National Program for Rehabilitation of Polluted Sites in India

Guidance document for assessment and remediation of contaminated sites in India

Volume I - Methodologies and Guidance

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Ministry of Environment and Forests
GOVERNMENT OF INDIA

Volume I

0 Introduction

0 Introduction

0.1 Objectives and scope of this Guidance document

Key objective

The key objective of this Guidance document is to provide different agencies, both Government and non-government, involved in the assessment and remediation of contaminated sites in India with methodologies. These methodologies mainly cover [i] the process for selecting and implementing preferred remediation options and [ii] the technical guidelines and standards that can be applied.

The Guidance document has been developed so that the agencies involved in the assessment, investigation and remediation of contaminated sites on a day to day basis will find it to be a practical manual for years to come.

Scope

This Guidance document is arranged in three Volumes as follows:

- Volume I: Methodologies and Guidance;
- Volume II: Standards and Checklists;
- Volume III: Tools and Manuals.

Volume I guides the user through every step of the assessment and remediation process by providing relevant information, flowcharts, practical guidance and considerations. For standards and checklists the user is referred to Volume II, and for more detailed technical manuals to Volume III. The Guidance document is designed as a standalone reference manual and can therefore be considered to either include or refer to all information relevant for dealing effectively with contaminated sites.

It should be noted that the contaminated site remediation industry in Europe, USA and similar countries has accumulated its knowledge and experience over a period of more than 35 years. It is therefore not intended to capture all that in this Guidance document. By contrast, the Guidance document aims to provide a judicious mix of general overviews and detailed specifications to encapsulate the global practical knowledge and theoretical basis, international industry practices and above all, the great wealth of practical experience around the world for an experienced and trained technical manager in India to take up the next steps of the National Program for Remediation of Polluted Sites (NPRPS).

The document was developed while keeping in mind factors such as [i] the nascent phase the site remediation industry in India is in, [ii] the wide ranging variety and complexity of individual sites and their particular characteristics, [iii] the capacity gaps at different levels, and [iv] the particular interrelation between technical and non technical (legislative, legal, financial) factors typical for India.

Content
The Guidance document covers the entire gamut of technical aspects stakeholders need to address while dealing with a contaminated site in India. Each aspect is dealt with the appropriate degree of general descriptions and specific details. The document presents the complete process of dealing with a contaminated site, from identification through assessment and remediation to delisting, in a sequence of fourteen steps, explains their interrelations, and provides detailed presentation of each of the steps. While the focus is on practical, technical, aspects, wherever relevant reference is made to institutional, legal and financial aspects.

Targeted users: technical and non-technical
The aim of the Guidance document is to provide practical guidance to various types of users by providing references to technical issues they face on a day to day basis. While all professionally involved stakeholders may find the information useful, the Guidance document is mainly aimed at the competent authorities and/or agencies assigned to implement any part of site remediation works.

The Guidance document can be used by a non-industry professional, policymaker or manager, or as a technical manual by those more directly involved in site remediation in India. While the general reader does not need to know anything about site remediation, a degree of familiarity with basic remediation issues is expected from the technical user wishing to explore the details.

The level and complexity of technical details included assumes that the user is trained as an engineer or manager, is dealing with contaminated sites on a day to day basis, and has a background in the fields of one or more of: [i] civil engineering, [ii] chemical engineering, [iii] geology, [iv] hydrology or [v] environmental (waste) management. However, the document is set up in such a way that it is also useful for decision makers and those persons supporting the engineers.

For providing technical guidance and supervision
With the help of the Guidance document a trained engineer should be able to give technical direction to the approach of the assessment and the remediation of a contaminated site. The document will guide such a reader through every step of the assessment and remediation process by providing, among other information, flowcharts, data, checklists, and considerations. Detailed information is included, e.g. in the form of data overviews, checklists and technical manuals. For additional detailed information, e.g. on methods, equipment and models, the Guidance document refers to websites and other documents.

For dealing with contamination, not its prevention
Experience in many countries has led to international consensus that dealing with existing contamination on a site is very different from preventing such contamination in the first place. It is well accepted that the key in prevention is a thorough environmental awareness. For example, at sites where potentially contaminating activities take place, technical measures to prevent hazardous substances from penetrating into soil, groundwater or surface water are necessary. One of the better known of these measures is providing the site with an impermeable floor.

This Guidance document primarily deals with issues concerning assessment and remediation of already contaminated sites. Any technical measures for the protection of soil, groundwater and surface water or for the prevention of further contamination are covered only in passing, where appropriate.

For training and technical capacity building
An equally important intended use of the Guidance document is for initial training and technical capacity building among various stakeholders and agencies involved in the Indian site decontamination industry. While it is impractical to capture in one document many hundreds of man years of global site decontamination experience, the emphasis in the Guidance document is on providing practical knowledge and, quite literally, guidance, to a person involved in the Indian site decontamination Industry.

A non-technical person, for example a policy decision maker, a finance professional or a project manager, may use relevant sections of this document to familiarise him- or herself with the process of identification, assessment and remediation of contaminated sites and how it affects the non-technical decision parameters.

For a technical professional involved in a specific aspect of carrying out, supervising or regulating site decontamination, both organised overviews, adequately contextualised, and sufficient details on those aspects are provided. It is intended that after digesting the specific information provided in the Guidance document, the technical professional may seek further details in the wide ranging references the Guidance document provides.

Terms and definitions – the Glossary
For terms and definitions please refer to the Glossary, presented at the end of Volume I.

0.2 Introduction to contaminated sites

Generally, around the world, it is an accepted practice to describe contaminated sites as areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the near and surrounding environment (see Glossary for the formal definition of a contaminated site).

Such sites often pose multi-faceted health and environmental problems to society. They can adversely impact any or all parts of the surrounding environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, agricultural, recreational, industrial, rural, urban, or wilderness areas. This situation is also applicable in India. This document is aimed at dealing with a broad range of types of contaminated sites occurring in India.

However under NPRPS bio-medical wastes, mining wastes and radioactive wastes have not been considered as these are dealt separately under the relevant Acts and the rules made thereunder. Various elements of the process and content of assessment and remediation, as described in this Guidance Document, can be used for remediation of other types of waste as well.

While it is recognised that legal aspects of the origin of a contaminated site may or may not be clear, the technical issues concerning disposal or dumping remain the same for legal or illegal contamination.

More specifically, the types of sites addressed in this Guidance document are:

- "Point" sites, such as dumps of waste or individual contaminated facilities (an example is shown in figure I-0.1 below);
- "Area" sites, a site within a broader area of ongoing and legacy contamination where the site of concern needs to be addressed in this wider context. An example of this is an individual dump within an industrial area, where there are also other sources of pollution (an example is shown in figure I-0.2 below);
- Municipal dumps, often with an unclear history, which may contain hazardous substances dumped before the municipality gained effective control (an example is shown in figure I-0.3 below);
- Brownfields, which may, or may not, have clear ownership and which have development potential if the contamination problems can be successfully resolved.

Figure I-0.1 Waste material at Ranipet site, typical "point" site

Figure I-0.2 Contaminated land near Eloor, typical "area" site

Waste versus soil contamination

A by product of almost every human activity anywhere is waste, which can manifest itself in countless different forms. Not all waste automatically leads to soil contamination. In fact, when waste is effectively reused, it can actually avert soil contamination. Waste does lead to soil contamination when it negatively affects soil or groundwater or other environmental features. Most often, this is due to uncontrolled dumping or lack of timely suitable remediation measures.

The soil comprises three phases

"Soil" is one of the most universally used every day terms in all societies and often means the same to all users, except maybe in very specific contexts. In this document, soil is considered to comprise three phases, including the organisms living in these phases:

- Solid phase, consisting of the sand, loam, and clay particles, but also including the organic solid elements, like decomposing leaves;
- Liquid phase, consisting of the groundwater;
- Gaseous phase, consisting of the air trapped among the soil particles.

Underwater soil is usually referred to as 'sediment', and also comprises three phases, albeit that the gaseous phase is very small.

Soil contamination can occur in any of these three phases or in any combination thereof. Contamination of the solid phase may be visible, e.g. when hazardous waste has been dumped on top of the soil, or not visible, e.g. when dumped waste was covered. However, contamination of the liquid and gaseous phase is often not clearly visible, and almost always entails specific, sometimes far greater, risks. This is because local soil contamination often spreads relatively easily, thereby contaminating ever larger volumes of soil, groundwater or air.

Figure I-0.3 Municipal Waste dump site of Dhapa

0.3 General description of contaminated sites in India

At the time of writing this edition of the Guidance document the availability of formal data on contaminated sites in India was still relatively limited. An analysis of available data at the time showed that in the sites already formally identified, only a relatively small number of contaminants were present, i.e. mainly heavy metals, pesticides and fluoride. However, it is felt by experts and generally agreed in India that when a comprehensive inventory of contaminated sites is carried out over longer periods of time, the extent of the contaminated sites, the range of contaminants and types of sites can increase substantially. This is the conclusion when considering the size of the country, the extent and diversity of its economy and industry, the industrial and non-industrial processes adopted (which are usually comparable to international processes) and the current practices of handling contamination in different sectors.

Keeping this in mind and taking cues from global practices, a system has been developed for the generic classification of types of contaminated sites in India. All sites identified in India at the time of writing this document could be assigned to a type within this classification system, except in cases where contamination is limited to surface water.

Contaminated site classification system
The proposed classification system distinguishes the following main types of contaminated sites:

- Source related:
  - Type S1: Land bound solid phase contamination
  - Type S2: Water bound sediments solid phase contamination
  - Type L: Land bound liquid phase contamination
- Pathway related:
  - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
  - Type P2: Groundwater contaminations

Depending on the specific situation, a site may fit into more than one of these types. Subtypes are defined where necessary to enable the system to absorb additional specific site characteristics.

This system is, in our view, fully suitable to typify and classify the large number of contaminated sites that may be added to the current inventory in future. The complete classification system is outlined in the explanation of the typology in the Glossary.

0.4 Introduction to the concept of Risks and Intervention

When contaminated sites require intervention: the concept of risks
Contaminated sites can cause risks to human health and to the environment. The extent of risk and the impact of contamination depends on many factors, but key is the probability of contact between the contamination and the surroundings. In case there is no contact between the contamination and humans or the environment the

contamination carries no risk. This is, in all its simplicity, a conceptually important point to keep in mind.

International experience shows that not all soil contamination requires intervention. In the Netherlands, for example, the soil decontamination industry has evolved over the last 35 years and the expertise developed indicates that an optimum exists between the two extremes of decontaminating all contamination at all sites, so as to eliminate all potential risks, or decontaminating only to a certain acceptable level of risk at selected sites. Such an optimum is specific to a country or region and is influenced by many factors, such as the site inventory, characteristics of sites, geography, hydrology, as well as social, cultural, financial and political factors. For India too such an optimum needs to be found. This will involve taking into account considerations specific for India. Experience from other countries is a useful guide in reaching such an optimum balance.

The perception of a "risk" associated with an event or situation depends on a multitude of complex factors. Among these are the context, the observer, environmental factors, time factors, the historical record, the human factor. In view of this, the international site remediation efforts over the years have developed tools and approaches for quantitative assessment of risks associated with a particular contaminated site. These tools and approaches are applicable in India and it is recommended they should be applied.

Risk assessment: the Source-Pathway-Receptor approach

In this context, it is internationally agreed that it is vital to determine the chance that either humans or the environment will get in contact with the contamination. The widely accepted approach for this risk assessment is the 'Source – Pathway – Receptor' (SPR) approach. Within this approach, the source is the contamination, e.g. a leaking oil tank or a layer of pure oil in the topsoil. The pathway is the route between the source and the receptor, and the receptor is a human, animal, plant, ecosystem, property or a controlled water that may be affected by the contamination. An example of the three is shown in figure I-0.4 below. The generally accepted principle is that adverse effects of contamination are only considered to occur when contamination actually threatens humans or resources, i.e. puts them at some substantial risk. This happens only when all of the three elements (source, pathway and receptor) are present.

Figure I-0.4 Source - Pathway - Receptor

Risk from contamination?
An amount of waste is stored on an industrial site (source). Water containing hazardous elements leaches into the soil and into the groundwater, which takes it further downstream (pathway). The contaminated groundwater reaches a well that is used for drinking water by the local community (receptor) → *YES, in this situation there is a risk that the contamination causes adverse effects on human health.* Assessment should be aimed at establishing whether that risk may be substantial, in which case there may be a need for intervention.

In the situation described above the waste is stored in an enclosed space and the water that leaches out is captured and removed in a controlled way to be treated elsewhere (there is no pathway, so the hazardous elements cannot reach any receptor → *NO, in this situation there is no substantial risk that the contamination causes adverse effects on human health.*

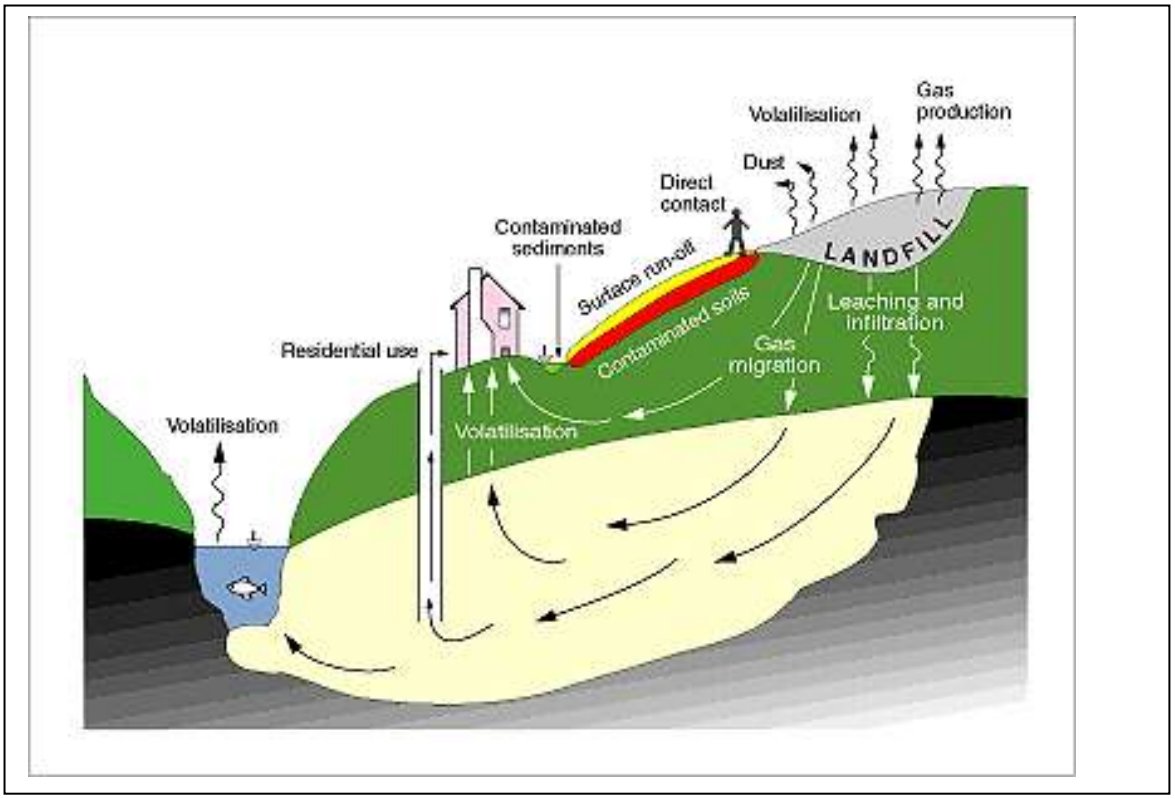
At any given site the exact situation with respect to each of these three elements and their interconnectivities determine [i] the need to intervene, [ii] the points of intervention (start and end), as well as [iii] the focus and the potential types of remediation options. Site assessment should show whether contamination puts human health or the environment at substantial risk. Only in case these risks are deemed unacceptable by the prevailing law or by the stakeholders the need for intervention arises. Only then a process of selection of intervention (remediation) measures needs to be initiated, eventually leading to remediation action.

In various risk assessment methodologies, the contamination (source) is clearly identified, as well as what that source may affect (receptor) and through what route the source may reach the receptor (pathway). It is important to note that receptors may be located on-site as well as off-site, and also that while in a current situation there may be no pathway, this can still develop over time (sometimes long periods), by diffusion through groundwater, surface water, sediment or air.

Most of the available risk assessment methodologies use a tiered approach, which starts with a relatively quick qualitative assessment. If needed this may be followed by a more elaborate semi-quantitative assessment, based on model calculations, and, again if needed, a comprehensive quantitative assessment. A quantitative approach involves actual measurements in contact media, such as indoor air, vegetables or drinking water.

Information for risk assessment: the Conceptual Site Model
No matter what approach is used, input of site data will be needed. Conceptual Site Models (CSM) are commonly used to implement a structured and efficient investigation for risk assessment. Such a model is developed by integrating as much relevant information on the contaminant situation as possible. This helps to understand the mechanics at the site, and may result in an image like the one in Figure I.0.5 below. Volume III-2.2-i presents guidance on how to develop a CSM and its role in the assessment and remediation of sites.

Figure I.0.5 Conceptual model of landfill exposure sources and environmental pathways



Source: Petts, J. and G. Edulgee. Environmental Impact Assessment for Waste Treatment and Disposal Facilities, p. 229. John Wiley and Sons, Chichester, 1994

Socio-economic issues

In addition to the adverse effects to human health and the environment, a contaminated site and its remediation process can cause lesser or greater social and economic disturbance in local and regional surroundings. International experience gives some pointers, which are also applicable to India.

Pollution during remediation

During remediation works, impacts of air and noise pollution on the local communities depend on the duration of the project activities. For example, if the transportation distance for waste from the site to say a landfill site is short the air pollution impact will be less. Higher air pollution impact can be anticipated if a lot of loading and unloading is required for site development. Noise pollution may be due to excavation activity, loading and unloading of waste, transport vehicle movement. Spillage of wastes during transportation may cause negative impacts on the community. However, if proper measures to stabilise the waste are taken this impact will get reduced.

Potential accidents

Transportation by road may cause accidents. This risk increases with increasing transportation frequency and distance.

Land value
Research has found that the public perception of the value of contaminated land is often not in line with reality. The general public usually perceives contaminated land to have hardly any value. In many cases, this perception has created a significant obstacle for redevelopment plans involving contaminated sites. In reality, when redevelopment and remediation plans are integrated from the start, costs for remediation often turn out to be much lower than the value of the land, even prior to remediation. Communication and awareness building may help to reverse this perception.

Business activity, income and employment
Remediating a site may have both positive and negative effects on income and employment of individuals or a group. The larger the remediation action the more positive the long term impact on employment opportunities is likely to be. Development of a site for storage and disposal of waste also generates employment opportunities. In extreme cases of contamination remediation may induce positive health effects. The reduction of the (unpaid) sick leave days may in turn lead to increased income for the local community.

Remediation action may also negatively impact business activity and endanger the livelihood of the local community or part thereof at and near a contaminated site. As a general rule, the impact of long term remediation action is usually significantly higher than the impact of short term remediation action. An example of negative impact of remediation is a clean capping layer, applied as a remediation measure, that renders impossible existing use of a landfill by the local community. In this situation support for the remediation option is likely to be impacted negatively by of the effect on the existing situation. In such a case a proposed solution should include a livelihood for the affected part of the local community.

Socio-economic impact may be direct, indirect and cumulative, depending on the site and remediation characteristics.

Assessment of the socio-economic issues
In each specific case, these and other potential social-economic issues should be assessed through a formal and structured effort. The aim of this effort should be to determine the level of significance of any given issue and a quantification, as far as possible, of the socio-economic costs and benefits. This process entails
[i] identification of the socio-economic issues of the nearby areas, including the type of settlements, and [ii] assessment of the significance of the impact of each issue, either quantified or in qualitative terms like low, medium, or high.

The need for community involvement
It is generally accepted that the community affected by any economic activity, including remediation of a site, has a legitimate right to understand and to be involved in decisions that may affect them. Therefore, close interaction with the affected community, e.g. by public consultation meetings like the one in figure I-0.6 below, is recommended and may also prevent undue concerns about the risks during

remediation or site testing work. Community involvement and consultation is most effective when initiated at an early stage of any remediation project.

Assessment of the impact of socio-economic issues is an integrated part of any site assessment and remediation process. Views of the stakeholders, including the local community, are needed for designing any successful remediation project. The consultation process helps in making the project responsive to social development concerns, and increases the chances of reaching options that enhance benefits for the community while mitigating risk and adverse impacts.

Figure I-0.6 Public Consultation Meeting
(picture by Andra Pradesh Pollution Control Board)

0.5 Guiding principles for decision making

Programme level
A number of guiding principles serve as reference points for international policymakers and programme managers when developing site assessment and remediation programmes. These principles are commonly applied, regardless of geographic, social, cultural and economic contexts. Therefore, these principles can be, with proper review and adaptation to Indian conditions, considered for use as a reference framework for India, at Central as well as State level.

Strategic principles at programme level
Pollution by itself does not usually incite action, it is when risks become apparent that wheels are set in motion. The main guiding principle is always the elimination of or minimizing the risks for human health caused by pollution, with the prevention of risks for the environment following closely. With drinking water being the strategic asset that it is, a guiding principle is the protection of the groundwater quality in aquifers for drinking water storage or with drinking water storage potential.

Typically, the capacity required to assess and remediate the listed sites exceeds the available capacity. In that case, the guiding principle of site prioritisation is applied. A guiding principle of a different nature is the one that states that the notification of sites should be a solid procedure. The reason for this is that notification of a site usually incites stakeholders, including operators, owners, the local community, developers, NGO's and local authorities, to expect that remediation may be implemented in the near future.

Typical strategic principles for a remediation programme

- Elimination of or minimizing the risks to human health and to the environment caused by contaminated sites;
- Protection of groundwater quality in aquifers for drinking water storage or with drinking water storage potential;
- Prioritisation of sites for remediation action, in case the capacity required to assess and remediate the listed sites exceeds the available capacity;
- Development and implementation of a solid procedure for the notification of contaminated sites.

Typical operational principles for a remediation programme

The operational principles for a remediation programme are largely based on the strategic principles. Because the prevention of risks is key, any site assessment and remediation programme will be based on the assessment of risks. The information such assessment yields is needed to establish the risks, to prioritise the sites and to direct remediation action towards the reduction of those risks.

- Assessment of risks and potential risks caused by contaminated sites and by probably contaminated sites;
- Application of the Source-Pathway-Receptor approach, including standard target values for remediation, coupled with risk-based action;
- Implementation of capacity building, e.g. by offering a structure for the systematic acquisition of knowledge and hands on experience;
- Reconnaissance and notification of newly discovered probably contaminated sites.

Individual Site level

Guiding principles are also available for those dealing with an individual contaminated site.

Typical strategic principles for a site specific approach

- Appraisal of remediation objectives, including prevention of further contamination, using generic and site specific criteria (environmental results, technical feasibility/risks, costs, impact of works, available time, spatial planning, social aspects);
- Application of simple, robust and validated site assessment and remediation solutions. Innovative technologies might be considered if these have been successfully applied in well-documented field trials;
- Prioritisation of the reduction of human health risks, as opposed to ecological risks, unless highly valued ecosystems are under threat.

Figure I-0.7 Prevention of actual contaminating activities is important before starting remediation activities

Typical operational principles for a site specific approach

- Whenever possible, application of an integrated approach, i.e. a combination of remediation with reconstruction or redevelopment of the site and/or its surrounding area. In practice, this will usually mean that the remediation design is integrated in the redevelopment plan. In some cases it can be the other way around, when land use planning needs to be adapted to the contamination situation.

  An example of a situation that may call for adapting intended land use to the contamination situation is intended redevelopment of a former dumpsite for toxic waste. Remediation towards a situation that renders the site fit for agricultural or residential use would require high costs, whereas it may be more cost effective to aim the remediation at use of the site as an industrial area.

- Whenever final remediation objectives can be reached in the longer run but not at once, application of a stepwise approach for improvement of the site situation. This under the condition that the most important risks can be brought under control (figure I-0.7) and temporary safety measures are in place where necessary;
- Design and implementation of an iterative sequence of activities for the assessment of contamination and the selection of the most appropriate remediation option. Review of and discussion on intermediate data, results and designs at several stages often leads to the most effective and efficient remediation solutions;
- Focus on assessment activities that provide useful information for the selection of a remediation option and re-use of the site.

0.6 Legal, institutional and financial aspects

At the time of writing this edition of the Guidance document which public institutions should become the competent authorities on the assessment and remediation of contaminated sites was still under discussion. The options under consideration were broadly to either grant this responsibility to the State and Territorial Governments or to establish a new **Remediation of Polluted Sites Authority** at the central government level by the **Ministry of Environment and Forests**. In the latter case, the role of the competent authority on dealing with polluted sites would be vested in this Authority and the Environment Restoration Fund would be managed by the **National Environment Restoration Fund**..

In general terms and in either case, the **Central Pollution Control Board (CPCB)** coordinates site assessment and the compilation of data on contaminated sites, and provides conditions for effective dealing with contaminated sites, like training facilities. On state or union territory level the remediation of sites and their reuse is facilitated by the **State or Union Territory Government**, while site assessment and data management lies with the **State Pollution Control Board (SPCB)** or the **Pollution Control Committee (PCC)**.

The performance of site assessment is usually commissioned to an independent third party **site investigator**, while site remediation is usually performed by a third party **remediation contractor**. Post remediation monitoring can be performed by either a site investigator or a remediation contractor. All are likely to engage an independent accredited **laboratory**, either third party or part of CPCB or SPCB, for the analysis and testing of soil, sediment, groundwater and surface water samples, collected during site assessment or remediation.

This Guidance document could serve as a knowledge base for the technical aspects that are important for all stakeholders mentioned above. The legal, institutional and financial aspects are set out in more detail in the Task-4 report of Assignment 3, ‘National Program for Remediation of Polluted Sites’.

0.7 Steps in the site assessment and remediation process

In this Guidance document the entire process of intervention in a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of fourteen distinct Steps. This set of Steps covers all activities that are performed in dealing with such a site. Wherever applicable, this Guidance document refers to these fourteen Steps. The same Steps, with identical descriptions, are also used in correlation with the non technical aspects, i.e. legal, financial and institutional, of dealing with polluted sites.

The fourteen Steps are visualised in figure I.0.8 and outlined in table I.0.1 below.

Figure I.0.8 The fourteen Steps in the site assessment and remediation process

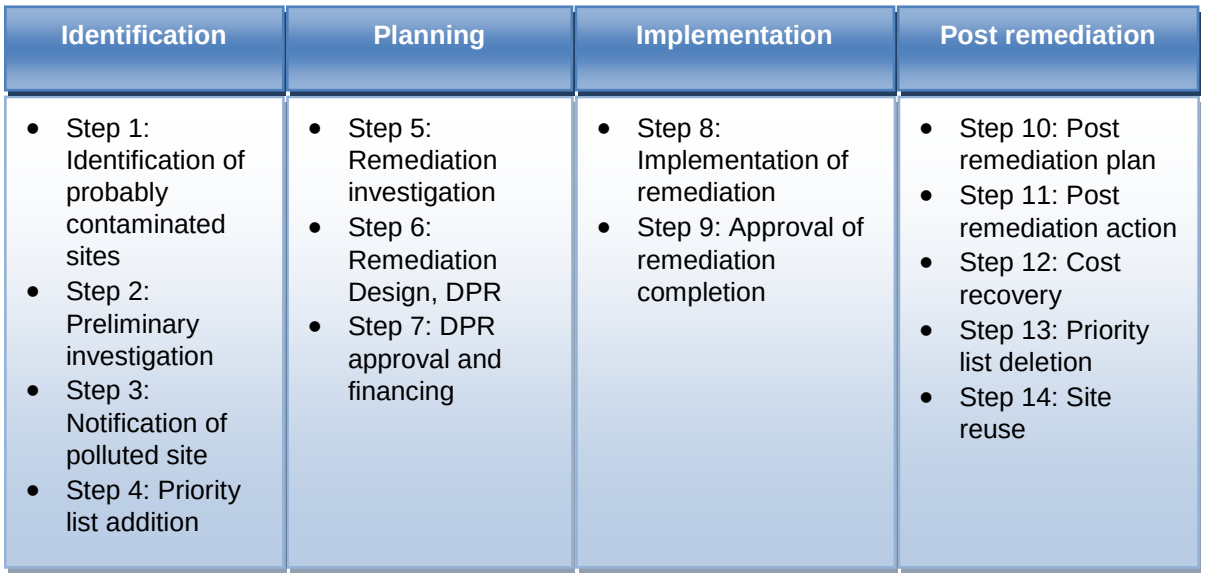


Table I.0.1 The fourteen Steps in the site assessment and remediation process

Step	Title	Concise description
Identification		
1	Identification of probably contaminated sites	A structured procedure for the identification of polluted sites, the collection and systematic computerised storage of data serving that purpose.
2	Preliminary investigation	A preliminary site assessment is performed in a desk study and a site inspection, to confirm types of contaminants present. In case the results of the preliminary site assessment warrant this, a preliminary site investigation is performed. This involves investigation to assess if the site may pose threat to human health and environment.
3	Notification of polluted site	Notification of a contaminated site as 'polluted site' to restrict activities pending final remediation, trace liable parties.
4	Priority list addition	The programme managing activities to rank sites based on the threat to human health and environment.
Planning		
5	Remediation investigation	Detailed site assessment, including risk assessment, is commissioned to provide information for inventorying and designing multiple options for rehabilitation. For each option the (post) remediation target and the recommended approach are described. The potential options will be

Step	Title	Concise description
		assessed using a set of criteria, and as a result of this assessment the optimum option will be selected.
6	Remediation design, Detailed Project Report	The selected remediation option is designed in greater detail, detailed costing and planning is carried out and responsibilities are analysed in a Detailed Project Report (DPR).
7	DPR approval and funding	The competent authority would approve the DPR. Furthermore, the process of raising funds, maintaining funds and disbursing funds for remediation activities.
Implementation		
8	Implementation of remediation	Preparation, commissioning and implementation of remediation works. Supervision and validation investigation during implementation.
9	Approval of remediation completion	Evaluation of the remediation works and approval of the results by the competent authority.
Post remediation		
10	Post Remediation Plan	In case residual contamination remains at the site, post remediation measures are designed to ensure end goals of remediation will be reached. The measures are described in a plan including long term review.
11	Post Remediation Action	The site is monitored periodically to ensure pollution limits are within the values as determined by the end goals of final clean up report and that the land is being used for the purpose as permitted by the end results. If necessary active maintenance measures are taking place.
12	Cost recovery	Any costs, fees and penalty that have not been paid in advance or recovered from responsible person would be recovered either by enforcing financial security or through the recovery process of arrears of land revenue or public demand.
13	Priority list deletion	Upon completion of remediation activities, the site is marked in the database as 'remediated'. If necessary monitoring activities may continue.
14	Site reuse	Reuse of the site after approval of remediation results.

0.8 How to use this Guidance document

Document structure
This Guidance document is organised as a set of documents, arranged in three Volumes:

Volume I	Methodologies and guidance
Volume II	Standards and checklists
Volume III	Tools and manuals

This **Volume I** is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

Volume II contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I. Therefore this Volume I document should be used in conjunction with the other two Volumes.

Volume III contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for fieldwork and laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.

Effective use of this document
In Volume I the user will find guidance on the performance of every one of the fourteen Steps in the site assessment and remediation process. The structure of the document seeks to aid the user to quickly familiarise himself with the essence of every Step, after which he may refer to the guidance on the activities to be performed.

Each of the next Chapters presents guidance to a single Step. For quick and easy reference the numbering of the Steps corresponds with the Chapter numbering. For example, Step 5, Remediation investigation, is presented in Section 5. More complex Steps have been subdivided in Tasks, presented in Subsections. For example, Step 5 consists of five Tasks, presented in Subsections 5.1 through 5.5. This means the

user may find guidance on the performance of Task 5.3, Setting remediation objectives, in Subsection 5.3, and so on.

The user who wishes to quickly grasp the sequence of steps may refer to the Overview of the Guidance document, on the fold out page at the end of this Volume. Should he wish some more detail on the different steps he may combine this with the introduction to every Step, invariably presented in the first part of every Section. For example: the introduction to Task 5.3 may be found in Subsection 5.3.1, the introduction to Task 5.4 in Subsection 5.4.1, and so on.

The user who wishes to be guided in the performance of a particular Step may refer to the Section describing that Step. Every Section is invariably structured as shown below.

Presentation of description of Steps and Tasks in Volume I of Guidance document

- Section 1: Introduction to and scope of Step
  - Brief summary of the Step;
  - Flowchart showing the position of the step in the process;
  - List of the activities to be performed within the scope of the Step;
  - Brief reference to the parties responsible for performance of the activities.
- Section 2: Guidance for performing the activities of Step
  - Description of the activities to be performed;
  - References to Volume II for standards and checklists, to Volume III for manuals and tools, and to external sources for more detailed information supporting performance of the activities;
- Section 3: Step output
  - brief summary of the output the Step should result in.

For guidance on a particular Task the user may refer to the outline above, while reading ‘Subsection’ for ‘Section’.

Volume I

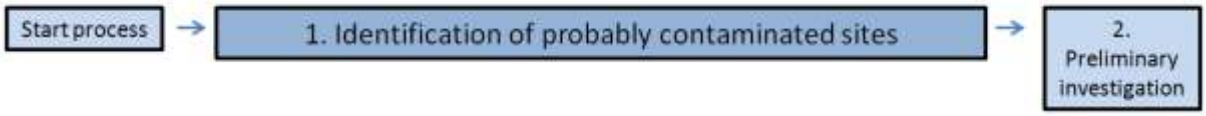
Step 1 Identification of probably contaminated sites

Step 1: Identification of probably contaminated sites

1.1 Introduction to and scope of Step 1

General description and connection to other Steps

Step 1 concerns the identification of probably contaminated sites as defined in Box I-1.1. In this Step 1 a decision can be made whether or not a site may be regarded as a probably contaminated site requiring further investigation.
This is the first step in the process of assessment and possible remediation of a contaminated site. The figure below shows how this step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation.



Activities

Within this step the following activities are to be performed:

1) The collection of information on probably contaminated sites (for example any existing site investigation reports, regulatory records, petitions, or complaints);
2) The verification and evaluation of the information obtained. This may also require a site visit.

Box I-1.1 Definition of a probably contaminated site

A probably contaminated site is an area (whether or not delineated) where the presence of contaminants is suspected but not conclusively determined or where contaminants exceed specified standards but the threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity is not conclusively established.
A probably contaminated site may require further investigation to establish whether it is a contaminated site that requires remediation.
The area may consist of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.

Responsible Parties

The activities in this step are typically carried out by technical specialists within the competent authority for the assessment and remediation process. If a specialized agency/consultant is appointed to review the information this should be supervised by the competent authority.

The team involved should demonstrate in-depth knowledge and experience of hazardous waste production associated with industrial processes, and of the environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability).

1.2 Guidance for performing the activities of Step 1

This section presents concise guidance for the performance of the activities within Step 1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Data Collection

Information regarding probably contaminated sites may be derived from reactive or proactive processes.

In a reactive process of Data Collection the competent authority may receive petitions, reports, complaints etc. from local or state level agencies, government agencies, the general public and NGOs. Some examples to illustrate which information may be received:

- Reports on the production, treatment, transport and disposal of hazardous waste, by private parties, including operators and land owners, members of the public or government agencies.
- Petitions or complaints on the suspicion of presence of hazardous materials or substances at a site, by the public or local government agencies. This may include reports on nuisance caused by odour or dust, or visual evidence of the presence of waste material.
- Complaints, through various governmental organisations. These complaints should be forwarded to the competent authority.

Figure I-1.1: coloured tap water, indication of contaminated ground water

The use of a standardised petition format will improve the completeness and quality of the information necessary for submission of a well-founded petition (refer *Example Petition format for identification of probably contaminated sites, Volume II-1-a*).

In a proactive process of Data Collection the data are gathered through a structured process for systematic information collection by the competent authority. This kind of information may be obtained following reviews of:

- hazardous waste registers regarding generation, transport, treatment and disposal of hazardous waste;
- the locations of municipal solid waste dumps;
- records of government agencies that own or control land;
- regional plans and development plans regarding spatial planning;
- industries regarding change of land use.

Activity 2 – Data verification and evaluation

The data obtained during the Data Collection should be verified and evaluated. The initial step is to establish whether the data contains sufficient information to warrant any further investigation of the site or not. The data needed to make this decision is described in the *Checklist relevant data for identification of probably contaminated sites, Volume II-1-b*. In the event there is insufficient data, or data of insufficient quality, to make the decision, then more data should be collected.

Verification of data can be done by collecting information independently from the person or organisation responsible for submitting the original petition, report or complaint. Often, a brief site visit may be beneficial to enable a visual verification of the situation by the reviewing team. Interviewing relevant stakeholders usually yields information that will at the very least provide colouring to the previously collected data. In addition, information by stakeholders will prove useful in the verification of these data. At this stage, interviews can generally be limited to local stakeholders, whom may be interviewed during the site visit.

Stakeholder	**Interview objective**	**Level**
Site owner	collect information, verify data	site
Site operator	collect information, verify data	site
Local businesses and residents	collect information, verify data	site and direct vicinity

Figure I-1.2: Site visit

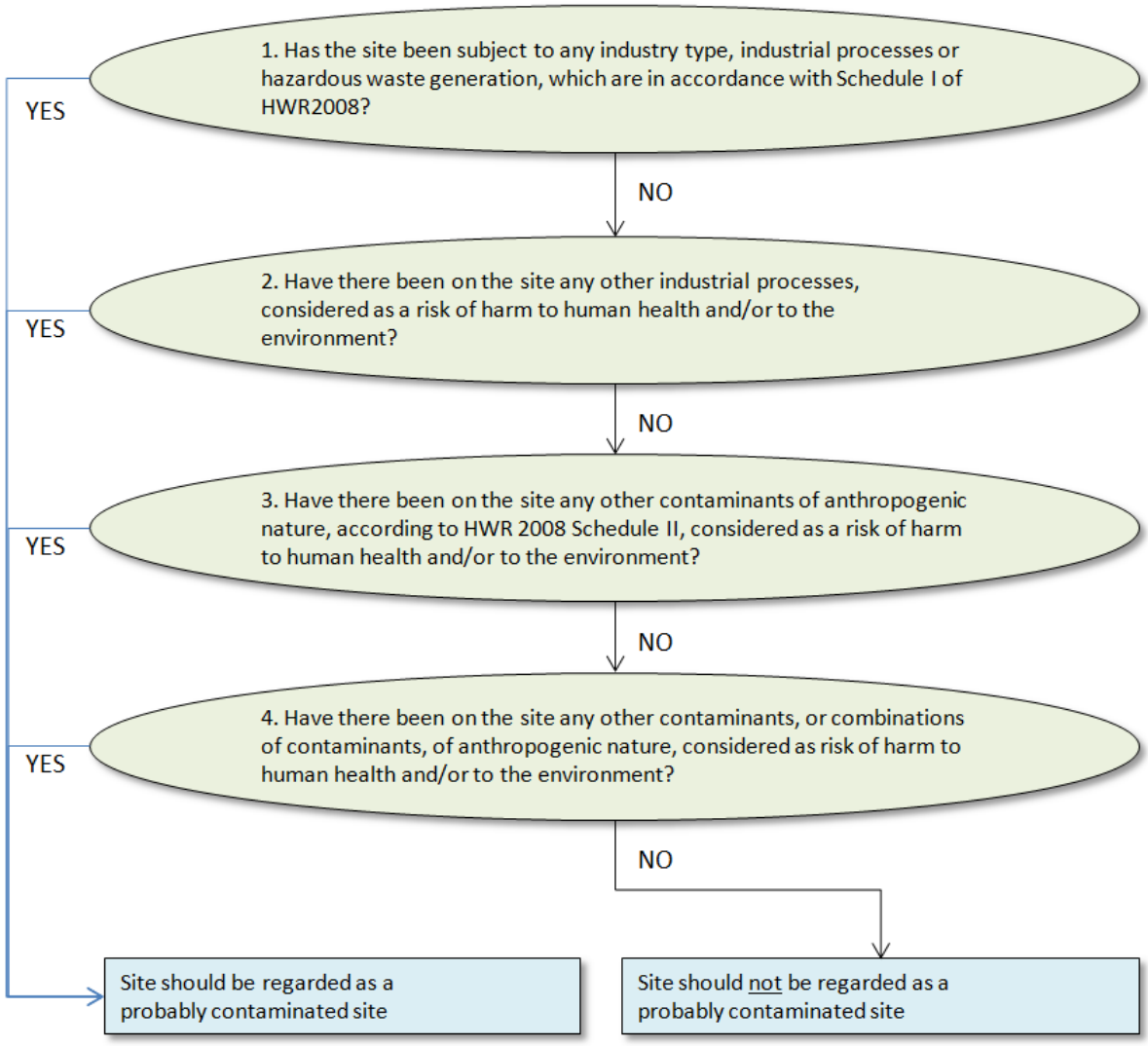
Once the appropriate data has been obtained and verified an evaluation assessment of whether or not the site qualifies as a 'probably contaminated site' may be undertaken. This evaluation comprises answering the following questions:

1. Has the site been subject to any industry type (number 1.12 of *Checklist relevant data for identification of probably contaminated sites, Volume II-1-b*), industrial processes (Checklist, number 2.3) or hazardous waste generation (Checklist, number 2.4), which are in accordance with Schedule I of Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008?
2. Have there been on the site any other industrial processes (Checklist, number 2.3), considered as a risk of harm to human health and/or to the environment?
3. Have there been on the site any other contaminants of anthropogenic nature (Checklist, numbers 2.2 and 2.6), according to Schedule II of Hazardous Waste Rules 2008, considered as a risk of harm to human health and/or to the environment?
4. Have there been on the site any other contaminants, or combinations of contaminants, of anthropogenic nature (Checklist, number 2.6), considered as risk of harm to human health and/or to the environment?

If either one or more than one of these four questions is answered by 'yes' the site should be regarded as a 'probably contaminated site'. If all of these four questions are answered by 'no', and there is no actual indication of significant contamination at the site, the site should not be regarded as a 'probably contaminated site'.

The evaluation is visualised in the flowchart below.

Figure I-1.3: Flowchart for evaluation of probably contaminated site in Step 1



1.3 Step 1 output

The output of this Step is the decision record for the conclusion as to whether or not the site is regarded as a probably contaminated site. If yes, further assessment may be undertaken. This assessment is described in the following Section, on Step 2, Preliminary investigation. The data on the site and the decision record should be included in the database of contaminated sites.

If the site does not qualify as a probably contaminated site it is not necessary to continue the assessment process in Step 2. The data on the site and the decision record can be submitted into the archives.

Volume I

Step 2 Preliminary investigation

Task 2.1 Preliminary site assessment

Step 2: Preliminary investigation

Task 2.1: Preliminary site assessment

2.1.1 Introduction to and scope of Task 2.1

General description and connection to other Steps
Step 2 concerns the preliminary investigation of individual sites which have been recognised as probably contaminated sites during the previous Step 1. The purpose of the preliminary investigation is to establish whether or not a site should be regarded as a contaminated site as defined in Box I-2.1.1.

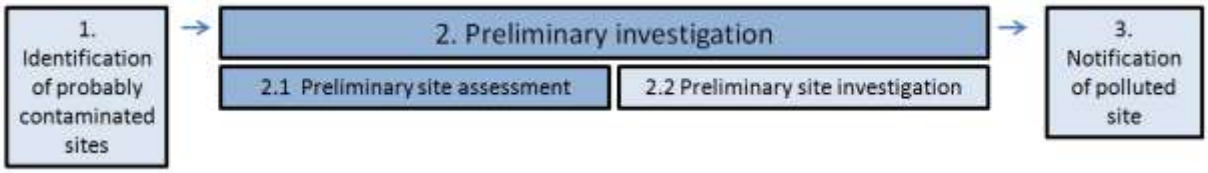
Box I-2.1.1 Definition of a contaminated site

A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.

If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.

This is the second step in the process of assessment and (possible) remediation of a site that could be a contaminated site. Step 2 is divided into two tasks: preliminary site assessment (Task 2.1) and preliminary site investigation (Task 2.2).
The objective of Task 2.1 preliminary site assessment is to focus as quickly as possible on imminent threats to human health and/or the environment to verify if the site is a contaminated site.

The figure below shows how this Task 2.1 is connected to the preceding and subsequent steps and tasks within the sequence of site assessment and remediation.



Activities
Within this task the following activities are to be performed:

1) A desk study is carried out on the available information of the site. Information in reports and petitions is assessed and new information is inventoried.

2) A site inspection is carried out to verify the information of the desk study and to prepare a plan for sampling and testing.
3) At the locations where main sources of contamination and relevant pathways to possible affected receptors are expected limited sampling and testing is carried out.
4) The results are compared with the Screening and Response levels and a conclusion is drawn as to whether or not the site should be regarded as a contaminated site. Recommendations on the necessity to carry out preliminary site investigation (Task 2.2) and specific aims of that investigation are presented.
5) Reporting of results of the preliminary site assessment and review of the report.

Responsible Parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the preliminary investigation. The work should be supervised by a senior colleague, and close cooperation with the competent authority is necessary to collect important information during the desk study and to prepare the site inspection and sampling.

The team involved should demonstrate in-depth knowledge and experience in the assessment of contaminated sites, including interpretation of topographic and geological maps and reports. The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.

2.1.2 Guidance for performing the activities of Task 2.1

This section presents concise guidance for the performance of the activities within Task 2.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

The detailed information on the execution of the preliminary site assessment can be found in section Volume III-2.1-i of this Guidance Document. This section comprises the Site Inspection Protocol (SIP) which contains several elements:
- General introduction on the use of the SIP;
- Checklists and manuals for execution of the individual activities;
- Recommendations for proper health and safety measures during the site visit and for reporting the results.

The SIP is related to the information inventoried and summarized in the database of contaminated sites. The information in this database enables the prioritization of sites in a program for remediation of polluted sites.

Activity 1 – Desk study

A review of the site information within reports, petitions and complaints obtained at Step 1 is performed (refer Box I-2.1.2 below). It is necessary to have as much information as possible concerning the history and land use both on site and off site (representing the surrounding area). This information indicates the possibility of the presence of contamination at the site.

Box I-2.1.2 Practical tip: Importance of desk study

It is very important to focus attention on the desk study at this stage of the process of assessment and remediation. If sources of contamination are not recognised it can lead to under-estimation of the extent of potential contamination and potential risks to receptors may not be recognized.
Furthermore, this can lead to unexpected problems during future site activities e.g. when reconstruction or reuse of the site will necessitate digging in subsoil or extraction of groundwater.

In addition an incomplete inventory of contamination sources and exposure pathways can lead to ineffective remediation plans. There are many examples of projects where, unfortunately, remediation activities had to be re-designed, causing exceedance of budgets and in some instances the remediation objectives previously agreed were not achieved.

The points below should be considered when assessing existing primary data:

- determine what data are available;
- evaluate purpose and scope of previous investigations;
- review sampling locations, dates, depths and sample descriptions;
- evaluate the sampling results and hazardous substance concentrations;
- review field preparation and collection techniques for previous samples;
- review available laboratory documentation;
- assess usability of previous primary data.

The data review may identify gaps in the available data. Additional information can be obtained from maps, data bases or governmental information.

The available reviewed information and the newly collected information can be summarised in a table and information gaps should be indicated before the site inspection is carried out (refer *Volume III-2.1-i SIP, Appendix E, table 1 Existing and general information and table 2 Overall assessment of data and data gaps*).

Based on all the compiled information a work plan should be devised prior to the site inspection. This work plan should include all reconnaissance activities and identify the specific information to be collected e.g. sampling from drinking water wells, noting the local hydrogeology, estimating the population at risk, interviews with specific stakeholders (such as occupants, current or former owners, neighbours, manager, employees and government officials) etc.

On completion of the desk study a review should be carried out to confirm whether there is any indication of contaminating activities at the site. If it is established that there is no such indication it should be concluded that the information from step 1 is incorrect. The site should be classified as 'not a probably contaminated site' and the database should be revised accordingly. Further investigation activities should not be regarded necessary for the site.

Activity 2 – Site inspection

The site inspection is a field visit to observe the site and the potential sources of contamination (on-site reconnaissance) and to undertake a perimeter survey of the facility as well as a survey of the local site environs (off-site reconnaissance). During this site inspection information is obtained to fill the gaps and the existing available information is verified. If possible photographs should also be taken.

The site inspection needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, equipment, e.g. for sampling, needs to be prepared. Interviewing relevant stakeholders is an integrated part of the preliminary site assessment. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may only be applicable to large scale sites.

Stakeholder	**Interview objective**	**Level**
Site owner	collect information, verify data	site
Site operator's health facility director	collect information, verify data	site
Local businesses, residents and NGO's	collect information, verify data	site and direct vicinity
Municipal authorities, including Water Supply and Sanitation	collect information	local
District administrator	collect information, e.g. on land ownership	district
State authorities, including SPCB and Groundwater Authority	collect information	state

During the site inspection health and safety guidelines have to be taken into account (refer *Volume III-2.1-i SIP, section 3*).

The information gathered during the site inspection should be summarized in tables (refer *Volume III-2.1-i SIP, section 5 –on-site- and 6 –off-site-*) and a sketch map should be drawn showing the principal recorded occurrences and expected sources of contamination the main exposure and migration pathways of pollutants and the locations of receptors.

Activity 3 – Limited sampling and testing

An initial assessment of the contamination present at the site may be ascertained from samples taken during the site inspection. These samples should be obtained from locations where the main sources of pollution are expected, and at locations within migration pathways. Because only a limited number of samples are obtained, the sample locations should be well chosen, and guidance is provided in Box I-2.1.3 below.

The sampling should be carried out according to the Sample Protocol (refer *Volume III-2.1-i SIP, Appendix A*).

The samples should be tested in a laboratory to assess the levels of contamination present. Laboratories should operate in accordance with specific accreditation criteria (refer *Checklist prequalification for site investigation, Volume II-2.1-a*).

Box I-2.1.3 Practical tip: Possible locations for sampling

Possible locations for sampling of sources and pathways:

- visual indication of cause of pollution such as the presence of (former) industrial process equipment, storage tanks, broken pipelines, etc;
- visual evidence of hazardous material by means of colour or odour or the composition of material, or uneven ground surface;
- reported location with confirmed high concentration levels in previous sampling results;
- where an incident (spill / uncontrolled release) has occurred identified by a former employee of a company;
- areas which can easily be accessed by humans and areas of sensitive use (residential, playground, agriculture);
- drinking water wells downstream of the site (to collect groundwater samples to assess if this pathway is contaminated);
- surface water at or near the site if expected to be contaminated by hazardous waste material;
- at discharge points with noticeable contamination an effluent sample should be taken;
- in cases of sites with effluent discharges a 'source sample' should also include a sample of the sediment.

The parameters for determination within each sample scheduled for analysis will depend on the hazardous waste material potentially present (refer *Volume III-2.1-i SIP, Appendix C*). For the various activities representative tracer components have been described. The tracer components can be seen as components of concern. If there is existing information about contaminants from previous investigations, this information should be used to select tracers. It has to be stated that not all the listed tracers necessarily have to be analysed at a site, but the list can be used as a starting point for the assessing analysis program at a specific site.

Figure I-2.1.1a and 1b: Sampling of soil and groundwater (pictures by COWI, Kadam)

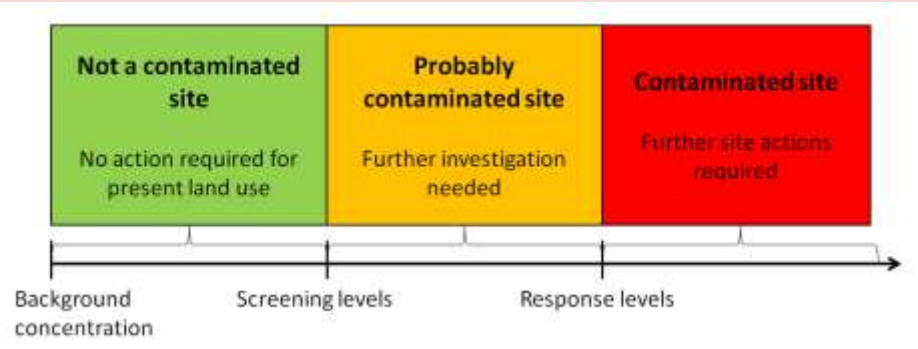
Activity 4 – Comparing testing results with standards

The laboratory testing will result in a list of concentration levels for various parameters / substances. These concentration levels have to be compared with the Screening levels and the Response levels (refer *Volume II-2.1-b*). A brief explanation on these levels is provided in Box I-2.1.4.

Box I-2.1.4 Explanation: Screening levels and Response levels

Screening levels are generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.

Response levels are generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.



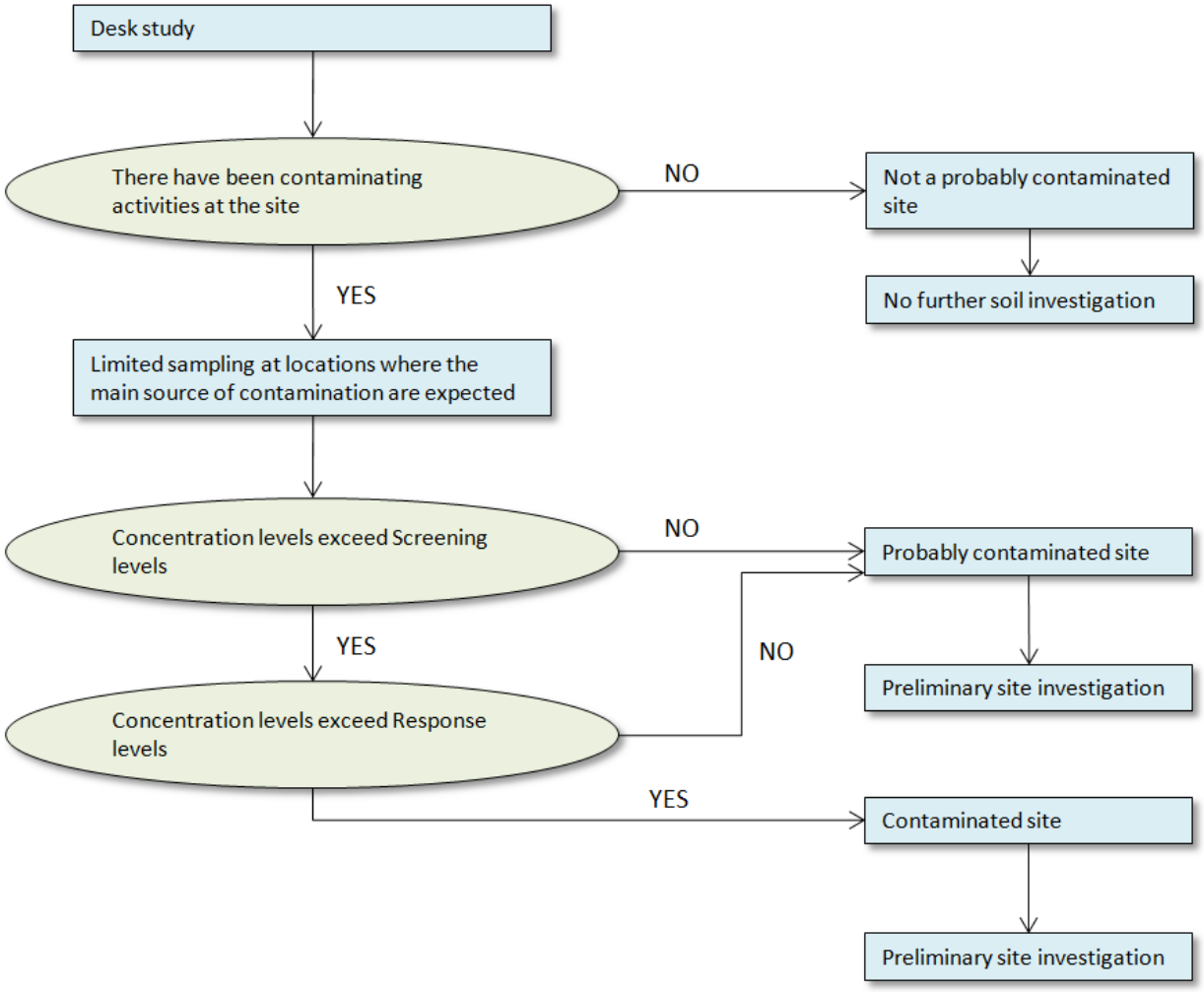
Note that that for certain contaminants such as Persistent Organic Pollutants, no background concentrations should be used, as there is no natural background for these substances.

The outcome of the comparison will determine whether or not the site should be regarded as a contaminated site (refer to definition in Box I-2.1.1). The following situations can occur:

- If the concentration level of one or multiple contaminants exist at or below Screening levels the site cannot directly be regarded as 'not a probably contaminated site'. This because of the fact that only a limited number of samples were taken. Further investigation is necessary to assess if there are any further sources of contamination at the site which may cause a risk to present or future land use. This can be done by a preliminary site investigation.
- If one or multiple contaminants exceed Screening levels but at or below Response levels the site may be determined as probably contaminated site. Then preliminary site investigation should be carried out as well. This is because of the fact that only a limited number of samples were taken and there may be other locations at the site where higher concentration of contaminants occur;
- If one or multiple contaminants exceed Response levels the site can be classified as a contaminated site. Often it is not clear if all sources and pathways have been identified and samples may not have been taken. In that case a preliminary site investigation is necessary. If it is clear that all sources and relevant pathways have been identified and samples were taken at these points, no preliminary site investigation is necessary. In that case the site may be notified directly as a contaminated site and prioritisation can take place (Step 3 and Step 4 of the assessment and remediation process).

All these situations are illustrated in the below result flowchart for the comparison of concentration levels with Screening and Response levels.

Figure I-2.1.3: Preliminary site assessment result flowchart in Task 2.1



Activity 5 – Reporting and review

The activities carried out, the methods used and the results of the preliminary site assessment should be described in the report. The chapters of the report are structured in accordance with the stages of the investigation itself (refer *Checklist for preliminary site assessment report, Volume II-2.1-c*).

Finally, a conclusion should be drawn as to whether or not the site meets the definition of contaminated site. Recommendations should also be provided for the next step in the assessment and remediation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided.

It is important that this document contains copies of the original sources of information in databases, previous reports and other sources. This is because at later stages of the assessment and remediation process, it is often necessary to revert to the original information when interpreting newly collected data.

2.1.3 Task 2.1 output

The output of this task 2.1 is the conclusion whether the site should be regarded as a contaminated site. If so, or if there is not enough information, further investigation is necessary to obtain more information.

If the site is not regarded as a contaminated site, it is not necessary to continue the process of assessment and remediation of the site. The site information and the decision should be registered on the database.

Volume I

Step 2 Preliminary investigation

Task 2.2 Preliminary site investigation

Step 2: Preliminary investigation

Task 2.2: Preliminary site investigation

2.2.1 Introduction to and scope of Task 2.2

General description and connection to other Steps
Step 2 concerns the preliminary investigation of individual sites which have been recognised as probably contaminated sites during the previous step 1. The purpose of the preliminary investigation is to establish whether or not a site should be regarded as a contaminated site as defined in Box I-2.2.1.

Box I-2.2.1 Definition of a contaminated site

A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.

If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.

This is the second step in the process of assessment and (possible) remediation of a site that could be a contaminated site. Step 2 is divided into two tasks: preliminary site assessment (Task 2.1) and preliminary site investigation (Task 2.2). The objective of the preliminary site investigation is to identify all sources of contamination and the relevant pathways linking them to the receptors of concern.

The figure below shows how this Task 2.2 is connected to the preceding and subsequent steps and tasks within the sequence of site assessment and remediation.

Activities
Within this task the following activities are performed:

1) Design of the investigation and testing strategy
2) Fieldwork and laboratory testing
3) Comparison of the test results with standards
4) Reporting of the preliminary site investigation and review of the report.

Responsible parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the preliminary investigation. The work should be supervised by a senior colleague. Cooperation with the site owner and competent authority is necessary to prepare the field work and to grant access to the site.
The team involved should demonstrate in-depth knowledge and experience in the assessment of contaminated sites and interpretation of information obtained from reports and maps on the topography and geology of a site. The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.

2.2.2 Guidance for performing the activities of Task 2.2

This section presents concise guidance for the performance of the activities within Task 2.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Because the preliminary site investigation is a follow up of the preliminary site assessment a lot of information on the execution of the preliminary site investigation can be found in the Site Inspection Protocol (SIP) (ref. *Volume III-2.1-i*). This SIP comprises:
- General introduction on the use of the SIP;
- Checklists and manuals for preparation and execution of the individual activities;
- Recommendations for proper health and safety measures during the site visit and for reporting the results.

The SIP is related to the information inventoried for a database on probably contaminated sites. The information held in this database enables the prioritisation of sites in a program for remediation of polluted sites.

Activity 1 – Investigation strategy

The starting point of the preliminary site investigation is a review of the output from the preliminary site assessment. The desk study information within the preliminary site assessment should already provide a detailed history of the site use.

The potential sources, pathways and receptors of concern should be established based on previous reports or petitions, maps, records, aerial photographs and interviews with owners or other informed parties. If there is doubt on the results of the desk study during the preliminary site assessment or if the report cannot be regarded as valid anymore, parts of the desk study should be carried out again. Depending on the land use and changes in land use, a period of 5 years can be used as a rule of thumb as the period for carrying out a new desk study.

During the preliminary site assessment the activities of the fieldwork have been focussed on locations where the highest contaminant concentrations were expected and the locations of the most sensitive land use. For the preliminary site investigation it is necessary to verify all potential sources, pathways and receptors at the site.

The investigation strategy to achieve this objective efficiently starts with the typology of the contaminated site (see Box I-2.2.2 for a short explanation of typology of contaminated sites. For a more detailed explanation we refer to the Glossary in the Annex of this Volume I). For each type of contamination a different investigation strategy is provided and from that points of attention for the fieldwork and laboratory work are specified in the *Checklist investigation strategy preliminary site investigation (*ref. *Volume II-2.2-a).*
Note: at any contaminated site more than one type of contamination can occur. For each type of contamination and for each source a separate investigation strategy can be developed.

Box I-2.2.2 Explanation: Typology of contaminated sites

Contaminated sites are delineated areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the environment. These sites often pose multi-faceted health and environmental problems. They can impact all components of the environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, industrial, rural, urban, or wilderness areas. All these elements are combined in a typology of contaminated sites. This typology is of importance for the assessment and design process of remediation.

The following main types of contaminated sites are distinguished based on the causing activity and pathway of spreading of contamination:

Source related:
- Type S1: Land bound solid phase contamination
- Type S2: Water bound sediments solid phase contamination
- Type L: Land bound liquid phase contamination

Pathway related:
- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
- Type P2: Groundwater contaminations

Note: depending on a specific situation, a combination of these types may be possible. Example: a land bound storage of chromium containing hazardous waste (type S1), causing leachate of chromium to groundwater and leading to a contaminated groundwater plume (type P2).

Further explanation on the typology is provided in the Glossary.

If additional site specific information is available the general type can be made more site-specific by developing a Conceptual Site Model (CSM). The CSM supports the investigator to visualize the possible sources, pathways and receptors relevant at the site. See Box I-2.2.3 for a short explanation of the Conceptual Site Model. For more

detailed information how to apply the CSM refer to *Manual Conceptual Site Model an identifying the Source-Pathway-Receptor, Volume III-2.1-i*.

Box I-2.2.3 Explanation: Conceptual Site model

The Conceptual Site Model is a representation of the characteristics of the site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors. It crystallises understanding of what needs to be done to achieve the investigation of contaminated sites, the assessment of risks and from this point appropriate remediation techniques to achieve remediation objectives.

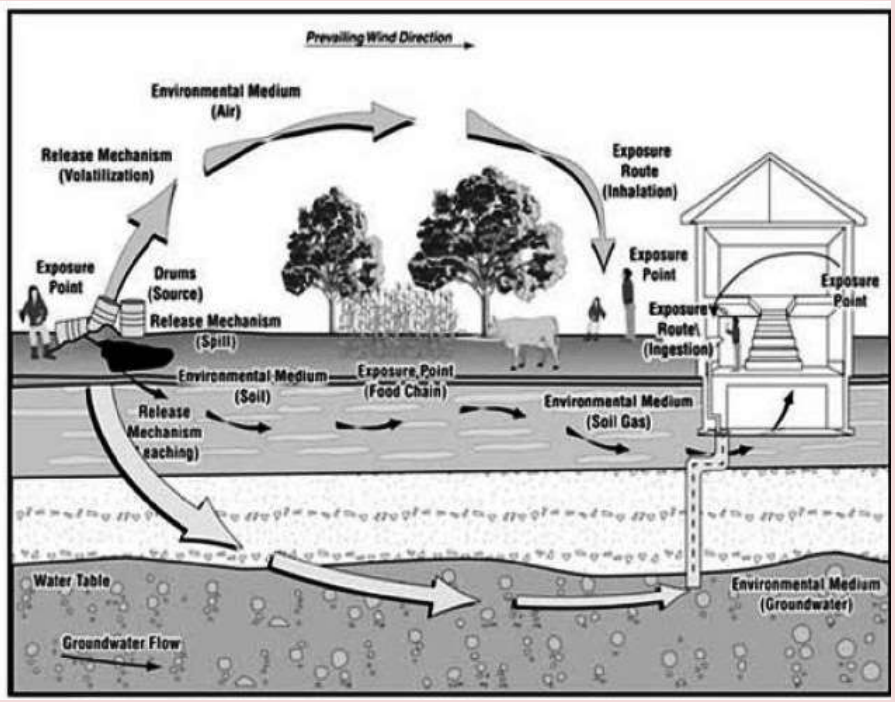


Figure I-2.2.1: Example of a schematic exposure pathway in a Conceptual Site Model (source: Public Health Assessment Guidance Manual, Agency for Toxic Substances and Disease Registry, 2005)

Based on the investigation strategy an investigation protocol is prepared, regarding assessment of the contamination levels of the source and identification of the major pathways and receptors of concern. This protocol should pay attention to the following elements:

- Screening and sampling technical equipment;
- Sampling pattern and depth of samples, number of samples, use of composite samples;
- Analytical test parameters / determinants required;
- QA/QC procedures such as use of field blanks/trips blanks, procedures to avoid cross contamination by sampling equipment etc.

Technical equipment for site assessment

Generally two ways of carrying out field investigation are distinguished: screening methods which provide an area-wide information and sampling methods at specific locations.

There are several screening methods that provide qualitative information from which the possible presence of contamination can be concluded. Some examples are illustrated in Box I-2.2.4 below. An overview of screening techniques is provided in the *Overview of techniques for site investigation, Volume III-2.2-ii.* This approach can help to provide a first rough indication of the source of contamination and delineation of a contaminated site.

Box I-2.2.4 Example Site screening methods

For recognition of the presence of heavy metals in soil or waste material an XRF device can be used. This equipment detects increased levels of heavy metals in samples.

For volatile organic components the use of a soil vapour survey technique can be helpful. A portable Photo-ionization Detector can detect these components in a soil or water sample.

For hydrocarbon site investigations a Cone Penetration Test (CPT) mounted UV fluorescence screening tool can be used for a quick reconnaissance of a site for hydro carbon contaminations.

Note.
Screening methods are often sensitive to side-effects caused by naturally occurring substances, the indirect type of measurement or the calibration shifting during the use of the screening tool. For instance i- the fluorescence sensor may deliver false positives in cases of high proportions of peat and other naturally occurring organic carbon or ii- a clay layer or saline groundwater body may be mistaken for a contaminated plume by a electromagnetic mapping (EM).
Verification and calibration procedures are tool or supplier specific.
It is especially necessary to align screening values with other data such as laboratory analyses and typically cannot be used as the only tool for data acquisition.

Based on the outcome of such screening methods additional sampling and testing is always necessary to provide quantitative results of the concentration levels of components in the soil, sediment, groundwater or surface water.

For groundwater sampling existing groundwater wells can be used, but sometimes it is not clear how the installations have been designed, and which stratum the groundwater is derived from. To obtain accurate information for a specific level new dedicated monitoring wells should be installed.
An overview of possible technical equipment for collection of samples (soil, sediment, surface water, groundwater) is provided in the *Overview of techniques for site investigation, Volume III-2.2-ii*.

Sampling pattern, number of samples and depth of samples
Knowledge of the possible location of contamination sources is important for defining the sampling pattern. Small areas where contaminated material is concentrated in one place (point source contamination) can be investigated during the preliminary site investigation by a few representative samples collected from one or two exploratory excavations. In case contaminated material is spread over a large area it is necessary to use a pattern of samples to collect representative information of the contaminated site. The *Checklist investigation strategy preliminary site investigation*

Volume II-2.2-a provides a first indication of the sampling pattern and number of samples.

There are some additional aspects that should be taken into account when developing a sampling strategy for a specific site:

- Restrictions for investigation such as buildings, subsurface infrastructure and site boundaries;
- If possible some samples should be obtained for identification of background quality of soil, groundwater, sediment or surface water which has not been influenced by this particular contamination;
- Samples of groundwater may be obtained from selected existing observation wells in the aquifer beneath the surface of the site, for monitoring water level elevation and water quality at appropriate locations. The depth of the well and the filter (if any) should be known. If there is data from previous sampling or level measurements it is important to know the frequency and period relating to the hydrological environs (influence of monsoon).

Parameters for laboratory testing:

The parameters important for the investigation can be selected based on:

- Previous industrial operation processes or waste generation, discharges or disposal activities. The type of industry determines the parameters involved (ref. *Volume III-2.1-i SIP, Appendix C*).
- Specific observations during site inspection and field work of signs which indicate contamination not related to the above mentioned activities.
- Characteristics of the components regarding mobility or retardation. For assessment of groundwater quality the most mobile tracers are interesting to focus on. For sediments, components with high binding capacity are important to focus on when investigating a surface water body near to a former point of discharge.
- It is always recommended to test samples for a broad spectrum of parameters. This because it is possible that there may have been polluting activities at the site that are either unknown or not documented in databases. These activities may possibly have caused contamination with different characteristics compared to the known activities.

Activity 2 – Fieldwork and laboratory testing

The fieldwork needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, sampling equipment needs to be prepared.

The stakeholder consultation is needed, both to inform them on the fieldwork plan and to secure their support for the plan. The consultation may also yield information that can be useful in the final design of the fieldwork plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may only be applicable to large scale sites.

Stakeholder	Interview objective	Level
Site owner	provide information, secure support	site
Site operator's health facility director	provide information, secure support	site
Local businesses, residents and NGO's	provide information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information, secure support	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information, secure support	state
For large scale site: national authorities, including Surveyor of India and Central Ground Water Board	collect information	national

During the site inspection health and safety guidelines have to be taken into account by the field team (ref. *Volume III-2.1-i SIP, section 3*).

The activities in the field should be described in a logbook of the field investigator. Detailed descriptions of each source and of relevant pathways and receptors should include:

- Regarding source: type, location, dimensions, sensory perceptions/observations of possible pollution (form or colour or smell or stressed vegetation);
- Samples should be taken of the material assumed to be most contaminated based on visual / olfactory evidence of contamination;
- Regarding pathway: depth of groundwater, presence of surface water and possible overland flow route from source to the nearest surface water body;
- Regarding receptors: dwellings, schools/playgrounds, use of groundwater wells, crops or cattle, other sensitive environments, land use in the vicinity.

Furthermore, the activities carried should be accurately described for inclusion in the report.
The descriptions should be accompanied by sketches of the site (location of sources, dimensions, distances to receptors, significant site features, with marking of north and scale. The locations of exploratory holes should preferably be indicated by XYZ-coordinates, using GPS.

Note: Always be flexible on fieldwork activities to maintain efficiency. Based on the initial field work results additional samples and testing may be appropriate in case of unexpected indications of pollution.

The sampling should be carried out according to the Sample Protocol (ref*. Volume III-2.1-i SIP, Appendix A*).
The samples should be tested in a laboratory to assess the levels of contamination in the sample. Laboratories should operate in accordance with specific accreditation criteria (ref. *Volume II-2.1-a*).

The parameters for determination within each sample scheduled for analysis will depend on the hazardous waste material potentially present (refer *Volume III-2.1-i*

SIP, Appendix C). For the various activities representative tracer components have been described. The tracer components can be seen as components of concern. If there is existing information about contaminants from previous investigations, this information should be used to select tracers. It has to be stated that not all the listed tracers necessarily have to be analysed at a site, but the list can be used as a starting point for the assessing analysis program at a specific site.

Figure I-2.2.2a and 2b: Sampling of soil and groundwater (pictures by COWI, Kadam)

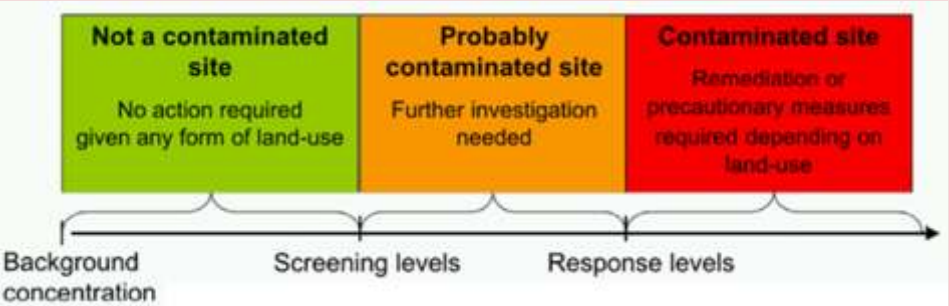
Activity 3 – Comparison of testing results with standards

The laboratory test results should be tabulated and recorded in terms of concentration levels for each parameter / substance per sample. These concentration levels are compared with the Screening levels and the Response levels (ref. *Volume II -2.1-b*). A short explanation on these levels is provided in Box I-2.2.5 below.

Box I-2.1.4 Explanation: Screening levels and Response levels

Screening levels are generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.

Response levels are generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.



Note that that for certain contaminants such as Persistent Organic Pollutants, no background concentrations should be used, as there is no natural background for these substances.

The outcome of the comparison will define if the site should be regarded as a contaminated site (refer to definition in Box I-2.2.1). The following situations can occur:

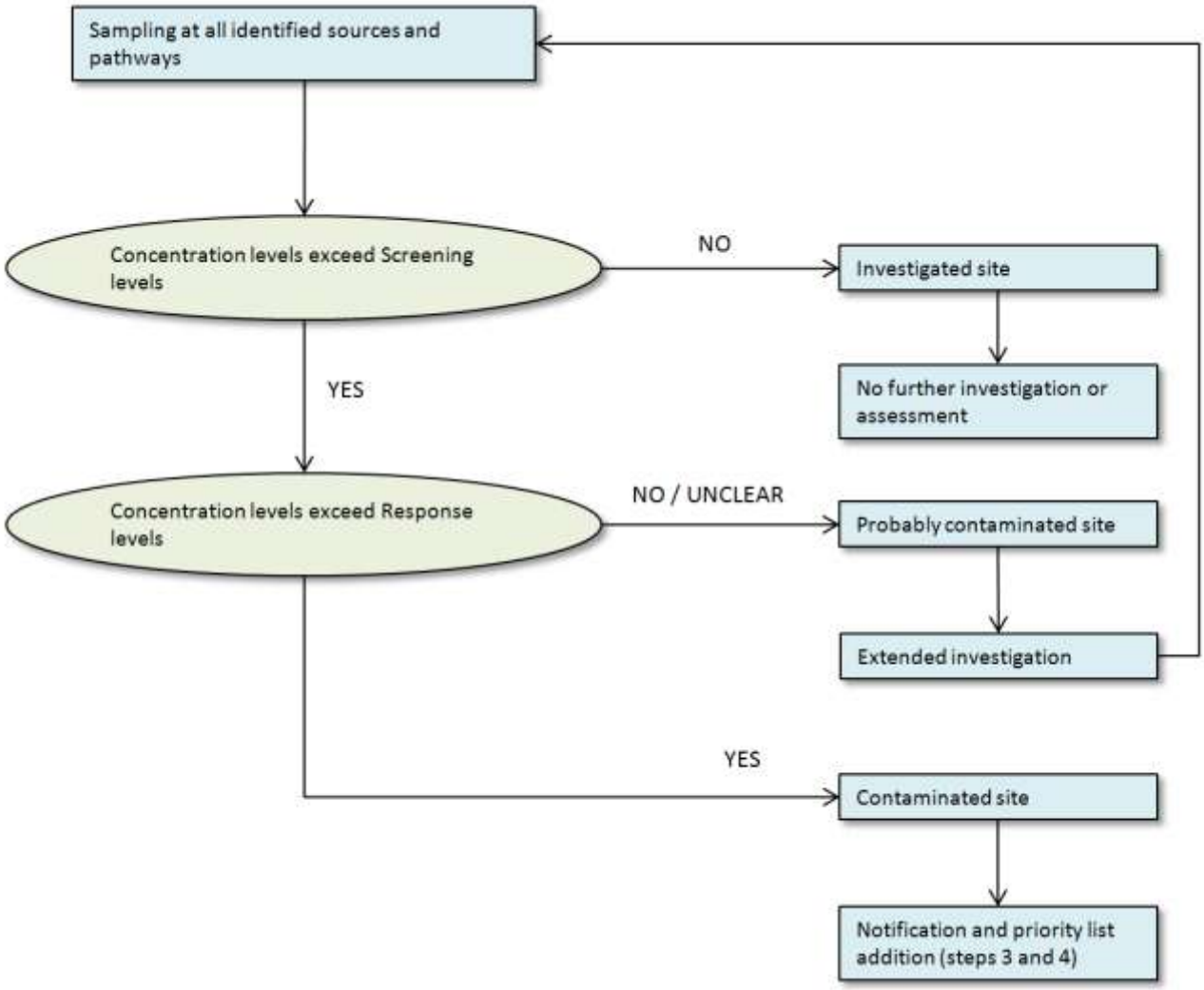
- If concentration levels of contaminants in all samples do not exceed Screening levels it can be concluded that there is no imminent threat to human health and/or the environment and the site can directly be regarded as ‘investigated site’ which has not proven to be contaminated. There has been sufficient investigation undertaken and further investigation or assessment of the site is not necessary.
- If concentration levels exceed the Screening levels but are lower than Response levels it is not directly possible to determine the site as a ‘contaminated site’ or as ‘not a contaminated site’. If the outcome of the preliminary site investigation is not clear further investigation using elements of the detailed site investigation (Task 5.1) may be recommended.
- If concentration levels exceed Response levels it can be concluded that imminent threats to human health and/or the environment may occur and the site may be classified as a contaminated site. The site should be notified and prioritisation should be carried out (Step 3 and Step 4 of the assessment and remediation process).

All these situations are illustrated in the below result flowchart for the comparison of concentration levels with Screening and Response levels.

In some areas the natural background levels may be higher compared to the Screening levels, e.g. the natural background levels of metals and other inorganic chemicals can vary widely and this should be taken into account when applying the

Screening levels. Where it can be demonstrated that natural background concentrations are elevated (e.g. heavy metal concentrations in mineralised areas), it would be appropriate to develop less stringent assessment criteria. However care needs to be taken when establishing the level of the natural background and its natural variation as the local background may be influenced by historic mining and/or waste disposal activities.
For some contaminants such as Persistent Organic Pollutants, no background values should be used, as there is no natural background for these substances.

Figure I-2.2.3: Preliminary site investigation result flowchart in Task 2.2



Activity 4 – Reporting and review

Details of all activities carried out, the equipment and methods used and the results of the preliminary site investigation should be included in the site investigation report. The chapters of the report should be arranged in the same sequence of the investigation activities (ref. *Checklist for preliminary site investigation report, Volume II-2.2-b*). The topics in this checklist may be used as elements in Terms of Reference for the investigation of a specific site.

The relevant elements of the previous report of the preliminary site assessment can be incorporated in the report of the preliminary site investigation, if still valid.
In the preliminary site investigation report all major sources, pathways and receptors of concern should be identified. It is very important to recognize if there are indications of ongoing hazardous waste generation or fresh waste disposal or discharge on the site. If that is the case the first step must be to prevent these activities from occurring before proceeding with the remediation investigation.

Furthermore the initial Conceptual Site Model should be reviewed and probably adjusted based on the results of the preliminary site investigation.
If enough data is available groundwater level contour maps may be developed in order to indicate the groundwater flow direction.

When interpreting the results of groundwater quality the possible influence of seasons should be taken into account, see Box I-2.2.6.

Box I-2.2.6 Practical tip: Seasonal Influences

Groundwater levels may vary due to the influence of rainfall or flooding causing replenishment of the shallow groundwater level. There can be an influence from surface water level changes on the groundwater level near water bodies. Rising surface water in monsoon periods will cause an increase of the groundwater level. Changes in groundwater level can impact contamination distribution and concentration in soil and groundwater. Constituents bound to soil particles may be released and may be dissolved into groundwater causing increasing concentration levels. After a while equilibrium will be restored with a new balance between bound and dissolved particles so the concentration level remains the same until further changes in groundwater level occur. Groundwater level varying over the season in this way may cause periodical increasing and decreasing contamination concentration levels. They as well may have an effect on light non-aqueous phase liquids (LNAPL) on the groundwater surface which tend to reduce in thickness or disappear when water levels rise.

Although the primary purpose of a preliminary site investigation has not been to delineate the contamination it is often possible to provide a rough estimate of the extent of and boundaries of the contamination. When interpreting the data it may appear that several zones of distinct contamination may be present within the single contaminated sites. Each may be sufficiently distinguished to represent a contaminated site in it's own right. This is important for the legal notification of the contaminated site (step 3).

Finally a conclusion has to be drawn if the site has to be regarded as a contaminated site or not. Recommendations should be provided for the next step in the remediation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided. The report has to contain as much as possible verifiable information meaning that copies of all original data from desk study, site inspection, field work and laboratory testing should be provided in annexes.

The investigating agency should ensure appropriate quality assurance protocols and systems have been adhered to including prescribed protocols, the calibration of field instruments, proper sampling and collection techniques and by providing records of responsibility, non-conformity events, corrective measures and data deficiencies.

The report is then reviewed by the competent authority regarding contaminated sites, ref. *Checklist review and approval preliminary site investigation reports, Volume II-2.2-b*.

2.2.3 Task 2.2 output

The output of this task is the conclusion whether or not the site should be regarded as a contaminated site. If so, the next steps of the process of assessment and remediation, Step 3 notification and Step 4 prioritization should follow in succession. After that the remediation investigation (Step 5) can proceed.

If the site is not regarded as contaminated site it is not necessary to continue the process of assessment and remediation of the site. The site information and the decision should be registered by submitting it into the database.

Volume I

Step 3 Notification of polluted site

Step 3: Notification of polluted site

3.1 Introduction to and scope of Step 3

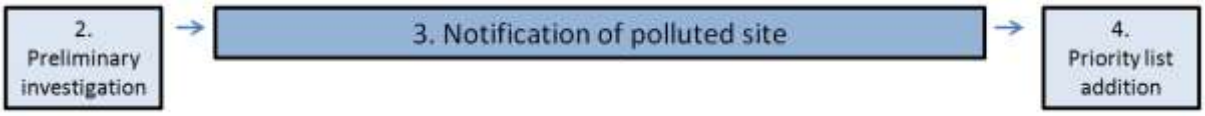
General description and connection to other Steps

Step 3 concerns the notification of a contaminated site by the competent authority as a 'polluted site' as defined in Box I-3.1 which requires remediation. Furthermore this notification has the effect of restricting further on-going activities at the site, depending upon the threats caused by the contamination.
Parallel to the above activities, parties responsible for contamination need to be identified and liability for the remediation and for paying the cost of remediation and rehabilitation of the affected environment and community needs to be assigned to them.

Box I-3.1 Definition of a polluted site

A polluted site means areas where hazardous substances exist at levels and in conditions which may pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living creatures, plants, micro-organisms, property, water quality or the environment in general, determined in the manner prescribed.

This is the third step in the process of assessment and remediation of a contaminated site.
The figure below shows how this Step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation. Step 4 Priority list addition can be carried out parallel to this Step 3.



Activities

Within this step there are a number of activities to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Final Task 4 report, PWC June 2014). Here, the guidance focuses on the technical aspects, and hence on the following activities:

1) Delineate the site;
2) Impose site use restrictions and temporary safety measures.

Responsible Parties

The activities in this step are typically carried out by technical, legal, financial and social specialists within the competent authority for the assessment and remediation process. The team involved should be able to interpret the technical information and recommendations of preliminary site investigation reports, and to link these properly to institutional, legal and financial consequences. Review is typically performed by senior staff members, to prepare the regulatory decision by the appropriate official.

3.2 Guidance for performing the activities of Step 3

This section presents concise guidance for the performance of the activities within Step 3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Delineate the contaminated site

In order to notify a contaminated site as polluted site the boundaries of this site need to be established. Based on the preliminary site investigation report an overview of the contamination of a site is provided. All relevant sources, pathways and receptors of concern have been identified, described and preferably marked on a map. Although a preliminary site investigation is not intended for delineation of the contamination the collected information should provide a first indication of the contaminated area. This indicative information should be used to delineate the site. As these data will be used to notify a site, a decision with potentially far reaching consequences, proper care should be applied while performing this activity. When assessing the preliminary site investigation report it should be confirmed that the report contains at least the following elements:

- Sufficient data, both from historical sources as well as from the field, on the contamination situation in soil and sediment and, if applicable, in groundwater and surface water. These data should comprise at least the location of all samples and, if applicable, monitoring wells, a description of the stratigraphy and composition of the soil, the depth of the groundwater table, relevant observations from site inspection, and results of laboratory testing;
- Proper interpretation of all data and clear summary of the results;
- Conclusions, which can be related to the results.

Box I-3.2 provides some practical tips for the delineation of a contaminated site.

The data collected from official sources need to be verified through consultation of officials concerned with land matters.

Stakeholder	**Interview objective**	**Level**
Local authorities, including Patwari, Kotwal, Revenue Department	collect and verify information	local
District Collector	collect and verify information	district

When interpreting the data it may appear that the situation involves not one contaminated site, but several. In such a case, all identified contaminated sites need to be distinguished and assessed separately before notification can take place.

During the remediation investigation, Step 5 in the sequence of steps of assessment and remediation, further information will be developed so that more detailed delineation of the contaminated site from the surrounding area can be made.

Box I-3.2 Practical tip: How to delineate a contaminated site

The possibility for delineation of the contaminated site and the level of detail involved depends on the quality of the available information. It is always important to combine different pieces of information such as:

- The information collected during the desk study provides an indication of the situation of the presumed contamination at the site:
  - the industrial activities and the location of specific activities may indicate where typical waste material may be located and what will be the chemicals of concern;
  - the geological and hydrological characteristics may indicate the pathways of the contamination and where spreading of contamination is expected. Information about the time since polluting activities started and the permeability of the soil and the direction and speed of the groundwater flow may provide a first indication of the distance to where contamination might have spread. For contaminated sediment information of surface water flow is necessary to have an indication of the distance to where contamination might have spread;
  - the previous and current land use may indicate activities through which contaminated material can be moved or covered. This may have caused a totally different situation of the contaminated site than initially caused by the polluting activities.
- Maybe previous investigations already provide some information about the boundaries of the contamination.
- During site inspection sensory observation of contaminated material or information of effects of the contamination may indicate the presence of this material. If a presumed source of contamination is detected the surrounding area should be searched to find out where there is no indication of this material anymore. This can e.g. be the color of material lying at the surface, the shape and differences in height of the surface level or differences in vegetation. Combined with the results of the desk study a first rough conceptual site model (CSM) can be developed. In this CSM the area where contamination may be indicated.
- The preliminary site investigation report provides concentration levels of samples (soil, sediment, groundwater or surface water) which may indicate the locations where contaminated material is present and other locations where the levels do not exceed background concentration values. Possibly the sources of contamination presumed from the desk study can be confirmed.
- These results can support or contradict the conceptual site model, so this model can be updated incorporating the new information.

Activity 2 – Impose site use restrictions and temporary safety measures

Once a site has been notified this automatically sets in motion the next steps in the assessment and remediation process. It should be noted that often this sequence can take a lot of time, due to multiple reasons, e.g. the further investigation of the site and the preparation of the remediation may be technically complex or it may be necessary to carefully study remediation options before selecting the most effective and efficient option. Also, funding of the further assessment and remediation steps can take time. Furthermore, plans for redevelopment of the site or the surrounding area may define the moment when remediation works should start.

It may be that threats to human health or to the environment are assessed to be very severe, resulting in the need to rapidly respond to these threats. This can be the case if e.g. a clear relation can be made between the contamination of the site and current health problems of people living at or near the site (or in case this kind of threats is likely to occur in the very near future). If remediation works cannot start at short notice restrictions to the current site use should be considered. An example of a site use restriction is to prohibit use of the site for habitation.

By applying temporary safety measures the imminent risks caused by the contamination can be managed. An example of a temporary safety measure is to place fencing thereby implementing the site use restriction of prohibiting access.
If this leads to the necessity to make special arrangements for water and food supply the State Government may need to be involved.

A comprehensive overview of potential site use restrictions and temporary safety measures is presented in the *Checklist restrictions to site use and temporary safety measures, Volume II-3-a*.
Two examples of temporary safety measures are illustrated in the figures below.

Figure I-3.1: Example of fencing of a contaminated site

Figure I-3.2: Example of temporary safety measure to prevent new contamination from spill. The clamp is applied to stop a leak on a leaky pipe header running

3.3 Step 3 output

The output of this step is the site being notified based on the delineation and the conclusion whether there are site use restrictions which require the need of temporary safety measures. Further result of this step is information which relate to former contaminating activities and possible responsible parties.

Step 4 Priority list addition can be carried out parallel to this step 3. After that the remediation investigation (Step 5) can start.

If there is not enough information to delineate the site and as a result of that notification is found not be possible more detailed investigation should be considered.

Volume I

Step 4 Priority list addition

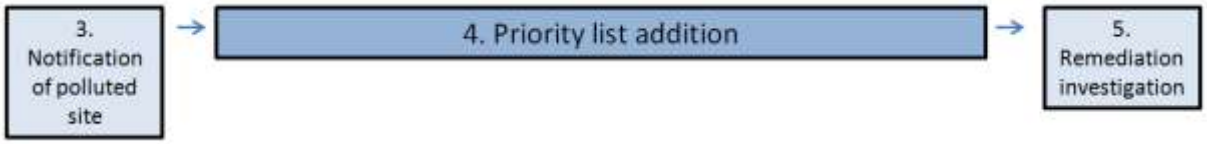
Step 4 Priority list addition

4.1 Introduction

General description and connection to other steps
Step 4 concerns the ranking of contaminated sites according to the priority their further investigation and remediation warrants, in comparison to other contaminated sites. This priority is related to the threat to human health and environment. A computerized database of priority sites with ranking features will be maintained and updated by the competent authority.

This section will discuss the technical aspects of this listing process, i.e. the application of prioritisation criteria to the parameters of a specific contaminated site. Step 4 commences with the assessment of relevant data on the site and ends with the presentation of a priority score for the site.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation. It should be noted that this Step may be performed in parallel with Step 3 Notification of polluted site.



Activities
A number of activities are performed in Step 4. In this document only the technical aspects to these are discussed:

1) Assess available data on the contaminated site;
2) Apply prioritisation algorithm to obtain priority score.

For detailed guidance on the prioritisation algorithm we refer to the Report of Prioritization of sites (part of NPRPS-Inventory and mapping of contaminated sites, COWI, Feb. 2015). The mentioned report includes explanation on two stages of prioritization. In this section we refer only to Stage II prioritization which is relevant for sites where a preliminary investigation has been carried out.

Responsible parties
The activities in this step are typically carried out by the competent authority for the assessment and remediation process. The team involved should demonstrate ability to interpret the information and recommendations of preliminary site investigation reports. This requires in-depth knowledge of and experience with the characteristics of contaminations (e.g. mobility, biodegradability) and its potential effects on humans and the environment.

4.2 Guidance for performing the activities of Step 4

This section presents concise guidance for the performance of the activities within Step 4. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Assess available data on the site

The first activity is to assess the available relevant data required for the prioritization system. Relevant parameters are listed in Table I.4.1 below. This table also indicates from which data sources these data may be retrieved.

Table I.4.1 Parameters relevant for prioritisation system

Parameter	**Data source**
On the source	
source concentration	site inspection or site investigation report
quantity of source	site inspection or desktop study
toxicity factor	Geoenviron Data Base
mobility factor	Geoenviron Data Base
On the pathway	
containment (access to contaminant)	technical judgement based on site access
attenuation reflecting directness of path to receptor	US reference values
On the receptor	
land use	site inspection
population at risk	desktop study, site inspection
sensitivity of receptor	site inspection
groundwater system at risk	Central Groundwater Boards, site inspection
surface water at risk	State Governments for Rivers, site inspection
sensitive ecosystems	site inspection

The data collected from official sources need to be verified through consultation of officials concerned with land matters.

Stakeholder	**Interview objective**	**Level**
District Collector	collect and verify information	district

Activity 2 – Apply prioritisation algorithm to obtain priority score

In this activity the available data on the parameters listed in Table I.4.1 are processed in the prioritisation algorithm. To enable this, the data need to be converted into numerical values eligible to process the algorithm. Basic guidance for this is provided by table I.4.2 below.

Table I.4.2 Parameter values for prioritisation system

Code	Parameter	Scoring basis	Scoring range
On the source			
C	Source concentration	Marks as Low, Medium, High or ratio to Screening Level	1 – 10
Q	Quantity of source	Volume, or Low, Medium, High	1 – 10
T	Toxicity factor	A list of chemicals	0 – 10
M	Mobility factor	List of chemical characteristics	0 – 10
On the pathway			
F	Pathway Factor = containment * attenuation	 access to source directness to source	1 – 1.2 1 – 0.1 1 – 0.1
On the receptor			
L	Land use at the site	Low, Medium, High risk	1 – 10
P	Population at risk	log(pop) within 1 km radius or Low, Medium, High	1 – 10
S	Sensitivity of receptor	Low, Medium, High	0 – 10
G	Groundwater system at risk (use/importance of aquifer)	Low, Medium, High	0 – 10
SW	Surface Water at risk (use/importance of surface water)	Low, Medium, High	0 – 10
E	Sensitive ecosystems	Distance to designated reserves, etc.: Low, Medium, High	0 – 10

Once the data on the parameters have been converted into a score within the scoring range these scores can be applied into the following prioritisation algorithm:

Priority score = [C + Q + T + M](F) + [L + P + S + G + SW + E]

The *Checklist information for application prioritization system Volume II-4-a* provides additional guidance on the parameters needed to effectively use the prioritisation system.

Figure I-4.1: Example of contaminated material at the surface

Figure I-4.2: Example of possible receptors at contaminated site

4.3 Step 4 output

The output of this Step 4 is a priority score for the contaminated site at hand, which should be used to prioritize the site in relation to other contaminated sites and subsequently to include the site at the Priority list.

Volume I

Step 5 Remediation investigation

Task 5.1 Detailed site investigation

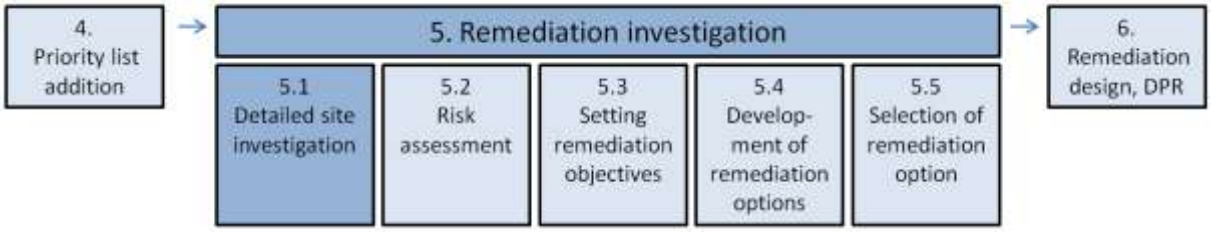
Step 5: Remediation investigation

Task 5.1: Detailed Site Investigation

5.1.1: Introduction to and scope of Task 5.1

General description and connection to other Steps and Tasks
Task 5.1, Detailed Site Investigation, concerns the identification of the nature, extent and concentrations of the substances at the contaminated site and of the site conditions. The results provide key information for risk assessment and the development of remediation options.

The figure below illustrates how this task 5.1 is connected to the preceding and following Steps and Tasks in the sequence of site assessment and remediation. The risk assessment may be developed sequential to the detailed site investigation and the results may be combined in one report.



Activities
The following activities are performed in Task 5.1:

1) Investigation strategy
2) Fieldwork and laboratory testing
3) Analysis and interpretation of exploratory data
4) Reporting detailed site investigation

Responsible Parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the site investigation. The work should be supervised by a senior colleague. Cooperation with the site owner and competent authorities is necessary to prepare the field work and to grant access to the site.
The team involved should demonstrate in-depth knowledge and experience in the investigation of contaminated sites and interpretation of exploratory results in relation to information obtained from reports and maps on the topography and geology of a site. It may be required to involve experts on modelling groundwater flow and subsurface transport of contamination.
The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.
For complex issues regarding the interpretation of exploratory results research institutes may be involved.

5.1.2 Guidance for performing the activities of Task 5.1

This section presents concise guidance for the performance of the activities within Task 5.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Investigation strategy

The starting point of the detailed site investigation is to define the scope for the investigation and to establish the required information. The detailed site investigation is generally aimed at:

- Providing comprehensive information on the nature, extent and concentrations of the substances at the contaminated site:
  - delineation of the area of the identified contaminating substances in soil, groundwater, sediment or surface water, related to the sources of contamination at the notified contaminated site (Step 3);
  - location and contours of concentration levels of the contamination;
  - assess contaminant dispersal in soil, groundwater, surface water, sediments, air and dust, direction and speed of spreading
- Providing information on the site conditions to identify and assess all contaminant pathways with respect to assess risks (refer to Task 5.2 for Risk assessment) such as a comprehensive geological and hydrogeological assessment;
- Providing information on site conditions to assess possible options for remediation (refer to Task 5.4 for Development of remediation options), e.g. permeability of stratigraphic subsurface layers, density of soil material, or concentration of general parameters in groundwater (iron, related to groundwater abstraction techniques).

Information of the contaminated site already has been obtained by a preliminary site investigation which provides a detailed history of the site use and an identification of all major sources, pathways and receptors of concern. Although the primary purpose of a preliminary site investigation has not been to delineate the contamination an indication of the extent of and boundaries to the contamination should be described.

The Conceptual Site Model is a key element during this detailed site assessment. The CSM enables the investigator to visualize the possible sources, pathways and receptors and focus on the areas for investigation relevant at the site, refer *Volume III-2.1-i, Manual Conceptual Site Model and identifying the Source-Pathway-Receptor*, on how to apply the CSM.
In the preliminary site investigation (Task 2.2) the CSM already has been developed.

If there is doubt on the results of the preliminary site investigation or if the report cannot be regarded as valid anymore, parts of the desk study or identification of sources, pathways and receptors should be carried out again in the detailed site investigation phase. Depending on the land use and changes and the contaminated substances involved, a period of 5 years can be used as a rule of thumb as the period for carrying out an update of the preliminary site investigation.

Detailed site assessment is always a site specific exercise for which a specific investigation protocol should be developed. An example of the development of an investigation strategy is included in *Example investigation strategy detailed site investigation, Volume III-5.1-i*.

Based on the investigation strategy a detailed investigation protocol is prepared, regarding assessment of the contamination levels of the source and identification of the major pathways and receptors of concern. This protocol should pay attention to the following elements:

- Required information and data gaps;
- Screening and sampling technical equipment (refer *Overview of techniques for site remediation (Volume III-2.2-i*), an example is illustrated in figure I-5.1.1 below;
- Sampling rationale and design (media, locations, pattern and depth of samples) and the required level of detail of information), refer to Box I-5.1.1 below for an example;
- Number of samples;
- Screening of observations wells or necessity for drilling new wells;
- Necessity for multisampling events;
- Methods for establishing stratigraphy and characteristics of subsurface layers;
- Analytical test parameters for determination required. Based on the chemicals of concern as reported in the preliminary site investigation. In addition parameters referring to risk assessment or the applicability of remediation techniques may be tested (e.g. inorganic chemistry to describe redox conditions and potential for natural degradation, macro ions for assessing water treatment, bacterial analyzes, etc.).;
- Restrictions for investigation such as buildings, subsurface infrastructure and site boundaries;
- Quality assurance and quality control procedures such as use of field blanks/trips blanks, procedures to avoid cross contamination by sampling equipment etc.

Box I-5.1.1 Example for sampling design

The spacing and number of sampling points depends very much on the situation of the contaminated site. Based on experience the knowledge has gained that no generic sampling designs should be applied during the detailed site investigation phase.

To explain the differences in design for two totally different situations of contamination an indication on the number of sampling points are mentioned:

- Top layer of soil contaminated with heavy metals on a site of 1 ha: to achieve a representative impression of the actual situation about 10 boreholes may be drilled and for every distinct soil layer (at least every 50 centimetres) a sample will be taken;
- Volatile hydrogen chloride contamination has infiltrated the soil into the base of the aquifer: applying a CSM is of major importance to understand how the contamination may be located in soil and groundwater. The number of sampling points is not simply related to the surface of the above example of a contaminated top layer. Maybe tens or even hundreds of samples may be necessary to delineate the contamination. Apart from the primary contaminant parameters other parameters are required to obtain information of the macro chemical and biological situation of the aquifer.

Figure I-5.1.1: example of field work: tripod for drilling boreholes and placing water wells

Elements for Terms of Reference for the detailed investigation of a specific site may be selected from the topics in the *Checklist for detailed site investigation report, Volume II-5.1-a*.

Activity 2 - Fieldwork and laboratory testing

The field work may be assigned to third parties. Samples should be tested in a laboratory to assess the levels of contamination in the sample. Laboratories should operate in accordance with required accreditation criteria.
For the selection of third parties the *Checklist prequalification for site investigation, Volume II-2.1-a* may be used.

The fieldwork needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, sampling equipment needs to be prepared.

The stakeholder consultation is needed, both to inform them on the fieldwork plan and to secure their support for the plan. The consultation may also yield information that can be useful in the final design of the fieldwork plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.

Stakeholder	Interview objective	Level
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national

During the site investigation health and safety guidelines have to be taken into account by the field work team (refer *Volume III-2.1-i SIP, section 3*).
The sampling should be carried out by using the Sample Protocol (refer *Volume III-2.1-i SIP, Appendix A*).

The activities in the field should be described in a logbook of the field work team. The activities carried out should be accurately described for inclusion in the report.
The descriptions should be accompanied by sketches and pictures of the site (location of sources, dimensions, distances to receptors, significant site features, with marking of north arrow and scale. The locations of exploratory holes, wells or other observation points should preferably be indicated by XYZ-coordinates, using GPS.
Possible deviations from the original investigation protocol should be described in detail (refer Box I-5.1.2 below).

Box I-5.1.2 Practical tip: flexibility during field work

During field work activities certain observations may lead to considerations for deviation of the original investigation protocol. Therefore it is required to maintain flexible on fieldwork activities to achieve good results in an efficient manner. Based on the initial field work results additional samples and testing may be appropriate in case of unexpected indications of pollution. Multiple sampling events have to be taken into account and an iterative approach of detailed site assessment may be considered for efficiency reasons.

Activity 3 - Analysis and interpretation of exploratory data

Interpretation laboratory testing results against Screening and Response levels
The laboratory test results should be tabulated and recorded in terms of concentration levels for each parameter / substance per sample. These concentration levels are compared with the appropriate *Screening levels and the Response levels, Volume II -2.1-b*.

In some areas the natural background levels may be higher compared to the Screening levels, e.g. the natural background levels of metals and other inorganic chemicals can vary widely and this should be taken into account when applying the screening levels. Where it can be demonstrated that natural background concentrations are elevated (e.g. heavy metal concentrations in mineralised areas), it would be appropriate to develop less stringent assessment criteria. However care needs to be taken when establishing the level of the natural background and its natural variation as the local background may be influenced by historic mining and/or waste disposal activities.

Preparation of groundwater level contour maps
The results of measuring groundwater levels in observation wells should be outlined in a contour map. This should be combined with interpretation of the geological, hydrological and hydrogeological features of the site to estimate groundwater flow direction and speed.

For complex situations it may be required to carry out modelling of groundwater flow and contaminant transport and information on general geochemical parameters should be collected during fieldwork (refer *Tools for risk assessment, Volume III-5.2-i*).

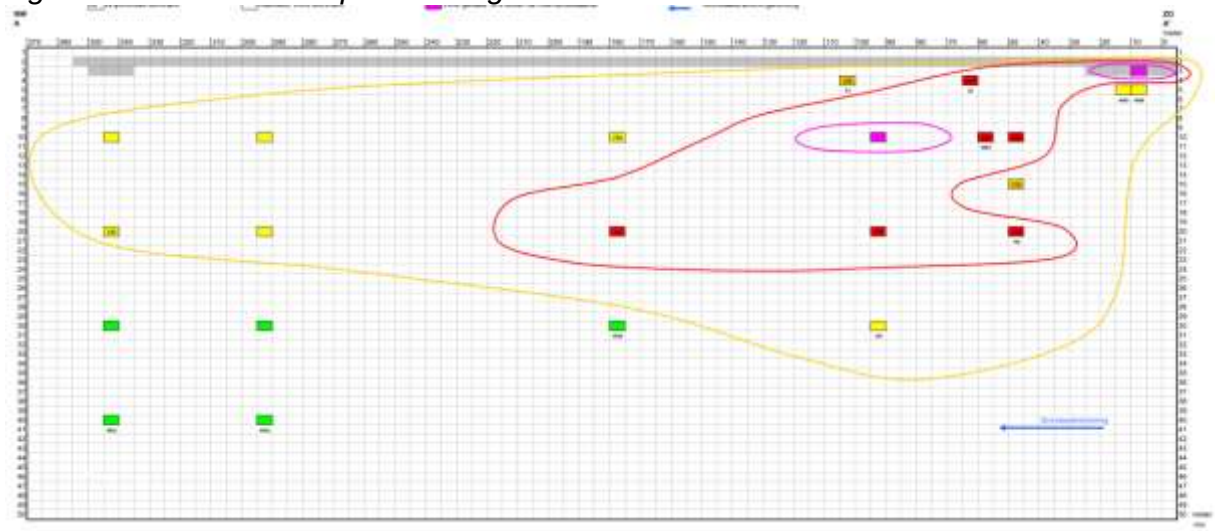
Activity 4 – Reporting detailed site investigation

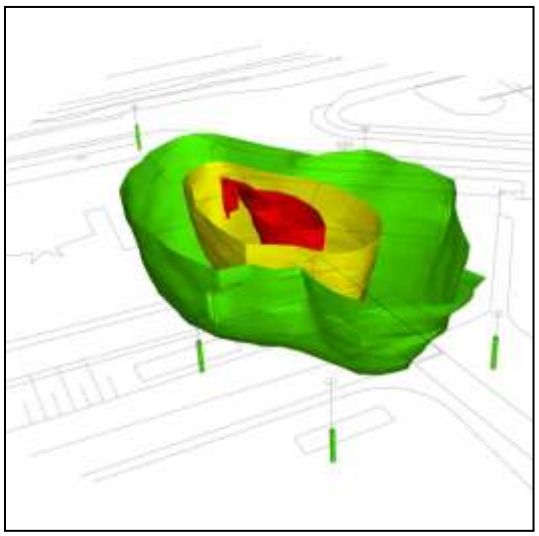
Details of all activities carried out, the equipment and methods used and the results of the detailed site investigation should be included in the site investigation report. The chapters of the report should be arranged in the same sequence of the investigation activities (refer *Checklist for detailed site investigation report, Volume II-5.1-a*).

The relevant elements of the previous report of the preliminary site investigation should be incorporated in the report of the preliminary site investigation.
The Conceptual Site Model should be reviewed and adjusted based on the results of the detailed site investigation.

The extent and amount of contaminated material and the manner it has been migrated should be described and outlined trough maps. Concentration levels and delineation of contaminated soil, groundwater and sediment can be explained clearly in this way. More than one map and use of colors for different categories of concentration levels may be required for optimal result. If there are uncertainties they should be indicated clearly. It may be not necessary to fill all data gaps because the decision on the remediation may not be depending on it.

Figure I-5.1.2.a-c: example drawings of contamination situation





When interpreting the data it may appear that several zones of distinct contamination can be present within the single contaminated sites. Each may be sufficiently distinguished to represent a contaminated site in it's own right. This is important regarding the confirmation of legal notification of the contaminated site which has taken place in Step 3.

Finally, a conclusion should be drawn regarding the predefined scope of the investigation. Recommendations should be provided for the next step in the remediation investigation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided.

The report has to contain as much as possible verifiable information meaning that copies of all original data from desk study, site inspection, exploratory field work and laboratory testing and modelling should be provided in annexes.
The investigating organisation should ensure appropriate quality assurance protocols and systems have been adhered to including prescribed protocols, the calibration of

field instruments, proper sampling and collection techniques and by providing records of responsibility, non-conformity events, corrective measures and data deficiencies.

Before proceeding to the risk assessment and further steps in the preparation of remediation it is useful to discuss the results with the competent authority regarding contaminated sites.

5.1.3 Task 5.1 output

The output of this Task 5.1 provides clear information on the nature, extent and concentrations of the substances at the contaminated site and on the site conditions. A checklist of elements a detailed investigation report may contain is presented in *Volume II-5.1-a.*

The competent authority responsible for reviewing the risk assessment report may refer to the checklist mentioned above. First, it needs to be determined which of these elements are relevant for the situation at hand. The competent authority may then proceed by assessing whether the report contains all these relevant elements. Data in the report should be complete and presented clearly. Most importantly, the report should show that the data and other information underpin the conclusions and provide enough information for risk assessment and development of remediation options.

Volume I

Step 5 Remediation investigation

Task 5.2 Risk assessment

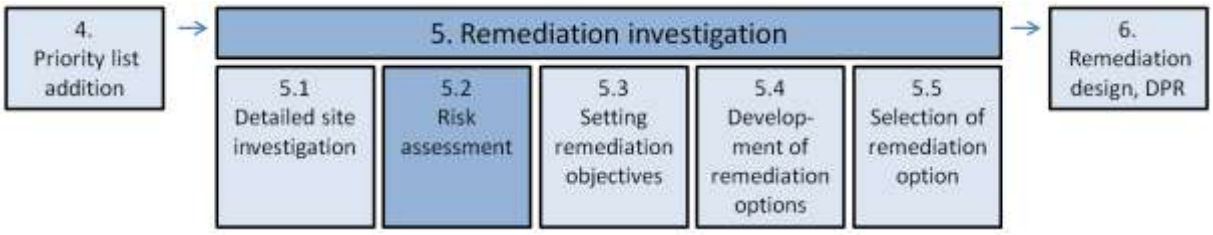
Step 5: Remediation investigation

Task 5.2: Risk Assessment

5.2.1 Introduction to and scope of task 5.2

General description and connection to other Steps and Tasks
Task 5.2, "Risk Assessment", concerns the assessment of the risks caused by the contamination as investigated during Task 5.1 Detailed site investigation. Risk assessment is the process of identifying, assessing and evaluating the risks that may be associated with a threat to human health and/or the environment at a contaminated site. The result of the risk assessment provides information to determine if remediation is warranted and if so, to provide input for the selection of remediation objectives and the development of remediation options. This way, the remediation objectives established in Task 5.3 and the remediation options developed in Task 5.4 are aligned with the identified risks.

The figure below illustrates how this Task 5.2 is connected to the preceding and following Steps and Tasks in the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 5.2:

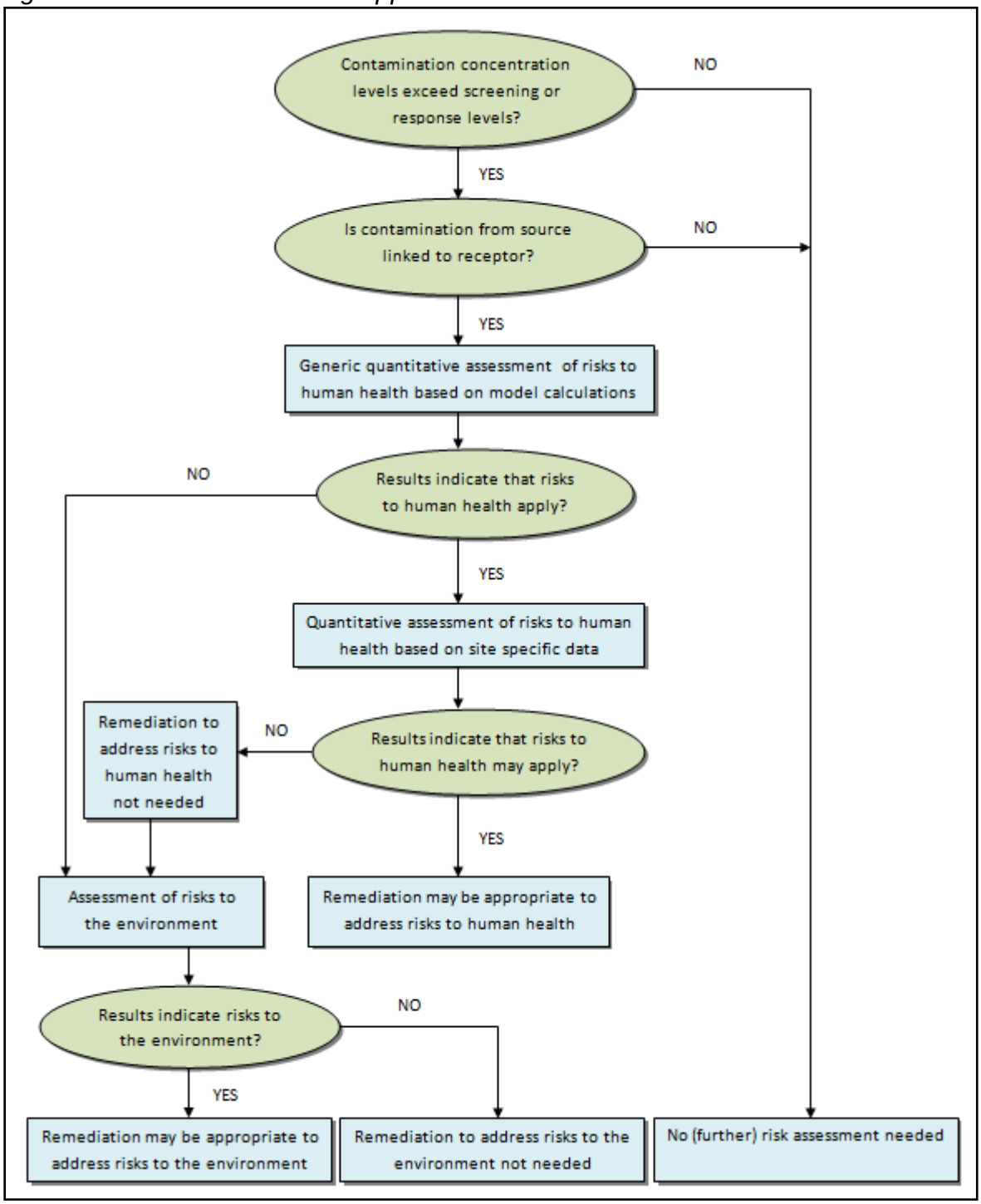
1. Assess contaminant concentration levels;
2. Identify applicable source-pathway-receptor-combinations for human health;
3. Perform a generic quantitative risk assessment for human health;
4. If necessary, perform a more detailed quantitative risk assessment for human health;
5. If necessary, perform a risk assessment for the environment.

This sequence of activities provides a tiered approach to achieve a sound and efficient decision on whether the contamination leads to risks for human health and/or the environment in the current situation at the site. This is visualised in figure I-5.2.1

Responsible Parties
The activities in this step are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience in the risk assessment of contaminated sites. For complex risk assessment studies research institutes may be involved.

Figure I-5.2.1 Flowchart tiered approach for risk assessment



5.2.2 Guidance for performing the activities of Task 5.2

This section presents concise guidance for the performance of the activities within Task 5.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Assess contaminant concentration levels

The aim of this activity is to draw a preliminary conclusion on whether the pollution may cause risks. This is done by comparing the contaminant concentration levels described in previous investigation reports with general key values for soil, sediment and groundwater quality (refer *Screening and Response levels, Volume II-2.1-b*). This activity may have been performed during the preliminary or detailed site investigation. In that case the results of the activity should have been incorporated in the respective site investigation reports.

In cases where the contaminant concentration levels are below the Screening levels it can be concluded that there are no relevant risks to human health or the environment. Based on this the competent authority may decide to remove the site from the Priority list of contaminated sites and determine as investigated site.

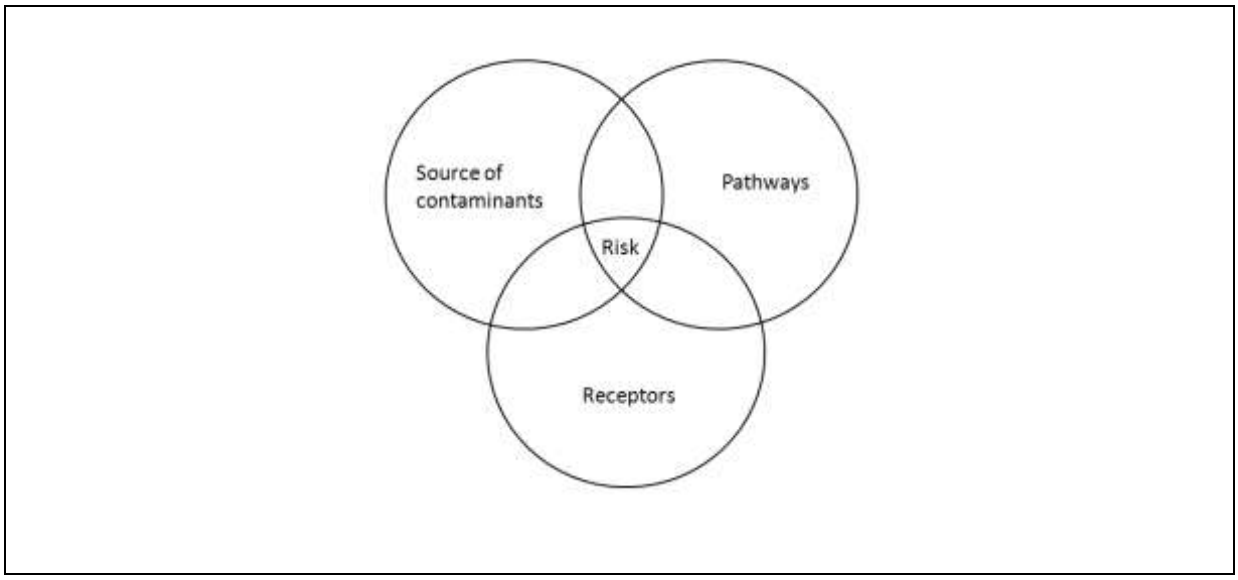
In case contaminant concentration levels exceed the Response levels there may be risks involved. This means further risk assessment is required, which would typically commence by proceeding to activity 2.

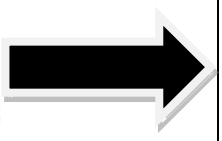
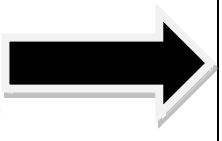
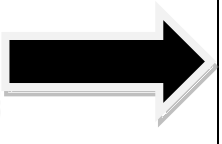
Activity 2 – Identify applicable source-pathway-receptor combinations for human health

The occurrence of risks depends on three components: source, pathway and receptor. It is important to note that all three of these components must be present for risks to occur. This is illustrated in figure I-5.2.2. In a situation where for example high concentrations of chemicals occur in a source but there are no receptors that can come into contact with these chemicals then risks cannot occur. It has to be emphasized that in future the situation of the site may change and contact with chemicals may become a possibility.

- Source: the location from which a contaminant(s) has entered or may enter a physical system. A primary source, such as a location at which drums have leaked onto surface soils, may produce a secondary source, such as contaminated soils;. Sources may hence be primary or secondary
- Pathway: the course through which contaminants in the environment may move away from the source(s) to potential environmental receptors.
- Receptor: humans and other living organisms potentially exposed to and adversely affected by contaminants because they are present at the source(s) or along contaminant migration pathways.

Figure I-5.2.2-a and b Risks occur only if source, pathway and receptor are all present (demonstrated in two different ways)



Source	Pathway	Receptor	Risks?
			Risk from this source may apply for this receptor
			No risk from this source for this receptor
			
			

Therefore, to assess whether the contamination may pose risks to human health and/or the environment it should first be established if all three components are present. This is typically done by identifying which combinations occur of the source from which contaminants are released, the transport medium that carries the contaminants to the receptors and the receptors that may come into contact with the contaminants. This is the qualitative phase of the risk assessment process. A diagram may be used to visualise the combinations that occur at the site. Such a

diagram clearly shows the exposure routes (refer *Tools for risk assessment, Volume III-5.2-i* for an example). The resulting diagram serves as a basis for the quantification of risks, as in that phase attention should be paid only to the potential source-pathway-receptor-combinations.

The source-pathway-receptor-combinations applicable to assess human risks depend on the structure and use of the contaminated site and its vicinity. The source-pathway-receptor combinations resulting in the most threatening exposure are:

- Contact of human with contamination through:
  - Direct contact with contaminated soil or groundwater (ingestion of soil or groundwater, inhalation of dust, dermal uptake of contaminants from the soil or from the groundwater) (figure I.5.2.3 below);
  - Ingestion of cultivated crops grown on the contaminated site;
  - Ingestion of fish from contaminated water;
  - Ingestion of drinking water from contaminated groundwater;
  - Inhalation of indoor air influenced by contaminated soil or groundwater.
- For ecology:
  - Uptake of contaminants from the top layer of the soil;
  - The leaching of contaminants to surface water.

Figure I.5.2.3-a and b Examples of direct contact of human with contaminated soil and groundwater

Activity 3 – Perform a generic quantitative risk assessment for human health

In case relevant source-pathway-receptor-combinations are identified a generic quantitative risk assessment for human may be carried out in order to quantify the risks the contamination may pose to human health. This is done by applying a generic risk assessment model. Internationally, different generic models for risk assessment are applied. These models show varying degrees of complexity in investigation and many are related specifically to the local legislative requirements. Each has a slightly different emphasis, depending on the focus of the agency and the types of sites expected to be encountered. Examples of risk assessment models are presented in *Volume III-5.2-i Tools for risk assessment*.

For effective use of any of these models data from the detailed site investigation report are required as input. Otherwise, for this activity no specific measurements are performed.

Most of the models calculate the intake of contamination by humans, expressed in mg contaminant per kg bodyweight. To determine whether or not there are risks to human health, the intake of a contaminant needs to be compared to a certain critical exposure value. When this level is exceeded for one or more of the contaminants this implies the presence of an unacceptable risk for human health.

In case it is concluded that the results from this activity satisfactorily express the risks in the given situation the assessment of risks for human health may be concluded. However, most of the available generic models for risk assessment are 'conservative'. This means that the default parameters used and the calculation of the level of risk will tend to overestimate this level. This is an important drawback, because it should be avoided that model calculations indicate that there are no risks while in practice there are actual risks. Due to this conservative approach the model calculations may indicate risks to human health where in the actual situation there are no risks. If it is suspected that this situation occurs, the risk assessment can be refined by performing activity 4. Typically, the results of the risk assessment so far are discussed with the competent authority, to reach a shared conclusion on whether to perform Activity 4 or not.

Stakeholder	Interview objective	Level
Competent authority	provide information and discuss conclusion	level of competent authority

Activity 4 – Perform a more detailed quantitative risk assessment for human health

In this activity more detailed information is collected for a more refined site specific risk assessment. If so desired, this activity can also be carried out to support the result of the generic model calculation.

The site specific risk assessment is carried out by collecting additional relevant information, e.g. by measuring the concentration of substances in contact media such as indoor or outdoor air samples, drinking water samples, crop samples or dust samples. Care should be taken to measure in these samples the same contaminants that have been identified in the soil samples during the site investigation. Subsequently, the risk assessment model calculated concentrations in e.g. indoor air or crops can be replaced by measured concentrations. Because the results of these measurements are more reliable than the results of modelling, a final site specific conclusion based on measurements in contact media can be drawn.

Activity 5 – Perform a risk assessment for the environment

If the contaminated site is situated in an area with high ecological value (land use: forests and other natural area), it may be required to assess the risks the contamination poses to the environment. The decision on whether this requirement applies to the site at hand or not is usually discussed with the competent authority.

Stakeholder	Interview objective	Level
Competent authority	provide information and discuss conclusion	level of competent authority

For such an assessment a tiered approach is also applicable. An example of an available method is the Soil Quality Triad. This method of Dutch origin combines the results of three types of assessment: chemical analysis, toxicity tests and ecological field surveys. Based on integration of the results of these three surveys the assessment provides a sound basis for a decision on remediation.

5.2.3 Task 5.2 output

The output of Task 5.2 provides clear information whether the contamination causes unacceptable risks for human health and/or the environment or not. If risks are present, the assessment provides insight which part of the contamination causes risks and by which pathways. This is useful information for the development of remediation options.

The result of extensive detailed risk study might indicate there are no unacceptable risks involved for current and future land use. In that case the notification as contaminated site may be reconsidered. If risk assessment indicates there are no unacceptable risks for current land use but there may be unacceptable risks after change of land use the priority for remediation measures may be reconsidered and monitoring of the land use may be implemented.

The checklist of elements for a risk assessment report is presented in *Volume II-5.2-a.* The competent authority charged with reviewing the risk assessment report may refer to this checklist. First, it needs to be determined which of these elements are relevant for the situation at hand. The competent authority may then proceed by assessing whether the report contains all these relevant elements. Data in the report should be complete and presented clearly. Most important, the report should show that the data and other information underpin the conclusions.

Volume I

Step 5 Remediation investigation

Task 5.3 Setting remediation objectives and requirements

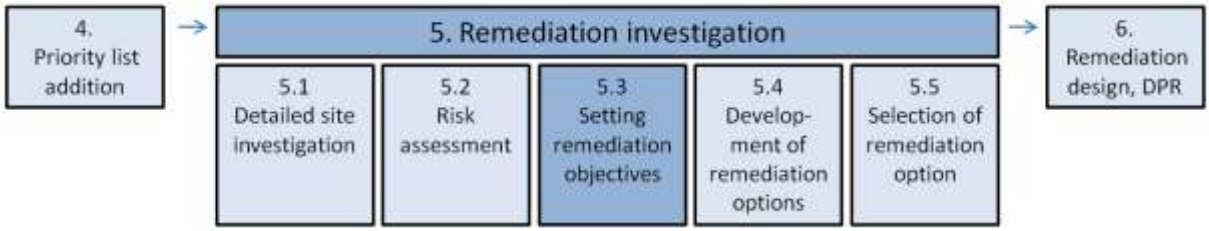
Step 5: Remediation investigation

Task 5.3: Setting remediation objectives and requirements

5.3.1 Introduction to and scope of Task 5.3

General description and connection to other Steps and Tasks
Task 5.3 is part of Step 5 Remediation Investigation and concerns the setting of remediation objectives and remediation requirements for the identified contaminated site.

Task 5.3 commences with the output from Task 5.2 which outlines where at the site contamination is resulting in unacceptable risks for the current or future site use. It ends with a clear focus on the remediation objectives and requirements including the considerations which have lead to them. This also forms the starting point for the subsequent Task 5.4.
The figure below shows how this Task is connected to the preceding and following Steps and Tasks within the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 5.3:

1) Establish remediation objectives;
2) Establish remediation requirements.

Responsible Parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved requires knowledge of the remediation regulation and should demonstrate in-depth knowledge and experience of the environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability). In addition, the team should have experience of the performance of remediation techniques and their physical, hydrological and social impacts. Cooperation with the site owner (non-orphan site) and the competent authorities (orphan sites) would be appropriate, in view of the potentially considerable implications of decisions made at this stage.

A review and approval by the competent authorities is required before moving to the next task 5.4 ‘Development of Remediation Options’.

5.3.2 Guidance for performing the activities of Task 5.3

This section presents concise guidance for the performance of the activities within Task 5.3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Establish remediation objectives

General principle governing this decision
The main aim of remediation of contaminated sites is to eliminate unacceptable risks of harm to human health and the environment or to reduce the risks to an acceptable level.

To eliminate the unacceptable risks complete removal or treatment of the contamination source is not always required. Often, the risk of actual exposure to high contaminant concentrations is limited, e.g. because the site is capped or because the contaminated material is above groundwater level. Therefore, the fundamental decision is to establish whether a complete restoration to pristine conditions is appropriate, or if an alternative approach is warranted. This approach would need to satisfactorily address the risks and would take into consideration the intended site use, costs, liability or long term obligations. This Section discusses the main considerations for this decision.

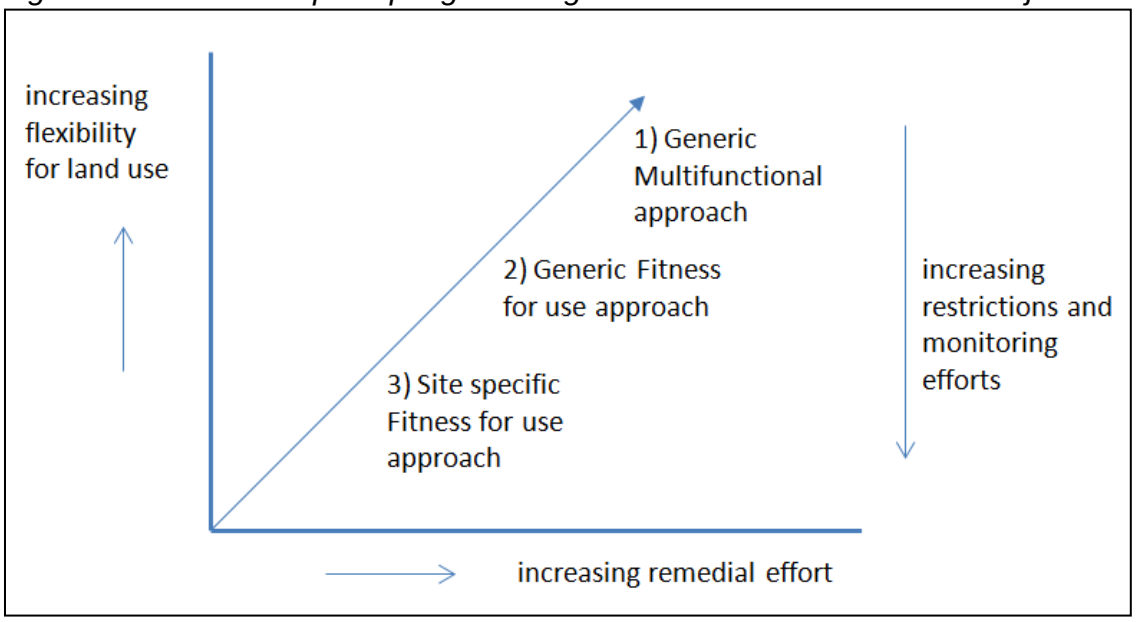
The decision on the remediation objectives is primarily governed by the general principle that more remediation effort results in increased land use flexibility/possibilities and less monitoring or maintenance requirements as illustrated in figure I-5.3.1.

The objective of complete restoration of a site to pristine conditions renders the site fit for all forms of land use. This is termed ‘multifunctional’, and requires a generic multifunctional approach, which will in practice mean complete removal of all contamination.

Alternatively, should complete restoration of the site be either not possible or desirable, the strategic decision will be to restore the site to such a level that is will be fit for the current or intended future use. This requires either a generic fitness for use or a site specific fitness for use approach. This approach can, for example, involve the blocking of exposure pathways or removal of affected receptors instead of removal of the source.

A generic multifunctional approach renders the site fit for all use without any post remediation constraints or liabilities. However, this approach typically involves high initial costs and sometimes high environmental impact regarding use of energy and materials and other negative effects. A fitness for use or cost effective approach is typically characterized by lower initial costs, but may result, depending on the situation, in considerable maintenance costs and site use restrictions.

Figure I.5.3.1General principle governing the decision on remediation objectives



In Box I-5.3.1 the major considerations which influence the selection of remediation objectives. For additional information, a.o. on international practices refer to *Background information for setting Remediation objectives, Volume II-5.3-a*.

Box I-5.3.1 Considerations for complete removal versus fitness for use

- Small site area and small volumes of contaminated material: complete removal or clean-up to background or target levels is relatively straightforward at such sites, and at relatively low cost.
- Liabilities: if the contamination is completely removed, there will be no potential future liabilities. This approach presents a high degree of confidence against any future legal claims or discussions regarding the presence of contamination. For this reason private companies may select this approach.
- Technical complexity and physical constraints, e.g. depth of the contaminants, groundwater depth, subsurface infrastructure, sensitive structures or the presence of other contaminants, may preclude complete removal;
- Long-term constraints and financial commitments, such as on-going monitoring and maintenance costs, and site use restrictions may not be appropriate.

If a fitness for use approach is selected, risk-based generic or site specific remediation target levels may be selected. The choice between either site specific or generic remediation target levels depends on cost-benefit considerations.

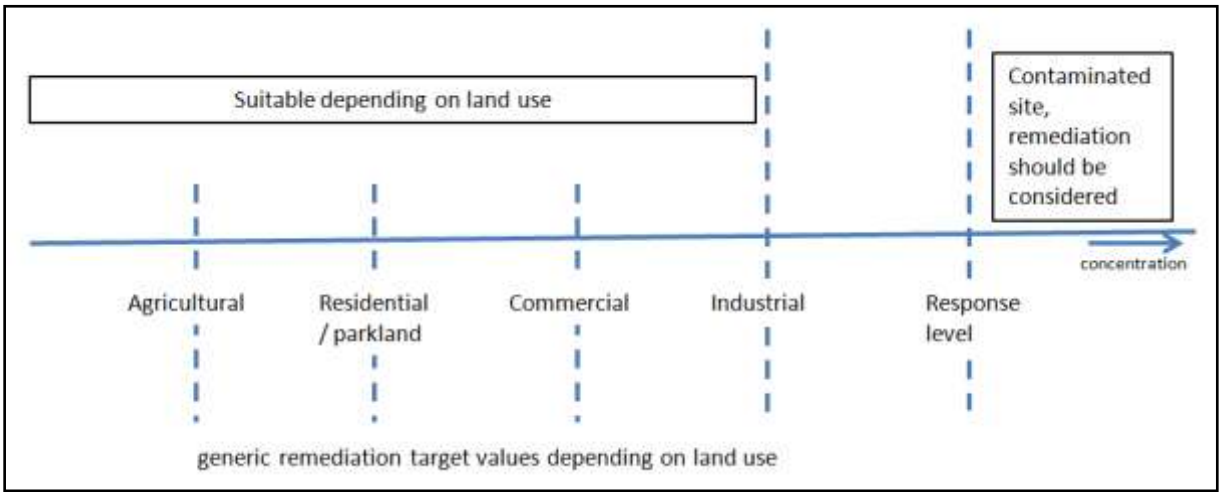
A generic target level will provide more future site use flexibility/possibilities. This because the target level is fit for a generic set of possible site uses within a particular land use category. Categories of land use are listed in Table I-5.3.1 below.

Table I-5.3.1 Categories of land use

Land use	**Category of land use in regard of the generic remediation target level for soil and sediment**
Agricultural land Kitchen garden Forests and other natural area	Agricultural
Habitation settlements (residential, school, kindergarten/playground, recreational park)	Residential / park land
Commercial	Commercial (relatively accessible sites)
Industrial Infrastructure (e.g. roads, parking, railway, subsurface cables and pipes) Waste land	Industrial (limited accessible sites)
Water bodies	For sediment depending on land use of the surrounding area
Mixed (to be specified for each use)	Select the most vulnerable of land use
Other (to be specified for each use)	Select the most vulnerable of land use

The decision on whether or not remediation is to be implemented is based on the assessment of contaminant concentration levels in soil (or sediment) and groundwater against the Response level. Remediation should result in a situation where the (lower) screening levels for the current or intended future land use are met. Figure I.5.3.2 below schematically shows the relation between the response levels on the one hand and the different screening levels on the other.

Figure I.5.3.2 Schematic overview of generic remediation target levels for soil and sediment and position relative to response levels



For the Screening levels the Canadian soil quality guidelines are applied. These generic soil quality guidelines present a level of negligible risk (soil remediated to these levels will represent a healthy, functioning ecosystem capable of sustaining the current and future uses of the site by ecological receptors and humans, including uses of groundwater). When the site investigation shows these levels are not exceeded no further investigation is required. These levels are below the Response levels which are based on the Dutch intervention values.

The Screening levels for soil and sediment are presented for four categories of land use: 1) agricultural, 2) residential/parkland, 3) commercial and 4) industrial land use. Each of these forms of land use represents a different impact of (contaminated) soil to humans and to the environment.
For groundwater the Indian Standards for Drinking Water are applied as generic target levels for remediation. If compounds are not addressed by these standards the generic remediation target levels are taken from Guidelines for Canadian Drinking Water Quality. Where Canadian values are also unavailable the levels from WHO Guidelines for Drinking water apply.

The Screening levels for the quality of soil, sediment, groundwater and surface water are listed in *Volume II-2.1-b*. It is proposed to align the generic remediation target levels with these site screening levels. In this way these levels can be regarded as remediation target levels within the framework of a generic fitness for use threat reduction. For comparison, the table also lists the response levels.

Application of generic remediation target levels is carried out as follows:
1) Determine the current or future use of the site and, if relevant, of groundwater and relate this use to one of the land use categories in Table I.5.3.1;
2) Determine remediation target values for soil (or sediment) and, if relevant, for groundwater by referring to the levels applicable to the relevant land use category in *Volume II-2.1-b Screening and Response levels*;
3) Establish whether specific conditions apply which may influence remediation target levels.

A site specific target level is tailor made for the site specific current or intended future site use (e.g. in case there are significant ecological concerns because of sensitive habitats for wildlife or endangered species). In case of special site characteristics (e.g. in case of a very large contaminated site which will result in very high remediation costs) or in case there are certain data gaps it may be recommended to develop site specific target levels as well. This offers cost effective remediation options, but minimizes site use flexibility/possibilities, because it is developed specifically for the use of the site at hand. Another advantage of using site specific target levels is that site specific background concentrations of naturally occurring substances can be taken into account (refer Box I-5.3.2).

Box I-5.3.2 Contaminants of natural origin

High background levels of naturally occurring substances may be present in soil or groundwater. For example, arsenic is a commonly occurring groundwater contaminant associated with particular geological formations. Remediating such contamination would be impracticable as natural replenishment of the contaminant would be inevitable. This underlines the importance to determine whether a contamination has been caused by human influence.

Cost benefit analysis is typically applied in cases of groundwater contamination. The costs associated with remediation of extensive plumes of dissolved contaminants within groundwater bodies can be extremely high without a clearly identified endpoint. The cost / benefit approach identifies a site specific remediation goal which optimises the remediation costs to reduce contaminant concentrations. Otherwise,

the further, incremental reduction in contaminant concentrations achieved by additional effort can become significantly disproportionate to the cost involved.

The decision for such an approach will depend on the local circumstances. For example, if groundwater is the only source of drinking water and it is directly consumed after abstraction, cost / benefit analysis may be considered.

Activity 2 – Establish remediation requirements

Remediation requirements comprise the physical, functional or management tasks and the performance criteria which enable an effective remediation option.
Typical requirements include:

- Plans for redevelopment of site or the surrounding area may influence which remediation options may be developed.
- The degree to which the remediation option is robust (refer explanation in Box I-5.3.3 below).
- The extent to which management is necessary to implement site use restrictions, to monitor groundwater plumes, or the maintenance of pump and treat plant etc.
- Commercial and social aspects concerning property value, employment opportunities and the views of local stakeholders.

The requirements identified define the criteria which are incorporated into the remediation options appraisal (refer *Checklist Criteria for comparison and appraisal of remediation options, Volume II-5.5-a)*.

Box I-5.3.3 Explanation of robust (solid) remediation

Robust (solid) remediation options are able to adapt to changes in site or soil conditions without endangering the performance of the option. Examples of robust options include:

- A cover layer designed to provide intrinsic protection from unauthorized excavation and construction activities. This can be achieved by incorporating a durable layer within the clean cover system which is very hard to dig through without heavy machines. In case of sites influenced by occasional flooding a cover layer may be not a robust remediation due to vulnerability for erosion;
- Systems monitoring the spreading of groundwater plumes typically incorporate monitoring wells which are used for periodical sampling. In case the system is sensitive to changes in groundwater flow direction, or is situated in an area with periodical changes in groundwater use, the monitoring system can be designed to accommodate the abstraction of groundwater as well. In addition, automated sensors can be used for continuous monitoring of the groundwater flow;
- In urban build-up areas source removal by excavation and off-site disposal is generally inappropriate. In such cases a clean cover layer can be installed which can be designed for the specific site use. A uniform and deep cover layer would facilitate such future activities without the continuous risk of accidentally disturbing contamination below the cover layer.

5.3.3 Task 5.3 output

The output of Task 5.3 is a detailed description of the remediation objectives, the target levels to be achieved and performance requirements for the remediation of the site. This description should include the rationale leading to the resulting remediation objectives and performance requirements.

The results of Task 5.3 will largely determine which remediation options may be developed. Therefore, the output should be submitted to the competent authorities for review, even if a formal decision is not required.
During the following Task 5.4 remediation options are developed and the most favourable option is identified during Task 5.5. During these Tasks 5.4 and 5.5 the conclusion may be drawn that the performance requirements set in Task 5.3 are too stringent to meet. Therefore, it may be necessary to anticipate this situation by going through all these Tasks in an iterative way, combining development of remediation objectives, remediation requirements and remediation options.

Volume I

Step 5 Remediation investigation

Task 5.4 Development of remediation options

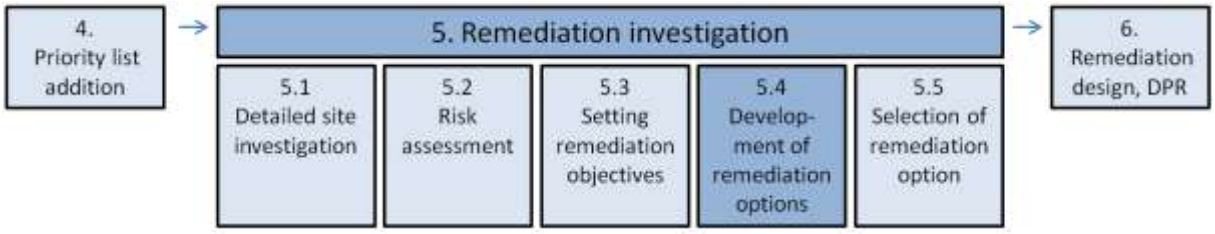
Step 5: Remediation investigation

Task 5.4 Development of remediation options

5.4.1 Introduction to and scope of task 5.4

General description and connection to other Steps and Tasks
Task 5.4 is part of Step 5 Remediation Investigation and concerns the development and suitability assessment of remediation options that may be appropriate to meet the remediation objectives established in Task 5.3. A remediation option is typically a combination of one or more remediation techniques that will enable to achieve the remediation objectives.

Task 5.4 commences with the assessment of the remediation objectives established in the preceding Task 5.3. It ends with the presentation of suitable remediation options from which one will be selected in the subsequent Task 5.5.
The figure below shows how this Task is connected to preceding and following Steps and Tasks within the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 5.4:

1) Assess the remediation objectives and requirements;
2) Identify constraints to remediation;
3) Identify applicable remediation techniques;
4) Develop applicable remediation options.

Responsible parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

5.4.2 Guidance for performing the Activities of Task 5.4

This section presents concise guidance for the performance of the activities within Task 5.4. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Assess the remediation objectives and requirements

All remediation options considered in Task 5.4 should be able to meet the remediation objectives and requirements. Therefore, the first activity is to carefully assess the objectives and requirements which are to be met, in order to identify performance criteria relevant for consideration in the remediation options appraisal.
An example of these criteria is the target level for contaminating substances in soil and in groundwater.

Activity 2 – Identify constraints to remediation

In addition to the remediation objectives and requirements there may also be constraints imposed on the remediation.

They do not have an impact on the remediation objectives or requirements, but may affect how these objectives can be achieved:

- They may restrict or limit the range of applicable remediation techniques;
- They may determine the technical specifications for the techniques.

Constraints comprise technical and non-technical issues. Some examples of constraints are listed in Box I-5.4.1below.

Potential constraints for remediation may be identified by the party or the parties responsible for the site, for example the site owner or developer or, in the case of orphan sites, the competent authority. Constraints may also arise from consultations with other stakeholders, e.g. the municipality regarding spatial planning of the surrounding area or the local community. As constraints can have considerable influence on the remediation, the performing agent should consult all stakeholders who may raise an issue which could constrain the proposed remediation.

If a large number of stakeholders is involved the list of constraints may grow to a considerable extent. At a later stage this may lead to the conclusion that they impose a prohibitive financial burden on the remediation or that conflicting interests may need to be dealt with. Therefore, the activities in this Task may need repeated reviews during later activities. When a certain constraint is subject to change the stakeholder linked to that specific constraint should always be consulted.

Box I-5.4.1 Examples of remediation constraints

Soil remediation is often performed as part of redevelopment of an area. This intention will typically have been established in Task 5.3, along with the remediation target levels (concentrations of contamination in soil, sediment, groundwater or surface water) to be achieved. In most cases, the remediation process would be aligned with the redevelopment, leading to constraints such as the following:

- The redevelopment will require the site to be available for the intended future use at a specific date. The remediation planning should therefore aim to be completed by that date. This time constraint would rule out remediation options which would require a lengthier period of time to complete.
- In case post remediation measures have to be implemented at the redeveloped site, these measures need to fit in the future site use. They should not give rise to impacts on site users from noise (e.g. a groundwater treatment plant) and should not need to be replaced on a regular basis (e.g. a groundwater pumping system).

Physical restrictions such as nearby structures that must not be destabilised, or services and communications that must not be interrupted, e.g. railroads or power lines:

- Contaminated material may be present at a site with historic or vulnerable buildings which may be afforded protection. Where contamination source excavation and removal is proposed, excavation techniques should be considered carefully, because such techniques may cause damage to the building. Where this is proposed, additional measures to protect the building should be examined. However, should these measures then turn out to be too expensive or too high risk, these techniques for source removal should be rejected.
- When buildings or structures are located near the remediation site, the groundwater level should not be lowered too much, to prevent destabilisation of foundations leading to their potential settlement. This constraint would limit the potential capacity of the proposed remediation technique, e.g. the abstraction rate and zone of influence of a pump and treat system.

During the implementation of remediation certain activities may cause nuisance e.g. noise, the spreading of dust or the temporary closure of major infrastructure. For sites situated in urban areas specific limits may be imposed on the degree to which this nuisance is acceptable (restricted operating hours or the use of less noisy equipment). It may also lead to the selection of a different access route to the site, a different type of pump and treat system or even to the use of a different type of remediation technique etc.

Other examples of constraints to remediation are:

- Specific issues raised by interested parties such as the future owner, or stakeholder expectations etc;
- Corporate environmental policies:
- A requirement to avoid long term costs;
- A requirement to optimize sustainability within each of the options;
- A requirement not to affect groundwater wells during the implementation of the remediation activities;
- Abundant rainfall or evaporation may influence groundwater and surface water levels and may influence certain remediation techniques.

Activity 3 – Identify applicable remediation techniques

A remediation option typically consists of a combination of remediation techniques tailored to meet specific site remediation objectives, requirements and constraints. To develop an option, the performing agent starts by identifying techniques applicable to the given situation from a list of all possible techniques. The Overview of remediation techniques and Menu of options, Volume III-5.4-i provide detailed information on techniques.

Applicable techniques are typically identified through a process of elimination, i.e. dismissal of techniques deemed unsuitable for the specific situation. This identification is based on the objectives and requirements developed in Task 5.3 and constraints identified in Activity 2 of this task. The data needed to perform this identification can be found in the applicability matrix and the generic and site specific characteristics and in the description of strengths and weaknesses, opportunities and threats of the remediation techniques (for both refer to *Volume III-5.4-i*).

Box I-5.4.2 Example: rejection of unsuitable remediation techniques

In this example, the remediation objective is the complete removal of all solid phase contamination. One of the principal constraints is the requirement that remediation must be completed within a period of a six months. This is because the redevelopment works programme requires the site to be available for the intended future use at that time. A number of the remediation techniques, or combinations thereof, will not meet this constraint and can, therefore, be rejected immediately. Only the identified techniques that can meet this constraint are considered further.

Potential techniques should not be hastily rejected as options that might have turned out to be applicable may not be given due consideration. For example: construction of a physical vertical groundwater barrier (cut-off wall) may result in the migration of polluted groundwater through the base of the confined contamination, and, therefore, this method may be rejected. However, this potential risk can be solved by combining the barrier with a groundwater extraction system. A combination of these two techniques may result in full confinement with the benefit of a low groundwater extraction flux, comprising a cost-effective solution.

An important note on the application of relatively unknown remediation techniques. A remediation technique must be technically proven before it can be applied with any guarantee of success. This means a newly developed, or otherwise unknown, remediation technique needs to be tested, at first under laboratory circumstances, but eventually also in the field, before it should be considered for application at any given site. The flowchart *Application newly developed remediation techniques, Volume II.5.4-a* provides more detailed guidance on this issue.

On completion of Activity 3 a list of potentially applicable remediation techniques should be recorded as the activity output. This should preferably also include technical specifications that should be taken into account (e.g. to meet the remediation re-

quirements) and any possible data gaps and uncertainty to be addressed by additional detailed site investigation.

Activity 4 – Develop applicable remediation options

The implementation of a single remediation technique is typically insufficient to meet the identified remediation objectives, requirements and constraints. Hence, often two or more remediation techniques are combined in a remediation option.
The process of combining remediation techniques to form a remediation option is the scope of this activity. The result will be a number of potential remediation options each covering the whole range of remediation objectives.

The number of remediation options developed is typically three or four, depending on the site-specific remediation objectives, requirements and constraints. For each remediation option listed, all criteria on which the option will be evaluated during Task 5.5 should be described and illustrated. An overview of these criteria can be found in the *Checklist Criteria for comparison and appraisal of remediation options, Volume II-5.5-a.*

Whilst there is no established process that should be followed when developing the remediation options, an iterative procedure is recommended (refer Box I-5.4.3 for examples).

Box I-5.4.3 Example: reasons for iterative option development

At some point in the process of option development issues may arise which need further investigation before the option development can be finalised. Examples of such issues are:

- complete delineation of the contaminated area;
- assessment of biodegradation rates in the subsoil in order to establish whether biodegradability of a contaminated groundwater plume is a possible option;
- assessment of social impacts of the options, e.g. when an option implies the capping of a waste dumping site it may mean this will have a negative impact on employment of communities using the site for economical purposes.

In contrast some technical details can be dealt with during the Remediation design (Step 6). An example of this would be the measurement of soil permeability, to be assessed in Step 6 in order to design the spacing of groundwater abstraction wells.

Recommendations and suggestions are provided below to enable the performing agent in his task to develop the remediation options.

Best practice
The Menu of remediation options (refer *Volume III-5.4-i*) offers an overview of best practice for all types of contaminated sites included in the Typology.

These options present a blueprint of preferred ('prioritized') options for remediation, i.e. the theoretically most appropriate remediation option for a variety of settings. Please note that the site- specific objectives, requirements and constraints may be conducive to develop further remediation options which are not featured in the Menu of remediation options.

The Menu of remediation options provides a first indication of potential remediation options that may be suitable for the situation at hand. For small and simple sites one or more best practice methods included in the menu may directly apply. In more complex situations the best practice overview will help the performing agent to make the first steps in the development of options.

Conceptual Site Model
While developing remediation options, the Conceptual Site Model (CSM), including the description of the sources, pathways and receptors (SPR's), is a useful tool (refer *Volume III-2.2-ii*).
The CSM enables to understand [i] how the identified sources, pathways and receptors combine to present unacceptable risks, [ii] how the pollutant linkages are interconnected and [iii] how intervention in respect of either one or more of the sources, pathways or receptors by implementing the actual remediation techniques can reduce the risks.

Some examples of the CSM approach to designing a remediation scheme are provided below. The text also illustrates the benefits of remediation techniques which either have an impact on more than one of the sources, pathways and receptors, or benefit from a combination of techniques applied to individual sources, pathways and receptors:

- *Source Intervention* can reduce the risk of leaching of chemicals leading to groundwater contamination. Source intervention can also prevent the contact between receptors and the source and thus reduce the human health risks without the need for any further pathway or receptor controls. Examples of source intervention are removal of the contamination source (e.g. by excavation) or treatment in situ (e.g. by in-situ bioremediation).

- *Pathway Intervention* will reduce the risks of contaminant migration. An example of pathway intervention is interception of contaminated groundwater including treatment and discharge. An important issue in such a case is that where the source remains untreated, the interception including treatment and discharge will be necessary for a considerable time. However, when the interception of the pathway is combined with reduction of leaching from the source, a more effective remediation solution can be achieved. Another example of pathway intervention is capping of contaminated soil material by applying a capping layer. The use of a permeable capping layer will only reduce the direct human contact. However, in case the

capping layer includes a impermeable element, the risks of spreading of contaminants are also reduced rendering the technique more efficient.

- *Receptor Intervention* mainly involves site use restrictions such as controlling an individual's exposure to pollutants by administrative means. These controls may comprise legal or contractual restrictions on access to, or use of, a garden or play ground. Other measures are focused on the protection or removal of the receptor and can be classified as temporary safety measures. Examples include re-housing, prohibiting access by fencing the site, preventing the use of groundwater for a potable source, e.g. by closing wells and providing water by alternative means (piping system, tanks, trucks).

Models for groundwater flow and mass transport

Models for groundwater flow and mass transport can be used to understand the hydrogeological regime and the pollutant mass transport mechanism. They provide detailed insight into aspects such as groundwater flow direction, plume migration and biodegradation rates. The use of such models allows an assessment of the remediation option suitability (e.g. aquifer permeability and applicability of groundwater control), effectiveness (e.g. volume of groundwater required for full plume capture, or reduction of plume size achieved by source removal) and configuration (e.g. number, depth and spacing of wells). They may also enable predicting any undesired consequences (e.g. effect of lowering of groundwater table on the construction of buildings and structures, or drought).

During this Task the model calculations are used just to get a basic insight into the above mentioned aspects. In Task 6, Remediation design, more thorough model calculations are sometimes required to derive the actual technical details needed for the design and implementation of the remediation works.

Practical rules of thumb

During the process of development of options the following practical and generic rules of thumb can be applied by the performing agent:

- Remediation techniques for removing the contamination load within a plume are most cost effective when combined with flux reduction from the source.
- The use of natural soil processes improves the efficiency of the remediation approach. For example: if time and space are available, the removal of groundwater contamination is more efficient if natural attenuation can be applied using the original inherent soil capabilities for biodegradation. This technique is slow but costs are low, even when natural conditions are enhanced by injecting the substratum with nutrients, oxygen etc.
- A combination of techniques can be efficient. For example, the removal of contaminants by excavating can be very efficient but only to the groundwater level. Below this depth, in situ extraction techniques are more cost-effective.
- If redevelopment or new construction works are planned on a site, a combined execution of the activities is usually attractive from various perspectives, e.g. costs, time, sustainability, and nuisance (refer Box I-5.4.4 below).

Box I-5.4.4 Practical information: redevelopment and remediation

Remediation of a contaminated site may be executed as an integrated part of a redevelopment plan for the area. This approach provides multiple opportunities to combine activities and to save on costs for both the remediation and redevelopment activities. Examples of combined activities are: [i] the excavation of contaminated soil can present an opportunity to utilise the resulting void as a basement or parking lot or [ii] the construction of new roads, pavements and building floor slabs can provide effective cover layers as an alternative to the construction of a cover system above contaminated soil or [iii] the excavated material may be reused or recycled into new raw materials e.g. organic matter from landfill sites or clayey material for brick manufacture.

When combining site remediation with site redevelopment it is advisable to develop the remediation options as an integrated part of the redevelopment plans. The consultant charged with the remediation investigation should cooperate with the site owner or site redeveloper and the engineers responsible for the design of the redevelopment. This cooperation should start at an early stage of the preparation phase providing maximum opportunities to combine both remediation and redevelopment activities. If started in an early stage this cooperation the land use plan can easily be adapted to the contamination situation. Often it is economically sensible e.g. to plan a parking lot on a former gasoline station instead of a playground or school garden. Even after decontamination of land people may not be willing to use that land for residential or other purposes. The possibility of using the land for setting up solar power generation system may be considered.

Cost estimates
For all remediation options costing is required. These costs may be estimated with an accuracy of plus or minus 20%. This is sufficient in order to compare the magnitude of costs of the different remediation options.

5.4.3 Task 5.4 output

The output of Task 5.4 is a set of applicable remediation options appropriate for the identified remediation objectives, requirements and preconditions. All options should be described in such a way that the selection of the most favourable option can be carried out in the next Task. The description of these options should include the technical specifications that should be taken into account (e.g. performance criteria to meet the requirements) or any data gaps and uncertainties requiring detailed site investigation.

Volume I

Step 5 Remediation investigation

Task 5.5 Selection remediation option

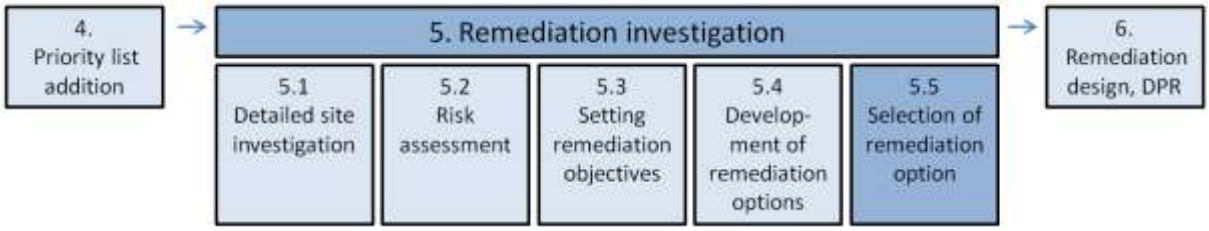
Step 5: Remediation investigation

Task 5.5: Selection remediation option

5.5.1 Introduction to and scope of Task 5.5

General description and connection to other steps and tasks
Task 5.5 is part of Step 5 Remediation Investigation and concerns the selection of the most applicable remediation option, i.e. the option best meeting all objectives, requirements and constraints established in the previous steps. The selection of this option is basically performed by matching the output of the preceding Task 5.4, i.e. the characteristics of several remediation options, with a standardized set of criteria. The most applicable remediation option is put forward to the competent authority for approval and provides input for the detailed engineering in a Remediation design plan (DPR) in the subsequent Step 6.

The figure below shows how this task is connected to the preceding and following steps and tasks within the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 5.5:

1) Compare and appraise remediation options;
2) Consult with relevant stakeholders;
3) Prepare remediation investigation report, including stakeholder views;
4) Review and approval of remediation investigation report and select most favourable remediation option.

Responsible parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

A review by the competent authorities is required before moving to the next Step 6.

5.5.2 Guidance for performing the activities of Task 5.5

This section presents concise guidance for the performance of the activities within Task 5.5. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Compare and appraise remediation options

The previous Task 5.4 would have yielded a set of potentially applicable remediation options. In this Activity these options are compared and appraised, as a first move towards selection of the most favourable remediation option. The result of this Activity should enable stakeholder consultation (Activity 2), the writing of the Remediation investigation report (Activity 3) and the eventual selection of the most suitable remediation option (Activity 4).

Criteria to be included in the comparison and appraisal
The implementation of a remediation option can affect a wide variety of criteria like costs, site reuse potential and social impacts. The criteria that are expected to be affected by any of the remediation options should be used as criteria in the comparison and appraisal process. These may be selected from the comprehensive list of these criteria, presented in the *Checklist Criteria for comparison and appraisal of remediation options, Volume II.5.5-a*. They can also be located in the generic analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) of remediation techniques in *The Overview of remediation techniques and Menu of options, Volume III.5.4-i*.

Methods for comparison and appraisal
Following structured and comprehensive methods of comparison and appraisal of remediation options may be applied: descriptive methods, qualitative overview methods and quantitative overview methods. It is advised to apply one of these methods to obtain an overview of all characteristics of the remediation options and the differences among them. Such a method may also serve as a useful tool for the stakeholder consultation. Which method is most suitable depends on the number of remediation options and the complexity of these options. Examples of these types of methods are presented in *Volume III-5.5-i*.

Some practical issues to consider during the comparison and appraisal process:
- An ideal remediation option meets all criteria in a well balanced way. If this balance is not met with either of the remediation options the process could result in an unsatisfactory remediation option. In that case it may be necessary [i] to reconsider the objectives, requirements and constraints that should to be addressed by the remediation, [ii] to adjust the redevelopment plans, [iii] to fine tune the remediation options or to develop new options;
- In most cases the process of design, evaluation and selection will not end up with one single solution unconditionally acceptable for all parties. These steps therefore often are made in an iterative process. During this iterative process the design and conditions should gradually develop towards a most favourable option. Trans-

parency in all activities and close contact with the important stakeholders is a key element in this optimising process;
- The comparison and appraisal process may also yield recommendations that will need attention during the subsequent design and implementation of a remediation option. Examples of such recommendations are presented in Box I-5.5.1 below.

Box I-5.5.1 Examples of recommendations that warrant attention in further steps

- A most favourable remediation option can be based on a technique which has only been used in laboratory and never in field conditions. In this case this option can be indicated as the most favourable option only after a field test or pilot remediation has proven to give a certain level of results (for guidance on this see Volume II-5.4-a).
- The exact delineation of a contamination should be assessed in case complete removal is anticipated.
- In case remediation of a groundwater plume is selected as the most favourable remediation option, the biodegradability of the contaminants should be confirmed by additional site assessment first.

Activity 2 – Consult with relevant stakeholders

The implementation of remediation measures may considerably affect stakeholders. The issues involved can be of a social or environmental nature, like noise and dust production by remediation equipment or trucks, and even temporary relocation of inhabitants. Different remediation options can also have different economic effects, as they may e.g. affect the value of the property differently. Therefore the selection and design of the remediation option should be subject to stakeholder consultation. The results of the comparison and appraisal of remediation options (Activity 1) provides a solid basis to start stakeholder consultation as they discuss all relevant issues like level of risk reduction, technical risks, costs, sustainability, planning, post remediation site use potential.

Stakeholders with partial responsibilities in the remediation process and stakeholders that may have to deal with impacts of the remediation, should be involved during the selection of the remediation option. Example of these stakeholders are:
- Municipal Water board or Water Sanitation Department: water quality and, if applicable, use of the water supply and sewage system for a prolonged period of time;
- Municipality or Traffic Police Authorities Transport Department: traffic issues related to the remediation works;
- Urban Development Department or Industries Department: possibilities for post remediation site use and, if applicable, site use restrictions.

Stakeholders that should at least be informed on the backgrounds and results of the remediation option are for example site users, inhabitants and other people with primary dependence on the site use. In case of larger impact by the remediation it may serve well to involve these stakeholders already in the process of development of remediation options. This action can be vital in gathering support for the selected remediation option. In cases where resistance against the selected remediation option runs high, the selected option may be modified or even reconsidered. In higher profile situations, it may be useful to involve local elected representatives, local politi-

cal party workers, media agencies and noted local personalities in the stakeholder consultations.

The stakeholder consultation should yield detailed information on their interests, which should be considered while selecting the most favourable remediation option and also later, during the remediation design and implementation of the remediation works. In some cases the stakeholder consultation may even lead to development of a new remediation option that may be included in the selection process.

Activity 3 – Prepare remediation investigation report, including stakeholder views

The process of comparing, appraising and eventually selecting remediation options should be well documented. This is done in a Remediation investigation report which presents the results of the detailed site investigation (Task 5.1), the risk assessment (Task 5.2), the setting of the remediation objectives and requirements (Task 5.3), the development of the remediation options (Task 5.4) and the comparison and appraisal of the remediation options, including the stakeholder consultation (Task 5.5) (refer *Checklist Remediation investigation report, Volume II.5.5-b.*

Activity 4 – Review and approve remediation investigation report and select most favourable remediation option

Once the selection of the most applicable remediation is completed, the resulting option should be put forward to the competent authority for approval.

The implementation of a remediation work may require approval by other authorities, e.g. the local water board in case of effluents into water bodies under their jurisdiction. In such cases, a sound and timely coordination among the involved authorities is crucial to prevent conflicting requirements.

5.5.3 Task 5.5 output

The output of this Task 5.5 is a selected most favourable remediation option, approved by the competent authority and preferably accepted by as many stakeholders as possible. The Remediation investigation report, in which the development, comparison, appraisal and selection process of this remediation option is documented, provides insight in the rationale for the eventual selection of the remediation option and for the actions to meet stakeholder interests. That report also includes a list of issues that need to be addressed during the following steps.

Based on this output a Remediation design plan (DPR) is prepared in the subsequent Step 6.

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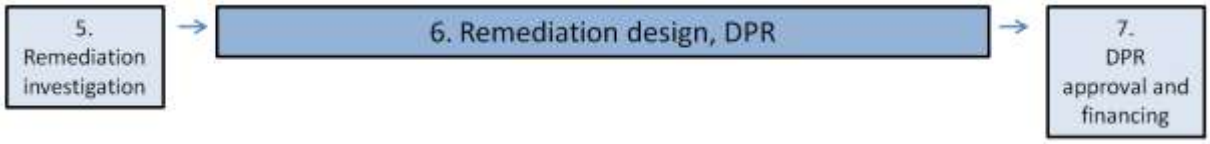
Step 6 Remediation design, DPR

Step 6: Remediation design, DPR.

6.1 Introduction to and scope of Step 6

General description and connection to other steps
Step 6 concerns the design of the remediation and the development of a Detailed Project Report (DPR). In the DPR a detailed description of the remediation activities is provided. Part of this DPR is an estimation of the costs required for the funding of the project (Step 7). The DPR is providing the technical information to be elaborated in the bidding documents during the implementation of the remediation (Step 8). Step 6 starts with a summary of the remediation option selected at the end of the preceding Step 5 Remediation investigation. It ends with the presentation and approval of the DPR.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
Within this Step the following activities are to be performed:

1) Design of the remediation: the technical system for the remediation will be presented. Detailed descriptions and drawings of the remediation measures will be reported.
2) Costing and planning of the remediation: all activities are summarized and a costing is provided for each of these activities (volumes, amounts and unit prices). A planning of activities is made indicating the time involved for the activities.
3) Environmental and social impact assessment and consultation of stakeholders

Responsible parties
The activities listed above will typically be performed by technical experts in the specialized agency or consultant charged with the remediation investigation.. The work should be supervised by a senior colleague. The team involved should have in-depth knowledge of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques. The team involved should be able to interpret the technical information and link the necessary measures to costs involved. For various elements of the cost estimation information from authorities may be required.

6.2 Guidance for performing the activities of Step 6

This section presents concise guidance for the performance of the activities within Step 6. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 - Design of the remediation

The design of the remediation is meant to detail out the selected remediation option into separate, interconnected activities. The technical and organisational aspects of these activities and their environmental impact should be described in a Detailed Project Report or remediation design plan (DPR). For some of the technical measures it should be assessed if they are applicable for the specific site. Sometimes modelling can be required to assess the effects of the remedial measures e.g. the mass transport of contaminants when using ground water extraction or the degradation of contamination to predict the results of biological techniques.

The DPR is based on the selected remediation option during Task 5.5. If the remediation is combined with reconstruction or redevelopment activities at the site it should be described in detail how the activities of remediation and redevelopment are linked and which impact they have.

A stakeholder consultation is needed, both to inform the stakeholders on the intended remediation measures and to secure their support. The consultation may also yield information that can be useful in the final design of the remediation measures. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.

In case it is expected that the remediation will leave no residual contamination the decision on land use after remediation closure needs to be taken at this stage. In such cases therefore, the remediation design also needs to address this issue. This will then necessitate the involvement of a land use designation authority, which may take the shape of an interdepartmental committee with land use experts.

Stakeholder	Interview objective	Level
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
In case it is expected the remediation will leave no residual contamination: Land Registration Office	discuss conclusion on land use post remediation	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national
Competent authority	provide information and discuss conclusion	level of competent authority

In the DPR the remediation objective is described as detailed as possible.
This allows for verification activities to be carried out, on the bases of which it is possible to conclude if the remediation objective is reached. For remediation techniques with can take a long period of time, the DPR should describe the management of the necessary monitoring activities to verify the progress of the remediation

If the remediation activities are causing waste, e.g. due to excavation, the Hazardous Waste Rules-2008 may apply with respect to transport, disposal or treatment of this material.

During the execution of remediation works unexpected issues will almost always occur. Examples include contaminated material in the subsoil which is present deeper than expected or permeability of the soil which is less than expected.
For the situation that the intended remediation objective cannot be achieved by the presented techniques, a fall-back scenario should be detailed and included in the DPR. This scenario provides technical measures by which the remediation objective eventually can be achieved.
Clear and measurable criteria for the success of the remediation should be part of the DPR. This allows the competent authority and the organization responsible for the remediation to make arrangements on the management of the remedial activities.

The remediation design plan / DPR has a standardized structure and content (refer *Checklist DPR including verification plan, Volume II-6-a*)

Activity 2 - Costing and planning of the remediation

All remediation activities are summarized and a costing is made for each of these activities. These activities do not only involve the technical measures of the remediation. The preparation of the work, including costs for demolishing building or replacement of inhabitants may be involved as well. The costs for management, supervision and verification of the remediation works should be included as well. The previous costs of investigation of the site and preparation of the remediation design may be summarized to the total of relevant costs.

The remediation may be combined with redevelopment of the site. It is important to distinguish costs for remediation and costs for redevelopment (e.g. a situation where an existing building should be demolished before remediation and reconstruction can take place. The demolition costs can be designated to the remediation as well as to the reconstruction). Depending on the financing parties of remediation and reconstruction this can be a major issue and point for discussion.

An overview of cost elements of a remediation is presented in the *Example format cost estimation remediation, Volume II-6-b*. The costing should include volumes, amounts and unit prices.

Some of the cost elements may be estimated quite accurately, some elements may be difficult to estimate (examples are provided in Box I-6.1). It may be useful to apply a bandwidth for elements which have large impact on the total costs.

Box I-6.1 Examples of uncertainties in cost estimates

- There may be uncertainties in the exact delineation of the contamination which can cause a deviation of the amount of contaminated material to be treated.
- The time necessary to achieve the desired results for an in-situ remediation.
- The starting point of the remediation project may not be known, which may have impact on the rate for disposal of excavated material on a TSDF.

Furthermore a planning of activities is made. In this planning the remediation activities as well as the verification activities are scheduled.

Activity 3 - Environmental and social impact assessment and stakeholder consultation

The remedial measures described in the DPR can have effects on the environment and the surroundings of the contaminated site. There may be negative effects from remedial measurements due to noise or dust by equipment used or by transport of contaminated material from the site.
During remediation the use of the site and surrounding area may be temporarily prohibited and this can have impact on communities using the site for economical purposes.

The environmental impact assessment should consider the effects of the remediation on the environment. It must include amongst others measures to minimise damage or nuisance caused by the remediation activities and measures to improve sustainability (e.g. reducing energy consumption). The social impact assessment must consider the effects of the remediation measures for the communities using the site. It should describe how communication is organised and what measures will be taken to minimise the effects of the remediation for the communities involved. It should also illustrate how the remediation of the site has positive effects on the possibilities for the owner and involved communities

All these effects are assessed in an Environmental and social impact assessment report (refer *Manual for environmental and social impact assessment for remediation of contaminated sites, Volume III-6-i*).

6.3 Step 6 output

The output of this step is a Detailed Project Report providing a clear and detailed description of the remediation system and the various techniques used. Furthermore a detailed planning and costing of the remedial measures are provided. Finally the report of an Environmental and social assessment is developed.
The competent authority has the responsibility for reviewing the DPR. If there is a necessity for involving stakeholders, the authority can share the report with these stakeholders. In that case maybe the costing can be regarded as non public element of the DPR.

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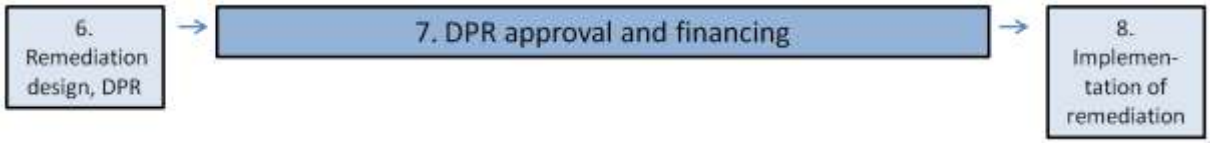
Step 7 DPR approval and financing

Step 7: DPR approval and financing

7.1 Introduction to and scope of Step 7

General description and connection to other steps
Step 7 concerns the approval of the remediation design in the DPR and the financing of the remediation works. Both these elements are required before getting into the actual process of remediation.
The figure below shows how this Step is connected to the preceding and subsequent Steps within the sequence of site assessment and remediation. The financing element of this Step 7 can start directly after notification of the contaminated site in Step 3.



Activities
Within this step a number of activities are to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Task 4 report, PWC June 2014). Here, the guidance focuses on the one activity with technical/financial aspects:

1) Review and approval of DPR by the competent authority

Responsible Parties
Review is typically performed by senior staff members of the competent authority, in order to prepare the decision by the appropriate official. The team involved should be able to interpret the technical information of the DPR and link the necessary measures to costs involved.

7.2 Guidance for performing the activity of Step 7

This section presents concise guidance for the performance of the activity within Step 7. It is intended to enable the user to quickly gain an understanding of the necessary activity.

Activity 1 - Review and approval of DPR

The report of the remediation design / DPR will be reviewed by the competent authority. Points of attention for this review are provided in the *Checklist review and approval Detailed Project Report, Volume II-7-a:*

- The remediation objectives according to the selected remediation option (Task 5.5) should be met;
- The remediation should be technically well feasible;
- If the remediation is combined with reconstruction activities at the site the planning of the reconstruction does not have a negative impact on the remediation

measures (example: this could happen if in-situ remediation measures are applied and during the exploitation period of these measures groundwater extraction is applied to prepare reconstruction which can have a negative effect on the performance of the remediation);
- The results of the environmental and social impact assessment are acceptable and within regulatory permits. Where technically possible and economically reasonable additional measures will be applied to reduce negative impact of the remediation measures (examples: spraying of water in case of dust formation; temporary replacement of dwellings for residents during excavation);
- There are clear criteria to assess the progress and final result of the remediation (examples: permeability of a top clay layer used for containment of a site; concentration levels of pollutants and chemical properties of groundwater);
- The activities to verify the progress and results of the remediation are clearly described;
- Uncertainties which may have effect on the remediation result are indicated explicitly and the DPR provides scenarios and measures in case these uncertainties will occur.

7.3 Step 7 output

The output of this step is the approved DPR and certainty on budgets for the remediation and post remediation costs. Based on this the preparation of the remediation works can proceed.

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Step 8 Implementation of remediation

Task 8.1 Preparation and authorization

Step 8: Implementation of remediation

Task 8.1: Preparation and authorisation

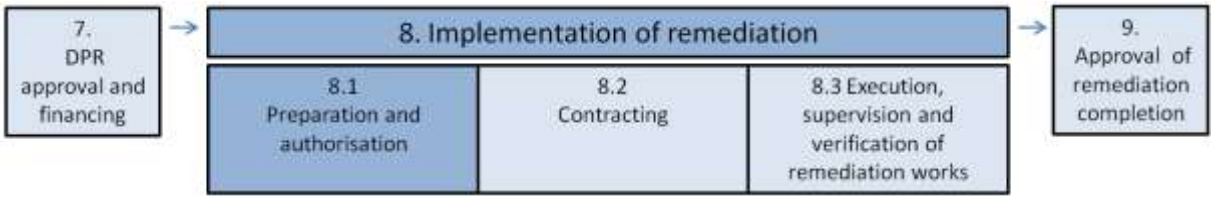
8.1.1 Introduction to and scope of task 8.1

General description and connection to other Steps and Tasks

Step 8 concerns the implementation of the remediation of the established contaminated site. The remediation works have been described in the DPR (developed in Step 6) where the technical design of the selected remediation option (Task 5.5) is described in detail.

Step 8 is divided into three tasks: preparation and authorisation (Task 8.1), contracting (Task 8.2) and the execution and supervision and verification of the remediation (Task 8.3). Before the execution of the remediation works can start these remedial works should be authorised and necessary regulatory permits, licenses and/or consents should be met. This activity can take place parallel or in sequence with the contracting Step 8.2.

The figure below shows how this Task 8.1 is connected to the preceding and subsequent Steps and Tasks within the sequence of site assessment and remediation.



Activities
Within this Task 8.1 the following activities are to be performed:

1) Inventory of required permits.
2) Applying for the permits.

Responsible Parties
Generally, the organisation responsible for the remediation (authority, company or private party or person) will instruct the preparation of a project to ensure all regulatory obligations concerning the remediation works are met. This organisation can appoint a specialised third party, to take care for arranging these permits and licenses. The contractor may arrange these permits and licenses as a first step of the execution of the remediation works as well.
The team involved should be able to assess the information of the technical system and make conclusions on the required permits, licenses and consents. Knowledge of regional and local regulations is required as well.

8.1.2 Guidance for performing the activities of Task 8.1

This section presents concise guidance for the performance of the activities within Task 8.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 –Inventory of required permits

The required permits should be inventoried, refer *Checklist permits necessary for remediation works, Volume II-8.1-a.* This is depending on the characteristics of the remediation design and the specific equipment the contractor will use during the execution of the remedial works, examples are provided in Box I-8.1.1 below.

Box I-8.1.1: Examples of activities for which the permits may be applicable

The remediation activities will have an impact on the contaminated site and its direct surroundings but the impact of the remediation may be more than that. Some examples:

- always transport of equipment to and from the site is involved in a remediation project;
- when removing of excavated material from the site there may be a large impact on the local transport network;
- at the site where treatment or disposal of the material takes place there may be a permanent installation which will require permits and licenses independently.

Activity 2 – Applying for the permits

The required permits, licenses and consents should be applied at the various governmental organisations. The municipal government and maybe different departments will surely be involved. Maybe the state government has to be consulted for specific regulations. Water boards may have to be involved if the remediation works have impact on ground water or surface water.

Providing detailed information of the impact and planning of the remediation works may be necessary during the application process. Part of this information may be obtained from the results of the Environmental and Social Impact Assessment, developed during Step 6 Remediation design, DPR.

8.1.3 Task 8.1 output

The output of this task 8.1 is a document including all obtained and signed permits, licenses and consents at this stage required for execution of the remediation works. May be the contractor will have to apply for permits just before the remediation works start in case specific equipment is involved.

This document with (copies of) all obtained permits, licenses and consents should always be readily available during the execution of the remediation works. In case the specific activities or specific equipment may be changed during the remedial works it is necessary to check if it is still possible to meet the obligations of the permits, licenses and consents.

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Step 8 Implementation of remediation

Task 8.2 Contracting

Step 8: Implementation of remediation

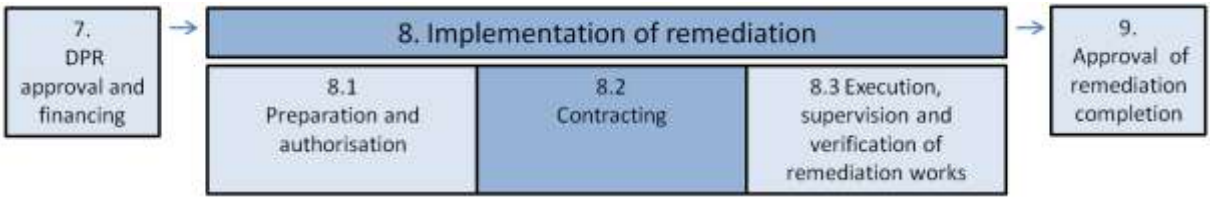
Task 8.2: Contracting

8.2.1 Introduction to and scope of task 8.2

General description and connection to other steps and tasks
Step 8 concerns the implementation of the remediation of the contaminated site. The remediation works are described in the DPR (developed in Step 6) wherein a technical design of the selected remediation option (Task 5.5) is elaborated.

Step 8 is divided into three tasks: preparation and authorisation (Task 8.1), contracting (Task 8.2) and the execution and supervision and verification of the remediation (Task 8.3).
The objective of Task 8.2 contracting is the selection and appointment of a contractor which can offer adequate results against acceptable costs.
Generally there are two main options for contracting: traditional contracting and design and build. Design and build implies the client directly employs a contractor to provide both design and implementation. With traditional contracting the client directly employs the designer for a DPR (Step 6) and the contractor for the remediation (Step 8) using separate contracts. In this section we will describe the traditional contracting process.

The contracting phase (Task 8.2) is carried out after the DPR approval and financing (Step 7) has been arranged and the authorization of the remediation by the competent authorities. The contracting is based on bid documents to be developed during this step. After the appointment of the works has taken place the execution of the remediation works can start.
The figure below shows how this Task 8.2 is connected to the preceding and subsequent Steps and Tasks within the sequence of site assessment and remediation.



Activities
Within this Task 8.2 the following activities are to be performed:
1) Preparation of bid documents.
2) Selection and appointment of the contractor.

Responsible Parties
Generally, the client/organization responsible for the remediation (authority, company or private party or person) will instruct the development of bid documents and the contracting of a project. This organization can hire a consultant to develop the bid documents and to implement the contracting procedure. State and National Government needs to be involved throughout this Task.

The preparation of the bid documents and the contracting process should be supervised by senior colleagues with technical as well as financial background.

The team involved should demonstrate in-depth knowledge how to translate the remediation measures, described in the DPR into detailed technical activities. Knowledge of practical possibilities of technical solutions is necessary to develop these bid documents.
Furthermore experience with contracting procedures is required and capabilities on administrative, legal and financial aspects.

8.2.2 Guidance for performing the activities of Task 8.2

This section presents concise guidance for the performance of the activities within Task 8.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Prepare bid documents

In a bid document a very detailed technical description is provided of the remediation works as designed and reported in the DPR. It clearly defines the activities and measures and the results to be achieved by the contractor and the applicable criteria. It includes detailed description of activities, location of work, transport of equipment and traffic measures, building materials and waste material, temporary storage facilities at the site. In these descriptions reference is made to detailed drawings or pictures which have to be included (various scales; overviews and cross-sections; technical constructions). The bid document should describe possible preconditions for executing the work (e.g. accessibility of the site, security measures, daily routine time schedules).

Based on the bid document parties/contractors should be able to:
- develop a work plan of technical activities;
- include the health and safety measures for workers and people in neighboring area;
- identify the applicable equipment and project team (with possible subcontractors);
- calculate costs for an offer;
- develop a time schedule.

Despite of intensive investigation efforts during detailed site investigation there will always be some uncertainties regarding the exact delineation of the subsurface contamination or the behavior of substances in soil, sediment or groundwater. In the bid document clearly should be described how to deal with these uncertainties during the remediation works regarding the technical, legal and financial consequences.

Uncertainties are inevitable, due to the fact that the soil is largely invisible and any investigation is based on tests on a limited part of the total soil and groundwater volume. However, the uncertainties can be such that the investigation can be deemed

insufficient. In such cases it may be considered to hold the Consultant liable for insufficient work. Therefore, this issue should be a point of attention in the drafting of the bid documents.

Activity 2 – Selection and appointment of contractor

The activities are depending on the chosen method of the tendering process. The tendering process is a method where the Indian Government, as well as Municipalities and most Corporations issue a procurement notice in newspapers, official government publications and over the internet for purchasing goods or services.
There are different tendering processes for different types of tenders.
The three types of tendering methods are:

1. Open Tendering;
2. Selective Tendering and
3. Negotiated Tendering.

Open Tendering Process
After the bid documents are finalised the tendering process comprises various stages.
The first stage includes the pre-qualification stage, where the client lays down criteria for qualifying for the work being tendered. This phase is considered as an important stage as it drastically cuts the number of bidders and selects only capable bidders.
The second stage is the tender invitation phase, where the client publishes or issues invitations to shortlisted bidders or to the public. This may not require media channels for communication.
The third stage is the tender clarifications and addenda phase, in which the client responds to the queries raised by the bidders in writing. It also engages possible issuance of tender addendums amending parts of the tender documents.
The fourth stage is the tender offer/bid submission phase where bids are presented in the form specified, mostly sealed envelopes and then there is the tender opening and the post tender clarification phase whereby the client goes through the tenders and seeks any clarification from the bidders.
The next stage is the award phase where the client issues an acceptance letter to the successful bidder who is usually, but not always, the lowest bidder and the last stage includes the formalisation of contract phase where the necessary documents are signed to formalize the agreement.

Selective tendering process
In a selective tendering process, the client selects only contractors that have delivered excellent results in previous similar tenders. This process includes three ways such as:

1. an advertisement may produce several interested contractors and suitable firms are selected to tender;
2. the consultants may contact those they would wish to put on an ad-hoc list and
3. many local authorities and national bodies keep approved lists of contractors in certain categories, such as work type and cost range.

Negotiated tendering process
In this process the client holds a one-to-one discussion with contractors to negotiate the terms of contract, as such tenders are mainly used for specialised projects like lift

systems, airport projects etc. at a larger level which includes a limited number of contractors who engage in these kind of projects from the industry.

In the Indian tendering scenario, frameworks are determined by guidelines set by the relevant international bodies including FIDIC (International Federation of Consulting Engineers for engineering) related tenders like computer tenders, civil work tenders and generators tenders.
However, the Indian Central and State Governments, Indian Municipalities and establishments such as Universities, the Military and Hospitals are governed by strict laws and only open competition bids are accepted.

It may be required to contract more than one party for the remediation works, an example is provided in Box I-8.2.1 below.

Box I-8.2.1 Example more than one party required to execute the work

It may be necessary to appoint more than one party to execute the work to be done. For instance in the situation where constructions present at the site have to be demolished anticipating the excavation of contaminated soil. Or the situation where a contractor executes an excavation work at the site and the excavated material is transported and treated by another contractor. For the supervision and verification of the remedial works the client always should appoint a third party which is independent from the contractor.

In the process of an open tendering for the remediation work there are various stages. The first stage includes the pre-qualification stage, where the client lays down criteria for qualifying for the work being tendered. This phase is considered as an important stage as it drastically cuts the number of bidders and selects only capable bidders.

Apart from financial and legal criteria there are several criteria possible to consider in the prequalification of a contractor. Some examples of these criteria are illustrated in Box I-8.2.2 below and more comprehensive in the *Checklist prequalification of contractors, Volume II-8.2-a*.

Box I-8.2.2 Examples of prequalification criteria

Company experience

- Track record of similar projects. Does the company or consortium have experience with the remediation techniques? Have these remediation works been implemented by the company in similar situations (type of contaminated site);
- Track record of projects with proven good project management skills;
- Company has appropriate health and safety policies and procedures in place;
- Pays attention to sustainability of certain aspects of the implementation (e.g. attention to save energy and to prevent nuisance);
- Quality management system.

Experience of Team and Team leader

- Good technical, management and communication skills;
- Capacity of the team is large enough to enable flexibility and to finalize the works according to the scheduled date;
- Awareness of policy and regulatory issues;
- Awareness of the need for verification;
- Ability to mobilize to the site in an acceptable period of time;
- Risk management approach to deal with uncertainties in the project.

8.2.3 Task 8.2 output

The output of this Task 8.2 is the contracting of a party, meeting the criteria of the bid documents, to implement the remediation works against agreed cost and time schedules.

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Step 8 Implementation of remediation

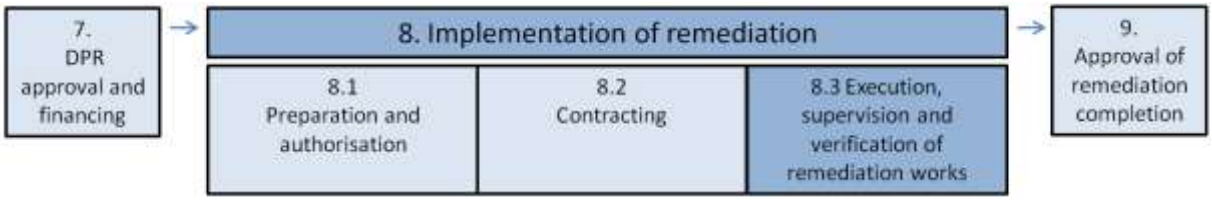
Task 8.3 Execution, supervision and verification of remediation works

Step 8: Implementation of remediation

Task 8.3: Execution, supervision and verification of remediation measures

8.3.1 Introduction to and scope of Task 8.3

General description and connection to other Steps and Tasks
Task 8.3 concerns the execution of the remediation measures, as well as supervision and verification of the same.
The figure below shows how this Step is connected to preceding and following Steps and Tasks within the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 8.3:

1) Prepare remediation measures;
2) Verify preparation of remediation measures;
3) Execute and manage remediation measures;
4) Verify remediation measures against contract and specifications;
5) Report verification results in a Remediation evaluation report.

Responsible parties
Activities 1 and 3 in this Task are typically carried out by technical specialists employed by a contractor. The team involved should demonstrate in-depth knowledge and experience of e.g. the remediation techniques and the characteristics of the contamination to be remediated.

Activities 2, 4 and 5 in this Task are typically carried out by technical specialists within a specialised consultant. It may be decided that these activities are assigned to SPCB, State and Central Government.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

The verification and reporting (Activities 4 and 5) are performed on behalf of the client and should therefore be carried out by a person or a team independent from the owner, occupier or the contractor. This requires special attention in case the supervision is carried out by specialists employed by the contractor. This is likely to happen

in case the contractor has entered into a Design, Construct and Management contract with the client.

In case the competent authority performs verification of the progress and results this is usually done in addition to the verification as described in Activity 4.

8.3.2 Guidance for performing the activities

This section presents concise guidance for the performance of the activities within Task 8.3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Prepare remediation measures

The responsible party for the execution of the remediation measures, typically a contractor, will commence by preparing a detailed plan for the execution of the measures according to the obtained permits (Task 8.1) and the contract (Task 8.1). Referring to the DPR, prepared in Step 6, may be in order, as that provides important background information on the remediation. Besides the technical aspects of the measures this plan should contain a health and safety plan, aimed at protection of both the onsite workers and inhabitants and other users of the site and its surrounding area. Elements a Health and Safety plan should include are listed in the *Checklist Health and Safety plan, Volume II 8.3-a*. The specific safety measures depend of course on the nature of contaminants, the local situation of the site and Health and Safety Regulations. Furthermore, the plan should provide for efficient organisation and logistics of the remediation measures. Examples of constraints the plan may need to deal with are presented in Box I-8.3.1 below.

Box I.8.3.1 Examples of constraints for execution of remediation measures

Example situation: remediation measures are to be executed in an area where other activities are ongoing, e.g. a production unit at an industrial site.

In this example situation, the following constraints to the intended remediation measures may apply:

- Limited workspace, e.g. for placement of remediation equipment, for temporary storage of waste or for an on-site treatment plant;
- Limited access to the site for vehicles and capacity;
- Limited or otherwise regulated time, e.g. when the remediation is part of broader rehabilitation activities;
- Buildings and their foundations. When excavation is intended these may need to be temporarily stabilised;
- Cables, wiring and pipes for transporting electricity and liquid raw materials or waste. These may need to be temporarily redirected.

Activity 2 – Verify preparation of remediation measures

Like the remediation measures themselves, their preparation is also verified. This verification typically includes checks on whether the required permits have been issued prior to the start of the work, on whether the health and safety plan is adequate (refer *Checklist Health and Safety plan, Volume II 8.3-a)*, on whether the authorities have been informed about the start of works, and on whether the stakeholder involvement has been adequately organised.

The verification of the preparations also includes a check on whether the data on the situation at the site are still in accordance with the actual situation. The basis for this check is the remediation plan (approved DPR), prepared in Step 6. Especially in case a long time has passed since the remediation plan was developed the situation may have altered. In such situations it may be necessary to have the Conceptual Site Model updated, so the intended remediation measures can be modified accordingly. In case of major changes in the situation it may even be necessary to modify the DPR (Step 6). Examples of such a situation are: mobile contaminants may have moved further through the soil with groundwater flow or some digging has taken place at the site causing a displacement of superficially present contaminated material.

Activity 3 – Execute and manage remediation measures

To determine whether the intended remediation measures can effectively meet the remediation objectives, pilot testing may be conducted. Depending on the situation this pilot testing can be carried out before detailed design of the remediation measures or before the start of execution of the remediation measures.

Execution
Execution of the remediation measures takes place according to the remediation plan. That plan should contain a clear outline of every measure, demonstrating how it is performed, its frequency (if periodic), parameters to be measured or sampled, target levels and what to do whenever either critical deviations or non critical deviations occur. For guidance on this last item refer to Volume I, Step 11, Activity 3. Including a description of the aim and background of measures can help to gain support from affected parties.

Management and reporting
The contractor periodically informs the client on the progress of the remediation measures. These reports should provide at least the following information:

- Progress of measures against the planning. Identification of delays or potential delays;
- Description and photographic records of the executed activities;
- Required modifications to the remediation measures;
- Necessity of activities not expected before and not agreed in the contract;
- Forecast of the activities and implications for the budget when extra activities are needed;

- If applicable, health and safety accidents or environmental incidents;
- Details of site visits made by regulators;
- Evidence (e.g. results of measurements) of conformance with permits, licenses and/or consents.

Relevant stakeholders on the site and in its surroundings should also be periodically informed on the progress. To them, the testing of nuisance caused by remediation activities may be of special interest.

Stakeholder	Interview objective	Level
Site owner	provide information, discuss progress	site
Site operator's health facility director	provide information, discuss progress	site
Local businesses, residents and NGO's	provide information, discuss progress	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information, discuss progress	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information, discuss progress	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	provide information, discuss progress	national
Competent authority	provide information, discuss progress	level of competent authority

Activity 4 – Verify remediation measures against contract and specifications

During the execution of the remedial measures the supervisor periodically verifies the conditions at the site. The actions this entails will have been outlined in the verification plan, developed in Step 6. This plan would also provide the frequency of the actions by the supervisor, the samples to take, what needs to be reported and otherwise communicated etc. The intensity of the actions to be performed may in certain situations require permanent presence of the supervisor at the site.

The verification focuses on whether the contractor executes the measures in conformity with the outline in the remediation plan (DPR), developed in Step 6. In case of deviations from that plan the supervisor discusses the reasons for this deviation with the contractor. In case the deviation necessitates modifications to the remediation measures the supervisor may impose these on the contractor. In case a deviation leads to a critical situation the supervisor may recommend to modify the remediation plan (DPR) or even to inform the competent authority, who may decide to temporarily discontinue the execution of the remediation measures. Box I-8.3.2 provides practical information how to deal with deviations from the remediation plan.

Box I-8.3.2 Practical information on dealing with deviation of remediation plan by the supervisor

Although a contaminated site may have been investigated thoroughly, almost always the contamination in the soil and groundwater has a different appearance and magnitude compared to the description in the preremediation reports. Any soil investigation is dependent on a relatively small amount of sampling compared to the volume of soil and groundwater and as such will give a different picture than reality.

A remediation plan/DPR describes the activities necessary to approach the contaminated situation as assessed. If the actual contaminated situation varies from the assessed situation the remediation works should be adjusted. For instance if in a corner of a site contamination was expected but during excavation this contamination is not found, the excavated area can be reduced compared to the boundaries described in the DPR. This is a sensible strategy the supervisor has to approve. Normally the DPR describes how to deal with deviations of the actual situation.

Another example of such a situation that may call for modification of the remediation plan is where during excavation contamination turns out to be present in much deeper soil layers than previously expected while the ongoing remediation measures are not sufficient to reach that depth.

The supervisors' periodic verifications also serves to manage the environmental aspects of the remediation. An example of this is periodic sampling of excavated material to determine its potential for reuse. In case excavated material turns out to be contaminated the supervisor may direct that it should be transported to a treatment plant or to a TSDF. If not contaminated he may indicate appropriate reuse options.

The periodic verifications include the collection of data, in conformity with the verification plan. Usually this is achieved by taking soil samples at defined locations in the wall or floor of an excavation pit and sending them to an accredited laboratory for testing. The periodic verification can also involve measuring the water quality after treatment, measuring the thickness of a capping layer and monitoring the nuisance at site boundaries (noise, dust, odour, etc.). The time span of this periodic testing is in line with the time span of the remediation measures and can cover several years.

In case unforeseen events considerably change the situation at the site the supervisor may impose modification of the remediation measures. An example of such a situation is when, through demolishing a building and its foundations, contaminated material has accidentally ended up among clean soil material.

The supervisor should keep a log in which he records daily events at the site and results of any measurements. This log will later serve to prepare the Remediation evaluation report (Activity 5).

A checklist of elements of supervision and verification is presented in the *Checklist supervision and verification of remediation measures, Volume II-8.3-b*.

The supervisor can also have a role in the health and safety measures by signalling unsafe situations, upon which the contractor may need to take the appropriate actions.

One of the most vital tasks of the supervisor is to perform verifications at preset critical moments in the remediation process. Example of such moments is the moment when an excavation has reached its predefined boundaries: before supplementing the excavated pit with clean soil material, the supervisor should take samples from the pit wall and bottom to verify whether the remediation objectives have been met.

Activity 5 – Report verification results in a Remediation evaluation report

The collected information on the verification activities are reported by the environmental supervisor, refer *Checklist Remediation evaluation report, Volume II-8.3-c*. All data, including copies of analytical reports and testing results and a logbook of the remediation period, are added to the report. The results of the remediation are compared to the expectations described in the remediation plan/DPR, e.g. are the concentration levels of the soil samples below the target levels as described in the DPR?

In the Remediation evaluation report a.o. following questions should be answered:
- Was it possible to verify the remediation results?
- Is the remediation result acceptable compared to the expectations in the DPR?
- Has the remediation been carried out in the way it was planned and approved before?
- If not, were the measures adjusted accordingly?
- Is contamination not being removed which requires post remediation action?

This evaluation report is the basis for the client and for the competent authority to decide on approval of the environmental results of the remediation and to take a decision on the possibilities for future land use.

8.3.3 Task 8.3 output

The output of this Task 8.3 is a Remediation evaluation report, to be reviewed and approved by the competent authority during Step 9.

Volume I

Step 9 Approval of remediation completion

Step 9: Approval of remediation completion

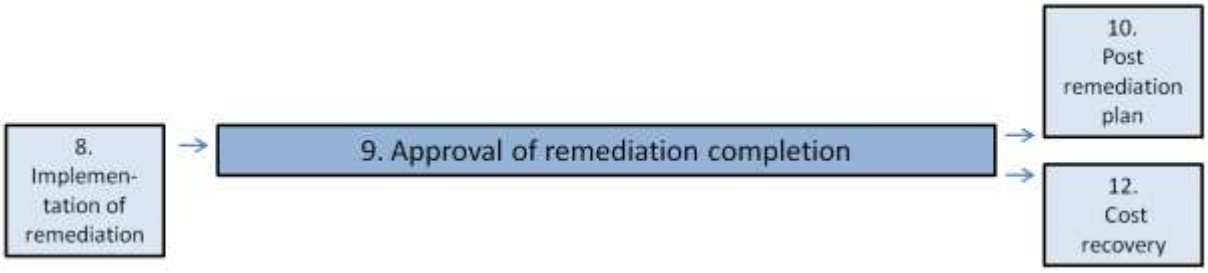
9.1 Introduction to and scope of Step 9

General description and connection to other Steps
Step 9 concerns the review and approval of the remediation activities by the competent authority.

After the remediation activities have been completed the activities and their results would have been presented in a remediation evaluation report (Step 8). These results need to be approved by the competent authority, based on a review of the same report, in this Step 9. In case the remediation has left no residual contamination on the site, the authority may unconditionally approve the remediation. In such a case steps 10 and 11 may be skipped altogether, so the next steps will be Step 12 Cost recovery, Step 13 Priority list deletion, and Step 14 Site reuse.

In case residual contamination has been left behind on the site after remediation, the competent authority may accompany the approval of the remediation with a decision that post remediation action needs to be carried out. In such a case, a post remediation plan will need to be developed in the subsequent Step 10.

Step 9 commences with a review of the remediation evaluation report plan developed in Task 8.3. It ends with the presentation of the decision.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activity is performed in Step 9:

1) Review the Remediation evaluation report and approval of the remediation completion.

Responsible parties
The activity in this Step is typically carried out by technical specialists within the competent authority for the remediation process.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques, as well as awareness of social aspects and consequences for spatial planning.

9.2 Guidance for performing the activities of Step 9

This section presents concise guidance for the performance of the activity within Step 9. It is intended to enable the user to quickly gain an understanding of the necessary activity.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

Activity 1 – Review the Remediation evaluation report and approval of the remediation completion

Review of the remediation report
Step 9 primarily aims to review whether the results of the remediation, presented in the Remediation evaluation report, developed in Task 8.3, meet the expectations, raised by the agreed remediation design plan/DPR, developed in Step 6. A set of criteria for this review is presented in the *Checklist review and approval remediation completion, Volume II-9-a*.

Criteria for the success of the remediation can be very clear, e.g. reduction of the concentration of a certain parameter to below a certain level. In practice, it is not always easy to deal with such criteria. An example in Box I-9.1 below illustrates this.

Box I-9.1 Example of complication in dealing with remediation success criteria

Example situation: remediation was carried out by excavating contaminated soil material. During this excavation it turned out that the volume of contaminated soil material was considerably larger than expected based on the previous site investigation results. This because some soil material below a building foundation, where it could not be reached during the investigation, turned out to be contaminated. Upon encountering this material, the contractor has decided not to remove this contamination, due to disproportionate costs to reduce limited risks.

During review of the Remediation evaluation report, the competent authority may decide to accept the contractor's decision, under the condition that post remediation measures are implemented to control risks associated with the residual contaminated soil material.

Remediation projects may comprise several phases, e.g. when excavation of contaminated soil material was followed by the extraction and treatment of contaminated groundwater. Another example is an in-situ remediation where after an initial phase of installing the equipment a remediation period of several of years followed. In such situations the Remediation evaluation report should expressly discuss all phases of the remediation. A common situation is that the last phase of remediation covers a considerable time period. In such a situation a remediation evaluation report covering all phases but the last one can be considered. In practice, a period of one year is

commonly used, after which reports on intermediate results of the last phase can be submitted for review and approval.

In cases where post remediation measures had been integrated in the remediation strategy upfront, it can be beneficial to simultaneously review the post remediation plan, developed in Step 10, if this is already available.

Approval of the remediation results and presentation of conclusions on next step
Based on the outcome of the review (Activity 1) the competent authority develops and presents a conclusion on approval of the remediation results. This conclusion should also contain an outline of the current situation at the site, as well as the possibilities for site use. Essentially three types of conclusion are possible:

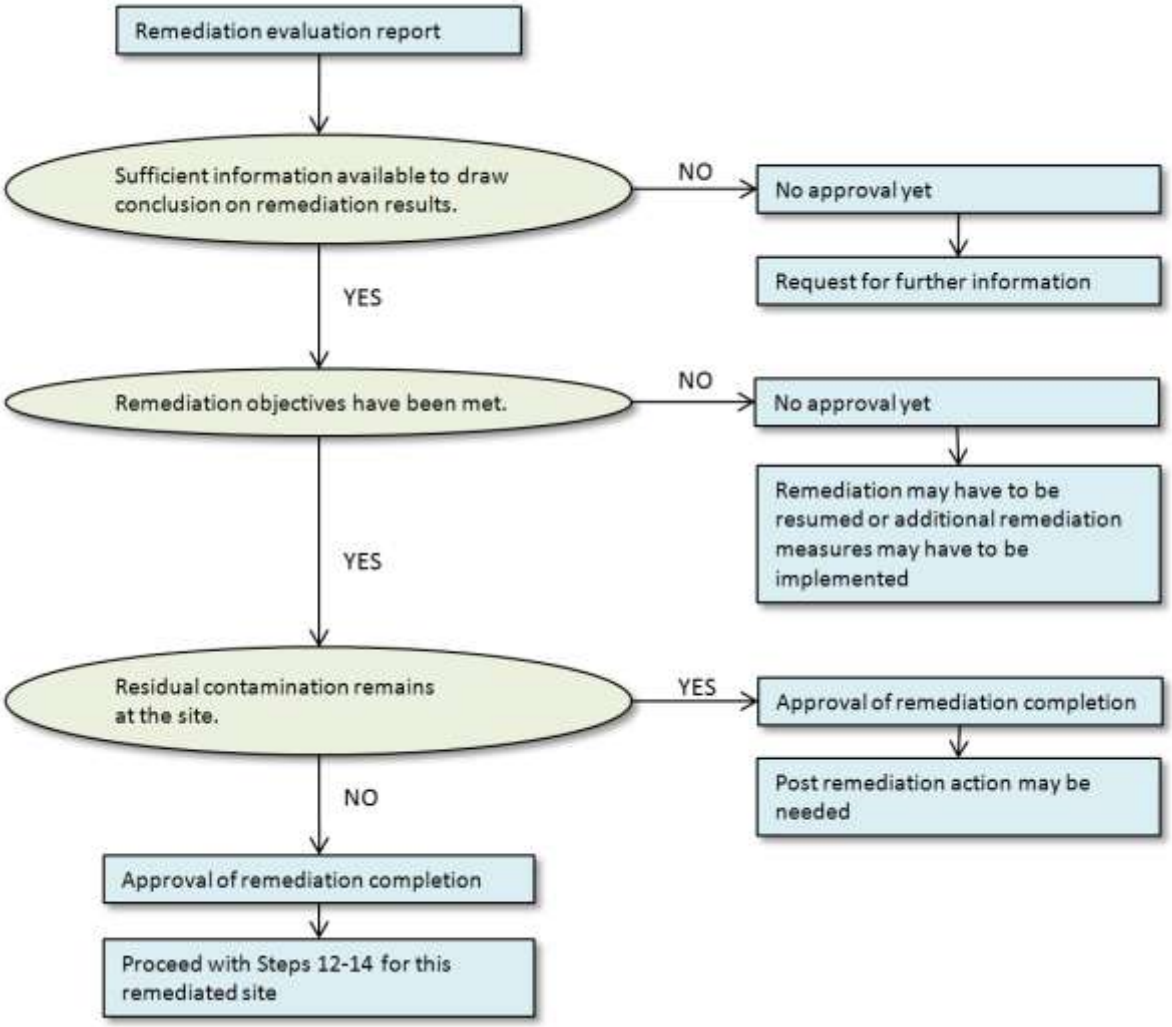
1. Gaps in the forwarded information bar a conclusion. In this case the competent authority may request completion of the remediation evaluation report, so as a conclusion can be prepared.

2. The remediation objectives have not been met. The competent authority may decide the remediation to be resumed or additional remediation measures should be implemented. In this case the competent authority may give appropriate instructions as to their implementation. In case this involves additional investigation the process is resumed at Task 5.1 Detailed site investigation. In case additional investigation is not needed the process is resumed at Step 6 Remediation design, DPR.

3. The remediation objectives have been met. The remediation phase may be formally terminated.
    a. residual contamination remains on the site. In this case post remediation measures may be needed. In case the Remediation evaluation report proposes such measures the competent authority may need to approve these measures (Step 10) and give instructions for implementation (Step 11). In case the Remediation evaluation report does not propose such measures, the competent authority may give instructions to develop such measures (Step 10) and for their implementation (Step 11);
    b. no residual contamination remains on site. In this case the competent authority may proceed with Step 12 Cost recovery, Step 13 Priority list deletion, and Step 14 Site reuse.

This review process is visualised in the flowchart below.

Figure I-9.1 Flowchart for review of remediation results and conclusion on next step.



9.3 Step 9 output

The output of Step 9 is a clear conclusion on approval of the remediation results. This conclusion should also contain an outline of the current situation at the site, as well as the possibilities for site use. Instructions for the next steps also form part of the output of Step 9.

Volume I

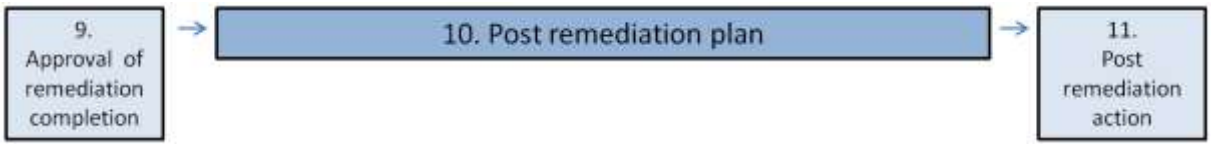
Step 10 Post remediation plan

Step 10 Post remediation plan

10.1 Introduction to and scope of Task 10

General description and connection to other Steps
Step 10 concerns design and approval of a Post remediation plan. Such a plan is required only when a remediation is completed while leaving residual contaminations at the site. In such cases site use restrictions are likely to be in force, and technical measures may be necessary to prevent future human and ecological risks and risks of spreading of the residual contaminations.

Step 10 commences with a review of the remediation evaluation report, developed in Task 8.3 and approved in Step 9, as that report establishes the need of post remediation measures. Step 10 ends with an approved post remediation plan, the basis for the implementation of the port remediation measures in Step 11.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activities are performed in Step 10:
1) Preparation of post remediation plan;
2) Review and approval of post remediation plan.

Responsible parties
The activities in this Step are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant. The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of post remediation techniques and the physical, hydrological and social impact of these techniques.

A review by the competent authority is required before moving to the next Step 11 Post remediation action.

10.2 Guidance for performing the activities of Step 10

This section presents concise guidance for the performance of the activity within Step 9. It is intended to enable the user to quickly gain an understanding of the necessary activity.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

Activity 1 Preparation of post remediation plan

The post remediation plan describes all the technical and supporting management activities such as monitoring, maintenance, repairs and corrective actions to keep a remediated site in such a state as to prevent future risks. The post remediation plan should provide for a long term guarantee to the competent authority for a long lasting and adequate risk control.

The nature of post remediation measures can be deceptively similar to certain types of remediation measures. Box I-10.1 below provides guidance in distinguishing the one from the other.

Box I-10.1 Post remediation measures versus remediation measures

Post remediation measures will start after the remediation works have been completed and the results have been approved by the competent authorities. Post remediation measures do not aim to remove the residual contaminants, but rather to control and fix the situation reached by the remediation measures and to prevent the residual contaminants to cause future human and ecological risks and risks of spreading. Post remediation measures typically are long term and can run up to several years or even decades.

By contrast, long term extensive remediation measures are performed during remediation. These measures resemble post remediation measures in that they are long term and can last up to several years. The difference with post remediation measures is that the long term extensive remediation measures are aimed to reach the remediation objectives by reducing the contaminant level. Such measures typically form part of in situ techniques, based on slow natural processes to degrade or precipitate contaminations.

The design of a post remediation plan should commence by a review of the remediation evaluation report, developed in Task 8.3 and approved in Step 9, as that report establishes the need of post remediation measures. In cases where residual contamination has remained at the site that report should also list the site use restrictions to prevent risks. Examples of these restrictions are presented in Box I-10.2 below.

Box I-10.2 Examples of site use restrictions

- no digging (either with or without human safety measures like gloves);
- no vegetable growing for human consumption;
- no use of groundwater for irrigation or human consumption;
- no cultivating of plants with roots growing to a depth > 0.5 m;
- no construction of residences (to prevent vapours from the soil to enter buildings);
- no site use change without prior consent by the competent authority.

Two different types of measures to prevent risks can be distinguished, examples of which are presented in Box I-10.3:

- *Management measures:* activities which are focused on compliance with the site use restrictions or the monitoring of a stable physical situation that can be disturbed by human impact or natural processes;
- *Technical measures:* activities which are focused on the maintenance and the continuity in operation of active measures.

Box. I. 10.3 Examples of post remediation measures

Management measures

- Registration of site use restrictions and administrative management of the land use;
- Monitoring compliance with site use restrictions;
- Raising of awareness;
- Monitoring of contaminant concentration levels in stable groundwater plume.

Technical measures

- Monitoring and maintenance of clean top layer covering contaminated material;
- Operation of geohydrological isolation of a groundwater plume, including operation of a pump and treat system;
- Maintenance of groundwater drainage system to prevent contaminated groundwater to enter residences;
- Monitoring of permeability of vertical barriers and maintenance of these barriers if necessary;
- Maintenance of the biological activity in the soil to be able to degrade remaining contamination;
- Maintenance of the monitoring system.

During the post remediation phase critical deviation points and non-critical deviation points may come up that might lead to future human and ecological risks and risks of spreading of the contaminations. These deviation points should be anticipated in the post remediation plan by outlining counter measures. Critical deviation points may result in additional site use restrictions. But if the risks due to the residual contaminations cannot be controlled by the post remediation measures, there may be a need to commence additional remediation measures. For the design and implementation of these measures a detailed project report (DPR), including an authorisation of the au-

thorities is needed (Step 6). Examples of critical and non critical deviation points are presented in Box I-10.4 below.

Box I-10.4 Examples of critical and non-critical deviation points

An example of a non-critical deviation point is the following: the capping layer (covering a contaminated site) is slightly damaged. Due to the damage the thickness and/or the composition of the capping layer may not meet the original requirements anymore. By restoring the capping layer the situation at the site can be restored into the situation as it was directly after the implementation phase of the remediation.

An example of a critical deviation point is the following: the concentration of contaminations in groundwater are unexpectedly rising to a non acceptable level. The reduction of the concentrations can only be realised by implementing additional removal of the contaminated source.

The post remediation plan should include a list of the potential critical and non critical deviation points, a list of action levels, how these levels can be detected in time, what kind of counter measures might be adequate, as well as the design of the decision process on counter measures. Monitoring is a useful tool to keep an eye on all deviation points.

Only a post remediation plan that meets both the scope of the post remediation activities and the prospects of site users and owners gives a good basis for the implementation of the post remediation activities. If the design of technical measurements fits in the way the site is used anyway it will not be a problem for the site users to take the site use restrictions into account. Consultation of the local community or site users will help to define the exact design of the measures and thus to acquire long term support for the site use restrictions and post remediation activities.

Practical aspects of the implementation of the post remediation activities should be part of the post remediation plan. Depending on the situation at hand those aspects typically include:

- Scheme of monitoring activities;
- Scheme of maintenance, repairs and replacement of parts of the post remediation system, e.g. groundwater pumping system, horizontal capping layer, monitoring wells;
- Log of all recordings, activities, contacts and results of the post remediation actions;
- Periodic reporting of the site status;
- Planning schedule for all activities described.

A management scheme is necessary to describe all tasks, responsibilities and persons or institutions to which these are addressed to. As management can only be effective if based on periodic status reporting, the post remediation plan should state the frequency of post remediation status reporting.

The *Checklist Post remediation plan, Volume II-10-a* provides a comprehensive overview of elements a full scale post remediation plan may contain. The post remediation plan is forwarded to the competent authority for approval.

A stakeholder consultation is needed, both to inform the stakeholders on the post remediation plan and to secure their support. The consultation may also yield information that can be useful in the final design of the post remediation plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.
The decision on land use post remediation needs to be taken at this stage. Therefore, the post remediation plan also needs to address this issue. This necessitates the involvement of a land use designation authority, which may take the shape of an interdepartmental committee with land use experts.

Stakeholder	**Interview objective**	**Level**
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
Land Registration Office	discuss conclusion on land use post remediation	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national

Activity 2 Review and approval of post remediation plan

The competent authority reviews the post remediation plan. The *Checklist review and approval Post remediation plan, Volume II-10-b* provides guidance for this Activity. The competent authority may also find guidance in the text on Activity 1 above.

10.3 Step 10 output

The output of this Step 10 is a Post remediation plan, approved by the competent authority, describing all activities needed to prevent future human and ecological risks and risks of spreading of the residual contamination left on the site after the finalization of the remediation.

Based on this output the post remediation activities can be implemented in the subsequent Step 11.

Volume I

Step 11 Post remediation action

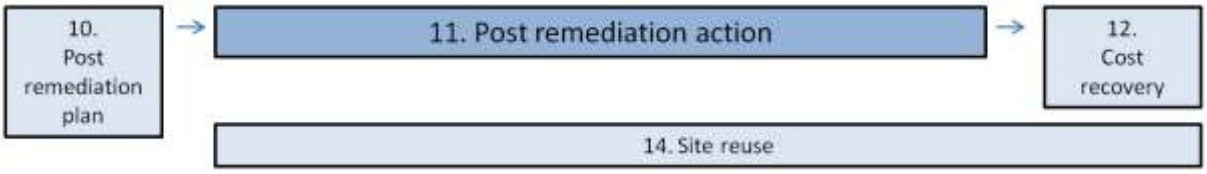
Step 11: Post remediation action

11.1 Introduction to and scope of Step 11

General description and connection to other Steps
Step 11 concerns the implementation of the post remedial action outlined in the Post remediation plan. This is required only when a remediation is completed while leaving residual contaminations at the site. In such cases site use restrictions are likely to be in force, and technical measures may be necessary to prevent future human and ecological risks and risks of spreading of the residual contaminations.

Step 11 commences with a review of the Post remediation plan developed and approved in Step 10. It ends if and when an approved Post remediation status report demonstrates that the residual contaminations do no longer require attention. In certain situations Step 11 may go on in perpetuity, which may or may not bar site reuse.

If the situation on the site allows it, Steps 11 and 14 (Site reuse) can be implemented simultaneously.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activities are performed in Step 11:

1) Prepare Post remediation implementation programme;
2) Outsource implementation of post remediation activities;
3) Implement post remediation activities;
4) Supervise and verify post remediation activities and prepare periodical Post remediation status report;
5) Periodically review and approve Post remediation status report.

Responsible parties
Activity 3 in this Task is typically carried out by technical specialists employed by a contractor. The team involved should demonstrate in-depth knowledge and experience of e.g. the post remediation techniques and the characteristics of the contamination involved.

Activities 1, 2 and 4 in this Task are typically carried out by technical specialists within a specialised consultant. The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of post remediation techniques and the physical, hydrological and social impact of these techniques.

The supervision and verification are performed on behalf of the client and should therefore be carried out by a person or a team independent from the contractor. This requires special attention in case the supervision is carried out by specialists employed by the contractor.

Activity 5 has to be carried out by experts of the competent authority.

11.2 Guidance for performing the activities of Step 11

This section presents concise guidance for the performance of the activities within Step 11. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

Activity 1 – Prepare Post remediation implementation programme

The approved Post remediation plan is the basis for the implementation of post remediation action. In this Activity this plan is translated into a Post remediation implementation programme, essentially a smart list of operational measures to be implemented, typically over a time frame of two to five years. Most operational measures during post remediation will be repeated periodically. The frequency of this will largely determine the time frame of the implementation programme: the higher the frequency the shorter the time frame of the implementation programme. The frequency of the operational measures typically is high whenever a site is situated in a dynamic area. This warrants revision of the implementation programme after a relatively short period of time, say two years. A high frequency of operational measures is also often seen during the initial phase of post remediation, after which it may gradually slow down. In that situation revisions of the implementation programme tend to last longer as the post remediation progresses. Aspects related to the contracting phase (see under Activity 2) can also influence the time frame of an implementation programme.

In case the post remediation measures are to be assigned to a third party (see under Activity 2 below) the Post remediation implementation programme can be a useful Annex to the Terms of Reference.

The nature of post remediation measures can be deceptively similar to certain types of remediation measures. Box I-10.1 (see Volume I, Step 10) provides guidance in distinguishing the one from the other.

Post remediation is a matter of measures periodically repeated over a relatively long period of time, from years to decades and even longer. This means two things: firstly, management is crucial and can only be effective if based on periodic status reporting (see under Activity 4). Therefore, the Post remediation implementation programme should state the frequency of Post remediation status reporting. Secondly, a Post

remediation implementation programme should contain measures in all of the following categories: monitoring, inspection, maintenance, replacement, management.

Situations with layers capping a residual contamination in soil and with residual contamination in groundwater make for the majority of all post remediation situations. Box I-11.1 below presents examples of implementation measures in all five categories for situations with capping layers, while Box I-11.2 does the same for situations with residual contamination in groundwater.

Box I-11.1 Examples of post remediation implementation measures for situations with a layer capping contamination in soil

Situation: during remediation (Step 8) a clean layer has been installed isolating a volume of contaminated soil. The capping layer effectively prevents human contact with the contaminated soil. With that, the remediation objective of blocking the pathway between the contaminated soil (source) and humans (receptors) has been met. The remediation has been reported and the report has been approved by the competent authority, effectively concluding the remediation (Step 9). In order to ensure the remediation objective is maintained for as long as is deemed necessary, it has been decided that post remediation action is needed.
The Post remediation plan (Step 10) states that the post remediation measures should ensure the capping layer continues to prevent receptors to get in contact with the contaminated soil. Measures to that end have been described in a general sense. In this Step 11 these are translated into implementation measures, e.g. the following:

- *monitoring measures*: inspection of the thickness of the capping layer once every X months. The thickness should be at least Y. During the inspection the integrity of the capping layer should be guaranteed. Therefore non destructive inspections are preferred before destructive methods. Example non-destructive sample methods are GRP (ground penetrating radar), surface elevation levelling (settling of the contaminated layer below the capping layer will be a point of uncertainty), visual inspection (has its limitations as it is impossible to estimate the thickness of a layer. Visual inspections typically are only applicable to signal cracks, ruptures, settling, and slides or shearing along slopes). Typical destructive sample methods are digging (with possibility for lines repairs due to the digging) or drilling. Markers or signalling layers in the capping-contamination transition zone may help to improve the quality of radar or prevent damage by drilling.
- *inspection measures*: inspect the capping layer every X months and record visible signs of erosion, washing, settling, unauthorised digging and unauthorised reuse of contaminated material in the capping layer.
- *maintenance measures*: restore the capping layer whenever monitoring or inspection measures demonstrate this is needed.
- *replacement measures*: see maintenance measures.
- *management measures*: 1) instructions on site use, 2) awareness campaign to prevent damage to a capping layer, 3) official procedure for approval of specific types of site use, e.g. construction of drainage in a capping layer.

Box I-11.2 Examples of post remediation implementation measures for situations with a residual contamination in groundwater

Situation: during remediation (Step 8) contamination in groundwater has been removed to such a degree that risks have become acceptable. With this result the remediation objective of getting the source in an acceptable state has been met. The remediation has been reported and the report has been approved by the competent authority, effectively concluding the remediation completion (Step 9). In order to ensure the remediation objective is maintained for as long as is deemed necessary, it has been decided that post remediation is needed.
The Post remediation plan (Step 10) states that the post remediation measures should ensure the contaminant levels in the groundwater remain at such levels as to keep the risks acceptable. Measures to that end have been described in a general sense. In this Step 11 these are translated into implementation measures, e.g. the following.

- *monitoring measures*:
  - 1) measure groundwater flow and sample contamination levels, relevant for the given situation and according to the applicable standards, at the monitoring wells shown on a map every X weeks. Report results and advise corrective action whenever these show concentration levels become unacceptably high or whenever the contaminated groundwater spreads beyond the predefined border.
  - 2) measure groundwater discharge by the pumps installed for post remediation and sample contamination levels every X days. Report measurement results and advise maintenance or replacement measures whenever the discharge deviates unacceptably from the predefined intended volume or concentration levels become unacceptably high.
  - 3) measure the groundwater level every X days, report results and advise corrective action whenever the groundwater level exceeds a predefined action level or whenever volatile contaminations threaten to enter building basements. Corrective action can be e.g. temporary intensified monitoring or a more comprehensive testing method.
- *inspection measures*: inspect the groundwater post remediation system every X months, record visible signs of wear and advise maintenance or replacement measures whenever this is deemed necessary.
- *maintenance measures*: take whatever measures are needed to maintain the groundwater pumps and the water purifying plant in good working order, e.g. to prevent the pipes from leaking.
- *replacement measures*: replace monitoring wells, active carbon in a water purifying plant or water pumps whenever this is needed to keep the system in good working order.
- *management measures*: instructions on site use.

As can be seen in the examples in the boxes above, the description of every measure should show how it is performed, its frequency (if periodic), parameters to be measured or sampled, target levels and what to do whenever either critical deviations or non critical deviations occur. For guidance on this last item see under Activity 3 below. Including a description of the aim and background of measures can help to gain support from affected parties.

Stakeholder involvement
Stakeholder involvement is crucial for most of the post remediation sites as the site use and post remediation system are closely interdependent. Therefore, prior to post remediation site users and the community should be involved. This can be done by the formation of a local committee, functioning as a part of panchayat in rural areas or as a ward committee in urban areas. Consultation of local political leaders can help in a balanced communication towards the community.

Owners, site users, inhabitants and others with primary dependence on the use of the site should be informed about the intended site use restrictions, as well as about the necessity and eventually the results of the post remediation measures. Authorities on spatial planning and land use should be informed as well (State Government, Urban and Rural Development Department, Revenue Department, Environment Department).

Activity 2 – Assign implementation of post remediation activities

Post remediation occurs in a variety of situations. The decision to assign/outsource the implementation of post remediation measures depends on the scope of the measures to be implemented and the position and involvement of the site owner to the site. Examples of situations where the site owner may take the post remediation or part thereof upon himself are presented in Box I-11.3 below.

Box I-11.3 Examples of situations where site owner may perform post remediation

- A TSDF owner who possesses the skills required to maintain a capping layer may decide to implement post remediation measures himself;
- An owner of an operational industrial site may decide to implement management measures (like supervision of compliance with site use restrictions) himself. In this situation, he may still outsource the remaining technical measures;
- An owner of an operational industrial site who possesses the skills required to perform groundwater sampling may decide to implement monitoring measures himself. In this situation, he may still outsource the remaining technical measures.

In case it is decided to assign/outsource the implementation of post remediation measures or part thereof the procedure commences by the preparation of bid documents. These should at least include Terms of Reference. These can then be used in the prequalification, which should result in the selection of able contractors. Guidance on the prequalification can be found in the *Checklist prequalification for remediation, Volume II.8.2-a*.

Post remediation action typically lasts a long time, which is often not even to be determined beforehand. Therefore the issue of the time frame merits special attention, in addition to the generic elements listed in the checklist mentioned above. Some of the options to be considered for this are:

- A predefined period, typically covering two or three years. This period should not be too short to optimise the costs and to minimise loss of information and hands on experience due to the handing over of the archive and change of project team;
- A period aligned with the time scope of the Post remediation implementation programme, developed in Activity 1 above;
- A period aligned with site redevelopment planning;
- A period aligned the planning of major maintenance and revisions of parts of the system. For example, if the life span of a water treatment plant is expected to be fifteen years, that may also serve as the contract time frame;
- A period aligned with intended site ownership transaction;
- An undefined period. This may imply the contract will only be terminated if and when the post remediation is terminated.

In a phase that may literally proceed in perpetuity, an exit strategy warrants special attention. Whenever residual contaminations turn out to have been removed, either by natural causes (e.g. by biodegradation) or by implemented measures, termination of the post remediation action may be considered. This action commences by evaluating the new situation in the Post remediation status report (see under Activity 4 below). In case it is expected the situation in the field will remain more or less stable forever it will be useful to formulate an exit strategy. This strategy should include criteria at which the post remediation measures may be terminated, and a method for termination.

Once the contractor has been selected, a contract will be formulated. The following issues merit special attention, largely with regard to the extensive time frame:
- Scope of the contract. While a contract including all risks and all replacement of expensive parts of the remediation system will be costly, it should be considered that the replacement itself can also be very dear. Examples are the complete restoration of a capping layer after it has been washed away by monsoons or the replacement of a bio-screen earlier than predicted;
- Continuity of data, information and experience with the site should be guaranteed during the entire contract period and beyond, e.g. by using a data management system (preferably online) and a provision that all data and experience shall be handed over to the client upon termination of the contract;
- Continuity of post remediation activities should be guaranteed. While a full guarantee cannot be given a good track record and a periodic payment schedule may offer some basic security.

Activity 3 – Implement post remediation activities

The party responsible for Activity 3 proceeds to implement the measures outlined in the Post remediation implementation programme, developed in Activity 1. During implementation any deviation from what is expected warrants adequate intervention. Whenever a deviation occurs, it should first be assessed whether corrective measures will enable restoration of the situation before the deviation occurred. If this is the case the deviation is regarded as non critical, otherwise it is a critical deviation.

Handling a critical deviation
A critical deviation impacts the integrity of the post remediation system and therefore calls for immediate intervention to prevent damage and risks. Examples of critical deviations are presented in Box I-11.4 below.

Box I-11.4 Examples of critical deviation points

- Evaporation of volatile contamination into buildings is much higher than predicted in the Post remediation plan. All implemented measures fail to prevent human exposure to these contaminations. This means additional remediation measures like additional source removal (e.g. digging of contaminated soil), breaking of pathway (installation of additional ventilation or dam proof floors in the building) or relocating of receptors (evacuation of building residents) need to be implemented to terminate the exposure;
- Current or future site use differs from the use as described in the Post remediation plan or in the latest Post remediation status report and will result in future risks. Either enforcement on the unauthorised site use should be performed or additional remediation measures need to be implemented to accommodate this site use.

As a deviation of this magnitude cannot be corrected with limited effort the Post remediation plan may need to be revised, meaning going back to Step 10 (e.g. more stringent site use restrictions are imposed) and proceeding from there. It may even be necessary to implement additional site investigation and additional remediation measures. This means going back to Step 5 and proceeding from there. In such cases the following actions should be taken, in this order:

- Implement appropriate temporary safety measures to prevent damage and risks;
- In case of risks inform the competent authority about the situation;
- Register the event and inform relevant stakeholders;
- Design remediation objectives, based on the new situation (Step 5);
- Design corrective measures (DPR) to meet new remediation objectives, and acquire approval from competent authority (Steps 6 and 7);
- Implement the corrective measures, revise Remediation evaluation report (Step 8) and acquire approval from competent authority (Step 9);
- Revise Post remediation plan (Step 10) and Post remediation implementation programme (Step 11, Activity 1);
- Implement revised Post remediation implementation programme (Step 11, Activity 3).

Handling a non critical deviation
A non critical deviation can be corrected with limited effort and impact on the post remediation system. The deviation may have no effect on the evaluation of data, the performance of the post remediation system or the use of the site. Corrective measures will enable restoration of the situation before the deviation occurred. Examples of non critical deviations are presented in Box I-11.5 below.

Box I-11.5 Examples of non critical deviation points

- Geohydrological isolation system does not lead to a predefined lowering of the groundwater level. As an additional post remediation measure the discharge of the groundwater pumps may be adjusted;
- Capping layer shows limited damage. As an additional post remediation measure this may be repaired;
- Monitoring well is jammed with mud, rendering groundwater sampling impossible. As an additional post remediation measure a new monitoring well can be installed.

A non critical deviation may be countered by implementing the following actions, in this order:

- Register the event;
- If necessary implement immediate actions to prevent further escalation into actual risks and damage;
- Inform the party responsible for the post remedial actions about the situation;
- Inform other stakeholders to prevent further escalation;
- Implement corrective measures to reset the situation to before the deviation occurred. These measures can be of very different nature, such as an increase of the monitoring intensity, additional communication on site use restriction, additional supervision on site use or minor changes in technical specifications to make the system more intrinsic reliable;
- Evaluate the Post remediation implementation programme and revise to prevent repetition of the event (Step 11, Activity 1).

Health and safety

During the implementation of the post remediation activities health and safety measures should be taken into account, refer *Checklist Health and Safety plan, Volume II.8.3-a*.

Stakeholder involvement

During implementation, the site users should be kept well informed on implementation of measures and progress of the post remediation. Signposting will clarify site use restrictions to the community.

Registration

All implemented post remediation measures should be well documented and archived in a post remediation archive. This archive should contain the following data: implemented measure, date or dates of implementation, person in charge, working method and documents and instruments used, sample identification and laboratory performing analysis (if applicable) and results. This archive will be the basis for reference in case of unexpected performance of the post remediation system and for the Post remediation status report, developed in Activity 4.

Activity 4 – Supervise and verify post remediation measures and prepare and verify periodical Post remediation status report

Supervision of implementation of measures
When post remediation involves a complex structure of measures it may be useful to have the implementation of the measures supervised.

Preparation of Post remediation status report
As stated before, post remediation typically lasts a long time, measured in years or in decades. Therefore, the management of post remediation merits special attention. For effective management of such long lasting action periodic status reporting is needed. The frequency of these reports should be stated in the Post remediation plan (Step 10) as well as in the Post remediation implementation programme (see under Activity 1 above).

The periodic Post remediation status report should present a solid insight in the status of the site at the moments predefined in the Post remediation plan and in the Post remediation implementation programme. Based on this report the competent authority should be able to review the implementation of the post remediation measures and to draw conclusions on whether the risks are actually addressed in correspondence with the description in the Post remediation plan.

The preparation of a periodic Post remediation status report commences by analysing the results of the implementation of the measures (see Activity 3), to be found in the post remediation archive. These results should be especially screened on inconsistencies and deviations from the objectives preset in the Post remediation plan. The results are then summarised in the Post remediation status report, followed by an evaluation of the present status of the site. The report should also include conclusions on the functioning of the post remediation system, and, if applicable, suggestions for modifications thereof. In case this kind of suggestions are made, the Post remediation implementation programme should be revised accordingly (see Box I-11.6 below) and the suggested measures implemented.

The *Checklist Post remediation status report, Volume II-11-a* presents an overview of elements to include in the Post remediation status report.

Verification of Post remediation status report
The Post remediation status report is typically prepared by the party responsible for the implementation of the post remediation measures. In case of potential conflict of interest the Post remediation status report should be verified by an independent third party. In such a situation, this third party should be authorized to perform his own measurements and samplings for verification of the reported results.

Review of Post remediation status report
The Post remediation status report should be forwarded to the competent authority for review and approval (see under Activity 5 below).

Box I-11.6 Optimisation of the Post remediation implementation programme

The Post remediation plan describes the technical and management measurements needed to prevent future human and ecological risks and risks of spreading of the contaminations due to residual contaminations. During the execution of the post-remediation activities it may be concluded that the intensity of the post-remediation activities can be lowered without risks. For example when the results of monitoring indicate that concentration levels are continuously dropping. Using the CSM tool this process can be understood and it is predicted that concentrations will not increase in the future. Using this knowledge the monitoring frequency can be lowered accordingly.

Using this approach, theoretically all technical activities can be reduced to zero. Management activities can also be reduced but a minimum level of management will be needed as long a contaminations are present. It is very well conceivable that the communication on site use restrictions at the starting point of a redevelopment plan is a good example of the minimal level of management activity.

Activity 5 – Review and approval of Post remediation status report

The competent authority reviews the Post remediation status report. The *Checklist review and approval Post remediation status report, Volume II-11-b* provides guidance for the performance of this Activity.

In case the Post remediation status report proposes modifications to the post remediation system the competent authority may need to authorise these modifications.

In case the Post remediation status report proposes termination of the post remediation measures the competent authority will need to authorise this termination. In such cases a previously developed exit strategy should be present and should be used as a basis for this important decision.

11.3 Step 11 output

The output of this Step 11 is a Post remediation status report, approved by the competent authority, describing the current status of the site with ongoing post remediation measures.

Based on this output the post remediation measures can be continued according to the guidance in this Step 11, or, in some cases, terminated.

Volume I

Step 12 Cost recovery

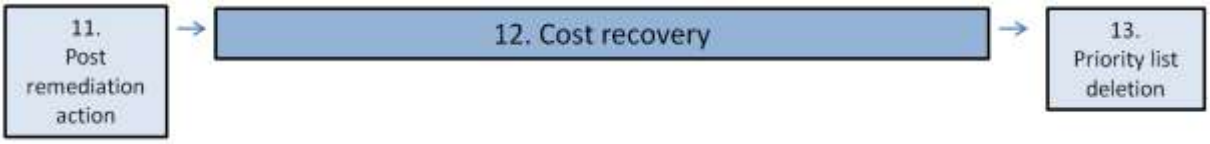
Step 12: Cost recovery

12.1 Introduction to and scope of Step 12

General description and connection to other Steps

Step 12 concerns the activities required to recover the costs for the previously undertaken assessment, remediation and post remediation measures in case the costs have been funded by the government. This step is mostly concerned with organisational, legal and financial aspects. From a technical point of view it is important to present a clear overview of the costs which have been involved in the assessment and (post) remediation activities.

The figure below shows how this Step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation. After each Step with large financial consequences action may be undertaken to recover costs. This regards not only the remediation works (Step 8) and the post remediation action (Step 11) but costs involved for preliminary investigation (Step 2) remediation investigation (Step 5) and development of DPR (Step 6) may be significant as well.



Activities

Within this step a number of activities are to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Task 4 report, PWC June 2014). Here, the guidance focuses on the one activity with technical/financial aspects:

1) Preparing cost overview of executed assessment and (post) remediation works

Responsible Parties

The activity listed above will typically be performed by technical, legal and financial specialists of the competent authority may be supported by the specialized agency or consultant which have been involved in the DPR phase or the remediation phase of the project. For various elements of the cost estimation information from different authorities may be required.

The team involved should be able to assess the costs and to link the costs presented to the information in the technical reports. Review is typically performed by senior staff members.

12.2 Guidance for performing the activity of Step 12

This section presents concise guidance for the performance of the activities within Step 12. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Activity 1 – Preparing cost overview of executed assessment and (post) remediation works

Where sites have been remediated using dedicated government funds, fully or partially, an attempt may be made to recover costs from the liable party.

In order to prepare an adequate cost overview it is required to identify which measures had to be taken for assessment, remediation and possible post remediation measures of the contaminated site. The following information should be collected:

- Evaluation reports of the remediation and post remediation works;
- The cost overviews of involved contractors, consultants, site investigators, laboratories, research institutes, other third parties and of involved governmental organisations;
- The DPR and the estimated remediation costs before start of the remediation. During Step 6 the cost estimation has been developed aimed to allocate/raise funds. This cost estimate, which should consist of a detailed listing of cost elements, should be used to compare to the actual involved costs, refer *Example format cost estimation remediation, Volume II-6-b*.

The costs involved may not only include the technical measures of the remediation. The preparation of the work, including costs for demolishing building or replacement of inhabitants may be included as well. The costs for management, supervision and verification of the remediation and post remediation works should be included too. The previous costs of investigation of the site and preparation of the remediation design may be summarized to the total of relevant costs.

The remediation may have been combined with redevelopment of the site. It is important to distinguish costs for remediation and costs for redevelopment (e.g. a situation where an existing building has been demolished before remediation and reconstruction could take place. The demolition costs may be designated to the remediation as well as to the reconstruction. If there haven't been made appointments on these issues this may be an important point for discussion when trying to recover costs.

12.3 Step 12 output

The output of this Step 12 is the overview of costs related to the executed assessment of the site, the preparation and execution, supervision of the remediation and post remediation works.
With this cost overview the necessary activities to recover the costs can proceed.

Volume I

Step 13 Priority list deletion

Step 13 Priority list deletion

13.1 Introduction to and scope of Step 13

General description and connection to other Steps

Step 13 concerns the deletion from the Priority list of a site where previous contamination has been remediated to such a degree that risks no longer exist or are deemed acceptable.

In case the remediation has left no residual contamination the competent authority would have declared the remediation to be completed and cleared the site for reuse. Where such a site was listed on the Priority list the competent authority for that list would in this Step 13 only need to mark the site as remediated and delete the site from the Priority list. In that situation there are no technical aspects to be discussed in this Step.

In case the remediation has left residual contamination the competent authority would have declared the remediation to be completed (Step 9). After that a post remediation plan would have been prepared and subsequently approved (Step 10), after which the post remediation action (Step 11) can commence to prevent future human and ecological risks and risks of spreading of the contaminations. In such a case site use restrictions are likely to apply. Step 13 commences with the assessment of applicable site use restrictions and ends with the marking of the conclusions on this in the database.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.

Activities

A number of activities are performed in Step 13. In this document only the technical aspects to these are discussed:

1) Assess and record site use restrictions.

Responsible parties

The activities in this step are typically carried out by the competent authority for the assessment and remediation process. The team involved should demonstrate ability to interpret the information and recommendations of site remediation works and post remediation status reports. This requires in-depth knowledge of and experience with the characteristics of contaminations (e.g. mobility, biodegradability) and its potential effects on humans and the environment.

13.2 Guidance for performing the activity of Step 13

This section presents concise guidance for the performance of the activities within Step 13. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Activity 1 – Assess and record site use restrictions

The situation discussed here is that of a remediated site with residual contaminants present at the time of commencement of this Step 13.

The presence of the residual contaminants is likely to have resulted in site use restrictions. These would be outlined in the post remediation plan (Step 10). In case the post remediation action is ongoing, the site use restrictions could also be outlined in the latest post remediation status report (Step 11). The party responsible for this Step 13 needs to assess these site use restrictions and have them recorded in the computerized database of contaminated sites maintained and updated by the competent authority.

Stakeholders need to be informed on the deletion of a site from the priority list. In case site use restrictions are imposed, these need to communicated to the stakeholders, as do any changes in the site use restrictions.

Stakeholder	**Interview objective**	**Level**
Site owner	provide information	site
Site operator's health facility director	provide information	site
Local businesses, residents and NGO's	provide information	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information	local
In case site use restrictions need to be formally recorded: Land Registration Office	provide information	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	provide information	national
Competent authority on land matters	discuss conclusion	district / local

13.3 Step 13 output

The output of this Step 13 is the deletion of the site from the Priority list and the registration of the restrictions that apply to the use of the site that needs to be recorded in the database of contaminated sites.

Volume I

Step 14 Site reuse

Step 14: Site Reuse

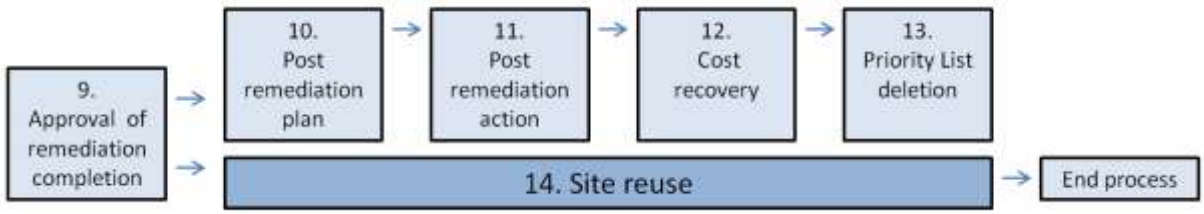
14.1 Introduction to and scope of Step 14

General description and connection to other Steps
Step 14 concerns the reuse of the remediated site. Step 14 commences with the handover of control of the site to the appropriate party, i.e. the former or the new site owner.

In case the remediation has left no residual contamination the competent authority would have declared the remediation to be completed and cleared the site for reuse (Step 9). Where such a site was listed on the Priority list the competent authority for that list would have marked the site as remediated (Step 13). In that situation there are no technical aspects to be discussed in this Step 14.

In case the remediation has left residual contamination the competent authority would have declared the remediation to be completed (Step 9). After that a post remediation plan would have been prepared and subsequently approved (Step 10), after which the post remediation action (Step 11) can commence to prevent future human and ecological risks and risks of spreading of the contaminations. If the situation on the site allows it, Steps 11 (post remediation activities) and 14 (site reuse) can be implemented simultaneously. This Step 14 presents guidance to the technical aspects of site reuse in such a situation.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activities are performed in Step 14:
1) Anticipate to site use restrictions;
2) Arrangements to enable post remediation action.

Responsible parties
The activities in this Step are typically carried out by the competent authority and the future site owner.

14.2 Guidance for performing the activities of Step 14

This section presents concise guidance for the performance of the activities within Step 14. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Activity 1 Anticipate to site use restrictions

The situation discussed here is that of a site at which remediation activities have been carried out but residual contaminants are still present at the time of handover of control to the new site owner.

The presence of the residual contaminants may have resulted in site use restrictions. These would be outlined in the post remediation plan (Step 10). In case the post remediation action is ongoing, the site use restrictions could also be outlined in the latest post remediation status report (Step 11). Violation of these site use restrictions may result in risks to human health or to the environment or in risks of spreading of the residual contaminants. Apart from the damage this may inflict, it is important to note that, depending on the legal situation, the site owner or the site user may be held responsible for this damage.

Change of site use not authorised by the post remediation plan or the latest post remediation status report will result in a critical deviation. This could imply that the site use should be reconsidered or that additional remediation measures need to be implemented to accommodate this site use. Where this occurs refer to Step 11 Post remediation action for guidance.

In case site use restrictions are imposed, these need to communicated to the stake-holders, as do any changes in the site use restrictions.

Stakeholder	**Interview objective**	**Level**
Site owner	provide information	site
Site operator's health facility director	provide information	site
Local businesses, residents and NGO's	provide information	site and direct vicinity
Municipal authorities. In case the po-tential contamination may include groundwater or surface water, includ-ing Water Supply and Sanitation	provide information	local
Land Registration Office	provide information on the change in land value for the revenue records	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwa-ter Authority	provide information	state
For large scale site: national authori-ties, including CPCB, Surveyor of India and Central Ground Water Board	provide information	national
Competent authority on land matters	discuss conclusion	district / local

Activity 2 Arrangements to enable post remediation action

The organization responsible for the post remediation action should have access to the site to implement the actions as outlined in the post remediation implementation programme or in the latest post remediation status report (Step 11). It is important to note that these actions may take place over an extensive time frame, expressed in years or even in decades or in perpetuity, and may in cases considerably affect site use. Where this occurs the competent authority may consider a temporary land use claim.

In case it is decided, by the competent authority or by the site owner, that the site owner will perform some or all post remediation action, the site owner can refer to Step 11 for guidance. He should note that all results may be subject to verification by an independent third party and will be subject to approval by the competent authority.

14.3 Step 14 output

The output of this Step 14 is, if necessary, a series of arrangements to enable implementation of post remediation actions as well as proper and effective site reuse simultaneously.

Volume I
Glossary

Volume I
Glossary of terms and topics

A

term / topic	definition
accreditation criteria	Criteria to be met for certification of a specific task or technical operation.
anthropogenic	Related to human activities.
aquifer	An underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

B

term / topic	definition
background concentration	The concentration of a substance in ground water, surface water, air, sediment, or soil at a source(s) or nearby reference location, and not attributable to the source(s) under consideration. Background samples may be contaminated, either by naturally occurring or manmade sources, but not by the source(s) under consideration.
biodegradability	Capability of being decomposed by bacteria or other living organisms in either one or more steps of decomposition and thereby lowering the concentration levels. Often associated with degradability of contaminants. Intermediate products may result in temporary rise in toxicity (e.g. vinyl chloride).
bioremediation	The use of either naturally occurring or deliberately introduced microorganisms to consume and break down environmental contaminations, in order to clean a polluted site
boring / borehole	Penetration into the subsurface with removal of soil/rock material by using, e.g., a hollow tubeshaped tool.

C

term / topic	definition
calibration	Mark (a gauge or a reading of an instrument) with a standard scale of readings.
competent authority	The public organisation bearing primary responsibility for the legal decisions, except those taken by a court of law, related to the assessment and remediation of a particular contaminated site or probably contaminated site.
Conceptual Site Model	A written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system.
constraints	Issues that do not have an impact on the remediation objectives or requirements, but that may affect how these objectives can be achieved.
complete removal	Removal of al contaminants from the soil or groundwater to a natural background level by the implementation of a remediation option
composition of the soil	The different parts (minerals, organic material, etc.) of which the soil is made of; the way in which the different parts are organized giving it a specific structure (e.g. geohydrological anisotropy)
containment	Control of migration of gaseous, liquid or solid contaminated media from a site by use of measures, such as covering systems, vertical in-ground barriers and in-ground horizontal barriers; depending on sitespecific factors, these measures may be used alone or in combination.

contaminant	Any substance, that is potentially hazardous to human health or the environment and is present in the environment at concentrations above its background concentration.
contaminated site	A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources. If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.
contamination	Discharge of contaminant at a site or migration of contaminant to a site.
contour maps	A map marked with contour lines connecting points of equal values (e.g. concentration level, hydraulic head).
cost benefit analysis	A systematic process for calculating and comparing costs and benefits of a remediation. The purpose is either to determine if it is a sound investment and decision or to provide a basis for comparing two or more remediation options.
cost effective	A form of economic analysis that compares the relative costs and outcomes of two or more remediation options. The analysis is often used where it may be inappropriate to monetize health effect.
cost recovery	Where sites have been rehabilitated using government funds, fully or partially, an attempt has to be made to recover the costs from the liable party. This may also be possible for orphan sites also.
critical deviations	Observed deviations of the CSM or the (post) remediation that will result in e.g. a de-functioning of the remediation technique, affect on the functional use of the site, the quality of the monitoring.

D

term / topic	**definition**
delineation	Process of finding boundaries of contamination at a contaminated site.
desk study	The gathering of information (geohydrology, history, etc.).
detailed site investigation	Main stage of intrusive site investigation, which involves the collection and analysis of soil and other media as a means of further informing the conceptual model and the risk assessment. This investigation may be undertaken in a single or a number of successive stages.
deviation point, critical	Event or development, occurring during post remediation, that is of such a kind that counter measures to restore the situation as reached by the remediation cannot be effective within the scope of the original post remediation plan.
deviation point, non critical	Event or development, occurring during post remediation, that is of such a kind that counter measures to restore the situation as reached by the remediation can be effective within the scope of the original post remediation plan.
discharge	Any act of spilling, releasing, leaking, dumping, pouring, pumping, emitting, emptying, injecting, escaping, leaching or disposing contaminants into the environment including drums, barrels, containers containing such contaminants.
Dispersion	*see migration*

DPR; Detailed Project Report	Report which provides details of the technical remediation activity to be conducted, cost and time of rehabilitation, stakeholder engagement, and post remediation monitoring.
drilling	Usually a vertical penetration into the subsurface with removal of soil/rock material by using motor-driven drilling equipment

E

term / topic	definition
ecological risk	Risks for ecology are formed when the biodiversity is affected (the contamination could cause a decline in species), when the recycling functions are affected and when bio-accumulation and poisoning can take place.
ecosystem	An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system.
environment	Environment includes water, air and land and the inter- relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property.
environmental and social impact assessment	the analyses and evaluation of the impact of soil remediation on the environment and/or society.
environmental transport	Movement of a chemical or physical agent in the environment after it has been released from a source to an environmental medium, for example, movement through the air, surface water, groundwater, soil, sediment, or food chain.
evaluation report	Report describing the execution and verification results of remedial actions.
evaporation	phase change from liquid into vapour
excavation	Removal of soil, fill, sediment, etc., from the ground for treatment or disposal.
exploratory holes	Drillings through which observations, samplings en measurements can be executed in order to get a better understanding of the Conceptual Site Model enabling site investigation and remediation.
exposure route	The process by which a contaminant or physical agent in the environment comes into direct contact with the body, tissues, or exchange boundaries of an environmental receptor organism, for example, ingestion, inhalation, dermal absorption, root uptake, and gill uptake.
ex-situ	Where contaminated material is removed from the ground prior to above-ground treatment or encapsulation and/or disposal on or off site.

F

term / topic	definition
fieldwork	Practical work (sampling, testing, measurements, observations) conducted by a researcher in the natural environment, rather than in a laboratory or office.
fitness for use	A remediation goal that meets a predefined site use, under anticipated (generic fitness for use) or specified user conditions (site specific fitness for use).
flux	The action or process of flowing or flowing out expressed as the amount of a substance passing a boundary within a specific time lapse.

G

term / topic	definition
generic remediation target levels	A preset level of concentration of a specific contaminant to be achieved without taking into account any site, area or site specific requirements are to be assessed.
groundwater	Water which is being held in, and can be recovered from, an underground formation.
groundwater level	Underground surface below which the ground is wholly saturated with water.
groundwater quality	The physical, chemical, and biological qualities of groundwater.

H

term / topic	definition
habitats	The natural home or environment of an animal, plant, or other organism.
human health	The health of human beings possibly affected by a contaminated site. (related to the NPRPS).
toxic substances	Any substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plant, micro-organism, property or the environment.
hazardous waste	Any waste which by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances as defined in "Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008".

I

term / topic	definition
identification	Identification of probably contaminated sites is a legally mandated, structured procedure for identifying polluted sites and submitting their details for further investigation to authorities.
impermeable	Not allowing fluid to pass through.
Independent third party	A party not related to the case in any way. Commentary: in certain cases it is imaginable that the independent party is the competent authority. Examples of parties who cannot be regarded as independent party are site owner, any site occupier and any party involved in the site's development.
industrial processes	Processes in accordance with 'Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008'.
in-situ	Where contaminated material is treated without prior excavation (of solids) or abstraction (of liquids) from the ground.
investigated site	If on the basis of such assessment or investigation, the contaminants exist at or below screening levels and there is no existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as investigated site.
investigation strategy	Plan of action designed to achieve of the CSM necessary for a specific step in the remediation process.
isolation	*see containment*

L

term / topic	definition
land use and site activity	Generic land use including residential, agricultural, industrial, commercial or public use and any site specific activity, whether designate in a plan in force by law or the actual use of such land or site, that may expose a receptor to a contaminant including but not limited to use of or contact with soil, use of or contact with surface water or municipal water supply and abstraction and use of or contact with groundwater and related activities including construction, excavation, drilling, demolition, industry, operation, process, residence, commerce, trade, entertainment, recreation, education, cultivation and movement of vehicles and people. Categories of land use applied in this report: Agriculture land, Waste land, Water bodies, Forests, Habitation settlement; Commercial, Industrial, Mixed, Other.
logbook	Systematic daily or hourly record of activities, readings, measurements, events, and/or occurrences.
long term extensive remediation measures	measures performed during remediation which may run for long periods of time (up to several years) to reach the remediation objectives.

M

term / topic	definition
maintenance	Activities carried out to ensure that remediation performs as required over a specified design life.
management of polluted / contaminated sites	Activities to respond to the (probable) threats to human health and/or the environment caused by contaminated sites. These activities can contain technical, legal, institutional and financial elements.
menu of options	Overview giving insight in the most likely ('prioritized') remediation objectives, most likely (non)technical choices for remediation measures and specific conditions or alternative approaches in a variety of settings for different types of contaminated sites.
migration	Transport of contaminants / constituents through soil and/or surface water.
migration pathway	The course through which contaminants in the environment may move away from the source(s) to potential receptors.
mobile substances / mobility	Matter possibly consisting of or containing contaminants that has the property of displacement in soil, groundwater or surface water due to different natural or chemical processes like e.g. mass flow, gravity flow, osmosis, mass transport, leaching
monitoring	Process of repetitive observation, for defined purposes of one or more elements of the environment according to pre-arranged schedules in space and time, using comparable methods for environmental sensing and data collection.
monitoring wells	Groundwater sampling point from which the quality (amount of contaminants, pH, minerals, etc.) of the groundwater can be determined.
multifunctional	The property of a site that it can be used for any kind of use without any restrictions due to the presence of contaminants.

N

term / topic	definition
Priority list	A list of confirmed contaminated sites ranked according to prioritization criteria to determine the order in which sites are to be remediated.
natural background concentration	Concentration of a substance that is derived solely from natural sources (i.e. of geonic origin), commonly expressed in terms of average, a range of values or a natural background value.
natural contaminants	Substances present in a relative high concentration level without antropogenic cause.

natural soil processes	Chemical, biological or physical soil characteristics that determine accommodation or buffering of changes in soil quality.

O

term / topic	definition
observation wells	*see monitoring wells*

P

term / topic	definition
pathway	Path a chemical takes from a source to a receptor. Each exposure pathway links a source to a receptor.
performance criteria	Criterion under which the remediation options can be implemented.
permits	An official document giving a party authorization to implement a certain activity.
plume	Contaminated groundwater containing constituents derived from the source of the contamination.
point source contamination	Distinct and delimited contamination emitting contaminated material to its surrounding (i.c. groundwater, vadose zone, free air, surface water) or plants, animals and microbes.
pollutant linkage	The combination of a contaminant, a receptor and a pathway can create a risk when they are linked together.
polluted site	Areas where hazardous substances exist at levels and in conditions which may pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living creatures, plants, micro-organisms, property, water quality or the environment in general, determined in the manner prescribed.
post remediation activities / measures	Activities necessary after the physical clean-up activities have been completed, in order to manage the situation regarding possible negative effects of remaining contamination. These activities can have technical, legal, institutional or financial aspects.
post remediation implementation programme	Programme for planning of operational activities in the post remediation phase. Such programmes may be aimed at the planning of monitoring, inspection, maintenance, replacement and management activities.
post remediation monitoring	Monitoring of the activities necessary after the physical clean-up activities, in order to manage the situation regarding possible negative effects of remaining pollution. These activities can have technical, legal, institutional or financial aspects.
post remediation plan	Plan describing all technical and supporting management activities needed to keep a remediated site where residual contamination remained in such a state as to prevent the residual contamination to pose risks to human health, the environment or spreading.
precipitate	Formation of a solid in a solution or inside another solid during a chemical reaction or by diffusion in a solid
preliminary investigation	A preliminary investigation of the site shall be conducted to understand if the site poses no/some threat to human health and environment and site inspection is then carried out for sites that have some threats by taking samples of air, water and soil at the site.
preliminary site assessment	Investigation if activities at a site might have caused contamination (reconnaissance) and confirmation of the presence or absence of contamination by limited sampling.
primary source	Contaminations found in the soil on a place where they initially entered the soil. E.g. the area immediately around a leaking oil drum
prioritization criteria	Criteria used to make a priority for assessment and rehabilitation of contaminated sites under NPRPS.

probably contaminated site	A probably contaminated site is an area (whether or not delineated) where the presence of contaminants is suspected but not conclusively determined or where contaminants exceed specified standards but the threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity is not conclusively established. A probably contaminated site may require further investigation to establish whether it is a contaminated site that requires remediation. The area may consist of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.
pump and treat	Extraction and subsequent treatment (purifying plant) of contaminated groundwater. Effluent is either injected into the soil again or disposed onto an open water system.

Q

term / topic	definition
QA/QC for site assessment	The combination of quality assurance, the process or set of processes used to measure and assure the quality of a site assessment, and quality control, the process of meeting the results of a site assessment to standards.
quality	Description of the chemical quality of the soil, groundwater, sediment or surface water.

R

term / topic	definition
receptor	Humans and other living organisms potentially exposed to and adversely affected by contaminants because they are present at the source(s) or along contaminant migration pathways.
redevelopment plan	Plan for any new construction(s) on a site or an area that has pre-existing uses.
remediated site	A site where remediation and post remediation measures have been implemented and there is no residual contamination.
remediation	The doing of any works, or carrying out of any operations or taking of any steps in relation to a polluted site for the purpose of (a) identifying or investigating or preventing or minimising or remedying or mitigating the adverse effects by reason of which polluted site is such site; (b) restoring the quality of environment, flora and fauna at the site to an acceptable level; and includes making of subsequent inspections from time to time for the purpose of keeping under review the condition of the site in question, in the manner prescribed.
remediation design	A technical design for remedial action at the site included in a Detailed Project Report.
remediation goal	*see remediation objective*
remediation objective	Generic term for any objective, including those related to technical (for example risk reduction, residual contamination concentrations or engineering performance), administrative and legal requirements.
remediation option	A means of reducing or controlling the risks associated with a particular source-pathway-receptor combination to a defined level.
remediation requirement	Preset conditions that need to be met before a remediation can be implemented as planned.
remediation target	*see remediation objective*
remediation technique	Physical tools and solutions that can be implemented to eliminate or reduce the presence or negative effects of contaminations in soil or groundwater.

residual contamination	After completion of remediation and post remediation measures, contaminants exist in excess of screening level or there may be existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property, that may be mitigated or eliminated with land use and site activity restrictions.
resources	Commodities such as food, water, sand, agriculture land.
Response level	Generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.
restricted site	A site where remediation and post remediation measures have been implemented and there is residual contamination requiring land use and site activity restrictions.
risk	A combination of the probability, or frequency of occurrence of a defined threat and the magnitude of the consequences of the occurrence related to combinations of Source, Pathway and Receptor.
risk assessment	The process of identifying, assessing and evaluating the risks that may be associated with a threat to human health and/or the environment at a contaminated site. Risk assessment can be carried out by a qualitative identification of potential risks or by calculation of dispersion and exposure.

S

term / topic	**definition**
safety	Freedom from unacceptable risk of harm (during assessment or remediation activities).
sample	Portion of material (soil, groundwater, sediment or surface water) selected from a larger quantity of material.
sample protocol	Technical guidance for the field team in order to ensure quality of sampling, ensure uniformity and to allow for effective assessment of fieldwork quality.
sampling strategy	Arrangement by which a sampling protocol is to be conducted.
sampling technique	All appropriate procedures and sampling devices to obtain and describe samples of soil, groundwater, sediment or surface water, either in the field or during transportation and in laboratory.
Screening level	Generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.
secondary source	Contaminations found in the soil after having been transported from a primary source. E.g. DNAPL layer found at the bottom of a aquifer
sediment	Soils and their parent material beneath the surface water body.
selection remediation option	Process of selection of the most favourable remediation option using certain selection criteria.
sensitive use	Use of land or surface water which is determining the risks for human health and/or the environment.
site	Any area, place, premise, establishment, land and related structures including well, pit, pond, lagoon, landfill, groundwater, sediments, building, structure, pipeline and container and any facility, factory, industry, operation, process or equipment located over such area.
site assessment	Investigation on the content, extent, delineation or risks of a (probably) contaminated site.
site inspection	Inventory and mapping of a probably contaminated site

Site Reuse	Local government shall designate the site use as per the remediation plan and handover the land for use.
site specific remediation target level	A preset target level that facilitates a specified predefined use of a single site.
soil	Upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes. It is composed of mineral particles, organic matter, water, air and living organisms organized in genetic soil horizons.
soil characterization	Determination of relevant physical, chemical and biological properties of the soil.
soil threatening activities	Activities possible causing a soil to get contaminated.
source	Source in relation to a contaminant means the location from which a contaminant has entered or may enter the environment and the soil, water, sediments that have been contaminated at the point of entry of the contaminant but excludes contamination through migration. (A primary source, such as a location at which drums have leaked onto surface soils, may produce a secondary source, such as contaminated soils; sources may hence be primary or secondary.)
spreading	*see migration*
stakeholder	person or organization who is affected by the effects of a contaminated site or has interest in the assessment and remediation activities at the site
stratigraphy	The order and relative position of geological strata (layers) and their relationship to the geological timescale.
substance	Any chemical element or chemical compound.
surface water	All water at the surface, including lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, wetlands, inlets, canals, oceans within the relevant territorial limits and all other bodies, natural or artificial, inland or coastal, fresh or salt.

T

term / topic	**definition**
target level / target values	A preset level of concentration of a specific contaminant to be achieved when implementing a remediation option.
temporary safety measures	Measures for preventing unacceptable risks pending final remedial measures.
tendering process	Development and implementation of bidding documents for outsourcing assessment activities and/or (post) remediation works.
threats to human health and/or the environment	The situation in which existing or imminent negative impact on human beings and or the environment can occur due to exposure to constituents present at a contaminated site.
topography	The arrangement of the natural and artificial physical features of an area.
toxic and hazardous substances	Substances/constituents as per the 'Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008'.
tracers	(natural or injected) Matter carried by water which will give information concerning the direction and/or velocity of the water as well as potential contaminants which could be transported by the water.
TSDF	Treatment, Storage and Disposal Facility.
Typology	The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites (see Annex of this Glossary for extended explanation of Typology of contaminated sites).

V

term / topic	definition
verification	The process of demonstrating that the risk/threats has/have been reduced to meet (post) remediation criteria and objectives.

W

term / topic	definition
water body	A body of water forming a physiographical feature, for example a sea or a reservoir.

Annex to the Glossary

Explanation of Typology of contaminated sites

1 Introduction

The typology of contaminated sites offers important elements when developing a site assessment strategy and remediation options in a manageable way. These elements are activities leading to contamination, geometry and type of contamination. Combined with site specific information on chemical substances and soil characteristics this typology is useful to get insight in realistic remediation options to facilitate the process of remediation option appraisal.

2 Typology

Table T1 presents an overview of the typology, by showing all activities leading to contaminated soil and types of spreading. These activities are regardless of the party causing the contamination. E.g. liquid phase contaminations are not necessary focused only to industrial activities. On the other hand it is expected that most of this type of contaminations can be found in industrial areas. The following main types of contaminated sites are distinguished using this approach:

Source related:

- Type S1: Land bound solid phase contamination;
- Type S2: Water bound sediments solid phase contamination;
- Type L: Land bound liquid phase contamination. The source of this type of contaminations is connected to human activities or infrastructure.

Pathway related:

- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids);
- Type P2: Groundwater contaminations.

Note 1: Although elements in the typology are based on the 'source-pathway-receptor' approach, it is not primary 'receptor' (risk) based. The typology is not based on risks (risks to human health, ecological risks, spreading or vaporizing). This is because site assessment and soil remediation options appraisal, for which this typology is developed, is not limited to the assessment of unacceptable risks, but needs to give insight in a contaminated site as a whole.

Note 2: depending on a specific situation:

- a combination of these types may be found on one site. Example: a land bound storage of Chromium containing hazardous waste (type S1), leaching Chromium to groundwater and leading to a contaminated groundwater plume (type P2). This combination of types on one single site could result in multiple site assessment strategies and multiple remedial options, each assessing the different types of contaminants (both the site assessment and remediation approach can be combined for practical reasons);
- multiple sites can form a cluster of contaminated sites of a specific type or combination of types. A combination of sites of a specific type in a single cluster or a combination of types on a single site can be recognized. These situations could be indicated as a "cluster-site" with a wide variety of scales. In general, the applicability of remediation techniques will not depend on this setting, but correct balancing of remediation techniques per type of site in a cluster will lead stakeholders to the best applicable remediation option.

Note 3: Both in type L as in type P1 liquid phase contaminants are involved. Type P1 is distinguished from type L by the specific type of contaminant, Non-Aqueous Phase Liquids (NAPL's), which have a characteristic spreading pattern on or in the groundwater aquifer. This

characteristic leads to different site assessment strategies, spreading mechanisms, risk profiles and remediation approaches for type P1 sites, as compared to type L sites. A type L site may, due to further spreading of the contaminant plume, develop over time into a type P1 site.

The main types listed above are based on normative characteristics, which play a role in determining the basics for remediation options. Side characteristics may do so as well, but their influence will in certain cases be restricted to the finer points (mostly technical details) in the selection of remediation options or to the planning or implementation of remediation actions. Thus subtypes come into perspective when remediation option appraisal is going into the second step of option appraisal, the detailed engineering phase. In this detailed engineering phase aspects have to be included related to contaminant specific specifications of remediation techniques, assessment of specific social aspects of the remediation actions or site use specific technical requirements.
Case example. The first step of a site specific remediation option appraisal, based on normative characteristics only, has shown that the remediation should be implemented within a period of less than two months and should result in a removal of all contaminants. In this case only then the site will meet the specific needs for planned reconstruction works. At this point it is already clear that only excavating techniques will be applicable, rendering the assessment of in situ techniques obsolete. This saves gathering and analysing detailed information on the performance of these techniques (e.g. contaminant related performance of in situ techniques) as this will not meet any purpose.

Subtypes can be distinguished based on the following secondary criteria:

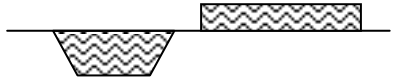
- **Type S1 and L** related subtypes are defined, based on the activity causing the contamination. HW-Schedule I (listing processes generating hazardous wastes) may help to focus on possible activities.
  In Table T1 these subtypes are coded ‘a’ through ‘f’ (type S) and ‘a’ through ‘d´ (type L).
  These subtypes are distinguished to support the site assessment.

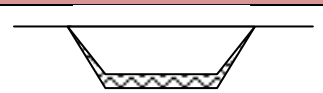
- **Type P1** related subtypes are defined, based on the bulk density of a NAPL (non aqueous phase liquids, dense and light).
  In Table T1 these subtypes are coded ‘a’ and ‘b’ (type P1).
  These subtypes are distinguished to support the site assessment.

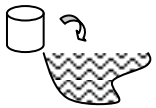
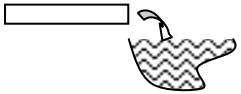
The typology is aimed to support the remediation options appraisal. Some examples to illustrate this point. A site assessment plan for a S1-f type contaminated site (deposition by flooding or washing) will focus on the boundaries of the flooded areas of a river system, easily recognizable on maps or areal pictures. Once the pattern of flooding is known an extensive sampling plan can be carried out to validate the flooding pattern and to validate the hypothesis on the spreading of the contamination with field data. By contrast, a site assessment plan for a S1-c type of contaminated site (storage of contaminated material) will focus on a relatively small area where human activities such as incineration have taken place.

The total volume of the removal of contaminated material, which accounts for the major part of remediation costs, will be smaller for a S1-e type of contaminated site (atmospheric deposition) than for a S1-a type (soil mixed with contaminated material). Therefore, it is more likely that the best applicable remediation option on a S1-e type site will be a complete removal of all contaminants, where for a S1-a type site a capping option is more likely to come into perspective.

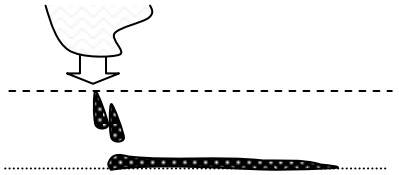
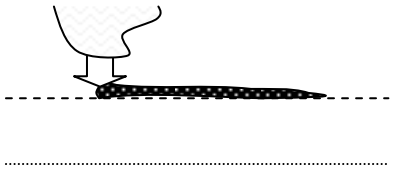
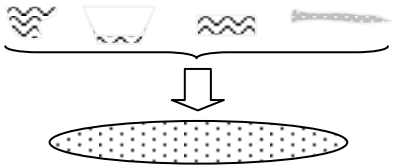
Table T1 Typology

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
S-1	Solid phase contamination (land bound site)		
S1-a *	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	
S1-b **	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	
S1-c **	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	
S1-d *	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	
S1-e *	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	
S1-f *	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
		determined by the flooding of flow of a water system.	
S-2	Solid phase contaminations (water bound site)		
S-2 **	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
L-1	Liquid phase contaminations		
L1-a *	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	
L1-b *	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	
L1-c *	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	
L1-d	Spills or leaks of liquids. (either on surface or in rivers/lakes) *Note. Possibly leading to type S2 or P2.*	Liquid contamination in soil situated at the end of a transport piping or drain system.	

*) caused by multiple sources or situation where source cannot be attributed.

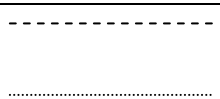
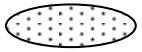
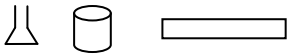
Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
P-1	Liquid phase related		
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL [a])) in permeable soil. (bulk density > water)	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the botom of an aquiffer can result in a 'secondary source' of spreading of type P-2)	
P1-b	Light Non-Aqueous Phase Liquid (LNAPL [b])) in permeable soil. (bulk density < water)	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2)	
P-2	Leached or dissolved contaminants		
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	

a) A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.

b) Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove

LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.

Table T2 Key to icons in table T1

Icon	Key
	Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.
	Groundwater table Base of aquifer / top of impermeable layer.
	Liquid waste. Pure or mixed with soil.
	Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.
	Contaminated groundwater plume. Depending on permeability of the soil.
	DNALP or LNAPL.
	Spill / leakage.
	Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.

Overview Guidance document for assessment and remediation of contaminated sites in India

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1st edition, March 2015

Step / Task	Volume I: Methodologies and guidance	Volume II: Standards and checklists	Volume III: Tools and manuals
1 Identification of probably contaminated sites	Data collection	II-1-a Example petition format for identification of probably contaminated sites	
	Data verification and evaluation	II-1-b Checklist relevant data for identification of probably contaminated sites	
2 Preliminary investigation			
2.1 Preliminary site assessment	Desk study	II-2.1-a Checklist prequalification for site investigation	III-2.1-i Site Inspection Protocol
	Site inspection		
	Limited sampling and testing		
	Comparing testing results with standards	II-2.1-b Screening and response levels	
	Reporting and review	II-2.1-c Checklist preliminary site assessment report	
2.1 Preliminary site investigation	Investigation strategy	II-2.2-a Checklist investigation strategy preliminary site investigation	III-2.2-i Manual Conceptual Site Model and identifying the Source-Pathway-Receptor
	Fieldwork and laboratory testing		III-2.2-ii Overview of techniques for site investigation
	Comparison of testing results with standards		
	Reporting and review	II-2.2-b Checklist preliminary site investigation report	
		II-2.2-c Checklist review and approval preliminary site investigation report	
3 Notification of polluted site	Delineate the contaminated site		
	Impose site use restrictions and temporary safety measures	II-3-a Checklist restrictions to site use and temporary safety measures	
4 Priority list addition	Assess available data on the site		
	Apply prioritisation algorithm to obtain priority score	II-4-a Checklist information for application prioritisation system	
5 Remediation investigation			
5.1 Detailed site investigation	Investigation strategy		III-5.1-i Example investigation strategy detailed site investigation
	Fieldwork and laboratory testing		
	Analysis and interpretation of exploratory data		
	Reporting detailed site investigation	II-5.1-a Checklist detailed site investigation report	
5.2 Risk assessment	Assess contaminant concentration levels	II-5.2-a Checklist risk assessment report	III-5.2-i Tools for risk assessment
	Identify applicable source-pathway-receptor combinations for human health		
	Perform a generic quantitative risk assessment for human health		
	Perform a more detailed quantitative risk assessment for human health		
	Perform a risk assessment for the environment		
5.3 Setting remediation objectives and requirements	Establish Remediation objectives	II-5.3-a Background information for setting remediation objectives	
	Establish Remediation requirements		
5.4 Development of remediation options	Assess the remediation objectives and requirements		
	Identify constraints to remediation		
	Identify applicable remediation techniques	II-5.4-a Flowchart application newly developed remediation techniques	III-5.4-i Overview remediation techniques and menu of options
	Develop applicable remediation options		
5.5 Selection remediation option	Compare and appraise remediation options	II-5.5-a Checklist Criteria for comparison and appraisal of remediation options	III-5.5-i Examples of methods for remediation option evaluation
	Consultation with stakeholders		
	Prepare remediation investigation report including stakeholder views	II-5.5-b Checklist Remediation investigation report	
	Review and approval of remediation investigation report and select most favourable remediation option	II-5.5-c Checklist Review and approval Remediation Investigation report	
6 Remediation design, DPR	Design of the remediation	II-6-a Checklist DPR including verification plan	
	Costing and planning of the remediation	II-6-b Example format cost estimation remediation	
	Environmental and social impact assessment and stakeholder consultation		III-6-i Manual for environmental and social impact assessment for remediation of contaminated sites
7 DPR approval and financing	Review and approval of DPR	II-7-a Checklist review and approval Detailed Project Report	
8 Implementation of remediation			
8.1 Preparation and authorization	Inventory of required permits	II-8.1-a Checklist permits for remediation works	
	Applying for the permits		
8.2 Contracting	Preparation of bid document		
	Selection and assignment of contractor	II-8.2-a Checklist prequalification for remediation	
8.3 Execution, supervision and verification of remediation works	Prepare remediation measures		
	Execute and manage remediation measures	II-8.3-a Checklist Health and Safety plan	
	Verify preparation of remediation measures		
	Verify remediation measures against contract and specifications	II-8.3-b Checklist supervision and verification remediation measures	
	Report verification results in a Remediation evaluation report	II-8.3-c Checklist Remediation evaluation report	
9 Approval of remediation completion	Review and approval of remediation completion	II-9-a Checklist review and approval remediation completion	
10 Post remediation plan	Preparation of post remediation plan	II-10-a Checklist Post remediation plan	
	Review and approval of post remediation plan	II-10-b Checklist review and approval Post remediation plan	
11 Post remediation action	Prepare Post remediation implementation programme		
	Assign implementation of post remediation activities		
	Implement post remediation activities		
	Supervise and verify post remediation measures and prepare Periodical post remediation status report	II-11-a Checklist Post remediation status report	
	Review and approval of Post remediation status report	II-11-b Checklist review and approval Post remediation status report	
12 Cost recovery	Preparing cost overview of executed assessment and (post) remediation works		
13 Priority list deletion	Assess and record site use restrictions		
14 Site reuse	Anticipate to site use restrictions		
	Arrangements to enable post remediation action		
Glossary			

Colophon

Colophon

Context
The Ministry of Environment and Forests (MoEF), Government of India, has taken up the Capacity Building for Industrial Pollution Management Project (CBIPMP) with the assistance of the World Bank. The intention is to develop a National Programme for Rehabilitation of Polluted Sites (NPRPS). Details of this project are available on the MoEF website (http://moef.nic.in/sites/default/files/cbipmp/index.htm).

As a part of the CBIPMP project, MoEF in March 2012 commissioned a consortium led by Grontmij Nederland BV (Netherlands) and otherwise comprising of Shah Technical Consultants Pvt.Ltd. (India), Technochem Agencies Pvt.Ltd. (India) and Indus Technologies Netherlands BV (Netherlands and India) to undertake a consultancy assignment for "Development of Methodologies for National Programme for Rehabilitation of Polluted Sites".

The key objective of this assignment was to develop methodologies for the implementation of remediation projects in India by government and non-government agencies under the NPRPS. These methodologies mainly cover [i] the process for selecting and implementing preferred remediation options and [ii] the technical guidelines and standards that can be applied.

Development of the document
The Grontmij consortium has executed the assignment between April 2012 and March 2015, with its team of Dutch, Indian and international experts. The assignment comprised:

- a large number of desk studies on a wide variety of topics;
- review of national and international standards, practices, experience and learning;
- field visits to several contaminated sites in India;
- extensive discussions with several stakeholders, including CPCB, SPCBs, individual technical experts, academics and field staff in charge of the sites;
- discussions with experts outside the consortium;
- evaluation of previous reports, evaluation and incorporation of field tests conducted in the past and in parallel by other assignments;
- stakeholder meetings to gain input on draft reports;
- discussions with the Technical Expert Panel and supervising experts from the Ministry and World Bank.

In performing the study, a number of specific tasks have been carried out as mandated by the Terms of Reference of the assignment. For each task, a detailed report has been prepared by the Grontmij consortium. This Guidance document consists of three Volumes.

Key authors of this document include: Arthur de Groof, Paul Oude Boerrigter, Rob Heijer, Paul Verhaagen, Ravi Jambagi, Sukla Sen, Hemant Rane and Deepak Deshpande.

Initial use
The Guidance document provides MoEF, agencies such as CPCB and SPCBs and various other stakeholders with a comprehensive reference manual to further develop the NPRPS effectively, educate and train key technical staff and to enable MoEF to initiate necessary steps towards remediation of sites, whether identified at the time of publication or as yet to be identified.