CONTAMINATED LAND AND RISK ASSSESSMENT: THE BASICS
Necessary Steps Prior to Remediation and Development

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ABSTRACT

Co-incident with the onset of the 2000 – 2006 NDP, the skills and complexities required to communicate risk associated with contaminated land to the satisfaction of the competent authorities have risen considerably. Greater pressures for the redevelopment of derelict and contaminated land are occurring in the major cities in Ireland such as Dublin, Cork, and Limerick. Larger towns such as Kilkenny or Youghal require the remediation of former town gas facilities to make way for new commercial developments. The application of the risk assessment philosophy to contaminated land cleanup in Ireland has increased due to the EPA's involvement in contaminated land/risk assessment networks, such as CARACAS and CLARINET, as well as an overall increasing awareness of risk assessment at an EU level. In the UK there has been Government policy to promote redevelopment of brownfield sites, which has been comprehensively supported by a large suite of documentation and guidance issued internationally (UK EA, US EPA, etc.). This paper summarises the most useful UK EA documents regarding risk assessment procedures and arising remedial strategy. In particular this paper urges that contaminated land specialists in Ireland should implement the Investigation of Contaminated Sites - Code of Practice (BS 10175:2001). Furthermore, it is considered best practice that all contaminated land remedial strategy reports detail a conceptual site model (CSM). The main purpose of this paper is to assist environmental consultants, engineers, hydrogeologists, and contaminated land specialists, in reporting remedial strategy and hence achieve faster regulatory decisions at the EPA and Local Authorities, for the remainder of the NDP period, and beyond 2006.

1. INTRODUCTION

The number of brownfield[1] sites or facilities with contaminated land problems are significantly less in Ireland than those of most other European countries, due to Ireland's relative late arrival into the industrial age. The extent of contaminated land sites in Ireland is modest, in the region of 2000 sites (Brogan *et al*, 1999), occurring in the petroleum retail sector, at various industrial sites, at closed landfill sites, timber treatment yards, scrap yards, railway yards and former gasworks sites.

[1] Brownfields are sites that:
- have been affected by the former uses of the site and surrounding land
- are derelict or underused
- have real or perceived contamination problems
- are mainly in developed urban areas

and require intervention to bring them back to beneficial use.
From: Brownfields and Redevelopment of Urban Areas. 2002. Report prepared by Working Group "Brownfield Redevelopment" of the Concerted Action "Contaminated Land Rehabilitation Network for Environmental Technologies" (CLARINET), funded by the European Commission, DG Research.

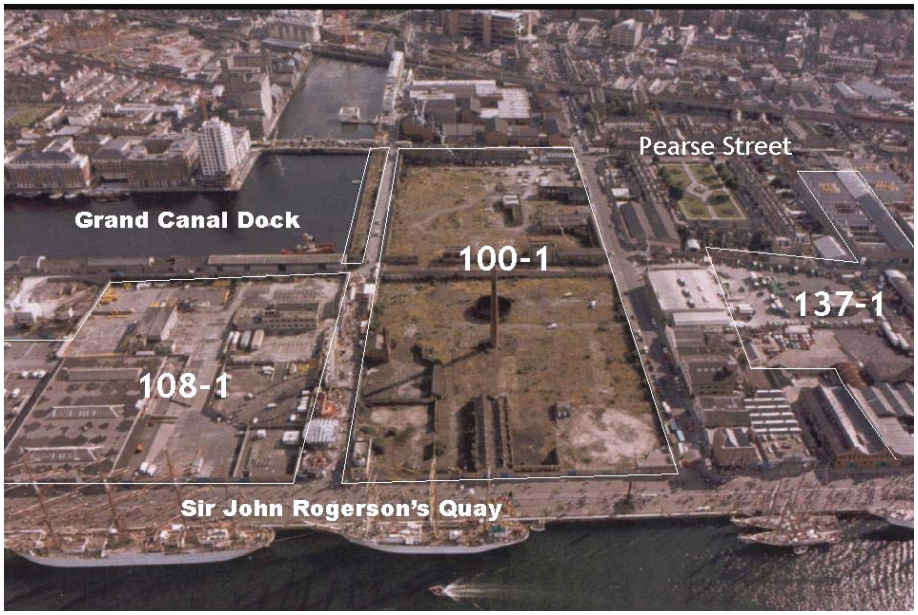
Small-scale developer-driven remediation projects became common during the *Celtic Tiger* economy of the mid 1990s, where the cleanup of contaminated sites, typically petrol stations and miscellaneous industrial/storage yards were undertaken as part of environmental due-diligence requirements.

The EPA has seen an increase in the number of queries arising from environmental consultants, engineers, and Local Authorities regarding contaminated land remediation over recent years, and has written many decision letters notifying proposed remediation projects of waste licence or permit requirements, if any. Too often the EPA receives reports based on Dutch Intervention/Target Values and UK ICRCL (which were withdrawn in 2000 and replaced by CLEA) with no conceptual model of pathway or receptors, and often with no clarity or logic to the proposed remedial strategy. Frequently reports strive to achieve the end result of a clean soil rather than factor in the end use, causing the unnecessary removal of large amounts of soil as a waste. Reports achieving such target values implies that the remediation goal is the recovery of the soil's or groundwater's functional properties to support human, plant and animal life (Nathanial & Bardos 2002), rather than the more practical and sustainable goal of cleanup for an intended use/end user.

The purpose of this paper is to aid interested parties in reporting remedial strategy and hence achieve faster regulatory decisions at the EPA and Local Authorities. Much of the following is based on EPA experience of agreeing remediation strategies at over 30 (IPC) facilities where there is significant contamination and from the processing and assessment of seven brownfield *waste* licence applications into their resultant decisions (Waste Licences 80-1, 100-1, 108-1, 137-1, 164-1, 181-1, and proposed decision 190-1[2]). Each waste facility and six of the IPC facilities have a remediation strategy based on a quantified, site specific risk assessment. Furthermore, the IPC sites are using MNA[3] technology. Figure 1 shows some of the Dublin facilities.

Details on the legal aspects of contaminated land cleanup in Ireland including EPA and Local Authority positions can be found in Doak, Carty, & Lynott (2003).

Figure 1: Aerial view of Sir John Rogerson's Quay Dublin 2, facing south. Outlines show three individual brownfield sites (with their waste licence register numbers) which are/were remediated during 2000 – 2003. 100-1 had up to 15 gasometers, only the original chimney remains, preserved for heritage purposes. 100-1 and 108-1 were successfully remediated – both waste licences were surrendered by EPA decisions in 2002 and 2003, respectively. 137-1 started remediation in summer 2003.



[2] These licences and proposed decision are available to view on the EPA website (www.epa.ie) and their inspector reports are available via the author's email address. (Four facilities in Dublin, two unauthorised landfills in Co.Wicklow, and a gasworks in Waterford).

[3] MNA: Monitored Natural Attenuation.

2. RISK ASSESSMENT AND CONTAMINATED LAND

The Licensing Unit of the EPA has reviewed the UK EA approach to risk assessment and contaminated land, and supports its application in Ireland. The UK EA and National House Building Council (EA & NHBC 2000) note that the safe development of contaminated land for housing can be achieved consistently by applying appropriate risk management techniques[4]. In order for land to be affected by contamination there must be a source of contamination (*ie* toxic substance in the ground), a receptor that can be harmed (*ie* a person's health or a controlled water) and a pathway that the receptor can be exposed to the contamination (*ie* direct skin exposure/drinking of contaminated water). The source-pathway-receptor concept is central to the UK statutory definition of contaminated land[5]. In Ireland the source-pathway-receptor concept has been championed by the Geological Survey of Ireland over the last 10 years (and in particular by Donal Daly, Head of Groundwater Section), where it has been used as a basis for the implementation of the many county scale GSI Groundwater Protection Schemes.

The UK EA consider that where the risk to a receptor is considered to be unacceptably high, the risk needs to be reduced, which normally means that remedial treatment will be required. However, the presence of a contaminant does not necessarily mean that there is a risk of harm to a receptor. The pollutant linkage must be established before the existence of an unacceptable risk can be confirmed. These concepts are more often referred to as the 'suitable for use' principle. The Irish EPA has licensed the five gasworks brownfield projects on a similar *suitable for use* basis, where remediation is achieved by removing or treating the contamination, and/or blocking the groundwater pathway (by cement-bentonite cut-off wall), and protecting the receptor (human health and nearby surface water bodies).

3. RISK ASSESSMENT AT EU LEVEL & ITS COMMUNICATION

A recent European Environment Agency (EEA) report (EEA 2001) on the precautionary principle[6] states that the regulation of scientific uncertainty or unpredicted effects can be managed by risk assessment, where risk is a function of probability theory. They determine that risk assessment is a valid technique to prevent damage to the environment and provides a robust basis for decision-making. However the report concludes that risk assessment may be too narrow in scope to determine general uncertainty (which instead can be accounted for by using safety factors or sensitivity analysis), and cannot account for the possibility of the unknown (ignorance). Moreover, the EEA finds that there is a deep dislocation between regulatory agencies and the public about scientific uncertainty and ignorance. Public surveys in relation to GMOs on both sides of the Atlantic indicate that scientific risk assessment focuses on uncertainties while public concerns centre on ignorance. The EEA considers that the concepts of risk, uncertainty, and ignorance need to be better communicated to the public to regain their confidence in adopting risk assessment and arising remedial strategies:

[4] In 1998, the UK Government set a target of 60% of new homes in the UK to be built on previously developed land (brownfield sites), a significant proportion of which is contaminated and would require remedial treatment.

[5] Contaminated Land, is land that appears to the local authority in whose area it is situated to be in such a condition, by reason of substance in, on or under the land, that significant harm is being caused or there is significant possibility of such harm being caused; or pollution of controlled waters is being, or is likely to be caused. *UK Part IIA Environmental Protection Act 1990* (inserted by Environment Act 1995).

[6] **Precautionary Principle**. From *Communication on the precautionary principle*, EU COM(2000)1 (February 2000). The precautionary principle is not defined in the Treaty, which prescribes it only once - to protect the environment. The precautionary principle should be considered within a structured approach to the analysis of risk, which comprises three elements: risk assessment, risk management, risk communication. The precautionary principle is particularly relevant to the management of risk.

> *'It is for these reasons that the involvement of stakeholders in regulatory appraisal needs to begin at the beginning rather than being artificially confined to the later remediation phases. The stages of hazard and risk appraisal, management, and communication are not sequential, as in the traditional model, but require stakeholder involvement at the earliest stage.'* p 186 (EEA 2001).

The UK Interdepartmental Liaison Group on Risk Assessment has produced an excellent guide to Risk Communication (ILGRA, 1998) including a 'five minute guide for speaking about risk issues – for the harassed manager'. Many companies and consultancies will experience problems with contaminated land and communication with stakeholders. Some common communication problems and suggested solutions are described in eight steps for the UK sector (Wylie *et al*, 2001), and as 'do's and don'ts of written contaminated land communication' in Wehrmeyer (2001).

4. A PROCEDURE FOR RISK ASSESSMENT

The EA & NHBC (2000) report best describes a logical procedure for the risk assessment of contaminated land. The report divides risk assessment into four stages to be carried out before any remedial works begin:

Hazard Identification > Hazard Assessment > Risk Estimation > Risk Evaluation

the details of which appear in Table 1 below, and Diagram 1 overleaf:

TABLE 1: Details of Stage Requirements for Risk Assessment (after EA & NHBC 2000)

Hazard Identification Stage 1a	Hazard Assessment Stage 1b	Risk Estimation Stage 2a	Risk Evaluation Stage 2b
Walkover/Deskstudy Identify Contaminants of Concern	Develop **Conceptual Site Model** (CSM)	Design & Implement Site Investigations Qualitative/Quantitative Risk Assessment Determine risks to human health, surface & groundwater using models such as CLEA, SNIFFER, R&D 20 etc	Evaluate the Critical Receptor and the Risk Management Objectives (human health? prevent pollution of groundwater/ prevent gas migration to buildings? etc) Decide Risk Management Techniques (remedial works)

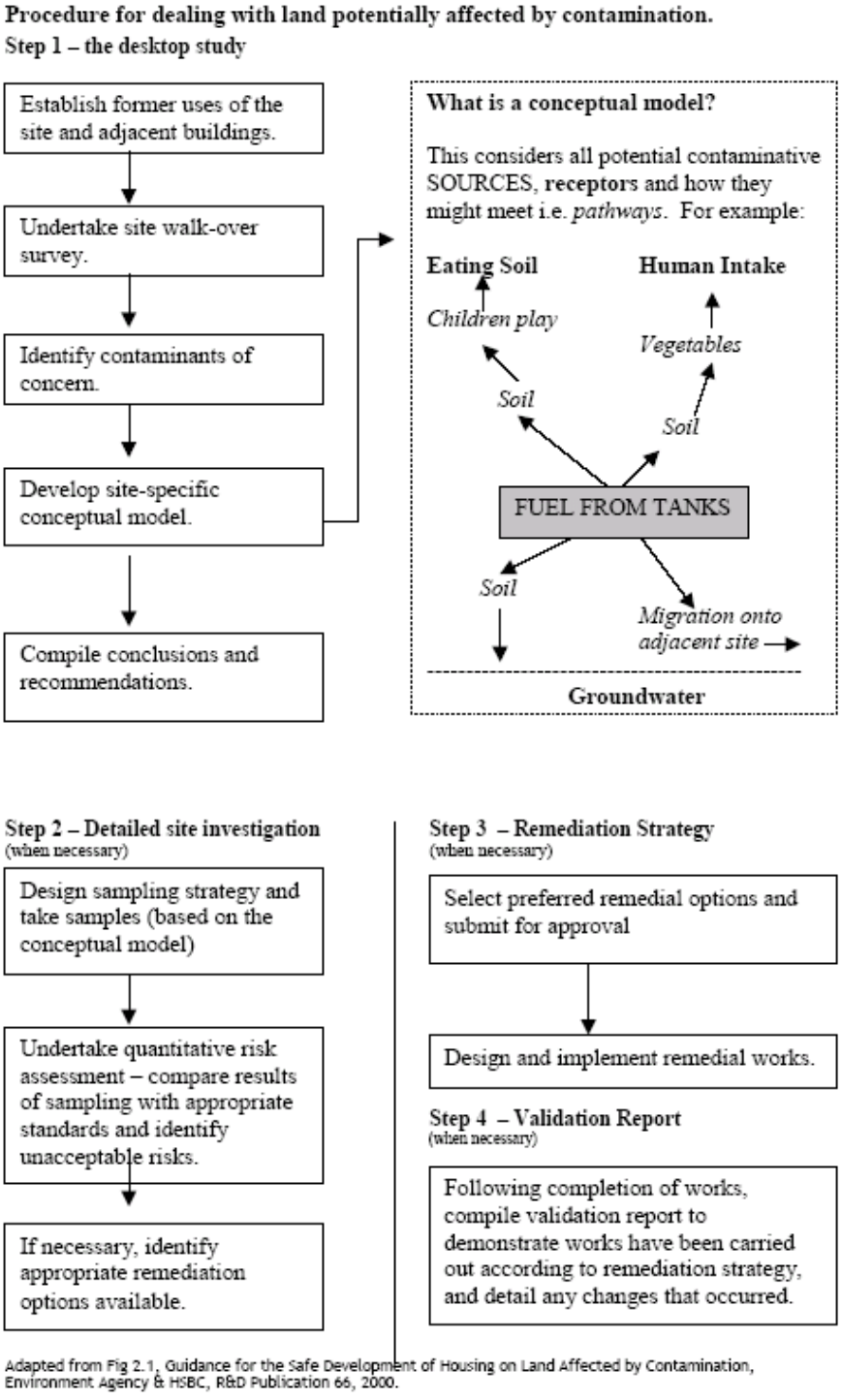
To support the above risk assessment approach, the EA and UK Dept for Environment, Food and Rural Affairs (DEFRA 2002) developed new CLEA (Contaminated Land Exposure Assessment Model) guideline values for a number of parameters in order to determine risks to human health. The CLEA values can be accessed via the UK EA website[7] where there are free model downloads and factsheets. In addition to the assessment of risks to human health the risk assessment procedure should work on other potential receptors identified in the Phase 1 walkover and arising *Conceptual Site Model* such as groundwater, rivers, or an SPA. Again the EA has published tools to aid assessment of risks to waters, namely R&D Publication 20 (EA 1999)[8], and has published consultation documents on ecological risk assessment (EA 2003a). Furthermore the EA has published two other useful documents on hydrogeological risk assessment for landfills (EA 2003b) and the assessment of health risks from petroleum hydrocarbons in contaminated soil (EA 2003c).

[7] www.environment-agency.gov.uk

[8] The European Commission in October 2000 issued a 20-page document on Environmental Risk Assessment for contaminated land (EU Commission, 2000), which is loosely based on the UK EA R&D Publication 20.

The details and guidance to carrying out the field/site aspects for the first three stages (1a, 1b, & 2a) of a risk assessment as outlined in Table 1 are prescribed in British Standard 10175:2001[9]; an important slimline guidance document.

Diagram 1: Procedure for Dealing with Contaminated Land (extract of London Borough Publication UK (page 2): *Contaminated Land. A Guide to Help Developers Meet Planning Requirements*).



Boxes 1 and 2, below, are useful risk definitions and concepts defined in BS 10175. Particular note should be made of the definition of a conceptual model.

BOX 1

RISK ASSESSMENT

Risk:

Probability of the occurrence of, and magnitude of the consequences of, and unwanted adverse effect on a receptor

Risk Assessment:

Process of establishing, to the extent possible, the existence, nature and significance of risk

from BS10175:2001

BOX 2

KEY CONCEPTS to RISK ASSESSMENT

Conceptual Model:

Text/schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the basis of information from the phase 1 investigation and refined during subsequent phases of investigation

Source – Pathway – Receptor

from BS10175:2001

The Irish EPA has proposed a methodology and flowchart for assessing groundwater quality and suggests *interim guideline values* to gauge any remedial action (EPA 2003). Where *interim guideline values* in groundwater are exceeded further assessment will be required by risk assessment.

Recent EPA brownfield licences for the remediation of illegal landfills (*eg.* 80-1) require that a conceptual site model be submitted to the EPA to identify potential contaminants, pathways and receptors, prior to the development of any risk assessment. The risk assessment is required (by a grid system) to scope the necessary remediation strategy and the site specific clean-up target levels. Furthermore, all of the above EA/NHBC procedures and BS 10175 guidance have been implemented by applicants in applying for a gasworks remediation licence at the behest of the Agency. Local Authorities may also require a risk assessment to be carried out at the smaller contaminated land projects they authorise. Figure 2 below, represents the type of schematic conceptual model that the EPA requires.

Overall the EPA has applied all aspects of the EU precautionary principle - risk assessment, risk management, risk communication - into the contaminated land remediation projects it has licensed.

5. THE CONCEPTUAL SITE MODEL AND PRACTICALITIES

The Licensing Unit of the EPA recommends the full implementation of BS 10175:2001 *Investigation of Contaminated Sites - Code of Practice*, and the risk assessment procedures described in Section 4, above. The EPA's main objective is to see that all contaminated land remedial strategy reports detail a conceptual site model (CSM), a proposed remediation design, and a monitoring programme. Detailed guidance on the development of a conceptual model for groundwater - source pathway receptor - is available at (EA 2001).

In practice, the CSM can be used as a simple medium to explain all stages of the risk assessment. The benefits are obvious. A CSM will bring clarity and logic to all discussions between either the client/developer/consultant/regulatory authority. The CSM can be updated throughout the remedial project, and is presented at the end of the project at validation/licence surrender/project completion. Figure 3 is a copy of the CSM submitted for the surrender of Waste Licence 108-1.

Figure 2: Example Conceptual Model for Groundwater from EA 2001. Plan view of groundwater contours, and cross-section view showing source-pathway-receptor.

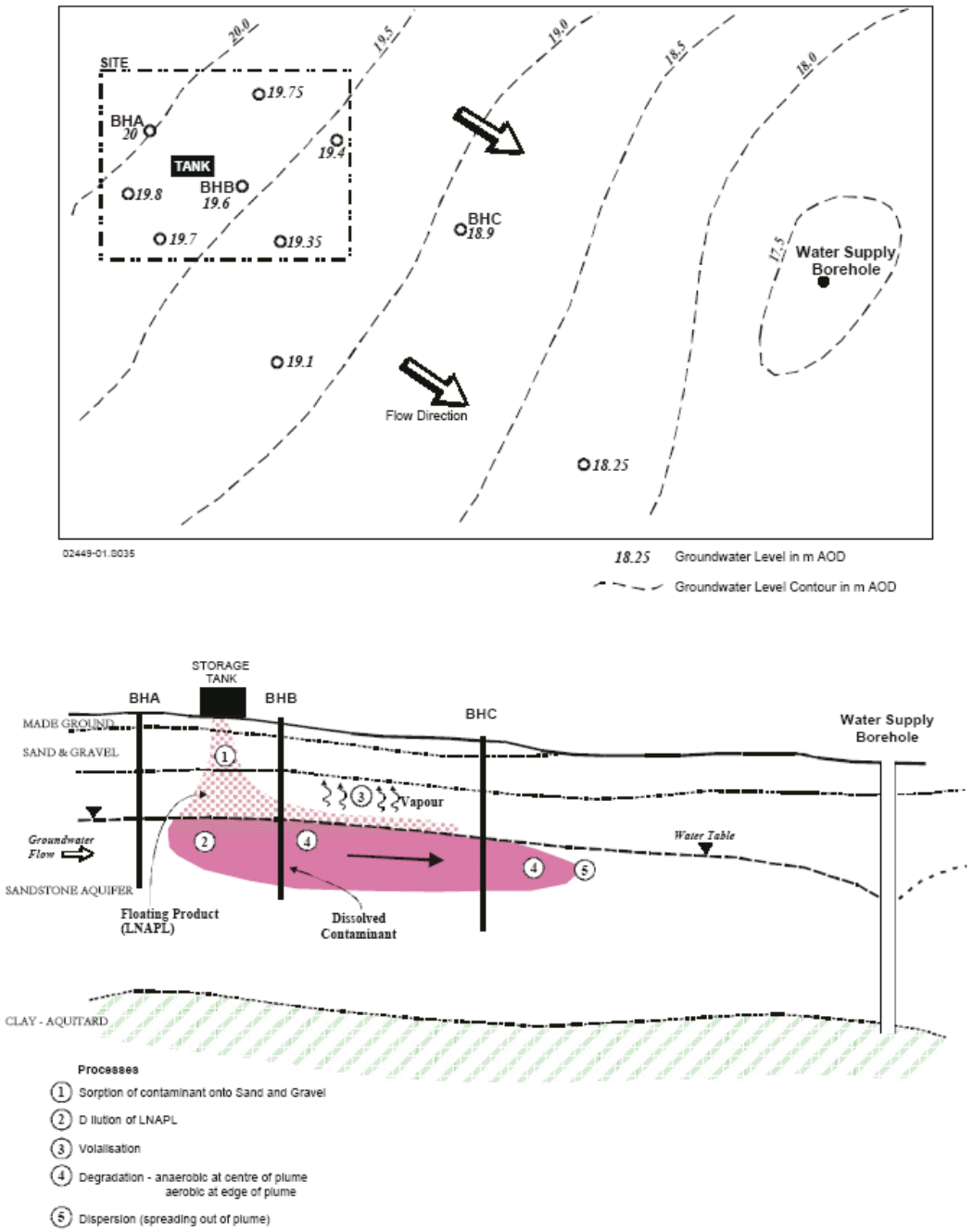
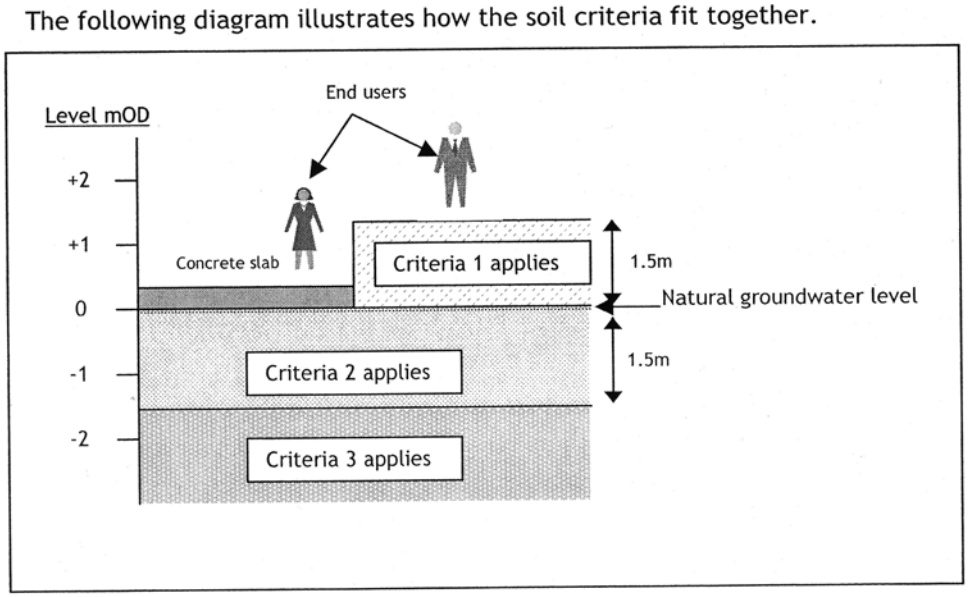


Figure 3: Conceptual Model for the 108-1 DDDA facility in a finished state with three types of soil. Main receptor is human health. The diagram refers to soil criteria (extract of Validation/Surrender report 13 Dec 2002):

- Criteria 1- Imported clean soils or soils from site that meet criteria 1 site action values. Suitable for use as top/subsoil.
- Criteria 2- Soils emplaced below a concrete slab to c. 1.5m depth. Soils are 'cleaned soils' to a value discerned in the human health and/or groundwater risk assessment.
- Criteria 3- Any soils deeper than 1.5m. These soils are not considered to pose a risk to human health. However any leachable substances that may re-contaminate groundwater (when site is flooded) are removed.



6. CONCLUDING REMARKS

The EPA supports the remediation of brownfields particularly in central urban areas to support sustainable economic development, reduce the generation of contaminated soils waste, and help safeguard and improve the quality of life of city citizens.

A key tool for the assessment of cleanup is the development of a *conceptual site model* and a *quantitative risk assessment,* using clear risk based decisions and logic built on the intended future use of the effected and adjacent land. The excavated soils can be treated on-site by permit or licence (if hazardous); or exported from site to authorised facilities in Ireland or Europe. Brownfield remediated sites in Ireland have significant development potential and when remediated, are catalysts for urban regeneration.

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REFERENCES

Brogan, J., Carty, G., Crowe, M., & Leech, B., 1999. Ireland. *In* Ferguson, C.C. & Kasamas, H. (ed.). *Risk Assessment for Contaminated Sites in Europe.* Vol. 2. Policy Frameworks. LQM Press, Nottingham. UK.

Doak, M., Carty, G., & Lynott, D. *The Remediation of Contaminated Land in the Republic of Ireland.* Proceedings Ninth International Waste Management and Landfill Symposium. 6-10 October 2003, (Cagliari), Sardinia , Italy.

DEFRA, 2002. *Assessment of Risks to Human Health from Land Contamination and CLEA.* UK

EA 1999. *Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources*. R&D Publication 20. UK.

EA & NHBC 2000. *Guidance for the Safe Development of Housing on Land Affected by Contamination*. R&D Publication 66. UK.

EA 2001. *Guide to Good Practice for the Development of Conceptual Models and the Selection and Application of Mathematical Models of Contaminant Transport Processes in the Subsurface.* National Groundwater & Contaminated Land Centre report NC/99/38/2. Bristol, UK.

EA 2003a. *Ecological Risk Assessment – A framework and methods for assessing harm to ecosystems from contaminants in soil.* Bristol, UK.

EA 2003b. *Hydrogeological Risk Assessment For Landfills.* March 2003.Bristol, UK.

EA 2003c. *Principles for evaluating the human health risks from petroleum hydrocarbons in soils: a consultation paper.* R&D Technical report P5-080/TR1. UK.

EEA, 2001. *Late lessons from early warning: the precautionary principle 1896-2000.* EEA Environment Issue Report No. 22, Luxembourg.

EPA, 2003. *Towards Setting Guideline Values for the Protection of Groundwater in Ireland – Interim Report.* EPA Ireland.

EU Commission, 2000. *Towards sustainable economic and development cooperation. Environmental Integration Manual (p173 –185).* EU Commission web site.

ILGRA (1998). *Risk communication – a guide to regulatory practice.* http://www.hse.gov.uk/dst/risk.pdf

Nathanial, J., Bardos, P., & Nathanial, P., 2002. *Contaminated Land Management – Ready Reference.* EPP Publications & Land Quality Press. www.epppublications.com. Richmond. UK.

Wehrmeyer, W., 2001. *A Guide to Communicating Contaminated Land Risk.* Land Contamination & Reclamation. Vol. 9, No. 1. EPP Publications. UK.

Wiley, J., *et al* 2001. *Risk Communication for Contaminated Land: Developing Guidelines from Practical Observations and Case Studies.* Land Contamination & Reclamation. Vol. 9, No. 1. EPP Publications. UK.