Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Universitatea "Politehnica" din Timisoara, Romania
19 Aprilie 2013

Teza de abilitare
Habilitation Thesis

Radu Constantin Gogu

Universitatea Tehnica de Constructii Bucuresti, Romania
Departamentul de Hidraulica si Protectia mediului

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Overview on the scientific, academic, and professional directions

- Starting from the research, academic and professional experience gained over about 23 years in various academic institutions of different countries as Romania, Belgium, Switzerland, Spain and Greece and essentially based on ***the last three years, the current activity*** is focused on the ***Groundwater Engineering Research Centre (CCIAS)*** of the Technical University of Civil Engineering, Bucharest

- **CCIAS** develops groundwater research studies covering different areas like hydrogeology, geology, hydrology, structures and foundations, hydraulics, geographic information systems, computer science, mathematics, chemistry, and biology.

Overview on the scientific, academic, and professional directions

Research activity center mainly groundwater modeling in urban areas , hydrogeological data management, and groundwater resources protection.

ACTIONS

- Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts;
- Improve the hydraulic characterization of underground structures in relationship to groundwater;
- Expand hydrogeological and geological data models needed for the spatial data infrastructure (INSPIRE);
- Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure (water supply, sewer system, subway lines, foundations, etc);
- Build up and apply groundwater protection strategies

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

The detailed modelling of sedimentary media (alluvial sediments, deltas, etc.) that form important aquifers is very complex for two reasons:

1. **the intrinsic natural heterogeneity** of the geological medium
2. **the data management tools** (manipulating geological and hydrogeological data needed to implement them in the hydrogeological models) **are not enough developed**.

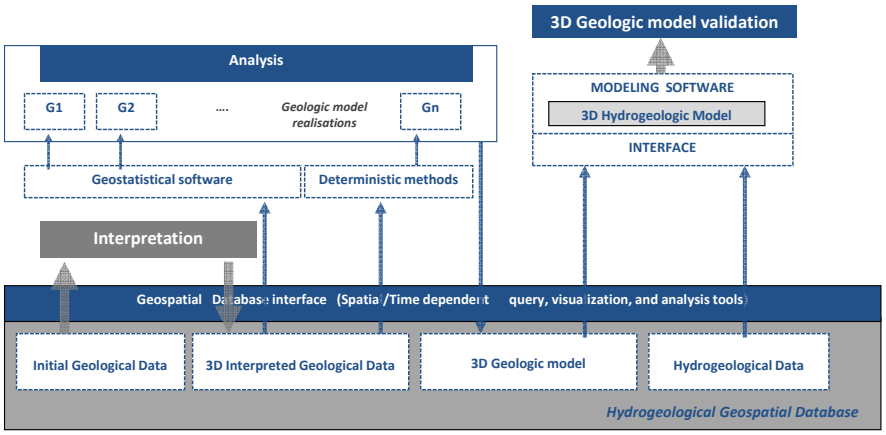
Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

OBJECTIVES

Iterative Conceptual Model approach

1. **Groundwater data management**
   a. Hydrogeological Conceptual model definition
   b. Data visualization
   c. Pre-modeling HG data processing
2. **Hydrogeological 3D modeling**
   a. Development and application of 3D geological characterization techniques in sedimentary media
   b. Development of hydraulic parameterization techniques from a 3D geological model in sedimentary media
   c. HG Conceptual model definition / heterogeneity ➔ data treatment (interpretation, interpolation, geostatistics, stochastic, …)
   d. Generate 3D hydrogeological models

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

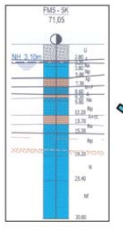


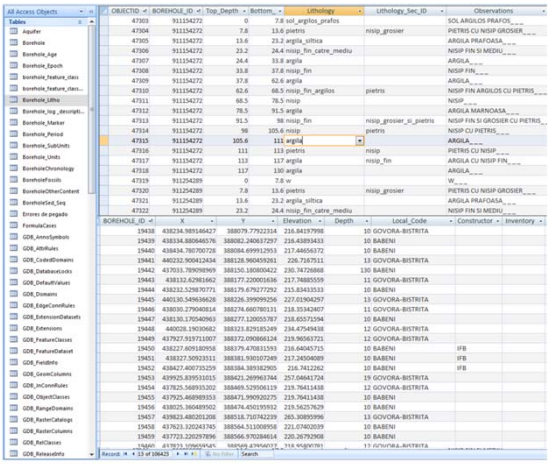
Modeling platform

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Database structure



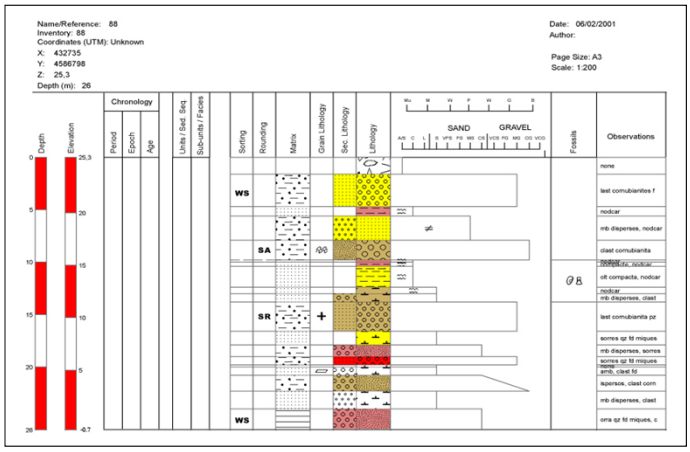


Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

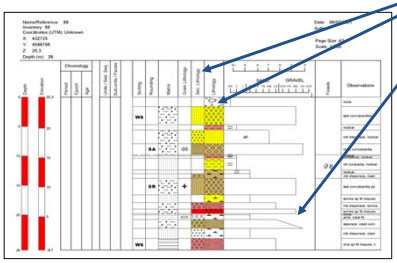


Litho-stratigraphic data vizualization

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

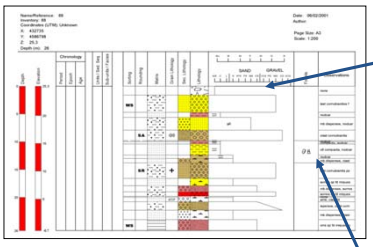


Litologia					
Antropic		Silty_sand		Grainstone	
Soil		Fine_gravel_ (granule)		Boundstone	
Clay		Medium_ gravel_ (pebble)		Dolomite	
Silt		Coarse_ gravel_ (cobble)		Limestone	
Lutite		Very_ coarse_ gravel_ (boulder)		Anydrite	
Very_fine_ sand		Heterometri_ gravel		Salt	
Fine_sand		Clayey_ gravel		Gypsum	
Medium_ sand		Silty_gravel		Granite	
Coarse_ sand		Marl		Meteorized_ granite	
Very_coarse _sand		Mudstone		Metamorphic_ rock	
Heterome- tric_sand		Wackstone		Volcanic_ rock	
Clayey_ sand		Packstone		Other_ igneous_ rocks	

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools



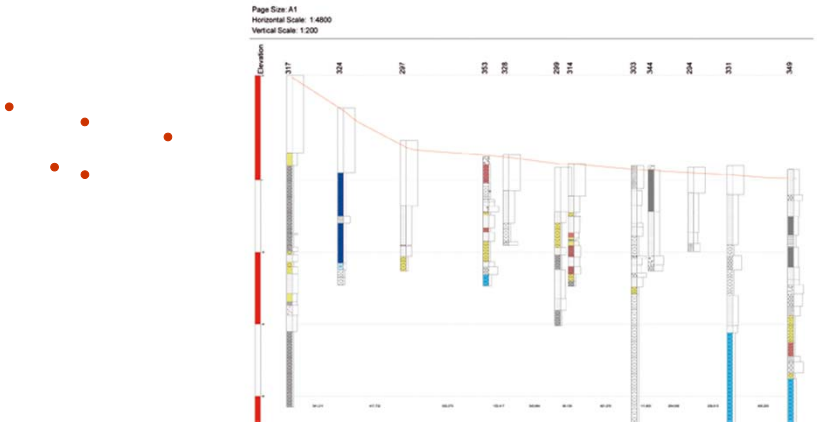
Estructura			
Paralell		Ripple_marks	
Paralell_lamination		Base_current_marks	
Cross_bedding		Bioturbation	
Irregular_bedding		Plant_roots	
Fining_upward		Mud_cracks	
Coarsening_upward		Slump_structures	
Graded_bedding		Convolute_bedding	
No_apparent_bedding		Load_cast	
Nodular_bedding			

Fòssils			
Algae		Serpulids	
Corals		Bryozoa	
Echinoids		Pelagic_foraminifera	
Fossils_abundant		Benthonic_foraminifera	
Gasteropods		Foraminifera	
Mollusc		Ostracods	
Clams		Plant_remains	
Oysters		Worm_tubes	
Fish			

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

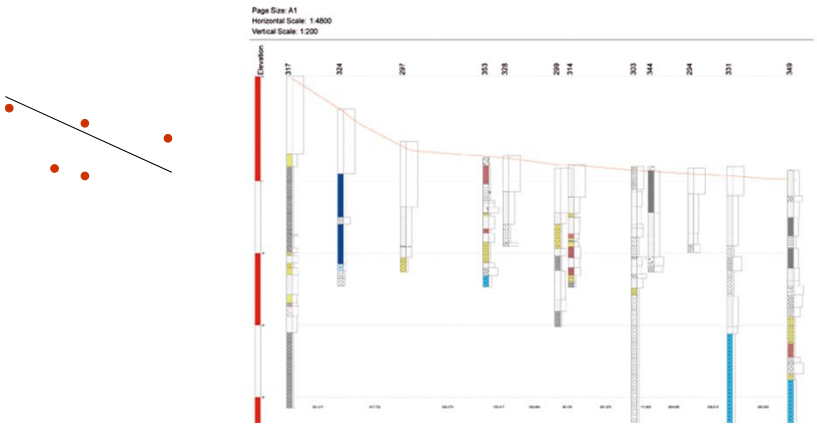


Geological profile generation

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

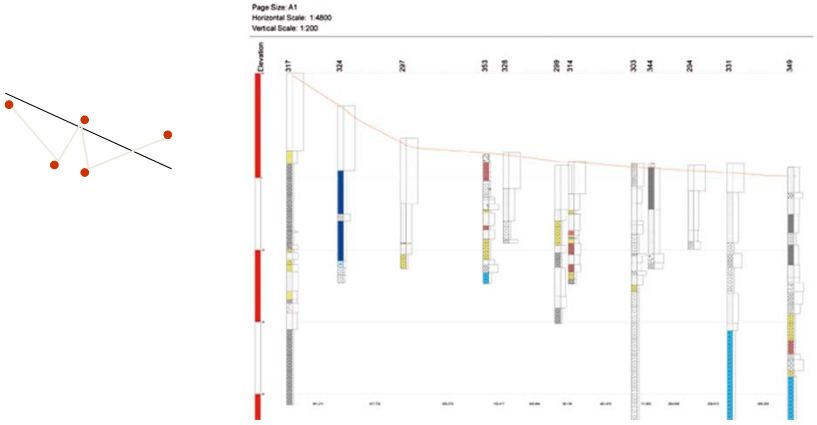


Geological profile generation

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

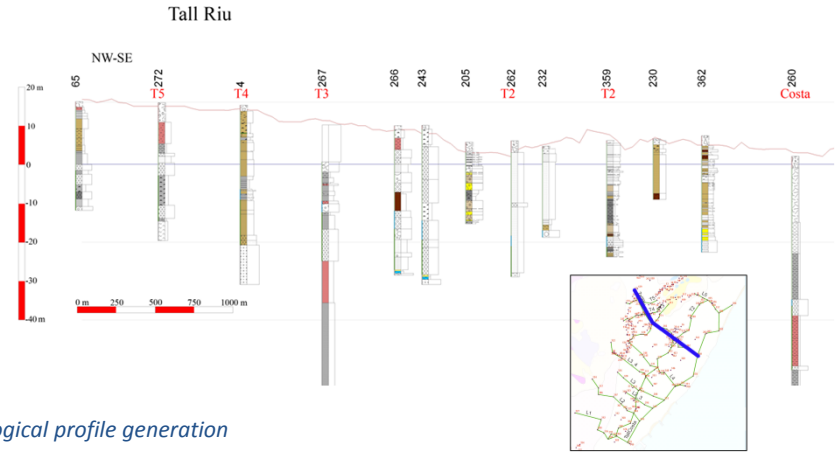


Geological profile generation

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

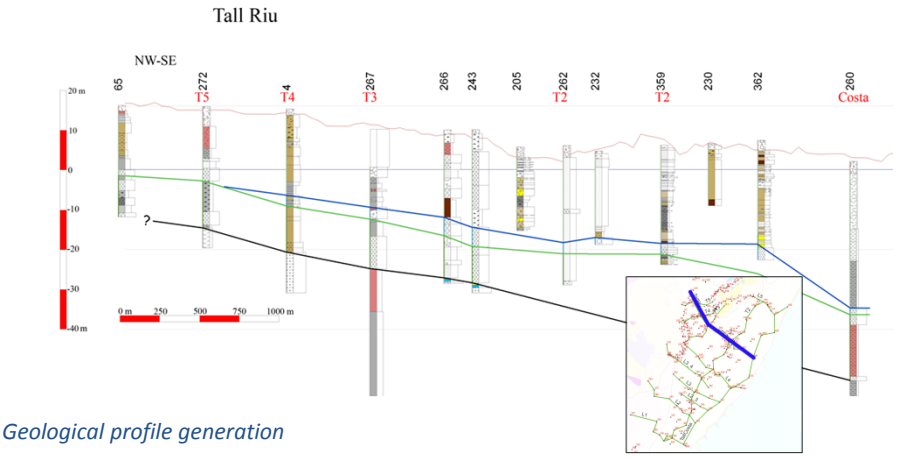


Geological profile generation

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools



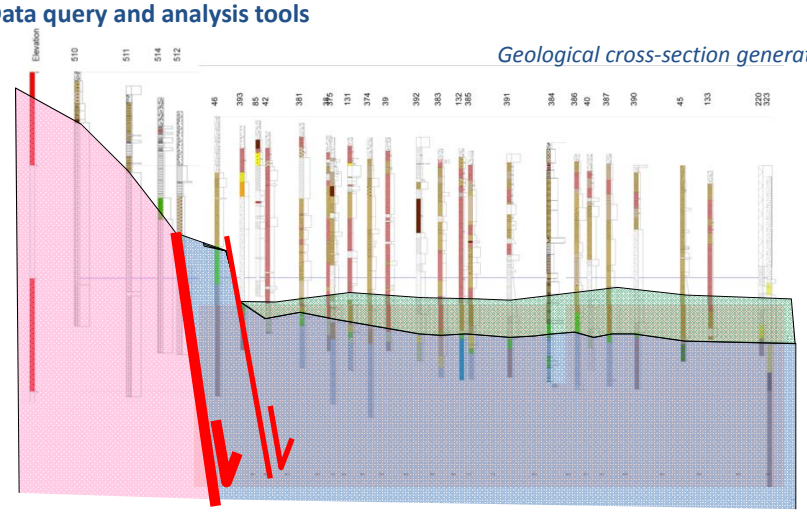
Geological profile generation

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Data query and analysis tools

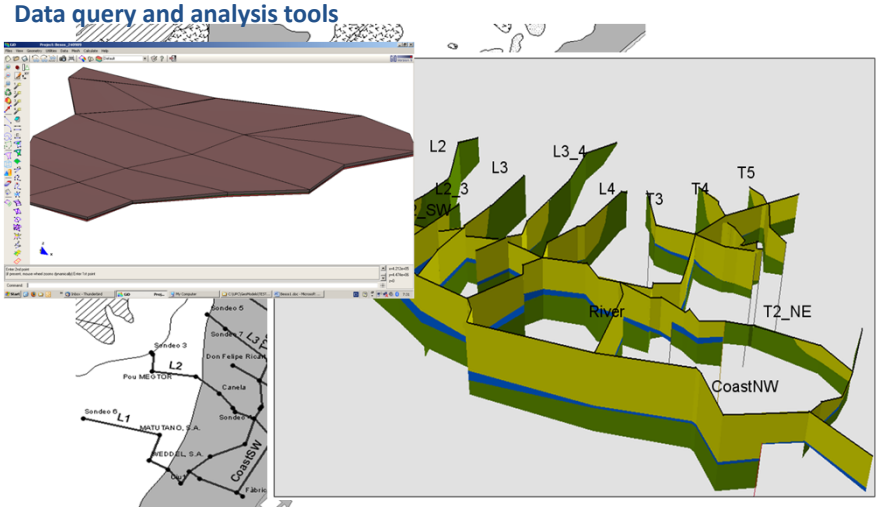
Geological cross-section generation



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

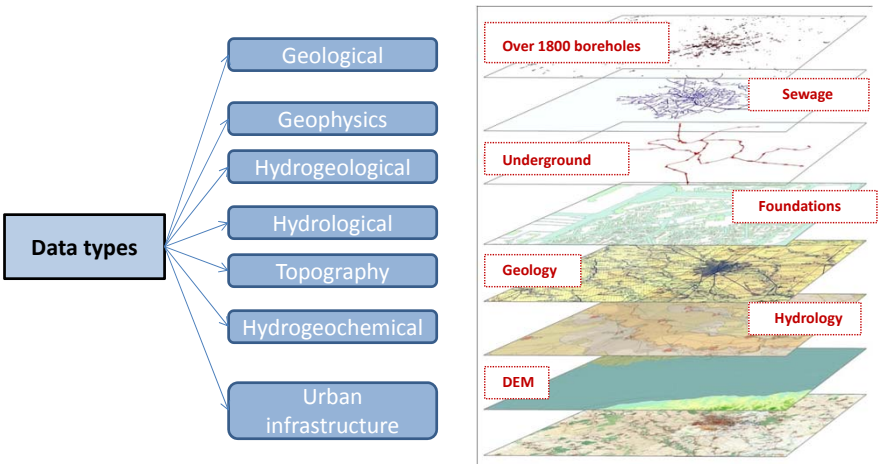
Data query and analysis tools



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Bucharest city geological model

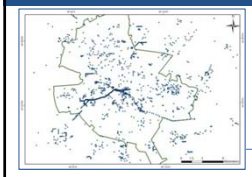


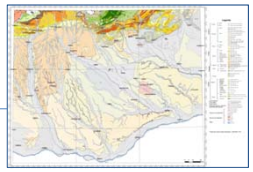
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

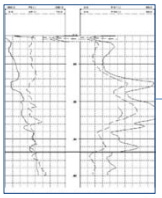
Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

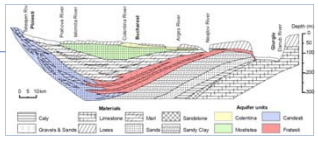
Bucharest city geological model

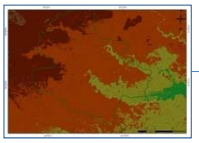
Data sources

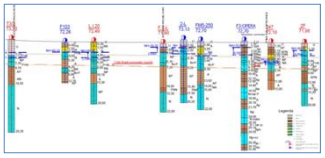










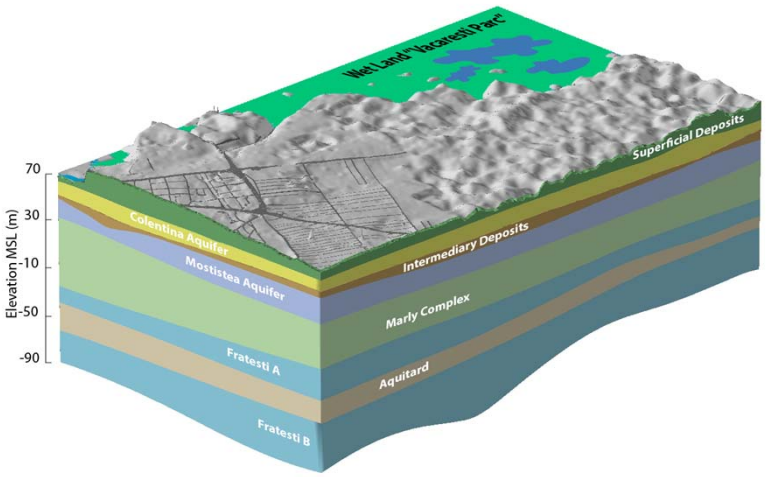


- 493 Boreholes with depths between 5-375meters
- Geological map 1:200.000
- Geological cross-section
- Geophysical logging
- DTM

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

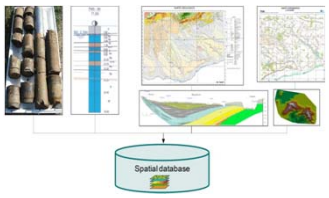
Bucharest city geological model



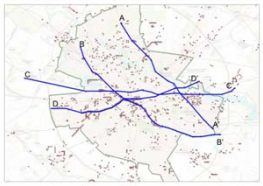
Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

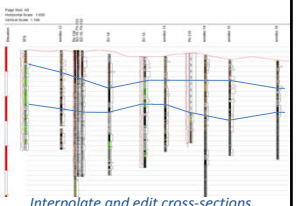
Bucharest city - workflow for the 3D geological model



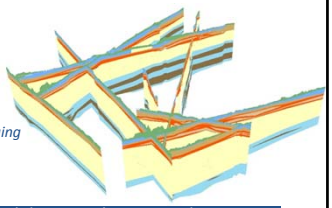
Data collecting



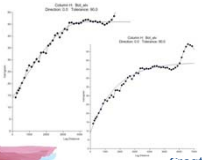
Define geological cross-sections

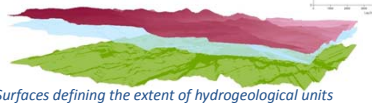


Interpolate and edit cross-sections



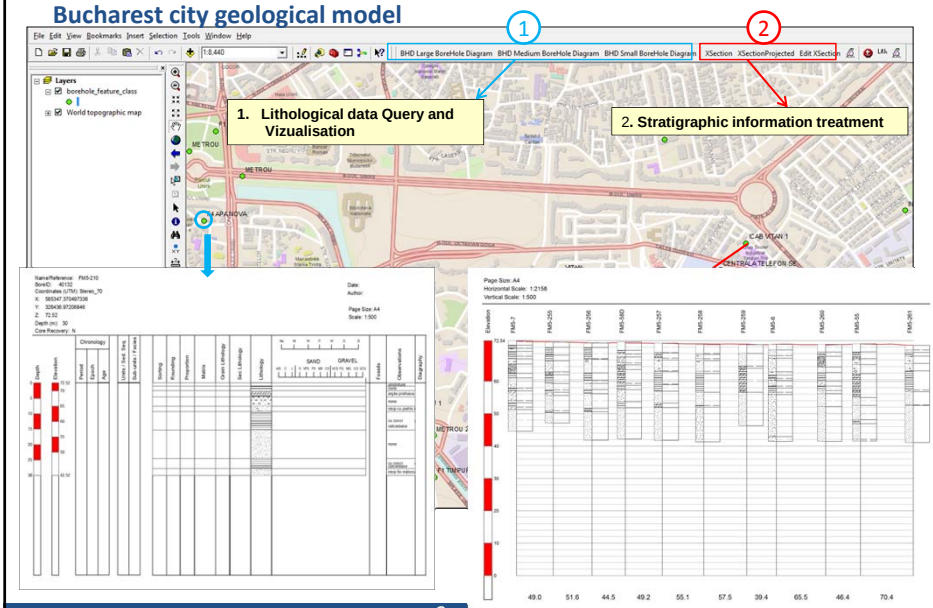
Create surfaces - Kirigging



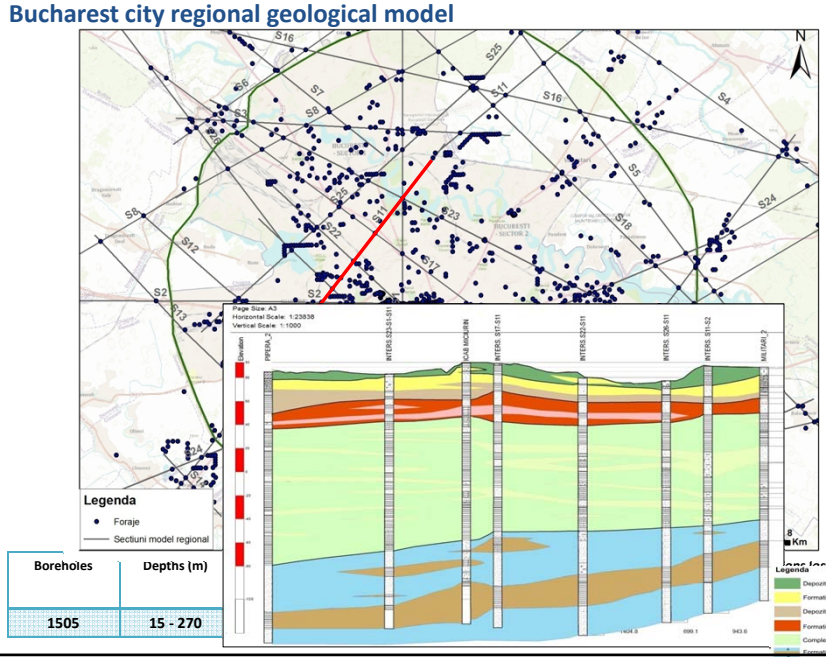


Surfaces defining the extent of hydrogeological units

Bucharest city geological model



Bucharest city regional geological model

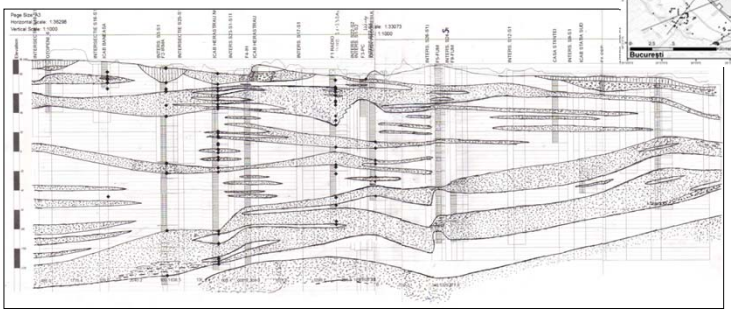


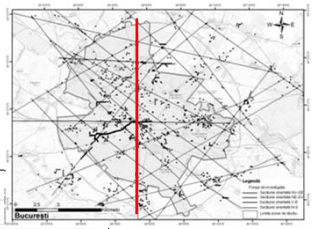
Boreholes	Depths (m)
1505	15 - 270

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Bucharest city regional geological model

Geological profile analysis

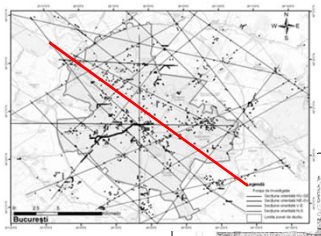




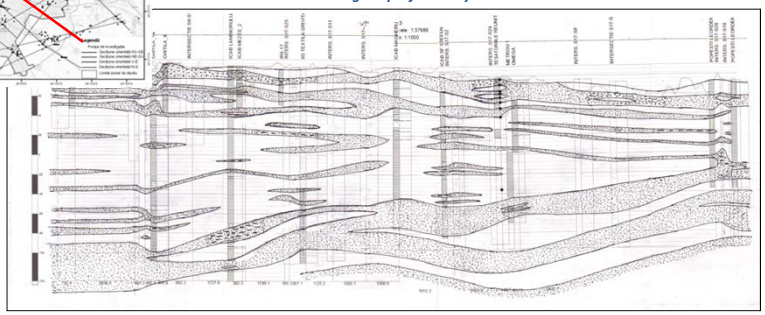
Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Bucharest city regional geological model

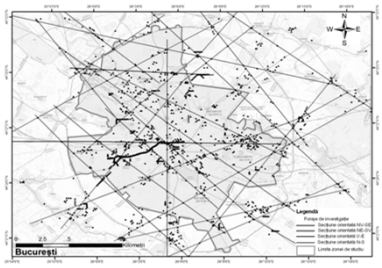


Geological profile analysis



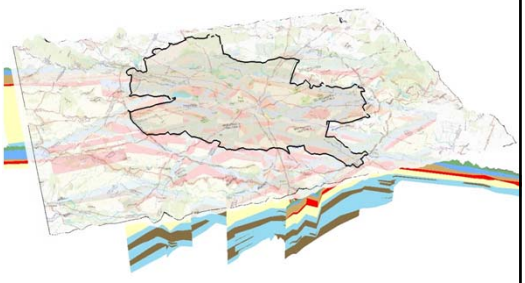
Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

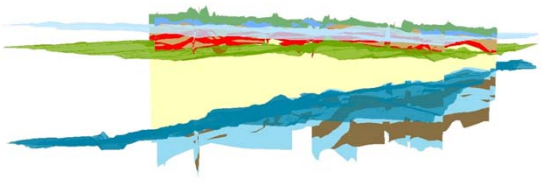
Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts



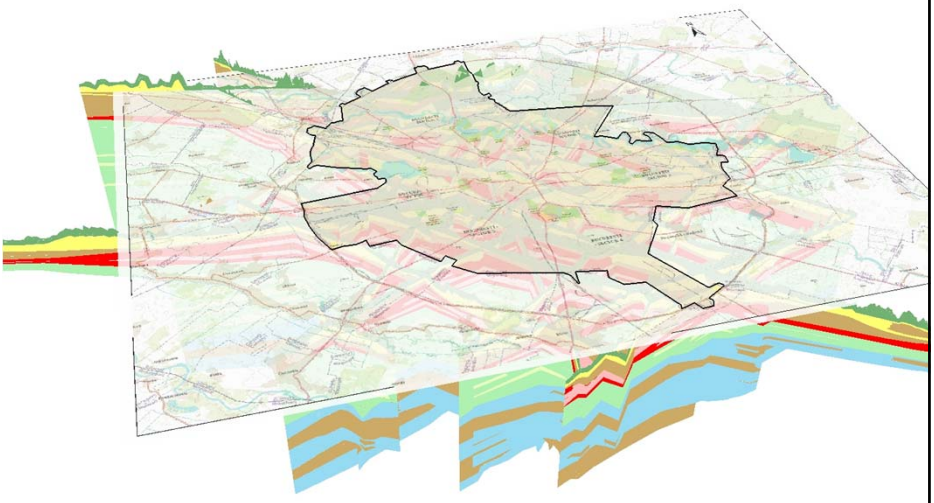
46 geological profiles

Detalied 3D geological model



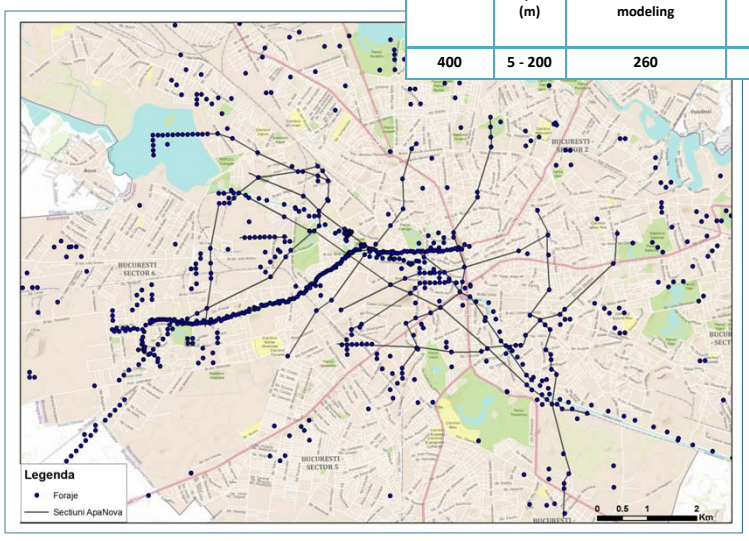


Bucharest city regional geological model

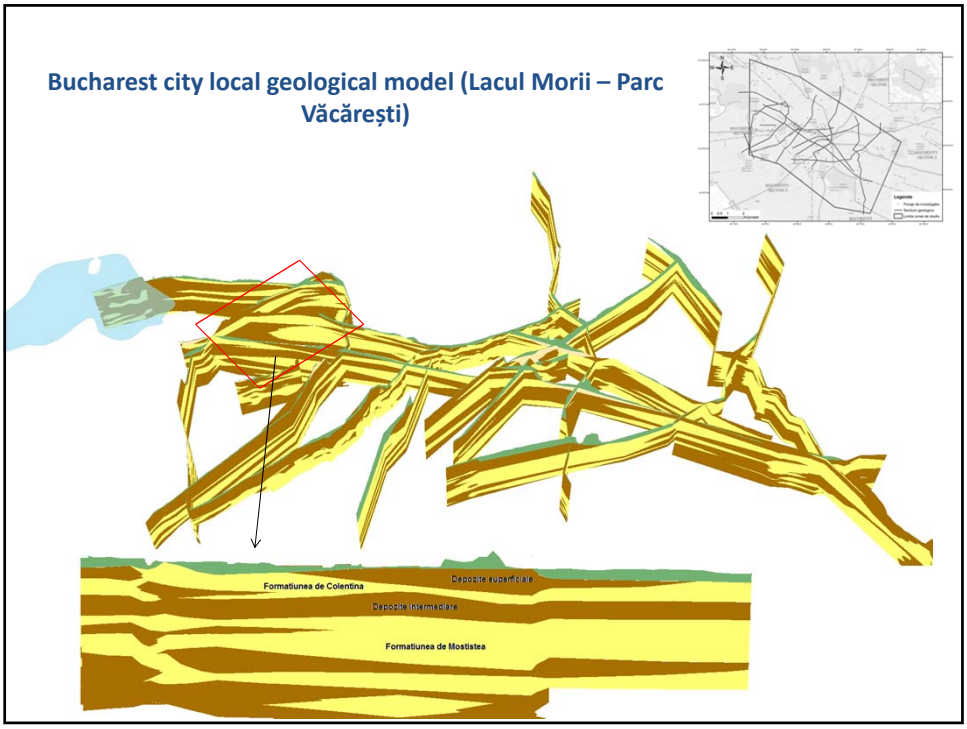


Bucharest city local geological model (Lacul Morii – Parc Văcărești)

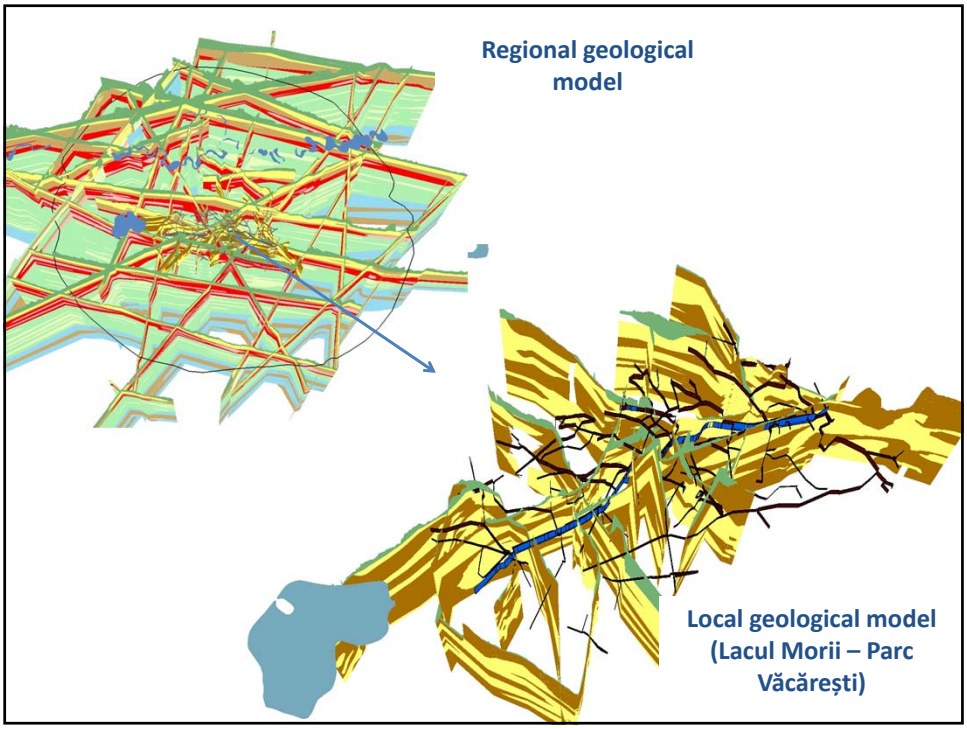
Boreholes	Depths (m)	Boreholes for modeling	Investigation depths (m)
400	5 - 200	260	50



Bucharest city local geological model (Lacul Morii – Parc Văcărești)

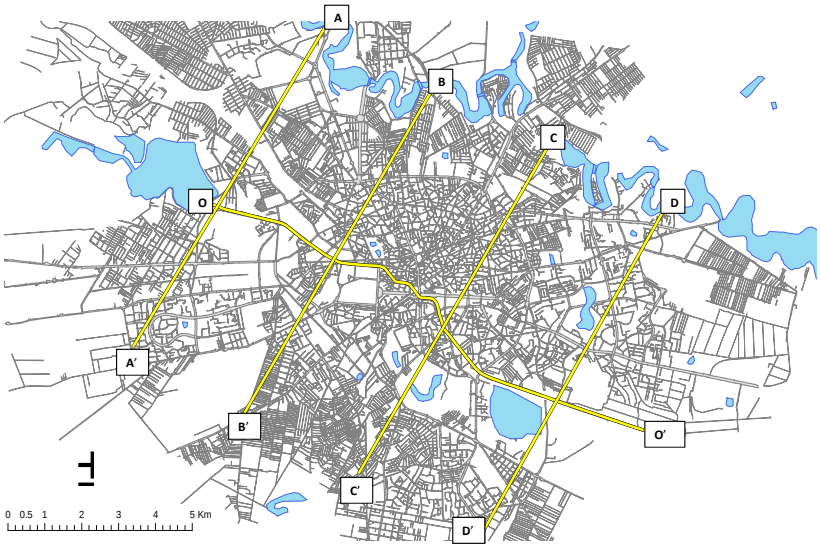


Regional geological model

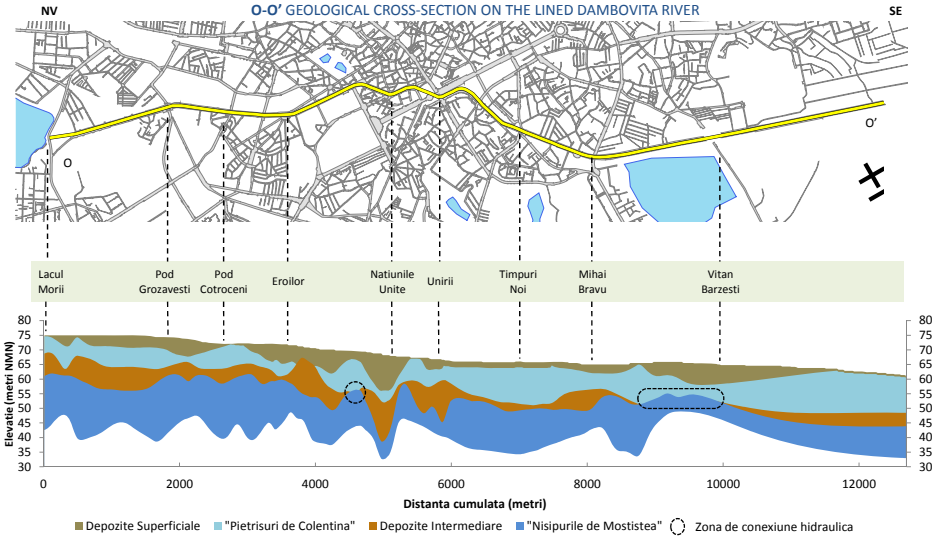


Local geological model (Lacul Morii – Parc Văcărești)

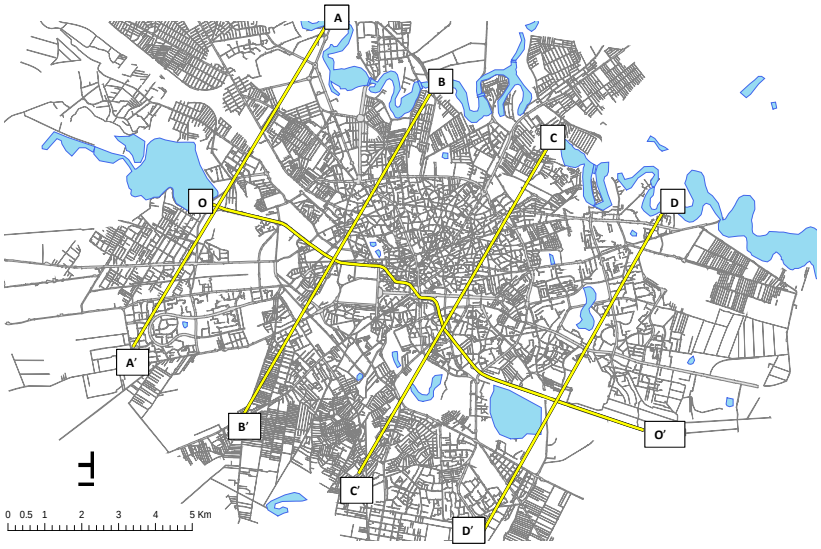
LOCATION OF GEOLOGICAL CROSS-SECTIONS



O-O' GEOLOGICAL CROSS-SECTION ON THE LINED DAMBOVITA RIVER



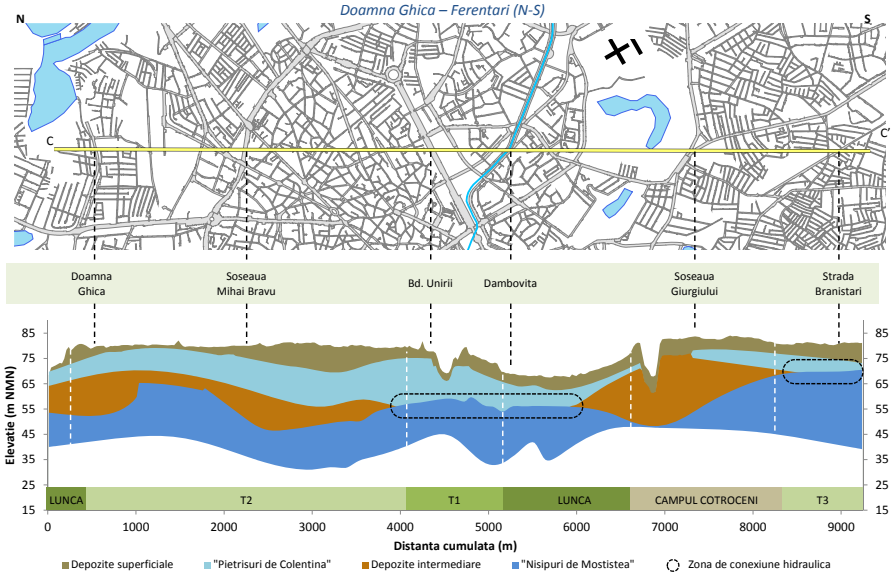
LOCATION OF GEOLOGICAL CROSS-SECTIONS



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

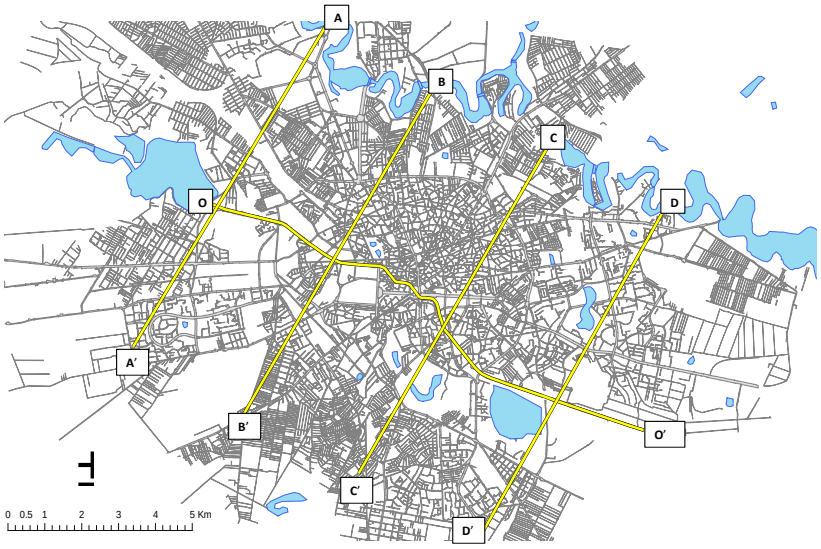
C - C' GEOLOGICAL CROSS-SECTION

Doamna Ghica – Ferentari (N-S)



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

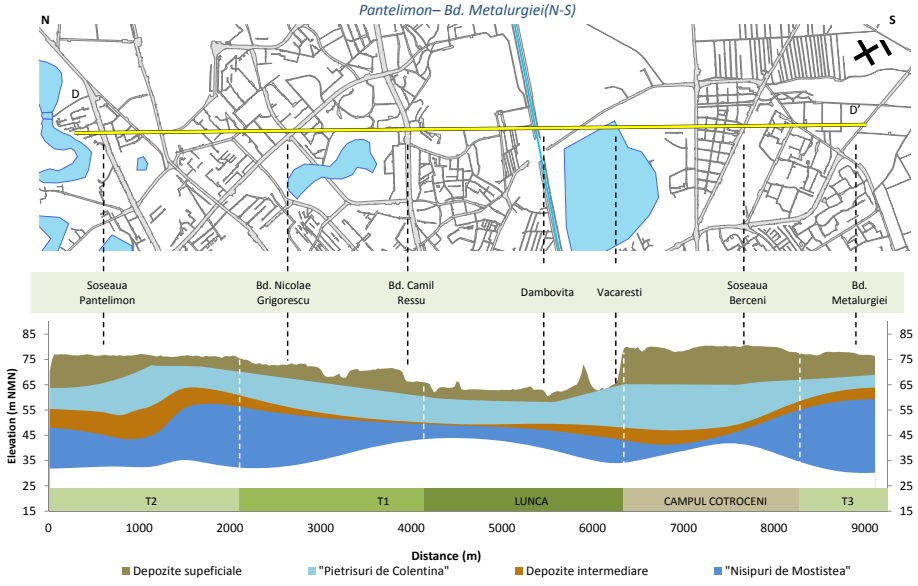
LOCATION OF GEOLOGICAL CROSS-SECTIONS



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

D-D' GEOLOGICAL CROSS-SECTION

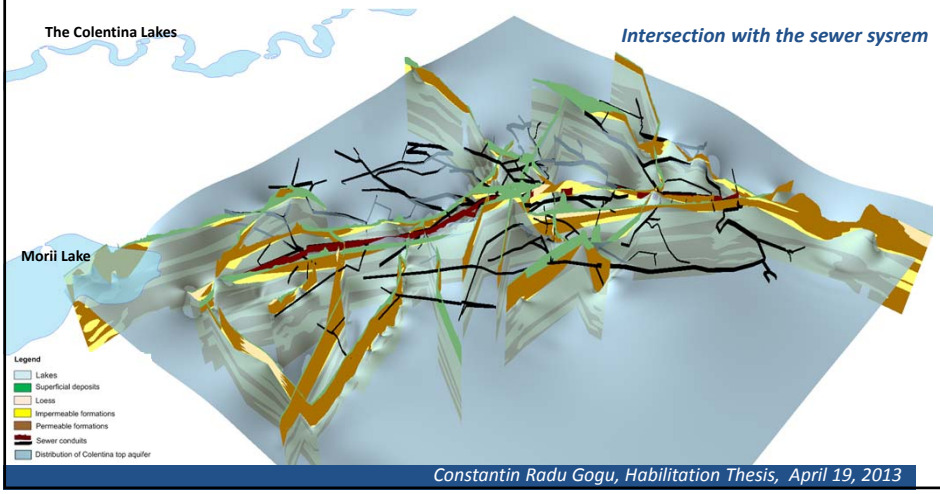
Pantelimon– Bd. Metalurgiei(N-S)



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Bucharest city local geological model (Lacul Morii – Parc Văcărești)

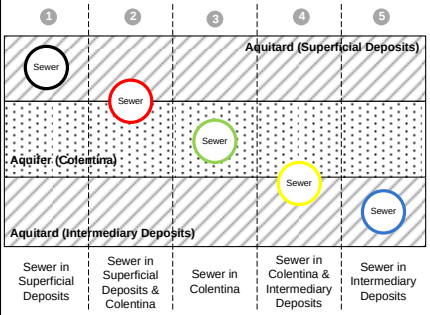


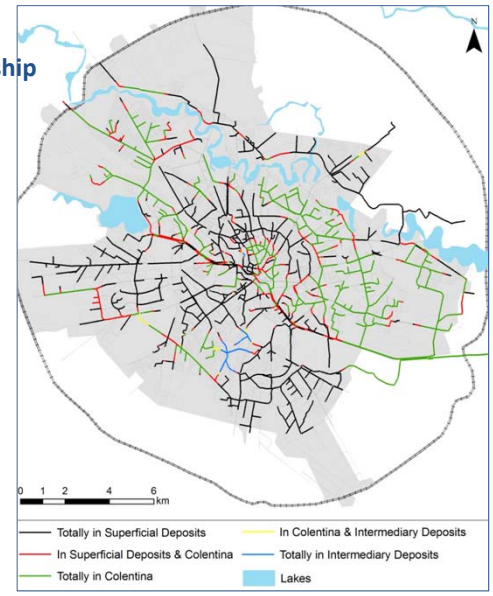
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

The sewer system location in relationship to the local geological model



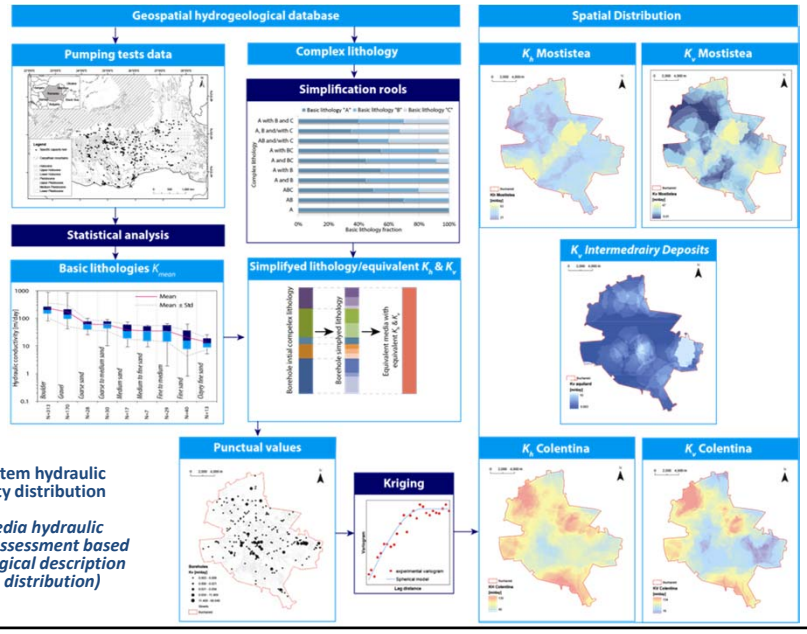


Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

- Aquifer system hydraulic conductivity assessment in Bucharest city region
  - Aquifer media hydraulic conductivity assessment based on the lithological description (grain size distribution)
  - Hydraulic conductivity analysis based on empirical formulas (literature)

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013



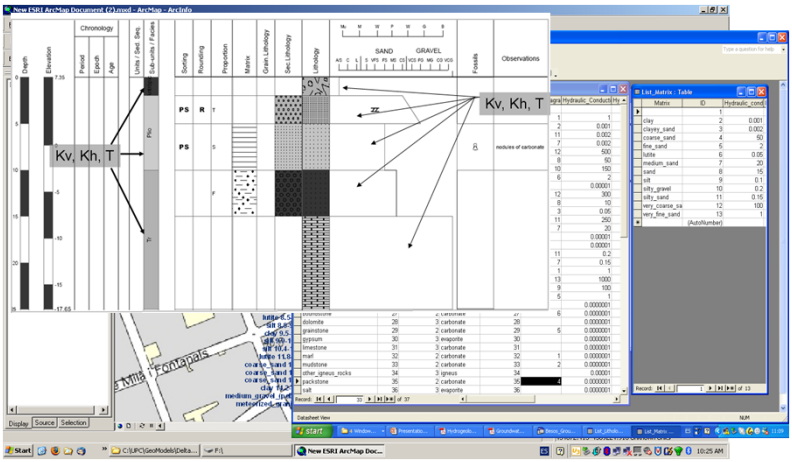
Aquifer system hydraulic conductivity distribution

Aquifer media hydraulic conductivity assessment based on the lithological description (grain size distribution)

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

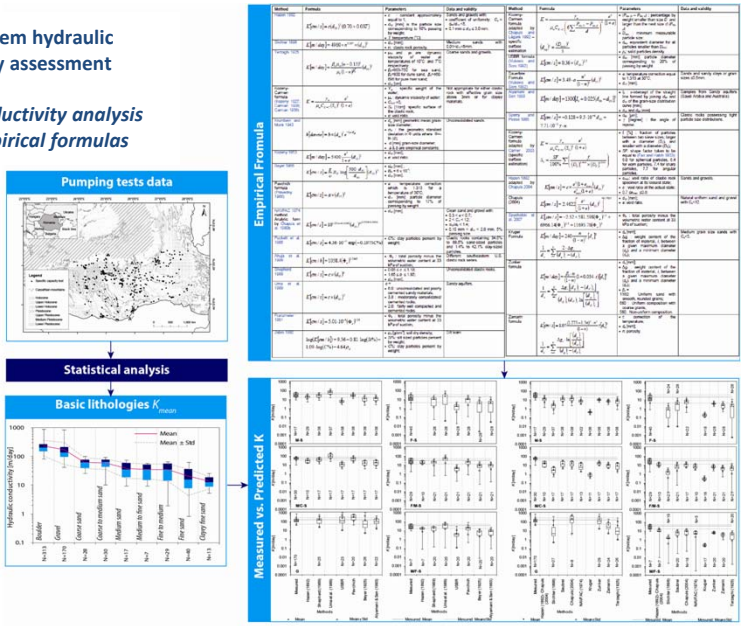
Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Hydraulic conductivity quantification



Aquifer system hydraulic conductivity assessment

Hydraulic conductivity analysis based on empirical formulas



Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts

Hydraulic conductivity analysis based on empirical formulas

A review of empirical formulas for the estimation of the hydraulic conductivity

Reference	Formula	Parameters	Data and validity
Hazen [22]	$K_s[cm/s] = c \times (d_{10})^2$	$1 \le c \le 1.5$; d_{10} [mm]: particle size diameter corresponding to 10% finer by dry mass on the grain size distribution curve (mm)	Sands & gravels with: Loose compactness (the porosity, n, or the void ratio, e, close to their maximum values); Coefficient of uniformity: $C_u = d_{60}/d_{10} < 5$, 0.1 mm $\le d_{10} \le 3.0$ mm.
Kozeny-Carman [23-24]	$K = \frac{\gamma_w}{\mu_w} \times \frac{1}{C_{K-C}} \times \frac{1}{(S_0)^2} \times \frac{e^3}{(1+e)}$	γ_w : specific weight of water; μ_w : dynamic coefficient of viscosity of water; C_{K-C} =5; S_0 [1/cm]: specific surface of the soil; e : void ratio.	Not appropriate for either soil with effective size above 3mm or for clayey soils.
Kozeny [25]	$K\ [m/day] = 5400 \frac{e^3}{(1+e)} (d_{10})^2$	d_{10}[mm]; e : void ratio.	
U.S. Bureau of Reclamation formula [26]	$K\ [m/day] = C \times 0.36 \times (d_{20})^{2.3}$	C: conversion factor for K from [cm/s] to [m/day]; d_{20} [mm]: particle size diameter corresponding to 20% finer by dry mass on the grain size distribution curve (mm)	
Pavchich Formula [27]	$K\ [m/day] = C \times a \times (d_{17})^2$	C: conversion factor for K from [cm/s] to [m/day]; a : temperature correction which is 1.313 for a temperature of 30°C; d_{17} [mm]: particle size diameter corresponding to 17% finer by dry mass on the grain size distribution curve (mm)	
Slichter [28]	$K\ [m/day] = 4960 \times n^{3.287} \times (d_{10})^2$	d_{10} [mm]; n: soil porosity.	
Terzaghi [29]	$K[m/day] = C \times R \times \frac{g}{\nu} \frac{(n-0.13)^2}{(1+n)^{2/3}} (d_{10})^2$	C : conversion factor for K from [cm/s] to [m/day]; R : coefficient dependent on the nature of the grain surface (8.4 x 10^{-3}) ;ν: kinematic viscosity for water at 30°C; d_{10} [cm].	
Beyer [30]	$K\ [m/day] = C \frac{g}{\nu} B_N \log\left(\frac{500}{\frac{d_{60}}{d_{10}}}\right) (d_{10})^2$	d_{60} [cm]; C : conversion factor for K from [cm/s] to [m/day]; $B_N = 6 \times 10^{-4}$; d_{10} [cm]	
Chapuis [31]	$K[cm/s] = 2.4622 \left[(d_{10})^2 \frac{e^3}{(1+e)}\right]^{0.7825}$	d_{10} [mm]; e : void ratio	Natural uniform sand and gravel (C_u<12)
Alyamani & Sen [32]	$K[m/day] = 1300[I_0 + 0.025(d_{50} - d_{10})]^2$	I_0 : x-intercept of the straight line formed by joining d_{10} and d_{10} of the grain-size distribution curve [mm]; d_{10} and d_{50} [mm]	Soil sample from Sandy aquifers (Saudi Arabia and Australia)
Sperry & Peirce [33]	$K\left[\frac{cm}{s}\right] = -0.128 + 9.5 \times 10^{-4} d_{50} + 7.71 \times 10^{-3} \gamma \times n$	d_{50} [µm]; γ [degree]: the angle of repose	Granular materials showing tight particle size distributions

(Bouckemacha MA, Gogu CR, Bica I, 2012)

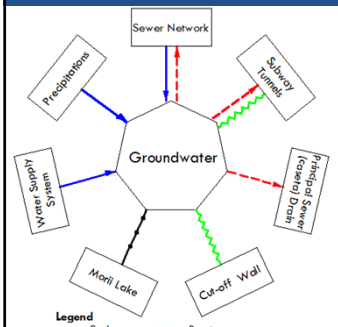
Improve the hydraulic characterization of underground structures in relationship to groundwater

- Assessment of the interaction between groundwater and urban infrastructure in Bucharest City

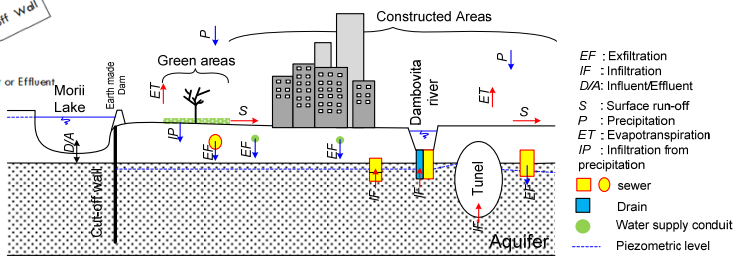
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve the hydraulic characterization of underground structures in relationship to groundwater

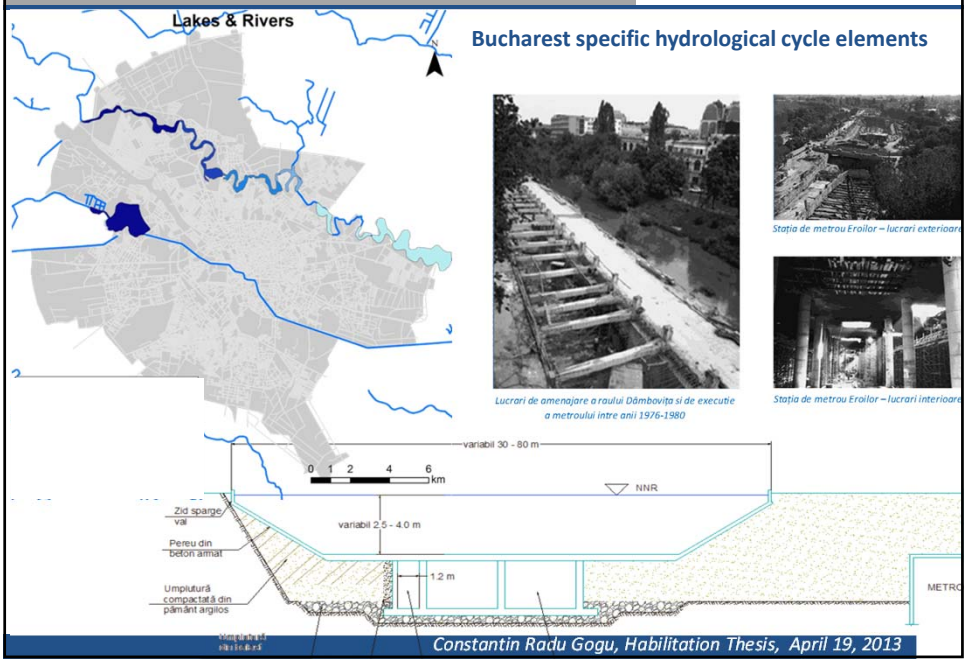
Conceptual Schema



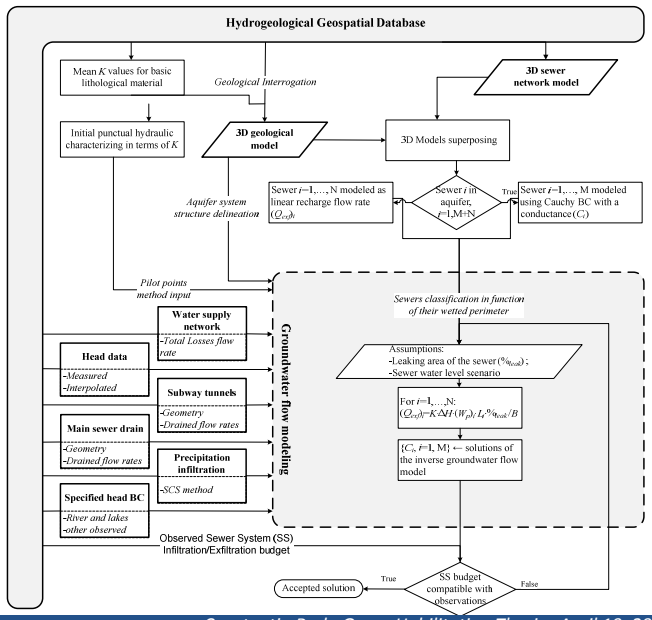
Urban hydrological cycle components



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013



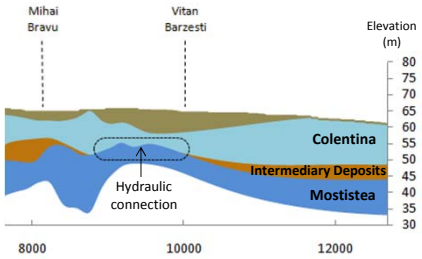
Hydrogeological Conceptual Model



Groundwater flow modeling settings

SETTINGS

- **Steady state**
- **Multi layered** : due to the direct **Hydraulic Connection** between aquifers
  - Colentina Aquifer
  - Intermediary deposits
  - Mostistea Aquifer
- **Pseudo -2D**

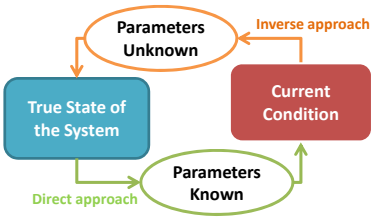


NUMERICAL METHOD

- **Finite difference** using USGS's MODFLOW solver (Harbaugh et al. 2000)

CALIBRATION TECHNIQUES

- Inverse modeling: sewer conductance values quantification
- Pilot point: aquifer system parametrizing in terms of hydraulic conductivity
- Trial & Error: Exfiltration flow rates form sewers



Groundwater flow required data

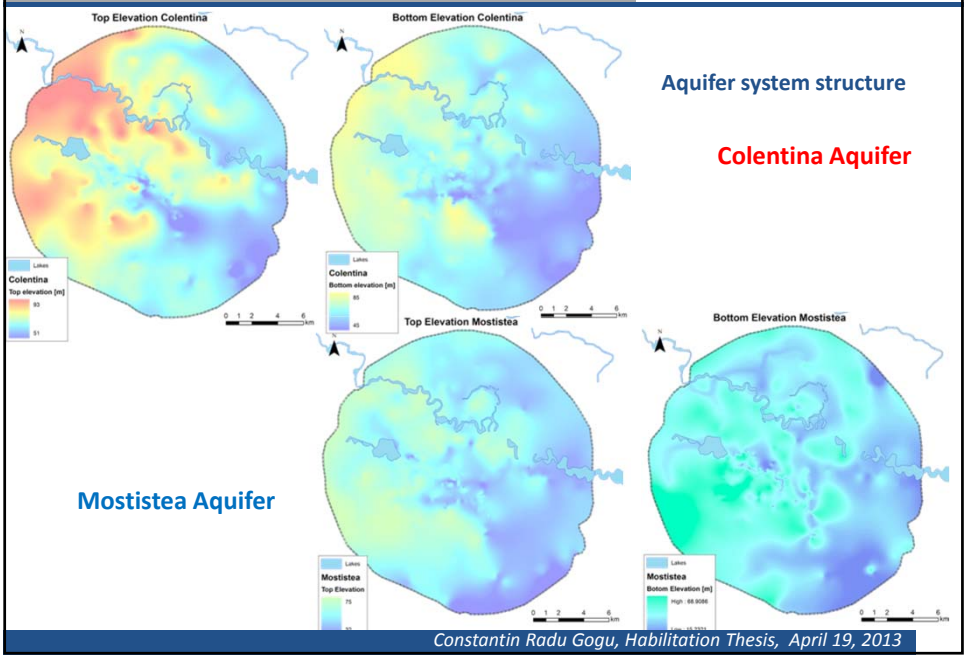
nr	Component	Sub component	Variables	Type	Source	Status
1	Aquifer system	Structure	Top & bottom elevations	input	Geological model	Finalized
		Parametrizing	Horizontal & vertical hydraulic conductivity Kh, Kv	Input (pilot point method)	Lithological description	Finalized
					Pumping tests	More data required
2	Precipitation		GW Recharge	input		Assessed
3	Water supply network (WSN)		GW Recharge	input		Assessed
4	Subway tunnels	Infiltrations	GW discharge	input	Measurement	Assessed
		Barrier effect	Geometry	input	Measurement	Finalized
			Hydraulic characteristic	input	Molding	In progress

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

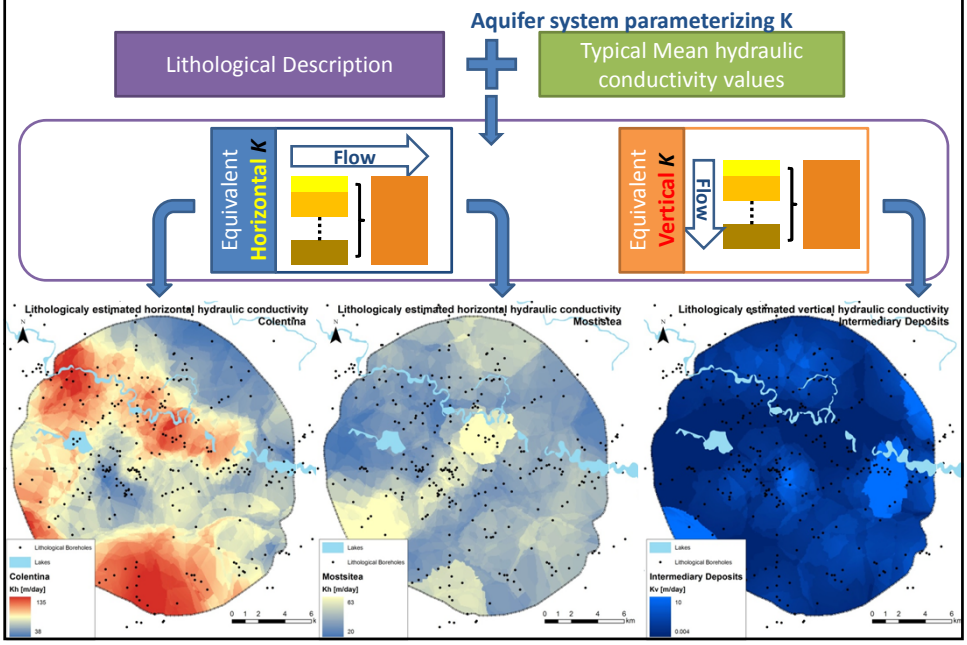
nr	Component	Sub component	Variables	Type	Source	Status
5	Lakes & Rivers		Geometry	input		Finalized
			Water levels	input	Measurement	Finalized
6	Sewer system	Hydraulics	Water levels	input	ANB estimations	Available
			Water budget	input	ANB estimations	Available
			Sewers Conductance values (*C*)	Output (inverse modeling)	GW model calibration	
		Geometry	Position in aquifer system	input	Sewers intersection with Geological model	Finalized
7	Piezometrical head data		HColentina HMostistea	Input (inverse modeling)	Measurement & interpolation	More data required

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013



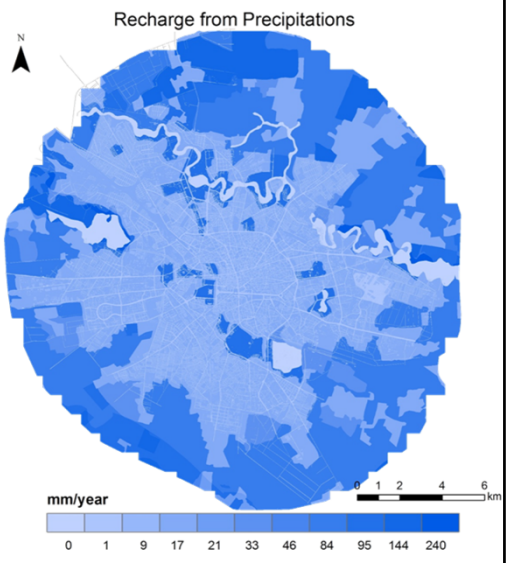
- The recharge is quantified using Soil Conservation Service Model (United States Department of Agriculture 1954):

$$F = \frac{S(P - I_a)}{P - I_a + S}$$

$$S = 254\left(\frac{100}{CN} - 1\right)$$

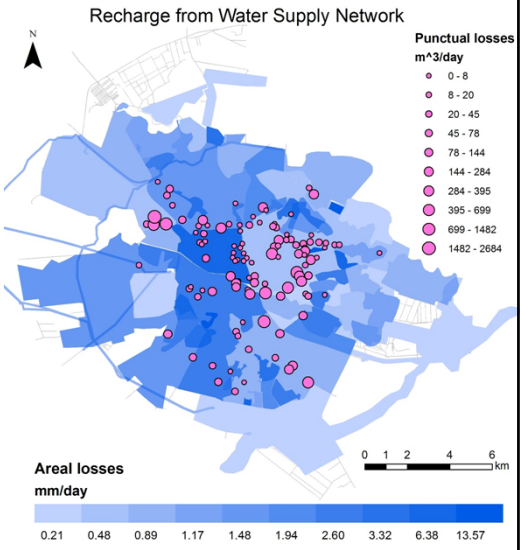
- Where, S[mm] is the potential storage in the soil; CN is the Curve Number and is a characteristic of the soil type, land use and the initial degree of saturation known as the antecedent moisture condition; I_a : initial abstraction and is usually taken to be 20% of S;

Infiltration from rainfall



- Water Supply Network (WSN) losses:
  - **Areal**: from
    - Low pressure pipes
    - High pressure pipes
    - Industrial users
    - Aqueduct
  - **Punctual**
    - Hidrofor station
- Groundwater Recharge is considered to be 85% of the technical total losses

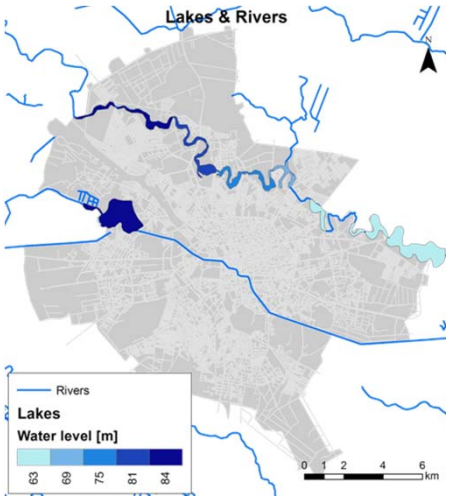
Water supply network losses



Improve the hydraulic characterization of underground structures in relationship to groundwater

Lakes and rivers

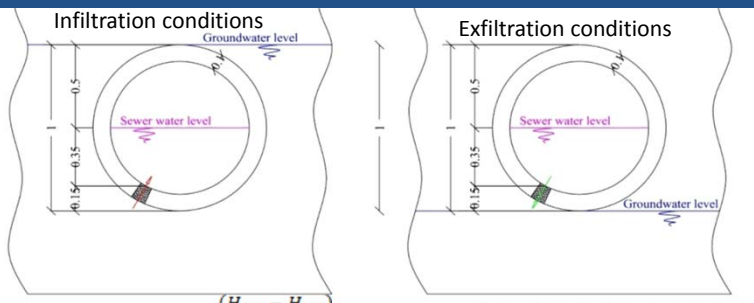
- **Variables**
  - Geometry
  - Water levels
- **Use**
  - Boundary condition:
    - Specified head
  - Exchange between groundwater and surface water bodies



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

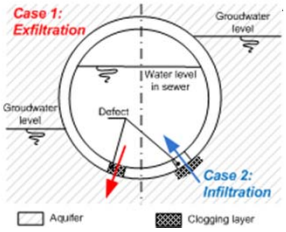
Improve the hydraulic characterization of underground structures in relationship to groundwater

Sewer system



$$Q = K_{clogging} \times A_{clogging} \times \frac{(H_{GW} - H_{SW})}{B_{clogging}}$$

	infiltration	Exfiltration
H_{GW}-H_{SW} (m)	0.5	-0.35
$K_{clogging}$ (m/day)	7.35	
$A_{deffect}$ (cm²)	1	
$B_{clogging}$ (m)	0.1	
Q (l/day)	3.67	-2.57

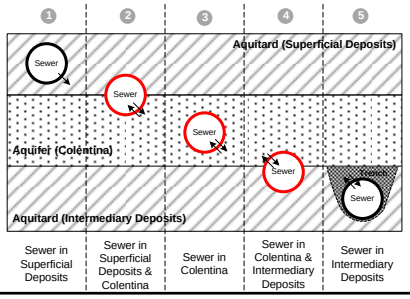


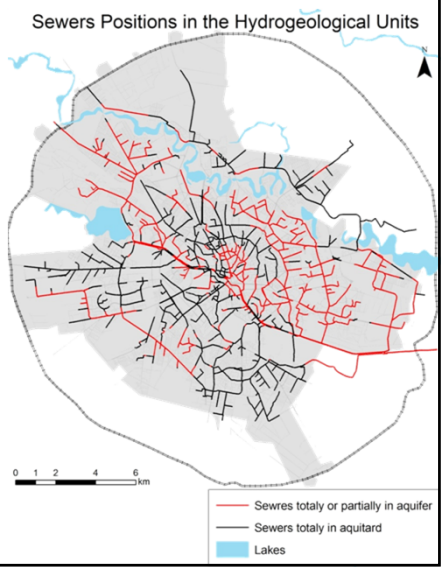
Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Sewer system

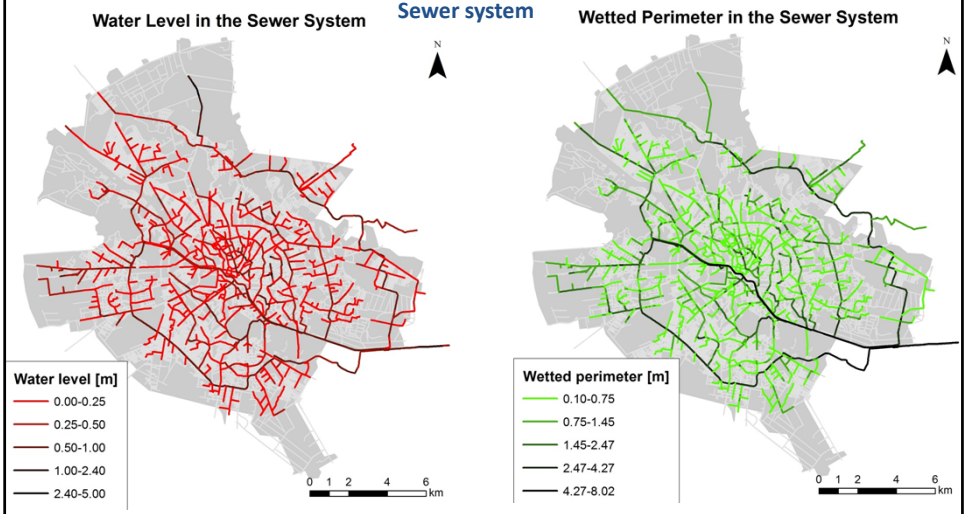
- Sewer system modeling using **leakage factor approach** has the following assumptions:
  1) All sewers might have defects
  2) **Uniform** distribution of defects
  3) Defect area is **proportional** to sewer's **wetted perimeter**
  4) Sewers in the Superficial deposits are subjected to **exfiltrations only**;
  5) All other sewers can exhibit **infiltration or exfiltrations**.





Improve the hydraulic characterization of underground structures in relationship to groundwater

Sewer system



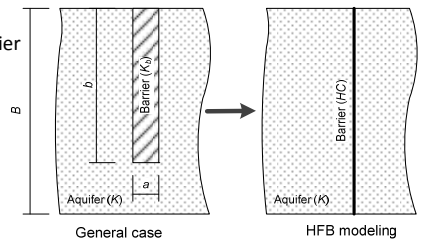
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Improve the hydraulic characterization of underground structures in relationship to groundwater

Subway tunnels & stations

- **Effects**
  - Discharge sink
  - Flow barrier
- **Data**
  - Geometry & location
  - Position in the aquifer system
  - Groundwater Seepage flow rate
  - Hydraulic conductivity of the aquifer and the barrier
- **Modeling**
  - ***Drain***
    - using observed seepage flow rate
  - ***Flow barrier***
    - Equivalent fully penetrating barrier

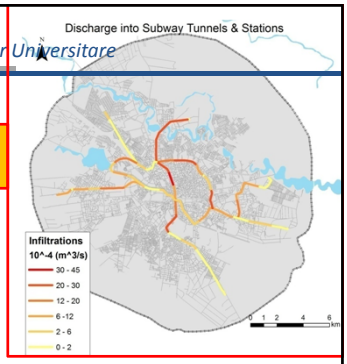
$$HC = \frac{T_{eq}}{a} = \frac{\dfrac{bK_b + (B-b)K}{B}B}{a} = \frac{bK_b + (B-b)K}{a}$$



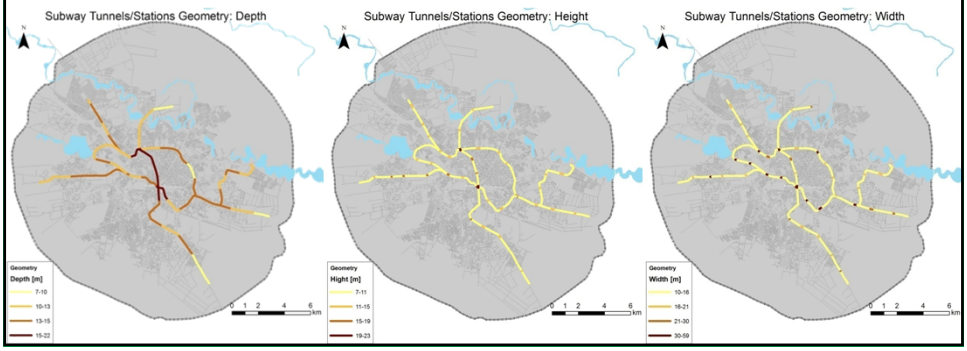
Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Sink Effect Variable (Infiltration)

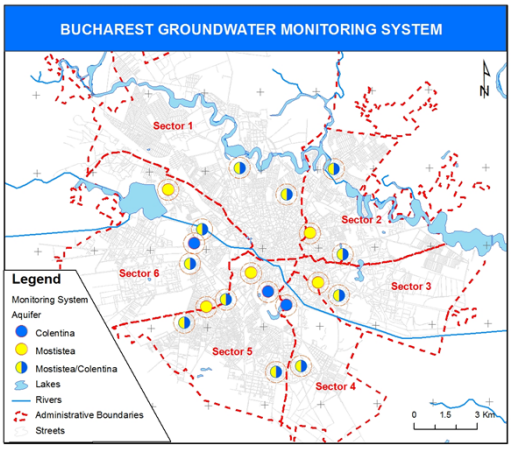
Subway tunnels & stations



Barrier effect Variable (Geometry)



Improve the hydraulic characterization of underground structures in relationship to groundwater



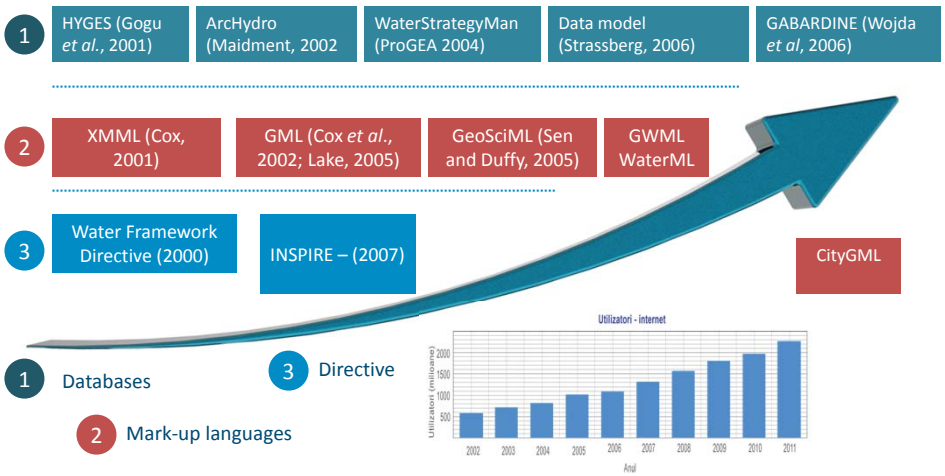
Nr. Crt.	Location	ID	Aquifer	Depth	Screens	Welllog
1	Parc Tineretului	F60C	Colentina	20	4-10	
2		F60C	Colentina	13.0	5.0-8.0 -- 8.0-11.0	Da
3	Serban Voda	F57C	Colentina	10.2	4.5-9.5	Da
4	Lamotesti	F76M	Mostistea	38.38	16.0 -28.0 -- 33.0-38.0	Da
5		F77C	Colentina	7.8	5.0-8.0	Da
6	Straduintei	F78M	Mostistea	34.7	18.0 -23.0 -- 23.0 - 28.0	Da
7		F79C	Colentina	13.4	6.5 - 8.5	Da
8	Constructorilor	F01M	Mostistea	30.25		Da
9	Cotroceni	F4	Colentina	14.85		Nu
10		F8	Colentina	13.88		Nu
11	Surduc	F52M	Mostistea	27.3	13.0-28.0	Da
12	Tismana	F38M	Mostistea/Colentina	24.16	14.0 - 11.0 -- 18.0 - 16.0 -- 20.0 -26.0	Da
13		F40C	Mostistea/Colentina	24.16	14.0 - 11.0 -- 18.0 - 16.0 -- 20.0 -26.0	Da
14	Agatha Barsescu	F44M	Mostistea	26.8	13.0 - 23.0	Da
15		P44M	Mostistea	26.8	13.0 - 23.0	Nu
16	Ramnicu Sarat	F64M	Mostistea	31.35	20.0 - 25.0	Da
17		F65C	Colentina	10.9	4.0 - 7.0	Nu
18	Facultatea de Instalatii	F28M	Mostistea	31.8	28.0 - 35.0	Da
19	Parcul Herastrau	F05M	Mostistea	39	29.0-34.0	Da
20		F06C	Colentina	10.72	3.5-12 -- 10.0-7.0	Nu
21	Titan C1	F1MC1	Mostistea	35	31.0 - 26.0	Da
22		F1CC1	Colentina	8.7	4.0 - 11.0	Nu
23		F2MC1	Mostistea	35	31.0-26.0	Da
5		F2CC1	Colentina	15	5.0-11.0	Da
25	Parcul Circului	F14M	Mostistea	27.3	22.5-19.5	Da
26		F15C	Colentina	7.13	4.8 - 9.2	Nu
27	Dr. Taberei Vasile Milea	F34M	Mostistea	35	20.0-30.0	Da
28		P34M	Mostistea	35	20.0-30.0	Da
29		F35C	Colentina	20	14.0-17.0	Da
30		P35C	Colentina	18	13.0 - 16.0	Da
31	Ferentari	F01M	Mostistea	30	26.0-18.0	Da
32		P01C	Colentina	18	13.0-16.0	Da
33	Leresti	F1ML	Mostistea	30	18.0 - 26.0	Da
34		F1CL	Colentina	17.5	13.5-9.0	Nu
35	Grozavesti	F1CG	Colentina	8.5	3.5-6.5	Da
36		F2CG	Colentina	16	12.0 - 14.0	Da
37	Colentina	F3	Colentina	25	11 -16.5 -- 17.5 - 20	Da
38		P21	Mostistea			Nu

Improve the hydraulic characterization of underground structures in relationship to groundwater

Groundwater flow model expected results

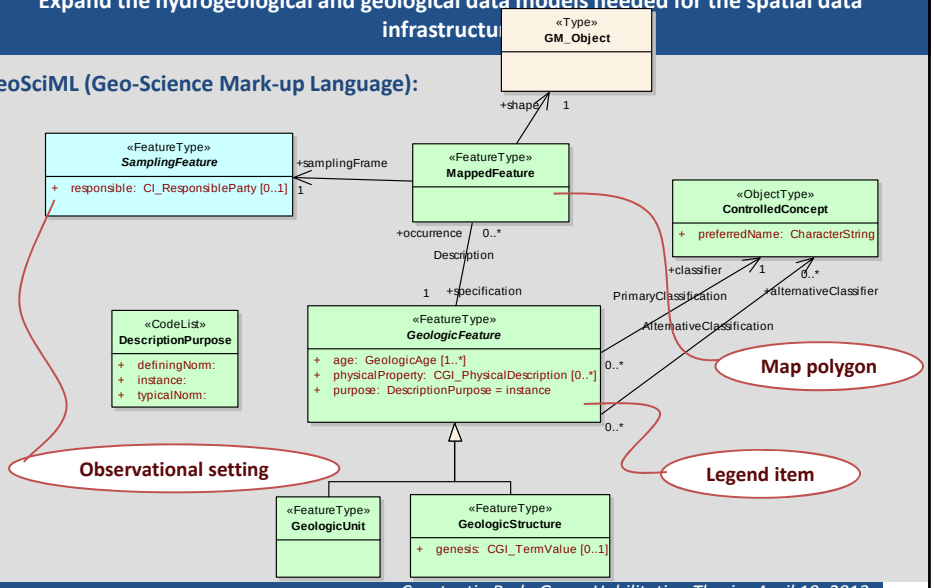
- Identification of the **SEWER SEGMENTS SUSCEPTIBLE** to groundwater **INFILTRATION**
- Identification of the **SEWER SEGMENTS SUSCEPTIBLE** to sewer **EXFILTRATION** to groundwater
- Decomposing the overall observed infiltration flow rate (at Glina WWTP) into :
  - Simulated infiltrated flow rate
  - Simulated exfiltration flow rate
- Further

Expand the hydrogeological and geological data models needed for the spatial data infrastructure



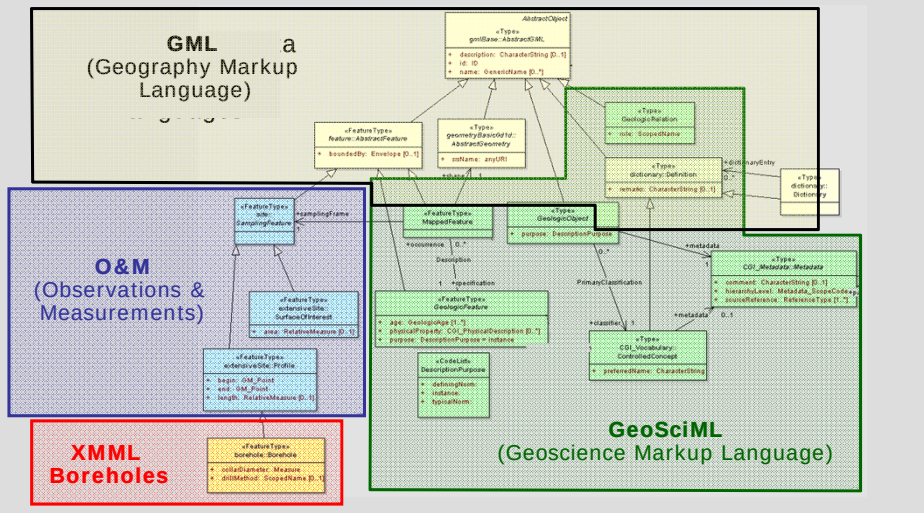
Expand the hydrogeological and geological data models needed for the spatial data infrastructu

GeoSciML (Geo-Science Mark-up Language):



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

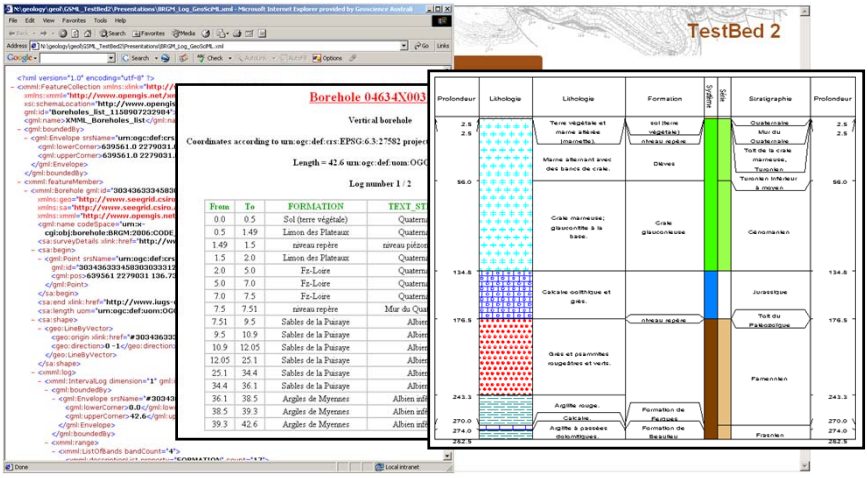
Expand the hydrogeological and geological data models needed for the spatial data infrastructure



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

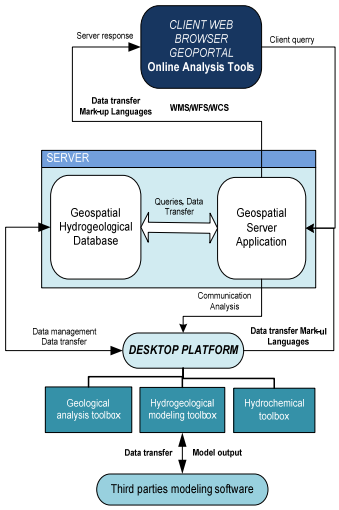
Expand the hydrogeological and geological data models needed for the spatial data infrastructure

GeoSciML (Geo-Science Mark-up Language)



Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture



Expert *(specialists in geology, hydrogeology, water management, geotechnics).*

Decisional *(local stakeholders, local authority, etc.).*

Public

The software platform architecture is based on three major components.

Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

SERVER APPLICATION
Database

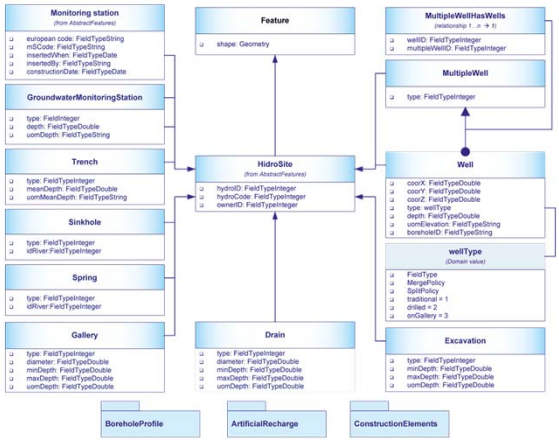
International standards for Geo-Spatial data transfer.

Object – Orientated approach.

Open Geospatial Consortium (OGC)

International Organization for Standardization (ISO)

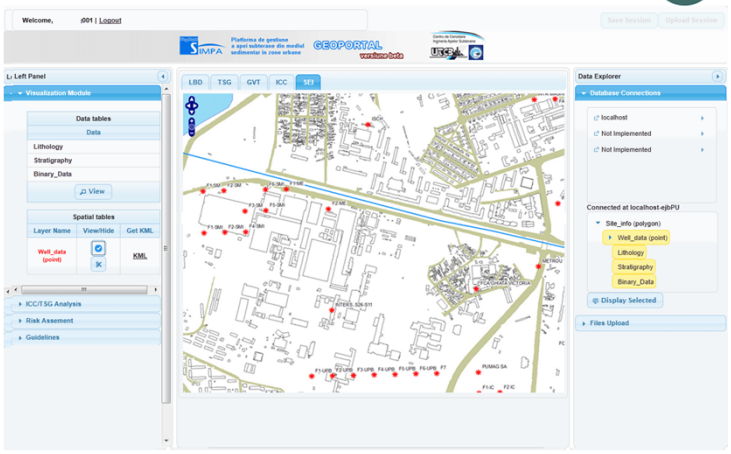
Platform architecture



Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture

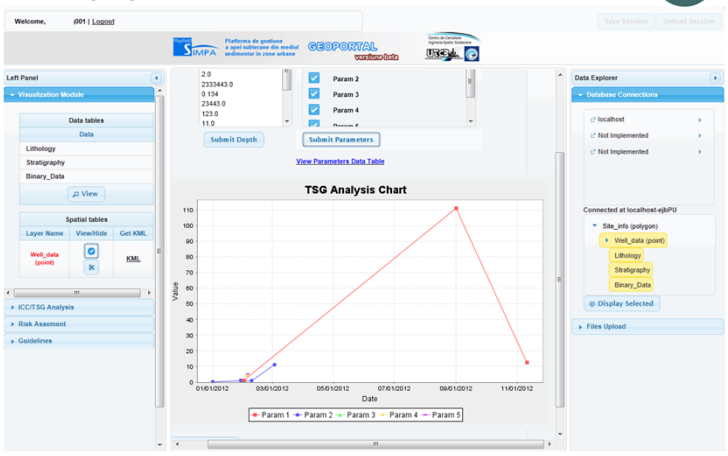
GEOPORTAL APPLICATION



Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture

GEOPORTAL APPLICATION

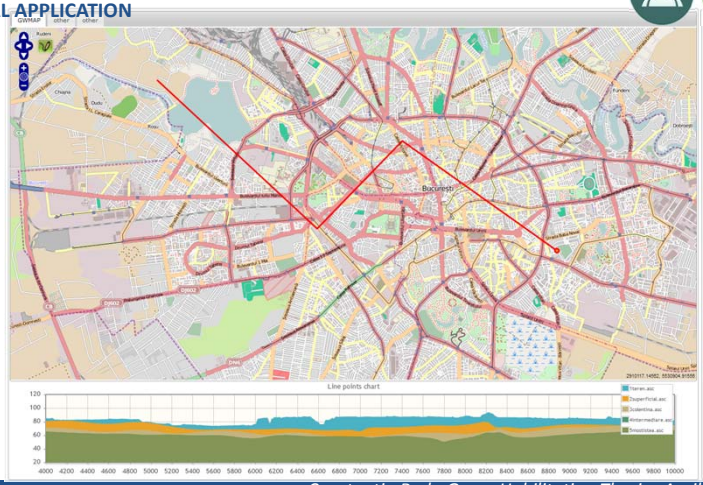


Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture

GEOPORTAL APPLICATION



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

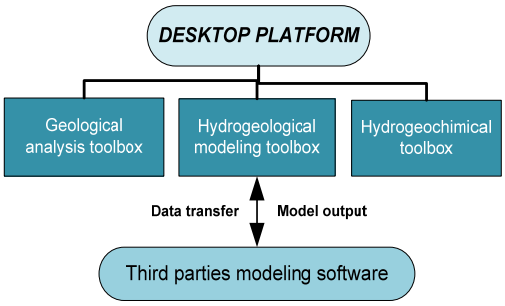
Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture

DESKTOP APPLICATION

Data management

Modeling and analysis



*The desktop platform is designed to be used by **specialists** and **researchers.***

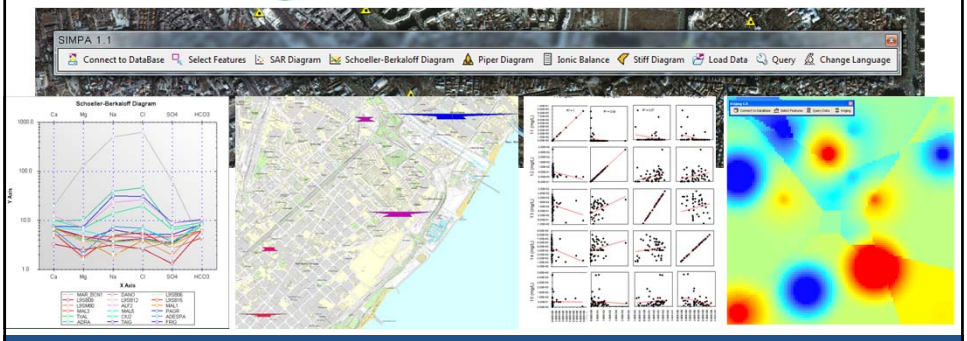
*The platform is developed under a **GIS framework** (ArcGIS).*

Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

Platform architecture

DESKTOP PLATFORM

Hydro Chemical analysis

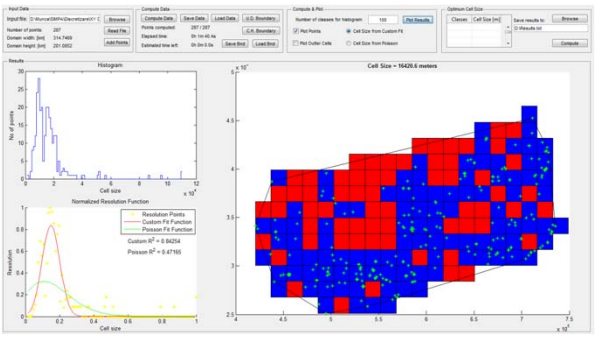


The hydrochemical toolbox performs a series of hydrochemical analysis for groundwater quality data: hydrochemical parameter statistics (univariable, bivariable,analysis), geostatistics (using GSLib library), general chemical diagrams, charts and maps (Stiff Map, Wilcox diagram, Ionic Balance, Piper Diagram) and a series of parameter orientated maps.

Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure

DESKTOP PLATFORM
Hydrogeology

Platform architecture



The third toolbox is an interface between the platform and other third parties software (such as **GMS** - Groundwater Modelling System). Data from the geospatial database are exported to the modelling software and the outputs of model can be imported back to the platform. Beside the communication capabilities, the toolbox can generate an optimal cell-size modelling grid on the basis of the hydrogeological data spatial distribution.

Build up and apply groundwater protection strategies

"Intrinsic vulnerability is the term used to define ***the vulnerability of groundwater to contaminants*** generated by human activities. It takes account of the inherent ***geological, hydrological*** and ***hydrogeological*** characteristics of an area but is ***independent of the nature of the contaminants"***

„***Specific vulnerability*** is the term used to define the vulnerability of groundwater to a ***particular contaminant or group of contaminants***. It takes account of the ***properties of the contaminants*** and their relationship with the various components of ***intrinsic vulnerability*** "

Build up and apply groundwater protection strategies

Characteristics of the groundwater vulnerability assessment :

- Vulnerability of groundwater is a *relative, non-measurable,* and *dimensionless property*.
- The evaluation of groundwater vulnerability should be made *case by case.*
- The assessment methods are mainly based on *Overlay and index techniques* (GIS)

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

Methods for the assessment of the intrinsic groundwater vulnerability

» **HCS** (hydrogeological complex and settings methods)

References: Albinet & Margat (1970) B.R.G.M. (1976) / Vrana (1968) / Olmer & Rezac (1974) / Josopait & Schverdtfeger (1979) / Vrana (1984) / Subirana Asturias & Casas Ponsanti (1984) / Breeuwsma et al. (1986) / Ostry et al. (1987) / Civita et al. (1988)

» **MS** (matrix system methods)

References: Haertle (1983) / Engelen (1985) / Ministry Flemish Comm. (1987) / Carter et al. (1987) / Palmer (1988) / Hungarian system – Madl Szonyi and Fule (1998) Irish method – Daly and Drew (1999)

» **RS** (rating system)

References: Fenge (1976) / Villumsen et al (1983) / Zaporozec (1985) / Sotornicova & Vrba (1987) / Marcolongo & Pretto (1987) / **GOD** - Foster (1987) / Schmidt (1987) / SEEPAGE - Moore J.S. (1988) / AVI - Van Stempvoort et al (1993) / REKS – Malik and Svasta (1998)

» **PCSM** (point count system model - rating and weighting system)

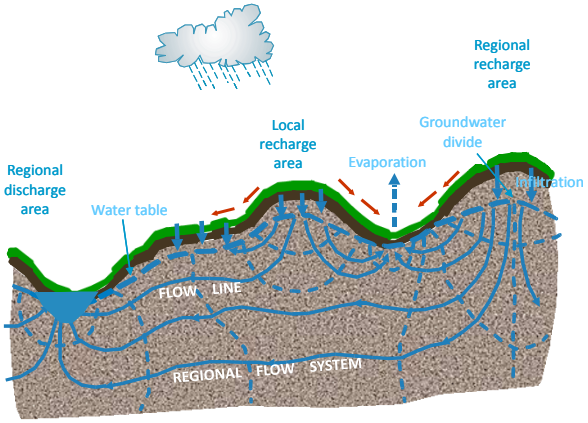
References: Trojan & Perry (1988) / **DRASTIC**-Aller et al. (1987) / SINTACS - Civita (1994) / **ISIS** - De Regibus (1994) / **EPIK** – (Doerfliger and Zwahlen 1997) / **German method** – von Hoyer and Söfner (1998) / VULK – Jeannin (2001) / PI - Goldscheider (2002) / and ... European Approach - Daly et al. (2002).

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Build up and apply groundwater protection strategies

Basic parameters

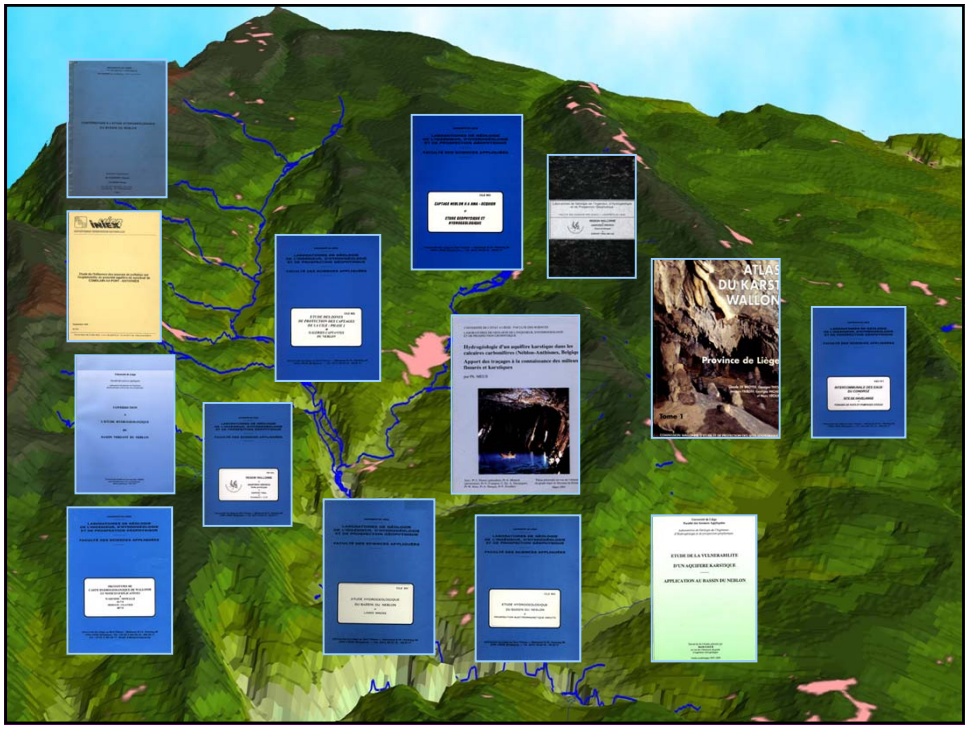
- Precipitations
- Topographical surface
- Soil characteristics
- Net recharge
- Unsaturated zone (lithology and depth)
- Aquifer media, hydraulic conductivity and depth
- Aquifer connexion to surface water
- Land use ***etc. ....***



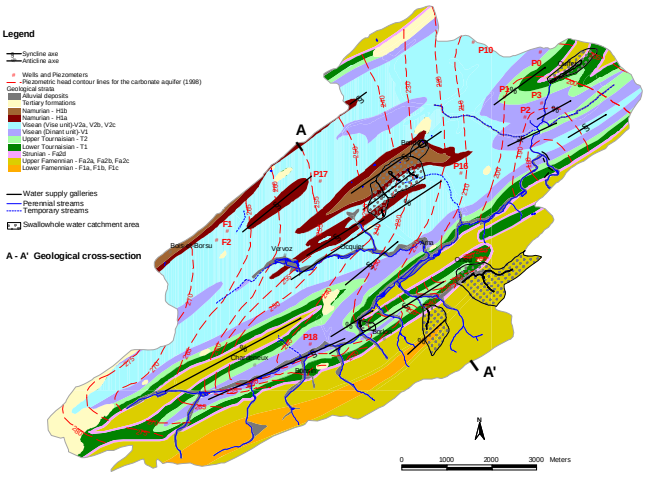
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013


ATLAS
DU KARST
WALLON
Province de Liège
Tome 1
ETUDE DE LA VULNERABILITE
D'UN AQUIFERE KARSTIQUE
APPLICATION AU BASSIN DU NEBLON

Build up and apply groundwater protection strategies

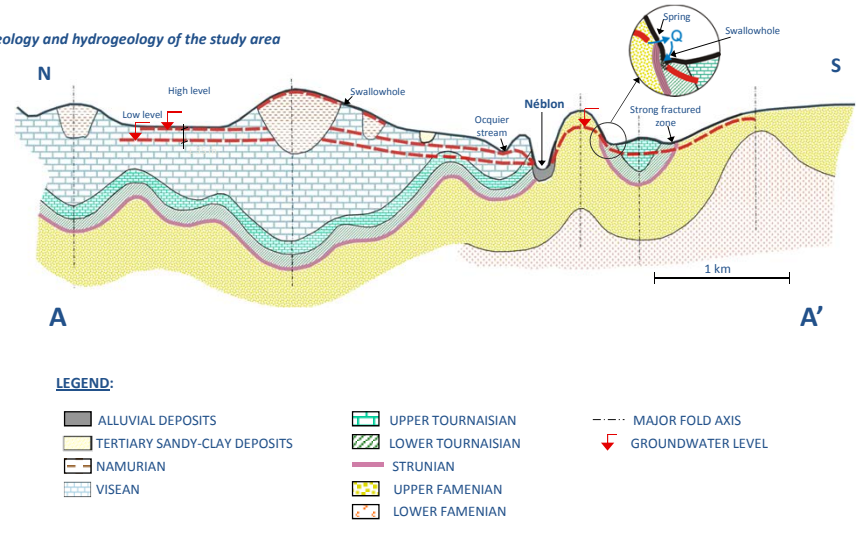


Geology and hydrogeology of the study area

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

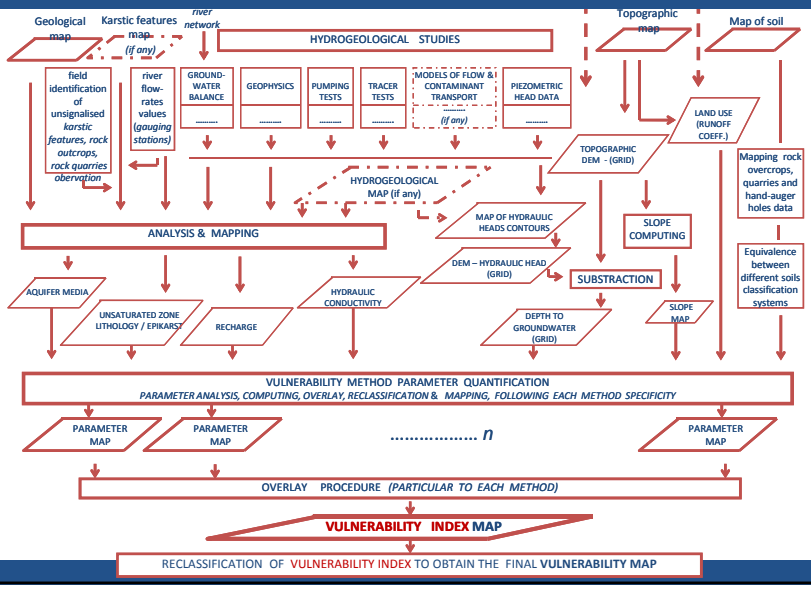
Build up and apply groundwater protection strategies

Geology and hydrogeology of the study area

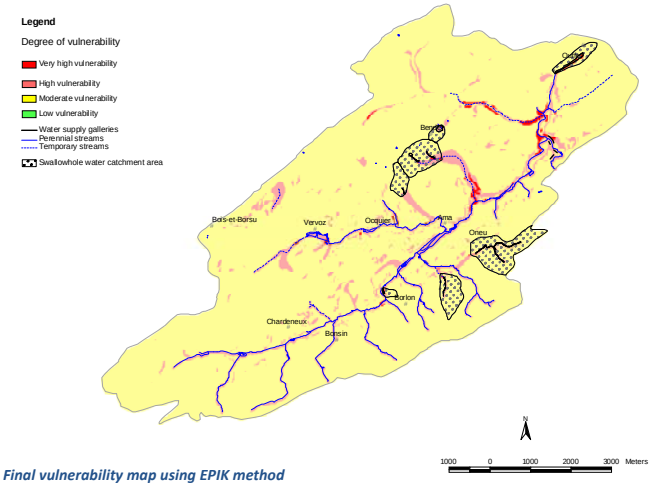


Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Build up and apply groundwater protection strategies

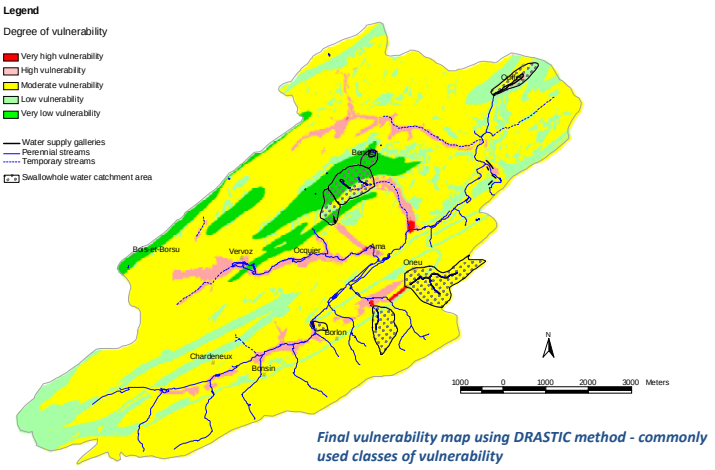


Build up and apply groundwater protection strategies



Final vulnerability map using EPIK method

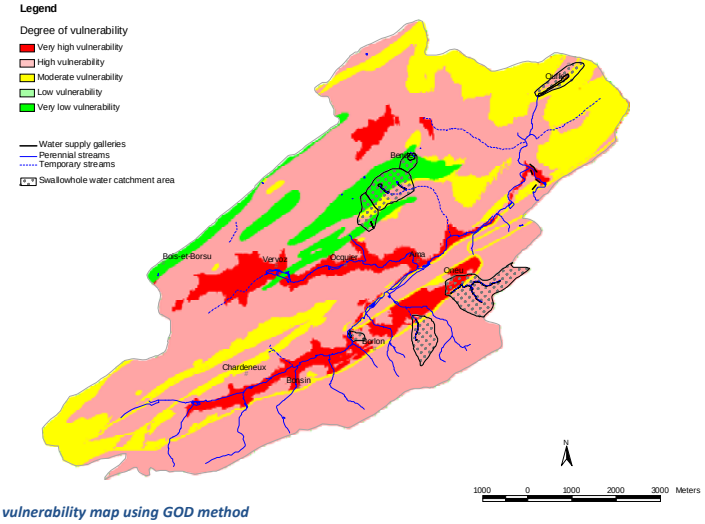
Build up and apply groundwater protection strategies



Final vulnerability map using DRASTIC method - commonly used classes of vulnerability

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

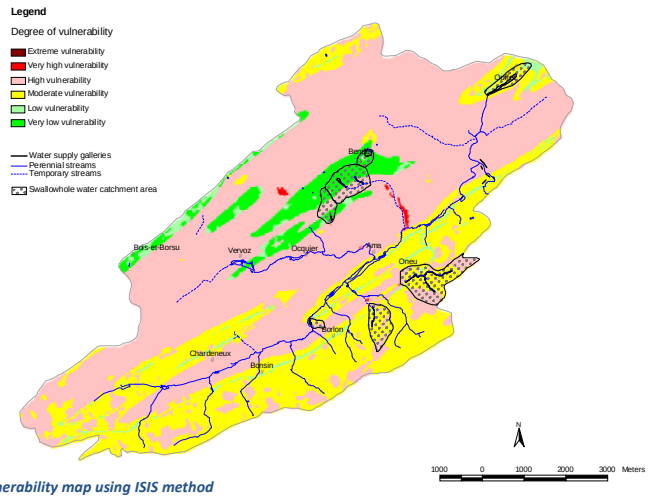


Final vulnerability map using GOD method

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

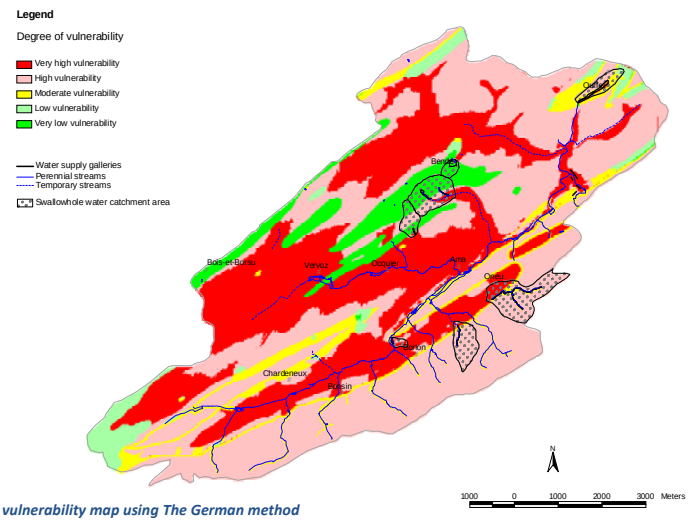


Final vulnerability map using ISIS method

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

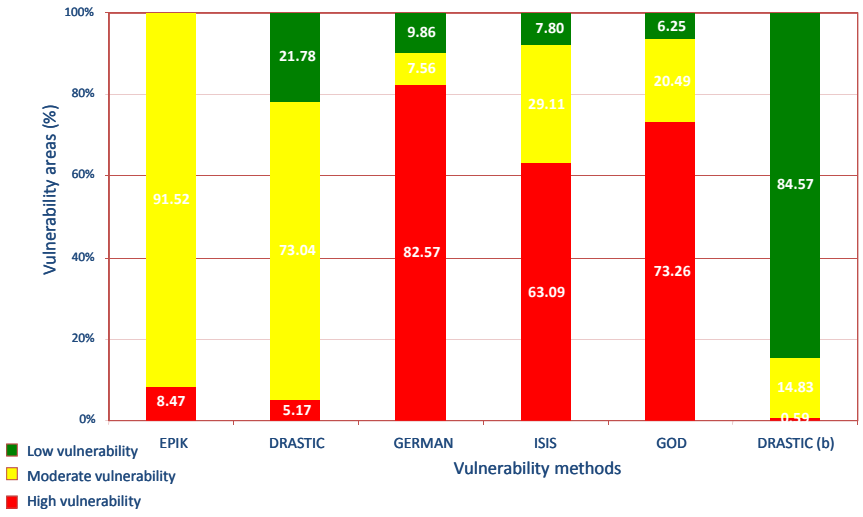


Final vulnerability map using The German method

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

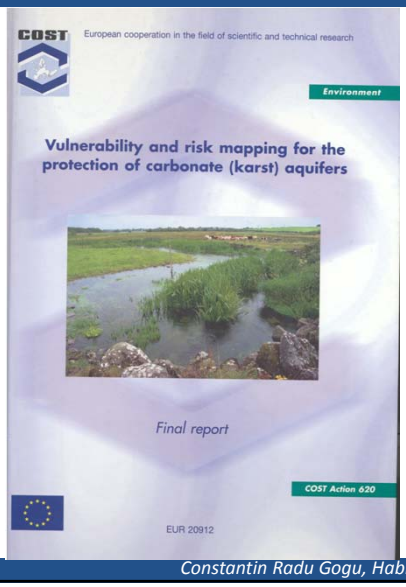
Build up and apply groundwater protection strategies



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

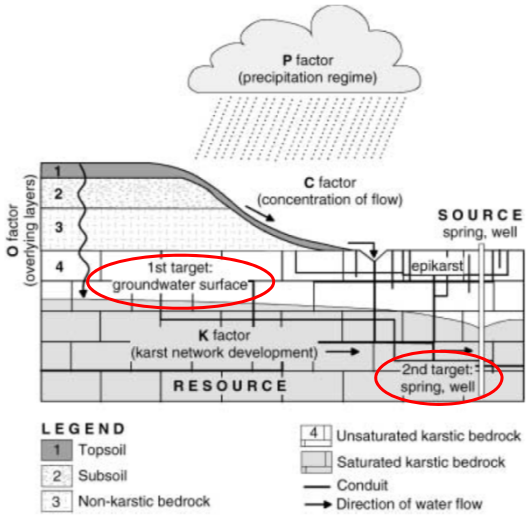
Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies



Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Build up and apply groundwater protection strategies



Consiliul National de Atestare a Titlurilor, Diplomelor si Certificatelor Universitare

Build up and apply groundwater protection strategies

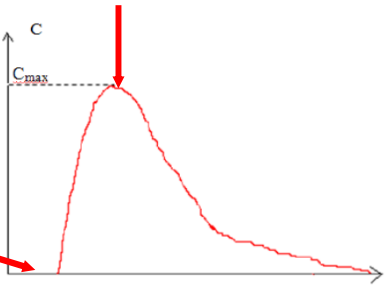
METHOD	BASIC PARAMETERS															
	Topography/ Slope	Stream flow network density	Characteristics of soils: Thickness texture and mineralogy	Characteristics of soils: Effective moisture	Characteristics of soils: Permeability	Characteristics of soils: Physical and Chemicals properties	Aquifer connect to surface water	Recharge	Characteristics Unsaturated zone	Depth to water	Hydrogeological features	Aquifer hydraulic conductivity	Thickness if the aquifer	Land use	Precipitation	Karst network
GOD									X	X	X					
DRASTIC	X		X					X	X	X	X	X				
AVI			X		X				X	X						
SINTACS	X	X	X				X	X	X	X	X	X	X	X		
ISIS	X		X			X		X	X	X	X			X		
GERMAN																
EPIK	X		X				X	X	X		X			X		
IRISH																
KARSTIC	X		X					X	X		X	X				X
PI	X	X	X		X	X	X	X	X	X	X			X		
COP	X	X	X			X	X	X	X	X	X		X	X	X	
COP+K	X	X	X			X	X		X	X	X		X	X	X	X
VUKA	X	X	X			X	X		X	X	X		X	X	X	
SLOVENE	X	X	X			X	X		X	X	X		X	X	X	X
SIMPLIFIED		X	X		X		X				X					
RISKE	X		X		X	X			X	X	X		X	X		
RISK	X		X		X	X			X	X	X		X	X		
PaPRIKa	X		X		X	X			X	X	X		X	X		X

Constantin Radu Gogu, Habilitation Thesis, April 19, 2013

Build up and apply groundwater protection strategies

Process based vulnerability assessment

- **Question 2:** Which will be the contamination level ?



- **Question 1:** In case of pollution, how long does it take to reach the target ?

-**Question 3:** How long could the target be contaminated ?

Overview on the scientific, academic, and professional directions

The research focuses mainly **urban groundwater modelling, hidrogeological data management,** and **groundwater ressources protection.**

ACTIONS

- Improve hydrogeological modeling by developing geological models techniques using stratigraphic analysis concepts;
- Improve the hydraulic characterization of underground structures in relationship to groundwater;
- Expand hydrogeological and geological data models needed for the spatial data infrastructure (INSPIRE);
- Develop a hydrogeological qualitative and quantitative information management framework in relationship to urban infrastructure (water supply, sewer system, subway lines, foundations, etc);
- Build up and apply groundwater protection strategies

Thank you for your attention!