

1 Remediation Options Appraisal – Appendix B

1.1 Introduction

- 1.1.1 A Remediation Options Appraisal (ROA) has been developed based on current regulatory guidance, and to establish the most sustainable and cost-effective method for achieving the remediation objectives. The ROA considers the available techniques, an evaluation of these techniques, and proposed final remediation option or combination of options while considering the environmental setting and proposed access / road infrastructure and laydown area development.

1.2 Remediation Objectives

- 1.2.1 The overall objective is to develop a remediation scheme that meets the requirements of Development Control Order (DCO) Requirement 12 – Contamination and Remediation and improves the land condition to a standard so that it may not be determined as “contaminated land” as currently defined at Section 78A(2) of the Environmental Protection Act 1990 (“EPA”).
- 1.2.2 The site remediation objectives are to identify a shortlist of feasible remediation options that will:
- remove unacceptable risks to human health associated with direct exposure of site employees and visitors to soils containing hydrocarbons, metals and asbestos;
 - remove unacceptable risks associated with migration of free phase hydrocarbons into Swansea Bay foreshore; and
 - Implement a sustainable remediation scheme, which balances the aspiration to reduce waste and maximise materials re-use against the need to minimise impact on the local community in terms of nuisance, health and safety as far as reasonably practicable.

1.3 Human Health – Direct Contact / Ingestion

- 1.3.1 The previous site investigations have indicated that site is predominantly reclaimed land formed by the deposition of made ground which is typical of the industrial land surrounding the docklands area. This includes predominantly silt, sand and gravel (likely to be dredged material) with inclusions of brick, clinker, ash, slag and concrete.
- 1.3.2 The laboratory chemical analysis of soils sampled during previous site investigations included 63 samples from the upper 0.5m out of a total of 190 samples tested. The chemical concentrations that exceeded the generic assessment criteria protective of human health in a commercial land use setting from the 63 shallow samples included lead (12 samples), arsenic (2 samples), nickel (1 sample) and polycyclic aromatic hydrocarbons (3 samples). Furthermore, asbestos fibres were identified in 12 of the 63 shallow samples by microscopic analysis but were below the analytical detection limits (<0.001%) in the subsequent quantification tests. No extractable petroleum hydrocarbon concentrations were measured in the soil samples from the upper 0.5m above the human health assessment criteria.
- 1.3.3 The proposed development assumes that the direct contact pathway between soil and soil derived dust and future human site operatives is mitigated at the position of the new road pavements and junctions. The Contractor Laydown Area and Western

Landfall Area are generally unpaved and therefore human exposure to shallow soils and soil derived dust in these locations is plausible. However, the laboratory chemical results indicate only a small proportion of the soils from the uppermost 0.5m, from which human exposure is most likely, exceed the assessment criteria with averaged concentrations below the assessment criteria. Furthermore, the likely creation of a laydown platform constructed with granular material will act as a cap that reduces the likelihood of the release soil derived dusts from the site soils.

- 1.3.4 The above assessment indicates that the chemical soil concentrations do not represent an unacceptable risk to the health for future site employees or visitors engaged in the Swansea Tidal Lagoon construction project. Therefore, soil remediation for the purpose of protecting the future human health of the workforce from contaminated soils and dusts is not required.
- 1.3.5 Construction and earthworks workers are excluded from this assessment as they are able to control possible exposure risk through risk assessment and mitigation by adoption of code of construction practices.

1.4 Human Health – Vapour Inhalation

- 1.4.1 Hydrocarbon contamination has been detected in the deeper soils, particularly located in the vadose zone above the groundwater as as free phase hydrocarbon product on the groundwater. This hydrocarbon contamination has the potential to generate vapours. However, the proposed scheme includes roads and open contractor laydown areas possibly including temporary containerised offices. Migration of hydrocarbon vapours into enclosed habitable spaces where concentrations could accumulate and represent a risk to health are therefore unlikely. Soil remediation for the purpose of protecting the future human health of the workforce from vapour inhalation is not required.

1.5 Controlled Waters

- 1.5.1 The previous investigations included the laboratory chemical analysis of 22 groundwater samples and the comparison of the results with Environmental Quality Standards (EQS) for coastal and transitional waters or drinking water standards where EQS were not available. The results indicated that metals and petroleum hydrocarbons are detected in the groundwater at concentrations that exceed the selected criteria.
- 1.5.2 The source of the metal concentrations is likely to be leaching from the made ground deposited to reclaim the wider docklands area. The elevated metal concentrations are therefore likely to be commensurate with the regional groundwater quality in the industrial and urbanised area of Swansea. The use of EQS and drinking water standards in the previous assessments is also a conservative approach. Groundwater abstraction for consumption is unlikely from the shallow site groundwater and the EQS are applicable at the receiving water where significant dilution would occur. The risk to the quality of surface water in the immediately adjacent Swansea Bay is therefore reduced and remediation measures to reduce the regional metal concentrations in groundwater as part of this scheme are unrealistic.
- 1.5.3 The identified hydrocarbon contamination is likely to have occurred from the historical operations at the docklands, which was removed in the 1990s. The previous reports advocate that natural attenuation will have been occurring since those operations ceased and will continue throughout the proposed 120-year planned operation of the tidal lagoon. Furthermore, the proposed development does not include significant deep below ground construction or piling that would create preferential pathways.

- 1.5.4 It is acknowledged that free phase hydrocarbon contamination has been detected on the groundwater at several locations within the scheme boundary. This material represents an ongoing source of dissolved hydrocarbon contamination and possible impact to the water quality in Swansea Bay. The removal of free-phase hydrocarbon material would significantly shorten the timescales for natural attenuation to occur and should be the focus of the future land remediation efforts at the site.

1.6 Objective Summary

- 1.6.1 This evaluation has not indicated that the proposed scheme represents an unacceptable risk to human health. Furthermore, many of the detected chemical constituents in groundwater at the site are representative of the wider groundwater quality of the Swansea Bay area and a legacy of the land reclamation and industrialisation of this location. However, the presence of free-phase hydrocarbon product on the groundwater, a legacy of the storage and distribution of hydrocarbon products to marine jetties that ceased in the 1990s, represents an unacceptable risk to surface water quality in Swansea Bay and should therefore be the focus of the remedial effort.
- 1.6.2 The remedial options available and considered in Table 1 below were informed through Atkins' knowledge and understanding of the site, best practicable environmental options (BPEO), stakeholder views, timescales, and wider site-specific factors, such as limited access and structural stability of the jetty.
- 1.6.3 There are a number of approaches that could be used to reduce the mass of free phase hydrocarbons in the site soils and groundwater:
- Engineering solutions: such as excavation and off-site disposal of grossly impacted soils or pumping of free-phase material; or
 - Process-based solutions: typically involving physical, biological, chemical, and thermal treatment processes.
- 1.6.4 It is likely that a combination of technologies along with monitoring and validation will be required. The feasibility of each remediation technique is determined as follows:
- Inappropriate – the technique does not achieve the remediation objectives and does not provide a long-term and cost-effective solution;
 - Achievable – the technique does achieve the remediation objective but is not a long-term or cost-effective solution; and
 - Most effective – the technique achieves the remediation objective and is a long-term and cost-effective solution.

1.6.5 Table 1: Remediation Feasibility Assessment

Remedial Option	Comments on feasibility		Confirmation of feasibility
	Advantages	Disadvantages	
Excavation and ex-situ pre-treatment of soils grossly impacted by hydrocarbons	- Removes the hydrocarbon source from the site and reduces source mass contributing to more rapid natural attenuation of residual concentrations. - Potential to use part of the site to undertake some pre-treatment for the likely limited volumes to reduce concentrations (i.e. windrows). - Easily verifiable by visual assessment and onsite instrument-based monitoring. - Unlikely to significantly impact programme.	- Requires subsequent landfilling if the pre-treatment fails to significantly reduce hydrocarbon mass to acceptable levels allowing onsite reuse. - Generates traffic in local community and beyond if offsite disposal is required. - Import required to fill the voids generated by the excavations.	Most Effective: soils grossly impacted by hydrocarbons, if uncovered during earthworks, can be removed and possibly pre-treated contributing to betterment and reducing timescales for natural attenuation process. Anticipated to be used in conjunction with another remedial option.
Removal of free-phase material from groundwater in existing sampling wells	- Implementation is rapid. - Could remove hydrocarbon mass for a relatively low cost. - Can be repeated over multiple visits and over a long-term while monitoring the rebound. - Results may suggest locations where further delineation and extraction points are needed. - Unlikely to impact project timescale.	Only removes hydrocarbon mass from limited point sources	Most Effective: free phase material on the groundwater and some dissolved phase concentrations can be rapidly removed at low cost reducing hydrocarbon mass and reducing natural attenuation timescales. Anticipated to be used in conjunction with another remedial option.
Bio-remediation (ex-situ)	- Effective at addressing organic contamination. - Suited to granular soils. - Homogeneity of soil improved.	- Relatively slow process. - The presence of gross contamination may impede treatment methodology. - May still require off-site disposal of soils following treatment. - Large treatment area required. - Potential onsite air quality issues.	Achievable: but only for small volumes of grossly impacted soils. Remediation may require longer-term treatment and land area. The treatment technique may not achieve sufficient betterment for onsite reuse.

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Remedial Option	Comments on feasibility		Confirmation of feasibility
	Advantages	Disadvantages	
Solidification / stabilisation (ex-situ)	• Binds the contaminants by reducing leachability. • Inexpensive compared to off-site disposal.	• Potentially increased carbon usage if cement is used. • Requires long term trials and interpretation to demonstrate effectiveness. • Original contaminants remain within soil matrix. • Unlikely to be cost-effective for relatively small volumes of soils. • Time consuming to adopt potentially affecting programme.	Achievable but not considered to be sustainable and cost effective based on the limited volume of material required for stabilisation.
Do nothing	• Does not require energy consumption or use of natural resources. • Does not affect project timescales.	• Source of hydrocarbon impact remains and extends the timescale for natural attenuation. • Possible impact to the foreshore and lagoon impacting water quality and aesthetic impact of the scheme.	Inappropriate based on the objective to reduce free-phase hydrocarbon mass for the scheme.
Cover system	• No advantages identified.	• Cover systems will not contribute to the removal of the free-phase hydrocarbon mass. • Potential land raise. • Significant heavy traffic needed to deliver the capping material and unnecessary use of natural resources.	Inappropriate based on the objective to reduce free-phase hydrocarbon mass for the scheme.
Soil washing	• Can treat a wide range of contaminants.	• Requires a large working area. • Expensive to adopt for the relatively small volumes likely to be encountered during earthworks. • Disposal or further treatment of fines fraction may be required. • Suitable for granular material only.	Inappropriate : due to the high cost and likely low volumes of material for treatment.
Thermal desorption	• Suited to organic contamination.	• High costs of equipment • Significant energy usage • Large treatment area	Inappropriate due to high cost and relatively small volumes of impacted soils.

1.7 Recommended Remediation Techniques

- 1.7.1 The results on this ROA have concluded that a combination of techniques will provide the most appropriate remedial solution to achieve the objective of reducing free-phase hydrocarbon mass from soils and groundwater while shortening natural attenuation timescales and maintaining the construction programme. These techniques include:

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- Removal of grossly impacted hydrocarbon contaminated soils uncovered during earthworks (i.e. when excavating service trenches or reducing ground levels for road pavement construction);
- Possible onsite ex-situ treatment of soils, by windrows or bio-treatments, if onsite space permits. If not, then offsite ex-situ treatment and disposal will be required;
- Multiple visits to remove of free-phase hydrocarbons and significant dissolved phase groundwater contamination from existing sampling wells to reduce hydrocarbon mass; and
- Possible delineation and installation of additional groundwater extraction points if significant free-phase volumes persist in site sampling wells.