Moderate adverse**: Potentially moderate effect upon human health or safe occupancy of buildings. Severe temporary change to water quality of ground water or surface water body. Temporary harmful impact on animal or plant populations.

**Minor adverse**: Potentially temporary or minor effect upon human health. Minor, local-scale reduction in the quality of potable groundwater or surface water resources of local importance, reversible with time. Reversible widespread reduction in the quality of groundwater or surface water resources used for commercial or industrial abstractions. Reversible small scale detrimental impact on animal or plant populations.

**Negligible**: No appreciable effect upon human health, potable groundwater or surface water resources of any importance, animal or plant health. Any minor impacts are reversible.


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**Minor beneficial**: Minor reduction in potential effects upon human health. Minor local-scale improvement to the quality of potable groundwater or surface water resources. Moderate to significant improvement to the quality of groundwater or surface water resources used for commercial or industrial abstraction only. Minor reduction in potential impact on animal or plant populations.

**Moderate beneficial**: Moderate reduction in potential effects upon human health and safe occupancy of buildings. Moderate local scale of improvement to the quality of controlled waters. Moderate reduction in potential impact on animal or plant populations.

**Major beneficial**: Major reduction in potential effects upon human health. Significant local-scale/ moderate to significant regional scale improvement to the quality of potable groundwater or surface water resources. Major reduction in potential impacts on animal or plant populations.

### 2.5 Limitations, Assumptions and Exceptions

It is important to recognise that contamination can be both widespread and relatively localised, depending upon its source and nature etc. No investigation, however comprehensive, can be expected to determine absolutely the nature and extent of all the contamination which could be present on any site. There will always be an element of uncertainty about the ground conditions including contamination. This potential for currently undetected contamination to be present must therefore be taken into account not only in the impact assessment presented here but also in consideration of future development activities, for example, health and safety planning, financial planning and risk management and in the implementation of the below ground works during construction.


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# 3 Baseline Conditions

This section provides a description of the current baseline environmental conditions of the site with respect to contamination. The area covered within the report includes the land within the site boundary, and any surrounding land which could impact the development or be susceptible to impact as a result of development.

## 3.1 Site Description

The site is located off Butts Lane, Bodelva, Cornwall at a National Grid Reference of 204310,055710. The site is roughly rectangular in shape and occupies approximately 2.81ha. The site forms part of The Eden Project and is termed as 'Tomato'. The site is bounded largely by agricultural (pasture) land with Butts Lane and Carne Cross bordering the eastern and northern site boundaries. The site is currently unoccupied and is covered by a mixture of rough grass, reeds and overgrown gravel hardcore. An area of tarmacadam is located at the gated site entrance in the north-east.

## 3.2 Site History

With reference to historical maps, the site has remained undeveloped since 1882, comprising rough grassland, heath, bracken, woodland and marshes. Up until 1970 the site was divided into five plots, after this date the plots were reconfigured into seven. By 1995 the plot designation had been removed with the ground level of the majority of the site being raised to its existing level at approximately 133.0 to 136.0mAOD. Anecdotal evidence suggests the dumped material should largely comprise soil, shale and building rubble from redevelopment of the former St Austell Rugby Ground into the site of the existing Asda Superstore. The site was identified as a licensed landfill between January 1990 and June 1992 (licensed for inert, industrial, household and special waste (excavated soil, subsoil and rock)).

## 3.3 Geology and Hydrogeology

According to the Geological Survey of Great Britain 1:50,000 Geological Map of Bodmin, Sheet 347 (drift edition) the site is shown as being underlain (in sequence) by Alluvium comprising silty clays, sands, gravels and peat overlying Granite.

The feldspars in the granite in this area of Cornwall are heavily altered to the mineral kaolinite (or locally as kaolin or China Clay) *via* a reaction with geothermal waters known as kaolinitisation (or locally as kaolinisation). This process turns the original hard competent rock, that could be cut and polished, into a clayey sandy material which easily disaggregates in water. Kaolinite has been


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extracted for commercial purposes in this area of Cornwall for over 100 years, and the Pit at the Eden Project once produced China Clay.

The superficial deposits and granitic bedrock underlying the site are classified as Secondary A Aquifers as part of The Groundwater Regulations 2009. The site does not lie within an EA Groundwater Source Protection Zone. The nearest licensed groundwater abstraction is located 133m to the north-east at Little Carne Farm. Groundwater is used for general farming and domestic applications.

### 3.4 Hydrology

Spring fed streams/drainage channels run along the southern and western site boundaries. The channel running to south flows through a culvert beneath The Eden Project access road issuing to the north towards Treverbyn Stream (located approximately 800m N). The channel running at the western site boundary runs into an attenuation pond located in the north of the site, which in turn flows north towards Treverbyn Stream; which has been designated with an Environment Agency GQA Grade of A. A further attenuation pond is located 24m to the northeast of the site.

There are no recorded surface water abstractions located within 1km of the site. The site is classified as being at low risk from flooding (located with in Flood Zone 1).

### 3.5 Ecology

The site comprises a mixture of woodland, hedgerows, semi improved grassland, marshy grassland and dense scrub. The central part of the site contains an area of semi-natural broadleaved woodland, which is protected under a Tree Protection Order (TPO). There are also hedgerows along the western and southern boundaries. The site is currently undergoing an ecological assessment. Please refer to the ecological survey reports submitted in support of the planning application for further information.

### 3.6 Ground Investigations

Table 4 provides a summary of all of the ground investigations that have been carried out at the site. The reports from historical investigations (John Grimes Partnership, 3rd April 2002) have been reviewed in detail and the results presented in the Buro Happold Geoenvironmental Interpretative Report (July 2010) presented as Appendix A. The results from the recent (2010) investigation are also provided in this report. The main findings of these investigations have been summarised in the following sections.


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**Table 4: Summary of ground investigations**

| Company / Date | | Report | Investigation Detail |
|---|---|---|---|
| April 2002 | John Grimes Partnership | Only logs and chemical analysis results provided. | Five trial pits (up to 4.2mbgl)<br>Limited chemical analysis |
| July 2010 | Buro Happold | EGS Eden Geothermal Geoenvironmental Interpretative Report | Four boreholes (up to 50mbgl)<br>Ten window samples (up to 6.0mbgl)<br>Seven trial pits (up to 3.6mbgl)<br>Groundwater monitoring standpipes installed in all 4 boreholes<br>Gas monitoring standpipe installed in 10 window sample holes |

The ground investigations detailed in Table 4 have shown that the geological sequence beneath the site is generally as predicted by the published geological data. This sequence comprises Made Ground overlying in sequence; relic topsoil (including peat), Alluvium (silt, clay and sand) and Granite bedrock.

Made Ground was recorded across the site and exhibited varying characteristics of its landfill origin. The general Made Ground contained variable anthropogenic inclusions including concrete, brick, tree branches, tarmac, plastic and white goods with a maximum thickness of 3.6m. A black layer containing pottery, pipe plastic and a refrigerator was identified between 1.1 and 2.0mbgl was recorded in one trial pit location with a high frequency of woody fragments and tree branches identified in another. Additionally, fragments of sheeting identified as possible cement bound asbestos (chrysotile) containing material were noted between 0.2 and 0.6mbgl in another location.

Perched groundwater was recorded within the Made Ground between 0.50 and 2.82mbgl, with groundwater recorded with the Granite Secondary A Aquifer between 1.83 and 4.17mbgl.

### 3.6.1 Soil Contamination

Contaminant concentrations (including metals, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons) were recorded below commercial industrial screening criteria in Made Ground and natural material.


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With the exception of arsenic and benzo(a)pyrene, all contaminant concentrations were recorded below residential (without plant uptake) screening criteria in Made Ground. The conservative average value (US95) for arsenic was above the residential screening criteria. Only one sample of Made Ground recorded elevated benzo(a)pyrene (4020mg/kg). The Made Ground at this location contained a large proportion of dark coloured branches and wood suggesting partial burning. It was considered that the presence of benzo(a)pyrene was related to the residue of this partially burnt wood and hence this sample was not included in the calculation of the US95. The resultant US95 for benzo(a)pyrene was therefore below residential screening criteria.

Phytotoxic metal (copper and zinc) concentrations were recorded below the relevant screening criteria.

### 3.6.2 Groundwater Contamination

Heavy metals within the Made Ground are not considered to be highly leachable based on leachate results.

No distinguishable odours, visible sheens or light or dense non-aqueous phase liquids (LNAPL / DNAPL) were observed on water purged from any borehole. Some exceedances of screening criteria were recorded in groundwater samples. Of note were elevated concentrations of copper (above Freshwater Environmental Quality Standards) and selenium (above UK Drinking Water Standards).

### 3.6.3 Ground Gas

Ground gas monitoring was undertaken at ten locations across the site on five separate occasions between 25th March and 25th May 2010 (Buro Happold July 2010). Significantly elevated concentrations of methane (up to 69.7% v/v) and to a lesser extent carbon dioxide (up to 18.6% v/v) were recorded over the monitoring period. Consistently very low flow rates were recorded, ranging from -0.2 to +0.3l/hr. The gas regime at the site was designated as Characteristic Situation 2 but require gas protection measures for commercial/industrial developments.

The site is also situated in an area where > 30% of homes within a 1km radius of the site are above the radon action level, and as such, all proposed site buildings will require full radon protection measures and subsequent monitoring.

### 3.6.4 Potential Sources of Contamination

The potential sources of contamination identified from both the desk study information and ground investigations are summarised in Table 6.


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**Table 6: Potential Sources of Contamination**

| Potential Source(s) | Location | Potential Contaminants of Concern/Comments |
|---|---|---|
| Made Ground and fly-tipped material | Onsite | Described as soft to firm sandy clays, clayey sands, clayey silty sandy slate gravels and soft sandy silts. Variable anthropogenic inclusions including concrete, brick, tree branches, tarmac, plastic and white goods.<br>Slightly elevated concentrations of arsenic and benzo(a)pyrene above residential screening criteria.<br>Soil leachability relatively low. Occasional exceedences of copper and selenium recorded in groundwater.<br>Crysotile (White) asbestos identified in one location.<br>Elevated $CO_2$ (max 18.6%) and methane (max 69.7%). Consistently low flow rates (<0.3 l/h). |
| Granite | Onsite | Radon |


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# 4 Predicted Construction Effects

The construction phase of the Eden EGS Plant consists of three phases; (i) the enabling works and (ii) drilling and (iii) construction of the remaining plant. During the enabling works, the topsoil will be scrapped off with temporary haul roads and a concrete drilling platform constructed. Temporary accommodation (for drilling operators), offices, welfare facilities, fuel storage/dispensing and general storage areas will also be constructed. A mud pit / lagoon and cuttings pit will be excavated for use during the drilling works. During drilling, two boreholes will be driven up to 4km into the granite. On completion, water will be pumped down at a rate high enough to create a fracture network in the granite, producing a reservoir which will connect the two boreholes together. Circulating water/brine will then be used to extract energy in the form of heat *via* the Energy Plant. The indicative layout for the construction pl

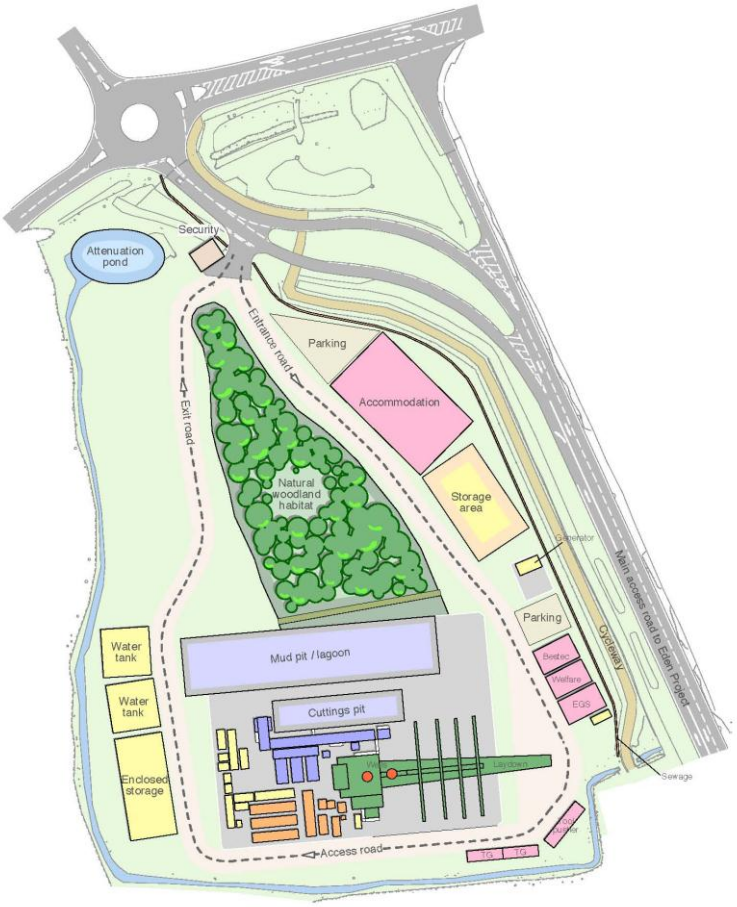



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**Figure 1. Indicative construction phase layout**

Conditions during the construction phase differ from the current situation and operation phases in that materials could be exposed to agents such as water and air that could lead to dispersion of contaminants in the environment and to direct contact with construction personnel.

Site specific source pathway receptor linkages for the construction phase of the proposed development have been considered with respect to the identified contamination sources, the future uses of the site and the potential linking pathways. Site specific receptors and pathways for the construction phase are described in Table.7.

**Table 7: Potential contamination receptor pathways – construction phase**

| Receptor type | Receptor | Pathway |
|---|---|---|
| Human Health | Construction workers / temporary residents | Direct contact and dermal uptake, soil and dust ingestion, dust and vapour inhalation, gas migration/accumulation. |
| | Offsite users (local residents, public, commercial/industrial) | Soil and dust ingestion during enabling works/construction including possible asbestos fibres, ingestion of contaminated water |
| Natural Environmental | Granite (Secondary A Aquifer) | Vertical migration via permeable strata. |
| | Surface Water (including TPO area) | Surface water runoff<br>Vertical and lateral migration via permeable |
| | Flora | Plant uptake due to dust generation |

During the development of the site, construction workers could come into contact with potentially contaminated Made Ground specifically associated with fly-tipped material. All buildings onsite during the construction phase will be raised above the ground preventing the build up and accumulation of ground gases (methane, carbon dioxide and radon).

Site users, adjacent residents and members of the public could be affected by contaminated dust generated by the development works on site unless appropriate mitigation measures are employed. Fire and explosion hazards are present due to the potential migration and accumulation of ground gas (methane, carbon dioxide) both on and offsite. Similarly there is a potential that *flora* both on and


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off-site could also be affected by deposition of dust generated on site, however this impact is considered to be negligible given the low concentrations of phytotoxic metals recorded.

The Granite Aquifer could be affected by the increased leaching of contaminants from the Made Ground if it is disturbed, or the cover thickness is reduced as part of the construction process. It may also be impacted during piling and drilling *via* the creation of preferential pathways, or the driving of contaminants down into the aquifer.

Where excavated, contaminated soil is stockpiled on site, rainwater could percolate through the stockpile and leach contaminants potentially increasing the contaminant loading within the underlying groundwater and surface water features. The use of fuel for machinery (JCBs, piling and drilling rigs), vehicles and generators along with storage of paints and other chemicals/solvents during construction poses a risk to groundwater and surface water from potential leaks and/or spills.

The significance of these identified potential impacts is outlined below Table 8.

**Table 8: Potential construction impacts (before mitigation)**

| **Receptor** | **Receptor sensitivity** | **Impact** | **Magnitude of change** | **Significance of impact** |
|---|---|---|---|---|
| Construction workers / temporary residents | Medium | Health impacts from direct contact, dermal uptake, soil & dust ingestion. | Small | Minor (adverse) |
| Construction workers / temporary residents | Medium | Gas / vapour inhalation, migration & accumulation | No Change | Negligible |
| Adjacent site users and members of the public | Medium | Health impacts from inhalation and ingestion of contaminated dust particles | Small | Minor (adverse) |
| Granite Aquifer & surface water features | Medium | Degradation of groundwater and surface water quality *via* increased leaching and mobilisation of contaminants and surface water run-off | Small | Minor (adverse) |
| Granite Aquifer & surface water features | Medium | Degradation of groundwater and surface water quality *via* fuel spills & other chemicals (e.g. paints & solvents). | Medium | **Moderate** (adverse) |
| Granite Aquifer | Medium | Degradation of groundwater via the creation of temporary preferential pathways, or the driving of contaminants down into the aquifer. | Small | Minor (adverse) |


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| Receptor | Receptor sensitivity | Impact | Magnitude of change | Significance of impact |
|---|---|---|---|---|
| Adjacent Flora | Low | Exposure to phytotoxic contaminated materials (deposited as dust) that could inhibit / prevent plant growth | No Change | Negligible |


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# 5 Predicted Operational Effects

The Eden EGS Plant will be made up of two boreholes, driven approximately 4.5 km into the granite beneath the Eden Project. The rock at that depth is anticipated to be at about 170-190°C; water injected down the first borehole will be returned to the surface at around 150°C *via* the second borehole. The superheated water will be used to generate electricity, *via* a heat exchanger, and will then be returned to the injection borehole at about 70°C. The plant will cover an area about the size of a rugby pitch, and the buildings will be no more than 10m in height. The mud pit/lagoon and cuttings pit will be constructed using reinforced concrete, and will be cleaned out and converted into reservoirs for storage of the water/brine (pumped around the system) should the plant need to be shut down for maintenance. The layout of the operational phase is provided as Figure 2.

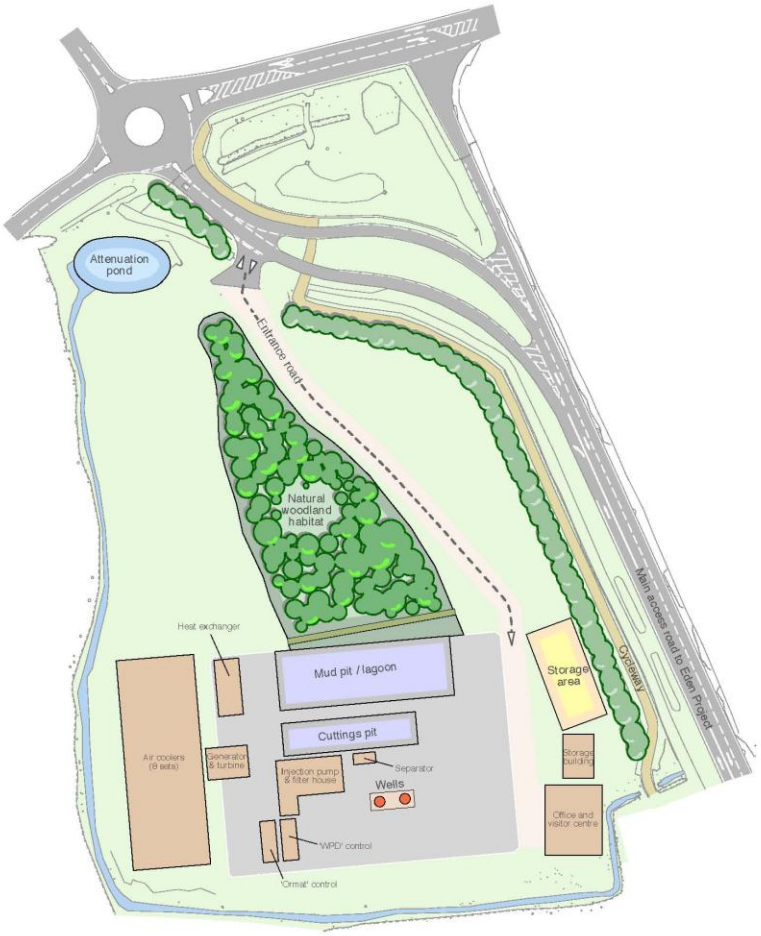



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**Figure 2. Operational phase layout**

Site specific receptors and pathways during the operational phase are described in Table 9.

**Table 9: Potential contamination receptor pathways – operational phases**

| Receptor type | Receptor | Pathway |
|---|---|---|
| Human Health | Site end users –maintenance workers | Vapour/gas inhalation, migration & accumulation (indoor and outdoor air) |
| | Adjacent site users and members of the public | Vapour/gas inhalation, migration & accumulation (indoor and outdoor air) |
| Natural Environmental | Granite (Secondary A Aquifer) | Vertical migration via permeable strata. |
| | Surface Water (including TPO area) | Vertical and lateral migration via permeable strata, surface water run-off |
| Built Environment | Underground services, structures | Direct contact |

Future site users (maintenance workers) could be adversely impacted due to gas migration/accumulation into new buildings onsite. As the majority of the proposed development where maintenance workers will be working will be hard standing (plant buildings etc) the likelihood of uncontrolled exposure with contaminated soil is not considered to differ from the current condition. This impact has therefore been assessed as negligible.

There is the potential for the creation of permanent preferential pathways to be created from the drilling process into the Granite Aquifer, which will allow preferential migration of contaminants from the surface. Pipework associated with the operation of each borehole will be fully cased and grouted (concrete mixture) to the surface minimising the creation of vertical preferential pathways into the aquifer, other than within the pipe. Contaminant concentrations in the near surface soils are unlikely to be highly elevated, hence this impact has been assessed as negligible.

Built structures and infrastructure of the project could be affected by the presence of contaminants in the underlying soils, particularly aggressive determinands (e.g. sulphates, chlorides, acids) certain organic contaminants, soil gases and volatile organic compounds. Typically, where these contaminants are encountered at elevated concentrations, significant erosion of concrete and steel


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foundations can occur along with the deterioration of plastic services such as water supply pipe-work etc.

Similarly future activities of the proposed development during the operation could impact on soil and groundwater conditions beneath the site. Examples of this include the potential for spillage and/or loss from the reservoir. The pumps and plant equipment will be solely electric eliminating the need for fuel storage onsite.

The significance of the potential impacts associated with the operational stage of the project are presented in Table 10 on following page.

**Table 10: Potential operational impacts (before mitigation)**

| Receptor | Receptor sensitivity | Impact | Magnitude of change | Significance of impact |
|---|---|---|---|---|
| Maintenance workers | Medium | Health impacts from gas / vapour inhalation, fire and explosion from gas migration/ accumulation | Large | **Major** (adverse) |
| Granite Aquifer & surface water | Medium | Spillage/loss of water/brine from reservoir | Medium | **Moderate** (adverse) |
| Proposed Buildings | Low | Potential corrosion /damage of building materials and services.<br>Fire and explosion from gas migration/ accumulation. | Small | Minor (adverse) |


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# 6 Mitigation Measures and Residual Effects

Mitigation measures have been derived by assessing the risks to human health and the environment identified in previous ground investigations in accordance with CLR11.

### 6.1 Construction Mitigation Measures

The following mitigation measures (Table 11) will be managed through the site specific Construction Environment Management Plan (CEMP) and associated Working Method Statements (WMS) which will need to be completed prior to construction. The mitigation strategies implemented should be reviewed regularly to best suit the practices currently being undertaken on site.

**Table 11: Construction impact mitigation measures**

| Risk | Mitigation measures |
|---|---|
| Direct contact with contaminants in the Made Ground during site development | Appropriate use of personal protective equipment (PPE) and safe working practices. PPE should, as a minimum, include the use of dust-proof overalls, dust/vapour masks (where appropriate), eye protection and nitrile gloves etc as required. Construction workers should remain vigilant of ground conditions at all times and should report any suspect areas of potential contamination. |
| Health impacts from inhalation and ingestion of contaminated dust particles | During construction phases of work, dust suppression measures should be employed by the contractor as necessary to prevent the potential generation of contaminated dust particles and migration off site. This should include the use of water sprays during dry spells, cleaning up of spills from site vehicles, the use of wheel washes for site vehicles and sheeting of loads for off-site disposal. |
| Degradation of Granite Aquifer and surface water *via* increased leaching and mobilisation of contaminants | Where excavation of grossly contaminated soils (if encountered) is required, stockpiling of this material will be avoided if possible. Stockpiles will be covered when not in use and placed on impermeable sheeting/hardstanding to prevent migration of contaminants into the underlying soils.<br>Pollution control measures will be implemented by the contractor where required and spillage containment will be present on site at all times.<br>Drilling arisings and mud will be temporarily stored in concrete lined lagoons, before being removed for disposal offsite at an appropriately licensed facility. |


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| Risk | Mitigation measures |
|---|---|
| Degradation of Granite Aquifer *via* creation of temporary preferential pathway or driving of solid contaminants into the underlying aquifer during piling and drilling. | A Drilling Method Statement is required from the drilling contractors to ensure appropriate casing and grouting is undertaken.<br>The likely piling method will be driven pre-cast. Contaminant concentrations within the surface material are not highly elevated and therefore a Foundations Work Risk Assessment is not required. |
| Degradation of Granite Aquifer and surface water *via* fuel and chemical spills. | All fuels and chemicals used during construction/drilling will be stored and used in accordance with current regulatory and industry guidance. For example, all fuels will be stored within 110% bunded areas, all chemicals will be stored on appropriately sized drip trays located on hardstanding within dedicated chemical storage areas as a minimum and safe working procedures will be adopted to minimise accidental spillage etc.<br>An oil/water interceptor and surface water drainage system in accordance with current regulatory and industry guidance to be installed between the site generator and fuels storage/dispensing area hardstanding, and also where surface water drainage from the drilling platform discharges into the attenuation pond.<br>Control measures will be implemented by the contractor on re-fuelling activities, storage of fuels and chemicals and vehicle movements and parking.<br>A spill response plan should be incorporated into the CEMP outlining the measures to be implemented by the contractor should an unintentional release of a potentially contaminating substance, this should included methods for containment (such as drain blockers etc), removal (such as absorbents etc), reporting and corrective measured to avoid a repeat occurrence etc. |

### 6.2 Operational Mitigation Measures

In order to avoid, reduce and minimise any significant adverse effects related to the ground conditions across the site, mitigation controls must be considered from the beginning of the detailed design phase. This will enable mitigation to be embedded in the design and therefore reduce the need for active controls during occupation. Based on the existing information, the following measures (Table 12) to mitigate operational impacts have been proposed.

**Table 12: Operational impact mitigation measures**


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| Risk | Mitigation measures |
|---|---|
| Health impacts, explosion & fire from gas/vapour inhalation, migration & accumulation. | Gas protection measures typical of Characteristic Situation 2 (CIRIA 665) will be incorporated into all new buildings onsite.<br>Full radon protection measures required.<br>Appropriate use of PPE and safe working procedures in any below ground/confined space work. |
| Health impacts from direct contact, dermal uptake, soil ingestion. | Construction of clean backfill service trenches, and provision of PPE as required. |
| Potential corrosion/damage of building materials and services | The underlying ground conditions have not been identified as being potentially corrosive to concrete. Specific mixes of concrete (ACEC classification of AC-1d) will be used for building foundations<br>Low concentrations of toxic, corrosive and organic contaminants were recorded in surface material. Suitable pipe materials for water supply etc will be used. |
| Degradation of Granite Aquifer and surface water *via* leaching of stored water/brine in reservoir. | Mud pit/lagoon to be cleaned out and re-used as reservoir for water/brine should the system have to be depressurised during essential maintenance etc. Reservoir to incorporate welded, double skinned minimum 3mm gauge HDPE membrane. |

### 6.3 Residual Effects

Potential adverse impacts identified have been addressed and mitigation measures proposed to minimise the scale of any impact on the receptors. For all of the adverse impacts identified, the residual impact after mitigation has been incorporated will be negligible.

Steps will be taken to ensure that good practice procedures both in construction and health and safety during the site development and any required remediation will be adhered to. Environmental management procedures should be outlined in a site specific Environmental Management Plan (EMP) to be agreed with the Environment Agency and Cornwall County Council prior to commencing the works.


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# 7 Conclusion

There is evidence for potential contamination (although limited) to be present within the soil and groundwater across the site. Additionally, elevated levels of ground gases (methane and carbon dioxide) have been recorded. The presence of this potential contamination gives rise to a number of potential impacts to people and the environment during construction and in the final development. Nevertheless, these potential risks can all be addressed through appropriate mitigation.

The key potential impact during the construction phase is:

- Degradation of groundwater and surface water quality *via* fuel spills & other chemicals.

This potential risk could be mitigated by the adoption of safe working practices such as pre-planned stockpile management; measures to control run-off and leachate collection/treatment (oil/water interceptor) etc, and the storage of fuels and chemicals in accordance with current regulatory and industry guidance. These mitigation measures should be managed through the Construction Environment Management Plan (CEMP).

Key potential impacts during the operational phase are:

- Health impacts to maintenance workers due to gas/vapour inhalation, migration & accumulation; and
- Degradation of groundwater and surface water quality *via* spillage/loss of water/brine from reservoir.

These potential risks to maintenance workers would be mitigated by the incorporation of gas protection measures into all new buildings onsite (required in any case to mitigate risks from radon). Risks to controlled waters can be mitigated by the means of appropriately constructed reservoir ((welded, double skinned HDPE membrane).

Assuming that the proposed mitigation package is adopted; residual impacts from the development are assessed to be negligible.


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# Appendix A – Geoenvironmental Interpretative Report


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