



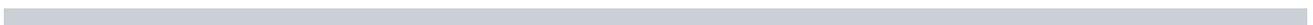
MINISTRY OF DEFENCE

**Defence  
Infrastructure  
Organisation**

## **Dalgety Bay Inspection**

### **Investigation Plan**

**February 2012**



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## INTRODUCTION

### Background

1. The Ministry of Defence (MOD) has offered to assist SEPA further with their inspection of land, beach and foreshore at Dalgety Bay within the red boundary defined in **Figure 1**. The aim is to identify significant pollutant linkages<sup>1</sup> and support on behalf of SEPA the work of the independent Expert Group charged with examining the level of risk to human health and the need for and scope of any further work including remediation. To this end MOD has agreed to develop and deliver a site investigation plan, commonly referred to as a Phase 2 Land Quality Assessment, voluntarily and without prejudice in consultation with both SEPA and the Expert Group, for the area of concern within Dalgety Bay that has been identified by SEPA
2. Ongoing monthly monitoring to the criteria recommended by the Expert Group combined with the warning signs (currently being updated), cordons and information available through the HPA, SEPA, NHS Fife and Community Council is understood to provide suitable and sufficient risk management measures over the short to medium term.

### Aim

3. To provide a focussed assessment of the land quality including the risk to health across the red zoned area presented in **Figure 1** in order to inform the work of SEPA and the independent Expert Group. To do this there is a need to quantify the presence, nature and extent of radium contamination in a logical and rational manner achieving both economy in the expenditure of resources and confidence in the end result.

### Timing

4. Timescales provided for the different investigation stages are indicative only and will be subject to amendment following completion of the initial conceptual site model (Stage 1) and the findings of the investigation components/stages described below. The intention is to complete each investigation stage as quickly as possible.

### Approach

5. In compiling this investigation plan MOD has assumed that those involved in its development and review are familiar with the UK Contaminated Land Regime and its extension to radioactively contaminated land in Scotland through the Radioactively Contaminated Land Regulations 2007 (Scotland). Similarly MOD has assumed that those individuals and groups are familiar with the associated Statutory Guidance, model procedures and UK best practice mentioned below.
6. This plan seeks to build on, rather than repeat, previous work and follow best practice as outlined in the CIRIA Safegrounds Land Management Guide<sup>i</sup> and in other recognised guidance developed for and/or encompassing the management of radioactive land contamination including CLR 11<sup>2</sup>. In undertaking and reporting the investigation MOD will take account of the relevant work undertaken by the Dounreay Particle Advisory Group (DPAG).
7. Preliminary works including a geophysical and topographical surveys have already commenced in advance of the plan due to the time constraints imposed to have a final plan by the

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<sup>1</sup> Statutory guidance states B.33 SEPA should identify all significant pollutant linkages (as defined in paragraph A.22 of Chapter A) as the basis for the determination. All three elements of any pollutant linkage (pollutant, pathway and receptor) should be identified. A linkage which forms a basis for the determination that land is contaminated land is then a "significant pollutant linkage"; and any pollutant which forms part of it is a "significant pollutant"

<sup>2</sup> CLR 11: Model Procedures for the Management of Land Contamination published by Defra and the Environment Agency

end of February 2012. Reports of this work will be provided to SEPA and the Expert Group in advance of any subsequent similar work.

## REVIEW OF PREVIOUS WORK AND GAP ANALYSIS

8. An examination of the work undertaken to date in comparison with established UK best practice identified the following gaps:

- a. Absence of a Conceptual Site Model for the area of Dalgety Bay shown in **Figure 1**. This is required in order to set out and agree the critical viable pollutant linkages of concern. Radium has been found in areas subject to erosion in recent storms. Such areas may provide the principal pathway for material migrating onto the beach.
- b. Requirement for the informed investigation of areas of Made Ground. This requires adequate knowledge of the nature and extent of any historic events that are relevant to addressing the causative mechanisms, such as land re-profiling, that are responsible for the land contamination. Whilst it is understood that recent surveys by SEPA identified areas of made ground near/adjacent to the foreshore that may contain the source of the observed radium contamination; other areas may also have been subject to landfilling etc.
- c. MOD's interests in the former RNAS Donibristle site located adjacent the beach terminated on 30 November 1959, therefore, MOD shall require SEPA (given its powers to investigate) to obtain and release to MOD all information which relates to historical events post MOD occupancy to better inform the investigation plan.
- d. Absence of an agreed risk assessment. Whilst there is no benefit in the duplication of the risk assessment work being carried out by either SEPA or members of the Expert Group; the absence of a risk assessment makes it difficult to determine and justify the need for and scope of any further work. **Figure 2** sets out the process<sup>3</sup> that should be followed according to UK best practice.

As a result this plan seeks to:

- a. Establish the environmental setting and site sensitivity.
- b. Undertake hazard identification and assessment.
- c. Develop an initial Conceptual Site Model (CSM) using the available information. This will show the source of known and suspected radium contamination and the plausible pathways and receptors.
- d. Undertake geophysical surveys to obtain information on ground conditions that will assist in identifying and understanding the nature and extent of any made ground and historic land profiling.
- e. Carry out a series of topographical surveys to provide information on erosion and help establish the nature of current coastal erosion.
- f. Undertake an initial high level review of the coastal processes and sea defences at Dalgety Bay.
- g. Carry out a radiological walkover survey to identify radiation levels at the ground surface.

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<sup>3</sup> CLR 11: Model Procedures for the Management of Land Contamination published by Defra and the Environment Agency

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- h. Use the accumulated information to target radiological monitoring and sampling of soil and fill materials on areas of Made Ground and develop the Sampling and Analysis Plan
  - i. Quantify the presence, nature and extent of radium contamination.
  - j. Carry out radiological monitoring and soil sampling to test the “null hypothesis”.
  - k. Revise the initial Conceptual Site Model to take account of the investigation (Phase 2 LQA) findings. The primary purpose of the investigation is to quantify the presence, nature and extent of radium contamination and identify the viable pollutant linkages.
  - l. Undertake a Tiered Risk Assessment in accordance with current best practice as set out in R&D 66<sup>ii</sup> and NIGLQ<sup>iii</sup>.
  - m. Present the findings to SEPA and the Expert Group.

## METHODOLOGY AND APPROACH

9. A staged approach has been adopted in accordance with current UK best practice and is summarised in the following sections:

### Stage 1a:

10. Utilise the available information to prepare an Initial Conceptual Site Model (CSM); showing the sources of known and suspected radium contamination and the plausible pathways and receptors and develop a Tier 1 Qualitative (Preliminary) Risk Assessment (QRA) to inform the site investigation. The elements of the initial CSM are presented in **Annex A**. A summary of the tiered risk assessment process is presented in **Annex B**.

### Stage 1b:

11. Undertake preliminary radiological, geophysical and topographical surveys to aid in the identification of areas requiring targeted investigation and investigate whether initial planning by MOD and the Expert Group can be practically achieved. These enabling works began in December as detailed in MODs letter to SEPA on 23<sup>rd</sup> December (copied to the Chair of the Expert Group) The geophysical survey was commenced on 24<sup>th</sup> January 2012 and a copy of the draft report is presented in **Annex C**. Ongoing radiological surveys are also being undertaken on a monthly basis which may help further inform the CSM. All the information from this stage will be used to further refine the Tier 1 Qualitative Risk Assessment before progressing to Stage 2 of the investigation plan.

### Stage 2:

13. Undertake the Phase 2 Land Quality Assessment (targeted intrusive and non-intrusive investigation) which mirrors the approach adopted previously within the residential areas of Dalgety Bay. This is likely to involve the following subject to the outcome of Stage 1:

- a. Further topographic surveys to understand changes in geomorphology.
- b. Initial high level review of the coastal processes and sea defences at Dalgety Bay.
- c. Further geophysical surveys to determine areas of ground disturbance and landfilling/raising.
- d. Radiological monitoring surveys.
- e. Targeted intrusive investigation using primarily trial pits in areas of known or suspected radium contamination to confirm the presence, nature and extent and inform the quantification of the environmental and health risks. A number of pits will also be dug to confirm the “null hypothesis” The number, nature, location and extent of trial pitting and sampling will be determined by the findings of the topographical, geophysical and radiological surveys together with visual and historical information.
- f. Development of a Sampling and Analysis Plan.
- g. Facilitating assurance work by SEPA.

### Stage 3:

14. Compile and interpret the Stage 2 investigation findings, revise/refine<sup>4</sup> the Conceptual Site Model in line with the findings and develop a Tier 2 Generic Quantitative Risk Assessment<sup>iv</sup> (GQRA) using the Radioactively Contaminated Land Exposure Assessment Methodology (RCLEA) configured for patchy contamination, should SEPA (and the Expert Group) consider this to be appropriate. In the case of the source of radioactivity being attributed to discrete artefacts then current best practice guidance will be applied. This stage will also involve the consideration of likely coastal movements as a result of erosion and the advice of a coastal engineer will be sought as appropriate.

### Stages 4 and 5:

15. The parties (MOD and SEPA) anticipate that this investigation plan will establish the significant pollutant linkages which together with any necessary DQRA<sup>5</sup> and remediation criteria will inform the identification and appraisal of the subsequent management options including remediation options (if appropriate). This will then enable SEPA to progress the relevant management option(s) with the 'Appropriate Person(s)' bearing the responsibility in whole or in part for mitigating the risks. Included in this is responsibility for any necessary remediation.

16. It would therefore, be premature to develop management or for that matter remediation options prior to the completion of the investigation and risk assessment, establishment of remediation criteria by SEPA (under advisement of the Expert Group) and the determination<sup>6</sup> of the 'Appropriate Person(s)' in accordance with the statutory regime.

*However, further to a recent request from SEPA and in advance of SEPA concluding their determination of the 'Appropriate Person(s)', but on completion of the investigation and DQRA (if necessary) and establishment of remediation criteria by SEPA, MOD will assist SEPA further, without prejudice, by developing Outline Management Options (including what, if any, remediation options may be appropriate) to be taken forward by SEPA with the 'Appropriate Person(s)' and other interested parties including landowners. In the event that the investigation indicates that remediation is required, it will be a matter for SEPA to apportion responsibility for remediation and to agree a remediation plan with all Appropriate Persons. The investigation (which includes the development of outline management options) as set out in this plan will neither constitute a remediation plan nor address responsibility for remediation.*

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<sup>4</sup> In revising the Conceptual Site Model consideration will be given to likely future use of land which is consistent with current planning consents.

<sup>5</sup> Detailed Quantitative Risk Assessment (DQRA) compiled by the HPA and Expert Group and drawing upon the work of the DPAG where appropriate. There is no intention for MOD to duplicate or pre-empt the work of either the HPA or the Expert Group.

<sup>6</sup> It is recognised that in determining appropriate person SEPA will take into consideration all historic events which would have a causative effect in terms of the site being regarded as meeting the definition of Radioactively Contaminated Land.

## CONSTRAINTS AND CONSIDERATIONS

17. The key constraints and considerations that apply to the development of the investigation plan are as follows:

- a. In developing this plan care has been taken to minimise the potential environmental impact and risk of making the situation worse through for instance creating preferential pathways by inadvertently changing depth or orientation of radium particles/point sources.
- b. During the various stages of investigation ongoing monitoring for public health will continue. MOD's aim is to meet the monitoring objectives (criteria) set by the Expert Group. To this end MOD has been trialling and evaluating the practicability of the revised monitoring protocols developed by AMEC which are presented in **Annex D**. As agreed MOD will periodically (every 3-4 months) review the monitoring approach and criteria with the Expert Group and SEPA to ensure the criteria and monitoring are fit for purpose. This will include consideration of whether the criteria should be revised and whether there are any alternative more effective (time, cost, performance) monitoring approaches that could be deployed.. The nature and outcome of any review will be agreed with SEPA and the Expert Group. The successful deployment of the monitoring and other interim measures including the proposed revisions to signage are understood to provide suitable and sufficient risk management measures at this time.
- c. The final scope of the Intrusive investigation work will be informed by the initial CSM and the non intrusive survey work.
- d. The contaminant of concern has been identified as radium 226 by SEPA and the Local Authority. The investigation plan has therefore, been developed within the context of the Contaminated Land Regulations 2007 (Scotland) which has primacy.
- e. Waste disposal issues must be addressed prior to commencement of works as separation of particles from the surrounding matrix risks creating intermediate rather than low level waste.
- f. This plan and its implementation is on a voluntarily without prejudice basis.
- g. MOD's ability to carry through the investigation plan will be dependent upon landowners co-operating and allowing the necessary access to their property. If necessary MOD will look to SEPA to facilitate access using their statutory powers. The intention is to undertake each investigation stage as quickly as possible.
- h. Landowners and other parties with an interest may wish to input in the design of the investigation plan and the development of any subsequent remediation plan. Hence, further development and review cannot be discounted and MOD will look to SEPA to co-ordinate and facilitate the involvement of such parties.

### STAGE 1 (MARCH 2012 TO MAY 2012)

#### Development of an Initial Conceptual Site Model (CSM)

18. The construction of the CSM will document the logic behind both the discounting of the non-viable pathways and receptors and the inclusion of the plausible pathways and receptors

with respect to the source of the radium-226 contamination. The initial CSM will therefore, provide the audit trail necessary to allow those reviewing the model to understand the thought process and rationale. The initial CSM will draw on the information currently available with greatest reliance being placed on finalised and assured reports, data and findings. The elements of the initial CSM under consideration are presented in **Annex A** together with the key uncertainties.

19. The timeframe set out above allows for the completion of information gathering and data collation as a reciprocal exchange of documents between SEPA and MOD is ongoing. As best practice requires an iterative approach, the investigation elements from Stage 2 will further inform the CSM which will be reviewed with SEPA at each stage of the investigation.

### **Tier 1 Qualitative (Preliminary) Risk Assessment**

20. As set out previously the initial CSM presents a representation of the viable source-pathway-receptor relationships (or linkages) on the basis of the identified hazards, in this case the radium-226 particles/artefacts. The aim of the Tier 1 Qualitative Risk Assessment is to establish the nature and magnitude of the potential risk to human health and the environment taking into account: the site situation, whether risks are acute or chronic, the likelihood (probability) of encounter/exposure, uncertainty, sensitivity of the receptor and the severity of the potential consequence. If there is no plausible pollutant linkage then there is no potential significant risk.

21. The Tiered Risk Assessment process is set out at **Annex B**

### **STAGE 2 (MAY 2012 TO OCTOBER 2012) LQA INTRUSIVE AND NON-INTRUSIVE INVESTIGATION**

22. In developing Stage 2 it has been necessary to make a number of assumptions with respect to the outcome of Stage 1. Based on the available information the investigation will comprise the following components and may be subject to amendment following Stage 1:

#### **Topographic Survey**

23. As mentioned above, a preparatory survey was undertaken in December 2011 in order to inform the development of the plan. Repeat topographic surveys will be undertaken on each occasion that Stage 2 monitoring is carried out. This will help gauge the nature and extent of coastal erosion within the areas where this is believed to be the cause of the observed radium contamination on the beach and foreshore.

24. A copy of the topographical survey coverage is provided as **Figure 3a and 3b**. The scope of the topographical survey methodology is presented at **Annex E**.

#### **Geophysics Survey**

25. The results of the preparatory survey by Amec will be used to inform and refine the number and nature of investigation and sampling locations across the zones shown in **Figure 1**. A copy of the geophysical survey is enclosed within **Annex C**.

26. Ground Penetration Radar (GPR) will be deployed to further assist in mapping the extent of disturbed and made ground possibly associated with periods of infilling and land raising activities etc. The maximum depth of investigation (penetration) will be influenced by the composition of soils and fill materials, moisture levels and nature of the underlying geology etc. Whilst the previous GPR signal typically penetrated depths of between 0.5m-2m using a dual frequency system the intention is to penetrate to between 5m-10m bgl based on the findings of recent work undertaken by SEPA in the area of Ross Plantation.

27. A fixed frequency electromagnetic survey and gradient magnetic survey has also been undertaken to aid establishment of disturbed ground and to assist in characterising the composition of infill materials which cannot be achieved using GPR alone. The intention is to undertake further such surveys as part of Stage 2.

### **Radiological Walkover Survey (areas of Made Ground)**

28. The objective of this survey is to obtain a map of radiation levels that can be compared with the results of the geophysical survey to identify areas for further intrusive investigation and sampling and so provide a better understanding of conditions beneath the surface. The nature of any walkover will be determined by the CSM and by a critical examination of candidate monitoring systems which will involve an element of field or laboratory testing. Larger volume detectors offer lower limits of detection but their field deployment can cause logistical problems and the variation in background over the ground surface at Dalgety Bay is an important factor in determining a preferred monitoring system and/or technique. In view of this uncertainty, trial pitting might prove to be the only feasible means of determining ground conditions at some depths of possible concern. A range of options are being investigated, in consultation with SEPA and Subject Matter Experts, and a report of the outcome of this work will be submitted for comment by the Expert Group before the walkover survey begins. Amec's Radiological Walkover Monitoring Protocols for the monthly surveys are presented in **Annex F**.

### **Intrusive Investigation**

29. The number, location and nature of the trial pits necessary to determine the physical characteristics, presence, nature and extent of common strata and structural features within areas of Made Ground will be informed by the geophysical, topographic and radiological walkover survey results, observations and pertinent historical information together with the initial CSM. The anomalies and percentage selected for investigation will depend upon the initial CSM and the physical characteristics of the ground encountered.

30. Whilst there is no industry standard for determining the number of sample points (sampling density) a minimum of 30 trial pits is anticipated at this stage. However, it must be noted that regardless of the number of sampling points a degree of uncertainty will exist.

31. The overarching aim is to delineate the nature and extent of sources of radioactivity namely radium-226 artefacts etc within the ground. All investigation and sampling locations will be logged in accordance with **BS5930<sup>v</sup>**.

32. Similarly a number of locations will be investigated where no evidence of buried radium-226 sources/particles has been identified in order to provide a check on the "null hypothesis".

33. Every effort will be taken to prevent the cross contamination of sampling locations and ensure appropriate reinstatement of trial pits to mitigate any physical hazard and avoid the risk of radium-226 buried at depth being brought to the surface. Each hole will therefore be subject to radiation monitoring during excavation and reinstatement.

### **Sampling, Analysis and Monitoring**

34. The Sampling Strategy and Plan will take account of: the ground conditions, requirements set out within the Safegrounds Guidance<sup>vi</sup>, CLR6<sup>vii</sup> and the recommendations of the Expert Group. The intent is to provide sufficient representative samples to meet the needs of SEPA and the Expert Group. As a general guide it is envisaged that up to 3 samples will be collected per trial hole.

35. Should radium-226 point sources of significance<sup>7</sup> be identified then consideration will be given to repeating the sampling strategy to establish the presence of any residual radiological contamination that might be otherwise masked by such a source. An appropriate Quality Assurance Regime will be in place to provide a check on the accuracy and precision of the sampling and analyses, this will be in accordance with current best practice and verified by MODs Radiological Protection Advisor (RPA). An example of the Quality Assurance Regime with respect to radiological surveys and sample management is provided as **Annex G**.

36. Monitoring procedures will be based on the need to locate and remove radioactive point sources. So as not to increase the hazard posed to operatives, radioactive sources will not be segregated from the surrounding matrix. Excavated material will be placed in suitable sample pots, labelled and the activity concentration determined by weight and the response of hand held instrument used in a standard geometry. The output will comprise maps showing gamma radiation levels at locations identified by GPS and spreadsheets showing the activity concentration of the material removed from each location.

37. All radioactive point sources recovered during the survey will be kept in the onsite authorised radioactive materials store, pending further characterisation (separation of particle from surrounding matrix, activity assessment by gamma spectrometry, photography of source against gridded background) as recommended by the Expert Group in February 2012. The aim is to provide sufficient information to support the work of SEPA and the Expert Group whilst minimising the risk of unnecessary exposure by laboratory personnel etc; and unnecessary expenditure. The recovered sources will be available for further characterisation by MOD and/or SEPA should that be required to inform the risk assessment. Material that is no longer required will be scheduled for disposal.

## **STAGE 3 COMPILE INVESTIGATION FINDINGS, RISK ASSESSMENT AND REVISION OF CSM (OCTOBER 2012 TO JANUARY 2013)**

### **STAGE 3a**

#### **Compile Investigation findings**

38. The findings of the investigation including the data will be compiled and reported as detailed at paragraph 47.

#### **Revise CSM and Update Tier 1 Qualitative Risk Assessment (QRA)**

39. The CSM will be refined on the basis of the site specific data from Stage 2 and reviewed with SEPA. This will be used to confirm or discount the potential plausible pollutant linkages previously identified in the initial CSM. The Tier 1 QRA will be updated. The likely magnitude and probability of harm that may result from an identified hazard (contaminant source) and which receptors will or are likely to be affected will be estimated.

#### **Develop Tier 2 Generic Quantitative Risk Assessment (GQRA)**

40. The Tier 2 GQRA will be developed using RCLEA and relevant guidance as detailed previously in this plan, should SEPA (and the Expert Group) consider this to be appropriate.

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<sup>7</sup> Significance – excess of the statutory limits as prescribed in the contaminated land regime.

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## STAGE 3b

### Outline Management Options (provisional timescale February 2013 to May 2013)

41. Further to recent correspondence from SEPA, MOD will set out within the investigation report outline management options which may include remediation. These must be practical options to address the SPL (Significant Pollutant Linkages) such that the unacceptable risks associated with the radium contamination is addressed. The options should be distinct and range from the 'do minimum' to the 'maximum possible'. Whilst CLR 11 focuses on the identification of options to address individual pollutant linkages the more holistic approach advocated by CIRIA W28 may be preferable as this should produce a more integrated cost effective solution.

42. It may be appropriate to sift the outline options at this stage in order to whittle the number down to a manageable size (ordinarily 3 options would be envisaged). The criteria will include: technical feasibility and practicality. This stage is dependant on the progress of any required Detailed Quantitative Risk Assessment and the establishment of remediation criteria by SEPA.

**Stages 4 and 5 are to be progressed by the Appropriate Person(s) with SEPA and land owners; the timing of this work will be dependant upon the works undertake by SEPA to identify the appropriate person or persons; these stages are outside the scope of this plan but are detailed below for completeness.**

### STAGE 4 DETAILED MANAGEMENT OPTIONS DEVELOPMENT AND APPRAISAL

43. Stage 4 and any subsequent stages comprise the long term management / remediation solutions to the issues identified and confirmed within Stage 3 and any subsequent Tier 3 Detailed Quantitative Risk Assessment (DQRA) or iteration thereof.

44. In identifying the detailed management options the 'Appropriate Person(s)' and interested parties should consider: source removal, pathway disruption and receptor protection as well as the cost benefit of undertaking further site investigation, data collection and risk assessment to reduce the level of uncertainty.

### STAGE 5 MANAGEMENT PLAN DEVELOPMENT AND DELIVERY

45. This stage will be delivered by the 'Appropriate Person(s)' and interested parties in consultation with SEPA taking into account the cost benefit (including socio-economic factors) of implementing the plan.

### PROGRAMME

46. The provisional investigation and reporting programme is presented at **Annex H**.

### DELIVERABLES AND REPORTING

47. A single report that follows the MOD Land Quality Assessment report format will be produced detailing: methodologies, QA and QC protocols, field measurements, trial pit logs, laboratory analyses, a revised CSM, Tier 1 QRA and if required a Tier 2 GQRA. This will be presented to SEPA and the Expert Group.

## FIGURES

Figure 1 Extent of Area for Investigation in Red

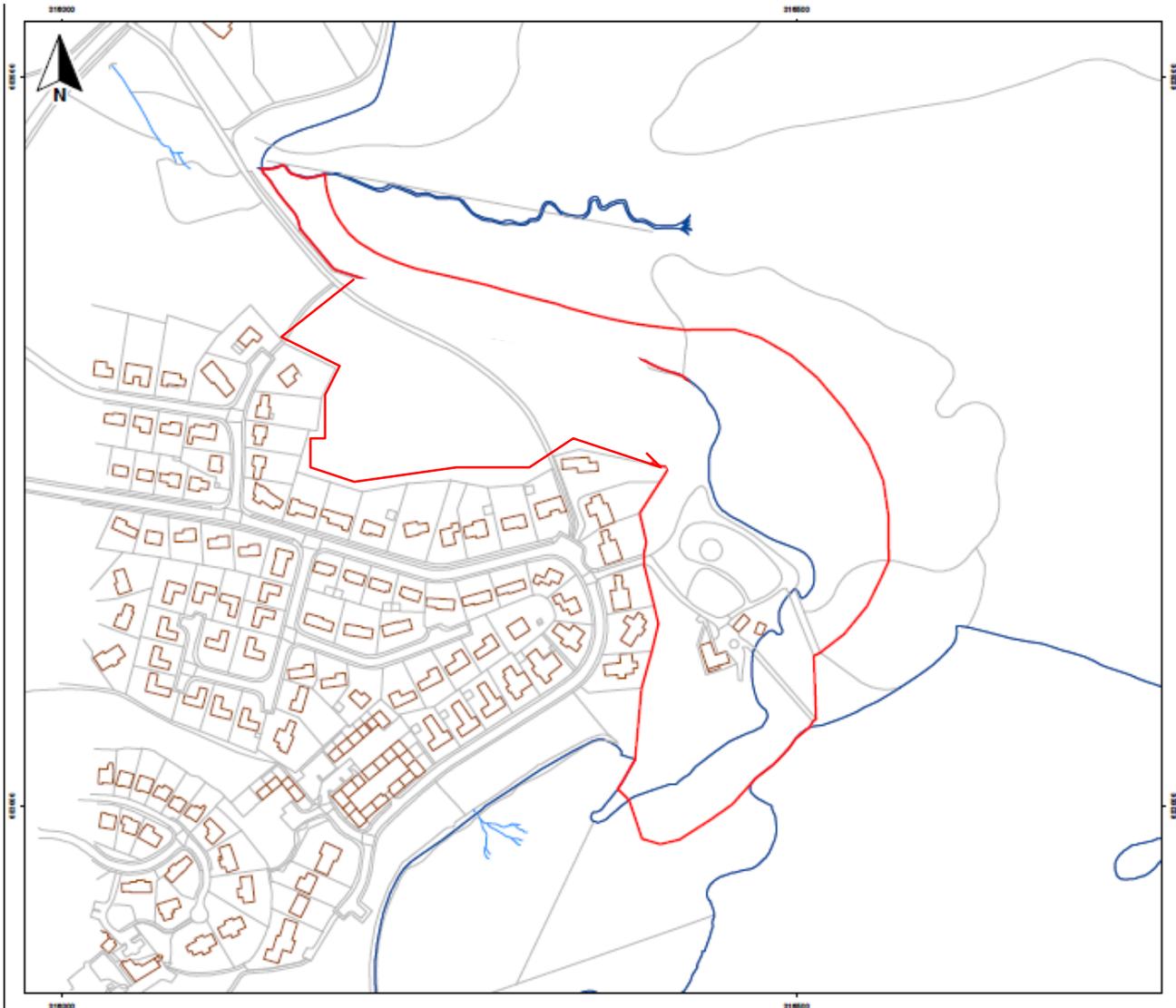
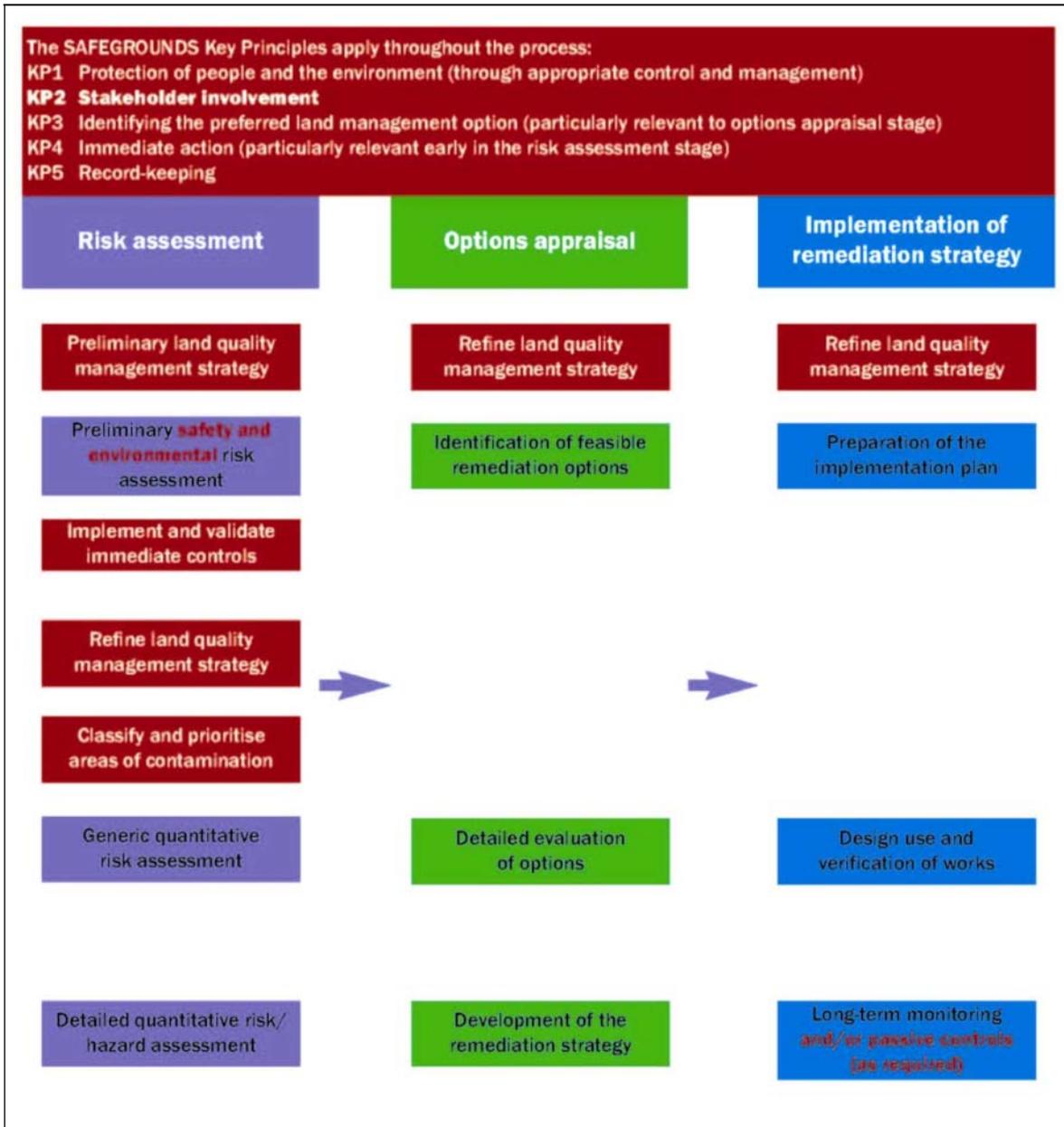


Figure 2 Land Quality Assessment and Management Process



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*Figure 3a and 3b Topographical Survey*

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**DRAFT CONCEPTUAL SITE MODEL (CSM) ELEMENTS**

**Annex A,- Draft Conceptual Site Model (CSM) Elements, Uncertainties and Investigation Actions**

| CSM Element          | Sub-Element   | Key Uncertainties   | Investigation Options already completed on DBSC Site & Beach | Investigation Options on DBSC Site & Beach  | Element Addressed At Project Stage    |
|----------------------|---|---|--|---|---------------------------------------|
| Source / Contaminant | <p>Source and origin of suspected current host material not fully known. Potential for entrainment of other contaminants not fully known. Date and period of transposition of original source to suspected current host material not known.</p> <p>Location and current host material<br/>(Possible presence outside intertidal area; possible presence within the intertidal area)</p> | <p>Location and full extent of suspected host material not known.</p> <p>Location and full extent of suspected host material not known. Potential for host material outwith 'established' site area (i.e. intertidal area, Sailing Club boat park and headland) not fully understood.</p> | <p>Aerial photo review / GIS preparation carried out.</p>    | <p>Investigate Boat Park and eastern extremity of Ross Plantation for physical characteristics and structural features within MG / NG - <i>spatial</i> investigation.</p> <p>Investigation of a number of transects across the beach to evaluate Particle Size Distribution (PSD) of beach sediments and variation with depth. Consider minimally-disruptive intrusive investigation (e.g. geophysical surveys or augers) across beach transects to evaluate presence of anthropogenic horizons on beach.</p> | <p>One and Two</p> <p>One and Two</p> |

| CSM Element | Sub-Element  | Key Uncertainties   | Uncertainty Reduction Measures / Investigation Options already completed on DBSC Site & Beach                          | Future Planned Uncertainty Reduction Measures / Investigation Options on DBSC Site & Beach                     | Element Addressed At Project Stage |
|-------------|--|---|--|--|------------------------------------|
|             | Magnitude / volumes of contamination, and contaminated media.  | As previous sub-elements – definitive location and characterisation information not known. Greater cost for reliable characterisation information from greater depth. Difficulty of assessing contamination presence / magnitude, or precluding presence, at depth. |  | Investigate a proportion of point sources in the Dalgety Bay Sailing Club area - <i>targeted</i> investigation | One and Two                        |
|             | Potential waste categories and waste streams   | As previous sub-elements – definitive characterisation information not known.   |  |  | Three                              |
|             | Source characteristics: isotope ratios, physical aspects (occurrence / inclusions, friability, density, size), size vs. Dose relationship<br>Activity concentration and dose range | Key assumption is that the materials recovered to date, and reported in SEPA, 2008, and Entec, 2010, are a representative sample of the true contamination population.  |  | Laboratory radiometric analysis of a selection of recovered point sources.                                     | Two                                |
|             | Movement of host material (e.g. Coastal Engineering measures)  | Development and movement of materials which may explain location of source material. (e.g. previous additions / changes to coastal engineering measures)  | Topographic survey and condition record of rock armoured coastline. Aerial photo review / GIS preparation carried out. | Physical composition of fill material in areas to rear of rock armour  | One and Two                        |
|             | Emerging Sources due to changes in the environment   |   | Topographic survey and condition record of rock armoured coastline. Aerial photo review / GIS preparation carried out. |  |                                    |

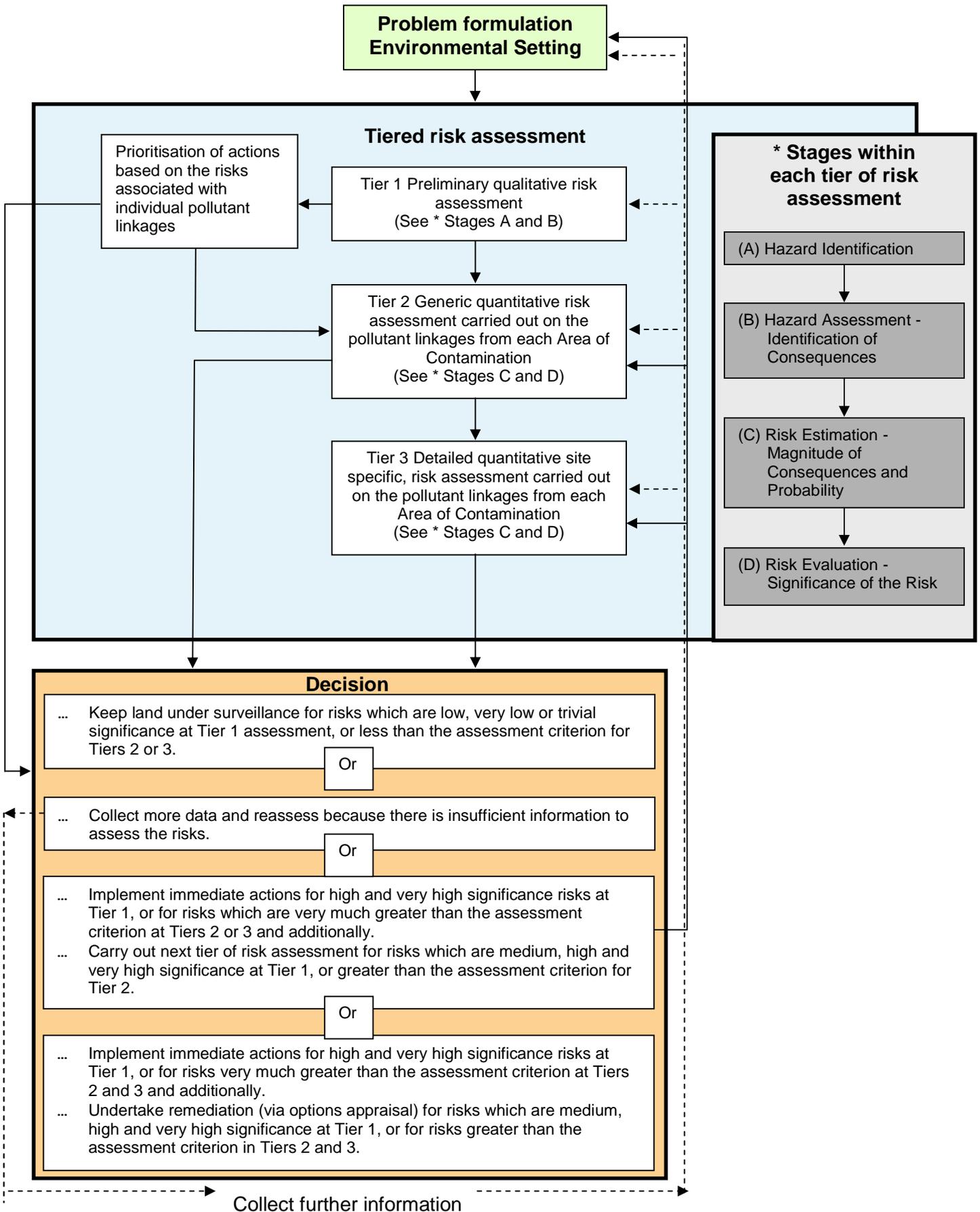
| <b>CSM Element</b> | <b>Sub-Element</b>   | <b>Key Uncertainties</b>   | <b>Uncertainty Reduction Measures / Investigation Options already completed on DBSC Site &amp; Beach</b> | <b>Future Planned Uncertainty Reduction Measures / Investigation Options on DBSC Site &amp; Beach</b>                   | <b>Element Addressed At Project Stage</b> |
|--------------------|--|--|--|---|---|
| <b>Pathway</b>     | Likelihood of encounter (any receptor – not habits or risk based)                                    | Key assumption is that the results of the previous monitoring surveys are representative of (a) the likelihood of encounter across all affected areas and (b) the mode of encounter across all affected areas. |  | Consideration of overall contaminant spatial distribution within site zones, once intrusive investigations carried out. | Two and Three                             |
|                    | Means of exchange between original source, current host material and encounter-available environment | Full dynamics of the headland, beach and intertidal zone not fully understood. Design basis, effectiveness and current condition of the erosion protection measures on the coastline not fully understood.     |  | Comparative topographic surveys as above.   | Two                                       |
|                    | Continuing erosion of likely candidate source areas  | As above   | Topographic survey and condition record of rock armoured coastline.                                      | Several, comparative, topographic surveys to enable volumetric erosion/deposition patterns to be evaluated.             | One and Two                               |
|                    | Continuing erosion and re-disposition of beach   | As above   | Topographic survey and condition record of rock armoured coastline.                                      | Comparative topographic surveys as above.   | Two                                       |

| CSM Element | Sub-Element   | Key Uncertainties  | Uncertainty Reduction Measures / Investigation Options already completed on DBSC Site & Beach | Future Planned Uncertainty Reduction Measures / Investigation Options on DBSC Site & Beach | Element Addressed At Project Stage |
|-------------|---|--|---|--|------------------------------------|
|             | Caches of sources in the environment, and transport potential | Likelihood, location and magnitude of 'environmental' – e.g. point sources that have migrated from their original location and/or host material, as a result of environmental processes – caches of contamination, such as sea-bed contamination, wind-blown fine particulate transport onto land areas etc. |   | SEPA confirmed no offshore caches of point sources   | Three                              |

| CSM Element | Sub-Element   | Key Uncertainties   | Uncertainty Reduction Measures / Investigation Options already completed on DBSC Site & Beach | Future Planned Uncertainty Reduction Measures / Investigation Options on DBSC Site & Beach                     | Element Addressed At Project Stage |
|-------------|---|---|---|--|------------------------------------|
| Receptor    | Current use of affected areas – likelihood of committed dose                                    | Contemporary 'habits' – use of affected areas by potential receptors – to form basis of hazard assessment. Habits survey carried out in the past, reported in SEPA, 2006 (site specific habits information found by that report to be insufficient – NRPB-W41 generalised data used instead). |   |  | Three                              |
|             | Summary of available controls on usual and ad-hoc receptor activities on the affected areas     | Legal and practical ability of a party to exercise control – ownership of beach and other affected areas. Practicality of introducing a reliable control, especially given the current use/benefit/resource value of the site.  |   |  | Three                              |
|             | Ownership of affected areas – likelihood of precluding access                                   | Potential integrating effectiveness of exercising control (i.e. affected area across several ownerships).   |   |  | Three                              |
|             | Habit modifications (e.g. education, signage, means of decontamination on exit)                 | User adherence to specified measures. Potential for additional measures or physical controls.   |   |  | Three                              |
|             | Future use of affected areas – likelihood of committed dose (reference A.27 Statutory Guidance) | Use that is likely to be made of affected areas by potential receptors, which is considered to be consistent with any existing planning permission  |   | Probability Assessment (scope to be considered as part of any required detailed quantitative risk assessment). | Three                              |
|             | Water environment   | Consideration given to the water environment at the request of SEPA.  |   |  | One                                |

**SUMMARY OF TIERED RISK ASSESSMENT PROCESS**

Adapted from the NDA Direct Research Portfolio: Practitioners' Guide TSG (10)0664



**GEOPHYSICAL DRAFT SURVEY REPORT**

**AMEC MONTHLY SURVEY PROTOCOLS**

**TOPOGRAPHIC SURVEY SCOPE (SPECIFICATION) & INITIAL SURVEY OUTPUT**

**AMEC RADIOLOGICAL WALKOVER MONITORING PROTOCOLS**

**AMEC's QA/QC AND SAMPLE MANAGEMENT**

**AMEC's PROVISIONAL PROGRAMME**

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## REFERENCES

<sup>i</sup> SAFEGROUNDS. Good Practice Guidance for the management of contaminated land on nuclear-licensed and defence sites. CIRIA 2009.

<sup>ii</sup> R&D Publication 66: Guidance for the Safe Development of Housing on Land Affected by Contamination, 2008

<sup>iii</sup> Nuclear Industry Group For Land Quality: Qualitative Risk Assessment for Land Contamination, including Radioactive Contamination, 2012

<sup>v</sup> Eurocode 7 2010 and BSI 5930, The Code of Practice for Site Investigations. 1999.

<sup>vi</sup> SAFEGROUNDS. Good Practice Guidance for site characterisation. CIRIA 2009

<sup>vii</sup> CLR 6 Prioritisation and Categorisation procedure for Sites which may be Contaminated. 1995