Network Oriented Risk-assessment by In-situ Screening of Contaminated sites

NORISC

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Author:	***WP3***
Editor:	***Gerhard Schwarz and Bo Thunholm, Geological Survey of Sweden***
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User's Guide to the Decision Support System on Site Investigation Methods in NORISC (Appendix 5)

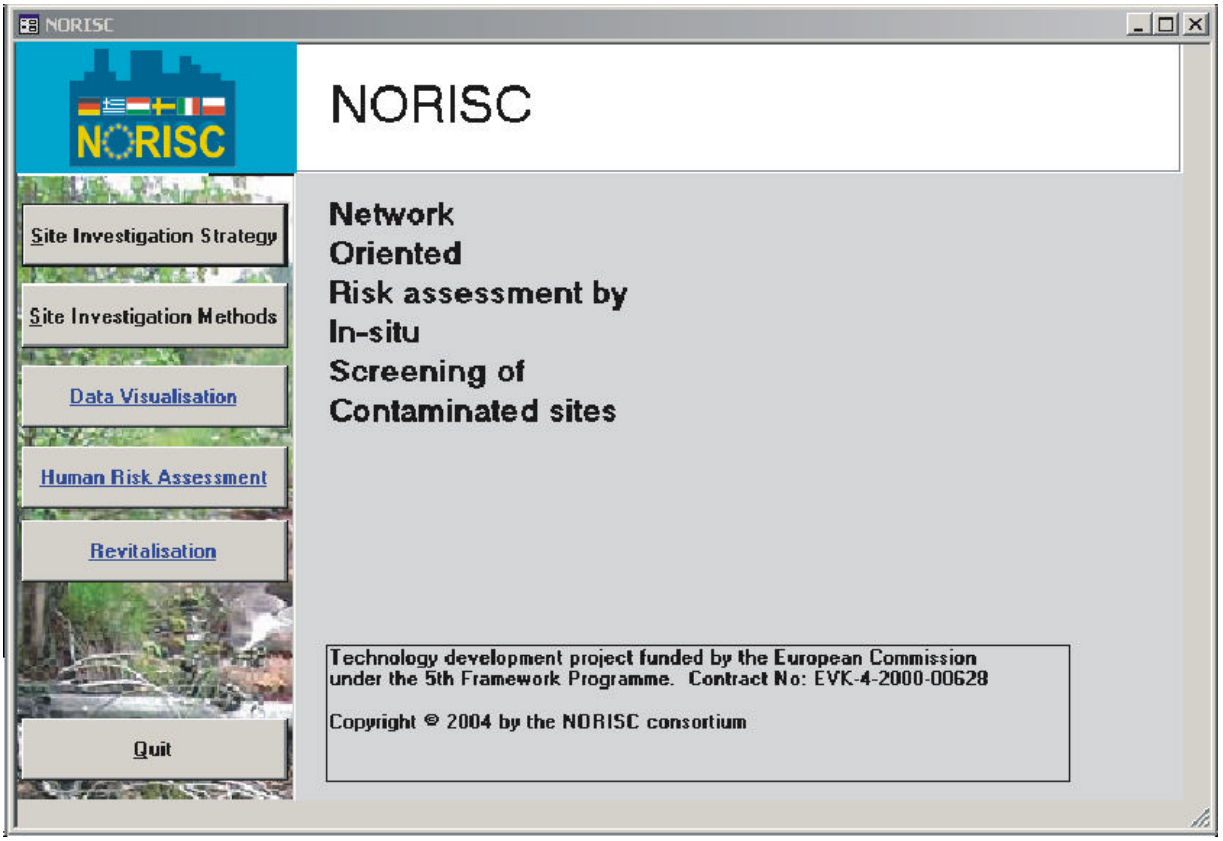
Contents

Introduction

The NORISC software was developed mainly as a Decision Support System (DSS) for selecting the most appropriate combination of methods to investigate contaminated sites. Furthermore, the package provides modules on site investigation strategy (SIS), data visualisation, human risk assessment and revitalisation (see figure below). The SIS-module consists of a number of documents; i.e., SIS-check list, SIS-full documentation, contamination profiles, user's guide for site investigation methods, and guides for quality assurance/quality control, data visualisation, human risk assessment, and revitalisation. The other four modules of the NORISC shell are executable and require different kind input in order generate certain output to support the investigation of contaminated sites.

In this document, we concentrate on the module about site investigation methods and will describe in manual form how the system is to be operated. In addition to recommending combinations of methods a cost estimation for the site investigation is given. However, combining the output of the DSS with professional and more specific knowledge in site investigations may result in other combinations of investigation methods than those suggested by the software. Such discrepancies may be attributed to site-specific conditions that are beyond the scope of a decision support system. Thus, the DSS should be regarded as a tool for providing recommendations.

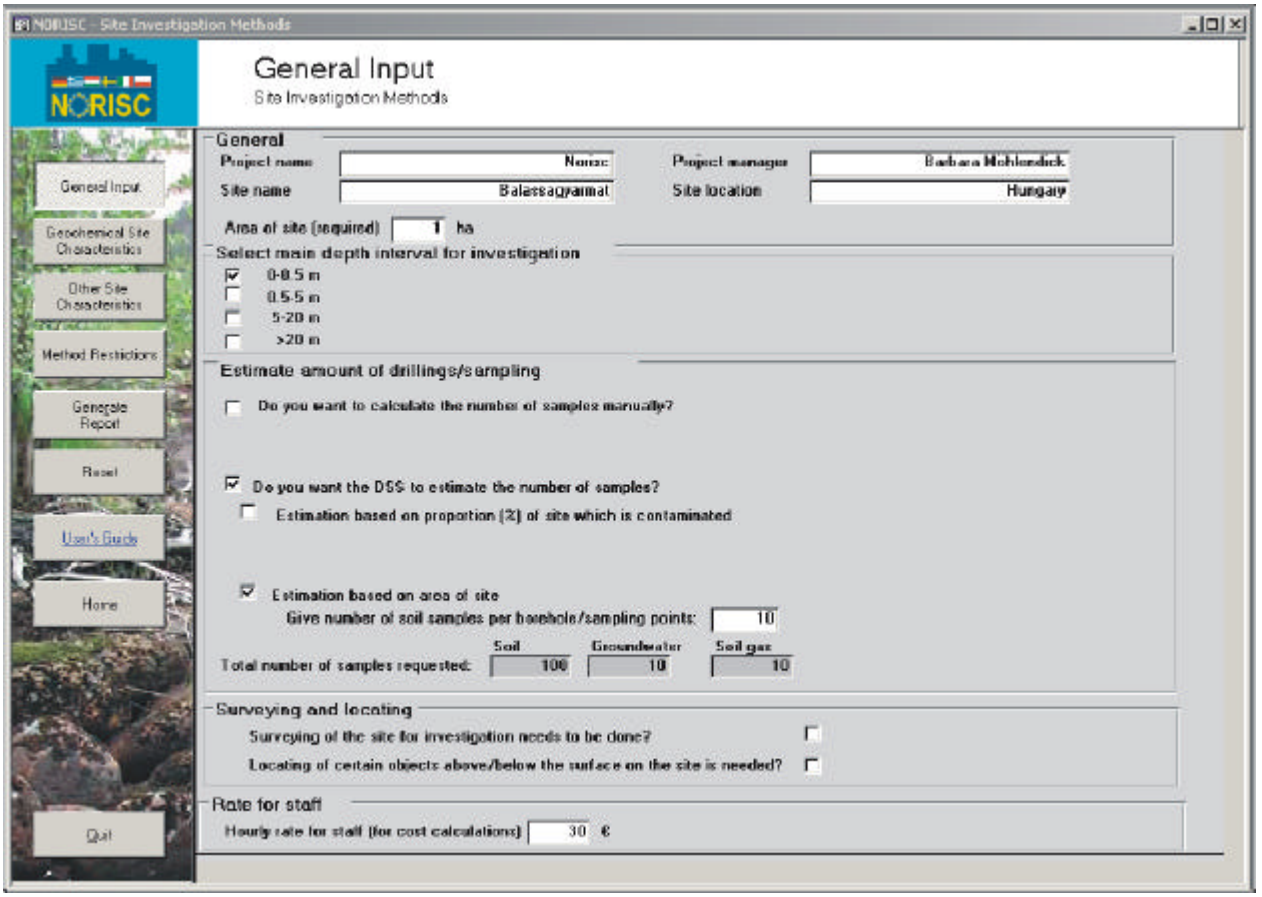
This document is the user's manual of the decision support system along with some additional technical information. Software requirements: The present version of the DSS - Site Investigation Methods requires Microsoft® Access 97 and Excel 97.



Part one: Input to the DSS - Site Investigation Methods

General input

This window is designed to provide general information about the site. Some information is optional such as project name and site name, while other information, such as the estimated number of required samples is obligatory, and used to calculate costs. In the following we will discuss the individual window subsets.



General

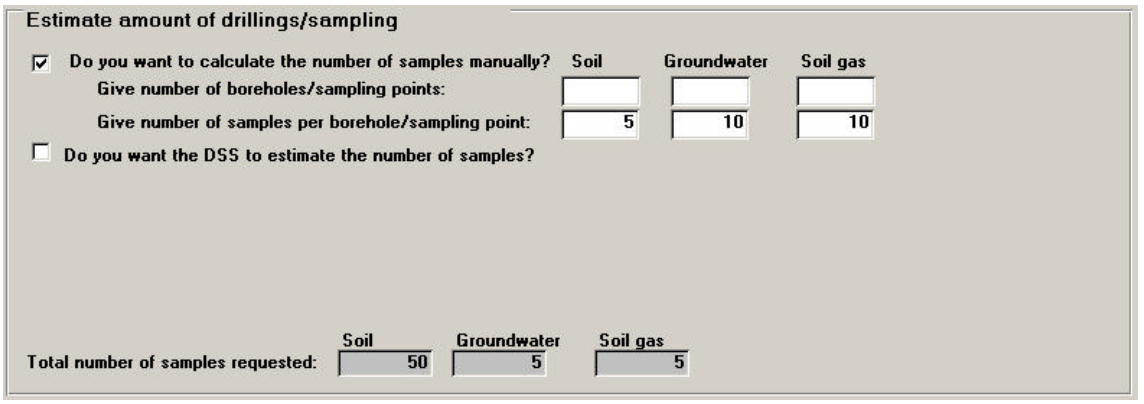
This part is largely used to gather some basic information to identify the project later on. Attributes such as the name of the site, responsible project manager etc. obviously have no influence on the output of the DSS, although such labels are essential to identify its results. An input that is non-optional is the area of the site. It has to be provided in order to estimate the total number of sampling points and to estimate costs.

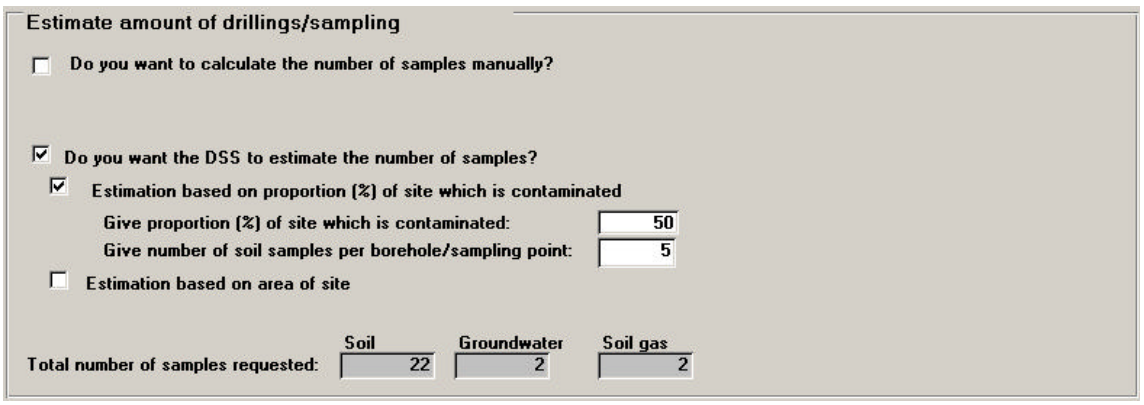
Main depth interval for investigation

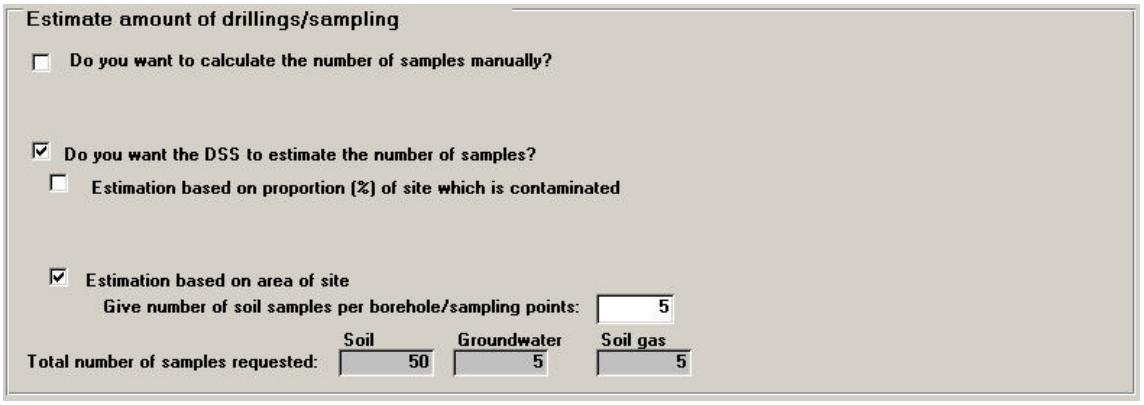
The main depth interval (below ground surface) that should be investigated has to be given. Investigation methods are suitable for different depth ranges, which means that this option influences the selection of suitable methods. In addition, the target depth affects the estimated costs for some methods (e.g., drillings), whereas the costs of other methods are assumed to be less or non-sensitive to the depth of investigation (e.g., mostly geophysical methods).

Amount of drillings/samples

The number of requested samples to be taken at a site is used to estimate costs. The number of sampling points can be calculated by the DSS or entered manually. However, the number of samples at each sampling point has to be provided manually in every case. This means that the estimated number of samples per drilling point or any other sampling point, such as a pit, has to be given by the user. The estimated number of samples can be given by taking into account either the proportion of the site that is supposed to be contaminated or the area of the site. In both cases the number of samples in groundwater and soil accounts for 10 % of the amount of samples in soil.







Surveying and locating

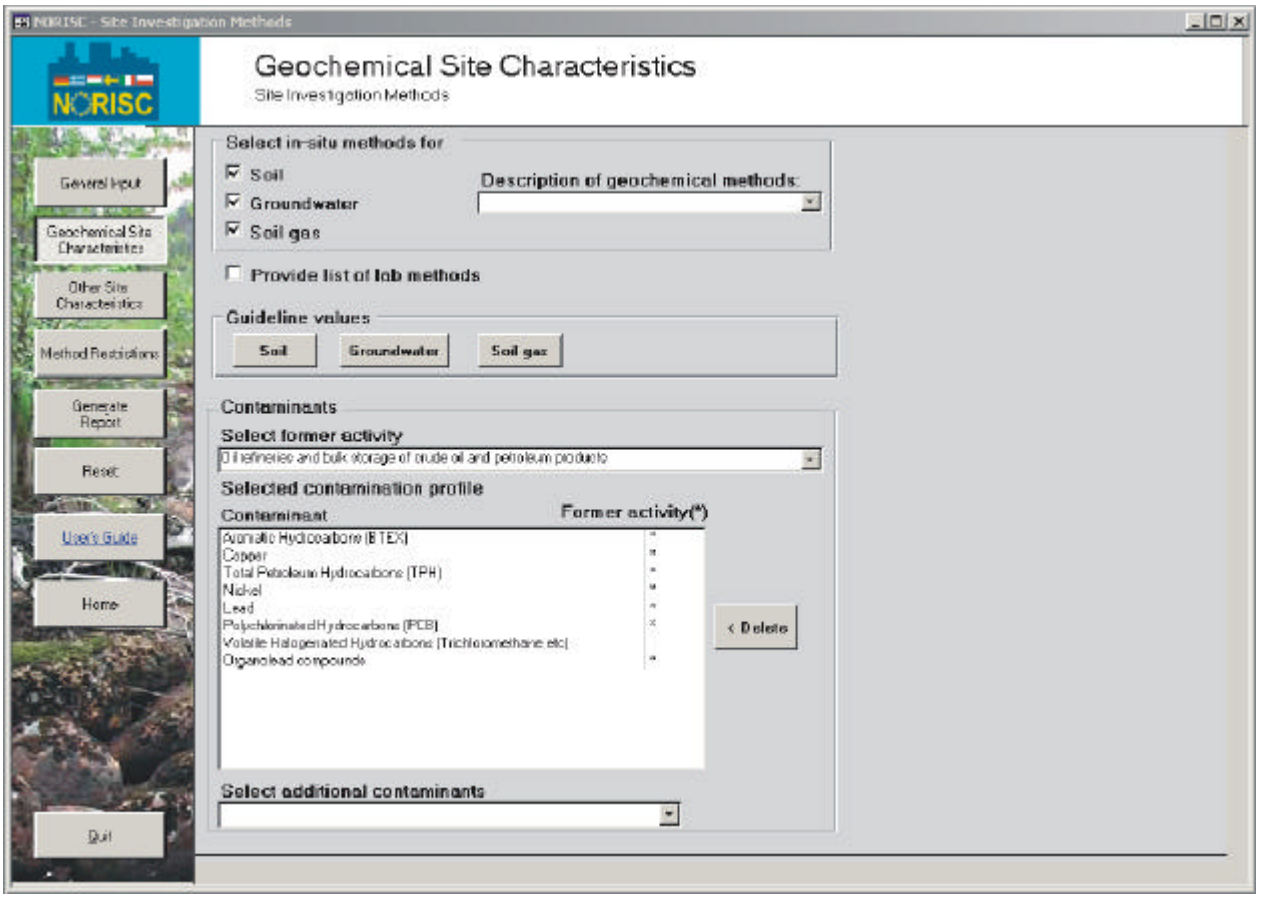
Entering the requested information on surveying and locating gives some general information in the output section on surveying, positioning and locating. In this context, surveying means a general positioning procedure at a site such as installing a regular grid and measuring the level of the ground surface. Locating means that certain objects at a site are given positions.

Rate for staff

Rate (€) for staff is used to estimate manpower costs.

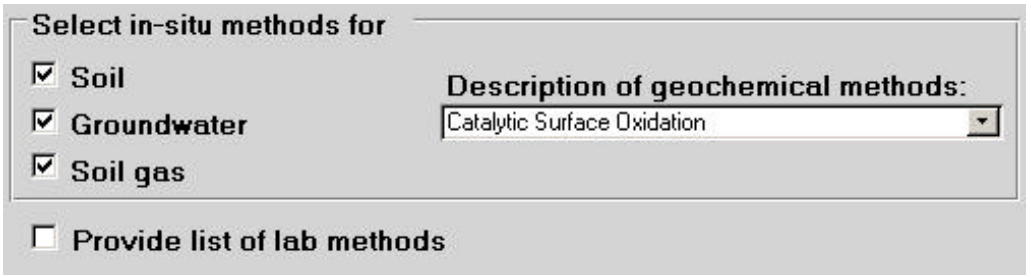
Geochemical site characteristics

This part of the decision support system deals with the geochemical investigation of a site. Input given is used to generate combinations of geochemical methods that are provided in ranking order in the output sheets of the software.



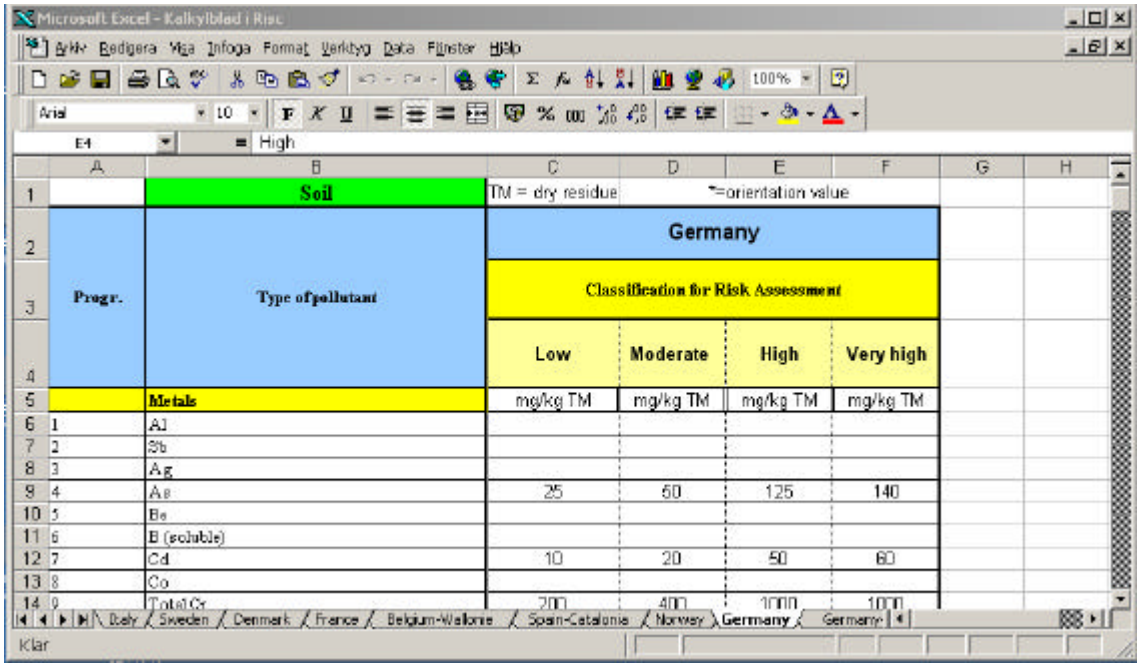
Selection of in-situ methods

Selection of geochemical methods can be made separately for soil, groundwater and soil gas. Methods are usually in-situ methods or portable lab methods. However, ordinary lab methods can also be selected if requested. This could be useful because some contaminants require lab methods exclusively. If requested, each possible geochemical methods can be described in a separate window.



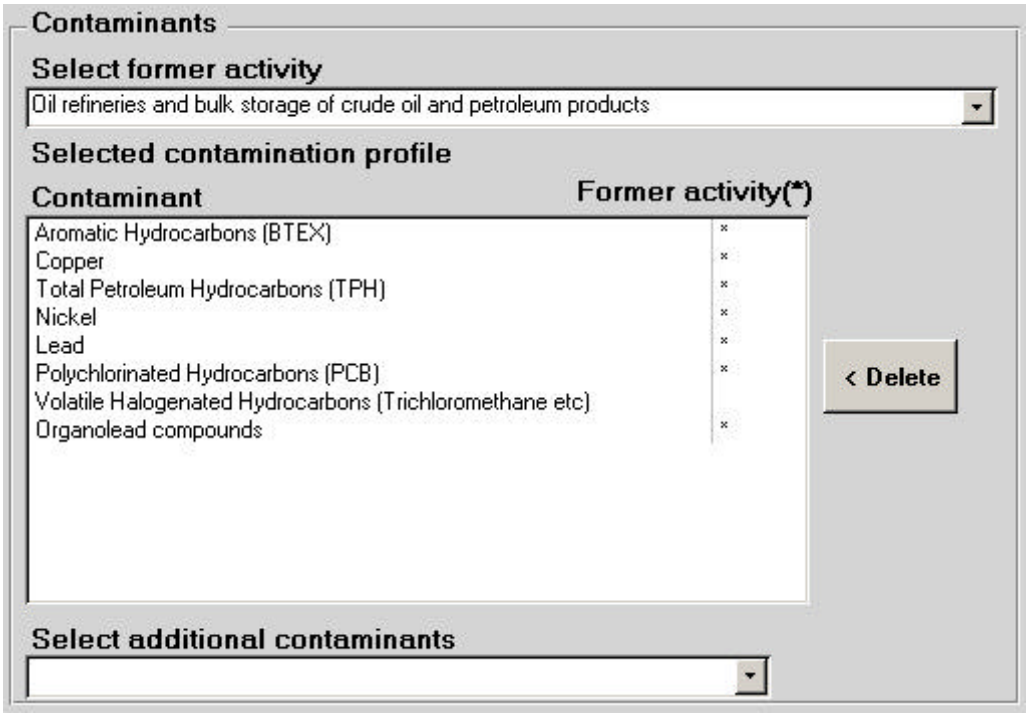
Guideline values

In this section, guideline values for a number of European countries can be viewed in an excel-sheet. Guideline values can be used for a number of applications and may give important support for both the selection of methods and for the decision on risk assessment and remediation. It should be noted that site-specific guideline values are common in some countries (i.e. the provided guideline values may not be used in a strict way). In addition, the definition of guideline values is an on-going process. In some rare cases the values indicated below may already be out-dated.



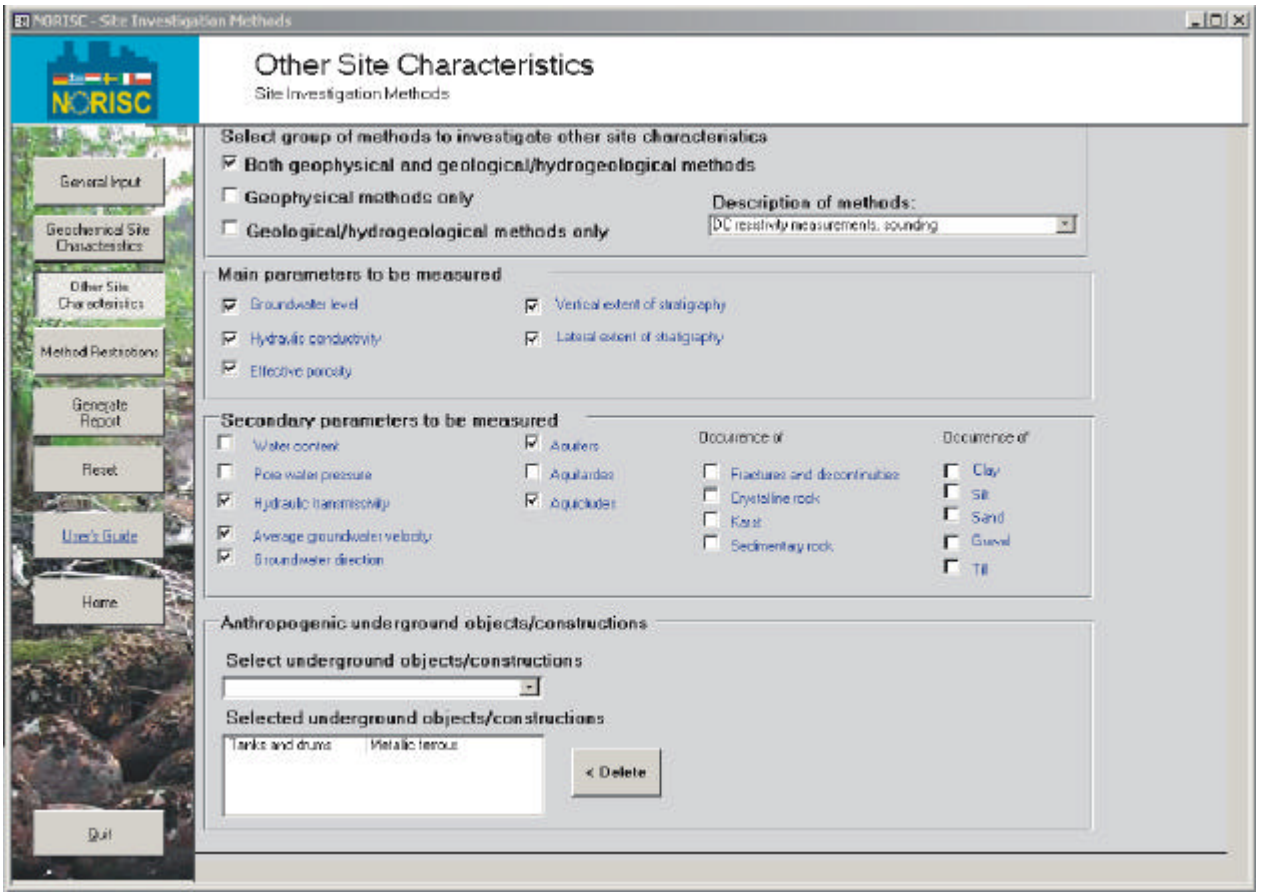
Contaminants

The estimated contamination profile (i.e. the group of suspected contaminants) at a given site can be selected by specifying the former activity. The former activity then defines a certain group of contaminants. After the group of contaminants has been provided, certain contaminants can be withdrawn or added to that group. It is also possible to select individual contaminants without pre-selection of any former activity, which means that the contamination profile is built up manually.



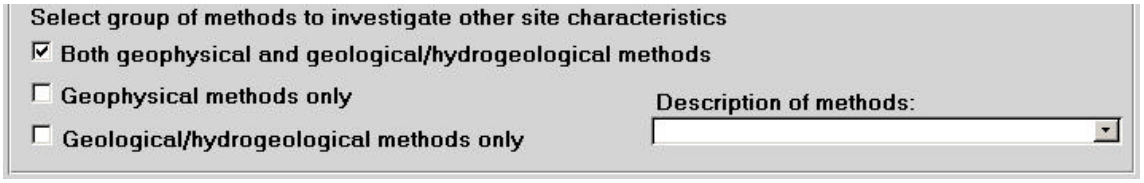
Other site characteristics

The section on other site characteristics deals with characteristics that are not considered as geochemical ones. This means that hydrogeological and geophysical parameters can be selected here. In addition, the opportunity to investigate anthropogenic objects such as pipes and cables, etc. is provided. The selection of site characteristics is used to automatically generate methods for investigating them.



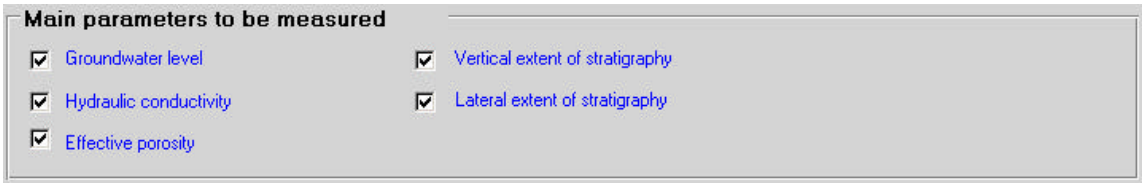
Groups of methods to be used

The selection of requested parameters generates a combination of methods in the output. It is possible to combine geological/hydrogeological investigation methods and geophysical ones or to select only one of the two groups. If requested, each possible geophysical and geological/hydrogeological method can be described in a separate window.



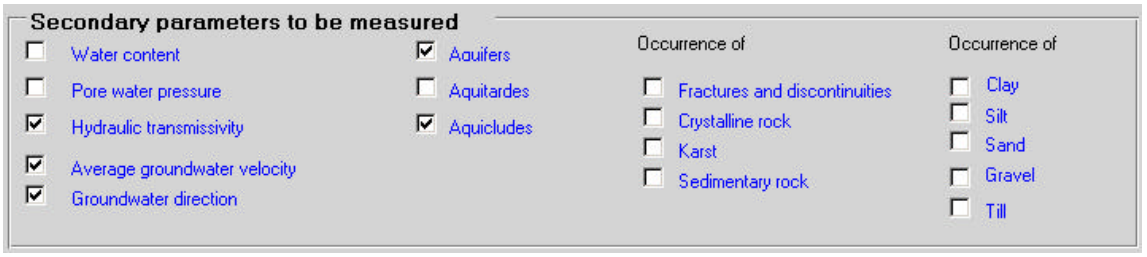
Main parameters

This group of site characteristics considers the most important preconditions for the distribution and spreading of contaminants. If requested, each main parameter can be described in a separate window.



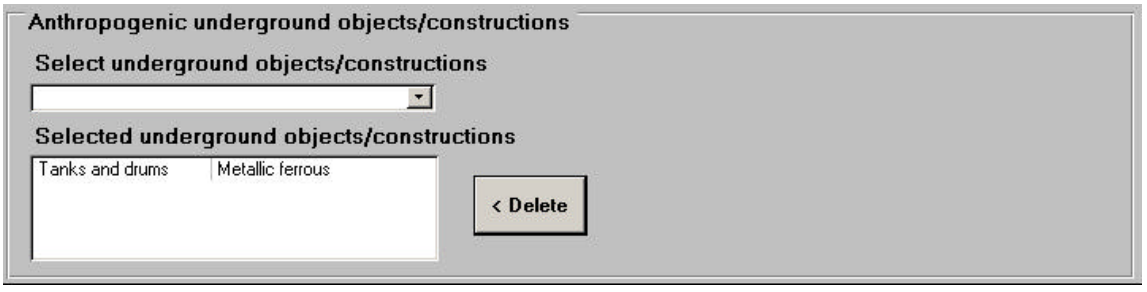
Secondary parameters

This group of site characteristics is considered to be of minor importance when investigating contaminated sites. However, in certain cases, depending on specific requirements, some of these site characteristics could be of interest. The conceptual differences between some of the site characteristics should be noted: Parameters such as “water contents” and “pore water pressure” usually have quantitative data as attributes. Other site characteristics like “till” and “gravel” are supposed to be adopted as qualitative attributes such as “exist” (yes/no) or as some brief information on depth and thickness. If requested, each secondary parameter can be described in a separate window.



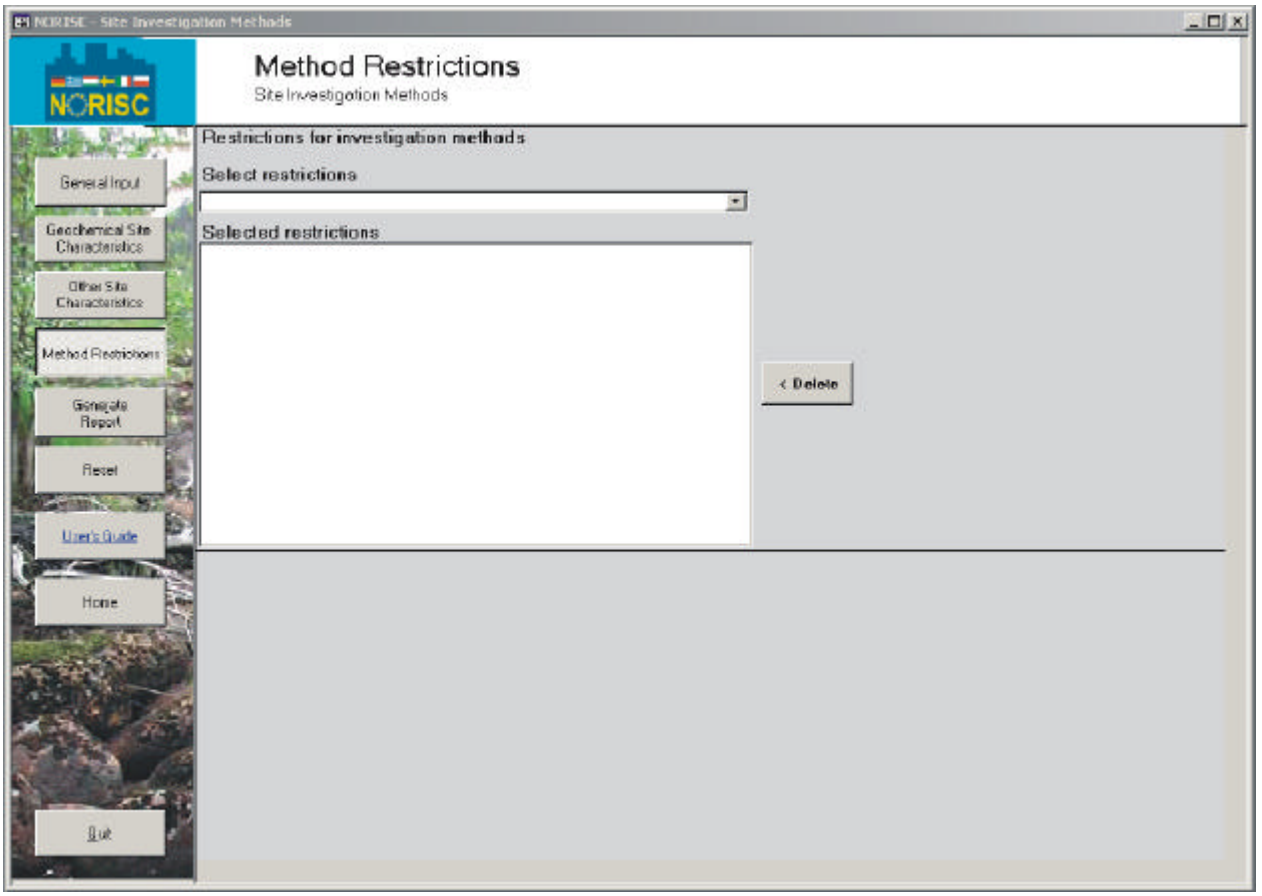
Underground objects

Underground objects can be of both natural and man-made origin. It should be noted that a certain object might request investigation while it could also result in restrictions on the site investigation (next chapter).



Restrictions for site investigations

The selection of methods is influenced by any kind of restrictions. Some geophysical methods will be excluded if restrictions such as electric power lines or railroads are located within the area to be investigated.



Part two: Output from the DSS - Site Investigation Methods

The output of the DSS is given in various excel sheets, divided into chapters. The output should be regarded as guidance for selecting methods to investigate contaminated sites. The names of the chapters in this manual refer to the excel sheets in the output.

Results

This sheet of the DSS output gives a summary of the information available about the most suitable combination of geochemical and non-geochemical methods. The “suitability” for the methods to deal with selected site characteristics is also provided. “Suitability” is given rank A as the first degree of suitability, and rank B as the second degree of suitability. If only one method is suggested it is supposed that this single method will be able to quantify all requested contaminants or site characteristics. If more than one geochemical method is suggested, all the recommended methods in the combination are expected to quantify the selected contaminants. A combination of 1-3 geochemical in-situ methods is provided. If more than one non-geochemical method is suggested, all the recommended methods in the combination are expected to quantify the selected site characteristics. 3 combinations of 1-3 geophysical/hydrogeological/geological methods are provided.

Geochemical laboratory methods are provided in a separate sheet if they were asked for. If geological and geophysical methods were requested a combination of 0 - 3 methods will be provided.

Geochemical methods for soil/groundwater/soil air

Compared to the sheet ”Results” these sheets give more details of the selected geochemical methods for soil, groundwater and soil air. For all possible methods suitability, cost and time are indicated.

Detection limits

Detection limits for all possible geochemical methods are shown here. It should be noted that the detection limit might vary considerably for the same type of equipment and for the same contaminant. This is indicated by the minimum and maximum value for the detection limits.

Other methods

Compared to the sheet ”Results” this sheet gives more detailed descriptions of the selected geological and geophysical methods. For all possible methods suitability, cost and time are given.

Lab methods

All possible laboratory methods for the selected contamination profile are shown.

Selected parameters

All selected data of the input part of the software are shown here.

Surveying and locating

If “Surveying and locating “ was selected in the input section of the DSS, some general information including suggested methods will be shown in this sheet.

Description of site characteristics

All selected site characteristics are presented here, including their description.

Description of geochemical methods

All selected geochemical methods are presented here, including a description for each method.

Description of other methods

All selected geological and geophysical methods are described in this sheet.

Part three: Description of tables and formulas

Tables

The software for providing combinations of methods is based on a database in Access. This database consists of a number of different tables. The most important tables are the following ones:

Guideline values: This group of tables provides guideline values for most European countries and for more or less different purposes. For instance, one purpose could be the definition of guideline values for risk assessment and another purpose could be the definition of threshold values for future land use. This group of tables is used for visualisation and to support the user when selecting methods.

Contamination profiles: This table provides groups of contaminants for a number of activities. The main objective is to make it easier for the user to select possible contaminants. A selected activity in the software gives a certain contamination profile. Deleting and adding contaminants will change a selected contamination profile.

Geochemical methods: This group of tables provides suitability ranks for a number of geochemical methods according to their suitability to deal with contaminants. Another important piece of information concerns the costs involved for each method, detection limits for methods and contaminants and the ability of the methods to be applied in the field or in the laboratory.

Non-geochemical methods: This group of tables handles the suitability of geophysical and hydrogeological/geological methods to deal with various site characteristics. In addition, data on costs for each method are provided.

Restrictions: A table on restrictions is used to exclude selected methods if they are sensitive to a certain restriction. For example, ground penetrating radar that is not suitable if a superficial clay layer exists at a given site.

In some cases the tables described above have the numbers 1, 2, 3, 4 and 6, respectively. This means that table number 5 does not exist. Table number 5 existed in an early version of the software. However, during the software development this table number was removed from the software.

Formulas

Estimation of number of samples

Number of samples in the input section is given by the proportion of a site that is contaminated:

$N = \log(0.05) / \log(1-a)$

Where N = is the number of samples to detect a contamination and a = the proportion of a site that is contaminated ($0 < a < 1$).

Another possibility is to use the area of a site:

$N = \text{Max}(1, 22.5 \times \text{sqrt}(A) - 12.5)$

where the area (A) is given in hectares.

Cost calculations – geochemical methods

When interpreting the formulas for cost calculation of geochemical methods the following notions should be considered

mde_time = Mobilization/demobilization time (minutes)
s_time = Time per sample (minutes)
n_sample = Number of samples
s_cost = Cost per sample (€)
eq_cost = Cost for equipment (€)
nr_person = Number of persons needed for equipment
use_factor = Factor for number of samples needed for the method. If a suggested grid uses 80 samples/nodes a use factor of 0.3 means that $0.3 \times 80=24$ samples is needed
fieldtime = mde_time + n_sample × s_time × use_factor

Cost calculation for one geochemical method is given as a sum of (1) cost for mobilization/demobilization of equipment, (2) sample cost, (3) cost for rental of equipment and (4) cost for people working at the site:

Cost for one geochemical method =
mde_time × cost of staff +
n_sample × use_factor × s_cost +
fieldtime × eq_cost × 0.01 +
nr_person × n_sample × s_time * use_factor × cost of staff

and

Total fieldtime (h) = maximum of individual fieldtimes
Total cost = Sum of individual costs

Cost calculations – hydrogeological/geological/geophysical methods

When interpreting the formulas for cost calculation of non-geochemical methods (i.e. geological/hydrogeological/geophysical methods) the following notions should be considered

mde_time = Mobilization/demobilization time (hours for other methods)
eq_cost = Cost for equipment (€)
nr_person = Persons needed for equipment
interpret = Factor of area_time for interpreting the geophysical data
area_time = Time (h) to investigate 1 ha
fieldtime = mde_time + area_time × area
cost_method = cost for one geological/hydrogeological or geophysical method
cost_depth = cost for one geological/hydrogeological or geophysical method where depth is considered

Cost calculation for one geochemical method is given as a sum of (1) cost for people working at the site (including mobilization/demobilization of equipment), (2) cost for rental of equipment and (3) cost interpretation of data:

cost_method =
fieldtime × nr_person × cost of staff +
eq_cost × 0.01 × fieldtime +
area_time × area × interpret × cost of staff

Most of the geological and hydrogeological methods (e.g. drilling) have been given a depth relation for the cost calculation. This means that the calculated cost for one method according to the formula described above is used as:

cost_depth = cost_method × depth

Total fieldtime (h) = sum of individual fieldtimes
Total cost = Sum of individual costs

Combination approach

The software provides combinations of methods according to the following criteria:

1 – 3 geochemical field methods or portable lab methods will be selected in at least one combination depending on the required site characteristics,

0 – 3 geological / geophysical method will be selected in at least one combination.

In addition possible laboratory methods will be shown although they are not a part in the combination process.

The combination procedure is based on the suitability rank for each method. Suitability is divided into four levels:

A: High level of suitability,
B: Medium level of suitability,
C: Low level of suitability,
D: Not suitable at all.

In this combination approach the combination of methods that results in the highest degree of suitability for a contamination profile or other site characteristics will be placed in first position as the best group of methods. If several groups of methods have the same degree of suitability, the cheapest combination will be regarded as the best combination. Thus, the calculation of costs is very important to provide the best combination of methods.