URBAN SMS Soil Management Strategy

Technical concept "Soil indicator" Stuttgart – application concept for the URBAN SMS tool “Loss of Soil Resource”

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REPORT

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1 INTRODUCTION

The document in hands is part of INTERREG IV B project URBAN SMS, work package 4 "Soil Manager Suite". It is an internal working document describing the further development of the soil protection concept Stuttgart (BOKS) and to basically lay out the concept idea to transnational partners. In particular it is a basis for the development of the URBAN SMS-TOOL „Loss of Soil Resource" which is a GIS-tool to calculate the loss (or gain) of soil quality in case of land use change.
Land use change causes usually a significant loss of nature and landscape so it is necessary to quantify the value of different environmental compartments and also their losses. The protection of soil is often not sufficiently considered.
In Stuttgart is with the already established soil protection concept (BOKS) a method for assessing soil quality available. This method is suitable as a bases for a GIS-supported, automated "soil indicator".
This report includes the analysis of the existing approach in Stuttgart and the demands on the development.

2 BRIEF DESCRIPTION OF THE SOIL PROTECTION CONCEPT OF THE CITY OF STUTTGART (BOKS)

It is necessary to provide information in a simple and transparent manner about soil condition and soil quality for the sustainable and efficient utilisation of soil resources. The loss in soil quality must be presented to political decision carriers, professional planners and the interested public in a suitable form that does not presuppose any soil expertise.

Map of soil quality as a decision-making basis

The soil protection concept of the city of Stuttgart (BOKS) enables transparent management of the resource soil (cf. WOLFF2007), by making available a "map of soil quality" covering the city area of Stuttgart. The efficiency of the soil is evaluated in this soil quality map using a six point scale from 5 (= very high) to 0 (= absent) (cf. Fig. 1).

The basis for the evaluation of soil quality is the city soil mapping (HOLLAND 1995). As a basis for the soil properties, the **natural soil functions** were determined as per BBodSchG (German soil protection law):

- Sites for natural vegetation and cultivated plants
- Compensating elements in water circulation

- Filters and buffers for pollutants

and also the function of soil as an **archive of natural and cultural history**.

The four soil functions were aggregated into an overall map with the help of a summary evaluation, this map shows the potential of the soils worthy of protection (re: methodology, cf. CITY OF STUTTGART 2006). The function of soils as a habitat of rare flora and fauna is not evaluated in BOKS.

The following **anthropogenic influences** are taken into account in the evaluation of the soil quality, in addition to the summary evaluation of the soil functions:

- **Sealing** (differentiated into six sealing grades, evaluation on basis of sealing grade)
  Data specifications: Sealing map from 2007, made available by the city of Stuttgart Civil Engineering Office).

- **Contaminated sites** and other harmful soil changes (e.g. abandoned sites, abandoned landfills, industrial sites, accidents and deposition areas), evaluation max. 1 soil quality point. Contaminated sites with particular need for action, evaluation max. 0 soil quality points.
  Data specifications: Large-scale available information system regarding contaminated sites (ISAS) from 2009, made available by the city of Stuttgart Environmental Office).

- **Landfills** (removed from the register of contaminated areas) and **areas with disposal-relevant soils**, evaluation max. 2 soil quality points
  Data specifications: Large-scale available register of soils from 2009, made available by the city of Stuttgart Environmental Office).

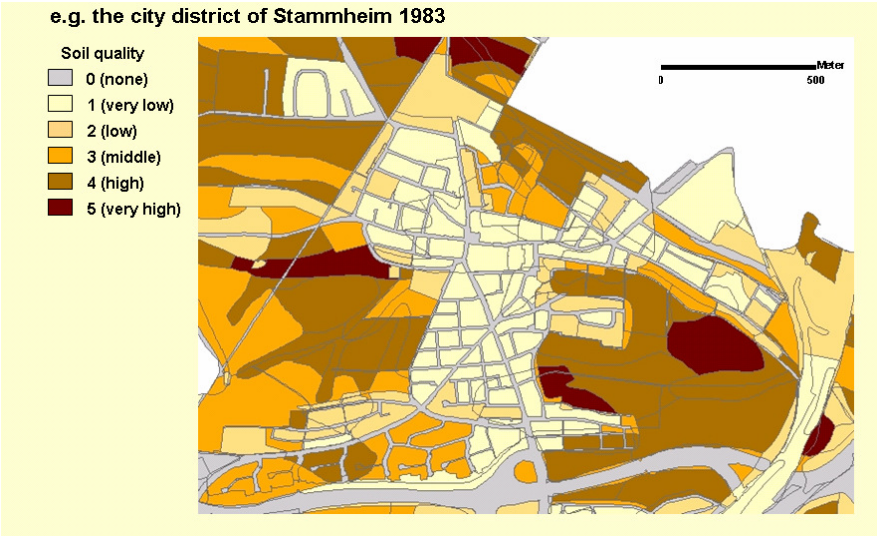

Figure 1: Map of soil quality, example based on Stuttgart-Stammheim

The **results map for "soil quality"** offers in this respect advantages to decision-makers and the public sector:

- Status determination: The quality and spatial distribution are displayed transparently.
- Monitoring: The soil consumption in volume (area) and quality (soil quality) can be measured and balanced with the "soil indication" (cf. Fig. 2).
- Decision support: The room for manoeuvre in planning sustainable management can be determined.

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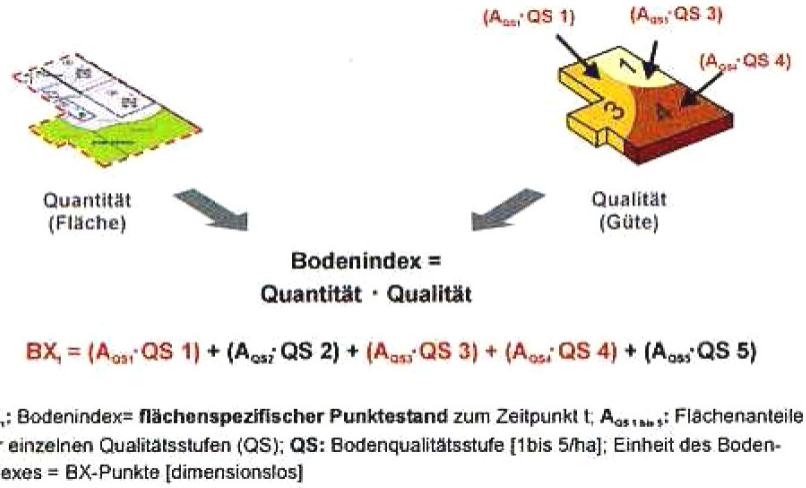


BX$_t$: Bodenindex= **flächenspezifischer Punktestand** zum Zeitpunkt t; **A$_{QS\ 1\ bis\ 5}$:** Flächenanteile der einzelnen Qualitätsstufen (QS); **QS:** Bodenqualitätsstufe [1bis 5/ha]; Einheit des Bodenindexes = BX-Punkte [dimensionslos]

Figure 2: Soil index points in the Stuttgart soil protection concept

3 AIMS AND BENEFITS OF THE SOIL INDICATOR

The soil indicator as an instrument for soil monitoring

Manual analysis of data has so far been necessary in order to use the advantages of the soil quality map and determine the soil encroachment qualitatively and quantitatively using the soil index points (area x soil quality) with the help of soil indication (cf. Fig. 2). Based on this, automated data analysis using a suitable software application would be useful. The existing information about soil quality in Stuttgart should be made useful in a simple manner by means of a "soil indicator", a GIS-supported analysis calculater. The functionalities of the soil indicator are described in Chapter 2.

The aim is to develop acceptance for soil protection measures and an awareness of the consequences of soil encroachment through the transparent provision of data.

The concept can be transferred to other communities (knowledge transfer into other areas). Implementation will be based on existing maps or maps still to be developed. The analysis is made possible by the combination (intersection) of individual area information and their effects on the overall sector with regards to planned utilisation and is flexibly applicable ("modular system").

Benefits of the soil indication tool

The soil indicator will facilitate work in community environmental offices and increase their efficiency. It enables the depiction of distributed data pools in a map for the processing of questions regarding soil and water protection. The emphasis here is on large-scale soil information. The system can be expanded if necessary.

4 REQUIREMENT ANALYSIS

4.1 Query 1: Report function: Analysis calculater regarding soil quality for planning areas

Function description

The soil indicator will help in generating automated reports for areas under planning (e.g. planned change of use in FNP). The information enables a forecast of which soils will be affected or destroyed. The aim of this forecasting tool is decision support regarding in which area a new building area should be planned. Ideally, planners and political decision carriers would then decide to use areas with lower soil quality.

The user can mark a specific area (drawing options - mark) or select an area to obtain information in the form of layout reports based on the integrated maps and data (e.g. regarding soil quality). A summary report can be generated via the query for more area information in which, e.g. the area percentage of the queried information can be set out.

The output is implemented through the analysis of master data from the soil quality map in the form of texts and maps, as well as area data regarding the soil quality in the planning area that would be affected by the building or sealing. The report function is proposed as an extension of ArcGIS 9.3.

Data specifications

The following data specifications are necessary for the analysis:

- The map of soil quality is available as an area shape file (planungskarte.shp) and contains the master data which can be queried as described below (cf. Chapter 4.2).

- The planning area is available for queries either in digital format as a polygon (area shape) or made available by the planning office as a polygon or is generated from scratch via the standard drawing function in ArcGIS (cf. Chapter 4.2).

Information provision / planned reports

The following information from the soil quality map should be made available in a layout summary report (cf. Fig. 3):

- Data about the ACTUAL status of the area with the following information:

    - Data on soil quality (soil index points before implementation of planning in ACTUAL status) and the area concerned (in m^2).

    - Data on sealing grade of area in ACTUAL status.

    - Data on whether contaminated sites or harmful soil changes are present.

    - Data on whether an archive of cultural or natural history is present.

- Soil sub-functions (PR, WK, PFGES, ARCHIV) should also be listed in the report. It must be ensured, during output, that the sub-functions are shown with the original analysis, i.e. that they are listed with their potential function performance, without intersection with contaminated sites and sealings.

Various end uses (e.g. building, sealing, garden use, etc.) can be listed in the planning shape (no homogeneous planning areas). The soil quality points should be listed separately according to use (and therefore corresponding sealing grade) in the output report.

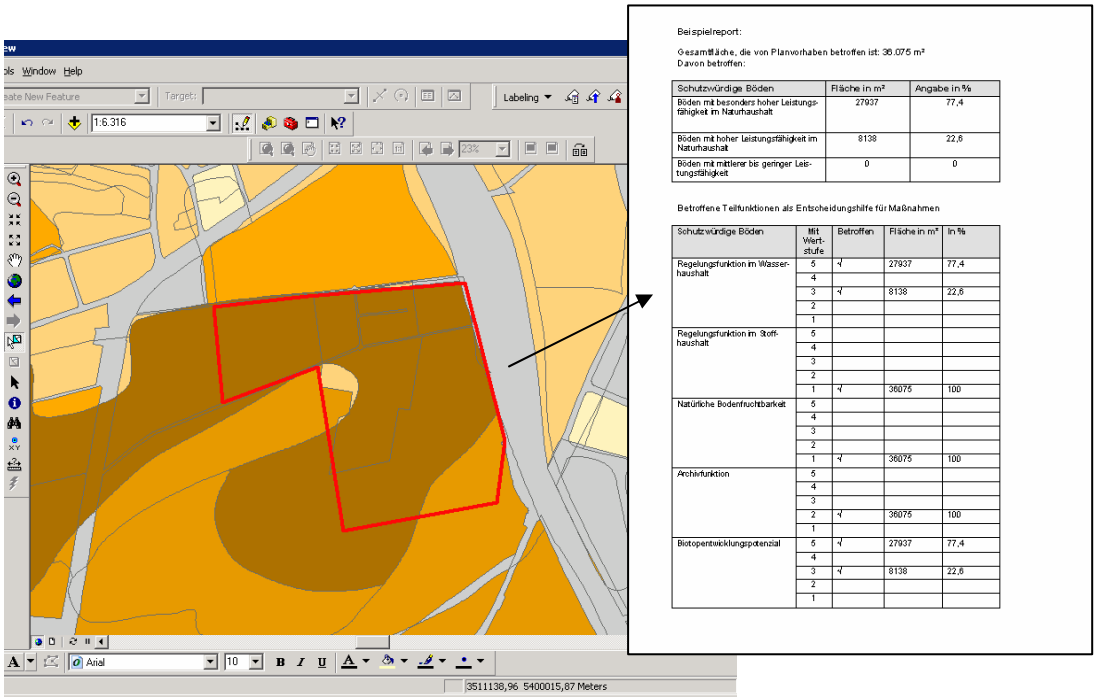
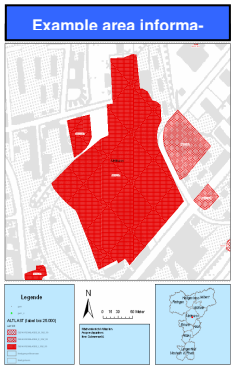


Figure 3: Creating reports

Output formats and report layouts

The information is output as a report in the form of text and tables.

In addition, the reports will be supplemented by an automatically generated map section. This map section contains the outline of the planning area and the soil quality points before implementation of the planning, together with the contents described above.



Benefits

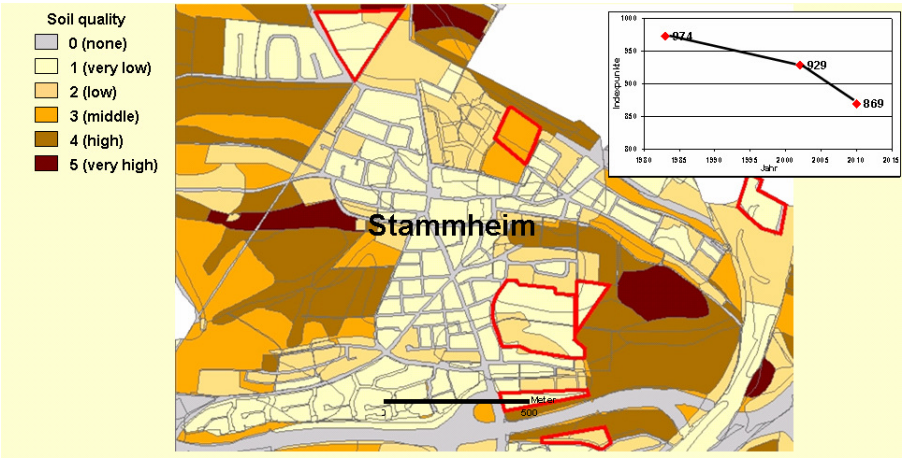
The data are suitable for rapid, dutiful assessment of the actual quality conditions of soils in the area of selected regions (e.g. with regards to development schemes, SEA, basis of opinions for FNP and environmental reports, etc. The interpretation is also suitable for effective evaluation of alternative areas in order to direct building to inner-city or previously used areas with low soil quality.

4.2 Query 2: Soil indication / prognosis tool for defined planning to describe consequences

Function description: Query function

The soil indicator should implement an automatic balancing or soil indication with which the change in soil index points for the city area of Stuttgart due to soil encroachment can be queried.

Information can be queried from the soil quality map with the help of the soil indication. The changes in soil quality caused by the changed utilisation is shown on a planning area (e.g. building, sealing, etc.). The changes (loss or gain) in the soil quality leads to a change in the soil index points (BX) determined for Stuttgart (cf. Fig. 4). Output is implemented following the analysis of master data in the form of texts and diagrams. The report function is proposed as an extension of ArcGIS 9.3.



.Figure 4: Trend statement using soil index points

Data specifications

The following data specifications are necessary for evaluation:

- The map of soil quality is available as an area shape file (planungskarte.shp) and contains the master data with which the balancing is implemented (cf. Chapter 4.2).
- The planning area is available for queries either in digital format as a polygon (area shape) or made available by the planning office as a polygon or is generated from scratch via the standard drawing function in ArcGIS (cf. Chapter 4.2). The planning area must include the final planning specifications for the query and be translated into the categories required for interpretation (cf. Chapter 4.2.).

Information provision / planned reports

The following information from the soil quality map should be made available in the report:

- Data on soil quality in planning area after utilisation change e.g. building, sealing, i.e. soil index points for the planning area after implementation of plans (TARGET status); determined from the planning area with different new sealing grade x soil quality in various classifications).
- Summarised evaluation of intervention (difference in planning area), i.e. data on how many soil index points will be lost due to the planning/utilisation change.
- Data on new overall index points for the city area of Stuttgart following change of use in the planning area.
- If the planning area contains various uses, grading is required based on the sealing grade classification. → Definition of requirements for the query polygon (cf. Chapter 4.2).

Output formats and report layouts

The information is output as a report in the form of text, tables and diagrams.

- Text with standard wording where the actual soil index points can be entered.
- Table with data for comparison.
- Diagram in which changes over a defined period of time can be displayed. These could be columns (grouped or stacked), bars (grouped or stacked) and pie diagrams (probable specification of one layout style).
- Saving of all layout and positioning parameters in a configuration file.

Benefits

The query function enables the depiction of changes in soil status either through definite planning decisions or within specified planning periods, e.g. output of annual changes in soil quality. As these changes enable a direct comparison with targets set by the city of Stuttgart, the system offers a significant basis for political decisions regarding urbanisation.

Questions (to be clarified)

In what form should data about planning building be made available from the urban planning office? What information is standard, which technical requirements should the information fulfill (file format, e.g. geo data, shape files, pdf printouts, etc. and data format, e.g. ATKIS, etc.)?

What additional outlay is incurred by evaluation of soil index points over a certain period of time?

4.3 Intersection: Soil indication / updating of soil quality map

Expansion: Updating the soil quality map

The soil quality map can be updated with the help of the soil indication. The information from the soil quality map is thereby combined (intersected) with the information about the planning area. The output is implemented by changes (write authorisations) to master data in the planning map of soil quality. I.e. this soil quality map is changed by this function without the possibility of reversing this process to restore the original status. This function is required when the B-plan is confirmed in a specific format by a statute resolution.

Alternatively, it is technically possible to save various planning states in a database with versioned geometry configurations. This function permits reversal of versions but is very complicated in implementation.

Data specifications

The following data specifications are necessary for evaluation:

- The map of soil quality is available as an area shape file (planungskarte.shp) and contains the master data with which the balancing is implemented (cf. Chapter 4.2).

- The planning area is available for queries either in digital format as a polygon (area shape) or made available by the planning office as a polygon or is generated from scratch via the standard drawing function in ArcGIS (cf. Chapter 4.2). The planning area must include the final planning specifications for the update and be translated into the categories required for interpretation (cf. Chapter 4.2.).

Output format

The soil quality planning map is changed by the intersection. A report is not output.

The export of geometry data (shapes), e.g. soil quality map for SIAS is possible via the normal ArcGIS function. There is therefore no need for modification.

Benefits

The intersection function enables the updating of the soil quality planning map.

5 TECHNICAL FRAMEWORK CONDITIONS

5.1 General requirements

The soil indicator for the city of Stuttgart is planned as a desktop application for ArcGIS 9.3.

Users will be employees of the city of Stuttgart environmental office. They have access to ArcGIS 9.3 (approx. 6 workstations). The project data (e.g. shapes) are stored on a central network accessible from each workstation. In order to avoid access infringements, the write authorisations must be agreed with the city of Stuttgart and implemented accordingly.

The target group for the information and reports evaluated by the Environmental Office comprises political decision carriers, community and specialist authorities, city and landscape planners and members of the public interested/involved in environmental issues.

The export of shapes for SIAS is implemented via the standard functions ArcGIS.

5.2 Data specifications and formats

Description of soil quality map

The soil quality map data are available as shape files (Planungskarte.shp). All relevant information is contained in the attribute table (cf. Fig. 5).

Attributes of planungskarte

FID	Shape *	FLAECHE	UMFANG	BAUBL_NR	VERKLASS	ALTLASTEN	SIGS	ARCHIV	GB	PR	FPAHO	FPORG	FPGES	WK	MULTIPLIK	QSV1	QSV	QSMAX	QSVA	QSVAA
0	Polygon	30,76	119,02		1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
1	Polygon	8950,67	443,44	441202	1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
2	Polygon	7866,69	451,11	441202	1	Altablagerungen und Altstandorte	24		4	4	5	3	4	4	1	4	4	1	1	1
3	Polygon	7,07	46,82		1	Altablagerungen und Altstandorte	24		4	4	5	3	4	4	1	4	4	1	1	1
4	Polygon	3,58	15,89		1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
5	Polygon	81066,78	2850,6	441202	1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
6	Polygon	187,37	225,74		0	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
7	Polygon	200,89	141,5		0	keine	95		2	2	4	1	3	2	1	2	2	2	2	2
8	Polygon	71424,1	1698,67	441202	1	keine	95		2	2	4	1	3	2	1	2	2	2	2	2
9	Polygon	182,01	168,06		0	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
10	Polygon	19717,82	633,69	441202	1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
11	Polygon	80,59	63,48		0	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
12	Polygon	247606,64	2896,68	441202	1	Altablagerungen und Altstandorte	55		4	4	5	3	4	3	1	4	4	1	1	1
13	Polygon	178,95	122,23		0	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
14	Polygon	17587,42	928,93	441202	1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
15	Polygon	388,63	181,95		1	keine	95		2	2	4	1	3	2	1	2	2	2	2	2
16	Polygon	14,7	37,58		1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
17	Polygon	10915,52	552,23	441202	1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
18	Polygon	2094,25	860,78		1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
19	Polygon	3949,81	331,92	441202	1	Altablagerungen und Altstandorte	2		3	3	4	2	3	2	1	3	3	1	1	1
20	Polygon	165478,84	4756,56	441202	1	keine	35		4	4	5	3	4	4	1	4	4	4	4	4
21	Polygon	20026,61	1368,64	441202	1	keine	2		3	3	4	2	3	2	1	3	3	3	3	3
22	Polygon	33,5	27,26		1	keine	35		4	4	5	3	4	4	1	4	4	4	4	4
23	Polygon	23394,29	1055,19	441202	1	Altablagerungen und Altstandorte	24		4	4	5	3	4	4	1	4	4	1	1	1
24	Polygon	14,28	25,05		1	keine	35		4	4	5	3	4	4	1	4	4	4	4	4
25	Polygon	1767,92	171,5	441202	1	Altablagerungen und Altstandorte	35		4	4	5	3	4	4	1	4	4	1	1	1
26	Polygon	80697,39	1809,7	441202	1	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
27	Polygon	3187,52	598,54	441202	1	Altablagerungen und Altstandorte	2		3	3	4	2	3	2	1	3	3	1	1	1
28	Polygon	133776,62	2793,31	441202	1	keine	4		5	5	5	3	4	5	1	5	5	5	5	5
29	Polygon	2661,58	443,58		1	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
30	Polygon	145457,4	1758,12	642105	1	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
31	Polygon	24,99	37,63		0	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
32	Polygon	54122,13	1404,26	441202	1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
33	Polygon	25073,94	605,09	441202	1	keine	24		4	4	5	3	4	4	1	4	4	4	4	4
34	Polygon	2661,24	447,43	441202	1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
35	Polygon	5280,29	653,84	441202	1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
36	Polygon	101080,63	1465,55	642108	1	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
37	Polygon	3625,05	684,71		0	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
38	Polygon	497,12	231,27		1	keine	55		4	4	5	3	4	3	1	4	4	4	4	4
39	Polygon	5984,23	1483,6		6	keine	4		5	5	5	3	4	5	0	0	0	0	0	0
40	Polygon	978,56	282,57		6	keine	35		4	4	5	3	4	4	0	0	0	0	0	0
41	Polygon	48331,47	1462,59	441203	1	keine	4		5	5	5	3	4	5	1	5	5	5	5	5
42	Polygon	4359,58	513,58		1	keine	21	Archiv	5	5	5	3	4	4	1	5	5	5	5	5
43	Polygon	24677,68	832,26	441203	1	keine	35		4	4	5	3	4	4	1	4	4	4	4	4
44	Polygon	15707,24	725,27	441202	1	keine	51		3	4	5	3	4	2	1	3	3	3	3	3

Record: 1 Show: All Selected Records (0 out of 30565 Selected) Options

.Figure 5: Attribute table of shape files (Planungskarte.shp) 2006

The summarised evaluation of potential soil quality (potential of natural soil functions without anthropogenic influences) is listed in the table column "BODFUNK". The actual soil quality “QS_GES” (former “QSVAA”) is determined from this in accordance with the functional relationships shown in Table 1.

Table 1: Functional relationships for determination of soil quality as per BOKS

Source	Column labels	Description	Functional relationships
Soil mapped as per Holland 1995 (Bod_funk.shp)	AREA	Area size of polygon in m^2	Relevance for calculation of soil index points (BX)
	PERIME-TER	Scope of polygon in m	
	BODEN-TYP	Signature of mapped soil types as per Holland 1995 (previously SIG5)	Basis for evaluation of soil functions as per Holland 1995
	GB	Overall evaluation = Potential of natural soil functions (Classes 1 to 5)	Aggregated from PR, FPGES and WK and subject to the arithmetic mean (cf. City of Stuttgart 2006)
	PR	Sub-function: Sites for natural vegetation and cultivated plants	Evaluation as per Holland 1995
	FPANO	Sub-function: Filters and buffers for inor-ganic pollutants	Evaluation as per Holland 1995
	FPORG	Sub-function: Filters and buffers for or-ganic pollutants	Evaluation as per Holland 1995
	FPGES	Sub-function: Filters and buffers for pol-lutants, total	Evaluation as per Holland 1995
	WK	Sub-function: Compensating elements in water circulation	Evaluation as per Holland 1995
	GE-WAESSE R	Mapped water bodies	Evaluation as per Holland 1995
Archive function bddenkmal_ges.shp geotope_gesamt.shp	ARCHIV	Archive function (geotope / ground monument / soil archive)	If an archive is present, then BODFUNK = 5
	FUND-STELLE	Entry „Place of finding“	The archive function “place of finding” does not change the soil quality stage of the particular area. They are shown hatched in the soil quality map.
New column	BODFUNK	Overall evaluation = Potential of natural soil functions (Classes 1 to 5)	Aggregated from GB und ARCHIV
Sealing map Versiegelungskar-te_100202.shp	VERKLAS S	Classified sealing grade Class I (≤ 10 %) to VI (> 90%) and “Gew” = water bodies	Data source “soil map”, provided by the Stuttgart Environmental Office, date 10 Dec 2008
	MUL-TIPLIK	Reduction factor (reduces the soil quality (BODFUNK))	Reduction factor (f_m), obtained from the sealing class (VERKLASS). Multiplication with soil quality (BODFUNK) gives the new calculated value (QS_RECH)
New column	QS_RECH	Quality stage of soil (QS_V calculated) in consideration of the sealing grade; (previ-ously QSV1)	Calculated result of multiplication of MUL-TIPLIK with BODFUNK, with 2 places after the comma
	QS_VER	Quality stage of soil (QS_V rounded off) in consideration of the sealing grade; (previ-ously QSV)	Rounded off result of QS_RECH Relevant value for further calculations with-out places after the comma

Source	Column labels	Description	Functional relationships
Data of contaminated sites and landfills (Altlasten_ges_090723.shp)	ALTLAST	Contaminated sites, contaminated sites with particular need for action, landfills and areas with relevance for disposal	Data basis: register of soil and contaminated sites
	QS_MAX	Maximum quality stage of soil, taking into account contaminated sites and landfills	Result of the evaluation of ALTLAST. The evaluation leads to a maximum soil quality grade (QS_MAX), in accordance with function restrictions Entered criteria: ***Contaminated sites: QS_{max}= 1*** *- All areas in the register of contaminated areas (abandoned sites, abandoned landfills, industrial sites, accidents, deposition areas, other), exception for areas with need for action "B" and criterion "disposal relevance". As at: 15.07.09.* ***Contaminated sites with particular need for action QS_{max}= 0*** *- For areas in the register of contaminated areas with particular need for action. As at: 15.07.09.* ***Areas with disposal relevance and removed Landfills: QS_{max}= 2*** *- Areas in register of soils with need for action "B" and criterion "disposal relevance". As at: 15.07.09.* *- Abandoned landfills removed from the register of contaminated sites and soil. As at: 15.07.09.*
New column	QS_GES	Total evaluation of soil quality taking into account archive function, sealings and contaminated sites/landfills (final result); (previously QSVAA) Classes 0 (no function performance) to 5 (very high soil quality) 99= no soil quality evaluation, e.g. along rail track, intersection areas on city outskirts (if existent)	Total result from QS_VER and QS_MAX

Query polygon requirements

The following requirements for the query polygon result from the technical framework conditions, the structure of the data basis for the soil quality map and the procedures for evaluation of the soil quality:

- The query polygon of the planning area must be present as a closed area shape.
- The information about the presence of contaminated sites or harmful soil changes is already clarified and contained in the table column "ALTLAST" in the soil quality map.
- The data about sealing is given in percentage of sealing grade. The sealing class and the corresponding reduction factor are determined from this using the BOKS method (cf. City of Stuttgart 2006). I.e. the outlines of the defining data for building planning regarding location and size of the building sites, etc. must be given or interpreted during the creation of the polygon.

6 SUMMARY

Reports with planning relevant information can be made available in a simple manner with the automatic querying of changes in soil quality due to change in use within the city of Stuttgart.

The "soil indicator" offers the following applications:

- Query of soil quality in a planning area (ACTUAL status).
- Query of soil quality in a planning area after implementation of planning (TARGET status).
- Query of change in soil index points in city area through change of use in a planning area.
- Automated intersection and updating of data in the soil quality map within a planning region.

7 REFERENCES

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URBAN SMS Soil Management Strategy

This paper belongs to the following section of URBAN SMS work plan:
WP4 Soil manager suite / 4.2 selection and optimisation / 4.2.1 soil evaluation method

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