

NORISC



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

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User’s Guide to the Decision Support System on Site Investigation Methods in NORISC (Appendix 5)

Contents

| | |
|---|----|
| Introduction..... | 3 |
| Part one: Input to the DSS..... | 4 |
| General input..... | 4 |
| <i>General</i> | 4 |
| <i>Main depth interval for investigation</i> | 5 |
| <i>Amount of drillings/samples</i> | 5 |
| <i>Surveying and locating</i> | 6 |
| <i>Rate for staff</i> | 6 |
| Geochemical site characteristics | 6 |
| <i>Selection of in-situ methods</i> | 7 |
| <i>Guideline values</i> | 7 |
| <i>Contaminants</i> | 8 |
| Other site characteristics | 9 |
| <i>Groups of methods to be used</i> | 9 |
| <i>Main parameters</i> | 9 |
| <i>Secondary parameters</i> | 10 |
| <i>Underground objects</i> | 10 |
| Restrictions for site investigations | 10 |
| Part two: Output from the DSS | 12 |
| Results..... | 12 |
| Geochemical methods for soil/groundwater/soil air..... | 12 |
| Detection limit..... | 12 |
| Other methods | 12 |
| Lab methods..... | 13 |
| Selected parameters..... | 13 |
| Surveying and locating..... | 13 |
| Description of site characteristics | 13 |
| Description of geochemical methods | 13 |
| Description of other methods | 13 |
| Part three: Description of tables and formulas | 14 |
| Tables..... | 14 |
| Formulas | 14 |
| <i>Estimation of number of samples</i> | 14 |
| <i>Cost calculations – geochemical methods</i> | 15 |
| <i>Cost calculations – hydrogeological/geological/geophysical methods</i> | 15 |
| <i>Combination approach</i> | 16 |

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 (HRA), remediation and some statistics on data processing. Some of these modules are given in manual form only, while others are executable.

In this document], we concentrate on the decision support system (DSS) about site investigation methods and will describe in manual form how the system is 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 knowledge 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 the DSS. 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.

Part one: Input to the DSS

General input

This window is designed to provide general information on the site. Some information is optional such as general information about the site, 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.

The screenshot shows the 'General input' window of the NORISC software. The window title is 'NORISC - Site Investigation Methods'. The main title is 'General input' and the subtitle is 'Site Investigation Methods'. On the left side, there is a vertical menu with buttons for 'General Input', 'Geochemical site characteristics', 'Other site characteristics', 'Method restrictions', 'Run', 'Reset', 'User's guide', and 'Home'. The main area contains the following fields and options:

- General**
 - Project name: Project Manager:
 - Site name: Site location:
 - Area of site (required): ha
 - Select main depth interval for investigation:
 - 0-0.5 m
 - 0.5-5 m
 - 5-20 m
 - >20 m
 - Estimate amount of drillings/sampling
 - Do you want to calculate the number of samples manually?
 - Do you want the DSS to estimate the number of samples?
 - Estimation based on proportion (%) of site which is contaminated
 - Estimation based on area of site
 - Give number of soil samples per borehole/sampling points:
 - Total number of samples requested:

| | | |
|---------------------------------|--------------------------------|--------------------------------|
| Soil | Groundwater | Soil gas |
| <input type="text" value="50"/> | <input type="text" value="5"/> | <input type="text" value="5"/> |
 - Surveying and locating
 - Surveying of the site for investigation needs to be done?
 - Locating of certain objects above/below the surface on the site is needed?
 - Rate for staff
 - Hourly rate for staff (for cost calculations): €

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.

The close-up screenshot shows the 'General' section of the software interface. It contains the following fields and options:

- Project name: Project Manager:
- Site name: Site location (X,Y):
- Area of site(required): ha
- Do you want risk assessment?

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).

| Select main depth interval for investigation | |
|--|---------|
| <input type="checkbox"/> | 0-0.5 m |
| <input type="checkbox"/> | 0.5-5 m |
| <input checked="" type="checkbox"/> | 5-20 m |
| <input type="checkbox"/> | >20 m |

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.

| Estimate amount of drillings/sampling | | | |
|---------------------------------------|--|---------------------------------|---------------------------------|
| <input checked="" type="checkbox"/> | Do you want to calculate the number of samples manually? | Soil | Groundwater |
| | Give number of boreholes/sampling points: | <input type="text"/> | <input type="text"/> |
| | Give number of samples per borehole/sampling point: | <input type="text" value="5"/> | <input type="text" value="10"/> |
| <input type="checkbox"/> | Do you want the DSS to estimate the number of samples? | Soil gas | <input type="text" value="10"/> |
| | | Soil | Groundwater |
| Total number of samples requested: | | <input type="text" value="50"/> | <input type="text" value="5"/> |

| Estimate amount of drillings/sampling | | | |
|---------------------------------------|--|---------------------------------|--------------------------------|
| <input type="checkbox"/> | Do you want to calculate the number of samples manually? | | |
| <input checked="" type="checkbox"/> | Do you want the DSS to estimate the number of samples? | | |
| <input checked="" type="checkbox"/> | Estimation based on proportion (%) of site which is contaminated | | |
| | Give proportion (%) of site which is contaminated: | <input type="text" value="50"/> | |
| | Give number of soil samples per borehole/sampling point: | <input type="text" value="5"/> | |
| <input type="checkbox"/> | Estimation based on area of site | | |
| | | Soil | Groundwater |
| Total number of samples requested: | | <input type="text" value="22"/> | <input type="text" value="2"/> |

Estimate amount of drillings/sampling

Do you want to calculate the number of samples manually?

Do you want the DSS to estimate the number of samples?

Estimation based on proportion [%] of site which is contaminated

Estimation based on area of site

Give number of soil samples per borehole/sampling points:

| | | | |
|------------------------------------|---------------------------------|--------------------------------|--------------------------------|
| Total number of samples requested: | Soil | Groundwater | Soil gas |
| | <input type="text" value="50"/> | <input type="text" value="5"/> | <input type="text" value="5"/> |

Surveying and locating

Suggestion: 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.

Surveying and locating

Surveying of the site for investigation need to be done?

Locating of certain objects above/below surface on the site is needed?

Rate for staff

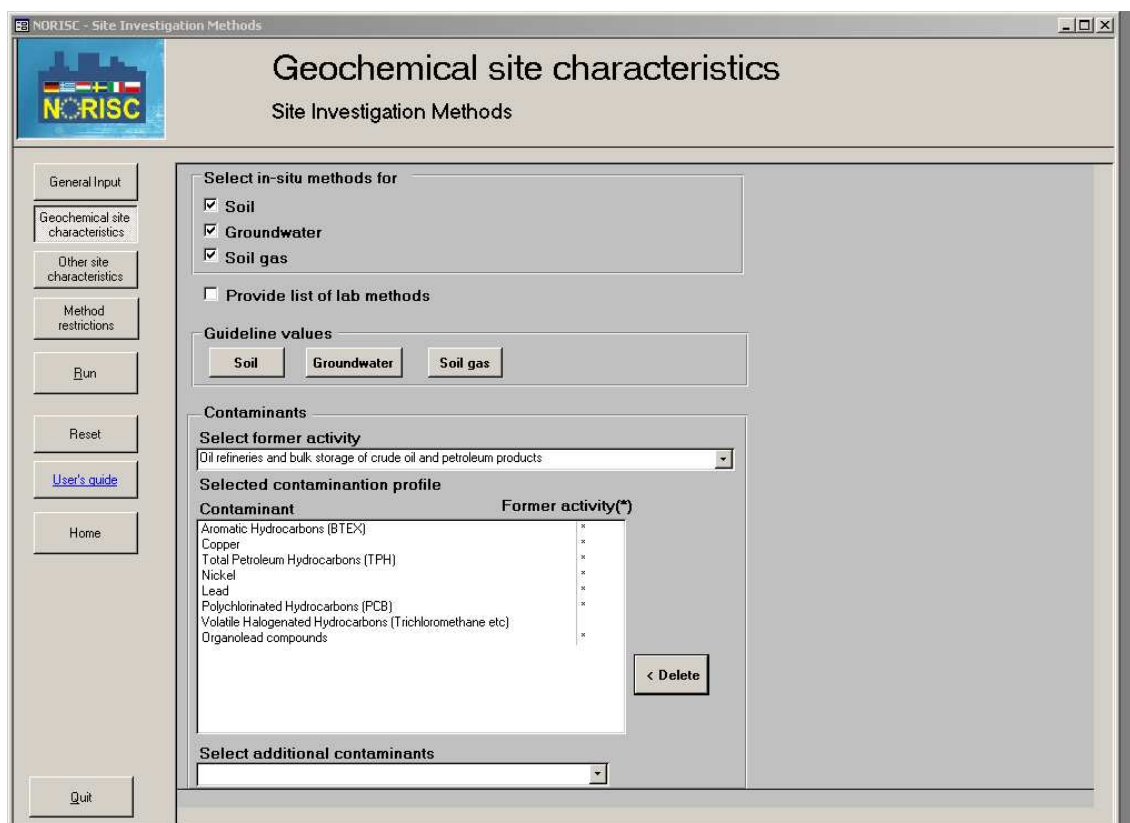
Rate (€) for staff is used to estimate manpower costs.

Rate for staff

Hourly rate for staff(for cost calculations) €

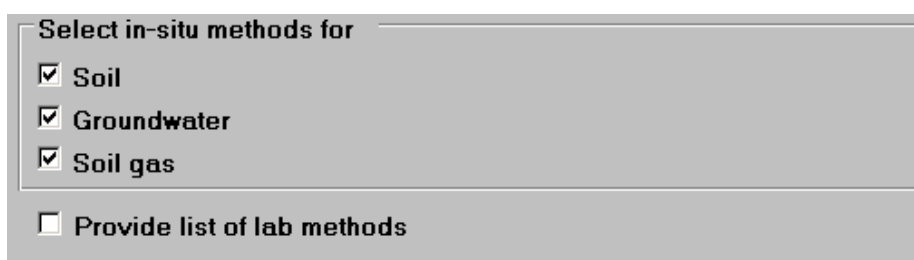
Geochemical site characteristics

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.



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

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values is an on-going process. In some rare cases the values indicated below may already be out-dated.

Guideline values

Soil Groundwater Soil gas

Microsoft Excel - Kalkylblad i Risc

Arkiv Redigera Visa Infoga Format Verktyg Data Fönster Hjälp

Arial 10

| E4 | | = High | | | | | | |
|----|--------|-------------------|------------------------------------|---------------------|----------|-----------|---|---|
| 1 | A | B | C | D | E | F | G | H |
| | | Soil | TM = dry residue | *=orientation value | | | | |
| 2 | | | Germany | | | | | |
| 3 | Progr. | Type of pollutant | Classification for Risk Assessment | | | | | |
| 4 | | | Low | Moderate | High | Very high | | |
| 5 | | Metals | mg/kg TM | mg/kg TM | mg/kg TM | mg/kg TM | | |
| 6 | 1 | Al | | | | | | |
| 7 | 2 | Sb | | | | | | |
| 8 | 3 | Ag | | | | | | |
| 9 | 4 | As | 25 | 50 | 125 | 140 | | |
| 10 | 5 | Be | | | | | | |
| 11 | 6 | B (soluble) | | | | | | |
| 12 | 7 | Cd | 10 | 20 | 50 | 60 | | |
| 13 | 8 | Co | | | | | | |
| 14 | 9 | Total Cr | 200 | 400 | 1000 | 1000 | | |

Italy Sweden Denmark France Belgium-Wallonie Spain-Catalonia Norway Germany

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.

Contaminants

Select former activity
Oil refineries and bulk storage of crude oil and petroleum products

Selected contamination profile

| Contaminant | Former activity(*) |
|--|--------------------|
| Aromatic Hydrocarbons (BTEX) | * |
| Copper | * |
| Total Petroleum Hydrocarbons (TPH) | * |
| Nickel | * |
| Lead | * |
| Polychlorinated Hydrocarbons (PCB) | * |
| Volatile Halogenated Hydrocarbons (Trichloromethane etc) | * |
| Organolead compounds | * |

< Delete

Select additional contaminants

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 man-made 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.

Main parameters

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This group of site characteristics considers the most important preconditions for the distribution and spreading of contaminants.

| Main parameters to be measured | |
|--|---|
| <input checked="" type="checkbox"/> Groundwater level | <input checked="" type="checkbox"/> Vertical extent of stratigraphy |
| <input checked="" type="checkbox"/> Hydraulic conductivity | <input checked="" type="checkbox"/> Lateral extent of stratigraphy |
| <input checked="" type="checkbox"/> Effective porosity | |

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 values 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.

| Secondary parameters to be measured | | | |
|--|--|--|---------------------------------|
| <input type="checkbox"/> Water content | <input checked="" type="checkbox"/> Aquifers | Occurrence of | Occurrence of |
| <input type="checkbox"/> Pore water pressure | <input type="checkbox"/> Aquitardes | <input type="checkbox"/> Fractures and discontinuities | <input type="checkbox"/> Clay |
| <input checked="" type="checkbox"/> Hydraulic transmissivity | <input checked="" type="checkbox"/> Aquicludes | <input type="checkbox"/> Crystalline rock | <input type="checkbox"/> Silt |
| <input checked="" type="checkbox"/> Average groundwater velocity | | <input type="checkbox"/> Karst | <input type="checkbox"/> Sand |
| <input checked="" type="checkbox"/> Groundwater direction | | <input type="checkbox"/> Sedimentary rock | <input type="checkbox"/> Gravel |
| | | | <input type="checkbox"/> Till |

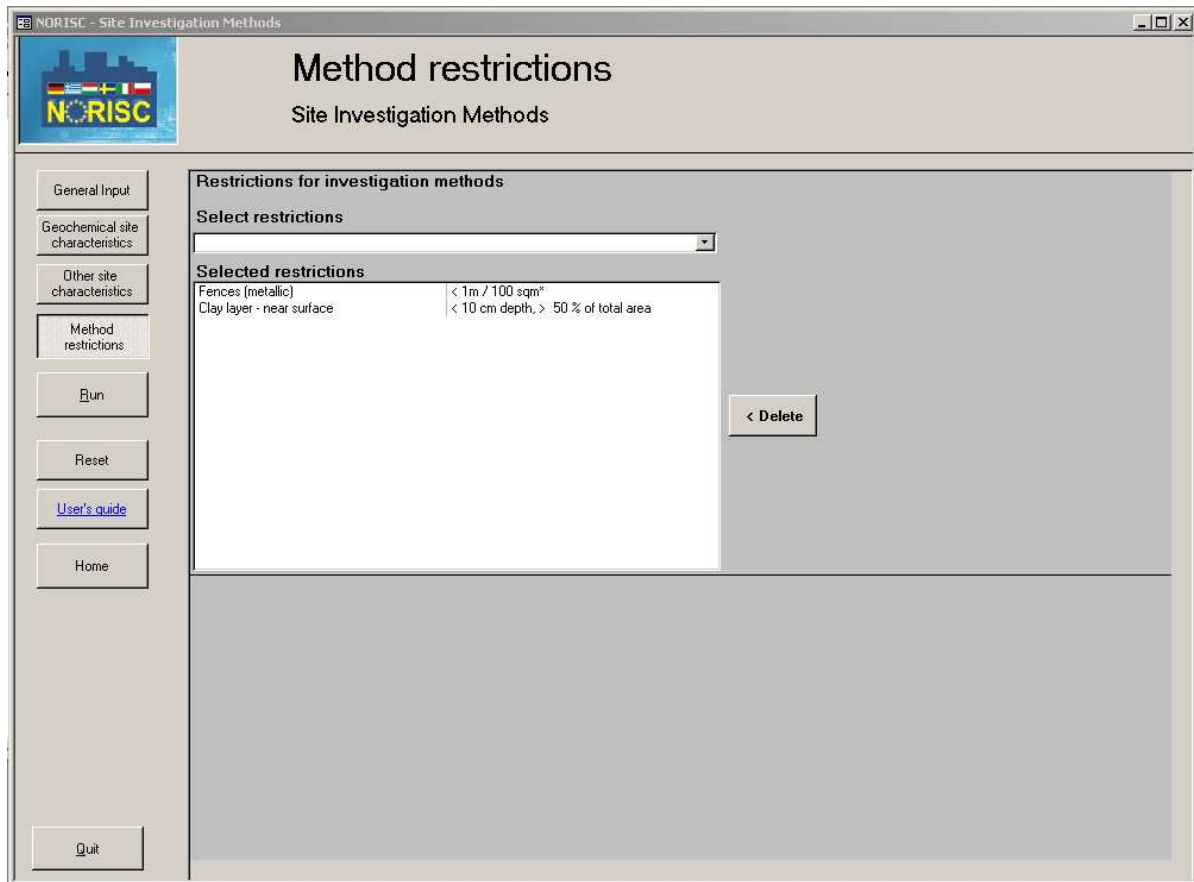
Underground objects

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).

| Anthropogenic underground objects/constructions | |
|---|------------------|
| Select underground objects/constructions | |
| <input type="text"/> | |
| Selected underground objects/constructions | |
| Tanks and drums | Metallic ferrous |
| <input type="button" value=" < Delete"/> | |

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

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 limit

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. However, 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.

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 = $mde_time + n_sample \times s_time \times use_factor$

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 =
 $mde_time \times \text{cost of staff} +$
 $n_sample \times use_factor \times s_cost +$
 $fieldtime \times eq_cost \times 0.01 +$
 $nr_person \times n_sample \times s_time * use_factor \times \text{cost of staff}$

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 = $mde_time + area_time \times area$
 cost_method = cost for one geological/hydrogeological or geophysical method

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$cost_depth$ = 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:

$cost_method =$
 $fieldtime \times nr_person \times cost\ of\ staff +$
 $eq_cost \times 0.01 \times fieldtime +$
 $area_time \times area \times interpret \times cost\ of\ staff$

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:

$cost_depth = cost_method \times depth$

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.